ENGINEERING DEPARTMENT
TRANSMISSION DIVISION

AUTOMATIC TELEPHONE & ELECTRIC CO. LTD.
STROWGER WORKS
LIVERPOOL

PLESSEY GROUP

CARD MOUNTED 12 CIRCUIT

CHANNELLING EQUIPMENT

CMR 10180/1-2 (6'Frame)

Operating Bulletin 7082

Iss. 1 Mar 1965.
Automatic Telephone & Electric Co. Ltd.
Strowger Works, Edge Lane,
Liverpool. England.

Preface

This operating bulletin covers all the carrier equiment required for a standard system. It is arranged as shown below into four sections, each section being headed by a numbered divider card.

Any non-standard equipment used in the system, or any special modifications made to suit a particular contract, will be dealt with in a short section immediately following the contents list. Where no such section is included, it may be taken that the system supplied, other than sub-equipping, is exactly as described in this bulletin.

A separate handbook OB7013 contains information and suggestions relating to the installation of CM type carrier equipment will normally be provided for each terminal station.

Any additional information or assistance required in setting-up or operating the equipment will be freely provided on request.

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Circuit drawings of each of the preceding units are included at the end of this section in numerical order.

GENERAL DESCRIPTION

INTRODUCTION

This bulletin describes the 12 channel carrier equipment supplied on CMR 10180/1-2 racksides which form self-contained terminals designed to provide up to 12 high grade carrier derived speech circuits complete with-out-of-band signalling facilities. Each speech circuit occupies a band width of 4 Kc/s and the channels are transposed to form a base-band 60-108 Kc/s (when fully equipped) to which another group, already transposed to occupy 6-54 Kc/s could be connected so that the two would then together occupy 6-108 Kc/s equivalent to 24 channels.

To meet contractual requirements the present equipment is sub-equipped as follows:- Racksides CMR 10180/1 SPL Serial Nos. 11766 and 11768 are each equipped with both way group equipment and channelling for Channels 7-12 (60-84 Kc/s) and will be installed at Terminals "A" and "C" as shown on route diagram ES64-4574. Rackside CMR 10180/1 SPL Serial No. 11767 is equipped with two sets of both way group equipment and two sets of channelling for Channels 7-12 (60-84 Kc/s) and will be installed at Terminal "B" where it will provide communication to Terminal "A" and to Terminal "C".

All rackside are single sided and are 6 feet tall. They are supplied complete with a. c. operated power supplies and incorporate built in frequency generating and synchronising equipment. All audio circuits incorporate 2W/4W conversion equipment and have ring down relays associated with them. The complete equipment conforms with the standards recommended by the C. C. I. T. T. and may be integrated with an existing multi channel system if required.

It is transistorised throughout and is constructed on the card mounted principle (hence the term CM), the components which form a particular circuit function being mounted on a circuit card (or cards).

Summary of Electrical Features

Up to 12 speech channels each covering the audio band 300-3400 c/s are assembled to form a basic 12 channel group translated to occupy the C. C. I. T. T. group B band 60-108 Kc/s or part thereof. This process is accomplished by two stages of modulation in which "sub groups" of three channels are first formed, up to four of them being separately modulated and combined to form a complete group. When racksides are sub-equipped dummy cards are inserted to maintain circuit continuity. Where necessary appropriate loading resistors are provided either to provide correct termination or to maintain loading. Once the C. C. I. T. T. group or part thereof is produced the band is applied to group combining equipment where if need be the band associated with an external group, suitably transformed to 6-54 Kc/s, may be combined with it.

In the return direction the 6-54 Kc/s band (if used) will be separated from the remainder of the incoming signal which will then undergo similar processes to those already described, the four sub-groups (or less if sub-equipped) being first recovered followed by the individual channels.

The following optional facilities may be provided:-

(a) A bothway out-of-band signal channel associated with each speech channel. The signalling equipment may be supplied to operate either at high level (-5 dBm0) or -15 dBm0, the operating levels being fixed for whichever signalling equipment is supplied. The facilities may be used in conjunction with inbuilt relay sets to provide ringdown signalling between manual exchanges when local relay sets are not available. Alternatively the "E" and "M" wires of the individual signalling channels may be extended directly to the exchange if automatic pulse code operation is to be employed.

(b) The audio input and output terminations of each channel may be extended directly to the exchange on either a four wire or two wire basis, the desired mode of operation being adopted through use of links and sockets in association with 2W/4Wire conversion hybrids which can be supplied.

The various carrier and pilot frequencies employed in the system are derived from high stable 12 Kc/s master oscillators. The 3825 c/s signalling oscillator employs a crystal control circuit.

Frequency synchronism is maintained throughout the system by means of a 60 Kc/s pilot, generated at and derived from the 12 Kc/s master oscillator at Terminal "B". This pilot is sent out as part of the composite carrier band sent out from Terminal "B" towards Terminal "A" in one direction and towards Terminal "C" in the other. At terminals "A" and "C" locally generated 60 Kc/s carriers are compared with the standard received from "B", the local oscillator being re-adjusted until the 60 Kc/s produced by it is synchronised to the standard.

To facilitate testing and aligning the system selected test points in the transmission path, the carrier generating equipment and the power supply circuits are brought out to standard test/access sockets which are mounted on the front face of the equipment. These sockets will usually be found affixed to either the left or right hand side uprights which form the rack frame work and by use of suitable patching cords appropriate test equipment can be patched thereto to enable commissioning and routine maintenance to be proceded.

Mechanical Features

The terminal rackside dimensions are 6 feet tall x 20.5 inches wide x 9 inches deep. Its weight will vary from 400 to 550 lb according to the amount and type of equipment fitted. It is single sided and protective doors are fitted to cover the working side of it.

Equipment shelves are affixed to the rackside by means of horizontal guides which are attached to the side members of the frame. The shelves slide into position and are secured by captive screws (held in flanges formed at the rear of the shelves). These screws locate in bars fitted behind the shelves and at the rear of the rackside. Any shelf may be withdrawn if necessary from the rackside.

All shelves are fitted with moulded guide strips which are grooved front-to-rear at 0.2 inch interval, the printed card units shaped to fit them.

Connection between cards and shelf wiring is by means of plug-in type contacts affixed on the actual card and spring loaded contacts which form part of 22 way multiple connector sockets conveniently mounted at the rear of each shelf. Locating key ways on the connector sockets ensure correct positioning of the printed cards.

Component designation strips, tag numbers, attenuator settings etc. are conveniently printed on the component side of each card. In addition, a symbol showing two cardinal points of the compass (North and West) is used to assist in establishing whether a particular component is mounted along or across a particular card, reference being made first to the relevant circuit drawing where the connections will be shown as "N" or "W".

Where necessary to complete a particular circuit function two or more cards may be grouped together to form a multi-card unit (designated CMM) the individual cards being attached by four bolts and spacing bushes.

Termination block/test tablets are fitted at each shelf end and they form a convenient means of inter-connecting the various types of equipment installed in the rackside.

Installer's cabling is brought in through entrance holes at the top of the rack frame and are fed down cable ducts which run the full length of the rack. Cabling can therefore be terminated on the tag blocks so obviating the need for special terminating panels with their associated cabling.

The tagblocks are conveniently hinged to enable them to be swung clear to expose both the internal wiring and the installers cabling.

A simplified block diagram appears on most of the left-hand rack doors. These have been prepared to assist technical personnel who will find on them most of the relevant test information. The right hand doors carry layout diagrams which show the position and designation of all units and printed cards.

Drawing Code No's

The various items of equipment and their associated production drawings are identified by number codes with three prefix letters whose significance is as follows:-

CMA ..... Ordering code No. for printed card

CMB ..... As above for wired (non printed card) unit

CMM..... As above for multi printed card unit

CMR ..... Ordering code and assembly drawing for complete rack

CMS ..... Circuit schematic drawing for any type of card or unit

CMW ......List of inter-unit and inter-shelf cable form drawings required for use on a given rackside

CMZ ..... Ordering code for a filter or other sealed sub-unit

TC ...... Ordering code of certain components - also rackside point-to-point wiring drawings

ES ...... This prefix is applied to explanatory drawings specially prepared for use in this bulletin

X .... Small text insert explanatory drawings

Abbreviations

The following terms and abbreviations used in this bulletin are as defined.

Channel... A single bothway speech circuit

G.D.F. .. Group distribution frame. Also used to refer to the transmission path at any point between the channelling and group equipments.

Group .... 12 channels translated to the band 60-108 Kc/s

Modem ... Abbreviation for unit which contains both modulator and demodulator circuits, e.g. channel modem unit CMM 20050.

Pad ...... Fixed or variable attenuator

Pilot ..... Signal of fixed level and frequency injected into main transmission path, for regulation or synchronisation purposes.

P.V. ..... Percentage variation. This refers to a type of d.c. test meter scaled in $\pm$ % from mid-scale. The meter is a 1v F.S.D. 5000 ohms movement and is used for most d.c. measurements on CM equipment. Most d.c. test points are arranged so that under normal conditions the P.V. meter will read mid-scale $\pm$ a given percentage.

Signalling . This term is used with reference to the control circuit associated with each speech channel whereby ringdown or dialling pulses are passed between terminals via the carrier system. The term as used here is not to be confused with the term 'signal' which may refer to any voltage conveying intelligence.

Sub-Group . Three channels translated to occupy the band 12-24 Kc/s.

Strap ..... An adjustable soldered connection between tags - also the operation of fitting it, e.g. 'strap tags 23 and 26 together'.

T.M.S.... Transmission measuring set, i.e. for measuring loss or level in dBm.

V.F. ..... Voice frequency or audio. Often used with reference to the connections between exchange and carrier equipment, (e.g. V.F. line).

Abbreviations relating to the decibel

dB = decibel = 10 $\log_{10}$ of ratio of two powers = $10 \log_{10} \frac{P1}{P2}$

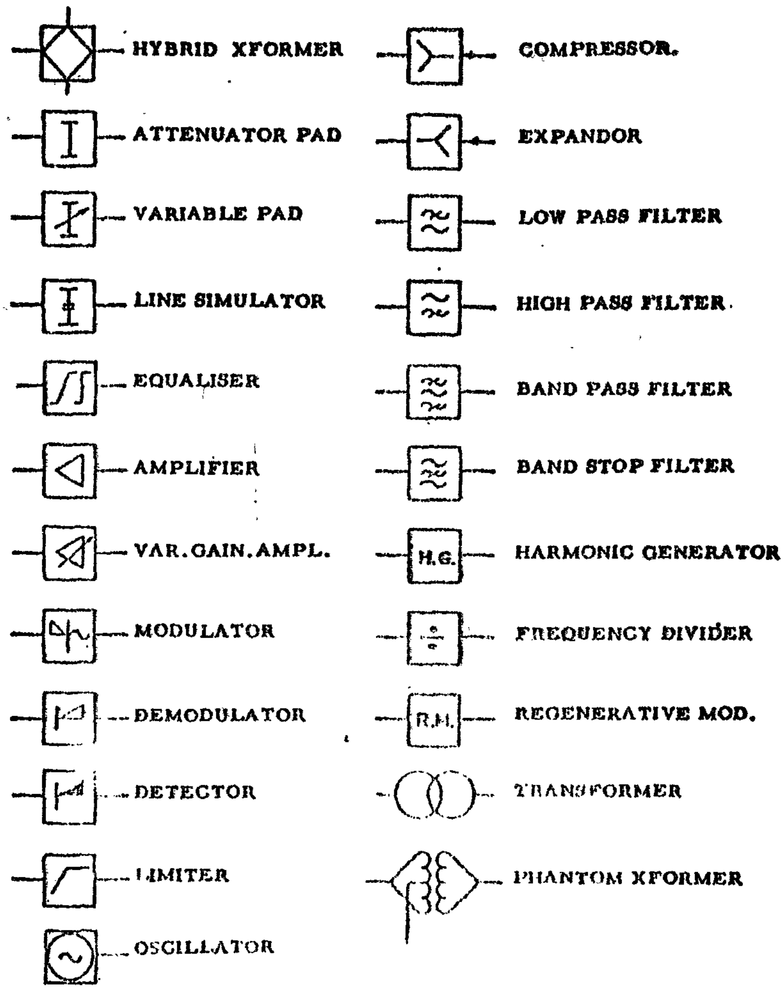
dBm = Level in dB relative to a fixed power of 1 milliwatt i.e. OdBm equals 1 milliwatt into the given impedance

dBr = Level in dB relative to the instantaneous level of incoming speech at the 2-wire V.F. point. If the nominal 2-wire level is OdBm then dBr = dBm for line-up purposes.

dBmO = Level of some steady signal (such as pilot or signalling tone) at a given point compared with the equivalent of a V.F. test tone at the same point. E.g. if at some point the signal level due to an incoming V.F. test tone is -37 dBm while the pilot level is -57 dBm, then the pilot level is said to be -20 dBmO.

BLOCK SCHEMATIC SYMBOLS

X191



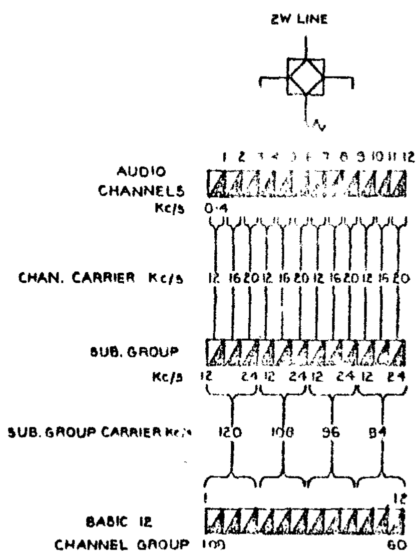
FREQUENCY TRANSLATION

Modulation Processes

The accompanying diagram illustrates the manner in which up to 12 audio speech channels are progressively translated to their final positions in the line baseband.

The basic channelling equipment which carries out the initial two stages of modulation will first be described.

X 101



Basic Channelling & Signalling

Ref drg ES64-4311 & 4087

Frequency translation from the audio band to the group baseband 60-108 Kc/s is achieved by a two-stage modulation process; this reduces the number of different types of modem unit required and permits the use of relatively simple and robust L/C band-pass filters.

In the first stage, three channels are assembled to form a 'sub-group', by modulating carriers of 12, 16 and 20 Kc/s respectively and selecting the resultant upper sidebands which cover the range 12-24 Kc/s.

In the second stage, four of these sub-groups are used to modulate carriers of 84, 96, 108 and 120 Kc/s respectively. Selection of the lower sidebands produces the basic group band of 60-108 Kc/s.

The reverse process is carried out in the receive direction of transmission to recover the 12 audio channels from the basic group baseband.

Channel Transmit Path

Taking any given channel: the incoming speech signals from exchange are fed via the 4W TRANS access links to the input circuit of the relevant channel modem unit. The input circuit consists of an arrangement of pads whereby the nominal level of signals (test tone level) is set to -17 dBr at the input to the limiter amplifier which follows. This is achieved by means of a fixed 13 dB pad, (which may be strapped either in or out of circuit), followed by a pad holder AP6 which may contain any required value of pad unit or which may be by-passed altogether. (E.g. for a -4 dBr input, the 13 dB pad would be strapped in circuit and AP6 would be by-passed). All the channel modem units on the rackside will usually be factory set to accommodate the 4W input level quoted by the customer.

The limiter amplifier is designed to act as a linear amplifier for all signals up to +4 dB above nominal input level. Signals above this level are clipped so that the output from the limiter can never exceed +8 dB above nominal speech level. This feature ensures that overloading of subsequent circuits cannot occur due to excessive incoming speech level.

The output from the limiter is confined within the band 0-3.4 Kc/s by means of a low-pass filter and then passed through a hybrid network where the signalling tone is injected into the transmit path when required. The speech and signalling channels share a common path from this point on.

The signals are fed through the channel modulator, which is also supplied with a carrier of 12, 16 or 20 Kc/s as appropriate and the resultant sidebands pass via a 0-3 dB adjustable attenuator to the equalised channel band pass filter which selects the required upper sideband. This filter also suppresses the equivalent of audio frequencies below 300 c/s, and has an attenuation peak 175 c/s below the carrier frequency in order to reject signals which might otherwise interfere with the signalling tone in the adjacent channel.

The outputs from the three channel band-pass filters forming a sub-group are commoned and taken via the SUB GRP TRANS IN access links to the sub-group modulator at a level of -34 dBr in 600 ohms unbalanced.

The applied signals in the range 12-24 Kc/s modulate one of the sub-group carriers (84, 96, 108 or 120 Kc/s) and the resultant lower sideband is selected by a suitable low pass-filter. A 0-3 dB adjustable attenuator which follows, allows the over-all level of each sub-group to be adjusted individually as required.

The inverted lower sidebands of each sub-group are next fed to a combination of hybrid transformers which serve to combine them to form a complete 60-108 Kc/s basic group. The use of the hybrid networks prevents interference between sub-groups at the combining point.

The over-all level is now raised by a fixed gain 20 dB amplifier and the output passed via a 60-108 Kc/s band-pass filter to the G.D.F. via the CHAN EQPT OUT access links at a level of -37 dBr in 75 ohms unbalanced.

Channel Receive Path

The incoming 60-108 Kc/s group baseband is received via the CHAN EQPT IN links at a nominal level of -8 dBr in 75 ohms unbalanced. The signals pass via a 60-108 Kc/s band-pass 'cleaning-up' filter and a 10 dB isolating pad to the receive hybrid networks. These hybrids distribute the input to the four sub-group stages.

Each sub-group demodulator is preceded by a 0-7 dB level adjustment attenuator and a low-pass filter which selects the required portion of the sideband input. The resultant lower sideband from the demodulation process is selected by a 24 Kc/s low-pass filter and raised in level by a 30 dB fixed gain amplifier to a level of -10 dBr in 600 ohms unbalanced at the SUB GRP REC access links.

The signals are then fed to the paralled inputs of the four channel receive band-pass filters. The selected portion of the band is fed to the appropriate channel demodulator and the resulting sideband output passed through a hybrid circuit in the associated signalling unit where the signalling tone is extracted by a suitable filter. The speech sidebands then pass back to the channel modem unit where the lower sideband resulting from the demodulation process is selected by a 3400 c/s low-pass filter. This filter ensures adequate suppression of vestiges of the adjacent channel, carrier leak, and upper sideband.

The output level is raised by an amplifier having a maximum gain of 36 dB. This amplifier is fitted with an input potentiometer (operated by a movable link on the front face of the unit) which enables the gain to be reduced up to 10 dB from maximum in 1 dB steps. A pad holder AP39 is wired in series with the output and is normally by-passed but can, if required, be fitted with a suitable level dropping pad where a nominal output level below +4 dBr is required.

Pilot Stop Filters

The transmission paths of sub-groups 2, 3 and 4 on the send path and sub-group 2 on the receive path are completed via a by-pass card CMB 40943/12. This card, or one similar, is fitted as a standard item on basic channelling equipment and appears between the sub-group modem and combining circuits.

When required, one or more filters may be fitted in place of the loops as required; e.g. an 84.08 Kc/s stop filter may be required in sub-group 2 receive path to prevent an incoming 84.08 Kc/s group reference pilot from causing interference with the out-of-band signalling tone on channel 6. In this case the by-pass card is replaced by a card unit which mounts the required filter for sub-group 2 and also completes the other paths.

Signalling Circuits

A signalling tone of 3.825 Kc/s is supplied from the carrier generating equipment and is connected to the inputs of all the signalling static relays - one of which is associated with each speech transmit path. A static relay is switched 'on' by an earth extended over the associated signalling send leg (M wire) from the local exchange, thus allowing signalling tone to be injected into the associated speech channel outside the normal speech range but within the 4 Kc/s channel allocation.

The signalling tone passes through the system in the same way as a V.F. tone from the same channel and is detected at the receiving terminal to operate a dry-reed relay which extends an earth loop over the signalling receive leg (E wire) to the distant exchange. The level of the tones throughout the common transmission paths is -5 dBmO for high level working or -15 dBmO for low-level working.

The system can be adapted to ringdown signalling by means of the inbuilt ringdown relay sets which cause incoming low-frequency ringing current to operate a relay which in turn, extends an earth over the relevant signalling send leg as before. In the receive direction, the signalling detector relay is caused to switch a local ringing supply onto the exchange line. Thus, L.F. ringing can be made to pass between exchanges in either direction via the intervening carrier equipment.

V.F. Terminations & Ringdown Relays

Two transformers forming a hybrid, together with associated capacitors and terminating resistors, are available for each channel fitted and these are used to provide 2-wire to 4-wire conversion operating in a 600 ohm circuit. The hybrid also permits injection of low frequency signalling (17 or 25 c/s) over the 2-wire line or d.c. signalling over each leg of the 2-wire line and earth. Strap connections permit the hybrid balance winding to be terminated internally or externally.

Ringdown relay sets, two per card unit, are available for each channel fitted. These provide facilities for the conversion of ringdown signalling between exchange or switchboard 2-wire line and the transmit and receive legs of the out-of-band signalling circuit. Where the relay sets are omitted from the rack, they are replaced with by-pass units CMB 40943/11 to maintain circuit continuity.

Load Simulators

Where for reasons of economy one or more channel units are deleted from a working sub-group, a simulator card CMB 40967/1 is fitted in place of each missing unit. This simulator merely provides the carrier supply with a 62 ohm load equal to that of the unused modem. A similar card CMB 40967/2 is fitted in place of each signalling unit removed to maintain the correct load on the signalling tone source.

Ref. Drgs. ES64-4573 and 4574

Note: Facilities are provided for combining the basic group (or part thereof) produced by the present rackside with that of an external group already transposed to 6-54 Kc/s. By this means a fully equipped rackside CMR 10180/1, when combined with an external group, produces a line band extending from 6-108 Kc/s. In the reverse direction a similar band would first be divided into 6-54 Kc/s and 60-108 Kc/s sections, the 6-54 Kc/s being handled by external equipment and 60-108 Kc/s demodulated in the present rackside.

In the present application all three CMR 10180/1 racksides are sub-equipped. In addition to being sub-equipped the external group facilities are not at present required; 75 ohm terminations have therefore been fitted in order to maintain hybrid balance.

At terminals "A" and "C" only Channels 7 to 12 are required and these result in a line band of 60-84 Kc/s instead of 60-108 Kc/s. This line band is developed in the channelling equipment, channels 1 to 6 being omitted by deleting the six channel units, their associated signalling, 2W/4W terminating and ringdown relays. The following are also deleted:-

84-96 and 96-108 Kc/s sub-group units, the sub-group combining unit, the 108 and 120 Kc/s sub-group carrier amplifiers and the pilot injection units.

At terminal "B" two sets of channelling and group equipment are installed, one facing terminal "A" and one terminal "C". (See Drg. ES64-4374). Both sets are identical and are sub-equipped to provide line bands of 60-84 Kc/s equivalent to Channels 7 to 12. As in the case at terminals "A" and "C" the facility for adding an external 6-54 Kc/s is provided for but being unused at present 75 ohm terminations have been fitted.

The circuit description is as follows:-

(a) Terminal "A" (Transmit Path) Drg. Ref. ES64-4373 and 4374

Output from the rackside's channelling equipment (60-84 Kc/s at present) arrives at tags SK1/6 c-d (GP EQMT TRANS IN) at -37 dBr. From this point it is extended to a hybrid and where it could be combined with the 6-54 Kc/s external group which would pass to the hybrid via SK1/9 c-d/a-b, a 54 Kc/s low-pass filter and an equaliser. The output from the hybrid is applied to a 30-42 dB amplifier. Next follows a level adjustment pad after which the line band leaves the equipment at SK1/2-3 (SYSTEM OUT) at a nominal level of -10 dBr. If terminal "A" assumes control a 60 Kc/s pilot is applied at -20 dBm at SK1/18-19 (PILOT IN) the pilot level being reduced to -15 dBm0 at the point of injection.

(b) Terminal "A" (Receive Path) Drg. Ref. ES64-4373 and 4374

Incoming signals arrive from radio at a nominal level of -30 dBr with the sync pilot (if used) at -45 dBm i.e. -15 dBm0. The line band at present will occupy 60-84 Kc/s but if the rackside was fully equipped and designed to carry the external group it would then extend from 6-108 Kc/s. In any event the incoming signal enters the rackside at SYSTEM IN/SK2/2-3 and is applied to a hybrid which is used to separate the 60-108 and 6-54 Kc/s bands if two groups are being handled. In the present circumstances one outlet from the hybrid is extended to SK2/9 a-b and being unused is terminated in 75 ohms. (Between the hybrid outlet there is a matching transformer and a 54 Kc/s low-pass filter which would normally be used to accept the 6-54 Kc/s band). The second outlet from the hybrid is applied to a level adjustment pad and thence to a 60 Kc/s high-pass filter by which the 60-108 Kc/s band or part thereof is accepted. From this filter the selected band is amplified after which the incoming 60 Kc/s pilot (if Terminal "A" is not control) is separated from the rest of the band which is passed to the channelling equipment at -8 dBr via SK2/6 a-b/c-d (GP EQMT REC OUT). Assuming an incoming pilot is received it will be raised to -28 dBm prior to being extended via SK2/18-19 (SYNC PLT REC) to the synchronising equipment on the frequency generator.

(c) Terminal "C" (Transmit Path)

Exactly the same arrangement obtains at terminal "C" as at "A" and the description in sub para (a) applies equally well.

(d) Terminal "C" (Receive Path)

Exactly the same arrangement obtains at terminal "C" as at "A" and the description in sub para (b) applies equally well.

(e) Terminal "B" (Transmit Path) Ref. Drgs. ES64-4573 and 4574

At this station two identical sets of group equipment are installed on the CMR 10180/1 rackside and operate in exactly the same way as at Terminals "A" or "C" and as described in sub para (a).

(f) <u>Terminal "B"</u> (Receive Path) Ref. Drg. ES64-4573 and 4574

Two identical sets of receive path equipment are installed and are operated in exactly the same way as at Terminals "A" or "C" as described in sub para (b).

FREQUENCY GENERATION

Ref drg ES64-4475

The frequency generating equipment provides all the necessary carrier frequencies for the translating equipment mounted on the rackside, together with the line pilot and out-of-band signalling tone. Spare outlets at all frequencies are available.

The frequencies supplied are as follows:-

Channel carriers	12, 16 and 20 Kc/s
Sub-group carriers	84, 96, 108 and 120 Kc/s
Sync Pilot	60 Kc/s
Signalling tone.............	3.825 Kc/s.

Derivation of Frequencies

All the frequencies, with the exception of the 3.825 Kc/s tone, are derived by arithmetical processes from a 12 Kc/s master source. This source consists of a highly stable crystal controlled oscillator CMM 20002, the crystal being enclosed within a thermostatically controlled oven. By this means, a long term frequency stability of at least 4 parts in 10^6 per month is achieved.

The various frequencies are derived from the 12 Kc/s source by circuits which carry out the four primary arithmetical operations of addition, subtraction, multiplication and division.

Frequency addition and/or subtraction is carried out by feeding the two frequencies concerned into a balanced ring modulator, one as 'carrier' input, the other as 'signal' input. The F1 + F2 and F1-F2 sidebands are then selected by suitable filtration.

Frequency multiplication is carried out by means of harmonic generators in which odd harmonics of the fundamental input frequency are produced by saturated iron cored inductors. Even harmonics are obtained from diode rectifier networks. Filtration is employed to select the required harmonics.

Frequency division may be achieved by means of one or more bistable circuits in tandem, each performing a $\div 2$ function.

Where the fundamental frequency is to be divided by an odd number a regenerative modulator is used (see later in this section).

12 Kc/s Channel Carrier:

This is a direct output from the 12 Kc/s master oscillator.

16 & 20 Kc/s Channel Carriers:

A regenerative modulator (CMM 20008) is used in which the 12 Kc/s input is used to 'lock' a 4 Kc/s L/C oscillator. The output of this oscillator is passed through an 'even' harmonic generator and the fourth harmonic is selected to provide the 16 Kc/s output. The second harmonic at 8 Kc/s is added to the 12 Kc/s input via a ring modulator to provide the 20 Kc/s output after suitable filtration. The difference frequency output of the modulator (12-8=4 Kc/s) is fed back to the input of the 4 Kc/s oscillator to complete the regenerative loop.

84, 96, 108 Kc/s Sub-group Carriers.

These are the 7th, 8th, 9th, and 10th harmonics respectively of 12 Kc/s and are selected by sharply tuned filters from the 'odd' and 'even' outputs of harmonic generator CMA 30034.

60 Kc/s Pilot.

This is the 5th harmonic of 12 Kc/s and is selected by a sharply tuned filter from the 'odd' output of harmonic generator CMA 30034.

3.825 Kc/s Signalling Tone:

This is generated by a separate crystal controlled oscillator CMA 30007.

<u>Carrier Amplifiers</u>

Each generated frequency is raised to the required level by means of a tuned amplifier having an adjustable input attenuator to permit each carrier supply to be maintained at the correct output level.

Auxiliary outlets are available on most of the amplifiers but these are all unused.

All carrier amplifier cards carry a pair of test sockets on their front edge. The upper pair lavelled 'TEST IN' form a 75 ohm level measuring point at the output from the relevant supply filters. A 180 ohms series resistor is included to prevent an accidental short circuit when testing, this has the effect of causing most types of medium impedance test meters to read up to 1dB less than true carrier level. A high impedance meter should therefore be used if available.

The 'TEST OUT' socket is a standard reference test point arranged to give a reading of -10dBm on a test meter set to 600 ohms loss (i.e terminated by 600 ohms) when the input attenuator on the amplifier has been correctly set. The -10dBm reading indicates that the amplifier is supplying its distribution circuit at the correct level.

Frequency Distribution

The main output from each frequency supply amplifier is connected to a distribution network. These networks are designed to reduce interference between transmission paths, via the common carrier source, by arranging for the distribution networks to have an impedance of 75 ohms and feeding from amplifiers having a much lower impedance, this also ensures good regulation.

The supplies required for the rack equipment are connected through to their injection points via the rack wiring. The spare outlets are connected to shelf end tagblocks and are available for use with external equipment when required. Each outlet on the distribution card has an associated terminating resistor strapped into circuit to maintain a constant load impedance on the generator source, this resistor must be disconnected whenever an outlet is brought into use.

<u>POWER SUPPLIES</u>

The power supply equipment mounted on the rackside, for a.c. operation, consists of a power input panel, mains transformer(s), and power supply unit. For d.c. operation, an external dc/ac converter is required.

The power supply circuitry is designed to cater for the following requirements, operating from an a.c. input voltage in the range 100-125 or 200-250 volts at 45-60 c/s. The total power consumption is approx 100 watts.

(a) 24v a.c. for feeding the master oscillator oven heater and the soldering iron socket. Max load approx 2 amps.

(b) 20v d.c. unsmoothed to supply any ringdown relays etc. Max load approx 250 mA.

(c) 12v d.c. regulated, from five main fused outlets to supply all transistorised circuits. Max load 2.2 amps.

(d) 5v & 1v bias supplies for the channel limiters. Derived from the main 12v regulated supply.

(e) Optional 75v ringing supply at half mains frequency.

The supply to the rackside should be on a ring-main basis, the supply cable being passed through the rack via 2 inch dia holes in the lower part of the side member. The cables are terminated on the special 'live' and 'neutral' connector block mounted on the power input panel using an insulated box-spanner. The connector allows work to proceed without the necessity for disconnecting the supply to all racks fed from the 'ring main' loop.

A fused power socket is mounted on the input panel for supplying external equipment, in addition a fused 24v a.c. socket is provided for feeding a low voltage soldering iron.

A single pole switch SA connects the a.c. input, via an anti-surge fuse to the primary of the power transformer which is suitably tapped in 5 volt steps. The transformer is bolted to the bottom plate of the rack with its terminal plate facing forward.

