No. 186

The Institution of Post Office Electrical Engineers.

Telephone Service Observations

J. J. PERKINS, A.M.I.E.E.

A Paper read before the London Centre (Harrogate Group) on the 11th January 1945, and at other Centres during the Session.

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1. INTRODUCTION.

In order to maintain a satisfactory service it is essential that means should be provided to enable the administration to obtain a measure of the service given to the subscribers in order that any tendencies towards deterioration may be corrected at an early stage. For this purpose it is necessary to observe the service and record the various operations in the setting-up of telephone calls.

2. TYPES OF OBSERVATIONS.

Various types of observations are carried out involving the connection of observation equipment at different points in the routing of a call. For convenience, however, the types may be classified under the following headings:—

Local Service, Toll and 0, and Trunk Observations.

3. LOCAL SERVICE OBSERVATIONS.

This consists of observing the sequence of operations in the setting-up of a local call which may or may not involve operator assistance. At small exchanges the quality of service is sampled by Service Inspectors who visit the subscribers and observe the progress of test calls made by the subscribers. At larger exchanges the service is observed continuously during the daytime by trained observers at the exchanges concerned. Where there are several exchanges in an area, economy is effected by observing the subscribers connected to these exchanges from a central exchange termed a District Observation Centre.

The institution of observations instead of service inspections is governed by:—

(*a*) The number of subscribers' lines working on an exchange. In general this number should exceed 500 before service observation equipment is provided.

(*b*) The type of exchange equipment in use at the exchange under consideration. It is not economical to provide the facility at certain non-standard exchanges (*e.g.*, Fleetwood Relay Automatic Exchange).

(*c*) The availability of a junction not exceeding 2000 ohms loop resistance.

(*d*) The regular attendance of an engineering officer at the exchange concerned for the purpose of changing the lines to be observed.

The Number of Observations required.

To obtain an exact record of the service given it would be necessary to observe every call that is made. This is impracticable, so a sample is taken which will provide a picture of the service as a whole. It is obvious that the larger the sample the more nearly will this picture represent the service given, but the difficulty has been to determine the minimum number of observations necessary.

After theoretical consideration and practical trial it has been decided that a sample of 500 observations per month on each observed exchange, automanual board or demand centre is necessary in order that the sample obtained will provide a satisfactory measure of the service.

History.

When first introduced service observation apparatus was quite simple, consisting of a tapping circuit connected to a subscriber's line and terminated on a jack at an observation desk, as shown in Fig. 1.

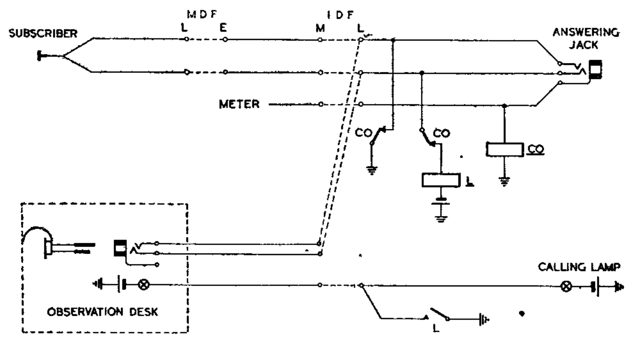


Fig. 1.—Local Service Observation Equipment. Early Type.

The glowing of the lamp associated with the observation jack indicated the commencement of a call, observations being taken by the insertion of a plug into the observation jack. Apart from the additional transmission loss introduced by the listening tap the arrangement was satisfactory provided the observation desk was in the same building as the exchange being observed. Observing from a remote exchange was uneconomical however as a separate junction was necessary for each subscriber's line under observation.

In 1915 equipment was developed to enable a number of subscribers to be connected, one at a time, to one observation junction, the subscribers' tapping circuits being associated with the junction by means of a line finder.

With the advent of automatic exchange working a redesign of the observation equipment was necessary to permit:—

(*a*) The immediate and automatic connection of the calling subscriber's line to the observation equipment to enable the number dialled by the subscriber to be displayed. The period between the lifting of a receiver to the receipt of the first dialled impulse is usually too short to enable manual connection by the observer to be completed in time for the number dialled to be recorded.

(*b*) The control of release of the observation junction equipment by the observer in order that repeated attempts to set up a call may be observed.

One of the first equipments incorporating the foregoing facilities was provided at Torquay in 1926.

Present Standard Centralised Service Observation Equipment.

The experience gained led to the development of equipment suitable for use at centres where a large number of junctions terminate on a suite of two or more observation positions (Fig. 2).

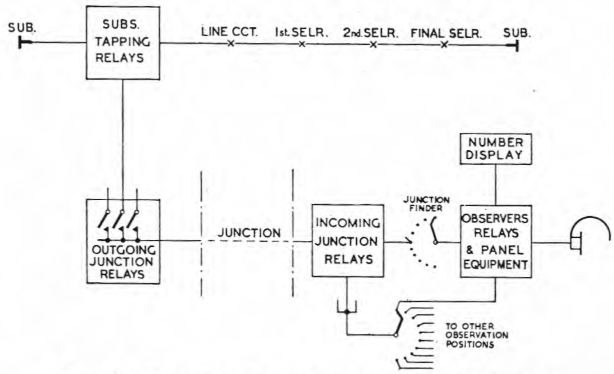


Fig. 2.—Present Standard Centralised Service Observation Equipment.

Each subscriber's line under observation is connected to a tapping relay-set. Ten tapping relay-sets are usually associated with each outgoing junction relay-set, but as many as 50 may be connected. The outgoing junction relay-set is common to the subscribers' tapping relay-sets connected to one junction and is taken into use when a call originates on a subscriber's line under observation. At the observation centre junction finders extend the junction to the observer's listening and number display equipment. Where there are two or more positions the calls are distributed to a disengaged position by an allotter.

Fig. **3** shows an observation and control panel and Fig. **4** a suite of observation positions.

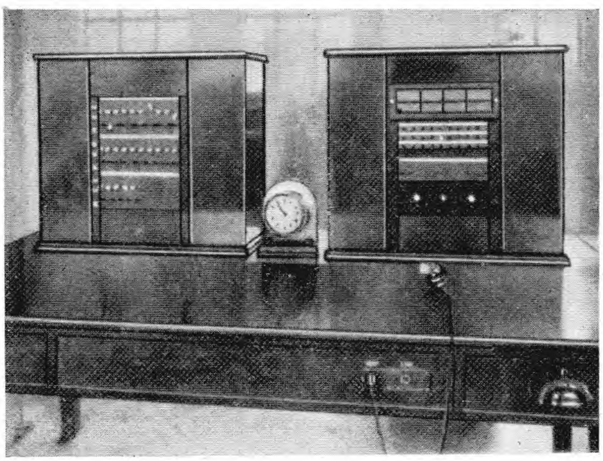


Fig. 3.—Observation and Control Panel.

