THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

SUBSCRIBER TRUNK DIALLING

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Vol. 51 **Part 4** **JANUARY 1959**

Subscriber Trunk Dialling Number

FOREWORD

The inauguration of Subscriber Trunk Dialling by Her Majesty the Queen, described in the opening pages of this special issue of the *Post Office Electrical Engineers' Journal*, marks an historic step forward in trunk telephone operation in the United Kingdom. This royal recognition will be an immense encouragement to all staff in the important tasks that lie ahead.

We can rightly be proud of the engineering achievements that have made S.T.D. possible. The fully electronic controlling equipment at Bristol is a world "first" of great significance, and this and other new apparatus involved are entirely British in conception and manufacture. But this is only a beginning. Many other new developments are approaching completion, including new types of register-translator equipment, signalling systems and subscribers' apparatus. The future is indeed full of interest and promise. We feel confident that the research and development initiative of the Post Office headquarters staffs, and of the manufacturing industry, combined with the fine work of the field organizations in connexion with provision and maintenance, will enable the British telephone system to maintain its position as one of the best in the world.

This special "S.T.D." number provides a comprehensive description of the new scheme, and will serve as a valuable technical reference for all those concerned with this great project as it spreads through the national telephone system.

Chairman of Board of Editors

HER MAJESTY THE QUEEN, IN THE PRESENCE OF HIS ROYAL HIGHNESS THE DUKE OF EDINBURGH AND THE POSTMASTER GENERAL, MAKING THE INAUGURAL CALL

SUBSCRIBER TRUNK DIALLING

Inauguration by Her Majesty the Queen

On 5 December 1958 Her Majesty the Queen greatly honoured the Post Office by inaugurating Subscriber Trunk Dialling in the United Kingdom, the first stage of which provides trunk dialling facilities from more than 18,000 telephones connected to Bristol Central telephone exchange.

The ceremony took place in the apparatus room at the telephone exchange. Her Majesty was accompanied by His Royal Highness the Duke of Edinburgh, and in addition to the Postmaster General, the Right Honourable Ernest Marples, M.P., the distinguished company included the Lord Lieutenant for the County of Bristol, the Lord Mayor of Bristol, the Assistant Postmaster General, the Director General, the Deputy Director General (Telecommunications), the Engineer-in-Chief, the Director of Inland Telecommunications and the Regional Director of the South-Western Region.

At the invitation of the Postmaster General, the Queen made a telephone call to the Lord Provost of Edinburgh by dialling 0 31 CAL 3636. The conversation was relayed by loudspeakers to those present.

The Lord Provost, the Right Honourable Ian A. Johnson-Gilbert, offered Her Majesty the loyal greetings of the citizens of Edinburgh, and the Queen replied:

> "Thank you, and would you, My Lord Provost, please convey my greetings to them. I am always interested in any development which brings my people closer together. In a few moments Bristol subscribers will be able to make trunk calls merely by dialling the right number, up to a distance of some 300 miles. In time the whole United Kingdom will enjoy the advantages of this new service which the Post Office has introduced."

The Lord Provost concluded:

> "May I express my gratitude to Your Majesty for the honour which you have done to me and to Scotland in making the first call in this new service to me."

Then, at 3.33 p.m., the Queen operated a key which connected Bristol Central exchange subscribers to the new service, and the Postmaster General presented to Her Majesty the colonial-blue telephone she had used. This is the first of the new design of telephone which the Post Office intends to introduce during 1959.

Earlier the Queen, accompanied by His Royal Highness the Duke of Edinburgh, had visited an exhibition of subscriber trunk dialling where the Postmaster General had demonstrated how the new service works. After the ceremony the royal visitors saw the electronic register-translators and talked with members of the staff. They also visited the telephone switchroom.

The General Plan for Subscriber Trunk Dialling

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The conversion of the United Kingdom telephone system to a fully automatic service started more than 40 years ago with the installation of the first local automatic exchanges, and at the present time about 80 per cent of subscribers are able to dial local calls. Although the distance over which subscribers can dial their own calls has been increased to 20 miles or more, subscriber trunk dialling represents more than a further extension of the subscribers' dialling range. The opportunity has been taken of reassessing the merits of some of the traditional features of the manual control of trunk telephone calls and this has led to the introduction of a number of changes and new facilities. This article broadly describes the plan for subscriber trunk dialling in the United Kingdom and serves to introduce the other articles in this Journal.

INTRODUCTION

THE introduction of subscriber trunk dialling[1] (S.T.D.) marks a further stage in the conversion of the telephone system of this country to a fully automatic service. The process started more than 40 years ago when the first local automatic exchanges were installed and has continued until at the present time about 80 per cent of subscribers are able to dial local calls. During this period the distance over which subscribers can dial their own calls has been increased to 20 or more miles, but for many years the limit has been set by general policy rather than by technical considerations. Longer-distance calls have been controlled by operators. With the introduction of S.T.D. more is involved than just a further extension of the subscribers' dialling range as, apart from the control of routing and the recording of information for charging purposes, the manual control of trunk traffic enables services to be offered which are not available on local calls. The extension of automatic methods, however, has presented an opportunity to reassess the merits of some of these traditional features, and has led to a number of changes and to the introduction of new facilities to assist the subscriber in using the service.

OUTLINE OF EXISTING SYSTEM

Before dealing with the detailed problems involved in the introduction of S.T.D., it is desirable to review the salient features of the existing system, particularly in so far as methods of routing and charging are concerned. It is thus possible to see how S.T.D. fits into the broad picture of the development of the telephone system.

Local Service

The telephone system of this country contains a variety of equipment representing the many stages through which the system has progressed. Apart from the several types of manual exchange still in service, the automatic exchanges vary, not only in method of working but also in details of the design of switch mechanisms and of circuits, both of which have changed considerably over the past 40 years.

The method of working an automatic exchange has usually been adapted to suit the needs of the local service. Thus, in small towns and in rural areas a single exchange serves the local community and access to subscribers on nearby automatic exchanges is obtained by dialling codes followed by the subscribers' local numbers. In large towns and cities served by a number of exchanges, a range of subscribers' local numbers is usually shared between the exchanges to form a linked-numbering-scheme area. The dialling procedure is uniform throughout such an area, and the dialling of a subscriber's local number is sufficient to route the call, first to the required exchange and then to the wanted subscriber. Special dialling codes are used for access to exchanges outside the linked-numbering-scheme area.

In the six very large linked-numbering-scheme areas, London, Birmingham, Manchester, Liverpool, Glasgow and Edinburgh, letters have been introduced into the local numbers to assist subscribers in dialling numbers of seven digits. In practice the subscribers' local numbers are made up of the first three letters of the exchange name followed by four figures. The large number of exchanges in these six areas, combined with the use of letters, made it very desirable to use an exchange system with a high degree of flexibility in respect of routing. This has been achieved by using the translating facilities of the director system, the director being a particular form of register-translator.

For the smaller linked-numbering-scheme areas the general pattern is a central main exchange surrounded by a number of satellite exchanges. In this arrangement, usually referred to as a non-director area, the absence of translating facilities means that the allocation of subscribers' numbers is closely associated with the routing of calls.

The method of charging for calls dialled by subscribers is to record for each call one or more unit fees on a meter associated with the originating subscriber's line, no account being taken of the duration of a call. Before January 1958 up to four units per call were recorded, the actual number depending upon the straight-line distance between the exchanges concerned. Since January 1958, however, when group charging was introduced, only a single unit is charged for all local calls, i.e. to exchanges within the same charging group or in an adjacent group.

Trunk Service

For long-distance traffic the country is divided into some 270 group-centre areas, each with a trunk exchange —the group centre—from which operators control the trunk traffic originating within the area. Long-distance incoming traffic also circulates via the group centre. Certain large group centres have been specially adapted for transit switching and are termed zone centres. Partly to limit the numbei of transit-switching operations, but chiefly to ensure a satisfactory grade of transmission, the existing trunk-switching plan caters for each group centre to be directly connected to at least one zone centre and for all zone centres to be fully interconnected. Not more than two intermediate zone-switching centres should therefore be involved on any one call. In practice the plan has not yet been fully implemented and a few routings involve three zone centres. This basic trunk

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network is augmented by direct auxiliary circuits between group centres and a large proportion of the local trunk traffic is carried on these auxiliary circuits.

During recent years a large part of the switching equipment at zone and group centres has been mechanized[2] and, together with the provision of dialling facilities on trunk circuits, has led to the adoption of "single-operator control" for much of the trunk traffic. In such cases the controlling operator at a group centre can, by dialling suitable digits, route a call via one or more intermediate zone or group centres to the objective exchange and required subscriber. The switching equipment is of the non-director type, the operator being required to dial the actual routing digits which, for any one objective exchange, vary according to where the call originates.

The method of charging for trunk calls is based partly on distance and partly on duration. Before January 1958 the distance between exchanges was used in the same way as for local calls, but since the introduction of group charging the distance between nominated measuring points within charging groups has been adopted. The duration of a call is measured in minutes with a minimum charge to cover a 3-minute period. The controlling operator times the call and records the relevant information on a ticket.

FUNDAMENTAL REQUIREMENTS FOR S.T.D.

The method of providing S.T.D. facilities varies in different countries. The particular scheme adopted usually reflects the local conditions in respect of the size of the country, number of telephones and the type and layout of existing plant. In this country it was decided that the scheme adopted for S.T.D. should, as far as possible, meet the following requirements.

(*a*) *Future Growth.* It should be able to meet growth in the telephone system for a long time ahead, say 100 years.

(*b*) *Universal Application.* It should be possible to apply the scheme to all automatic exchanges. It follows that the scheme should have sufficient inherent flexibility to meet the varying conditions throughout the country, and to meet possible future changes in requirements.

(*c*) *Economic to Provide and Maintain.* With some 6,000 exchanges, serving more than 7,000,000 telephones and a large trunk and junction cable network, it is essential that any S.T.D. scheme should involve a minimum of cost and disturbance to existing equipment and line plant. Any large-scale replacement of exchange equipment would obviously be undesirable on the ground of cost, and extensive rearrangements involving modification to the wiring of equipment that has been in service for many years would also be open to serious practical objections. The introduction of S.T.D. should not involve simultaneous action at a large number of exchanges and, in fact, it should be possible to introduce the scheme progressively in the light of prevailing circumstances.

(*d*) *Subscribers' Requirements.* Any scheme should be simple and straightforward for subscribers to understand and use, and should involve the minimum change to subscribers' existing facilities and dialling procedure. Provision should also be made for such special aids and features that subscribers have enjoyed under a manually operated trunk service as are appropriate to an automatic service. An indication of the charge for a particular call as soon as it has been completed is an example of this type of requirement.

(*e*) *Coin-Box Lines.* These contribute about 20 per cent of the total trunk traffic. If the maximum operator savings are to be realized, it should be possible to dial trunk calls from these lines and to collect automatically the appropriate fee, depending upon the duration and chargeable distance of the call.

(*f*) *Retention of Manual-Board Service.* Subscribers should not be compelled to dial their trunk calls but should be able to route them via an operator if they so prefer. However, it is expected that the volume of manually controlled trunk traffic will be considerably reduced. The scheme should permit the remaining traffic, together with associated manual-board services (e.g. "Assistance" and "Directory Inquiries"), to be concentrated on fewer manual boards, often located many miles from the originating exchange.

(*g*) *Statistics.* Methods should be devised for producing the statistical data for routing, circuit provision and general tariff purposes which can now be obtained from an analysis of the tickets prepared by operators to record details of telephone calls.

GENERAL PRINCIPLES OF DESIGN

Arising partly from the fundamental requirements and partly from engineering considerations, it was decided to adopt certain general principles in the design of equipment for S.T.D. The object has been to provide the subscriber with a very reliable service, with adequate facilities and in the most economical manner. The more important of these principles are indicated below.

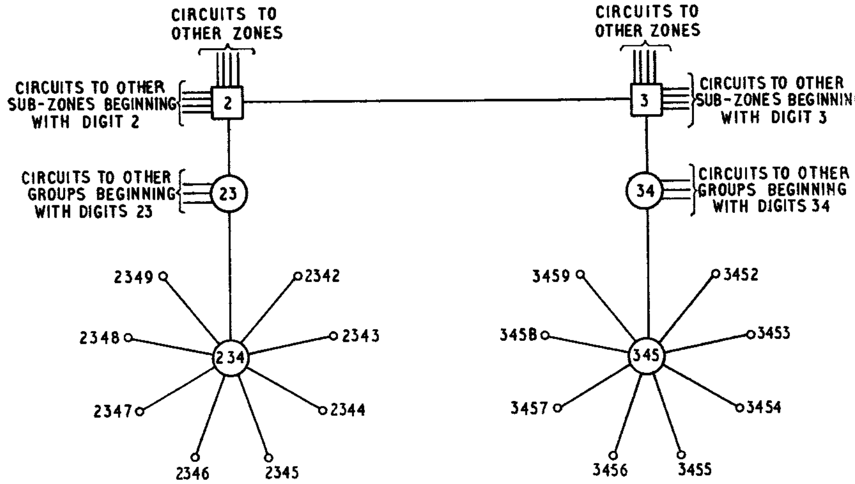
(*a*) *Access to Automatic Exchanges only.* As S.T.D. is intended as a service between subscribers on automatic exchanges, the equipment should be designed to give these facilities in the most satisfactory manner. Additional expense or equipment complication should not be incurred in giving access to manual exchanges which, in any event, it is hoped will be replaced by automatic equipment before long.

(*b*) *Centralization of Equipment.* It is very desirable that any additional equipment installed in small and outlying exchanges should be both as simple as possible and kept to a minimum. Therefore the principle should be adopted of centralizing the more costly and complex equipment at relatively few centres where it can be used more economically and where its correct functioning can be more easily supervised.

(*c*) *New Design Techniques.* The new problems posed by S.T.D. offer a chance of using some of the many new techniques, particularly in the electronic field, which have become available in recent years. In the interests of service reliability, however, new techniques should be used only after they have passed stringent laboratory tests. The general principle, therefore, should be to use those techniques that offer the best solution to a particular problem, taking account of both cost and service requirements.

(*d*) *Flexibility.* The possibility of changes in the facilities required by subscribers is always present. With a new service such as S.T.D. the possibility of change is greater and hence, in designing equipment, allowance should be made for some future changes of facilities. In particular, flexibility should be inherent in the system to allow for uneven growth in different parts of the country and to permit changes in call charges to be effected readily.

(*e*) *Reliability.* As much more equipment and line plant is involved with subscriber trunk dialling than hitherto on calls dialled by subscribers, particular attention must be paid to reliability. It is essential, therefore, that not only should the equipment concerned be inherently very reliable, but that in the event of a fault occurring the effect on the service should be minimized. This latter point could be covered to some extent by ensuring that as far as possible a subscriber who fails to get through on a first attempt will, on a second attempt, use a different set of equipment.



The number shown against each exchange represents the national code of the exchange

FIG. 1—THE DECADE SYSTEM OF NATIONAL NUMBERING

NUMBERING, CHARGING AND ROUTING UNDER S.T.D.

National Numbers

Each subscriber in the country can at the present time be identified by a name representing an exchange, or linked numbering scheme, and a local number. Under S.T.D. conditions, the name must be replaced by a code which can be signalled to the exchange by a dial or key-set in the form of digits. It is possible, therefore, to identify any subscriber on a national basis by a group of digits consisting of a code for his particular exchange or linked numbering scheme, followed by the digits of his local number. Together these two groups of digits could form the subscriber's national number.

A subscriber's national number formed in this manner will always contain more digits than his local number and this fact, together with the desire not to change existing dialling procedure, means that national numbers will normally be used only for access to distant exchanges. To distinguish between the two series of numbers—national and local—it has been arranged that all national numbers will commence with a digit (the prefix) which is not used in the local numbering scheme. Only two digits, 1 and 0, could readily be made available for this purpose. Digit 1 is subject to false traffic simulated by line faults or by subscribers' mis-operation of the telephone, and was therefore considered unsuitable for the purpose as the equipment required for S.T.D. would be taken into use unnecessarily. On the other hand, digit 0 has for many years been used for access to the manual board. There will, however, be a considerable reduction in the manual-board traffic when S.T.D. is introduced, so that the use of a single-digit code for access to the manual board will no longer be justified. An investigation has shown that a 3-digit code beginning with digit 1 would be little affected by false traffic and in view of this it has been decided to change the manual-board assistance code from 0 to 100 and to adopt 0 as the prefix digit for national numbers. All national numbers will therefore commence with 0 and will be easily distinguishable from local numbers.

National Numbers and Routing

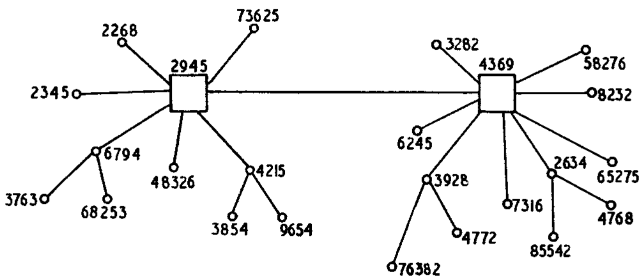
From a technical point of view the information contained in the national number is used both for routing the call to the required destination and for indicating the correct charging rate. These functions are to some extent interdependent, but it is convenient to deal with the routing aspect first.

There are a number of ways in which the code portion of national numbers could be allocated, and they vary from schemes based on the geographical location of an exchange to schemes providing full flexibility. In a typical scheme based on geographical location the country could be divided into 10 zones, each zone could be sub-divided into 10 sub-zones and these could again be further sub-divided on a decimal basis into groups and exchanges. The whole network would then conform to a "decade" pattern, as in Fig. 1. An advantage claimed for this type of scheme is that routing can be on a straightforward basis, it being unnecessary to employ complicated translating equipment. If used in this simple manner, with each exchange in effect being worked as a satellite on a main exchange in each zone, the routing of calls must follow a standard star pattern as it normally does in a non-director multi-exchange area. For example, in Fig. 1 a call from exchange 2345 to exchange 3456 would be routed via exchanges 234 and 23 to a first selector at exchange 2, and then via exchanges 3, 34 and 345.

In practice, in view of the circuitous routing often involved, it is essential to supplement the basic trunk network by an auxiliary network of circuits and also to provide exchange equipment which has the necessary discriminating facilities. In order to avoid engaging the series of trunk circuits to the main exchange on every S.T.D. call it becomes desirable to store the digits received at each exchange until the discriminating equipment can decide whether the call should be routed over a direct auxiliary circuit or to the next higher centre in the basic network. The net effect is that the routing of calls is, in fact, controlled by "register-discriminators," which for comparable facilities differ little in cost and complexity from register-translators.

An objection to a scheme of this type is its lack of flexibility in meeting anticipated growth. New exchanges required as the result of the building of new towns or the growth of new industries can be accommodated to a limited extent by leaving a number of codes spare in each sub-zone and group, but sooner or later a situation is likely to arise where no spare codes are available locally and extensive rearrangement of equipment and line plant is necessary. While it is no doubt prudent with any scheme to leave a proportion of spare codes it is preferable for them to be in one common pool so that they can be allocated in any manner circumstances may require. A further objection to the introduction of such a scheme in the United Kingdom is that the present pattern of line plant layout does not lend itself to a star pattern of routing of the kind envisaged.

A typical example of a scheme giving full flexibility is provided by the director system, but for application on a national basis it would have to be modified to provide for 4-digit and 5-digit exchange codes. With such a scheme codes could be allocated as shown in Fig. 2, the codes for adjacent exchanges being entirely independent of one another. Although numerical codes have been shown it would, of course, be possible to use letters, as is done in the director system, either by themselves or in combination with figures. Such codes could be made to represent exchange names, districts or divisions of counties. Many schemes of this type were examined but all involved the use of translating facilities greatly in excess of those provided by the normal director and were likely to be costly.



The number shown against each exchange represents the national code of the exchange

FIG. 2—THE FULLY FLEXIBLE SYSTEM OF NATIONAL NUMBERING

It is possible to devise a number of schemes which in varying degree incorporate one or more features of the two typical arrangements outlined. In essence it becomes a question of providing sufficient translating facilities to give adequate flexibility and to enable the existing line plant layout to be retained, without introducing the high cost and complication associated with the type of equipment required for the fully flexible scheme. In the manual control of trunk routing, the country is already divided into some 270 group-centre areas and incoming long-distance traffic is routed first to the group centre and then to the individual exchange. The traffic to a group-centre area will follow many different routes depending upon the point of origin, but within the area the routing is always the same. A similar scheme could be used for S.T.D. traffic; translating facilities could be used in routing a call to a particular group-centre area, while the actual dialled digits could be used for selecting an exchange within an area. The national code for each exchange would in effect be in two parts, the first part representing the group-centre area and the second the exchange within the area.

The arrangement is shown in Fig. 3, where exchange A represents the group centre and, neglecting the prefix, is obtained by dialling the code 234, whether the call originates at B and is routed via a direct circuit to A or whether it originates at C or D and is routed via intermediate switching points. The actual digits used in routing a call from A to its dependent exchanges are indicated and show how the exchange code is formed.

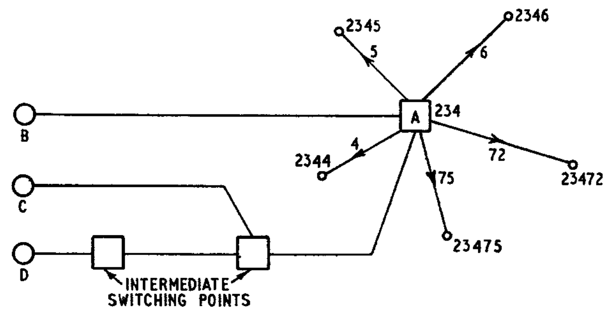


FIG. 3—NUMBERING SYSTEM USING A COMMON NATIONAL CODE FOR A GROUP OF EXCHANGES

With less than 1,000 groups, three digits are adequate to identify a group, while the number of additional digits required to identify a particular exchange will depend upon the number of exchanges within the group. Therefore, translation will be required on not more than three digits of the national number where traffic is routed via the terminal group. Short-distance traffic, however, is sometimes carried on auxiliary circuits direct to the terminal exchange, and to enable these auxiliary routes to be fully exploited it will be necessary in these few cases to examine an additional one or two digits before routing can be determined. A scheme of this type, which provides full flexibility in the choice of routing between groups and in the allocation of group codes, meets the essential requirements for this country and has been adopted.

National Numbers and Charging

The charging rate appropriate to a call must also be obtained by examination of the national number. At the time the original plans were being made the call charge was determined in most cases from the straight-line distance between the exchanges where a call originated and terminated. If this method had continued it would have been necessary in effect to equip each exchange with a device to identify each of the 6,000 other exchanges in the country. The translating equipment provided for routing purposes can easily be arranged to indicate the charging rate as well, but much of the advantage of a scheme of determining the routing after examining only three digits would be lost if it were necessary to examine further digits for charging purposes.

For many years it has been the practice for common call charges to apply for a number of exchanges serving a large town. It is obvious that an extension of this principle would considerably simplify the charging problem by reducing both the number of charging points to be identified and the number of originating exchanges having different charges. In particular, there are advantages in a close association of a group-centre area identified by not more than three digits for routing purposes and a group of exchanges associated for charging purposes. The existing group centres, however, serve areas whose size differs considerably, and if exchanges are to be grouped together for charging purposes it is very desirable that the areas covered by these "charging groups" should be comparable to ensure an equality of treatment for all subscribers.

Other factors could also affect the size of a charging group. In particular, anomalies in the charges for calls of comparable point-to-point distance, but in different directions, are inherent in any charging system based on groups and increase with the size of the groups.

There is also a service advantage in arranging the boundaries of charging groups so that each covers a particular community, e.g. a large town and its neighbouring dormitory area or a market town and its surrounding villages. After taking account of all these factors it has been found possible to produce a satisfactory scheme which involves the setting up of about 640 charging groups. Although inevitably some rearrangement of exchanges served by different group centres has been necessary, in most cases it has been possible, with only minor rearrangements of line plant, to divide up existing group-centre areas into suitable charging groups.[3] Where routing and charging requirements conflict it has been arranged either for a charging group to be divided into two "numbering groups," each with a separate national code, or for a "group switching centre" to serve more than one charging group. A group with a remote switching centre is called a "dependent group."

The principle of producing charging groups by dividing up existing group-centre areas is shown in Fig. 4, where the two group-centre areas shown have

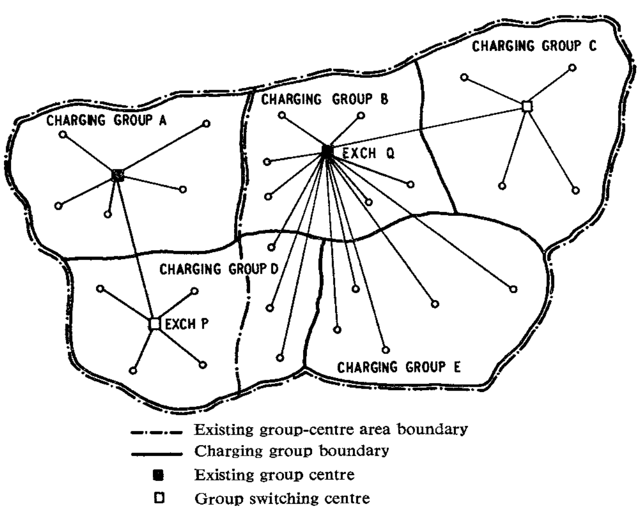


FIG. 4—EXAMPLE OF DIVISION OF GROUP-CENTRE AREAS INTO CHARGING AND NUMBERING GROUPS

been divided into a total of five charging groups. In charging groups A, B and C the existing plant layout has enabled charging groups of roughly similar sizes to be formed around convenient switching centres. In charging group D, however, line plant does not exist for all the exchanges to be connected to one switching centre, and traffic to some of the exchanges will continue to be routed via exchange P and traffic to the remaining exchanges via exchange Q. There will thus be two separate numbering groups in charging group D. As a long-term solution line-plant rearrangements could make one of the numbering groups redundant. Charging group E is an example of a dependent group. In practice most charging groups will contain only one numbering group, but there will be some which contain more.

Arising from the foregoing general considerations it follows that the use at an originating exchange of equipment with facilities for translating normally only three digits, but in a few cases four or five digits, would meet both the routing and charge-determining requirements for S.T.D. To avoid a subscriber having to pause during dialling while the translating function is performed, it is necessary to store the dialled digits on a register. The equipment which combines the function of storing and translating is called a "register-translator" and is similar in principle to a director.

Partly in preparation for S.T.D. at a later date, and partly because of the immediate savings in operating costs which could be achieved by increasing the dialling range, a system of call charges based on charging groups was introduced in January 1958.

Number of Digits in National Numbers

It has been assumed that during the next 100 years the number of subscribers will grow to at least 20,000,000. On this basis alone, some national numbers will need eight digits, excluding the prefix, but the required capacity of a numbering scheme is affected by other factors, including the following:

(*a*) The ease with which the numbering capacity can be made available at those points where it is required.

(*b*) The use of special codes for access to the manual board and to nearby exchanges.

(*c*) The extent to which it is desired to retain existing subscribers' numbers unchanged.

(*d*) The limitations in the allocation of particular digits which might arise from the use of letters.

After consideration of all the relevant factors it was decided to allocate national numbers on the basis of a maximum of nine effective digits, i.e. 10 digits including the prefix.

The practical capacity of such a numbering scheme, although considerably less than the theoretical figure of 10^9, should be entirely adequate. If three of the nine digits are assumed to be used to identify each numbering group, six digits remain for use within the group. As explained later, the digits 1 and 0 cannot be used when they follow the group code, so that each numbering group could contain the equivalent of 80 exchanges, each with a theoretical maximum capacity of 10,000 lines. At present each numbering group contains, on the average, only nine exchanges of about 800 lines each so that initially it is seldom necessary to use within the numbering group more than four or five of the six digits available. In practice, therefore, national numbers will contain eight, nine or 10 digits, including the prefix. This variability in the number of digits permits the retention of local numbering schemes with mixed numbers of four and five digits or five and six digits and provides an adequate degree of flexibility to meet future growth. It does, however, introduce a problem as some indication that a complete number has been dialled is required so that any common equipment, such as a register-translator employed during the setting up of a call, can be released. A number of possible solutions, including the following, were examined:

(*a*) Increasing the translating facilities of the register-translators at the originating exchange so that they could determine the number of digits to accept on each call.

(*b*) Signalling back from the terminal exchange that all information has been received.

(*c*) Making the release of the common equipment dependent on receipt of an answer signal.

(*d*) Arranging for the register-translators to release automatically if further digits following the seventh (excluding the prefix) are not received within a short period.

The first three solutions were rejected chiefly on the grounds of cost, and the automatic "time-out" facility of (*d*) was adopted as being the cheapest and easiest to introduce into the present telephone system.

National Numbering Scheme

As already indicated, the general form of national numbers will be 0 ABC XX xxxx, where 0 is the prefix and ABC the effective code for the numbering group. The digits represented by XX identify the particular exchange within the numbering group and the local number is represented by xxxx. The national code for small exchanges with self-contained numbering schemes will be represented in the above example by 0 ABC XX. For some larger exchanges, and particularly those forming parts of linked-numbering-scheme areas, the digits represented by XX will be omitted or form part of the local numbering scheme, and the national code for the exchange becomes the same as the numbering group code, i.e. 0 ABC. The director areas have been treated specially, a 2-digit code being used for London and a 3-digit code for each of the other five director areas.

National codes could consist of figures or letters or a combination of both. Experience in director areas has suggested that the use of letters having some significance, for example the first three letters of the exchange name, does assist subscribers in dialling numbers containing many digits. It has been decided therefore to introduce letters into the national codes and that where possible they should be the first two letters of the principal town in the group followed by one or more figures. Where the name of a suitable local town cannot be used a name representing the district will be adopted. In order to avoid any confusion, letters additional to those already used in the local number will not form part of the national codes for director exchanges.

Examples of typical national numbers are given in Table 1.

METHOD OF CHARGING FOR CALLS

The dialling of trunk calls by subscribers makes it necessary to have some automatic means of recording call charges against the subscriber who originates the call. Broadly, there are two ways in which this can be done. One possibility is to apply to trunk calls the principle which has hitherto been applied to local calls and arrange that all call charges are recorded on a meter or its equivalent associated with each subscriber's line. It is implicit in such a system that only a bulk-total meter-reading is available for accounting purposes, and hence it is not possible to give the subscriber a detailed statement showing the particulars of each trunk call. Call accounting on this basis has come to be known as "bulk billing." The alternative is to adopt some automatic means of producing the equivalent of the call ticket, which on a manually controlled call is prepared by the controlling operator; this method is known as "automatic call-ticketing."

The system of metering and bulk billing is by far the easier to apply to the telephone network of the United Kingdom. Suitable meters already exist at the great majority of the automatic exchanges, and the extension of their use to record trunk-call charges is much more attractive than the alternative of providing equipment for automatic call-ticketing, which involves, amongst other things, the provision of a system of calling-line identification. Consideration of these factors led to the decision to adopt metering and bulk billing as the basis upon which the call-charging system should be developed. There are many ways in which call charges can be recorded on a meter but the particular method of metering which has been adopted involves single operations of the subscriber's meter at intervals which vary from a few seconds to several minutes, according to the chargeable distance over which a call is made. The method is referred to as "periodic metering"[4] and it has been decided to apply it to both local and trunk calls that are dialled by the subscriber. An important feature of periodic metering is that it enables short-duration trunk calls to be made for a unit fee.

TABLE 1
Typical National Numbers

Type of Exchange	Typical Number at Present	Typical National Number
London director	ABB 1234	0 1 ABB 1234
Provincial director	MID 1234	0 21 MID 1234
Non-director group switching centre:		
4-digit	Truro 2345	0 TR3 2345
5-digit	Leicester 22345	0 LE3 22345
6-digit	Syston 862345 (a Leicester satellite)	0 LE3 862345
Other non-director exchanges and U.A.X.s:		
3-digit	Three Waters 256 (in Truro group)	0 TR3 56 256
4-digit	Droitwich 3223 (in Wolverhampton group)	0 WO5 7 3223
4-digit	Perranporth 2121 (in Truro group)	0 TR3 72 2121
5-digit	Whitley Bay 23456 (in Newcastle group)	0 NE3 6 23456

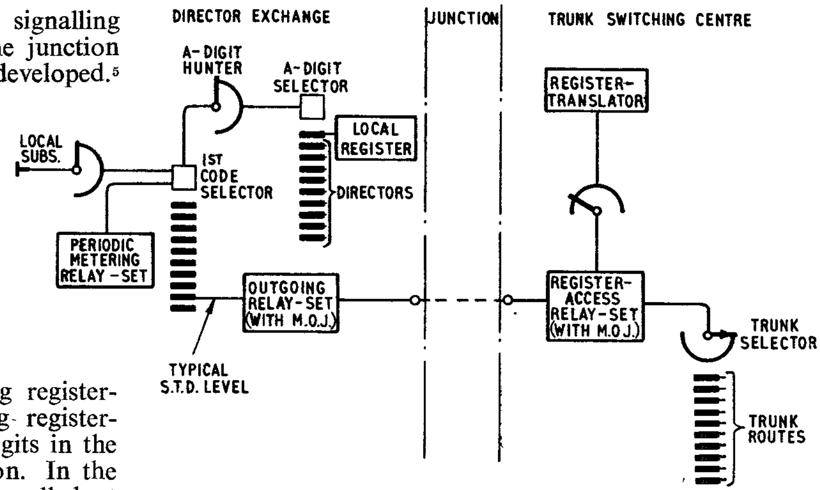
LOCATION OF REGISTER-TRANSLATORS

Reference has already been made to the use of register-translators for the control of routing and charging on S.T.D. calls. The register-translators, however, need not always be located at the originating exchange. The dialling of the digit 0 could route a call over a junction to a central point, for example the group switching centre, where the concentration of S.T.D. traffic from a number of exchanges would ensure more efficient use of the register-translator equipment. If, however, the register-translators are also to determine the charging rate, it is necessary for information to be sent back to the originating exchange. This could be done by sending a signal to indicate the appropriate charging rate, the necessary meter pulses being generated at the originating exchange, or by transmitting the meter pulses over the junction. The latter method is preferred because the economic advantages of centralization could also be applied to the equipment which generates and controls meter pulses. Its success depends upon the existence of a satisfactory signalling system for transmitting meter pulses over the junction during conversation. Such a system has been developed.[5] In the majority of charging groups, therefore, register-translators and associated meter-pulse equipment will be located only at the group switching centre.

The register-translators that determine the charging rate are referred to as the "controlling register-translators"[6] whether they are located at an originating exchange or at a switching centre.

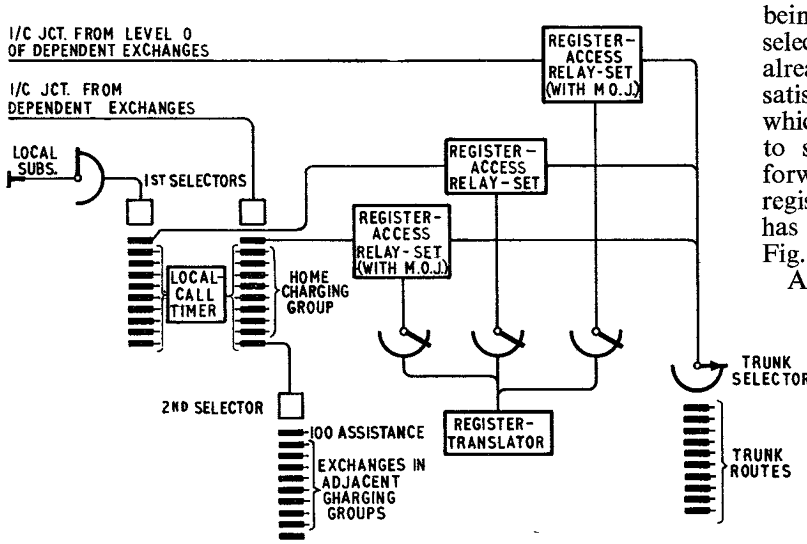
METHOD OF ROUTING CONTROL

There are two principal methods of using register-translators. In one method the controlling register-translator is arranged to provide sufficient digits in the translation to route any call to its destination. In the other method, register-translators are also installed at transit exchanges. The receipt of all or part of a national code by a controlling register causes it to select a route within its own exchange and then repeat the code to a register-translator at a transit exchange which in turn causes a route to be selected through that exchange. The code may be repeated from the controlling register-translator to each transit register-translator in turn or passed on from transit register-translator to transit register-translator. In either case the register-translators at any one exchange control the routing through that exchange only. The two methods are usually referred to as "right-through," and "own-exchange-only" control respectively. The right-through method is used in the director system, but if applied on a national basis not only would the controlling register-translator be very large and costly, but any change in routing would result in changes to all translators throughout the country. A study has shown that overall economies can be achieved by using the own-exchange-only principle, and it has been decided to adopt it. It follows, however, that in general only those calls which can be obtained over direct routes to the distant group switching centre can be dialled by subscribers until such time as register-translators are provided at transit centres.



M.O.J. = Metering over junction

FIG. 6—TYPICAL TRUNKING ARRANGEMENT SHOWING ACCESS TO REGISTER-TRANSLATOR EQUIPMENT IN A DIRECTOR AREA



M.O.J. = Metering over junction

FIG. 5—TYPICAL TRUNKING ARRANGEMENT SHOWING ACCESS TO REGISTER-TRANSLATOR EQUIPMENT IN A NON-DIRECTOR AREA

TRUNKING PRINCIPLES

Originating Traffic

The principle of obtaining connexion to the register-translator equipment is shown in Fig. 5 and 6. In Fig. 5, apart from the straightforward case where the local exchange is in the same building as the group switching centre, two methods are indicated for dealing with traffic from remote exchanges. In the first method S.T.D. traffic is routed over separate junctions direct to the register-access relay-sets, while in the second method the S.T.D. traffic shares junctions with other traffic and terminates on selectors. The first method will normally be used for satellite exchanges, and the second method for small exchanges such as U.A.X.s, where the saving in the number of junctions resulting from the use of a common group of circuits is worth the extra equipment costs involved.

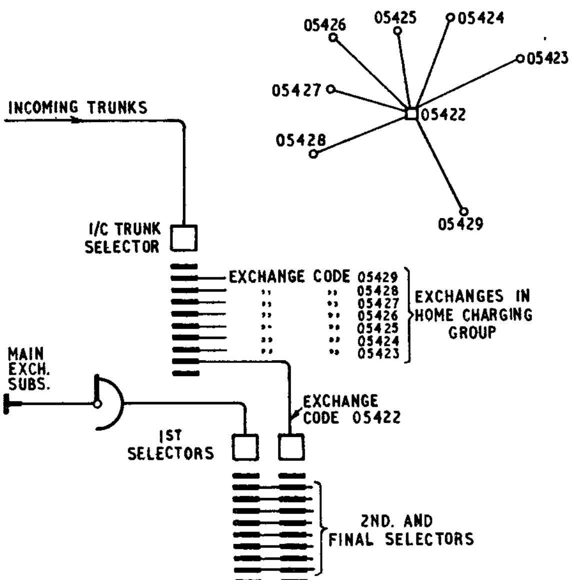
In director areas an additional factor is introduced, as the digits dialled by a subscriber are normally received by the director equipment. A similar method could be used for S.T.D. traffic, the register-translators being connected to the 0 level of the A-digit selectors, but the advantages of centralization already mentioned would thereby be lost. A more satisfactory method is to provide a pulse repeater which, on seizure, transmits a predetermined digit to step the 1st code selector and then repeats forward all digits received to the controlling register-translator equipment. The pulse repeater has been called a "local register,"[7] and is shown in Fig. 6.

As a controlling register-translator is only involved during the setting up of a call, it is arranged to indicate to the register-access relay-set the appropriate charging rate, and it is in this relay-set that the meter pulses are generated after the called subscriber has answered. Where the local exchange is remote, the meter pulses are signalled over the junction from the register-access relay-set to the outgoing relay-set at the remote exchange.

For local calls which do not use the S.T.D. equipment it is necessary to provide other equipment to give the periodic-metering facility. A typical method of connecting this equipment in a non-director exchange is shown in Fig. 5, where it is referred to as a "local-call timer."[8] In director exchanges (Fig. 6), the periodic-metering equipment is directly associated with 1st code selectors.

Incoming Traffic

As regards S.T.D. traffic incoming to a numbering group, reference has already been made to the fact that certain digits of the national code may represent the actual routing digits within a group. For example, in Fig. 7, the incoming trunk circuits could terminate at



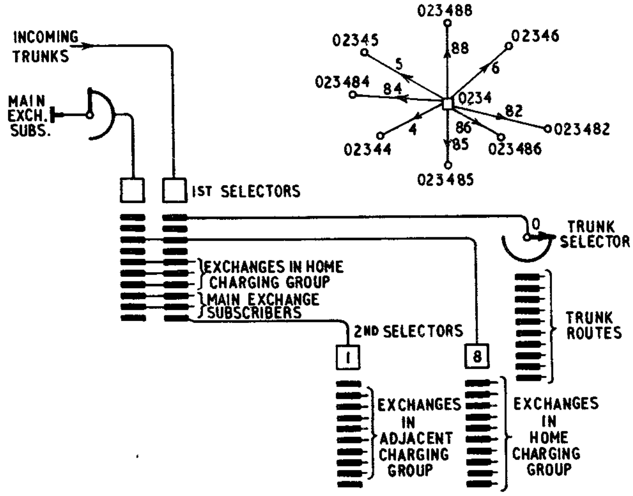
The group code is 0542

FIG. 7—DISTRIBUTION OF INCOMING TRAFFIC AT A GROUP SWITCHING CENTRE USING SEPARATE INCOMING TRUNK SELECTORS

the group switching centre on a selector, the levels of which give access to the dependent exchanges. In a numbering group with a few exchanges, one additional digit only would be required, but where a larger number of dependent exchanges are concerned, two additional digits would have to be added to the group code to form the national codes. This method of arranging the trunking is useful where the group contains only small exchanges of roughly equal size. It has the disadvantage, however, that all traffic to the group passes through at least one additional switching stage, and the resultant exchange codes are correspondingly longer.

A more general case is represented by the numbering group that contains a relatively large exchange or linked numbering scheme associated with the group switching centre and is surrounded by a number of smaller exchanges. Under these conditions it is more economic to line up the incoming trunk selectors with the local 1st selectors, as shown in Fig. 8, and thus save an additional switching stage on a large proportion of the calls. It also introduces a number of service advantages in that shorter national codes are used for the larger exchanges, and that the digits added to the group code to form the national codes for the dependent exchanges can be the same as those used for dialling codes from the group switching centre to these same exchanges.

The director areas fall into a special category, as



The group code is 0234

FIG. 8—DISTRIBUTION OF INCOMING TRAFFIC AT A GROUP SWITCHING CENTRE WITHOUT SEPARATE INCOMING TRUNK SELECTORS

routing within each area is based on the use of translation. It is more economic to adopt the same principle for incoming trunk traffic, and therefore incoming register-translator equipment[9] will be used. As a result, the national codes for exchanges in director areas will be entirely independent of the actual routing digits employed. Similar independence of numbering and routing could of course be given by introducing incoming register-translator equipment in the non-director group switching centres, but it would be undesirable to make the introduction of S.T.D. dependent on the installation of such equipment at a large number of exchanges.

Prevention of Unauthorized Routings

It is sometimes necessary to route traffic through one group switching centre to exchanges outside the home group. In these cases it is arranged to route such traffic via either level 1 or level 0 of the incoming trunk selectors, and as the controlling register-translators are arranged to bar access to any call where the digit 1 or 0 is dialled immediately following the group code, subscribers are thus prevented from experimenting and devising routings which might involve an incorrect charge. The digits 1 and 0, however, can form part of a translated code so that by this means traffic can be routed via level 1 or 0 provided the correct group code is dialled. In addition, where circuits are used jointly by subscriber-dialled and operator-dialled traffic, the operators will be able to dial the necessary routing digits. The 1 and 0 "barring" facility thus prevents unauthorized routing of S.T.D. calls without it being necessary to segregate junctions or selectors into special groups according to the access permitted.

In Fig. 8, level 0 of the incoming selectors is connected to the trunk selectors and level 1 gives access to exchanges in adjacent charging groups. As the barring facility applies to both levels 1 and 0 the allocation of these levels on the incoming trunk selectors is interchangeable should this be desirable in individual cases.

PREPARATIONS FOR INTERNATIONAL SUBSCRIBER DIALLING

In view of the small amount of international traffic that is expected to be dialled by subscribers connected to the majority of exchanges, it is most unlikely that the provision of special equipment, junctions, etc., on the lines of that proposed for S.T.D. would ever be economic except for a few exchanges. International subscriber dialling (I.S.D.) can, in some respects, be considered as an extension of the subscriber dialling range. The total number of digits to be dialled on an international call will normally be greater than those on S.T.D. calls, but it has been decided that the method of charging the subscriber for I.S.D. calls will resemble closely that adopted for S.T.D. It becomes possible, therefore, to use for I.S.D. much of the equipment provided at originating exchanges and group switching centres for S.T.D., with resultant savings in cost. In fact, by adopting an international access code (010) that begins with the S.T.D. prefix, no modifications are required at an originating exchange. At a group switching centre some additional equipment will be required, but until it is decided to introduce the service it is only necessary to ensure that the register-translators can recognize the I.S.D. code and arrange to call in such additional equipment as may be necessary.

MISCELLANEOUS FACILITIES

Apart from those features of S.T.D. which involve numbering, routing and charging, it is necessary to use automatic equipment to provide a number of facilities that are at present provided by operators. An exact equivalent of the manual service is not, however, always required or desirable. An outline of some of the requirements is given in the following paragraphs.

A.D.C. and Similar Services

An operator-controlled service has enabled a number of additional facilities to be provided fairly easily. In this category "Advise Duration and Charge" (A.D.C.), "Reverse Charge" and "Personal Call" might be mentioned as facilities associated chiefly with the trunk service and which are widely used by subscribers. The adoption of periodic metering, whereby a call of short duration can be obtained for a unit fee, in effect enables a personal-call facility to be provided more cheaply than with operator-controlled calls. Similarly, it is likely that the needs of the majority of telephone users who require the reverse-charge facility will be met, because for unit fee it should be possible to ring a subscriber, give details of your number and ask to be rung back. The equivalent of the A.D.C. facility can be given by informing the subscriber of the number of units recorded on each call. This can best be achieved by repeating the meter pulses over the subscriber's line to a private meter which can be associated with his telephone and which will operate in parallel with the meter at the exchange. The provision of such facilities has involved the development of a suitable private meter[10] and a method of operating it without interfering with conversation.

Coin-Box Lines

Telephones with associated coin-boxes are used extensively throughout the United Kingdom telephone system, and of the 130,000 such lines, about half are fitted in public kiosks. The existing coin-box telephone permits unit-fee calls only to be dialled, all other calls being routed via an operator. To enable trunk calls to be dialled it has been necessary to develop a new coin-box system, the "Pay-on-Answer" system,[11] which is particularly well suited for operation with a tariff based on periodic metering. The fundamental principle of this system is that the coin slots are normally closed and it is possible to insert money in the coin-box only when a call has been established and the called subscriber has answered. The complication and cost of a "suspense" mechanism with its deposit and refund magnets, which is necessary with a pre-payment system, is therefore avoided and it is possible to keep the coin-box and its associated telephone circuit relatively simple and inexpensive.

The control equipment is located at the exchange and connects a distinctive tone to the line when the subscriber answers and reconnects it whenever the period has expired for which payment has been made. This tone is referred to as "pay tone" and indicates to the caller that the call will shortly be disconnected unless money is inserted in the box. With the pay-on-answer system the coin-box user is given a service similar to that available to the ordinary subscriber as it will be possible to obtain short-duration trunk calls for the equivalent of unit fee. It will also be possible to obtain calls via a manual board, in which case the operator will supervise the insertion of the necessary fee.

Barred-Trunk Facility

It has been the custom for many years for some subscribers to have their service restricted to local calls only. This has been arranged either by a special note of such subscribers' numbers being kept at the manual board or by associating such lines with the coin-box group. Neither of these methods is applicable when subscribers dial their own trunk calls and some other way of restricting the service is required. One method, which is used abroad, is to disconnect the call when a predetermined number of units has been recorded on the meter. This does not, however, prevent the simulation of a long-duration trunk call by making a series of calls to the same number, and it was decided not to adopt it.

An alternative method is to prevent any calls being set up which begin with the digit 0. An arrangement of this type can be so designed that the subscriber can call in the barring facility at will by means of a suitable control unit and key, and thus limit the use of the telephone when he is absent. For those subscribers who consider a barred-trunk facility essential a barring facility on these lines will be available, but as it involves additional equipment for which a charge is made it is not expected that its use will be widespread. The equipment can also bar calls attempted via the manual board by preventing calls being set up which begin with the digits 10.

Disputed Accounts

Should a subscriber dispute the accuracy of his account, a special recording device can be associated with his line to record details of all incoming and outgoing calls, including the charges registered on the subscriber's meter. A call-by-call record of this type taken over a period is usually adequate to satisfy the subscriber that the calls charged against him have in fact been made, although, of course, it does not give details of the calls which led to the original query. The special recorder used is referred to as the disputed-accounts equipment.

Traffic-Sampling Equipment

Information for general statistical purposes is at present obtained by an analysis of the trunk-call tickets and similar information is required under full automatic conditions. Information on the traffic carried by the various trunk circuits can be obtained by ordinary traffic-recording methods, but analysis of the calls by destination, duration, etc., can be more economically achieved by sampling. The ultimate aim is to obtain such information in a form which can be fed to a computor, but the equipment being provided for the initial installation at Bristol will record the details on paper tape, which has to be read visually. For the purpose of the sample all S.T.D. calls will be counted and every *n*th call connected to the recorder. The value of *n* can be varied, but it is likely to be about 100.

PROGRAM OF INTRODUCTION

The introduction of S.T.D. will, of necessity, be a gradual process in view of the large number of exchanges involved, but at least 75 per cent of subscribers should have the facility by 1970. The minimum amount of work was involved in developing equipment for S.T.D. at non-director main exchanges, and hence this type of exchange was tackled first. The introduction of S.T.D. at Bristol main exchange[12] will be followed in the near future by the provision of S.T.D. at many similar exchanges.

The director exchange forms, perhaps, the most important category of exchange as far as the volume of trunk traffic is concerned, and the development of suitable equipment is now well advanced. The provision of S.T.D. facilities at director exchanges is planned to commence in about 2 years' time. In the meantime, S.T.D. will be extended to some group-selector-type satellite exchanges and other non-director exchanges in charging groups where the switching centre has already been provided with S.T.D. equipment. Equipment is also being developed for discriminating satellite exchanges, and a number of possible methods of giving the required facilities at U.A.X.s are being examined.

The extension of the service to all subscribers will, of course, depend upon the conversion of existing manual exchanges to automatic working, and it will be necessary to provide register-translator equipment at transit centres before all calls can be dialled by subscribers.

CONCLUSIONS

In planning the introduction of S.T.D. the opportunity has been taken to examine many of the traditional aspects of the service to ensure that the needs of a fully automatic service will be met in the most satisfactory and economic manner. A national numbering scheme has been produced which can be applied with a minimum of change to the existing service and which should meet the needs of the country for at least the next 100 years. In addition, radical changes have been made in the method of charging for calls and this has led to considerable simplification in the design of equipment. New facilities to assist the subscriber in dialling trunk calls have been introduced and many new items of equipment have been developed. Details of some of the more important developments are included in other articles in this issue of the Journal. From the economic point of view, the cost of the equipment provided for S.T.D. at those centres where the trunk mechanization equipment has already been installed is not very different from the cost of the manual boards that are replaced, so that a very large part of the operating costs will be saved. The subscriber is, of course, required to dial numbers of eight to 10 digits but in return he will get both a faster and cheaper service than has hitherto been possible.

ACKNOWLEDGEMENTS

The introduction of S.T.D. has been a combined operation by many people in several Departments of the Post Office and by the manufacturers. The author would like to pay tribute to his many colleagues, only a few of whose names appear in this Journal but whose enthusiasm and untiring efforts have enabled the manufacture and installation of the equipment to be completed on time.

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Controlling Register-Translators

Part 1—General Principles and Facilities

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U.D.C. 621.395.341.72:621.395.374

With subscriber trunk dialling, automatic equipment must take over the functions hitherto performed by a controlling operator in setting up a trunk call. The equipment is known as a controlling register-translator. The register-translator receives the digits dialled by the subscriber, determines the charging rate for the call and transmits appropriate information in the form of trains of pulses to enable the call to be routed to its destination. This article describes the facilities provided by controlling register-translators and the general principles of their design.

INTRODUCTION

It has been shown in an earlier article[1] in this Journal that translating equipment is required to control the routing of a call through the mechanized trunk telephone network; register-translators are to be used for this purpose and, as the name implies, this equipment is capable of recording information received at its input and supplying an appropriate translation. The register-translators required for subscriber trunk dialling (S.T.D.) fall into three main categories depending upon their functions and their positions in the network, and on this basis they may be classed as controlling, transit or incoming. Controlling register-translators are provided at trunk switching centres to deal with originating subscriber-dialled trunk traffic, and in this article it is proposed to consider the facilities they offer and the general principles underlying their design.

In the early stages of S.T.D. at least, controlling register-translators will be required to receive and send digital information in the form of trains of standard pulses. The subject has therefore been treated with this requirement primarily in mind.

ACCESS

The methods of trunking to be adopted at local exchanges of the various types are such that a subscriber is in effect connected to a controlling register-translator after dialling the first digit of a national number, which is always the digit 0. The precise means by which a connexion is established depends upon the type of exchange in question, and two examples are illustrated.

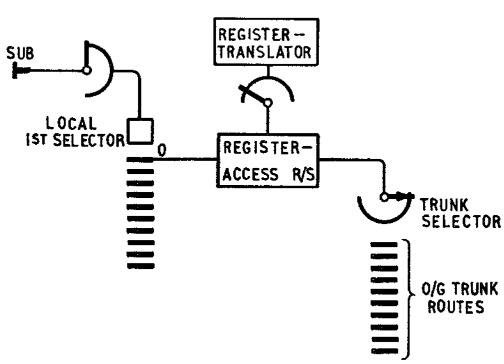

FIG. 1—TRUNKING DIAGRAM OF A NON-DIRECTOR TRUNK SWITCHING CENTRE, SHOWING ACCESS TO REGISTER-TRANSLATOR

Fig. 1 refers to a main non-director exchange which is also a trunk switching centre and is, therefore, equipped with register-translators on site. Each outlet on level 0 of the first selectors gives access to a register-access relay-set connected in the normal transmission path. During the time a call is being set up, the relay-set provides an input path to the register-translator over which the digits dialled by the subscriber are received; it also provides an output path from the register-translator over which digital information can be transmitted. When setting up is completed the register-translator is released and the relay-set is switched to provide a through connexion for speech.

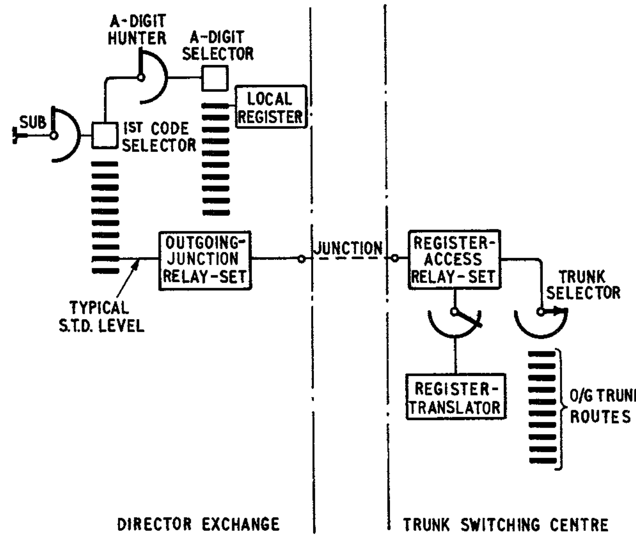

FIG. 2—TRUNKING ARRANGEMENTS IN DIRECTOR AREAS, SHOWING ACCESS TO REGISTER-TRANSLATOR

Fig. 2 refers to a director exchange which has access to controlling register-translators at a remote trunk switching centre. The initial digit of a national number is received by an A-digit selector which on each outlet of level 0 gives access to a local register.[2] The local register, in the first instance, is required to transmit a predetermined digit to position the 1st code selector and, thereafter, to repeat all the digits it has received to a register-translator at the trunk switching centre. Access to this register-translator is again obtained via a register-access relay-set which performs a function similar to that already described.

It is a specific requirement that the equipment should be so designed that it is unnecessary for the subscriber to make a deliberate pause in dialling or to await receipt of a signal such as a second dial tone. This applies, in particular, to the interval between the first and second digits of a national number, the point at which it is apparent that connexion to a register-translator is required.

Brief mention must also be made of two other requirements: firstly, to safeguard service by providing, as

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far as possible, for the use of different equipment on a repeat attempt, the register-hunters associated with the register-access relay-sets should be of a non-homing type and incorporate a step-on feature; secondly, to prevent the use of unauthorized routings, the relay-sets should be so designed that it is not possible to dial through them once the transmission path has been established on release of the register-translator.

INPUT AND OUTPUT

The information that is received by a controlling register-translator comprises the second and subsequent digits of the called subscriber's national number. These digits indicate the objective numbering group, the exchange within that group and the local number of the subscriber required. The register-translator must in turn provide information which will establish the routing of the call and indicate the appropriate call-charge rate. To do so it must translate the "code" portion of the information it has received.

The prime function of the register-translator is to control the setting-up of calls, which are routed into the objective group via its group switching centre. For this purpose the equipment is basically required to translate codes comprising not more than three digits but, to permit it to be used in certain cases where adequate information cannot be derived in this way, the facility of translating a limited number of 4-digit or 5-digit codes is required. It should, however, be noted that in this context, and in all the references that follow, the initial digit 0 is not regarded as being part of the code in question.

SECTIONS OF A REGISTER-TRANSLATOR

A controlling register-translator may be regarded as comprising four sections. Firstly there is a storage section in which the information received at the input is stored digit by digit; next there is a code-identification section in which the code received is identified from all other possible codes; then there is the translation section in which all the required translations are available; and lastly there is a sending section which is required to send out charging and routing information derived from the translation, and also to repeat some or all of the original information which is held in the storage section. These four sections and the manner in which they are interconnected are illustrated in simple block schematic form in Fig. 3.

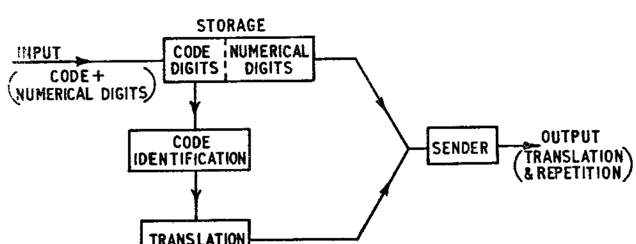

FIG. 3—BLOCK SCHEMATIC DIAGRAM OF A REGISTER-TRANSLATOR

The degree of readiness with which the four sections of a register-translator can be separately identified is in practice largely dependent upon the technique adopted in the design. Nevertheless, the approach is a useful one in specifying the main requirements of the equipment and in comparing register-translators of different types.

Storage

A controlling register-translator must be capable of receiving and storing all the digits of a national number, other than the initial digit 0, and the storage section is provided with nine storage units for this purpose. These units may take various forms depending upon the techniques employed.

It has already been stated that in certain circumstances it may be necessary to translate a code comprising as many as five digits. It follows that the digital information stored in the first five storage units must be made available to the code identification section of the register-translator. In addition, to permit the repetition of stored information following translation, it is necessary to arrange that the information in any storage unit can be made available to the sending section.

During the dialling of a national number the calling subscriber may pause between successive digits. While allowing for this to happen it is necessary to ensure that the register-translator is not held for an unduly long time, either by exceedingly slow dialling or by failure to receive an adequate number of digits. Accordingly, it is arranged that the register-translator is released if receipt of any digit is delayed by more than about 20 seconds. This facility is, however, modified in respect of some of the later digits, as described below under the heading "Release of the Register-Translator."

Code Identification

The code information received by the storage units has to be transferred to the code-identification section, where the individual signals from each storage unit are combined to give an indication of the code in question; working codes are subsequently translated while the identification of a spare code results in a signal indicating that it is unobtainable.

As previously mentioned, the register-translator will generally be required to translate codes comprising not more than three digits. The total number of codes of this type cannot exceed 1,000 and it is primarily the need to identify codes in this range that governs the design of the code-identification section. It might be argued that the allocation of short codes to the six director areas[1] in effect reduces the 3-digit code series to 850 and that a consequential reduction in code-identification requirements can be made. Other considerations, however, make it undesirable in practice to reduce the capacity to this extent; among these is the need to provide certain barring facilities, which are referred to later. In consequence, the minimum requirement has been stipulated as identification of 900 3-digit codes plus 10 2-digit codes. Even so it has been found convenient in most designs to provide for the full range of 1,000 codes.

The requirement to identify a limited number of 4-digit or 5-digit codes can be met by examining one or two additional digits following a few selected 3-digit codes. The selection of these codes, which may number about 20, must however be flexible to take account of the varying needs of centres in different geographical locations. Additional provision for code identification is of course necessary but, as the facility may not always be called for, it has been specified that where the design technique permits the equipment should be so arranged that the extra components can be added if and when required.

Translation

The translation section of a register-translator contains all the translations that the equipment need supply, and the identification of a particular code causes the appropriate translation to be selected. Each translation is, in effect, made up of a number of instructions and each of these instructions is used to control the operation of the register-translator in some way. Some of the instructions are used to control the sending section and they, therefore, affect the output of the register-translator directly. Instructions for other purposes may also be included, but the use of these may well be governed by the particular design technique that is adopted.

In considering the translation section two main questions arise:

(*a*) How many different translations are required?

(*b*) How much information must a translation provide?

The answers to both questions largely depend upon the extent to which the register-translator is required to control the routing of a call.[1] Broadly there are two possibilities. The controlling register-translator could determine the routing right through to the distant end, but this would necessitate each group code having its own individual translation; moreover, the maximum amount of routing information to be supplied by a translation would be considerable as it would be necessary to cater for the transmission of sufficient digits to meet the case of the most complex routing via a number of transit centres. Alternatively, the register-translator could be so arranged that it was only required to control the selection of the appropriate outgoing route to the next switching centre, where another register-translator would take control of the next stage of routing. The number of routing digits then required is small; furthermore, where calls to a number of groups pass over the same route to a transit centre, it is no longer necessary to provide a different routing translation for each group code. In such circumstances the number of routing translations is governed by the number of outgoing routes. With this method of working the repetition of code digits from one register-translator to another is, of course, necessary to enable each in turn to select the correct path through its own switching centre. In practice, controlling register-translators will provide for routing on this basis and also some "right-through" routing; the use of right-through routing will, however, be confined to the simpler cases.

Consideration of routing alone is not sufficient to determine completely the answers to the two questions. In addition to supplying routing information the translation must also provide an indication of the call-charge rate. Thus, where a routing translation can be shared by a number of groups it may still be necessary to discriminate for charging purposes. The number of translations must then be at least as great as the number of route-rate combinations required and it may be greater, depending upon the way in which other instructions are combined with routing and charging information.

One form of instruction which affects the output directly is an instruction in each translation to determine how much of the information held in the storage section should be repeated. The various possibilities will be considered when dealing with the sending section, but for the moment it should be noted that when this type of instruction, or any other necessitated by the design techniques employed, is included in a translation further variables are introduced and sharing is possible only between group codes to which the complete combination of instructions is applicable.

In practice, the avoidance of complex right-through routings permits a comparatively low limit to be set on the maximum number of routing digits sent out by the controlling register-translator. For example, the register-translators provided at Bristol for the opening of the service are designed to supply a maximum of five routing digits.

The limitation on right-through routing also means that the number of different translations required will be appreciably less than the number of working group codes; the precise number will, however, depend upon the centre at which the controlling register-translators are installed. To meet the needs of individual centres with economy, it has been specified that where the cost of added translations is a material factor the equipment should be arranged to permit some flexibility in the number provided.

Sending

The sender is arranged to transmit digital information in accordance with the instructions received from the translation section. The digits sent out are used to control the operation of other items of equipment and the requirements of the system can conveniently be met if the output takes the form of a metering digit followed by a number of routing digits, followed in turn by the repetition of digits stored.

The metering digit is required to operate a fee-selecting device in the access relay-set to ensure that when the call is answered metering will be applied at the correct rate; the routing digits are, of course, required to control the operation of subsequent selectors. The value of each digit and the number of routing digits required are both determined by the translation instructions. A further instruction determines the amount of repetition necessary; the register-translator is required to cater for six possibilities, and repetition can commence with the first, second, third, fourth, fifth or sixth digit stored. This variation is necessary to meet the various conditions that can be encountered on different calls. Full repetition is provided to enable the controlling register-translator to pass forward complete information to later equipment that is also required to translate the group code. The first digit is not repeated on calls routed direct to incoming register-translators[3] or directors at the group switching centre serving the London director area, while on calls routed direct to similar equipment in other director areas the first two digits are not repeated. For direct routing to a group switching centre serving a non-director area the first three digits may be omitted, while the omission of further digits has application in conjunction with the special facility of translating 4-digit or 5-digit codes.

RELEASE OF THE REGISTER-TRANSLATOR

Because of the variability[1] which is permitted in the number of digits making up a national number, it is possible for a controlling register-translator to receive on a legitimate call seven, eight or nine digits. If nine digits are received there is no difficulty in recognizing when the storage of digits is complete as all storage units will be filled in such a case. If, however, the call is such that only seven or eight digits are stored, no positive indication of the completion of storage will be given. The last few digits of a national number are always repeated by the controlling register-translator and it follows that if the completion of storage is in doubt the completion of sending must also be in doubt; in such circumstances it is not possible for the register-translator to determine the point at which it should clear down.

There are a number of possible ways in which this difficulty can be overcome. The arrangement to be adopted is a simple one and amounts to the provision of a "time-out" facility in the controlling register-translator. If seven digits are received the register-translator allows a short interval for the possible arrival of an eighth digit. This interval has been fixed initially at 4 seconds, and if it expires before the eighth digit is received it can be assumed that storage is complete. If eight digits have been received a similar interval is allowed for the possible receipt of a ninth digit. If nine digits are received, the time-out facility is inoperative and the positive indication possible under full storage conditions is used.

All legitimate calls require the repetition of the seventh digit, followed by the eighth and ninth digits if these have been received. The register-translator is permitted to repeat stored digits up to and including the sixth as soon after receipt as may be necessary. The repetition of the seventh, eighth and ninth digits is not, however, permitted before the completion of storage has been signalled. In consequence, these digits are always repeated in close sequence with only a standard inter-digital pause between them.

The use of the time-out facility can cause a slight delay in setting up calls on which the register-translator receives only seven or eight digits. The delay will not, however, exceed the time-out interval and it will, in some instances, be negligible. Nevertheless, it was considered desirable to avoid any possibility of delay from this source on calls to the London director area, which are in the 8-digit class. Accordingly the register-translator is required to cancel the time-out between the eighth and ninth digits on recognition of a London call and to signal full storage when eight digits have been received.

FORCED RELEASE AND BARRING

Arrangements are made to release the register-translator if a spare code is dialled or if less than seven digits are received, an inter-digital period of about 20 seconds being allowed for receipt of a further digit before an incomplete set-up is assumed. The register-translator is also released if the digit 1 or 0 is dialled by a subscriber immediately following a group code. When forced release is brought into operation the register-translator releases the forward connexion and clears down after sending a signal to the register-access relay-set, which results in the transmission of number-unobtainable tone to the calling subscriber.

The relay-set itself provides for forced release if the register-translator has not otherwise released within 3 to 6 minutes of seizure. It also provides for forced release should a call remain unanswered for 3 to 6 minutes or should the "called subscriber held" condition persist for a similar period. In each case the forward connexion is cleared and number-unobtainable tone is transmitted to the caller. The period mentioned is, however, under review and may be altered.

THE USE OF COMMON TRANSLATORS

While it is possible to construct a register-translator in such a way that the storage, code-identification, translation and sending sections are all contained within a single unit, there is considerable advantage to be gained in certain cases if they are so arranged that the storage and sending sections are contained in one unit, known as the register, and the code-identification and translation sections are contained in a second unit, known as the translator. The rate at which digits can be received and stored, and the rate at which the sender can transmit, are conditioned by the need to employ 10 p.p.s. pulsing. In consequence, these two processes are slow by comparison with the rate at which a code can be identified and a translation determined. Thus the holding time of the translator is basically much shorter than the register holding time and advantage can be taken of this condition to make one translator serve a number of registers.

Adoption of this technique leads to some complication in the arrangements for associating the register and translator units one with the other, and entails the provision of suitable standby arrangements and safeguards to ensure that all registers are not disabled by a fault in the common translator. For any application the cost of adopting the common-translator technique must be weighed against the cost of providing identification and translation in each register. Where code identification and translation can be accomplished in a simple manner the single-unit construction is attractive but where, as in a controlling register-translator, these sections are complex the division of functions and the use of a common translator is justified.

PROVISION FOR INTERNATIONAL SUBSCRIBER DIALLING

Although the register-translators are provided primarily to control subscriber-dialled trunk traffic on the inland network the ultimate extension of the subscribers' dialling range to include calls to other countries has been kept in mind. Certain features have been incorporated in the present designs in anticipation of this requirement.

REGISTER-TRANSLATORS OF VARIOUS DESIGNS

The earliest register-translators to be designed were those required for non-director centres. At the time this development was about to start the application of electronic techniques to equipment of this type was also being investigated; the particular technique then sufficiently advanced to make its application practicable was based upon the use of cold-cathode tubes. To permit a realistic comparison to be made between equipment using this technique and that designed on more traditional lines, it was decided to develop both electronic and electromechanical register-translators and to introduce both types into the network to enable their performance to be compared under service conditions. Accordingly a few installations have been planned to use electronic register-translators. The installation at Bristol is one of these.

By the time development of register-translators for director areas was commenced it had become possible to consider the use of magnetic-drum storage as a basis for design and a similar policy was adopted. Work has, therefore, proceeded on both an electromechanical and a drum-type register-translator.

References

[1] Francis, H. E. The General Plan for Subscriber Trunk Dialling. (In this issue of the *P.O.E.E.J.*)

[2] Sheppard, S. H. Local Register for Director Exchanges. (In this issue of the *P.O.E.E.J.*)

[3] Waters, H. S. and Sheppard, S. H. Incoming Register-Translator for Director Areas. (In this issue of the *P.O.E.E.J.*)

Controlling Register-Translators

Part 2—Electromechanical Register-Translators

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U.D.C. 621.395.341.72:621.395.374

Separate types of electromechanical register-translators have been designed for use in non-director and director exchange areas and both types of equipment are described in this article. The registers and translators are constructed as separate units, one translator normally serving a group of up to 15 registers.

OUTLINE OF SYSTEM

ALTHOUGH the basic register-translator functions of routing and charging control are similar in both director and non-director exchanges, differences in the detailed requirements have led to the design of two types of equipment. The non-director type has now been developed and will be coming into service at several exchanges during 1959, whilst the director type is at present undergoing development testing. Both equipments employ common translators and, although differing in detail, conform to the same functional pattern. Fig. 1, which shows the main elements of the system, and the outline of operation which follows, are applicable to both types of equipment.

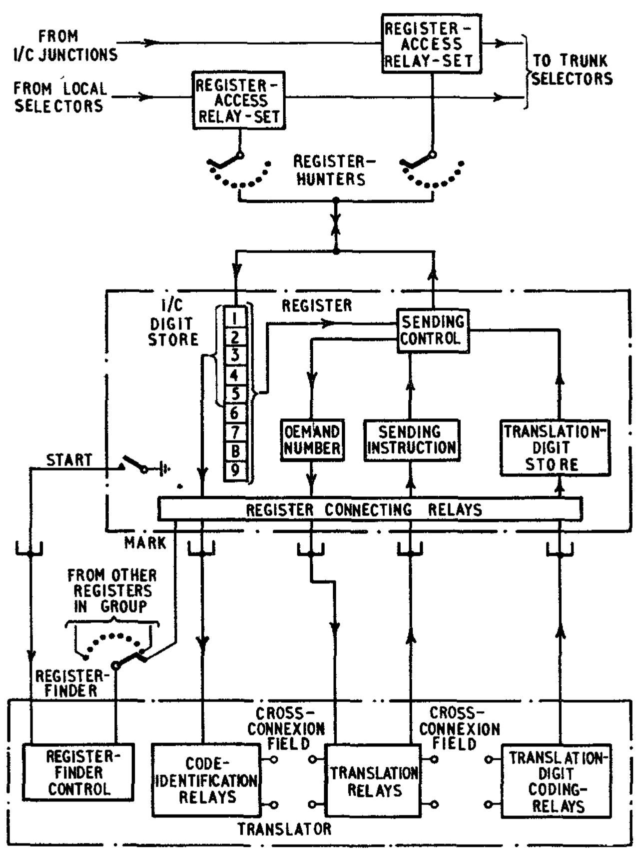

FIG. 1—BLOCK SCHEMATIC DIAGRAM OF SYSTEM

On seizure by a call, the register-access relay-set causes its associated register-hunter to find a free register. The digits of the national number, except the initial digit 0, are received by the relay-set, repeated to the register and stored in the incoming-digit store. When the first three digits have been received and stored the register applies start and mark conditions to the translator, which is common to a group of registers. The register-finder hunts for, and switches to, the calling register. Simultaneous or overlapping demands from registers served by the same translator are dealt with in the order in which they appear on the register-finder banks.

When found by the translator, a group of relays in the register is operated to couple the equipments together. The three digits stored in the register are marked into the translator and identified by a group of relays. In the majority of cases translation is possible from the 3-digit code, and the translator operates a translation relay appropriate to the particular combination of routing and charging rate. This causes two signals to be returned to the register; a digit indicating the call-charging rate and a sending instruction to show which digits of the stored national number should be sent following the routing digits.

If three digits are insufficient to permit translation, a translation relay is not operated but a signal is returned to the register indicating that fresh application should be made on receipt of the fourth or fourth and fifth digits.

On receipt of the fee digit and sending instruction the register releases the translator, which can then deal with demands from other registers. One translation digit only is returned to the register on each demand, the register indicating to the translator which digit is required. The fee digit is sent by the register to the access relay-set and selects the appropriate metering rate. Succeeding digits returned by the translator are for routing and are sent by the register, via the access relay-set, to step the trunk selectors.

When the final routing digit is reached the translator sends with it an additional signal denoting it is the last. The register sends this digit and then sends those of the stored digits indicated by the sending instruction. On completion of sending, the transmission path is established through the relay-set and the register releases.

The translators for the non-director and director equipments are similar in principle and, with the exception of the register-finder uniselector, are of all-relay design. Opportunity has been taken in the register design to gain operational experience of different storage techniques, the non-director-type equipment employing uniselectors, except foı the translation-digit store where relays are used, while the director type equipment uses relays for all storage and counting functions. In the more detailed description of the main circuit functions that follows, those circuit elements which are similar in the two equipments are described only for the non-director type.

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RECEIPT AND STORAGE OF THE NATIONAL NUMBER

Non-Director Scheme

The initial digit 0 of the national number steps the 1st selector in the originating exchange to level 0 and in the following inter-digital pause the selector hunts for a register-access relay-set. When the access relay-set is seized by the call its associated register-hunter in turn hunts for a free register. Under adverse conditions the combined hunting times of the 1st selector and register-hunter can exceed the inter-digital pause. To avoid losing calls, the first digit received is temporarily stored on a uniselector in the access relay-set and subsequently transferred to the register. The succeeding digits are repeated directly to the register over a separate path from that used for transfer of the first digit so that the two processes can continue simultaneously.

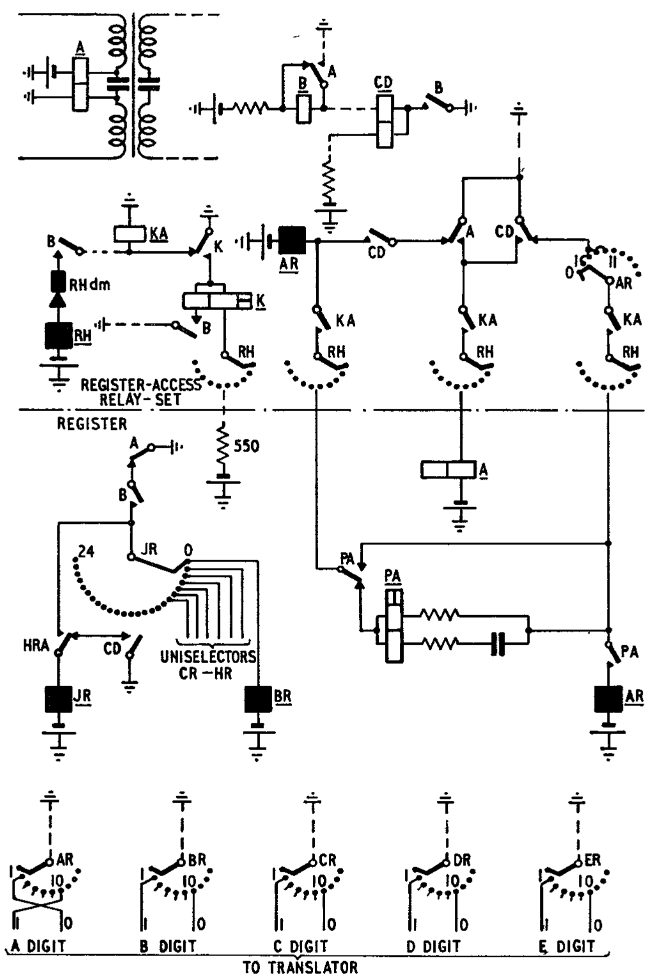


FIG 2.—DIGIT STORAGE IN NON-DIRECTOR-AREA REGISTER

Fig. 2 shows the circuit element for digit storage and marking of the first five digits, the A–E digits, into the translator. When a relay-set is seized, relays A and B operate and complete the register-hunter drive circuit, which is cut when relay K operates to the 550-ohm battery of a free register. When the A digit is received it is stored by uniselector AR in the register-access relay-set. Relay CD releases during the inter-digital pause following the A digit and, provided a free register has been found (relay KA operated), the circuit is completed to commence self-interaction of the register pulse-generating relay PA. This relay steps uniselector AR in the access relay-set from the position reached on receipt of the A digit to contact 11, where the earth is disconnected from relay PA and pulsing ceases. Uniselector AR in the register steps to the same pulses so that the digit is stored in the register as its complement with respect to 11 and is given its correct significance by wiring transpositions.

The B and subsequent digits are repeated by the access relay-set A relay to the register for storage by uniselectors BR–JR. Uniselector JR acts as a digit distributor during receipt of the B–H digits, after which relay HRA operates and uniselector JR is used to store the J digit. Uniselector storage affords a convenient arrangement for marking the A–E digits to the translator, which requires a signal on one out of 10 leads for each digit. These signals are readily available from arcs of the corresponding storage uniselectors.

Director Scheme

The introduction of a local register on level 0 of the A-digit selectors at the director exchange permits control of the length of the inter-digital pause between each digit received by the register-access relay-set. Sufficient time is allowed between seizure of the register-access relay-set and receipt of the A digit for the register-hunter to search for, and seize, a free register. Consequently the A digit, as well as each subsequent digit, can be repeated directly to the register and digit storage in the relay-set is not required.

The dialled pulses received by the register A relay (see Fig. 3) are counted and converted into binary code by the four pairs of relays W, WA to Z, ZA as shown in Table 1. On the first break of each pulse train, relays

TABLE 1
Counting Relay Sequence in Director-Area Register

Digit	Pulse	Relays Operated							
		W	WA	X	XA	Y	YA	Z	ZA
1	B	√							
	M	√	√						
2	B		√	√					
	M			√	√				
3	B	√		√	√				
	M	√	√	√	√				
4	B		√		√	√			
	M					√	√		
5	B	√				√	√		
	M	√	√			√	√		
6	B		√	√		√	√		
	M			√	√	√	√		
7	B	√		√	√	√	√		
	M	√	√	√	√	√	√		
8	B		√		√		√	√	
	M							√	√
9	B	√						√	√
	M	√	√					√	√
0	B		√	√				√	√
	M			√	√			√	√

Note: B = Relay A released. M = Relay A operated.

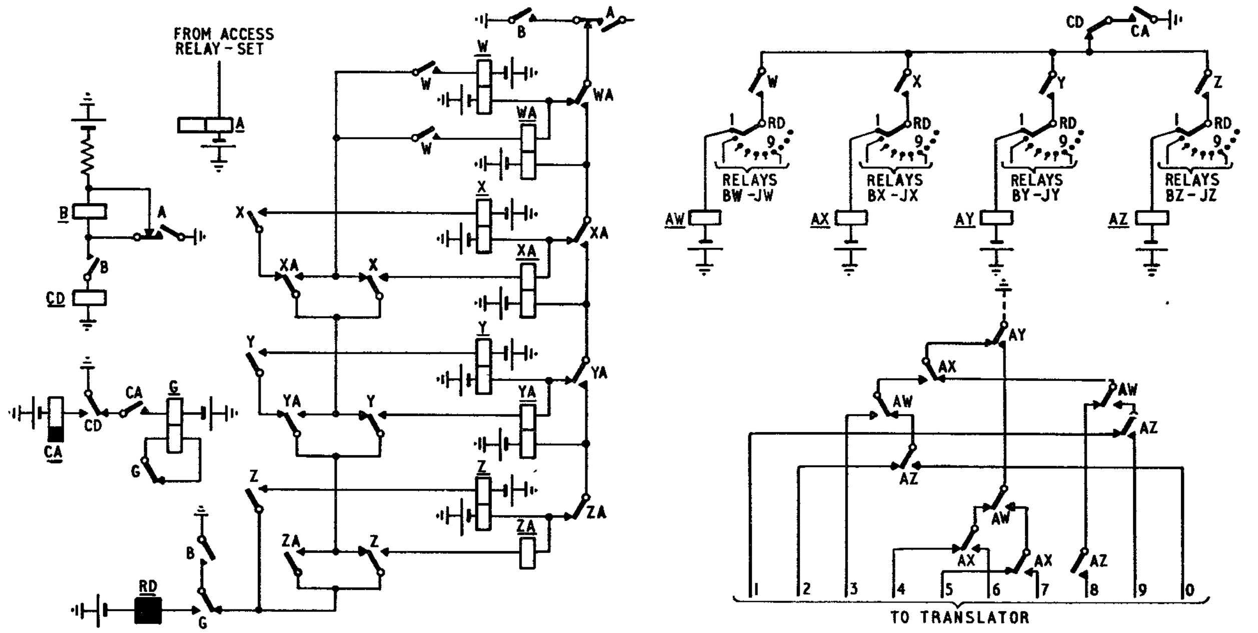


FIG. 3—DIGIT STORAGE IN DIRECTOR-AREA REGISTER

CD and CA operate and, during the following inter-digital pause, release in sequence, giving a pulse to relay G and to those of the storage relays AW–AZ which are marked by the operated relays of the incoming counter. Relay G operates slowly to give the digit-storage relays time to operate and lock (not shown), and when operated energizes uniselector RD and releases the counter relays. Release of relay CA releases relay G, which causes uniselector RD to step to the next digit store and the register is then ready to receive and store the next digit.

Storage of the incoming digits in binary code requires only four relays per digit but necessitates re-conversion to decimal code of the A–E digits before marking into the translator. This conversion is provided by the contact arrangement of the storage relays, as shown in Fig. 3 for the A digit. Similar contact arrangements on relays BW–BZ to EW–EZ are employed for the B–E digits, respectively.

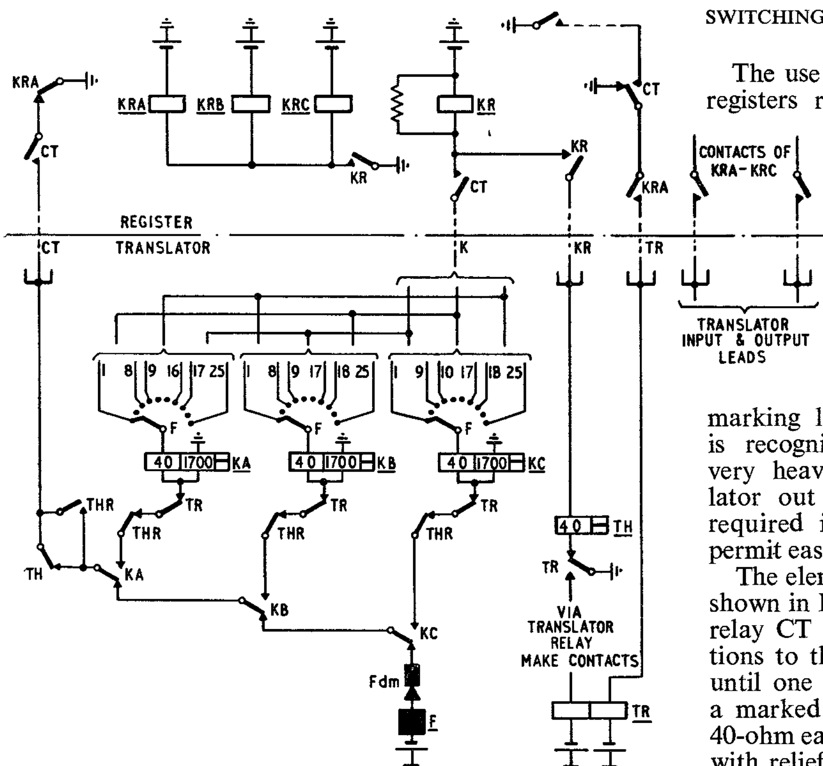
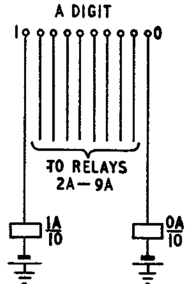


FIG. 4—CONTROL OF REGISTER-FINDER

SWITCHING BETWEEN REGISTERS AND THE COMMON TRANSLATOR

The use of a common translator serving a number of registers requires provision of a speedy and reliable register-to-translator switching scheme. The number of wires to be connected greatly exceeds the capacity of any rotary switch and the system adopted employs a group of switching relays in each register. Control of selection and switching is provided by a uniselector register-finder in the translator. By including the switching relays in the register rather than in the translator their number is considerably reduced, since one contact can then serve a group of 10 digit-marking leads, of which there are a total of 50. It is recognized that the register-finder uniselector is very heavily worked and to avoid putting the translator out of service when maintenance attention is required it has been mounted as a plug-in unit to permit easy replacement by a spare unit.

The elements of the selection and switching circuit are shown in Fig. 4. When a register requires the translator, relay CT operates and connects start and mark conditions to the CT and K wires. Register-finder F drives until one of the testing relays KA, KB or KC reaches a marked K wire and operates to cut the drive. The 40-ohm earth via a testing relay operates relay KR which, with relief relays KRA–KRC, switch the register to the translator multiple.



While the translator is dealing with this demand, the register-finder pre-selects the next calling register. By overlapping the translation and hunting functions in this way the translator is permitted to handle more demands than if the functions were performed sequentially. Assuming that relay KA has switched, the circuit functions as follows.

Relay KR in operating connects relay TH in series with KR and in parallel with relay KA. Relay TH operates, releases relay KA and prevents the register-finder driving until the relief relay THR has disconnected the KA, KB, KC switching circuits. Operation of relay THR completes the drive circuit and the register-finder hunts. The next calling register is found but switching is prevented until the translator has cleared from the previous demand. When the translation cycle has been completed correctly, earth is connected to the TR lead to operate relay TR. Relay TR releases relays TH and KR to clear the connexion, complete clear-down being checked by the release of relay TR, which permits switching to the next register.

The use of multiple testing relays serves a twofold purpose. First, in conjunction with the slipped bank wiring it permits any calling register to be found within eight steps and so reduces wear on the uniselector mechanism. Its second purpose, which will be described more fully later, provides for a system of partner working whereby control of a group of registers, normally working to a translator that has been taken out of service, may be transferred to another translator.

If simultaneous demands from registers occur on corresponding outlets of different arcs, two or even the three testing relays operate. The registers are then dealt with in the order KA, KB, KC since switching only occurs on that outlet on which earth from the CT lead short-circuits the 1700-ohm winding of the testing relay.

CODE IDENTIFICATION

The routing and charging rate for a call can be determined in most cases by identification of the 3-digit group code. These digits are signalled to the translator as an earth on one out of 10 wires on the three groups of digit wires shown in Fig. 5.

Assuming that the code to be identified is 111 then relay 1A will operate. The contacts of this relay offer the 10 relays 11B–10B to the B-digit wires. Earth on B-digit wire 1 operates relay 11B via contact 1A1, and the contacts of relay 11B connect the 10 code tags 111–110 to the C-digit leads. Earth on C-digit lead 1 then appears on code tag 111 via contact 11B1. The 3-digit code-identification circuit comprises 110 relays and permits identification of any code as a unique marking on one of the 1,000 code tags.

Identification to the fourth or fifth digit is occasionally required before translation can take place. These cases are catered for by further groups of code relays, shown in Fig. 6, connected to the D-digit and E-digit leads from the register. The contacts of these relays, of which only one group is shown, may be associated by cross-connexions with any code requiring further expansion. Relays

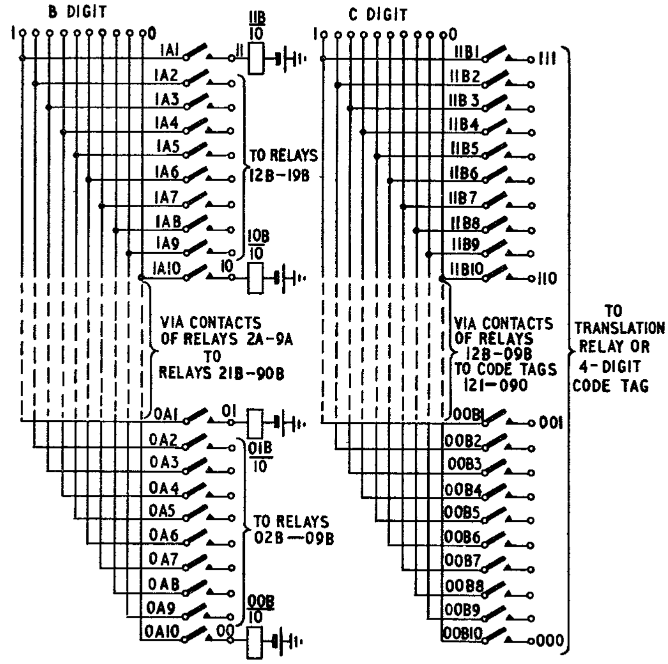


FIG. 5—3-DIGIT CODE IDENTIFICATION

ASA and BSA indicate to the register when the fourth and fifth digits are required.

The 10-contact relay,* which is economically essential to this circuit, is a new addition to the 3000-type range, which has hitherto been limited to a maximum of eight contacts.

RETURN OF TRANSLATION INFORMATION TO THE REGISTER

The translation information required by the register to complete a subscriber-dialled trunk call consists of a fee digit and from one to five routing digits in non-

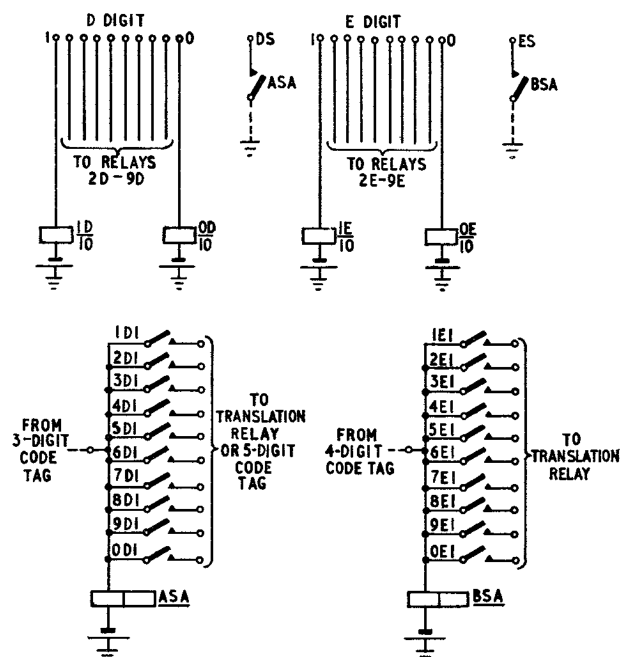


FIG. 6—4-DIGIT AND 5-DIGIT CODE IDENTIFICATION

* ROGERS, B. H. E. The Post Office Type 10 Relay. *P.O.E.E.J.*, Vol. 51, p. 14, Apr. 1958.

director areas and from one to six routing digits in director areas. This information is obtained from the translator by a separate demand for each digit. For each call the register makes up to seven demands on the translator; each demand occupies the translator for a nominal time of 150 ms. This "one digit per demand" system reduces the translation-digit storage requirements in the register to a minimum but, conversely, increases the total translator holding time per register and, hence, reduces the maximum number of registers which can be connected to one translator. Because a minimum of two translators must always be provided to safeguard against translator failures, the economic advantage of the greater register capacity per translator derived from a multiple transfer system cannot be realized at many installations. It was considered, therefore, that for general application to installations greatly varying in size the "one digit per demand" system would prove considerably cheaper overall.