Access is gained by unscrewing the four bolts holding the power input panel and pulling the panel clear on the end of its flexible connecting cables. The strap connections required for operation on any given mains supply voltage, in the ranges 100-125v and 200-250v, are given in the chart in the commissioning section.

As shown on the supply and fusing diagram X 332/1, the 24v a.c. supply is derived from a secondary winding on the mains transformer,. the 20v unsmoothed d.c. is derived from a separate winding and a full-wave bridge rectifier which forms part of the power supply unit CMB 40907/3. The 12v regulated d.c. supply is derived from a 22-0-22v centre tapped secondary on the mains transformer and undergoes full-wave rectification and smoothing in the power supply unit which also includes a transistorised voltage stabilisation circuit. The 5v and lv bias supplies are obtained from potential divider networks placed across the main 12v stabilised supply.

Ringing and ringer start facilities are normally taken from station supplies and should be connected to the installers tagblock at the end of the power supply shelf. If inbuilt ringing supplies are required, facilities are available for mounting an auxiliary transformer and a half-mains ringing supply unit CMA 30206. The auxiliary transformer (T2) provides a 75-0-75v output, when fed from the 125v tappings on the mains supply transformer (T2), this is 'chopped' at half-mains frequency by the action of the ringing supply unit which also provides a 'ringer start' facility to switch on the ringer current as it is required.

Fuses:

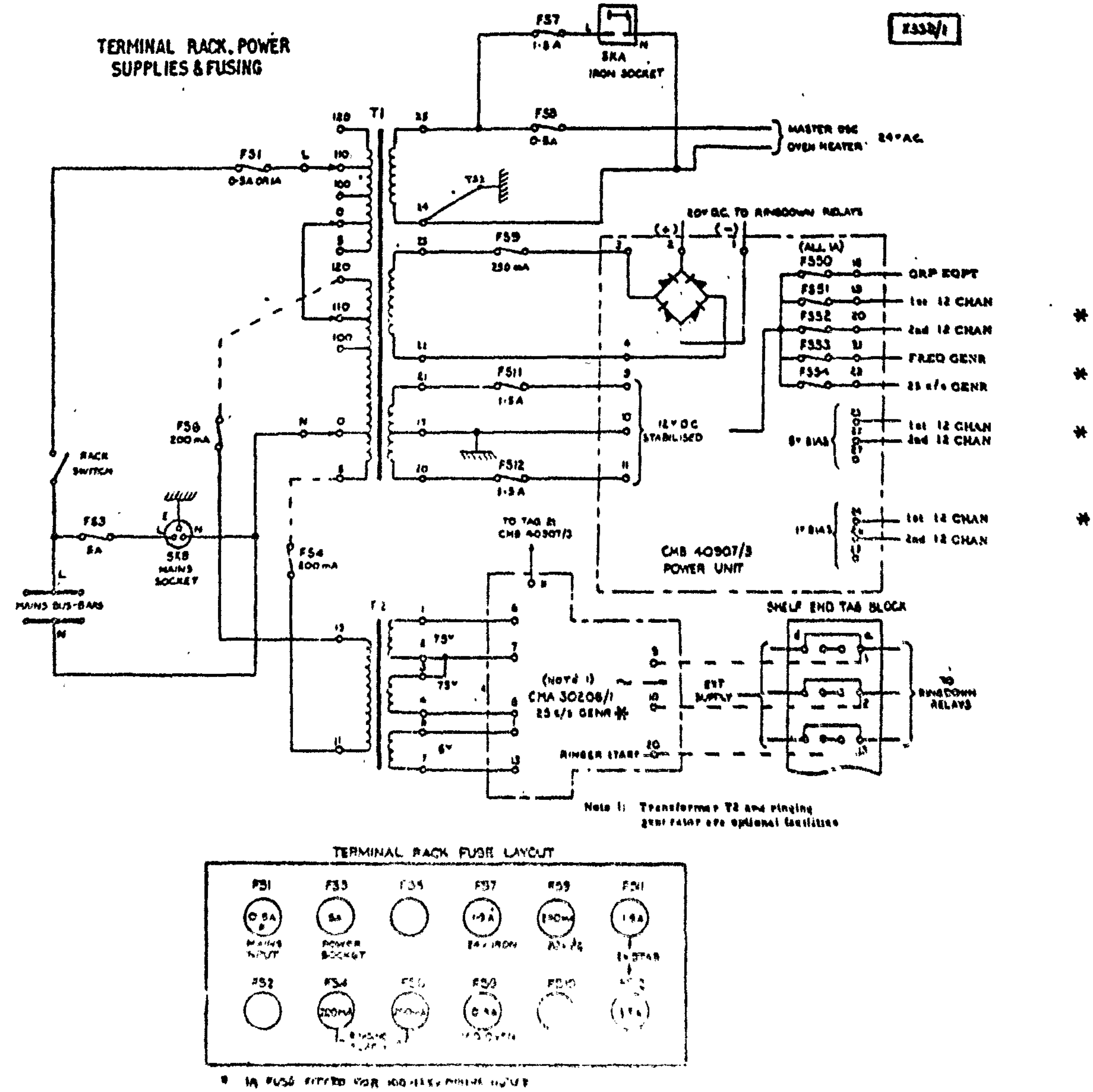
Access to the cartridge type fuses can be gained by removing the front cover of the power input panel, this is held in place by two coin operated fasteners. Similar cartridge fuses are mounted on the power supply unit CMB 40907 and serve to provide a separate 12v outlet to each section of the rack equipment.

The current rating of the cartridge fuses is indicated by a coloured spot which appears on the fuse itself and next to the relevant fuse holder. The colour code used is as follows:-

5A	Black & White	1.0A	Dark Blue	150 mA	Red
3A	White	500 mA	Yellow	100 mA	Grey
1.5A	Light Blue	250 mA	Brown	60 mA	Black

Power Supply & Fusing

Typical 24-Channel Rackside



**** NOT APPLICABLE TO THE PRESENT RACKSIDE**

Carefully unpack the rackside and examine it for possible damage sustained in transit, then ensure that all units are pushed securely into their jack sockets.

Test the floor mounting area, using a spirit level. If necessary remove any surface irregularities either by use of a plane on wood floors, or by means of suitable packing pieces on concrete floors. When satisfied that the floor surface is true, drill holes for the coach screws by which the base of the rackside will be secured.

Move the rackside into its alloted position and secure tie-bars to it. After confirming that the rack is vertical, tighten down the coach screws.

For fuller details of use of tie-bars, screw sizes and preferred methods of making-off cable ends refer to the Installation Bulletin OB7013, a copy of which is usually available at each terminal.

Before proceeding with the cabling operation reference should be made to the relevant rack wiring (TC) diagrams to obtain any required information about the termination points of all equipment. The code numbers of these diagrams are listed on the CMW drawings. Note that SK1 is the left-hand installers block and SK2 the right-hand block.

Power Supply Cabling Wire to Drg. No. TC 255230

Use 3/0. 036 inch PVC insulated cable.

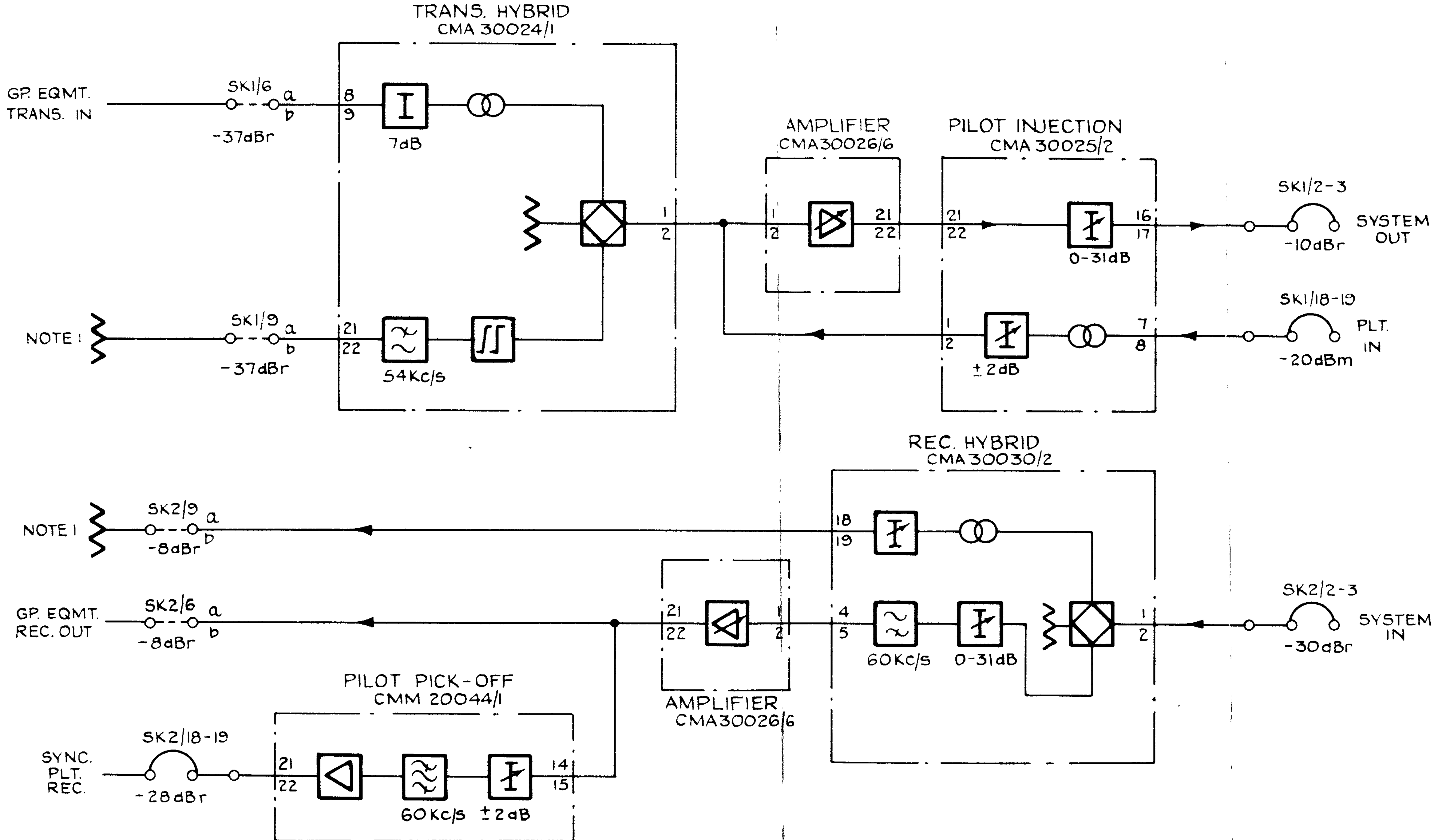
'Live' lead to	'L' busbar on power input panel			
'Neutral' lead to ..	'N' "	"	"	"
'Earth lead to	TS2/1"	"	"	"

Connect station earth to rack earth lug on top member of rack frame using 7/0. 036 inch bare tinned copper wire.

ROUTE DIAGRAM (RADAR LINK CIRCUITS)

ES64-4574 ISSUE. I.

GROUP EQUIPMENT
ES64-4573
ISS. I.



NOTES

1. UNUSED CIRCUITS TERMINATED IN 75Ω
2. ON ASS1 TWO SETS OF GROUP EQMT ARE FITTED

BASIC 12 CHANNEL SIGNALLING THROUGH CIRCUIT SCHEMATIC ES64-A/4087

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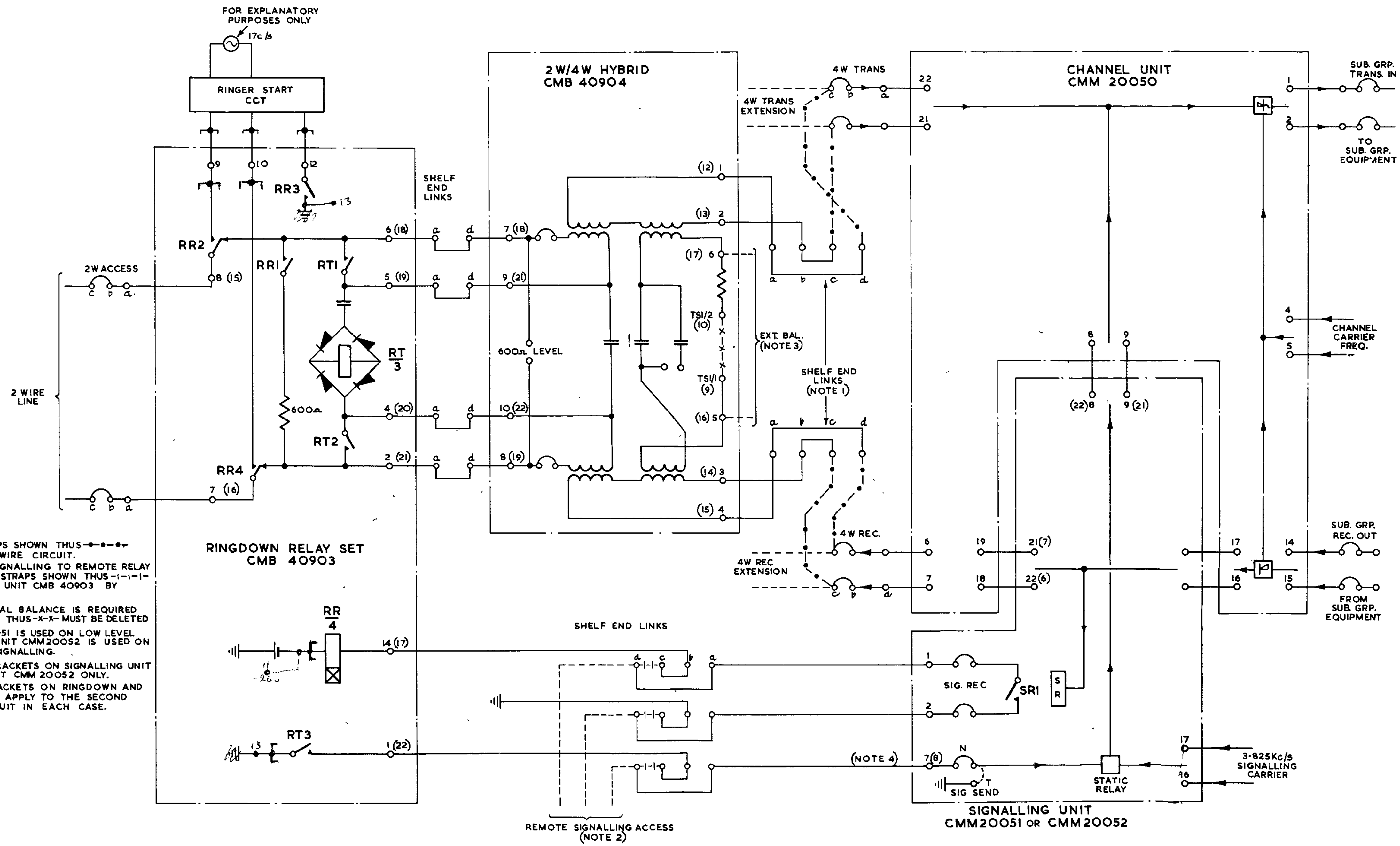
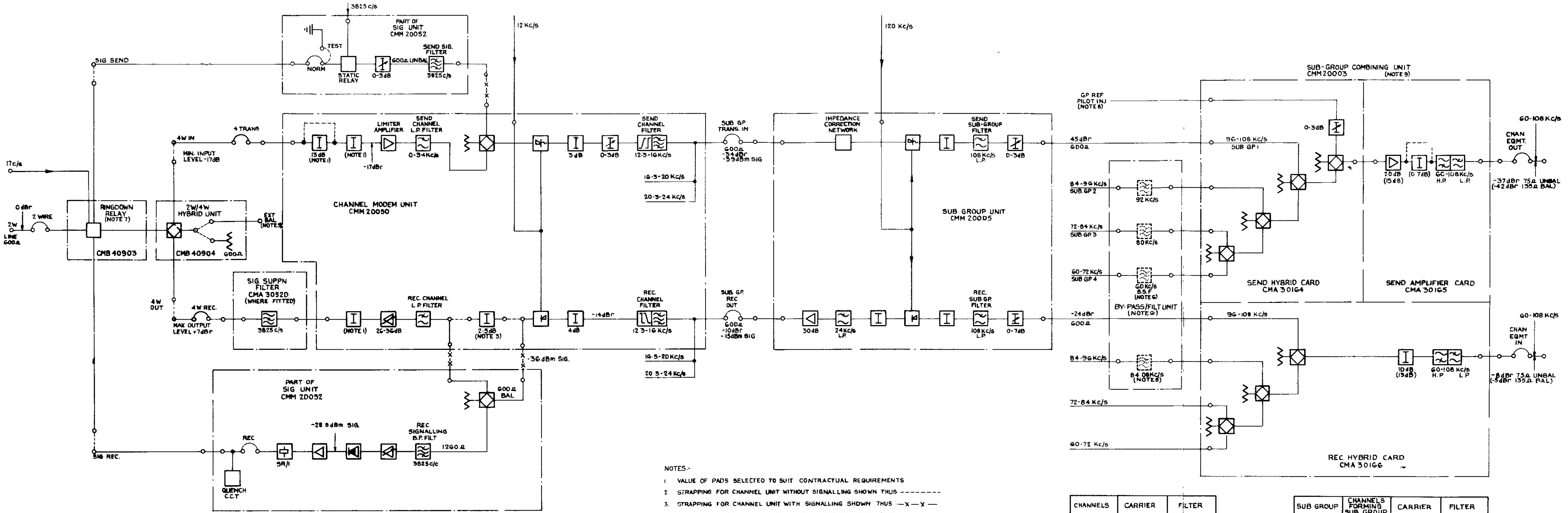


NOTES

1. DELETE STRAPS SHOWN THUS -•-•-•- TO EXTEND 4 WIRE CIRCUIT.
2. TO EXTEND SIGNALLING TO REMOTE RELAY SETS DELETE STRAPS SHOWN THUS -I-I-I- AND REPLACE UNIT CMB 40903 BY DUMMY CARD.
3. WHEN EXTERNAL BALANCE IS REQUIRED STRAP SHOWN THUS -x-x- MUST BE DELETED
4. UNIT CMM20051 IS USED ON LOW LEVEL SIGNALLING. UNIT CMM20052 IS USED ON HIGH LEVEL SIGNALLING.
5. TAG Nos IN BRACKETS ON SIGNALLING UNIT APPLY TO UNIT CMM 20052 ONLY.
6. TAG Nos IN BRACKETS ON RINGDOWN AND HYBRID UNITS APPLY TO THE SECOND SIMILAR CIRCUIT IN EACH CASE.

BASIC CHANNELLING WITH H L SIGNALLING
ES64-4311 FIG 3 ISSUE 3



NOTES:-

1 VALUE OF PADS SELECTED TO SUIT CONTRACTUAL REQUIREMENTS
2 STRAPPING FOR CHANNEL UNIT WITHOUT SIGNALLING SHOWN THUS --------
3. STRAPPING FOR CHANNEL UNIT WITH SIGNALLING SHOWN THUS —X—X—
4 LEVELS AND IMPEDANCES IN BRACKETS REFER TO ALTERNATIVE A.P.O. AND AMERICAN G.D.F REQUIREMENTS.
5. STRAP AS REQUIRED
6 SUPPRESSION FILTERS FITTED AS REQUIRED
7. OPTIONAL 2W/4W AND RINGDOWN SIGNALLING FACILITIES FITTED IF REQUIRED
8 84·08 Kc/s PILOT FACILITY USED ONLY FOR LARGE STATION PRACTICE
9 WHERE THE ALTERNATIVE A.P.O G.D.F LEVELS ARE REQUIRED, THE THREE SEPARATE CARDS SHOWN WILL BE FITTED IN PLACE OF MULTI-CARD UNIT CMM 20003. THE 0-7dB ATTENUATOR WILL ONLY BE FITTED IN THIS CASE

CHANNELS	CARRIER	FILTER
1,4,7 & 10	12 Kc/s	12·3-16 Kc/s
2, 5, 8 & 11	16 Kc/s	16·3-20 Kc/s
3, 6, 9 & 12	20 Kc/s	20·3-24 Kc/s

SUB GROUP	CHANNELS FORMING SUB GROUP	CARRIER	FILTER
1	1, 2 & 3	120 Kc/s	0-108 Kc/s
2	4, 5 & 6	108 Kc/s	0-96 Kc/s
3	7, 8 & 9	96 Kc/s	0-84 Kc/s
4	10, 11 & 12	84 Kc/s	0-72 Kc/s

ES64-4475

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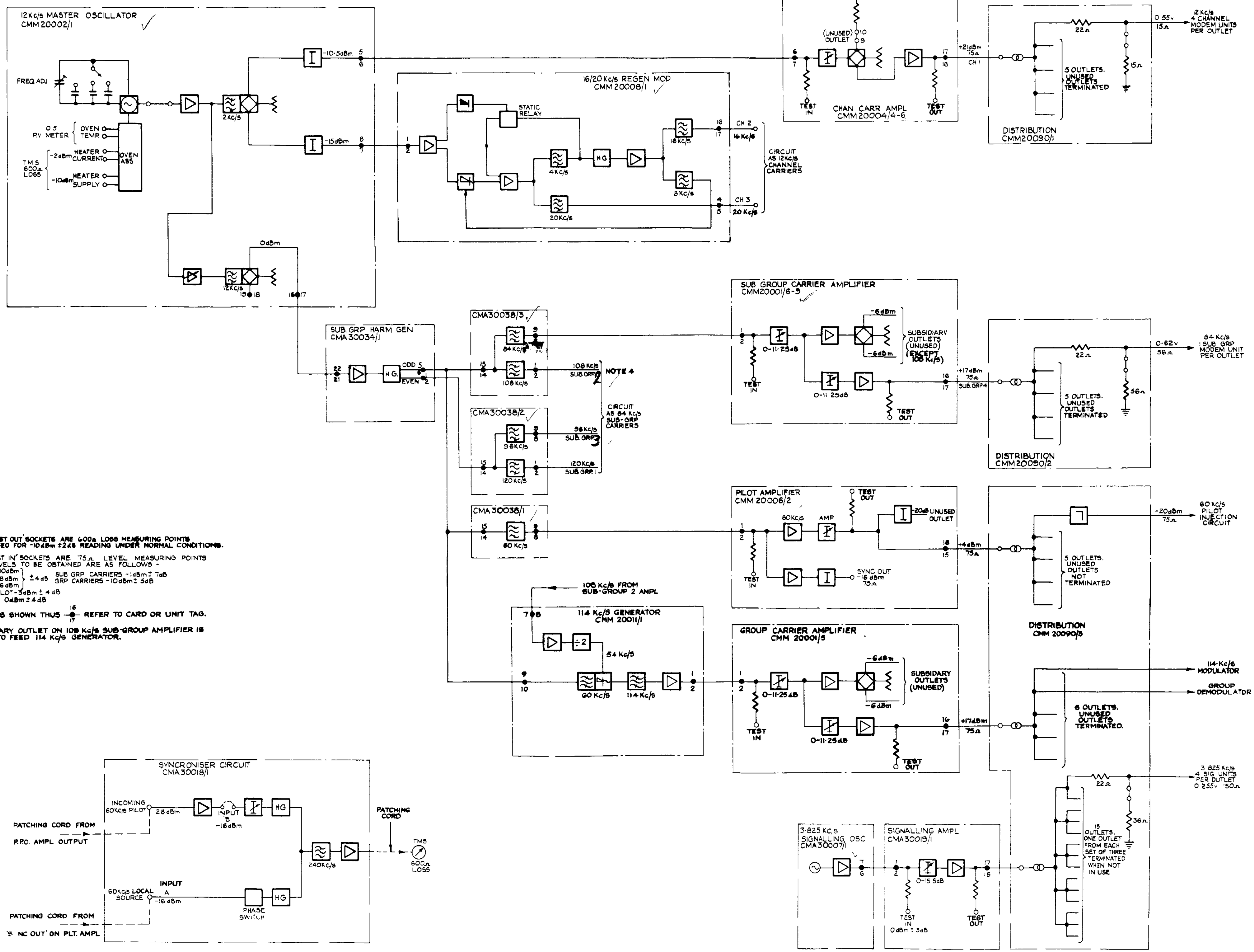
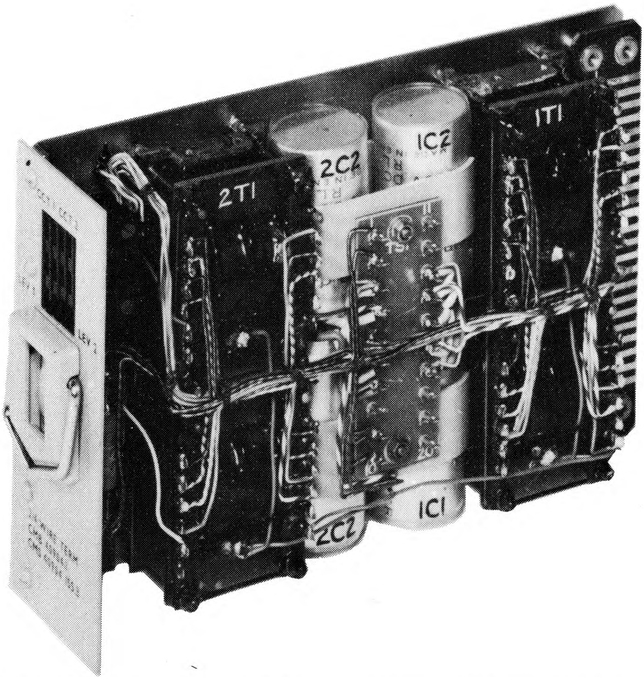


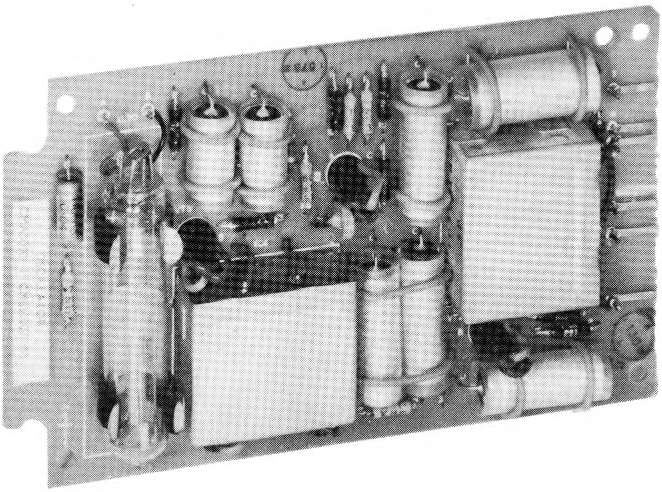
NOTES

1. THE 'TEST OUT' SOCKETS ARE 600Ω LOSS MEASURING POINTS ARRANGED FOR -10dBm ±2dB READING UNDER NORMAL CONDITIONS.
2. THE 'TEST IN' SOCKETS ARE 75Ω LEVEL MEASURING POINTS THE LEVELS TO BE OBTAINED ARE AS FOLLOWS -
   12 Kc/s - 10dBm, 16Kc/s - 8 dBm, 20Kc/s - 6 dBm } ±4dB
   SUB GRP CARRIERS -1dBm ± 7dB
   GRP CARRIERS -10dBm ± 5dB
   60Kc/s PILOT - 3dBm ± 4 dB
   114 Kc/S 0dBm ± 4 dB
3. FIGURES SHOWN THUS —●— (16/17) REFER TO CARD OR UNIT TAG.
4. AUXILIARY OUTLET ON 108 Kc/s SUB-GROUP AMPLIFIER IS USED TO FEED 114 Kc/S GENERATOR.