Sequence of Observed Conditions.

When a calling subscriber's line is associated with an observation position a " green " lamp lights, indicating the observation junction picked-up and a " white " lamp responds to the movement of the subscribers' receiver rest. The number dialled is displayed on a lamp panel and when the called subscriber answers a " red " lamp glows. Periods of tone corresponding to the application of metering conditions are heard by the observer. When the observed subscriber replaces his receiver the " white " and " red " lamps are extinguished. The display lamps are extinguished by the operation of the " Display Release Key " on the observation panel.

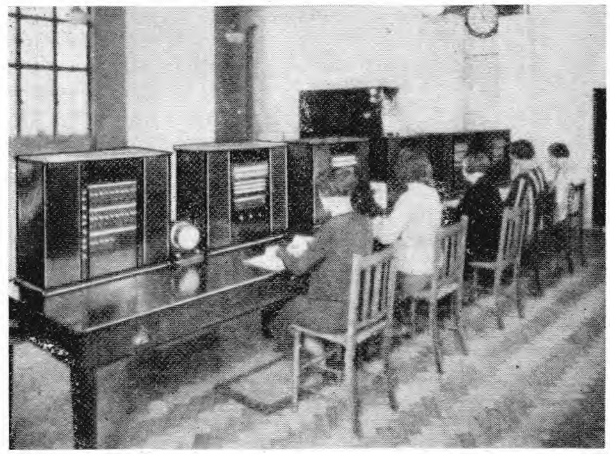


Fig. 4.—Suite of Observation Positions.

Repeat calls made from the same subscriber's line are extended to the same observer. If it is desired to release the subscriber's line from the observation position the "Subscriber's Release Key" is operated: to release the junction as well as the subscriber the "Subscriber and Junction Release Key" is operated.

Defects.

It ought to be an essential requirement of observation equipment that it should not have any effect on the performance of the lines being observed. By reference to Fig. **5** it will be seen that this requirement is not met by the present arrangement which suffers from the following defects:—

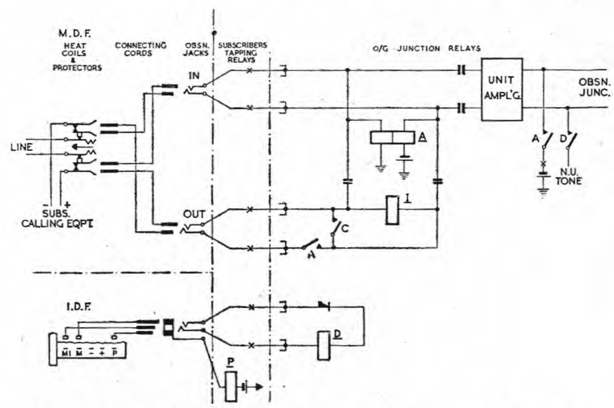


Fig. 5.—Observation Access to Subscribers' Lines.

(*a*) The impulses dialled by the subscriber are repeated by relay A to the selector. This results in additional distortion of the dialled impulses and under adverse circuit conditions a call which would normally be completed satisfactorily may fail if the attempt is made when the line is under observation.

(*b*) An additional transmission loss of approximately 1 db. is introduced by the tapping equipment. 0.8 db. by the bridge and 0.2 db. by the listening tap.

(c) The observation tapping equipment is connected to the subscribers' lines by means of clips and cords at the Main and Intermediate Distribution Frames. These connections are a source of trouble as they are easily disturbed. Furthermore, the services of an engineering officer are necessary to change the lines under observation and as frequent changes are necessary (usually every two days), the total time spent on this work must be considerable. Difficulty is also experienced in obtaining a sufficient number of observations to provide a full load for observation operators when all the subscribers' lines on an exchange are connected in turn to the observation equipment. In view of this it is the present practice to observe on selected busy subscribers' lines only. Thus the results obtained are *not* representative of the service given to all the subscribers on the exchange concerned.

4. TOLL AND O OBSERVATIONS.

The samples of calls observed on local service observations which require operator assistance, *e.g.*, 0 and TOLL, are too small to provide a reliable indication of the service and separate observations are taken on these circuits.

Present Arrangements.

These observations are in general taken at the automanual switchboard by the use of an observation cord or condensered headset. Fig. **6** shows the circuit connections of these items.

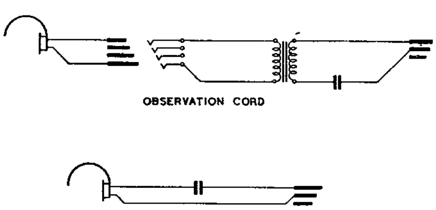


FIG. **6**.—OBSERVATION CORD AND CONDENSERED HEADSET.

The observation cord consists of a standard switchboard plug and cord connected to a high impedance coil in the position. Observations are carried out by plugging into the answering multiple of a calling circuit with the plug attached to the observation cord or condensered headset.

The items recorded by the observers are (*a*) speed of answer by the automanual switchboard operator, indicated by the lapse of time between the glowing of the calling lamps until the operator answers. (*b*) Time to disconnect and (*c*) calls lost.

Defects.

The location of an observer at an automanual switchboard is undesirable as the operators are aware that observations are being taken and this factor no doubt re-acts on the speed of answer and disconnect results. Furthermore, in the absence of supervisory signals to the observer, the correct timing of the " time to disconnect " is very difficult as it must be timed from the clicks heard when the subscriber hangs up and the operator clears down the connection. Apart from the foregoing traffic disabilities, the use of condensered headsets is viewed with some concern by the Engineering Department as the listening tap introduces a transmission loss of approximately 4.5 db. and no restriction can be imposed as to the types of circuits on which the headsets may be used as they are terminated on standard switchboard plugs. This type of headset, which was not designed for this purpose, has now been superseded for observation purposes by a high impedance headset which introduces a loss of only 0.1 db. at 800 c/s and 0.05 db. at 2000 c/s.

5. TRUNK OBSERVATIONS.

Trunk observation centres are to be found at the majority of the Zone Centres, and certain large Group Centres.

Observations at these exchanges are carried out from spare positions equipped with observation cords. A typical observation cord circuit is shown in Fig. **7**, and is used for observing both outgoing and incoming calls.