The translator employs a cross-connexion field on which translations are set up by soldered connexions. The need to make additions and changes to translations from time to time causes this, like all such translation fields, to be a potential source of faults. The situation is alleviated to some extent by the use of the common translator, which reduces translation fields in an exchange to a small number compared with an individual translator scheme. However, the consequences of a fault are more serious since the service given by a number of registers is affected and, to prevent mis-routings and lost calls due to this cause, self-checking signalling is used when passing the translation information back to the register. If an error is detected the translator is put out of service and an alarm given.

The non-director-type equipment employs a two-out-of-six code which is inherently self-checking, but the director equipment, in which binary storage is generally used, employs a system based on binary signalling on four wires supplemented by two additional wires for checking purposes.

Non-Director Scheme

When a register has switched to the translator an earth signal is connected to operate one of the relays TA–TF (Fig. 7) indicating which translation digit is required. Relay TA operates for the fee digit, relay TB for the first routing digit, relay TC for the second routing digit, etc. The appropriate translation relay TS operates, after identification of the terminal exchange code as described in the previous section, and earth is connected via the translation cross-connexion field to operate one of the translation-digit relays NA–NM. Each of these 12 relays marks its corresponding digit to the register by connecting earth to two out of six leads, U–Z. The digit is stored on relays U–Z in the register and an arrangement of contacts on these relays operates the translator-release relay TR provided no more, or no less, than two of these relays are operated.

As well as the fee and routing information, "Sending-Instruction" and "Last Translation-Digit" signals are required by the register. The "Sending-Instruction" signal is an earth on one of the leads OM1–5 and this is given on the first demand for a translation digit. The "Last Translation-Digit" signal is an earth on lead OR at the same time as the last digit is marked on leads U–Z.

Director Scheme

The method of obtaining a translation digit in the director-area equipment is similar to the non-director equipment for the operation of the demand relays, the cross-connexion of the translation field, and marking of the "Sending-Instruction" and "Last Translation-Digit" signals. The arrangement for transferring translation digits to the register differs, however, and is shown in Fig. 8.

The translation digit is transferred by coding it into binary form and marking this to the register as a signal on one or two out of four leads, W–Z. The digit is stored in the register on relays ZW–ZZ. A weakness of the binary coding on four leads is that a disconnexion fault or contact between binary-digit marking leads may result in the transfer of an incorrect digit. This is safeguarded by the addition of a signal over either one of two further leads, CC1 and CC2, so that operation of TR occurs only if the correct binary digit is received. The leads that are marked for transferring the digits 1–0 are shown in Table 2.

REGISTER SENDING CONTROL

Non-Director Scheme

The sending-control circuit, as shown in Fig. 9, is similar to that used in a director, with the additional facility of sending all or part of the stored number

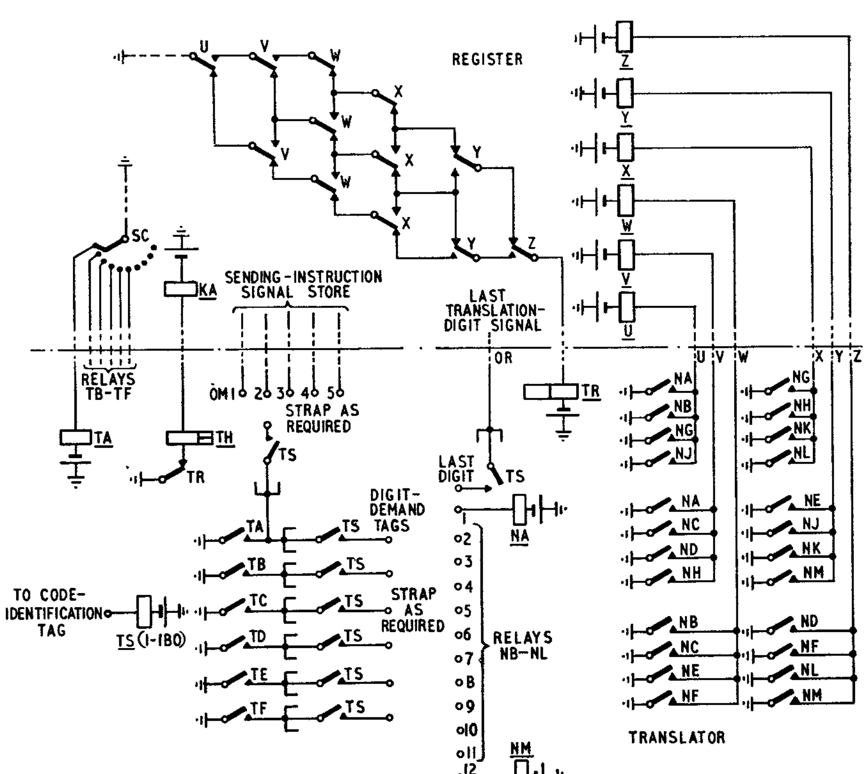


FIG. 7—TRANSFER OF TRANSLATION DIGIT IN NON-DIRECTOR-AREA REGISTER-TRANSLATOR

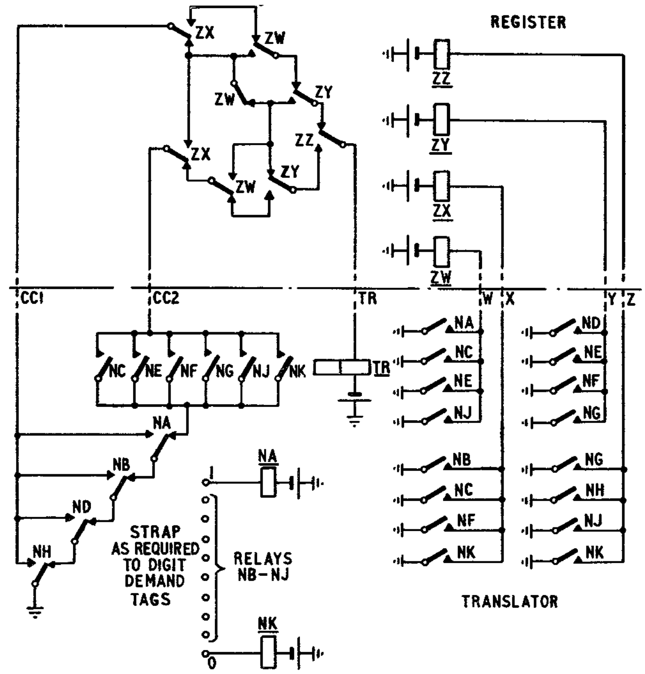


FIG. 8—TRANSFER OF TRANSLATION DIGIT IN DIRECTOR-AREA REGISTER-TRANSLATOR

TABLE 2
Leads marked for digit transfer in Director-Area Register-Translator.

Digit	Leads Marked					
	CC1	CC2	W	X	Y	Z
1	√		√			
2	√			√		
3		√	√	√		
4	√				√	
5		√	√		√	
6		√		√	√	
7		√			√	√
8	√					√
9		√	√			√
0		√		√		√

following the routing digits. Sending commences on receipt of the first translation digit (fee digit) with the connexion of earth to the 10 p.p.s. self-interacting relay P. Pulses from relay P are transmitted, with relay EF normal, to step uniselector AR in the register-access relay-set. After sending the fee digit, relay EF operates and subsequent digits are sent on the negative and positive leads. The send switch S counts the pulses transmitted and operates relay SZ to terminate sending when the marking for the appropriate digit is reached. With the operation of relay SZ the send switch drives to contact 14, takes seven steps under the control of relay P, then drives to the home contact and releases relay SZ. The seven controlled steps, together with the release of relay SZ, provide a minimum inter-digital pause of 800 ms.

The order in which digits are sent is controlled by uniselector SC, which takes one step for each operation and release of relay SZ. When the last routing digit is reached relay OR operates, causing uniselector SC to drive over the remaining routing-digit outlets. The sending instruction previously received from the translator is stored on relays OX–OZ and causes uniselector SC to continue driving until it reaches the first of the stored digits to be transmitted. Sending then continues until all the remaining stored digits have been sent, when uniselector SC steps to contact 15 and operates relay CO in the register-access relay-set. Relay CO operating switches the call through and releases the register.

Director Scheme

The sending-control circuit is shown in Fig. 10. Sending commences with the receipt of the first translation digit on relays ZW–ZZ. Digits are counted out by a binary-pulse counting element, similar to that shown in Fig. 3 for receiving pulses, driven by a contact of pulsing relay AB. The successive digits set up on relays SW–SZ are compared with the digit stored on relays ZW–ZZ, and when coincidence occurs relay SP operates. To permit the same counter to be used for timing the inter-

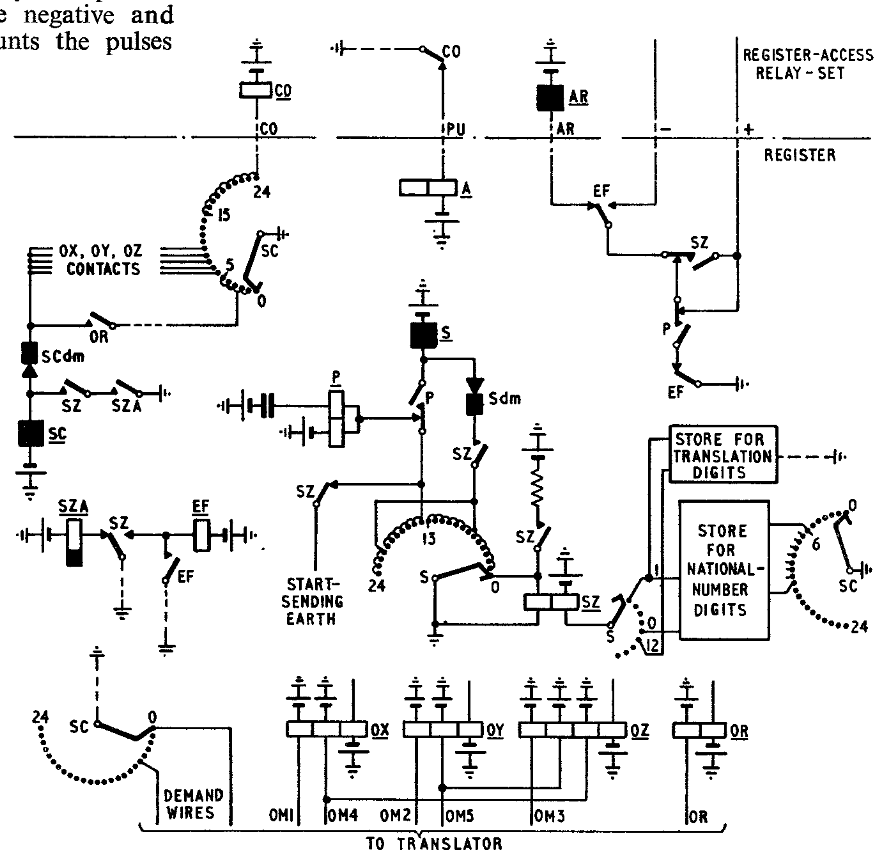


FIG. 9—DIGIT-SENDING CONTROL IN NON-DIRECTOR-AREA REGISTER

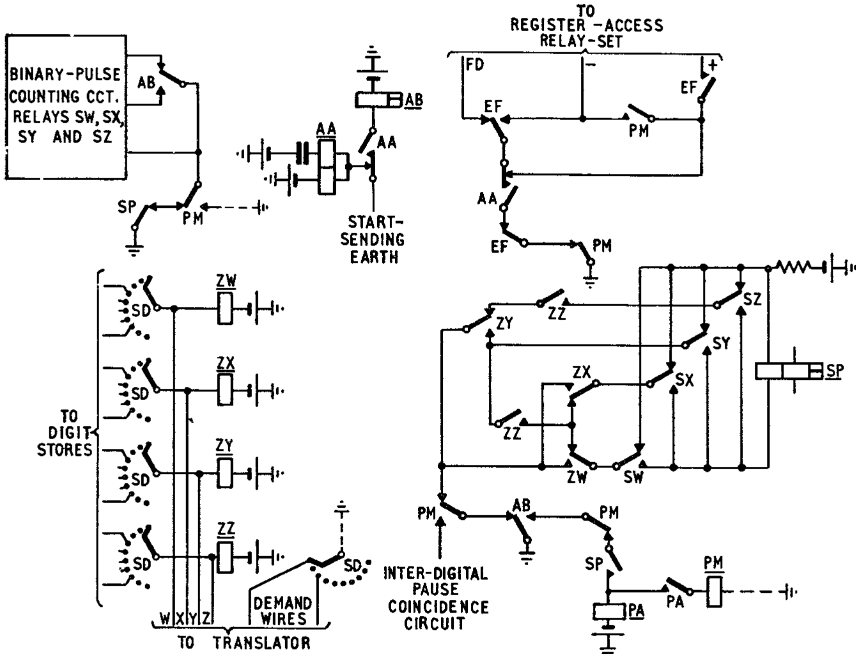


FIG. 10—DIGIT-SENDING CONTROL IN DIRECTOR-AREA REGISTER

digital pause accurately it is arranged that relay SP operates on the penultimate pulse of the digit-train. For digit 1 a pre-operate circuit for relay SP is used; this is not shown in Fig. 10. The final pulse of the digit being sent is counted by two additional relays PA and PM, and during its transmission the counter is released. When relay PM operates, sending to line is terminated, but relay AB continues to pulse with the counter now timing the inter-digital pause. Coincidence of the counter relays with the selected inter-digital pause marking completes the timing.

The sequence of sending is controlled by uniselector SD in a similar way to that of the non-director equipment. When the translation digits have been sent, those digits of the stored number which it is necessary to send are taken successively from their stores by relays ZW–ZZ and transmitted in the same way. Release of the register follows in a similar manner to that for the non-director circuit.

CONTROL OF METERING

The fee digit for a call is determined by the translator, passed to the register and used to step a uniselector in the register-access relay-set to select the appropriate meter-pulse supply.

TABLE 3
Relay Operating Sequence of Pulse-Division Circuit

Relay	Pulse Number													
	1		2		3		4		5		6		7	
	on	off	on	off	on	off	on	off	on	off	on	off	on	off
PA	√	√			√	√			√	√			√	√
PB		√	√	√	√							√	√	√
PC				√	√	√	√	√	√					
PD								√	√	√	√	√	√	
MP													√	

The common pulse supply is at six times the frequency of the required metering rate and a pulse-division circuit is provided in the relay-set. Pulse division will normally be carried out by a ratchet relay operating on a 6-step cycle but in the early equipment the relay counting circuit shown in Fig. 11 is used.

When the called subscriber answers, the line relay, D, operates relay DD, which locks. Relay J, which has previously been operated, operates relay MP during its release lag. Relay MP returns a meter pulse to the subscriber's meter either directly or via junction signalling relays to a distant exchange.

Release of relay J connects relay CD to the common pulse supply. The pulses repeated by relay CD operate and release relays PA–PD in the sequence shown in Table 3, and on the seventh pulse relay MP also operates to return a further meter pulse. After the seventh pulse the counter returns to the condition it was in following the first pulse so that on the next and subsequent counts relay MP is operated by each succeeding sixth pulse.

A relay counter has been used in preference to a uniselector because of its lower current consumption. Numbers of relay-sets will be pulsing simultaneously

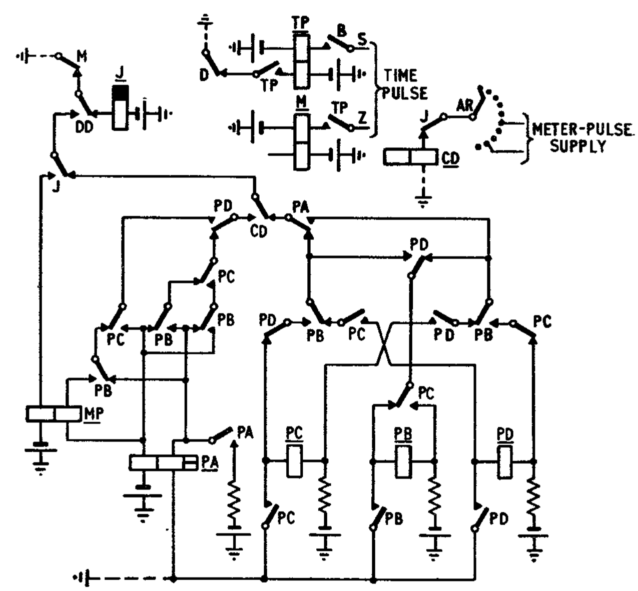


FIG 11—CONTROL OF PERIODIC METERING

from the common pulse supply and it is desirable to minimize the pulsating current drawn from the 50-volt supply. Once metering has commenced, control of its termination is placed with the calling subscriber. To prevent excessive charging should the calling subscriber not replace his receiver correctly, it is arranged that release of relay D, when the called subscriber clears, completes a circuit for relay TP. After a time-pulse period, relay M is operated to stop metering and to forcibly release the forward connexion.

TRANSLATOR PARTNER WORKING

Since a translator serves a number of registers it is necessary to make alternative provision should their normal translator fail or be taken out of service for maintenance. To cover this condition a system of partner working is provided in which translators are interconnected in groups of two or three. When a translator is taken out of service, either automatically by fault-detection circuits or manually, the group of registers that it normally serves is transferred to another translator. This translator then deals with its own group of registers plus its partner's group. When a group of three translators is provided, an additional facility exists whereby the three associated groups of registers may be served by any one of the translators. This condition is, however, only operative under manual control since the one translator cannot satisfactorily handle the combined busy-hour traffic from the three groups.

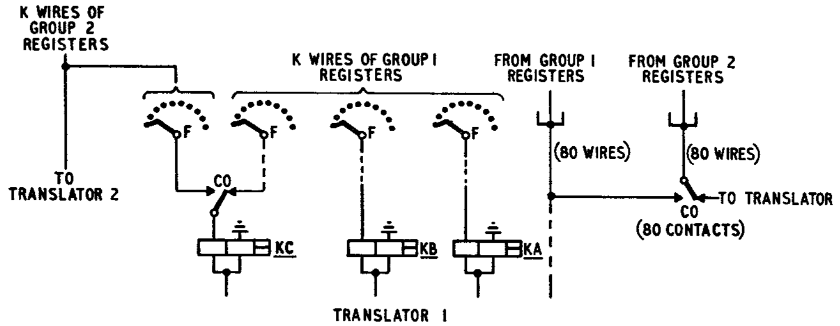


FIG. 12—PRINCIPLE OF TRANSLATOR PARTNER WORKING

Fig. 12 shows in simplified form the principle by which control of a group of registers is taken over for partner working. The K wires of the registers in the partner group are connected to the register-finder but are not normally tested. Under partner-working conditions relay CO is operated and switches one of the three testing relays to test the partner-group registers and switches the two translator multiples together.

TRANSLATOR TRAFFIC CAPACITY

Demands from registers on the translator, subsequent to the first, are made during the inter-digital pause and no additional delay is caused to a call if the translator can meet the demand within this period. When peaks of traffic occur, however, it is necessary to tolerate some delay to secure economic provision of equipment, in the same way that with other switching systems a proportion of lost calls must be accepted at times of heavy traffic. It is desirable to keep this delay as short as possible since it extends the period between completion of dialling by the subscriber and his receipt of supervisory tones. Also, if the delay is permitted to become appreciable the consequent increase in register holding time will cause a loss of traffic capacity at this stage tending to offset the saving of translator cost that is achieved by its heavier loading.

A further limiting factor arises from the fault-detection system used. On making a demand to the translator each register checks the delay in receiving a reply against a 6-second time pulse. If no reply is received within this period it is assumed that a fault exists and the translator is switched out of service and an alarm given. It is obviously desirable that this condition should not be caused by the delays that occur at peaks of traffic.

A theoretical study of the traffic characteristics of the system has been made to determine a suitable number of registers to associate with one translator. The results of this study indicate that delay will be small with 15 registers per translator under normal conditions, and this basis of provision has been adopted for initial installations. Under partner working conditions, when 30 registers may be connected, delay is still not appreciable. The average anticipated delay per call during the busy hour under these two loadings is 100 ms and 450 ms, respectively, whilst the proportion of calls experiencing more than 2 seconds delay is 0·0005 and 0·04, respectively.

ACKNOWLEDGEMENTS

The development of the equipment described above was carried out on behalf of the British Telephone Technical Development Committee by the Post Office in conjunction with the General Electric Co., Ltd. (non-director-area equipment) and the Automatic Telephone & Electric Co., Ltd. (director-area equipment).

Controlling Register-Translators

Part 3—Electronic Register-Translator using Cold-Cathode Discharge Tubes

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U.D.C. 621.395.341.7:621.385.12:621.395.374

The article describes electronic register-translator equipment which employs cold-cathode discharge tubes using the "voltage-transfer" circuit technique. The equipment has been developed to provide subscriber-trunk-dialling facilities at larger non-director centres, and the initial installation at Bristol is of this type.

OUTLINE OF SYSTEM

ELECTRONIC register-translator equipment using cold-cathode tubes has been developed to provide subscriber-trunk-dialling (S.T.D.) facilities at the larger non-director centres, and the initial installation at Bristol is of this type.

Register

A register is composed of cold-cathode-tube circuits and an associated relay-set. The relay-set provides a link between the electronic circuits and the electro-mechanical equipment in the exchange. Connexion to a register is obtained from a register-access relay-set via a register-hunter, this equipment being the same as that used for access to the equivalent electromechanical register. When a register is seized, a relay is operated to switch on the h.t. supply to the electronic equipment, which then becomes operative. The electronic equipment employs cold-cathode discharge tubes exclusively, and these are used in counting chains for digit counting and control purposes and also as individual storage tubes which, in groups of five, store the digits dialled in two-out-of-five code.

To simplify the register, control of the order in which digits are sent has been incorporated in the common translator which, in this respect, acts as a common control for a number of registers. Thus, during setting up of a call, transmission of each digit requires an association of the register and translator.

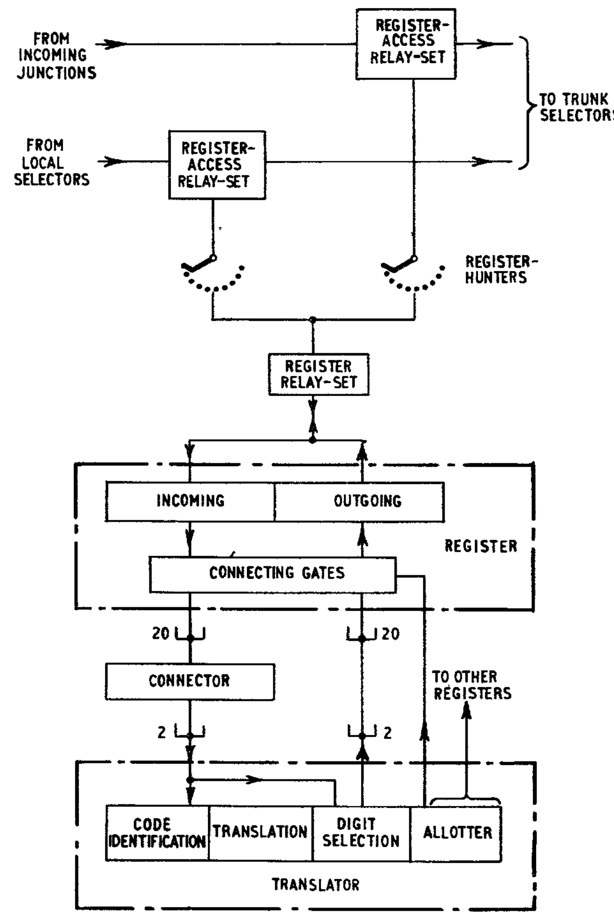

FIG. 1—BLOCK SCHEMATIC DIAGRAM OF SYSTEM

Translator

A translator serves 40 registers, and the way in which registers are connected to the translator is shown in Fig. 1. The translator incorporates an allotter, which connects one register at a time to the translator. While this connexion is maintained the register signals to the translator all the digits stored and the identity of the last digit which the register has sent. If sufficient information is available the translator signals back to the register the next digit to be transmitted. The translator then releases that register and the allotter steps on to connect the next register, and the procedure is repeated. The electronic translator can deal with a register in a very short time and a fixed period of $16\frac{2}{3}$ ms has been adopted. The allotter operates continuously so that each register is connected once every $666\frac{2}{3}$ ms.

While the translator is connected, it examines the information stored in the register and determines what action, if any, is required. Digits of the national number that have to be transmitted by the register are transferred to the register pulsing-out equipment via the translator. This arrangement permits the translator to check the transfer of these digits and to control the release of the last few. While a register is sending a digit, connexion with the translator is prevented.

Although the connecting gates are part of the register equipment they are controlled by the allotter. The output impedance of these gates is high and, to avoid the delay that would arise due to the capacitance of the wiring between register and translator, one cold-cathode tube per wire is used as a repeater. Fifty-nine of these repeating tubes, which are common to 20 registers, form a connector.

Standby Translator

A standby translator is provided for one or two working translators. Thus, a full installation of 80 registers requires three translators, two in operation serving 40 registers each and one available as the standby. The standby translator has access to all 80 registers of the installation and can be associated with either group of 40 registers via duplicate connecting gates, connectors

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and common wiring. This duplication avoids the possibility of a fault affecting both normal and standby operation.

Pulse Generator

The electronic equipment is controlled by a system of common pulses which are supplied by the pulse generator. Two pulse generators are provided for each installation of up to 80 registers and either can be used to supply the equipment while the other acts as the standby. The sequence of the 11 pulses required is shown in Fig. 2.

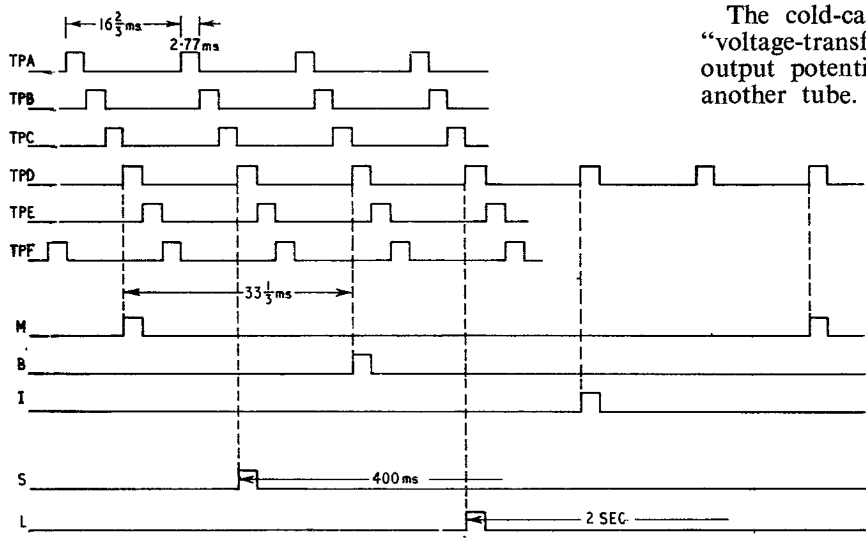


FIG. 2—PULSES SUPPLIED BY THE PULSE GENERATOR

Each pulse rises from earth potential to about +160 volts and is of 2·77 ms duration. Pulses TPA–TPF each have a recurrence frequency of 60 p.p.s.; pulses M, B and I, each having a recurrence frequency of 10 p.p.s., are synchronized with a TPD pulse and phased $33\frac{1}{3}$ ms apart. The S and L pulses are also synchronized with a TPD pulse and recur at 400-millisecond and 2-second intervals, respectively.

The pulse generator uses some hot-cathode valves. An oscillator operating at 180 c/s controls the frequency of pulses, and four power units, switched on and off 180 times per second, produce four phased power pulses, each of 2·77 ms duration and +240 volts amplitude. Cold-cathode tubes connected as counting circuits reduce the frequency successively to 60 p.p.s., 10 p.p.s., $2\frac{1}{2}$ p.p.s. and $\frac{1}{2}$ p.p.s. These counter circuits control the striking of other cold-cathode tubes, which have their anodes connected to the power pulses referred to, and the outputs of these tubes provide the pulses used by the electronic equipment.

TABLE 1
Characteristics of Cold-Cathode Tube CCT6

Anode–cathode breakdown voltage (min)	250 V
Normal continuous anode current	1–5 mA
Maximum pulsed anode current	40 mA
Anode–cathode stabilize voltage	60–80 V
Trigger–cathode breakdown voltage	70–90 V

* BEESLEY, J. H. Cold-Cathode Voltage-Transfer Circuits. *G.E.C. Telecommunications*, No. 23, p. 6, Feb. 1957 and No. 24, p. 30, June 1957.

ELECTRONIC CIRCUIT ELEMENTS

Introduction

With the exception of the power units and some miscellaneous items, the electronic equipment is built up from a few basic circuit elements. It is not necessary to refer to the detailed operation of these elements in describing the functioning of the main circuits; to do so would involve frequent repetition and diagrams would be complex. Therefore, the operation of typical circuits and examples of how elements are interconnected will be explained briefly first, and then a detailed description of main circuits will follow using functional diagrams.

The cold-cathode tubes in this equipment use the "voltage-transfer" method of operation* in which the output potential from one tube is sufficient to strike another tube. This technique requires a high-voltage cold-cathode tube, and in the equipment described here the CCT6 tube is used exclusively. The characteristics of this tube are given in Table 1.

Signals between tubes are controlled by rectifier gating, these gates being formed by resistors and miniature selenium rectifiers.

Basic Element

Fig. 3 shows a basic circuit element, the operation of which illustrates the principle of the voltage-transfer method for cold-cathode tubes. With V1 conducting, a potential of +150 volts (all voltages given are nominal) exists at the cathode and current flows through R1, MR1 and R2 to earth. MR1 is conducting and is a low resistance compared with R1 and R2; it may therefore be neglected. R1 and R2 form a potential divider between the cathode of V1 (+150 volts) and earth, which results in the trigger of V3 being at approximately one-fifth of the voltage at the cathode of V1, i.e. 30 volts. This potential is, however, insufficient to strike V3. If V2 is now struck, its cathode rises to +150 volts, and

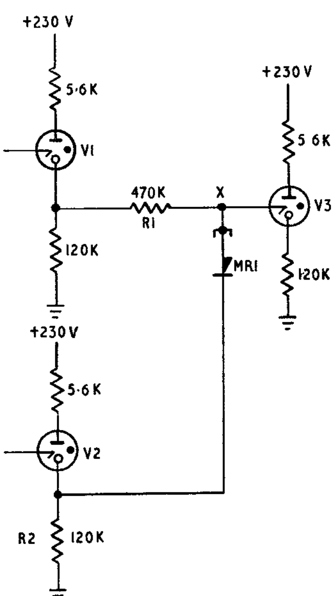


FIG. 3—BASIC ELEMENT OF VOLTAGE-TRANSFER CIRCUITS

the potential at the trigger of V3 rises to +150 volts and V3 also strikes. If V2 alone is conducting, current cannot flow through MR1 in its reverse direction so that the trigger of V3 remains at earth potential. Several tubes can be used to control the striking of V3 by providing each with a control rectifier similar to MR1 and commoning all rectifiers at the point marked X in Fig. 3.

Counting Circuit

A typical voltage-transfer counter circuit is shown in Fig. 4. These counters require two stepping leads, X and Y, to which spaced signals of 120 volts minimum amplitude are applied alternately. The counter is brought into use by applying a signal to the start lead ST, thus striking V1. When V1 strikes, current flows through R1 and R4 to charge the cathode capacitor C1, causing the anode potential to fall sharply to +130 volts and the cathode potential to rise sharply to +60 volts. As C1 charges, these potentials rise exponentially to a final value of +220 volts and +150 volts, respectively.

When a signal of at least +120 volts is applied to the X lead current flows through MR7 and RX to earth, and the junction of MR7 and RX rises to within a few volts of the applied signal. Thus, the potential at the trigger of V2 rises, and V2 strikes. The voltage waveforms at the anode and cathode of V2 are similar to those described for V1 and shown in Fig. 4. At the instant V2 strikes, the common anode connexion again falls to +130 volts and V1 is extinguished, because the main-gap voltage across V1 is reduced below the stabilize voltage of the tube. With V1 extinguished capacitor C1 discharges through R4 and R3.

After sufficient time has elapsed for the anode and cathode potentials to reach a steady value, a signal may be applied to the Y lead to advance the counter to position V3. A subsequent signal on the X lead will advance the counter to position V4. Thus, signals on the X lead step the counter to even-numbered tubes and signals on the Y lead step the counter to odd-numbered tubes. An output from the last tube of a counter may be connected to the input of the first tube, forming the counter into a ring, provided that there are an even number of tubes in the counter. Ring counters are used for frequency division in the pulse generator.

The drive signals on the X and Y leads must not coincide and sufficient time must be allowed between pulses to enable the cathode capacitor of the extinguishing tube to discharge. The drive signals may be derived from a pulse generator, or from non-adjacent tubes of a similar counter circuit. The symbol used for the counter in functional diagrams is also shown in Fig. 4.

The counter circuit just described may be adapted to step in an irregular sequence for control purposes. Any tube in the circuit may be struck directly by using gates to combine signals from other counters or from the pulse generator, provided that only one tube is struck at a time. When a tube strikes it extinguishes any tube in the circuit already conducting. By this means a few tubes in a circuit may be used in sequence to form a local ring counter, and when circumstances change the ring may be rearranged or a new ring formed. Where counter circuits are used in this manner the functional diagrams show the controlling gates as required for explanation.

Typical Circuit

Fig. 5 shows, as a further example of voltage-transfer technique, a circuit for coding and storing a decimal digit in two-out-of-five code. Tubes IPX and IP1–10 form a counter which is used to count dial pulses. The five tubes V–Z store one digit in a two-out-of-five code. Tubes IP1–10 are connected via coding gates to resistors R1–5, and the connexions are arranged so that each one of these tubes produces signals on a different pair of these resistors. As the counter is stepped, the signals on the resistors R1–5 change to indicate the two-out-of-five code corresponding to each step of the counter. When counting is complete an "end-of-digit" signal strikes tube ID causing its cathode potential to rise. This potential is applied, via resistors, to the triggers of the five storage tubes, and the two tubes marked by the incoming digit strike. The storage tubes remain conducting until the h.t. is switched off.

Tube ID is in the incoming-digit distributor and is extinguished after about 66 ms by the counter stepping. Stores for further digits are commoned at the outputs of the coding gates, and as further digits are received they are passed into successive stores as their respective ID tubes conduct. The circuit of Fig. 5 is shown in functional form as part of Fig. 6, where the counter IP is shown as the incoming-pulse counter and the tube ID is part of the incoming-digit distributor.

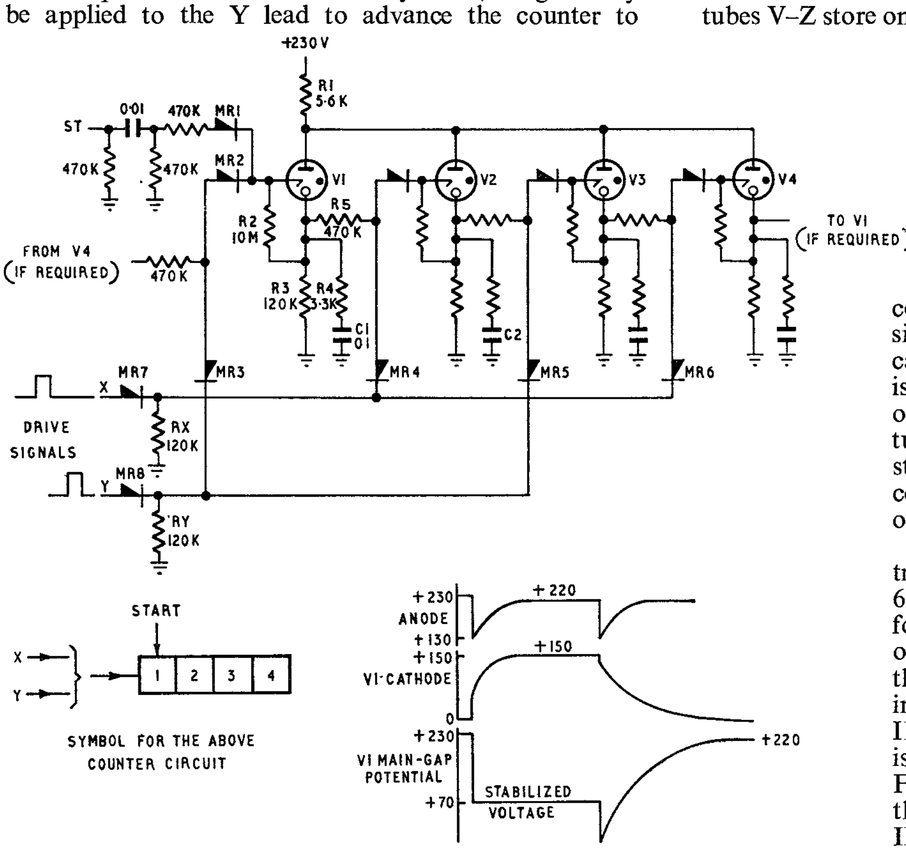
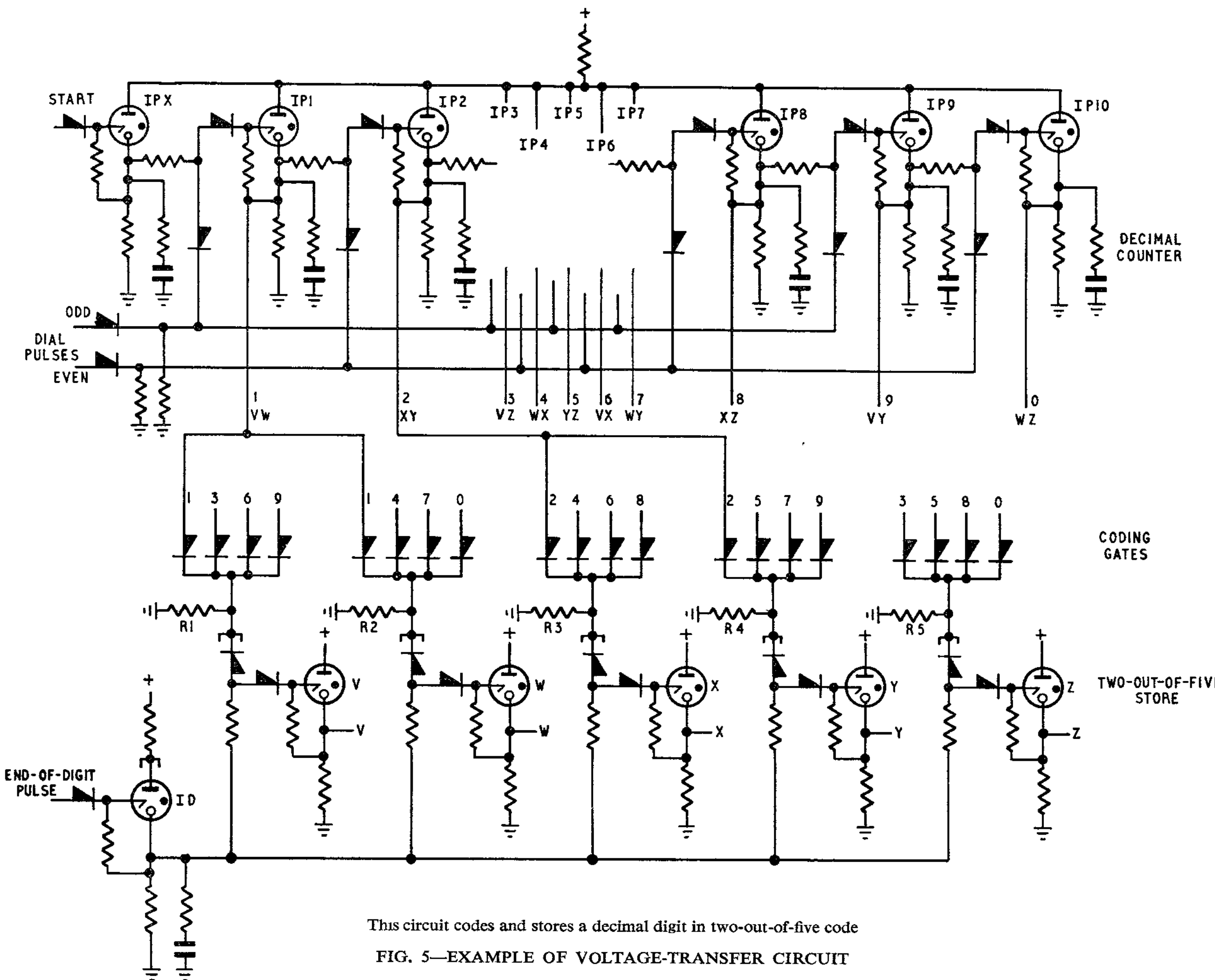


FIG. 4—VOLTAGE-TRANSFER COUNTER



This circuit codes and stores a decimal digit in two-out-of-five code

FIG. 5—EXAMPLE OF VOLTAGE-TRANSFER CIRCUIT

GENERAL DESCRIPTION

Seizure of the Register and Receipt of Digits

Access to the register is obtained using the same type of relay-set as that for the equivalent electromechanical register. The register relay-set is seized by an earth on the P wire and h.t. is connected to the register. Connexion of the h.t. generates a start signal, which strikes start tubes in various counter circuits.

Fig. 6 shows in functional form the circuit used for detecting, counting and storing in two-out-of-five code the trains of digits received. The circuit also caters for timing an 18-second forced-release period if no digit is received or incomplete dialling occurs, and also for timing the 4-second period used to determine the end of dialling. The circuit includes an incoming-control circuit IC, an incoming-pulse counter IP and an incoming-digit distributor ID.

The primary use of the incoming-pulse counter is to count the pulses of received digits, but the counter is also used to time the 18-second and 4-second periods, referred to above, by counting a fixed number of pulses from the pulse generator. This procedure is possible because the counter can be reset rapidly when required to count dial pulses. The start pulse, on seizure, initiates the 18-second timing by striking tubes IPS and IC16. The timing loop comprises tubes IC13–16, which form a ring counter driven by the 2-second L pulses applied to tubes IC14 and IC16 and the I pulse applied to tubes IC13 and IC15. Each cycle of the ring steps the incoming-pulse counter twice, once when tube IC14 strikes and again when tube IC16 strikes. If no dial pulses are received the incoming-pulse counter is stepped to tube IP9 and this leads to forced release of the call.

Earth, which is connected to the PU wire on seizure, is disconnected for each break pulse of the digits received. The first break pulse, coupled with a signal from one of the tubes IC13–16, allows tube IC17 to strike to the first TPA pulse to occur during the break. With tube IC17 conducting the subsequent TPF pulse strikes tube IC18, which in turn strikes tube IPX to restore the incoming-pulse counter to normal, ready for counting the digit just commencing. Tube IC18 also, in conjunction with the break pulse on the PU wire, causes tube IC1 to strike on the next TPA pulse. Tubes IC1–4 form a ring counter, which steps to TPA and TPF pulses until the break pulse ceases.

At the end of the break pulse reconnexion of earth to the PU wire prevents tubes IC1 and IC3 from striking and the counter stops with either tube IC2 or tube IC4 conducting. The next TPD pulse will step the counter to either tube IC5 or tube IC7 according to whether the tube conducting in the incoming-pulse counter is in an even or an odd numbered position, respectively. In the case of the first pulse the home tube IPX provides an "even" signal, which in combination with either tube IC2 or tube IC4 and a TPD pulse strikes tube IC5.

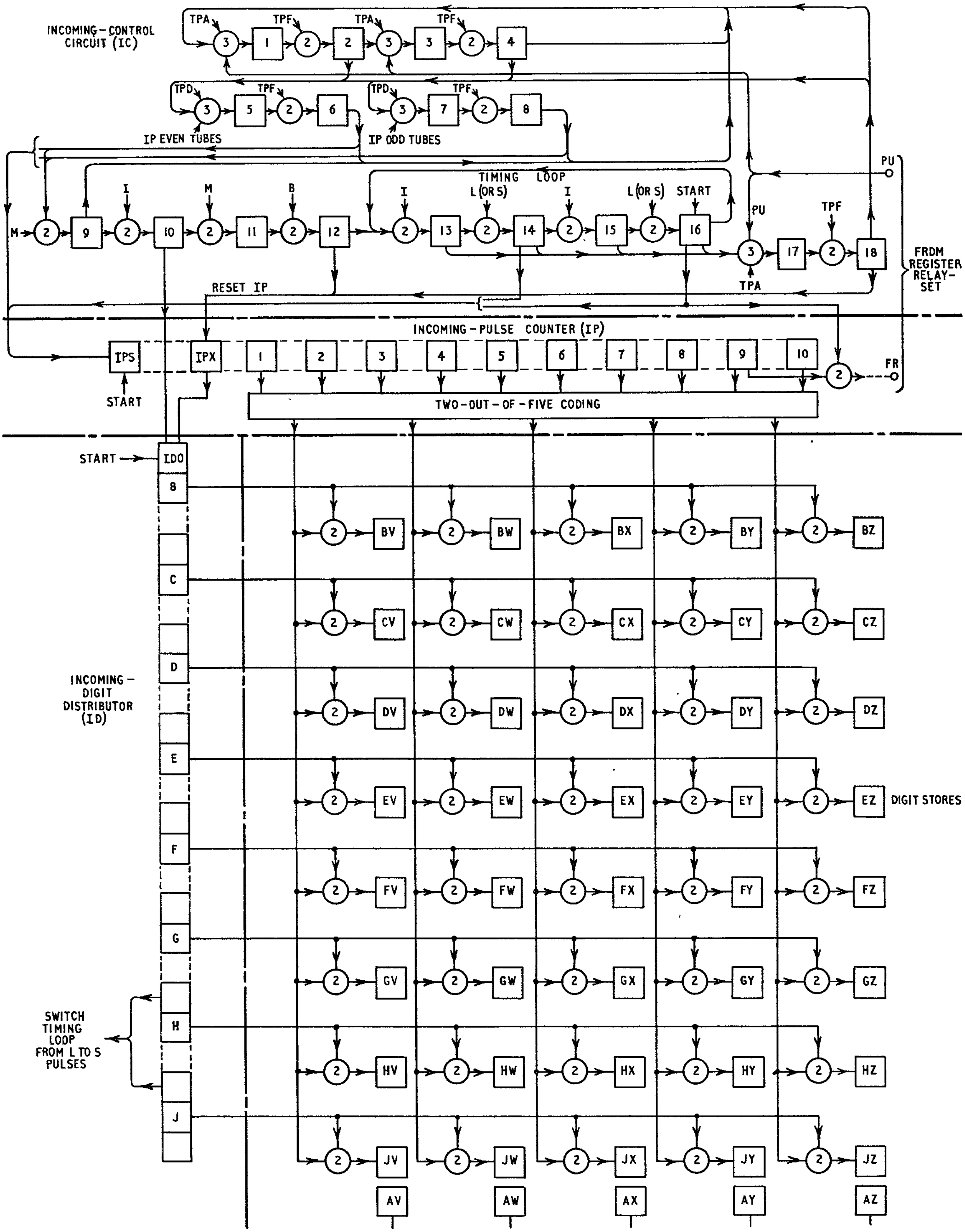


FIG. 6—FUNCTIONAL CIRCUIT OF THE INCOMING SECTION OF THE REGISTER

Tube IC6 strikes to a TPF pulse and tube IC9 to the subsequent M pulse. Tube IC10 strikes to an I pulse, $66\frac{2}{3}$ ms later. During the period that tube IC6 is conducting its output advances the incoming-pulse counter one step. While tubes IC6 or IC9 are conducting, the circuit will revert to cycling on tubes IC1–4 should another dial pulse arrive. Thus, during disconnexion of the PU wire, tubes IC1–4 cycle as a ring and at the end of the pulse the incoming-control circuit steps towards position IC10. In passing position IC6 or IC8 the dial pulse is recorded. If the pulse received is one of a train of pulses the next pulse will occur before tube IC10 is reached, which takes a minimum of 86 ms.

When an inter-digital pause occurs tube IC10 will be reached and this tube provides the end-of-digit signal. The first digit to be received is the B digit (third digit of the national number), the A digit having been previously received and stored in the register-access relay-set. The end-of-digit signal steps the incoming-digit distributor from the start position to position B, where it opens the gates of store B and allows the digit marked on the incoming-pulse counter to pass, via the coding rectifiers, into this store. The M, B and I pulses step the incoming-control circuit through positions IC11 and IC12 to IC13 and timing of the forced-release period on tubes IC13–16 recommences. When passing through position IC12 a signal resets the incoming-pulse counter to tube IPX, and tube IPX steps the incoming-digit distributor to an intermediate position to remove the gating signal from store B. Succeeding digits are received and stored in the same way in the appropriate stores.

After storing the G digit (eighth digit of the national number) the incoming-digit distributor provides a signal to place the timing loop under the control of the 400-millisecond S pulses instead of L pulses. If 4 seconds elapses without any H digit being received, tube IP10 is reached and equipment, not shown in the diagram, strikes all five tubes in store H to record that "4-second time-out" has occurred. The final tube in the incoming-digit distributor is also struck and this restores the timing loop to normal. If an H digit is received, a 4-second time-out following storage of this digit is dealt with similarly, the indication being stored in the J-digit store.

Transfer of the A Digit from the Register-Access Relay-Set to the A-Digit Store

The A digit is stored on uniselector AR in the register-access relay-set. The register determines the value of the digit by pulsing the uniselector over the AR wire and counting the number of pulses required to step the uniselector to outlet 11, as shown in Fig. 7.

On seizure of the register the start signal strikes tubes OC4 and OPA in the outgoing-control circuit OC and outgoing-pulse counter OP, respectively. At the beginning of the first pulse of the B digit, tube IT9 in the inter-digital-pause counter IT is struck by tube IC17 in combination with tube ID0. Tube IT9 provides a signal which causes part of the outgoing-control circuit to operate as a 4-step ring counter using tubes OC1, 2, 4 and 5. Tubes OC2 and OC5 provide signals to drive the outgoing-pulse counter at 10 p.p.s. The outgoing-control-circuit tubes step under the control of I and B pulses, and signals from the outgoing-pulse counter ensure correct odd/even sequencing of the drive signals; these details are not shown in Fig. 7. Four tubes are used to generate the drive signals so that overlapping is avoided. On the first B pulse following the striking of tube IT9, the outgoing-control circuit steps from tube OC4 to tube OC5, and also steps the outgoing-pulse counter from tube OPA to tube OP0. At the same time the outputs from tubes OC5 and IT9, and a B pulse, combine to strike tube ORX, causing relay X to operate and energize the magnet of uniselector AR. After $33\frac{1}{3}$ ms the output from tube IT9 and an I pulse strike tube OC1. At the same time tube ORY strikes, extinguishing tube ORX, which releases relay X and thus steps uniselector AR. After a further $33\frac{1}{3}$ ms tube ORZ strikes to an M pulse and tube ORY is extinguished. The next B pulse strikes tube OC2, which steps the outgoing-pulse counter from tube OP0 to tube OP9. At the same time tube ORX strikes and relay X re-operates. The cycle is repeated until uniselector AR reaches outlet 11, when the earth is removed from the CO wire allowing the potential of the

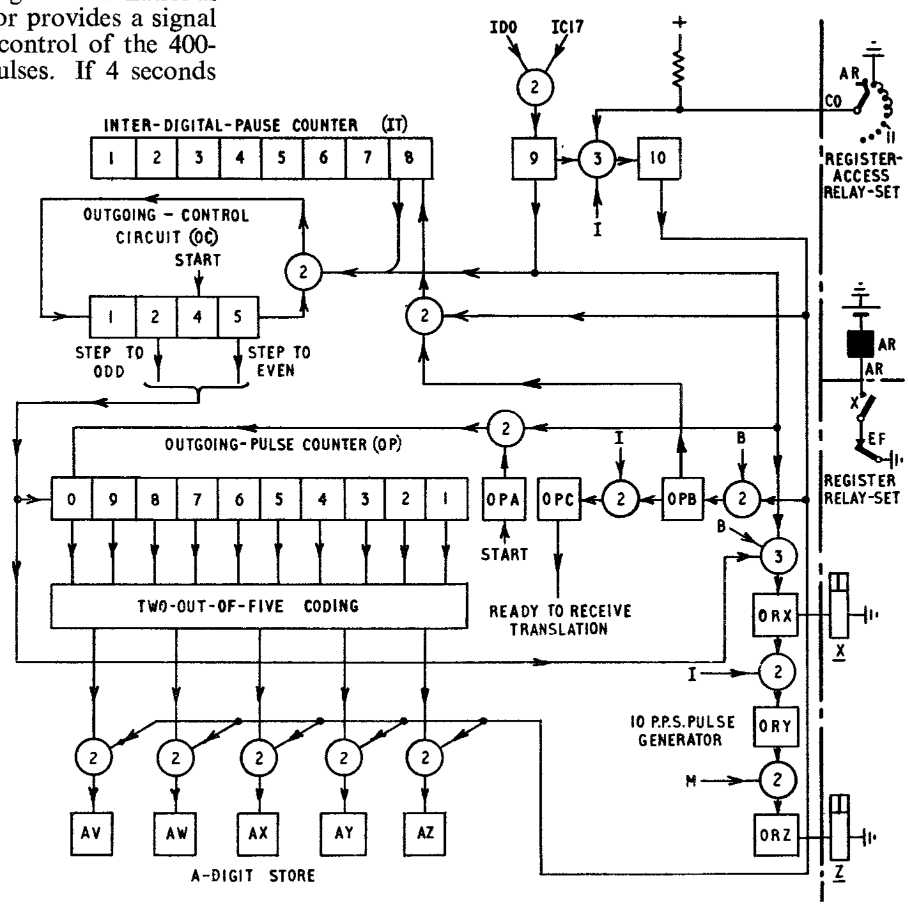


FIG. 7—FUNCTIONAL CIRCUIT FOR A-DIGIT TRANSFER AND PULSING OUT BY THE REGISTER

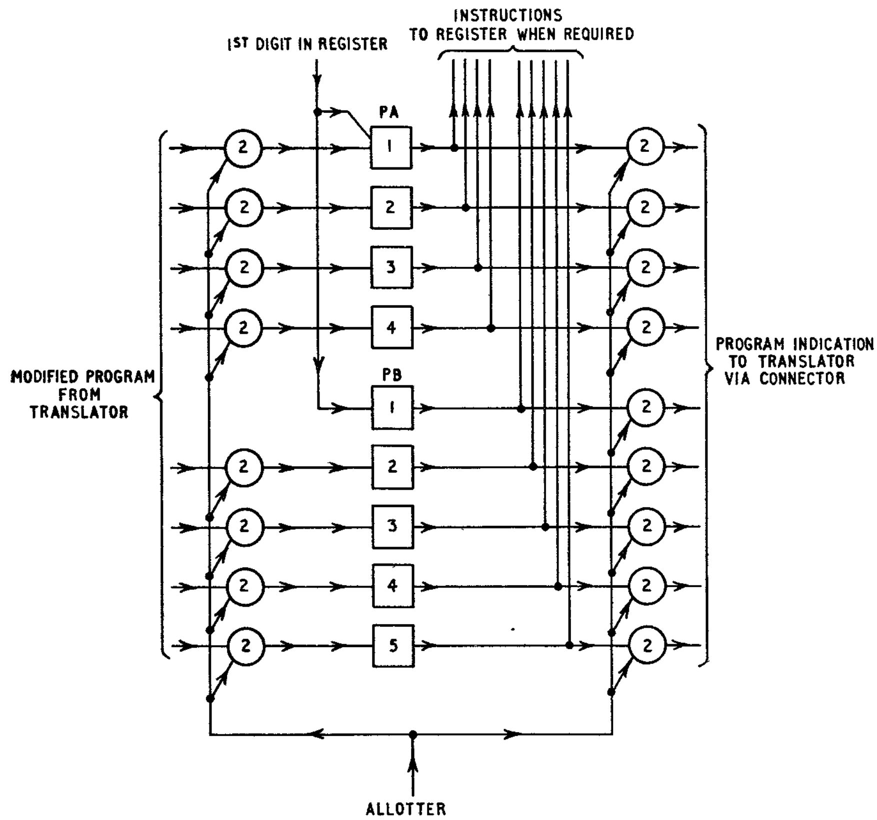


FIG. 8—FUNCTIONAL CIRCUIT OF THE PROGRAM SECTION OF THE REGISTER

established. If the translator supplies a digit for transmission it will also change the program setting to identify the digit being sent. While normal pulsing out is taking place the program indication is used by the translator and has no direct control over the register functioning. However, there are some circumstances in which it is used by the translator to indicate that the register should take some specific action; for example, when a long inter-digital pause is required, when a spare code has been received, or when the last digit is being pulsed out and the register is required to clear down afterwards.

The Allotter

The allotter is part of the translator and consists of two cold-cathode ring counters, which divide by eight and five successively. The first counter is stepped by the translator once every $16\frac{2}{3}$ ms and the second counter is driven by the first. Thus, the two counters provide 40 different combinations in sequence and these combinations are repeated every 40 steps, i.e. every $666\frac{2}{3}$ ms. Each one of the 40 individual combinations controls one register.

CO wire to rise and strike tube IT10. Tube IT10, by extinguishing tube IT9, prevents further operation.

The numerical value of the A digit is now indicated by the outgoing-pulse counter. This is coded into its two-out-of-five code form and signalled to the A-digit store, under the control of tube IT10. The subsequent B pulse strikes tube OPB, which in turn strikes tube IT8, thereby extinguishing tube IT10 to remove the gate signal from the A-digit store. The following I pulse strikes tube OPC to indicate that there is no digit in the outgoing-pulse counter and that it is free to receive a digit from the translator.

Program Section of the Register

The program section of the register maintains a record of the digits sent by the register in order to control the sending sequence. Nineteen program indications are used, but, to economize in tubes and wires to the translator, the indication is stored as a combination of two signals, a one-out-of-four signal and a one-out-of-five signal, which give 20 combinations. These signals are stored on two sets of cold-cathode tubes PA1–4 and PB1–5, as shown in Fig. 8. Within each group the striking of any one tube extinguishes any other conducting tube.

The program recorded by the PA and PB tubes passes to the translator when connexion to the translator is

Translation Principles

The basic operation of the translator is shown in Fig. 9. When a register is connected to the translator it signals the digits it has received, and these signals appear at A–J at the left of the diagram. Each of the lines A–J represent five wires on which a digit is signalled in two-out-of-five code. The register also signals the stage of the sending program that has been reached; nine wires are used for this purpose, and they are represented on the diagram by the line marked PG.

The code-identification equipment makes use of the digits A–E to identify the route and charge rate. Normally

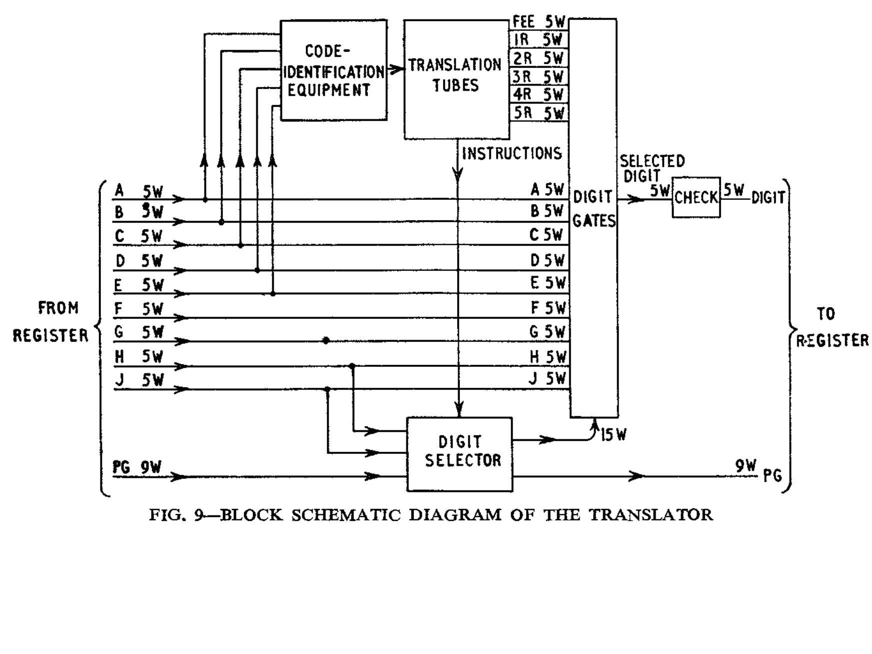


FIG. 9—BLOCK SCHEMATIC DIAGRAM OF THE TRANSLATOR

only the three digits A, B and C are required, but exceptionally the D, or D and E, digits are used. If the register has received insufficient digits for the code to be identified no further action takes place; in effect, the register is ignored. If, however, sufficient digits are available the code-identification equipment produces an output which is connected to one of the translation tubes. The selected translation tube produces the appropriate fee digit and routing digits, and these digits are then coded in the two-out-of-five form. Again, one line is shown on the diagram for each digit. The translation tube also produces some instruction signals to control the progress of the call at certain stages, these instructions being passed to the digit selector. It can be seen from Fig. 9 that on the output side 15 digits are available, each in two-out-of-five form. The digit selector decides which one of these digits the register requires, and the selected digit is signalled to the register on five wires; simultaneously the new program stage is signalled to the register.

These operations are completed in less than 11 ms, which leaves over 5 ms for the translator to prepare for connexion of the next register. This is done by switching off the h.t. supply to the cold-cathode tubes. The h.t. supply is produced by a stabilized power unit and a connexion from the translator to the power unit is used to switch off the supply. At the same time as the h.t. supply is switched off, the allotter is stepped to prepare for connexion of the next register. At the beginning of a new $16\frac{2}{3}$ ms period the h.t. supply is switched on again and the cycle of events is repeated, with the translator now connected to the next register in the allotter cycle.

Code Identification and Translation

Fig. 10 shows the code-identification and translation equipment in greater detail. Each of the five digits A–E is expanded from the two-out-of-five code to decimal code by striking one of ten tubes for each digit. Thus, a signal will appear on one wire in each group of ten except where digits have not yet been dialled. Ten 2-digit gates are provided, which identify London codes 11–10. The single digit 1 indicates a London call, but provision must be made to bar the use of a 1 or 0 immediately following the London code. Accordingly, it is arranged that the gates for 11 and 10 are connected as spare codes and the gates for 12–19 are connected to the London translation tube. Nine hundred 3-digit gates are provided to identify 3-digit codes in the range 211 to 000; that is, all 3-digit codes with the exception of London numbers. From this it will be seen that the receipt of the A, B and C digits results in an output from one, and only one, of the 910 gates referred to. Normally the gate outputs are connected to translation tubes as appropriate, but where it is necessary to examine the D digit before the route can be established the gate output is connected to an ABC tube instead of a translation tube. The ABC tube acts as an amplifier to control another set of 10 gates. Each of these 10 gates is connected to a different D-digit wire, so that 10 4-digit code terminals are produced. The ABC tubes and their associated gates are provided in two groups of 10, and one or both groups may be omitted. Five-digit codes are produced in a similar manner, with the E digit controlling 10 gates associated with each ABCD tube. ABCD tubes are provided in one group of 10.

The 240 translation tubes are provided in 24 groups of 10, and each code output is connected to one of these tubes. Where several codes require identical translations they are commoned to one translation tube. Spare codes are also connected to a translation tube, and up to 50 spare codes may be commoned together to one tube. When a translation tube strikes it provides

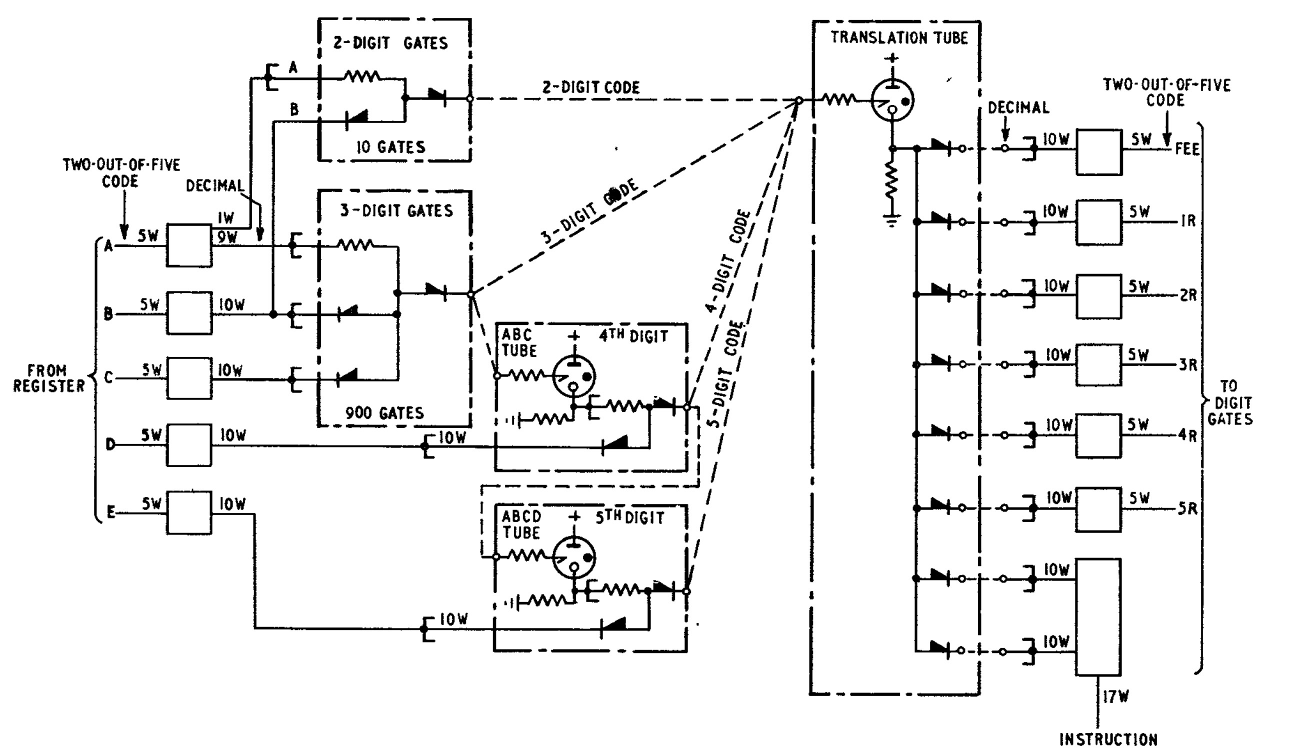


FIG. 10—CODE-IDENTIFICATION AND TRANSLATION SECTIONS OF THE TRANSLATOR

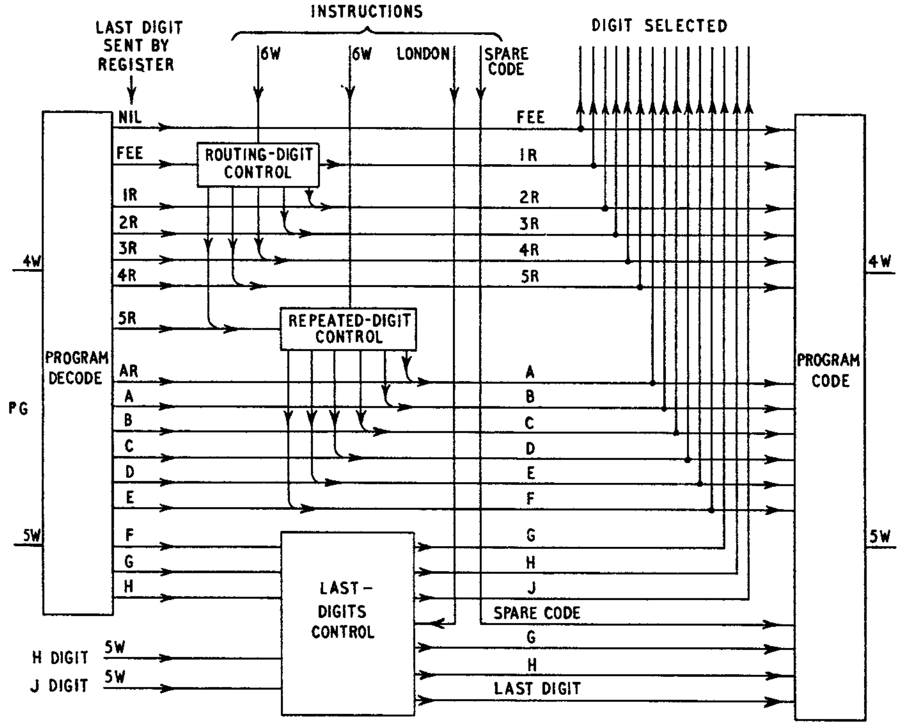


FIG. 11—DIGIT-SELECTOR SECTION OF THE TRANSLATOR

an output on eight decoupled terminals, which are strapped to form the translation.

There are eight separate groups of terminals on the common side of the translation field, each group having the ten terminals necessary for each possible translation digit. The eight digits comprise one fee digit, five routing digits and two instruction digits. The fee and routing digits are coded in the two-out-of-five form ready for transmission to a register, while the two instruction digits combine to produce the signals required by the digit selector. Where any of the eight digits is not required no strap is provided, and the associated decoupling rectifier may be omitted. Spare code translations require the strapping of one instruction digit only.

Digit Selector

Fig. 11 shows details of the digit selector. The program is received from the register as a signal on one of four wires together with a signal on one of five other wires. These two signals combine to mark, on one of 16 wires, the program stage reached by the register. In general, when a signal appears on one of these wires it passes to the output side where it causes the next digit in the sequence to be selected. For example, if a register has sent no digits, the fee digit, which is the first in the sequence, is selected to be passed to the register. In this way the register receives, one at a time, each digit in the sequence. The identity of the selected digit is also coded to be passed to the register as the new program stage. However, certain exceptions to this general procedure occur.

When the fee digit has been sent, an instruction from the translation tube is used to select either the first, second, third, fourth or fifth routing digit as the next digit in sequence. This permits unwanted routing digits to be omitted, the later digits being used when less than five are required.

When the last routing digit has been sent, another instruction is used to select the A, B, C, D, E or F digit as the next in sequence. This permits the earlier digits of the national number to be repeated by the register, or not, as required by the translation. If the alternative routing facility becomes operative on a call the register will, on reaching this stage, alter the program from 5R to AR and the A digit will be selected as next in sequence without reference to the instruction.

The G, H and J digits are subject to special control. None of these may be sent until the end of dialling has been established. This is determined by a 4-second time-out period after the G or H digits (five-out-of-five signalled on the H-digit or J-digit wires), or by the J digit being received, or by the H digit being received when the translation tube indicates that the call is to London. When one of these conditions is established the G, H or J digit may be released as required. The program indication is given separately, however, as any of these digits may be the last, and the register will be given a "last-digit" program indication to initiate clear-down of the register when the last digit is signalled, whether it be the G, H or J digit.

A spare code is signalled to the register as a program indication outside the normal sequence.

Transfer of the Translation Digit to the Register

Fig. 12 shows how a translation digit is received by a register from the translator. Tube OPC indicates when there is no digit in the register outgoing-pulse counter, and the register is, therefore, ready to receive a translation digit. When the register is allotted to the translator the gates between the register and translator are opened, and the translator signals to the register in the two-out-of-five code the digit to be sent. The digit is decoded into a decimal indication and the appropriate tube in the outgoing-pulse counter is struck. Before the digit is sent it is coded again in the two-out-of-five code (using the same equipment as that for transferring the A digit to the A-digit store) and returned to the translator to be checked.

Sending the Translation Digits

The first digit to be pulsed out is the fee digit and it is sent as earth pulses over the AR wire to step uniselector AR in the register-access relay-set, as shown in Fig. 7. One of the tubes OP1–0 is struck by signals from the translator to indicate the digit to be pulsed out, and as soon as this occurs the outgoing-control circuit operates as described for transfer of the A digit. The outgoing-pulse counter steps at 10 p.p.s. until tube OPB is reached, when the desired number of pulses will have been transmitted to uniselector AR. When tube OPB is reached it strikes tubes EF1 and IT1, as shown in Fig. 13. Tube EF1 operates relay EF, which changes over the pulsing-out conditions so that all subsequent digits are trans-

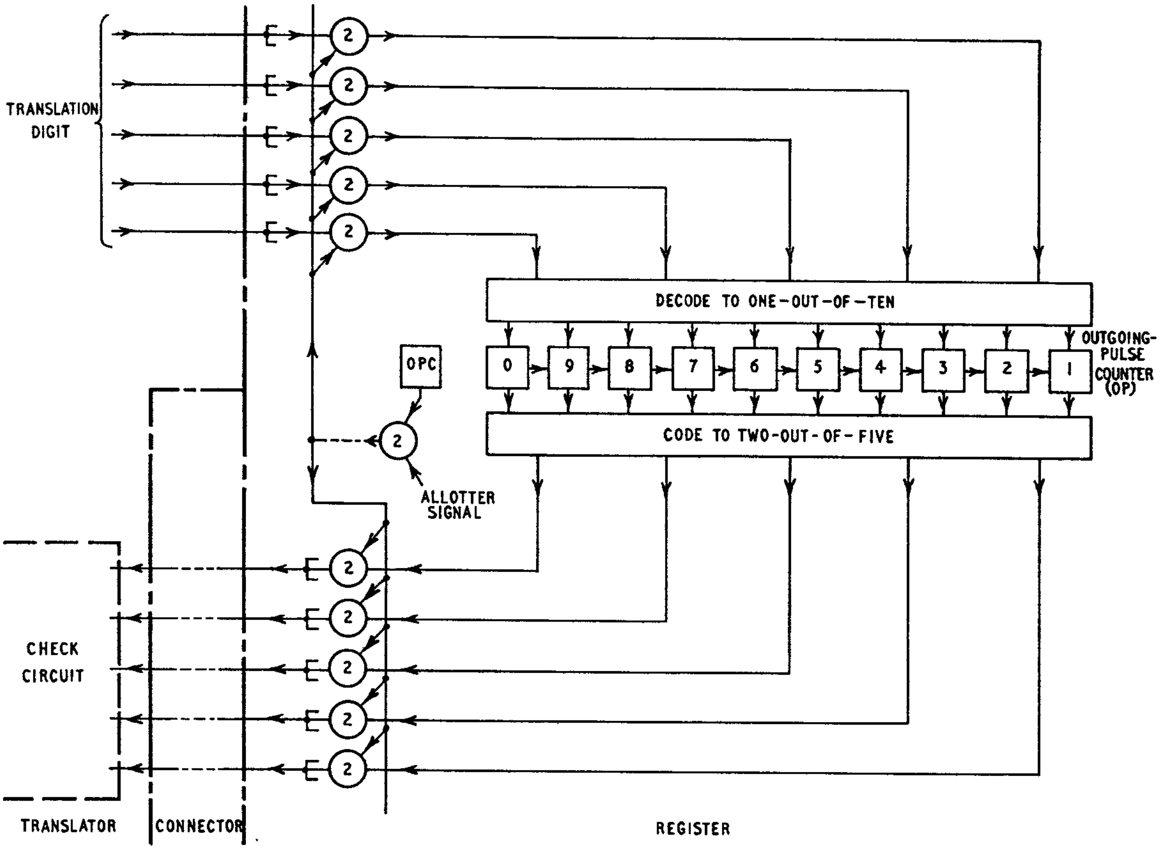


FIG. 12—FUNCTIONAL CIRCUIT FOR THE RECEIPT OF THE TRANSLATION DIGIT BY THE REGISTER

mitted as loop-dialling pulses. Pulsing out is controlled by two relays, X and Z, of which relay Z is normally operated. These relays operate directly from the output of cold-cathode counter tubes. The relays operate quickly, but their release is slowed by the cathode capacitors. The relays are shown in Fig. 7 but the contacts in the pulsing-out loop are shown in Fig. 13, for convenience. When sending loop pulses, a B pulse initiates the operation of relay X and the release of relay Z. Relay X breaks the loop and relay Z, releasing more slowly, is ineffective. After $33\frac{1}{3}$ ms an I pulse causes relay X to release. After a further $33\frac{1}{3}$ ms an M pulse initiates operation of relay Z, which restores the loop. This cycle repeats for each pulse transmitted, the next pulse commencing after another interval of $33\frac{1}{3}$ ms. The M, B and I pulses are equally spaced $33\frac{1}{3}$ ms apart and, therefore, the ratio of the pulses transmitted is ideal. This method of controlling the outgoing loop is used so that this ratio will be distorted as little as possible by the pulsing-out relays.

When tube IT1 is struck by tube OPB, the control of the outgoing-control circuit is radically changed. Instead of driving the outgoing-pulse counter using tubes OC1, 2, 4 and 5 it drives the inter-digital-pause counter using tubes OC1, 3, 4 and 6 to provide an inter-digital pause. Signals from tubes IT1–7 ensure correct odd/even sequencing, without overlap of the drive signals. After eight steps at 10 p.p.s. the inter-digital-pause counter reaches tube IT8 and the outgoing-control circuit is restored to its former role. While the inter-digital-pause counter is measuring the inter-digital pause, the outgoing-pulse counter steps to tube OPC to indicate that it is ready for a further translation digit, and when the register is allotted (within 667 ms) the translator strikes one of the tubes OP1–0 to indicate the first routing digit. This is pulsed out as soon as the inter-digital pause of 833 ms is complete. This procedure is repeated as other digits are pulsed out.

Delays in pulsing out may occur when the translator cannot supply a digit; for example, because insufficient digits have been received. A deliberate delay occurs following the sending of the final routing digit, when an inter-digital pause of 1,433 ms is provided and relay D is connected in the outgoing loop to test for reverse current (the alternative-routing signal). These facilities are controlled by the program for the final routing digit (tubes PA3 and PB5, shown in Fig. 8). When the final routing digit has been sent the outgoing-pulse counter steps to tube OPA, instead of tube OPB, under the control of tubes PA3 and PB5. When the inter-digital-pause counter reaches tube IT2, tube EF2 is struck. This releases relay EF, which connects relay D in the outgoing loop. If relay D operates, the program is altered to indicate to the translator that an alternative route has been seized. When the inter-digital-pause counter reaches tube IT7 it is reset to tube IT1 by tube OPA, and the count starts again. Tube IT1, together with tube EF2, strikes tube OPB and tube OPA is extinguished. Tube OPB re-strikes tube EF1, which re-operates relay EF, and the circuit is back to normal. The final 833 ms of the long inter-digital pause is generated in the same way as a normal inter-digital pause.

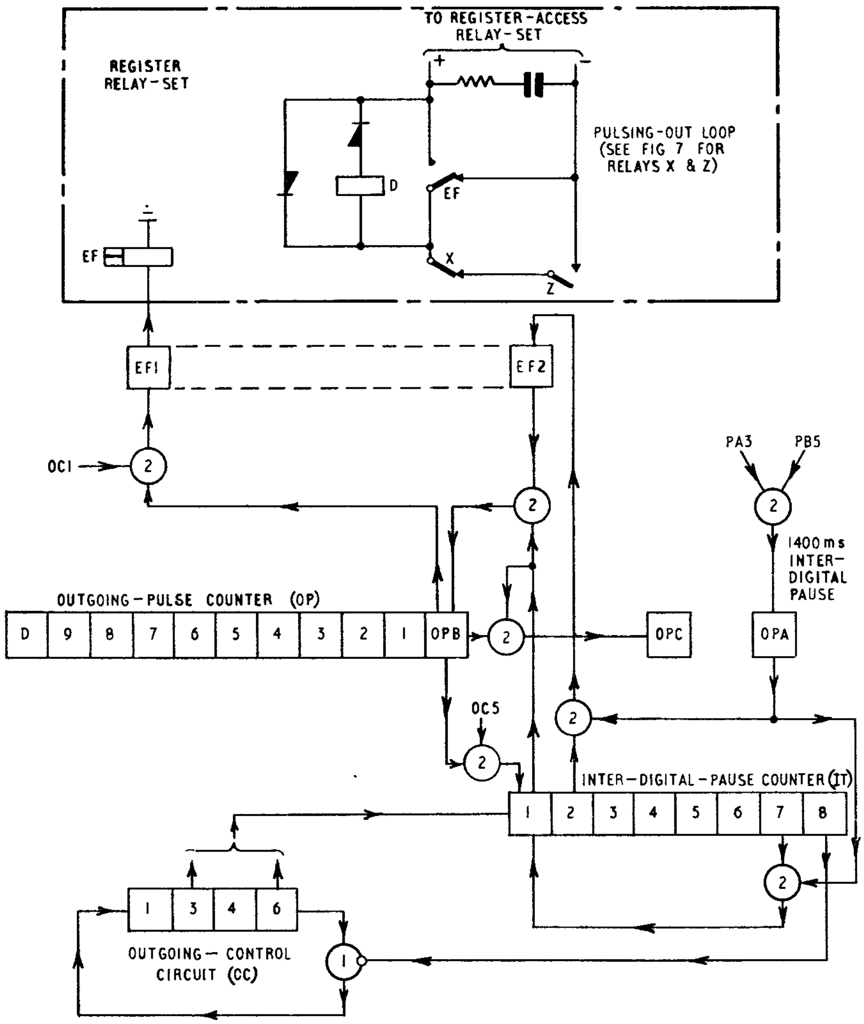


FIG. 13—FUNCTIONAL CIRCUIT FOR THE REGISTER INTER-DIGITAL PAUSE AND REGISTER PULSING-OUT LOOP

Fault Detection

The translator makes three checks in the course of its operation. The first check is that the selected digit, before being signalled to the register, has neither more, nor less, than two signals on the five wires. The second check is made to ensure that a digit is in fact transmitted to the register when the control circuits indicate that dialling is complete. The third check is that the digit and program signalled to a register are transmitted back to the translator where they are checked to ensure that they have been correctly received by the register.

Consideration of these three simple checks will show that misoperation of the register storage equipment, a fault on the signalling wires between a register and the translator, misoperation of the translator, or failure of a register to receive a translation digit and new program correctly, will be detected on the first occasion that a fault interferes with the progress of a call. For example, if two of the wires used for signalling digits from the register to the translator should come into contact the equipment will not misoperate if neither wire is used, or if both wires are used, during a call. If, however, one of the wires only is used then the contact will give a false indication on the second wire and a three-out-of-five condition will arise. This condition will be detected by the first check circuits referred to. The use of the two-out-of-five code for storage and signalling enables these comprehensive checks to be made simply, and this was one of the main reasons for its adoption.

Action after Fault Detection

When the check circuit detects a fault, the translator prevents further stepping of the allotter and gives a signal to the register that is connected and to the translator change-over circuit. The register, on receiving a fault signal, forcibly releases the register-access relay-set, thereby returning number-unobtainable tone to the caller. The register, however, does not clear down but locks itself out of service, retaining the stored digits that were dialled by the caller and the program stage reached. The translator change-over circuit gives an alarm, switches the translator out of service and brings the standby translator into service. This change-over is made without interfering with any other call that may be in progress. Registers may, however, have to wait a little longer than the usual $666\frac{2}{3}$ ms between translator connexions while the change-over takes place. It is not possible to indicate reliably whether the fault occurred in the register or in the translator and so both items are removed from service. The information that is retained by the register will usually enable the maintenance staff to locate the fault quite easily, because the signals that gave rise to the fault can be repeated precisely.

Power Supplies

The electronic equipment is mains operated. The translators and pulse generators have individual power units but the registers have one power unit for each group of 20 registers, with an additional power unit for standby. In the event of mains failure, a monitor circuit detects the failure before any part of the equipment can be affected and a prompt alarm is given. If the break is sufficiently long for the equipment to fail then the normal alarm and change-over arrangements are prevented from operating. When the a.c. power is restored, a period is allowed for hot-cathode valves to warm up, the period being governed by the duration of the break, and then all equipment is reset in service as it was before the failure. With restoration of a.c. power the prompt alarm ceases, but a meter, provided to record the number of times failure is detected, is operated so that attention is drawn to an unreliable supply.

ACKNOWLEDGEMENTS

The development of the equipment described above was carried out on behalf of the British Telephone Technical Development Committee by the General Electric Co., Ltd.

Controlling Register-Translators

Part 4—Magnetic-Drum Register-Translator

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U.D.C. 621.395.341.7:621.395.625.3;621.395.374

For large register-translator installations the magnetic-drum storage technique can provide a cheaper system than one based on conventional electromechanical principles. This article describes a register-translator system employing this technique which has been designed for use in centralized installations in director areas. In this system 47 registers and a common translator are provided by a single magnetic drum and the associated equipment.

INTRODUCTION

FOR large register-translator installations the magnetic-drum storage technique can provide a cheaper system than one based on conventional electromechanical principles. This arises from two main factors; firstly, the fundamental storage unit is cheap since a drum can provide storage capacity for up to 32,000 digits, and secondly, common circuits, although in themselves expensive, operate at high speed and can control the functions of large numbers of registers. A register-translator scheme employing this technique has been designed for use in centralized installations in director areas. The design provides 47 registers and a common translator by the use of a single magnetic drum and associated equipment.

OUTLINE OF SYSTEM

Time-Division Sharing

The magnetic-drum register-translator system is based on a time-division sharing technique, which in itself is not a new concept in telecommunications. In the system described here the equipment that controls all the active operations of a register is shared by many registers, which are connected in time sequence. The inactive operations, for example, that of memorizing dialled numbers and other information, require storage space that is individual to each register, and a small part of the surface of a magnetic drum is allocated for this purpose, being referred to as the register stores. Access to a register from the exchange equipment is obtained via connecting equipment which is also individual to each register.

The number of registers that can share the common equipment is determined by the speed at which the common equipment can operate and the maximum interval that may elapse between its successive connexions to a register. The operating speed is set by the design of the equipment, and in this design connexion to the register for less than 2 ms is sufficient to perform the required control functions. The interval between connexions is determined by the basic operations which the register must perform; namely, to receive and send loop-dialling pulse trains.

Sending is carried out at the standard speed of 10 p.p.s. and, since only one pulse is transmitted at a time, the system is arranged so that the common equipment controlling this function is connected to each register 10 times every second. At each connexion the stored information is examined and, as required, a pulse to line is initiated or not. A pulse train is formed by transmitting pulses at consecutive connexions of the common equipment, whereas a standard inter-digital pause is formed by transmitting no pulse for eight consecutive connexions. The common equipment, at each connexion, alters the information stored in the register to record the action taken. For the 98 ms that elapses between connexions to a particular register the common equipment is free to deal with other registers.

Miscellaneous facilities, such as the register clear-down sequence, are also controlled by common equipment connected 10 times per second, but a higher frequency of connexion is necessary to control the receipt of dial pulses, which arrive at random. These pulses are detected by sampling the line condition (loop or disconnexion) every $16\frac{2}{3}$ ms and the sampling equipment is, therefore, connected to each register 60 times per second. This repetition rate requires one sampling equipment for each eight or nine registers and it is, therefore, kept as simple as possible; its function is limited to detecting pulses and recording each pulse in the register store. Other equipment, connected 10 times per second, is used to count these pulses and rearrange them as digits in the register store. Thus, the register common equipment is in two sections, a small part operating on a $16\frac{2}{3}$ ms cycle and the remainder operating on a 100 ms cycle. These two sections are related by arranging that six $16\frac{2}{3}$ ms equipments, each with eight associated registers, are provided for each set of 100 ms equipment. The 100 ms equipment is connected sequentially to each of the six $16\frac{2}{3}$ ms equipments for $16\frac{2}{3}$ ms and is, therefore, connected sequentially to all 48 registers once every 100 ms, as shown in Fig. 1.

The Magnetic Drum

The nickel-surfaced magnetic drum used by this register-translator is 9 in. in diameter with circumfer-

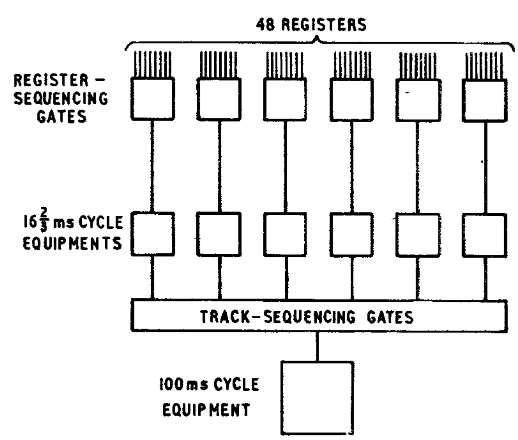

FIG. 1—BLOCK SCHEMATIC DIAGRAM SHOWING CONNEXION OF REGISTER COMMON EQUIPMENT

† The authors are, respectively, Executive Engineer and Assistant Engineer, Telephone Exchange Systems Development Branch, E.-in-C.'s Office.

ential tracks spaced at 20 per inch. The method of storing information on the surface of a magnetic drum has been described previously.* The basic storage element can be considered as a binary magnetic cell which can be set to either one of two states to record either one of two distinct signals; in recording these signals the previous state of the cell is overwritten. In this article the two signals that may be recorded will be referred to as 1 and 0. Each track on the drum provides 2,880 cells spaced equally round the circumference, giving a density of about 102 cells per inch of track. In this equipment the cells are grouped into 480 "words" of six cells each, and the words are grouped into 15 "registers" of 32 words each. Groups are identified by "clock" circuits, which count the cells as they pass a fixed point and produce signals to identify each group.

The magnetic drum is used in two operational modes. Firstly, where information is stored permanently, as in the case of translations, the information is recorded on the drum via a "write" head and, once this is done, the write head is not used again except when it is required for changing a translation. A "read" head enables the stored information to be examined at each revolution of the drum, once every 28 ms approximately, and reading may be repeated indefinitely without affecting the stored signals. The second mode of operation is used where the stored information is altered frequently, as in the case of register stores, and is known as the regenerative-loop technique. Signals are recorded on the drum via a write head and the information is then carried round by the drum's rotation. When it passes under the read head the output signal is amplified, time corrected and connected to the write head (via the write amplifier, etc.), where it is once more recorded on the drum.

The information is now recorded in two positions on the surface of the drum, the original record passing the read head and a new record leaving the write head. The original record continues to rotate until, 28 ms after being written, it completes one revolution and returns to the write head where information being written obliterates it. Meanwhile the new record has also been rotating and, reaching the read head in less than 28 ms, repeats the process. Thus information recorded by the regenerative-loop method is repeated at intervals which are shorter than the time taken by the drum to complete one revolution, the interval depending on the spacing between the write head and the read head.

Heads of the register regenerative loop are spaced so that stored information is carried nine-fifteenths of a revolution between writing and reading and, therefore, stored information repeats once every $16\frac{4}{5}$ ms. Since there are 15 register spaces to a complete revolution the regenerative loop provides storage capacity for nine registers.

A pre-read head, positioned one-fifteenth of a revolution in advance of the normal read head, provides a facility in addition to the register regenerative loop. The pre-read head is used to signal stored information to the common equipment one register period in advance of information from the normal read head, thus giving advance knowledge of the condition of a register in order to prepare for the operations required.

The pre-read heads of the register tracks are each switched in turn to the 100 ms common equipment in the same way as the normal read heads. The pre-read head should be switched one register period in advance of the read head, but, to avoid generating two sets of switching signals in the clock circuits, both read and pre-read heads are switched at the same time and the first register period in each track is not used. This leaves eight working registers to each track.

Ten tracks on the drum operate as regenerative loops, of which six are used for register stores, one is used to obtain access to the translator (the transfer track) and three are used when altering translation information. Thirty-four tracks record permanent information, 30 being used to store translations (the library tracks), three to indicate the location of translations in the library tracks (the address tracks) and one to synchronize the clock circuits (the synchronizing track).

On the library tracks eight words are allocated to each translation, so that 60 translations may be accommodated on each track. However, to simplify the process of locating translations only 50 translation spaces per track are used.

The speed of the drum is controlled by an output from the synchronizing track, which is connected via a filter circuit, rectifier and d.c. amplifier to the coils of an eddy-current brake on the drum driving shaft. If the speed rises above normal the amplitude of the signal leaving the filter increases because of the rise in frequency. This results in an increase of current in the brake coils, which restricts the rise in speed.

The Equipment

The main items of the register-translator system are shown in the block schematic diagram (Fig. 2). A fully equipped system comprises 47 register equipments, six register-track equipments and one of each of the other items; the function of each item will be explained under its respective title. It should be noted that, although there is capacity for 48 registers, one position is reserved for test purposes and, therefore, there are only 47 register equipments. Equipment not shown in Fig. 2 includes power supplies, alarm circuits and test equipment. The electronic equipment operates from an a.c. mains supply and, therefore, standby supplies are required. The various d.c. potentials required by the electronic equipment are generated by power units, and one set of power equipment supplies a complete system of 47 registers. Alarm circuits provide indications of failure of the a.c. mains supply, failure of a register power unit output, failure of the electronic equipment as indicated by the built-in check circuits, or failure of the negative 50-volt exchange battery supply.

The common electronic equipment is built up from a few basic elements; namely, gates, bistable trigger circuits and amplifiers. The gate circuits are formed using germanium rectifiers and resistors in a conventional manner. The bistable trigger circuits, which are referred to simply as "triggers" in the following description, are a variation of the Eccles-Jordan circuit and employ two hot-cathode valves. These triggers are, in effect, electronic side-stable relays, whose high speed of setting and resetting permits the achievement of rapid switching, as required by this equipment. The setting of a trigger is determined by the signal connected to its input. The change of setting, however, is controlled by a "strobe" pulse, from the clock circuits, which occurs at the end of a cell period. This arrangement permits

*Marwing, K.G. Design Features of the Lee Green Magnetic-Drum Register-Translator. *P.O.E.E.J.*, Vol. 51, p. 137, July 1958.