TYPICAL WIRED & NON-WIRED UNITS



2W/4W TERMINATION UNIT   CMB 40904/1



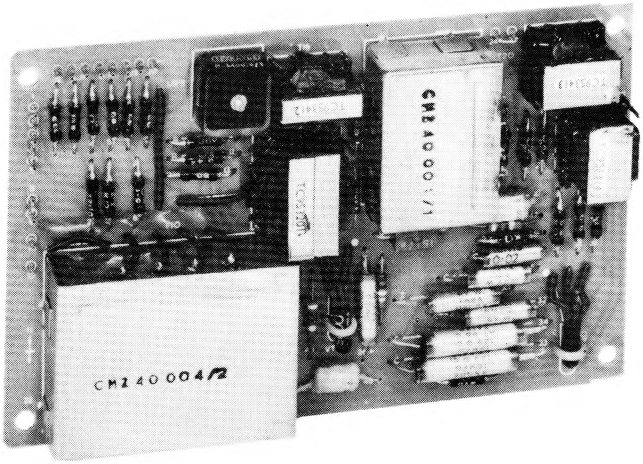
3.825 Kc/s OSCILLATOR   CMA 30007/1

ES64-4442

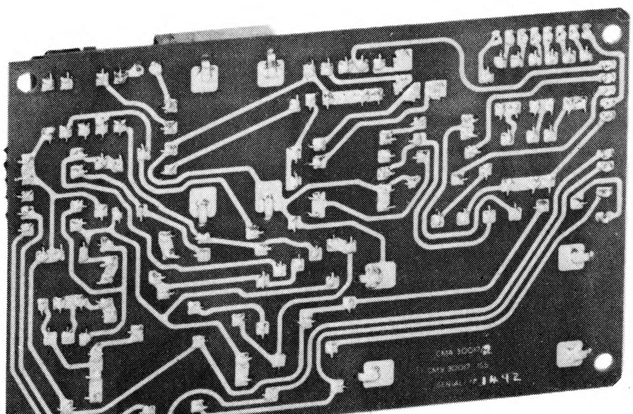
Scale: approx $\frac{1}{2}$ full size

TYPICAL UNI-CARD ASSEMBLY

SUB-GROUP RECEIVE CARD. CMA 30017



COMPONENT SIDE

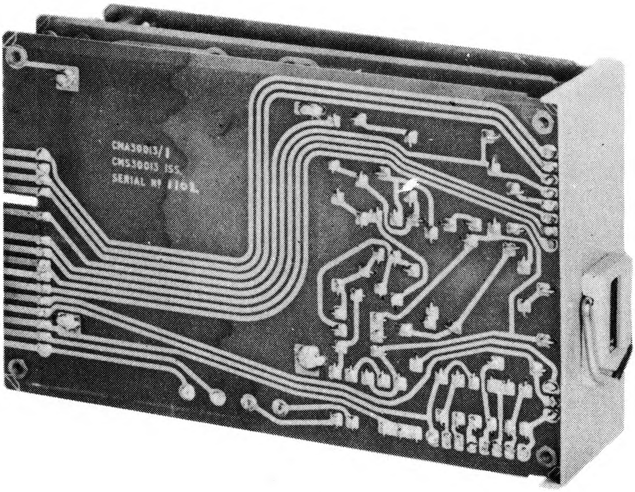


CIRCUIT SIDE

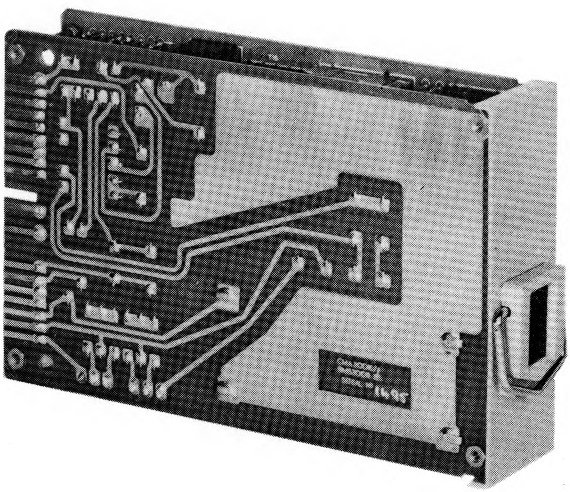
ES64-4441

Scale: approx $\frac{1}{2}$ full size

<u>TYPICAL MULTI-CARD ASSEMBLY</u>



SUB-GROUP COMBINING UNIT   CMM 20003

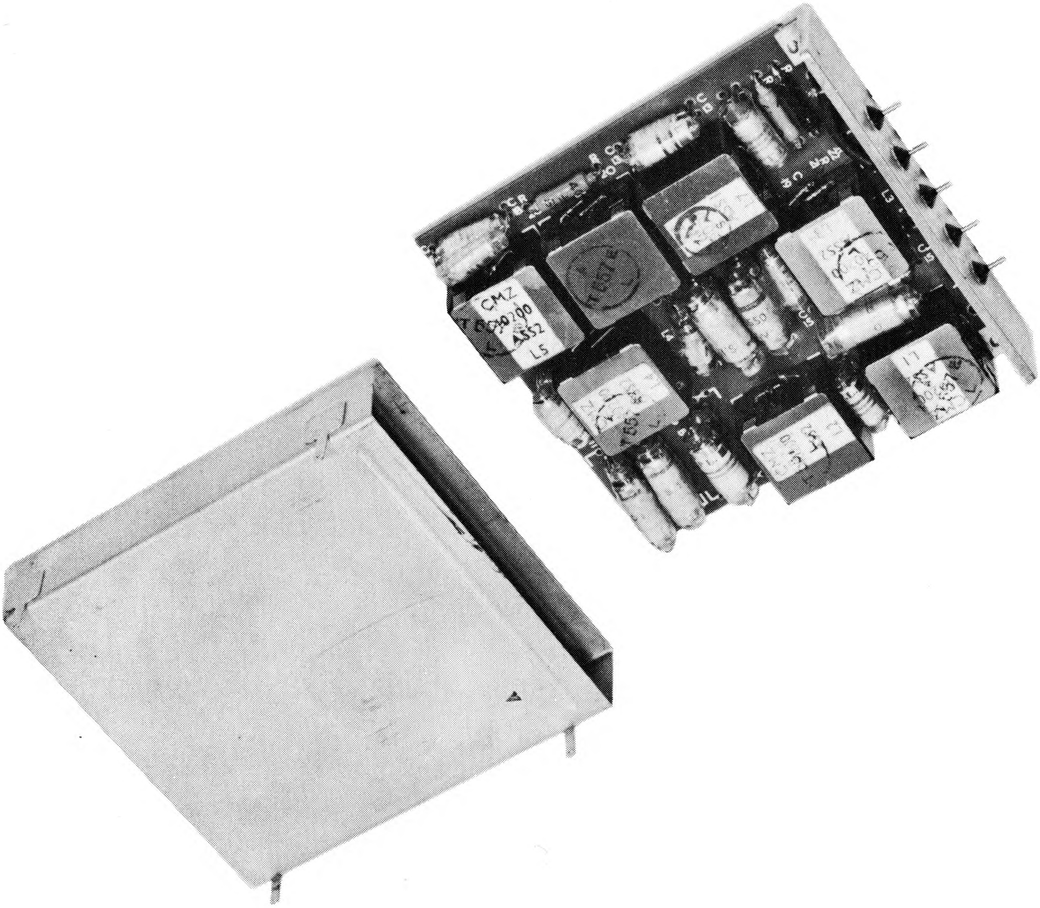


SUB-GROUP MODEM UNIT   CMM 20005

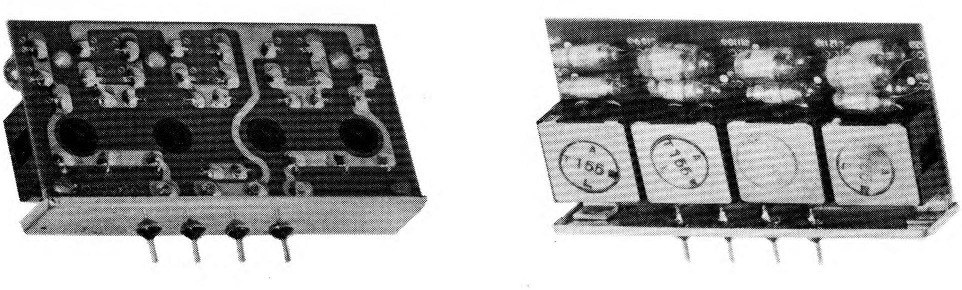
ES64-4443

Scale: approx ½ full size

TYPICAL C.M. FILTERS

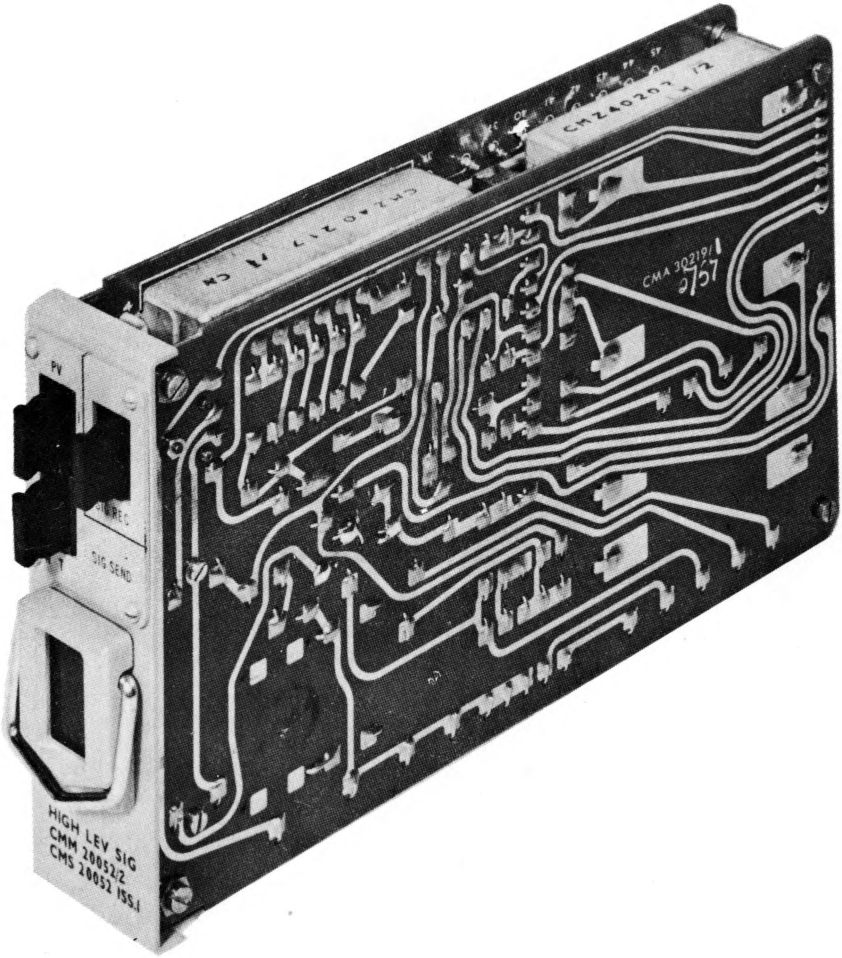


CHANNEL BAND-PASS FILTER CMZ 40200



SUB-GROUP L.P. FILTER CMZ 40000

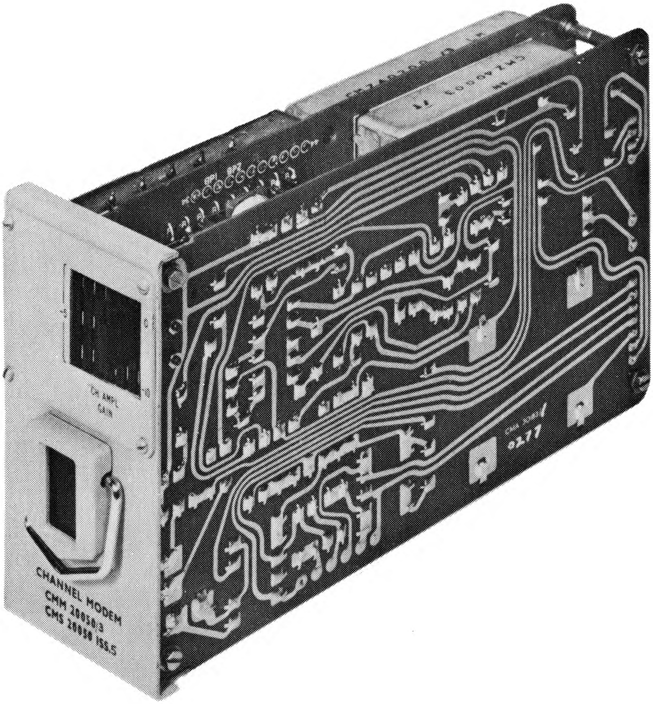
;S64-4444 Scale: approx $\frac{1}{2}$ full size

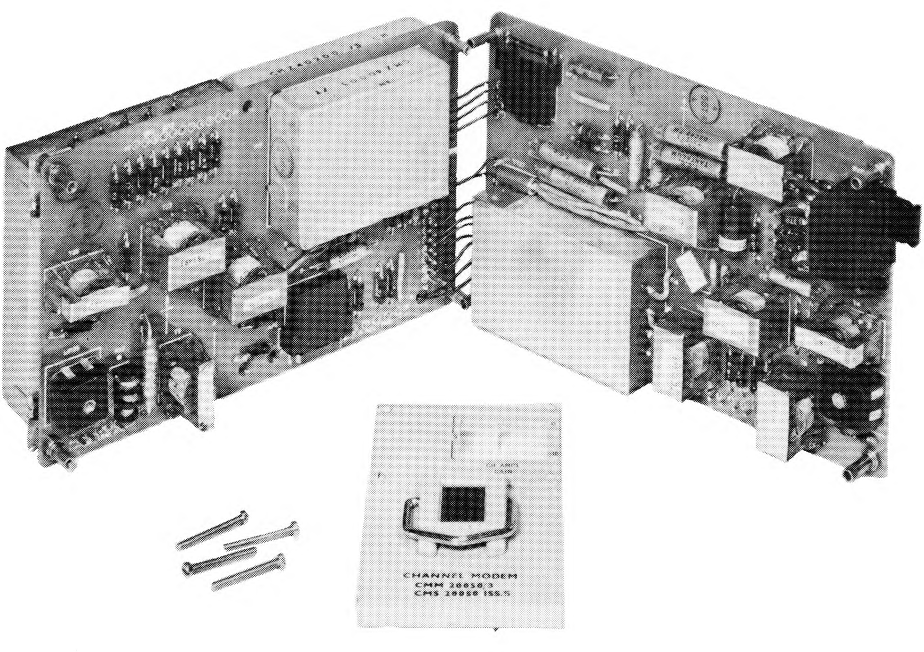


ES64-4447

Scale: approx $\frac{2}{3}$ full size

CHANNEL MODEM UNIT CMM 20050





ES64-4445

Scale: approx $\frac{1}{2}$ full size

COMMISSIONING

The carrier equipment will have been fully tested and adjusted for optimum performance before despatch, hence the commissioning procedure should involve little more than lining up the system to suit the particular route and then checking that its performance meets the required specification. Full details are given of all circuit adjustments which may prove necessary but generally no re-adjustment should be made unless a particular test result falls outside the tolerance quoted here.

System performance tests such as crosstalk, intermodulation, etc. are not described, since the nature and extent of this type of test will depend on the requirement of the administration concerned.

Test Equipment

The following items of test equipment will be necessary.

1. Signal generator 300 c/s - 150 Kc/s. To be used for supplying audio test tones and basic group (60-108 Kc/s) frequencies.
2. Transmission measuring set. To be used for loss and level measurements in the above frequency range and at 50 c/s.
3. 5000 ohm, 1 volt F.S.D. d.c. meter ('P.V' meter).
4. Psophometer (optional item).

Measurement & Testing Conventions

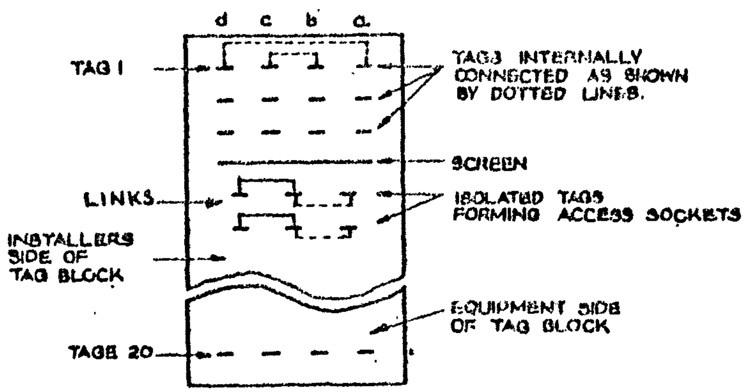
A 'level' measurement is a measurement which does not disturb the circuit under test in any way. It is carried out by bridging the high impedance measuring set across the transmission path at the required point.

A 'loss' measurement is carried out by breaking the transmission path and terminating the end under test in its characteristic impedance.

Note:- There will often be an appreciable discrepancy between a given 'loss' and 'level' measurement due to the tolerance in impedance matching of filters, modulators, etc. For this reason, most of the tests quoted here will be loss measurements, the corresponding level measurements applying only when undertaking routine maintenance checks with the system in traffic.

On the shelf-end test tablets the arrangement of the internal wiring is such that level measurements are always made across the inner pair of access sockets, while loss measurements are made across either the inner or outer pair of sockets, depending upon which is connected to the source of the signal to be measured. The middle and inner pairs of sockets are generally wired together internally.

On translation equipment (channelling, group modem etc) the left-hand test tablets carry transmit path or input connections and the right hand tablets, receive or output connections.



All pairs of test sockets have their 'earthy' or low potential side as the lower or right-hand socket (except power unit test sockets which are reversed to allow for the fact that earth is common positive). Patching cords supplied for use with the equipment have their 'live' side indicated by ribbing on the side of the plug nearest the live pin.

References to gain or loss in a circuit are in decibels, (dB). All absolute levels, (dBm) are with reference to a power of one milliwatt. Levels in dBr are with reference to the test tone level chosen for the 2-wire V.F. point. If this chosen level is OdBm then, for lining-up purposes, dBr = dBm.

Circuit Adjustments

Where adjustable strappings on printed card units require re-setting, care should be exercised when unsoldering existing straps to avoid damaging the terminal tags (which are attached directly to the printed track). A new connection should be made by wrapping the connecting wire $1\frac{1}{2}$ times around the top of its tag and then soldering. If the wire is wound around the base of the tag difficulty may be experienced in removing it for any subsequent re-adjustment. Adjacent tags may be strapped with 25 S.W.G. (0.020 inch) bare tinned copper wire.

Through Path Levels

Unless any special instructions have been received the equipment is lined up in the factory to the levels quoted in the following table. These levels have been assumed for commissioning purposes but may be modified on site to suit local conditions.

2-WIRE LINE	OdBm	600 ohm bal
4W TRANS IN	-4 dBr	600 ohm bal
4W REC OUT	+4 dBr	600 ohm bal
SUB-GP TRANS IN	-34 dBr	600 ohm bal
SUB-GP TRANS OUT	-10 dBr	600 ohm bal
CHAN EQPT OUT (GDF)	-37 dBr	75 ohm unbal
CHAN EQPT IN (GDF)	-8 dBr	75 ohm unbal
SYSTEM OUT	-10 dBr	75 ohm unbal *
SYSTEM IN	-30 dBr	75 ohm unbal *

It should be noted that the impedances marked thus * may be varied by the use of line matching transformers. Equalisers may be added on receive path equipment to obtain a flat response over the line baseband.

Throughout the main transmission paths, 'out-of-band' signalling tones relative to speech sideband signals.

POWER SUPPLIES

(i) Check that the tappings on the primary of the mains input transformer are correctly set for the local supply voltage (see table below). Access to the transformer is gained by unscrewing the four retaining bolts which hold the front of the power input panel CMB 40910 to the rack frame. On drawing the panel forward the transformer tag board will be exposed. Re-connect and solder the flying leads on this tag-board if necessary and replace the panel.

(ii) Switch the rack on (on/off switch on power input panel at foot of rack). Patch a P.V. meter into each pair of numbered sockets on the front face of the power rectifier and stabiliser unit. The readings obtained should all be mid-scale ± 6%, except at test point PV6 where the tolerance is ± 30%. If the readings are outside the tolerances given, re-adjust the tappings on the resistor chain in the stabiliser unit - see drawing CMS 40907.

If any wired test point fails to give a reading, inspect the fuses on the stabiliser unit and on the power input panel, ensure that the cartridge holders are fully screwed home.

MAINS INPUT TAPPINGS

200-250V. MAINS			
VOLTS	STRAP TAG 'L' TO	STRAP TAG 'N' TO	STRAP THESE TAGS
200	8	2	3-7
205	8	1	3-7
210	9	2	3-7
215	9	1	3-7
220	9	2	4-7
225	9	1	4-7
230	10	2	4-7
235	10	1	4-7
240	10	2	5-7
245	10	1	5-7
250	10	1	5-6

100-125V. MAINS			
VOLTS	STRAP TAG 'L' TO	STRAP TAG 'N' TO	STRAP THESE TAGS
100	8	7	8-3, 7-2
105	8	6	8-3, 6-1
110	9	7	9-4, 7-2
115	9	6	9-4, 6-1
120	10	7	10-5, 7-2
125	10	7	10-5, 6-1

Master Oscillator and Crystal Oven Tests

(i) Immediately after the rack is first switched on, connect a transmission measuring set, switched to 600 ohms loss, to the HEATER SUPPLY test socket on the front face of the master oscillator unit CMM 20002. A reading of approx -10 dBm should be obtained thus indicating that the 24v a.c. oven heater supply is correct. N.B:- the meter used must read accurately (or with a known error) at the mains supply frequency.

(ii) Connect the T.M.S. to the HEATER CURRENT socket and note that a reading of approx -2 dBm is obtained, thus indicating that the oven heater winding is drawing the correct current.

(iii) Connect a P.V. meter to the OVEN TEMP socket and note that a deflection of roughly $\frac{3}{4}$-scale is obtained indicating that the oven temperature is below 50°C. Now leave the oven to reach steady operating temperature (approx 30 minutes).

(iv) Re-check the HEATER CURRENT. If the oven has reached normal operating temperature (55°C) it will have commenced to cycle. This will be indicated by the T.M.S. reading falling to zero at regular intervals. The time for one complete cycle (on-off-on) should be from one to five minutes. The ratio between 'on' and 'off' periods will depend upon the ambient temparature; an on/off ratio of 1:3 (1 'on' to 3 'off') would be normal for an ambient temperature of 20°C.

(v) Re-check OVEN TEMP. The P.V. meter should now read approx mid-scale, indicating that the oven temperature lies within the normal operating range (50-60°C). A reading of $\frac{1}{4}$-scale indicates that the oven temperature has risen above 60°C. This is a fault condition and should be investigated. If the guard circuit does not operate - automatically cutting off the oven heater supply, the rack should be switched off to avoid overheating the crystal oven.

Carrier Output Levels

A block fitted with two pairs of test sockets will be found attached to the front edge of each carrier supply amplifier unit.

The upper pair designated 'TEST IN' are used to monitor the amplifier input as a 75 ohm level measurement. The reading obtained at this point will usually be about 1 dB lower than the true level, due to the 180 ohm resistor wired in series with the test point to guard against accidental short-circuit.

The lower pair of sockets, designated 'TEST OUT,' is arranged to give a standard reading of -10dBm on a meter set to 600 ohms loss. Each type of amplifier is arranged to give the same -10dBm reading under normal conditions, irrespective of its normal output level. This socket is used to check the line-up of generating equipment and for routine maintenance tests.

Each amplifier is fitted with an adjustable input attenuator which can be re-set when necessary to maintain the correct output level.

Checks should be made as shown in the following table using a T. M. S. set to 600 ohms loss. Amplifier locations given are for a typical rackside.

FREQ	CODE	POSITION	SOCKET	READING
12 Kc/s	CMM20062/1	KC	TEST OUT	-10 dBm ± 2 dB
16 Kc/s	" /2	KD	"	" "
20 Kc/s	" /3	KE	"	" "
84 Kc/s	CMM20061/1	JD	"	" "
96 Kc/s	" /2	JE	"	" "
108 Kc/s	" /3	JF	"	" "
120 Kc/s	" /4	JG	"	" "
60 Kc/s	CMM20006/2	JJ	"	" "

Should any of the readings fall outside the stated tolerance (but not otherwise) re-adjust the input attenuator of the amplifier concerned, referring to the appropriate circuit diagram to identify strap positions.

Amplifier Input Levels

When all the carrier generator circuits have been checked and re-adjusted where necessary, measurements should be made at each 'TEST IN' socket using a T. M. S. set to 75 ohms level, and the readings thus obtained recorded as a basic for future maintenance work.

The levels measured may depart considerably from the nominal figures quoted on the relevant block schematic diagram due to the accumulated tolerances on the losses of filters, harmonic generators, etc., they will however be of considerable assistance in monitoring the long-term performance of the generating equipment.

BASIC CHANNELLING EQUIPMENT

General

The nominal speech level into each channel limiter requires to be set to -17 dBr in order that the limiter may function correctly. In many cases a level of -4 dBr (corresponding to a level of (OdBr at the two-wire line) will be required and to this end a 13 dB input pad will be found already wired into circuit in each channel modem unit CMM 20050. Where a nominal input level of less than -4 dBr is required, the 13 dB pad is strapped out of circuit and use is made of a special pad holder, designated AP6, into which any required value of pad assembly may be wired. This operation will normally be carried out in the factory when the users requirements are known in advance, but it is important nevertheless to check that all input circuits are set to the requirements of the system before proceeding with any further tests.

Where the input circuits of particular channels are to be altered on site, the following procedure should be followed with each channel unit affected:

(i) Take the 13 dB input pad out of circuit (if necessary) by cutting straps joining tags 24-25 and 27-28 on the send card and strapping tags 23-24 and 26-27.

(ii) Cut strap A-D and B-C on pad holder AP6 (bottom of left-hand card) and slide in the required pad assembly with printed-card side of pad unit facing base-board. Strap outer tags on pad to tags A & D respectively on pad holder, and inner tags on pad to tags B & C. Solder all connections.

Transmit Path

Remove all the 4 WIRE TRANS links and the CHAN EQPT OUT links thus isolating the transmit path of the basic channelling equipment. Check that no signalling tones are being transmitted by ensuring that the send link on the front face of each signalling unit is temporarily removed.

Connect the T.M.S., set to 75 ohms loss, to the inner pair of CHAN EQPT OUT sockets. Apply an 800 c/s test tone at a level of -4 dBm (if this is the chosen 4W input level) to the inner pair of 4W TRANS IN sockets of each channel in turn. The recorded level should be -37 dBm + 1 dB in each case.

Any channel level which falls outside this tolerance may be corrected by means of the adjustable output pad in the channel modem unit concerned (see drg CMS 20050).

If a complete sub-group of three channels (CH1-3 or 4-6, etc) falls outside the tolerance, it may be preferred to adjust the output attenuator of the common sub-group modem unit CMM 20005.

Receive Path

The test tones required for lining up the receive path may be derived from the distant channelling equipment, assuming that all the intervening equipment has already been checked and aligned. However if a suitable signal generator is available, it may be preferred to inject the required frequencies into the receive path directly, by removing the CHAN EQPT IN links and connecting the source to the inner pair of sockets. The frequencies should be applied at a level of -8 dBm in 75 ohms.

Each of the frequencies given in the table is equivalent to an 800 c/s test tone applied at the distant terminal to the channel shown.

Channel	Sideband Freq.	Channel	Sideband Freq.
1	107.2	7	83.2
2	103.2	8	79.2
3	99.2	9	75.2
4	95.2	10	71.2
5	91.2	11	67.2
6	87.2	12	63.2

Measure the output at the relevant inner pair of 4 WIRE REC OUT sockets using the TMS set to 600 ohms loss, with all 4 WIRE REC bridging links removed and with the gain control link on the front face of each channel unit set to maximum gain (zero dB position). Readings should be between +7 and +10 dBm.

If any output falls outside this tolerance, remove the SUB GRP REC links and take a 600 ohms loss measurement at the inner pair of sockets. The level of any channel within the sub-group should be about -10 dBm. It is permissible to re-set the sub-group receive attenuator (see drg CMS 20005) to correct the 4W output level provided that the level at the SUB GRP REC access point remains within ± 1.5 dB of -10 dBm.

Finally re-check each channel output level, setting the gain control link on each channel unit to give a level of +4 dBm ± 0.5 dB.

On a fully equipped rack, repeat all tests on second 12-channel block.

Group Translating Circuits

(a) Receive Path Ref. Drg. ES64-4573 and 4574

Apply an 84 Kc/s test tone to SYSTEM IN SK2/2-3 and adjust input level to -30 dBm. Connect a TMS set to read 75 ohm LOSS to SK2/6 a-b. The instrument should read -8 dBm $\pm$ 0.5 dB. If necessary readjust the variable pad in the REC HYBRID CMA 30030/2 and the gain of the amplifier CMA 30026/6 to meet this requirement.

Transfer TMS to SYNC PLT REC OUT SK2/18-19. Decrease level of applied signal 15 dB to -45 dBm and readjust frequency to 60 Kc/s. Note setting of TMS and peak to maximum by slight readjustment of test oscillator. The meter should read -28 dBm $\pm$ 1 dB. If need be readjust pad on the Pilot pick-off unit CMM 20044/1 to meet this.

Transfer TMS to SK2/9 a-b. The meter should read -48 dBm $\pm$ 1 dB.

Repeat these tests (at Terminal "B" only) on the second set of group equipment.

(b) Transmit Path Ref. Drg. ES64-4573 and 4574

Apply a test tone of 84 Kc/s at -37 dBm to GP EQMT TRANS IN SK1/6 a-b. Connect a TMS set to measure 75 ohm LOSS to SYSTEM OUT SK1/2-3. The meter should read -10 dBm $\pm$ 1 dB. If necessary adjust the pad in CMA 30025/2 to meet this.

Transfer test oscillator to PILOT IN SK1/18-19, readjust frequency to 60 Kc/s and test level to -20 dBm. Adjust the pilot path level adjustment pad in CMA 30025/2 to ensure a TMS reading of -25 dBm $\pm$ 0.5 dB.

Transfer test oscillator to SK1/9 a-b and readjust test level to -37 dBm at 30 Kc/s. The level at SYSTEM OUT should be -10 dBm $\pm$ 1 dB.

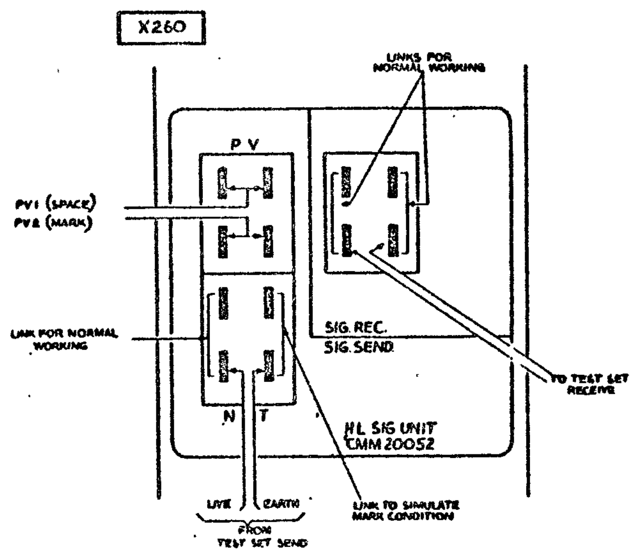
Repeat these tests (at Terminal "B" only) on the second set of group equipment.

SIGNALLING

Preliminary testing of the signalling circuits should be delayed until the remainder of the rack equipment has been lined-up and adjusted for optimum performance.

As either ringdown or dialling impulses may be used, the following test procedure covers both methods of signalling. Where dialling impulses are used, the ringdown relay sets normally fitted on the rack are replaced by through circuit patching cards to maintain speech path continuity and the signalling legs are extended to the exchange equipment.

The following sketch shows the test socket arrangement on the front of each H. L. signalling unit CMM20052.



Output Level

Remove the SYSTEM OUT links. Connect a suitable T. M. S to the inner pair of SYSTEM OUT sockets. Place a link in the bottom right 'sig-send' test sockets designated 'T', thus simulating a mark condition on the send leg. Check that the resultant level of signalling tone at the system out sockets is -5dBmO $\pm$ 1dB, repeat for each channel equipped. If the output level from any channel is incorrect, adjust the 0-3dB variable pad in the output of the relevant signalling unit.

Replace all 'sig-send' links to the 'N' (left-hand) position, thus restoring circuits to through working.

Bias

With links in normal 'N' position check the static relay bias of each signalling unit by connecting a P.V. meter to the PV1 (upper) test socket. A mid-scale reading $\pm$ 10% should be obtained on each unit. Repeat test at each PV2 (lower) socket. A reading of mid-scale $\pm$ 10% should again be obtained. If necessary, adjust the resistor chain R20-24 (tags 29-34) on the send card, see drg CMS 20052.

Change links to test 'T' position and repeat test at each PV2 socket, a mid-scale reading $\pm$ 10% should be again obtained.

Sensitivity

(a) Loop the SYSTEM OUT/IN sockets via an amplifier & variable attenuator to off-set the difference in levels at these points. Set the gain of the looping circuit to 29dB initially.

If ringdown relays are fitted, remove the covers from the relay sets CMB40903. Verify that when each RT relay is operated manually, the associated RR relay closes.

Increase the over-all loss of the transmit/receive path loop by 13dB (re-set the looping attenuator). Repeat preceding test and note that all RR relays still operate. Then, increase the loss by a further 5dB and again repeat test, this time no RR relays should operate. These tests establish that the signalling channels will continue to operate under abnormal line conditions but will not operate to noise or interference signals received at 18dB below normal signalling tone level.

Any channel which fails to meet both conditions may be corrected by adjusting the strapping between tag 23 and tags 24-28, this modifies the gain of the receive card CMA 30219 in unit CMM20052. Restore all links to normal when testing is completed.

(b) Where ringdown relays are not fitted, connect the send terminals of a signalling distortion measuring set to the lower pair of 'N' and 'T' sockets of unit under test and inject a signal of 30 bauds at 1:1 ratio, connect the receive terminals of the measuring set to the upper pair of SIG REC sockets. Verify that the test set is receiving signals and that these signals continue to operate test set when looping loss is set to 13dB but cease when loss is increased by a further 5dB. Restore all links to normal.

Signalling Distortion

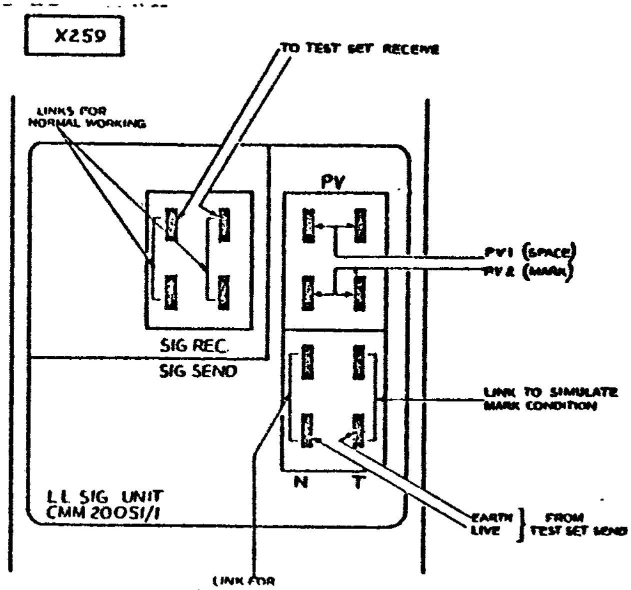
This test is only necessary where dialling tones are to be conveyed by the signalling channels. A signalling distortion or telegraph distortion measuring set is required, connected as in part (b) of previous test.