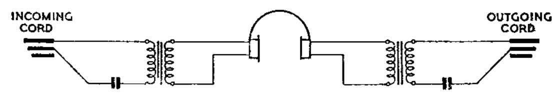


FIG. **7**.—TRUNK OBSERVATION CORD CIRCUIT.

Method of Observing Outgoing Calls.

The observer inserts the incoming plug into a multiple appearance of a calling trunk-demand circuit and listens for the call demanded. On hearing the demand the observer watches the free-line signals on the route concerned in order to locate the circuit selected by the operator. If no circuits are available on the primary route the observer watches the authorised alternative route. When indication of the selected circuit is obtained by movement of the free-line signal the observer plugs into this circuit with the outgoing observation plug.

Method of Observing Incoming Calls.

Observations on incoming calls are taken by inserting the observation incoming plug into a multiple answering jack of a calling circuit.

Defects.

This arrangement has the following defects:—

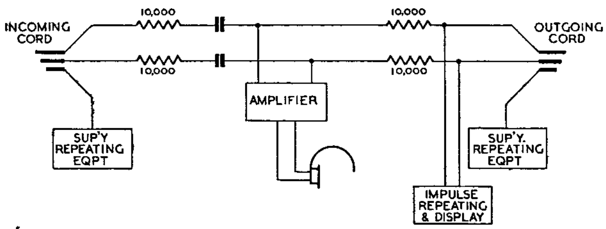
(1) Additional transmission loss is introduced by the listening tap.
(2) The method of locating the outgoing trunk circuit picked up by a controlling operator is unreliable.
(3) No signals are provided on the observation position to repeat to the observer the supervisory conditions on the controlling operator's cord circuits.

Temporary Arrangements at 2V.F. Centres.

With the introduction of 2V.F. dialling on trunk circuits the distortion of the dialled impulses by the observation listening tap could not be tolerated.

Furthermore the information obtained from such observations was not sufficient to enable the nature of the difficulties encountered to be determined.

Equipment was therefore developed and provided as a temporary measure at Zone Centres pending the provision of a standard scheme. The equipment provided at the London, Bristol and Plymouth Zone Centres is shown in Fig. **8**, and consists of:—



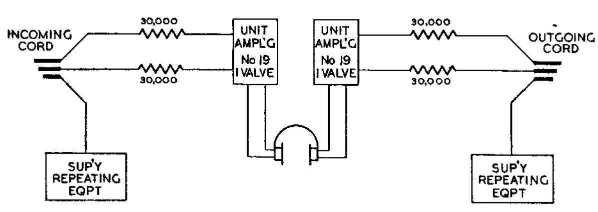
Experimental Trunk Observation Equipment.
Fig. 8.—With Display.

(*a*) A high impedance input circuit to a volume limiting amplifier. This amplifier provides an output volume to the observer equal to that which would be afforded by a direct tapping circuit, thereby enabling the observer to judge the volume and quality of transmission taking place. The volume limiting device is required to protect the observer from discomfort resulting from the effects of near end signals which are fed back at a high level.

(*b*) Valve impulse repeating equipment to repeat the impulses dialled by the controlling operator to a lamp display panel on the observation position.

(*c*) Valve supervisory repeating equipment on the incoming and outgoing sleeves of the observation cords to repeat the supervisory signals to the observer.

At the other Zone Centres, observations on 2V.F. trunk circuits are taken with very simple equipment, shown in Fig. **9**, which consists of a high impedance



Experimental Trunk Observation Equipment.
Fig. 9.—Without Display.

input circuit to two standard 1 valve amplifiers and valve supervisory repeating equipment connected to the sleeves of the incoming and outgoing cords. The positions used for taking observations on 2V.F. circuits are modified trunk positions which form part of the trunk suite. The method of observing is the same as that described above for the early type of trunk observations.

6. SUMMARY.

The foregoing is a brief outline of the existing observation arrangements. Sufficient detail has been given, however, in order that the shortcomings of the present arrangements may be appreciated.

The Department goes to considerable lengths in providing suitable line and exchange plant to enable calls to be set up within certain defined transmission limits and it is deplorable that the circuits may be degraded by an additional 4.5 db. in order to determine whether the service is satisfactory. A similar position arises when impulsing is considered. The number of dialling links permitted is dependent on the characteristics of the individual links and the type of equipment concerned. When the line is under observation, however, a further impulse repetition is added.

Reviewing the present position of Local Service, Toll and 0 and Trunk observation arrangements the weaknesses may be summarised as follows:—

Local Service.	Toll and 0.	Trunk.
Additional impulse distortion.		Additional impulse distortion.
Additional transmission loss.	Additional transmission loss.	Additional transmission loss.
Clip and cord connections.	Manual selection.	Manual selection.
Insufficient number of observations.	Observations taken at switchboard.	Observations taken at switchboard.
	Absence of supervisory signals.	Absence of supervisory signals.
		Manual association of incoming and outgoing circuits.

Certain of the weaknesses with the Trunk observation arrangements summarised above apply to the old type equipment only. The temporary 2V.F. observation equipment being a more recent development introduces negligible distortion and transmission loss.

7. METHOD OF OVERCOMING OR REDUCING THE DIFFICULTIES EXPERIENCED WITH THE PRESENT EQUIPMENT.

The following sections describe proposed methods of overcoming or reducing the difficulties experienced with the present observation equipment. It will be seen from the summary that certain of the disabilities are common to the three types of observation equipment. This renders possible the development of standard items suitable for each type of observation equipment. For example, an amplifier developed for Trunk observations would also be suitable for Local Service and Toll and 0 observations.

Impulse Distortion.

The impulse distortion introduced by the existing tapping arrangements is eliminated by the use of high impedance valve equipment. The principle of this type of equipment as applied to Local Service observations is shown in Fig. **10**. The arrangement utilises

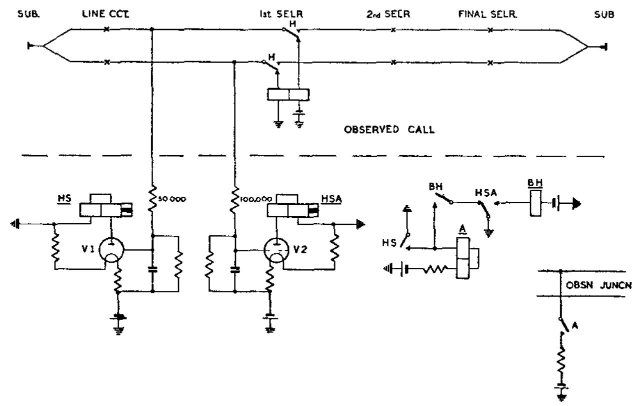


FIG. **10**.—PRINCIPLE OF VALVE TAPPING IMPULSE REPEATING EQUIPMENT.

two valves. Valve V1 with a high-speed relay (HS) in the anode circuit repeats the impulses dialled by the subscriber to the observation display equipment. V2 with its associated high-speed relay (HSA) suppresses false impulses.