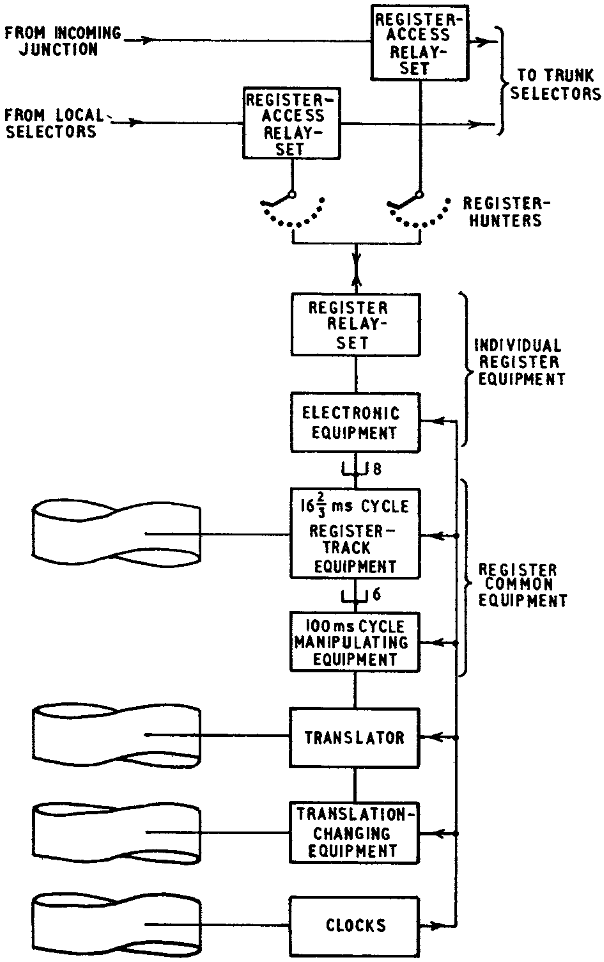

FIG. 2—BLOCK SCHEMATIC DIAGRAM OF SYSTEM

the trigger to provide an output throughout a cell period even though during that period the signal connected to its input changes. The amplifier circuits of various conventional types comprise a.c. amplifiers, cathode followers and invertors. The triggers and amplifiers use sub-miniature hot-cathode valves.

Clock Circuits

One track on the drum is used to control the clock circuits, which in turn provide the system of pulses to control the operation of the whole equipment. This synchronizing track has 0 recorded in every cell except one, the single 1 in this cell being used as a reference point from which to identify the drum position. An output from the read amplifier of the synchronizing track is used to control a multivibrator, which in turn produces the strobe pulses at a frequency of 103,680 p.p.s. Strobe pulses are used to indicate to the clock circuits when each binary cell passes under the synchronizing-track read head. They are also used in equipment associated with read amplifiers to sample the output signal at the appropriate instant, to determine the condition recorded.

The clock circuits consist of six interconnected frequency-dividing circuits, each of which is referred to individually as a clock. Details of the technique used for frequency dividing may be found in the reference already given. The first clock produces six pulses, as

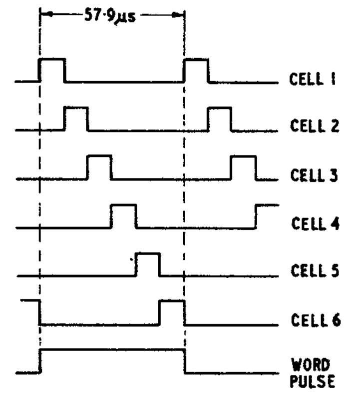

FIG. 3—CLOCK PULSES FOR IDENTIFICATION OF BINARY CELLS IN EACH WORD

shown in Fig. 3, which are used to identify each of the six binary cells in a word. Each pulse is on for 9·7 μs and off for 48·2 μs, approximately, successive pulses commencing as the previous one ceases. When a sequence of six pulses is completed the process repeats. Each of these six cell pulses, therefore, repeats at one-sixth the frequency of strobe pulses, i.e. 17,280 p.p.s. The second clock, which is driven by the first, produces a repeating series of 32 pulses to identify the 32 words of a complete register store. Other control pulses used are derived in a similar manner, and details are given in Table 1. The final clock is used for test purposes only. It enables library tracks, address tracks, the clock track and associated equipment to be examined by the use of a cathode-ray oscilloscope.

TABLE 1
Control Pulses for the Magnetic-Drum Equipment

Pulse	Condition or Drum Position Identified	Number of Pulses in Series	On Period	Off Period	Repetition Period	Frequency in p.p.s.
Strobe	Individual cells ..	2	1 μs*	8·7 μs *	9·7 μs*	103,680
Cell	Cells in a word ..	6	9 7 μs*	48·2 μs*	57·9 μs*	17,280
Word	Words in a register ..	32	57 9 μs*	1·8 ms*	1·9 ms*	540
Register	Registers on a track regenerative loop ..	9	1 9 ms*	14·8ms*	16⅔ ms	60
Track	Tracks switched to 100 ms common equipment	6	16⅔ ms	83⅓ ms	100 ms	10
½ Second	½-second timing period	5	100 ms	400 ms	500 ms	2
Drum	Register periods of a complete track ..	15	1·9 ms*	25·9ms*	27·8ms*	36

Note: * indicates approximate values.

Where the electronic equipment uses combinations of clock pulses to identify particular cells and the combination is used in several places, economies are made by combining the clock pulses in the clock equipment and connecting the output, via a single wire, to the several places required.

Individual Register Equipment

The individual register equipment is in two parts, the register relay-set and the electronic equipment. The register relay-set provides a link between the electronic circuits and the exchange equipment, and employs relays in conventional electromechanical circuits. The register electronic equipment includes gates to connect the individual register to the time-shared track equipment and cold-cathode tubes to repeat signals received from the common equipment. The cold-cathode tubes provide the power to operate relays in the register relay-set.

Register Common Equipment

The register-track equipment is common to eight registers and includes the regenerative loop, which provides the storage space for the registers served. Also included are the $16\frac{2}{3}$ ms cycle manipulating equipment, and the gates to connect the track equipment to the 100 ms cycle manipulating equipment, which is common to six register-track equipments.

The common manipulating equipment is almost wholly formed by gates and triggers. Its function is to examine, in the correct time sequence, the information stored in each register and, when particular conditions are indicated, to take the appropriate action. The various conditions are identified by the use of clock pulses and are memorized during manipulation by the use of triggers. When a register has been dealt with, the triggers are reset before operations with the next register commence. The manipulation equipment is divided into several sections, each dealing with a particular function.

Translator

The registers apply to the common translator for a translation when they have received three code digits, and one register is dealt with at a time. Connexion to a register is established by offering the translator to each register in sequence, every register being covered in 100 ms. If a register requires the translator the offering sequence stops for 100 ms while the register is being dealt with. A complete translation is returned to the register on a single application, except where the fourth or fifth code digit is required to identify the route. The translator equipment includes a regenerative-loop store to hold the code or translation temporarily, 30 library tracks recording 50 translations each and three address tracks used to identify the position of a translation in a library track. A separate translation is provided for every 3-digit code, up to 300 for 4-digit codes and up to 200 for 5-digit codes.

Translation-Changing Equipment

Translation-changing equipment is used to amend translations and to write translations and address tracks when an installation is being set up. The equipment is built around a key panel with plunger-type keys to indicate decimal numbers and lever-type keys and a rotary switch to control operations. Three regenerative-loop stores are used to store information temporarily. When information to be stored in a track is fully assembled it is transferred to this track by plugging a connexion into the associated write head; these write heads are not used for any other function.

PROGRESS OF A CALL

In the following sections the operations performed by the equipment in dealing with a call are described with reference to Fig. 4. The procedure of receiving and storing digits is described in detail with reference to the functions of individual triggers, whereas the remaining operations are described in more general terms. The detailed description is given to explain the technique employed by the common manipulating equipment.

Seizure of a Register

The register is seized by a register-access relay-set via a register-hunter in the same way as in the equivalent electromechanical equipment. Pulses from the calling line are received as earth signals in the register relay-set and repeated in suitable form to the electronic equipment. Eight registers are commoned to a register-track equipment via individual gates controlled by register clock pulses. Each register has its gate controlled by a different pulse of the series so that it is connected in time sequence once every $16\frac{2}{3}$ ms.

Each register is allocated storage space in a register regenerative-loop track, which provides storage capacity for eight registers, the ninth space being used for testing purposes. Information stored in the register spaces appears serially at the reading output, one cell at a time, with registers following each other and the whole sequence repeating every $16\frac{2}{3}$ ms. For the period of nearly 2 ms, during which the information in respect of one particular register is making its appearance, the gate connected to a contact of relay A of that register relay-set will be open. The manipulating equipment may, therefore, observe at the same time both the condition of the calling line and the information already stored in respect of the call. Table 2 shows the order in

TABLE 2
Order in which Information in the Registers Becomes Available for Manipulation

Word	Use	Cell	Indication
1	Control	1	O/G digit busied
2	Control	2	spare
3	spare	3	spare
4	spare	4	Translation in progress
5	Fee digit	5	Count } I/C i.d.p.
6	1st routing digit	6	Cancel
7	2nd routing digit		
8	3rd routing digit		
9	4th routing digit		
10	5th routing digit		
11	6th routing digit		
12	spare	1	I/C busy
13	A digit	2	O/G busy
14	B digit	3	2^0 } binary number
15	C digit	4	2^1
16	D digit	5	2^2
17	E digit	6	2^3
18	F digit		
19	G digit		
20	H digit	1	apply barring to D digit
21	J digit	2	spare
22	K digit	3	2^0 } O/G i.d.p. count
23	L digit	4	2^1
24	M digit	5	2^2
25	N digit	6	2^3
26	P digit		
27	R digit	1	spare
28	spare	2	shorten O/G i.d.p.
29	spare	3	O/G i.d.p. in progress
30	Control	4	line condition
31	4 sec and 20 sec count	5	break pulse detected
32	Control	6	break pulse detected

Note: i.d.p. = inter-digital pause

which stored information for each register becomes available, the sequence starting with cell 1, word 1, and ending with cell 6, word 32. Twenty-two words are used to store decimal digits, the digits being recorded in binary code in cells 3–6, while cells 1 and 2 store information to control the receipt and transmission of the digits. Digits are arranged in the order in which they are to be

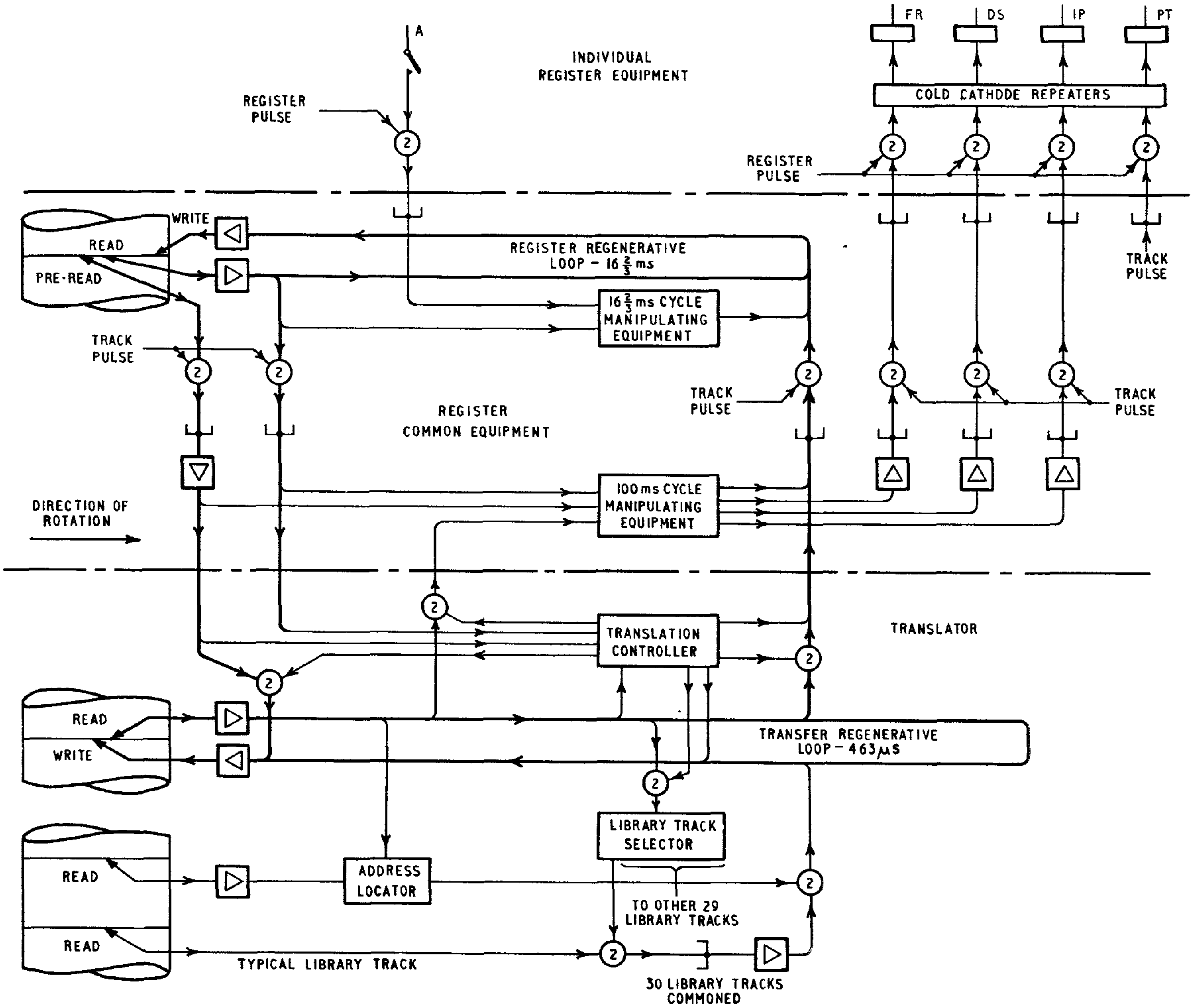

FIG. 4—FUNCTIONAL CIRCUIT OF REGISTER-TRANSLATOR

transmitted, which, neglecting the translation digits, is the same as the order in which the digits are received. In this article digits received by the register are referred to as the A–R digits, as listed in Table 2. The K–R digit stores provide for international working, which may be required in the future. Five words are used for control purposes and three of these, words 1, 30 and 32, are shown in detail. When the register is first seized, all cells of the register digit-stores will be indicating 0.

Pulse Detection

A functional diagram of the $16\frac{2}{3}$ ms cycle register-track equipment is shown in Fig. 5. The regenerative loop is formed by connecting the output of the read amplifier to the input of the write amplifier via two invertors, CH1 and CH2. These invertors are used to enable new information to be injected conveniently. The output of the read-amplifier equipment is on two wires, 0 and 1, and a signal appears on one of these wires according to the condition of the cell being read.

When a cell storing 0 is being indicated a signal appears on wire "0." This signal is connected to CH1, which inverts the signal, rendering it ineffective. The output of CH1 is then inverted by CH2, which produces an effective signal, this signal being connected to input "0" of the write amplifier, causing 0 to be written. When a cell storing 1 is being indicated there will be an ineffective signal output on wire "0." This condition is inverted by CH1 to produce an effective signal, which is connected to input 1 of the write amplifier causing 1 to be written. This effective signal is also inverted by CH2 but the output is ineffective.

If a signal is applied to the write-0 wire then 0 is recorded, irrespective of the read-amplifier output. Similarly, if a signal is applied to the write-1 wire, a 1 is recorded irrespective of both the read-amplifier output and any signal on the write-0 wire. Thus, when writing 0 or 1 anything recorded previously is erased and, if both 0 and 1 are written simultaneously, the 1 takes precedence. These arrangements permit economies in the manipulating equipment.

The manipulating equipment has access to the two outputs of the read-amplifier equipment and to the two write inputs (see Fig. 5). At cell 1, word 32, trigger TG

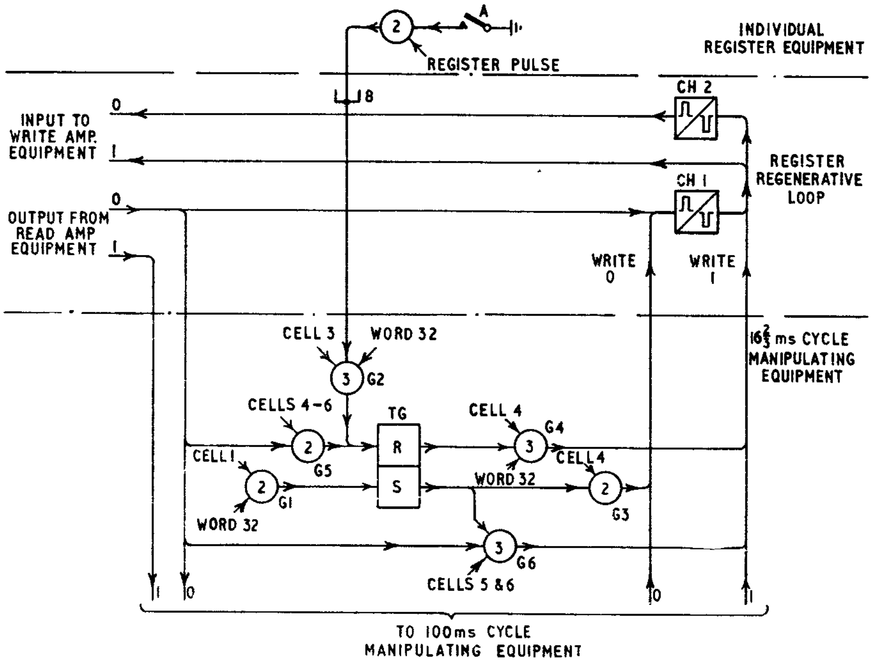

FIG. 5—FUNCTIONAL CIRCUIT FOR PULSE DETECTION ($16\frac{2}{3}$ ms CYCLE)

is set by gate G1 under control of clock pulses. When cell 3 is reached trigger TG is reset by gate G2 if the line is looped. Trigger TG now indicates the line condition, i.e. set for disconnexion and reset for loop, and this is recorded in cell 4 by gate G3 or gate G4, as 0 for set (disconnexion) or 1 for reset (loop), respectively. Also, during cell 4 the read output indicates the condition of the calling line as recorded $16\frac{2}{3}$ ms earlier, and, if a disconnexion is indicated, trigger TG is reset by gate G5, change-over occurring at the end of the cell period.

Thus, while a register is idle (this also applies during a break pulse) trigger TG, set at the beginning of word 32, causes 0 to be written in cell 4 and is then reset by the 0 written $16\frac{2}{3}$ ms earlier. This process is repeated at each connexion of the $16\frac{2}{3}$ ms cycle manipulating equipment. When the register is seized (this also applies during a make pulse) trigger TG is reset by the loop before cell 4 is reached, so that a 1 is written in cell 4. Again, this process is repeated at each connexion of the $16\frac{2}{3}$ ms cycle manipulating equipment.

When the manipulating equipment is connected for the first time after the beginning of a break pulse, trigger TG is not reset by the loop, and 0 is written in cell 4 by gate G3. Also, since 1 was written $16\frac{2}{3}$ ms earlier trigger TG is not reset, and cell 5 is reached with trigger TG set, indicating that a break pulse has been detected. Trigger TG now records the break pulse by writing 1 in cell 5, via gate G6, after which the trigger is reset by the 0 previously recorded in cell 5 (G5). Every 100 ms the 100 ms manipulating equipment removes the break-pulse signal by writing 0 in cell 5. If, because of a fast dial, a second break pulse is detected before the first has been removed, trigger TG will not be reset at the end of cell 5 because a 1 will have been previously recorded. Trigger TG, therefore, proceeds to write a 1 in cell 6, via gate G6 (to indicate receipt of a second pulse), and is then reset by the 0 previously recorded in cell 6 (G5).

Counting and Storing Digits

Line-condition information in word 32 has to be manipulated into the register stores which are in advance of it. The pre-read head is used to inspect word 32 before normal reading takes place, and, in effect, places the line condition in advance of word 1, as shown in Fig. 6. Thus, the manipulating equipment is prepared before normal access commences.

Fig. 7 shows the functional diagram of that part of the 100 ms cycle manipulating equipment which performs the functions of counting the incoming pulses and storing the digits in the digit stores. Three triggers, TG1–3, are used and they are reset by clock pulses via gates G1–3, respectively. Then, using signals from the pre-read head, trigger TG1 is set by gate G4 if a break pulse has been detected (1 recorded in cell 5, word 32).

The condition of cell 1 in words 13–27 (stores for dialled digits) indicates which digits have been received (1 recorded), and which digits have not yet been received or only partially received (0 recorded). The first digit store in the sequence with 0 recorded in cell 1 is therefore the store into which received pulses should be placed. The condition of cell 1 is examined during words 13–27 by gate G6, and trigger TG3 is set when 0 is signalled. Trigger TG3 then controls the addition of one to the binary number stored in cells

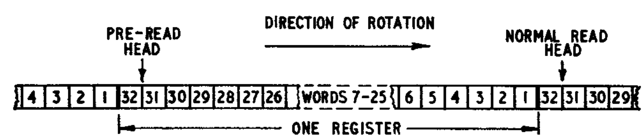

FIG. 6—RELATIVE POSITIONS OF THE PRE-READ AND READ HEADS ON A REGISTER TRACK

3–6 of the word selected. This operation is executed by writing 0 in cells 3–6 (G7) until a previously recorded 0 is signalled. This is detected by gate G8, which writes 1 (overwriting the 0), and also resets triggers TG1 and TG3 so that later cells are left unchanged. That this process results in one being added may be seen by reference to Table 3.

TABLE 3

Cells used for Storage, in Binary Code, of Pulses Received

Pulses Received	Binary Number			
	Cell 3	Cell 4	Cell 5	Cell 6
Nil	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1
10	0	1	0	1

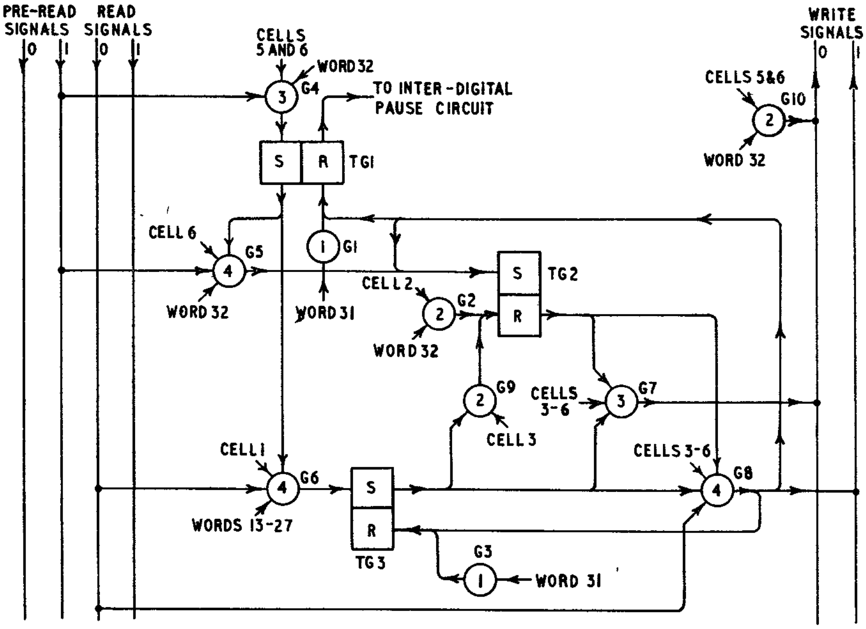

FIG. 7—FUNCTIONAL CIRCUIT FOR COUNTING AND STORING DIGITS (100 ms CYCLE)

When two break pulses have been detected trigger TG1 is set at cell 5, word 32, via gate G4, as already described for a single break pulse, but in addition trigger TG2 is set, via gate G5, to the 1 recorded in cell 6, word 32. With trigger TG2 set, gates G7 and G8 cannot apply adding conditions to cell 3. However, trigger TG2 is reset by gate G9 at cell 3. Thus, information in cell 3 remains unchanged and the adding process commences at cell 4, which results in two being added to the stored number instead of one.

When word 32 is reached, 0 is written in cells 5 and 6 by gate G10 to remove the break-pulse signals which have just been manipulated.

Inter-digital Pause Detection

This function is controlled by a single trigger, TG4, assisted by trigger TG1 in the pulse-counting circuit just described. The functional diagram of the circuit is shown in Fig. 8. Trigger TG4 is reset during word 32 by gate G1.

At the first connexion of the 100 ms equipment during an inter-digital pause the final pulse of the train just ending will be recorded in the appropriate store and there is no indication that an inter-digital pause is commencing.

At the second connexion of the 100 ms equipment during an inter-digital pause, trigger TG1 will be in the reset condition when word 1 commences, because no break pulse has been detected during the previous 100 ms. The condition of trigger TG1 is recorded in cell 5, word 1, by gate G3 writing 1, this signal overwriting the 0 being signalled simultaneously by gate G2.

At the third connexion of the 100 ms equipment during an inter-digital pause, the process described in the previous paragraph is repeated. However, when cell 5, word 1, is reached trigger TG4 is set via gate G4, because 1 was recorded in this position during the previous connexion. This condition indicates the end of a pulse train. The condition of trigger TG4 is recorded in cell 6, word 1, by gate G5 writing 1, this signal overwriting the 0 being signalled simultaneously by gate G2. The circuit now proceeds to "busy" the word store which recorded pulses of the train just ended, by writing 1 in cell 1 of that word. Trigger TG4 writes 1 in cell 1 of words 13–27, via gate G7, until the first unbusied word is reached, when the 0 previously recorded stops this process by resetting trigger TG4 via gate G8. Thus, a word already busied is unaltered because 1 is written where a 1 already existed, the first unbusied word is busied as required, and subsequent words are unaffected. Since pulses are stored in the first unbusied word, the next digit to be recorded will be stored one word later. In this way digits are stored successively in words 13 onwards.

At the fourth and subsequent connexions of the 100 ms equipment during an inter-digital pause, the procedure just described is followed until cell 6, word 1, is reached. At this time the 1 previously recorded will reset trigger TG4 via gate G6 and no further action will take place during each of the connexions.

When the first pulse of the next digit is received, trigger TG1 will be set during word 32 and, therefore, trigger TG4 remains reset. Consequently gates G3, G5 and G7 cannot overwrite the 0 signals being written by gate G2 during word 1 and therefore the signals previously recorded in cells 5 and 6 are cancelled.

End of Dialling

After receipt of the eighth digit of the national number

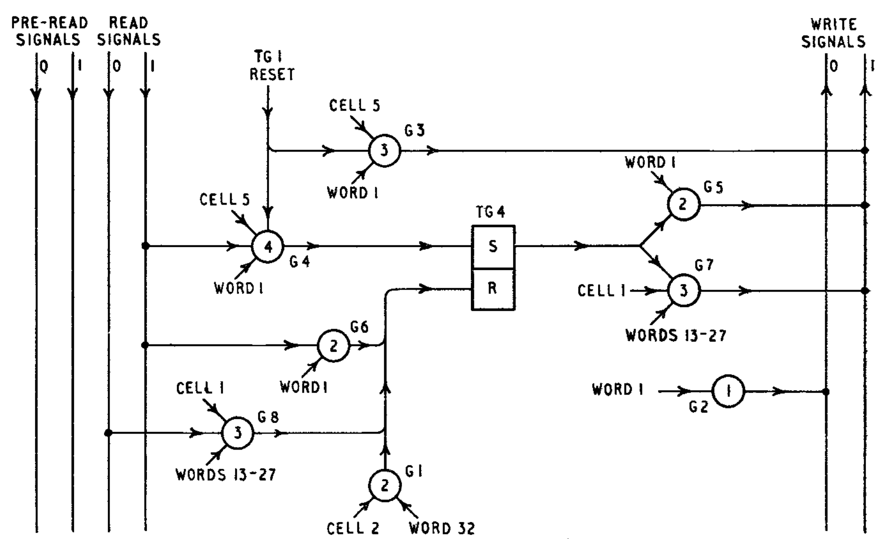

FIG. 8—FUNCTIONAL CIRCUIT FOR INCOMING INTER-DIGITAL PAUSE DETECTION (100 ms CYCLE)

(the G digit) a period of 4 seconds is timed to establish whether dialling is complete. This period is measured by counting, in word 31, the number of consecutive connexions of the common equipment during which no incoming break pulse is detected, i.e. nothing recorded in cells 5 or 6, word 32. If a 1 is seen in either of these positions, 0 is written in each cell of word 31 to reset the count. If both cells record 0 then one is added to the count, which is recorded in binary form. If the count reaches 40 then 4 seconds has elapsed and completion of dialling is assumed. At the next connexion of the common equipment the condition is detected by use of the pre-read signals, and the common equipment then proceeds to busy every digit-storage space so that no more digits can be recorded. This is done by writing 1 in cell 1 of every digit store.

If the first pulse of the H digit is received before 4 seconds elapses the count is reset as described, and the operation repeats after the H digit is received. Thus, if 4 seconds elapses before the J digit is received all empty stores are busied in a similar manner.

When the J digit has been received, or when the H digit has been received and the call is to London (A and B digits in the range 11–19), similar action is taken and all empty stores are busied.

Translation

To obtain a translation, the code digits stored in a register requiring the translation must be signalled to the translator. When the translation has been obtained it must be signalled back to the register initiating the demand. In transferring information to and from the translator some time delay will be involved since both registers and translations are located in time and, even if they are coincident, some manipulation is required. The necessary delay is provided by storage in the transfer regenerative loop, which provides storage capacity for eight words circulating in one-quarter of a register period. Information stored in this transfer loop reappears four times during each register period; for example, a signal recorded during word 5 will reappear at words 13, 21, 29 and then again at word 5 of the next register period, as shown in Table 4. Translations stored in the library tracks also occupy eight words with the individual translations commencing at words 5, 13, 21 and 29. Thus, the eight words stored in the

TABLE 4

Information Stored in Transfer Loop

Words				Information Stored when Applying for a Translation	Information Stored when Translation Obtained
5	13	21	29	A digit	Fee digit
6	14	22	30	B digit	1st routing digit
7	15	23	31	C digit	2nd routing digit
8	16	24	32	—	3rd routing digit
9	17	25	1	—	4th routing digit
10	18	26	2	—	5th routing digit
11	19	27	3	—	6th routing digit
12	20	28	4	—	Instructions

transfer loop circulate in synchronism with translations on the library tracks.

The transfer loop is busied by writing 1 in cell 1, word 5, and the translator operations commence at this time. If 0 is recorded, then the transfer loop, and therefore the translator, is free. The translation controller connects the pre-read signal to the transfer loop during words 5 to 11 (fee and routing digits) and anything stored in these positions in the register is copied into the transfer loop. If nothing is recorded during this period it indicates that the register has not yet received a translation, in which case the copying is continued during words 13, 14, and 15 (the A, B and C digits). If the C digit is present it indicates that the register is waiting for translation information (three code digits stored but no translation stored) and the translation process follows. If a translation is present, or if the C digit is not present, the register does not require translation information and the transfer loop is cleared by writing 0 throughout words 21–28. The process then repeats for the next register in sequence, and continues to repeat with successive registers until a register is found that requires a translation. All registers are examined in this way every 100 ms.

When a register requires a translation the transfer loop is busied by writing 1 in cell 1, word 13. Then the register originating the application is marked by writing 1 in cell 4, word 1, of the register, the foregoing operations having been controlled by the pre-read signals. Next, the library-track selector is set to select one of 20 library tracks and connect it to the library-track amplifier. One of 10 pairs of tracks is selected by the A digit, and one or other track of the pair is selected according to whether the B digit is odd or even; this is done by signalling from the transfer loop to the library-track selector, the condition of cells 3 to 6 of word 5, A digit, and cell 3 of word 6, B digit odd or even (see Table 4). Each library track records 50 translations (10 additional translation spaces are spare) and the 50 translations recorded in the selected library track are now available at the amplifier output and will be signalled in sequence repeating every 28 ms as the drum revolves. The layout of the library tracks is shown in Fig. 9.

The particular translation required is determined by

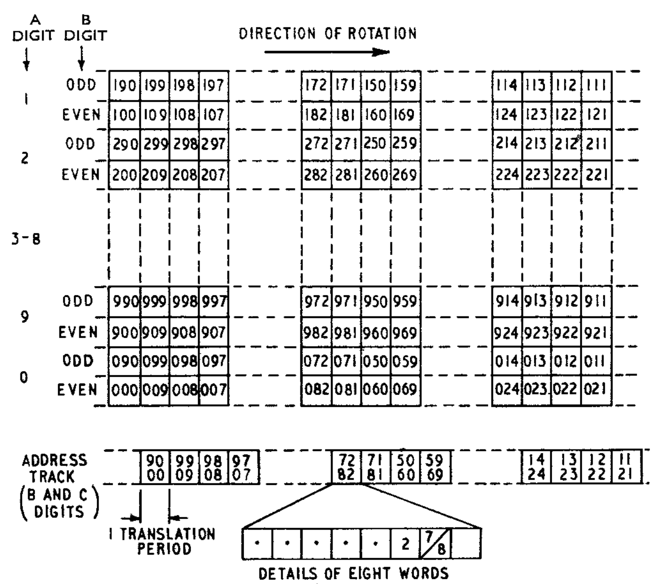

FIG. 9—LAYOUT OF LIBRARY TRACKS

the B and C digits. In the case of the B digit, only five indications are required as the odd or even significance has been used to select the library track; the five indications are given by cells 4–6 only, of the B digit. The identity of translations in terms of the B and C digits is the same for all 20 library tracks and therefore a single track, the address track, is used to store the 50 identities. The B and C digits stored in the transfer loop are repeated every translation period of eight words, and the address locator compares these B and C digits with the B and C digits signalled by the address track. Within one revolution of the drum coincidence will occur, and this indicates that the required translation will be signalled by the library track during the next translation period. The address locator connects the output of the library-track amplifier to the transfer loop during this translation period and the translation stored in the library track is copied into the transfer loop, overwriting the code digits previously recorded.

Having found the translation, the translation controller looks for the register that originated the operation and which was marked by writing 1 in cell 4, word 1. When this mark is found, its presence is memorized, the mark removed and during words 5–11 the fee digit and routing digits are copied from the transfer loop to the register store. During word 12 the instructions are recorded on four triggers, the use of which are explained under "Preparation for Sending." The transfer loop is cleared by writing 0 throughout words 5–12, and with this operation the translator is freed, ready for use by another register.

If a translation cannot be supplied until four code digits have been received, the operations described above are followed when three code digits have been received, and an "intermediate translation" is returned by the translator. However, an intermediate translation cannot be pulsed out by the register. When the fourth code digit is received another application is made to the translator, and the intermediate translation, together with the D digit, are used to select a translation from one of six library tracks used for this purpose. Should a fifth digit be required to obtain a translation a second intermediate translation will be supplied, and the process repeated when the E digit has been received. This time the translation will be selected from one of four library tracks used for 5-digit code translations. The process for translating on 4-digit and 5-digit codes requires the use of two extra address tracks, which are not shown in Fig. 4.

Preparation for Sending

Digits to be pulsed out by a register vary from call to call since there may be less than six routing digits, and the early digits of the national number may not require retransmission. The digits which are to be pulsed out are marked by writing 1 in cell 2 of their respective stores. In the case of the fee digit and the routing digits, cells 1 and 2 are marked in the library store, and when the translation is received by a register these marks will be received also. If less than six routing digits are involved, the unwanted digit stores will not be marked.

When the translation is received the instructions are memorized by four triggers. Three of these indicate, in binary code, the number of digits of the national number which must not be transmitted. Commencing with word 13 (the A digit) the three triggers, connected as a binary-counting circuit, count down the number of words. The triggers will indicate zero when the appropriate numbei of digits have passed, and all succeeding digit stores are marked in cell 2 to indicate that they are to be pulsed out. At a later stage in the call, when the end of dialling has been established, digit stores that are empty will have this mark removed. The fourth trigger indicates that barring of D digits 1 and 0 is required, and the condition of this trigger is recorded in cell 1, word 30, for later use.

Pulsing Out

Digits may be pulsed out when a 1 in cell 1 indicates that the digit has been completely received and a 1 in cell 2 indicates that the digit is to be transmitted. If any digit store is marked in this way, pulsing out takes place unless an inter-digital pause is in progress or, in the case of the G, H and J digits, unless special restraint is applied.

The pulsing-out circuit observes words 5–27 and detects the first digit store with a 1 in both cells 1 and 2. Having identified the digit to be pulsed out the equipment subtracts one from the number stored in cells 3–6 by writing 1 where 0 was stored previously, writing 0 where 1 was stored previously and stopping this process after the first 1. That this process results in the subtraction of one may be seen by reference to Table 3. After subtracting one from the stored number the equipment initiates a break pulse on the outgoing loop of the register concerned, as follows. Triggers are used to memorize the condition and produce a lengthened pulse for transmission to the individual register equipment. The lengthened pulse is over $1\frac{1}{2}$ ms in duration and must occur within a single register period; therefore the pulse is delayed until the register period following the one in which the condition arose. The lengthened pulse is amplified and directed to the appropriate register, being gated successively by a track pulse and then a register pulse, as shown in Fig. 10. The latter gate is connected directly to a cold-cathode tube, which strikes to the $1\frac{1}{2}$ ms pulse. The cold-cathode tube operates relay IP and a contact of this relay disconnects the outgoing loop.

Relay PT (Fig. 4) is operated via equipment similar to that used to operate relay IP but it is controlled by a track pulse which occurs four track periods later than the pulse which controlled relay IP. A delay of four track periods is $66\frac{2}{3}$ ms and, therefore, relay PT operates to

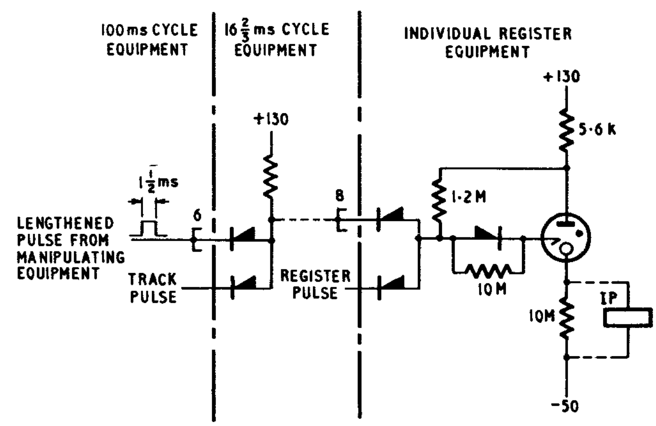

FIG. 10—CIRCUIT FOR CONTROLLING RELAYS FROM ELECTRONIC EQUIPMENT

reconnect the outgoing loop, $66\frac{2}{3}$ ms after the loop was disconnected by relay IP.

Generation of Inter-digital Pause

While a digit is being pulsed out, the duration of the inter-digital pause to follow is recorded in word 30 by writing, in binary code, in cells 3–6 the number of 100 ms periods required for the pause. This procedure permits the standard pause to be shortened or lengthened in certain circumstances.

When a pulse train is complete the binary number stored, in cells 3–6 of the digit being pulsed out, will be zero. At the next connexion of the common equipment the zero condition will be detected, and, as a consequence, no pulse will be transmitted to relay IP in the register relay-set and the condition will be recorded by writing 1 in cell 3, word 32. On subsequent connexions of the common equipment the mark in cell 3, word 32, is detected using the pre-read signal; this prevents further pulsing out and leads to the busying of the digit, which has just been pulsed out, by writing 0 in cell 2 of the appropriate word. A record is made that this operation has been carried out by writing 1 in cell 1, word 1, and on subsequent connexions this prevents the busying of other digits.

On each of the aforementioned connexions of the common equipment, one is subtracted from the binary number recorded in cells 3–6 of word 30. When this binary number indicates zero the mark in cell 3, word 32, is removed by writing 0. At the next connexion of the common equipment pulsing out may recommence and the mark in cell 1, word 1, is removed.

Control of Final Digits

The eighth, ninth and tenth digits of the national number (G, H and J digits) must not be transmitted until the end of dialling has been detected. When this occurs all digit stores are busied as explained under "End of Dialling." The pulsing-out equipment examines the last digit store (word 27) using the pre-read signals and, if the digit is not busied, pulsing out of the G, H and J digits is prevented. When the end of dialling is detected, word 27 is busied and pulsing out can proceed.

Normal Clear-down

When there are no digits waiting to be pulsed out, i.e. no digit store records a 1 in cell 2, and the inter-digital pause has expired, pulsing out is complete. When these conditions are detected a pulse is transmitted to the register relay-set to operate relay DS (Fig. 4). This pulse is routed to the appropriate relay-set using equipment which is identical to that used to operate relay IP for pulsing out. Relay DS, in operating, transmits a signal to the register-access relay-set to initiate clear-down. The register-access relay-set releases relay A in the register relay-set and gives a disconnexion signal to the electronic equipment. This disconnexion is recognized, initially, as a break pulse; then, after 200–300 ms, since no other break pulses are detected, incoming inter-digital pause detection takes place. This signal, together with a signal that a disconnexion still exists (0 in cell 4, word 32), indicates that the holding condition has been removed. When this combination occurs a pulse is transmitted to the register relay-set to operate relay FR (Fig. 4), and all storage space in the register is cleared ready for receipt of another call. Relay FR causes the register relay-set to release.

Release of Calls not Completed

If a call clears before the register has completed operations, relay A releases and the procedure described in the previous paragraph is followed, leading to the operation of relay FR. The operation of relay FR, when relay DS has not previously operated, causes forced release of the register connexion.

If more than 20 seconds elapses without receipt of a break pulse the call is forcibly released. The 4-second timing equipment is used for this purpose, and it operates as described for end-of-dialling detection except that a $\frac{1}{2}$-second clock pulse permits counting to occur only at every fifth connexion of the common equipment. Thus, 20 seconds elapses before a count of 40 is reached. When this occurs, relay FR is operated and the call is forcibly released.

If a spare code is dialled a translation containing no digits will be supplied to the register; this condition is detected and the call forcibly released.

FAULT DETECTION FEATURES

The electronic circuits incorporate built-in checking features to check the operation of the common equipment.

The first register period in each register regenerative loop is not used as a register for reasons explained earlier in this article; however, it is used to check the operation of the register-track circuits. During each 100 ms period two break pulses are signalled into this register by clock pulses which simulate dialling. The pulses are detected and recorded by the $16\frac{2}{3}$ ms common equipment. The 100 ms common equipment checks the presence of two pulses, cancels them and then checks cancellation.

Equipment is provided which checks the operation of the library tracks. The 30 library tracks are tested in sequence at the rate of two per second. At each test a special translation, recorded in one of the ten spare translation stores, is read off the library track via the transfer loop and the translation is checked.

The 100 ms common equipment is checked by applying a continuous series of test calls via one particular register. This register has no relay-set provided, and the output from the electronic equipment which normally operates relay IP is connected to the input of the electronic equipment which is normally controlled by relay A. Thus, pulsing out from the register is connected back to the input and is recorded in the register as received digits. The test circuit writes a test number in digit stores A–E of the register. This leads to a test translation that requires five code digits involving three applications to the translator. The translation is pulsed out, received again and checked. Various other checks are made before the call clears and the process repeats.

If the clock circuits fail to maintain synchronism with the output of the drum synchronizing track, the condition is detected. This detects failure of the clock circuits and also checks the drum speed.

When failure is detected all registers are forcibly released and busied and an alarm is given.

ACKNOWLEDGEMENTS

The development of the equipment described above was carried out on behalf of the British Telephone Technical Development Committee by the Automatic Telephone & Electric Co., Ltd.

Local Register for Director Exchanges

S. H. SHEPPARD†

U.D.C. 621.395.374:621.395.341.7

In director areas, outgoing subscriber-dialled trunk calls will be controlled by register-translators at a trunk switching centre, access to these register-translators being obtained via local registers at each director exchange. The function of the local registers, which are described in this article, is to route the call to the trunk switching centre and then to repeat into the register-translators the digits dialled by the subscriber.

INTRODUCTION

SUBSCRIBER-dialled trunk calls from a group of director exchanges will be controlled by register-translators provided at a trunk switching centre but, in addition, local registers are necessary at each director exchange to supply a routing digit to the 1st code selectors and then to repeat to the controlling register-translators the digits dialled by the subscribers.

When a national number is dialled, the prefix digit 0 received by the A-digit selector causes a free local register trunked from the 0 level to be seized. Further digits dialled by the subscriber are stored by the register and the first digit to be stored causes the local register to transmit a predetermined routing digit, which steps the 1st code selector to the level allocated to subscriber-trunk-dialled (S.T.D.) traffic. Outlets of this level are connected via outgoing relay-sets to direct junctions terminating on register-access relay-sets at the trunk switching centre, where the register-translators control the forward routing of the calls. When the calls are answered, meter pulses at the appropriate rate are transmitted over the junctions from the register-access relay-sets to the originating exchange.[1]

FACILITIES

The routing digit required at a particular exchange is the same for all S.T.D. calls and is predetermined by U-point strapping on the registers.

To cater for the ultimate requirement of international subscriber trunk dialling (I.S.D.) provision is made to detect the I.S.D. prefix code (010) and to apply a release sequence appropriate to the class of call, I.S.D. or S.T.D.

The maximum number of digits to be stored and retransmitted by the register is 15 for an international call and nine for a national call. Since there is an indefinite number of digits for any particular call it is necessary to release the register under time-pulse control if no further digits are received during a predetermined interval, which has been fixed initially at 4 seconds. This "time out" feature is similar to that provided on the controlling register-translators.[2]

After transmission of the routing digit by the local register an extended inter-digital pause follows to allow time for the 1st code selector to search for a free outgoing junction to the trunk switching centre and for the register-hunter at that exchange to search for and seize a free register. Inter-digital pauses between subsequent digits are reduced below the normal value to take advantage of the fact that there is no selector search between digits, and this speeds up retransmission of information and allows the local register send-control element to follow closely behind the receive element. However, to ensure that the send control does not overtake the receive element it is arranged that the inter-digital pause is extended when necessary to prevent retransmission commencing whilst a digit is being received.

CIRCUIT DESIGN PRINCIPLES

Digit Storage and Regeneration

To allow time for pulsing out the routing digit, and for the register-hunter at the trunk switching centre to search, it is necessary to provide storage for digits that may be received from the subscriber during this period. The duration of digit storage is short and the requirement is best met by a "closed loop" system in which the digit store is progressively reset as digits are transmitted and becomes available for re-use. The familiar mechanical pulse-regenerator is a typical example of such a system and an electrical equivalent of this device is used for the local register.

The operating principle of the regenerative circuit element is illustrated in Fig. 1. Digits dialled by the subscriber are received successively on a 50-point uniselector, RS, and during each inter-digital pause a relay, CD, releases to mark the end of the digit by charging the capacitor connected to the outlet on which the wipers are resting. Uniselector TS, stepping under the control of a pulse generator, allows pulses to be transmitted to line until its wipers encounter a charged capacitor, when operation of relay PD stops the pulse generator. A transistor (XA) provides the detecting element and its circuit is arranged such that the base is normally at a positive potential relative to the emitter, keeping the transistor in the cut-off condition. Application of the potential from a charged capacitor makes the base of the transistor negative relative to the emitter and emitter–collector current flows, under saturated conditions, to operate relay PD. Current drawn by the base circuit of the transistor discharges the capacitor and relay PD is released after a short interval but circuit arrangements provide for the appropriate inter-digital pause to be timed before the pulse generator is restarted.

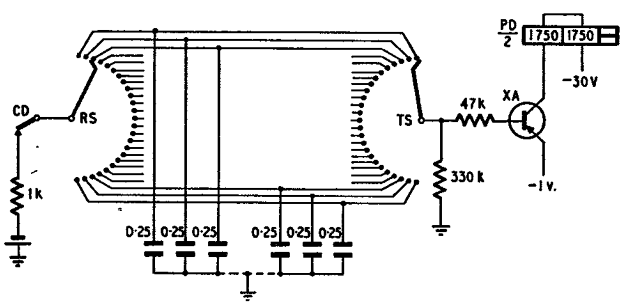

FIG. 1—PRINCIPLES OF DIGIT REGENERATIVE CIRCUIT

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[1]HEPTINSTALL, D. L., and RYAN, W. A. Metering over Junctions. (In this issue of the *P.O.E.E.J.*)

[2]WALKER, N. Controlling Register-Translators, Part 1.—General Principles and Facilities. (In this issue of the *P.O.E.E.J.*)

When coincidence is established between switches RS and TS, due to the stored digits all having been transmitted, the marking battery from CD holds transistor XA in the saturated condition and relay PD remains operated, enabling this condition to be recognized.

To avoid false operations of relay PD due to residual charges retained by capacitors, it is arranged that an auxiliary arc of switch RS, cross-connected to be phased one step in advance of the marking wiper, connects a discharge resistor to the capacitors in turn.

Transmission of Predetermined Routing Digit

The numerical value of the routing digit is determined by strapping arrangements which have the effect of displacing the normal home position of uniselector RS by a number of steps equivalent to the digit to be sent. Transmission of the routing digit does not commence until the register has received and stored a digit dialled by the subscriber. This delay is introduced to avoid false seizure of the junctions and controlling register-translator in the event of subscribers inadvertently dialling 0 in place of 100 for the assistance code. The reduced inter-digital pause that can be used for signalling between registers, since no selector search is involved, allows a rapid discharge of stored digits, and the storage capacity (50 pulses) is adequate to prevent switch RS overtaking TS under the most adverse conditions.

TIMING CIRCUIT

The timing requirements of the register circuit include an extended inter-digital pause after the routing digit has been sent (1,500 ms approximately) to allow time for seizure of the controlling register-translator, a shortened pause between succeeding digits (400 ms approximately), and a 4–5 second "time out" feature at the appropriate dialling stage. These intervals are timed by the circuit element shown in Fig. 2.

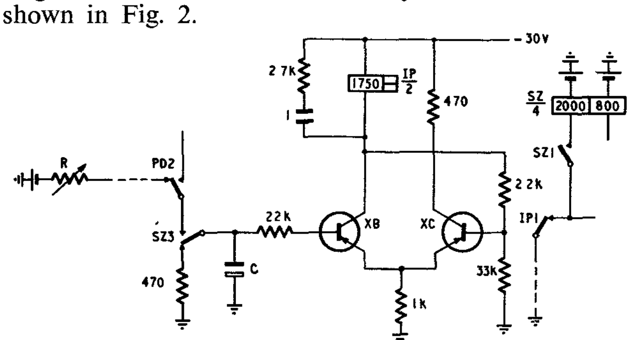

FIG. 2—TIMING CIRCUIT

Capacitor-resistor networks are associated with a transistor trigger circuit to operate relay IP at the end of the required delay period. With the circuit normal, contact SZ3 unoperated, transistor XC is "on" and its emitter current produces a bias voltage across the common emitter resistor which turns "off" transistor XB. Contact SZ3 operates to start the timing circuit and capacitor C charges through resistor R. As the voltage rises on the capacitor the base of transistor XB reaches the same potential as its emitter and collector current commences to flow. The resulting potential difference across relay IP causes the base of transistor XC to become less negative and the circuit rapidly passes to its alternative stable state with transistor XB "on" and XC "off." Release of relay SZ causes capacitor C to be discharged and resets the circuit.

RELEASE OF REGISTER

The number of digits to be regenerated by the local register is variable and provision is made in the circuit to recognize the type of call, namely, national or international, and to record the number of digits received so that an appropriate register-release sequence occurs at the correct stage for the respective types of call. International calls are distinguished by the prefix digits 10 and receipt of this combination is registered by the operation and locking of a relay from an arc of the digit-receiving uniselector (RS) under the control of the digit-counting switch. The latter discrimination is necessary because the digit-receiving switch may perform more than one complete revolution.

Forced release of the register occurs under time-pulse control if no digits are received or in the event of excessive delay between digits. As it is not practicable to apply the condition on the basis of overall holding time, due to the variable number of digits and the "time out" feature, the forced-release timing circuit operates from 16-second S and Z pulses and is reset as each digit is received. This timing period allows adequate time to subscribers dialling unfamiliar codes and an unaccustomed number of digits, but is shorter than the equivalent period for the controlling register-translator so that, in general, forced release is applied by the local register.

During homing of the uniselectors in the local register it is necessary to ensure that no residual charge can remain on the capacitors connected to the group of contacts between the normal and displaced home position of the RS switch marking arc. This is achieved by 2-stage homing, the switch being first driven to contact 50 and then allowed to self-drive to its home contact, ensuring that the discharge wiper passes over the whole group of outlets concerned.

OPERATION OF LOCAL REGISTER WITH EXISTING EQUIPMENT

The local register must be suitable for operation with all existing types of A-digit selector, including early equipment which does not incorporate battery testing and in some instances uses the PU wire for forced-release signals in place of a separate lead. Since the present standard arrangement will predominate and the early equipment will ultimately be replaced, it would be uneconomic to provide a single circuit with full flexibility and two designs have been produced. One of these circuits is intended for use with all types of early equipment and is provided with terminal points which may be strapped to suit various requirements.

CONCLUSIONS

Although the technique used for pulse storage and regeneration in the local register for director areas is not novel, it is the first time that it has been used by the Post Office in heavily-worked common equipment.

It is anticipated that the use of this method of digit storage will result in low maintenance costs.

Incoming Register-Translator for Director Areas

H. S. WATERS and S. H. SHEPPARD†

U.D.C. 621.395.341.72:621.395.374

An examination is made of the facilities required for subscriber and operator dialling to distant director areas, and the reasons for evolving incoming register-translator equipment are given. The circuit arrangements adopted to provide the required facilities are described.

INTRODUCTION

ON trunk calls to director exchanges an examination of the numbering-group code by the controlling register-translator will result in a call being routed to the group switching centre of the required director area. The routings within the switching centre bear no relation to the director-exchange letter codes, which must be translated into the required routing digits on similar principles to those appertaining to the director itself.

Whilst the controlling register-translator could have been designed to examine the letter codes and to translate them to route calls to the required director exchanges, the added complexity, cost and size of the equipment, together with the difficulty of maintaining up-to-date translations throughout the country for all director areas, render such an arrangement very undesirable. Instead, the letter codes will be examined and translated by equipment located in the group switching centres of director areas.

Operators have for many years been dialling letter codes into trunk-director equipment for calls terminating within director areas. Under trunk mechanization, however, operators dial codes comprising the routing digits into the non-director selector train at trunk switching centres, which gives unrestricted tandem dialling facilities, e.g. to group centres and to minor exchanges outside the director area. Non-director codes corresponding to the routing digits are also used for calls terminating within the director area. Consequently the existing trunk-director equipment will no longer be required for operator-dialled traffic and is being recovered. However, at the outset of subscriber trunk dialling, sufficient trunk-director equipment is being retained for dealing with subscriber-dialled calls from other director and non-director areas.

Where operators are dialling the trunk-mechanization routing digits there will therefore be two groups of trunk circuits from areas equipped for subscriber trunk dialling, one group terminating on the trunk-director equipment for subscriber-dialled calls and the other group being connected to selectors for operator dialling.

To avoid the necessity for retaining two groups of circuits, where provided, and to avoid the division of other routes as subscriber trunk dialling is extended to the whole of the country, incoming register-translator equipment employing modern techniques will be provided. The equipment, which is described in this article, will cater for letter dialling by subscribers and for code dialling by operators over a single group of incoming circuits.

The present trunk-director equipment was designed only for calls incoming on circuits using the standard 2 v.f. signalling system (Signalling System, A.C., No. 1) but the new equipment will be suitable for any type of circuit working on a strowger basis.

BASIC REQUIREMENTS

The incoming register-translator equipment is designed primarily for calls that terminate within the director area and for code dialling by operators to any extent that may be required. Except in the case of junctions using loop-disconnect signalling, each incoming circuit will be connected via its line equipment to a register-access relay-set and thence to the normal selector train. Incoming loop-disconnect-signalling junctions will terminate directly on special register-access relay-sets which will incorporate a transmission bridge and junction guarding facilities (Fig. 1).

On subscriber-dialled calls to the director area, which will always consist of the 3-letter 4-numerical number, the register will obtain the required routing information from the translator and control the setting-up of the call. Normally not more than three translated digits are required for routing calls through the trunk switching centre to any director exchange. However, provision has been made for a fourth translated digit which would be required should rearrangement of the junction network to cater for transit routing of trunk calls prove practicable. In addition, the fourth routing digit has immediate application for 2-link subscriber dialling to a 5-digit area using an 0x code, as described later in this article.

Operators will be able to dial the present routing codes, preceded by the digit 1, for access to director

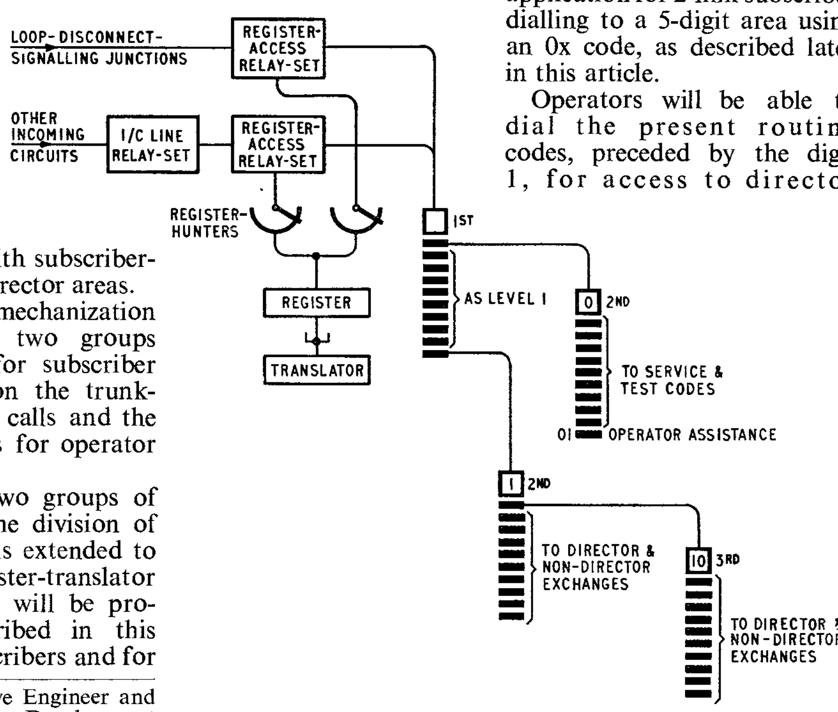

FIG. 1—TYPICAL TRUNKING AT A GROUP SWITCHING CENTRE IN A DIRECTOR AREA

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exchanges and on a transit basis to other areas. The digit 1, the first digit to be received, will be detected in the register-access relay-set and result in that digit being absorbed, in switching through for code dialling and in release of the register if one has already been seized. Operators may also obtain access to director-exchange subscribers by dialling the 3-letter 4-numerical digits into the register.

Operators will be able to dial the standard assistance code, 01, for access to an operator dealing with assistance traffic for the director area. The digits 01 will be accepted by the register, which will repeat them unchanged to the selector train for access to an assistance circuit trunked from level 01. In this case no application is made to the translator.

The standard service codes and test numbers in the range 02 to 00 will be preceded by the digit 1.

On subscriber-dialled calls, the long inter-digital pause provided by the controlling register following the sending of the last routing digit allows for an incoming register to be associated in time to receive the required director-exchange subscriber's number. On operator-dialled calls, however, no controlling register is used and the operator must herself give the long inter-digital pause in dialling calls which require the incoming register, i.e. for letter dialling to director subscribers and for the assistance code 01. No such pause is of course required when operators dial routing codes preceded by the digit 1 as on such calls the incoming register is not used.

ADDITIONAL FACILITIES

It is intended eventually to route transit calls over a separate network designed specifically for the purpose. In the meantime subscribers can be given some of the transit routings available to operators on the existing network. There are two ways by which such subscriber-dialled calls can be dealt with, method (*a*) which follows being the first choice for any particular routing.

Method (*a*). The call is extended through the group switching centre on a non-translated basis as for operator-dialled calls. The translation from the controlling register-translator includes the digit 1 and the routing digits required at the group switching centre. As for operator-dialled calls, the digit 1 is absorbed and the equipment is conditioned for non-register working.

A limiting factor with this arrangement is that the total routing digits must not exceed four in number, i.e. a maximum of five translated digits, allowing for the digit 1 to be supplied as a translation digit. Two digits will usually be required to reach the group switching centre, in which case dialling access cannot be given to routes trunked from a later selector stage than 2nd selectors.

Method (*b*). For access to exchanges trunked from 3rd selectors, for which method (*a*) is usually unsuitable, the incoming register-translator can deal with 90 3-digit codes in the range 021 to 000, i.e. codes not required for letter dialling to director exchanges and excluding the operator assistance code 01.

The translation from the controlling register-translator comprises the two local routing digits and one of the above 3-digit codes, i.e. five translation digits. At the group switching centre, the 3-digit code is translated as required to route the call to its destination.

There are two limiting factors so far as this method is concerned.

(i) It is suitable only when a regenerator is in circuit, e.g. on circuits using Signalling System, A.C., No. 1, which will be the type of circuit usually employed. The delay introduced by the regenerator is necessary to give time for a register to be associated between seizure of the incoming equipment and receipt of the digit 0, as in this case the long inter-digital pause is given after and not before the stage at which a register must be associated.

(ii) The incoming register-translator is designed to accept only 7-digit numbers so that access cannot be given to non-director areas with a mixed numbering scheme. Usually access will be given only to uniform 4-digit numbering areas but exceptionally access could be given to a wholly 5-digit area at the expense of allocating a series of 0xy codes. At the group switching centre the digits 0xy, where y is the first numerical digit, would be translated with the digit y repeated without change as the last translation digit, i.e. using a 4-digit translation if trunking from a 3rd selector level. Access to a 5-digit area would thus require in effect a separate 0xy code for each working 1st selector level in the 5-digit numbering plan.

There are two overriding factors affecting both methods (*a*) and (*b*). One is that access can be given only to directly-connected non-director exchanges or linked numbering schemes. The other is that the number of different translations provided by the controlling register-translator for normal routings plus those used for 2-link dialling by methods (*a*) and (*b*) must not exceed the designed capacity, with due allowance for new direct routes expected during the exchange design period.

It should perhaps be pointed out that all the limiting factors mentioned concern only the routing of subscriber-dialled transit calls during the interim period before a new network is provided. Nevertheless, without appreciable additional cost and complexity in the incoming equipment, 2-link transit routings can be used at the outset and will dispose of many calls by subscriber dialling which otherwise would have to be operator controlled.

The inclusion of these arrangements does not involve the risk of subscribers obtaining calls incorrectly as the controlling register-translator bars the call if a charging group code followed immediately by the digit 1 or 0 is dialled. In this way a subscriber is prevented from obtaining a transit call at an incorrect fee by dialling the charging group code for a director area followed by the digit 1 for non-register working or by an 0xy code. The correct charging group code must be dialled for the controlling register-translator to supply the digit 1 or the required 0xy code as the case may be.

CIRCUIT ARRANGEMENTS

Design Considerations

A feature of this register-translator which has had an important bearing on design is that four routing digits is the maximum number required. This has, for example, permitted the full translation to be obtained on a single application to the translator, the digit stores carrying the A, B and C digits being reset to accept routing digits. The resetting requirement, in turn, has led to the use of coded digits and relay storage rather than uniselectors. Each digit store consists of five relays, two relays only being operated for any digit in the range 1–0. Incorrect coding, which results in other than two relays being operated, is readily detected as a fault condition. Choice of the "two-out-of-five" (2/5) code in place of binary code (four relays) was made to obtain the self-checking feature of the former and in particular to ensure that contact faults on the translation field would be detected and would not result in misrouted calls. For the conversion between strowger and 2/5 code, relay counting-circuits are employed in preference to uniselectors to take advantage of the new long-life relays (Post Office Type 10*) which will, it is anticipated, require little maintenance attention.

A common translator serves a group of registers and it is therefore necessary to make provision for a reserve to be available under fault conditions or when a translator must be withdrawn from service for translation changes, etc. This requirement is met by allocating a group of registers to a pair of translators, each of the translators normally serving half of the registers in the group but with provision made for either translator to carry the traffic from the whole group of registers if its partner is out of service. The maximum number of registers in a group depends upon the acceptable delay in obtaining a translation under busy conditions, and in particular when operating to a single translator, but equipment layout considerations also influence the decision. In the present case it was decided to use 20 registers per group and the calculated probability of delay, even with only one translator in service during the busy hour, indicates that 1 per cent of calls may be delayed more than 5 seconds.

A relay-chain allotter is used to control the operation of connecting relays, which couple registers requiring translations, in turn, to a translator. A uniselector has been used foı this function in similar circuits, but the alternative method is used here to provide information on whether the anticipated reduction of maintenance attention required justifies the higher capital cost of the relay-chain arrangement. Under conditions of overlapping demands from registers the translator is allocated sequentially commencing at the earliest register in the chain requiring a translation.

With both translators in service it is arranged that registers 1–10 in a group are served by translator A and registers 11–20 by translator B. Although somewhat less efficient than a full-availability scheme, this division greatly simplifies the guarding arrangements necessary to avoid double connexions and is preferable in view of the short holding time for the translators.

Outline of Circuit Operation

The block schematic diagram (Fig. 2) illustrates the arrangements adopted.

Access to the register-translator is obtained via a relay-set interposed between the incoming line relay-set and its associated 1st selector. The access relay-set discriminates, from the initial digit, between calls to be completed on a non-register basis (digit 1) and those for which the register-translator is required (digits 2–0). This function could be performed more economically in the register but the method adopted has the advantage that operators dialling routing digits need not pause to allow time for the register to be associated and, moreover, operator emergency routings are independent of possible register congestion or faults.

Digits received by the access relay-set are repeated to the register in the form of inverted strowger pulses (i.e. an earth pulse for each break period) and inter-digital pauses are signalled over a separate lead. The pulses are recorded by a relay counting-circuit and during the inter-digital pause the digit is transferred, in 2/5 code, to a relay store and the counting-circuit is reset. The counting-circuit serves as a digit store for the units digit.

After the receipt of the C digit the register obtains connexion to a common translator via the allotter and coupling-circuit. Start and mark conditions applied from the register result in the operation of appropriate connecting relays when the translator is available.

A feature of the relay-chain allotter, which controls the allocation of a translator to one of the registers, is the sequential treatment of overlapping demands from registers. This is achieved by allowing an operated chain relay to bypass all preceding relays in the chain and during its release lag to extend forward the start condition.

The translator receives the A, B and C digits in 2/5 code and, after code verification, the digits are expanded to denary code and combined to obtain a discrete marking of one of 900 code terminals. Each terminal is cross-connected either to a route relay or to a spare-code relay. The route relays each carry two independent translations and selection between these depends upon the A digit received. Operation of a route relay returns a signal to the register to reset the A, B and C digit-stores in readiness to receive the routing digits. A digit distributor in the translator marks the contacts of the route relay in turn and the appropriate translation digits are encoded in 2/5 code and applied to the digit stores in the register.

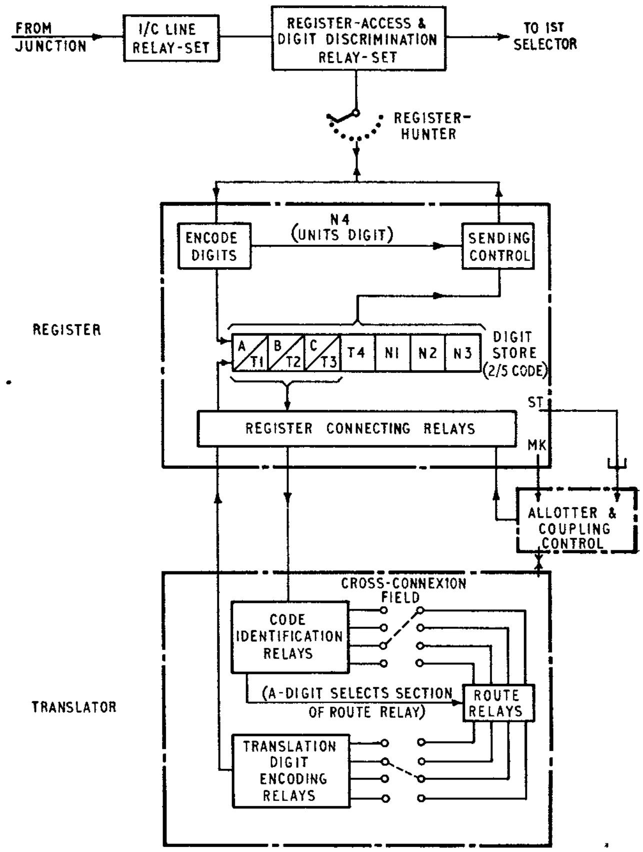


FIG. 2.—BLOCK SCHEMATIC DIAGRAM OF INCOMING REGISTER-TRANSLATOR EQUIPMENT FOR DIRECTOR AREAS

* Rogers, B. H. E. The Post Office Type 10 Relay. *P.O.E.E.J.*, Vol. 51, p. 14, Apr. 1958.

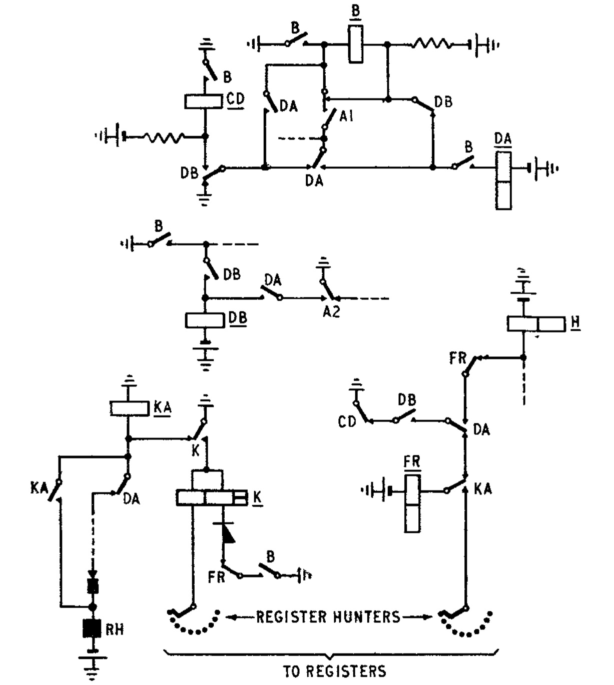


FIG. 3—DIGIT-DISCRIMINATING CIRCUIT OF REGISTER-ACCESS RELAY-SET

Should the translation require a fourth routing digit, a signal is applied to the register to change over the third group of marking wires to an additional digit store. Completion of translation or receipt of a spare code is signalled to the register from the translator and results in the release of the translator.

The routing and numerical digits are pulsed out by the register at 10 p.p.s. with normal inter-digital pauses. The sending-control circuit checks each digit in turn for correct coding (2/5), expands the digit to denary form, and detects coincidence with a relay counting-circuit recording the pulses transmitted.

Receipt of the service code 01 by the register is recognized as a code-only call and the digits are repeated to the selector train without application to the translator.

The register is released by the access relay-set in response to a "send finish" or "forced release" signal returned by the register.

Discriminatory Feature of Register-Access Relay-Set

Fig. 3 shows the circuit element which operates on receipt of the initial digit and discriminates between digit 1 and digits 2–0. Premature dialling is also detected from the receipt of a digit in the range 2–0 prior to register association.

On seizure of the circuit, relay A (not shown) and relays B and CD operate in turn and the subsequent release of relay A on receipt of the first break pulse completes a circuit to operate relay DA. Contacts of relay DA prevent further search by the register-hunter if a free register has not been found, and prepare a circuit for relay DB. The re-operation of relay A holds relay DA and operates relay DB. If the initial digit is other than a single pulse, the second release of relay A releases relay DA and this relay cannot then be re-operated. Relay CD releases during the inter-digital pause following the first digit and for an initial digit 1 operates relay H to switch the positive and negative wires (not shown) through to the associated selector. If the initial digit is not 1 the release of relay CD is ineffective unless relay KA is normal. This condition would indicate that a register had not been associated at the time the digit commenced and relay FR would be operated to return busy tone to the caller.

Storage of Received Digits by the Register

As already described, provision is made for an extended inter-digital pause, following seizure of the access relay-set, on calls to be routed under the control of the register-translator. This allows time for the register-hunter to search for and to seize a free register so that the initial digit is received by the register in addition to discrimination occurring. For an initial digit 1 the register, if one has already been seized, is released immediately.

The method of recording and storing digits in the register is illustrated in Fig. 4. Received digits are

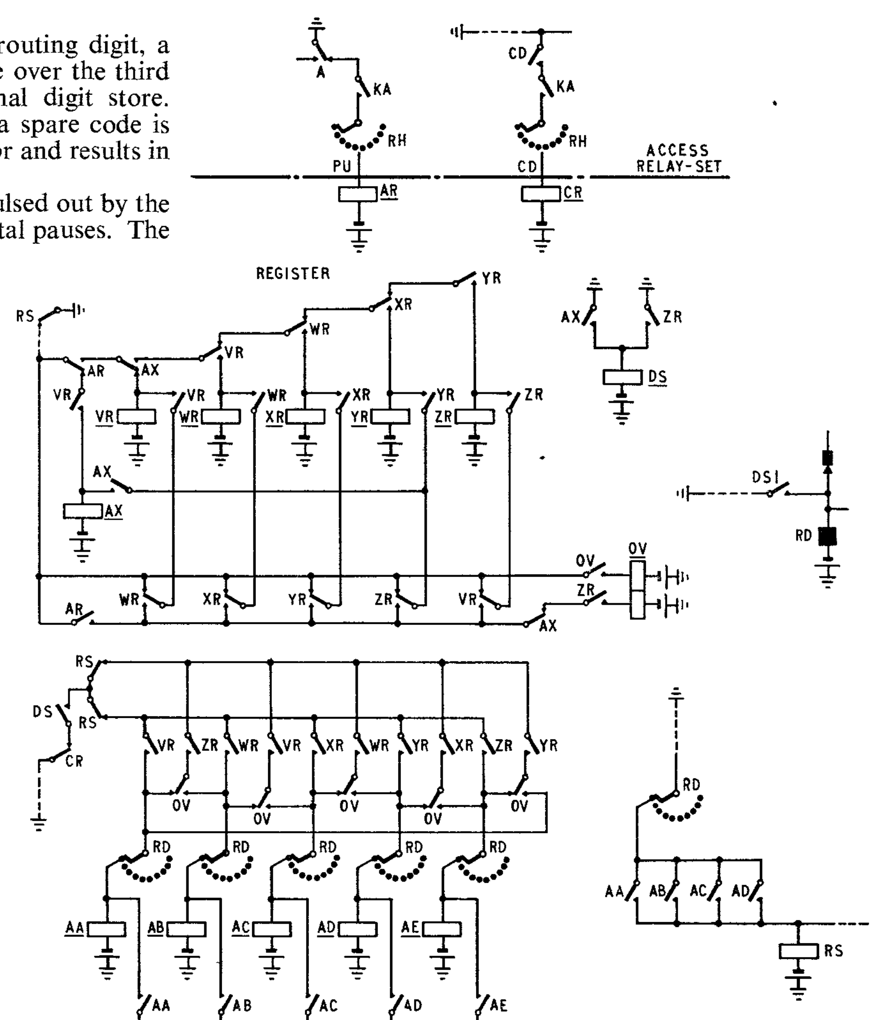


FIG. 4—RECEIVED-DIGIT ENCODING AND STORAGE

repeated to the register as earth pulses applied to the PU wire and inter-digital pauses are signalled by removal of the earth from the CD lead. Relay AR responds to the digit pulses and a relay counting-chain, comprising relays VR–ZR, AX and OV, is set in accordance with the digit received. Relay OV is operated for digits 6–0 and change-over contacts of this relay, in conjunction with an individual relay in the VR–ZR group, provide a 2/5 code marking to the wipers of the digit distributor RD. During the inter-digital pause relay CR is released, the digit is stored by the operation of two relays in the group AA–AE, and relay RS operates to reset the counting chain and, by the release of relay DS, allows switch RD to step. Succeeding digits are received and stored in a similar manner.

Seizure of Common Translator

After receipt of the C digit, relay ST in the register is operated to provide start and mark conditions to the allotter and coupling relay-set. Fig. 5 shows the general arrangements of the relay-chain allotter. Assuming Register No. 3 requires connexion to the translator, then earth will be applied to the common start lead, operating relay XS, and the individual marking contact ST2 will interrupt the chain and prepare an operating path for relay RC. If Register No. 3 is the earliest in the chain having its ST relay operated then the earth from contact XS will operate relay RC, and the contact of relay RC will bypass earlier registers in the chain and hold directly to the XS earth. The "translator-free" condition is denoted by application of earth to a further contact of relay XS and allows operation of relay CA. Contacts of relay CA prepare the circuits of the connecting relays (ASA/SAA) for all registers having access to the translator but only for Register No. 3 is the circuit completed for the connecting relays to operate. Relays ASA and SAA operating in Register No. 3 connect this register to the common translator where rélay BH operates and releases relay CA.

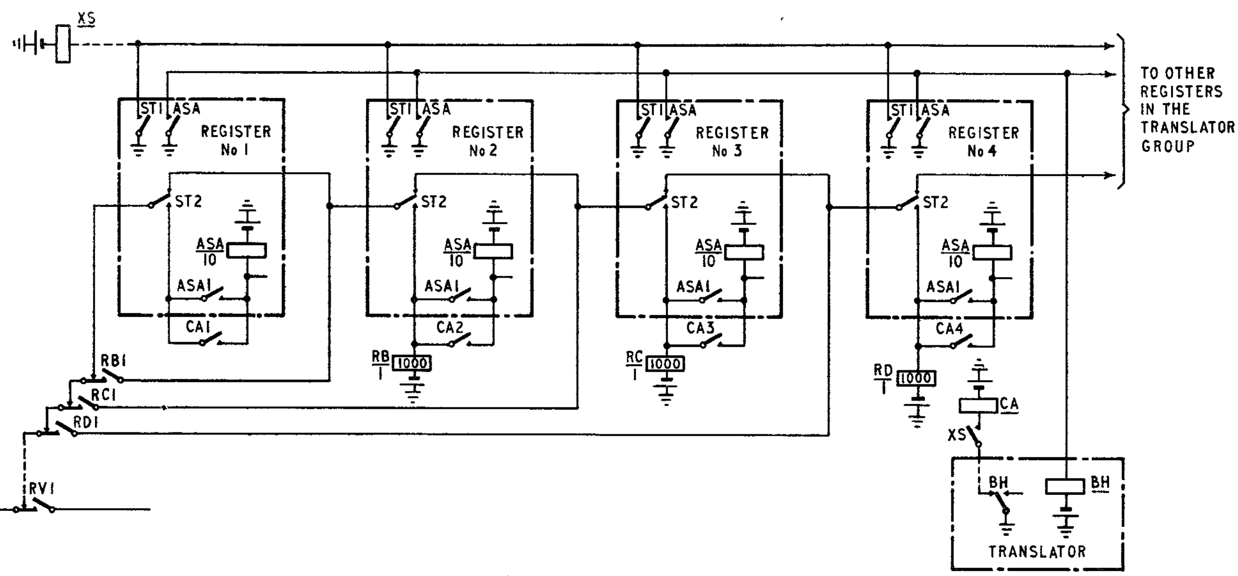
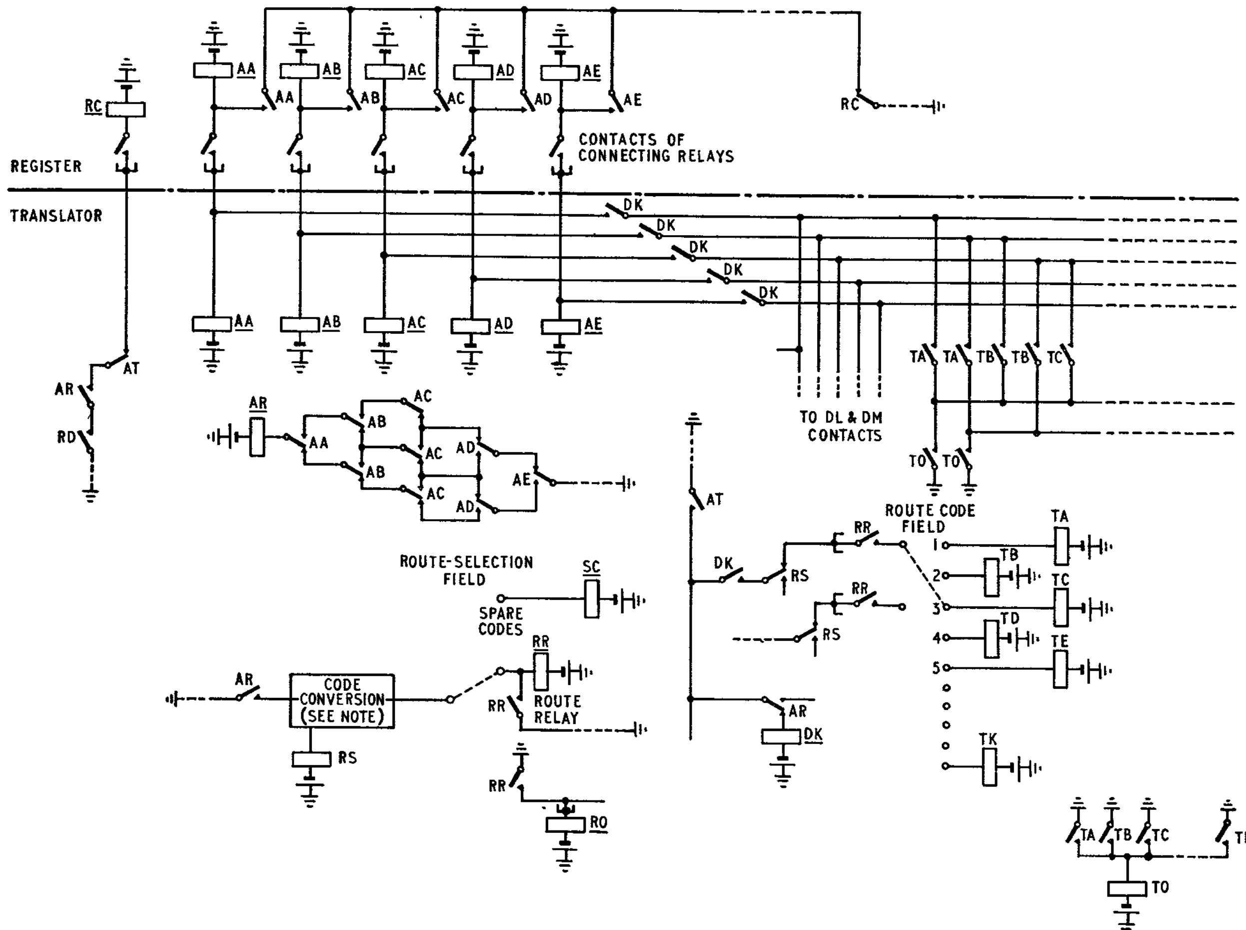


FIG. 5—RELAY-CHAIN ALLOTTER

Translation Cycle

On seizure of the translator the A, B and C digits are marked out from the register in 2/5 code on fifteen leads to the translator. Fig. 6 illustrates the marking leads for the A digit only but the arrangements for the B and C digits are similar. Each digit is checked in the translator for correct coding (operation of relay AR for the A digit by any two relays in group AA–AE being operated) and the A, B and C digits are expanded to denary code and combined to obtain a discrete marking of one of 900 code terminals on the route-selection field. The terminals are cross-connected to either an individual route relay or to a common spare-code relay. The route relays each carry two independent translations and selection between these depends upon the A digit received. A maximum of 200 route relays can be provided giving 400 possible translations. A selected route relay operates and locks and by the subsequent operation of relay RO, which is common to all route relays, a signal is applied to the register which operates relay RC and resets the digit stores carrying the A, B and C digits. This in turn releases the code-receiving relays in the translator and causes the routing digits to be marked out to the register. Referring to Fig. 6 it will be seen that the release of relay AR at this stage, with AT operated, operates relay DK and applies earth to the first contact of the selected route relay. This in turn is cross-connected to a digit terminal equivalent to the first routing digit required, in this case it is digit 3, and relay TC is operated. Relay TO, which is common to all digit relays (TA–TK), is in turn operated and the 2/5 code equivalent to digit 3 is applied to the marking wires from the register over which the A digit was received. Two relays in the group AA–AE in the register are operated and lock and relay AR in the translator again operates to verify correct coding. Relay DK is released and the remaining translation digits are applied successively to the B, C and, if required, T4 stores in the register (See Fig. 2). If the fourth routing digit is required the translator applies a signal to the register to cause the C digit marking wires to be changed over to the T4 digit store.

When all routing information has been supplied the translator applies a "translation-complete" signal to the register and relay ST in the register is released and in turn releases the translator. If further registers in the



Note: A, B and C digits, received on relay groups AA–AE, BA–BE and CA–CE, are expanded to denary code and combined to mark one terminal on the cross-connexion field.

FIG. 6—CIRCUIT FOR TRANSFERRING DIGITAL INFORMATION BETWEEN REGISTER AND TRANSLATOR

same group require the translator then, referring to Fig. 5, it will be seen that with ST released (Register No. 3) and during the release lag of relay RC, the earth from XS will be extended forward to operate relay RD or subsequent relays depending on which is the operated ST relay next in the chain. Successive overlapping demands for the translator are thus treated in cyclic order and the start condition reverts to the beginning of the chain when the register demand which is last in the chain has been dealt with or when there is an interval with no demands waiting attention.

Sending of Digits by the Register

Receipt of the "translation-complete" signal by the register initiates the transmission of routing and numerical information, and Fig. 7 shows the circuit elements concerned. A self-interacting relay P generates pulses at the required speed and ratio and the inter-digital pauses are timed by relay PT, which has a combined operate and release time of 800 ms minimum. Relays MA–ME read the 2/5 code of the

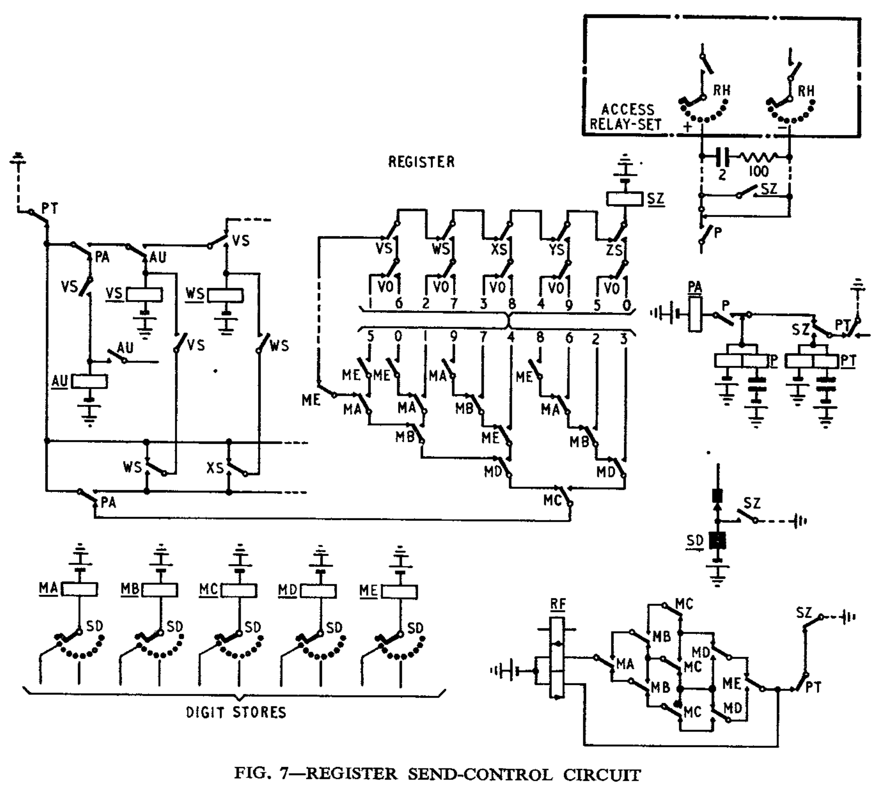


FIG. 7—REGISTER SEND-CONTROL CIRCUIT

digit from a store and contacts of these relays are used to verify correct coding (two relays operated) and to convert to a denary marking. A pulse-counting chain with a similar circuit to that used for the receiving element (Fig. 4) counts the pulses transmitted and relay SZ detects coincidence between marking contacts of these relays (VS–ZS and VO) and the marked lead on MA–ME contacts. The operation of relay SZ prevents further pulses being sent to line and energizes relay PT to measure an inter-digital pause. The digit distributor SD steps, the succeeding digit store is read and the digit is sent in a similar manner.

Auxiliary arcs of the send and receive distributor-switches control digit-sending relative to the receipt of numerical digits and in particular ensure that tens and units digits are received before the sending of the tens digit can commence.

A "send-finish" signal from the register operates relay H in the access relay-set to complete the transmission path and to release the register.

"Code-Only" Calls

The register has provision to detect digits 01 received as A and B digits and to retransmit these digits without application to the translator. With this exception the register is arranged uniformly to accept seven digits on all calls.

Operation Under Fault Conditions

Occurrence of fault conditions which can be identified as due to faulty operation of the register, e.g. a code error signal, causes the register to be locked out of service and an alarm to be given. Should the register encounter excessive delay in obtaining the translator or fail to be associated with it, the occurrence of the fault is recorded but register lock-out does not result unless the fault recurs on the succeeding call. Independent relay-chain allotters and connecting relays are provided for each translator to avoid the possibility of both translators becoming unserviceable due to a fault on common leads. In the idle condition, the contacts comprising the relay chain are monitored by chain-fail relays and a disconnexion, e.g. due to a dirty-contact fault, occurring on the primary sections of the chain, results in automatic change-over of the registers to the reserve translator and in an alarm being given. Similarly, a translator fault occurring has the same result and provision is also made for manual control of change-over. Circuit arrangements ensure that change-over can only become effective provided that the receiving translator is operating normally, and safeguards are provided to prevent interference with translations in progress.

The occurrence of a fault condition due to translator misoperation results in both the translator and the associated register becoming locked out of service, and an alarm is given. The fault indications and an examination of the digits held in the register stores will assist in localization of the fault. The remaining registers of the group are transferred to the partner translator.

If a fault occurs which cannot be positively identified as due to translator misoperation, e.g. incomplete receipt of the A, B and C code digits, the register is locked out of service but the translator does not change over unless the fault recurs on the next call dealt with by the translator.

Routine Test Arrangements

An automatic routiner is provided for the registers and by the use of test codes the receipt of a correct translation is verified. Due to the automatic lock-out features it is not practicable to simulate certain fault conditions by the routiner and a separate manual tester is provided to facilitate routine testing of these circuit features.

Manual test facilities are provided to enable the operation of a translator that has been withdrawn from service to be checked at both normal speed and with manual control of the stepping of the digit distributor. This latter feature permits digit-by-digit examination of a translation and by this means the accuracy of any selected translation can be verified.

ACKNOWLEDGEMENTS

The development of the equipment described in this article was carried out on behalf of the British Telephone Technical Development Committee by the Post Office in conjunction with Ericsson Telephones, Ltd.

Physical Design of Subscriber-Trunk-Dialling Equipment

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U.D.C. 621.395.374.002.2

The methods used for mounting the registers, translators and other equipment being provided for subscriber trunk dialling are described, and details are given of the novel forms of construction used for the electronic register-translators and other items to ensure that they function satisfactorily and are readily accessible.

INTRODUCTION

NEARLY 100 new items of equipment are being produced for the initial stages of subscriber trunk dialling (S.T.D.), ranging from a routiner-access circuit with one uniselector to a translator requiring a complete rack. Only about one-tenth of the items are suitable for standard relay-set or strip mounting, the remainder requiring special provision to be made. Many problems were met and solved in the course of the physical design work, and it is the purpose of this article to illustrate a few of the more outstanding ones. Whereever rack capacities are quoted, they refer to racks 10 ft 6½ in. high, although some 8 ft 6½ in. high are being developed as an alternative for use at exchanges with low headroom.

REGISTER-TRANSLATORS

Electromechanical Registers

Registers (and their associated translators) form the nucleus of the whole S.T.D. system, so it is inevitable that they contain a large amount of equipment, and that stringent precautions must be taken to make them reliable. For physical design purposes, the several registers that are being produced may be divided into two basic types:

Type A—those suitable for mounting on specially developed base-plates equipped on 4 ft 6 in. wide racks.

Type B—those more conveniently accommodated by standard mounting strips on 2 ft 9 in. wide racks.