With transmit and receive paths looped at SYSTEM OUT/IN access points via a 16dB attenuator, measure the distortion present when a 30 baud 1:1 signal is transmitted and received. The maximum signalling distortion should not exceed 9% (3 millisecs) as the loop gain is varied over the range -6dB to -10dB from normal.

* Alternative Low-Level Signalling

In certain installations, low level signalling may be used. In this case the signalling unit CMM 20051 replaces the high-level unit.

All tests are as previously detailed, except that in the transmit path line-up, the level out to line is -20 dBmO. The test sockets are as shown in sketch.



* Not applicable on CMR10180/1-2

L. F. Ringing

Apply low frequency ringing current (17-50 c/s) to each 2-wire line in turn and note that the appropriate RT relay operates. The relays are designed to operate with a maximum line resistance of 4000 ohms when fed from a 75 volt, 17 c/s source.

Manually operate each RR relay (or simulate a receive leg earth condition on each channel) and check that 75 volt low frequency current appears on the appropriate 2-wire line. If an inbuilt ringing supply generator is fitted on the rack, check that it switches on only during the time that an RR relay is operated. (The operation of the ringing generator will be audible as a buzzing tone).

SYSTEM TESTS

After each of the three sets of terminal equipment have been checked, the complete system can be aligned and tested.

When the required level adjustments and equalisation is completed, such performance tests as frequency response and limiting, may be carried out.

Terminal Transmit to Radio

Apply an 800 c/s test tone at a level of 0dBm to the 2-wire access point of channel 9 and adjust attenuator on CMA 30026/6 to give the required level into the radio equipment. (Nominal requirement -10 dBm).

Terminal Receive from Radio

Arrange for a test tone to be applied at channel 9 input at the distant terminal. Adjust the 0-31 dB attenuator on CMA 30026/6 to obtain a level of -8 dBm ± 1 dB in 75 ohms at the CHAN EQPT IN access points. Confirm that an output of +4 dBm can be obtained at CH9/4 Wire REC. If necessary adjust audio gain of CH 9 demod amp to meet this requirement.

Routing & Frequency Response. Terminals B to A and B to C (Both ways)

With the complete system aligned and operating normally, arrange for an 800 c/s test tone to be transmitted from the distant terminal via each channel in turn and check that the test tone is received at the corresponding 4W REC OUT sockets of each corresponding channel on the near end equipment.

Set the gain control links on the front of each near end channel unit to give a level of +4 dBm ± 0.5 dB at the 4W REC OUT access sockets at the local terminal. Check the over-all frequency response of each channel by injecting test frequencies at the distant end as follows:-

Frequency (c/s)	Output level (dB) relative to 800 c/s
300-400	+1.1 to -4.4
400-600	+1.1 to -2.2
600-2400	+1.1 to -1.1
2400-3000	+1.1 to -2.2
3000-3400	+1.1 to -4.4

Repeat tests at the other terminal.

Linearity & Limiting. Terminals B to A and B to C (Both ways)

Arrange for a 2 Kc/s test tone at normal level to be injected into the 4W TRANS IN point of each channel in turn at the distant terminal. Measure the output level at 4W REC OUT point at the near end terminal. Now repeat test with the applied level increased by 4dB (i.e. 0dBm if normal level is -4dBr at the 4-wire point). The measured output level should have risen by 4 dB $\pm$ 0.3dB.

Place the gain control link on each channel unit to the minimum gain (-10dB) position and again note the output level from each channel. Arrange for the input level to each channel to be increased by a further 12dB (i.e +12dBm). Check that the output level has not increased by more than 4dB from the previous figure. Finally restore the gain control link on each channel position to its original position.

These tests are intended to verify that each channel has a linear amplitude characteristic over the range from normal level to +4dB but, due to limiting action above this level, the output can never rise more than a further 4dB, irrespective of applied input level
Repeat tests at the other terminal.

Carrier Leak

Check that no signalling tone or V.F. signals are being transmitted. Connect a T.M.S. set to correct impedance, to the SYSTEM OUT point and check that the reading (due to total carrier leak) is at least 17 dB below normal signal level.

If the carrier leak appears to be excessive, each channel modem unit (CMM 20050) should be removed and replaced in turn, noting the improvement in carrier leak obtained by its removal. Thos units which appear to contribute most to the total carrier leak may be adjusted by strapping tags 29-33 inclusive in any combination which gives minimum 'leak'.
Note: These adjustments are factory preset and should normally only require attention after a very long period of use to counteract rectifier ageing. No adjustment is provided on sub-group or group modulators.

Noise

If a psophometer is available, the basic noise may be measured at each 4W REC OUT point. The readings obtained will to a great extent be due to noise or unwanted pick-up on the radio or cable link and therefore the figures obtained must be suitably corrected to obtain the signal-to-noise ratio of the terminal carrier equipment alone.

The noise on any channel should not exceed -66dB below signal level (or -62dBm for a +4dBm test level at the 4-wire output).

V.F. Terminating Hybrids

Check the operation of each 2W/4W hybrid transformer by restoring all the 4 WIRE TRANS and 4 WIRE REC links and transmit test tones at 0dBm via the inner pair of 2-WIRE sockets of each channel in turn. The received level at the 2-WIRE links at the distant terminal should be approx 0dBm for a + 4dBm signal level at the distant 4 WIRE REC point). Note that the hybrid transformers have an actual loss of about 3.6 dB so that the output will usually be a little greater than 0dBm.

Signalling

If the ringdown relays are fitted, apply low frequency, ringing current at the 2-Wire point of each channel in turn at the local terminal. Verify that the required ringing tone appears at the appropriate 2-Wire point at the distant terminal during the time that the local RR relay is operated.

If the dialling tones are to be used, check that test tones transmitted from the local exchange produce the required impulses at the distant exchange.

Synchronisation:

It is necessary for all the master oscillators in the system to be operating at precisely the same frequency.

It is usual for the M.O. at one station to be nominated the 'master' and for the 'slave' master oscillator at the distant terminal to be synchronised to it.

The means whereby the synchronisation is effected, consists of a 60 Kc/s pilot tone derived directly from the M.O. at the master station, this tone is injected into the main transmission path and may be 'picked-off' when required at the slave station.

The method to be employed at the slave station is as follows:-

(1) Connect a patching cord from the SYNC PILOT REC access links to the 'PILOT IN' socket on synchroniser card CMA 30018. The synchroniser card is located on one of the frequency generator shelves and should have a link fitted in its PILOT LINKS socket.

(2) Connect a second cord from the 'OUT' socket on the synchroniser card to the input terminals of a T.M.S. meter set to 600 ohms LOSS.

(3) Adjust the LEV ADJ link to give approximately $\frac{1}{4}$-scale deflection on the meter.

(4) Connect a cord from the SYNC OUT socket on the local 60 Kc/s amplifier CMM 20006 to the IN A socket on the synchroniser card.

When two frequencies are near synchronism the difference frequency will be displayed as a 'beat' on the T.M.S. meter. For rough calculations, 1 beat in 10 seconds indicates a difference of 1/40th of a cycle per second between local and incoming 60 Kc/s supplies.

(5) Synchronise the local source by small adjustments of the FREQ ADJ screwdriver control located on the front face of the 12 Kc/s master oscillator CMM 20002 until a zero beat is obtained.

If the difference in frequency is outside the range of this control, course control may be affected by altering the strapping between tag 26 and tags 23-25, (see drg. ES/CMS 20002).

It should be noted that synchronisation should not be attempted until all master oscillators in the system have been running uninterruptedly for several days.

MAINTENANCE OF CM EQUIPMENT

General

The degree of maintenance performed on the carrier equipment will depend upon staff availability and the grade of service required. Precise instructions will presumably be laid down by the administration concerned. The following instructions are therefore intended only as a guide to the type of routine testing which it is desirable to undertake and to the frequency with which such tests are carried out.

Special emphasis is placed on the desirability of keeping regular performance records, sample charts being included at the end of this section to aid the preparation of a suitable test schedule. Such records will assist the maintenance of efficient performance and will also be of great assistance when tracing any fault that may arise.

Power Supplies

Check the output from the power stabiliser unit at weekly intervals by patching a P.V. meter into each test socket on the front face of the stabiliser unit and note that the reading is within $\pm$ 5% of mid-scale. If all readings on a given stabiliser are outside this tolerance and the mains supply is found to be within 10% of nominal, it may be necessary to re-adjust the resistor chain strappings in the unit (refer to appropriate circuit drawing for details).

Frequency Generator Equipment

Each generator source should be tested-out at weekly intervals.

With a T.M.S. set to 600 ohms loss, patch into each amplifier output test socket and note that a reading of -10 dBm $\pm$ 2 dB is obtained in each case. If the output of one particular frequency is found to lie outside this tolerance, re-set the input attenuator of the associated amplifier to regain the correct output level. Record any re-adjustments on the performance record chart.

If several frequencies are found to have altered in level in the same sense (i.e. all too high or too low) refer to the frequency generator block schematic diagram and trace the frequencies back to their common source.

The 75 ohm amplifier input test point readings may be used in conjunction with the relevant block schematic diagram to establish whether the input levels are within the range of adjustment of the amplifier input attenuators. The levels obtained in practice at these points may vary somewhat due to the tolerance on the filters, harmonic generators etc. and are, therefore, only quoted as approximate figures on the schematic diagrams.

The master oscillator oven should be checked to ensure that it is cycling normally and that its temperature is normal, (see commissioning section).

Synchronisation

The master oscillators in the system should be synchronised to that chosen as the frequency standard at fairly frequent intervals (say fortnightly) during the first six months after commissioning. As the crystals age, the drift rates may be expected to fall eventually to a negligible rate, so that synchronisation may be carried out at progressively longer intervals. Record the amount and direction of drift in each case before synchronising.

Translation Equipment

A daily audio-audio check should be carried out on each speech channel, if convenient, to ensure that all are serviceable for traffic.

At weekly intervals a test tone should be transmitted in each direction via each channel and the level at each 4-wire receive socket checked to ensure that the circuit equivalents are maintained correct. Any output which falls outside the tolerance of +4 dBm $\pm$ 1 dB should be corrected by means of the gain control link on the face of the relevant channel unit.

At quarterly intervals check all the intermediate levels in the transmission paths and carry out (and record) any necessary re-adjustments to restore all levels to within their stated tolerances. Points to measure at include: the sub-group access on the basic channelling, the GDF point and the connections to and from the radio or line equipment.

Signalling Channels

A brief daily check of each circuit should be made by ringing through on each channel in each direction.

Once monthly check the static relay bias conditions at the PV1 and PV2 test sockets on the face of each signalling unit as detailed in the commissioning section.

FAULT LOCATION

General

In most cases the fault will be a simple one and can be quickly cleared if the following points are checked first:

(i) Check that the mains supply is reaching the rackside; i.e. look for loose or blown cartridge fuses or failure of a common mains supply.

(ii) Inspect racks for any card not pushed fully home in its guides.

(iii) If any cards or units have recently been removed, check that they have been replaced in their correct location on the rackside. The pair of letters signwritten on the front edge of the card unit should match the code letters signwritten on the shelf edge below the unit. The first letter of the code denotes the shelf; the second letter denotes the unit location on the shelf.

(iv) When a particular unit is suspected of being faulty, before going further, ease out and replace the unit a few times. Dust or grit on the contacts may cause a faulty connection to occur between the unit connectors and the jack socket. Examine the jack socket in case any spring contact has been accidentally damaged.

Failure of one or more Channels

A failure of a number of associated channels will indicate a fault in equipment common to all the faulty channels, (e.g. carrier supplies, sub-group or group equipment).

Where a fault is isolated to a single channel the following procedure is recommended. Using a test oscillator, send a test tone in at the 4 WIRE TRANS point on the faulty channel, connect a T.M.S. to the GDF point on the group concerned and check for a -37 dBm signal. In the same way, check the level at SYSTEM OUT etc. comparing the levels obtained with those marked on the relevant block schematic drawing and noting that the T.M.S. is set to the correct impedance for each test point.

When a point is found in the circuit where the tone is absent or a serious discrepancy in level occurs, return to the unit following the last access links at which the test signal was present. Plug this unit into a test extension jack and check signal level at input and output tags, continue signal tracing on all cards until fault is isolated.

Before finally deciding that an individual card is faulty, the following checks should be made before replacing it by an available spare.

If the unit is a modulator or demodulator, check that the carrier supply is reaching the tags of the unit.

The fault may be due to a short circuit in the rack wiring. Check this by removing the bridging links on the extension jack which connect the output from the card unit to the rack wiring, and measure the signal on the output of the card itself.

The faulting procedure outlined is for use on the transmit path, a similar procedure may be adopted for faults in the receive path, commencing at the system input and working back through the circuit to the 2W access point. Note that the signal applied at the GDF point should be the frequency equivalent to 800 c/s at 2W LINE for the particular channel concerned.

It should be noted that the levels quoted on all block schematic diagrams are based on the assumption that the impedance at the measuring points are always equal to their nominal value of 600 ohms, 75 ohms, etc.

In practice this is not always the case, particularly where filters or modulators are concerned. When such a mismatch occurs there will be an appreciable difference between LOSS and LEVEL measurement and further errors may arise due to carrier leak, noise, or spurious oscillations. If a discrepancy in levels is found, it is better to break the circuit, if conditions permit, and make a correctly terminated LOSS measurement.

<u>Carrier Supply Failure</u>

Use the relevant block schematic to determine the origin of any missing carrier frequency and work back through the supply circuit to trace the fault, using a T.M.S. meter set to 75 ohm LEVEL. It may not be possible to be certain when a faulty card has been reached, since the levels at various points cannot always be defined. It is helpful in this case to jack in a spare unit of the same code and so obtain a positive proof.

Distorted Speech

Check that the limiter stage in the channel unit is not being overloaded. This would occur if the input pad was of incorrect value or if it had been strapped out in error. Failing this, the limiter stage or its d.c. supplies may be at fault.

Excessive Noise or Interference

A broken earth connection is a possible source of this kind of trouble. Check that all card units are firmly in place and check any wiring that has recently been disturbed.

Rack Wiring Faults

Where a fault has been traced to the wiring between units, the repair may usually be effected most conveniently by removing the back cover plates on the rackside to expose the shelf wiring.

If the rear of the rackside is not accessible, the wiring to any jack socket may be exposed by removing the two holding screws on the socket and easing it forward. The coaxial cable used is of thin gauge and should be handled with reasonable care if any joint is to be remade.

If a fault has been traced to a test termination tablet on the end of a shelf, access to the wiring is obtained by removing the two holding screws; the tablet on the end of its guide may then be pulled clear to expose the connections. On a new rackside, trouble may be due to solder splashes or damaged insulation when fitting the installers cabling; tags are closely spaced so that short circuits from these causes are not impossible.

Fault Location within Card Units

When carrying out fault location or repairs on card units the following points should be noted.

Multi-card units may be opened up by loosening the four fixing screws, as illustrated at the end of this section. When re-assembling the units care should be taken not to trap any inter-card wiring. Handle card units with reasonable care, they may crack if dropped or roughly handled.

Before commencing any electrical tests inspect the card for possible source of trouble such as solder splashes, broken component lead-outs or deep scratches across the printed track. Emergency repairs to cracked or broken tracks may be effected by bridging the faulty section with a short soldered length of wire, removing any excess solder with a small stiff brush.

The printed circuit side of the card is covered with a protective layer of varnish, this must be scraped away from any joint that is to be used as a measuring point before electrical contact can be made. It is preferable to make such tests on the component side of the card.

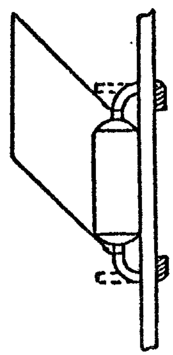
Transistors do not normally fail unless they have been subjected to heat or accidental application of wrong voltages. For this reason do not immediately suspect them of being faulty but check other components first. When other methods have been tried and it appears that a transistor is at fault it is best checked by substitution of a new one of the same code.

Certain transistors (OC71, OC44 etc.) are coated with paint, if this coating is damaged or removed, photo-electric action can occur resulting in a degree of instability of the collector current, it is advisable to replace or repaint any transistor affected in this manner.

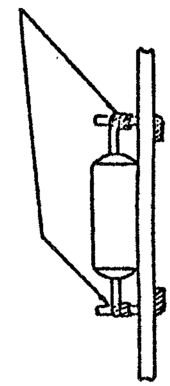
Should it be necessary to unsolder a component, extreme care should be taken since transistors, germanium diodes, and other miniature components are easily damaged by excessive heat. The method illustrated at the end of this section should be followed. Scrape the joint on the printed circuit of the card to clear any varnish, grip the wire end of the component on the other side of the card with pliers, (these will act as a heat shunt), then lift the soldered end clear using a small hot clean iron.

If a component is known to be faulty, it should be cut free from its solder ends leaving about $\frac{1}{4}$" stubs of wire as shown, the new component may then be soldered to these stubs.

CUT LEADS CLOSE TO
FAULTY COMPONENT
& THEN BEND VERTICAL



LEADS OF NEW COMPONENT
TURNED $1\frac{1}{2}$ TIMES AROUND
PROTRUDING WIRE STUBS
& THEN SOLDERED.



Relays

Most of the relays used on CM equipment are of the dry-reed relay type, whose contacts are sealed in glass tubes containing an inert gas and so are completely inacessible for maintenance. They are, however, extremely reliable and robust and have a satisfactory working life comparable with any of the electronic components with which they are associated.

A fault on this type of relay usually entails its replacement, by unsoldering its connecting tags from the printed circuit (see section on fault location) and fitting a new relay. If the fault is confined to the contacts themselves, it should be possible to cut the connections at the ends of the sealed tube, force out the tube from the surrounding coil bobbin and fit a new set of contacts in its place.

Cleaning Printed-Card Connectors

The gold-plated printed card connectors undergo a special cleaning process during manufacture and should give no trouble in service. Where, due to dusty conditions, trouble is experienced with dirty contacts, it will often be sufficient to clear the fault by pushing the affected card in and out a few times. This will, in effect, wipe the contacts clean.

If this is not sufficient, the connectors on the affected card may be cleaned using a solvent such as methylated spirit or propyl alcohol. The fluid should be applied sparingly using a soft rag and rubbed along each connector and not across the row of contacts or else varnish on the card will be dissolved and will spread over the contacts. Cleaning fluid must be kept well away from polystyrene capacitors.

Finally, a dry rag should be used to polish the contacts, wiping along each contact as before. The card should be replaced in the rackside immediately afterwards.

Regular contact cleaning should not form part of a maintenance schedule since besides being quite unnecessary, frequent handling of the cards may do more harm than good.

Replacements

Requests for replacement units or components should quote the following:-

(i) The CMR rack code & assembly no. (e.g. CMR 10034/1)

(ii) The unit code, assembly & issue no. (e.g. CMB 41939/1 Iss.1)

(iii) The code of the component concerned. This will be found in the apparatus schedule which accompanies the relevant unit schematic diagram.

All correspondence should be addressed to:-

The Engineering Manager,
Electronics Division (Transmission),
Automatic Telephone & Electric Co. Ltd.,
Strowger Works,
Liverpool. 7.

Chart No. 1.

MAINTENANCE RECORD CHARTS

Once Weekly: Audio - Audio record

Levels are taken by injecting an 800 c/s test tone into the 2 WIRE point on each channel in turn at the sending terminal (at a level OdBm, 600 ohms) and measuring the output level at the same point at the receiving terminal with a T.M.S. set to 600 ohms (bal) LOSS. Any unduly large variation in levels over a period should be investigated.

Date				
Group No.( )				
Channel No. 1.				
" 2.				
" 3.				
" 4.				
" 5.				
" 6.				
" 7.				
" 8.				
" 9.				
" 10.				
" 11.				
" 12.				

Chart No.2.

Once Monthly: Check Signalling bias, using 1v F.S.D. 5000 ohms D.C. meter.

Date					
Group No.( )					
CHAN 1	P.V.1				
	P.V.2				
CHAN 2	P.V.1				
	P.V.2				
CHAN 3	P.V.1				
	P.V.2				
CHAN 4	P.V.1				
	P.V.2				
CHAN 5	P.V.1				
	P.V.2				
CHAN 6	P.V.1				
	P.V.2				
CHAN 7	P.V.1				
	P.V.2				
CHAN 8	P.V.1				
	P.V.2				
CHAN 9	P.V.1				
	P.V.2				
CHAN 10	P.V.1				
	P.V.2				
CHAN 11	P.V.1				
	P.V.2				
CHAN 12	P.V.1				
	P.V.2				

Chart No. 3.

Once Weekly: Carrier Supply Check

Output levels are measured at the TEST OUT monitor points on the Carrier Amplifiers, or at the shelf end routine test points, with a T.M.S. set to 600 ohm LOSS.

Date						
12 Kc/s						
16 Kc/s						
20 Kc/s						
84 Kc/s						
96 Kc/s						
108 Kc/s						
120 Kc/s						
114 Kc/s						
3.825 Kc/s						
60 Kc/s						

Chart No. 4.

Once every 3 months: Check intermediate levels on channel and group equipment. Use an 800 c/s test tone on the two outer channels of each sub-group for measurements at the sub-group access links, e.g. for sub-group 1, use test tones on channels 1 & 3. For measurements at test points common to all 12 channels, use test tones on channels 1, 7 & 12.

Date					
Sub Grp. No. 1 TRANS					
" " " 2					
" " " 3					
" " " 4					
" " " 1 REC					
" " " 2 "					
" " " 3 "					
" " " 4 "					
CHAN EQPT OUT					
" " IN					
SYSTEM OUT					
SYSTEM IN					

Chart No. 5.

Once monthly: Check synchronisation of all master oscillators against master station; record amount and direction of drift (parts in 10^6) before re-setting oscillators.

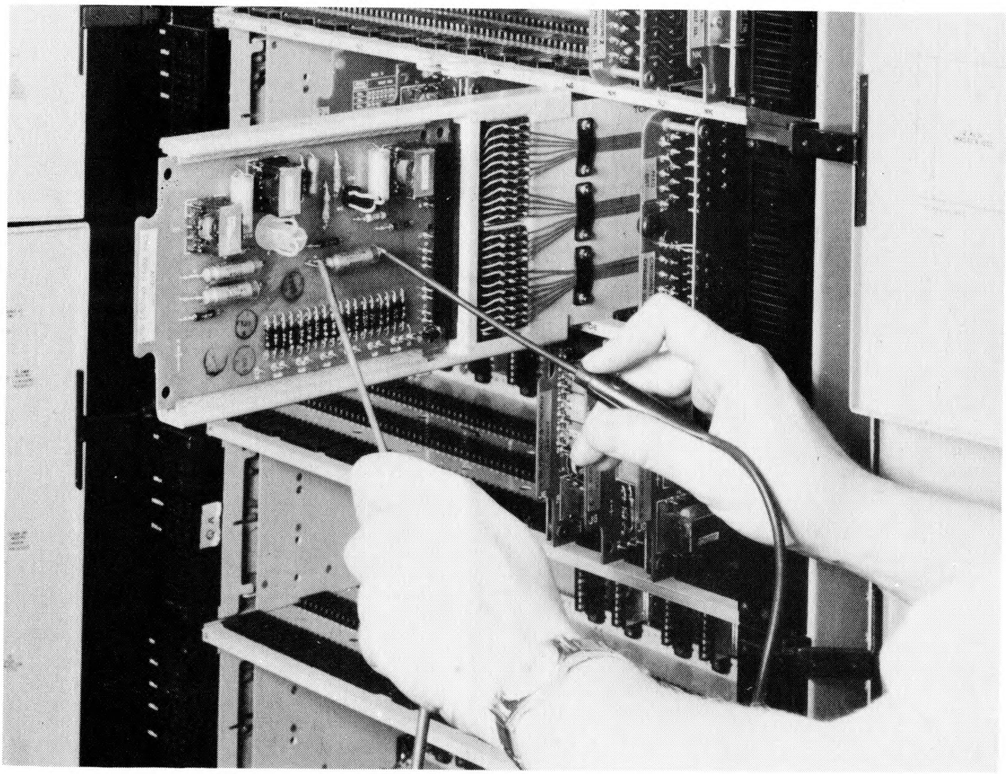
Date						
Drift						

EXTENSION TEST FRAMES.

The rack test frame or extension jack' (TC 94262) is used to mount a printed-circuit card clear of the rack equipment in order to make it accessible for fault location. All the electrical connections are carried through via access sockets and break links mounted on the frame itself. It is thus possible to disconnect any circuit from the rack wiring and to make current measurement on d.c. paths.

Where multi-card units are to be tested it may be necessary to use two or more frames to complete all circuits and/or support the weight of the unit.

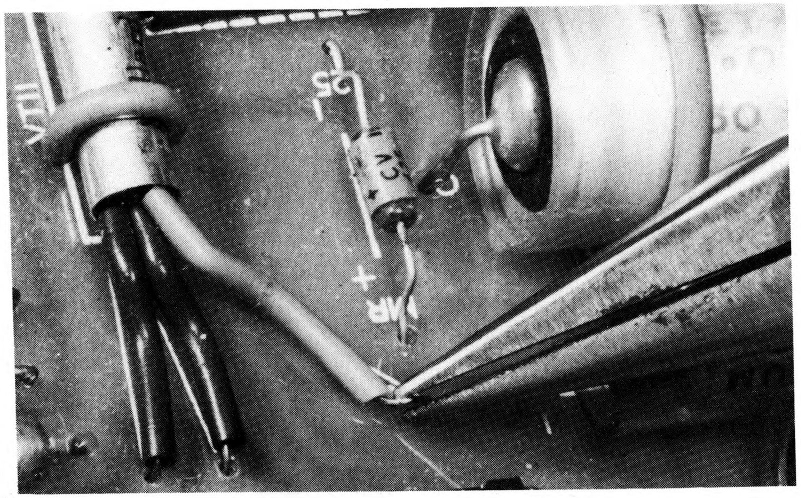
The bench test frame TC 94263 is used in the same way, but since it is made in two halves joined by a flexible cable the card may be tested on an adjacent test bench if desired. The wires in the cable are unscreened and therefore the rigid frame may be preferred at high frequencies.



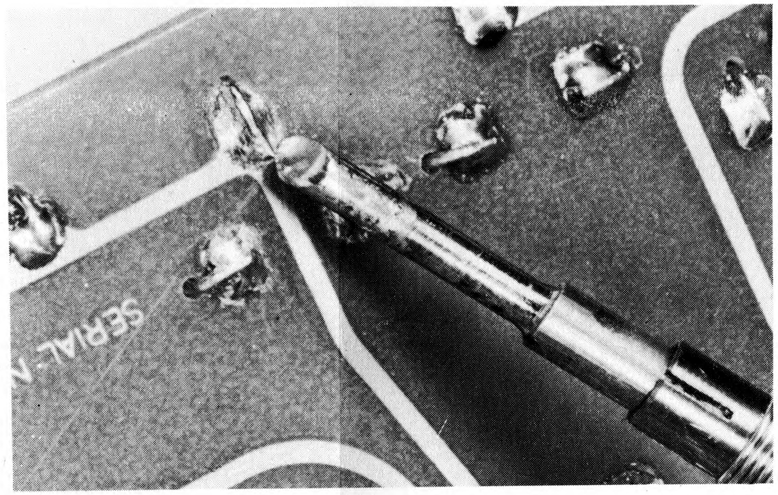
UNSOLDERING
CARD-MOUNTED
COMPONENTS

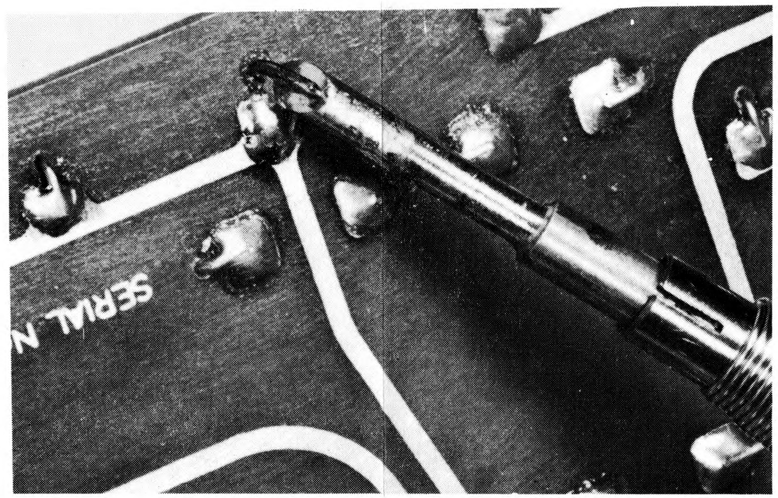
ES64-M/4083 ISSUE 1.

22.3.62.

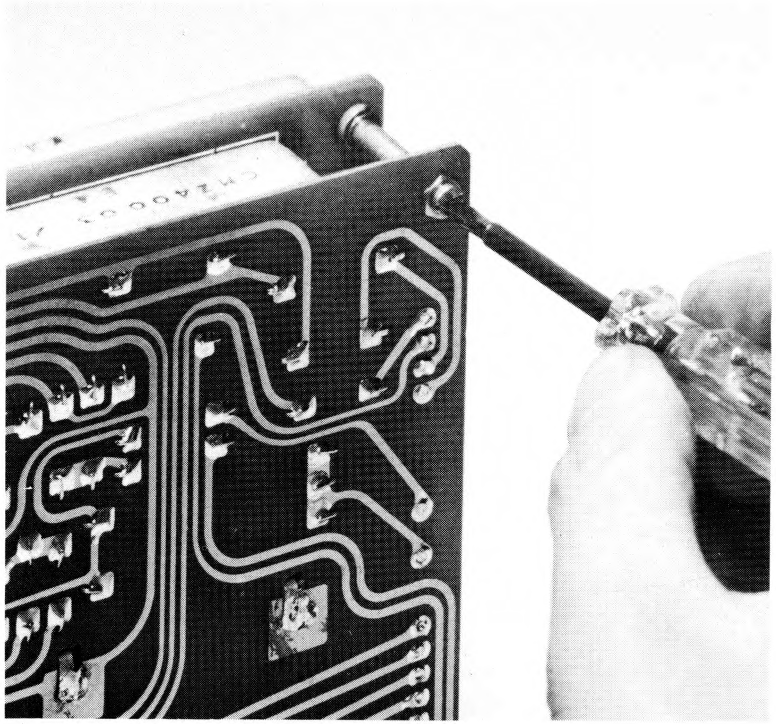


1. Use pliers as thermal shunt





2. & 3. Lift wire end with clean iron and withdraw component.