Under steady loop conditions, *i.e.*, when the subscriber removes his receiver, the potential on the control grid of V1 relative to the cathode is positive and relay HS operates. When the dial-contacts disconnect the line the control grid is negative and relay HS releases. Relay A in the tapping circuit repeats the impulses to the display equipment.

The function of the false impulse suppressor valve is to suppress the false impulse which would otherwise be registered on the change-over of the H relay contacts in the line. Under adverse adjustment the transit time of these contacts may be of the order of 80 to 90 milliseconds. The impulse suppressor circuit is similar to that of the impulse repeating valve circuit, but the control grid is connected to the positive line of the observed circuit.

Under steady loop conditions and during dialling the suppressor valve control grid is always at a positive potential relative to the cathode so relay HSA remains operated. If, however, during the switching of the selector H relay-contacts the potential of the impulse repeating valve grid becomes negative, so tending to release relay HS, then the potential of the suppressor valve grid also becomes negative and relay HSA releases. Contact HSA 1 releasing holds relay A in the tapping circuit during the period of the line disconnection.

Further details of valve tapping equipment are given in Appendix 2.

Valve tapping equipment on this principle is suitable for Local Service observations to repeat the impulses dialled by a subscriber and for Trunk observations to repeat the impulses dialled by the operator. For Toll and 0 observations it could be used to repeat the signalling conditions.

Transmission Loss.

The tapping loss of the listening circuit may be reduced to negligible proportions by utilising a high impedance input. The speech currents available for the observer, however, require considerable amplification.

A volume limiting device is also necessary to reduce the level of the tone signals to the observer. The essential functions of the amplifier therefore are to secure amplification of normal speech input and attenuation of the tone signals.

The principle of the volume limiting amplifier is shown in Fig. **11**. The input is fed via 20,000Ω to

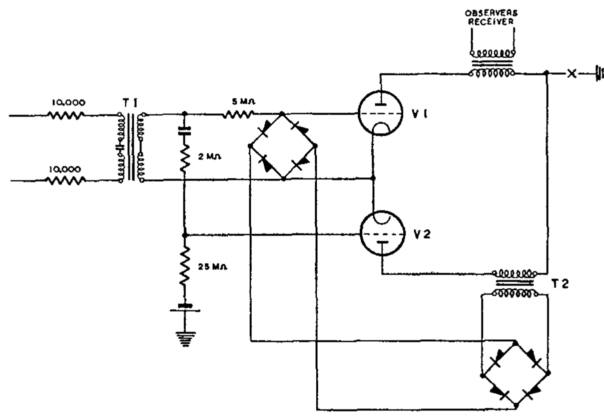


FIG. **11**.—PRINCIPLE OF VOLUME LIMITING AMPLIFIER.

the input transformer T1. Valve V1 acts as an amplifier and V2 as a control. The input circuit includes a bridge network of metal rectifiers. These rectifiers are connected back-to-back and the bridge impedance is very high in the absence of current from the control circuit. The input to the control valve is obtained from the secondary of the transformer T1. The output is fed via transformer T2 to another bridge network of rectifiers. The rectified output is smoothed and applied to the diagonals of the bridge in the input circuit of valve V1. The direct current through these rectifiers decreases their impedance and thereby alters the input to the amplifier valve V1. At normal speech levels the input of the control valve is small and little attenuation is introduced into the input of the amplifier valve. At higher input levels the resistance of the bridge is reduced. The response of the control circuit to loud signals is rapid and to reduce distortion of loud speech, due to rapid fluctuations of the amplification, a condenser and resistance shunt is provided. This makes the control circuit slow to restore as the charge on the condenser maintains the current through the attenuating network for an appreciable period.

Supervisory Repeating Equipment for Trunk Observations.

In order to repeat the controlling operator's cord circuit supervisory signals to the observer, valve tapping equipment is necessary as direct tapping would seriously affect the sleeve conditions of the controlling operator's cord circuit.

Fig. **12** shows the principle of a supervisory repeating circuit. Changes of potential on the sleeve

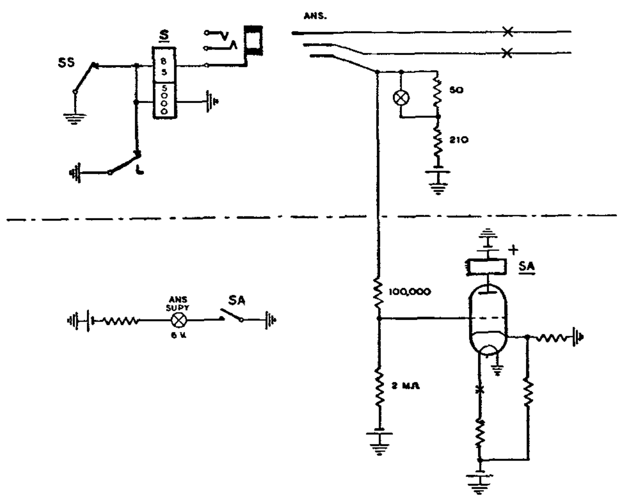


Fig. 12.—Supervisory Repeating Equipment.

connection are applied to the grid of the valve causing the anode current to vary. Relay SA operates or releases according to the magnitude of the anode current. With the observation equipment associated with a cord-circuit, relay SA will not operate due to the negative potential applied to the grid. When the controlling operator inserts an answering plug into the jack of a calling circuit the negative potential on the sleeve will still be sufficient to prevent the operation of relay SA. When the subscriber clears, however, the 5000Ω winding of relay S is short-circuited and the resultant change of potential reduces the negative on the grid to allow sufficient anode current to flow to operate relay SA and so light the supervisory repeating lamp. Similar conditions apply on the calling cord.

Method of Connection and Adequacy of Sample—Local Service Observations.

In order to reduce the fault liability of the present method of clip and cord connection use should be made of permanent connections between the observation equipment and the lines under observation. The amount of equipment necessary if each subscriber's line was connected to the observation equipment would be prohibitive, but it is essential that calls made by any subscriber should be capable of being observed. The solution is to connect the observation equipment to the earliest selector brought into use during the progress of a call, *i.e.*, 1st code selectors in Director exchanges, 1st selectors in Non-director exchanges and discriminating selectors in Satellite exchanges. With such a scheme it will not be possible to observe the operation of the subscriber's calling equipment, but this is not a serious drawback. This method of connection would also enable adequate samples to be obtained.