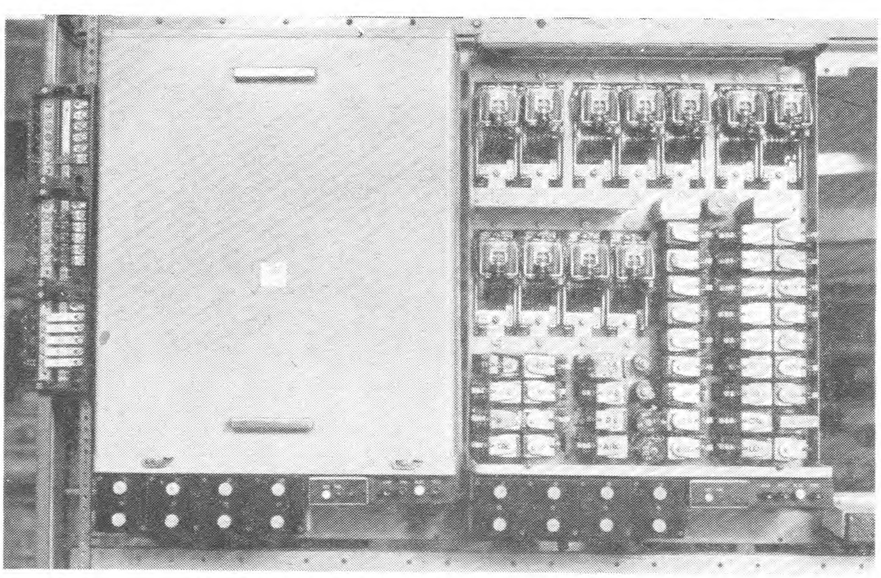
One example of Type A is the register used in non-director exchanges[1] and illustrated in Fig. 1. It contains 11 uniselectors and 38 relays, as well as many miscellaneous components, which render it unsuitable for any previous standard mounting arrangement. The use of 2,000-type-director base-plates would have been possible if the consequent number of interconnecting wires had not been too great for the U-points available. Alternatively, the apparatus could have been strip mounted, but this would have allowed only 12 circuits per rack with a rather inconvenient layout. The final scheme adopted makes use of a single plate with mounting space for all the apparatus and forming a self-contained unit.

Due to its weight and size, the register is bolted to the rack, and the individual external connexions are via a connexion strip at the rear. Nevertheless it is considered that the unit is sufficiently portable for it to be removed or replaced occasionally. The common wires to the translator constitute a vulnerable link in the chain of connexions, since a fault on these could affect a complete group of registers. Consequently, the registers are connected to the common wiring via removable links specially developed for the purpose, and described more fully in a later paragraph. These links also form a convenient access point for testing, and facilitate the removal of the register.

The 15 registers on a rack are wired in three vertical sections of five, each section having its outgoing connexions commoned to connexion strips at the top of the rack. These connexion strips may be connected to three separate translators (maximum of 75 registers) or, by suitable commoning, to two translators (maximum 50 registers). This scheme allows installations of any size to have their registers distributed among all the available translators and so reduces the risk of total failure.

A further example of Type A construction is the prototype of the controlling register for use in director areas.[1] This register stores the digits on relays instead of uniselectors so that accommodation has to be found for over 100 relays and two uniselectors. A plate has been developed on the same principle as the one for non-director registers, but with quite different apparatus layout. The send and receive relays have been put on a separate standard relay-set mounting so that they can be replaced readily in case of trouble. The extra components have reduced the rack accommodation to 10 registers.

The director-area incoming register[2] requires 96 relays and two uniselectors. It was decided to use six



The photograph shows two registers, one with its cover removed

FIG. 1—CONTROLLING ELECTROMECHANICAL REGISTER FOR NON-DIRECTOR EXCHANGES

† Executive Engineer, Telephone Exchange Standards and Maintenance Branch, E.-in.-C.'s Office.

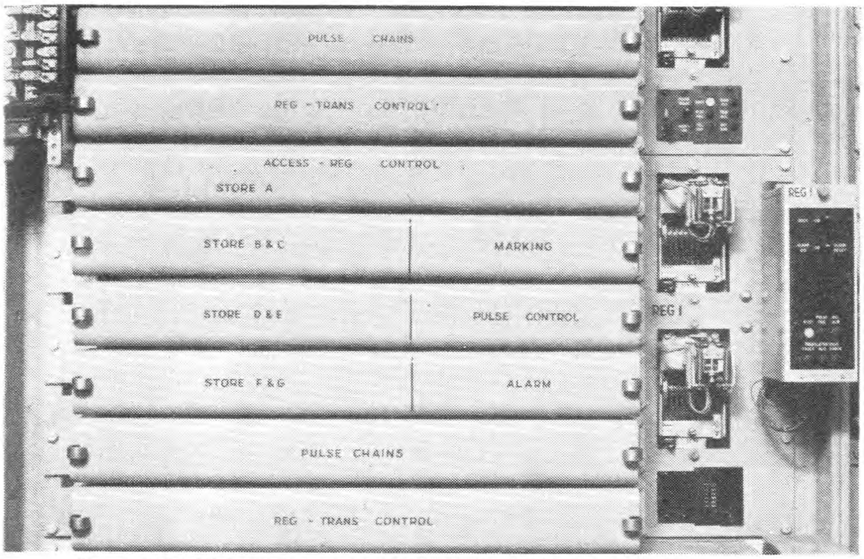


FIG. 2—INCOMING ELECTROMECHANICAL REGISTER FOR DIRECTOR AREAS

mounting strips together with a special combining plate to link the strips and to mount the uniselectors and test jacks, etc. (see Fig. 2). The Type B construction is used mainly because relays are included in the register to isolate the translator multiple, thus rendering links unnecessary and allowing all external connexions to be taken via a connexion strip. To avoid obscuring the relay tags at the rear right-hand end of the plate, the strip used is of the type newly developed for the termination of p.v.c.-covered wire. It is set at an angle and all wires pass through slots in the moulding. Seven of these registers are mounted on a 2 ft 9 in. wide rack, and may be combined in any desired arrangement for connexion to the translators.

Electromechanical Translators

A suitable mounting arrangement was developed for the non-director translator, and it has been found sufficiently flexible to allow it to be used, with minor modifications, for all the other translators. The basic unit is a plate which can be drilled in various ways to accommodate the following items (Fig. 3):

(*a*) 20 relays plus three connexion strips.
(*b*) 30 relays plus four jacks.
(*c*) 15 relays plus one uniselector plus four jacks.
(*d*) 20 relays plus plate for keys, switches and lamps.

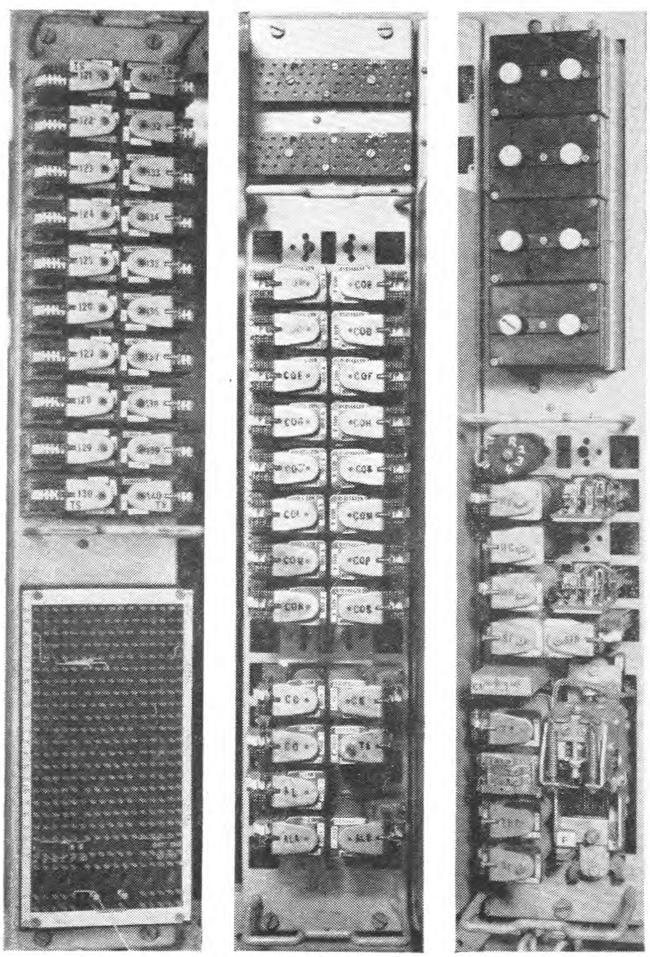
Assembly (*c*) is specially arranged so that it can be withdrawn from the rack should the uniselector bank require attention; it is in use as the register-finder on every call and hence is heavily worked. The connexion strips are made in nine different assemblies so that they can be combined in groups of three to give any desired jumpering facility. The basic units are bolted to the rack framework in the necessary quantities and combinations to form a translator. So far as possible all connexions are made via the assembly connexion strips so that the units are easily removable or replaceable. All jumper connexions are made on the face of the rack between, or on, the mounting plates, jumper rings being provided on the centre connexion strips and on the shelf. Where flexibility of connexion will rarely be required, semi-permanent jumpers are provided by appropriate cable forms so that the normal jumper runways are not unduly congested. The translation charts are contained in transparent pockets inside the hinged, removable covers.

The translators associated with controlling registers in non-director areas, and with incoming registers in director areas, are both of such a size that two translators occupy one rack. Where a third translator is required it must be mounted on a second rack, and the remainder of the space can be used for the third translator of another group or, where a second group is not needed, for the accommodation of a spare register-finder assembly.

The translator associated with controlling registers in director areas requires more translation relays than the preceding types and so has to be arranged on three shelves (Fig. 4). Only one translator may be fitted per rack and one of the plates on the centre shelf is omitted to provide space for vertical jumper wires.

Electronic Cold-Cathode-Tube Registers and Translators

The advent of circuits using cold-cathode discharge tubes[3] made a completely new type of mounting necessary. The requirements were few, but onerous:



(*a*) (*b*) (*c*)

Assemblies (*b*) and (*c*) are not fully equipped

FIG. 3—BASIC UNITS OF ELECTROMECHANICAL TRANSLATOR

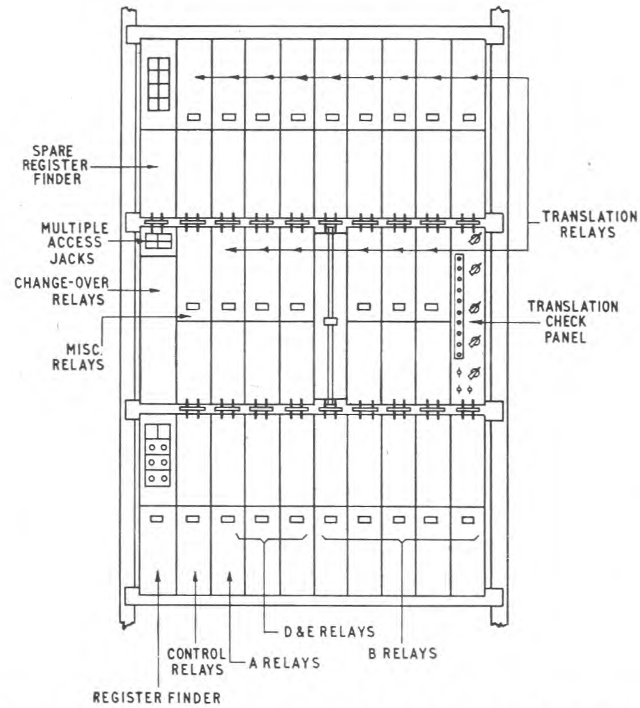


FIG. 4—CONTROLLING ELECTROMECHANICAL TRANSLATOR FOR DIRECTOR AREAS

(*a*) Easy access to translation fields.
(*b*) Easy access to all components for maintenance.
(*c*) Glow of all discharge tubes to be visible with the cover in position.
(*d*) Tubes to be protected from strong light.
(*e*) Tubes to have certain minimum illumination.
(*f*) Equipment to be safe to handle.

After consideration of various types of plug-in unit it was decided to utilize the leaf-and-book principle. The components are mounted on a flat framework with the tubes at one end and a connexion strip at the other, making a leaf. This leaf is then hinged at the end adjacent to the connexion strip and mounted into a framework, with up to 19 other leaves, to form a book. The book (or panel, as it is termed in this application) fits into a cubicle in the rack, external connexions being made via links and jacks similar to those developed for the electromechanical register.

Testing and observation can be carried out with the register in position by partly opening the leaves of the book, protection to personnel being provided by flexible insulating separators between the leaves. Replacement of components or alterations to wiring require the panel to be removed from the rack, by unscrewing the connecting links, moving the handles of the panel inwards and then pulling out the whole unit (Fig. 5). Spring catches on the handles render the panel easy and safe to carry. There are adequate guides and locating pins to make sure that the unit is correctly replaced. The panel is kept small so that it is light and yet provides sufficient accommodation for one register.

Experiments with various materials and colours indicated that the best protection from sunlight, whilst still allowing the tubes to be seen, was obtained from red Cobex (rigid p.v.c.) sheet, and this substance was used for all cubicle covers. Unfortunately it is a very good insulating material and so easily builds up electrostatic charges, which interfere with the operation of the tubes. To remedy this defect an expanded metal screen is placed in intimate contact with the inside of each cover and connected to the earthed framework. For the same reason, the tube envelopes are earthed by means of spring clips, and all plastic material, except s.r.b.p. (synthetic resin-bonded paper), is excluded from the vicinity of the tubes. The minimum illumination required to ensure that the tubes operate correctly is obtained by specifying fluorescent lighting of double the normal standard. At least half of the lights must be left permanently switched on.

Great difficulty was experienced in ensuring that no "cross-fire" existed between adjacent wires carrying pulses. This applied particularly to the leads between the registers and the connectors, where all the pulse leads converged, and to the translator tie wires. The remedy has been applied in three stages: the wires are physically separated by s.r.b.p. spacing pieces; rectifiers and resistors have been added and connected so that they discharge all wires between pulses, and so prevent accumulation of charge; the length of all wires is restricted to limit the capacitance.

The rack framework is similar to that of a standard 2,000-type rack. The vertical members are enclosed by sheet metal to form the troughing for the wiring and to mount the connecting jacks. The rack is divided down the middle, horizontal shelves and vertical divisions being added to give a maximum of 28 similar compartments.

On the register rack (Fig. 6 and 7), 20 of these compartments are used for registers and two for connectors. The centre two house control keys, lamps, miscellaneous relays and the test jacks giving access for the tester trolley. A large compartment equivalent in size to four small ones is used to accommodate a standard shelf holding 10 relay-sets. Each of these relay-sets provides the link between two electronic registers and the external electromechanical switching equipment. Since some of the relays

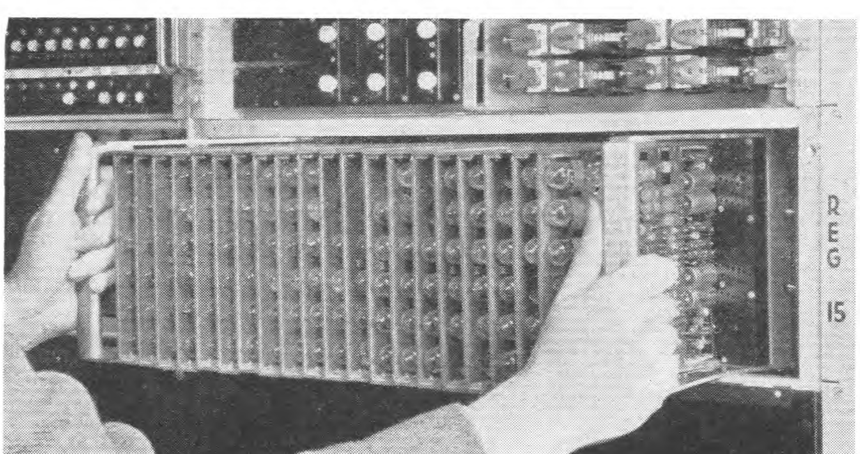


FIG. 5—REMOVAL OF ELECTRONIC REGISTER

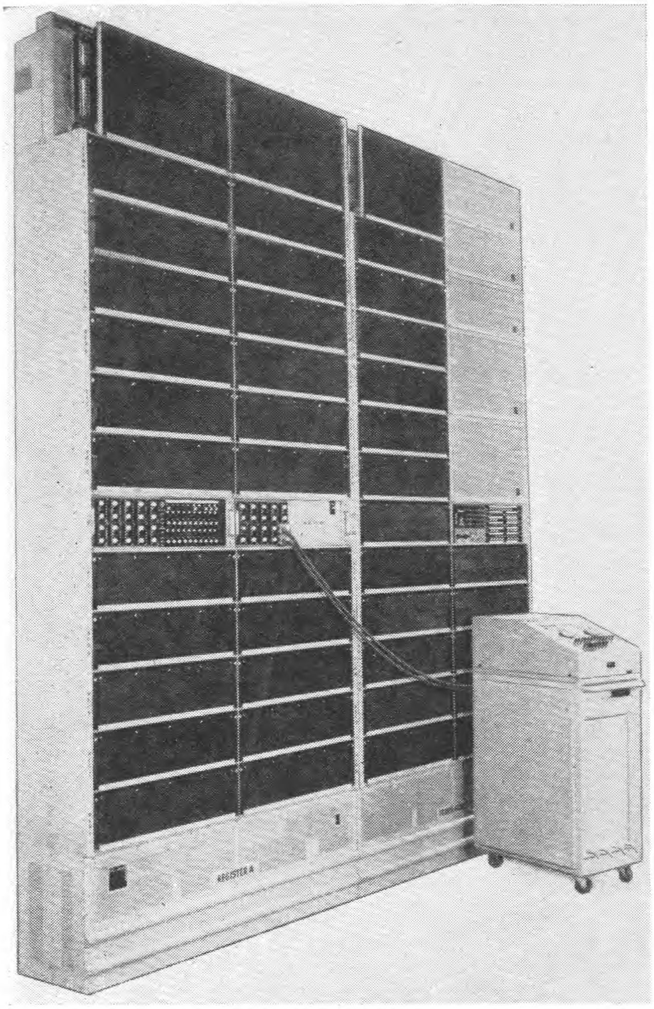


FIG. 6—RACKS OF ELECTRONIC REGISTERS AND TRANSLATORS

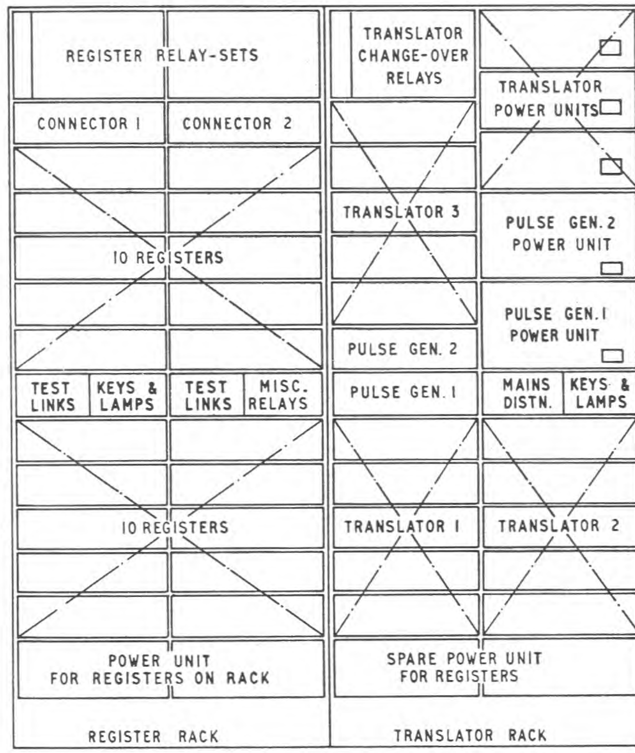


FIG. 7—LOCATION OF ITEMS ON ELECTRONIC REGISTER AND TRANSLATOR RACKS

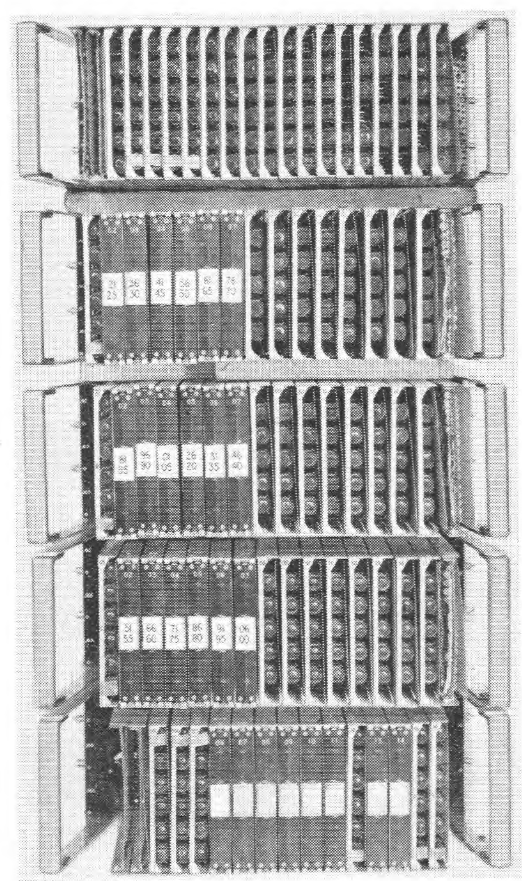
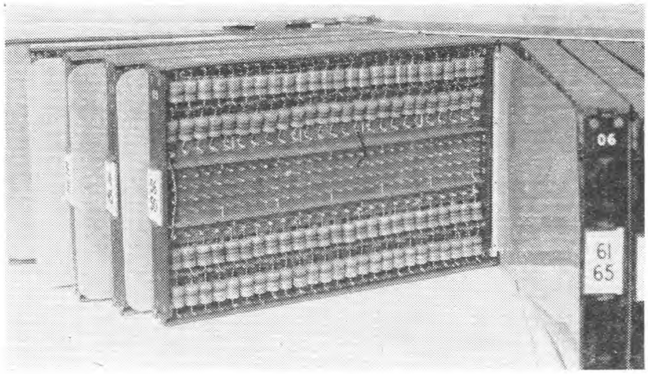


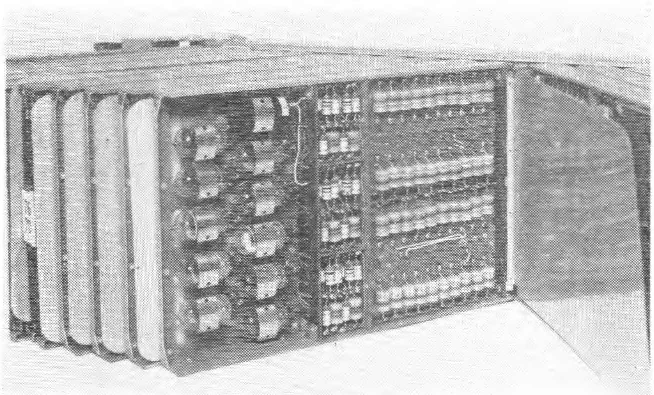
FIG. 8—ELECTRONIC TRANSLATOR PANELS

have medium voltage on their springs, they are protected by transparent covers in addition to the overall cover. Connexions to the rack are made through connexion strips at the rear of the relay-sets. At the foot of the rack is mounted a register power unit. Owing to the high voltages present it is protected by a perforated metal cover which can be removed only with some difficulty. The relays provided to permit change-over of the h.t. supply from the regular power unit to a spare unit, mounted on the translator rack, are housed under the same cover.

On the translator rack 15 compartments are used for three translators, two compartments for pulse generators, and one compartment for test equipment and a.c. mains distribution, whilst the remainder of the space is taken up by power supplies and control relays. Each translator (Fig. 8) has a control and register-allotter panel, three translation panels (Panels 1–3) over which the ABC code gates and translation tubes are distributed, and a special-facilities panel (Panel 4) for such functions as fourth and fifth digit identification. Each ABC code-gate leaf caters for 50 ABC codes and has access to a multiple (tags designated in white) serving 80 translation tubes on the same panel. Twenty of these "white" tie circuits are extended from each translation panel to Panel 4 in order to give the latter access to 60 of the translation tubes. Forty tie circuits (designated in red) are provided between the panels



(a) First Stage of Translation



(b) Second Stage of Translation

FIG. 9—ELECTRONIC TRANSLATOR

to make the special facilities available to all codes, and to allow even distribution of the translation tubes. The capacitance-discharge circuits for the tie circuits are also mounted in Panel 4. The allocation of a translation to a particular code is performed in two stages (Fig. 9):

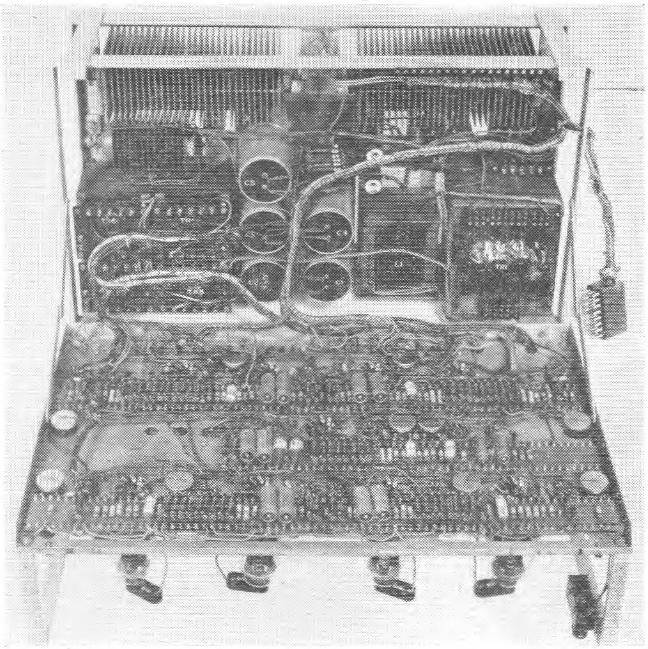
(a) The code is strapped (via a red tie circuit and expansion on Panel 4 if required) to a white tie circuit giving access to a convenient translation tube.

(b) The tags of the translation-tube output gates are strapped on the leaf to the appropriate translation digits.

All strap connexions are made using short tinned-copper straps insulated as necessary with sleeving.

Each translator and each pulse generator has its own power panel, and these are mounted together on the translator rack. The panels are partially withdrawable and are hinged to give access to the major components for simple testing, although, because of the high voltage used, 650 volts a.c., the power will have been disconnected by a microswitch mounted on the cover. For more complete testing and for component changing the whole power panel may be removed from the rack, all connexions being taken through multiway plugs and sockets (Fig. 10). Heat from the power panels is considerable, mainly due to the bleeder resistors, and has to be dissipated by a flow of air which passes through the shelves and out at the top via a "chimney."

The oscillator included in the pulse-generator power panel is a resistance-capacitance multi-vibrator and is very susceptible to surges from adjacent circuits. Its complete isolation from all external interference has been obtained by mounting it in a metal screening can with all leads



The hinged part of the panel is shown open

FIG. 10—POWER PANEL FOR PULSE GENERATOR

entering via lead-through capacitors, and by carefully controlling the bonding of wires having the same nominal potential. Further immunity from interference has been obtained by returning all circuits to a separate system known as the "electronic earth," which is bonded to the main earth at one point only, at which position a filter may be inserted, if required.

The a.c. mains supply for the system is fed to the translator rack, whence it is distributed to the register racks through cable troughing. This enables all power to be disconnected by one emergency switch on the translator rack and also gives central access to the mains fuses. At the foot of the translator rack is a spare register power panel, which is connected so that it can be taken into use automatically by any register rack. At the top are the miscellaneous relays mounted on hinged frameworks, which may be swung out for maintenance purposes and to allow access to the connexion strips behind.

Magnetic-Drum Registers and Translators

The magnetic-drum system being designed for S.T.D.[4] is a development of the experimental one fitted at Lee Green.[5] One of the most important differences is that for S.T.D. a 9 in. diameter drum (Fig. 11) is used with its axis horizontal and with provision for many more pick-up heads. This method of mounting improves accessibility for initial adjustment, reduces mechanical design problems and makes better use of the available space.

The mounting of the drum is of critical importance, mainly because of the closeness of the heads to the drum surface (about 0·001 in.) needed to give high signal strength. With 140 or more pick-up heads grouped round the drum it is evident that the bearings and drum construction must give extremely high concentricity, and must be extremely well balanced, both statically and dynamically. The manufacturers of the drum have succeeded in attaining the high standard of construction that is essential.

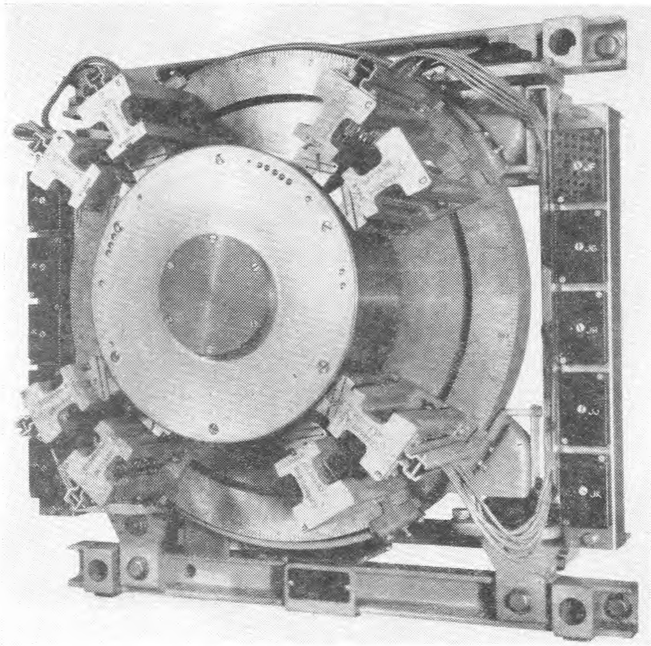
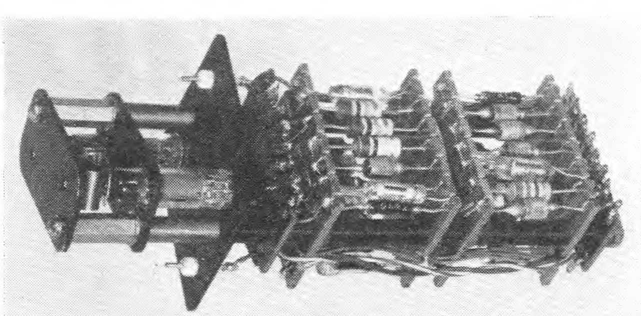


FIG. 11—MAGNETIC DRUM ASSEMBLY

Easy running of the drum is facilitated by a circulating oil system driven by two solenoid-operated pumps. The drum will run for several hours after the 3-phase power supply has been disconnected, and will operate satisfactorily for three months if the oil supply fails. The drum is protected from external shocks by mounting it on a framework which is secured to the rack by anti-vibration bushes. External connexions are via 36-way links and jacks so that the whole assembly may be withdrawn from the rack for major maintenance. Sudden or large changes in temperature are obviated by lockable draught-proof covers, and by the suitable ventilation of heat-producing panels.

The thermionic valve circuits are assembled as small sub-units (Fig. 12) which are wired on to flat double-sided panels (Fig. 13). These panels accommodate up to ten 2-valve units, or a reduced number of larger units, together with eight connexion strips for the large number of cold-cathode-tube gate circuits and miscellaneous components. The panels slide horizontally into a framework on the rack and the external connexions are completed by gold-plated plugs and sockets, special provision having been made for the coaxial cables feeding the pick-up heads. The heater current through the plugs is kept at a minimum by wiring pairs of valves in series and connecting them to a 12·6-volt supply.



The panel in which this unit is mounted is shown in Fig. 13

FIG. 12—SINGLE ELECTRONIC UNIT FOR MAGNETIC-DRUM REGISTER-TRANSLATOR

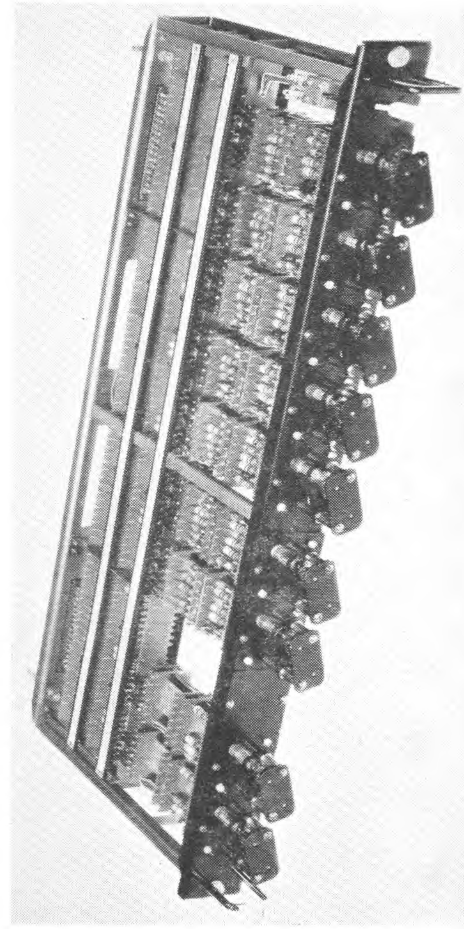


FIG. 13—ELECTRONIC PANEL FOR MAGNETIC-DRUM REGISTER-TRANSLATOR

Fig. 14 shows the prototype rack, which provides facilities for 48 registers and associated translation.

A group is formed by a suitable number of register racks plus a standard relay-set rack accommodating the coupling relay-sets. The typing-in unit consists of six panels similar to the main panels and so capable of being plugged into any rack whose translator store requires changing or checking.

REGISTER-ACCESS AND DISTRIBUTION RACK

The rack described is for non-director exchanges employing electronic registers, but other systems have a similar arrangement. The interconnexion of registers and register-access relay-sets is achieved by the use of tie circuits, which are provided on the basis of 10 per relay-set rack, with provision for expansion up to 20 if necessary. Access must also be provided for the register routiner to test the registers in the order they appear on their racks, not in the order of the register-hunter banks, and the connexions from the register-hunters to the registers must be capable of being switched from the trunk registers to special registers capable of handling international calls.

All these requirements are met by a specially developed rack. It can cater for three complete translator groups,

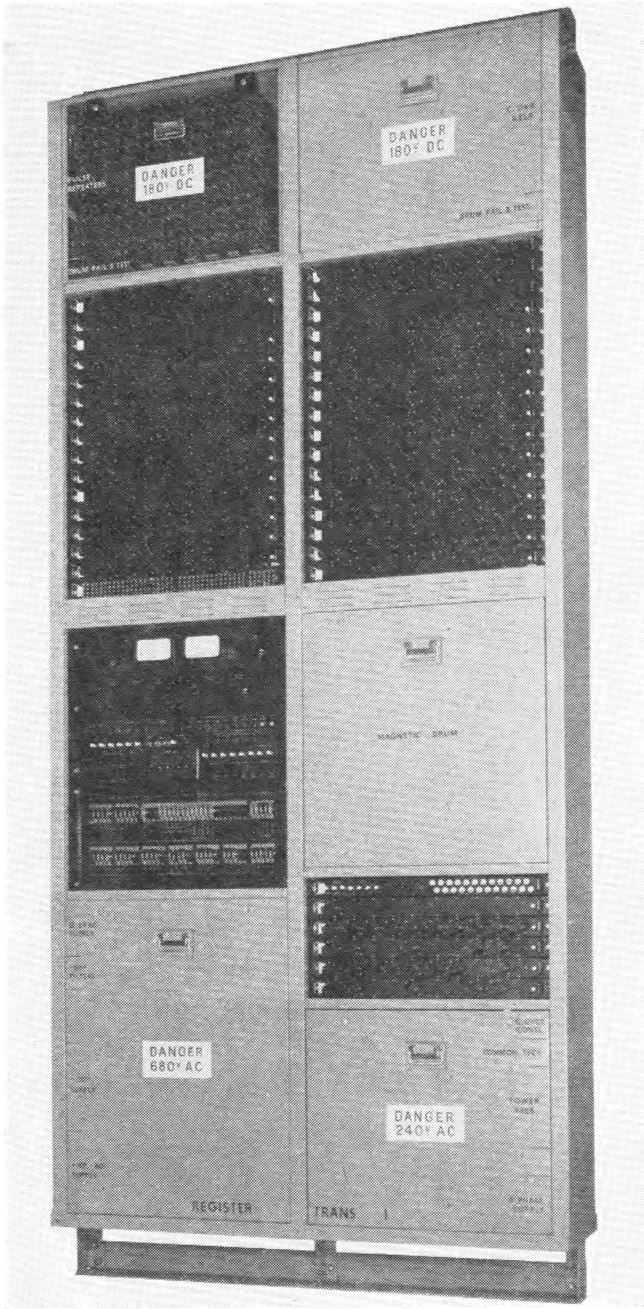


FIG. 14—MAGNETIC-DRUM REGISTER-TRANSLATOR RACK

i.e. 240 registers, 48 relay-set racks and nine translators, and so will suffice for the largest installations. The top portion of the rack contains the connexion strips for jumpering registers to register-hunters, and below these are the connexion strips for use when the international switching relays are fitted. When this latter facility is not required, the corresponding register connexion-strips are cabled together. Provision is made for strapping of the registers in groups and the connexion of the "group busy" meters. In the middle of the rack are the three groups of routiner-access selectors, containing one uniselector per rack of registers. The space below is allocated for motor uniselectors acting as international-register finders (two per group) and relays to perform the change-over function. Due to the large connexion strip (11-way), the cross-connexion frame is made up as a unit which is set back from the rack uprights and fills all the space between the guard rails.

REGISTER-ACCESS RELAY-SETS

The register-access relay-set for non-director exchanges is mounted on a 30-way base, giving 40 circuits per rack. Development is, however, proceeding in order to replace the Type 2 uniselector by a Type 4 uniselector and a group of relays by a ratchet relay (see later description) and so reduce the size.

The access circuit that terminates a junction from a remote non-director exchange is too large for a single relay-set and has had to be split into two 20-way relay-sets, giving only 30 circuits per rack.

The access circuits at trunk switching centres in director areas are similar to those for non-director areas, except that the local-access relay-set requires a 32-way base, giving 30 circuits per rack.

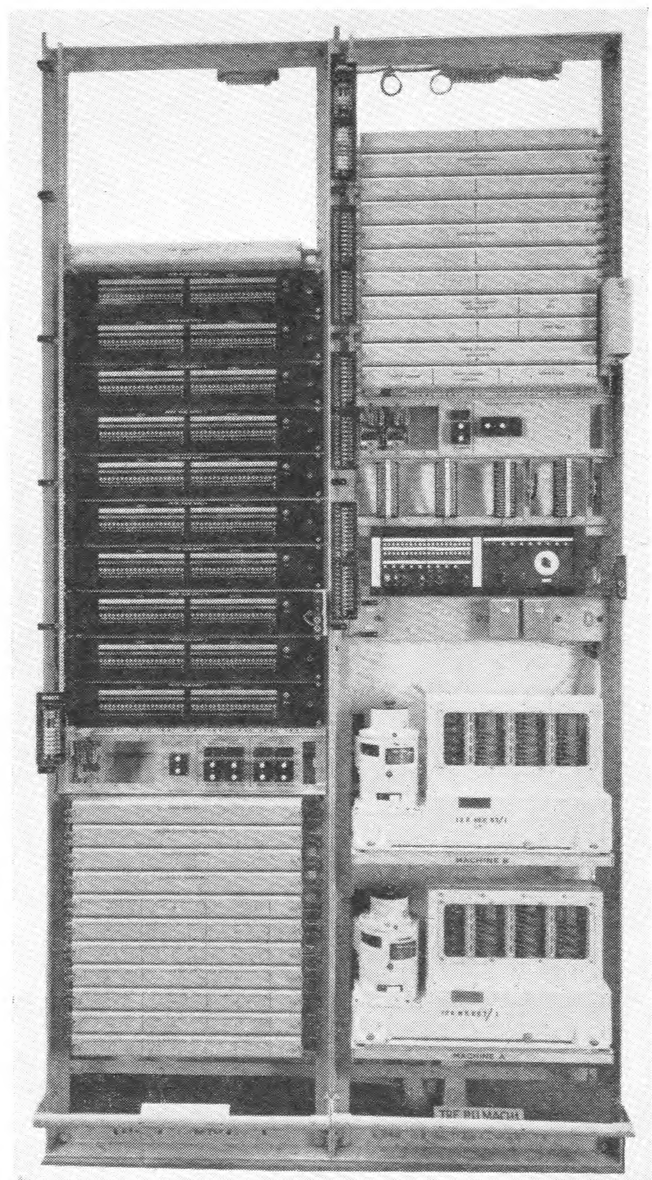


FIG. 15—RACKS OF TARIFF-CONTROL AND DISTRIBUTION EQUIPMENT

Incoming circuits to director areas are much simpler than the corresponding outgoing circuits since no meter-pulse facilities are required. Consequently they can be mounted on 12-way relay-set bases, fitted 70 to a rack.

Several rack layouts are being designed to cater for these and the other types of relay-set coming into use. They are of conventional design except for the provision of connexion strips to allow the fee-digit leads to be strapped to any meter-pulse supply and to cater for the extensive metering facilities required. The register-hunters and routiner-access uniselectors are mounted on standard shelves at a convenient height.

TARIFF-CONTROL EQUIPMENT

Associated with the access relay-set racks are the racks, shown in Fig. 15, which supply the meter pulses. New apparatus[6] designed for these racks includes the shelves for the meter-pulse machines (weighing 1 cwt each), the plug-and-jack mounting on the left-hand vertical, the motor-start panel and the 40-way fuse panels. Rapid change-over of the various circuits in the event of failure is required, but the number of inter-connexions and quantity of relays involved make previous standard methods impossible to apply. The jacks and links already developed for the registers are being used as change-ovei links and they have proved most satisfactory.

LOCAL REGISTER FOR DIRECTOR EXCHANGES

The local register[7] to be fitted in director exchanges remote from the trunk switching centre stores the digits on a capacitor network and requires only three uniselectors. One of these uniselectors has six levels and would normally have occupied 10 relay spaces. As this would have made an economical layout impossible, a new uniselector has been developed, with a smaller overall size, so that now a 6-level assembly can be accommodated in five relay spaces, i.e. the space previously required by uniselectors with a maximum of five levels. With this economy, it is possible to mount the register on two 32-way relay-sets, giving 20 circuits per rack.

Since the storage of digits is by means of electrostatic charges, high insulation resistance has to be maintained in the relevant portion of the circuit. This is accomplished by the use throughout of plastic foil (metallized polyethylene terephthalate) capacitors and p.v.c. (polyvinyl chloride) covered wiring. The transistors used have a very low power dissipation, and so no heat sink is needed. Special precautions have, however, to be taken when soldering the transistors in position, including, for example, the use of a thermal shunt.

All connexions are taken to the trunk distribution frame, whence they may be jumpered to the appropriate A-digit selector outlet.

LOCAL-CALL TIMING EQUIPMENT

The local-call timer[8] is an example of a small circuit required in large quantities. It consists of one uniselector, one relay and one rectifier plus another relay per three circuits. Twenty-one uniselectors can be accommodated on a 4 ft 6 in. wide shelf, so it was decided to adopt this number as the basic quantity. Nine such shelves fill a 10 ft 6½ in. high rack, providing 189 circuits in all. It was realized, however, that special precautions would have to be taken since, unlike a subscribers' uniselector rack, it would be possible for all uniselectors to be stepped together by the common 30-second pulse. At 0·75 amp per uniselector this would mean an instantaneous load of 150 amp per rack, with disastrous results to the sub-section fuse. Accordingly it is arranged to split the 30-second pulse supply into nine phases each feeding one shelf of uniselectors, thus reducing the maximum load per rack to 17 amp. Since then only one uniselector in a vertical column can step at a time, the number of negative battery fuses is reduced to 21, the battery leads being commoned vertically. One release-alarm relay is provided per shelf.

The Type 2 uniselector circuit is being superseded by a ratchet-relay circuit. These will be mounted in groups of eight circuits, each group occupying a standard strip-mounted plate together with a mounting plate for the test jacks and rectifiers. Twenty-one groups, i.e. 168 circuits, fill a 2 ft 9 in. wide rack.

Director exchanges require the timers to be associated with the 1st code selectors and to be capable also of relaying the trunk periodic-metering signals. Thus rather more equipment than for non-director exchanges is required and strip mounting is not as economical. For existing exchanges the circuits take the form of 10-way relay-sets (including ratchet relays) mounted on their own 4 ft 6 in. wide racks. Since two circuits are fitted on each base, a total of 220 per rack is obtained. The pulse-distribution relays occupy mounting plates fixed across the centre of the rack.

In new director exchanges, facilities for local-call timing and the relaying of meter pulses are being incorporated in the 1st code selector itself, so that separate relay-sets will not be required.

The equipment for producing the nine phases of the 30-second pulse supply occupies the lower half of a 2 ft 9 in. wide rack. The basic pulse circuits are mounted on relay-sets for quick interchangeability, but the dividing equipment is too bulky and has too many high-current connexions for this treatment. It has been strip mounted with change-over links and jacks. The latter are novel in that they are fitted by means of adapters to standard mounting plates. Field experience is required before it can be certain that the fuses provided in the pulse leads are adequate for the application. The uncertainty arises from the short length of the pulse, and the long melting time of a fuse rated at the pulse peak current. In this circuit the fuse is rated at 3 amp for a nominal peak current of 5 amp, and it is thought that this compromise will cause the fuse to be weakened by the first pulse and to blow satisfactorily on the second pulse after the occurrence of a fault taking 10 amp or more. The same effect could be obtained by the use of a two-stage powder-coated fuse, but it is considered to be not worth the extra cost of development.

MISCELLANEOUS CIRCUITS ON RELAY-SET RACKS

The subscriber's private-meter control circuit[9] requires a 60-volt 50 c/s signal to be fed into the subscriber's line. This supply is obtained from a transformer circuit mounted on a power panel on the rack and on which space has been left for an inductance-capacitance filter to suppress any noise received at the mains input. In the relay-set the injection transformer has a large iron circuit, and is rather larger than the two relay spaces allotted to it, thus encroaching on the adjacent mounting positions. In the space that would otherwise be wasted, a tubular capacitor and a rectifier are accommodated, both components requiring brackets to allow them to be fitted. The rectifier is of a type having very high backward resistance in order to prevent the circuit affecting other relays connected to the meter wire.

The coin and fee checking circuits at Bristol have several uniselectors, and are mounted on a director-type base, together with a 32-way relay-set base, giving 20 circuits per rack. The transistors in this circuit are the medium-power Post Office No. 4 type, and are bolted to metal brackets which act as heat sinks.

A superseding circuit is being developed, using rather more equipment than at Bristol, in order to allow of universal application and to give further facilities. Because of the extra space required, the uniselectors are mounted directly on the rack, with all the relays on two 28-way relay-set bases, giving only 15 circuits per rack.

SPECIAL APPARATUS

Several new pieces of apparatus have been developed for S.T.D., although they will, of course, have wider application in future. Some of the more important items are described.

Isolating Links, Plugs and Jacks

Difficulty has been experienced in the past with the rectangular-pin type of multiway plug and socket because the great force needed to insert and withdraw the plug made necessary reinforced mountings and general robustness. This difficulty has been overcome in a new series of plugs and jacks, some of which are illustrated in Fig. 16.

The plugs have wedge-shaped pins and are forced into position by screws so that very great contact pressure is obtained with little external force and the mountings need be only sufficiently large and strong to take the fixing screws. The jack contact is in two parts, a nickel-silver part to give good connexion and a spring-steel part to apply the pressure, obviating the usual compromise between contact and spring material. The link is a moulding containing 24 or 36 nickel-silver strips formed at each end in the same way as the plug pins. It is fixed in position on two adjacent jacks by means of screws similar to those for the plugs and gives the advantage of a removable connexion between two pieces of equipment without the necessity for flexible cords.

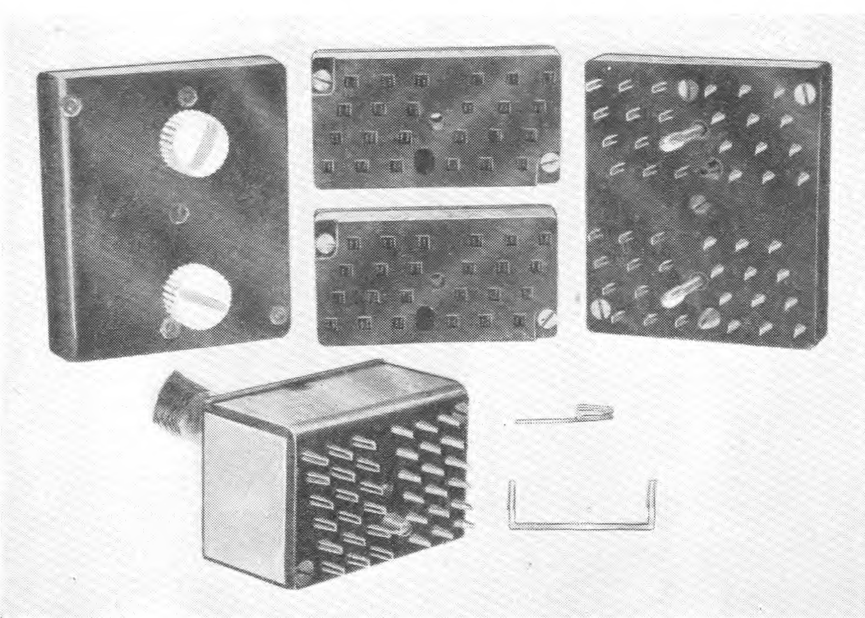


FIG. 16—PLUG, JACKS AND ISOLATING LINKS

For patching electromechanical registers to the translator via the test multiple or for connecting the tester trolley to the electronic registers, 24-way and 36-way test cords with plugs at each end have been developed.

Relays

The electromechanical translators store and translate digits on a decimal basis. As no suitable relay was available for this purpose, a 3,000-type relay with 10 make contacts was tested, but its life proved too short for such a heavy-duty application. Great improvement was obtained by the use of a comb instead of lifting pins for the spring operation, leading to the introduction of the Type 10 relay.[10]

The use of insulating material for lifting the springs makes the relay suitable also for medium voltage and it is used in the electronic registers and translators where 250 volts d.c. has to be switched.

Where the current exceeds 300 mA (translator and pulse-generator power panels) the Type 10 relay is unsuitable and a further type—the Relay 250-volt H.D. No. 3—has been developed. This latter is basically similar to the 3,000 type, but has keramot lifting pins, 18 mil springs and single contacts of Elkonite D56, which will carry up to 2·5 amp d.c. or 5 amp a.c. at 250 volts.

Ratchet Relay

The ratchet relay (Fig. 17) consists of a multi-step relay which fits into one 3,000-type relay space. The mechanism plugs into a 4-way jack, and is secured by a single screw. The coil operates an armature and pawl, which, on release, engages a 33-tooth or 36-tooth ratchet wheel. On the same shaft as the ratchet are fitted two cam wheels, which can be obtained with a sufficient number of cams to divide the operation into cycles of 3, 4, 6, 9, 11, 12 or 18 steps. Each cam operates a spring-set with a maximum of six springs. The single coil has a resistance of 400 ohms when it is essential that the resistance shall be a maximum, but for more general use it is only 250 ohms.

Type 4 Uniselector

The Type 4 uniselector (Fig. 18) is a miniature uniselector having three levels of 12 outlets each, and plugs into a 42-way jack in one 3,000-type relay space. The mechanism is reverse drive, and has the novel feature that no armature back-stop or pawl front-stop is required, the forward movement of the ratchet being arrested by a ratchet stop fixed to the armature.

Up to two bridging wipers may

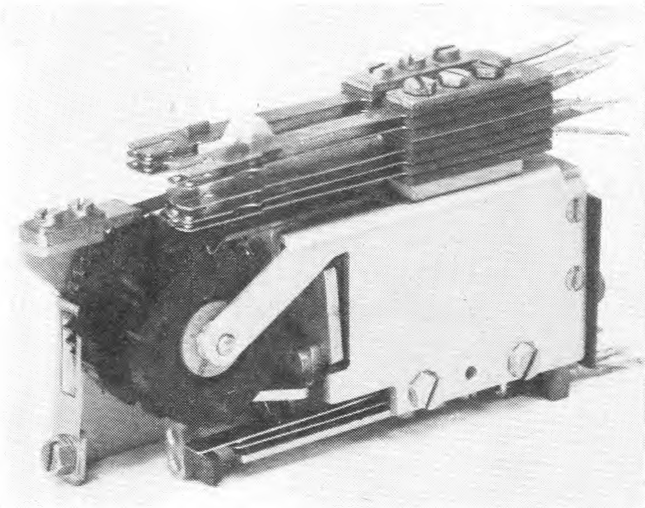


FIG. 17—RATCHET RELAY

be fitted, each wiper having three legs, thus requiring 36 teeth on the ratchet. The coil has a resistance of 250 ohms for 50-volt working, and has a non-linear spark-quench resistor connected across it.

ACKNOWLEDGEMENTS

Permission to publish certain of the photographs illustrating this article has been given by The General Electric Co., Ltd., and the Automatic Telephone and Electric Co., Ltd., and is gratefully acknowledged.

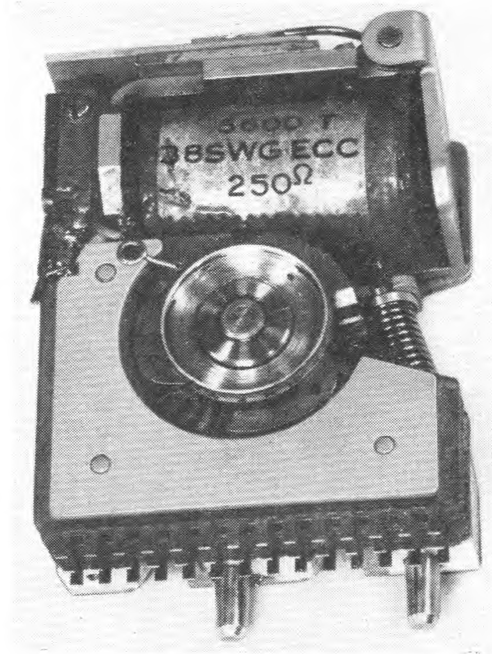


FIG. 18—TYPE 4 UNISELECTOR

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Periodic Metering

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U.D.C. 621.395.361

The factors influencing the choice of system for charging for trunk and local calls are discussed and a description is given of the method to be adopted for subscriber-dialled calls. On trunk calls the subscriber's meter will be operated once when the called subscriber answers and at regular intervals throughout the call, the frequency of operation of the meter depending on the distance of the call and whether the full-rate or cheap-rate tariff is in force. The charging for local calls, which is also described, is similar to that for trunk calls.

INTRODUCTION

THE two variables that have traditionally been considered in determining call charges are time and distance. In the past both have been reflected in trunk call charges, while locals calls have been untimed.

Bearing in mind the basis on which exchange equipment and line plant is provided, it is entirely reasonable that charges under automatic conditions should be related to the time variable. On the other hand, the effect of distance on the cost of a telephone call has, for many years, been decreasing as new methods of communication over long and medium distances have been introduced. Nevertheless, distance does remain a factor in the cost and for the present the system of charging must take some account of it. The tariff that will apply to subscriber-dialled trunk calls has, in fact, been based on considerations of both time and distance, but variations of call charges with distance are a good deal less marked than formerly.

CHOICE OF A METERING SYSTEM

The general requirements for trunk-call charging under fully automatic conditions[1] can be met by some system of registering meter pulses at intervals throughout the call, but the question immediately arises as to how these pulses and intervals should be arranged.

This question can perhaps be resolved more readily if for the moment the distance variable is neglected and consideration is confined to a call between two points a given distance apart. Under manual operating conditions it has been the practice to make an initial charge for the first 3 minutes of connexion and thereafter to charge for periods of 1 minute. If an attempt were made to reproduce such a feature by automatic means the equipment would have to apply a number of pulses to operate the calling subscriber's meter as soon as the call was answered. Each pulse would represent one charge unit and the number of pulses required would be determined by the number of single units in the 3-minute charge. The equipment would then be required to time a period of 3 minutes and apply a smaller number of pulses to the meter, this number being the equivalent of the 1-minute charge. Thereafter, it would be necessary to time a further period of 1 minute and reapply the 1-minute charge, this process being repeated until the call terminated. Fig. 1 illustrates how pulses would be applied and it can be seen that it would be necessary to have facilities for timing two different intervals and for applying two different groups of pulses. Clearly the equipment controlling the metering could be simplified if the intervals or the pulse groups or both could be made uniform.

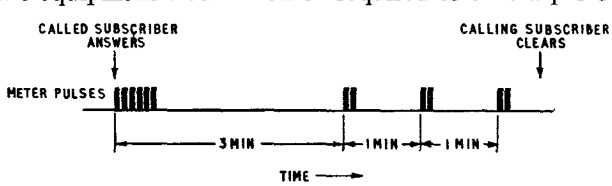

FIG. 1—SIMULATION OF "MANUAL" TARIFF

The need to differentiate between the initial and the subsequent charge on a manually controlled call arises because of the high setting-up cost that is involved. Under automatic conditions the cost of setting up a call is of less importance in relation to the overall cost but it is, nevertheless, a matter for some consideration whether or not it should be offset by the inclusion of a suitable element in the charge. Apart from this question, a system of metering based upon uniform intervals and uniform pulse groups would be suitable; moreover, under automatic conditions the setting-up charge element would in any event be small and if necessary it could be introduced by some special means such as the addition of a single pulse on answer.

To cater for calls over different chargeable distances it is necessary to have a number of different metering rates. Accepting the principle that on any one rate the pulse groups and the intervals should both be uniform, there are two ways in which the required variation of rates can be achieved. It is possible to arrange that the intervals between the groups of pulses are the same for all metering rates but that the number of pulses per group varies from rate to rate (Fig. 2(*a*)); alternatively,

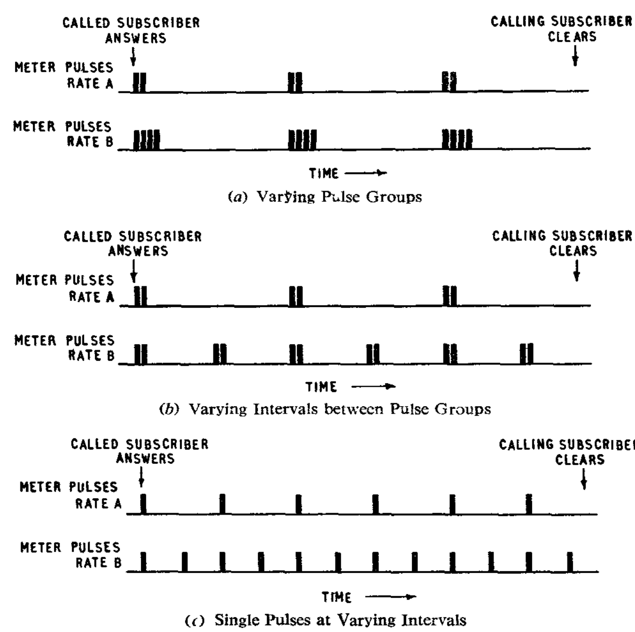

FIG. 2—POSSIBLE METHODS OF PROVIDING DIFFERENT METERING RATES

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the number of pulses in a group can be kept constant for all rates, in which case the interval between groups will vary (Fig. 2(*b*)). A metering system of the second type has the advantage that further simplification is immediately possible. This can be achieved as shown in Fig. 2(*c*) by reducing each pulse group to a single pulse and employing shorter intervals than would be appropriate to a system of multi-pulse groups. This simplification is attractive from the point of view of equipment design and it permits call charges to be brought more closely into a proportional relationship with call durations. Systems of this type are already well known and have been introduced in other countries, notably Sweden and Germany.

There are a number of ways in which single-pulse periodic metering can be arranged. The simplest method merely requires that connexion should be made to a common source of periodic meter pulses when the call is answered. The first pulse then occurs at random within the first nominal interval, although subsequent pulses are precisely spaced in relation to the first. If each pulse is regarded as a prepayment charge for the interval that follows it, it can be appreciated that no charge is made for the interval between receipt of the answer signal and the arrival of the first periodic meter pulse, and that in general there is a free period of conversation at the beginning of each call. This could be overcome by applying a special pulse immediately the call is answered: such methods were, in fact, examined but the extent of the random variation in the duration of the interval between the answer signal and the first periodic meter pulse was considered to be unacceptable to the subscriber.

It is apparent that randomness could be effectively removed by employing on each call individual timing equipment which would start the periodic-metering cycle when the call was answered and apply the first of the periodic pulses immediately. Although by such means a high degree of precision in call timing could be achieved, such a system would be complex and costly and for this reason is unattractive.

There is, however, a third method. This system offers a compromise between the other two, and it has been adopted because it provides an acceptable degree of accuracy while avoiding the high equipment costs that would be incurred with individual call-timing equipment. The basis of the system is that, on receipt of the answer signal, connexion is made to a common source of "supply" pulses which run at some multiple, n, of the required metering frequency. The supply pulses are counted as they are received and after receipt of a given number, x, a meter pulse is applied; the counting of supply pulses then continues for the duration of the call and for every n pulses subsequently received a further meter pulse is applied. Although the incidence of the first supply pulse after connexion is random the incidence of the first meter pulse can only vary (for a given value of x) within an interval equal to $1/n$ of the nominal metering interval. Subject to this limited variation, by choosing the value of x the first meter pulse can be positioned in time relative to the answer signal. If, for example, $x = 1$ the first meter pulse will occur near the beginning of the first nominal metering interval, but if $x = n$ it will occur toward the end of that interval; the effect of altering the value of x in this way is illustrated in Fig. 3. By applying a special pulse immediately the answer signal is received an initial charge can be assured, but the extent to

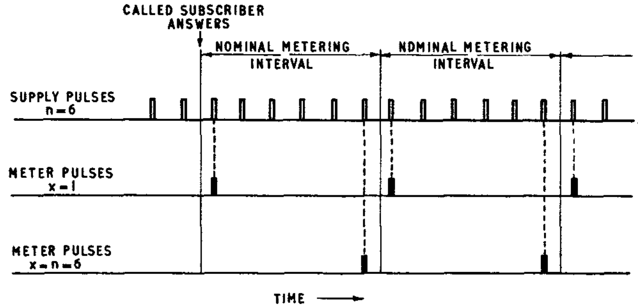

FIG. 3—EFFECT OF VARYING X

which this may be regarded as a setting-up charge depends upon the value of x which is chosen. After full consideration of this question it was decided that the pulse on answer should represent the only charge made in the initial metering interval, and that the value of x should be equal to $n + 1$. The pulse on answer can then be regarded solely as a prepayment charge for the first metering interval.

The practical application of this system is described later under "Metering of Trunk Calls," with reference to equipment designed to operate with a value of n equal to 6.

TRUNK-CALL TARIFF

The decision to employ periodic metering on subscriber-dialled trunk calls has led to a tariff which differs considerably from that applicable to trunk calls controlled by an operator. The new tariff for trunk calls dialled by ordinary subscribers during the full-rate period is shown in Table 1, which also gives details of the present tariff for trunk calls controlled by an operator.

TABLE 1

Ordinary Subscribers' Full-Rate Trunk Tariff

Subscriber-Dialled Calls		Operator-Controlled Calls	
Up to 35 miles	30 sec for 2d.	Up to 35 miles	1s.
35–50 miles	20 sec for 2d.	35–50 miles	1s. 9d.
Over 50 miles	12 sec for 2d.	50–75 miles	2s. 3d.
		75–125 miles	3s.
		Over 125 miles	3s. 6d.

Operator-controlled trunk calls are charged as shown for the first 3 minutes or part thereof, with proportionately smaller charges for each subsequent period of 1 minute. Call charges for subscriber-dialled trunk calls are, however, based upon the recording of unit-fee charges at intervals throughout the duration of the call, the intervals being shorter as chargeable distance increases. A comparison of these tariffs shows that the introduction of subscriber trunk dialling (S.T.D.) will bring about a reduction in the number of charge steps. In addition, the unit fee will be reduced to 2d.

A similar tariff applies to trunk calls dialled by coin-box users. The intervals allowed at unit fee are the same as for ordinary subscribers, but the unit fee for coin-box users is 3d. as the charge has to include an element which may be regarded as the rental of the coin-box.

On both ordinary and coin-box tariffs a cheap rate is applicable from 6 p.m. on weekdays and 2 p.m. on Sundays until 6 a.m. the following morning. In both cases the cheap rate is provided by increasing the time intervals by 50 per cent.

METERING OF TRUNK CALLS

The S.T.D. equipment that controls the application of meter pulses is the register-access relay-set.[2] During the time a call is being set up this relay-set is associated with a controlling register-translator and receives an indication of the metering rate appropriate to the call. This indication takes the form of a metering digit transmitted by the register and it is used to preselect one of a number of pulse supplies in preparation for metering. The present tariff requirements are met if, at any particular time, four different pulse supplies are made available at the register-access relay-set. On a trunk call, however, selection is confined to one of three supplies, the fourth being required in connexion with local calls, to which further reference will be made. On receipt of an answer signal the register-access relay-set sends one meter pulse which directly or indirectly operates the calling subscriber's meter and in effect charges for the initial interval irrespective of the periodic metering rate applicable. At the same time the preselected pulse supply is connected to a counter within the relay-set. The supply pulses are run at six times the frequency of the corresponding metering rate, while the counter is so designed that it causes the relay-set to deliver one meter pulse when the seventh supply pulse is received and thereafter one meter pulse for every six supply pulses received. By means of this device the second and subsequent metering intervals are precisely timed, but the first interval is in general greater than the nominal value. The effect is illustrated in Fig. 4, from which it

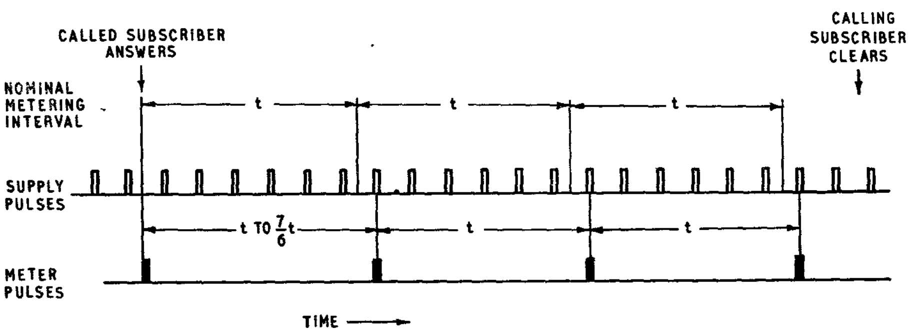

FIG. 4—TIMING OF METERING ON TRUNK CALLS

will be seen that any departure from the nominal metering interval operates in the subscriber's favour.

Rotary machines are used to generate the supply pulses and in practice two such machines are provided so that one can act as a standby for the other. The machines are designed to provide pulses at 20 different rates which, in conjunction with the divide-by-six counting arrangement in the relay-set, give metering intervals ranging from 8 to 360 seconds. Associated with the machines is a control equipment which provides for preselection of the supplies required for each tariff and for automatic switching from one selection to another at predetermined times to cater for daily changes in tariff. Facilities are included to permit a variation in the tariff change-over times from day to day, and the control equipment also provides for the monitoring of pulse supplies and the automatic change-over of machines both at regular intervals and under fault conditions. In addition, this equipment provides a tariff change-over signal which can be used to control the local-call metering equipment described later.

The machines and the control equipment are described in greater detail elsewhere in this Journal,[3] but sufficient has been said to show that the system has been devised in such a way that it not only provides for present tariff requirements, but also offers considerable flexibility to meet long-term changes.

LOCAL-CALL TARIFF

The introduction of periodic metering on trunk calls and the consequential registration of call charges as multiples of the unit fee make it impracticable to consider the trunk-call tariff without also considering the local-call tariff. After due consideration it was decided that local calls should be charged on a periodic-metering basis, as this would not only be fair in principle but would make it possible to bring about the reduction in the unit fee already mentioned. The tariff for local calls, which is being introduced as exchanges are equipped for S.T.D., is arranged accordingly and local calls will be charged at the rate of 2d. for 3 minutes (full rate) and 2d. for 6 minutes (cheap rate). These charges relate to calls originated by ordinary subscribers; for coin-box users the same periods of time are allowed but the unit fee is 3d.

METERING OF LOCAL CALLS

The method of charging for local calls follows the same general pattern as trunk-call charging and, as has already been indicated, the register-access relay-sets make provision for metering any local calls which are set up by means of the register-translators. The great majority of local calls are not, however, routed in this way but utilize other paths through the switching equipment. To provide periodic metering on such calls at existing exchanges, local-call timers[4] have been designed and these units are suitable for connexion at appropriate points in the switching train, their detailed construction varying in accordance with the type of exchange concerned.

The principle on which the local-call timers operate is somewhat different from that described in relation to trunk-call metering. When a local call is answered an initial meter pulse is transmitted in the normal way by, say, a final selector and this pulse is registered on the subscriber's meter to charge for the first time interval. The meter pulse is also detected in the local-call timer where it is used as a signal to connect a pulse supply running at 10 times the local metering rate. The supply pulses are counted in the local-call timer and a meter pulse is delivered for every 11 supply pulses received. The use of this technique safeguards the calling subscriber against loss of paid time during the first interval and gives him slightly more time than he should have during each subsequent interval (Fig. 5). It does, however, permit the equipment to be cheaper than it would be if each subsequent interval were of nominal duration.

The basic source of supply pulses for local-call timing is a master clock which delivers 6-second and 30-second pulses to a control unit.[3] This unit provides for long-term flexibility by generating supply pulses at five different frequencies, thus giving a corresponding choice of metering rates; it also includes an arrangement by which each supply-pulse frequency can be halved to provide for the cheap-rate tariff. In addition, the unit provides for monitoring and phasing the supplies. Each supply is distributed in nine phases, thereby limiting the battery load that can be imposed by the counting mechanisms of the local-call timers stepping in unison.

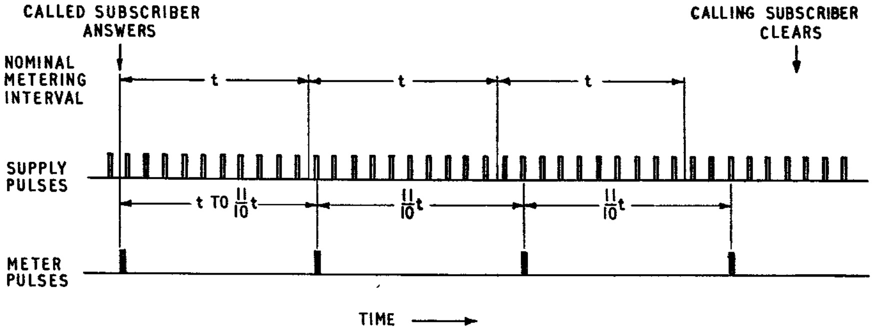

FIG. 5—TIMING OF METERING ON LOCAL CALLS

Tariff change-over is dependent upon receipt of the signal already mentioned under "Metering of Trunk Calls." At exchanges equipped with controlling register-translators, and consequently with equipment for the control of trunk-call metering, the change-over signal to the local-call metering equipment is directly applied. It can, however, be received over a junction circuit to control local-call metering equipment at a remote exchange. In these circumstances the arrangements are such that a junction fault will not prevent, but may precipitate, a change-over to the cheap rate.

CHECKING OF PULSE SUPPLIES

In addition to the facilities for automatic monitoring that are provided by both types of pulse-generating equipment, provision is made for checking by engineers and by operators. Engineering checks can be made directly on the equipment, but for operators' use, remote checking by means of a tone interrupted at pulse-supply frequency is being provided. To initiate a check on any supply at an exchange under her control, the operator dials a predetermined code. By observing the frequency of the signal received the operator can then check the supply and, by inference, verify that the correct tariff is in operation.

CONCLUSION

The introduction of periodic metering is advantageous from many points of view. On trunk calls subscribers will benefit because they will be able to make calls of short duration without incurring a 3-minute minimum charge. With periodic metering the minimum charge is no longer related to distance, but is in all cases only one unit fee. On longer-duration calls the charge will be more closely related to the time the connexion is held, thus avoiding the comparatively large incremental charge which was formerly payable if a call just exceeded, say, 3 minutes duration. In addition, subscribers will benefit on local calls of less than 3 minutes duration (6 minutes in the cheap period) on account of the reduction in the unit-fee charge which periodic metering has made possible. The system also offers the advantages of flexibility and simplicity. Full use is made of existing subscribers' meters and the accounting procedure is simplified considerably.

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[2] WALKER, N. Controlling Register-Translators, Part I.—General Principles and Facilities. (In this issue of the *P.O.E.E.J.*)

[3] RUSSELL, P. S., GORTON, B. D., LUMBER, A. L., and CUMMING, W. S. Pulse-Generating and Tariff-Control Equipment for Periodic Metering. (In this issue of the *P.O.E.E.J.*)

[4] ELLIS, D. R. B., and GORTON, B. D. Local-Call Timers. (In this issue of the *P.O.E.E.J.*)

Pulse-Generating and Tariff-Control Equipment for Periodic Metering

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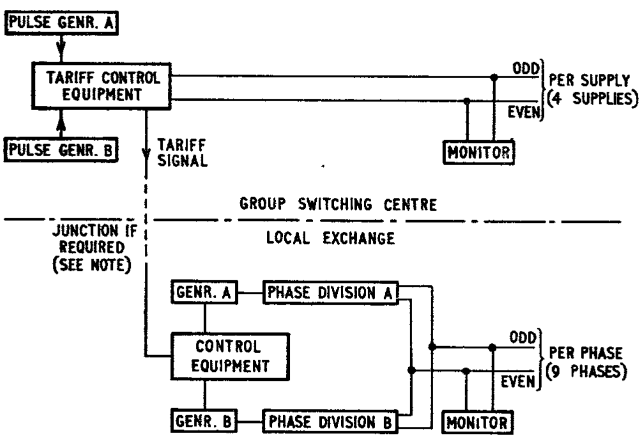
U.D.C. 621.373.43:621.395.361

The introduction of periodic metering for all subscriber-dialled calls, both trunk and local, and the change of the tariff at predetermined times of the day, require the provision of specially designed pulse-generating and tariff-control equipment. This article describes the mechanical design of the pulse generator and the equipment for automatically changing the tariff rates on calls controlled by register-translators. The pulse supplies for local-call timing are required at every local exchange and are generated by a separate unit, a description of which is also given.

INTRODUCTION

THE main items of equipment that have been designed for the generation and control of pulses for periodic metering[1] are shown in Fig. 1. The tariff-control equipment will normally be located at the group switching centre, and the associated pulse generators will supply the range of pulses required for those calls set up by the register-translator equipment.

In addition, specially designed pulse-generating and control equipment will be provided at all local exchanges for periodic metering on local calls.



Note: The tariff-control signal from the group switching centre may serve several exchanges

FIG. 1—BLOCK SCHEMATIC DIAGRAM OF PULSE-GENERATING AND TARIFF-CONTROL EQUIPMENT

THE PULSE GENERATOR

The pulse generator is designed to provide the pulse supplies necessary to meet the present and possible future requirements of the periodic-metering system. The facilities provided by the machine are:

(*a*) 20 pulse supplies with periodicities of $1\frac{1}{3}$, $1\frac{2}{3}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{3}$, $3\frac{3}{4}$, 4, 5, 6, $6\frac{2}{3}$, $7\frac{1}{2}$, 8, 10, 12, 15, 20, 30, 40 and 60 seconds.

(*b*) 60-second change-over pulse out of phase with the other pulses for use by the tariff-control equipment only.

(*c*) A maximum output on each pulse supply of 10 amp.

(*d*) Repetition accuracy of ±1 per cent.

(*e*) Pulse length of 250 ms ±10 per cent.

There are several methods by which pulses can be generated to meet the above requirements but one of the most reliable and straightforward methods is by the use of cam-operated spring-sets, as on existing meter-pulse and ringing machines, but with the speed of the motor driving the camshafts controlled so that the required accuracy of pulse periodicity is obtained.

The machine, which has been given the title Machine, Pulsing, No. 12A, is shown in Fig. 2. Basically, it comprises four camshafts driven by a 50-volt d.c. motor, with the armature and camshafts rotating in a vertical plane. The motor and camshaft mountings are fixed by spigots to the gear-box, which also acts as the base of the machine. A centrifugal governor maintains the speed of 3,000 r.p.m. with an accuracy better than ±1 per cent. Included in the motor circuit is a thermal-type overload protective device which operates and disconnects the motor circuit should the armature current or machine temperature rise above a certain limit. The motor speed is checked by means of a stroboscope and markings on the periphery of a wheel fitted to the armature shaft. The wheel can be seen in Fig. 2 through the lower cut-out in the motor casing.

The camshaft nearest the motor is driven at 15 r.p.m. through a two-stage worm reduction gear giving a total ratio of 200 : 1. The second, third and fourth camshafts are driven in turn from the first camshaft through spur gears and rotate at 12, 4 and $1\frac{1}{2}$ r.p.m. respectively. Back-lash has been kept to a minimum and a long life with little need for attention is expected from the gear-box. The camshafts are not an integral part of the gear-box but are connected by flexible couplings so that the required phasing between the shafts can easily be adjusted. This is a necessary feature due to the method of obtaining the pulses of longer periodicity.

The spring-sets are mounted on the camshaft mounting brackets at an angle to the front of the machine, as shown in Fig. 2. This manner of mounting reduces to a minimum the distance between the camshaft brackets, and thus the overall length of the machine, while still maintaining full accessibility to the spring-sets for maintenance purposes. Each spring contact is made of tungsten and is capable of breaking an inductive load of 5 amp when quenched with a 1 μF capacitor. Two outputs are supplied for each pulse giving the required total load capacity of 10 amp. The spring-sets and cams are enclosed in a protective cover but are visible through a perspex window fitted to the front of the cover.

Spark-quench capacitors connected across the spring-sets that generate the 250 ms pulses are mounted inside a box fitted to the rear of the machine, and on the back of the box is mounted the terminal strip for all the machine wiring. Inter-connexion between the spring-sets of the fast and slow shafts is carried out at the terminal

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[1] WALKER, N. Periodic Metering. (In this issue of the *P.O.E.E.J.*)

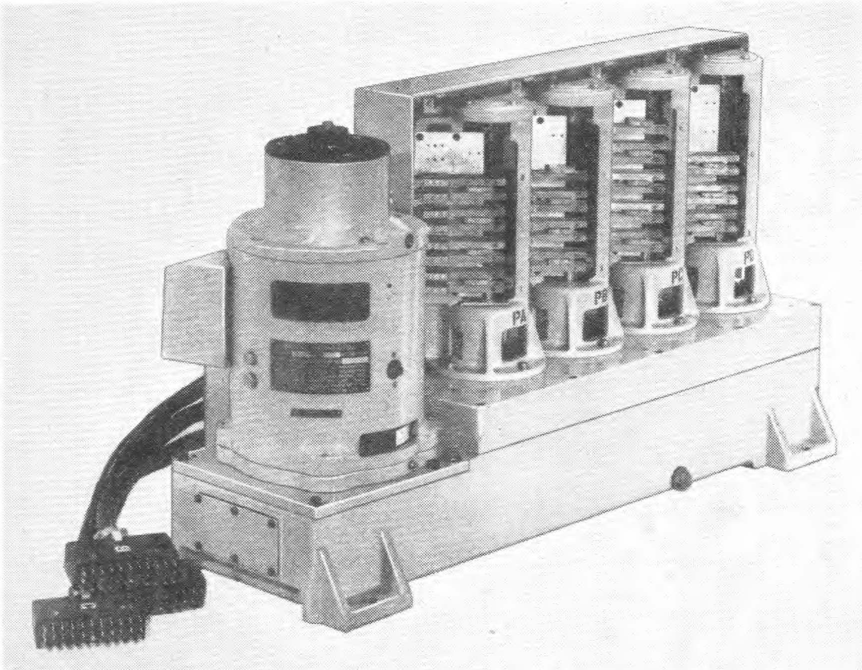


FIG. 2—MACHINE, PULSING, NO. 12A WITH FRONT COVER REMOVED

strip, to which are also connected the outgoing flexible conductors to the three 33-way machine-connecting plugs.

The machines are designed to mount between the vertical members of the standard 2 ft 9 in. apparatus rack and two machines are provided for every installation, each in turn acting as a main and standby. With this method of working the wear tends to be equalized and thus full use is made of both machines.

Camshaft Design

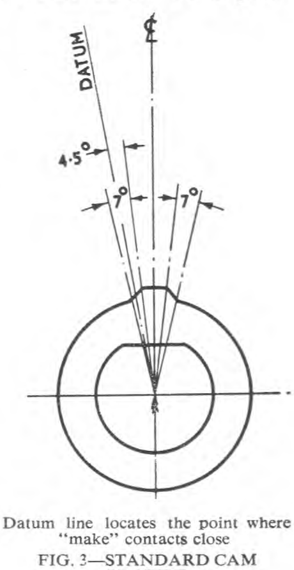
When the decision was made to use a machine for generating the required pulses it was apparent that in order to cover the wide range of pulse periodicities, while maintaining a reasonably accurate pulse-length, several camshafts would be necessary because it is only at higher camshaft speeds that pulse lengths of sufficient accuracy can be achieved.

The design of cam profile for operating spring-sets generating fixed-length pulses should allow the cam follower to operate the spring-set at a point on the slope leading to the cam projection so that the wear which takes place on the leading and trailing edges of the projection does not alter the operate period over the life of the cam. From Fig. 3 it will be seen that the slope used, on what is the standard cam design for this type of operation, extends over 7° and the point on the slope where the make contacts operate is displaced by 2·5° from the start of the slope, which means that 4·5° of the slope on either side of the cam projection functions as a part of the make period, the remainder of the period being obtained by the length of the projection between the slopes. Variation in adjustment and wear of the cam follower, lifting pin and contacts affect the operate and release point of the spring-set on the slope of the cam projection, and thus the smaller the proportion of the make period allocated to the slope the less the effect these factors have on the pulse length. This means that for accurate pulses the speed of rotation of the cam and hence the camshaft must be made as high as possible.

To generate a 250 ms pulse at a 60-second periodicity would require a total make period involving only $1\frac{1}{2}$° rotation of a camshaft turning at 1 r.p.m. At such a slow speed accuracy in the pulse length is impossible; in fact, before a reasonably accurate 250 ms pulse can be obtained by direct means a shaft speed of not less than 8 r.p.m. is required, and even at this speed the tolerance allowable on cam manufacture and spring-set adjustment would be extremely small.

This difficulty of providing satisfactory pulses at the longer periodicities can be overcome by lengthening the pulses so that a reasonable cam projection can be obtained and interrupting them at the appropriate time by a 250 ms pulse supplied from a camshaft rotating at a speed high enough to enable an accurate pulse to be generated. Fig. 4 shows one method used on the machine for generating and supplying the 250 ms pulses at the slower periodicities. Spring-set INT A generates the 250 ms pulse at a 5-second periodicity on a relatively fast camshaft but the pulses are only connected to the load when spring-sets INT B, INT C and INT D are operated. It will be seen that although INT A is supplying the load of three outputs the actual loading of the spring-set at any time is only equal to the load on one pulse output. Other pulses are obtained by taking this method a stage further by inter-relating the speed of two cam shafts. For example, a pulse having a periodicity of 60 second can be obtained from a shaft rotating at 1 r.p.m., but it can also be generated by connecting two pulses of 4-second and 15-second periodicity in series, as shown in Fig. 5. This permits the speed of the shaft supplying the 60-second pulse to be increased from 1 r.p.m. to 4 r.p.m. Fast shaft speeds have the advantage of shorter transit time of the lever spring on the spring-set, wider limits on adjustments, fewer cam projections, and wider manufacturing tolerances.

Where two pulses are connected in series to generate a pulse of longer periodicity it is essential that the camshafts bear a fixed relationship to each other. This is ensured by the gear-box. Furthermore, the periodicity of the faster pulse must not be a factor of the periodicity of the slower pulse; also, the pulse length must be arranged so that no spurious pulses are given at any intermediate point in the time cycle. Referring to Fig. 6, it can be seen from the timing chart that 15 seconds after the 4-second and 15-second pulses coin-



Datum line locates the point where "make" contacts close

FIG. 3—STANDARD CAM PROFILE

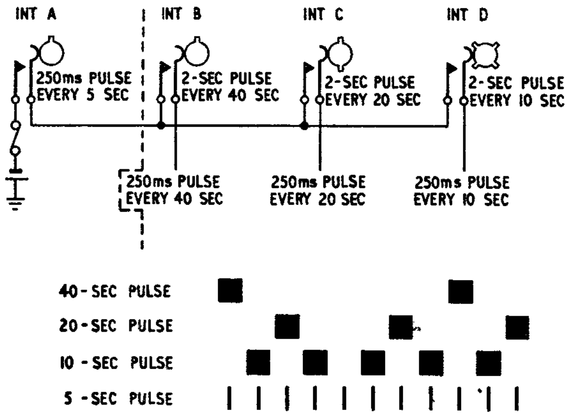


FIG. 4—GENERATION OF 40-, 20- AND 10-SECOND PULSE SUPPLY

cide to generate the 60-second pulse, the 15-second pulse is again supplied followed in turn by a 4-second pulse. The displacement in time at this point in the cycle between the centre points of the two pulses is thus only 1 second. It is clear, therefore, that the pulse length of the 15-second pulse must be short enough to avoid overlapping at a point such as this, while also being long enough to give a suitable cam projection. A pulse length of 1 second allows a satisfactory projection on the 15-second pulse camshaft, which is turning at 4 r.p.m., and it also gives sufficient clearance between the two pulses at the other points in the cycle. The 4-second pulse has a length of 250 ms and the nominal clearance will therefore be 375 ms, out of which allowance is made for adjustment and manufacturing limits.

Maintenance

It is expected that the machines will prove to be very reliable in service and they should run for years without any major overhaul being necessary. Most of the wear will take place on the spring-sets, mainly on the cam followers, lifting pins, and contacts. This wear tends to shorten the make period and is catered for by an adjustable buffer block, which allows the length of the make period to be altered. The machines should require very little maintenance attention and this is expected to be confined to an occasional check of the motor speed and spring-set adjustment.

TARIFF-CONTROL EQUIPMENT

The tariff-control equipment is located between the meter-pulse generators and the distribution point (Fig. 1) and effects changes in tariff by connecting the appropriate

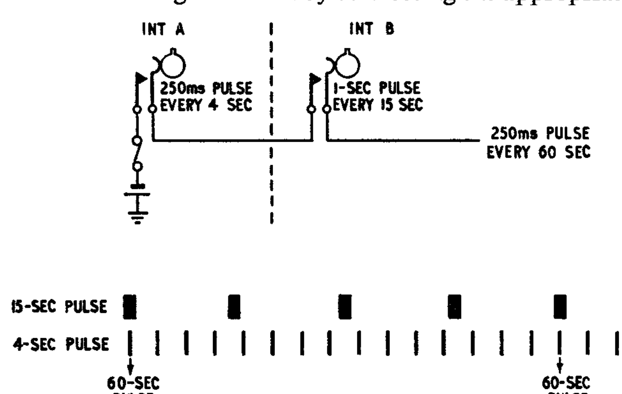


FIG. 5—GENERATION OF 60-SECOND PULSE SUPPLY

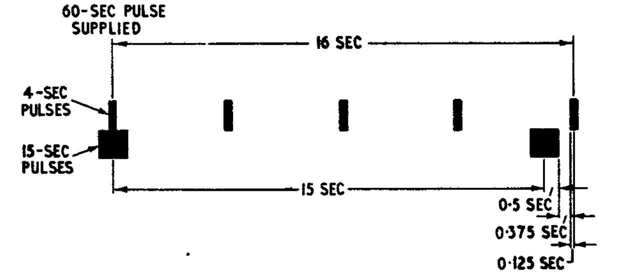


FIG. 6—PULSE-RELATIONSHIP CHART SHOWING PROXIMITY OF 4- AND 15-SECOND PULSES 15–16 SECONDS AFTER 60-SECOND PULSE HAS OCCURRED

pulse supplies at predetermined times to the distribution; it also monitors the pulse output and controls the change-over between machines.

The equipment comprises tariff-selection relays and first-pulse-absorption relays associated with each pulse generator, and the other items that are common to both machines. The latter include a Clock No. 62A, which is of the ratchet-and-pawl type, driven from the exchange master clock, a uniselector clock associated with an automatic tariff-control circuit, a pulse monitor, a change-over control and electronic alarm-delay circuit, and the manual control and indicator panel. The arrangement of the equipment is shown in Fig. 7.

Tariff-Control Circuit

The tariff-control circuit is required to control changes in tariff at predetermined times and consists of a uniselector that is stepped by half-hourly pulses from a Clock No. 62A and makes one complete revolution of its wipers every 24 hours. The wipers remain on each contact for half an hour and a tariff must be in force for a period that is a multiple of half an hour.

One arc of the uniselector clock controls the main tariff-selection relays, the release of one and the operation of another initiating a tariff change. Relay F controls the "Full" tariff, and relay C controls the "Cheap" tariff. Provision is made for a "Medium" tariff controlled by relay M should a third tariff rate be required. Other arcs control the half-hour lamps on the indicator panel that, together with the AM and PM (before and after noon) lamps, provide a display of "exchange" time.

Pulse Connexion Field

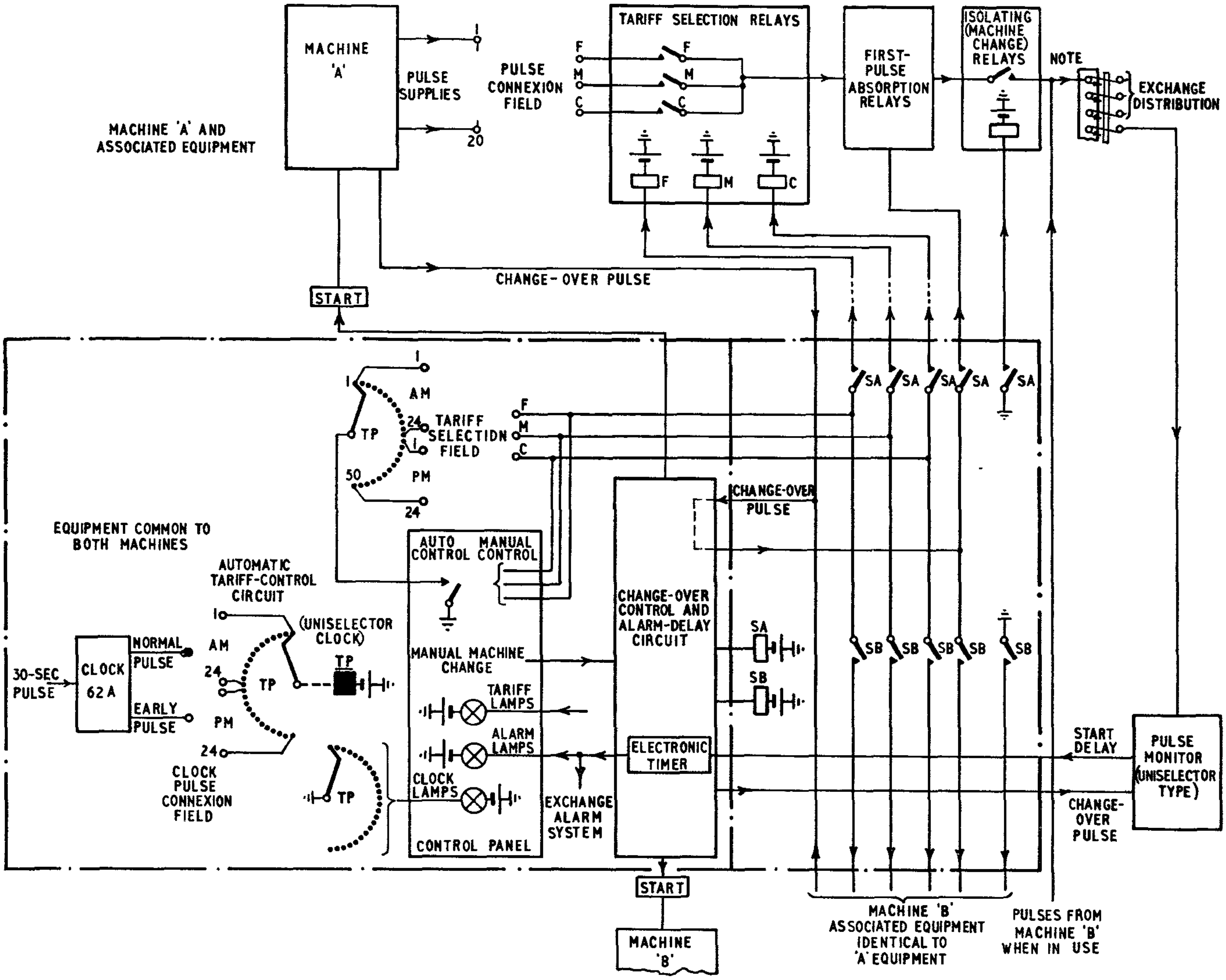
The pulse connexion field gives the maximum possible flexibility in that any pulse supply may be connected to the register-access relay-sets via the cross-connexion field and contacts of the tariff-selection relays. Two pulse rates, providing for the two tariffs, "Full" and "Cheap," are cross-connected to tags F and C associated with each pulse distribution.

Tariff-Selection Field.

The contacts of the clock uniselector are wired to tags on one side of the tariff-selection field designated AM 1–24 and PM 1–24. These are cross-connected to tags F or C according to the national daily tariffs.