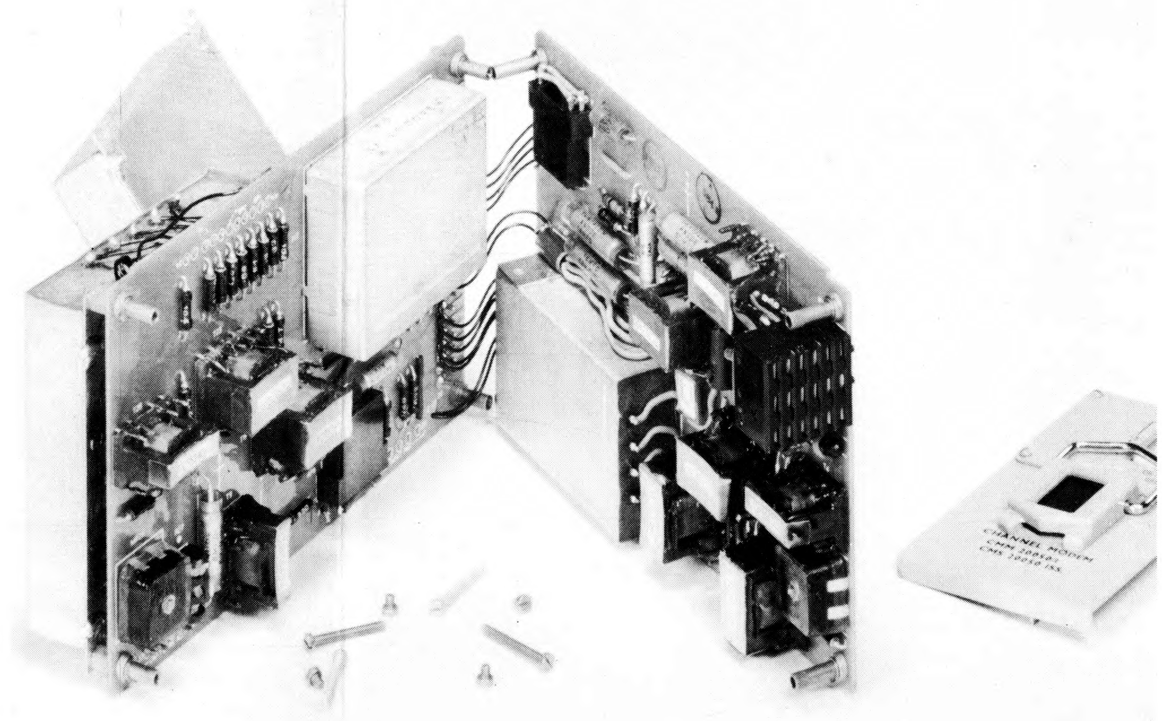


DISMANTLING

MULTI-CARD UNITS

ES64-M/4084

22.3.62.



UNIT & PRINTED CARD INFORMATION

This section comprises circuit drawings, apparatus schedules (component lists) and brief descriptions of all the units and printed cards used in this system.

The units and cards are listed under their assembly code numbers in numerical sequence. Although in general each description merely gives a brief summary of electrical features, comprehensive details are given of all the more complex units (e.g. channel modem, or master oscillator). Basic Filter units and certain other tuned circuits are contained in sealed cans, as no field adjustment of these units is possible, detailed circuitry has not been included.

The drawings which follow are again arranged in numerical sequence. Each drawing includes an apparatus schedule which lists all the components on the given unit or card and gives their ordering codes should replacements be required.

Requests for replacement units or components should quote the following.

(i) The CMR rack code and assembly numver (. e. g. CMR10154/1).

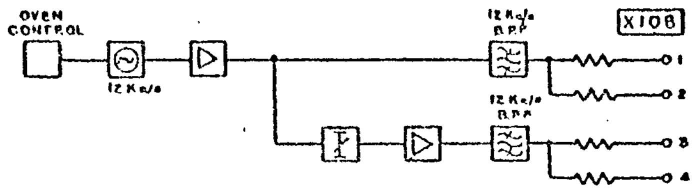
(ii) The unit code and assembly together with the issue number marked on the unit (e. g. CMM20050/1 Issue 5).

(iii) The code of the component as listed on the relevant apparatus schedule.

All correspondence should be addressed to:-

The Engineering Manager,
Electronics Division (Transmission)
Automatic Telephone & Electric Co. Ltd.,
Strowger Works,
Liverpool. 7. ENGLAND.

The unit consists of a highly stable 12 Kc/s crystal oscillator together with an associated buffer amplifier and circuits necessary for amplitude and temperature control, the unit is used to provide the basic 12 Kc/s frequency source from which all other carrier frequencies are derived.



Oscillator Circuit:

The crystal XL6 forms a positive feedback loop with the two-stage amplifier VT7 and VT15, this is tuned by TC8 to avoid oscillation at spurious frequencies. The back-to-back silicon diodes MR4 and MR5 are shunted across the feedback path to stabilise the output level by limiting action, with C22 used for d.c. blocking.

Frequency adjustment is provided by trimming capacitors C2, C3, C4, which are set to give the correct output frequency during factory testing. Fine frequency control is carried out by using the screwdriver control trimmer C1, accessible from the front face of the unit.

Output Circuit:

Buffer amplifier VT26 and tuned transformer TC31 provide outlets at -10.5 dBm and -15.0 dBm, the first outlet is used to feed the 12 Kc/s channel carrier amplifier, the second feeds a 16 & 20 Kc/s regenerative modulator CMM 20008.

A second amplifier circuit incorporating VT42 and tuned hybrid TC49 provide a pair of outlets at OdBm, these feed the sub-group and group harmonic generators.

All output impedances are 75 ohms unbalanced and the outlets are isolated from each other so that unused outlets need not be terminated.

A gain adjustment is provided for on the OdBm outlets only, this consists of resistor chain R33, 34, 35. The output level will fall as these are progressively strapped out of circuit. A gain control is not required for the -10.5 and -15 dBm outlets since their loads are not dependent upon exact input level.

Crystal Oven:

The crystal XL6, which has been selected and aged to provide a long term frequency stability, is enclosed in an oven block maintained at a temperature of $55^{\circ}C \pm 1^{\circ}$. The oven is heated by a cupro-nickel winding which surrounds the block and is fed from a 24v a.c. or d.c. supply.

To reduce the heater power required, the oven block is enclosed within a vacuum flask and this assembly is mounted in a metal container. Thermal dissipation is thus reduced to a minimum and the average heater power required is less than two watts.

Oven Control:

When first switching on, transistor VT12 is fully conducting with relay OC/1 operated, thus OC1 is closed and the oven circuit is complete. Contacts AL1 and AL2 are also closed.

When the oven temperature rises to $55^{\circ}C$, the contact thermometer CTH1 operates to short-circuit VT12 base to earth. With VT12 cut-off, relay OC/1 releases and power to the oven heater is removed. The temperature will then fall until CTH1 contact breaks and the cycle is repeated.

Temperature Alarms:

Under normal temperature conditions, the first pair of contacts of the double contact thermometer CTH2 are closed thereby short-circuiting tags MC17/3-4 and a voltage from the base of VT7 backs off the diode MR10.

If the oven temperature falls below $50^{\circ}C$, the short-circuit referred to will be removed and the back-bias on MR10 is taken off. This condition is used to signal an alarm and effect a changeover to standby equipment, i.e. low temp fault. (This condition will also obtain when first switching on).

Should the oven temp rise above 60°C the second pair of contacts of CTH2 will close and short circuit tags MC17/3-4-5. This will again remove the back-bias from diode MR10 and will also remove the base-bias to transistor VT7 so that it cuts-off and relay AL/2 releases. Contacts AL1 and AL2 will break the supply to the oven heater thus safeguarding the crystal, i.e. high temp fault.

Test Points:

OVEN TEMP .... A 'P.V.' meter (1v fsd. 5000 ohm) connected to the OVEN TEMP test point should read as follows:-

Low Temp	¾-scale deflection	
Normal	Mid " "	± 10%
High Temp	¼-scale "	

HEATER SUPPLY: A 'T.M.S.' meter set to 600 ohms Loss connected to the HEATER SUPPLY test point will read approx -10 dBm if the 24 volt supply is intact.

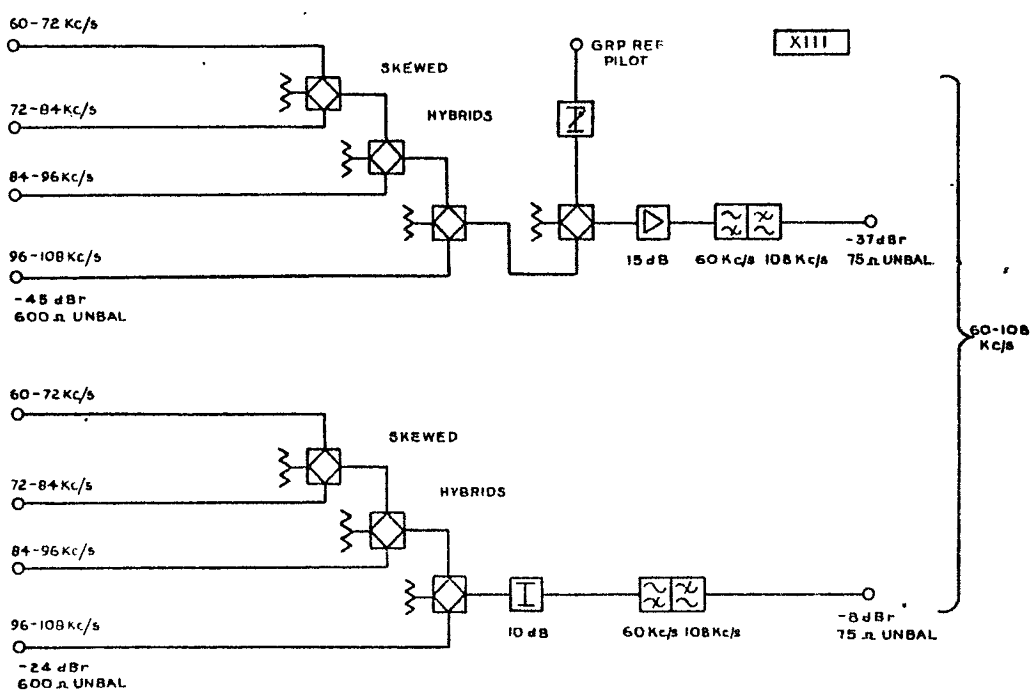
HEATER CURRENT: A 'T.M.S.' meter set to 600 ohms Loss connected to the HEATER CURRENT test point will read approx -2 dBm each time the oven heater draws current. The time for a complete on/off cycle may vary from one to four minutes. As a rough guide, a ratio of 1 'on' to 3 'off' is usual for an ambient temperature of 20°C.

Note: It is advisable to use meters which are isolated from earth for the above tests since all the test points are above earth potential. The T.M.S. meter used should be accurate down to 50 c/s.

Circuit data:

Current drain from 12v supply ...... 63 mA ± 20%
Current drawn by heater .... 210 mA ± 20%

This unit provides facilities for combining, in the transmit direction, the outputs from four sub-groups to form a composite band 60-108 Kc/s. In the receive direction, the incoming band 60-108 Kc/s is divided to form outlets for distribution to the subsequent sub-group stages.



Transmit Path:

In the transmit direction, side-band signals from the four sub-groups in the ranges 60-72, 72-84, 84-96 and 96-108 Kc/s enter the unit at -45 dBr, the input impedance being 600 ohms unbalanced. These signals are applied to an arrangement of skew hybrid transformers T27-T31 in which the four sub-groups are combined to form the basic group 60-108 Kc/s. The transformers are so designed that no inter-action between sub-groups occurs. Further, the insertion loss in each hybrid coil is designed to be the same for each sub-group i.e. 7 dB nominal.

Facilities are provided for the injection of a group reference pilot (84.08 Kc/s), if required, the assembly 1 version of the unit includes level adjustment pads which are omitted on assembly 2. The pad consists of resistors R20 to 26 incl. and strappings between tags 27 and 34 are made as required to ensure correct performance. (See Notes 1 and 2 on ES/CMS 20003).

The combined signal at 60-108 Kc/s is amplified in a two stage 15 dB fixed gain amplifier centred around VT7 and VT26. This amplifier has an input impedance of 600 ohms for which a specified return loss of 35 dB is obtained and by which satisfactory operation of the hybrids is ensured.

The output transformer T18, matches the high impedance of the amplifier (1305 ohms) to 75 ohms and applies the amplified signal to the sub-group combining high pass/low pass filter F19. This filter is designed to suppress signal leak at 12-15 Kc/s and the higher order modulation products peculiar to sub-group modulation. The nominal level at the unit output tags is -37 dBr (75 ohms unbalanced), the signal passing from this point to the G.D.F.

Receive Path:

Signals arriving at G.D.F have a nominal level -8 dBr (75 ohms unbalanced). From here they are applied to the sub-group combining high pass/low pass filter F41 which is identical to F19 in the send path. Its function is to 'clean' the 60-108 Kc/s applied signal by removal of all unwanted modulation products. This signal then passes via a 10 dB fixed pad into an arrangement of hybrid transformers T37-T34, (the purpose of the pad being to set the correct level and to ensure a suitable input impedance at the hybrids).

The output level of the four bands 60-72, 72-84, 84-96 and 96-108 Kc/s distributed to the four sub-group units, is -24 dBr nominal at 600 ohms unbalanced.

This unit mounts the equipment required to translate one sub-group to and from the appropriate portion of the 60-108 Kc/s band. It performs the modulation and demodulation process and also segregates the sidebands appropriate to the sub-group under consideration.

In the transmit direction signals equivalent to three channels and occupying the band 12-24 Kc/s are converted to a higher position in the frequency spectrum. These appear as lower sidebands of the applied carrier (84, 96, 108 or 120 Kc/s as applicable) in the 60-108 Kc/s band.

In the receive direction the reverse action takes place, each assembly of sub-group unit selecting its own sideband frequencies from the 60-108 Kc/s band and restoring them to the 12-24 Kc/s band.

Four similar assemblies are available. These differ only in the frequency characteristic of the filter appropriate to the sub-group. Details are as follows:-

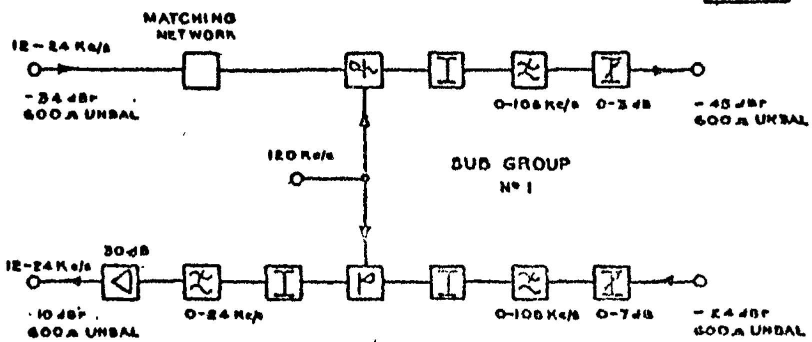
Assembly No.	Sub-Group	Carr. Freq.	Pass-band of Send or Rec Low Pass Filt.
1	1	120 Kc/s	0-108 Kc/s
2	2	108 "	0- 96 "
3	3	96 "	0- 84 "
4	4	84 "	0- 72 "

Send Path:

In the transmit direction, signals at -34 dBr are applied via a simple matching network to the sub-group modulator. This network, formed by R1/L1 raises the input impedance to 600 ohms (unbalanced) and provides a certain amount of pre-equalisation for the send sub-group lowpass filter which follows the modulator in the transmit path.

The modulator is of the miniature resin potted type employing copper oxide rectifiers which are carefully matched to ensure balanced operation and is supplied with the appropriate carrier frequency dictated by the relative position of the sub-group.

X110/2



The resultant output passes, via a fixed isolating pad, to the send sub-group lowpass filter which selects the appropriate lower sideband 60-72, 72-84, 84-96 or 96-108 Kc/s. The filters used have an input impedance of 1600 ohms, and include a section designed to suppress carrier leak. This is followed by an 0-3 dB pad, included to provide some compensation for slight changes in the modulator and for variations between the performances of individual filters. By this means the insertion loss of all sub-group units can be made equal. The level of the selected sideband at the unit output tags is -45 dBr, the point having an unbalanced impedance of 600 ohms.

Receive Path:

Signals in the range 60-108 Kc/s arrive at the 600 ohms unbalanced input tags at -24 dBr. Passing via an 0-7 dB pad, the signal is applied to the sub-group receive lowpass filter which is similar in design to the sub-group send filter, but omits the carrier leak suppression section. (The filter output impedance is 1000 ohms). Leaving the filter, the selected signal, part of the 60-108 Kc/s band forming the particular sub-group passes, via a matching pad, into the demodulator to which the appropriate carrier is applied.

The signal, now two sidebands resulting from the demodulation process, passes via a matching pad to the sub-group demod. filter in which the 12-24 Kc/s lower sideband is selected, the upper unwanted sideband and carrier being suppressed. The level at this point is -40 dBr.

The signal is next applied to a 30 dB fixed gain two-stage amplifier built around VT27-VT40. The circuit chosen employs over-all negative feedback for which a tertiary winding on the output transformer (T43) is provided. Resistor R45 and capacitor C46 build out the unit's output impedance to 600 ohms and the signal leaves at this point at a nominal level of -10 dBr.

CMM 20006/2 60 Kc/s Pilot Amplifier Unit

This multicard unit is designed to amplify and stabilise the 60 Kc/s supply from the sub-group harmonic generator CMA 30034/1.

The unit consists of a main amplifier formed by a pair of transformer coupled transistors VT9/VT17 (OC44 and OC72) in a conventional AGC controlled circuit operating at 60 Kc/s, the output being taken from VT17 via a tuned output transformer TC20 which has two secondary windings. The main outlet is taken at + 4 dBm from one of the two secondaries, the second one being used to feed 60 Kc/s to the AGC rectifiers MR's 26 to 29. The main outlet can be strapped to provide two 75 ohm outlets at -20 dBm. Output from the AGC rectifier is used to bias VT9 the effect being to alter the gain of the unit to offset change in output, thereby stabilising it. A zener diode MR7 is used to provide a reference against which the circuit operates, the potential across the diode being applied to the base of VT9. An additional outlet from VT17 is applied to a subsidiary amplifier VT44 to provide an outlet at -16 dBm for synchronising. This outlet is also used as part of the system alarm/changeover.

Circuit data:

Current drain : 12 mA ± 15%

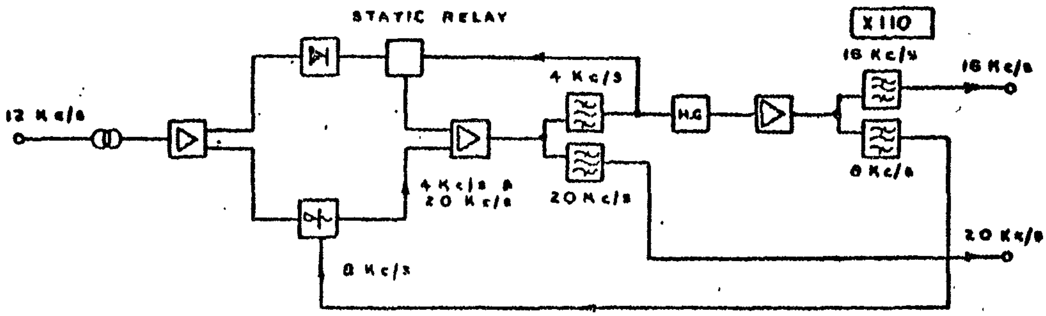
Routine test point level (R. T. E. Test OUT) -10 dBm (600 ohm LOSS)

Level at TEST IN : + 3dBm ± 3 dB

Level at SYNC OUT : - 16 dBm ± 4 dB

CMM 20008/1 16 & 20 Kc/s Regenerative Modulator

This multi-card unit is used to derive both the 16 and 20 Kc/s, channel carrier frequency from one of the 12 Kc/s master oscillator outputs. The circuit diagram is simplified and shown in block form in diagram X110.



Circuit Description:

The operation of the circuit is dependent on a 12 Kc/s input to the unit. Diodes MR12-13 provide a rectified output, stabilised by zener diode MR14. This output is used to bias back MR28 and thus remove the a.c. short-circuit which exists between the base of VT40 and the common 12 volt (+)ive line via MR28, C25, and R26. Removal of this short circuit results in VT40 functioning as a 4 Kc/s oscillator, TC38 being tuned to this frequency. The essential feedback loop is provided by C35, R36 and R37.

Diodes MR44-45, to which a 4 Kc/s input is applied, feed pulses (equivalent to the even harmonics of this frequency) to the base of VT52. This stage is provided with two collector loads TC50-51 which resonate at 8 and 16 Kc/s respectively. The 16 Kc/s output is taken from TC51 via a suitable band-pass filter.

The 8 Kc/s output is fed back as a carrier frequency for the modulator, MR21-24, which is also supplied with 12 Kc/s via T1, C4, VT8 and T7. Due to the modulation process, sum and difference frequencies of 4 and 20 Kc/s appear at the output of the modulator. This output is applied to the base of VT40 which 'locks-in' to the 4 Kc/s component to complete the regenerative action. The collector loads of VT40 consists of TC38 tuned to 4 Kc/s and also TC39 to 20 Kc/s, the output at this second frequency is selected by a bandpass filter to provide the 20 Kc/s carrier source.

Should the 12 Kc/s source fail in service, the backing-off bias to MR28 will be removed and as a result VT40 will cease oscillating causing both the 16 and 20 Kc/s outlets to fail.

To safeguard the output levels against possible changes in temperature within the unit, a thermistor RTH48 is inserted in the base feed to VT52.

Circuit data:

Z in, Z out	75 ohms
16 Kc/s Output	-8.3 $\pm$ 2.5 dB
20 Kc/s Output	-6.5 dBm
Current drain	13 mA $\pm$ 15%

<u>CMM 20044/2 Pilot Extraction Unit</u>

This multicard unit is used to extract the 60 Kc/s pilot from the main transmission band and to raise it to a suitable level (-28 dBm) for synchroning purposes.

The unit consists of a simple level adjustment pad, a 60 Kc/s pand pass crystal filter and an amplifier in which two OC45 transistors (VT's 5 & 15) provide a nominal 32 dB gain.

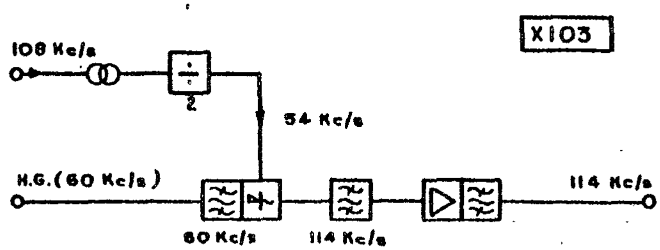
Circuit data:

Z in, Z out	75 ohms
60 Kc/s output	-28 dBm $\pm$ 2 dB
Current drain	13 mA $\pm$ 15%

CMM 20011/1 114 Kc/s Generator

This unit provides a 114 Kc/s group carrier supply from input frequencies of 60 Kc/s and 108 Kc/s.

As shown in the diagram below, 108 Kc/s (derived from an auxiliary outlet on the 108 Kc/s sub-group carrier amplifier) is divided by two and the resultant 54 Kc/s is modulated by 60 Kc/s (derived by filtration from the 'odd' harmonics outlet of the 12 Kc/s sub-group carrier harmonic generator). The upper sideband is then selected to provide the required 114 Kc/s output.



The 108 Kc/s input is passed through a single stage amplifier (VT8) and then serves to trigger the bistable circuit (VT18, VT30) to give a square wave output at 54 Kc/s. This 54 Kc/s output acts as switching or 'carrier' frequency in the following balanced ring modulator. The 60 Kc/s input is fed into this modulator via the tuned transformer circuit TC34. The modulator output is passed, via a 3 dB isolating pad, through a high-pass filter where the 54 & 60 Kc/s component, 114 Kc/s, is selected.

The filter is followed by an 8 dB isolating pad, and then a simple two-stage amplifier (VT54, VT67) raises the carrier supply to the required level.

Circuit data:

Current drain	16 mA ± 25%
60 Kc/s input level	+3 dBm 75 ohms
108 Kc/s input level	-6 dBm, 75 ohms
114 Kc/s output level	OdBm ± 3 dB, 75 ohms
Conversion loss of modulator card	31 dB ± 2 dB (75 ohms)
Gain of amplifier card	28.5 dB ± 2 dB in 75 (75 ohms)

This unit mounts the equipment for translating a single V.F. channel to and from the 12-24 Kc/s sub-group frequency band, together with facilities for the injection and extraction of high or low level 'out-of-band' signalling frequencies from associated signalling equipment.

In the transmit direction, V.F. signals in the range 300-3400 c/s are converted to a higher frequency band, appearing as the upper sideband of the applied 12, 16 or 20 Kc/s carrier. The reverse process takes place in the receive direction, each channel unit selecting its own band of carrier sideband frequencies and restoring them to the voice frequency range.

The unit is built in three assembly codes which differ as follows:-

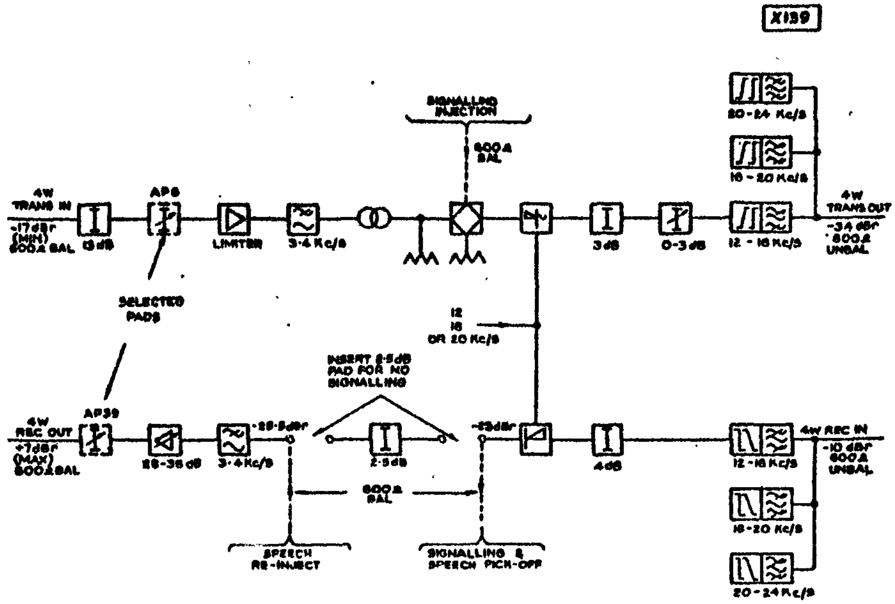
Assembly	1 CH1.	(12-16 Kc/s B.P. filter)
"	2 CH2.	(16-20 Kc/s B.P. filter)
"	3 CH3.	(20-24 Kc/s B.P. filter)

Send Path:

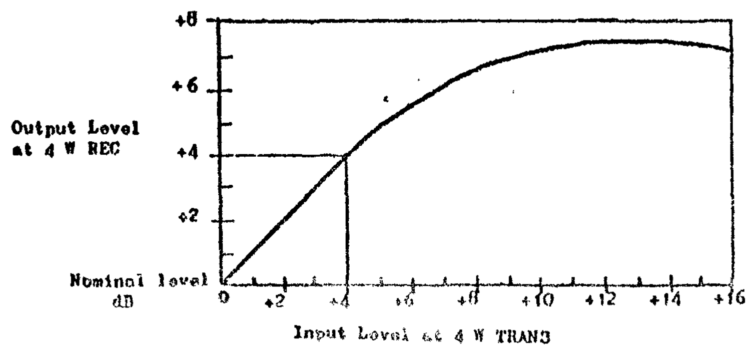
The channel unit send card is adjustable to cater for input levels between +13 and -17 dBr, with a return loss better than 20 dB when adjusted for input levels higher than -15 dBr.

The 600 ohm balanced input circuit is designed so that the nominal speech level to the limiter which follows, may be set to -17 dBr. This is achieved by the use of a fixed pad of 13 dB, which may be strapped out altogether if required; together with a pad holder, AP6, into which any desired value of pad assembly may be wired.

Thus - for an input level of -4 dBr, the 13 dB pad will be used and AP6 will be strapped out; whilst for a -16 dBr input, the 13 dB pad will be strapped out and 1 dB fitted in AP6, and so on.

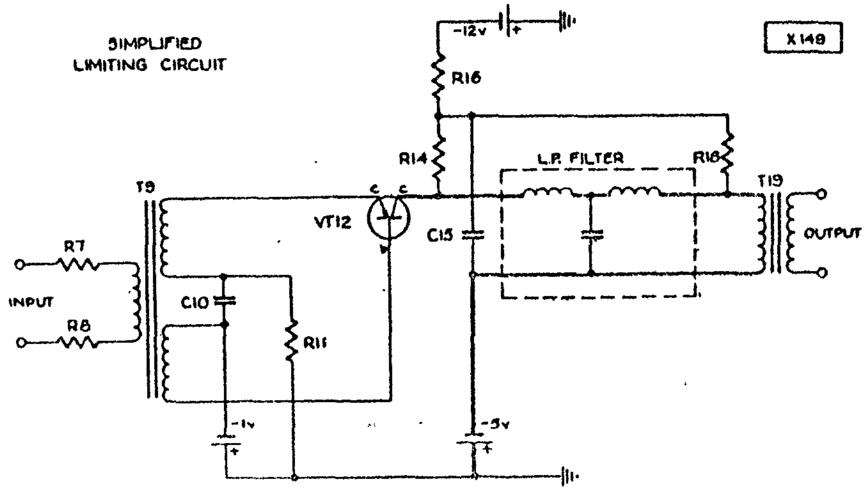


The limiter stage is designed so that, when presented with a nominal input level of -17 dBr, it will begin to limit for levels greater than -13 dBr and will ensure that the output never exceeds +8 dB above the nominal speech level. The characteristic is illustrated by the following diagram.



The operation of the limiter circuit is as follows:-

The signals are applied to the input transformer T9 which steps up the current applied to the emitter of VT12. R7 and R8 build the input impedance out to 600 ohms. R11 fixes the value of the emitter current and C10 decouples R11 to earth.



To increase the stage gain a controlled amount of positive feedback is applied by means of the winding on T9 which is in series with VT12 base.

The a.c. output circuit of CT12 (shown as a heavier black line in sketch X149) is completed via the L.P. filter coils, transformer T19, and the -5v supply. The D.C. potential between collector and emitter is thus held constant at 4v, (1v is dropped in the emitter bias circuit).

The limiting action takes place thus:

(a) Incoming (-)ve peaks cannot cause the output voltage at T19 to rise above 4v, since at this point VT12 bottoms i.e. the voltage drop across the collector load approaches the supply voltage, so that transistor action ceases.

(b) Incoming (+)ve peaks above a certain magnitude, drive VT19 into cut-off so limiting the output in this direction.

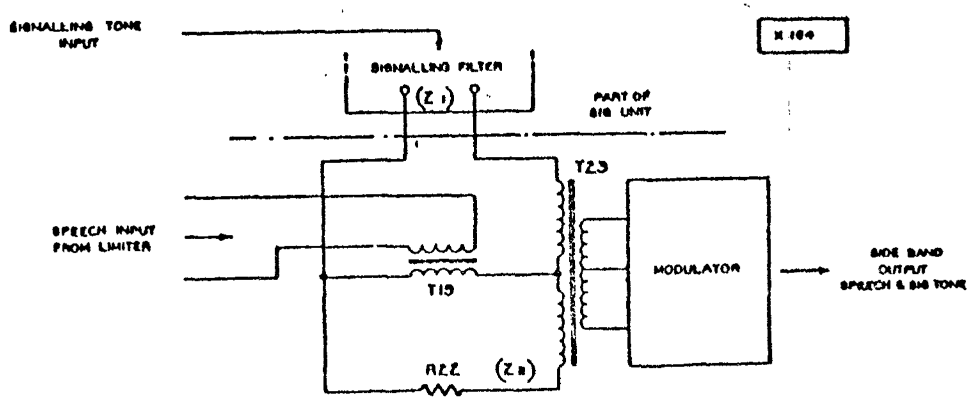
A steady direct current flows from the -12v supply via R16 and R14/R18 in parallel, through T19 primary, to the 5v supply. This current is arranged to approximately equal the opposing steady collector current of VT12 so that, by this means, the standing current in T19 primary is reduced to a minimum and magnetic saturation is avoided. R16 is a decoupling resistance, whilst R14 and R18, (earthed to A.C. by C15) provide correct terminations for the L.P. filter.