Fig. **13** shows the method of connecting the observation equipment to 1st selectors, the –ve, +ve, P and

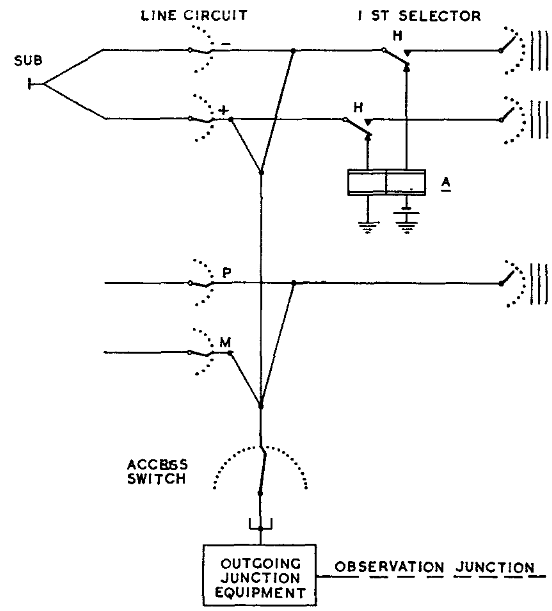


Fig. 13.—Observation Access to 1st Selectors.

M wires being connected to the banks of access switches. Access to the selector to be connected to the observation desk would be automatic.

In view of the short period between the seizure of the selector by a calling subscriber and the receipt of dialled impulses it may be necessary to position the access switches before the 1st selector is seized by a calling subscriber. Two or more access switches would be associated with each observation equipment to reduce the liability of the observer having to wait a long time for a call to mature. The first selector seizing the observation equipment would lock out the remaining access switches.

Number of Selectors to which access should be provided.

The percentage of 1st code selectors, 1st selectors and D.S.R's to subscribers' lines at an exchange varies according to the subscribers' calling rate. The traffic carried by the early choice selectors is high and to provide a continuous load on the observation junctions it would only be necessary to observe on a small number of these selectors.

The uniselectors and 1st selectors are arranged in groups, however, and subscribers in one group do not have access to the 1st selectors in another group. Similar conditions apply with 1st code selectors and D.S.R's. In order that observations can be taken at random on calls originated by *any* subscriber connected to an exchange, it would be necessary to provide access to at least one 1st selector in each group.

Fig. **14** shows the number of 1st code selectors, 1st selectors and discriminating selectors provided at selected exchanges and the "X" indicate the number to be connected to the observation access switch if it

The facilities required are:—

(*a*) Speed of answer by the automanual board operator.

(*b*) Time taken by the operator to disconnect on the receipt of clearing signals.

(*c*) Listening tap.

The most convenient access point is at the TOLL or 0 level relay-sets. Access to a typical 0 level relay-set is shown in Fig. **15**.

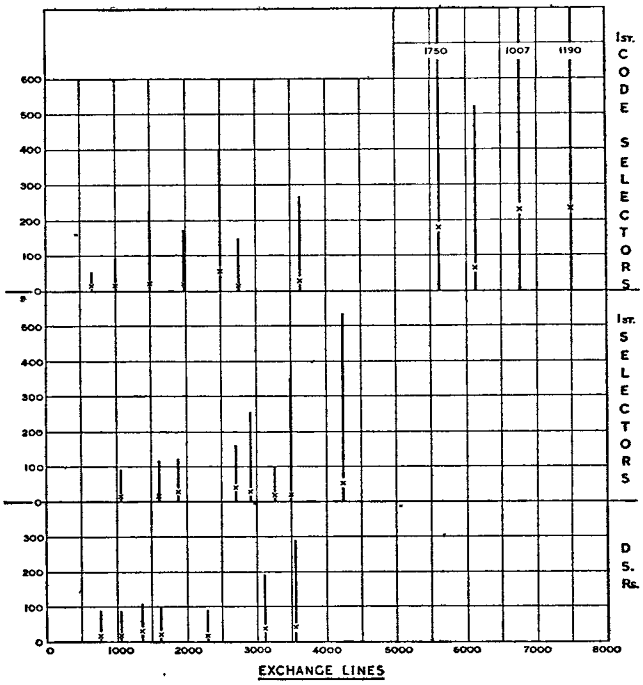


Fig. 14.—Number of Selectors to be Connected to Access Switch.

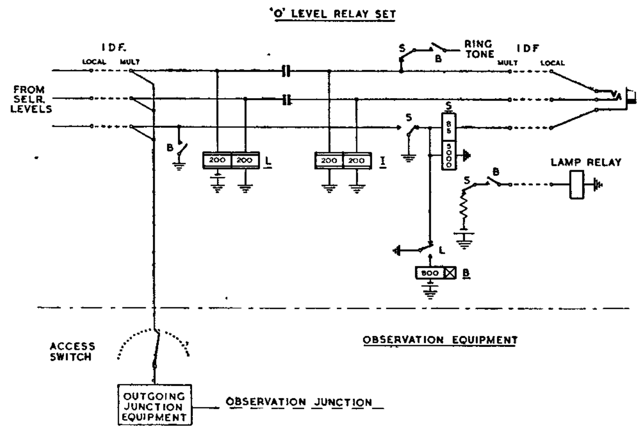


Fig. 15.—Observation Access to "0" Level Relay Set.

is ruled that it is essential to observe calls from *any* subscriber.

In one exchange investigated 189 selectors require to be connected, so provision must be made for access to a maximum of 200 selectors.

No single uniselector of sufficient capacity (200 outlet 5 bank, the 5th being used for control purposes) is available.

The Siemens motor uniselector is the largest type at present available and has 50 contacts and a maximum of 16 wipers. It will be possible therefore with a 10-wiper model to provide access to 100 selectors. If access is required to more than 100 selectors, two uniselectors will be necessary with wiper switching.

Control of release of the access switch from the call under observation will be from the observation desk. On the operation of a "release key" the access switch wipers will hunt for and remain on a free selector in readiness for the next call to mature.

Method of Connection. TOLL or 0 Observations.

In order that these observations may be taken remote from the automanual board it is necessary to provide automatic access from the observation desk or an appearance of the TOLL or 0 circuits on the observation desk.

From a service point of view it is desirable that these observations should be taken at the Local Service observation desks utilising the equipment provided for the Local Service observations. Access equipment is therefore desirable.

Three connections are required; to the negative and positive wires to provide a listening tap and to repeat the calling party seizure and clearing, and to the "P" wire to indicate to the observer when the operator clears.