Clock-Pulse Connexion Field

Pulses from the exchange master clock are used to control the Clock No. 62A, which in turn produces pulses to step the uniselector clock every half-hour. Two 30-minute pulses are however produced, one at the half-hour and the



Note: 10 meter-pulse supplies are provided, each in duplicate (odd and even supplies)

FIG. 7—BLOCK SCHEMATIC DIAGRAM OF TARIFF-CONTROL EQUIPMENT

other 1½ minutes earlier. The clock-pulse connexion field is provided to enable either pulse to be selected. Tags AM 1–24 and PM 1–24 (Fig. 7) are wired to an arc of the clock uniselector and may be cross-connected to either pulse. The "early" pulse enables the tariff change to be started 1½ minutes before the scheduled time when changing to a cheaper tariff. Since a 30-second pulse is used to drive the Clock No. 62A, in actual time the clock may be anything up to 30 seconds slow, and, due to the fact that the equipment may wait 60 seconds for the essential change-over pulse, the change of tariff is commenced early, ensuring that the cheaper tariff is always connected by the scheduled time.

Changes to a dearer tariff are started at the scheduled time, and since the factors described above are again operative, the change may be completed 1½ minutes late, which again is to the advantage of the subscribers.

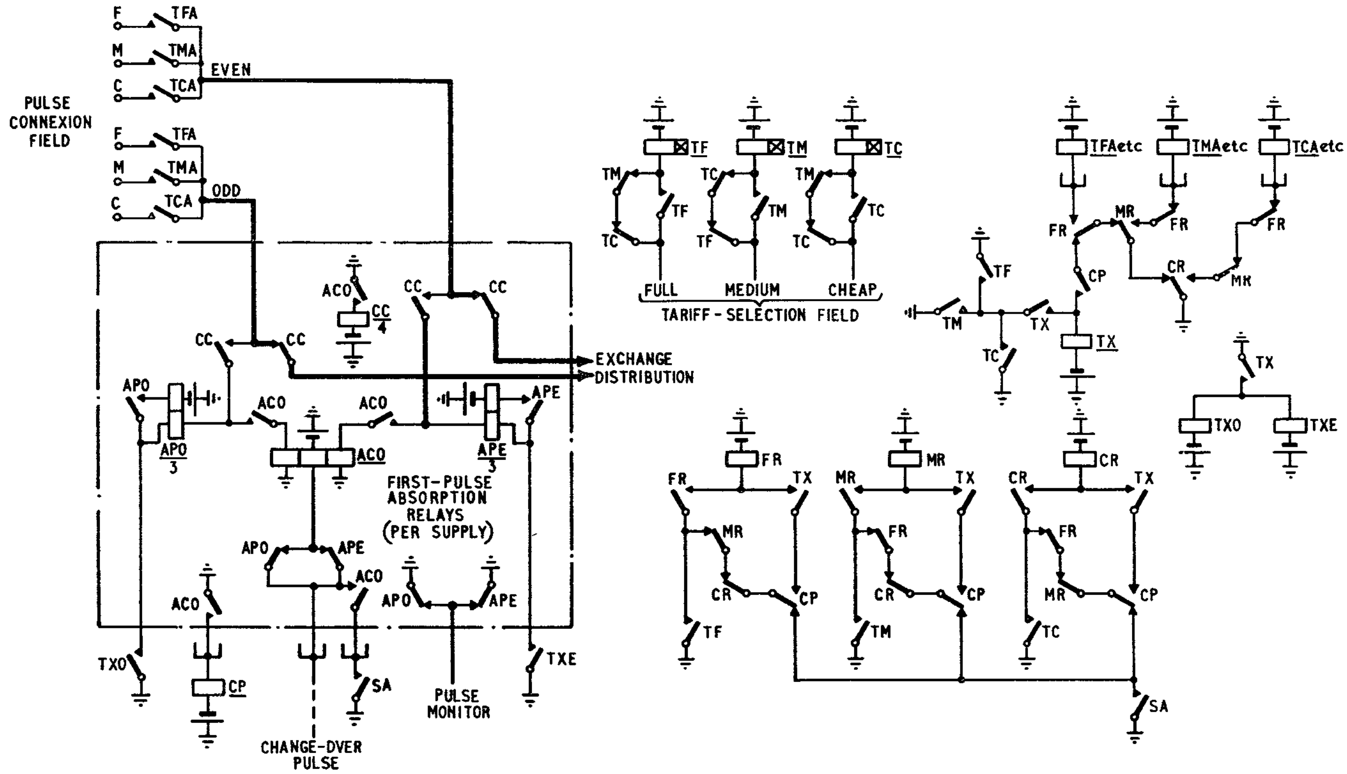
Change-over Pulse

The change-over pulse is provided for use within the equipment to start circuit operations for tariff and machine changes and to control the pulse monitor. It recurs every 60 seconds during the "off" period of all other pulses. During tariff and machine changes the distribution is disconnected from the machine while this pulse is "on," i.e. in the no-load period.

Pulse Monitor

The pulse monitor incorporates a uniselector which is stepped every minute by the change-over pulse. Between pulses, five of its wipers are connected to pulse-distribution leads and failure to detect a pulse on each lead initiates a machine change. In all there may be 20 leads used, 10 "odd" and 10 "even" supplies, and therefore a monitoring cycle is completed in four minutes. The pulse generation is arranged so that a pulse is normally connected to each lead within 36 seconds of the change-over pulse and an electronic timer in the equipment is set at 45 seconds on receipt of each change-over pulse. If the supply pulses are detected the timer is reset to time a 75-second period during which time a change-over pulse should be detected.

Failure to detect a supply pulse on each lead within 45 seconds of the change-over pulse, or failure to detect a change-over pulse within 75 seconds of the last supply pulse detected, causes a change of machines.



Special alloy contacts are fitted on relays TFA, TMA, TCA and CC

FIG. 8—SCHEMATIC DIAGRAM OF TARIFF-SELECTION AND FIRST-PULSE-ABSORPTION RELAYS

Automatic Tariff Changes

When the clock uniselector steps to a contact on which a change of tariff occurs the relay associated with the old tariff is released and the relay associated with the new tariff operates. Nothing further happens until on receipt of the next change-over pulse, which may occur up to 60 seconds later, the old tariff is disconnected and the new tariff is set up. The circuit is shown in Fig. 8.

First-Pulse Absorption

Before each supply is reconnected to the distribution after a change of tariff or machine the first pulse received from the machine is absorbed (Fig. 8). First-pulse absorption prevents the possibility of subscribers being overcharged during tariff and machine changes. Were it not for the absorption of the first pulse it would be possible to connect two pulses to the distribution in quick succession, one just before the old tariff is disconnected and another immediately after the new tariff is applied.

Machine Changes

The machines are run on alternate days to distribute wear evenly and also to prevent the associated equipment being idle for long periods. This 24-hour machine change takes place at 8 a.m., when it is probable that the load on the equipment is light and maintenance staff are in attendance.

The machines are also changed over automatically under the following fault conditions:

(*a*) When a meter pulse is not detected.

(*b*) When a change-over pulse is not detected.

(*c*) When a supply pulse is not absorbed following a tariff or machine change.

(*d*) When a change-over pulse is not received following a tariff or machine change.

(*e*) When the machine in use fails.

As with tariff changes, the distribution is not disconnected from the machine until a change-over pulse is received. From this it follows that if the machine change is initiated because the change-over pulse itself is missing some alternative arrangement must be made to disconnect the distribution at random. This presents the problem of breaking heavy currents of an inductive nature by relay contacts. After consideration of possible alternatives it was decided to use a modified heavy-duty relay developed for use with this equipment and having the following features:

(i) Special alloy contacts.
(ii) An armature with increased iron mass.
(iii) Increased armature travel.
(iv) Increased contact clearance (minimum 45 mils).
(v) Fast release time.

With this type of relay it was found that loads in excess of those likely to be encountered could be disconnected without arcing at the contacts. Quenches have been provided to suppress any residual sparking.

Signals to Other Equipment

Whenever the cheap tariff is in force a continuous signal is sent to the multiphase-pulse-generator circuit that provides the pulses for the local call timers. This ensures that the tariff is changed for local and trunk traffic at the same time.

A continuous signal indicating the tariff in force is sent to the tariff-controlled switching circuit for traffic meters, which connects the appropriate block of traffic meters to the access wires of the register-access relay-sets.

CIRCUIT OPERATION OF AN AUTOMATIC TARIFF CHANGE

When the clock uniselector steps to a contact on which a change in tariff occurs at, say, 6 p.m. from Full to Cheap rate, relay TF (Fig. 8) releases and in turn releases relay TX to register the condition of the impending change. Relay TC then operates as the first step in setting up the new tariff. Relay TX releases its relief relays TXO and TXE, which are Type 10 relays[2] having 10 make contacts. Relay TXO releases all the first-pulse absorption relays, APO, associated with the odd leads, while relay TXE releases all the APE relays associated with the even leads, of the 10 meter-pulse supplies. The release of these relays extends an earth to stop the pulse monitor until the change in tariff and first-pulse absorption have been completed. At the same time a relay operates to begin a 75-second delay period during which a change-over pulse should be received within 60 seconds if the equipment is working satisfactorily.

When this pulse is received the ACO relay associated with each meter-pulse-supply control circuit is operated. This relay operates relay CP and the associated CC relay, which disconnects the odd and even pulse-supply leads. Relay CP releases relay FR, which in turn releases its relief relays TFA, TFB, TFC, TFD and TFE and the old tariff is then disconnected.

The new tariff is then set up in the following manner. With relays CR, MR and FR released the circuit proves that the old tariff has been disconnected and with relays TC and CP operated a circuit is completed for relay TX to re-operate. This relay operates relay CR and relays TXO and TXE. Relay CR operates relief relays TCA, TCB, TCC, TCD and TCE and the supply pulses associated with the new tariff are connected to the pulse-absorption relays. Disconnexion of the old and setting up the new tariff takes place during the 250 ms period of the change-over pulse. The arrival of the change-over pulse is used to stop the 75-second delay period and to start a 45-second delay period during which time at least one supply pulse, depending on the pulse rate, should be received. This first pulse is absorbed but subsequent pulses are connected to the distribution in the following manner.

Relays APO and APE operate to the first supply pulse, at the new rate, on the odd and even leads respectively and hold to earth at the TXO and TXE contacts. Although relays APO and APE disconnect the operate winding of relay ACO, the relay holds over its earth-connected windings to the battery pulse on both odd and even supply leads. When the battery condition is replaced by an earth, relay ACO is short-circuited and releases. Relay CC then releases and subsequent pulses are connected to the distribution via the meter-pulse supply lead. When the last APO and APE relays have operated, earth is disconnected from the pulse monitor, which restarts.

PULSE SUPPLY FOR LOCAL-CALL TIMING

The application of periodic metering to local calls necessitates the provision of pulse-generating and control equipment designed specially for the purpose; this equipment is additional to the tariff-control equipment that is concerned with the periodic metering applied to calls controlled by the register-translators.

The pulse-generating and control equipment is required to deliver 50-volt negative-battery pulses of 250 ms nominal duration, and to earth the distribution leads between pulses. Pulses can be generated at five different rates, the intervals between pulses being 12, 18, 24, 30 or 36 seconds, and two of these rates can be used simultaneously, one for "ordinary" subscribers and one for call offices. To cater for a cheap tariff rate, the equipment is arranged to halve the periodicity of the pulse supplies in use on receipt of the appropriate tariff change-over signal.

Layout of Equipment

The equipment is mounted on a standard miscellaneous-apparatus rack and consists of a control circuit, "A" and "B" pulse generators, "A" and "B" phase-division equipments, and a common pulse monitor (Fig. 9). Distribution fuse panels are also mounted on the rack, together with multi-way disconnect jacks for maintenance of the special-alloy heavy-duty pulsing contacts which are connected to full 50-volt battery. To facilitate maintenance, particularly of the heavily worked uniselectors, the pulse-generating and monitoring circuits are incorporated in jacked-in relay-sets. When the "A" pulse generator and phase-division equipments are supplying the pulses, the "B" equipment acts as standby, and every 24 hours, on receipt of a clock pulse, the roles of the "A" and "B" equipments are interchanged. Interchange can also be effected manually by the operation of a key, and in addition to the normal "Receive Attention" and "Reset" keys a "Test Change-over" key is provided to simulate failure of one of the supplies.

Generation of Pulses

Earth pulses at intervals of 6 and 30 seconds are readily available in the larger automatic exchanges from the Clock No. 36. The 30-second pulse only requires conversion to a battery pulse of the necessary duration to meet one of the specified basic rates, and the remainder can be obtained by utilizing suitably wired arcs of a uniselector stepping to the 6-second clock pulses. The cheap-rate requirement can be met by absorbing alternate pulses as they are produced by the generator.

Pulse rates required for the "ordinary" and coin-box timing equipment are connected by means of straps within the pulse-generating relay-set, to the "OR" and "CB" tags respectively (Fig. 9). Relay P operates to the 6-second pulses and contact P1 steps uniselector SA. With the 18-second pulse rate in use, wiper SA2, in stepping to contact 3, operates relay OR, via the strapping and contact CR1. At the end of the next 6-second pulse, wiper SA2 steps to contact 4, and relay OR releases. Relay OR in releasing initiates the connexion of battery pulses to the phase leads. This cycle of operations is repeated, and earth via wiper SA2 operates relay OR on contacts 6, 9, 12, etc., to 24. On contact 25 a self-drive circuit is completed to step the wipers to contact 1, thus converting uniselector SA into a 24-outlet switch and thereby permitting its use as a "divide by 3 (2, 4 or 6)" element.

Basic pulse rates of 12, 24 and 36 seconds are similarly derived from suitably wired arcs of the SA uniselector. The 30-second pulses are derived directly from the pulsing of relay PU to 30-second clock pulses.

Phasing

To prevent overloading the exchange negative and positive batteries as a result of the large number of

[2] ROGERS, B. H. E. The Post Office Type 10 Relay. *P.O.E.E.J.* Vol. 51, p. 14, Apr. 1958.

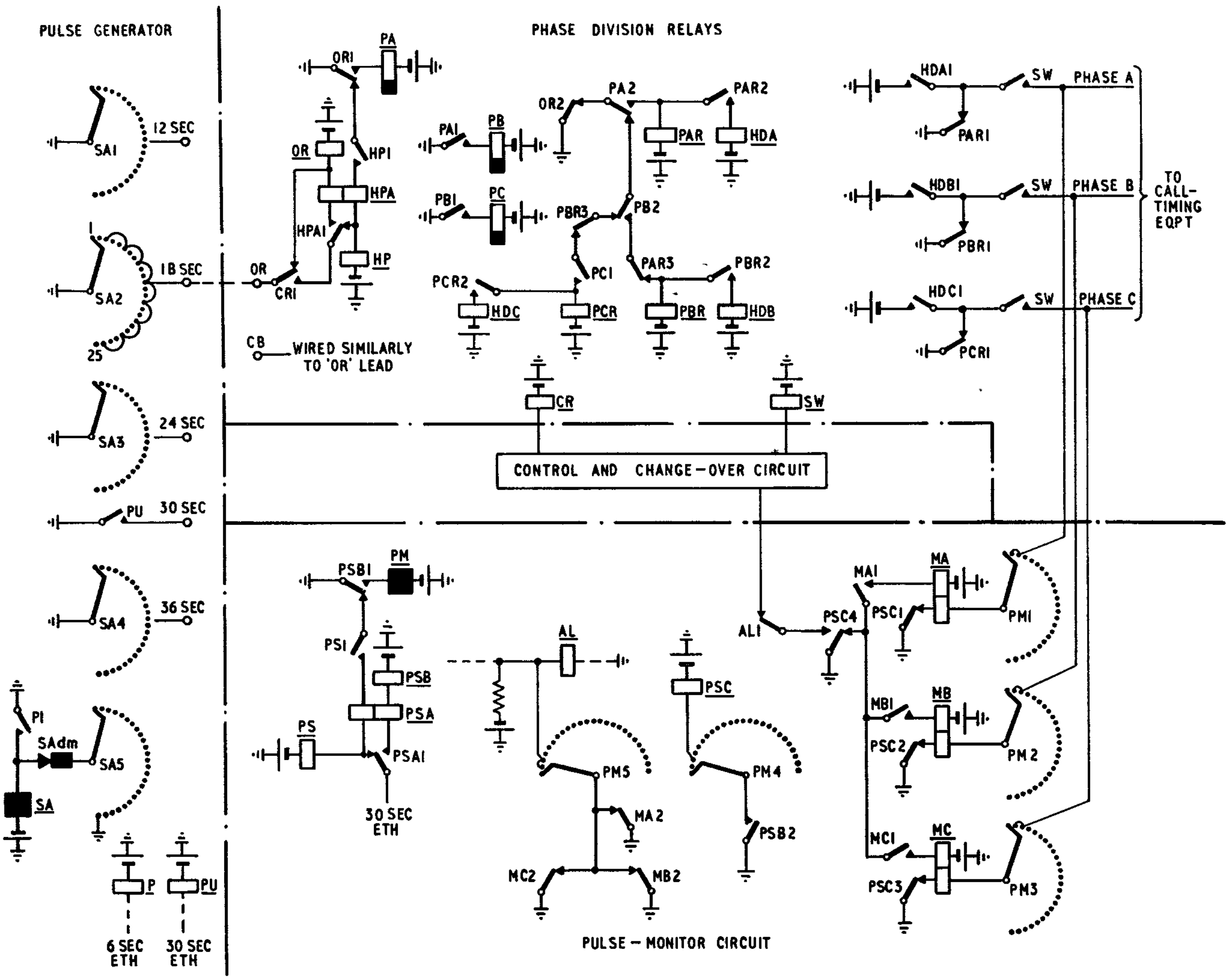


FIG. 9—SCHEMATIC DIAGRAM OF LOCAL-CALL TIMING EQUIPMENT

simultaneous counting operations taking place during local-call timing, it is necessary to produce the pulses in separate phases. For connexion to the racks of equipment timing "ordinary" subscribers' traffic (i.e. local-call timing circuits, periodic-metering circuits and 1st code selectors incorporating periodic metering), nine phases are provided. Each phase is split into an odd and even supply, the odd supply being connected to odd-numbered racks and the even to even-numbered racks. Similarly distributed are two additional phases, which are connected to the coin and fee-checking equipments associated with the pay-on-answer coin-box lines. For both "ordinary" and coin-box call timing, each shelf on a rack of equipment is connected to a separate phase. Phasing is effected by a sequential release of timed relays, each of which connects a pulse for the duration of its release lag. In Fig. 9 the circuit to provide three of the nine "ordinary" phases is shown; similar elements provide the two coin-box phases.

Relay OR is operated and released at 18-second intervals under the control of arc SA2. When relay OR operates, relays PA, PB and PC operate in sequence, and when the wiper is stepped off the wired contact, relay OR releases and disconnects relay PA at OR1. During the release lag of relay PA, relay PAR operates, disconnecting earth from phase lead "A" and operating relay HDA. With contact HDA1 operated, a battery pulse is connected to phase lead "A" until relay PA releases. Relays PAR and HDA then release, relay HDA being designed to have a shorter release time than relay PAR. With relay PA normal, the slow release of relay PB commences and, during its release lag, relays PBR and HDB operate, contact PBR1 disconnecting the earth from phase lead "B" and contact HDB1 connecting a battery pulse for the duration of the release lag of relay PB. A similar sequence is repeated during the release lag of relay PC. Contacts PAR 3 and PBR 3 prevent any overlapping of phases, e.g. only when relay PAR is released can relays PBR and HDB operate and connect the pulse to phase lead "B."

Cheap Tariff Rate

Relay CR is operated for the duration of the cheap-rate period by an earth extended from the tariff-control equipment. With contact CR1 operated, wiper SA2 in stepping to a wired contact now operates relay HP, and contact HP1 prepares an operate circuit for relay HPA. When the wiper steps to the next contact, relay HPA operates and contact HPA1 prepares the circuit for the operation of relay OR. Relay OR operates when wiper

SA2 next steps to a wired contact, and on its subsequent release a series of phased pulses is generated as before. Thus alternate pulses, via wiper SA2 at 18-second intervals, are absorbed.

Pulse Monitoring

In the method of pulse monitoring employed, checking relays MA, MB and MC are connected to sets of three phase leads in turn, for a period sufficient to cover the slowest rate of pulse repetition. If any one of these relays fails to operate, indicating an absence of pulses on the lead under examination, a deferred alarm indication is given and change-over to the standby equipment takes place. Should the standby equipment also fail, a prompt alarm is given.

One-minute stepping of the pulse-monitor uniselector PM is achieved by using a 30-second clock pulse in conjunction with a pulse-halving circuit (relays PS, PSA and PSB). Relay PSB operates at 1-minute intervals to step the uniselector, and by wiring pairs of contacts on the arcs of the phase leads, a 2-minute inspection period is provided. Relay PSC operates at the end of each 2-minute period, and should any of the checking relays have failed to operate, relay AL remains short-circuited. With contact AL1 normal, contact PSC4 connects a pulse to operate the alarm and change-over equipment; the standby equipment is then brought into use.

CONCLUSIONS

In the design of the pulse-generating and tariff-control equipment every effort has been made to ensure accuracy and reliability. The circuits include safeguards against overcharging the subscribers, while several vital circuits have been provided in duplicate to ensure that there shall be no failure of the supply of meter pulses.

Some of the equipment was designed in advance of a settlement of tariff policy and is more complicated than is now necessary. Several economies are being considered for more-simplified versions of the equipment.

ACKNOWLEDGEMENT

The authors acknowledge with thanks the assistance given in the development of the Machine, Pulsing, No. 12A by the manufacturer, W. Mackie and Co., Ltd.

The 5-Digit Meter

U.D.C. 621.395.6:621.395.363

WITH the introduction of subscriber trunk dialling more calls and more call fee-units will be automatically recorded on subscribers' meters, and so more subscribers' meters than at present will record a total of over 10,000 metering pulses in the period between successive meter readings. The meters of these high-calling-rate subscribers must either be read more frequently, which would be expensive, or must be changed for a meter capable of recording a total greater than 9999.

A new meter, to be known as the No. 150 Type, having five digit-wheels instead of four as in the No. 100 Type meter, has therefore been developed. It can be mounted in the same drillings and at the same mounting centres as the 100-type meter, and hence 100-type meters on heavy-calling-rate lines can be directly replaced by

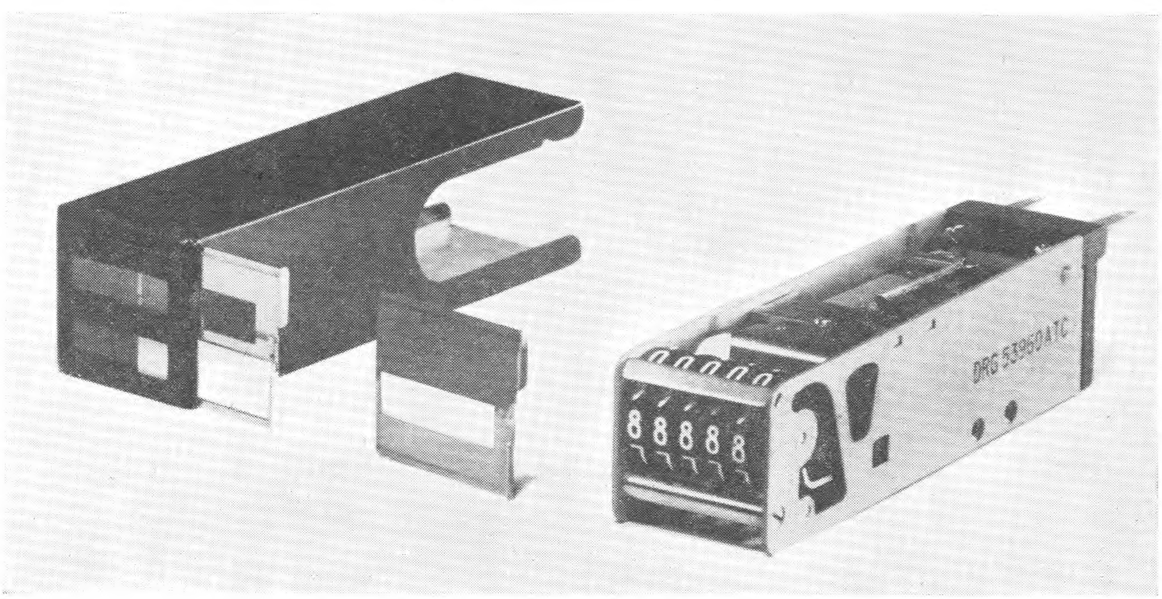


FIG. 1—THE 150-TYPE METER

150-type meters. Certain simplifications of design make it possible to produce the new meter at approximately the same cost as the old, and it is therefore economic to use the new meter for all new provision of subscribers' and traffic meters irrespective of calling rates.

The frame of the new meter is made wider than the 100-type meter frame to accommodate the five number-wheels. The left-hand side of the frame is set outwards at the front alongside the number-wheels and is also ribbed outwards by the same amount towards the rear so that the cover fits securely (see Fig. 1). Over the remaining length of the frame, however, it is the same width as the 100-type frame so that several of the meter piece-parts, including the coil assembly and part of the armature assembly, are identical with the 100-type parts. The meter cover is necessarily wider to fit the wider frame; but it has no end-cap like the 100-type meter, and it is because of this that the new meter is capable of being mounted at the same centres as the old.

The amount of outward set of the frame is only 0·040 in., the number-wheels being narrower than in the old meter. The numbers, although narrower, are plainer to view or to photograph for it has been possible to set them nearer to the window in the cover because there is no cover end-cap. Moreover, the wheels are of dyed black plastic, moulded in "Diakon" with inset white numbers, and they are not prone, as were the 100-type die-cast metal wheels, to disfiguration through loss of some of the peripheral coating of dull-black enamel.

To help ensure correct engagement between the number-wheels and pinions and to take up any slight wear which may occur on the ends of the number-wheel bosses, a spring plate of rectangular shape, formed out of 0·002 in. thick nickel-silver, is fitted over the number-wheel spindle between the number-wheels and the left-hand side of the frame. The end thrust exerted by this spring on the number-wheels is of the order of 10 grammes or less.

Besides their greater clarity, plastic number-wheels have the advantage over metal wheels that friction at the spindle remains low indefinitely, and a very sparing application of oil to the spindle during assembly will suffice for some millions of operations. They have the disadvantage, however, of being less resistant to cutting wear, and sharply pointed pawls cause relatively rapid wearing away of plastic ratchet-wheel teeth. (The ratchet wheel is an integral part of the units-wheel moulding.) In the 150-type meter, therefore, the pawl tip is rounded, the pawl being a thin nickel-silver spring with its end bent into a semicircle of 0·020 in. radius, as shown in Fig. 2. The other end of the spring pawl is riveted to the armature and so there are no pawl pivots which, in the 100-type meter, are sources of wear which eventually cause erratic stepping. This method of pawl construction is cheaper than the pivoted pawl of the older meter and helps to keep the cost of the 150-type meter comparable with that of the 100-type.

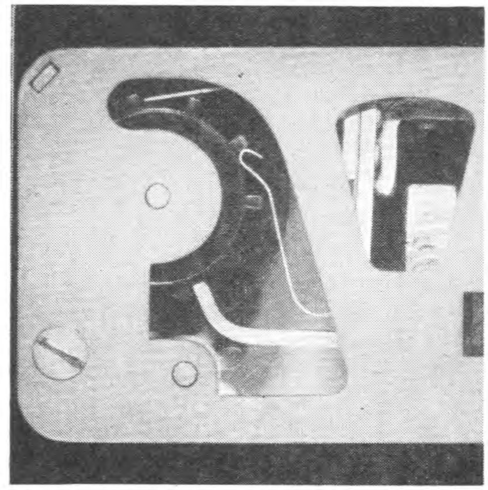


FIG. 2—RATCHET-WHEEL AND PAWL OF THE NEW METER

The other important simplification of the design is the method of securing the meter label and window without using a cover end-cap as in the 100-type meter. A slot is cut in the right-hand side of the frame near the window end and the plastic window is inserted through it, as also is the label and label-holder. The slot is not wide enough for all three to be inserted or withdrawn together, and the label and holder can be withdrawn leaving the window in position. The label holder is a thin, flat, nickel-silver tray with a window aperture through which the number wheels are visible behind the transparent plastic window. It is formed so that it holds the label securely between itself and the window and is indented so that it clicks into position when pressed fully home into the slot. It is lacquered red on its reverse side, so that to "blank out" a meter it is necessary only to withdraw the label and holder, reverse the holder so that its red side is facing forwards and its window aperture is at the bottom, reposition the label in front of the window aperture in the holder and reinsert label and holder through the slot.

The electrical performance of each version of the 150-type meter is required to be identical with that of its 100-type equivalent, but an appreciably longer life and improved reliability are expected from the new meter.

D. J. M.

Local-Call Timers

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The local-call timers described in this article have been designed to enable periodic metering to be used on local calls made by subscribers connected to non-director and director exchanges. In addition, the equipment for director exchanges allows the periodic metering pulses on trunk calls to be relayed through the 1st code selector to the subscriber's meter.

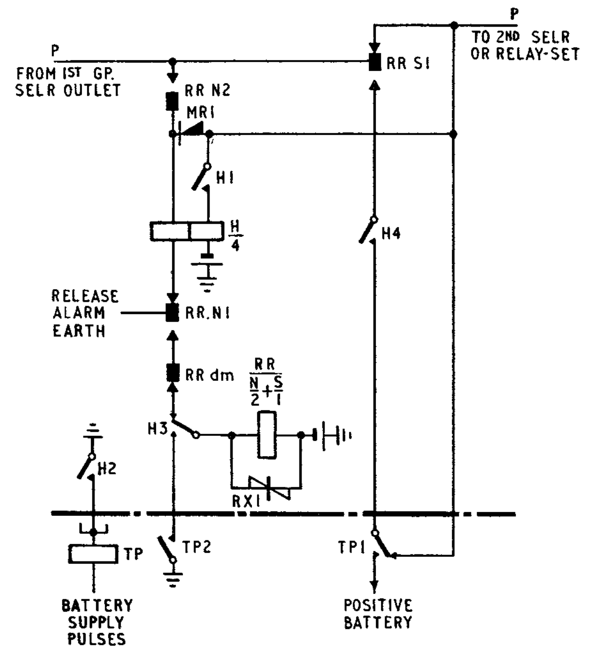
INTRODUCTION

THE change in the method of charging for calls has made it necessary to develop equipment to apply periodic metering[1] to local calls. The facility is provided by means of a small auxiliary equipment called the "local-call timer." In non-director exchanges the local-call timer is connected to the appropriate levels of the 1st selectors. In director exchanges, however, the local-call timer is associated with the 1st code selector and it has been found convenient to include facilities which, in conjunction with a small modification to the selector, enable the periodic metering pulses on trunk calls to be relayed from an outgoing subscriber-trunk-dialling (S.T.D.) relay-set through the 1st code selector to the subscriber's meter.

NON-DIRECTOR EXCHANGES

In the early S.T.D. installations, a Post Office Type 2 uniselector is being used as the counting device, but the ratchet relay will be used in the future because its size enables considerable economy to be made in both rack space and current consumption. The ratchet relay[2] is a reverse-drive counting device in which an electromagnet is used to pulse-operate two cams. Each cam operates a spring-set after a predetermined number of steps, and in the circuit descriptions which follow, spring-set RR.N refers to contacts which are operated when the cam steps from a "home" position, and spring-set RR.S refers to contacts which are operated after the cam has stepped to a predetermined position beyond a "home" position.

The equipment, the circuit of which is shown in Fig. 1, is connected in series with the P wire of the outlet of a 1st group selector. When the called subscriber answers, a positive-battery metering pulse is connected at the final selector or relay-set and, via contact RR.S1, operates the calling subscriber's meter. Simultaneously, relay H operates via rectifier MR1 and holds via H1 to earth connected to the P wire at the final selector or relay-set when the meter pulse is disconnected. Contact H2 completes the circuit for relay TP to operate each time a supply pulse is connected from the pulse generator. Each relay TP distributes the supply pulses to three local-call timers. When relay TP operates, the ratchet relay magnet is operated via contact H3. After the 10th supply pulse has been disconnected, the cams are at position 11 and spring-set RR.S1 operates. The P wire is now connected via TP1 and, during the transit time of spring-set RR.S1, preceding equipment is held via rectifier MR1 and RR.N2. When the 11th supply pulse is connected, TP1 connects positive battery to the



Spring-set RR.N operates when the cams of the ratchet relay (RR) step from the home position, and spring-set RR.S operates when the cams reach the 11th step

FIG 1—LOCAL-CALL PERIODIC-METERING CIRCUIT FOR NON-DIRECTOR EXCHANGES

subscriber's meter via RR.S1. Relay TP releases when the 11th supply pulse is disconnected and the ratchet relay cams step to the 12th (home) position. Spring-set RR.S1 releases to reconnect the P wire independently of contact TP1. On completion of the call, relay H releases and at H3 completes the self-drive circuit for the ratchet relay magnet to restore the cams to the next home position.

DIRECTOR EXCHANGES

In new designs of 1st code selector it has been possible to incorporate periodic metering in place of the multi-metering facilities provided hitherto. A similar solution was not, however, practicable for existing selectors and a method which involved minimum modification of the existing equipment was selected. Although methods a little less costly in equipment were possible, any saving was likely to be more than offset by incidental troubles caused by disturbance or, with older equipment, the need for complete rewiring. The scheme adopted has separately mounted equipment, directly cabled to the selectors. The only change to the selector is the fitting of a cord to the vertical-marking-bank wiper and a few wiring additions to selectors serving the pay-on-answer coin-box lines.[3]

Inherent in the adopted scheme is the ability to convert from one type of metering to another, e.g. 4th-wire earth metering to 4th-wire battery metering or vice versa, as many of the older exchanges contain more than one type. Two advantages accrue from this. Firstly, the associated S.T.D. outgoing relay-set is required to reproduce only one type of meter pulse, the choice of which is arbitrary;

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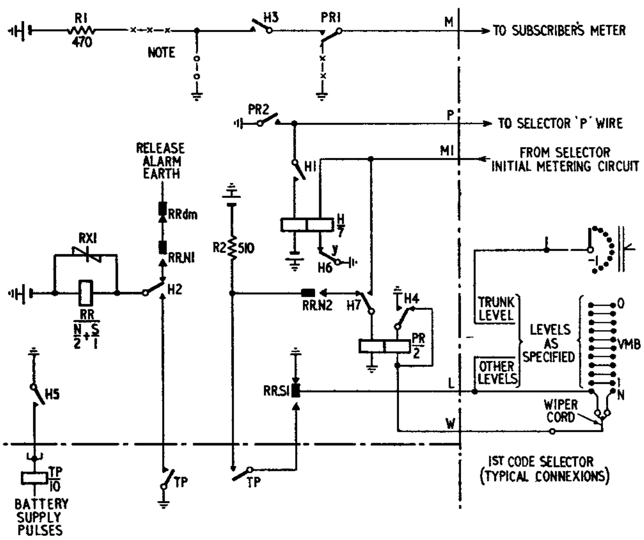
the standard negative-battery pulse has been chosen. Secondly, existing meter-pulse-conversion relays may be recovered when an exchange is converted to S.T.D.

Meter pulses from the outgoing S.T.D. relay-set are connected via the -1 wiper in the same manner as for 2nd code selector control of metering, except that the outlets on the trunk level are connected to register-access relay-sets via the I.D.F. The availability of the S.T.D. level is therefore reduced to 10.

Circuit Operation

The metering process commences with the receipt of a meter pulse from the associated 1st code selector shortly after the called subscriber answers. This pulse operates relays H and PR (Fig. 2) which together repeat the



Note: Battery-metering connexions —x—x— Earth-metering connexions —o—o—

FIG. 2—PERIODIC-METERING CIRCUIT FOR DIRECTOR EXCHANGES

meter pulse to the M wire. The operation of relay H also serves as a signal to start the timing of local calls. Battery pulses from a common supply are converted to earth pulses to step the ratchet relay. Relay PR responds to the 11th pulse via the vertical marking bank and the RR.S springs of the ratchet relay, and applies a further pulse to the subscriber's meter. The counting continues for the remainder of the call and a further meter pulse is connected on receipt of every subsequent 11th pulse.

Clearing. Earth is temporarily disconnected from the P wire after the calling subscriber has cleared to permit the release of relay K, in the subscriber's line circuit, and relay H. This short disconnexion of the guarding and holding earth is known as the "open period." Earth is reconnected to the P wire by the releasing selector and by relay PR, which reoperates during the homing of the ratchet relay. Failure of either mechanism to restore to normal leaves the selector guarded.

Guarding. Relay PR connects earth to the P wire during the application of each meter pulse to hold the selector and the subscriber's line circuit, should the selector remove its guarding and holding earth. If, at the end of the pulse, no earth exists on the P wire, the "open period" begins, relay H releases and the mechanisms restore to normal, the circuit being guarded during the restoration period. Relay H is designed to release during the open period while relay PR has an operate lag which prevents shortening the open period.

Trunk Calls. On calls via the trunk level of the 1st code selector the reversal from the S.T.D. relay-set operates relay D in the selector, which prepares the circuit for delayed metering. The first meter pulse received over the -1 wiper from the S.T.D. relay-set is "masked" since relay H can only operate (to connect relay PR to the -1 wiper) to the initial meter pulse from the 1st code selector which always occurs later. The first pulse from the S.T.D. level relay-set is thus ineffective but relay PR responds to all subsequent pulses received over the -1 wiper.

Earth Metering and Positive-Battery Metering. The circuit described is also used at exchanges with earth metering but in these exchanges the meter-pulse machines will be connected to produce battery pulses, and the periodic-metering circuit strapped to repeat pulses received from all sources (initial, trunk and local) as earth pulses.

Another circuit is used at positive-battery-metering exchanges with the difference that the initial meter pulse from the 1st code selector is not repeated but is fed via a through P wire.

Pay-on-Answer Coin-Box Selectors

The modification to the wiring of the selectors forming the pay-on-answer selector group is shown in Fig. 3.

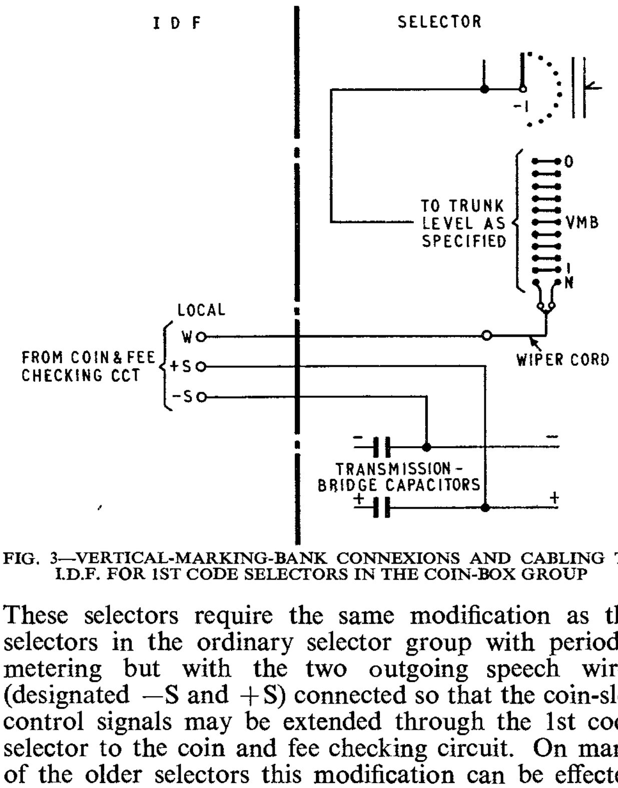


FIG. 3—VERTICAL-MARKING-BANK CONNEXIONS AND CABLING TO I.D.F. FOR 1ST CODE SELECTORS IN THE COIN-BOX GROUP

These selectors require the same modification as the selectors in the ordinary selector group with periodic metering but with the two outgoing speech wires (designated $-S$ and $+S$) connected so that the coin-slot control signals may be extended through the 1st code selector to the coin and fee checking circuit. On many of the older selectors this modification can be effected without disturbing the selectors as the transmission bridge capacitors are mounted on a rack and connected to the selector via the selector shelf jack U-points, on which the $-S$ and $+S$ wires may now be terminated.

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[2] BANHAM, H. Physical Design of Subscriber-Trunk-Dialling Equipment. (In this issue of the *P.O.E.E.J.*)
[3] BASTOW, F. J., COLLINGWOOD, J. D., NEWELL, E., and PRICE, C. K. The Pay-on-Answer Coin-Box System. (In this issue of the *P.O.E.E.J.*)

Metering over Junctions

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U.D.C. 621.395.123:621.395.335

Trunk calls dialled by a subscriber from a local exchange that is remote from its group switching centre will be charged for by sending signals over the junction from the switching centre to operate the subscriber's meter, the metering signal being transmitted by reversing the current flowing in the junction. To help ensure that the signals are inaudible to the subscribers, the line current will be first reduced, then reversed and lastly restored to its normal value, the process being repeated for each meter pulse.

INTRODUCTION

SUBSCRIBER-DIALLED trunk calls originated at a local exchange that is remote from its group switching centre will be charged for by returning meter pulses over the junction from the switching centre.

Most of the junctions used to connect local exchanges to their group switching centres are physical circuits within the limits of loop/disconnect pulsing. The loop/disconnect system has for many years employed a line-current reversal as a backward supervisory signal and it was therefore decided to investigate the feasibility of using a line-current reversal as a metering signal before giving detailed consideration to alternative types of signal, such as 50 c/s a.c. A metering system using line-current reversals has several merits. Since only a loop current is involved, the system is unaffected by earth-potential differences between the two ends of a junction and the system is free from signal imitation (and therefore from false metering) by earth and disconnexion line faults, contact with other lines, and longitudinally-induced voltages from power lines and electric railways. In addition, the line-current-reversal signal is known from long experience to be a reliable signal to use and special power supplies are not needed.

REDUCTION OF NOISE

Since the metering signals are sent during the conversational period of a call, it is essential that any noise resulting from their transmission should be at a level sufficiently low not to cause annoyance or distraction to the subscribers engaged on the call. The signals are transmitted at regular intervals, and, as might be expected, the tolerable noise level is influenced by the rate at which the signals are sent. To allow maximum flexibility for future expansion of subscriber trunk dialling, including international subscriber dialling, it was decided to provide for a maximum metering rate of once per second. It has been established by listening tests that, for metering rates of this order, the junction metering signals must to all intents and purposes be inaudible.

In the past, relatively simple relay switching circuits have been used to effect line current reversals for supervisory purposes. These are quite unsuitable for a periodic-metering system due to the considerable noise generated.

Attention was first directed towards the reduction of noise by interposing a low-pass filter between the current-reversing contacts and the line itself, and in designing a suitable filter, preference was given to components of the types most usually encountered in telephone-exchange switching equipment. Using a filter it was found possible to reduce the noise of the metering signals to a level which would have been acceptable for the slower rates of metering but for the faster rates further improvement was needed. Some improvement was possible by increasing the series inductance or shunt capacitance elements of the filter, or both. With large values of capacitance shunted across the signal path, there is danger of circuit misoperation due to relay interaction during the clearing down of a call. An increase of the series inductance is unavoidably accompanied by an increase in resistance, which reduces the line current, and the limit in this case is determined by the design of the line relays to meet the requirements of junctions of 2,000 ohms loop resistance. In this connexion, the pulsing performance during the setting up of a call had to be taken into account. A lower line current (and hence a larger inductance in the filter) might have been possible by departing from the type of line relay commonly employed for loop/disconnect pulsing. The use of telegraph-type line relays and electronic devices to replace the line relays were amongst the possibilities which were considered. The need for such devices did not, however, arise because the problem was solved in a different way.

It had been noticed during the laboratory tests that the noise level of the metering signals was relative to the value of line current being reversed; the lower the line current, the less the noise. It seemed therefore that the problem might be solved if means could be devised whereby the line current could first be reduced to a lower value, then reversed at the lower value and finally allowed to rise to its maximum value in the reverse direction. Two methods of temporarily reducing the line current were tested. In one method a resistor was shunted across the signal path, and in the other method additional resistance was introduced in series with the signal path. The shunt method was unsuitable because of noise generated when the shunt was disconnected after reversal of the line current. The series-resistance method gave satisfactory results, and it was found to be an easy matter to determine a compromise value for the series resistance to suit a wide range of junction resistances.

Some low-level noise was traced to magnetic induction into the coils of relays associated with the transmission bridges from other relays that were subject to flux changes during metering. These troubles were overcome by sufficiently separating the relays concerned on the mounting plates. The inductor of the filter also had to be protected in this way from inductive disturbances, including interference due to vibration of the armature of the high-speed A relay, which might momentarily release during the transmission of a meter pulse.

CIRCUIT OPERATION

Fig. 1 shows the basic circuit elements for transmitting and receiving meter pulses over a junction between a group switching centre and a local exchange. The filter

† The authors are, respectively, Executive Engineer and Assistant Engineer, Telephone Exchange Systems Development Branch, E.-in-C.'s Office.

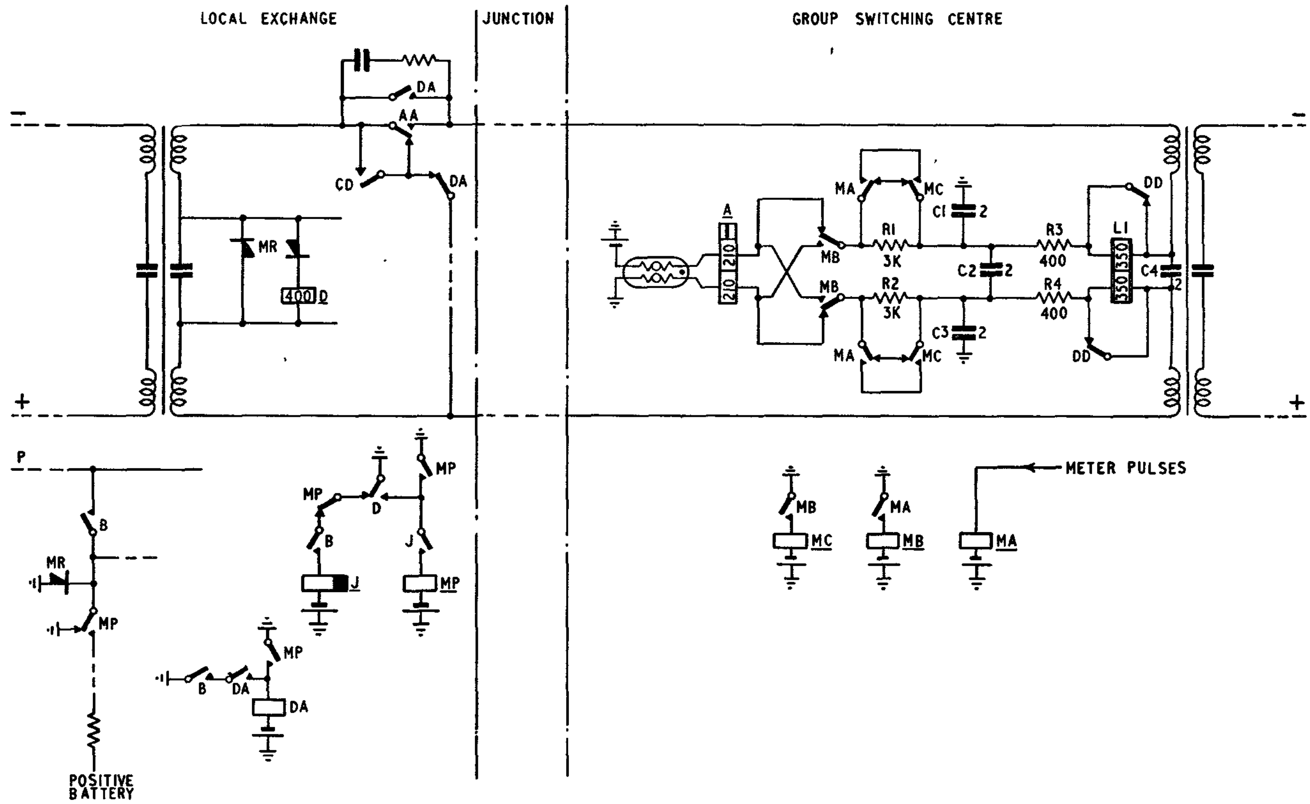


FIG. 1—CIRCUIT ELEMENTS USED FOR TRANSMITTING AND RECEIVING METER PULSES OVER JUNCTIONS

previously mentioned comprises the inductor L1 and capacitors C1, C2, C3 and C4. Inductor L1 is a 3,000-type retard coil and its windings are initially short-circuited to allow loop/disconnect pulsing over the junction from the local exchange. Pulse distortion due to capacitors C1, C2 and C3 is small and within tolerable limits.

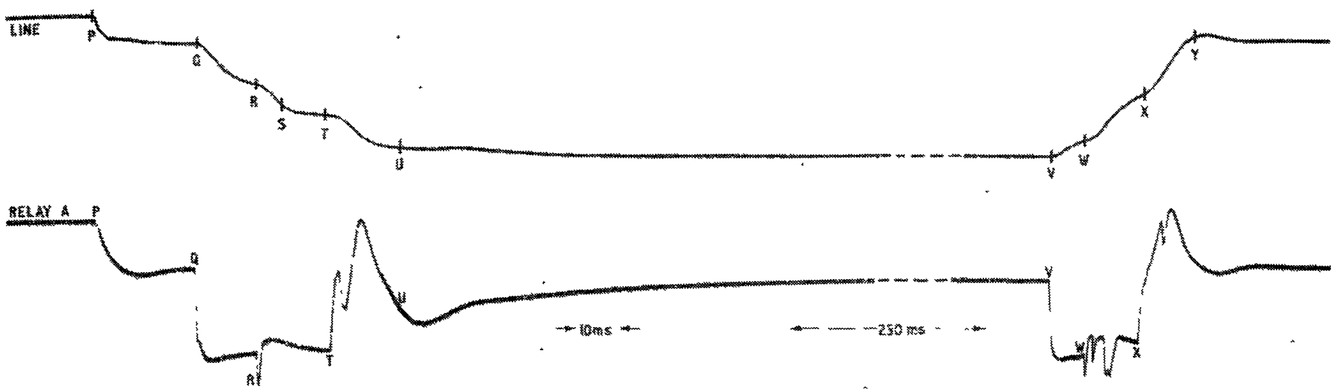
When a call is answered, contacts of relay DD remove the short-circuits from the coils of L1, which are connected so that the line current now flows through them in mutually-aiding directions. At this stage the line current has a value in the range of 12–25 mA, depending upon the loop resistance of the junction. Resistors R3 and R4 are permanently short-circuited for junctions of over 800 ohms loop resistance.

Meter pulses at the appropriate rate are applied to relay MA. At the beginning of each meter pulse, MA contacts remove short-circuits from resistors R1 and R2. The resistance of the signal path is thereby increased by 6,000 ohms and the line current falls to a value in the range of 6–8 mA. At this lower value the line current is reversed by contacts of relay MB, which is operated by relay MA. Relay MB in turn operates relay MC and contacts of MC now short-circuit R1 and R2, allowing the line current to rise to its maximum value in the reverse direction. At the end of a meter pulse, relay MA releases first, removing the short-circuits from R1 and R2. This is followed by the release of relay MB, which reverses the current back to its normal direction, and finally relay MC releases, again short-circuiting R1 and R2.

At the local exchange relay D responds to the line-current reversals, each operation and release of D corresponding to an operation and release of MA. The pulses are repeated by D to relay MP which, in turn, repeats them to the calling subscriber's meter in the form appropriate to the type of exchange equipment in use at the local exchange. Fig. 1 shows positive-battery metering such as would be used, for example, at a group-selector satellite exchange. The circuits of relays MP and J are so arranged that the duration of the pulse applied by MP to the subscriber's meter is approximately equal to the release lag of relay J, irrespective of the actual time for which D is operated. This ensures reliable operation of the meter in the event of the metering signals being shortened by transmission over the junction and by repetition by relay D. Furthermore, in the event of a fault that gives rise to prolonged reversal of the line current, the meter is not held operated for an excessive period.

On receipt of the initial meter pulse when a call is answered, relay DA at the local exchange operates and locks. Contacts of DA prevent interference with the receipt of subsequent meter pulses should relay AA release or relay CD operate. This prevents accidental or deliberate suppression of metering by continued dialling or switch-hook flashing on the part of the calling subscriber. To prevent suppression of the initial meter pulse itself by flashing or dialling at the moment that the call is answered, the circuit of the incoming junction termination is so arranged that the initial reversal of line current is maintained until the flashing or dialling ceases, and thereafter for a period of time approximately equal to the normal length of a meter pulse.

The effectiveness of the filter and three-stage change-over arrangement in reducing the noise level of the metering signals can be seen from the oscillogram in Fig. 2. Point P



The lower trace represents the current in the battery-connected coil of relay A immediately following the answering of a call. The upper trace represents the corresponding current in the negative line at the incoming end of the junction

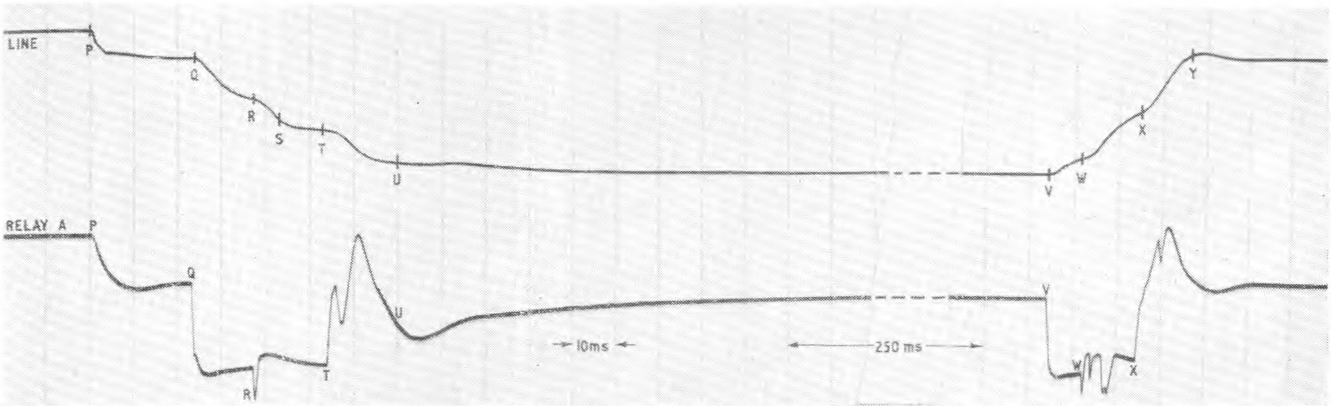
FIG. 2—OSCILLOGRAM OF THE CURRENT IN RELAY A AND IN THE LINE DURING THE TRANSMISSION OF A METER PULSE

marked on the oscillogram represents the point at which the DD relay contacts open, and the fall in current (both traces) between P and Q is due to the introduction of inductor L1 in series with the signal path. The contacts of relay MA operate at point Q and the sudden fall in the A relay current (lower trace) at this point is due to the introduction of resistors R1 and R2 in series with the signal path. The line current (upper trace) falls more gradually between Q and R due to the effects of the filter. At point R the current is reversed by the MB contacts and there is a momentary disconnexion of the A relay current (lower trace). At point T the MC contacts short-circuit R1 and R2 and this results in the surges seen on the lower trace between points T and U. The line current (upper trace) gradually reverses between points R and T and is zero in the vicinity of point S. At point U, approximately, the line current attains its maximum value in the reverse direction.

At point V the A relay current (lower trace) suddenly drops again due to the removal of short-circuits from R1 and R2 by the release of the MA contacts. At point W the current is reversed back to its normal direction by the release of the MB contacts. At X, resistors R1 and R2 are again short-circuited by the release of the MC contacts. The line current (upper trace) falls gradually between V and W, and reverses between W and Y, being zero in the vicinity of point X. It attains its maximum value in the normal direction at about point Y. The line current changes during the second and subsequent meter pulses are similar to those shown in Fig. 2 between points Q and Y. The changes between P and Q occur only when a call is first answered.

CONCLUSION

A system of transmitting meter pulses over junctions by means of current reversals has been adopted for loop/disconnect junctions. The system works satisfactorily with junction loop resistances of up to 2,000 ohms and has little effect on dialled pulses. The meter pulses can be transmitted at rates as high as once per second during the conversational period of a call, and are virtually inaudible to the subscribers engaged on the call.



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Subscribers' Private Meter Equipment

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U.D.C. 621.395.366.3: 621.395.374

Detailed telephone accounts will be replaced by bulk-billing when subscriber trunk dialling is introduced, and to give subscribers the equivalent of the Advise Duration and Charge (A.D.C.) facility, private meters may be provided at their premises on a rental basis. These meters will register the total chargeable units and also the units chargeable for the last call, or series of calls, made. This article describes the method of signalling meter information from the main exchange to the subscribers' premises and also the development of the types of meter to be used on individual exchange lines and at private branch exchanges.

INTRODUCTION

On the introduction of subscriber trunk dialling (S.T.D.), private meters will be available, at appropriate rentals, for association with the telephones of direct exchange lines and for association with the switchboards of private branch exchanges (P.B.X.s). Meters for individual lines will register total chargeable units, and also indicate the units chargeable to the last call, or series of calls, made. Meters associated with P.B.X. installations with more than three exchange lines have to meet other requirements. The method of signalling meter information to subscribers' premises from the main exchange is the same for all the types of meters described in this article.

EXCHANGE EQUIPMENT AND METHOD OF SIGNALLING

Development of the Metering System

The periodic-metering system[1] which is being introduced with S.T.D. involves the operation of the subscriber's exchange meter while conversation is taking place. It is possible to arrange for the subscriber's private meter to operate at the same time as the exchange meter or for the information to be stored at the exchange and repeated over the line on completion of the call. The former arrangement is considered preferable as it avoids the cost of storage equipment. It is necessary, however, to ensure that signals sent from the exchange to operate the private meter are inaudible. Any system using d.c. signals is likely to cause interruption to speech, so it was decided to use a.c. signals.

The use of a super-audio frequency to obtain the desired inaudibility would involve special frequency-generation equipment, special distribution arrangements and, probably, in view of the high attenuation of underground cable pairs, a transistor amplifier at the subscriber's premises. On the other hand, a system transmitting longitudinal 50 c/s current pulses over the earth phantom of the subscriber's line could be comparatively cheap and would, theoretically, be noiseless provided lines and apparatus were accurately balanced with respect to earth. However, little information was available about the values of longitudinal 50 c/s voltage of short duration that could be transmitted with the nominally balanced transmission bridges and lines existing in the field, without noise becoming audible during speech. (The C.C.I.T.T. recommended limits, for psophometric e.m.f.s., of 5 mV for open-wire circuits and 2 mV for cable circuits apply to continuous noise). It was known that serious noise interference had been experienced on certain shared-service lines that were subject to interference from the 50 c/s national grid system, and that this had been due to the generation of harmonics in the bridge rectifier and relay connected between each line and earth[2]. It appeared, therefore, that the subscriber's private meter would have to be of a design considerably different from that of any Post Office standard meter, and many tests were made to prove the feasibility of the scheme and to determine the required characteristics of the private meter.

As a result of these tests transverse psophometric voltages of 1 mV were found to be tolerable, and 2 mV disturbing, and it was decided, from a design point of view, that if possible psophometric transverse voltages during metering should not exceed 0·2 mV. (It is of interest to note that when an a.c.-operated private meter, in common use on the Continent, was tested using a signal voltage of 80 volts, 50 c/s to give the meter its minimum operate current of 35 mA, noise levels of the order of 5 mV were measured). The tests showed that if a meter could be designed to operate at a current of about 1–2 mA with an applied voltage of the order of 30–40 volts, the system would be satisfactory from a noise-level point of view. To avoid the provision of extra spring-sets in the telephone circuit to isolate the meter during dialling or ringing operations, the meter would be required (*a*) to have negligible shunt capacitance to minimize dial-pulse distortion, and (*b*) to be sharply tuned to 50 c/s to prevent false operation to ringing current at 17 c/s or 25 c/s. As described later, meters have been designed which can be operated with an acceptable margin of safety over subscribers' lines of 1000 ohms resistance. Using imperfectly balanced transmission bridges, transverse noise voltages of the order of only 0·03 mV were measured on good lines and 0·3 mV on lines with leakance unbalance.

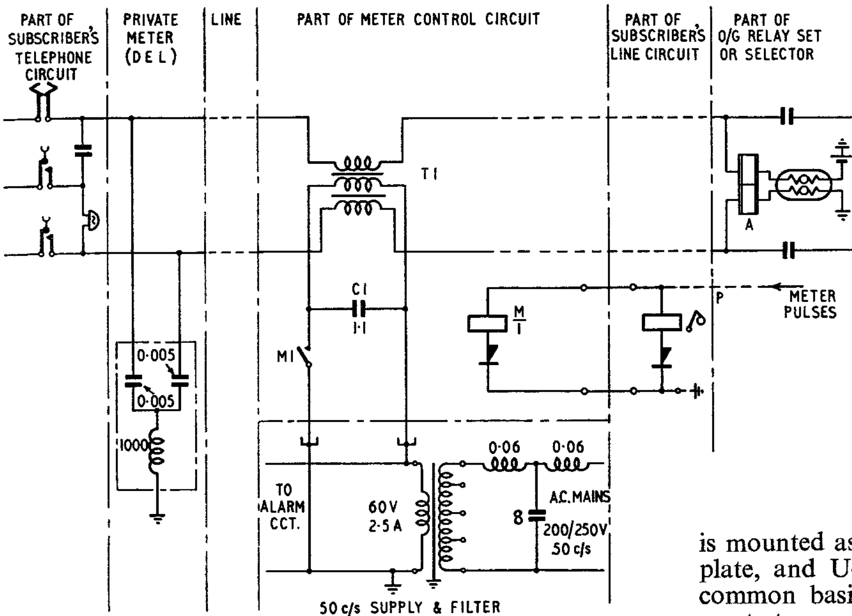
Circuit Operation

Fig. 1 shows the simplified circuit arrangement for operation of the private meter on a direct exchange line. Transformer T1 is of a type specially checked during manufacture to ensure good balance of the secondary windings. Relay M is operated on outgoing calls in parallel with the subscriber's ordinary meter, the meter pulses being of 200–250 ms duration, repeated at intervals determined by the charging rate. The operation of relay M results in a longitudinal voltage of 45 volts, 50 c/s being applied to the phantom of the calling subscriber's line from earth at the transmission bridge to earth via the private meter at the subscriber's premises. The figure of 45 volts ensures satisfactory operation of the meter without it being high enough to cause saturation of the injection transformer or to cause noise. Capacitor C1 and the primary of the injection transformer form a

† Mr. Gresswell is an Executive Engineer in the Telephone Exchange Systems Development Branch, and Mr. Belk and Mr. Alderson are Executive Engineers in the Subscribers' Apparatus and Miscellaneous Services Branch, E.-in-C.'s Office.

[1]WALKER, N., Periodic Metering. (In this issue of the *P.O.E.E.J.*)

[2]COBBE, D. W. R. Noise Interference from External Sources *P.O.E.E.J.*, Vol. 48, p. 41, Apr. 1955.



The 1,000-henry inductor in the private-meter circuit is the operating coil of the meter

FIG. 1—SUBSCRIBER'S PRIVATE-METER CONTROL CIRCUIT

parallel-tuned circuit such that minimum current is drawn from the supply. Provision is made for the inclusion of a filter in the mains supply if measurements on installation indicate that the harmonic content of the 200–250 volts mains supply exceeds 0·2 volts r.m.s. for any odd harmonics from the fifth upwards. The cost of the filter and the additional current consumed render its universal adoption undesirable.

On a call within an exchange, two subscribers, each equipped with private meters, may be connected together via the transmission bridge of a final selector. Since the transmission-bridge relays are inductive to transverse currents only, the bridge offers a low-impedance path to earth to the longitudinal metering currents and the called subscriber's meter is therefore effectively shunted. The voltage developed across this meter is of the order of 5 mV and there is therefore no chance of it operating.

Depending on the number of subscribers equipped with private meters, the control equipment can be placed between the subscriber's line and the associated L and K relays, i.e. be provided on the basis of separate equipment for each line, or can be placed between uniselector outlets and first selectors, i.e. provided on a common basis. Provision on a common basis would mean that 50 c/s meter-pulses would be transmitted to some subscribers' lines which were not equipped with private meters, including shared-service lines. Since shared-service subscribers' lines are connected to earth via the bell circuit, metering current would flow, dependent on the type of telephone used. While the thermistors in the bell circuits of certain telephones (e.g. Telephones No. 312) would not become sufficiently low resistance during the 250 ms meter-pulse, even at maximum pulse-repetition rate, for any effects such as bell tinkling or noise to develop, the rectifier and relay circuits used with other types of telephones (e.g. Telephones No. 310) would respond to the meter pulses, thereby causing noise and bell tinkling. Furthermore, the occurrence of the earth-calling condition on one of a sharing pair of circuits would produce noise if it coincided with a.c. meter pulses being transmitted on the other circuit of the pair. Provision of the metering equipment on a common basis would only be made, therefore, if trunking arrangements permitted segregation of shared-service subscribers. Future developments in the provision of shared service might remove this limitation.

When a separate metering control circuit is provided for each line fitted with a private meter the circuit is arranged to permit routine testing of the subscriber's exchange meter without transmitting a.c. meter pulses to the private meter. This requirement does not arise, of course, when the metering equipment is provided on a common basis.

The line a.c. injection equipment is mounted as a relay-set, two circuits on one mounting plate, and U-point strapping caters for connexion on a common basis or connexion on a "per line" basis to most types of subscribers' linefinder or uniselector circuits.

THE SUBSCRIBERS' PRIVATE METER

When the decision was taken to provide for a meter at the subscriber's premises, to be operated over the phantom circuit to earth, it soon became apparent that an entirely new and sensitive metering device would have to be developed. Existing Post Office apparatus had been designed to take far more power than could be allowed for the projected meter. A 100-type meter, for instance, needs about 40 mA for operation.

A review was made of the various meters that were available both in this country and abroad, but none appeared to meet the requirements, and the development of a suitable instrument was therefore put in hand. The two versions of the meter which were evolved are shown in Fig. 2 and 3. That shown in Fig. 2 has been coded Meter No. 19/FRA, while the version shown in Fig. 3 has been coded Meter No. 19/SSS.

Appearance

Because the meters will be used in subscribers' premises, appearance is of prime importance, and considerable effort has been expended in producing the final designs, both of which have been approved by the Council of Industrial Design.

A clock-face presentation was adopted because it was considered that at a normal operating voltage of 30 volts (minimum 20 volts), which was then under consideration, the wheel type of meter would need too much current, particularly as the meter was to give two readings, i.e. the total chargeable units and the units charged to the last call or series of calls. The latter reading is analogous to the "trip" reading on a car speedometer and will be referred to as the "trip" reading in this article.

It will be seen that both versions of the meters have three hands. The units hand and the resettable trip hand move one division of the scale for each operating pulse while the hundreds hand moves progressively over its scale, each division of which represents a complete revolution of the units hand. The trip hand is returned to zero by depressing the arm on one meter or by pressing the button on the other meter. Although the two designs are

FIG. 2—METER NO. 19/FRA

FIG. 3—METER NO. 19/SSS

quite different in construction and appearance, every effort has been made to ensure that the scales are similar.

Electrical Characteristics

One of the difficulties encountered during testing was to obtain sufficient rejection of the ringing voltage while retaining the necessary sensitivity to the operating voltage. For the ringing voltage a test figure of 120 volts, 25 c/s was adopted to cover adequately the highest voltage likely to be encountered under light ringing-load conditions. The normal operating voltage originally selected was 30 volts, but this was later increased to 45 volts to assist in making the meter insensitive to ringing voltages. Many circuits were considered in attempts to solve the ringing-rejection problem but as it was desirable to reject the ringing voltage even with the A wire disconnected, as might arise under fault conditions, a straightforward series-tuned circuit appeared to be the best practical approach.

The approximate values of the components finally chosen are indicated in Fig. 1. One meter has an impedance of approximately 75,000 ohms at 50 c/s in the operated position and takes a total current of approximately 0·6 mA, i.e. 0·3 mA per line wire. The circuit is sharply tuned, so that a variation in frequency of only $1\frac{1}{2}$ c/s reduces the operating current by 20 per cent. The other meter takes approximately 0·3 mA total current. Although the normal operating voltage is 45 volts, it was decided that the meters should operate satisfactorily at 32 volts, 50 c/s to allow for possible variations in: (*a*) the voltage and frequency of the mains supply and the standby generators, (*b*) the tolerances on the mains transformer and the injection transformer, and (*c*) the possible increase in friction in the mechanism over a period of use.

The meters take so little current that any out-of-balance voltages and consequent noise are negligible. Similarly the transmission loss due to the meter is negligible, the loss of 0·8 db in the metering circuit being due to the presence of the injection transformer.

The value of the capacitors is so small that the presence of the meter on a subscriber's line will not be detected by normal test-desk procedure—neither will normal line-testing affect the meter.

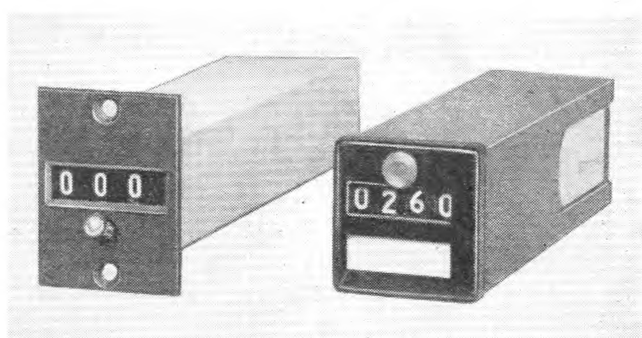
Use

The subscribers' private meter will be available for use with exclusive direct exchange lines, including those with extensions, small cordless switchboards, P.B.X. extensions and house exchange systems. It will be supplied complete with a 54 in. grebe-grey cord which normally will be connected into the instrument terminal block. A cover in the base of the meter gives access to the cord connexion screws, but the meter is sealed to prevent further access.

METERING AT PRIVATE BRANCH EXCHANGES

For economic reasons the subscribers' private meter is used for metering at cordless private manual branch exchanges with not more than three exchange lines. It is too bulky, however, for use on larger switchboards and for these the number-wheel type of meter has been adopted. Of the meters that were available, the exchange type (Fig. 4(*b*)) was chosen for total metering, but none met the requirements of trip metering and for this purpose a suitable meter (Fig. 4(*a*)) had to be developed. To meet the wide range of P.B.X. voltages, two versions of this meter have been produced: Meter No. 20A for 20–30 volt working and Meter No. 20B for 40–55 volt working.

These meters require too much power to be driven direct from the metering signal. This poses no problem



(*a*) (*b*)

FIG. 4.—(*a*) RESETTABLE COUNTER (METER NO. 20A) USED FOR TRIP METERING
(*b*) EXCHANGE-TYPE METER USED FOR TOTAL METERING

since power is available from the P.B.X. battery. It does however entail the provision of a metering unit (Fig. 5) to convert the incoming signal into a suitable pulse for operating the total and trip meters.

Facilities

The facilities available with number-wheel counters are total metering only, trip only and both total and trip.

Total metering is required by a subscriber wishing to keep a running total of his call charges. It is provided on a line-by-line basis and, clearly, in order to provide an overall total charge, all lines must be metered. Each line requires a metering unit, which can be used for trip-metering where this facility is also required.

Trip metering enables the operator to determine the costs of individual calls when required to do so by the subscriber. Thus under S.T.D. it replaces the Advise Duration and Charge service hitherto available to the operator. It is available as "straightforward" and "switched" metering, to meet the respective needs of the heavy and light user. With straightforward metering, switchboard meters are permanently associated with exchange lines, whereas with switched metering the meters, normally limited to two per switchboard position, are permanently associated with rotary switches, each of which gives access to up to 10 lines. Straightforward metering is not, however, appropriate for multiple-type installations where the larger number of exchange lines to be served and the appearance of the same lines on several positions would require the provision and accommodation of a large number of meters, and the duplication of the displays might create operating difficulties. Instead, the limit on the number of meter/switch combinations is raised to three. With switched trip-metering a measure of straightforward working can of course be achieved by the operator leaving idle meters switched to late-choice lines.

Although the facility itself is not affected, switched trip metering can be provided either by switching meters to metering units, already provided where total metering is practised, or by switching to line a combination of a metering unit permanently connected to a meter. The latter method, using fewer units, is normally adopted for economy where total metering is not required.

At cordless manual switchboards the use of the subscribers' private meter restricts the facilities to (*a*) combined total and trip, and (*b*) switched trip-metering. The latter is provided by a single meter connected to a 2-position or 3-position lever key for line selection. In this application the "totals" reading is of little significance.

The Metering Unit

The metering unit, Unit, Metering, No. 1A (Fig. 5), provides an output pulse of 100 ms minimum duration, after a delay of not less than 70 ms, from line signals in the range 37–45 volts, 48–51 c/s, 180–320 ms duration. This minimum output pulse ensures satisfactory meter stepping at the lower limits of the operating voltage ranges, e.g. 20 volts for Meter No. 20A, 40 volts for No. 20B; the delay of the device, together with the operating lags of the meters, guards against false operation by line-to-earth surge currents, as occur for instance when the line is under test from the exchange test-desk. The line current at 45 volts, 50 c/s is 1·2–1·5 mA, which is higher than that for the subscribers' private meter but necessarily so to allow for subsequent possible

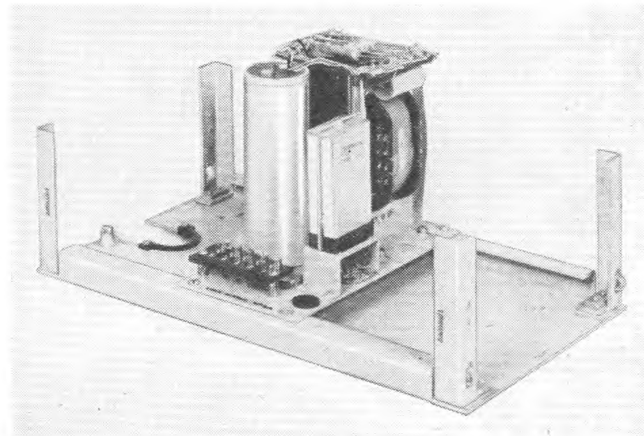


FIG. 5—METERING UNIT (UNIT, METERING, NO. 1A) MOUNTED ON A THREE-WAY PLATE

changes in the characteristics of the relay. The unit gives good rejection of incoming exchange ringing current especially where, under fault conditions, the ringing return circuit is completed via the metering unit and earth. Samples of the unit have been immune under such conditions to 25 c/s ringing at voltages exceeding 120 volts.

The relay, a miniature plug-in type of proprietary design, is polarized and has a one-side-stable characteristic. Thus the low-power-consumption feature of the polarized relay has been utilized, whilst avoiding the complication (that would arise with existing both-side-stable types) of providing stabilized power supplies at P.B.X.s for biasing purposes. In the circuit (Fig. 6) the function and value of capacitor C3 call for special comment. This capacitor smooths the rectified signal but, more important, provides, together with the effective resistance of the acceptor circuit (C1, C2, L1), a means of preventing transient operations of the relay. This integrating circuit also delays the metering signal but undue pulse shortening is avoided by the action of C3, which retards the release of the relay, and by the ringing of the tuned circuit on cessation of the signal.

Too high a value of C3 would introduce a delay which is too great for satisfactory operation of the relay to metering pulses, whereas with C3 too low in value short transient pulses would set up circulating currents in the relay-capacitor circuit sufficiently large to operate the relay and thus to nullify the effect of the time-delay feature. The value chosen (10μF) is therefore a com-

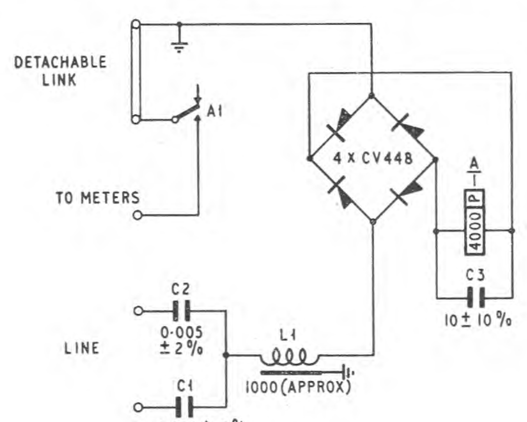


FIG. 6—SCHEMATIC DIAGRAM OF METERING UNIT

promise, and to achieve a close tolerance a metallized-paper-dielectric capacitor is used.

Mounting of Equipment

In choosing mounting arrangements for the equipment, the needs of the operator have naturally come first. The trip meters must be mounted on the switchboard and the readings clearly visible. In main exchanges timing meters are fitted to the key-shelf but there are practical objections to using this method for existing types of P.B.X. Instead, at P.B.X.s, the meters are mounted at eye level. Totals meters, being of less concern to the operator, are mounted away from the switchboard. Metering units are also mounted away from the switchboard in a suitable location such as the apparatus room, where one is available.

At single-position cord-type switchboards, trip meters and rotary switches are housed in a case fixed to the side of the switchboard. Two meters and two switches can be accommodated in one case. For multiple installations the meters, etc., are mounted on a plate and fitted in the face panel. Totals meters are fitted in groups of five in wooden cases, mounted in a convenient position away from the switchboard.

At P.A.B.X. No. 1 switchboards, the trip meters, rotary switches and sundry supervisory equipment (described later) are mounted in a box fixed to the top of the switchboard. Totals meters are mounted as previously described.

Cordless manual switchboards have the subscribers' private meters fitted to a plinth on top of the switchboard, with the lever key fixed above the second exchange-line indicator and positioned for horizontal throw.

For wall mounting of metering units, mounting plates with 6 in. deep dust covers are provided having capacities for 1, 3 and 5 units. The 5-way plate is suitable also for mounting on apparatus racks having 19 in. mounting plates.

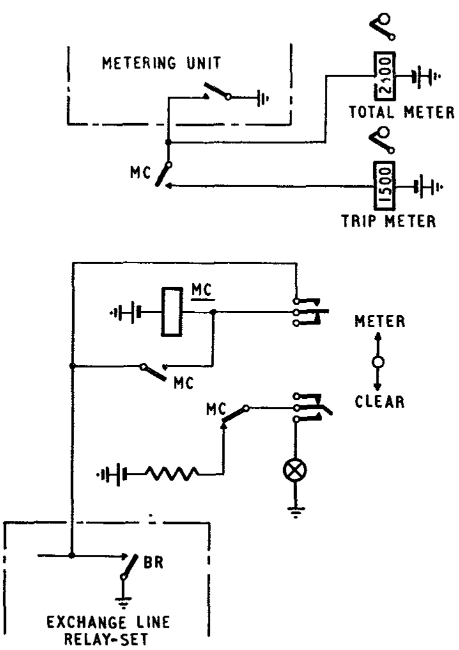


FIG. 7—CIRCUIT FOR PROVIDING TOTAL AND STRAIGHTFORWARD TRIP METERING AT A P.A.B.X. NO. 1

Supervising Facility for P.A.B.X. No. 1 Switchboards

In order to effect trip metering at P.A.B.X. No. 1 installations a supervisory circuit is necessary both to advise the operator of clears and also to prevent the trip total being added to by a directly dialled follow-on call.

A suitable circuit for straightforward trip metering is shown in Fig. 7. To start trip metering, the key is moved to the non-locking "meter" position, and then to the locking "clear" position. The first movement operates relay MC, which connects the meter to the metering unit, and the second movement prepares the circuit for the supervisory lamp. At the conclusion of the call, relay MC in releasing disconnects the meter and lights the lamp. This is extinguished on the restoration of the key to normal

With switched trip metering, the "clear" function of the key is dispensed with, the lamp circuit being completed via contacts of the rotary switch, which, when rotated to "off," or to an unused position, extinguishes the lamp.

Difficulties Encountered at Private Branch Exchanges

The maintenance of accuracy in the meter readings and the prevention of noise in the telephone loop are complicated at P.B.X.s by the fact that in certain circumstances the P.B.X. circuit may offer to the metering signal a path to earth of much lower impedance (zero in the worst case) than that of the metering unit. When this occurs the meters fail to register and a loud noise is heard on the line.

In most cases, difficulty can be avoided by appropriate operating procedures, and strict discipline in this respect is required. This will not, however, always overcome the difficulty and the intruding earth has to be masked from the metering unit. This is done by fitting a double-wound choke in the exchange line (one winding to each leg) connected so as to be inductive to longitudinal signals but non-inductive to transverse currents.

CONCLUSION

The metering arrangements that have been described will meet the known requirements of direct-exchange-line and P.B.X. subscribers. The P.B.X. arrangements are flexible in that they are readily adaptable to meet special requirements, e.g. totalling of switched trip readings. They also allow the facilities to be added to existing installations with a minimum of constructional change to the switchboard, and enable the work to be carried out with small disturbance to the operation of a working switchboard.

ACKNOWLEDGEMENTS

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The Pay-on-Answer Coin-Box System

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A new method of coin-box working was needed in conjunction with subscriber trunk dialling. A pay-on-answer system was evolved requiring the development of a completely new coin-box and the design of associated exchange equipment; these are described in this article.

INTRODUCTION

THE present coin-collecting box with its A and B buttons is nearly 35 years old in its basic design, and although it has from time to time been compared unfavourably with foreign systems having automatic collection and refund facilities, it has given good service. The system needs no special equipment at the exchange and is therefore simple and inexpensive. The Post Office is, however, introducing subscriber trunk dialling (S.T.D.) to reduce the number of operators required for completing trunk connexions, and as approximately one-third of the trunk calls made during the cheap night-rate period originate in call offices, it would be undesirable to exclude these from the scheme. No reasonable modification would have enabled the present box to be used to pay for automatically connected trunk calls and hence a new design of box was required.

Other requirements for which a new coin-box must cater include: the public demand for a slot to take a 3d. piece; the desire to time local calls from coin-boxes; the need for a simple method of adjusting the call charges, and the desire for a box of more pleasing appearance. These factors led to the development of a new coin-collecting system.

THE CHOICE OF A SYSTEM

The requirements could be met by either pre-payment or post-payment systems but attention was focused on the post-payment system because it avoided the need to hold money in suspense and thus permitted the A and B buttons to be eliminated without introducing the need for automatic deposit and refund mechanisms. A further advantage of a post-payment system is that it is intrinsically free from many types of fraudulent operation. Basically, the new system requires that money should be inserted to connect the speech path after the call has been set up and the called subscriber has answered. Once coins have been inserted they cannot be recovered by the caller, although worn or spurious coins will be rejected by the equipment. The new system has been named "pay-on-answer" to distinguish it from the existing manually controlled post-payment system.

A 3d. slot was an accepted requirement and it was considered that this slot should replace the 1d. slot of the present coin-box. This considerably increases the amount of money which the self-sealing cash container can hold and thus permits less-frequent clearance of the box. With 3d. as the basic unit the signalling code can take the form of one pulse for 3d., two for 6d. and four for 1s.

The remaining point to be considered was the method of charging. The new coin-box has to provide coin-box users with the full range of S.T.D. facilities. It has therefore to operate in conjunction with a periodic-metering system[1] on both local and S.T.D. calls. This implies that the pay-on-answer system should allow for extensions of a call by the insertion of further coins at various times throughout the call; the values of these coins being signalled to the exchange equipment, where they are recorded and compared, for each call, with the number of levied meter-pulses received.

Summarizing, the essential features of the system are as follows:

(*a*) Payment for calls should be made when the called subscriber answers and not, as with the present box, before dialling.

(*b*) There should be no buttons.

(*c*) The box should be capable of providing trunk-dialling facilities.

(*d*) There should be facilities for timing local calls and for extending the duration of these and other dialled calls by the insertion of additional money.

(*e*) The penny slot should be replaced by one for threepenny pieces.

OPERATION OF THE SYSTEM

Automatic Call

Referring to Fig. 1, on an automatic call the caller lifts the receiver, listens for dial tone and then dials the number.

(1) If the called subscriber is engaged, busy tone is returned and the caller clears.

(2) If the number is unobtainable, N.U. tone is returned and again the caller clears.

In cases (1) and (2) the coin slots remain locked and therefore coins cannot be inserted.

(3) If the called line is free, ring tone is returned to the caller.

When the called subscriber answers, the coin slots are unlocked and pay tone replaces ring tone. This pay tone, which is heard by both calling and called subscribers, informs the caller that coins must be inserted, and the called subscriber that the call is from a coin-box user.

(4) If the caller fails to insert coins then the pay tone persists for some 10 seconds, at the end of which time the coin slots are locked; 2 seconds later the call is "force-released" and N.U. tone is returned to the caller.

(5) If the caller inserts a coin (or coins) the pay tone is disconnected, the transmission path is opened and the conversation can begin.

When the period has elapsed for which payment has been made, pay tone is reconnected for some 3 seconds to inform both subscribers that the caller must insert a further coin (or coins) if the call is to continue.

(6) The caller may decline to insert a coin, and clear, or

(7) he may insert further coins. In this case pay tone

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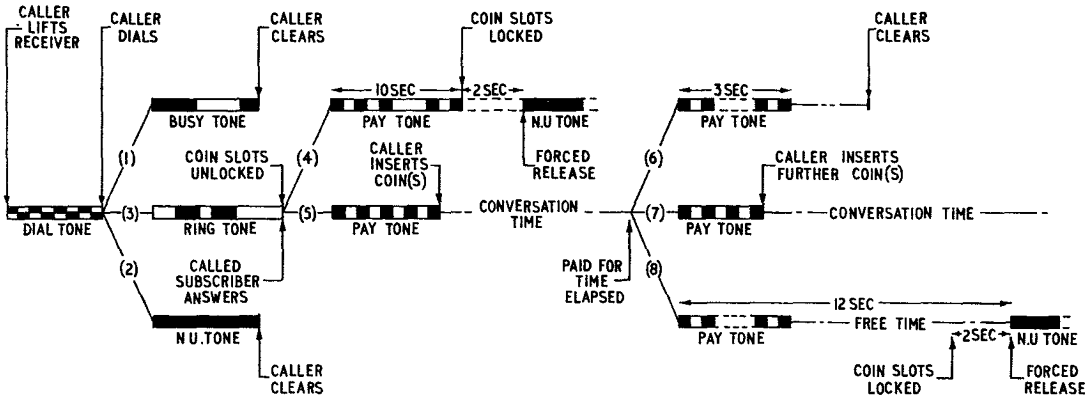


FIG. 1—AUTOMATIC CALL

is disconnected and the conversation may continue.

(8) The caller may, however, decline to insert further coins but continue the conversation, in which case the coin slots remain unlocked for some 10 seconds; after a further 2 seconds the call is force-released.

The transmission path is not disconnected during periods of subsequent pay tone and the 12-second period from the commencement of that tone until forced release is free time; only one free period is given per call although the application of pay tone may occur as often as is necessary. The coin slots are normally unlocked throughout the call from the time the called subscriber answers until clear down or forced release, and thus the caller may insert coins at any time. Pay tone consists of a 400 c/s tone interrupted at approximately 0·2 seconds on, 0·2 seconds off, although this may be changed as a result of international agreements.

Manual-Board Call

The origin of a call will be indicated at the exchange by either a distinctive lamp or, where the ordinary and coin-box junctions are in a common group, by the application of pay tone to the line when the operator answers. This discriminating tone, which cannot be heard by the caller, is disconnected by a momentary operation of the manual-board-position ring key.

When the operator requires the caller to insert coins into the box the coin slots are unlocked by a second momentary operation of the ring key. Each basic unit of money causes a 400 c/s pip of tone to be signalled to the operator, i.e. one pip for 3d. two for 6d. and four for 1s. This method of signalling eliminates the somewhat unsatisfactory existing method using gong and bell signals. The latter signals have been found difficult to distinguish on rural lines and where extraneous noise is present, and they also lend themselves to fraudulent simulation. Should the operator wish to recheck the amount of money inserted in the box during the call a further momentary operation of the ring key will cause the pips of tone to be repeated, equal in number to the actual amount inserted or to the amount in excess of any multiple of 24 units. For ease of counting, the pips are grouped into fours and, when rechecking, the slots are locked to prevent interference from other coins being inserted. This facility, which is referred to as an "audit" facility, may be used as often as is desired.

TECHNICAL OUTLINE OF THE SYSTEM

Trunking

Fig. 2 shows the basic trunking arrangement for a coin-box line in a non-director exchange. Each 1st selector in the coin-box group is preceded by a coin and fee checking (C.F.C.) equipment, as shown in the diagram.

Coin-Box Line Signalling

Two signals are required: the first is a signal, sent from the exchange to the coin-box, to unlock the coin-slots; the second is a signal from the coin-box to the exchange to indicate the value of coins inserted. If consideration is limited to a method of slot unlocking using direct-current signals, then the most satisfactory signal for coin-slot control is a reversal of the line potentials.

The coin-signalling system has to meet a wider range of requirements, and that chosen as offering the best compromise between simplicity in the coin-box and economic provision of equipment at the exchange is a loop/resistance method. As its title indicates, the signal consists of the reduction in line current caused by the insertion, at the coin-box, of a resistance of 5,000 ohms in the line loop. Each reduction in line current represents a single coin pulse and, to facilitate identification of a group of one, two or four coin pulses, the coin-pulse train is terminated by a short disconnexion of the line. Fraudulent simulation of the signal, e.g. by interfering with the handset cord, has been made difficult by suitable arrangement of the coin-box circuit; access to the lead-in wires has also been made difficult. A pulsing speed of 4 p.p.s. and a loop/resistance time ratio of about 2 : 1 have been chosen to ensure correct functioning of the

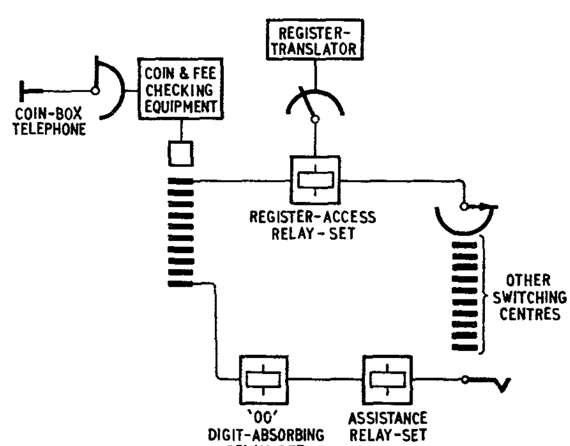


FIG. 2—TRUNKING OF COIN-BOX CIRCUITS AT A NON-DIRECTOR EXCHANGE

exchange meter and to facilitate the counting of tone pulses by the operator. It is hoped that the simplicity of the system will aid its reliability.

Manual-Board Signalling

A signal is required between the manual-board termination and the C.F.C. equipment for the purposes of coin-slot control, audit and, if required, coin-box discriminating-tone signalling. In director and discriminating satellite exchanges arrangements are made for this signal to bypass the 1st code selector, discriminating selector repeater (D.S.R.) or satellite 1st selector. Bypassing is achieved by providing an extra pair of wires from the outgoing side of the selector or repeater to the C.F.C. equipment. A further requirement is that the signal from the manual board must be inactive within the 1st code selector, D.S.R. or satellite 1st selector; this precludes the use of a reversal. In addition the signal-detecting element within the C.F.C. equipment must be of high input-impedance since it is required to be permanently connected across the outgoing positive and negative wires of the selector in the presence of speech. The signal used is a positive-battery pulse and the detecting circuit employs a transistor.

Treatment of Automatic Calls

When the call is answered by the called subscriber, receipt of the first meter pulse causes the C.F.C. equipment to cut the transmission path and return pay tone to both the called and calling lines. On local calls subsequent meter pulses are generated within the C.F.C. equipment whilst on calls completed by a register-translator they are returned from the associated relay-set. These latter meter pulses from the succeeding equipment arrive at the C.F.C. equipment after the appropriate period, irrespective of whether a coin has been inserted or not, and to give correct charging it is necessary to delay their effect by a time equal, in the first instance, to the interval between the receipt of the first meter pulse and the reconnexion of the transmission path on the insertion of the first coin. On national or international calls, where the metering rate is high, one or more of these pulses could arrive in the C.F.C. equipment during the initial pay-tone period and before the insertion of a coin, and arrangements must be made in the equipment to avoid any difficulties arising from this cause. The problem and the preferred solution to it are illustrated in the sequence chart of Fig. 3. It will be seen that a meter pulse (No. 2) is absorbed if it occurs before insertion of the first coin (A), and the time interval (t_1) between meter pulse 2 and the insertion of coin A is restored to the caller by delaying the levying of the next meter pulse (3). The extra 1 second of delay is explained later.

The arrangement to be used in the initial installation at Bristol follows a different principle. Pulses from the tariff-control equipment at six times the metering rate are repeated by the register-access relay-set and returned to the C.F.C. equipment, and a "divide by six" circuit is switched into use in the C.F.C. equipment only on insertion of the first coin. This circuit applies the first periodic pulse after counting seven supply pulses, to ensure that the first time interval is not less than the metering period, and thereafter a meter pulse is applied for every six supply pulses received. This was satisfactory at the time it was approved for use at Bristol, except perhaps for the rather frequent presence of positive-battery metering signals (a pulse every 2 seconds on a call of over 50 miles radial distance); subsequently, however, it was decided that it did not give adequate flexibility for possible future changes in tariff and that it would not be satisfactory for international subscriber-dialled calls. In addition, the maximum metering rate of one per second which can be handled by the metering-over-junctions system[2] would limit the international charging rates even if the divide factor were reduced to below six.