The function of the L.P. filter is to attenuate frequencies above 3.4 Kc/s thus preventing interference with the adjacent signalling channel.

The limiter output transformer T19 has, in addition to its secondary winding, a wound screen which is used for capacitive balancing purposes.

The speech signals pass through the signalling injection hybrid T23 which also serves as the modulator input transformer. Sketch X184 illustrates the operation of the circuit. The signalling filter is designed to have an output impedance equal to R22 (taking the transformer ratio into account), at both signalling frequency 3.825 Kc/s, and also at 175 c/s.

The hybrid is therefore balanced at these frequencies with consequent high attenuation to speech signals at these frequencies. Interference into the associated or the adjacent signalling channel is thereby prevented. For frequencies in the speech band 300 c/s - 3.4 Kc/s $Z1 \neq Z2$ so that the hybrid is unbalanced and the loss of the speech path is much less.



The modulator is of the miniature resin-potted type, employing copper-oxide rectifiers which are carefully matched to obtain balanced operation. The channel carrier frequency is fed in via the carrier leak adjustment circuit. Tag 33 may be strapped to any of tags 29-30-31-32 for minimum carrier leak and, in addition any one or more of resistors R27A-B or C may be strapped out if required for best results.

The sideband output resulting from the modulation process is fed via a fixed 3 dB isolating pad and adjustable 0-3 dB pad to the equalised channel band-pass filter which selects the required upper sideband. The equalisation compensates for the frequency characteristic of the low-pass as well as the band-pass filter.

The outputs from the three individual band-pass filters are connected in parallel at this point and signals in the range 12-24 Kc/s are fed to the subsequent sub-group stage at a level of -34 dBr into 600 ohms unbal.

Receive Path:

In the receive direction, signals from the associated sub-group stage are fed in at a level of -10 dBr in 600 ohms unbalanced, to the receive band-pass filter, which selects that portion of the 12-24 Kc/s band appropriate to the particular channel.

The signal then passes via a fixed 4 dB isolating pad to the demodulator, whose output includes the wanted lower sideband (300-3400 c/s). At this point in the transmission path, before the lower sideband is actually selected, facilities are provided for extraction of the 3.825 Kc/s signalling tone. Both speech and signalling frequencies are fed to the associated signalling unit where the signalling tone is selected by filtration and the speech signals returned to the transmission path at a level of -25.5 dBr.

If 'out-of-band' signalling facilities are not required, a 2.5 dB building-out pad is strapped into circuit to simulate the loss of the extraction circuit.

The required lower sideband is then selected by a 3.4 Kc/s lowpass filter and fed to the demod. amplifier via a potentiometer network, which adjusts the gain over a range of 10 dB in 1 dB steps by means of a shorting plug on the front face of the unit.

The demodulator amplifier consists of two transistor stages VT19 and VT27 with a nominal maximum gain of 36 dB.

Signals are applied to the base of VT19 via the input transformer T18. R17 and C41 ensure stability on maximum gain. R20 acts as collector load, and direct coupling is employed between VT19 collector and VT27 base. T28 is a parallel feeding choke fitted with a secondary winding which applies a.c. voltage feedback to the base emitter circuit of VT19. L29 is wound with resistance wire and serves as a current feedback resistor, the inductance providing frequency correction at high frequencies.

Finally, the signal is fed to the unit 4-wire receive point via the output transformer T35 and a fixed pad AP39 selected to suit contractual requirements. When the output required is +4 dBr the pad value is zero. The output impedance is 600 ohms unbalanced.

Circuit data:

Loss of bandpass filters in passband is 3-4 dB
Loss of receive lowpass filters below 3.4 Kc/s is less than 1.1 dB (Z in & Z out, 3600 ohms).
Current drain from supply .... 15.2 mA ± 15%

CMM 20052/1 High Level Signalling Unit

This multi card unit is designed to provide high level out-of-band signalling facilities, suitable for the transmission of dialling or ringdown pulses over an associated speech channel.

The signalling path employs a tone of 3.825 Kc/s, which operates at a level of -5 dBmO, and lies 0.425 Kc/s above the effective speech band (300-3400 c/s) of its associated V.F. channel.

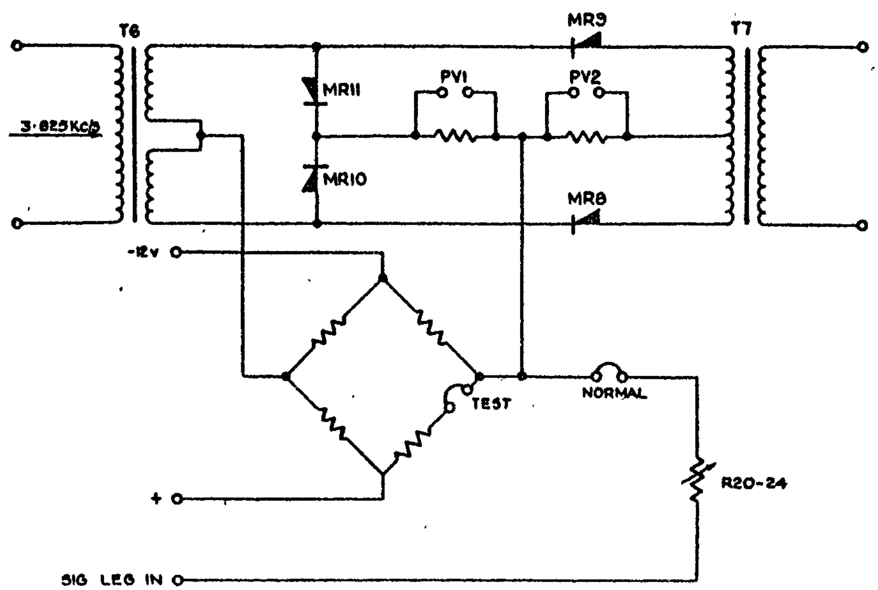
Signalling

Injection of the 3.825 Kc/s signalling tone into the transmission path, prior to the first stage of modulation, is controlled by means of a static relay, operated by an earth applied to the signalling line (M wire).

The signalling tone is fed continuously to the transmit static relay at a level of -11.5 dBm, and switching of the relay in sympathy with the signalling earth is governed by the balance of a bridge network, which controls the gating bias. One arm of the bridge is formed by the signalling line impedance, which is normally built out to 500 ohms by adjustment of the series resistor chain R20-24, to provide the correct operating condition. For test purposes, a link position SK29 (designated 'T') permits the resistor chain and line impedance to be replaced by a 500 ohms resistor.

The static relay bias condition is such that, in the quiescent state (No Signalling), the rectifiers MR10 and MR11 conduct, presenting a terminating impedance shunted across the signalling tone path, while MR9 and MR8 present a high series impedance. In this condition, a mid-scale deflection (0.5 volts) should be obtained across P.V.1 access point, indicating that the correct backing off bias is being applied.

X119/2



When the signalling line is earthed, the bias condition is reversed, permitting the signalling tone to pass via the send signalling band pass filter and an adjustable attenuator to the injection hybrid in the channel modulator input path. In this condition, a mid-scale deflection (0.5 volts) should be obtained across P.V.2 access point indicating that the correct forward bias is being applied. Any deviation from mid-scale can be corrected by adjustment of the resistor chain R20-24 in series with the signalling line.

The purpose of the bandpass filter is to permit a relatively gradual build-up of signalling voltage and thereby prevent interference with other channels, arising from the effects of sharp switching pulses applied to the static relay. The attenuator provides adjustment of from 0-3 dB around the nominal level to compensate for small differences in the discrimination of individual filters.

In the receive direction of transmission, the signalling tone is extracted at the output of the channel demodulator, by means of a 3.825 Kc/s bandpass filter from the hybrid T3.

The filter output level is raised by an amplifier which consists of two transistors, VT31 and VT33, both in grounded emitter configuration. The gain of the amplifier is adjusted by varying the negative feedback, R24-R29 being strapped accordingly.

The output of the amplifier is fed to the detector circuit (MR7 and MR8 with associated components) via a coupling network, which appears as a quarter wave line at signalling frequency. This network provides an impedance inversion at the amplifier output. R16, C34 and MR18 provide level compensation, which permits the receive signalling circuit to operate satisfactorily over the range +5 to -10 dB around the nominal level of -5 dBmO.

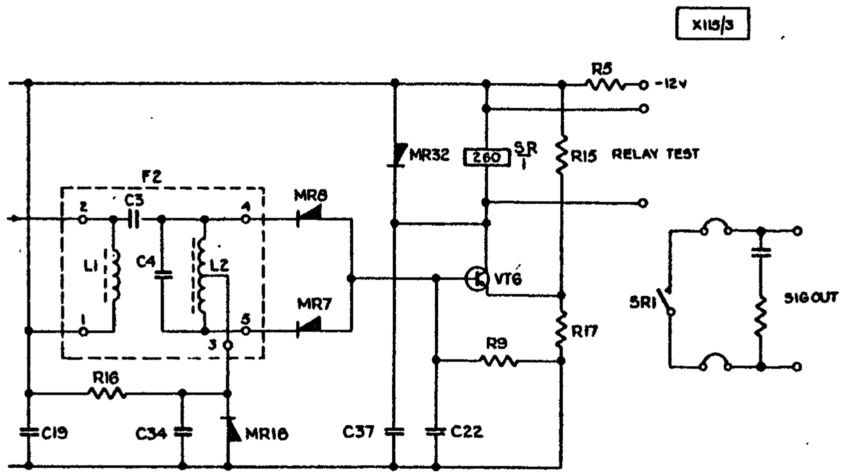
Finally, the output from the detector is fed to a single stage d.c. amplifier, VT6, in which a dry reed relay SR/1 provides the collector load. When operated, contact SR1 applies an earth to the signalling receive line (E wire), via the access links SK38, and spark quench circuit C35 and R36.

Level Compensated Signalling Detector

The coupling network F2, in addition to providing impedance inversion, converts from unbal to bal and provides d.c. paths for VT33 collector and for the rectified signal current. Terminals F2/1 and 3 are held at d.c. earth potential by C19 and C34 respectively. When no signal is applied MR18 is biassed forward by a small standing current determined by the value of R16. VT6 is cut off, R9, R15 and R17 being chosen substantially to maintain this condition even at high temperatures.

When a signal is applied VT6 conducts, the path for the rectified current being completed by MR18. It will be observed that the rectified current opposes the forward bias current in MR18, but it is arranged that VT6 bottoms before MR18 blocks. After VT6 bottoms, the rectifier current rises rapidly and MR18 blocks. (The path for the rectified current is now completed via the 12v power supply and R16).

The rectified voltage is divided between C22 and C34. The voltage across C22 is determined by the input voltage required to bottom VT6 - thus the excess voltage appearing across C34 is more than proportional to the input voltage.



Because VT6 conducts and bottoms before any appreciable voltage is developed across C34, the point in the build-up of the signal at which SR/1 operates is NOT affected by the compensation circuit, MR18/C34: SR/1 operates earlier for large signals than for small ones, as in an uncompensated receiver. It will be seen subsequently, however, that compensation is provided by arranging that SR/1 also releases earlier for large signals than for small ones.

When the signal begins to decay, the voltage across C22 follows the envelope of the decaying signal but the decaying charge in C34 opposes the voltage across C22. The rate of change of envelope voltage is numerically larger for large signals, than for small ones - thus VT6 cuts off earlier for large signals.

SR/1 therefore releases early in compensation for its early operation.

MR32 protects VT6 from the surge voltages that would otherwise be developed when VT6 is cut off. It also increases the release time of SR/1, and so assists in reducing the over-all impulse distortion. C37 prevents premature bottoming of VT6 by ripple voltages developed across SR/1.

Circuit data:

Z in, Z out	600 ohms
Current drain of send card.....	12.0 mA ± 15% (tone off) or 25.5 mA ± 15% (tone on)
Through loss of send card......	7.0 dB ± 1 dB
Current drain of receive card ..	8.6 mA ±, 20% (tone off) or 20 mA ± 2% (tone on)
Loss of receive path...........	2.5 dB ± 1 dB
Minimum input level to receiver for relay to operate..........	-50 dBm ± 3 dB

CMM 20061/1-4 Subgroup Carrier Amplifier

This unit comprises a parallel push pull output stage driven by a single transistor whose gain is temperature compensated. A number of strap in pad sections at the input to the unit enable it to be used with varying input levels and for it to provide an auxiliary output.

Circuit data:	Z IN 75 ohms Z OUT 75 ohms Nominal Output Nominal gain Current drain mA
Test Points :	TEST IN 75 ohm LEVEL TEST OUT 600 ohm LOSS.
Adjustments:	Pad, variable 0-15. 75dB in 0. 75dB steps.
Purpose:	To increase the level of the sub group carrier supplies from the frequency generator to ensure correct operating levels being applied to the sub group modulator & demodulators.

This unit comprises a pair of tandem connected push pull stages erating with tuned output transformers and with negative feed back. ie hybrid transformer T16 provides a spare outlet at low level and when used tags 9-10 must be strapped.

rcuit data	Z IN 75 ohms Z OUT 75 ohms Nominal output Nominal gain Current drain
est points	: TEST IN. 75 ohm LEVEL TEST OUT. 600 ohm LOSS
djustments	: Pad, variable 0-7dB in 1dB steps
urpose:	To increase the level of the channel carrier supplies from the frequency generator to ensure correct operating levels being applied to the channel modulators and demodulators.

CMA 30007/1 3.825 Kc/s Crystal Oscillator

This is an independent oscillator unit that generates the 3.825 Kc/s tone for all signalling channels. The crystal XL20 forms a positive feedback loop with the two stage amplifier VT5 and VT12, the amplifier being tuned by TC4 to avoid oscillation at spurious frequencies, the back-to-back silicon diodes MR18-19 are shunted across the feedback path to stabilise the output level by their limiting action. The thermistor RY34 stabilises the output against change in ambient temperature.

Circuit data:

Output level......................	0dBm into 75 ohm load
Level stability.................	± 0.4dB for temp range 20-50°C
Freq. Stability................	± 0.5 c/s " " "
Current drain..................	7.3 mA ± 10%
TEST OUT	-10 dBm 600 ohm loss

CMA 30024/2 54 Kc/s Low Pass Filter & Equaliser

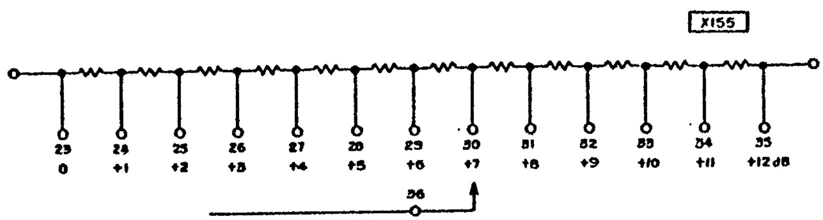
This unit comprises a 54 Kc/s low pass filter and equaliser network which are used to select the wanted lower side band (6-54 Kc/s) from the output of the 114 Kc/s group modulator.

The pass band loss of the filter is approx 0.5dB and in its stop band it provides approx 20dB discrimination.

This amplifier appears in both the transmit and receive paths of the group translating equipment.

The amplifier circuit is designed to give a substantially flat response over the frequency range 6-108 Kc/s and consists of two directly coupled grounded emitter stages followed by normal transformer coupled driver and output stages. Impedance correction components placed across the windings of both input and output transformers ensure a good return loss. Shaping networks together with voltage and current feedback are used to obtain a flat response.

The gain of the amplifier can be reduced by 12dB, in 1dB steps, from a maximum of 42dB by connecting tag 36 to tags 35-23 in turn as shown.



Circuit data:

Z in, Z out................	75 ohms
Gain......................	30-42 dB
Max output level..........	+5dBm
Frequency range.........	6-108 Kc/s

CMA 30030/2 Receive Circuit Hybrid and Filter Network

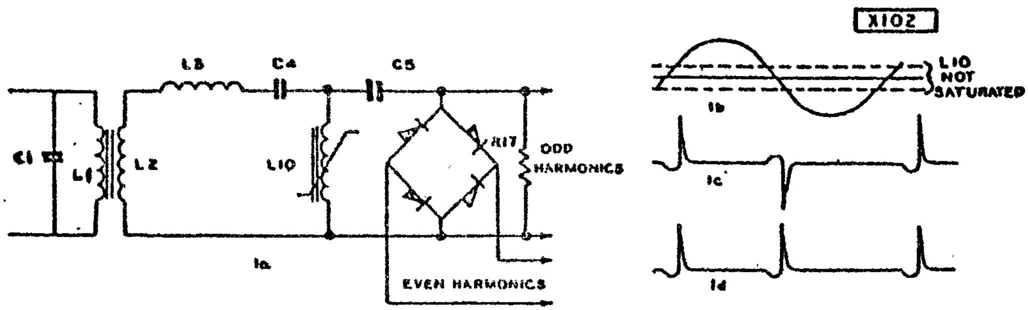
This unit is used to enable a 6-54 Kc/s 12 channel group to be separated from a 60-108 Kc/s group, assuming a composite 6-108 Kc/s band is applied to the input of the unit. Basically it consists of a hybrid transformer (T2), a circuit isolating device (T4), an -0-31 dB pad and a 60 Kc/s high-pass filter (F20).

The composite band is applied to tags 1-2, the 6-54 Kc/s and 60-108 Kc/s bands appearing at tags 18-19 and 16-17 respectively. In practice tags 16-17 and 14-15 may be strapped in which case the 60-108 Kc/s will then appear at tags 4-5.

CMA 30034/1 Sub Group Harmonic Generator

This generator operating with a 12 Kc/s input, is used to produce the 84, 96, 108 and 120 Kc/s sub-group carriers and the 60 Kc/s pilot. The circuit consists of a single-stage Class B push-pull amplifier, VT5 and VT6, driving a saturable reactor circuit, which together with a rectifier bridge, produces the required 'odd' and 'even' harmonics at separate outlets. Each outlet is fed to a set of paralleled filters, which select the required harmonics.

The amplifier input and output circuits are tuned by transformers TC1 and TC7 respectively. The nominal input level is 0dBm into 75 ohms. The copper resistor R3, provides temperature compensation.



SATURABLE REACTOR EXPLANATORY

In TC7, C1 and L2 are tuned to 12 Kc/s; L3 and C4 (modified by the external C9) together with saturable reactor L10 are also tuned to 12 Kc/s. These components form a filter and ensure that the current waveform applied to L10 is sinusoidal, thus making the production of harmonics independent of small changes in input waveform to the unit and of amplifier distortion.

L10 core remains in a saturated condition while the amplitude of the applied sine wave remains outside the levels indicated by the dotted lines. During this period, there is no flux change in L10, and consequently no voltage will be developed across its load.

When the amplitude of the applied waveform falls to a level at which L10 is no longer saturated, the capacitor C5 charges. As the reactor again saturates with the increasing amplitude of the applied waveform, the collapse of flux will allow C5 to discharge rapidly producing the pulse 1c, which contains the desired 'odd' harmonics. 1c, in fact, shows the current waveform through C5 and approximately the voltage waveform across R17. In order to develop the 'even' harmonics, the bridge doubler arrangement is added to the output circuit, reversing the polarity of alternate pulses giving the voltage waveform shown in 1d. It should be appreciated that the filter loads connected to the two output somewhat modify the output voltage waveform. R17, however, ensures that the waveform of the current through C5 (in TC7) is not critically dependent upon the filter loads.

CMA 30038/1-3 Band-pass Filters

These units mount 1 or 2 filter assemblies that are used to select the sub-group carrier frequencies and 60 Kc/s pilot from the outputs of an harmonic generator CMA 30034.

The assemblies used on this system are as follows:-

1. ... 60 Kc/s filter only
2. ... 96 & 120 Kc/s
3. ... 84 & 108 Kc/s

Circuit data:

Z in, Z out	75 ohms
Passband loss........	3.5 dB max

CMA 30206/1 Ringer Generator

This unit is used to provide an output of approx 75 volts at half the frequency of the local supply mains from which it is derived. It is used in conjunction with a mains transformer which operates from the local supply to provide 75-0-75 volt outlet and also a 6 volt 'trigger voltage'. The generator itself consists of (a) a single stage pulse generator and (b) an Eccles - Jordan bistable multi-vibrator.

The pulse generator employs an OC 44 (VT4) as a limiting device which produces a squared pulse which is used to trigger the multi-vibrator the trigger voltage being applied to the junction between MRs 15-17 and R16, C10 being the coupling device. Two dry reed relays RA/1 and RB/1 are employed as collector loads for VTs 13 and 21, the associated relay contacts RA1 and RB1 being used to switch the 75 volts supply.

VT4's base has applied to it 6 volts a. c. derived from the mains transformer and this supply is just high enough to cause limiting action by which the squared pulse becomes available to trigger the two transistors in the multi-vibrator. Under the action of this pulse VTs 13 and 21 conduct alternatively at half the mains frequency the two relays RA and RB cycling in sympathy.

This concentional balanced ring modulator is employed to effect the translation of the basic 60-108 Kc/s group to and from the band 6-54 Kc/s. A 0-7dB adjustable attenuator is included, together with a 108 Kc/s low-pass filter and filter equaliser. A 3dB isolating pad is provided between the modulator and filter to improve impedance matching.

When used on the R24B system, the carrier is applied at tags 17 and 19 with tags 17-18 strapped together, so that the unit presents a load to the carrier source equal to a mod/demod pair (56 ohms).

Circuit data:

Z in and Z out..................	75 ohms
Conversion loss (with 3 dB pad before and after modulator)......	12 dB $\pm$ 1dB
Loss of filter and equaliser......	1 dB min

CMA 30241/1 800 c/s Test oscillator

This test oscillator which is an optional item may be used for lining up the system initially and may then be used for routine maintenance testing and for synchronising the system.

It consists of asingle transistor (VT16) operating in an L/C (tuned) oscillator circuit to produce an 800 c/s output at a nominal level 0dBm. This level can be set accurately by means of strappings on tags 23 to 27 incl. Key KA has three positions. In its centre position the oscillator output is fed out at 0dBm and may be patched to the 2W access links of the present system.

In its "-4dBm " position a 4dB pad is inserted in the oscillator output path to enable the instrument to be patched to the 4W TRANS links in the present equipment.

In the "SYNC" position a rectifier MR10 is shunted across the oscillator output to ensure a high even harmonic content being available along with the 800 c/s fundamental. This enriched "output" can then be transmitted to the distant terminal for synchronising purposes. Rectifier MR19 is supplied for patching across a suitable portable level meter to detect frequency deviation (beating) between similar signals sent from the distant terminal.

Circuit data	Z OUT 600 ohms	
	Nominal level out	+0. 5dB
	Sync output level	-6 $\pm$ 2dB.
	Level Stability	$\pm$ 1. 0dB range 20C to 50°C
	Freq Stability	$\pm$ 10 c/s range 20C to 50°C
Current drain:	7. 3 mA	
Adjustments:	Output Level	
	Maximum (Strap tags 23 to 26)	
	Progressive	
	24-26	23-25
	25-26)	24-25
&	23-24)	23-24
	25-26	
	Min output	No Straps

CMA 30520/1   3.825 Kc/s Band Stop Filter.

This unit is inserted in the 4W REC path whenever high level out of band signalling is employed, its presence limiting the audio band and eliminating interference at 3825 c/s at the 4W REC point.

CMB 40903/1 Ringdown Relays

Two relay sets, the requirements for 2 channels are mounted on this card. Each relay set provides facilities for the conversion of 17 c/s ringdown signalling between the exchange or switchboard 2 wire line and the transmit and receive legs of an 'out-of-band' signalling circuit.

Two relays RR/4 and RT/3 are employed in each relay set. The first operating to a 24v d.c. supply, and the second to rectified 17 c/s or low frequency signalling pulses.

The operation of the relay set to signals in either direction is detailed below.

Send:

17 c/s ringdown signalling pulses from the exchange 2-wire line are fed via the unoperated contacts of RR2 and RR4 and the split winding of the associated 2W/4W hybrid to the bridge network MR1, which rectifies the low frequency pulses to operate relay RT/3.

Contacts RT1 and RT2 short circuit the split windings of the 2W/4W Hybrid.

Contacts RT3 complete the signalling earth loop to operate the associated 'out-of-band' transmit static relay.

Receive:

Incoming signalling operates relay SR/1 on the associated signalling receive card. This relay extends an earth loop to RR/4.

Relay RR/4 operates.

Contact RR1 places a 600 ohm load across the hybrid 2-wire winding.

Contacts RR2 and RR4 break the 2-wire line connections to the hybrid and replace it with 17 c/s ringing supply.

Contact RR3 extends a loop to start a 17 c/s generator, when necessary.

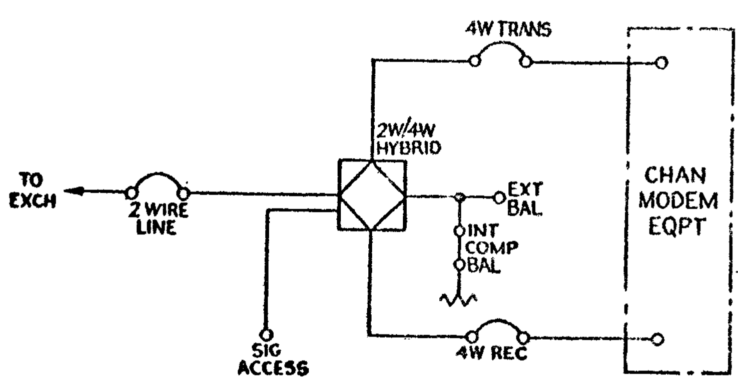
This unit is fitted on all channels which are to be operated on a two wire basis. Two similar circuits are contained in each unit. Each circuit provides a 2W/4W conversion and can be used for low frequency signalling (17 c/s) over the 2-wire line or d.c. signalling over each leg of the 2-wire line and earth.

An internal compromise balance network is provided comprising R1 and one section of C1. The internal networks can be disconnected when the use of an external balance is preferred.

Requirement	Connect tags	Disconnect tags
C/ct 1. Comp. bal.	TS1/ 1 & 2	TS1/15 & 16
C/ct 1. Ext. bal.	TS1/15 & 16	TS1/1 & 2
C/ct 2. Comp. bal.	TS1/ 9 & 10	TS1/5 & 2
C/ct 2. Ext. bal.	TS1/ 5 & 6	TS1/9 & 10

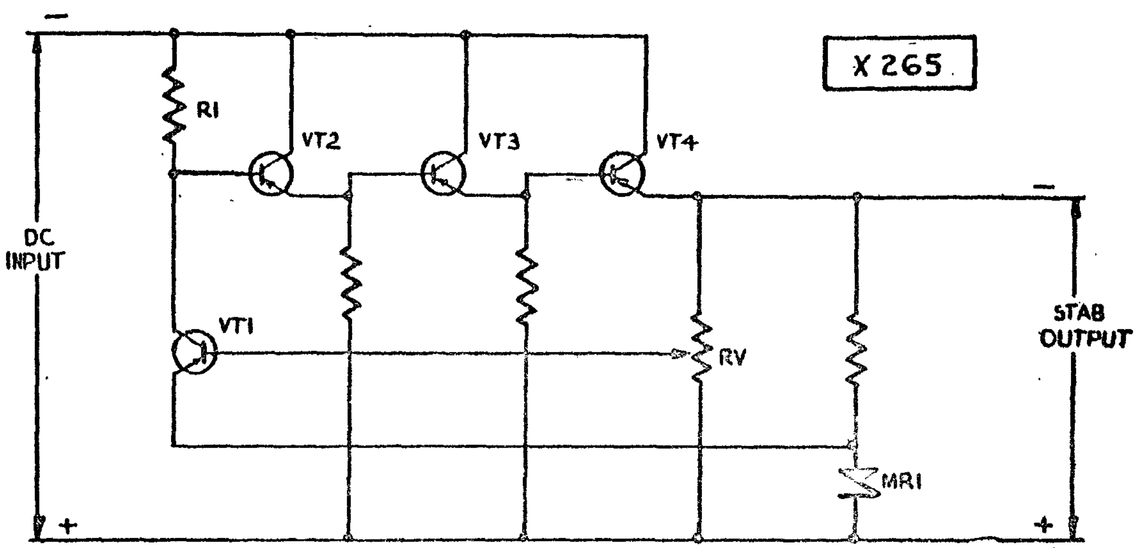
The units may be wired to access points located on the adjacent shelf end blocks, providing facilities for level measurements, terminating or breaking each circuit for test purposes. Alternatively access sockets may be mounted on the unit.

X 326



This unit is fed with an a.c. input of approx 22-0-22v from an externally mounted supply transformer and employs a bi-phase silicon rectifier to produce a d.c. output which is stabilised to 20v by the action of a transistorised regulation circuit.

The action of the stabiliser circuit may be followed with the aid of diagram X265. Note that in the actual circuit, ES/CMS 40907 Sh.2, the output stage VT4 in the diagram consists of two transistors in parallel.



Circuit Operation:

Part of the output voltage developed across the potential divider RV is fed back as a base bias to VT1. This is compared against a fixed reference voltage developed across a zener diode MR1 and applied to VT1 emitter, thus VT1 collector current is a direct function of the output voltage. Should the output voltage tend to rise, the collector current of VT1, flowing through R1 will increase and reduce the potential applied to the base of VT2. The collector current of VT2 will then fall, this effect is amplified by VT3 and passed to VT4. VT4 being in series with the supply will, by the fall in its emitter current, tend to restore the voltage to normal.

A tendency for the output voltage to fall would be countered by the reverse sequence of events.

The main output voltage can be adjusted to a precise value by means of tappings on the potential divider RV.

Five separately fused 12v outlets are available, each with a test socket designed to give a normal reading of 0.5v ± 3% on a 5000 ohms d.c. test meter (e.g. P.V. meter). Further outlets, for use as bias supplies at 1v and 5v, are also available, together with smoothed 20v d.c. supply connected to a test socket marked '20v Noisy', the test meter reading here is 0.5v ± 30%.

Circuit data:

Range of input voltage ...... ± 10% from normal
Main output voltage......... 12v ± 0.5v
Aux output voltage.......... 20v ± 6v
Max load current........... 2.2 amps

APPARATUS SCHEDULE

ES/CMS 20002 SH. 1.