The observation equipment at the observed exchange and at the observation centre should be suitable for both types of observations. Separate access switches will be necessary, however, together with certain auxiliary equipment for the TOLL and 0 level observations, in order that the equipment used to repeat metering conditions for Local Service observations may be used for repeating the "P" wire conditions when observing TOLL or 0 calls.

The following conditions will be repeated to the observer:—

(*a*) When the relay set is seized the loop applied will light the "white" and "green" lamps on the observation desk. Earth applied to the "P" wire will light the "red" lamp. Ring tone will also be heard.

(*b*) When the automanual board operator answers the ring tone will be disconnected. The duration of ring tone will therefore indicate the time to answer.

(*c*) When the calling party clears or flashes the "white" lamp will respond.

(*d*) When the operator clears down the connection the "red" lamp will dim. The lapse of time between the dimming of the "white" and "red" lamps will represent the time taken by the operator to disconnect.

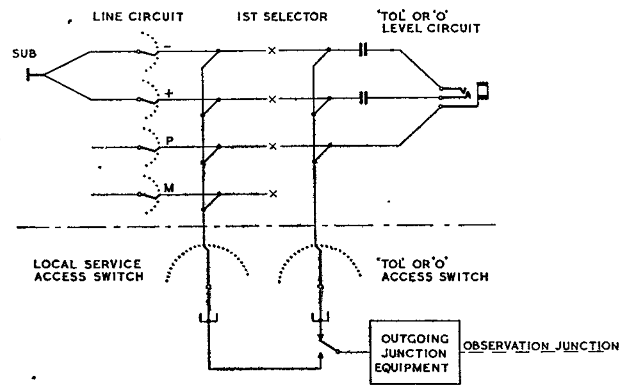


FIG. 16.—ACCESS CIRCUIT—LOCAL SERVICE, TOLL OR 0.

Fig. **16** shows the combined Local Service and TOLL or 0 observation equipment, key selection of the particular service to be observed (*i.e.*: TOLL, 0 or Local Service) being under the control of the observer. Simultaneous observations (Local Service, and TOLL or 0) for the same exchange would not be possible as only one observation junction would be provided.

Method of Connection for Trunk Observations.

In order that the various stages in the setting up of a trunk call may be observed, access to the incoming demand circuit is necessary so that the observer may hear the call requested; and access to the seized outgoing trunk in order that the number dialled and/or supervisory conditions may be repeated to the observation equipment. Provision must also be made for the observations to be taken remote from the switchboard.

These conditions could be met in one of the following ways:—

(*a*) By providing an appearance of the multiple of a number of incoming circuits and a complete multiple of the outgoing circuits on each observation position. This would involve the provision of a large multiple and the location of the display panels near the top of the positions. If the display panels were fitted at the bottom of the jack field the height of the multiple jacks would necessitate a stretch exceeding the permissible maximum and operating on such a position would be fatiguing. Association of the outgoing with the incoming side of a call would be carried out manually by watching the free line signals on the route concerned. Thus a considerable proportion of the observers time would be taken up in circuit connections when it should be used in recording the conditions observed.

(*b*) By providing automatic access to the demand circuits in a similar manner to that described for TOLL and 0 observations and automatic association of the calling circuit with the outgoing trunk picked up. This could be arranged by a condition returned through the cord circuit marking the contact on the bank of a finder to which the outgoing trunk circuit was connected. The wipers of the finder would then associate the outgoing with the incoming circuit. Apart from the difficulty in operating with manual association and the complicated circuit arrangements to provide automatic access, individual connections to each circuit (demand and outgoing trunk) would be necessary.

In the proposed Local Service observation arrangements, the number of connections have been considerably reduced by connection to common equipment, *i.e.*, Selectors. In a similar manner the number of connections required for Trunk observations could be reduced and the circuit arrangements considerably simplified. The common equipment used in setting up a call on an automanual board is the cord circuit. All the connections required, to repeat the supervisory conditions, provide a listening tap, and record the impulses dialled, could be made at this point. Furthermore no special arrangements are necessary to associate the demand circuit with the trunk picked up as the observation equipment will be connected to both sides of the cord circuit.

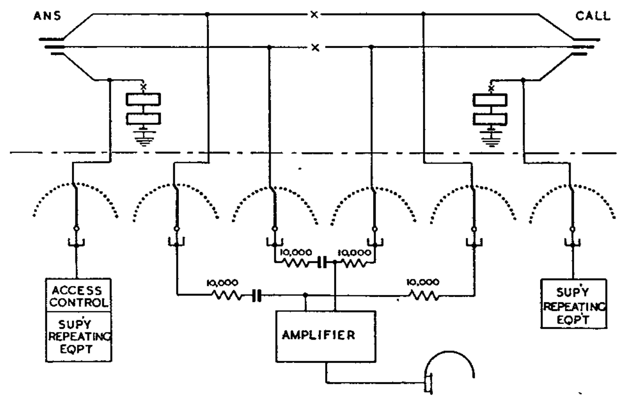


FIG. 17.—TRUNK OBSERVATION EQUIPMENT.

Fig. **17** shows the proposed arrangement. The answering and calling cords are connected to the banks of access switches, the wipers of which are connected to the observation equipment. The access switches would be arranged to rest on disengaged cord circuits.

To reduce the liability of an observation circuit waiting for a long period for the cord circuit to be taken into use, two or more access switches could be associated with each observation circuit and the first cord circuit taken into use would seize the observation equipment and disconnect the other associated access switches.

With the exception of certain key operations to control the release of the circuit under observation the operating would be automatic. The observers would therefore be able to concentrate on their primary duty which is to record the conditions observed during the setting-up of calls.

With this scheme the positions to be observed may be preselected by means of keys fitted on the observation control panel, incoming or outgoing observations being taken by preselecting the appropriate positions.

Busying of the cord circuits on unstaffed positions or visual indication to the observers of the staffed positions would be necessary. This could be arranged under the control of the operators' instrument jacks.

It will be recalled that by the connection of Local Service observation equipment to selectors the progress of a call to the stage of the seizure of the selector could not be observed. A similar condition would arise with Trunk observation equipment connected to the cord circuits, *i.e.,* it would not be possible to observe the speed of answer on the demand circuit. Equipment has been developed however, and is at present under trial, for the sole purpose of automatically recording the speed of answer on automanual board circuits.

Speed-of-Answer Recorder.