Referring again to Fig. 3, another difficulty brought into prominence on a high-metering-rate call is the loss of conversation time whenever a coin is inserted. On such calls this loss will be restored to the caller by delaying the levying of each subsequent meter pulse by 1 second for each coin after the first, as shown by coin B and meter pulses 3 and 4 and by coins C and D and meter pulse 5. When the delay time becomes greater than the metering period (6 seconds in the example) a meter pulse is absorbed and the delay reduced accordingly. This is illustrated by meter pulses 5, 6 and 7; pulse 5 is delayed by a total time of $t_1 + 3 = 7$ seconds and consequently pulse 6 is absorbed and the delay is reduced to t_2 (i.e. $7 - 6 = 1$ second). As no more money is inserted, pulse 7 and subsequent meter pulses are delayed by this time only.

Meter pulses 8 and 9 illustrate a further facility which is required on high-metering-rate calls, such as will occur with international subscriber dialling, when a meter pulse (9) arrives during the subsequent pay-tone or the free time period and causes a debt of 6d. This meter pulse is arranged to lock the slots and, 2 seconds later, to force release the call unless, prior to the slots locking, a coin has been inserted capable of taking the caller out of debt; a minimum of 6d. is required.

On lines from public call offices the C.F.C. equipment

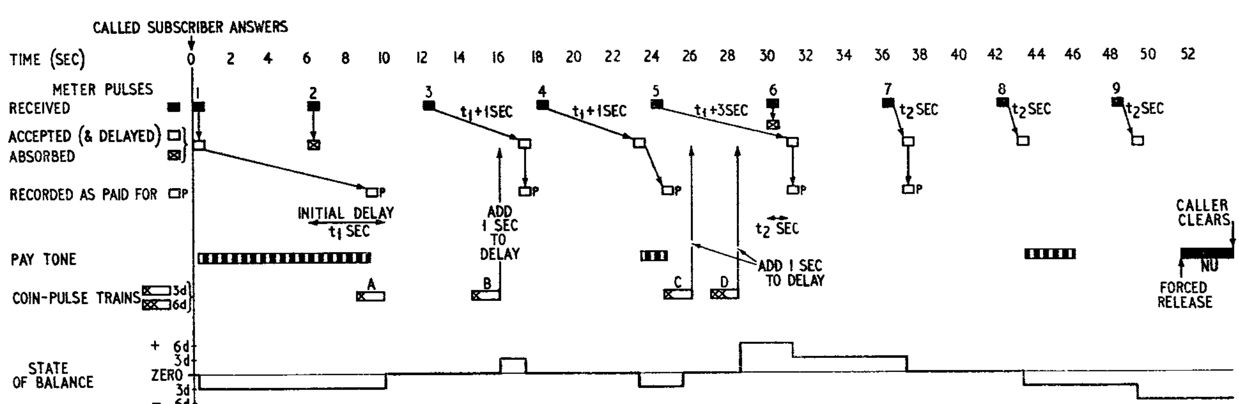
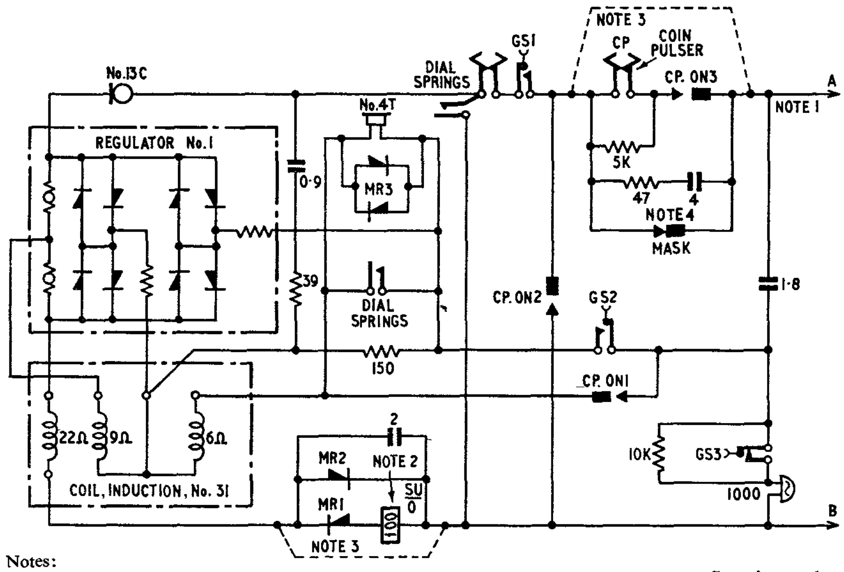


FIG 3—SEQUENCE CHART FOR HIGH-METERING-RATE CALL



Notes:
1. The A line is positive until the called subscriber answers, then negative.
2. Relay SU unlocks coin-slots when energized by current reversal (See Note 1).
3. These points are connected by a jack to provide "999" service with the mechanism removed.
4. The "Mask" springs are shown operated.

FIG. 4—PAY-ON-ANSWER COIN-BOX CIRCUIT

provides for recording all coin pulses on the exchange meter. On a subscriber's coin-box line, only those meter pulses are recorded (labelled P in Fig. 3) for which a corresponding coin pulse has been received. This ensures that the subscriber is not charged for answered calls for which a coin is not inserted.

Coin and Meter Pulse Registration

Provision is made in the C.F.C. equipment for incoming P, PM and M wires. The P wire provides holding and guarding facilities with or without positive-battery coin pulses. The PM wire provides holding and guarding facilities with positive-battery meter pulses or merely returns negative-battery or earth meter-pulses. In both cases meter-pulse registration is dependent upon one coin pulse per meter pulse having been received, i.e. the meter pulses registered must have been paid for. The M wire returns negative-battery or earth coin-pulses.

These alternatives cover all existing exchange metering systems and permit the use of two meters per coin-box line for the recording of both coin and paid-for meter pulses. With a single meter per calling equipment the public coin-box meter would be connected to record coin pulses and the subscriber's coin-box meter to record paid-for meter pulses.

CIRCUIT DESCRIPTION

Coin-Box Circuit

Fig. 4 shows the circuit of the coin-box. The telephone circuit itself is basically that of the new 700-type telephone.[3] Auxiliary dial springs are not required and hence the dial is of a standard type. A 100-ohm relay, SU, made sensitive by rectifiers to line reversals, is inserted to control the unlocking of the coin slots, but there is no reduction in the 1,000-ohm line limit of the 700-type telephone, because the low-resistance line-signalling relay in the C.F.C. equipment transmission bridge sufficiently compensates for the resistance of relay SU.

The resistance coin-pulses are generated by the coin pulser CP contacts, the resistance-capacitance network acting as a spark quench in addition to minimizing the click heard by the called subscriber at the commencement of each coin train. The functions of the off-normal springs (CP.ON) are given below, and Fig. 5 shows their timing relative to the coin pulses. The first coin pulse is 10 ms longer than subsequent ones to allow for its initial recognition in the C.F.C. equipment whenever coins are inserted.

(*a*) CP.ON1 short-circuits the receiver during coin pulsing. As the introduction of relay SU increased the direct current flowing through the receiver, the current was reduced to its normal value by the 10,000-ohm resistor switched in by GS3 to minimize the click when CP.ON1 operates.

(*b*) CP.ON2 is required to ensure that the line is closed by a precise 5,000-ohm coin-pulsing condition and to prevent interference with the coin pulsing by the gravity switch, the dial, or by the variable resistance of the transmitter. It was found, however, that its operation before commencement of coin pulsing, i.e. while the line current was high, caused a click to be heard by the called subscriber. Hence it is timed to operate approximately 50 ms after the commencement of the first coin-pulse, by which time the exchange equipment has disconnected the transmission path and thus prevented the called subscriber hearing any resulting click. The caller is, of course, protected by the CP.ON1 receiver short-circuit.

(*c*) CP.ON3 initiates the full break at the end of a coin train.

(*d*) Mask Contact. This prevents signals being sent by a rejected coin or by a coin which is finally withdrawn. Its resetting at the end of the cycle terminates the full break.

Coin and Fee Checking Circuit

The primary functions of the coin and fee checking

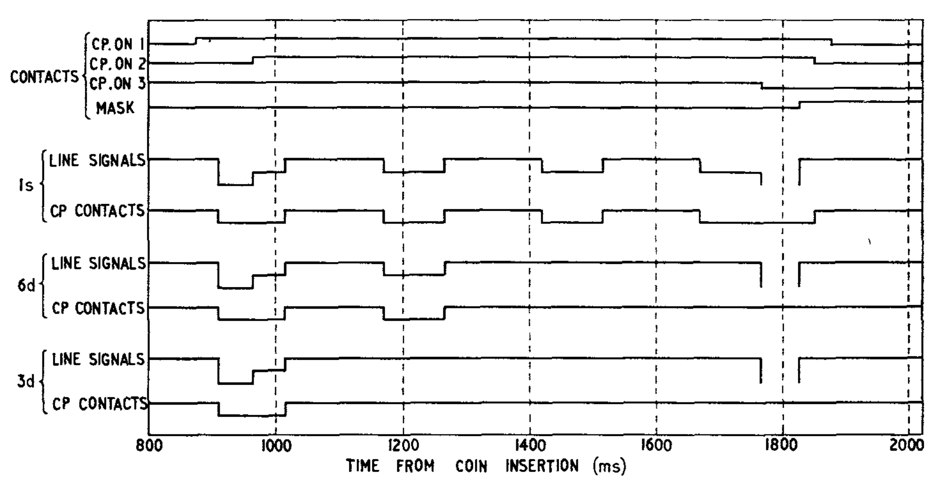


FIG. 5—PULSER TIMING CHART

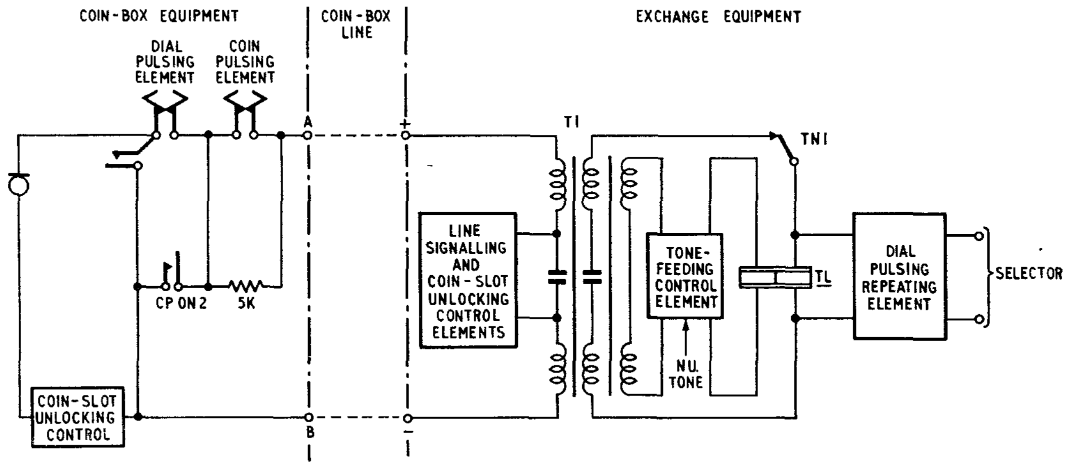


FIG. 6—BLOCK SCHEMATIC DIAGRAM OF COIN-BOX AND EXCHANGE EQUIPMENT

circuit are the detection of the signals generated by the insertion of coins, and the comparison, throughout the duration of the call, of the total number of coin pulses received with the total number of meter pulses proper to the call at that time. All other facilities arise from these basic requirements.

The need to detect coin signals in the presence of any line-current reversals from succeeding equipment, which could occur, for example, in the case of non-director and group-selector satellite exchanges, presented a number of problems, not the least of which was the possibility of over-registration due to the splitting of a coin signal by a reversal. A transmission bridge was introduced, therefore, which enabled complete control to be exercised over the coin-box line condition. A transformer-type bridge was employed because it permitted the use of a high-speed signalling relay and facilitated the sending of tones to either or both sides of the connexion, with or without continuity of the transmission path.

Fig. 6 shows, schematically, the method of extending the line through the exchange equipment. The tertiary winding of the transformer (T1) and retard coil TL provide for tone feed; relay TN (see contact TN1) is used to isolate one side of the connexion from the other when required, i.e. during the transmission of the initial pay tone, "audit" signals and repetitions of coin pulses.

The following paragraphs describe some of the more interesting details of the equipment.

Coin-Pulse Detection. Fig. 7 shows the method of identifying, by voltage discrimination, the type of pulse (dial or coin) being received from the coin-box. Relay LS responds to both dial and coin pulses but relay LL remains operated provided that the line, which may itself have a resistance of up to 1,000 ohms, is looped at the coin-box by a 5,000-ohm resistor, i.e. a total resistance lower than that normally permissible as the limit for low insulation.

The discriminating voltage appears across the ballast resistor and the small series resistor R2. It is undesirable to utilize the voltage developed across relay LS because of the possibility of damage to the transistor by "back e.m.f." during signalling. It will be appreciated that the ballast resistor, in tending to maintain a constant line current, operates unfavourably for this method of signalling, and, but for resistor R2, would have necessitated the detection of very small voltage variations. When a pulse is detected resistor R2 is switched into circuit by contact LSR1. The various voltages which can occur at the inspection point P under varying line conditions can be summarized as follows:

Coin-pulse condition, —0·8 volts to —1·08 volts

Line-open condition, 0 to —0·2 volts (due to low insulation)

A device for detecting these voltages must have comparatively high sensitivity and gain to guarantee the release of relay LL at —0·2 volts and its operation at —0·8 volts. These requirements are met by the circuit shown in Fig. 7, which uses a P.O. No. 4 transistor. A satisfactory performance is achieved with a transistor static gain as low as 20 (common-emitter configuration) although the specified minimum gain of the P.O. No. 4 transistor is 40. The base-to-collector leakage current, which rises with increase of temperature, tends to make the base increasingly negative with respect to the emitter, due to the voltage developed across the base input resistor. With the equipment in use the tendency is, therefore, for the transistor to remain in an "on" state, and so prevent the release of relay LL. The diode MR1 (Fig. 7), which is connected across the base resistor in such a way as to conduct the leakage current, prevents the base from going negative with respect to the emitter and ensures that the transistor will always turn "off" when so required. The quench circuit, C1, R3, connected across the coil of relay LL ensures that the collector

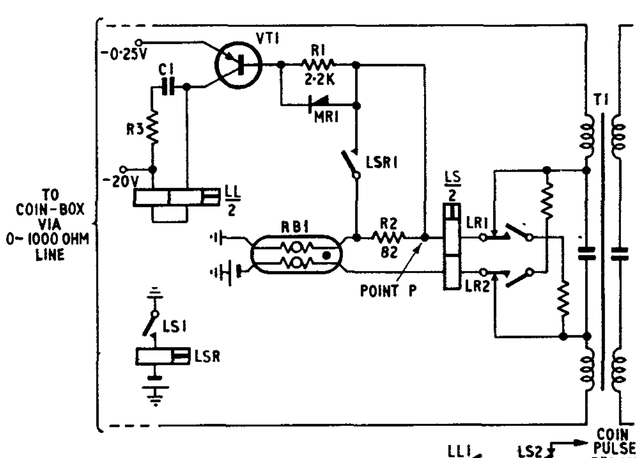
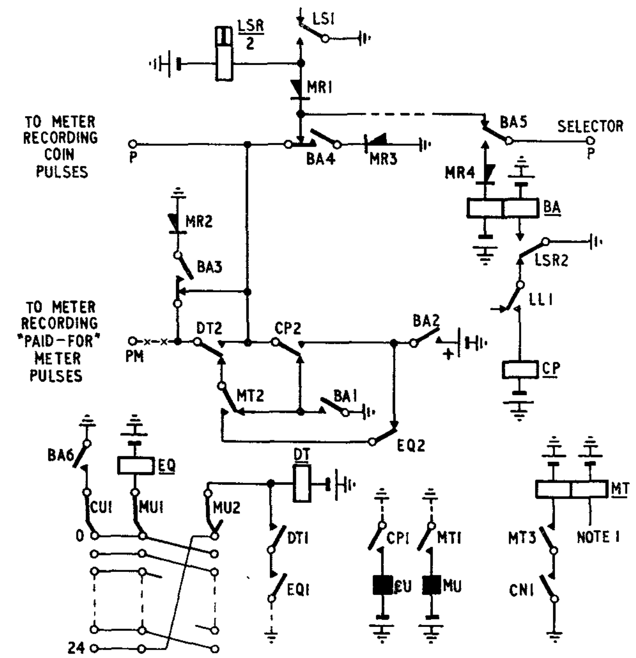


FIG. 7—COIN-PULSE DETECTING CIRCUIT



Notes:
1. Accepted meter pulses from Fig. 10 (S.T.D. call) or from local-call timing element.
2. The contacts marked CU1, and those marked MU1 and MU2, are the wiper and bank contacts of uniselectors CU and MU respectively.
3. The strapping (x–x) shown is that appropriate to a positive-battery-metering exchange.

FIG. 8—COIN AND METER PULSE COMPARISON AND REGISTRATION CIRCUIT

voltage does not exceed the maximum specified for the transistor. Fig. 7 shows also the method of controlling the coin slots. On seizure, the line polarity is such that relay SU in the coin-box remains normal and operates to unlock the slots only on the operation of relay LR.

Comparison and Registration of Coin and Meter Pulses. Fig. 8 shows the circuit element used to determine the state of the balance between the total number of coin pulses received and the total number of levied meter-pulses. The figure shows also the circuit element used to control the coin-box line-circuit meter, which may be associated with terminal P or PM, as required, to record "Total Coin Pulses" or "Total Paid-for Meter Pulses." Additional circuit arrangements allow for negative-battery or earth paid-for meter-pulses on terminal PM and include a terminal M (not shown in Fig. 8) to cater for negative-battery or earth coin-pulses.

On seizure, contact LS1 earths terminals P and PM to give fast guarding and holding conditions and operates relief relay LSR. Contact LSR2 operates relay BA, and contact BA1 takes over the guard and hold functions. Contacts BA3 and 4 provide alternative earth conditions via rectifiers MR2 and 3 to cover the transit time of the actual metering contacts. Contact BA5 splits the P wire to permit interception of the metering pulses returned from the succeeding equipment.

Uniselectors CU and MU are actuated, respectively, by coin pulses via relay CP and "accepted" meter pulses via relay MT, and take up positions throughout the call corresponding to the totals of those pulses received. The state of the caller's balance during the call is indicated by relays EQ and DT, which are controlled by arcs CU1, MU1 and MU2. There is a credit whilst both relays are normal, a zero balance when relay EQ only is operated, and a debit when relay DT only is operated. The holding circuit for relay DT (contacts DT1 and EQ1) ensures that relay DT remains operated should a further meter pulse be received while in debt. This situation can arise with international-call metering rates and results in the locking of the coin slots, followed some 2 seconds later by forced release. If, however, a coin is already in transit it must be detected and the call permitted to proceed only if, at the termination of the coin train, relay DT is normal.

Contact CP2 extends positive battery to terminal P for each coin pulse and, when there is a debit at the time of payment, to terminal PM. While there is a credit balance terminal PM is pulsed by successive accepted meter-pulses via contact MT2. When the balance becomes zero, contact EQ2 operates and inhibits contact MT2 to prevent the next accepted meter-pulse, which has not been paid for, from producing a corresponding pulse at terminal PM. However, contaet MT1 steps uniselector MU, and relay DT operates to initiate a pay demand. Terminal PM will be pulsed again by contact CP2 only during the coin train which must follow if the call is not going to be terminated. In order that contact DT2 shall not clip a pulse from contact CP2 it is necessary to ensure that, whenever a coin-pulse train and an accepted meter-pulse overlap, the meter pulse is extended until the end of the train. This is achieved by holding relay MT via contact MT3 and coin-pulse-train relay contact CN1 until relay CN releases at the end of the coin-pulse train.

The Delaying of Meter Pulses. The two remaining uniselectors TU and DU are associated with local-call timing, the accumulation of delay time and the delaying of meter pulses on S.T.D. calls. Uniselector DU, stepping at a rate of one outlet per second, times and stores the interval between the meter pulse, received from the succeeding equipment on called-subscriber answer, and the insertion of the first coin. However, should any subsequent meter pulses be received from the succeeding equipment during this period, the uniselector must home and recommence timing. It must also step once for each subsequent coin inserted to compensate for the resulting loss of conversation time. These requirements are met by the circuit shown in Fig. 9. At the end of the initial meter pulse a relay MY operates and contact MY1 extends the drive circuit for uniselector DU to contact

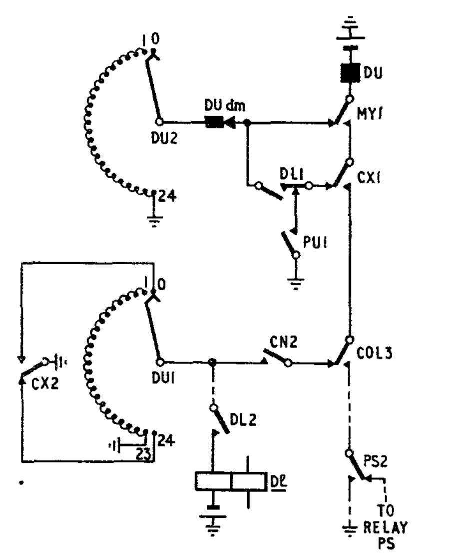


FIG. 9—DELAY-TIME CIRCUIT

PU1, which is pulsing at 1 p.p.s. The insertion of the first coin operates a relay CX which, at contact CX1, disconnects this drive circuit, the operation of relay CX being inhibited during a PU make-pulse to prevent clipping of that pulse. Relay DL operates for each subsequent meter pulse and, prior to the insertion of coins, i.e. with contact CX1 normal, contact DL1 causes uniselector DU to home. During homing a DL contact inhibits the operation of relay CX to prevent interruption of the homing circuit should a coin pulse be received. Coin-pulse-train relay contact CN2 steps uniselector DU once for each coin received. With contact CX2 operated, arc DU1 allows for a delay time of up to 23 seconds. On an S.T.D. call, each meter pulse from the succeeding equipment received after the insertion of coins is delayed by the delay time currently recorded on uniselector DU, before operating relay MT.

If a further meter pulse is received during the delay of the previous pulse, i.e. when the delay time exceeds the metering period, this further pulse must be absorbed and time equal to the metering period deducted from the delay time. Fig. 10 shows the circuit operation. A trunk-call relay TC operates on receipt of the second meter pulse and contact TC2 homes uniselector TU which, until this stage of the call, has been performing as a local-call timer. Relay DL operates to the second and subsequent meter pulses and, at contact DL2, prepares a circuit for relay DLA. With uniselector TU in its home position, and following the insertion of coins (CX3 contact operated), relay DLA operates and contact DLA1 connects one-second PU pulses to the TU magnet. The 1 p.p.s. stepping of uniselector TU continues until a PU pulse via arcs TU2 and DU3 operates relay MT. Contact MT5 releases relays DL and DLA so that uniselector TU homes. When a further meter pulse is received during the delaying period relay CDL operates and contact CDL3 energizes the timing relay PS. In addition, contacts CDL2 and CDL3 place the stepping of uniselectors TU and DU under the control of contacts PS 1 and PS2. Pulsing at a nominal 10 p.p.s., contacts PS1 and PS2 step the two uniselectors until uniselector TU, on stepping to its home position, disconnects the operate circuit of relay PS and releases relay CDL. Stepping of uniselector TU at 1 p.p.s. recommences until relay MT operates to record the previous meter pulse, when relays DL and DLA release, and uniselector TU homes, as before.

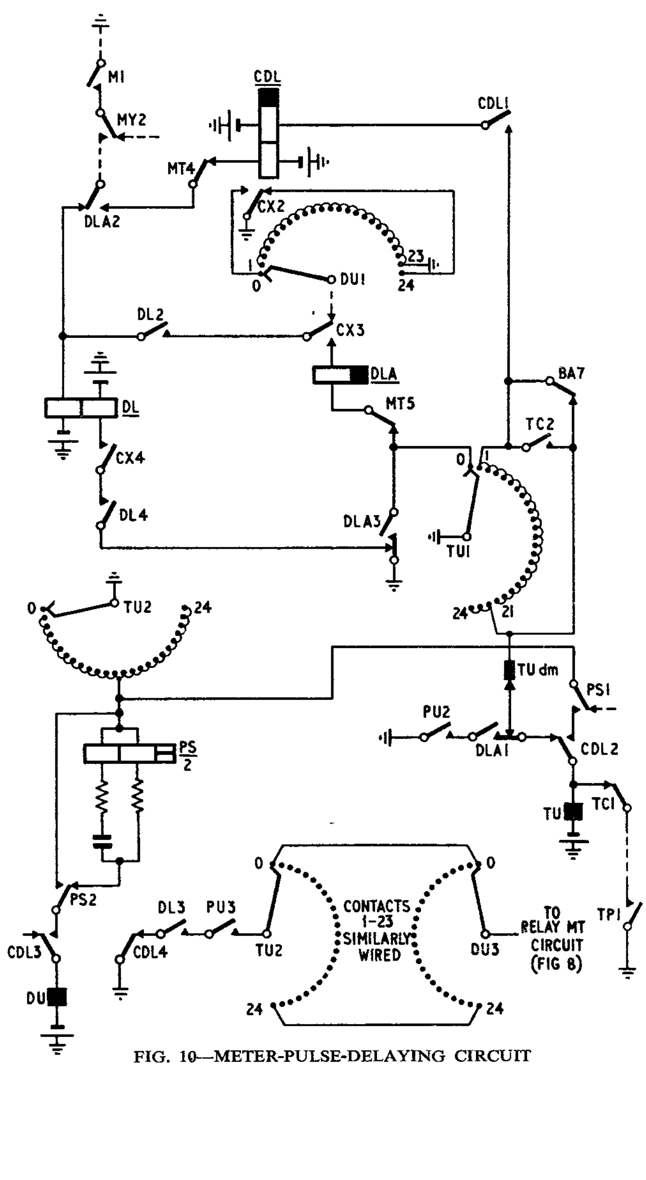
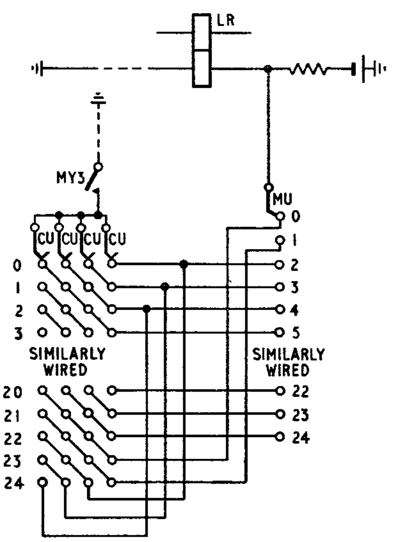


FIG. 10—METER-PULSE-DELAYING CIRCUIT

Maximum Credit. Reference has been made already to arcs CU1, MU1 and MU2 of the coin-pulse and meter-pulse uniselectors (see Fig. 8); further arcs CU2–5 and MU3 ensure that the limited storage capacity of the coin-pulse uniselector is not exceeded, by arranging for the locking of the coin-slots by the release of relay LR when a credit of 20 coin pulses has accrued (see Fig. 11). This allows for the circumstance in which a credit of 19 exists and a shilling is inserted giving a total credit of 23—the maximum that the circuit can accommodate. The slots are unlocked again when the receipt of a meter pulse (or pulses) reduces the credit to 19.



The contacts marked CU and MU are the wiper and bank contacts of uniselectors CU and MU

FIG. 11—MAXIMUM CREDIT CIRCUIT

Positive-Battery-Pulse Detection. Fig. 12 shows the circuit used for the detection of positive-battery signals returned, from the manual-board relay-set, to a director or discriminating-satellite exchange. The transistor has a high input-impedance which allows it to remain connected to the line during speech. Its high sensitivity makes it tolerant of positive-battery voltage variations and junction resistance.

Audit. A sequence uniselector SU, stepping at a rate

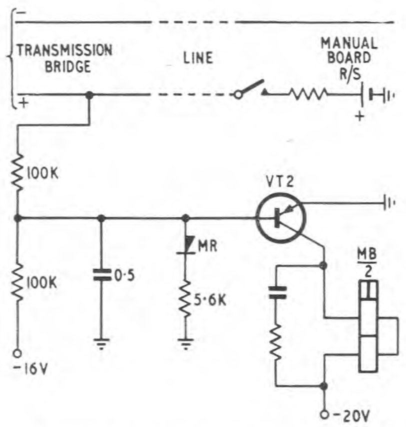


FIG. 12—POSITIVE-BATTERY-PULSE DETECTING CIRCUIT

of one outlet per second, times and controls the initial and subsequent pay-tone sequences. In addition, it is also involved in the generation of pips of tone for the audit facility. Following receipt of a positive-battery signal from the operator demanding audit, a relay AUD operates and contact AUD1 (see Fig. 13) energizes a

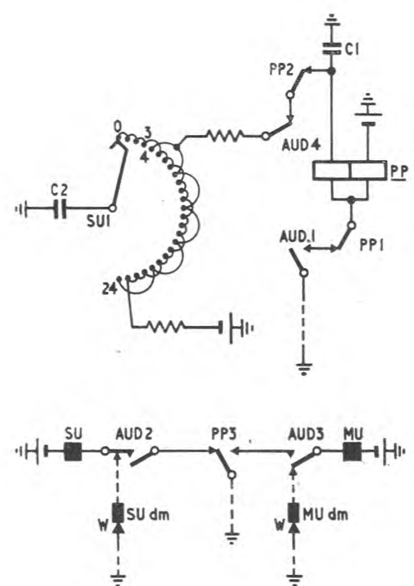


FIG. 13—AUDIT CIRCUIT

self-interacting-relay timing element PP. Relay PP pulses at approximately 0·2 seconds "on," 0·2 seconds "off" and a group of four pulses of tone is sent to the operator as uniselectors SU and MU step over outlets 0–3 under the control of contact PP3. The interval between this group of pulses and the next is achieved by the introduction of an additional capacitor, C2, at outlet 4 to increase the operate time of relay PP. The sending of audit pips and the stepping of uniselectors SU and MU continues in a similar manner until the operation of relay EQ (see Fig. 8) indicates that the number of pulses sent to the operator equals that of the coin pulses as stored on uniselector CU. Relay AUD then releases and uniselectors SU and MU home.

THE COIN-BOX

The general size and shape of the new box have been determined by the decisions to combine coin-box and telephone in a single instrument; to use aluminium alloy for the casing; and to restrict certain dimensions in the interests of interchangeability with the present box. The final appearance of the instrument is, however, the work of an industrial designer, and has received the approval of the Council of Industrial Design. It is to be known as a "Telephone No. 705" and is shown in Fig. 14.

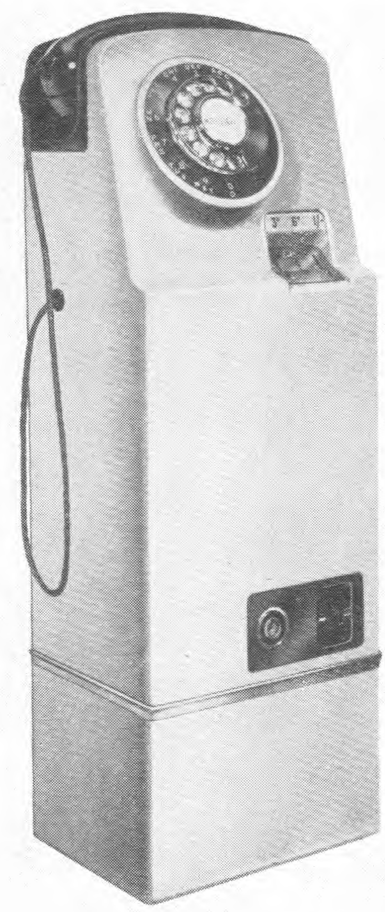


FIG. 14—TELEPHONE NO. 705

Description

The main sections of the casing are pressure castings in aluminium alloy, thus eliminating the possibility of rusting. The stove-enamelled finish, which will withstand a long period of normal wear-and-tear, is in a warm shade of grey. The handset and handset recess are black while the receiver rests and other bright fittings are of stainless steel. The coin-denomination plate has a matt chromium finish to enhance the legibility of the figures. The handset cord is grebe grey and the dial number-ring and the rejected-coin recess are in forest green, to blend with the case colouring.

The main components of the Telephone No. 705 are shown in Fig. 15. The cash compartment is bolted to the bottom of the backplate and, when assembled, the coin-operated mechanism is jacked into the top portion. The cash compartment and its sliding door are steel lined to give good security and, to prevent the accidental

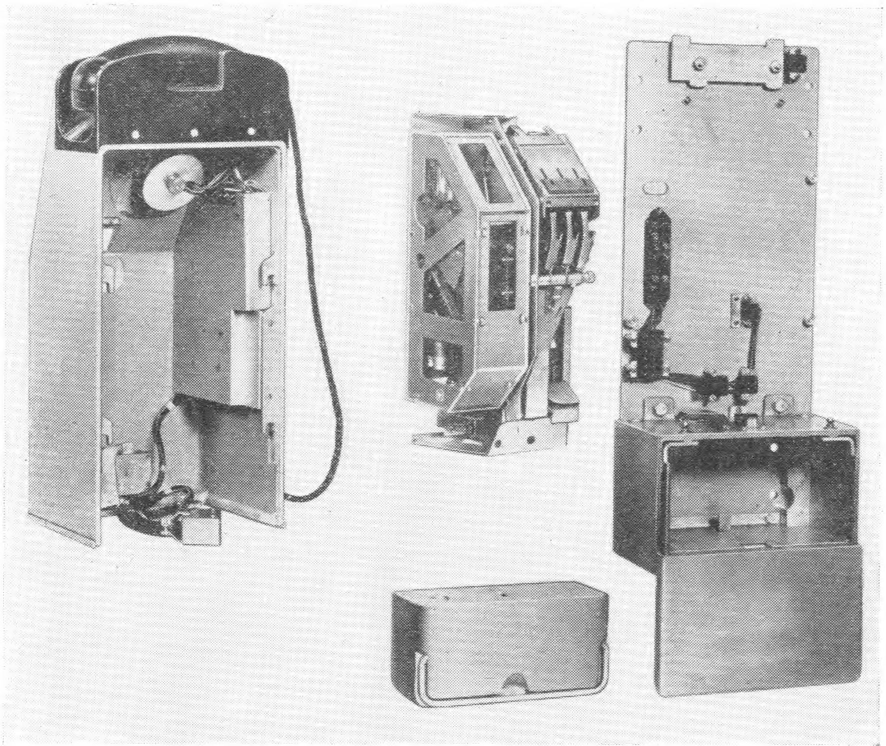


FIG. 15—MAIN COMPONENTS OF THE TELEPHONE NO. 705

omission of the "self-sealer", the door of the cash compartment cannot be fully shut unless a cash container is in position. When unlocked, the door drops downwards and allows the self-sealing cash container to be withdrawn like a drawer. The cover over the mechanism compartment is attached to the backplate in such a way as to make forcible removal difficult, and to prevent any strain being applied to the lock. This cover carries the whole of the telephone equipment so that when the mechanism is removed for maintenance the insertion of a plug into a socket on the backplate enables the telephone circuit to be used for non-chargeable calls. If the telephone is left in this condition for public use, the coin plate aperture is closed by a label stating, "TEMPORARILY OUT OF USE, except for calls to FIRE, POLICE, OR AMBULANCE".

The handset is the same as that used for the new Telephone No. 706, and the receiver rest has been designed to ensure that however the handset is replaced the gravity switch will operate and will not be fouled by the handset cord. Normally the bell-set, which carries the gravity-switch spring-set, is attached to the inside of the cover as shown in Fig. 15, but it can be removed for maintenance without disconnecting the circuit. The reject-coin return has to handle only one coin at a time, and this has enabled it to be designed to present a rejected coin to the caller so that it can be picked up cleanly. The locks of the cash and mechanism compartments and the self-sealer lock are the same as those used on the existing coin-box. Means of releasing the cash compartment or the mechanism cover in the event of a lock failing have been provided.

The coin-operated mechanism is shown in the centre of Fig. 15. The pulser mechanism can be seen on the left and the coin acceptor on the right of the central main frame. The main structural members throughout the mechanism are of mild steel, cadmium plated and passivated, whilst use is also made of stainless steel, anodized aluminium, nickel-silver and rigid p.v.c. for certain key parts. A transparent plastic cover is fitted over the pulser mechanism; although not airtight, this cover will reduce the amount of dust that settles on the spring sets and will afford protection against normal handling.

Operation

The movement imparted to the mechanism as the full diameter of the coin is inserted in the appropriate coin slot raises the pulser cams. When the cams are fully raised the coin falls inwards and the cams then commence to fall at their governed speed. The first half of their fall allows time for the coin to be tested and, during the second half, coin pulses are generated and these are transmitted to line provided that the coin has been accepted.

The coin acceptor has a coin plate with three slots, one each for threepenny pieces (twelve sided), sixpences and shillings. When a coin is pressed into the appropriate slot, the coin attempts to move an arm which has one end projecting part of the way across the slot. There are three such arms, one for each slot, and they have several functions. It is these arms which are electromechanically locked by relay SU under the control of the C.F.C. equipment to prevent the insertion of coins, and mechanically locked while one coin is being signalled to prevent a second coin being inserted before the operational cycle is complete. Before the operation of relay SU, the slots are kept locked by a latch which is put into lateral compression by pressure from a coin on any of the movable arms, and thus no force is transmitted to the relay armature; the mechanical locking is safeguarded in the same way. It is arranged that no two arms can be moved simultaneously, so that it is only possible to insert one denomination of coin at a time. The movement of any one of these arms by the insertion of a coin lifts the pulser cams in readiness for coin signalling and also positions the coin-pulser spring-set opposite the appropriate cam. This spring-set is normally positioned against the sixpenny cam to minimize the work to be done by the smallest coin. Once the coin has passed the movable arm it is checked on a coin tester similar in principle, but of improved design, to that used in existing coin-boxes. Where the use of counterfeit coins is prevalent a milling detector can be fitted to either or both of the silver-coin testers. After successfully passing the tester, the coin operates the mask contacts (see Fig. 4) to remove the short-circuit from the pulser, and then falls into the cash compartment.

The pulser mechanism has six cams linked to a dial-type governor in such a way that they can be quickly raised but will fall steadily during the 2-second period of the operational cycle. Should the pressure on the coin be relaxed during insertion a double-acting ratchet supports the cams at the point reached to avoid lost ground. This ratchet also prevents the cams being re-lifted once they have started their downward swing.

During each operation of the pulser, four spring-sets CP.ON1, CP.ON2, CP.ON3 and CP are actuated. A fifth spring-set, the MASK, is operated by any coin which successfully passes the coin tester and is reset as the cam bank comes to rest. CP.ON1, CP.ON2 and CP.ON3 are associated each with its own cam and operate in the same sequence independently of the value of coin inserted, but CP is mounted on a pivoted carriage and is positioned, during coin insertion, opposite the appropriate cam to produce one, two or four pulses. An interval of 900 ms is allowed between the fall of a coin and the commencement of pulsing to ensure that a slowly moving coin has had time to operate the mask. (See Fig. 5.)

The amount of energy available to operate the pulser is derived from the insertion of the coin, and it must be limited if the coin-insertion pressure is to be kept to an acceptable figure. For this reason the distance through which the cams can travel, and hence the length of a lobe on a cam, is rather short, and the precision with which the spring-sets can be adjusted relative to the cams must be high if the required accuracy of timing is to be obtained. It is arranged, therefore, that the engagement of the spring-sets with the cams can be adjusted accurately by means of rockers, and the relative timing of the spring-sets controlled by positioning the operating levers by means of spring-loaded screws giving a fine adjustment.

Maintenance

The coin-box equipment has been designed with the maintenance aspect very much in mind and is of unit construction throughout. Thus, any part of the casing which becomes worn or damaged in service can be replaced in the field without removing the backplate or the permanent wiring. The two main units of the mechanism are the coin acceptor and the pulser. It is not anticipated that the pulser will normally have parts replaced in the field but the coin acceptor has a readily detachable coin-runway assembly which can be changed if it becomes faulty. The front of the reject-coin guide-tube is detachable so that, for example, any jam caused by interference with the reject-coin slot can be readily cleared by the maintenance staff. It is thought probable that any fault on the pulsing unit will be dealt with at a coin-box overhaul centre, after the whole mechanism has been jacked out and a spare one inserted.

A testing kit has been prepared for use in an overhaul centre, and a multi-point test jack and plug are provided at the base of the pulsing unit to isolate and give access to the various circuit elements. The kit will enable the overall time of the fall of the cams to be set up correctly, and the correct positioning of the spring-sets to be obtained.

ACKNOWLEDGEMENTS

Acknowledgement is made to Messrs. Associated Automation Ltd., the development contractors for the new coin-box.

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Layout of Charging Groups and Rearrangement of Line Plant and Switching Equipment for Subscriber Trunk Dialling

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U.D.C. 654.15.03:621.395.374

Details are given of some of the factors taken into account when arranging the exchanges in the United Kingdom into about 640 charging groups in preparation for subscriber trunk dialling, and the changes necessary to the trunking of junction tandem exchanges are discussed.

INTRODUCTION

THE existing switching plan for dealing with trunk traffic was introduced over 35 years ago. It is based on operator control of trunk traffic at a number of group-centre exchanges.[1] When the scheme was originated, it was envisaged that there would be about 70 of these centres, and that each local exchange would be directly connected to a group centre for switching outgoing and incoming traffic. It was, however, uneconomic to establish direct routes in all cases because of the small volume of trunk traffic originated at many local exchanges and the considerable distance between some of the exchanges and their group centres. Some local exchanges were therefore connected to an intermediate exchange through which they obtained access to their group centre; these intermediate exchanges often became the collecting centres for several such local exchanges. By 1955, there were approximately 6,000 local exchanges in the country, and with the increase in trunk traffic that had occurred, the number of group-centre exchanges had grown to 250; furthermore, there were proposals in hand at that time for an increase to more than 300 group centres.

FORMING THE CHARGING GROUPS

To prepare for the system of subscriber trunk dialling (S.T.D.) to be used in the United Kingdom, it was decided to replace the call tariff based on the radial distance between exchanges by a system under which exchanges are formed into 600 to 700 charging groups, with call charges common to all exchanges in each group.

For the purpose of routing S.T.D. calls the country is also to be divided into some 700 numbering groups,[2] which will, in general, line up with the charging groups. Where this coincidence cannot be achieved it is essential to the scheme that each charging group should be formed from two or more complete numbering groups. It must normally be possible for traffic to and from all exchanges in the numbering group to be routed via a common switching centre, the "group switching centre" (G.S.C.), to which all the exchanges should be connected by direct circuits. Ideally, charging groups should be of uniform size and shape, and each G.S.C. should be within its numbering group. Existing group-centre areas, however, vary considerably in size and shape, and as in general existing junction cables radiate from a group centre out to the local exchanges (though geographical conditions can vary this arrangement considerably), cabling difficulties often arise in those charging groups which do not themselves contain the group centre (about half the charging groups). Consequently, in practice considerable difficulties arise in trying to form charging groups of reasonably uniform size without involving extensive rearrangements of line plant.

Any system of group charging is bound to introduce some charging anomalies since the call charges are not strictly related to the distances between exchanges. Probably the most noticeable anomaly would normally be between adjacent exchanges on opposite sides of a fee boundary, but this was avoided by the decision that calls to exchanges in the home and adjacent charging groups should be charged at the same fee. This also meant that the boundary of the home charging group became less important from the point of view of call fees than the outer boundary of the adjacent charging groups, which became the nearest fee boundary. Since this was considerably more distant than the home charging group boundary, fee anomalies were less significant, and more latitude in fixing the size and shape of charging groups was possible.

After a number of trial attempts it was eventually decided to adopt a procedure whereby charging-group boundaries were provisionally defined around the larger towns and the territory between them was divided up, the boundaries being adjusted to obtain a satisfactory layout from the charging point of view. Detailed consideration was not given to line plant at this stage. Each charging group and its unit-fee area, i.e. the combined area of the home and adjacent charging groups, were then examined in detail and adjusted to suit existing line-plant layout as far as possible.

It was decided that the director areas should each form one charging group, and this raised special problems in the case of London, because of the large size of the London director area (approximately a circle of 12½ miles radius). The charging groups adjacent to London were therefore made rather narrower, in order to reduce the London unit-fee area to a size nearer to that obtained in the rest of the country. Also, many London director exchanges at present have code dialling to exchanges in the 12½–20-mile belt round London, and it was desirable that this should be retained. The boundaries of the charging groups round London were therefore drawn to follow the 20-mile circle as closely as possible. In order to do this, the ideal configuration from the line plant point of view was departed from more frequently than in other parts of the country.

The charging groups finally defined numbered approximately 640. A large number of them contain more than 50,000 subscribers and more than 20 exchanges, whereas many contain less than 100 subscribers and only three or four exchanges (even ignoring small and remote islands). They vary in size from a maximum of about 600 square miles, in a district consisting largely of mountains, to about 40 square miles (again ignoring the islands). The unit-fee areas are much more uniform

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in size, varying, in inland areas, from about 1,500 square miles to about 600 square miles; coastal areas are generally smaller. Even this represents a fairly wide diversity in size but for practical purposes it is not as significant as it appears. The very large areas contain considerable stretches of moorland or mountains which, having no telephones, can be discounted.

Line Plant

The transmission plan for the country[3] allocates a maximum value of transmission loss to each type of link (e.g. minor exchange to group centre; group centre to zone centre) in a trunk connexion so that, when these links are switched in tandem to interconnect any two exchanges in the network, the total line loss will not exceed a specified maximum. The plan depends, therefore, on the availability of suitable plant between each group centre and its local exchanges, however distant from the group centre they may be.

For each proposed charging group it was necessary to study the layout of existing and proposed line plant in relation to a probable G.S.C. and also to ensure that the maximum permissible transmission loss would not be exceeded. Generally, a charging group consisting of exchanges in the immediate vicinity of a large town presented very few difficulties, but problems were provided by the charging groups immediately beyond these, and by charging groups in remote areas. The objects throughout the investigation were to ensure that:

(*a*) the adoption of suitable G.S.C.s would be possible when it became necessary to provide S.T.D. access to the charging group;

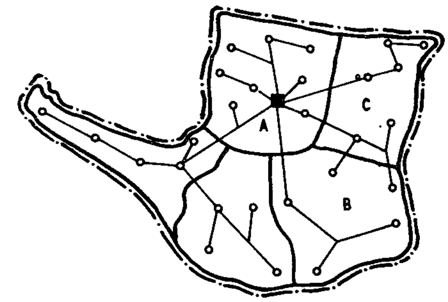
(*b*) the provision of new plant specifically to permit grouping of exchanges would be avoided as far as possible, and

(*c*) major rearrangement of existing line plant would not be entailed.

An existing group centre under the present transmission plan is obviously a suitable point to which trunk traffic could be routed for exchanges in its vicinity, and it becomes the natural choice of G.S.C. for the exchanges within its own charging group. In a few cases, the charging group, as finally adopted, has coincided exactly with the area at present served by an existing group centre. An example of this is shown in Fig. 1. The charging group provisionally proposed might well have included exchanges A, B and C, since these would have given the charging group a more uniform shape. These exchanges would have been excluded after the line plant had been studied, because, as the diagram shows, they are cabled in a different direction, and the cost of recabling them to the group centre for switching under S.T.D. conditions would be unwarranted.

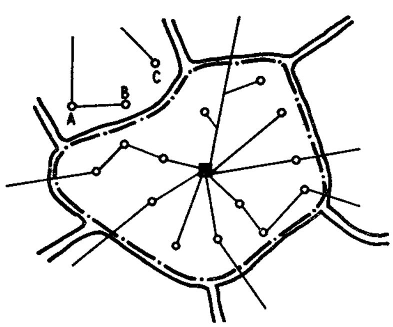
An existing group centre may also be the most suitable switching centre for the exchanges in a charging group adjacent to the home charging group. This happens when all the exchanges in the charging group are within a reasonable distance of the group centre (to which they will already be cabled) but none is suitably connected to be an acceptable cabling centre. An example of this type is shown in Fig. 2; the existing group centre is the most suitable switching centre for all exchanges in charging groups A, B and C, where cable routes are such that there is no exchange in either of charging groups B or C which would be suitable for switching traffic to all exchanges in its own charging group (or both charging groups).

Fig. 3 illustrates the case of a charging group consisting of exchanges *d* to *i*, which are in the territory served by an existing group centre X, and exchanges *j* and *k*, which are in the territory served by another group centre Y. Some of the exchanges *e* to *i* may be dependents which obtain connexion to X by switching at *d*. The existing cable layout is such that exchange *d* would be a suitable switching centre for all exchanges in the charging group, although it would be necessary to rearrange or augment the line plant to some degree. The alternative of pro-



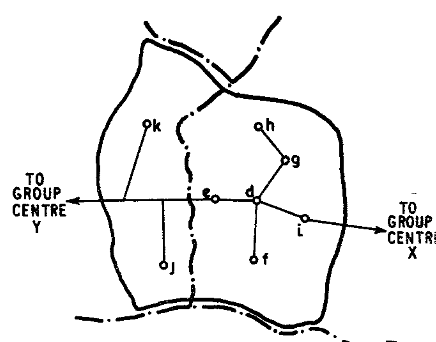
Boundary of existing group-centre area
Adopted charging group boundary
Existing group-centre exchange
Local exchange
Existing cable route

FIG. 2—EXISTING GROUP-CENTRE EXCHANGE SERVING AS GROUP SWITCHING CENTRE FOR THREE CHARGING GROUPS



Boundary of existing group-centre area and adopted charging group
Boundary of adjacent charging group
Existing group-centre exchange
Local exchange
Existing cable route

FIG. 1—CHARGING GROUP FORMED FROM EXISTING GROUP-CENTRE AREA



Boundary of existing group-centre area
Adopted charging group boundary
Local exchange
Existing cable route

FIG. 3—CHARGING GROUP FORMED FROM PARTS OF TWO GROUP-CENTRE AREAS

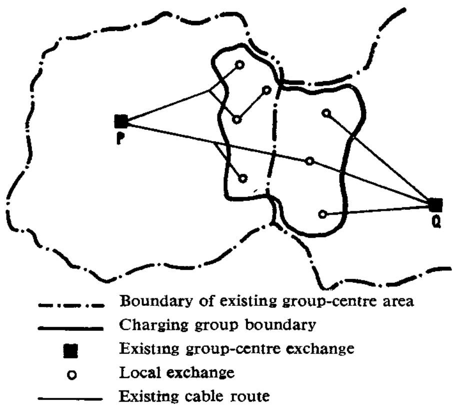


FIG 4—CHARGING GROUP BETWEEN TWO LARGE CITIES

viding direct circuits from each exchange in the charging group to either of the group centres at X or Y could well prove to be uneconomic.

A somewhat similar case is shown in Fig. 4, where the charging group has been formed between two large cities that are existing group centres. It will be seen from the cabling that there is no suitable exchange within the charging group which could serve as a switching centre, neither would it be reasonable to provide direct circuits from each exchange in the charging group to either of the existing group centres. In cases such as this, the best course would be to treat the charging group as two separate numbering groups, each with its own national code for routing purposes. One numbering group would be switched at group centre P, and the other at group centre Q. Although separate codes would be used, call charges from an originating exchange would be the same for both numbering groups. To avoid encroaching unduly on the spare national codes available, the number of areas that can be treated in this way has to be limited.

Fig. 5 illustrates the extent to which it has been possible to make the boundaries of group-centre areas and charging groups correspond. It will be noticed that

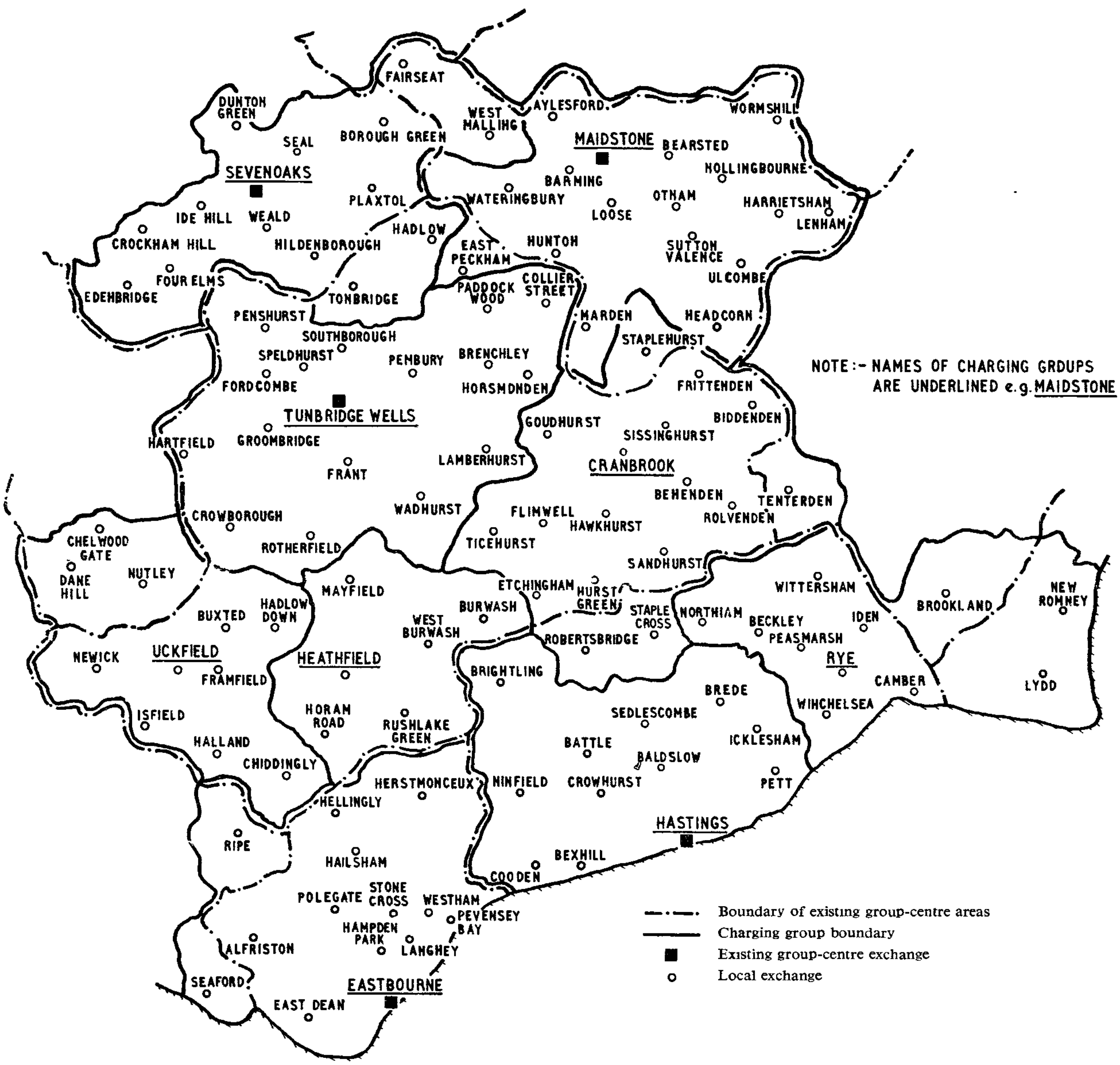


FIG 5—TYPICAL ARRANGEMENT OF CHARGING GROUPS, SHOWING BOUNDARIES OF EXISTING GROUP-CENTRE AREAS

group-centre-area boundaries coincide with charging-group boundaries over a fair part of their length, and that departures are, for the most part, only to the depth of one exchange area. The degree of success achieved in aligning the two boundaries varies throughout the country, but the stretch of territory shown is reasonably typical.

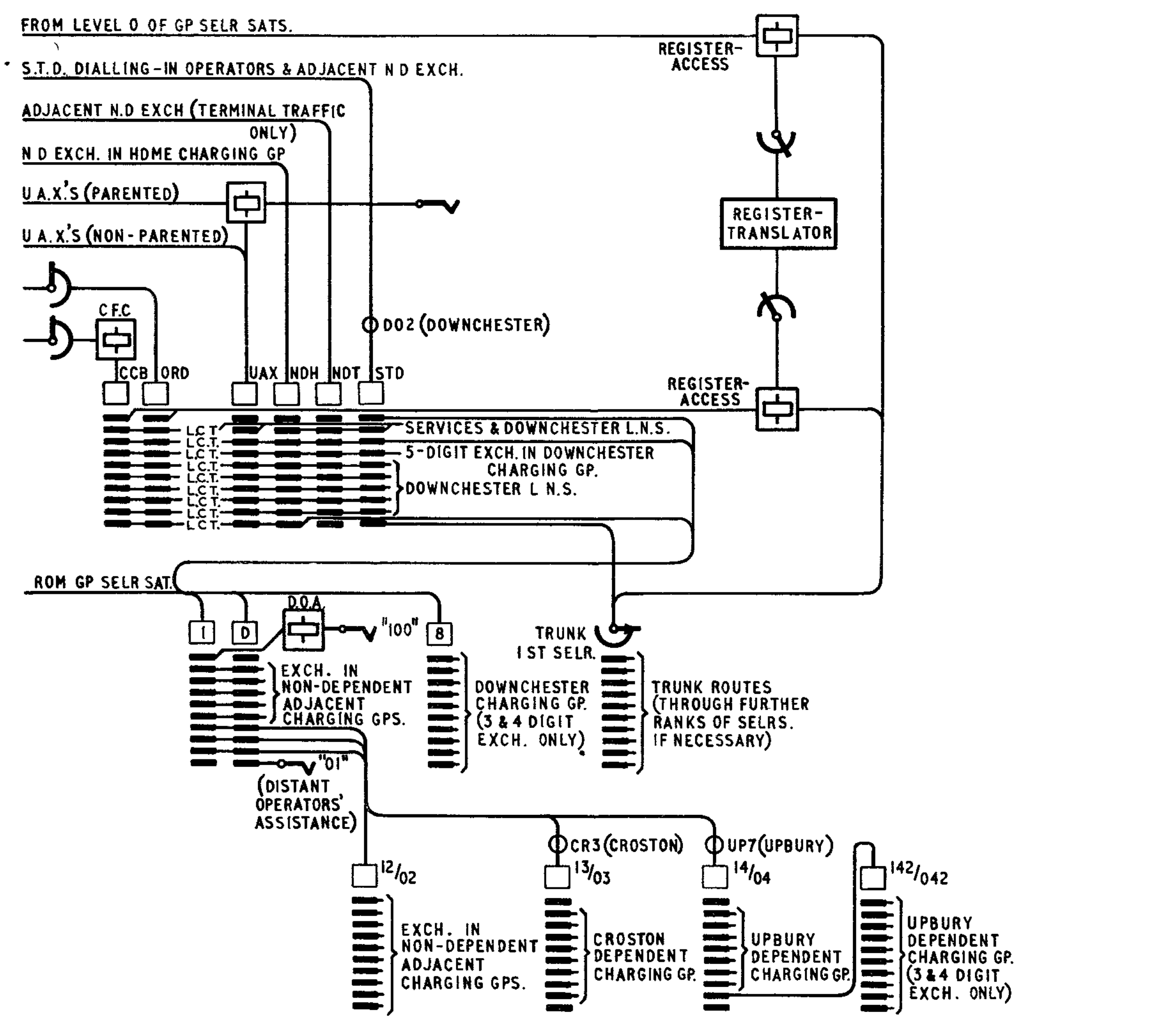
GROUP SWITCHING CENTRES

It will have been seen from the foregoing paragraphs that the charging groups have, for the most part, been built up round selected centres, and hence the choice of G.S.C. will usually be obvious. Quite frequently, however, there will be two or even more exchanges which would make suitable G.S.C.s. This is most likely to arise when a group-centre-area boundary cuts a charging group into two approximately equal parts, and the correct switching centre will need to be determined by a study of the relative costs of the alternatives. Line plant will normally represent the major part of the cost, but occasionally line plant costs will be marginal, and other factors will then be of importance, e.g. the availability and cost of accommodation, the savings obtained by sharing common equipment and line plant when a number of charging groups are served by one G.S.C., and the relative amounts of work involved in introducing S.T.D. at exchanges of different types.

TRUNKING

S.T.D. traffic to and from a numbering group and much of the subscriber local-code-dialled traffic will be routed through the group switching centre, which may serve more than one numbering group. The trunking of a typical non-director G.S.C. exchange ("Downchester") serving two dependent numbering groups, "Croston" and "Upbury," and equipped for S.T.D. and group charging, is shown in Fig. 6. The Downchester, Croston and Upbury charging groups each comprise one numbering group. To avoid unnecessarily complicating the diagram, it has been assumed that all the exchanges are automatic and all the satellites are of the group-selector type.

In this trunking diagram, level 0 of the coin-box and ordinary 1st selectors is trunked, via register-access relay-sets, to register-translators and the trunk tandem,[2] and level 1 of the coin-box, ordinary, U.A.X. and non-director (home-charging group) 1st selectors is used for local code dialling to adjacent charging groups. Level 10, however, is used for subscribers' assistance, and level 11



N.D. = Non-director; D O.A = Digit 0 absorbing; C.F.C. = Coin and fee checking; L.C.T. = Local-call timing relay-set; L.N.S. = Linked numbering scheme

FIG. 6—TRUNKING OF "DOWNCHESTER" EXCHANGE, A TYPICAL NON-DIRECTOR GROUP SWITCHING CENTRE

is left spare as it is liable to false traffic. Level 0 of the S.T.D. 1st selectors is combined with this level 1 at the 2nd selector stage to give distant subscribers S.T.D. access to dependent charging groups and distant operators access to dependent and non-dependent adjacent charging groups; some local-code-dialled traffic may also be routed over this path, as described later. Level 1 of the S.T.D. 1st selectors is used for access to the trunk tandem.

The use of levels 1 and 0 of the S.T.D. 1st selectors could be reversed, in which case 0 would be taken to the trunk tandem and 01, distant operators' assistance, would appear on trunk 1st selectors instead of on 2nd selectors in the junction tandem. In exchanges of the type depicted, however, it is unlikely that this would be done as all levels of trunk 1st selectors would normally be required for trunk routes.

Exchanges in the home and dependent charging groups are arranged on selectors in accordance with the charging group in which they are situated. All the junctions to exchanges in the home charging group are connected to 1st selectors or level-8 2nd selectors, and the two dependent charging groups, Croston and Upbury, are each served by a group of 3rd selectors on levels 13/03 and 14/04, respectively (the large number of exchanges in the Upbury charging group has made 4th selectors necessary). The remaining routes to exchanges in adjacent, i.e. non-dependent, charging groups are accommodated on the levels of level-1 2nd selectors not required for access to dependent charging groups, 3rd selectors being used if necessary.

Subscribers in the linked-numbering scheme obtain local-code-dialling access to the home charging group via levels 7 and 8, and to exchanges in adjacent charging groups via level 1, and other exchanges in the home charging group also have access to these levels. S.T.D. access, using Downchester controlling register-translators,[4] will be via the trunk switching equipment to directly connected automatic exchanges, and, if these are G.S.C.s trunked for S.T.D., via them to the local exchanges they serve as G.S.C. As an interim measure, the controlling register-translator will sometimes be used to route calls to a group centre, zone centre or G.S.C. via an intermediate centre. This is not a normal facility and, because the controlling register-translator has not much spare capacity for this type of routing, access is given only to exchanges to which the traffic is high enough to warrant it. S.T.D. transit-switching centres with their own register-translators will later be established and will permit indirect access on a wide scale as a normal feature.

Adjacent Charging Groups

U.A.X.s in adjacent charging groups can have access over levels 2 to 9 to the Downchester charging group, and over level 1 to those exchanges within unit-fee distance of the U.A.X. These U.A.X.s can be prevented from obtaining irregular access to exchanges outside their unit-fee areas by the barring equipment fitted on their outgoing junctions.

Non-director exchanges in adjacent charging groups are a more complicated case because, unless separate groups of junctions are justified, junctions incoming from these may carry a mixture of S.T.D., operator-code-dialled and subscriber local-code-dialled traffic. The subscriber local-code-dialled traffic will normally be chiefly to the G.S.C. and its charging group, but may in addition contain traffic to exchanges in charging groups adjacent to Downchester. To permit S.T.D. and operator access to all trunk and junction routes, the junctions terminate on 1st selectors in the S.T.D. group at the G.S.C. They are not normally fitted with barring equipment at the originating end and hence, if the junctions were used for local-code-dialled traffic, subscribers would be able to obtain irregular local-code-dialling access over levels 1 and 0 to exchanges in charging groups not adjacent to their own, and to trunk routes. This irregular access may be prevented by fitting barring equipment at the distant non-director exchange, or, if it is equipped for S.T.D., by routing the traffic via the register-translators, in which case normal S.T.D. codes would be dialled.

Non-director exchanges in adjacent charging groups may sometimes justify a separate group of junctions, carrying traffic to the G.S.C. and its charging group only, and irregular access can then be prevented by connecting these junctions to a separate group of 1st selectors having access to levels 2 to 9, but not to levels 1 or 0 (see Fig. 6). Junctions from non-director exchanges not equipped for S.T.D. and located in adjacent charging groups can be terminated on 1st selectors in this group provided that any operator-dialled traffic, or local-code-dialled traffic over them that could be completed over levels 1 and 0, is negligible.

Incoming S.T.D. Access

Subscribers connected to exchanges in other parts of the country equipped with register-translators may have S.T.D. access to the G.S.C. exchange and through it to automatic exchanges in the home and dependent charging groups. Access to the Downchester charging group is obtained by dialling 0 DO2. This routes the call to the point marked in the trunking of Fig. 6 by a small circle labelled DO2. From here, access to subscribers on the main exchange and its satellites is obtained by dialling the local number, and access to subscribers on the remaining exchanges in the charging group is obtained by dialling a 1-digit or 2-digit code (7, or 80 to 89) followed by the subscriber's local number. All access to the home charging group will be obtained over levels 2 to 9; levels 0 and 1 are reserved for access to adjacent charging groups and to trunk routes, and, if 0 or 1 is dialled immediately following the DO2, number-unobtainable tone will be returned by the controlling register-translator.[4] Access to the Croston and Upbury charging groups will be obtained by dialling 0 CR3 and 0 UP7, and this will route the calls to the points in the trunking marked by the circles labelled CR3 and UP7 (there is no difficulty in routing over level 0 of S.T.D. 1st selectors in this instance, as the digit forms part of the translation); from here, access will be obtained to individual exchanges by dialling a further 1-digit or 2-digit code (not 1 or 0), followed by the subscriber's local number.

Design Aspects

It will be seen that once the translation of the three digits immediately following the national prefix (0) has routed the call to a predetermined point in the trunking, access is obtained to the required exchange without further translation. All exchanges in the charging group should be accessible from levels 2 to 9 of the group of selectors immediately following this predetermined point, and, if irregular access is to be prevented, no other exchange should be accessible over these levels. Also, the level allocated to an exchange on these selectors, or the next rank (if provided), will fix the fifth and sixth digits of the national code.

In Fig. 6 an exchange on level 84 will have a national code 0 DO2 84, the last two digits, 84, being fixed by the trunking, and an exchange in the Upbury charging group on level 5 of the combined 14 and 04 3rd selectors will have a national code 0 UP7 5; the translation will route the call as far as level 04, and the last digit, 5, will be fixed by the trunking. Thus, any later changes to these levels would result in changes to national codes. These changes would involve considerable expense in reissuing dialling instructions to subscribers throughout the country, in addition to the expense and inconvenience normally incurred by subscribers' number changes. They would also lead to widespread amendments to operators' routing instructions, both in the United Kingdom and abroad. Thus every effort is made when designing exchanges to avoid designs likely to lead to such changes in the future, and, in particular, levels are left spare for any increase in the number of exchanges.

During design, the trunking must be arranged so that the number of digits in national numbers does not exceed 10, the maximum permissible. Four digits are required for the numbering group code, leaving six to route the call from the point reached by the translation to the local exchange and thence to the subscriber's line. Thus, in Fig. 6, since the translation of the Downchester code routes calls to the point marked DO2 and seizes the 1st selector, 5-digit exchanges in the Downchester charging group have to be connected to the outgoing levels of 1st selectors, but 4-digit exchanges may be placed on 2nd selector levels (level 8). In the case of the Upbury charging group, the translation routes calls to the point marked UP7 and seizes a 3rd selector, and hence 5-digit exchanges have to be connected to the outgoing levels of 3rd selectors, though 4-digit exchanges may be connected to 4th selector levels. The 3-digit exchanges are almost invariably treated as potential 4-digit exchanges.

Sometimes sufficient spare selector levels are not immediately available at a G.S.C. to accommodate the exchanges in the home charging group in this way, and some rearrangement of the local numbering scheme may be necessary. In the larger multi-exchange areas, where most 1st selector levels are normally being used for busy main-exchange subscribers or large satellites, it may sometimes be desirable to avoid rearrangements by adopting the trunking outlined in Fig. 7, where two codes are allocated to the charging group, one to the linked numbering scheme and the second to the remaining exchanges in the charging group. The translation of the second code can be used to route the calls to level 8, and from there the outgoing levels of 2nd and 3rd selectors can be reached by one or two untranslated digits respectively. Thus, exchanges in the charging group but outside the linked numbering scheme, which would otherwise have had to be placed on the outgoing levels of 1st and 2nd selectors to keep the length of national numbers to 10 digits, can be given outgoing levels of 2nd and 3rd selectors.

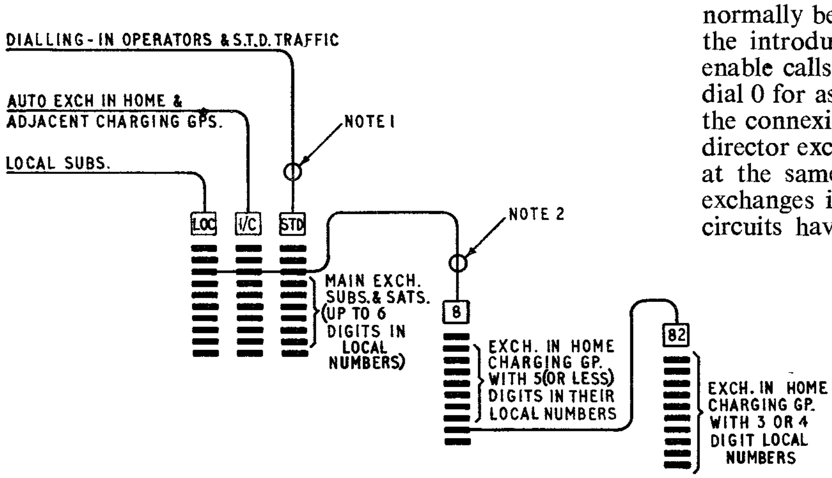
Director Areas

In director areas, controlling register-translators[4] and local registers[5] will be introduced in the trunking, as described elsewhere.[2] Also, incoming register-translators[6] will be installed in director-area trunk-tandem exchanges. Junction tandems may change in scope of access, or in size, as a result of the introduction of group charging, but the principles of design and routing remain unchanged. This is because the flexibility of routing provided by the director and incoming register-translator, and the simplification in charging resulting from each director area being a self-contained charging group, enable the necessary routing and charging changes to be introduced more easily in director than in non-director areas.

The Introduction of the 100 *Assistance Code*

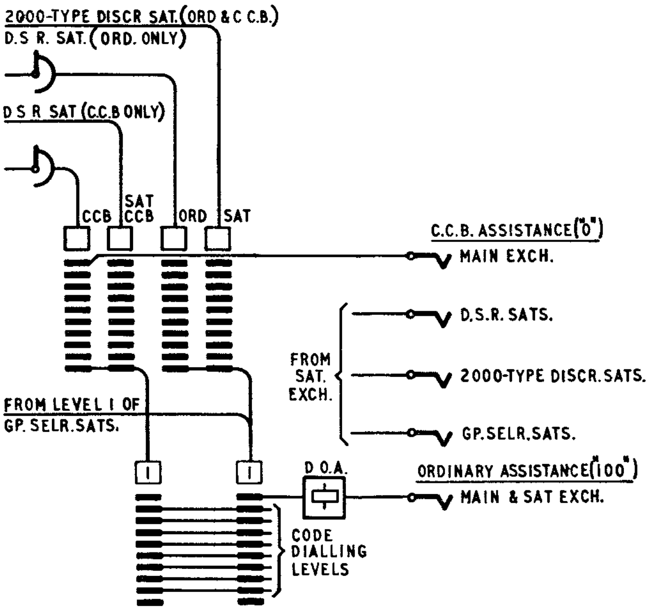
Until S.T.D. is introduced at an exchange, level 0 is used for access to the operator for assistance and, with a few exceptions, for trunk and toll calls. To enable 0 to be used for access to register-translators, it is necessary to allocate another code for access to the operator, and 100 has been chosen.

The assistance code on automatic exchanges would normally be changed from 0 to 100 some months before the introduction of S.T.D. at the exchange; this is to enable calls from any subscriber continuing, in error, to dial 0 for assistance to be intercepted for a period before the connexion of register-translators to level 0. At non-director exchanges level 1 selectors will often be installed at the same time to give local-code-dialling access to exchanges in adjacent charging groups. The assistance circuits have to be transferred from level 0 to 10 and 0-absorbing relay-sets fitted. At discriminating satellites, 100 traffic is routed over the common main-exchange group of junctions (instead of over a separate group of assistance circuits) provided their transmission loss is not too great for trunk traffic. Existing prepayment coin-boxes do not permit 100 to be dialled without coins being inserted, and hence coin-box lines connected to non-director exchanges will continue to use 0 to obtain assistance, using their existing direct circuits to the auto-manual



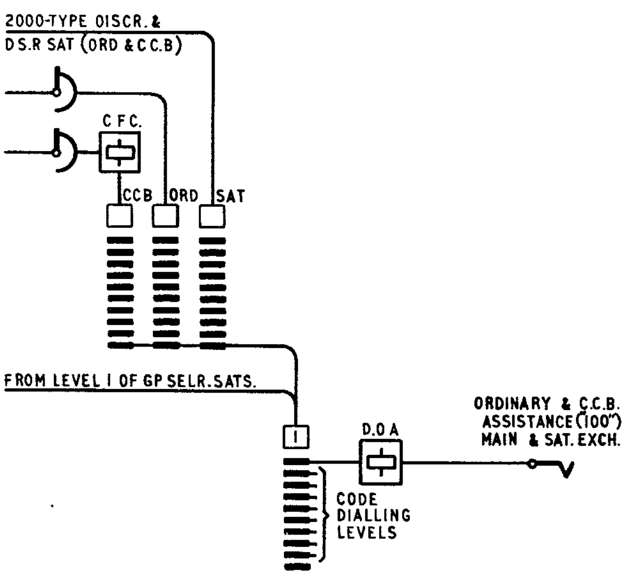
Notes:
1. Point reached by the translation of the national code for the linked numbering scheme.
2. Point reached by the translation of the national code for exchanges outside the linked numbering scheme but in the same charging group.

FIG. 7—TRUNKING OF A GROUP SWITCHING CENTRE WITH A SEPARATE NATIONAL CODE FOR THE LINKED NUMBERING SCHEME



D.S.R. = Discriminating selector repeater; D.O.A. = Digit 0 absorbing

FIG. 8—ASSISTANCE ARRANGEMENTS WITH PREPAYMENT COIN-BOXES



D.S.R. = Discriminating selector repeater; D.O.A. = Digit 0 absorbing; C.F.C. = Coin and fee checking

FIG. 9—ASSISTANCE ARRANGEMENTS WITH PAY-ON-ANSWER COIN-BOXES

switchboard. This is illustrated in Fig. 8. To prevent these coin-box lines obtaining access to the ordinary 100 circuits, the common main-exchange junction route from discriminating-selector-repeater (D.S.R.) satellites has to be split into ordinary and coin-box components, and slight modifications are necessary to the 2000-type discriminator. The new pay-on-answer coin-box[7] is specially designed to give S.T.D. and 100 facilities, and when this is fitted the coin-box assistance traffic can be routed over the same circuits as the ordinary assistance traffic (Fig. 9); to give the correct supervisory conditions for the new coin-box (coin-slot opening, coin-box discrimination, etc.), D.S.R.s and 2000-type discriminators have to be modified, and assistance relay-sets replaced or modified.

At director exchanges, to give the 100 assistance facility, the group of directors with manual-board facilities has to be connected to level 1 of A-digit selectors, and the circuit modified to accept 00, and only 00, over this level; these directors continue to serve other A-digit selector levels for ordinary traffic. Alternatively, a few directors (manual board or ordinary type) may be trunked from level 1 as a separate group dealing exclusively with 100 assistance traffic, without circuit modifications being necessary. In both cases, slight modifications are necessary to A-digit selectors. Coin-box lines in director areas use the same group of A-digit selectors and directors as ordinary subscribers, and hence, while prepayment coin-boxes are still in use, it is difficult to arrange for their assistance calls to be routed to the manual board on dialling 0, while at the same time ordinary subscribers are routed to S.T.D. register-translators on dialling the same digit. The A-digit selectors could be split into separate coin-box and ordinary groups but a survey of director exchanges has established that this would be an expensive operation, because, in general, sufficient spare bank and rack capacity is not available. The alternative of fitting specially modified dials at coin-box installations in director areas to enable them to dial the 100 code without inserting coins has therefore been adopted.

CONCLUSION

Factors that have influenced the determination of charging groups have been

(*a*) the availability of line plant in relation to a possible G.S.C.,

(*b*) the suitability of equipment and accommodation at possible G.S.C.s., and

(*c*) the need to avoid call charge anomalies.

It has been necessary to effect a compromise between conflicting influences in a number of instances. The location of all the G.S.C.s has not yet been determined, but it is clear that they will exceed existing group centres in number, though it is not expected that there will be more than 500.

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The First Subscriber-Trunk-Dialling Installation—at Bristol

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U.D.C. 621.395.374 : 621.395.74

On 5 December 1958 the first subscriber-trunk-dialling equipment in the United Kingdom was brought into use, enabling Bristol Central exchange subscribers to dial their own calls to subscribers served by 427 other telephone exchanges in various parts of the country. This article gives details of the equipment installed at Bristol and describes its planning, installation and testing.

INTRODUCTION

In April 1955 it was clear that the first subscriber-trunk-dialling (S.T.D.) equipment for which development would be completed would be that for non-director main exchanges, and consideration was given to the selection of a centre at which S.T.D. service could be opened not later than the spring of 1959. It was decided that the selected centre should preferably be one with a fair amount of trunk traffic, with direct routes to a large number of other towns throughout the country and where access to these routes via selector levels (trunk mechanization) would be available to operators for a short while before the S.T.D. service opened. This limited the choice of centre to one of the zone or large group centres where trunk mechanization would be completed by the autumn of 1958. It was also essential to have accommodation for the S.T.D. equipment. All these requirements were satisfied at Bristol, and in July 1955 it was decided to plan to have trunk mechanization in service by October 1958 and to open S.T.D. service for subscribers connected to Bristol Central exchange early in 1959. The service would be extended later to satellite exchanges in the multi-exchange area, starting during 1960.

The choice of Bristol for the first installation of S.T.D. equipment is interesting because it was there, in 1900, that the first C.B. multiple exchange in the United Kingdom was installed by the National Telephone Company. In fact, the S.T.D. equipment is installed in an extension of the very building that housed the C.B. exchange.

The initial installation of S.T.D. equipment allows the Bristol Central exchange subscribers (some 6,500 connexions) to dial their own trunk calls to subscribers served by most of the automatic exchanges in the areas listed in Table I, and it is estimated that this will result in 20 fewer manual-switchboard positions at Bristol being staffed during the busy hour.

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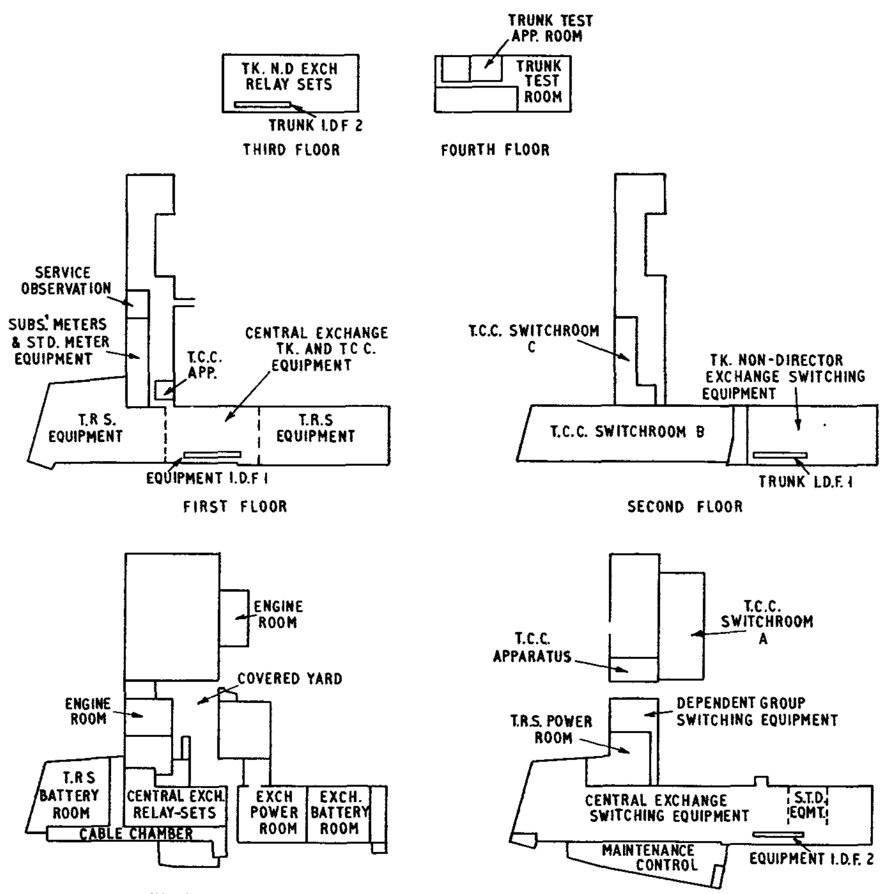
* Edinburgh is at present served partly by director and partly by non-director exchanges.

TABLE I

Director Areas	*Non-Director Areas (continued)*
London	Kingsbridge
Birmingham	Leeds
Edinburgh*	Leicester
Glasgow	Newcastle-on-Tyne
Liverpool	Newport
Manchester	Nottingham
	Penzance
Non-Director Areas	Plymouth
Bridgwater	Portsmouth
Brighton	Salisbury
Cardiff	Shaftesbury
Chester	Sheffield
Chippenham	Shepton Mallet
Dursley	Southampton
Edinburgh*	Swansea
Exeter	Swindon
Frome	Taunton
Gloucester	Truro
Grimsby	Worcester

The use of code 100 instead of 0 for giving subscribers access to the manual switchboard was introduced on 1 August 1958 and was brought into use simultaneously for satellite exchange subscribers as well as for Bristol Central exchange.



TK. N.D. = Trunk non-director; T.C.C. = Trunk control centre; T.R.S. = Telephone repeater station
For simplicity, staircases, some corridors and other building details are omitted and the occupancy of non-apparatus space is not shown

FIG 1—LAYOUT OF EQUIPMENT AND BUILDINGS AT BRISTOL

DESIGN AND LAYOUT OF THE INSTALLATION

The Bristol multi-exchange area consists of the Central exchange and nine satellites, to which a further satellite will be added when Filton is converted from a remote non-director exchange in 1960. The satellites are a mixture of discriminating selector repeater, satellite 1st selector with discriminator, and group selector types, and both pre-2000-type and 2000-type equipment exists at the main exchange (Central). The total number of exchange connexions in the multi-exchange area is just over 43,000, of which some 6,500 are connected to Central exchange, and the area is served by a mixed 5-digit and 6-digit numbering scheme.

When S.T.D. was first considered for Bristol, in the early summer of 1955, the local exchange equipment, trunk-control-centre manual switchboards, junction switching equipment, some through-trunk-switching equipment and the main Bristol repeater station were accommodated in a group of buildings in Telephone Avenue near the centre of the city. These buildings comprised the old National Telephone Company building, the original automatic exchange building provided in 1931 and an extension wing added in 1954. More than half of the extension wing was occupied as part of the Telephone Manager's Office, but negotiations were already in hand to accommodate the Telephone Manager's staff elsewhere and so permit the installation of a trunk non-director exchange. An order had been placed for an extension by 2,900 multiple of the local exchange (Extension 13), and initial-equipment-data had been prepared for a trunk non-director unit of some 2,500 trunks. The local exchange was typical of most old exchanges today. All the available space had been taken for equipment before the building was extended and the extension wing itself had been restricted to ten years' requirements. It was recognized that, as a result of the decision to install the trunk non-director equipment at Telephone Avenue, another building extension would be required to accommodate equipment for further growth of the existing services and for proposed new services. The remaining space in the extension wing could therefore be allocated to S.T.D. equipment.

The general layout of the buildings and equipment at Telephone Avenue, after the provision of S.T.D. equipment, is shown in Fig. 1.

Initial-equipment-data for the S.T.D. installation, to a design date of 1964, was prepared by 30 August 1956. The contract was placed on 12 October 1956 but the specification was a somewhat unusual document, liberally annotated "to be advised later" since considerable development work was still necessary by the Post Office and the contractors. Very close co-operation between Post Office Headquarters, the S.W. Region and the contractors was therefore necessary throughout the period of development, manufacture and installation.

Trunking

Bristol and its adjacent charging groups are shown in Fig. 2. Rangeworthy and Temple Cloud are dependent groups on the Bristol switching centre. Consideration of

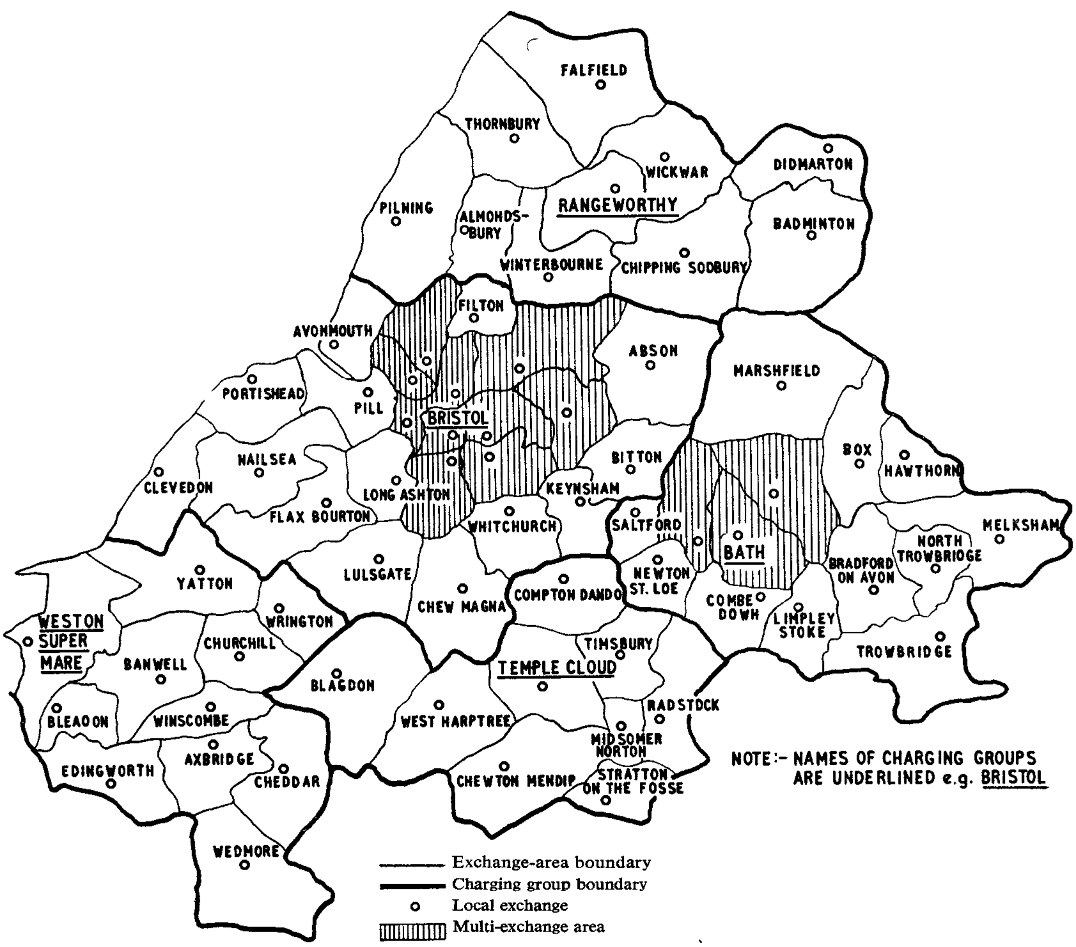
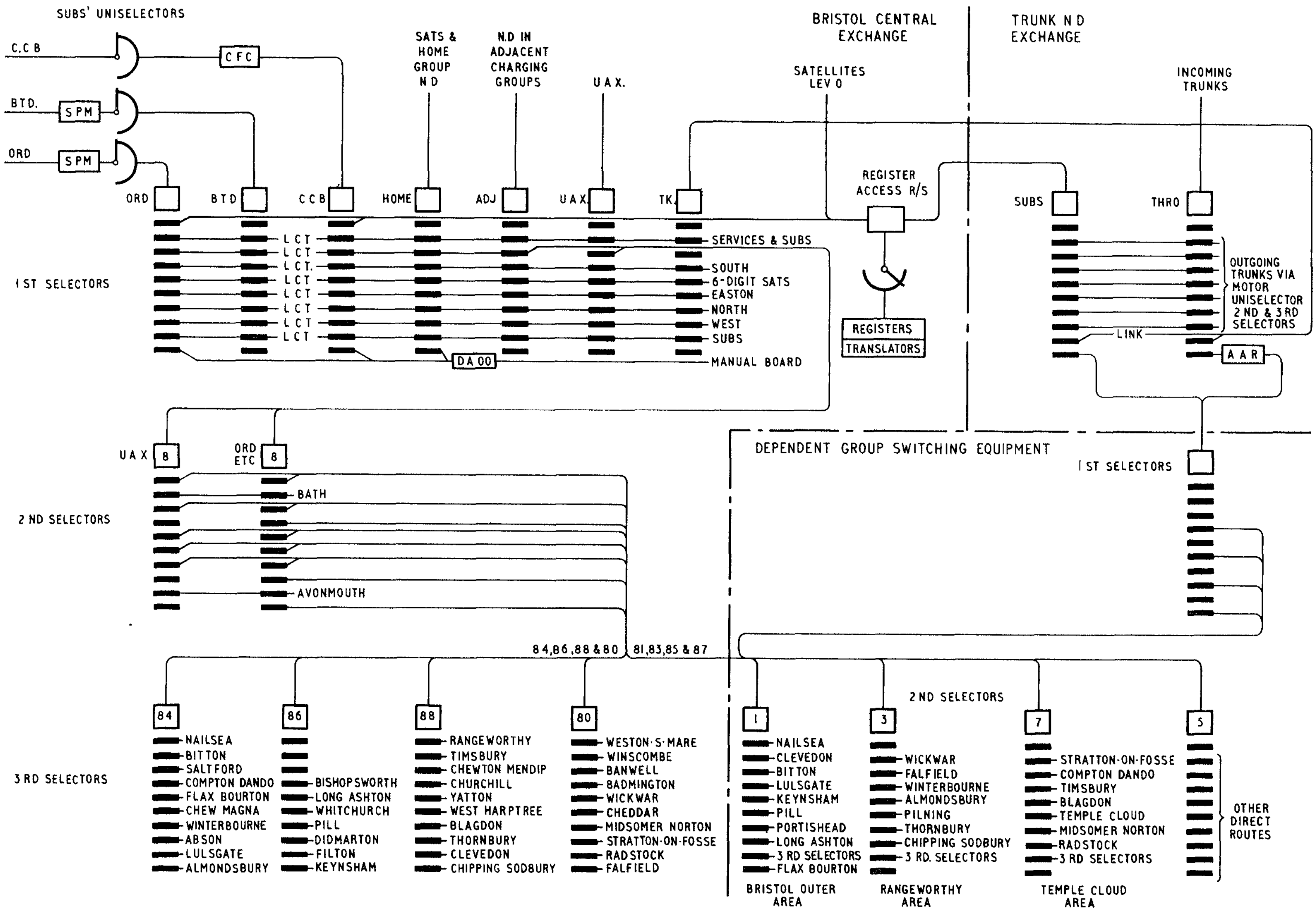


FIG. 2—BRISTOL AND ADJACENT CHARGING GROUPS



S P M = Subscriber's private meter equipment; to be provided only as required. B.T.D. = Barred trunk dialling. N.D. = Non-director. L C.T = Local-call timing relay-set. D.A.00 = Relay-set that absorbs digits 00. A.A.R. = Auto-auto relay-set with regenerator

FIG. 3—SIMPLIFIED TRUNKING DIAGRAM OF THE S.T.D. EQUIPMENT AT BRISTOL

the existing numbering scheme and of the number of exchanges to be served by the switching centre resulted in a decision to allocate two numbering groups to the home charging group. One numbering group serves Bristol Central and its satellites and the other serves the remaining exchanges in the home group. These details are reflected in the trunking of the switching centre, a simplified diagram of which is shown in Fig. 3. When the work of designing the installation started it had not been decided whether all traffic would be routed via register-translators or whether local dialling codes would be used for short distance calls. The design of the trunking had, therefore, to cater for both methods of handling the traffic. The existing level-8 switching had been developed over a number of years and the racks were widely spread in the layout of the equipment. It would not have been possible to cater for an increase of short-distance traffic and rearrangement of the existing grouping of routes via level 8 would have been necessary to prepare for the correct routing of incoming S.T.D. calls from other centres.