Issue. 5

CMA 30004

APPARATUS SCHEDULE					
R2	28·2K	±1%	1/4W	H.S.	
R3	2·88K	±1%	1/4W	H.S.	
R4	470Ω	±1%	1/4W	H.S.	
R5	928Ω	±1%	1/4W	H.S.	951-9663
R6	1·2K	±1%	1/4W	H.S.	
R8	22Ω	±1%	1/4W	H.S.	
R9	3·3K	±5%	1/4W	H.S.	
R11	12K	±10%	1/4W	C	
R13	82Ω	±10%	1/4W	C	
R14	3Ω	±5%	1/4W	H.S.	
R15	620Ω	±5%	1/4W	H.S.	
R16	30K	±5%	1/4W	H.S.	
VT7, VT12	OC72	MULLARD			
MR10	OA10				
SK1	TC94253				
MC17	CMZ40804 (SEE BELOW)				

CMA 30010

APPARATUS SCHEDULE					
R24	8·2K	±10%	1/4W	C	
R25	4·7K	±10%	1/4W	C	
R28	100Ω	±2%	1/8W	H.S.	
R29	1·2K	±2%	1/8W	H.S.	
R30	160Ω	±5%	1/8W	H.S.	
R33	220Ω	±5%	1/8W	H.S.	
R34	110Ω	±5%	1/8W	H.S.	
R35	56Ω	±5%	1/8W	H.S.	
R36	430Ω	±1%	1/8W	H.S.	
R38	5·6K	±2%	1/8W	H.S.	
R40	3K	±2%	1/8W	H.S.	
R41	130Ω	±5%	1/8W	H.S.	
R43	220Ω	±1%	1/8W	H.S.	
R44	560Ω	±2%	1/8W	H.S.	
R45	300Ω	±5%	1/8W	H.S.	
R46	27·6Ω	±1%	1/8W	H.S.	951-9683
R47	454Ω	±1%	1/8W	H.S.	951-9583
R48	49Ω	±1%	1/8W	H.S.	951-9576
R50	163Ω	±1%	1/8W	H.S.	951-9548
R51	374Ω	±1%	1/8W	H.S.	951-9536
R52	33Ω	±1%	1/8W	H.S.	
C23, C27, C39	0·5μF	±25%	150V	MP	
C32	1μF	±25%	150V	MP	
C37	0·25μF	±25%	150V	MP	
VT26, VT42	OC72	MULLARD			
TC31 TC49	CMZ 40403/8				

CMA 30009

APPARATUS SCHEDULE				
R5	8·2K	±2%	1/8W	H.S.
R6, R19	2·7K	±2%	1/8W	H.S.
R9	1K	±2%	1/8W	H.S.
R12	4·7K	±10%	1/4W	C.
R13	18K	±10%	1/4W	C
R14	12K	±10%	1/4W	C
R17	390Ω	±2%	1/8W	H.S.
R18	1·8K	±2%	1/8W	H.S.
R21	8·2K	±2%	1/8W	H.S.
C1	TC68220		6-70pF.	
C2	80pF	±1%	350V	S.M.
C3	120pF	±1%	350V	S.M.
C4	220pF	±5%	350V	S.M.
C10, C11	0·1μF	±25%	150V	M.P.
C16, C20, C22	0·25μF	±25%	150V	M.P.
VT7, VT15	OC44	MULLARD		
TC8	CMZ 40406/1			

CMZ 40804

APPARATUS SCHEDULE		
OC	TC99420	
AL	TC99421	
MR7, MR8	OA95	MULLARD
MR4 MR5	SX640	G.E.C.
L3	TC281601	
CTH.1	TC61020	
CTH 2	TC61019	
XL6	TC94098	
TUBE (VACUUM FLASK)	TC75619	

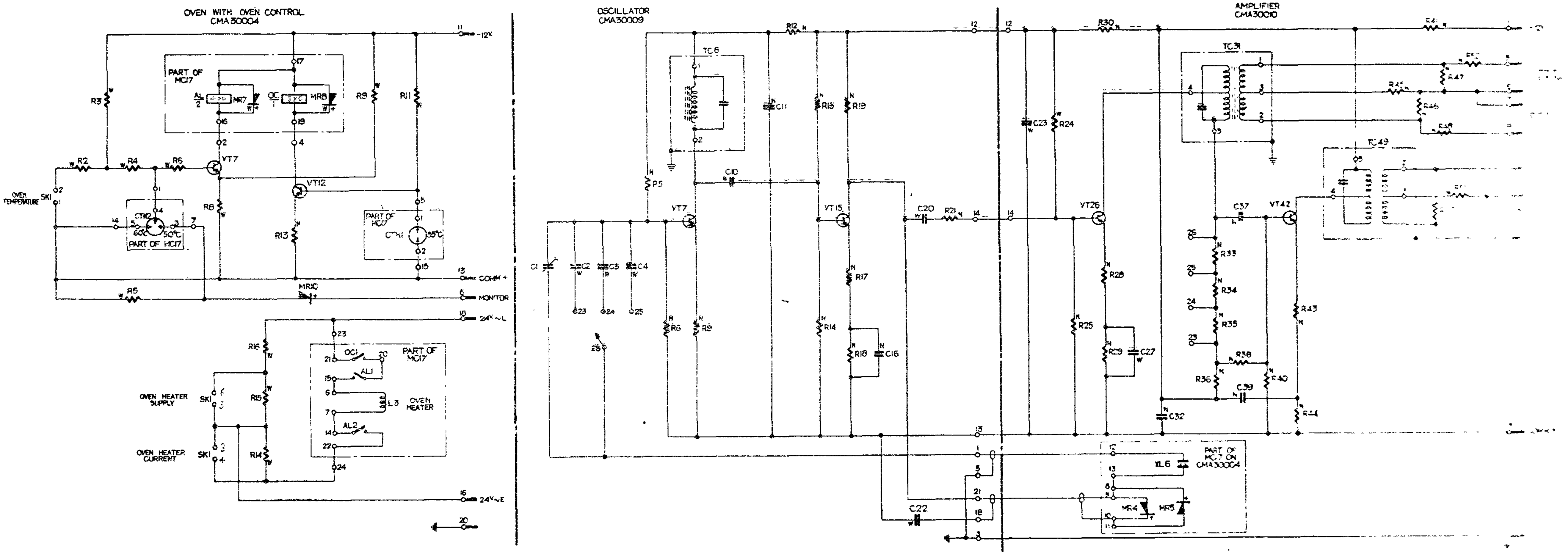
ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.

1	12Kc/s MASTER OSC. & OVEN WITH OVEN CONTROL UNIT
ASS	DESCRIPTION

12 Kc/s MASTER OSCILLATOR

ES/CMS 20002 SH. 1.

Issue. 5



APPARATUS SCHEDULE

ES/CMS20003 ISSUE 3

CMA 30012

APPARATUS SCHEDULE					
R27, R33	306Ω	±1%	1/8W	H.S	951-9537
R29, R35	895Ω	±1%	1/8W	H.S.	951-9546
R30, R36	454Ω	±1%	1/8W	H.S.	~~951-9550~~
R32	85Ω	±1%	1/8W	H.S.	951-9550
R38, R40	39Ω	±1%	1/8W	H.S.	951-9532
R39	53Ω	±1%	1/8W	H.S.	951-9572
T28, T34	TC 953202				
T31	TC 953204				
T37	TC 953203				
F41	CMZ 40257/1				

CMA 30013

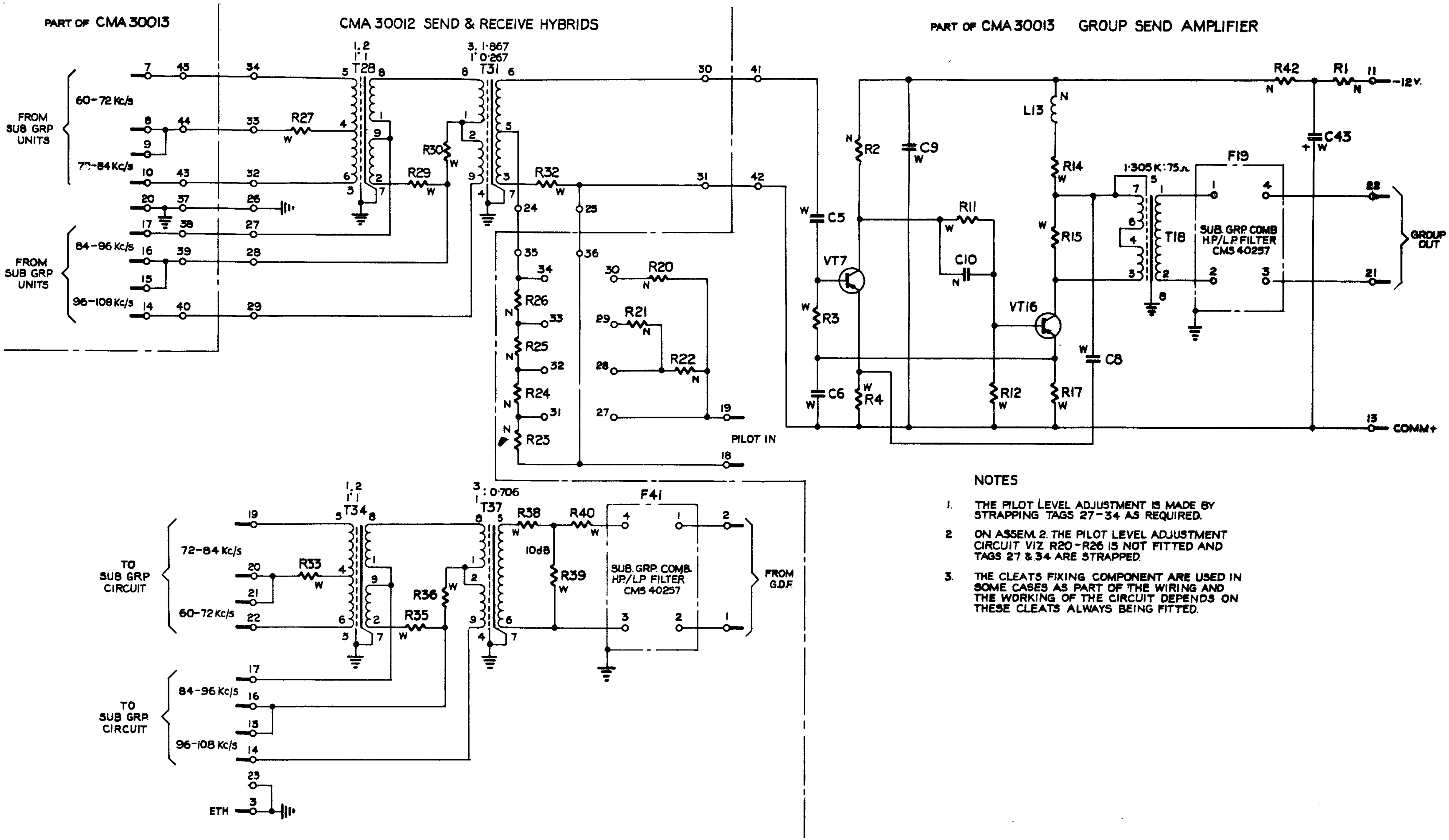
APPARATUS SCHEDULE					
R1, R42	510Ω	±5%	1/8W	H.S	
R2, R17	2·2K	±5%	1/8W	H.S	
R3	600Ω	±1%	1/8W	H.S	
R4	3·3K	±5%	1/8W	H.S.	
R11	4·7K	±5%	1/8W	H.S	
R12	15K	±5%	1/8W	H.S.	
R14	73·5Ω	±1%	1/8W	H.S	951-9538
R15	1·3K	±1%	1/8W	H.S	
R20	7·5Ω	±2%	1/8W	H.S.	951-9684
R21	2·7Ω	±5%	1/8W	H.S	951-9547
R22	2·4Ω	±5%	1/8W	H.S	951-9590
R23	70·6Ω	±1%	1/8W	H.S	
R24-R26	10Ω	±1%	1/8W	H.S	951-4116
C5, C6	1μF	±25%	150V	M.P	
C8	0·25μF	±25%	150V	M.P	
C9	0·5μF	±25%	150V	M.P	
C10	0·1μF	±25%	150V	M.P	
T18	TC953418				
L13	TC28653				
VT7, VT16	OC45 MULLARD				
F19	CMZ 40257/1				
C43	16μF	±20%	12V	T.C.C. TA	

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.

ASSEM	DESCRIPTION
2	W/O PILOT LEVEL ADJUSTMENT
1	W/- PILOT LEVEL ADJUSTMENT

SUB GROUP COMBINING UNIT

CMS20003 ISSUE 3.



NOTES

1. THE PILOT LEVEL ADJUSTMENT IS MADE BY STRAPPING TAGS 27-34 AS REQUIRED.
2. ON ASSEM. 2. THE PILOT LEVEL ADJUSTMENT CIRCUIT VIZ R20-R26 IS NOT FITTED AND TAGS 27 & 34 ARE STRAPPED.
3. THE CLEATS FIXING COMPONENT ARE USED IN SOME CASES AS PART OF THE WIRING AND THE WORKING OF THE CIRCUIT DEPENDS ON THESE CLEATS ALWAYS BEING FITTED.

APPARATUS SCHEDULE

ES/CMS 20005

Iss.4.

CMA 30016

APPARATUS SCHEDULE				
R1	228Ω	± 1%	1/8W	H. S.
R4 951-9592	2·16K	± 1%	1/8W	H S.
R6 951-9577	50Ω	± 1%	1/8W	H. S.
R8 951-9544	13·8K	± 1%	1/8W	H. S
R9 951-9535	366Ω	± 1%	1/8W	H S
R11,R13	33Ω	± 5%	1/8W	H S.
R12	5·1K	± 5%	1/8W	H. S
R14,R16	68Ω	± 5%	1/8W	H. S.
R15	2·7K	± 5%	1/8W	H. S.
MR5	TC95266			
T3	TC953411			
T7	TC953200			
L2	TC281604			
F10 (ASS. 1.)	CMZ 40000/1			
F10 (ASS 2)	CMZ 40000/2			
F10 (ASS 3)	CMZ 40000/3			
F10 (ASS.4.)	CMZ 40000/4			

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

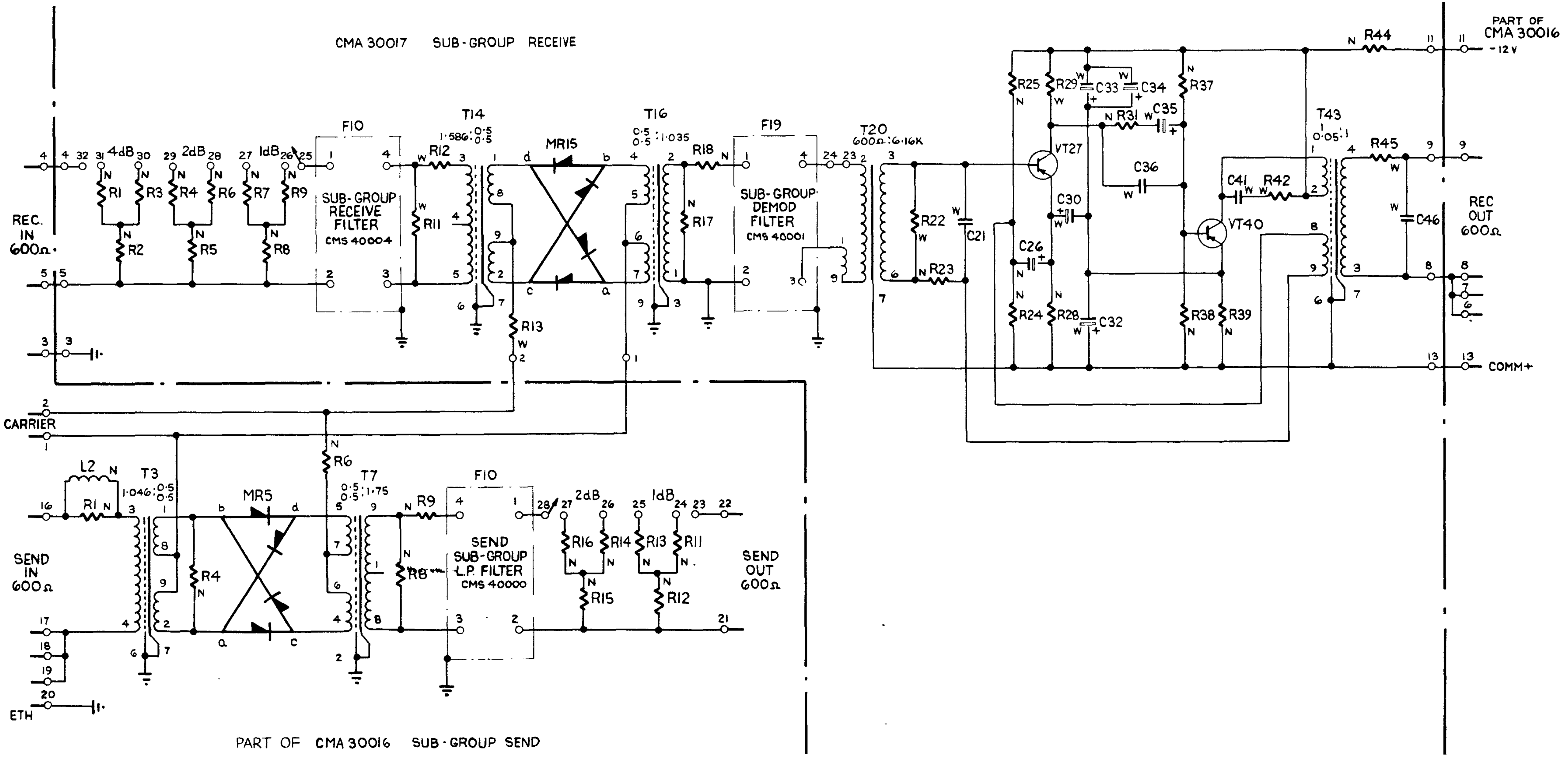
CMA 30017

APPARATUS SCHEDULE					
R1 R3	135Ω	± 1%	1/8W	H.S	
R2	1·26K	± 1%	1/8W	H S.	951-9686
R4,R6	68Ω	± 5%	1/8W	H S.	
R5	2·7K	± 5%	1/8W	H S.	
R7,R9	33Ω	± 5%	1/8W	H S	
R8	5·1K	± 5%	1/8W	H. S	
R11	3·42K	± 1%	1/8W	H. S	951-9522.
R12	360Ω	± 1%	1/8W	H S	
R13	50Ω	± 1%	1/8W	H S	951-9577
R17	1·35K	± 1%	1/8W	H S	951-9584
R18	282Ω	± 1%	1/8W	H S	951-9539
R22	6·8K	± 1%	1/8W	H. S	
R23	2·2K	± 1%	1/8W	H. S	
R25	15K	± 5%	1/8W	H S.	
R29	2·2K	± 5%	1/8W	H S	
R31	100K	± 10%	1/4W	C	
R37,R38	6·8K	± 1%	1/8W	H. S	
R39	1K	± 1%	1/8W	H. S.	
R44	470Ω	± 10%	1/4W	C	
R45	470Ω	± 1%	1/8W	H. S.	
C21	150pF	± 10%	350v	S. M.	
C26	3·3μF	± 20%	12v	T.C.C.T.A	
C30 C32	8μF +50% -20%		6v	T.C.C.T.A	
C33,C34	15μF ±20%		12v	T.C.C.T.A	
C35	0·1μF +50%-20%		150v	T.C.C.T.A	
C36	0·02μF	± 20%	200v	M.P	
C41 C46	1500pF	± 5%	350v	M.M	
MR15	TC 952606				
T14	TC 953201				
T16	TC953412				
T20	TC953566				
T43	TC953414				
VT27,VT40	OC45	MULLARD			
F10 (ASS 1)	CMZ 40004/1				
F10 (ASS 2)	CMZ 40004/2				
F10 (ASS 3)	CMZ 40004/3				
F10 (ASS 4)	CMZ 40004/4				
F19	CMZ 40001/1				
R24	11KΩ	± 5%	1/8W	H S	
R28	1·8KΩ	± 5%	1/8W	H. S.	
R42	68Ω	± 10%	1/4W	C.	

4.	60Kc/s TO 72Kc/s
3.	72Kc/s TO 84Kc/s
2	84Kc/s TO 96Kc/s
1	96Kc/s TO 108Kc/s
ASSEM.	DESCRIPTION

SUB GROUP MODEM UNIT

ES/CMS 20005 ISSUE 4



APPARATUS SCHEDULE

ES/CMS 20006 ISSUE 5

CMA 30021

	APPARATUS SCHEDULE				
	R1	180Ω	±5%	1/4 W	H.S.
	R3	62 Ω	±5%	1/4 W	H.S.
	R4	16 Ω	±5%	1/4 W	H.S.
	R6	1·8K	±10%	1/4 W	C
	R11	12K	±10%	1/4 W	C.
	R13	470Ω	±10%	1/4 W	C.
	R14	1·8K	±5%	1/4 W	H.S.
	R15	3·9K	±5%	1/4 W	H.S
	R18	100Ω	±5%	1/4 W	H.S.
	R19	680Ω	±5%	1/4 W	H.S.
	R21	0·82Ω	±10%		H.S.
	R22	1·8Ω	±10%	1/4 W	H.S.
	R23	3·6Ω	±5%	1/4 W	H.S
	R24	7·2Ω	±2%	1/4 W	H.S.
	R25	14·4Ω	±1%	1/4 W	H.S.
951-9466	R30	490Ω	±1%	1/4 W	H.S.
	R30A	9·1k	±1%	1/4 W	H.S.
951-9478	R31	98·2Ω	±1%	1/4 W	H.S.
	R32, R34	596Ω	±1%	1/4 W	H.S.
951-9550	R33, R35	85Ω	±1%	1/4 W	H.S
	R37	82Ω	±10%	1/4 W	C.
	R38 (ASS.1)	75Ω	±1%	1/4 W	H.S.
	C10	0·5µF	±25%	150V	M.P.
	C12	0·04µF	±20%	200V	M.P.
	C16	0·1µF	±25%	150V	M.P
	C36	8 µF	±20%	12V	T.C.C. T.A
	SK2	TC 94242			
	T5	TC 953436			
	MR7	OAZ 204 (MULLARD)			
	MR26, 27, 28 29	OA 10 (MULLARD)			
	VT9	OC 44 (MULLARD)			
	VT17	OC 72 (MULLARD)			
	RELAY ACO	TC 99421 (ASS.1)			
	TC8	CMZ 40402/1			
	TC 20	CMZ 40407/1			

CMA 30022

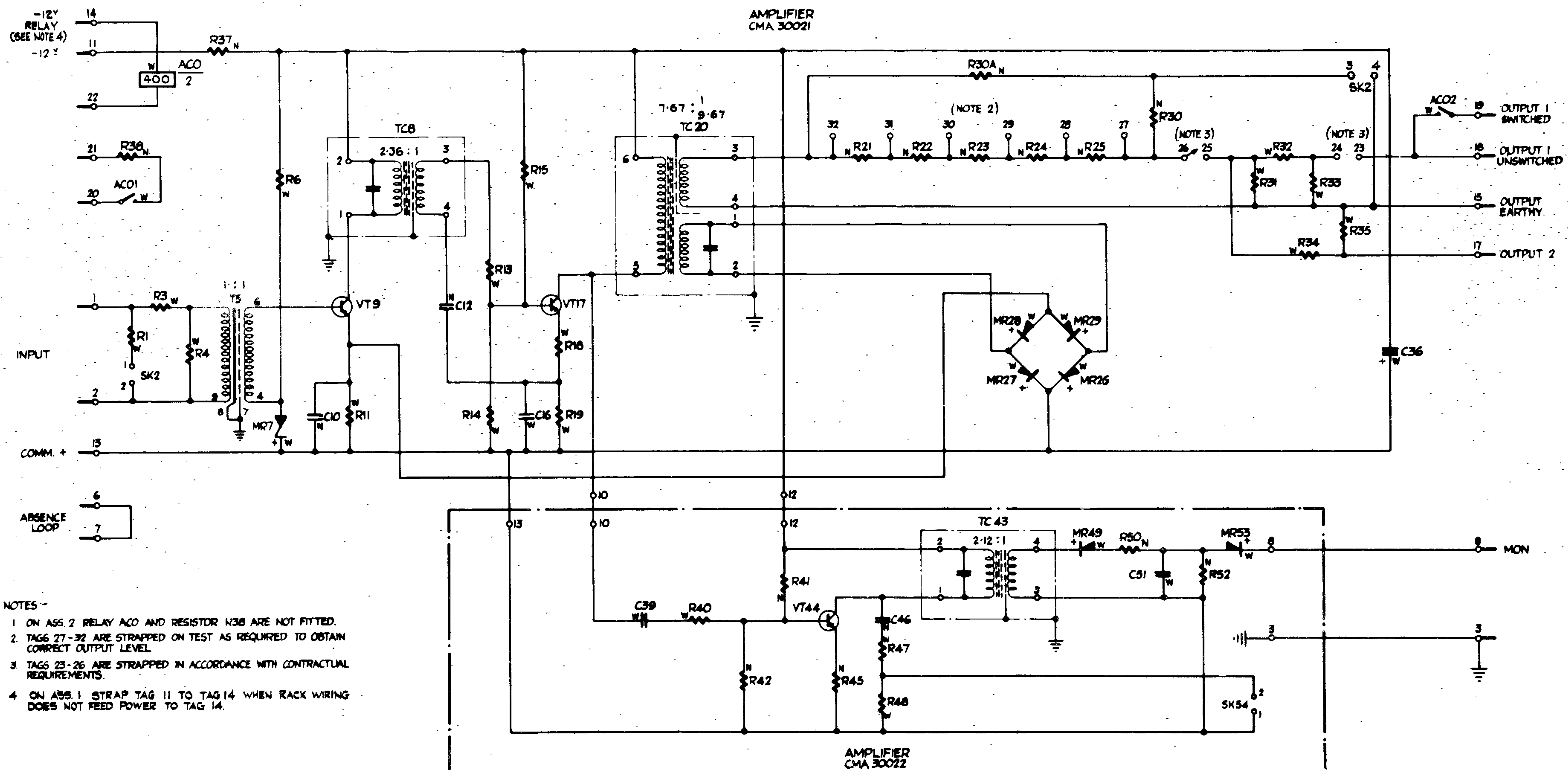
APPARATUS SCHEDULE					
R40	4·7k	±1%	1/4 W	H.S.	
R41	12K	±1%	1/4 W	H.S	
R42	3·3K	±1%	1/4 W	H.S	
R45,	820Ω	±1%	1/4 W	H.S	
R47	15K	±1%	1/4 W	H.S	
R50	100Ω	±10%	1/4 W	C.	
R52	1K	±10%	1/4 W	C.	
C39, C46	0·02µF	±20%	200V	M.P	
C51	0·5µF	±25%	150V	M.P.	
VT44	OC 72 (MULLARD)				
MR49, MR53	OA 10 (MULLARD)				
SK 54	TC 94242				
TC 43	CMZ 40402/2				
R48	910Ω	±1%	1/4 W	H.S.	951-9663

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.

ASS	CMA 30021	CMA 30022	DESCRIPTION
1	ASS.1.	ASS.1.	60Kc/S PILOT AMP
2	ASS.2.	ASS.1.	60 Kc/S PILOT AMP % %

APPARATUS SCHEDULE

CMS20006 ISSUE 5.



NOTES:-

1. ON ASS. 2 RELAY ACO AND RESISTOR R38 ARE NOT FITTED.
2. TAGS 27-32 ARE STRAPPED ON TEST AS REQUIRED TO OBTAIN CORRECT OUTPUT LEVEL.
3. TAGS 23-26 ARE STRAPPED IN ACCORDANCE WITH CONTRACTUAL REQUIREMENTS.
4. ON ASS. 1 STRAP TAG 11 TO TAG 14 WHEN RACK WIRING DOES NOT FEED POWER TO TAG 14.

APPARATUS SCHEDULE

ES/CMS 20008

Issue. 1. 16.5.61.

CMA 30035

APPARATUS SCHEDULE				
R31	220Ω	±10%	¼W	C
R33	10k	±5%	⅛W	H S
R34	3 3k	±5%	⅛W	H S.
R36	47k	±5%	⅛W	H S
R37	15k	±5%	⅛W	H S
R41	68Ω	±5%	⅛W	H S.
R42	470Ω	±5%	⅛W	H S.
R46	220k	±10%	¼W	C
R47	2 7k	±10%	¼W	C.
R49	1k	±10%	¼W	C
R53	56Ω	±5%	⅛W	H.S.
R54	680Ω	±10%	¼W	C.
C32, C43	2μF	±25%	150V	M.P.
C35	0·04μF	±20%	200V	M P
C56	1μF	±25%	150V	M P.
MR44, MR45	OA10 (MULLARD)			
RTH48	L 94492			
VT40, VT52	OC 72 (MULLARD)			
TC 38	CMZ 40401/2			
TC 39	CMZ 40203/5			
TC 50	CMZ 40203/7			
TC 51	CMZ 40203/6			

CMA 30036

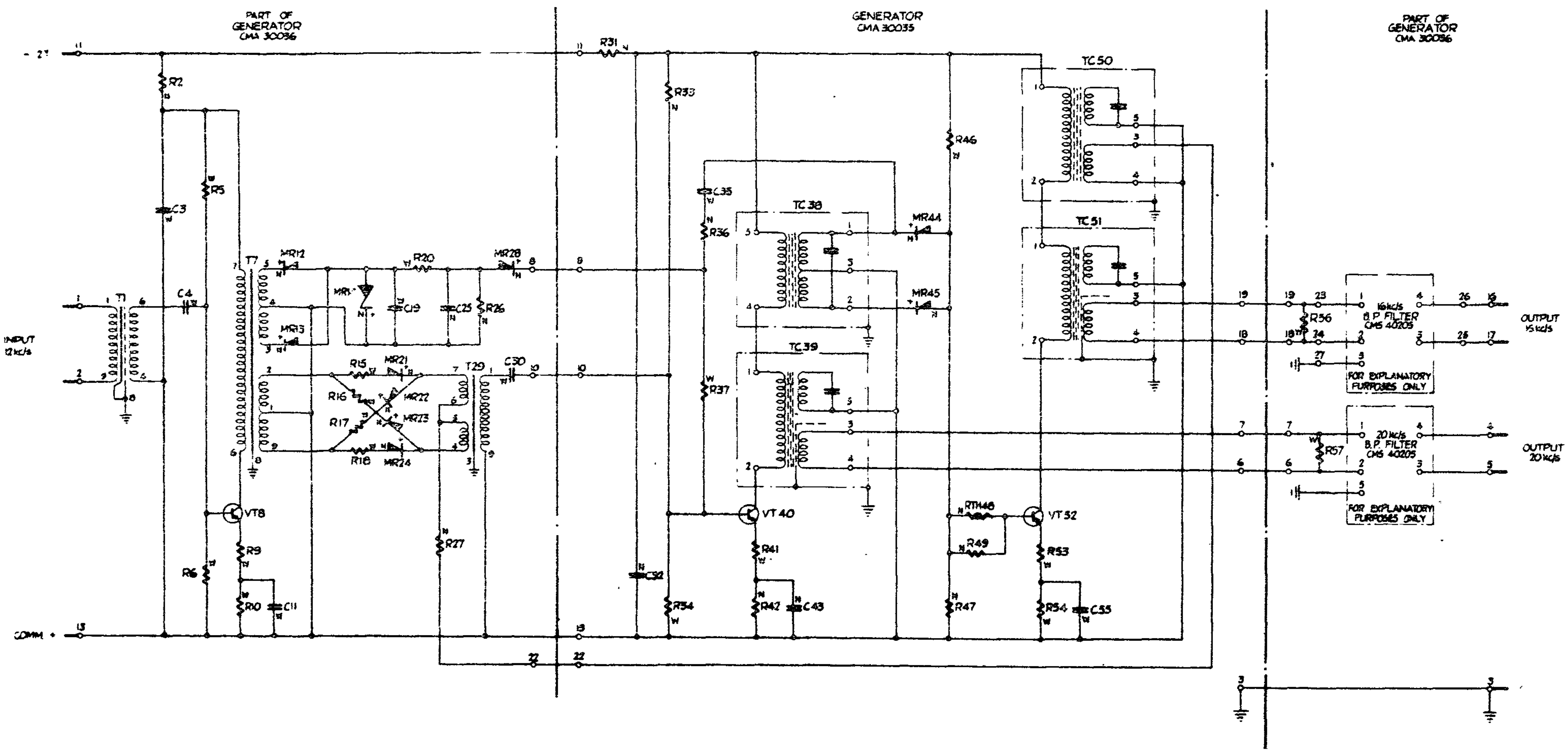
APPARATUS SCHEDULE				
R2	470Ω	±10%	¼W	C
R5	3·9k	±10%	¼W	C
R6	1·8k	±10%	¼W	C
R9	68Ω	±5%	⅛W	H S.
R10	560Ω	±10%	¼W	C
R15, 16, 17, 18	100Ω	±10%	¼W	C
R20	3·3k	±10%	¼W	C
R26	22k	±10%	¼W	C.
R27	82Ω	±10%	¼W	C
C3	2μF	±25%	150V	M P
C4	0·1μF	±25%	150V	M.P
C11 C30	1μF	±25%	150V	M P
C19, C25	0·04μF	±20%	200V	M P
T1	TC 953428			
T7	TC 953429			
T29	TC 953430			
VT8	OC 72 (MULLARD)			
MR12, 13, 21, 22, 23, 24 28	OA10 (MULLARD)			
MR14	OAZ 201 (MULLARD)			
R56	56Ω	±5%	⅛W	H S.
R57	220Ω	±5%	⅛W	H.S.