This recorder enables the traffic staff to obtain information regarding the time taken by operators to answer calls incoming from trunk and junction circuits. For this purpose considerable use is at present made of the Circuit Occupation Recorder shown in Fig. **18**. The " calls " meter operates and

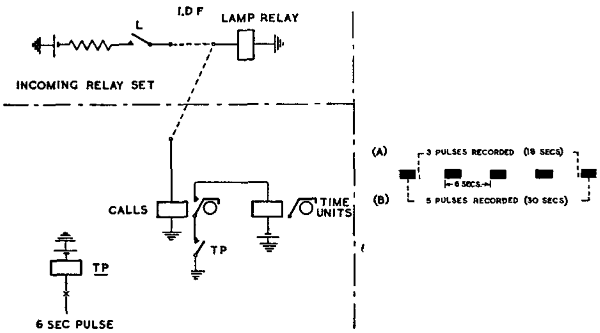


FIG. **18**.—CIRCUIT OCCUPATION RECORDER USED AS SPEED OF ANSWER RECORDER.

holds during the period that the calling lamp is alight and completes the circuit for the " Time " meter which is stepped by a pulse every 6 secs. Records taken with this recorder, which was designed for quite a different purpose, are not sufficiently accurate as the " calls " meter will respond to flashing. Furthermore the 6 second pulse used for timing is in constant operation and the degree of accuracy of time recorded for each call is dependent on the part of the 6 second pulse cycle when the " time " meter is connected or disconnected. This is illustrated in Fig. **18**, which shows two time records A and B. The time recorded would be 18 and 30 secs. respectively, *i.e.,* a difference of 12 secs., whereas the actual time difference is of the order of milliseconds. In practice the application of a weighting factor is necessary.

Speed-of-answer recording equipment has been developed and the liability to false recording has been reduced to a minimum. It consists of common equipment which may be connected to the lamp wires of 10 circuits on which it is desired to obtain records. A call appearing on one of the circuits will be associated with the recording equipment and the remaining nine circuits locked out until the equipment is free.

The following information is recorded on meters:—

(*a*) The total calls.

(*b*) The number of calls answered within 5 secs., 10 secs., 15 secs. and 20 secs.

It is not proposed to detail the circuit operations, but the following points are of interest:—

(1) To reduce the liability of the " calls " meter responding to flashing, a two seconds lag is provided, *i.e.,* the recorder does not commence to measure the time until two seconds after the start condition is received. When the operator answers two seconds are added to the timing. The result is that provided the release of the calling condition when flashing is less than two seconds, which is usually the case, it will not be recorded.

(2) To give reasonably accurate timing a 40 ms. pulse is used. This is derived from the 50 c/s mains supply in the following manner:—

A relay and a rectifier are connected to the output of an A.C. mains connected transformer. The relay operates and releases every 20 ms. The 20 ms. pulse obtained is applied to a pulse doubling circuit which supplies the 40 ms. pulses to step a time generating uniselector. A time counting uniselector steps once per sec., that is for each complete revolution of the time generating uniselector.

The meters recording the calls answered in 5, 10, 15 and 20 secs. are operated by relays connected to the appropriate bank contacts of the time counting uniselectors.

8. VALUE OF OBSERVATIONS.

The true value of a service is reflected by the benefits derived from it and this applies no less to observation results. Before considering the value, however, a brief outline of the method of summarising and presentation will be given.

Each observer is provided with schedules showing the various items which require recording. The observed results during each stage of a call are recorded.

The period necessary to obtain a representative sample of traffic is known as the Observation period. In general this period is one month. At the end of each period the results are summarised and weighted. Weighting is necessary in order that a comparison may be made between the observation results at different exchanges. Weighting consists of multiplying the items on the summary sheets by factors to obtain a " weighted " average for the exchange as a whole.

Copies of the summaries are supplied to the traffic and engineering officers directly concerned with the service at the exchange in question and to the Regional Director and Headquarters Telecommunications Department and E.-in-C's Office. The results are closely scrutinised and any necessary action taken. If, for example, the results show an abnormal number of failures which may be attributed to the telephone plant, the equipment concerned will receive special attention to determine and remove the cause.

Observation results taken after the introduction of a new system or method of working are of special interest. With 2V.F. dialling, for instance, the observation results have enabled a close watch to be kept on the working of the equipment and have helped to reveal design faults and operating irregularities.

Observation results also enable such items as unremunerative trunk and junction times to be determined and this in turn may lead to improved operating arrangements. These records are also of value in estimating equipment requirements, *e.g.*, the average time a subscriber listens to dial tone, N.U. tone or busy tone must be accounted for as during such time exchange equipment is being held.

9. CONCLUSIONS.

The traffic and engineering disabilities of the present observation arrangements have been appreciated for some years and in 1937 a Headquarters committee was set up to investigate the present arrangements and to recommend any alterations considered desirable to effect an improvement.

Various recommendations were made and field trials covering the different aspects were in progress when the committee work was suspended in 1939. The proposals in this paper are made with a view to overcoming the defects with the provision of a minimum amount of equipment in order that the additional fault liability introduced will be small. The methods proposed to overcome the defects do not necessarily follow the recommendations of the committee, but due regard has been paid to the items recommended for investigation.

APPENDICES.

1. *Meter Observations.*

In view of the importance of presenting correct accounts to subscribers it is essential that the number of debited calls should be accurate. Correct operation of subscribers' meters is of great importance and testing equipment is provided therefore to enable tests of the meters to be carried out at regular intervals. If a subscriber should dispute his account a special test of the operation of the meter concerned can be made by means of this equipment. Should a complaint be repeated, the line may be associated with meter observation equipment. A typical circuit is shown in Fig. **19**.

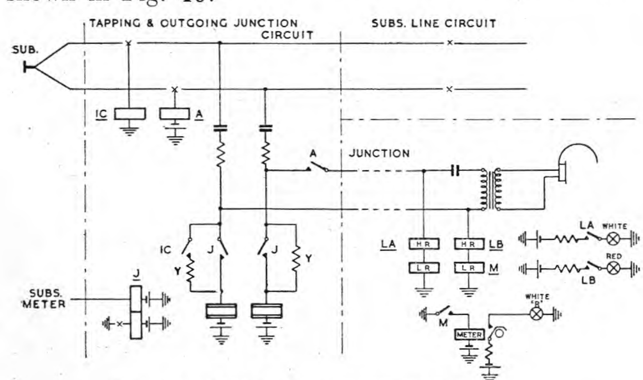


Fig. 19.—Meter Observation Circuit.

The subscriber's line concerned is associated with the observation circuit by means of plugs and cords at the main distribution frame. A connection is also made to the subscriber's meter at the routine test jack on the meter rack.

When the subscriber originates a call relay A operates and in turn operates relay LA which lights the "Originating Call Lamp" of the observation circuit located on a monitors desk.