It was decided therefore to install separate dependent-group switching equipment trunked for S.T.D. and to tee its outgoing junctions to the existing outlets for level-8 codes. In this way traffic could be transferred as required from the level-8 3rd selectors to the new switching equipment, and the released level-8 switching equipment could be re-used for growth in Central exchange. Operators at distant exchanges obtain access to the dependent-group switching equipment via level 1 of trunk 1st selectors, and when S.T.D. is provided at other centres incoming S.T.D. traffic will also be routed to the dependent-group switching equipment via level 1. Bristol subscribers have access to the dependent-group switching equipment via level-8 2nd selectors.

In addition to the usual groups of 1st selectors, separate 1st selector groups have been formed in Bristol Central for:

(*a*) incoming traffic from non-director exchanges in the home and adjacent charging groups,

(*b*) incoming trunk traffic to the Bristol multi-exchange numbering group, routed via level 2 of the trunk non-director 1st selectors,

(*c*) "barred trunk" service, if required, and

(*d*) a new coin-box group to facilitate the change-over to coin-fee-checking equipment as the new coin-boxes are introduced; only the new group is shown in Fig. 3.

Subscribers' private meter equipment is connected to individual lines, as required, on the incoming side of the subscriber's uniselector.

The trunking provides for separate groups of ordinary, coin-box, and satellite register-access relay-sets, but initially only the ordinary group is provided. The other two groups will be installed in 1959. All three groups will be served by a common suite of registers and translators.

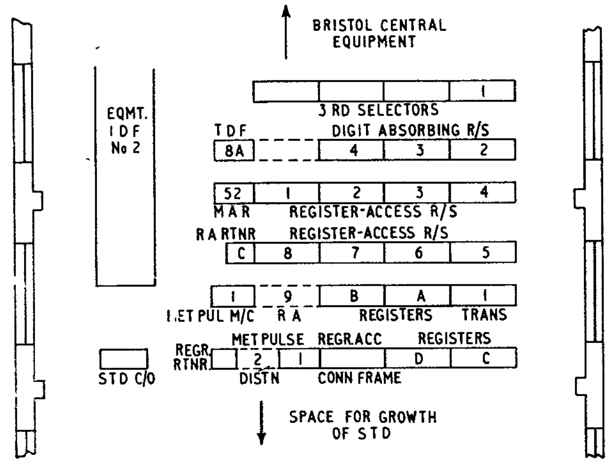
To minimize the possibility of a subscriber being connected to a faulty first-choice trunk on two consecutive attempts to make a call, the first and second outlets of each level serving a trunk route have been crossed on adjacent shelves of the trunk selectors. The first outlet on shelves A, C and E of each rack is cross-connected to the second outlet on shelves B and D and vice versa. The cross-connexion is made on the grading blocks at the rear of each rack, the connexions being made in wire covered with sleeving instead of the bare wire normally used for the commons. The trunk circuits on the first and second outlets are provided on alternative routes.

S.T.D. Traffic

Central exchange serves a predominantly business population and the estimate of S.T.D. traffic was therefore based on the day busy-hour. The traffic was assessed as 200 erlangs by projecting forward to 1964 the traffic originated by Central exchange subscribers on S.T.D. routes and assuming that the dialling of trunk calls by subscribers would stimulate this traffic to the extent of an increase of 100 per cent in calls and 30 per cent in traffic. The design of the switching centre and the provision of trunk circuits was deliberately on the generous side for this initial installation. Subscriber dialling on direct routes only was assumed. The policy of subscriber dialling over two trunk links in tandem has since been agreed but it was decided that the disturbance of design and installation by late changes should be avoided and that S.T.D. at Bristol should open with access to direct routes only. Extension to 2-link dialling will be introduced later when the volume of S.T.D. traffic has been confirmed by traffic records. The introduction of S.T.D. has increased the number of exchanges available to Bristol Central subscribers by direct dialling from 40 to 427.

Quantities and Layout of Equipment

Fig. 4 shows in detail the layout of the main items of S.T.D. equipment at Bristol. The locations of the other items of S.T.D. equipment are shown in Fig. 1. Fig. 5 is a view of the register and translator racks at Bristol.



M.A.R. = Miscellaneous apparatus rack; MET. PUL. M C = Meter-pulse machine

FIG. 4—LAYOUT OF MAIN ITEMS OF S.T.D. EQUIPMENT

Register-Access Relay-Sets. The number of register-access relay-sets provided was 320, mounted on eight fully-equipped racks. The relay-sets are spread systematically over three gradings from the 0 level of 1st selectors. Two of the gradings are from the old exchange equipment and the third from the graded racks of the new equipment installed during Extension 13. The register-access relay-set racks are located adjacent to the newest exchange equipment with short cabling to equipment I.D.F. No. 2.

Register-Translators. The register-translators are of the electronic type using cold-cathode discharge tubes that was developed by the General Electric Co. under B.T.T.D.C. procedure. The expected ordinary and coin-box traffic is well within the capacity of one suite of register-translators, consisting of four racks with a capacity of 80 registers and one rack containing three

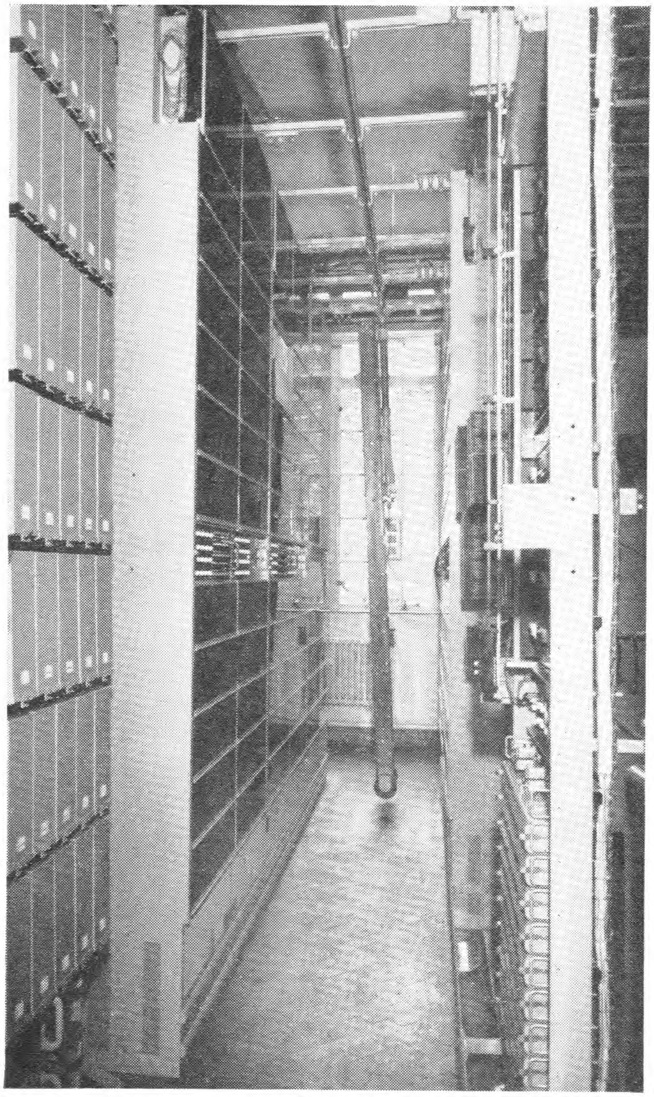


FIG. 5—REGISTER AND TRANSLATOR RACKS

translators. Register racks 1 and 2 are served by translator 1, register racks 3 and 4 are served by translator 2, and translator 3 is the reserve which is automatically brought into use in the event of failure of either of the other two. The expected traffic based on an average holding time of 30 seconds was 32 erlangs. Register-hunters associated with the register-access relay-sets are non-homing and their outlets are arranged in full-availability groups, the resulting three groups requiring 66 registers.

The full-availability groups are completed on the register-access connecting frame, to which the outlets of the register-hunters and the inputs of the registers are cabled for flexibility. Registers are allocated to register-hunter outlets in a systematic order to ensure the widest distribution of registers over adjacent outlets. Adjacent outlets are connected to registers on different racks and served by different translators; allocation also alternates between upper and lower halves of the register racks since each half is served by separate pulse-feeds.

The register-translators and the connecting frame are located immediately adjacent to the register-access relay-sets to restrict cabling. It was originally intended that the register-translators should be in one suite, with the equipment side facing the open space reserved for additional register-access relay-set racks, but it was uncertain whether, for design reasons, the suite should be split into two parts facing each other and, as it was imperative at that time to settle the layout, the split suite was adopted. It is most unfortunate that, in the event, this layout proves to have been unnecessary and the opportunity of presenting this show-piece of equipment to the best advantage has been lost.

The translators are provided with the full number (240) of translation tubes because it was considered that the number of routes and allowances for examination of additional digits would approach this figure by the design date. Expansion for examination of D and E digits has not, however, been used.

Digit-Absorbing Relay-Sets. The change from code 0 to code 100 for assistance traffic had to be made some time in advance of S.T.D. to clear level 0 of traffic, and the quantity of digit-absorbing relay-sets had, therefore, to be based on the existing traffic to level 0. Allowance for growth was not necessary because this traffic decreases on the opening of S.T.D. Four racks were required and these were located between the Central exchange equipment provided under Extension 13 and the register-access relay-sets. It was also necessary to provide digit-absorbing relay-sets at the group selector satellites.

Local-Call Timing Equipment. Seven racks of local-call timing equipment, equipped with 1,323 equipments, and their associated meter-pulse supply rack have been provided in an extension of the subscribers' meter room (Fig. 1, first floor). To reduce the resistance added to the P wire of connexions through the exchange, some local-call timers were cabled to each of the I.D.F.s and to a T.D.F., on which connexions are made between 1st selector outlets and 2nd selectors, thus avoiding tie-cables to these frames. Also, 20 lb/mile conductors were used because of the length of cable between the frames and the local-call timers. As a further safeguard against possible troubles due to high P-wire resistances, P-wire-splitting link-circuits were provided and connected between 1st selector outlets and local-call timers. Four relay-set racks equipped with 1,324 P-wire link-circuits (four circuits per relay-set base) were installed in a suite parallel with the local-call timers and the link-circuits were cabled direct to the input of the local-call timers.

Subscribers' Private Meter Equipment. The demand for subscribers' private meters was, and to a certain extent still is, an unknown quantity. Just prior to opening the service, requests for meters amounted to only 90 clock type (No. 19, combined total and trip), 90 cyclometer type (No. 20, trip) and 70 100-type (total). This represents a demand for meters for 0·7 per cent of single connexions, 2·5 per cent of P.B.X. connexions requiring the No. 19 meter and 3·4 per cent of P.B.X. connexions requiring the No. 20 meter. The exchange equipment can be connected in the line circuit or between the subscribers' uniselectors and 1st selectors of a separate group of uniselectors. Initially, the equipment has been arranged for connexion to individual lines at Bristol because, with the demand so uncertain, a separate group could have been expensive in the provision of switches or would have involved considerable rearrangement.

Disputed-Accounts Observation Equipment. It was estimated that four equipments would be sufficient for normal use at Bristol but that a maximum of 10 might be required. One permanently installed rack of four equipments has therefore been provided and the remaining six equipments are trolley-mounted so that the use of them can conveniently be shared with other exchanges.

Subscribers' 5-Digit Meters. With the introduction of quarterly accounts it was thought that not many 5-digit meters would be required, and only 700 were changed from 4-digit to 5-digit type before the opening of S.T.D.

Routiners

Routiners are to be provided for the register-access relay-sets and for the register-translators, but design of these items has to follow design of the main equipment and the routiners were not available for use at Bristol at the opening of S.T.D. Manual testers are being used until the routiners have been installed.

Centralized Service Observation and Traffic Analysis

Centralized service-observation positions and equipment of the new type[1] have been provided at Bristol. One position is required for normal observations and two positions, connected to the register-access relay-sets, have been provided to obtain statistical traffic information about S.T.D. These two positions will be replaced later by special traffic-analysing equipment that is being developed.

Traffic Meters. Normal traffic-recording equipment and traffic meters have been provided. In addition, call-count and charge-step meters have been provided on the following basis:

(*a*) Call-Count (Total): one per 10 register-access relay-sets, for recording effective and ineffective calls.

(*b*) Call-Count (Effective): one per 20 register-access relay-sets, for recording effective calls, i.e. those on which the called subscriber answered.

(*c*) Charge-Step (Full Rate): one per charge step per register-access relay-set rack, for recording effective calls per charge step.

(*d*) Charge-Step (Cheap Rate): one per charge step per register-access relay-set rack, for recording effective calls per charge step.

Eleven of each of the two types of charge-step meter have been provided per rack at Bristol because it was necessary to manufacture and install this equipment before the S.T.D. tariffs were fixed. Only four of each of these meters are required per rack for the tariff arrangements at the opening of S.T.D.

Power Plant

Common power plant, consisting of a power plant No. 213 with three 1,200-amp motor generator sets and two main batteries having plates of 12,040 ampere-hours capacity, serves the whole building. Because of the heavy load, the main risers of the busbar system are interleaved to avoid induction troubles. A circuit breaker is provided for each of the four main floors. The estimated load at the design date for the S.T.D. equipment alone is of the order of 250 amp busy-hour load and 1,800 ampere-hours day load. The a.c. load of the registers and translators is of the order of 6 kW.

PROVISION AND TESTING OF EQUIPMENT

When it was decided, in July 1955, that S.T.D. would be provided at Bristol, arrangements for ordering equipment for trunk mechanization were well advanced. The manufacturing and installation work involved in the provision of trunk mechanization was several times greater than that required for the S.T.D. equipment and it would not have been possible to delay the order for trunk mechanization to enable S.T.D. to be included. A separate contract was placed for the S.T.D. equipment (plus the dependent-group switching equipment) in October 1956. Both contracts were placed with the Automatic Telephone and Electric Co., but it was arranged that the General Electric Co., acting as a sub-contractor, would manufacture and install the registers and translators and manufacture the register-access relay-sets, since they had undertaken development of these items of equipment for the B.T.T.D.C. The "ready for service" dates for both trunk mechanization and S.T.D. were set at 1 September 1958 and it was envisaged that, after traffic trials, trunk mechanization would be brought into service by the end of September 1958 and S.T.D. service would begin early in 1959. The date for introducing trunk mechanization was achieved, and as the work on site progressed it was found possible to advance the date of opening of the S.T.D. service to the beginning of December 1958.

Normally, when the Post Office places a contract for telephone-exchange equipment, standard diagrams, drawings and specifications for the equipment required are available, and are quoted in the contract specification, but this was not possible for the Bristol S.T.D. equipment because much of the detailed design work for this new equipment had still to be completed at the time when the contract was placed. A joint engineering committee, on which the two contractors, the E.-in-C.'s Office, S.W. Region and Bristol Telephone Area were represented, was therefore set up to co-ordinate the design, manufacture and installation of S.T.D. equipment for Bristol and ensure that there were no avoidable delays in completing the installation of the equipment. Between December 1956 and January 1958 the committee was principally concerned with ensuring that design information was available to the contractors to meet their manufacturing programs and it met in London; after January 1958 the progress of installation work assumed greater importance and from then on the committee met at Bristol under Regional chairmanship.

Committees were also set up by the S.W. Region and Bristol Telephone Area, with representatives from all branches and divisions, to co-ordinate the many service aspects of the introduction of S.T.D. with the engineering work.

Acceptance Testing on Site

Acceptance testing of the dependent-group switching equipment and S.T.D. equipment, other than the registers and translators, mainly followed normal practices for 2000-type equipment and existing testers were used. There were, however, two important variations of normal practices that were adopted to enable installation target dates to be achieved. Except in the Post Office call-through test, joint testing by the contractor's and Post Office staff was permitted for both trunk mechanization and S.T.D. equipment, instead of sequential testing by the two parties, whenever this would reduce the total time taken for testing. Also, for checks of mechanical adjustments of 2-motion selectors it was agreed to use a new procedure that has been the

[1] BARNARD, A. J., and BECK, E. H. A. The New Centralized Service-Observation Equipment. *P.O.E.E.J.*, Vol. 49, p. 81, July 1956.

subject of field trials elsewhere as part of an examination of the general problem of reducing the time spent on these tests. In the standard procedure for checking mechanical adjustments all adjustments are checked on 10 per cent of the selectors on every rack after they have been fitted on the racks. With the experimental procedure a small sample is taken from the whole batch of selectors delivered to site and all adjustments that can be checked before the selectors are fitted on the racks are checked at any convenient time after the selectors have been delivered. This procedure reduced the time spent by the Post Office on checking mechanical adjustments and also allowed the checks to be made at a time that did not coincide with the increasing tempo of work in the later stages of installation. This variation from normal practice was particularly helpful for the trunk mechanization installation; it was used also for the dependent-group switching equipment of the S.T.D. installation.

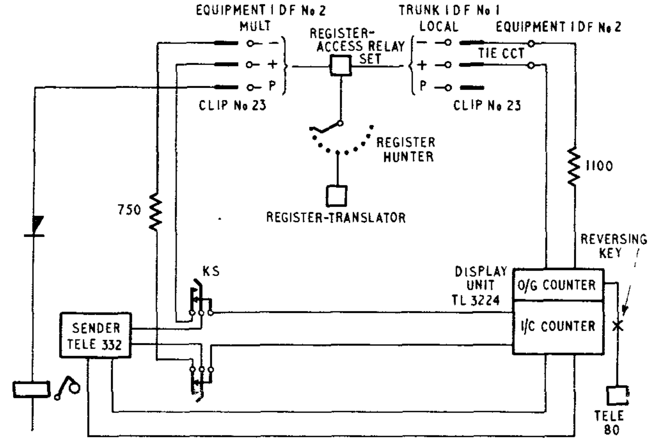
Testing of Register-Translators. The register-translators were subjected to intensive testing by the contractor before delivery to site, including tests of the equipment under conditions simulating those in which it would operate after installation at Bristol. The contractor also built a "flood" tester, which was used both for tests in the factory and on site and subsequently was lent to the Post Office for testing on site. The flood tester is capable of initiating 40 simultaneous calls repeated every 20 seconds. It is mounted on a rack 10 ft 6 in. by 2 ft 9 in. and consists of 40 relay-sets [seen in the left foreground of Fig. 5], each strapped to pulse out a different code followed by numerical digits; the dial pulses are supplied by a pulse machine mounted at the bottom of the rack. A control console is used to select the relay-set or sets that are to be used.

For functional tests use was made of a maintenance test box which incorporated the useful facility of permitting observation of certain functions of the register in "slow-motion." To prove rapidly that each register responded correctly to each working code wired in the translator an automatic sender was used which can send up to nine digits. A digit-display unit (Tester TL 3224) was used for monitoring the input to and output from the register-translator; it employs Dekatron tubes and provides three counters, one for counting up to nine input digits, one for recording up to 15 output digits and the third for monitoring the metering digit.

During the tests on site a double-beam oscilloscope was used to check the amplitude and correct phasing of the pulse-generator outputs, the second beam being used to display a reference level.

The Call-Through Test. Three hundred and twenty calls were made in the call-through test of the S.T.D. equipment, one from each register-access relay-set. The testing schedule ensured that each item of equipment was used and that all codes were tested using both working translators and the standby. The meter-pulse equipment and pulse generators were also changed over during the tests. No faults occurred during the call-through test.

The digits into and out of the register-translators were counted on the Tester TL 3224. The calls were originated from a Telephone No. 332 and passed, via the incoming counter of the tester, an artificial 750-ohm line, the register-access relay-set, the register-translator and an 1,100-ohm artificial line, to the outgoing counter of the tester, the arrangement being shown schematically in Fig. 6. The calls were answered on a Telephone No. 80 via a reversing key to give called-subscriber-answer



A temporary speaker circuit was provided between the Telephone No. 332 and Trunk I.D.F. No. 1

FIG. 6—CIRCUIT ARRANGEMENT FOR CALL-THROUGH TEST

metering conditions. The call was held until the second metering pulse was received and the time interval between metering pulses was checked. Speech tests were made by operating a key that disconnected the originating telephone from the incoming counter and connected it directly to the register-access relay-set.

The entire Post Office call-through test was completed in seven hours.

Other Engineering Tests and Traffic Trials

After the call-through test the flood tester was almost continuously in use for two or three weeks and some half-million calls were passed through the equipment. Then, from late August until just before opening the service, the tester was used for at least half an hour each day.

Tests were also made to ensure that a satisfactory service was being given by the distant trunk switching equipment and local telephone network.

Traffic tests were carried out during November 1958 to make a final check of the access and facilities provided for S.T.D. calls.

Field Trial of S.T.D. Service

On 1 October 1958 a field trial of S.T.D. commenced. Fifty service subscribers were provided with special lines having 0-level access to the S.T.D. equipment. To prevent unauthorized access these telephones were disconnected at 5.0 p.m. each day by means of the subscribers' preference keys on the uniselector racks. Three lines in the Bristol Central manual switchroom were left connected to enable tests to be made during the evening busy hour. These lines were provided with private meters, to permit a test of the periodic metering during the cheap rate period, and were connected also to disputed-accounts equipment. Early choices of the 1st selector grading serving the field-trial subscribers were connected via local-call-timing relay-sets to provide a test of this equipment.

WORK AT SUBSCRIBERS' PREMISES

The principal work at subscribers' premises consisted of changing dial plates (Dial Labels No. 350, etc.) and providing subscribers' private meters where they were required. In the Bristol Central exchange area the ratio of telephone stations to connexions is high and the provision of S.T.D. for the 6,500 connexions involved changing 18,800 dial plates. The work was facilitated by the fact that the Central exchange area is predominantly a business area and the fitters seldom had any difficulty in getting access to subscribers' installations.

Dial Plates

The work of changing the dial plates to plates of the lettered type was performed by three or four teams of four men each and went on throughout the period May 1957 to May 1958. The exchange area was divided into squares and each team was responsible for the work at subscribers' premises served by distribution points in squares allocated to the team. Every dial was tested before the plate was changed. At the larger P.B.X.s the dials at extension telephones were tested by means of portable dial-speed and ratio testers and the operators' dials were tested from the test-desk via exchange lines. A special tester[2], located at the maintenance control, was used for testing the dials of small P.B.X. and ordinary connexions. In addition to testing the dial, this tester also checked the insulation and loop resistance of the connexion and provided a ring-back facility that enabled bells to be checked and adjusted. Faulty dials were replaced and brought back to a central point for cleaning, adjustment and changing of the plate.

Subscribers' Private Meters

During June and July 1958 P.B.X. subscribers were visited and letters sent to all subscribers asking whether they required private meters. Early in July replies had been received asking for 40 clock-type, 75 cyclometer-type and four switched-type (P.B.X.) meters. Thereafter demands for meters increased slowly but by the beginning of November, when the work of fitting these meters began, orders for only 250 meters had been received. Meters had not been asked for by any shared-service subscriber. The installation of the meters was completed shortly before the opening date. Arrangements were made for the 50 c/s signal to be switched on at the subscriber's private-meter relay-set in the exchange whilst the fitter tested the private meter, and for a credit ticket to be prepared for the number of operations made by the subscriber's meter at the exchange during the test.

THE CHANGE FROM CODE 0 TO CODE 100 FOR ASSISTANCE TRAFFIC

The change from code 0 to code 100 for assistance traffic from non-coin-box subscribers was made at midnight on 31 July 1958. Notice of the change had been given in advance on the front cover of the telephone directory and was backed up by press and radio publicity during the day before the change. In addition, operators reminded all subscribers who dialled 0 on the 31 July that the new code should be dialled next day.

At Central exchange and at the group-selector satellites, change-over keys were inserted between the digit-absorbing relay-sets (connected to level 1 of 1st selectors) and the assistance-circuit relay-sets. To introduce the new assistance-code these keys were operated, disconnecting level 0 from the assistance-circuit relay-sets and connecting that level to changed-number announcing equipment and, at the same time, connecting level 1 via the digit-absorbing relay-sets to the assistance circuits. In mid-September the announcing equipment was removed and level 0 connected to N.U. tone.

At the discriminating-selector-repeater satellites subscribers were already routed to the common junction route to Central exchange if they had dialled 1, and received N.U. tone from the 1st selectors there. Hence, at Central, level 1 of the 1st selector's serving these satellite exchanges was trunked, via the digit-absorbing relay-sets, to the assistance-circuit relay-sets.

At the 2000-type discriminating satellites, modifications were required to enable discriminating facilities to be given on level 1 instead of level 8. Calls from subscribers dialling 100 are now routed by the discriminator over the common junction route on a non-metering manual-hold basis and are dealt with at Central in the same way as calls from discriminating-selector-repeater satellites. These arrangements have resulted in an increase in the number of common junction routes and 1st selectors at Central and it has been necessary to ensure that such routes are of high-grade circuits suitable for carrying trunk traffic. Also, the discriminating-selector-repeater and the 2000-type discriminating satellites have lost their individual identity in the common group of assistance circuits from the 1st selectors at Central.

The number of calls per day that were incorrectly dialled to level 0 after the change-over was 6,500 and

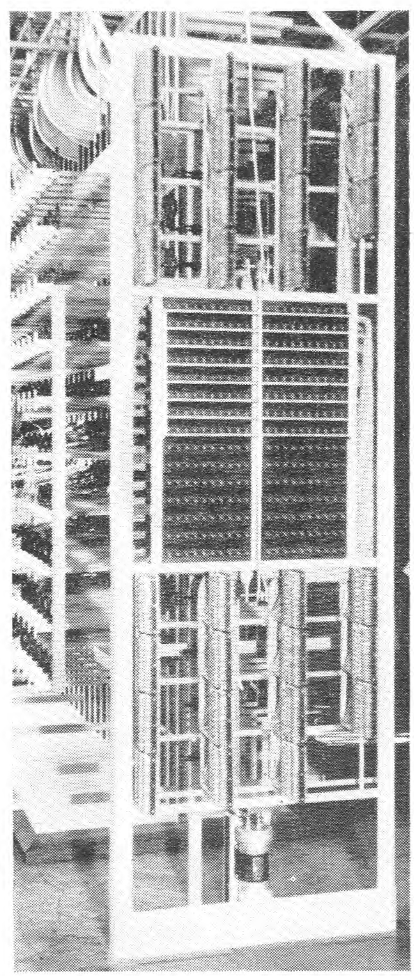


FIG. 7—CHANGE-OVER KEYS

[2] CHAPMAN, E. W., and NOTT, H. C. An Automatic Tester for Subscribers' Lines and Apparatus. *P.O.E.E.J.*, Vol. 51, p. 120, July 1958.

this gradually decreased to 2,000 by the time that the announcement was replaced by N.U. tone; the calls per day that were incorrectly dialled then increased to 4,000 and has since decreased slowly. About one month before the opening the calls that were incorrectly dialled by Bristol Central subscribers amounted to 950 per day, 230 being dialled during the busy hour.

PUTTING THE S.T.D. EQUIPMENT INTO SERVICE

After the assistance code had been changed from 0 to 100, level 0 was regraded and the trunks, totalling 320, were cabled and jumpered to the register-access relay-sets via break springs of change-over keys. Two trunks were routed via each key and, up to the time of change-over, N.U. tone was connected to the 0-level gradings via make springs of the keys, the keys being held in the operated position until the S.T.D. equipment was put into service. The isolation of the register-access relay-sets by these keys enabled testing of the S.T.D. equipment to continue prior to the opening of the service without risk of subscribers being accidentally connected to the equipment, and thus avoided the possibility of premature trunk dialling by subscribers.

The 160 keys required for the 320 trunks were mounted on a rack 8 ft 6 in. by 2 ft 9 in. (shown in Fig. 7) and were wired by local forms to connexion strips, which were also mounted on the rack. The keys were ganged horizontally by steel rods $\frac{1}{2}$in. in diameter and vertically by 1 in. × $\frac{1}{4}$ in. steel strips screwed to each end of the rods. A central bar linked to levers made it possible to restore all the keys simultaneously. Tests showed that a total force of 160 lb was needed to restore all the keys to their normal position simultaneously, but the levers reduce this force to about 9 lb. For safety, a restoring load of 25 lb was used and the system was held in the operated position by a latch which could be released by a cam mounted on the end of the shaft of a small motor. The motor was started by the operation of one key during the opening ceremony.

Special measures were necessary to ensure that, at the end of the first accounting period after the start of S.T.D., the total units recorded on subscribers' private meters were the same as the units recorded on their meters in the exchange. Hence the exchange meters of the subscribers concerned were read just before the S.T.D. service opened and the 50 c/s signal was then connected to the subscribers' private-meter relay-sets. Also, although the local-call-timing relay-sets were connected into the 1st selector grading before the S.T.D. service opened, the metering was rendered inoperative until the opening by disconnecting the positive battery.

The S.T.D. service at Bristol was successfully opened to the public at 3.33 p.m. on 5 December 1958.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the information and assistance they have received from many colleagues in the E.-in-C.'s Office, S.W. Region and Bristol Telephone Area during the preparation of this article.

Acknowledgement is also made to The General Electric Co., Ltd., for permission to reproduce Fig. 5.

Maintenance Aspects of Subscriber Trunk Dialling

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U.D.C. 621.395.374.004.5.

Although the introduction of subscriber trunk dialling will result in the trunk operator being replaced by automatic equipment, it is considered that no radical change in Post Office maintenance practice will be necessary. This article describes the more important maintenance features that have been incorporated in the new items of equipment that are being provided for subscriber trunk dialling and details are given of the routiners and other testers that have been designed for checking the performance of the equipment.

INTRODUCTION

THE advent of subscriber trunk dialling (S.T.D.) is of considerable significance to the maintenance engineer because it involves the replacement of the trunk operator by automatic equipment. The elimination of the human agent in the person of the operator must inevitably take away from the process of setting up a long-distance call a measure of flexibility and choice of action, particularly when abnormal or fault conditions are encountered. In the design of the routing and charging equipment, facilities have been incorporated which minimize the effect of plant faults on service and make up in some measure for the loss of the operator. This article outlines maintenance practice in relation to S.T.D. and describes the built-in facilities and testing equipment designed to aid the maintenance staff.

MAINTENANCE PRACTICE

The maintenance of the telephone system is based on tests, inspections and overhauls of the individual items of equipment and lines used in a chain of connexions, supplemented in some degree by limited testing of local telephone networks using artificial-traffic equipment or local-call senders. It is current policy to apply only functional tests, except in the case of pulsing circuit elements where distortion is likely to influence the successful operating of items connected in tandem. These elements are subjected to tests which ensure that they receive maintenance attention some time before they are liable to fail in service. The amount of testing, particularly where manual testers are used, is adjusted to the needs of the plant by determining the frequency of tests from "guide" figures based on performance. The decision to overhaul equipment is based both on inspection and on performance, as judged from the fault history of individual items. Testing by automatic routiners of the transmission and signalling performance on trunk and junction line links is a feature of the national system.

In the past the controlling operator on trunk connexions has been an important source of information as to the state of the plant, and with her removal under S.T.D. the question naturally arises as to the adequacy from the service point of view of bridging this gap by the extension of the existing maintenance process to the register-translators and associated equipment.

Experience obtained by Headquarters staff, who, as a field trial, have been given dialling access to the trunk network on a subscriber-dialling basis during the past 3 years, supports the view that no radical change in Post Office maintenance practice is necessary to ensure the success of S.T.D. As experience is gained with the maintenance of the early exchanges incorporating S.T.D. facilities the service aspect will be reviewed from time to time to decide whether any departure from the foregoing method of maintenance is desirable or necessary.

In the following sections a summary is given of the maintenance features incorporated in the main items of equipment, followed by details of routiners and testers which have been developed for use in checking the functioning of the new and modified items of equipment introduced for S.T.D.

ELECTROMECHANICAL REGISTER-TRANSLATORS

Each electromechanical translator is common to a number of registers, and at some installations a single translator will be sufficient to deal with the traffic. However, to allow for maintenance operations and to cater for temporary failure, one, or more, translators additional to traffic requirements will be provided at all installations. Normally all the translators will share the total load, an equal number of registers being associated with each.

In the event of a register failing to receive correct conditions from its translator an alarm is given, both register and translator are taken out of service and the remaining registers in the group are switched to share a translator serving another group of registers.

Register-translators are provided with a comprehensive system of alarms and forced-release facilities to ensure that they are not held for unnecessarily long periods due to subscribers' misoperation or equipment failure. Under the following conditions alarms are given:

(*a*) Failure of a single register to receive a translation in 6–12 seconds.

(*b*) Translator holding time excessive (greater than 200–300 ms).

(*c*) Translator release time excessive (greater than 130–200 ms).

In the event of any one of these occurrences:

(*i*) The register concerned will lock-out, remain busied and give a lamp indication of its identity.

(*ii*) The translator will be taken out of service and the group of registers it serves will be associated with the registers served by the next translator.

(*iii*) A deferred alarm will be given.

In the event of two or more registers encountering, simultaneously, condition (*a*) it is assumed that the translator is at fault, and while (*ii*) and (*iii*) still apply, the registers are not locked out. While the above conditions provide for translator or register equipment failures, the possibility of a fault on the register-translator multiple wiring also exists. Such a fault will give rise to register change-over, and it is necessary to prevent it causing a further translator to lock out. It is arranged, therefore, that until change-over has occurred, any further fault condition changes the deferred alarm to a prompt alarm but does not cause another lock out.

Manual control of the register-group change-over

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facility is provided to permit removal of a translator from service for maintenance purposes.

In addition to the conditions quoted in (*a*) to (*c*) above, each register is arranged to "time-out" should dialling be delayed for 20–40 seconds. A key is provided on each register to remove the facility if it is desired to feed in digits slowly for faulting purposes.

Facilities are provided to connect a translator, whose normal registers have been associated with another set of registers, to another register for testing purposes. The connexions are made to the normal jack points by a double-ended cord.

ELECTRONIC REGISTER-TRANSLATORS

An electronic translator with associated h.t. supply is provided additional to the one or two required to deal with the traffic. Unlike the electromechanical translators, each of which shares the load, one of the electronic translators acts purely as a standby.

Fault conditions within the register-translator equipment are detected by means of self-checking devices and cause the standby translator to be brought into use and an alarm to be given.

A standby pulse-generator and register power unit are provided, with automatic change-over when a fault is detected. All thermionic valves in the standby power units are kept ready for immediate use, so that change-over is not delayed because valve heaters need to warm up.

Any one of the translators, pulse generators or register power units may at any time be made to function as the standby.

The electronic register-translator incorporates certain alarm and forced-release facilities which differ from those provided for the electromechanical version. Details of these are as follows:

(*a*) A detector circuit incorporated in the pulse generator will operate if the pulse generator's ring-counters fail; automatic change-over to the standby results, and a deferred alarm is given. Failure of the standby pulse generator under these conditions gives a prompt alarm.

(*b*) A separate lamp indication is given on the translator if the allotter fails. The failure of the allotter to step is detected and, after about 1 second, the standby translator and allotter are brought into service.

(*c*) A relay monitors the output of each register power unit. If the h.t. potential drops below a certain value the relay releases and change-over to the standby power unit is effected. A deferred alarm is given but should a second power unit fail a prompt alarm is given.

(*d*) The mains supply is monitored so that mains failure can be detected.

Means are provided to enable a register-access relay-set to search for and find a specific register whilst maintaining it busy to other relay-sets.

Under test conditions the standby translator can be brought into use with any register that has access to it. While a translator is under test the fault detection circuits, which operate during the progress of a call if the register or translator become faulty, can be inhibited, so allowing the performance of the translator to be watched without the confusion of fault lock-out. The "start" condition to the allotter can also be inhibited when h.t. supply is connected to the standby translator, to check that no tubes break down with the full h.t. potential connected but with no signals on the trigger electrodes.

When a translator is acting as a standby it is important that anyone working on it should be able to prevent h.t. being switched on as a result of the failure of another translator. An "H.T. Guard" key prevents change-over under this condition. A rotary switch and jack give access to the switched and steady h.t. outputs of the power unit for the connexion of a voltmeter or oscilloscope.

The pulse generator and associated power unit can be tested after the removal of links which isolate the pulse generator from the common pulse-lead to the registers and translators. Access to the master pulses and steady h.t. supply on both the power unit in use and the one under test can be gained by means of a selector switch on the translator rack.

The 180 c/s oscillator driving the standby pulse generator can be stopped and the master pulses simulated under control of a key. The pulse, either slowed down or at a normal speed, can also be inspected by means of an oscilloscope or voltmeter, access being obtained by means of the rotary switch which selects the particular output required. When the standby equipment is under test, with links removed, the connexion of h.t., switched and steady, is under key control to provide safe conditions for working on the pulse generator.

Faulting of the electronic register-translator by means of a routiner is supplemented by the use of a portable tester which offers facilities that should prove very useful for locating faults in the electronic equipment. The most important of these facilities is the ability to slow down the operation of the register-translator equipment so that the effect of single pulses from the pulse generator can be observed. The operations of receiving a digit from the translator and transmitting it to the relay-set or display can be separated. A lamp display indicates the fee, routing and other digits pulsed out by the register. When this display is used, the routing and national-number digits are not transmitted to the auto-auto relay-set and trunk routings can, therefore, be dialled into the register without taking outgoing circuits into use.

ROUTINERS AND TESTERS FOR NON-DIRECTOR AREAS

Controlling Register and Translator

Arrangements have been made to test the controlling registers and translators as one unit using an automatic routiner. The access switches are wired to test the registers in numerical sequence. The testing of both items is through the medium of the register, using the translator normally associated with it. Operation of a change-over condition bringing the second-choice translator into use is indicated by the associated alarm.

The design of the routiner follows conventional lines for 2000-type equipment and includes facilities for associating a fault recorder.* The major tests are of a functional nature and employ two national test-codes which, under test conditions, are provided with translations designed to make a comprehensive check of the facilities given by both register and translator. Translations include all digits from 1 to 0 and include different metering digits for each code. A control wire from the routiner switches the translations of these national codes from "spare code" to the selected translation for the purpose of routine testing. Pulsing tests are made under short and long line conditions. Supplementary tests of

* URBEN, T. F. A. The Fault Recorder or Docket Printing Machine. *P.O.E.E.J.*, Vol. 45, p.115, Oct. 1952.

the register-translator include checks for busy conditions, correct seizure, forced release from spare code or from a barred code, correct pause between digits sent out, receipt of end-of-information signal, re-routing facility, and the correct release of the register.

Additional testing facilities provided on the routiner include:

(*a*) Retention of access marking so that if the routiner is taken for manual control it will, on restoration to automatic testing, continue from the point at which testing was interrupted.

(*b*) Sending any combination of nine digits of a national number into the register, with a lamp display of the translation received.

A portable tester is provided to check the speed and ratio of pulses received from the register, and an additional tester can be connected to the translator to make a check of the wiring following translation changes, or for investigation of a suspected wiring fault.

Arrangements have been made to patch an access relay-set and a register to a translator, by means of plugs and cords, to eliminate the complication which would be introduced by "hunting" and "forced release" conditions while investigation of a fault is proceeding.

Register-Access Relay-Sets

A common register-translator equipment will serve circuits from ordinary subscribers, coin-box lines and junctions incoming from remote exchanges. The access relay-sets serving the various groups have small differences in circuit conditions, but are tested by a common automatic routiner (for larger installations) or by a common tester. The automatic routiner is of the conventional 2000-type with facilities for fault recording. Connexion to the relay-set for testing purposes is made via access switches connected to the line terminations and by driving the register-hunter to the 25th outlet, which is wired to the routiner.

Tests made by the routiner and the tester include: pulsing performance under short and long line conditions, guarding of the P wire, correct performance of the hunter-switching relay and of the hunter switch, receipt of initial and subsequent meter pulses, guarding of equipment under clear-down conditions, and operation of forced release both from the access relay-set and the register. Discriminating circuits in the routiner or tester permit appropriate testing conditions to be applied to the type of relay-set under test. Retention of access marking is provided, as described for the register routiner.

Outgoing Junction Equipment at Satellite Exchanges

A manually operated tester for auto-auto relay-sets is provided for general application and will be used to test this equipment. Tests made include: performance of equipment under short and long line pulsing conditions, distortion due to the pulsing element, correct meter-pulse repetition, check of junction guarding and guarding to preceding equipment. A facility is provided to associate a transmission tester when it is required to carry out tests of this nature.

Local-Call Timing Equipment

The local-call timing equipment is tested by a manual tester. Facilities are provided for checking the response to the initial meter-pulse and the generation of periodic meter-pulses by testing the operation of the pulse-generating switch and the wiring of its banks.

ROUTINERS AND TESTERS FOR DIRECTOR AREAS

Controlling Register-Translator

A routiner of conventional 2000-type design with fault-recording facilities will be used for testing the controlling register-translators for director areas. Access uniselectors connect the routiner to the registers in rack sequence, giving a combined test of the register and translator in a manner similar to the arrangement for non-director areas. The routiner will test electromechanical and electronic equipment. Testing facilities follow closely those provided on the routiner already described for testing register-translators in non-director areas, utilizing two selected codes with translations selected to give maximum check of the translator equipment.

Register-Access Relay-Sets

The routiner for register-access relay-sets is similar to the equivalent routiner for non-director areas. Tests are made with the register-hunter standing on the 25th outlet. Discrimination in testing is given between incoming and local-access relay-sets, both being tested by a common routiner. Particular tests that are affected by discrimination are the pulsing performance of the line relay and metering conditions. In addition to tests made by the non-director routiner, a check is made of the line-padding resistors, with discrimination of the pulsing tests when the pads are in use, and of the congestion tone when dial pulses are received before a register has been found by the hunter.

Outgoing Junction Relay-Set

A manual tester is provided to test this equipment. It can be used also for testing 1st code selectors. Testing arrangements are similar to those already described for outgoing junction equipment at satellites in non-director areas and include short and long line pulsing, pulse distortion, metering, and the junction-guard conditions. Transmission tests can also be made with the aid of a separate transmission tester.

1st Code Selectors

For existing 1st code selectors that are modified for S.T.D. by the addition of separately mounted local-call timing equipment, the existing routiners are modified to check one metering pulse both from the local level and the S.T.D. level, a separate manual tester being used to test the timing circuit.

For 1st code selectors with local-call timing incorporated, a new routiner of conventional 2000-type with docket-printing facilities is provided. An important difference from the existing 1st code selector routiner is the provision of test lines on both the S.T.D. level and one local level. Separate tests are made of the current performance and pulsing of the line (LS) relay. Operation of the switch mechanism is checked by pulses simulating those normally received from the director. This method of testing should effect an improvement in the maintenance of this type of equipment.

The routiner also tests for correct operation of the A-digit hunter and switching relay, manual-hold conditions, switching and metering on local calls, switching and metering on S.T.D. calls, guarding against fraudulent pulsing, guarding against dual switching, release of the switch and the long-junction guard feature. Key controlled facilities are provided to test: busy tone, N.U. tone, dial tone, local-call timing pulses, and to check for correct operation of the routiner by simulating faulty conditions on the line and P wires. Pulse distortion and transmission can be measured by the tester mentioned under the previous item.

Local Register

As the local register functions as a pulse regenerator, the manual tester provided consists essentially of a dial for pulsing into the equipment with a lamp display to check receipt of a correct repetition. The additional digit generated within the register for stepping the 1st code selector is also checked by the lamp display. Facilities are also provided to check the speed and ratio of pulses from the register, measurement of the inter-digital pause, the long pause following the 1st digit, the digit-storing network of the register, and forced release conditions.

Register-Translator Equipment for Incoming Trunk Circuits

Routine testing of this register-translator is carried out by an automatic routiner of similar design to the one described for the non-director register. Access to the registers in a sequence corresponding to the mounting arrangement on racks is given by switches mounted on the register trunk-distribution rack. Tests are made by using three 3-digit codes, each code having a distinct translation of four digits, followed by four digits. The latter are selected to give a comprehensive check of the translator, and because only four translated digits can be allocated for each code, three test codes are required. For the purpose of testing, the translations for the selected codes are switched under the control of the routiner. Pulsing into the register is done under both short and long line conditions. Other tests made include: routing to service assistance code, correct seizure (including rejection of dual switching), guarding of the register while it is in use, and forced release conditions. By means of keys set under manual control, any combination of seven digits can be sent into the register, the digits received following translation being displayed on lamp strips. An auxiliary tester is provided to check the alarm conditions and to check the speed and ratio of pulses received from the register.

EQUIPMENT COMMON TO DIRECTOR AND NON-DIRECTOR AREAS

Subscribers' Private Meter Control Equipment

The subscribers' private meter control equipment is tested with the subscriber's uniselector standing on the home position, thus avoiding operation of the subscriber's private meter as a result of testing. A check is made by measuring the current in the primary circuit of the transformer when the meter controlling relay is operated. As a safeguard against application of the test in error when the equipment is in use, the testing current is limited to a value which will not operate the subscriber's meter. As the transformer secondary winding forms a part of the subscriber's calling circuit, a test to prove that part of the circuit is not a function of this tester.

Coin and Fee Checking Equipment

Tests of the equipment used for coin and fee checking on coin-box lines are effected mainly by listening for tones with the aid of a loudspeaker built into a manual tester. Appropriate circuit conditions are applied by the tester to check the supply of pay tone (or N.U. tone under the barring condition) heard by subscribers. A check is also made of pulses of tone heard by a manual-board operator (code 100 calls) when coins are inserted in the coin-box, or when an audit is made of the total coin-pulses registered. Other circuit conditions checked are: signals for control of coin slots, detection of fraudulent coin-pulses, the feature for discriminating between local and trunk calls, trunk-call metering, local-call timing (by applying accelerated pulses to check the stepping switch), line continuity under the seized condition, and circuit guarding conditions.

Service Observations

Quality-of-service observations will be in two categories —local and trunk. The local-service observations will be made by tapping at the 1st selectors; 0 and 100 level traffic will be ignored. The quality of service given to trunk-dialling subscribers will be observed at the register-access relay-sets for it is at this point, and not at the trunk selectors, that it will be possible to observe what the subscriber dials and the subsequent rate of metering.

CONCLUSIONS

The maintenance of the automatic telephone network under S.T.D. conditions has been reviewed, consideration being given to the extension of automatic equipment maintenance practice to meet the new conditions, and the provision of maintenance aids and testing equipment. We move into this new era with confidence that the high standard of service of which the British Post Office is justly proud will continue under S.T.D.

The Next Steps

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U.D.C. 654.15.01:621.395.374

The other articles in this special issue of the Journal have outlined the arrangements made for the introduction of subscriber trunk dialling in the United Kingdom and have described the special items of equipment that have been designed. This article reviews some of the outstanding problems and indicates possible technical solutions.

INTRODUCTION

THE provision of facilities for subscriber trunk dialling (S.T.D.) as outlined in the previous articles does not of itself complete the automatization of the telephone service. The need for the provision of register-translators at transit centres so that all national trunk calls can be dialled by subscribers has already been mentioned,[1] and additional equipment will have to be developed before subscribers can dial international trunk calls. The change in the character of the trunk service from an operator-controlled service to one where subscribers dial their own calls will mean a review of the functions of manual boards in the new conditions and will almost certainly lead to a reduction in the number of locations where manual boards are required. In the next few years automatic methods are likely to be used more extensively in those aspects of the service dealing with accounting, with collection and collation of statistics and in maintenance techniques. An outline of some of these problems and an indication of some possible technical solutions are given in the following paragraphs.

NEW NETWORK FOR TRANSIT TRUNK CALLS

Need for Separate Network

The method of routing control that has been adopted requires register-translators to be located at each transit trunk exchange. In the present trunk network, which was based originally on manual switching, two or three intermediate transit switching points may be involved, and it is likely that, with automatic switching, additional transit points will prove to be economic. Three or more transit registers could, therefore, be involved on an S.T.D. call. The use of any form of storage, however, either in the form of a register or pulse regenerator, necessarily increases the time of setting up a call. The total delay introduced by registers and pulse regenerators when used in conjunction with existing signalling and switching systems could be appreciable, and on calls routed over the full basic network the interval between the completion of dialling by the subscriber and the receipt of ring tone could exceed 30 seconds. Figures of this order are not only a serious service disadvantage, but represent so much lost circuit time. The delay can be considerably reduced by the use of rapid switching techniques at transit centres, together with rapid signalling techniques on the transit trunk network, and it should be possible to reduce the delay to something less than 10 seconds. To achieve this improvement, however, it will be necessary to develop and install new equipment at transit switching centres, so that the total time required to signal to, and switch through, a transit centre is of the order of 1–1½ seconds.

Fortunately, it is unnecessary to consider changing the existing equipment at trunk switching centres as it is already used chiefly for single-link traffic and can continue to carry this type of traffic satisfactorily. At the present time it has been found economic to route some traffic via an intermediate group centre rather than over the basic network, and to allow for this the controlling register-translators[2] provide more digits in the translations than would be justified by strict adherence to the "own-exchange-only" principle. Any spare capacity at existing trunk-switching centres made available by removing transit traffic can, therefore, be absorbed by the growth of single link and inter-group traffic.

The provision of separate switching equipment at transit centres will involve a separate network of trunk circuits for their interconnexion. However, this should not result in any appreciable loss of circuit efficiency if alternative routing is used as outlined later.

Advantages of a Separate Transit Trunk Network

Several other advantages arise from the use of a separate trunk network for transit traffic. Perhaps the most important is that it becomes possible to switch traffic at transit centres simply and cheaply on a 4-wire basis. The improvement in overall transmission between group switching centres thus made possible should enable economies to be made in the junction network between local exchanges and a group switching centre. The provision of 4-wire switching also simplifies the design of a system for the rapid signalling of numerical information between trunk switching centres, as separate go and return paths can be made available during the signalling period.

Outline of Proposed Transit Trunk Network

Details of a new transit trunk network have not yet been settled, but it is desirable to indicate the general lines it is likely to follow as it will affect many aspects of the trunk service, including automatic alternative routing and the location of auto-manual boards. It is likely that a new trunk-switching network will be similar to the existing trunk-switching plan in allowing for a maximum of seven links between local exchanges. The main differences will probably be as follows:

(*a*) In the new transit network, local exchanges will always be directly connected to the group switching centre, whereas in the existing network two links are permitted between the local exchange and the group centre.

(*b*) The segregation of transit and terminal traffic will result in fewer zone centres being fully interconnected.

(*c*) The sub-zone centre will form part of the basic network instead of being an auxiliary switching centre for certain classes of traffic only. Accordingly, group centres which have routes to sub-zone centres need not retain, for transmission reasons, direct routes to zone centres.

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(*d*) The number of sub-zone centres will increase because:

(i) a number of large group centres will be upgraded to sub-zone status as they will act as collecting centres for traffic from a number of group switching centres, and

(ii) a number of zone centres will be downgraded as they will no longer justify circuits to all other zone centres.

It is probable, therefore, that a new transit trunk network will be similar to that shown in Fig. 1. The

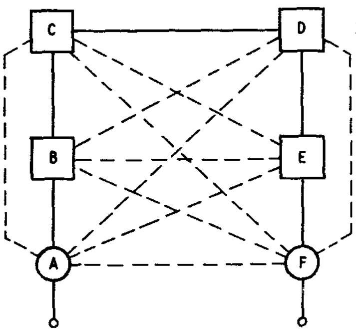

FIG. 1—PROBABLE ARRANGEMENT OF NEW TRANSIT TRUNK NETWORK

basic routes are shown as continuous lines and the broken lines indicate the auxiliary routes that will be possible.

Automatic Alternative Routing

Alternative routing has always been a feature of the trunk service, particularly under breakdown conditions. Its widespread use under normal traffic conditions, however, cannot always be justified economically when switching is carried out manually. With automatic switching at transit centres, alternative routing is more likely to be justified economically and will enable groups of circuits to be worked at a high efficiency with economies in line plant. The high-efficiency routes to which calls are first offered are known as "high-usage" routes, and the calls that fail on such a route are then offered to a fully provided route, i.e. a route provided on a normal grade of service and without alternative routing facilities.

Referring to Fig. 1, an example of alternative routing would be the case of calls from A to F, which first would be offered to the direct route with overflow to one of the routes to exchanges, B, C, D or E. If such a call were alternatively routed to, say, exchange B, it might then be offered to the direct B–F high-usage route, with overflow to C, D, or E, and so on until finally it would be offered only to fully provided routes without alternative routing. By ensuring that alternative routing is always to a fully provided route and that the call is circulated always towards its destination, the chance of a call being alternatively routed back to an exchange through which it has already passed is avoided.

In the special case where a route is divided into two components dealing respectively with terminal and transit traffic, alternative routing tends to limit the loss of efficiency which might otherwise arise. In Fig. 2, X and Y are group switching centres and the latter is located in the same building as the transit centre Z. The route between X and Y can be worked on a high-usage basis with overflow via Z.

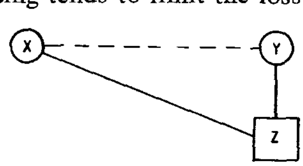

FIG. 2—ALTERNATIVE ROUTING

In considering alternative routing from one route to another, it is essential not to allow a large route, say 100 circuits, to overflow on to a very small route, say 10 circuits, because of the danger that calls for which the small route is the sole traffic outlet might be "squeezed out" by the overflow traffic from the large route. This raises the problem of the detailed trunking arrangements required to ensure that traffic that can overflow from a high-usage route does not get an enhanced grade of service at the expense of other classes of traffic using the fully-provided route. As a result of the studies that have been carried out so far, it appears practicable to provide automatic alternative routing on a satisfactory basis.

RAPID SWITCHING AND SIGNALLING SYSTEMS

It is evident that to achieve the necessary speed of setting up calls the present method of setting switches on a step-by-step basis under the direct control of strowger pulses, and of signalling the pulses at a nominal 10 p.p.s., must be abandoned.

Rapid Switching

As regards the switching function, the time taken is dependent both on the speed with which a switch can be made to operate and on the method of switch control. A study of both these aspects has shown that:

(*a*) The necessary speed of operation can be given by the motor uniselector, which is already used extensively for trunk switching.

(*b*) The principle of interconnected link-circuits using some form of relay switching, which gives a faster operation, might be advantageous in some circumstances.

(*c*) Some method of marker control should be used.

(*d*) Systems requiring a common marker for the whole exchange give the greatest degree of flexibility, but tend to be complicated. In large installations, consideration of the frequent operations necessary suggests that electronic control equipment would be essential.

The number of trunk circuits that will be switched is likely to vary from less than 100 at the smaller transit centres to 1,000 or more at the larger centres, and the same design of switching system may not be the most economic in both cases. For the smaller centres at least a switching system using one or two stages of motor uniselectors with sequential marking over the speech wires from the register-translator is likely to provide the most economical arrangement. However, the greater flexibility of a system using link circuits controlled by a common marker makes it desirable to examine further the possibilities of developing such a system for use at larger centres.

Rapid Signalling

In order that the maximum flexibility in the type of line signalling (e.g. v.f. or d.c.) used on particular links may be available, and to give overall economies both in line signalling equipment and numerical signalling equipment, it has been decided that the line signalling should be on a link-by-link basis and that numerical signalling equipment should be associated with the registers. The numerical signalling system will have to operate over both audio and h.f. transmission systems and will therefore have to be a voice-frequency system employing a suitable code to achieve a higher signalling speed than is given by strowger pulsing. There are, of course, many codes which could be employed, but two examples are the binary code of the international 2 v.f. signalling system and the two-out-of-six multi-frequency code such as is employed in the U.S.A. and has recently been introduced in one or two European countries.

The question of the type of signalling code to be used can be affected by the type of routing control employed; that is, whether the whole of the numerical information is repeated from point to point, or whether only that necessary to route the calls to the terminal group switching centre is passed to transit centres and the balance of the number is passed from end to end of the transit connexion. The characteristics of the transmission systems, particularly the transmission-loss deviations and the attenuation/frequency variation to be expected over a number of links in tandem, have to be considered in reaching any decision on the suitability of particular codes for end-to-end signalling. In general a binary code, similar in principle to that of the international system employing simple frequencies, gives rise to less severe problems of signalling-equipment design when transmitting over a number of links in a wholly 4-wire network. Multi-frequency pulsing could have advantages when end-to-end signalling is required over a network comprising both 2-wire and 4-wire circuits.

In weighing the merits of different codes the relative speed of signalling must also be considered. A multi-frequency code can normally be designed for faster signalling than a binary code, but it can be shown that in practice the effect of the difference on the setting-up times of calls would be very small.

These are, of course, only the main technical factors it is necessary to consider in reaching a decision (economics must also receive attention), and the arguments outlined have been specifically related to two particular possible signalling codes—others need also to be examined.

LOCATION OF MANUAL BOARDS

At the present time manual boards are located at each group centre and at such other points as may be necessary. With the introduction of S.T.D. the volume of traffic routed via these manual boards will be reduced considerably, and from a staffing point of view it is likely to be economic to concentrate the remaining traffic, at least during the night period, at only a few places and often remote from the originating group switching centre.

Manual-board traffic is of two kinds:

(*a*) that which terminates at the manual board, such as inquiry traffic, and

(*b*) that which is extended over the trunk network.

The former kind presents little difficulty technically and could be routed to any convenient nearby manual board, but for the latter class of traffic the location of the manual board is important to ensure that transmission requirements are met. If advantage is to be taken of the 4-wire switched network to allow economies to be made in the local junction network, then a manual board that deals with trunk traffic should be located at a transit centre, such as a sub-zone on the new transit network. It will also be necessary to ensure that traffic from the remote group switching centre can be extended at the manual board on a 4-wire basis to the trunk network. It is essential, therefore, that new equipment being designed for manual-board traffic should permit this form of routing to be adopted, although the continued existence of the present trunk network during the transition period will enable considerable latitude to be available in the choice of routing.

INTERNATIONAL SUBSCRIBER DIALLING

The final step in the automatization of the telephone service will not have been taken until any telephone subscriber can dial any other subscriber anywhere in the world. The full implementation of this cannot, of course, be achieved for a very long time, but the first steps to this end have already been taken, and a limited amount of international subscriber dialling, based on limited bilateral agreements, is already taking place between certain capitals and border cities in Europe.

Obviously, the first step to be taken in planning the introduction of international subscriber dialling (I.S.D.) is to reach international agreement on the operational facilities to be provided, and the International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) is at present engaged on an intensive study of the questions involved. In connexion with the introduction of semi-automatic working[3] the C.C.I.T.T. has already issued agreed specifications[4] for standard signalling systems, and in framing these specifications has taken into account the requirements of subscriber dialling. It has also allocated dialling codes for a large number of countries in Europe and the Mediterranean Basin and has earmarked codes for inter-continental traffic. The maximum number of digits likely to be met in any European national numbering schemes has also been determined. Agreement has been reached on acceptable methods for recording charges against subscribers and appreciable progress has been made toward a greater degree of standardization of supervisory tones (ring tone, busy tone, etc.).

The main outstanding problem is that of agreeing a basis of obtaining information for the settling of international telephone accounts that will be acceptable to administrations and not be too complex or costly to implement technically. Pending the solution of this problem it has been possible to take certain steps in designing S.T.D. equipment to incorporate features which will later permit the introduction of I.S.D.

It has been decided that United Kingdom subscribers will be charged for I.S.D. calls on the same basis as that adopted for national calls. This has the advantage that it is possible to use much of the S.T.D. equipment, already designed, for I.S.D. traffic, provided certain additional facilities are incorporated or can be readily and cheaply added.

On this basis it has been possible to design the S.T.D. equipment for local exchanges so that it is suitable for both S.T.D. and I.S.D. traffic. At trunk switching centres the controlling register-translators[2] have been designed to recognize the international access code (010) and call in such additional equipment as may be necessary. This equipment will have two functions:

(*a*) To provide additional storage capacity in the register for the extra digits involved, together with altering the basis upon which the register is released by the "time out" feature.

(*b*) To examine the country code and such digits of the foreign national number as may be necessary to determine the appropriate charge rate.

It has been possible, however, at negligible extra cost, to include these additional requirements for I.S.D. in the register-translator based on the magnetic-drum technique,[5] which is being developed for director areas.

In the initial stages at least, all international traffic will circulate through the International exchange in London. At the present time this exchange allows for outgoing traffic to be routed on a semi-automatic basis only and the international circuits are selected manually. Before I.S.D. can be introduced, therefore, it will be necessary to arrange for these circuits to be available from selector levels and to design a suitable outgoing register-translator to control the routing. It will also be necessary to provide equipment to give adequate statistical data both for traffic control and to meet the needs of international accounting.

As originating I.S.D. calls usually involve the transmission of many more digits than on S.T.D. calls, it is necessary to ensure that equipment used jointly for I.S.D. and S.T.D. traffic can handle the additional digits. When, as is likely in the early stages, I.S.D. traffic is routed from the originating trunk switching centre to London, the use of digit 1 to bypass the director-area incoming register-translators[6] enables the traffic to be routed through to the International exchange without the storage capacity of the registers resulting in any limitation.

For calls which will be routed over the new transit network the difficulty is overcome by the method of routing control adopted, whereby transit registers receive a 3-digit code only and the remaining digits are signalled right through to register-translators at the International exchange. The use of the new transit network will also have the advantage of providing 4-wire switching facilities for I.S.D. calls at the International exchange.

CONCLUSIONS

This article has reviewed very briefly some of the major problems at present under study to enable the degree of automatization of the telephone network to be further extended, and it is apparent that much more work has to be done before, even within the United Kingdom, it will be possible to say that the telephone system is fully automatic. Space has not permitted mention to be made in detail of the study of the automatization of ancillary facilities, such as the reading of subscribers' records of charges and the subsequent preparation of the account, the recording of traffic and revenue-distribution data in a form to permit subsequent machine analysis, etc., but a start has already been made on these studies. The solution of these problems provides a challenge to those engaged in the development of the telephone system which is being accepted with a quiet confidence that satisfactory solutions will be produced, particularly with the aid of new electronic components and techniques now becoming available.

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Notes and Comments

Board of Editors

As a consequence of Mr. A. H. C. Knox's appointment as President of the Associate Section, the Council of the Institution has appointed Mr. A. J. Leckenby to take his place on the Board of Editors. The Board would like to record its appreciation of the services rendered to the Journal by Mr. Knox.

The work of the editorial staff has recently been reorganized and Mr. J. H. Broadhurst, formerly an Assistant Editor, has been appointed Editor (Supplement), with special responsibility for the Supplement to the Journal and books of model answers to City and Guilds of London Institute examinations in telecommunications subjects. The new Assistant Editor is Mr. D. M. Gambier.

Premiums Awarded by the Radio Industry Council for Published Technical Articles

Each year the Radio Industry Council awards up to six premiums of 25 guineas each to writers of published technical articles which, in the opinion of the Council's panel of judges, are likely to enhance the reputation of the Industry and make more widely known British achievements in radio, television and electronics.

Any writer will be eligible who is not paid a salary wholly or mainly for writing and is not earning 25 per cent or more of his income from fees for articles or from book royalties.

Writers are invited to submit published articles (six copies of the journal, or of the relevant pages, proofs or reprints), together with signed declarations of eligibility, to the Secretary of the Radio Industry Council, 59 Russell Square, London, W.C.1, requesting consideration for an award. Articles will be considered for awards at the end of each year and the results announced early in the new year. Writers are, however, urged to send in their entries during the year as soon as possible after publication; all entries must reach the Radio Industry Council's offices before the end of the year.

Articles published in this Journal are eligible for the awards; it will not, however, be necessary for writers of articles published in this Journal to send copies to the Secretary of the Radio Industry Council when requesting consideration for an award, because copies of each issue of the Journal are sent to the members of the panel of judges.

Journal Binding

This issue completes Vol. 51 and readers wishing to have the volume bound should refer to page 387 for details of the facilities available.

Institution of Post Office Electrical Engineers

Annual Awards for Associate Section Papers—Session 1957–58

The Judging Committee having adjudicated on the papers submitted by the Local Centre Committees, prizes and Institution certificates have been awarded to the following in respect of the papers named:

First Prize of £7 7*s.*

- E. N. Harcourt, Technical Officer, Guildford Centre—"Cable Corrosion—Some Causes and Cures."

Prizes of £4 4*s. each*

- K. O. Verity, Technical Officer, London Centre—"Radioactivity and Some Peaceful Applications."
- P. W. G. Goodwin, Technical Officer, London Centre—"An Introduction to the Post Office Standard P.A.B.X.s."
- R. L. Adams, Technical Officer, Gloucester Centre—"Local Line Development."
- L. Vranch, Technical Officer, Bath Centre—"Wireless Direction Finding—An Introduction."

In addition, the following papers, which were considered worthy of submission to the Judging Committee for the main awards, have been awarded a prize of one guinea each:

- C. F. Carr, Technical Officer, Newcastle-on-Tyne Centre—"The Cathodic Protection of Telephone Cables."
- D. White, Technical Officer, Aberdeen Centre—"Radio and Television Interference Investigation."
- J. R. Haggart, Technical Officer, Edinburgh Centre—"A Brief Survey of Domestic Electrical Equipment."
- L. H. Summerfield, Technician IIA, Tunbridge Wells Centre—"Lead—its Versatility and Uses in Modern Industry."
- K. E. Guest, Technical Officer, Brighton Centre—"Air Navigation."
- J. S. Kendall, Technical Officer, Birmingham Centre—"Resistance Measurements."
- I. Berg, Technician IIA, London Power Centre—"Electrical Testing and Fault Finding."
- A. G. Weech, Technical Officer, London Power Centre—"A.C. Motors."

The Council of the Institution is indebted to Messrs. N. C. de Jong, T. S. Wylie and D. Waite for kindly undertaking the adjudication of the papers submitted for consideration.

Report on Annual Awards for Associate Section Papers—Session 1957–58

Council is indebted to Mr. N. C. de Jong, Chairman of the Judging Committee, for the following report:

Among the 13 papers entered for the 1957–58 awards, there were three outstanding ones which caused the Judging Committee much reflection before deciding on the first prize. Some of the others were also of a very high standard and well deserving of recognition. They not only reflect great credit on their authors but give some idea of the worthwhile efforts made by the Local Centre officers to promote the interests of the Associate Section.

In awarding the first prize to Mr. E. N. Harcourt, Guildford, for his paper on "Cable Corrosion—Some Causes and Cures," the committee has recognized the merit of an original-style presentation of a well-tried but specially interesting subject. A concise and well-illustrated description is given of the various forms of corrosion and the preventive measures in use. The author gives a very readable description of the chemistry of lead and its reaction to various forms of attack, and a capable technical explanation of our methods of testing and treatment. A brief survey of the latest applications of cathodic protection is included.

The two other papers which ran this one very close were "Radioactivity and Some Peaceful Applications" and "An Introduction to the Post Office Standard P.A.B.X.s." The former presents in a most attractive style a study of the composition of matter and an explanation of the electromagnetic radiations, including X-rays and gamma rays, their present uses and future potentialities. In this atomic age, when television has led to universal discussion, if not understanding, of the science of nuclear fission, radioactivity is a subject of topical appeal.

The paper on P.A.B.X.s deals with its subject in a thorough and purposeful way. It owes much of its descriptive features to official publications but has been so well prepared, illustrated and demonstrated that it does not suffer from the inclusion of standard lists of facilities and other features. A full description of the three types of P.A.B.X. is given, with details of their circuitry and common equipment and some pertinent comment on their design and development aspects.

"Local Line Development" is another example of a very sound presentation of a well-tried subject of general appeal. It sets out to cover the progress of a development scheme for a particular exchange area through its many stages from inclusion in the annual estimates to final authorization. Forecasting, with all the other information and material needed; methods of design, taking into account economic comparisons and transmission limits; preparation of works estimates and instructions, are some of the features described with a striking brevity. Despite this, the paper presents and illustrates this most useful subject in such a way as to justify inclusion in the awards.

There is little of brevity about "Wireless Direction Finding—An Introduction," but there is much evidence of originality and historical research by an enthusiast. The propagation of electromagnetic waves, properties of the ionosphere, aerial systems and aircraft direction-finding are among the items fully described, and the presentation is such as to justify the author's final certificate that composition and drawings represent his own unaided effort.

The reading of all the papers provided much of interest and enjoyment, but some of the would-be prize-winners should remember that, apart from using their own vocabulary and some originality, an orderly well-illustrated presentation adds to a favourable impression.

S. WELCH, *Secretary.*

Use of the Institution Library by Members of the Associate Section

Members of the Associate Section are reminded that they may borrow books from the Institution library and that there is no longer any need for their library requisitions to be countersigned. Copies of the revised catalogue of books may be obtained by Associate Section members from their Local Secretary or direct from the Librarian, price 6d.

Secretaries of Associate Section Centres publishing local journals may obtain from the Librarian a brief description of the contents of books added to the library.

Additions to the Library

Library requisition forms are available from Honorary Local Secretaries, from Associate Section Centre Secretaries and representatives, and from the Librarian, I.P.O.E.E., G.P.O., 2–12 Gresham Street, London, E.C.2.

2503 *Digital Computer Components and Circuits.* R. K. Richards (Amer. 1957).
Collects the ideas related to digital techniques and organizes them in a coherent and unified manner.

2504 *The Cosmic Radiation.* J. E. Hooper and M. Scharff (Danish 1958).
Provides an introduction to the subject suitable for students and physicists engaged in other fields.

2505 *Engineering Thermodynamics.* G. F. C. Rogers and Y. R. Mayhew (Brit. 1957).
Covers the fundamentals of applied thermodynamics courses up to honours degree standard.

2506 *Pulse and Time-Base Generators.* D. A. Levell (Brit. 1958).
An exposition of the principles underlying the design of circuits to generate pulses and time-base waveforms for radar, television and electronic instrumentation.

2507 *Transistor Electronics.* D. Dewitt and A. L. Rossoff (Amer. 1957).
Aims at preparing the engineer to use the transistor with a confidence based on a quantitative understanding of its operating mechanisms.

2508 *Synchronous Motors and Condensers.* D. D. Stephen (Brit. 1958).
An introduction to the characteristics of these motors; discusses the problems encountered when selecting the most suitable motor for a particular application.

2509 *High Quality Sound Reproduction* J. Moir (Brit. 1958).
For the professional engineer and the knowledgeable amateur, with particular reference to reproducing high-quality sound in domestic surroundings.

2510 *Automation in North America.* D.S.I.R. (Brit. 1958).
A report on visits to industrial, commercial and research establishments in the U.S.A. and Canada.

2511 *Television Engineering, Vol. 4—General Circuit Techniques.* S. W. Amos and D. C. Birkinshaw (Brit. 1958).
The last volume of the B.B.C. training manual on television engineering.

2512 *Solution of Problems in Electrical Technology.* H. Cotton (Brit. 1958).
In M.K.S. units. For students in first two years of university courses, or preparing for O.N.C. or H.N.C. exams.

2513 *The A.B.C. of Relativity.* B. Russell (Brit. 1958).
An introduction to the ideas of special and general relativity, and explains their practical applications to gravitation and the hydrogen bomb.

2514 *Engineering Drawing and Drawing Office Practice.* P. S. Houghton (Brit. 1958).
Illustrates the standard methods in the whole field of mechanical drawing.

2515 *Solid State Physical Electronics.* A. Van de Ziel (Brit. 1958).
Gives a comprehensive introduction to the subject, and is aimed at the fairly advanced student of electrical engineering.

2516 *A First Course in Statistics.* R. Loveday (Brit. 1958).
For those requiring an elementary introduction to the subject.

2517 *Radio Communication.* W. F. Lovering (Brit. 1958).
Presents, for engineers rather than mathematicians, the fundamentals of radio communication.

2518 *Calculus for Electronics.* A. E. Richmond. (Amer. 1958).
Presents those methods and results from the calculus which are of the most direct use in the study of circuits. The reader should be acquainted with the fundamentals of algebra and trigonometry, and familiarity with electric and electronic circuits is desirable.

W. D. FLORENCE, *Librarian.*

Regional Notes

London Telecommunications Region

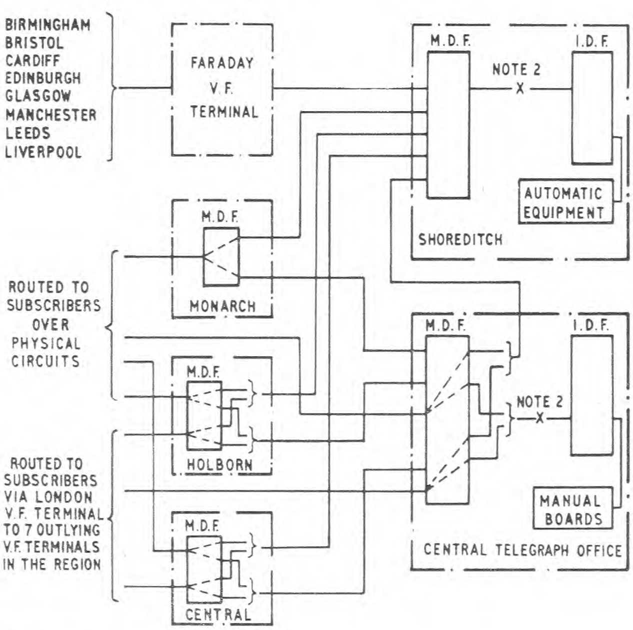
OPENING OF SHOREDITCH AUTOMATIC TELEX EXCHANGE

In 1954 the telex service, which up to then had operated within the telephone network, was transferred to an independent teleprinter manual-exchange system. This also included the international telex service, which had developed rapidly and was already using manual telegraph switchboards. It was realized at the time that this would be an expedient only and that full automatic working, with national and international dialling by subscribers, would be an urgent requirement.

In November 1957 construction of the London pilot automatic telex exchange was started, and it was completed, together with similar equipment at Leeds, by July 1958. The pilot exchange is in temporary accommodation in Shoreditch and is designed for 900 subscribers only, this being less than one third of the present total of London telex subscribers. The first stage of a three-stage transfer was carried out on 30 August 1958, when a small number of specially selected subscribers were changed over to the new exchange.

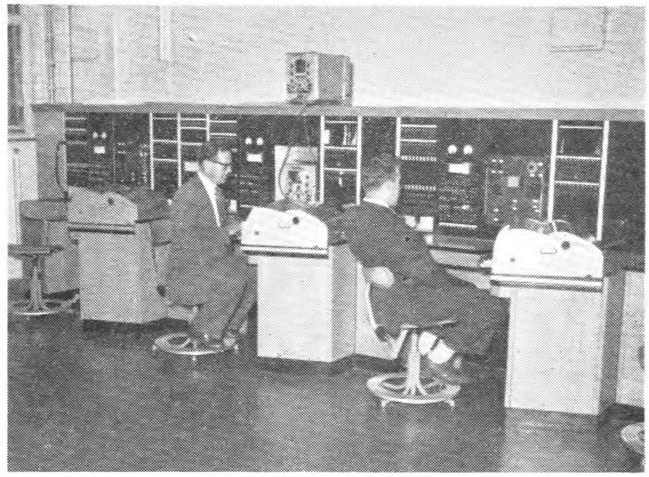
Many new and untried features such as "subscriber trunk dialling" and "time zone metering" are incorporated in the design, and it was decided that periods between stages should be one to two weeks, and that the transfer should commence with large-user groups such as cable companies and newspaper offices, together with Government departments and Post Office service lines. This cross-section, it was thought, would thoroughly test the system and reveal any unforeseen difficulties. The very thorough "flood testing" by both engineering and traffic staffs was sufficient to prove the performance of the equipment, and subsequent stages of the transfer followed without difficulty.

Before the transfer could be carried out it was necessary to convert telex subscribers' apparatus from manual to automatic working, and this required complete re-wiring of the tables to accommodate new-type teleprinters and station signalling equipment. This was quite an undertaking but, in spite of the late receipt of certain stores, it was carried out within the specified time.



Notes:
1. Only teed connexions are shown on the distribution frames.
2. Position of the break jacks on the engineering control boards.

GENERAL OUTLINE OF TEEING, AND ARRANGEMENT OF CIRCUITS, FOR THE TRANSFER



POST-TRANSFER TESTING OF TELEX LINES ON THE SPECIALLY-DESIGNED TEST-DESK

It was agreed to use a "peg transfer" system on the engineering control boards at Shoreditch and the Central Telegraph Office, paralleling for a short time the routes to both Shoreditch and the Central Telegraph Office by inserting fuses in both routes at the teeing point. This had no adverse effect on the subscribers' service.

The subscribers to be transferred were widely dispersed in the Region since, unlike a telephone exchange transfer, subscribers' terminations exist in each of eight Telephone Areas, the manual and automatic exchanges, plus three teeing points, being situated in the City Area and a fourth teeing point in the Centre Area, as shown in the sketch. A few subscribers working via m.c.v.f. telegraph systems were dealt with piecemeal between the first two stages of the transfer, as a small modification was necessary at the v.f. telegraph terminal coincident with the transfer. Pre-transfer testing required the checking of continuity and polarity after simulating change-over conditions, and post-transfer testing was done by the test clerks via test-final selectors, when, to identify the line with the number dialled, the "answer back" code had to be received and checked. The number of faults at the time of the transfer was negligible, with about 2 per cent of the lines returning the "ABS" condition due to subscribers having switched off the power supplies to their station equipment.

There was very close co-operation between the engineering and traffic staff throughout the whole operation and this, no doubt, was responsible for the success that attended the change-over.

R. W. C.

WATFORD NEW AUTOMATIC EXCHANGE

On 8 October 1958 a new non-director exchange, with a multiple of 8,600, was opened at Watford, replacing the existing pre-2,000-type exchange; 6,179 subscribers and 2,021 junctions were transferred from the old Watford exchange, while 3,600 Gadebrook subscribers were also affected by number changes and the disappearance of the separate exchange name of Gadebrook.

Watford is the parent for a group of four small non-director exchanges and before the opening there was a fifth, Gadebrook, sharing a common area with Watford. Watford and Gadebrook exchanges and the manual board were in the same building and it would have been simplest to replace all three. However, Gadebrook was a new exchange and, although the manual board is the same age as the Watford exchange and its capacity was almost exhausted, relief could be obtained by the introduction of dialling arrangements for the Watford subscribers into the London director area and, later, by the introduction of subscriber trunk dialling. It was, therefore, decided to replace only the Watford equipment and to leave the Gadebrook equipment and the manual board unaltered as far as possible.

The multiple capacity of the new exchange could not be accommodated within the existing 4-digit numbering scheme and it was, therefore, necessary to introduce a 5-digit numbering scheme. The director codes for Watford and Gadebrook were respectively WA2 and GA3 and so, to keep within the maximum of seven digits in the director area, these codes were changed to WA. All subscribers connected to the new Watford equipment have the digit 2 as the first of their 5-digit number while those connected to Gadebrook equipment have 5-digit numbers starting with 3. This was the first change of this kind in the L.T.R. and, in an attempt to reduce the amount of wrong dialling, the greatest possible publicity was given. Features appeared in B.B.C. sound and television programs and the local press displayed great interest. In order to intercept as many wrongly-dialled calls as possible, levels 4, 5 and 6 of the new exchange were connected to a changed-number announcer giving a recorded announcement. This will intercept local subscribers dialling the old numbers beginning with one of these figures. To intercept director-area subscribers dialling the old code followed by the new number, the new levels 22 and 33 were thrown spare and connected to a suite of changed-number interception positions at Colindale exchange.

Advantage was taken of the opening of the new exchange to change the dialling codes for the dependent exchanges so that as far as possible they all had the same codes for calls dialled via Watford.

Traffic trials started on 2 September, and dealt first with the junction network serving the dependent exchanges. The first stage of the change-over took place on 9 September when the dependent exchanges were routed via the new equipment, thus bringing into use the new codes. The traffic trials then continued, taking in more junction routes as they were completed, leading up to the main transfer on 8 October.

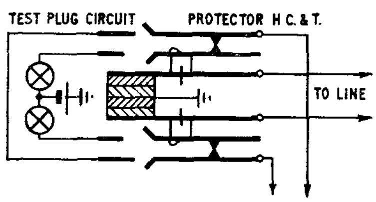
The change-over went very smoothly, the only slightly unusual feature being the use of wooden wedges in place of plugs 318 to disconnect the subscribers from the old M.D.F. This was decided upon at a fairly late date when it was realized that the large amount of work at Watford would tax the area manpower resources considerably. It was considered that the wooden wedges would require considerably less preparatory work than the plugs 318 and would also have a smaller fault liability. The wooden wedges were made by the Factories Department and were shaped so that when inserted they disconnected 20 circuits at the protector test springs. A temporary mezzanine platform was erected against the M.D.F., using a Youngman 24 ft portable platform on trestles.

The wedges were prepared by placing them in position resting against the heat coils and holding them in place by rubber bands. Although there was some previous experience of this method some anxiety was felt that trouble might occur due to

(*i*) heat coils with long pins earthing when the wedges were inserted, or

(*ii*) the wedges might be so hard to push in that the "cut-out" would be delayed.

To overcome (*i*) a preliminary check was made using an



CIRCUIT USED TO CHECK FOR HEAT COILS WITH LONG EARTHING PINS

old T. and P. U. plug with two lamps connected as shown in the sketch. This was inserted in each protector in turn and the outer springs pressed with the fingers. An earthing heat coil caused one of the lamps to light, and some 50 or 60 faulty heat coils were found by this test. At the change-over not one fault occurred on the old M.D.F. due to heat coils earthing. Difficulty (*ii*) was overcome by the simple expedient of applying a small amount of oil to the wedges and to the fixed springs. The success of this may be judged by the fact that the cut-out as timed from the central control took one minute, and as timed by an officer on the spot with a stop-watch, 45 seconds. J. O. C.

Midland Region

NOTTINGHAM TRUNK MECHANIZATION

As this number of the *P.O.E.E.J.* is being devoted to the subject of S.T.D. perhaps a further note on trunk mechanization, as an essential forerunner of S.T.D., will not be out of place.

All stages of the transfer to the new Telephone Building, Nottingham, have now been completed and the equipment concerned is working very satisfactorily. Involving as it did, a new repeater station, two trunk non-director units, a junction tandem exchange and an additional trunk control centre, all housed in a new building, the transfer arrangements were quite complex. This necessitated a very great deal of hard work on the part of the small group who planned the detailed operations. The need to keep the old Central exchange working in a reasonable manner made further complications. Considerable external work was involved; the majority of the MU and CJ cables (totalling about 6,000 pairs) were teed into the new building and 3,120 tie-pairs were provided.

The new equipment was brought into use in three main stages, the third stage being divided into three parts. Stages 1 and 2 were concerned with the junction tandem units, and stage 3 dealt with the trunk units and the trunk control centre. Broadly, the first part of stage 3 opened the two trunk units by providing an outgoing trunk network, the second part saw the opening of the trunk control centre, and the final part provided the incoming and bothway circuits to the trunk switches.

The repeater station transfer was carried out piecemeal, 49 carrier terminal groups and approximately 1,500 amplified circuits representing the bulk of the work. The total of all types of circuits handled under the trunk transfer arrangements was approximately 2,000, whilst the grand total of circuits, with those on the junction tandem exchange and the new trunk control centre, amounted to over 5,000.

All concerned with the transfer were kept informed by the issue of information bulletins, the idea being to keep everyone in the picture and at the same time to send detailed instructions to only those who really needed the information. For each transfer session, and during engineering and traffic tests, the detailed arrangements were set out, and considerable effort was spent in trying to ensure that those actively concerned fully understood the instructions and knew exactly what to do at the correct time.

This procedure proved itself admirably, since the transfer work was done using only the schedules and instructions provided. Experience showed that speaker circuits were an unnecessary complication and their use was discontinued after stage 2, circuits being switched at precise pre-arranged times. Excellent results, both during the post-transfer tests and in normal use, are attributable to the great care taken over the engineering and traffic tests. The importance of very careful pre-transfer testing cannot be overstressed.

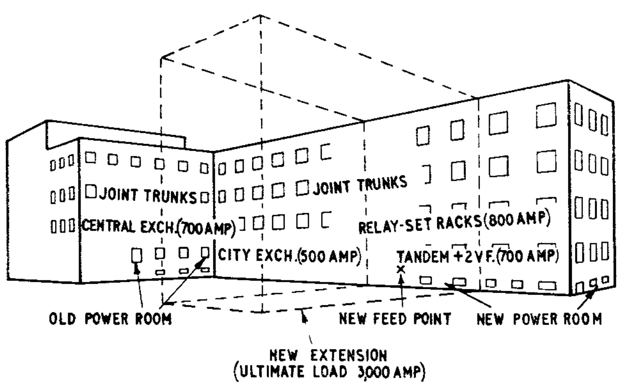
Both operational and engineering staff are very pleased with the new equipment, and trunk mechanization, as far as Nottingham telecommunications people are concerned, is now the accepted way of life. We are now eagerly looking forward to the time when we can start installing the equipment for S.T.D. E. A. B., C. C. P. and E. H. P.

Scotland

MOVING THE POSITION OF THE 50-VOLT POWER PLANT AT TELEPHONE HOUSE, GLASGOW

Towards the end of 1956 it became apparent that the two 50-volt, 10,200 Ah batteries at Telephone House, Glasgow, which had been in service since 1939, would require replating or replacing within a year or so. Before proceeding with a straightforward replating, it was necessary to consider what effect a proposed extension to the building would have on the total power requirements. It was, in fact, decided that if the whole building was to be served by a common 50-volt power plant, a capacity of 15,050 Ah per battery would be required, and specifications were prepared accordingly.

At the same time, it was realized that the location of the existing power and battery rooms was far from suitable for serving the new wing of the building and would necessitate very long and heavy busbar runs. Some space was available in the basement at the south-western corner of the existing building, as shown in the sketch, which it was considered would be suitable, after some adaptation, for power and battery rooms and would be reasonably central for both existing and ultimate loads.



REAR VIEW OF TELEPHONE HOUSE, GLASGOW, SHOWING DISPOSITION OF EQUIPMENT

Cost comparisons for (*i*) serving the new wing from the existing power rooms and (*ii*) moving the power plant to the basement and feeding all loads from there, showed that the latter would be the cheaper scheme, provided the move could be carried out without extensive duplication of equipment or busbars.

A further reason for the decision to move the power plant was that the accommodation released would be suitable for installation of telex automatic equipment, at an estimated saving of some £20,000 in building costs. To meet this requirement it was essential that the existing power and battery rooms should be cleared by September 1958 at the latest.

Time was relatively short and, after a number of contractors had declined to tender for moving the plant, it was decided to undertake by direct labour all work except the dismantling, transporting and re-erection of the three 3,000-amp generators, each of which weighs some 14 tons. Tenders were invited from a number of local electrical engineers for this part of the work and eventually a contract was placed with a Glasgow firm.

Specifications and detailed drawings for every stage of the transfer were prepared in the Regional office, each stage being fully discussed with the staff selected to carry out the work before being finally committed to paper. The work was facilitated by there being one spare distribution circuit-breaker and one spare machine circuit-breaker on the existing power board, but no duplicates of other common panels were available.

As the batteries were beginning to fail, it was decided that both must be retained until at least part of the load had been transferred to the new location. One battery circuit-breaker was required for the first of the new batteries and it was decided to release this by using fuses temporarily. This was done and, at the same time, the battery was disconnected from the power board. Copper busbar thrown spare was then used to common up the two batteries permanently at the rear of the power board, and the distributions and one generator were connected by temporary cables to this commoning bar, through their respective circuit-breakers. This permitted the battery panel, main discharge shunt and busbar assemblies on the rear of the power board to be released and shifted to the new location.

While this was being done, the battery contractor installed the first of the new batteries, the largest of their type ever to be installed in this country, and provided busbars to the battery panel at the new power board. The first motor generator was dismantled, moved, reassembled, overhauled and tested ready to charge the first new battery. The Area power staff ran new distribution busbars for the first distribution and teed them to the working busbars. The copper for this run was obtained by removing busbars from the existing runs across the old power room whilst on load. This was possible as the amount of copper in these runs was far in excess of requirements, the loads for which they had been designed never having materialized. The position was also eased by the new feed point being at approximately the middle of the distributions rather than at one end as hitherto, so that voltage-drop requirements could be met by feeders of much smaller total cross-section.

When the first battery had been completed the first distribution was transferred, and with the copper busbars and circuit-breaker thrown spare in the old power room the second distribution was transferred. It was then considered safe to permit recovery of the first of the old batteries, which released the second battery circuit-breaker for transfer to the new battery room.

Work proceeded on the installation of the second battery, the moving of the second machine, and the transfer of the third distribution. On completion of this work the third, and final, motor generator was shifted and the second old battery recovered.

Other work carried out during the transfer included the splitting of one existing distribution into two parts, provision of a new counter e.m.f. battery for the P.B.X. power feeds and transfer of the 50-volt positive battery. The whole job took some eight months to complete. It was carried out without a single interruption to service, and although standby generating equipment was available throughout this was never required. Tests on completion gave a maximum voltage drop from the battery busbar to the furthest rack fuse of 0·7 volt with the maximum load of 2,700 amp being taken from the system. The target date for handing over the old power and battery rooms to the Ministry of Works for adaptations in preparation for the installation of telex automatic equipment was met with time to spare, the evacuation being completed by the middle of August.

J. W. R.

Associate Section Notes

London Power Centre

Following upon the success of last year's program of activities, the current session is being conducted on similar lines. Seven technical papers are scheduled for presentation at general meetings as the subjects of discussion. The first of these was read on 16 October by Mr. M. G. Shrives, of the North Postal Engineering Section, the subject being "Mechanical Ventilation." As usual, some of the discussion went beyond the scope set by the author, but this was all to the good. The 20 November was chosen for the presentation of "Electric Lifts Analysed" by Mr. I. Berg; this was the first of a series of papers dealing with specific lifts in service in the Region.

Membership is still increasing, the present figure being about 320.

The monthly works visits maintain their popularity, and details of these appear in the London Power Centre News Letter.

P. J. F.

Ipswich Centre

A most interesting and instructive summer program commenced with a visit to I.C.I., Ltd., (Paints Division), Stowmarket, where members saw the manufacture of all types of paints, varnishes and cellulose finishes. This was followed in June by a visit to the East Anglian *Daily Times* newspaper offices, and here members saw the production of our local newspaper from reporter to the finished article. Monotype and linotype methods were described and demonstrated, as well as the production of colour plates for a local magazine and advertising leaflets.

The July visit to the new power station at Cliff Quay proved to be a most instructive evening. Then, in August, a most interesting visit was made to Cobbolds Brewery; our members left both wiser and refreshed.

The summer program ended with a visit to Messrs. E. R. and F. Turner, Electric Motor Works, where the manufacture, testing and application of a wide range of motors were demonstrated.

Our winter program started with a film show on 16 October consisting of five films.

This section is now one year old and it is most gratifying to have achieved a membership of 180.

E. W. C.

Glasgow and Scotland West Centre

The start of the session has been most encouraging. Our first meeting was an open one on subscriber trunk dialling (S.T.D.), and was attended by just over 100 persons, including some operators, colleagues from the Hamilton Centre and members of the Institution of Electrical Engineers. Our speaker, Mr. R. F. McLusky, Telephone Exchange Systems Development Branch, Engineering Department, gave an excellent account of the development and general principles of S.T.D. There were numerous questions from all aspects, the subscriber's, the maintenance engineer's, the operator's, etc. Their problems and difficulties were discussed at great length until the chairman was forced to call a halt to a most enjoyable and interesting evening.

The remainder of our program is as follows:

"Register-Translators," by Mr. D. L. Benson, A.M.I.E.E., Telephone Exchange Systems Development Branch, Engineering Department.

"Hi-Fi," by Mr. G. R. Marsh, Mullard Limited.

"British Railways Electrification," by Mr. Kenton, Chief Mechanical Engineer's Department, British Railways.

Visits to Renfrew Airport, Johnnie Walker, Kilmarnock, and Barr and Stroud.

J. F.

Edinburgh Centre

The first meeting of the 1958–59 session was held on 30 September 1958, in Rose Street Exchange, when a program of films was presented by the Secretary. Among those shown were:

"Atlantic Link," the transatlantic cable film.

"Foothold on Antarctica," by courtesy of the Petroleum Films Bureau.

"View of Middelharnis," by courtesy of the Petroleum Films Bureau.

"Snowdrift at Bleath Gill," by courtesy of the British Transport Commission.

"Foothold on Antarctica" was undoubtedly the most popular film of the evening.

The next two meetings consisted of visits to the B.P. refinery, Grangemouth (November), and the B.B.C. transmitter, Westerglen (December).

D. M. P.

Medway Centre

The annual general meeting and the first meeting of the Centre were held on the 16 October 1958. The following officers and committee were elected: *Chairman:* Mr. F. J. R. Veale; *Secretary:* Mr. F. J. R. Scott; *Committee:* Messrs. L. Ford, A. Simpson, L. E. Studham, R. A. Bushnell and C. P. Williams.

The incoming chairman expressed, on behalf of the members, his regret at the resignation of Mr. L. F. Pascoe, who had been chairman of the Centre since its inauguration in 1954. He also thanked him for his services to the Centre during the period of his chairmanship.

The speaker for the evening was Mr. J. Garland, of the London Centre, who presented his paper on the "Transatlantic Telephone Switching System."

Subjects for the future program include:

"Scientific Applications to Archaeology."

"Telecommunication in the U.S.A."

"Trunk Mechanization."

"Mullard Film Show."

"The Magnetic Drum."

"Underground and Overhead Flexibility."