When metering conditions are applied relay J operates and in short-circuiting the resistors Y allows relay M to operate. A contact of relay M operates the check meter and lights the "Registration Lamp." The red lamp lights on calls incoming to the subscriber, followed by the "white" lamp when the observed subscriber answers.

The listening tap is provided in order that the monitor may determine whether a call is proper to be metered or not.

Although the present arrangement is satisfactory as far as the check of single-metering calls are concerned it does not provide for checking the registration on calls exceeding one unit fee. Furthermore, to provide a complete record it is necessary for continuous attention to be given by the monitor.

Apart from a modification necessary to enable the check-meter to record more than one unit it would also be necessary to provide a display of the digits dialled by the subscriber in order that the monitor could check that the call made was proper to be metered as one or more units.

It has been appreciated for some time that this type of observation could be carried out by automatic methods.

Equipment designed for automatically recording digit and meter pulses on paper tape was found to be available in Switzerland and in 1936 a sample was obtained for trial. The equipment which is shown in Fig. **20** comprises two parts, *i.e.*, a printing

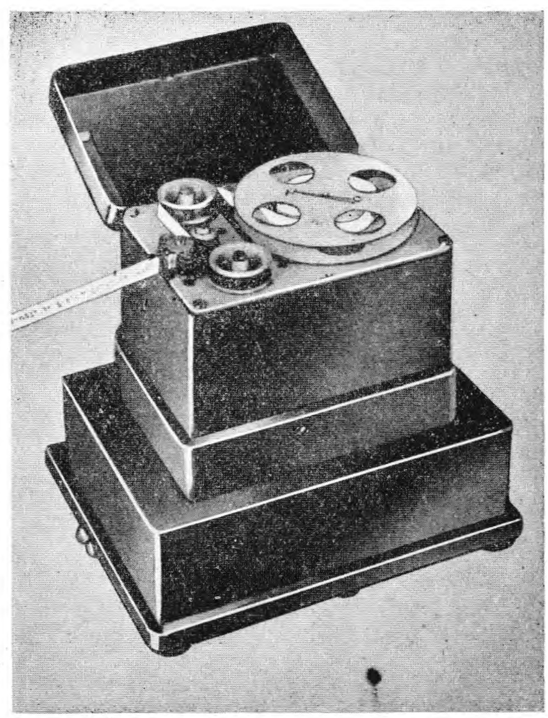


Fig. 20.—Zoller Recorder.

mechanism and a relay-set. Both are metal cased and the two can be contained in a combined carrying case. The complete recorder weighs about 30 lbs.

The following facilities are provided as illustrated on a sample tape record shown in Fig. **21**:—

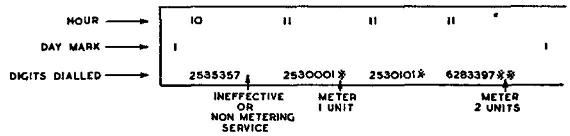


FIG. **21**.—ZOLLER RECORDER. SAMPLE TAPE RECORD.

(1) Record of digits dialled.
(2) Record of metering (single or multi-fee).
(3) Absence of (2) indicates that the call was either ineffective or to a non-metering service.
(4) A day mark recorded every 24 hours.
(5) Record of the hour when each call is made.

The equipment as designed includes an impulse-repeating relay in series with the line which introduces additional distortion of the impulses dialled by the subscribers.

Tests have been carried out, using a valve impulse repeating equipment of a similar type to that described for Local Service observations, and the results are satisfactory.

2. *Valve Tapping Equipment.*

The principle of the valve-type impulse repetition equipment is shown in Fig. **10**.

The fundamental requirements of a tapping device for service observation purposes are:—

(*a*) high impedance ;
(*b*) impulse-repetition to the number display with minimum distortion ;
(*c*) no effect on signalling and impulsing performance in particular on the observed circuit.

A suitable voltage for application to the grid of the impulse-repeating valve is that existing across either winding of the A relay under impulsing conditions. This is shown in Fig. **22*a***. Since the cathode of the

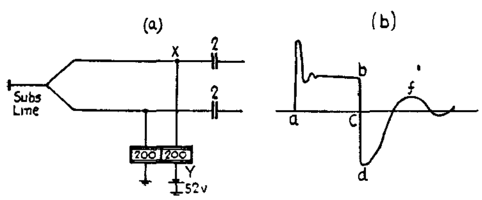


FIG. **22**.—VOLTAGE WAVEFORM ACROSS BATTERY CONNECTED WINDING OF SELECTOR RELAY A DURING IMPULSING.

valve is connected to negative battery, the negative winding of the A relay has been used to afford potentials positive with respect to the cathode. Suitable tapping points are therefore X and Y. The voltage waveform across the battery connected winding of relay A is shown in Fig. **22*b***. At the moment of make, *i.e.*, when the subscriber lifts his receiver, the voltage from X to Y rises with a superimposed oscillation due to the inductance and capacitance in the telephone instrument, X being positive to Y. This voltage remains constant for the whole make period, but when the circuit is broken at the dial contacts an oscillation *b*, *c*, *d* and *f* is set up between the subscriber's condenser and the impulsing relay. Due to the low resistance of the circuit and the high inductance of the 200 + 200 ohm relay this oscillation continues for some time and in particular produces a very definite peak of positive voltage at "*f*."

In order that the impulses may be correctly repeated to the observation display equipment the impulse-repeating relay must remain operated during the period "*a*" to "*c*," but must not operate to the "*f*" peak. To damp out the voltage peak "*f*" a condenser is inserted between the grid and the negative battery (Fig. **10**), a value of 0.3 μf being sufficient to remove all traces of the peak without seriously affecting the normal build up of anode current at "make." To prevent the grid attaining a positive bias under disconnection a 1 megohm leak is connected across this condenser. On a line of 500 ohms resistance the oscillation *c*, *d* and *f* is not so pronounced as on the zero line.

The approximate control grid potentials under the conditions shown in Fig. **10** with a subscriber's line of 500 ohms are given below.

Conditions.	Potentials in volts on the control grid of the			
	Impulse repeating valve.		False impulse Suppressor valve.	
	Relative to cathode.	Relative to earth.	Relative to cathode.	Relative to earth.
Steady loop ...	+ 6.5	− 39.5	+ 34	− 12
Dial contacts disconnected ...	− 4	− 50	+ 45	− 1
H contact in negative line disconnected ...	+ 43.5	− 2.5	+ 45	− 1
H contact in positive line disconnected ...	− 4	− 50	− 4	− 50
Both H contacts disconnected ...	− 4	− 50	− 4	− 50

It is seen therefore that under steady loop conditions and during dialling the suppressor valve control grid is always at a positive potential relative to the cathode.

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