E. J. R. S.

London Centre

The opening of the 1958 session saw the London Centre saying farewell to Mr. P. Sayers, who has given up his combined post of secretary, and editor of the London Centre Quarterly Journal, to take up a new post as a draughtsman in the L.T.R. drawing office. Mr. Sayers started his work on London Centre activities in the post of secretary of the South-West Area branch in 1948, the year following the inauguration of the London Centre after the war. He resigned this post in 1949, when he moved to the Long Distance Area, but not many months were to pass before he was on an Associate Section committee again, this time in the capacity of visits secretary of the London Centre. He became secretary of the Centre in 1951 and has occupied the post since then, except for the 1955–56 session. In 1954 he added the duties of editor of the London Centre journal to his secretarial work. His outstanding efforts were the Silver Jubilee Exhibition and Journal last year, both projects demanding much time and work. The very successful public lectures which have inaugurated the London Centre's last three sessions have been in no small measure due to his efforts, and the Transantarctic Exhibition lecture given by Mr. George Lowe, which launched the present session and was attended by over 450 members and friends, must have given him cause for great satisfaction as he completed his period of office. This record of ten years' faithful service and loyalty to the aims and objects of the London Centre speaks for itself and is an example to every member. As a recognition of his services to the Associate

Section the London Centre committee have made Mr. Sayers an honorary member for life. A more tangible recognition is to be made in the form of a presentation.

At the September committee meeting of the London Centre, Mr. D. W. Webber and Mr. E. S. Glynn were co-opted to the posts of secretary and editor, respectively.

The January lecture in the Conference Room, Waterloo Bridge House, will be devoted to "An Introduction to the Magnetic Drum as applied to Telecommunications," and will be given by Mr. J. E. Wright and Mr. W. Stores, of British Telecommunications Research, Ltd. A general description of its construction and operation will be given. Some applications, such as magnetic-drum metering, storage of telegraphic data, magnetic-drum controlled crossbar P.A.X. and the register-translator, will be discussed, together with a discussion in some detail of the "dialling-in" process. In February, there will be a lecture on Radio Astronomy, while in March, Mr. D. M. Gambier will talk on "Transatlantic Telephone Cables" and will deal with the new CANTAT cable scheme, and compare the transmission system with that of the first TAT project.

Two visits of interest must be mentioned for their enterprise and novelty. North-West and East Areas and the Circuit Laboratory organized visits to the Brussels International Exhibition, and South-West Area arranged a visit to the Atomic Energy Authority's atomic power station at Calder Hall, Cumberland. It is hoped there will be articles on these visits in an edition of the London Centre Journal.

D. W. W.

Sunderland Centre

The Sunderland Centre made a good start on the 1958–59 program by participating in two meetings and making one visit in eight days.

On 17 September a joint meeting was arranged at Newcastle to hear Mr. P. T. F. Kelly, Engineering Department, Main Lines Development and Maintenance Branch, who gave a most interesting lecture on the transatlantic cable.

The following evening, 18 September, 17 of our members visited the brewery of Vaux & Associated Breweries, Ltd., Sunderland, one of the largest in the North of England. On the tour of the plant we were conducted by Mr. Wilson and all were amazed at the different processes which were needed to produce a good beer.

A week later, on 25 September, Mr. F. L. N. Samuels, Telephone Exchange Systems Development Branch, Engineering Department, gave us a splendid lecture on the magnetic drum, which he illustrated with a large quantity of elaborate equipment. On this occasion we were supported by a party from the Newcastle Centre, who also appreciated the lecture.

We are looking forward to other lectures and visits which have been arranged for the rest of the session. W. C.

Darlington Centre

The following officers and committee have been elected: *Chairman:* Mr. J. Cowen; *Vice-Chairman:* Mr. A. Snowden; *Treasurer and Librarian:* Mr. M. J. Holland; *Committee:* Messrs. R. W. Cowen, Snr., D. E. Dodds, G. A. Garry, T. L. M. Hebron, J. McManners, R. Moore, H. Milburn, J. Ronaldson and H. Thompson; *Auditors:* Messrs. P. Dodd and A. S. Hyatt; *Local Secretary:* Mr. C. N. Hutchinson.

The following program has been arranged:

- 4 November 1958: Visit to Darlington Gasworks.
- 11 November 1958: "Photography," by Mr. E. A. Clark.
- 9 December 1958: "Installation Control Procedure," by Mr. E. R. Trotter.
- 13 January 1959: "The Line-Connector," by Mr. E. O. M. Grimshaw.
- 10 February 1959: "Radio and Television Interference," by Mr. R. Dodds, Centre Member.
- 17 March 1959: "Electronic Switching," by Mr. M. J. Rubin, Research Branch, Engineering Department.
- 24 March 1959: "Telephone Developments at Middlesbrough," by Mr. F. W. Allan, Area Engineer.
- 14 April 1959: Talk on Japan, by Mr. F. B. Joint.
- 19 May 1959: Annual general meeting.

C. N. H.

Huddersfield Centre

The session was opened by Mr. E. H. Wilkinson, Area Engineer, Internal, his paper being, "The Art of Public Speaking," It was delivered to a large audience, on 9 September, at the H.P.O., Huddersfield. The paper, which was both interesting and informative, was very well received.

On 7 October, the second meeting of the 1958–59 session was a visit to the I.C.I. Ltd., Huddersfield. A party of 40 people were conducted round the works, and many interesting and varied processes were seen. A light tea was provided afterwards by the I.C.I., concluding an excellent visit.

The next meeting, 13 November, was at the H.P.O., Hudderfiseld. A paper on "Subscriber Trunk Dialling" was given by Mr. T. Barker, Assistant Engineer, North Eastern Regional Office.

B. S.

Hull Centre

The 1958–59 session commenced with a special general meeting to elect committee members following resignations. The officers now are: *Chairman:* Mr. E. Rackley; *Vice-Chairman:* Mr. J. Battarbee; *Treasurer:* Mr. R. Baker; *Secretary:* Mr. L. Johnson; *Committee:* Messrs. C. Burn, R. Mell, R. Hall, C. Rowlands, R. Hudson, L. J. Webster and L. Wharton.

As a result of special attention by the committee to subscriber trunk dialling we have been fortunate in securing the following papers for the current session:

- October 1958: "Electronic Switching," by Mr. M. J. Rubin, Research Branch, Engineering Department.
- November 1958: "Subscriber Trunk Dialling," by Mr. R. F. McLusky, Telephone Exchange Systems Development Branch, Engineering Department.
- February 1959: "Local Problems of Subscriber Trunk Dialling," by Mr. H. V. J. Harris, Telephone Manager, Hull.

The last two papers of the session will be on "Public Electricity Distribution" and "Mobile V.H.F. Communications," given in March and April, respectively.

A visit to Hull College of Technology will also be arranged; watch the notice board for the date.

L. J.

Middlesbrough Centre

The following committee was formed during the 1957–58 session to re-establish the Middlesbrough Centre: *Chairman:* Mr. R. Costello; *Secretary:* Mr. N. Williams; *Treasurer:* Mr. K. Roe; *Committee:* Messrs. K. Ashworth and G. Harland.

Following two successful lectures towards the end of the last session, a full program was arranged for the 1958–59 session, as follows:

- 21 October 1958: "Colour Photography," by Mr. D. Wompra.
- 18 November 1958: "Duties of an Area Engineer," by Mr. F. W. Allan.
- 9 December 1958: "Television."
- 6 January 1959: "Police Organization," by Inspector Ross.
- 17 February 1959: Visit to Middlesbrough Rediffusion.
- 17 March 1959: "Electronic Switching," by Mr. M. J. Rubin.
- 14 April 1959: Annual general meeting.

G. H.

Newcastle Upon Tyne Centre

The 1958–59 session opened on 17 September 1958, at the Liberal Club, Pilgrim Street, Newcastle upon Tyne, with a paper on the transatlantic cable, by Mr. P. T. F. Kelly, Main Lines Development and Maintenance Branch, Engineering Department. The film "Atlantic Link" was shown at the same time to illustrate various points in the paper. On 25 September a joint meeting was held at Sunderland to hear a paper on the magnetic drum given by Mr. F. L. N. Samuels, Telephone Exchange Systems Development Branch, Engineering Department. It was gratifying to see the number of members who made the journey from Newcastle.

Twenty members were taken on a visit to Stella South power station on the evening of 26 August. This was followed on 23 September by a visit to the Central Electricity Generating Board's control room at Pelaw House, Chester-le-Street, at the invitation of the Central Electricity Generating Authority.

Darlington Locomotive Works was visited on 2 September by a party of 16 members. An exhaustive tour of the works was made, and the guides gave the party a very full description of various operations in the overhaul of steam locomotives.

Calder Hall atomic power station was visited by a party of 28 members on 11 September. The party travelled by coach to Carlisle, where a stop was made for lunch. They arrived at Calder Hall at 2 p.m. and a very instructive tour of the station was then made.

On Thursday, 16 October, a paper entitled "Telecommunication in Ceylon" was read by Mr. D. Holmes, (Newcastle, external planning).

Forthcoming papers are as follows:

Tuesday, 13 January 1959: "Journey into Space Continued." This is the second paper to be given by Mr. F. J. Acfield of the *Newcastle Evening Chronicle*.

Tuesday, 17 March 1959: "Radio Interference and Suppression," by Mr. L. C. Renton, of Newcastle Post Office radio interference staff.

Thursday, 19 February 1959: A film show is to be presented.

R. A. H.

Sheffield Centre

A visit was made on 4 September to the Shepcote Lane Rolling Mills where stainless steel, produced at the two parent firms Firth Vickers and Samuel Fox, is rolled into strip up to 1 metre wide. A roughing mill first reduces the heated ingot to about an inch thick; it then passes to the finishing mill, where it is wound on to a gas-heated drum to maintain the correct temperature. From this drum it passes through rollers on to a similar drum, this process continuing back and forth until the desired thickness is achieved. The roll pressure in the finishing mill is about 2,400 tons, sufficient to stretch the foot-square solid frame members a matter of one-tenth of an inch! The strip now undergoes several processes to give it a flawless finish, and in the final coiling stage it is interleaved with tissue paper to prevent scratching. All stages are remotely controlled from consoles, photo-electric cells being used to ensure correct alignment of the strip. A striking feature was the cleanliness of the whole mill. The power plant and remote control equipment would have provided material for a separate visit.

On 7 October, Mr. W. H. J. Coombes, of the Sheffield Hospitals Radiography Department, gave us an interesting talk on the discovery and advancement of X-rays. With the aid of slides he traced equipment development from the days of Röntgen to the two-million-volt apparatus in use in Sheffield to-day. The lecture was followed up in November by a visit to the Radiography Department to see a demonstration of the equipment.

We made a very profitable visit to the Doncaster Centre on 9 October, when Mr. T. Barker of the North-Eastern Regional headquarters was talking on subscriber trunk dialling, and were so impressed that we booked him on the spot to come to Sheffield during November.

"Fundamentals of Cable Design" was the title of a lecture given on 21 October by Mr. A. C. Holmes, Regional Liaison Officer. The talk was illustrated by slides and a film showing the manufacture of the London–Birmingham television cable.

Following a suggestion put forward at the annual general meeting, a Radio Section has been formed in Sheffield with the object of providing practical instruction in the design, construction and servicing of radio equipment. At an inaugural meeting held on 26 August, the following officers were elected: *Chairman:* Mr. F. S. Brasher; *Secretary:* Mr. J. E. Simons; *Treasurer:* Mr. A. Knowles; *Committee:* Messrs. R. F. Braiden, H. S. Beddus, K. Burrows and C. S. Shepherd.

We are indebted to Mr. Brasher for undertaking to prepare a series of talks; he gave us a good start on 20 October by talking about radio circuit components and leading up to the design of a simple resistance-capacitance coupled amplifier.

J. E. S.

Leeds Centre

The remaining items of our 1958–59 program comprise the following:

Friday, 20 March 1959: Visit to Ericsson Telephones, Ltd., Beeston, Nottingham.

Thursday, 14 April 1959: "Recent Developments in Aerial Cable Design," by Mr. J. Bluring, External Plant and Protection Branch, Engineering Department.

May 1959: Visit by air to London Airport, visiting airport communication systems. Flying by B.K.S. Airways from Yeadon Airport.

June 1959: Visit to British Relay Wireless relay station, Leeds.

On Thursday, 18 September 1958, an illustrated talk entitled "Transatlantic Systems" was given by Mr. P. T. F. Kelly, Main Lines Development and Maintenance Branch, Engineering Department, at the Griffin Hotel, Boar Lane, Leeds.

Mr. Kelly gave his introductory talk on the development of the transatlantic systems coupled with the transatlantic film. It was most interesting to see the rapid progress which has been made in the method of cable laying, and in the actual cable design. Mr. Kelly went on to describe the traffic requirements on such a system and some of the ingenious methods by which full use of both-way working has provided additional circuits to meet demands. The sample of the new transatlantic cable, with polythene as the basis of the design, caused much comment. A good attendance was recorded—35 members. Thanks were given to Mr. Kelly for the excellent manner in which he had given the talk, coupled with his light and entertaining approach to the subject.

On Wednesday, 8 October 1958, a party of 12 members made the journey by car to the factory of Mullard, Ltd., at Blackburn. The party were received by Mr. E. C. McDougall, of the Mullard Visits Organization. An introductory film was shown explaining various technical factors of valve manufacture and design. This was followed by a tour of the factory showing the various stages of valve manufacture; these stages were carefully explained by Mr. McDougall and his staff. The party were entertained to lunch at "The Shirebury Arms Hotel", Hurst Green, and much credit is due to the Mullard Visits Organization for such sumptuous hospitality. The tour was concluded by a visit to the laboratory and the test department, which proved to be very interesting, and after this, tea was taken in the visitors' lounge; thanks were expressed to Mr. McDougall and his staff for their efforts in providing a most enjoyable and instructive day.

C. B.

Post Office Electrical Engineers' Journal

Volume 51, April 1958—January 1959

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All communications should be addressed to the Managing Editor, *Post Office Electrical Engineers' Journal*, G.P.O., 2–12 Gresham Street, London, E.C.2. Telephone: HEAdquarters 1234. Remittances should be made payable to "*The P.O.E.E. Journal*" and should be crossed "& Co."

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Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Details of the books available are given at the end of the Supplement to the Journal.

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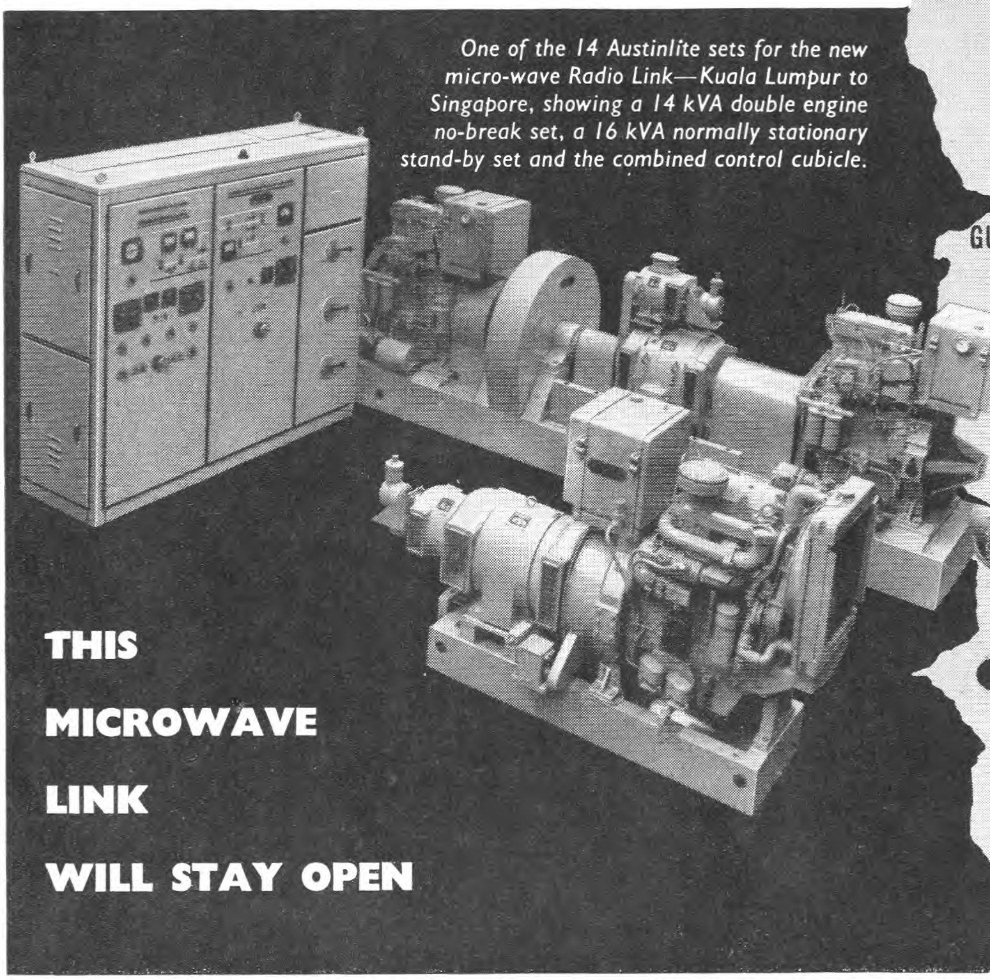

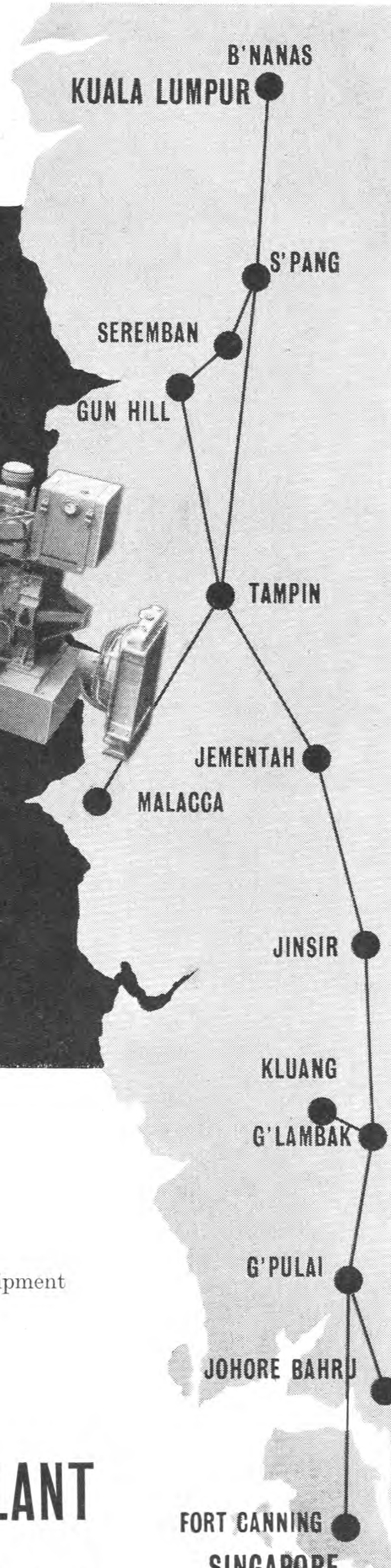

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The contract has been awarded on behalf of International Aeradio (Caribbean) Ltd. by International Aeradio Ltd., of London, and the system will be operated by International Aeradio (Caribbean) Ltd. for airlines operating the area, which include British West Indian Airways, Pan American Airways, Air France, B.O.A.C., T.C.A., Linea Aeropostal Venezolana, K.L.M., Varig and Aerolineas Argentinas.

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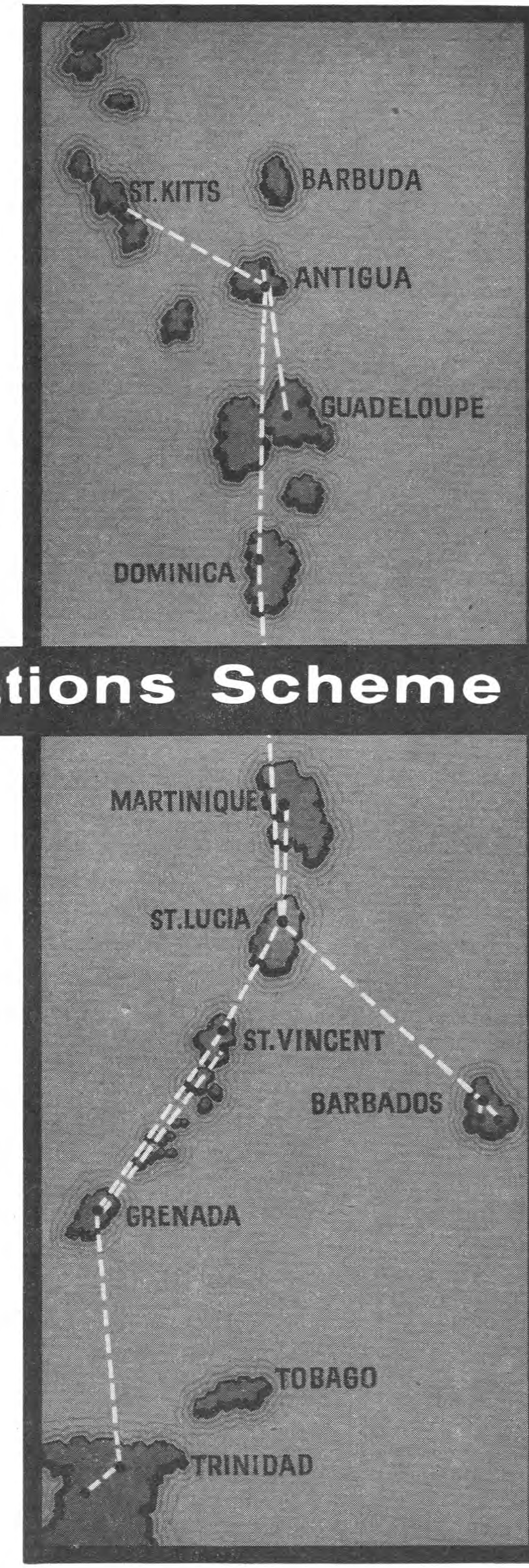

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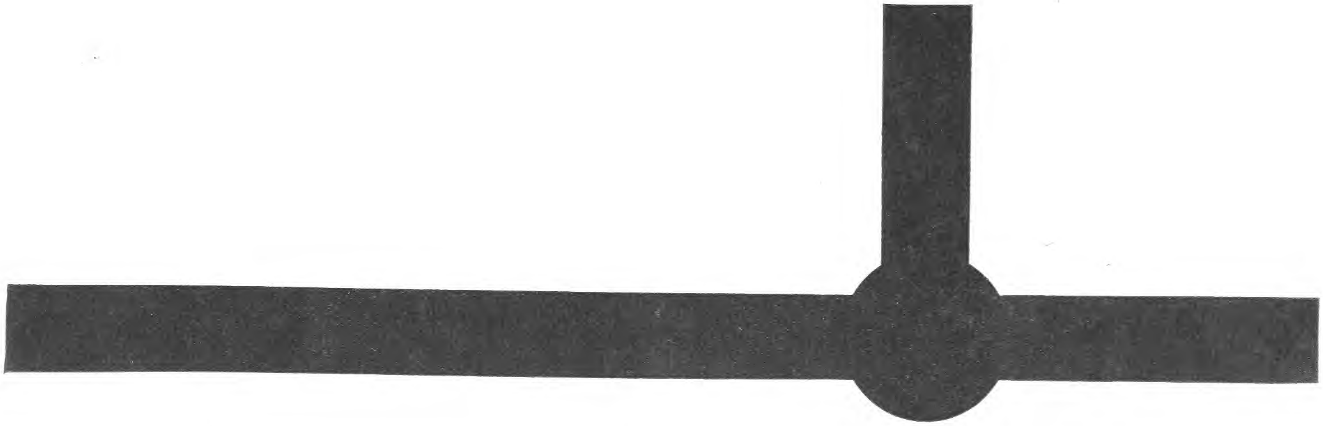

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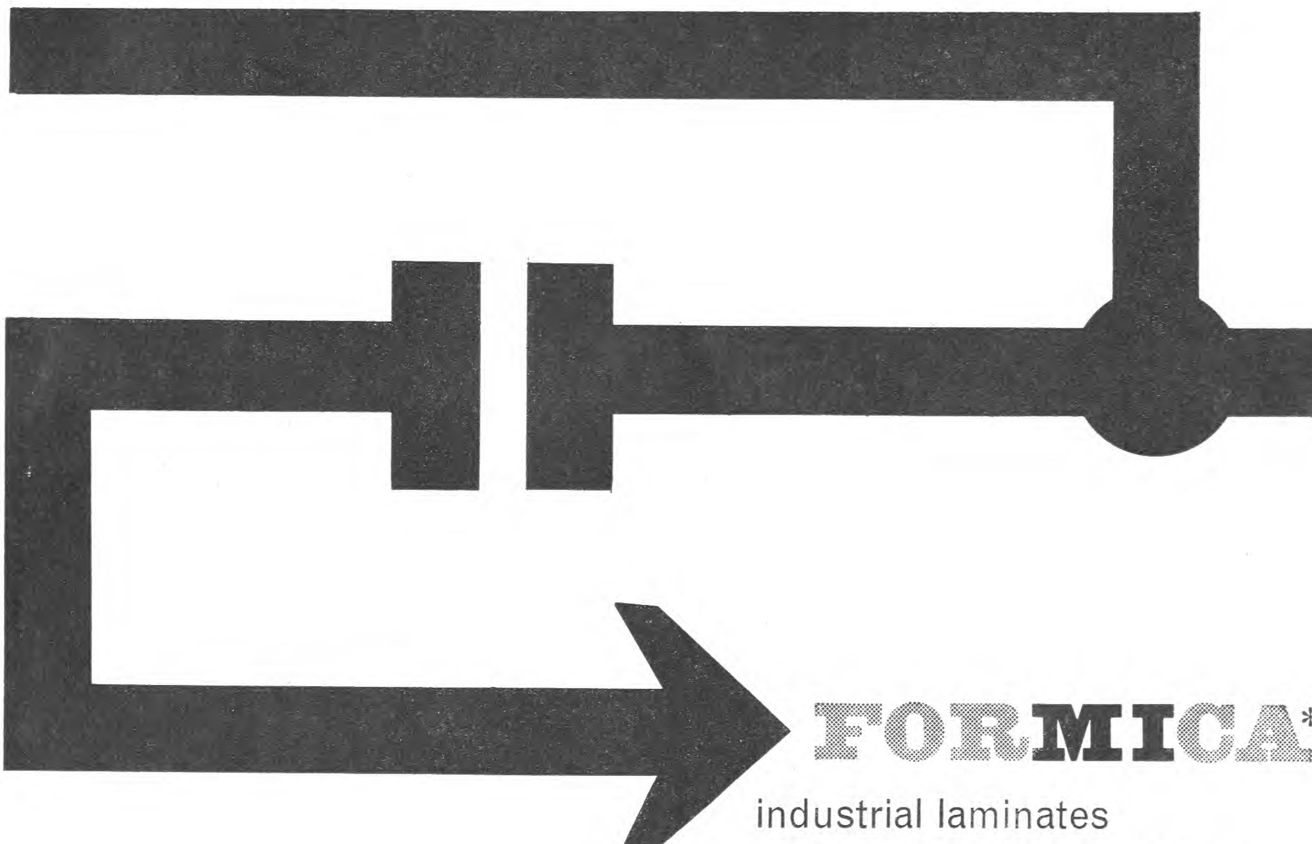

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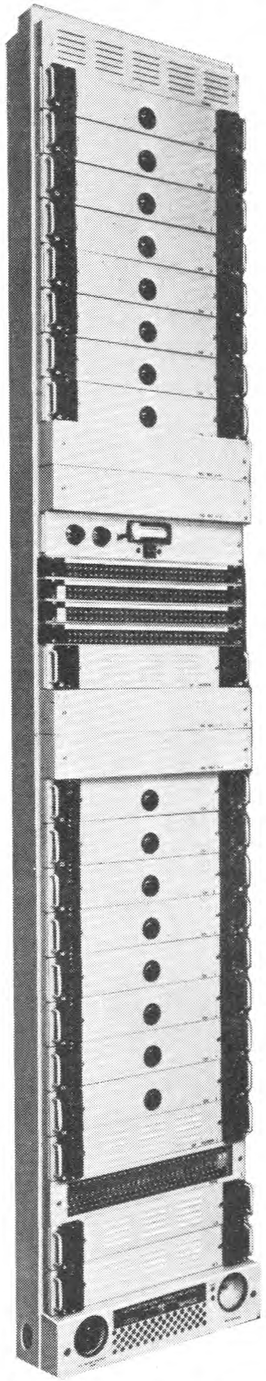

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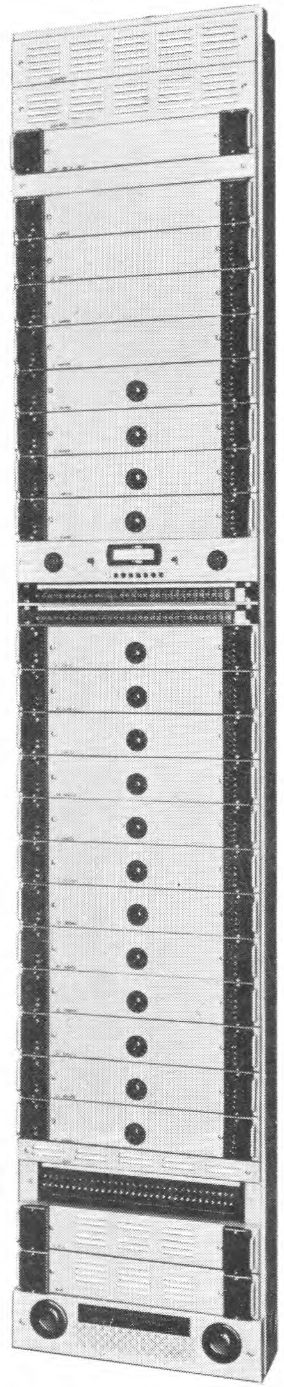

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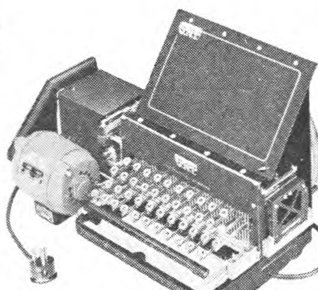

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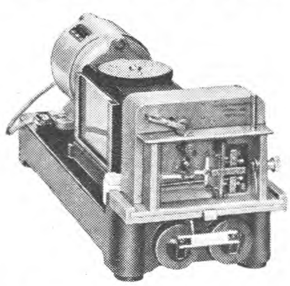

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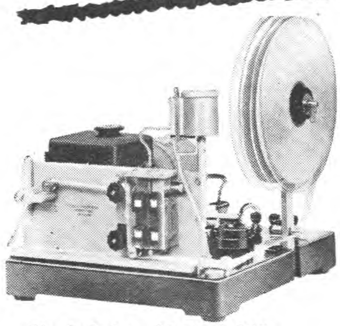

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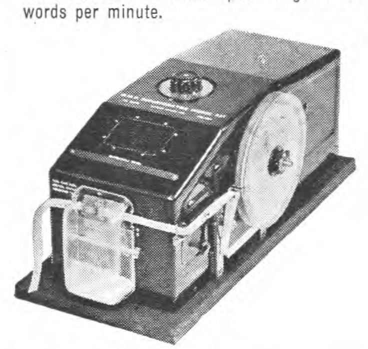

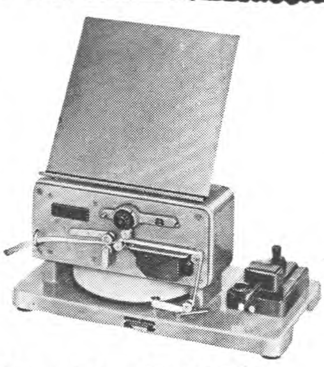

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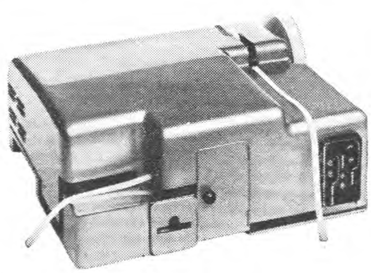

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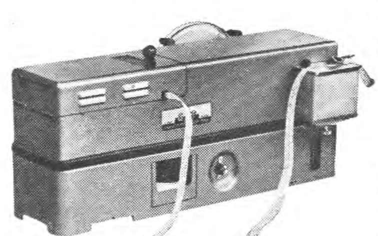

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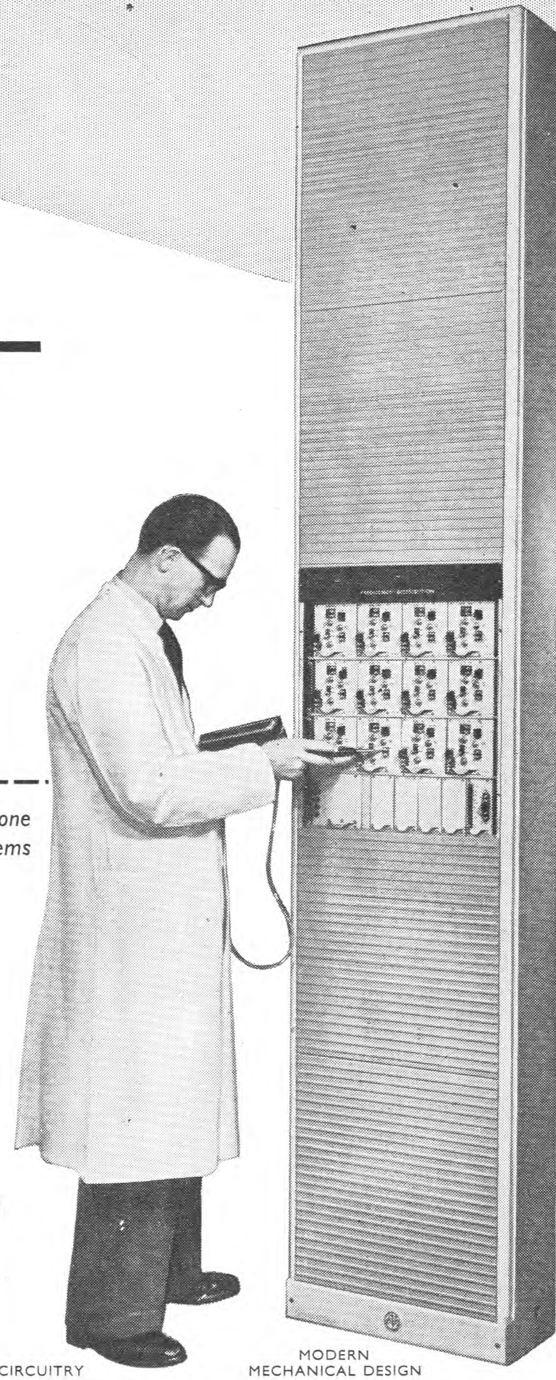

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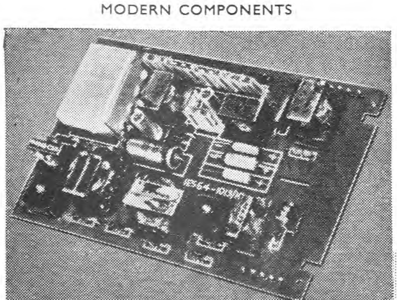

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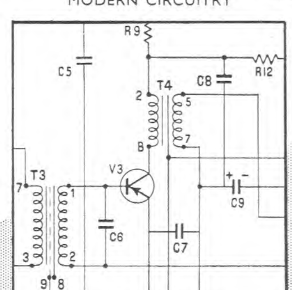

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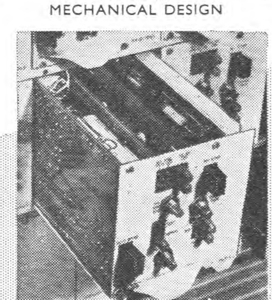

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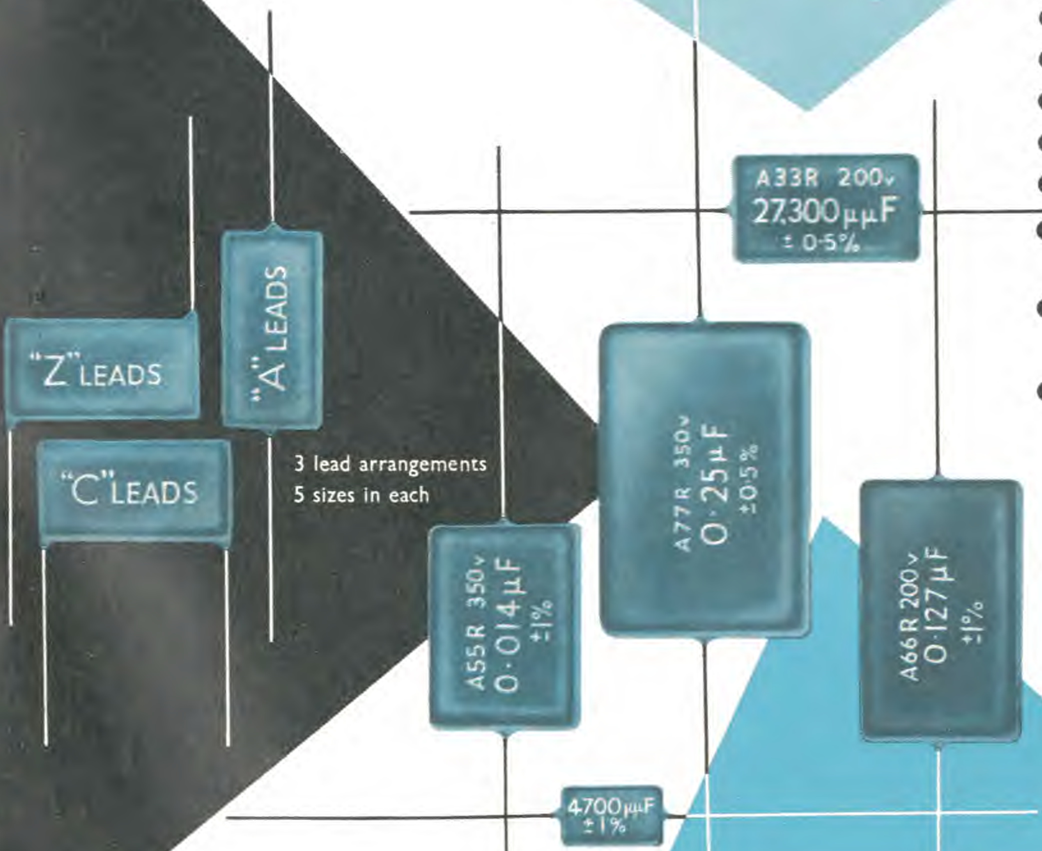
- Highest possible stability
- Smallest possible bulk
- Mechanically strong finish
- Tolerances down to ± 0.5%
- Choice of three lead arrangements
- Five sizes covering any value between 5μμF and 0.25μF
- Two ratings: 200 and 350 volts peak working



** JMC "fired" technique of assembly in which individual plates are welded together into a solid stable block without connecting foils or eyelets. This form of construction ensures the maximum long-term stability.*

SPECIALISED PRODUCTS OF

Johnson Matthey

JOHNSON, MATTHEY & CO., LIMITED, 73-83, HATTON GARDEN, LONDON, E.C.1. Telephone: Holborn 6989

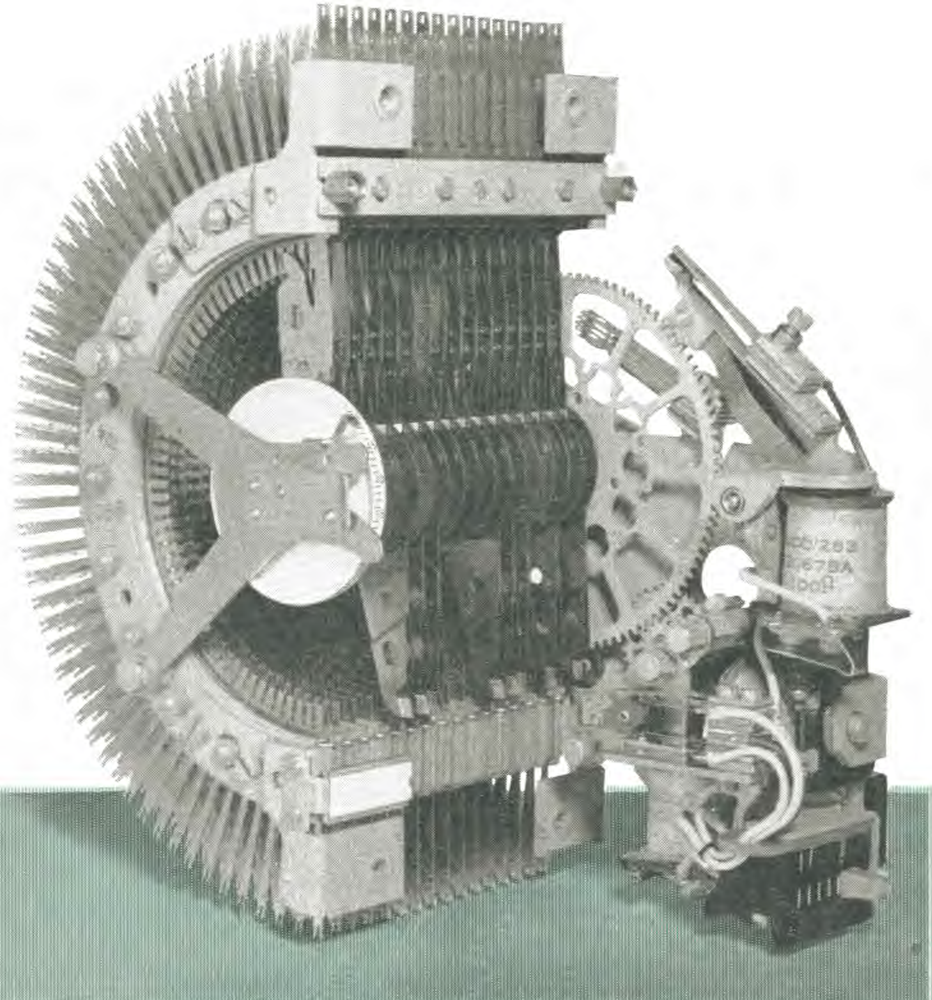
Vittoria Street, Birmingham, 1. Telephone: Central 8004

75-79 Eyre Street, Sheffield, 1. Telephone: 29212

subscriber

trunk

dialling



and the

SIEMENS EDISWAN

high speed

MOTOR UNISELECTOR

The success of Subscriber Trunk Dialling depends to a large extent on the provision of a grade of service on long distance routes similar to that enjoyed in local exchange switching. To achieve such service economically it is essential that a high outlet availability is provided at trunk switching centres, coupled with the facility for flexible allocation of outlets.

The Siemens Ediswan Motor Uniselector was expressly designed to meet these needs and its outstanding success in operator controlled trunk switching in the United Kingdom and many other parts of the world is a guarantee of its equal success under subscriber trunk dialling conditions. High search speed, twin wiper contact, low vibration and lack of microphonic noise are some of the further features which combine with the unique reliability of the mechanism to make it the obvious choice for modern trunk switching.

SIEMENS EDISON SWAN LTD *An A.E.I. Company*

Public Telephone Division, Woolwich, London S.E.18 Telephone Woolwich 2020

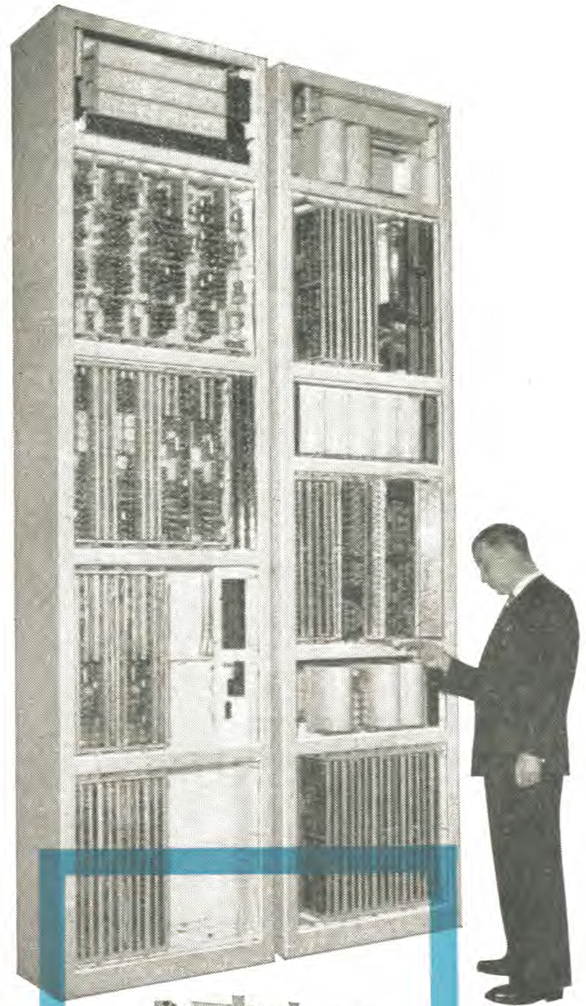
Subscriber Trunk Dialling and S.T.C.

The introduction of this revolutionary system represents a major step forward in the progress of the British Post Office Telephone System

S.T.C. have been one of the pioneers in the development of electronic components and systems techniques which have assisted in the introduction of the Subscriber Trunk Dialling system. Standard Telephones and Cables Ltd. have already planned the manufacture of automatic equipment to give STD service to approximately one hundred thousand subscribers.

In 1953 Electronic Registers using cold-cathode tubes were installed for public service in Richmond (Surrey) Exchange in co-operation with the British Post Office. This installation yielded practical information which enabled development to continue to an advanced stage.

Similar Electronic Register Equipment has been shipped to the U.S.A. for one of the most important Independent Telephone Companies for use in automatic telephone exchanges as a link with the nation-wide dialling network known as "Direct Distance Dialling" (D.D.D.), the U.S. counterpart of the U.K.'s Subscriber Trunk Dialling system. A noteworthy achievement for S.T.C. and British telecommunications.



Electronic Equipment mounted on racks.

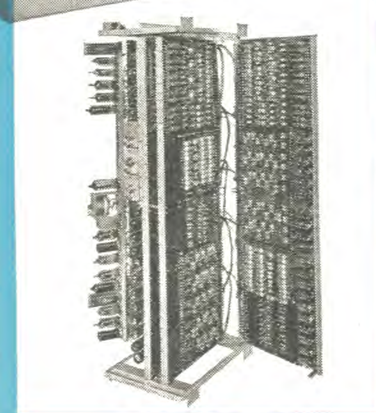
S.T.C. ELECTRONIC REGISTER EQUIPMENT

INCORPORATES A LARGE RANGE OF S.T.C. ELECTRONIC COMPONENTS INCLUDING:—

MINIATURE COLD-CATHODE TUBES

GERMANIUM, SELENIUM & SILICON DIODES

THERMIONIC VALVES

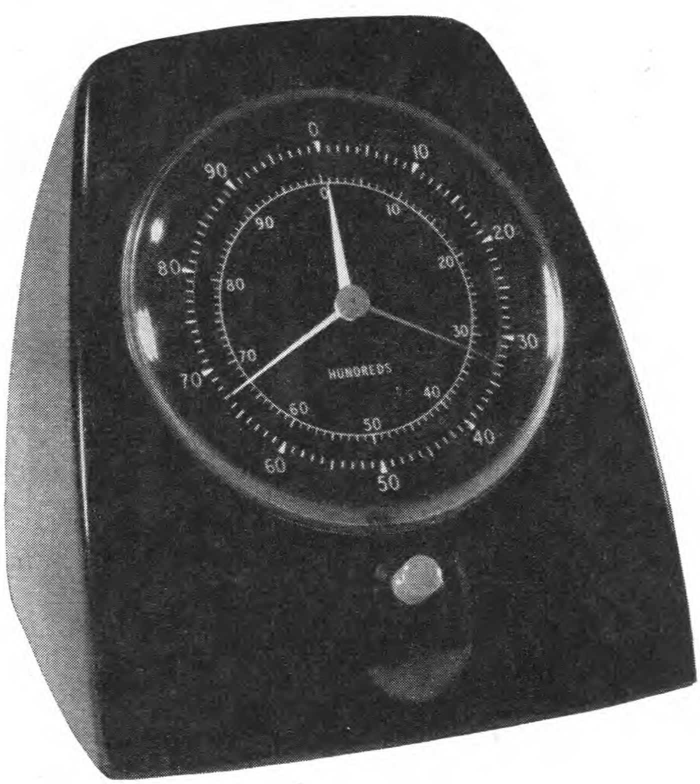


All the Components are mounted on a new "book type" panel which replaces normal wiring by printed circuits and soldered joints by wrapped joints. The panel units are fitted on "slide-in" shelves incorporated in the main structure of light-weight racks. New methods of equipment practice render considerable saving in space and weight and economy in maintenance.
S.T.C. will continue to play an important part in the introduction of the STD system in the British Post Office telephone network and at the same time offer technical advice on modern telecommunications techniques based on many years experience.

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

TELEPHONE DIVISION: OAKLEIGH ROAD · NEW SOUTHGATE · LONDON : N.11



SMITHS

are proud to be associated with S.T.D.

BACKGROUND On 5th December, 1958, the G.P.O.'s new Subscriber Trunk Dialling (S.T.D.) scheme came into operation on the Bristol Central Exchange, by 1970 it will embrace three-quarters of all trunk calls in the United Kingdom.

When S.T.D. is introduced, telephone calls, whether trunk or local, can be dialled. The calls will be charged in twopenny units. *It is these units that SMITHS Subscriber's Private Meter has been designed to indicate.*

THE INSTRUMENT This consists essentially of a meter, designed to British G.P.O. specification, housed in a shock resisting plastic case. The meter dial has two scales marked 0-100 units. The outer scale in yellow registers units, the inner white scale registers hundreds. A yellow and white pointer are associated with the two scales.

A third pointer in red also registers units but can be reset to zero by depressing the red button in order to register the cost of an individual call. Operation of the reset button does not interrupt the function of the meter and the yellow and white pointers will continue to summate the call charges.

SALIENT FEATURES No audible noise interference.

Does not respond to voltages less than 100V. 25 c/s A.C. under normal ringing conditions or fault conditions.

This meter will be available to subscribers on the S.T.D. system in the U.K. by rental from the G.P.O.

Overseas enquiries should be made direct to the address below.

SMITHS **INDUSTRIAL INSTRUMENT DIVISION**

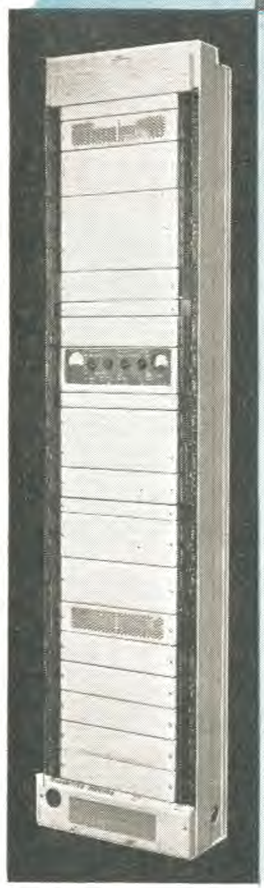
Chronos Works, North Circular Road, London, N.W.2. Telephone: GLAdstone 1136

G.E.C. Microwave Links

FIRST IN NIGERIA . . FIRST IN LIBYA

NOW in CANADA

The General Electric Company is to supply a multi-circuit microwave radio system between Saint John and Moncton, for The New Brunswick Telephone Company, Limited. G.E.C. 240-circuit 2000 Mc/s radio equipment will be employed, equipped initially for 60 speech circuits. The equipment will convey television signals instead of telephony circuits, if required. Three intermediate stations will be provided at Clarendon, Scotch Mountain and Mount Boyd. A standby link will be supplied with automatic changeover in the event of failure or degradation of the main signal. Further 240-circuit systems can be added as required using the same standby link as a protection channel. For information on the radio and multiplexing equipment, please write for Standard Specifications SPO.5501 and SPO.1370.



240 circuit terminal rack

G.E.C.

Everything for Telecommunications

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND

TELEPHONE, RADIO AND TELEVISION WORKS · COVENTRY · ENGLAND

Permanent Magnets

Design Advisory Service

No. 10

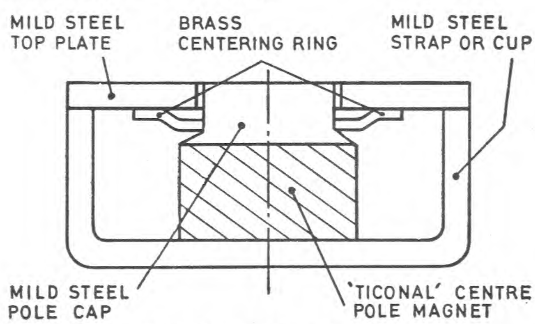
Moving Coil Applications –1

Advertisements in this series deal with general design considerations. If you require more specific information on the use of permanent magnets, please send your enquiry to the address below, mentioning the Design Advisory Service.

The use of modern permanent magnets has resulted in the efficiency of the magnetic systems for moving coil applications being substantially increased during recent years.

The magnet system employed for domestic loudspeakers, which is one of the best known moving coil applications, can be divided into two general types—'centre pole' and 'ring' designs.

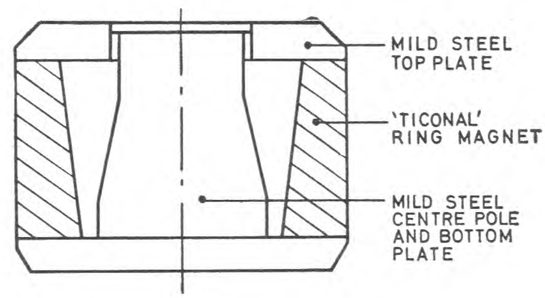
The centre pole design uses a small cylindrical magnet which forms the central pillar of the assembly and is surrounded by a mild steel strap or cup as illustrated. In this design, performance is limited by the size of the magnet which can be arranged within the assembly. If the diameter of the magnet necessitates a collector cap much larger than the one illustrated, the resultant excessive magnetic fringing or leakage will substantially reduce the efficiency of the assembly.



Section of a Typical Centre Pole Moving Coil Strap or Cup Type Assembly. Approximately ½ scale.

An example of the economical use of 'Ticonal' G, the foremost commercial magnet alloy available, is that a magnet with a diameter of 1.14″ and height .765″, weighing only 3.16 oz., will give a total gap flux of 31,200 maxwells. This is equivalent to an average flux density in a .033″ radial air gap of 10,500 gauss, with a mild steel pole diameter of .75″ and a top-plate thickness of .187″. This represents a magnetic efficiency of 50%.

When higher flux densities in the range of 12,000–17,000 gauss are required, the ring type of assembly is utilised. This type of assembly, which is illustrated, can seldom be designed with an efficiency higher than 30% and is, therefore, not normally used in the design of loudspeakers, where cost is an important factor.



Section of a Typical High Performance Ring Type Moving Coil Assembly. Approximately ½ scale.

For High Fidelity loudspeakers, where the performance is the most important consideration, and when flux densities in the region of 20,000 gauss are required, the ring type of construction is the only possible solution. However, the following table of leakage factors indicates how rapidly leakage losses increase with increasing gap flux density.

1″	diameter	speech	coil	·045″	gap	up	to	12,000 gauss	x 3
1″	,,	,,	,,	·045″	,,	,,	,,	16,000 gauss	x 6
1½″	,,	,,	,,	·050″	,,	,,	,,	16,000 gauss	x 6
2″	,,	,,	,,	·050″	,,	,,	,,	20,000 gauss	x 8

Whilst the designs mentioned above are referred to as loudspeaker systems, they are also applicable to many other applications using the dynamic moving coil principle, such as vibrators, punch card pulse actuators, public address pressure units, moving coil microphones, etc.

If you wish to receive reprints of this advertisement and others in this series write to the address below.

Mullard

'TICONAL' PERMANENT MAGNETS
'MAGNADUR' CERAMIC MAGNETS
FERROXCUBE MAGNETIC CORES

MULLARD LIMITED, COMPONENT DIVISION, MULLARD HOUSE, TORRINGTON PLACE, W.C.1. LANgham 6633

MC271

FROM ANY POINT OF VIEW—INCOMPARABLE

- - - the new ETELPHONE

- - - in colour

Functional simplicity has been the keynote throughout the design and development of this new telephone, with its classically restrained styling and use of the latest high efficiency circuit.
The careful thought and research given to this project has undoubtedly resulted in a successful combination of technical, functional and aesthetic improvements.
The addition of the well tried "Ericsson tropicalization" technique make these instruments particularly suitable for use overseas in adverse climatic conditions.
Colours for the case and handset which have been imaginatively chosen to harmonize with modern decorative schemes and furnishings, have a very high degree of light fastness, important for replacement colour matching.
The ETELPHONE is the export version of the New Post Office Telephone.

- MOULDED IN DIAKON
- CAN BE FULLY TROPICALIZED
- CARRYING HANDLE IS FITTED
- STRAIGHT OR COILED CORDS
- DIAL LOCK SWITCH AVAILABLE
- CONVERTIBLE TO WALL MOUNTING

All components are mounted on the base, with operation completely independent of the case. The base is a one-piece moulding in toughened polystyrene, incorporating the terminal insulation for conventional wiring. The case may be removed, without inverting the whole instrument, by releasing two screws adjacent to the cradle plungers.
The dial letters and numbers, shown on an annular ring, surround the finger plate giving improved visibility of the characters, thus reducing the incidence of wrong numbers.
Automatic regulation of the high performance is available in the form of an auxiliary unit, which may be connected by flexible wires terminating in spade tags or built on to a plug-in printed circuit. The light action cradle switch, with its enclosed springset, is provided with a linesman's latch which holds the switch in the operated position during maintenance. A dial lock switch (Ericsson Patent) is also available to prevent unauthorised outgoing calls being made.
When this telephone is fully tropicalized, the sound holes are fitted with gauze covers and the special finish of the internal components is of a very high standard to resist rigorous climatic conditions.
The instrument can be fitted with a central press button for shared service, recall, etc.

- TWO-TONE GREEN
- TWO-TONE GREY
- COLONIAL BLUE
- TOPAZ YELLOW
- LACQUER RED
- BLACK
- IVORY

FOR FURTHER INFORMATION PLEASE WRITE TO:—

T E L
ENGLAND

ERICSSON TELEPHONES LIMITED
ETELCO LIMITED

Head Office:— 22, LINCOLN'S INN FIELDS, LONDON W.C.2 TEL: HOLBORN 6936
Works:— BEESTON NOTTINGHAM AND SUNDERLAND.

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BRIDGWATER ■
BRIGHTON ■
CARDIFF ■
CHESTER ■
CHIPPENHAM ■
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SHEFFIELD ■
SHEPTON MALLET ■
SOUTHAMPTON ■
SWANSEA ■
SWINDON ■
TAUNTON ■
TRURO ■
WORCESTER ■

GRACE begins at BRISTOL

GRACE... Group Routing and Charging Equipment, a firm tribute to the forward-thinking policies of the British Post Office, has been installed in the Bristol Telephone Exchange.

G.E.C. are proud to record that, in supplying the electronic register-translator equipment—the first in the country—they have played their part in establishing the first step towards the eventual provision of automatic dialling between subscribers in all parts of the United Kingdom.

G.E.C.

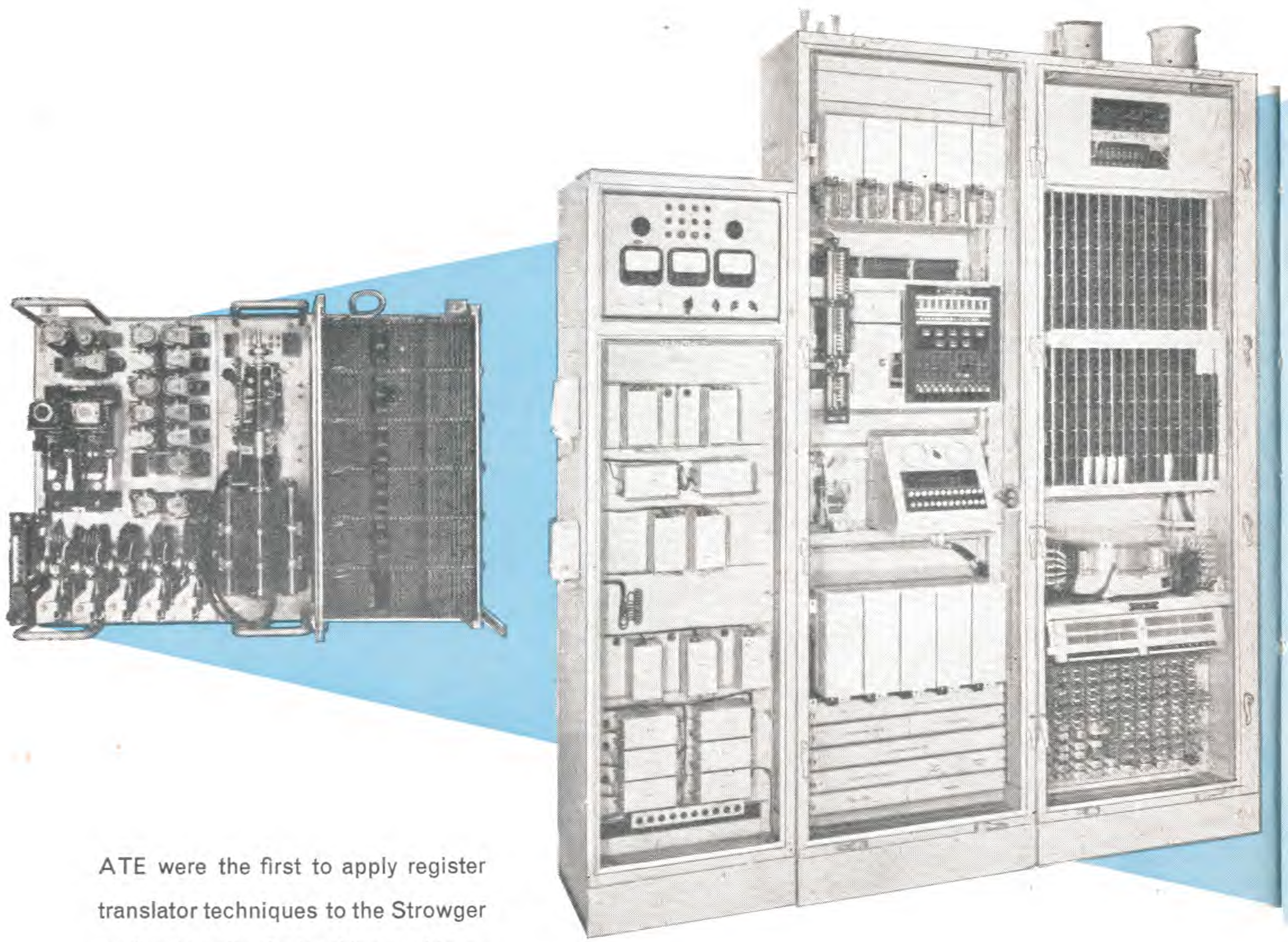
ELECTRONIC EQUIPMENT
FOR TELECOMMUNICATIONS

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND

TELEPHONE, RADIO AND TELEVISION WORKS, COVENTRY

GEC 22

A.T.E ----→ and SUBSCRIBER TRUNK DIALLING



ATE were the first to apply register translator techniques to the Strowger system to solve the trunking problems of metropolitan areas. The Director, introduced in London in 1925 and subsequently in Liverpool, Birmingham, Manchester and Glasgow, is still the standard translator for local call routing.

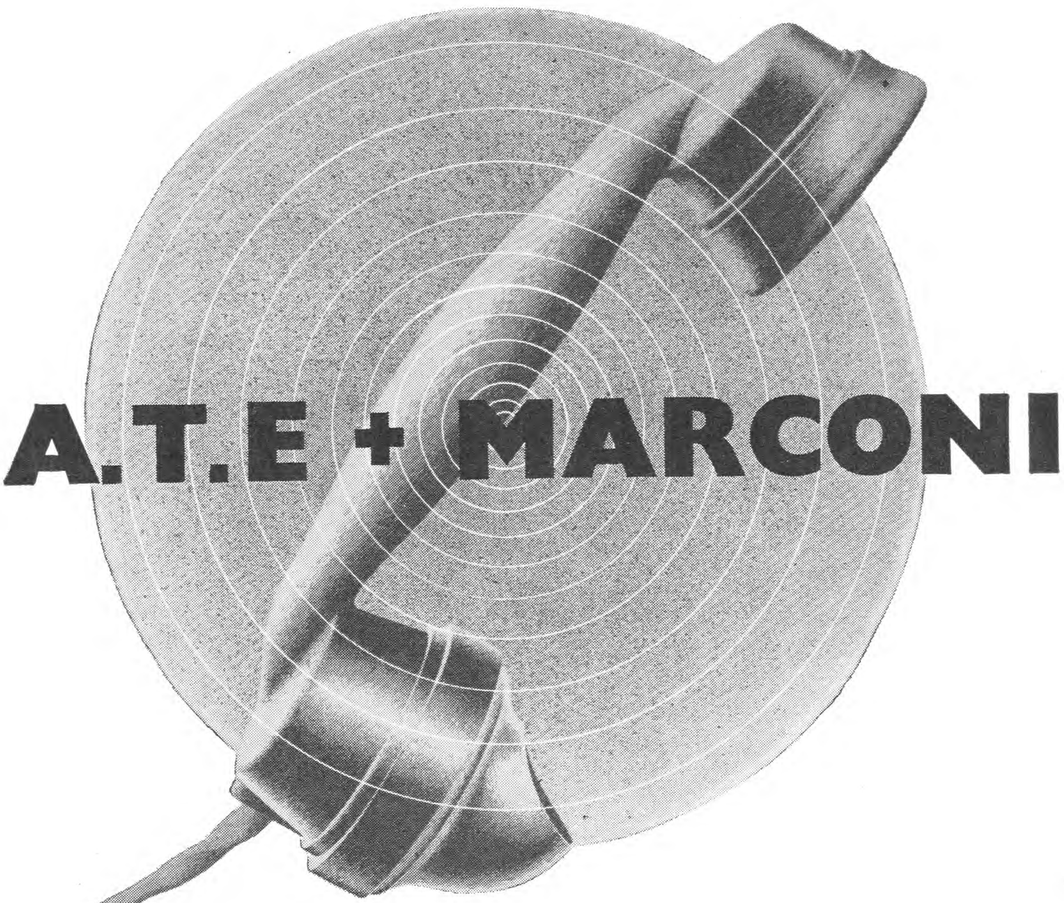
First also with the magnetic drum technique applied to register translators, ATE installed an experimental Director of this type in Lee Green exchange in November 1957.

This is the magnetic drum register translator designed by ATE in conjunction with the Post Office for STD originating in Director areas.

It is shown here being checked by ATE engineers and is at present under test in the Post Office Engineering Laboratories.

AUTOMATIC TELEPHONE & ELECTRIC CO., LTD.

AT7111



Combined Operations

The complexity of modern radio-multichannel systems involving hundreds of telephone channels has brought about a collaboration between the two leading specialist organizations in the field—Marconi's in radio, and A.T.E. in carrier transmission.

This completely unified approach to development, systems planning, supply, installation, maintenance of equipment and training of personnel covers radio-multichannel systems in the V.H.F., U.H.F. and S.H.F. frequency bands all over the world

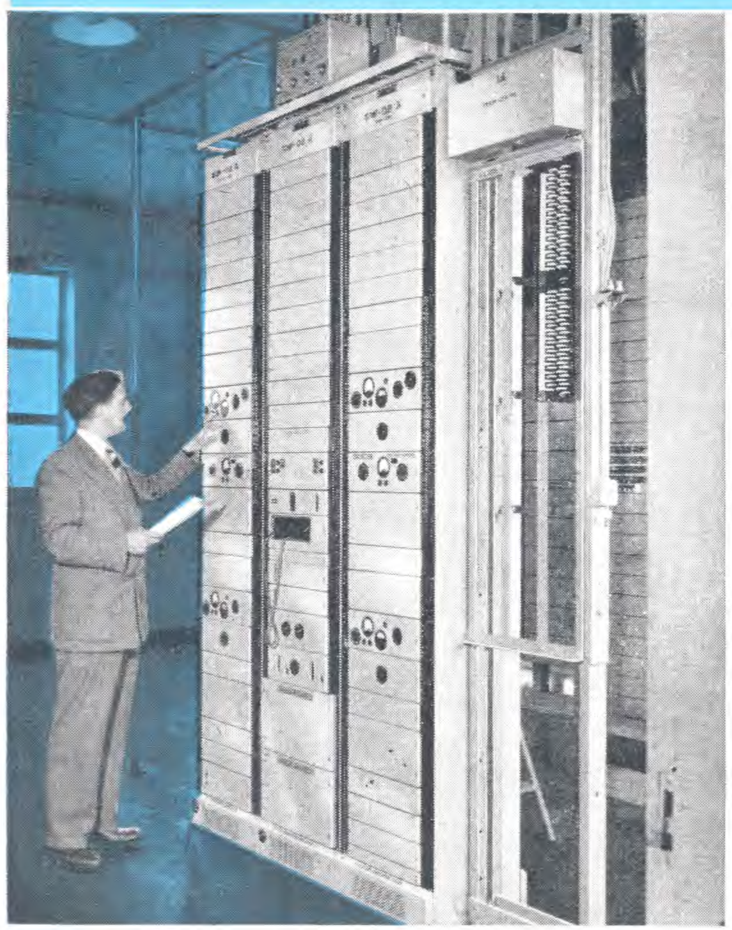
Full information may be obtained from either:
MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND.

or AUTOMATIC TELEPHONE & ELECTRIC CO. LTD., STROWGER HOUSE, ARUNDEL STREET, LONDON, W.C.2

STC Progress with Coaxial—

the backbone of the National Trunk Telephone networks

The wealth of experience gained by S.T.C. since 1935, when they manufactured the first long distance coaxial cable in Gt. Britain, has made S.T.C. and their Associates the foremost manufacturers of coaxial cable and transmission equipment in Europe. S.T.C. type 375 coaxial cable and S.T.C. 4 Mc/s line transmission systems have been supplied to many of the leading administrations and 12 Mc/s systems are now being supplied to Gt. Britain and Sweden.



Typical 4 Mc/s coaxial equipment. A main repeater installed between Glasgow and Oban.

Systems Progress

1948 2·6 Mc/s providing 600 telephone circuits. First installed between Leeds and Newcastle.

1950 4 Mc/s provides 960 circuits. First installed in South Africa. This equipment is in service in national and international telephone networks throughout the world.

1951 S.T.C. Submerged Repeaters for 36 circuits, with shore-based terminal equipment, was first installed between Netherlands and Denmark.

1956 S.T.C. Submerged Repeaters with capacity up to 120 circuits. First installed to provide 36 circuits for the Transatlantic Telephone Cable between Clarenville and Sidney Mines. In 1958: 120 circuits between England and Channel Isles.

1957 6 Mc/s for 625-line T.V. *or* 1260 telephone circuits. First installed between Rome and Naples.

1958 12 Mc/s provides 2700 telephone circuits *or* 1200 telephone circuits and 625-line T.V. (monochrome or colour). Installations for Gt. Britain and Sweden.

S.T.C. Systems equipment with a total capacity of over 5285000 circuit miles has been supplied to Administrations throughout the world.

A 3-core Type 975 T.V. Cable
B 6-core Type 375 Coaxial Cable
C Type 163, small-core Coaxial Cable

Cable Progress

1935 0·450 in. coaxial tube cable. Laid between London and Birmingham as the first coaxial cable installed outside the U.S.A.

1938 Type 375 cable using ebonite disc insulation. First installed between Manchester, Leeds and Newcastle.

1944 Type 375 cable using improved outer conductor more than 2500 route miles of cable in service.

1947 Type 375 cable with polythene disc insulation over 3700 route miles of cable installed.

1948 Type 975 cable for use at frequencies up to 26 Mc/s. Installed in Gt. Britain as part of T.V. Network.

1950 Type 375 cable with improved impedance characteristic.

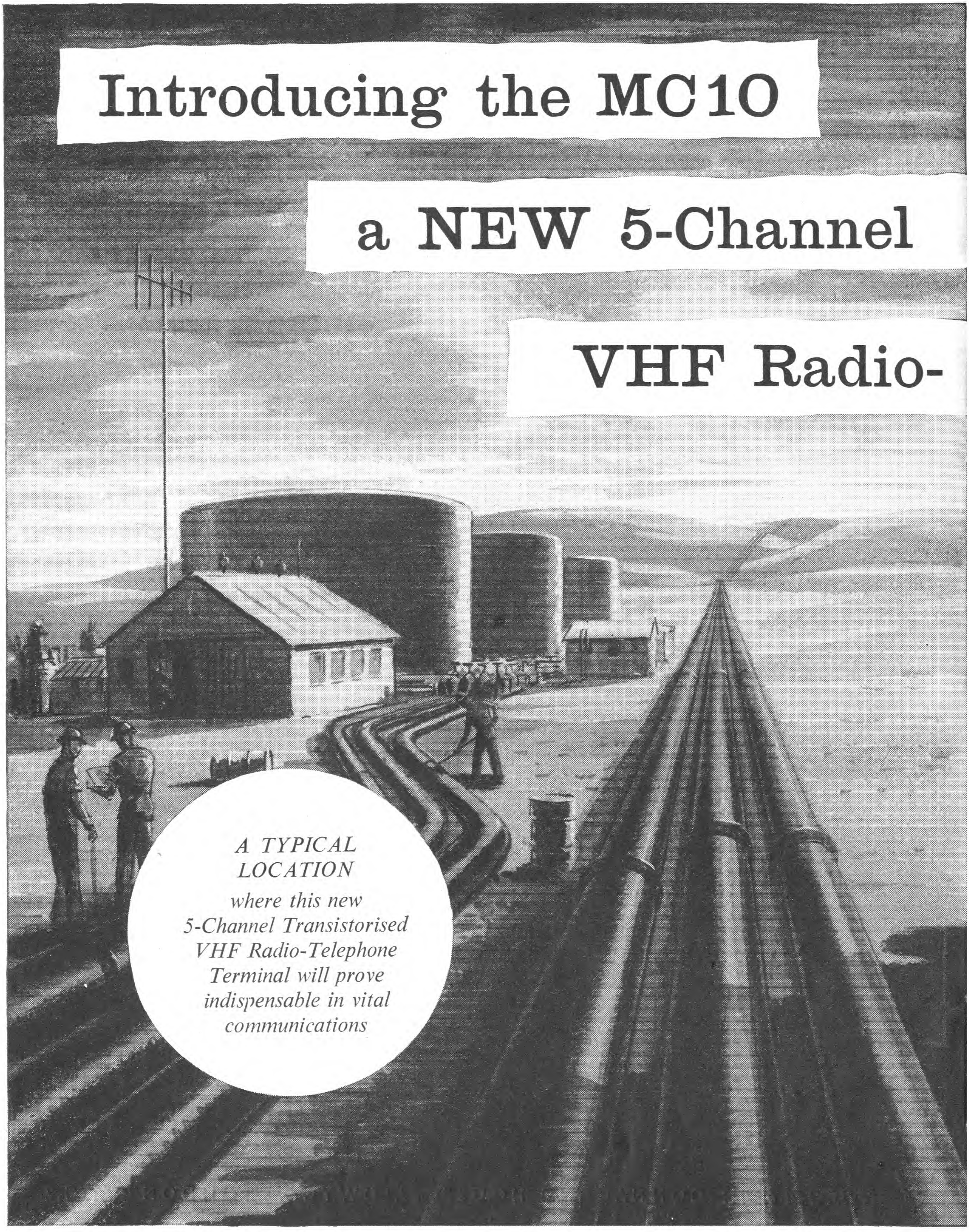
1958 Type 163 cable suitable for aerial or underground installation. 2, 4, 6, 8 or more coaxial cores 0·163 in. diameter. First installed between Eastbourne and Hastings.

1958 Submarine cable including armoured shore-end cable. Over 200 nautical miles have already been installed including Ramsgate to Ostend and Bournemouth to Channel Isles.

To date over 10000 route miles of cable incorporating over 36000 miles of coaxial tube are installed or on order.

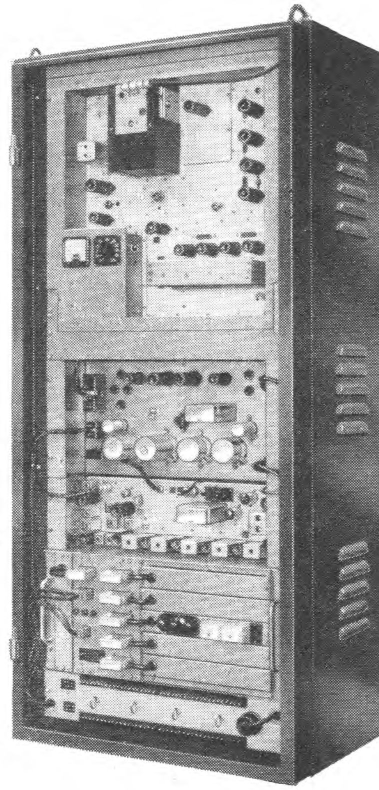
Standard Telephones and Cables Limited registered office: CONNAUGHT HOUSE · ALDWYCH · LONDON · W.C.2

Telecommunications Engineers


Introducing the MC10
a NEW 5-Channel
VHF Radio-
A TYPICAL LOCATION
where this new 5-Channel Transistorised VHF Radio-Telephone Terminal will prove indispensable in vital communications

Transistorised

Telephone Terminal



Compact design which at low cost provides five high-grade telephone circuits.

Radio

Frequency range 156 - 184 Mc/s
(other frequency ranges are available)
Transmitter power output 30 watts
Deviation 75 kc/s
Receiver Noise Factor 8db
All characteristics of the transmitter and receiver conform to CCIR specifications

Carrier Telephone Equipment

5 Telephone channels · 4 kc/s spaced
Equipped with Out of Band Signalling
Facilities for dialling, Ringdown or junction working
Printed Wiring · Plug-in Units
Crystal frequency control
Resin cast components

The result of co-operative enterprise between two great organizations

Redifon

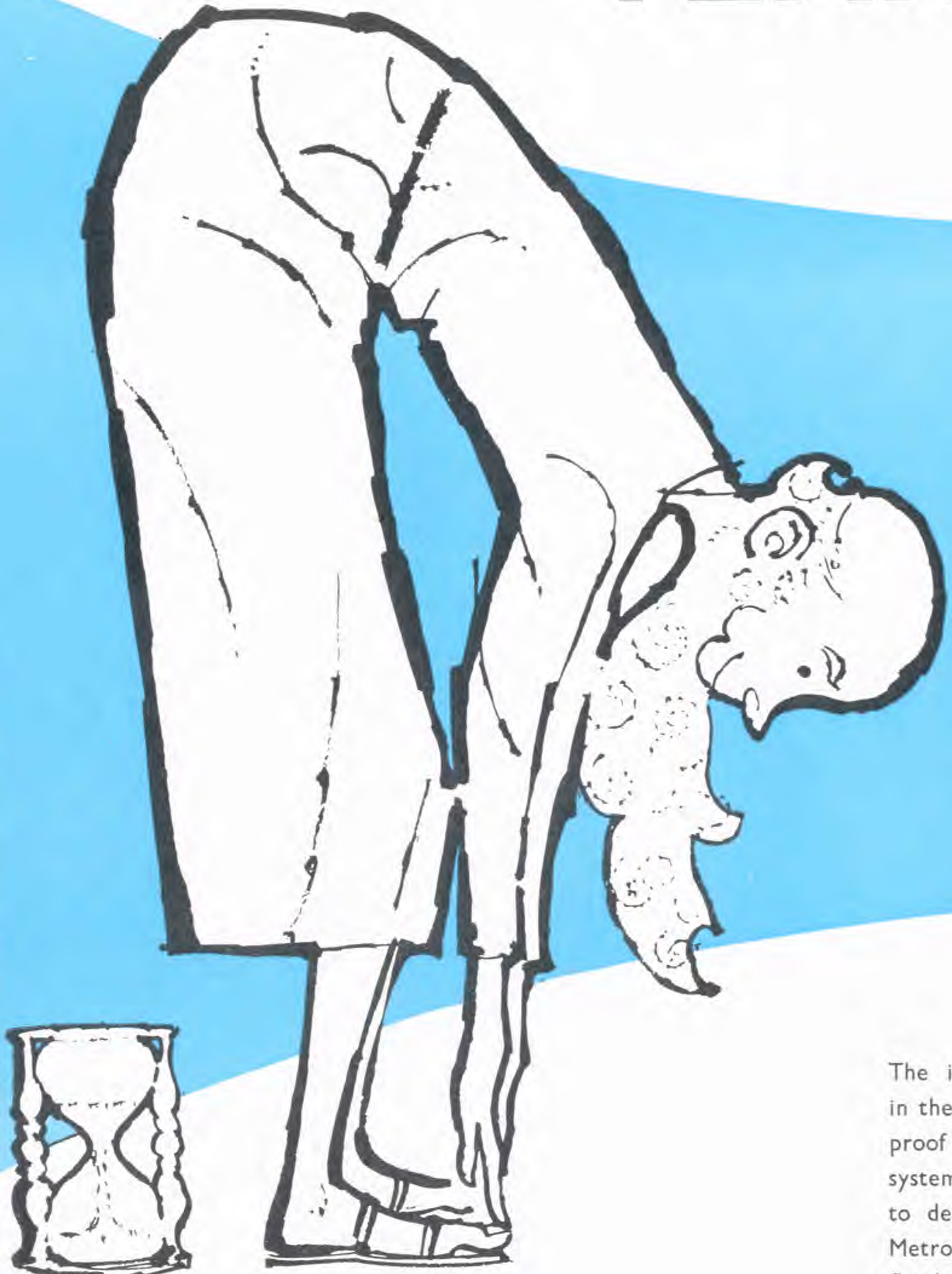
SIEMENS EDISWAN

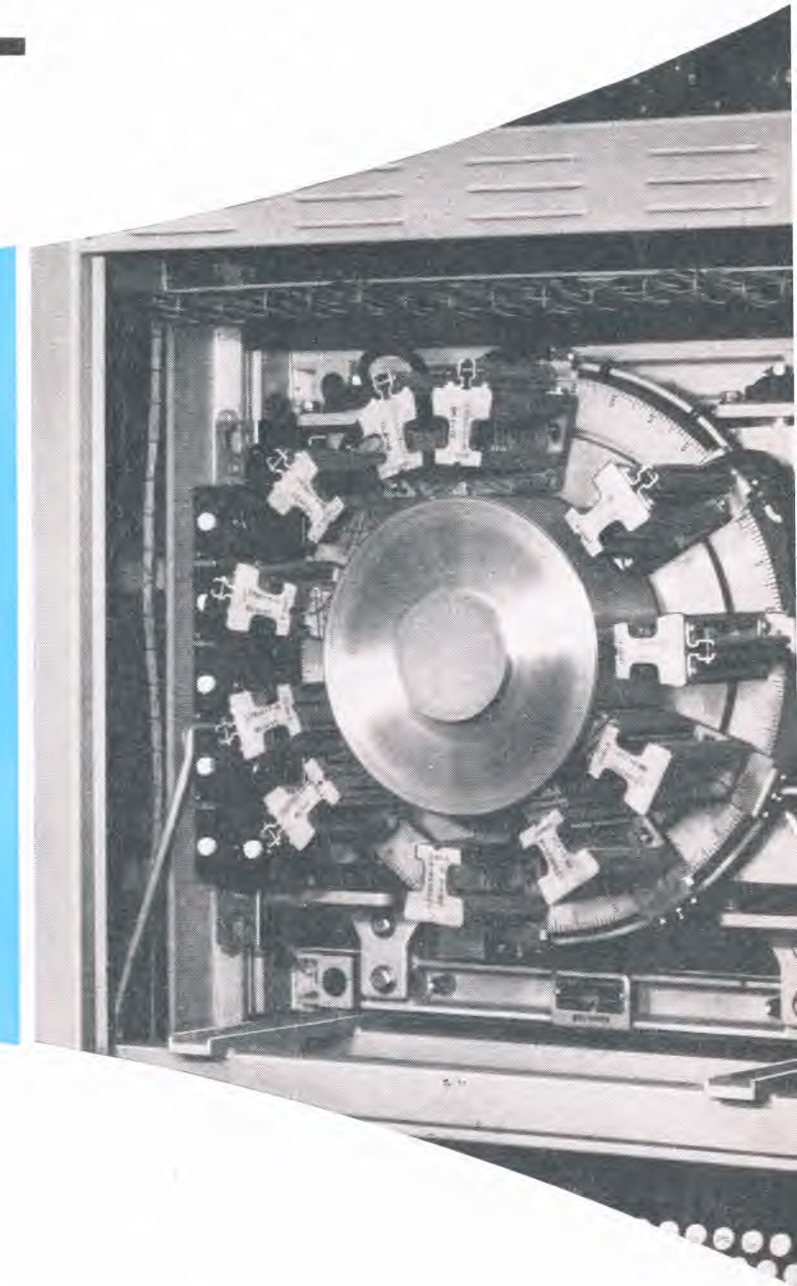
REDIFON LIMITED
Communications Division, Wandsworth, London, S.W.18
Telephone : VANdyke 7281
A Manufacturing Company in the Rediffusion Group

SIEMENS EDISON SWAN LIMITED
Transmission Division, Woolwich, London, S.E.18
Telephone : Woolwich 2020
An A.E.I. Company

70 YEARS OLD AND STILL THE MOST...

Flexible





The introduction of Subscriber Trunk dialling in the British Post Office network is still further proof of the inherent flexibility of the Strowger system. Born in 1892, Strowger was called upon to demonstrate in 1924 that it could cater for Metropolitan working without any loss of that flexibility; this it did by incorporating a Register-Translator, now known universally as the "Director". In 1958 it showed that it was still abreast of the times by accommodating the latest type of electronic register-translator permitting the superimposition of national dialling with time and distance metering on an already highly developed network.

ATE

AUTOMATIC TELEPHONE & ELECTRIC COMPANY LIMITED

AT 7

and now . . .

706, the new POST OFFICE TELEPHONE in colour

GPO

SIEMENS EDISWAN

TEL ENGLAND

THE introduction of a new telephone by the POST OFFICE to their many millions of subscribers is an undertaking of great magnitude.

THE design and development of this new 706 type telephone has been completed by Ericsson Telephones Limited and Siemens Edison Swan Ltd. with the close co-operation of the Post Office Engineering Dept., and has resulted in an instrument having a very high standard of performance and elegance.

IN consultation with the Council of Industrial Design, a range of single and two tone colours has been selected, suitable for harmonizing with a wide range of architectural colour schemes and furnishings with a maximum of tolerance.

AVAILABLE IN:—

- **TWO-TONE GREY**
- **TWO-TONE GREEN**
- **LACQUER RED**
- **COLONIAL BLUE**
- **TOPAZ YELLOW**
- **IVORY**
- **BLACK**

The case and lightweight handset is moulded in Diakon, having a greatly improved functional shape and designed to completely eliminate the use of metal inserts.

The dial letters and numbers shown on an annular ring, surround the finger plate giving improved visibility of the characters, thus reducing the incidence of wrong numbers. "Grebe" grey cords and desk block are common to all colours.

The instrument can be fitted with a central press button for shared service, recall, etc.

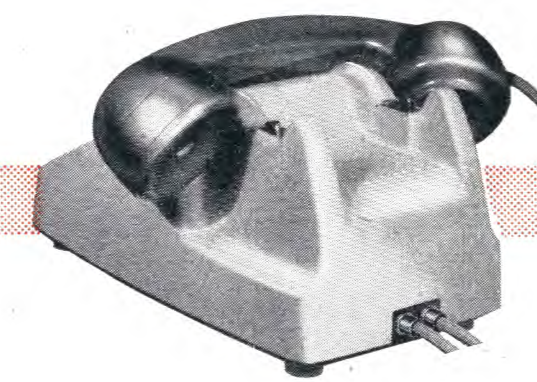
All components are mounted on the base, with operation completely independent of the case. Releasing two screws adjacent to the cradle plungers allows the case to be removed without inverting the telephone.

Conventional wiring is used with a one-piece moulded base of toughened polystyrene incorporating the terminal insulation, or alternatively with a PRINTED CIRCUIT using a pressed metal base.

The light action cradle switch with its enclosed springset is provided with a linesman's latch which holds the switch operated during maintenance.

Automatic regulation of the high performance is provided for short lines.

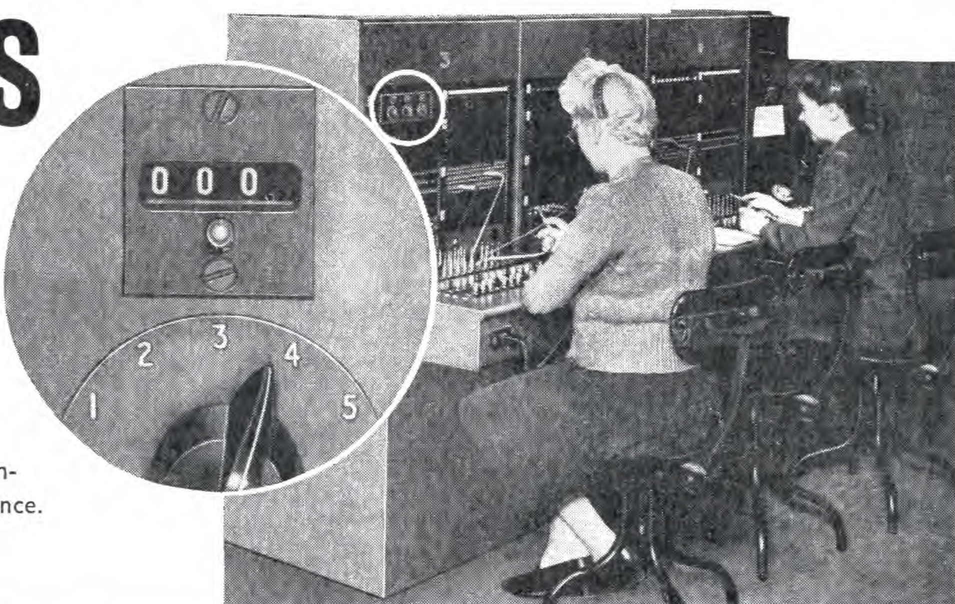
The rear aspect of the set is simple in form and the illustration below indicates the provision of an "off hook" rest position for the handset.



ERICSSON TELEPHONES LIMITED
ETELCO LIMITED
22 LINCOLNS INN FIELDS, LONDON, W.C.2
BEESTON, NOTTINGHAM & SUNDERLAND

SIEMENS EDISON SWAN LTD
WOOLWICH, LONDON, S.E.18 AN AEI COMPANY

E.95


0 0 0
1
2
3
4
5

Closed Circuit T.V. in the City of London

Standard Telephones & Cables Ltd., on behalf of the British Post Office, have manufactured and installed a system of small diameter coaxial cables radiating from Capel Court in the heart of the City of London. They will be used for the speedy transmission of Exchange information to individual Stockbroker's Offices on a Closed T.V. Circuit.

These cables are of a completely new type and are identical with those now being installed for high-quality telephony. Expanded polythene is used for the coaxial pair dielectrics and polythene for insulation of the control circuits and overall sheath. The cable is light, strong, impervious to moisture, easily handled and equally suitable for duct or aerial installation.

Like S.T.C., it has a major role in the future. For as closed circuit T.V. becomes more and more a part of the business scene, cables such as these will supply the means.

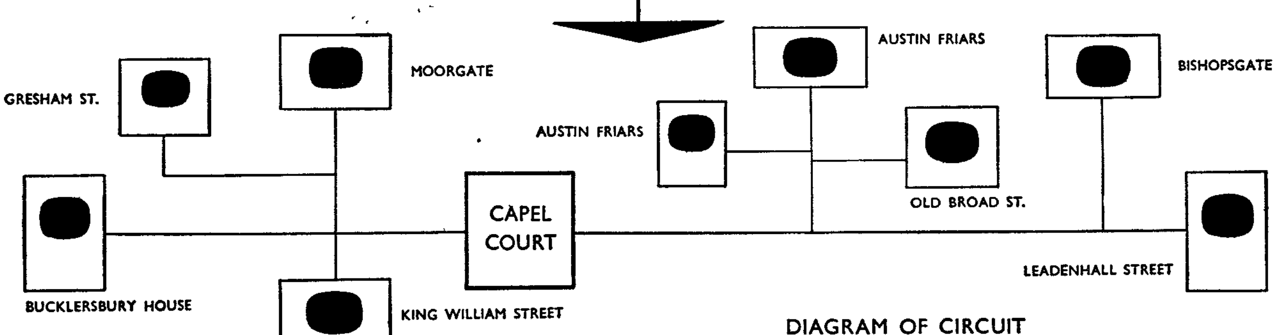


DIAGRAM OF CIRCUIT

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, W.C.2

TELEPHONE CABLE DIVISION: NORTH WOOLWICH · LONDON · E.16

Printed by SANDERS PHILLIPS & CO., LTD., The Baynard Press, Chryssell Road, London, S.W.9, and published by BIRCH & WHITTINGTON (*Prop. Dorling & Co. [Epsom], Ltd.*), Epsom, Surrey