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

16 & 20 Kc/s GENERATOR

ES/CMS 20008

Issue. 1. 16.5.61.



APPARATUS SCHEDULE

CMS 20044 SH 1.

ISS 5.

CMA 30031/1-4

APPARATUS SCHEDULE

R1	(ASS.4)	360Ω	±1%	1/4 W.	H.S.	
R2	(ASS.4)	47Ω	±5%	1/4 W.	H.S.	
R3	(ASS.4)	100Ω	±5%	1/4 W.	H.S.	
R4	(ASS.4)	220Ω	±5%	1/4 W.	H.S.	
R5	(ASS.4)	86·5Ω	±1%	1/4 W.	H.S.	
R1	(ASS.1)	1920Ω	±5%	1/4 W.	H.S.	~~951-9475~~
R2	(ASS.1)	240Ω	±5%	1/4 W.	H.S.	
R3	(ASS.1)	510Ω	±5%	1/4 W.	H.S.	
R4	(ASS.1)	1200Ω	±5%	1/4 W.	H.S.	
R5	(ASS.1)	77·8Ω	±1%	1/4 W.	H.S.	
R1	(ASS.2)	1·6K	±1%	1/4 W.	H.S.	
R2	(ASS.2.)	220Ω	±5%	1/4 W.	H.S.	
R3	(ASS.2.)	390Ω	±5%	1/4 W.	H.S.	
R4	(ASS.2)	910Ω	±5%	1/4 W.	H.S.	
R5	(ASS.2)	79·2Ω	±1%	1/4 W.	H.S.	
C6		TC682804		2-30pf		
XL7		TC94103				
XL9		TC94104				
N8		CMZ 40206/1				
R1	(ASS.3)	1·18K	±1%	1/4 W.	H.S.	
R2	(ASS.3)	150Ω	±5%	1/4 W.	H.S.	
R3	(ASS.3)	330Ω	±5%	1/4 W.	H.S.	
R4	(ASS.3)	750Ω	±5%	1/4 W.	H.S.	
R5	(ASS.3)	79·2Ω	±1%	1/4 W.	H.S.	

CMA 30032/1

APPARATUS SCHEDULE

R1	1K	±5%	1/8 W.	H.S.	
R2	12K	±1%	1/8 W.	H.S	
R4, R16	2·2K	±5%	1/8 W.	H.S.	
R6	3·3K	±5%	1/8 W.	H.S.	
R8	4·7K	±5%	1/8 W.	H.S.	
R11	15K	±5%	1/8 W.	H.S.	
R13	73·5Ω	±1%	1/8 W.	H.S.	951-9538
R14	4·14KΩ	±1%	1/8 W.	H.S.	
C3	1μf	±25%	150V	M.P.	
C7	0·5μf	±25%	150V	M.P.	
C9	0·1μf	±25%	150V	M.P.	
C10	0·25μf	±25%	150V	M.P.	
VT5, VT15	OC45 MULLARD				
L12	TC286[illegible]				
T17	TC9[illegible]				

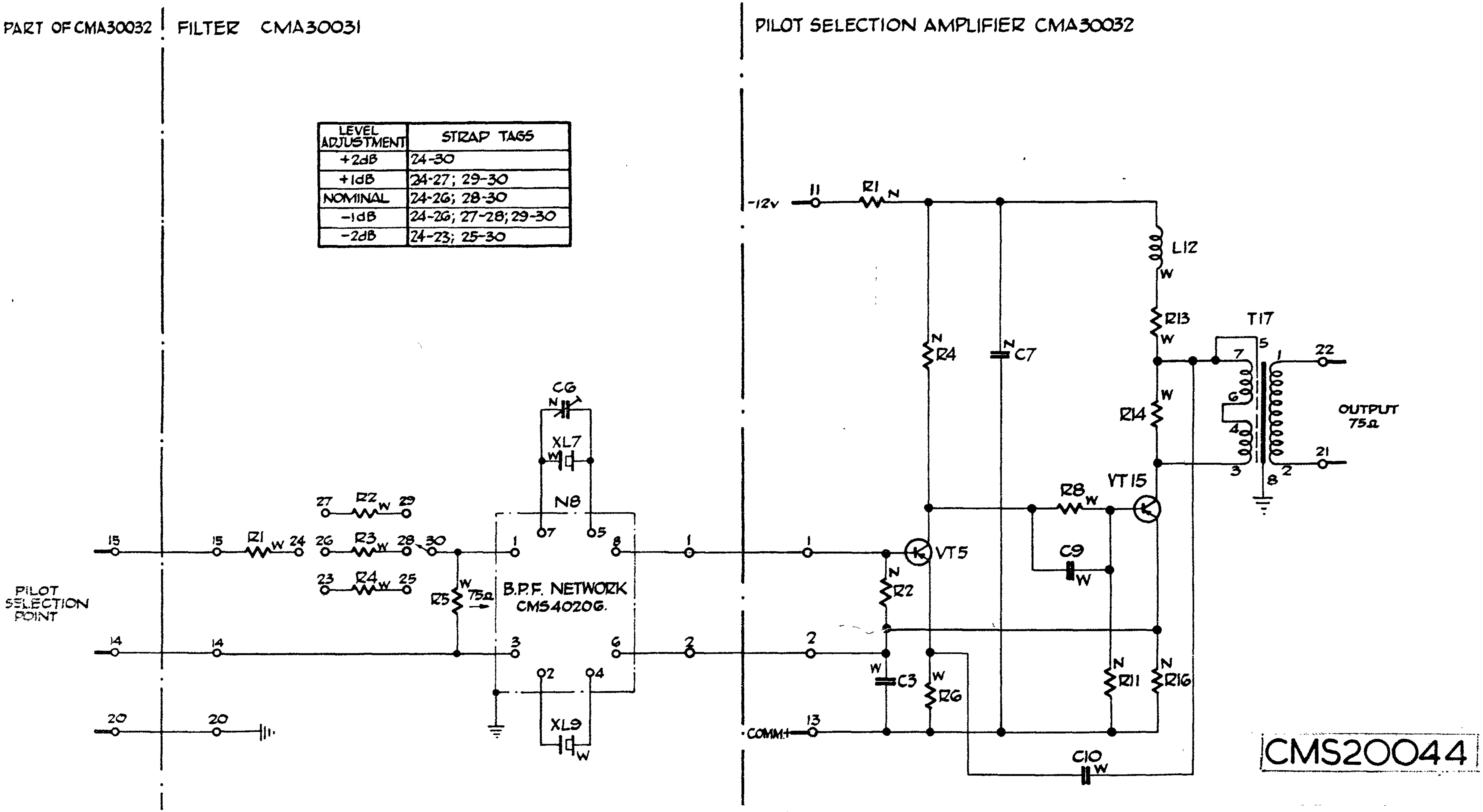
6	ASS.4.	ASS.1.	60K c/s PILOT SELECTION AMP. & FILTER (24 CHAN)
3	ASS.3.	ASS.1.	60K c/s PILOT SELECTION AMP & FILTER (24 CHAN)
2	ASS.2.	ASS.1.	60K c/s PILOT SELECTION AMP & FILTER (60 CHAN)
1	ASS.1.	ASS.1.	60K c/s PILOT SELECTION AMP. & FILTER (24 CHAN)
ASS	CMA 30031.	CMA 30032	DESCRIPTION

PILOT SELECTION AMPLIFIER & FILTER

ES/CMS 20044.Sh.1.

ISS.5.

LEVEL ADJUSTMENT	STRAP TAGS
+2dB	24-30
+1dB	24-27; 29-30
NOMINAL	24-26; 28-30
-1dB	24-26; 27-28; 29-30
-2dB	24-23; 25-30



APPARATUS SCHEDULE

ES/CMS 20050

Issue 5. 6.3.62.

CMA 30182

	APPARATUS SCHEDULE				
951-9585	R1,R4.(AS1)	946	± 1%	1/8 W	HS
951-9594	R2,R3(AS.1)	632	± 1%	1/8 W	HS
	R7, R8	220	± 1%	1/8 W	HS
	R11	820	± 1%	1/8 W	HS
	R14	6 8K	± 1%	1/8 W	HS
	R16	3K	± 1%	1/8 W	HS
	R18	8·2K	± 1%	1/8 W	HS
	R20, R21	4 7K	± 1%	1/8 W	HS
951-9543	R22	1·44K	± 1%	1/8 W	HS
951-9587	R24	2·12K	± 1%	1/8 W	HS
951-9532	R26	39	± 1%	1/8 W	HS
	R27	TC28286			
951-9549	R29, R30	104 Ω	± 1%	1/8 W	HS
	R32, R33	33	± 5%	1/8 W	HS
	R34	5·1K	± 5%	1/8 W	HS
	R35, R36	66	± 5%	1/8 W	HS
	R37	2 7K	± 5%	1/8 W	HS
	C10	8 µF ± 20% 6V T.C.C TA			NON
	C15	2 µF +50% -20% 12V T.C.C.TA			POLARISED
	T9	TC953492			
	T19	TC953494			
	T23	TC953493			
	T28	TC953401			
	MR25	TC95266			
	VT12	OC75 (MULLARD)			
	F17	CMZ 40003/1			
	R1, R4(ASS2)	3·6K	± 5%	1/8 W	HS
	R2-R3(ASS2)	110 Ω	± 5%	1/8 W	HS
	APG (ASS2)	CMZ 40800/2			
	R31	1·72K	± 1%	1/8 W	HS

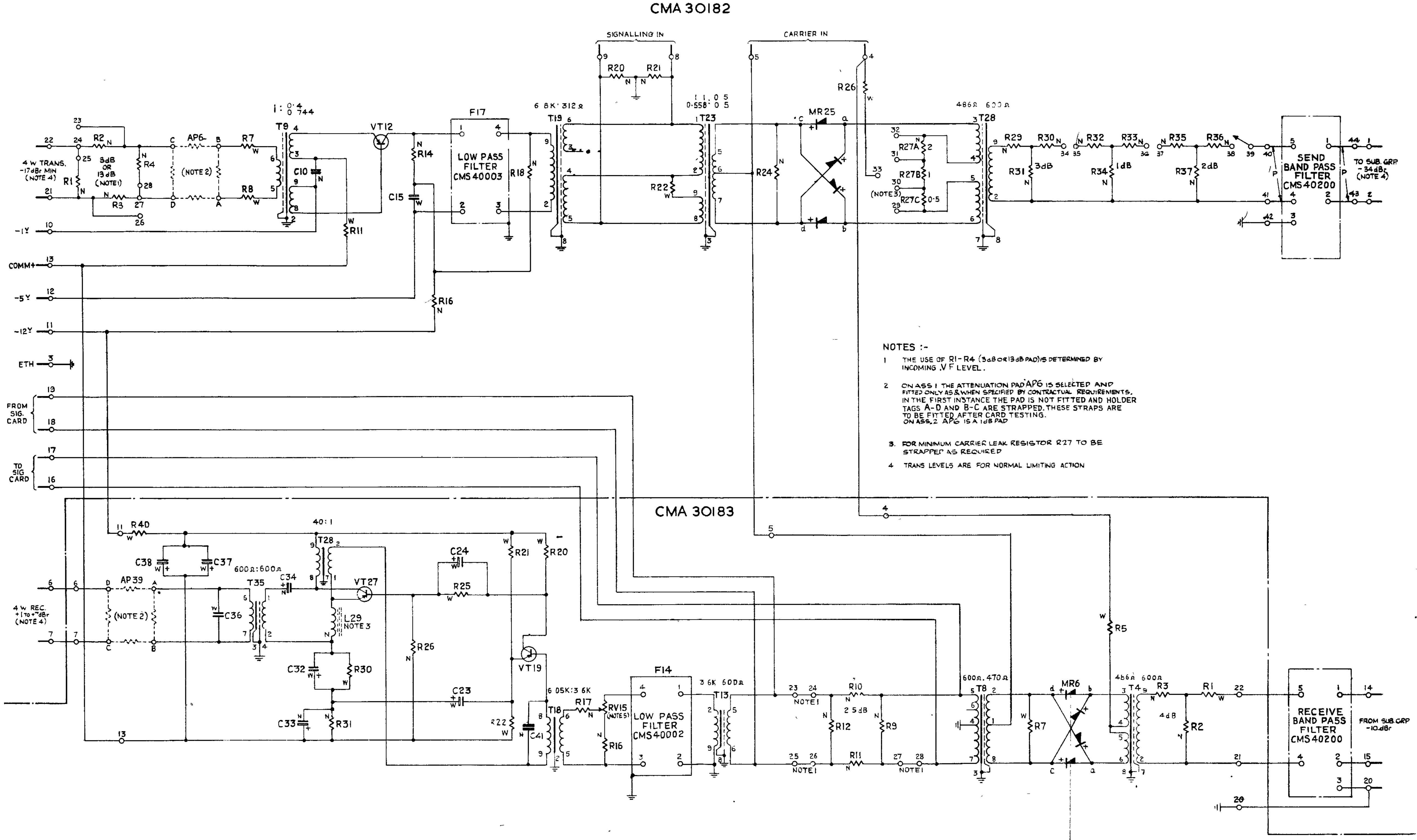
CMA 30183

APPARATUS SCHEDULE					
R1, R3	135	± 1%	1/8 W	HS	
R2	1·26K	± 1%	1/8 W	HS	951-9686
R5	43	± 1%	1/8 W	HS	951-9596
R7	1·6K	± 1%	1/8 W	HS	
R9, R12	4·3K	± 5%	1/8 W	HS	
R10, R11	91	± 5%	1/8 W	HS	
R16	1·26K	± 1%	1/8 W	HS	951-9686
R17	330	± 5%	1/8 W	HS	
R20	5·1K	± 5%	1/8 W	HS	
R21	3·3K	± 5%	1/8 W	HS	
R22	470	± 5%	1/8 W	HS	
R25	560	± 5%	1/8 W	HS	
R26	4·3K	± 5%	1/8 W	HS	
R30	18	± 5%	1/8 W	HS	
R31	200	± 5%	1/8 W	HS	
R40	15	± 10%	1/4 W	C	
C23, C32	50 µF ± 20% 3V T.C.C.TA				
C24	4 µF +50% -20% 6V T.C.C.TA				
C33	8 µF +50% -20% 6V T.C.C.TA				
C34	3 µF +50% -20% 12V T.C.C.TA				
C36	0 02 µF ± 20% 250V MP				
C37, C38	16 µF ± 20% 12V T.C.C TA				
T4	TC 953401				
T8	TC 953490				
T13	TC953491				
T18	TC 953403				
T28	TC 953400				
T35	TC953402				
MR6	TC 95256				
RV15	TC 72246				
VT19	OC71 (MULLARD)				
VT27	OC72 (MULLARD)				
L29	TC 281603				
F14	CMZ40002/1				
C41	2000 pf ± 5% 200V SM				

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

LAB REF - CMA 30182 AA/9
CMA 30183 AA/8

6	CMA 30182/2	CMA 30183/1	CMZ 40200/3	20 Kc/s	
5	CMA 30182/2	CMA 30183/1	CMZ 40200/2	16 Kc/s	OBSOLESCENT
4	CMA 30182/2	CMA 30183/1	CMZ 40200/1	12 Kc/s	
3	CMA 30182/1	CMA 30183/1	CMZ 40200/3	20 Kc/s	
2	CMA 30182/1	CMA 30183/1	CMZ 40200/2	16 Kc/s	
1	CMA 30182/1	CMA 30183/1	CMZ 40200/1	12 Kc/s	
ASS	TRANS CARD	REC CARD	B.P FILTERS	DESCRIPTION	REMARKS



NOTES :-

1 THE USE OF R1-R4 (3dB OR 13dB PAD) IS DETERMINED BY INCOMING V F LEVEL.

2 ON ASS 1 THE ATTENUATION PAD AP6 IS SELECTED AND FITTED ONLY AS & WHEN SPECIFIED BY CONTRACTUAL REQUIREMENTS. IN THE FIRST INSTANCE THE PAD IS NOT FITTED AND HOLDER TAGS A-D AND B-C ARE STRAPPED. THESE STRAPS ARE TO BE FITTED AFTER CARD TESTING. ON ASS.2 AP6 IS A 1dB PAD

3. FOR MINIMUM CARRIER LEAK RESISTOR R27 TO BE STRAPPED AS REQUIRED

4 TRANS LEVELS ARE FOR NORMAL LIMITING ACTION

NOTES :-

1. INSERT STRAPS BETWEEN TERMINALS 23-24, 25-26 AND 27-28 WHEN THERE IS NO OUT-OF-BAND SIGNALLING

2. THE ATTENUATION PAD AP39 IS SELECTED AND FITTED ONLY AS AND WHEN SPECIFIED BY CONTRACTUAL REQUIREMENTS. WHEN NOT REQUIRED HOLDER TAGS A-D AND B-C ARE STRAPPED.

3. L29 IS WOUND WITH RESISTANCE WIRE.

4. LOWER LEVELS OBTAINABLE BY FITTING AP39

5. 10dB BY 1dB STEPS

CHANNEL UNIT

ES/CMS 20050

Issue 5 6.3.62.

20050

APPARATUS SCHEDULE.

CMS 20052 Sh1.

CMA 30218

APPARATUS SCHEDULE				
R1	750	±1%	3/4W	HS
R2	500	±1%	1/2W	HS
R3	270	±1%	1/2W	HS
R4	750	±1%	1/2W	HS
R5	180	±5%	1/8W	HS
R12	330	±5%	1/8W	HS
R14	30K	±5%	1/8W	HS
R15, R16	200	±5%	1/8W	HS
R17, R18	430	±5%	1/8W	HS
R19	16K	±5%	1/8W	HS
R20	510	±5%	1/4W	HS
R21, R22	200	±5%	1/4W	HS
R23	100	±5%	1/4W	HS
R24	51	±5%	1/4W	HS
R25	138	±1%	1/8W	HS
R26	294	±1%	1/8W	HS
R27, R28	680	±5%	1/8W	HS
MR8/MR9	TC 95246			
MR10, MR11	TC 95 248			
T6	TC 953405			
T7	TC 953511			
SK29, SK30	TC 94241			
F13	CMZ 40217/1			

CMA 30219

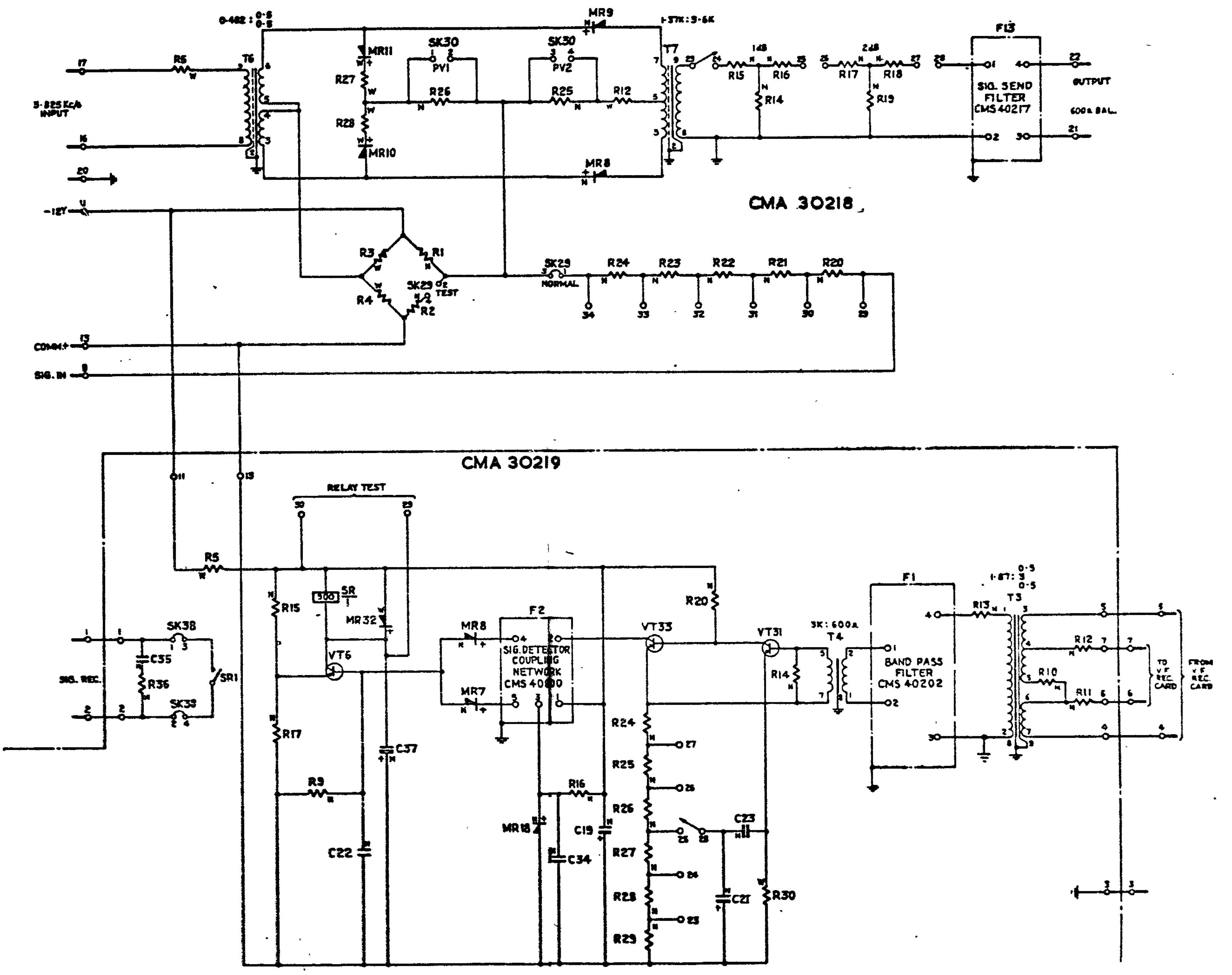
APPARATUS SCHEDULE				
R5	15	±5%	1/8W	HS
R9	3K	±5%	1/8W	HS
R10	1·76K	±1%	1/8W	HS
R11, R12	47	±5%	1/8W	HS
R13	51	±5%	1/8W	HS
R14	3·42K	±1%	1/8W	HS
R15	2·7K	±1%	1/4W	HS
R16	20K	±1%	1/8W	HS
R17	30	±1%	1/8W	HS
R20	15K	±5%	1/8W	HS
R24	6·2	±5%	1/8W	HS
R25	2	±5%	1/8W	HS
R26	2·4	±5%	1/8W	HS
R27	3	±5%	1/8W	HS
R28	3·9	±5%	1/8W	HS
R29	330	±5%	1/8W	HS
R30	1·3K	±5%	1/8W	HS
R36	100	±10%	1/4W	C
C19	32μF	±20%	12V	TCC TA
C21	8μF +50% -20%		6V	TCC TA
C22	0·25μF	±25%	150V	MP
C23*	1·0μF +50% -20%		12V	TCC TA
C34	1·0μF	±25%	150V	MP
C35	0·5μF	±25%	350V	MP
C37	0·5μF +50% -20%		50V	TCC TA
VT6, 33	CV 7006			
VT31	CV 7005			
MR7, 8, 18, 32	TC 95248			
SR	TC 99417			
SK38	TC 94241			
T3	TC 953512			
T4	TC 953495			
F1	CMZ 40202/2			
F2	CMZ 40600/1			

951-9522

* CAPACITOR C23 IS NON POLARISED

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.

H.L. SIGNALLING UNIT. ES/CMS 20052. Sh.1.



CMM 20061/1-12 incl.

CMA 30244

APPARATUS SCHEDULE

	R1	180Ω	±5%	¼W	H.S.
	R3,R2	25Ω	±1%	¼W	H.S.
	R10	100Ω	±1%	¼W	H.S.
	R5,R4	13 Ω	±5%	¼W	H.S.
	R11	220Ω	±5%	¼W	H.S.
	R7,R6	6·2Ω	±5%	¼W	H.S.
	R12	430Ω	±5%	¼W	H.S.
	R9,R8	3·3Ω	±5%	¼W	H.S.
	R13	910Ω	±5%	¼W	H.S.
	R16	30Ω	±1%	¼W	H.S.
951-9464	R18	65·6Ω	±1%	¼W	H.S.
	R19,R20	120 Ω	±1%	¼W	H.S.
	R21	100 Ω	±1%	¼W	H.S.
	R14 (ASS.3)	1470Ω	±1%	¼W	H.S.
	R15 (ASS.3)	20Ω	±5%	¼W	H.S.
	R17 (ASS.3)	110Ω	±5%	¼W	H.S.
	R17 (ASS.2)	240Ω	±5%	¼W	H.S.
	R14 (ASS.2)	875Ω	±1%	¼W	H.S.
	R22 (ASS.1)	41·4Ω	±1%	¼W	H.S.
951-9468	R14 (ASS.1.)	4·06K	±1%	¼W	H.S.
951-9693	R23 (ASS.1)	16·9Ω	±1%	¼W	H.S.
	R15 (ASS.1)	50Ω	±5%	¼W	H.S.
	R17 (ASS.1.)	55Ω	±5%	¼W	H.S.
	T1	TC 953423			
	SK1	TC94242			

CMA 30006

APPARATUS SCHEDULE

R42	10K	±5%	¼W	H.S.
R43	4·7K	±5%	¼W	H.S.
R45 951-9475	1·92K	±1%	¼W	H.S.
R49	69·2Ω	±1%	¼W	H.S.
R50	1·5K	±5%	¼W	H.S.
R52	150Ω	±10%	¼W	C.
R53	680Ω	±5%	¼W	H.S.
R55	220Ω	±5%	¼W	H.S.
R62-R65	10Ω	±5%	¼W	H.S.
R66,R67	150Ω	±5%	¼W	H.S.
R69	15Ω	±10%	¼W	C.
C39	2μF	±25%	150V	M.P.
C41,C60,C61	0·1μF	±25%	150V	M.P.
C44	1500pF.	±5 %	200V	S.M.
C48,C68	1μF	±25%	150V	M.P.
C54	0·5μF	±25%	150V	M.P.
C56,C61	470pF	±10%	350V	S.M.
RY47	K22	S.T.&C.		
VT46	CV7003 (OC44 MULLARD)			
VT57&60	CV7006 (OC72 MULLARD)			
T51	TC 953424			
TC70	(ASS.1)	CMZ 40404/1		
TC70	(ASS.2)	CMZ 40404/2		
TC70	(ASS.3)	CMZ 40404/3		
TC70	(ASS.4)	CMZ 40404/4		
TC70	(ASS.5)	CMZ 40404/5		
TC70	(ASS.6)	CMZ 40404/7		
TC70	(ASS.7)	CMZ 40404/8		
TC70	(ASS.8)	CMZ 40404/9		
TC70	(ASS.9)	CMZ 40404/6		
TC70	(ASS.10)	CMZ 40404/10		
TC70	(ASS.11)	CMZ 40404/11		
TC70	(ASS.12)	CMZ 40404/12		

ASS	CMA30244 ASS	CMA30006 ASS	DESCRIPTION
12	3	12	104 Kc/s AMP.
11	3	11	64 Kc/s AMP.
10	1	10	72 Kc/s AMP.
9	2	9	115 Kc/s AMP.
8	2	5	114 Kc/s AMP.
7	2	8	80 Kc/s AMP.
6	2	7	66 Kc/s AMP.
5	2	6	65 Kc/s AMP.
4	1	4	120 Kc/s AMP.
3	1	3	108 Kc/s AMP.
2	1	2	96 Kc/s AMP.
1	1	1	84 Kc/s AMP.

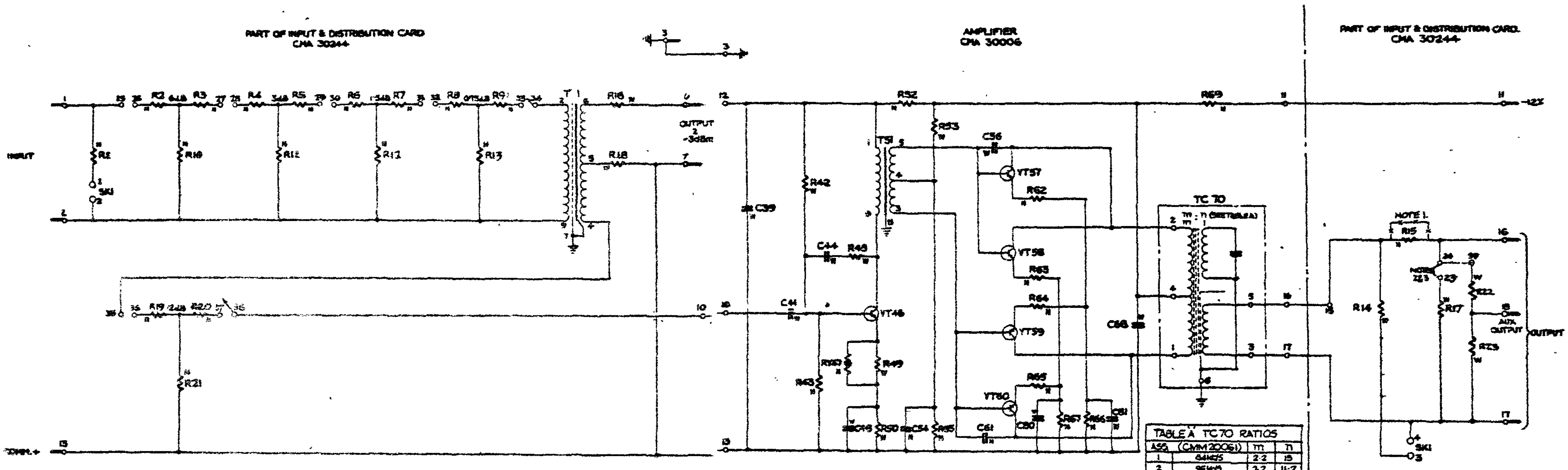
CARRIER AMPLIFIER
TRANSMISSION EQUIPMENT

CMS20061

CARRIER AMPLIFIER

ES/CMS 20061

ISS 9. Sept 1964



NOTES:-

1. RESISTOR R15 IS NOT IN CIRCUIT ON ASSEM. 3,4 & CIRCUIT READS AS SHOWN THUS
2. REMOVE STRAP ACROSS TERMINALS 23 & 24 WHEN AMPLIFIERS ARE REQUIRED TO PROVIDE ADDITIONAL OUTPUT TO ANCILLARY CARRIER MODULATORS.
3. REMOVE STRAP 23-24 AND ADD STRAP 24-39 WHEN AMPLIFIER IS REQUIRED TO PROVIDE AUXILLARY OUTPUT TO 114Kc/S GEN.

TABLE A TC70 RATIOS

ASS.	(CMM 20061)	TII	TI
1	84Kc/S	2·2	13
2	96Kc/S	3·2	11·2
3	108Kc/S	2·5	12·5
4	120Kc/S	2·5	11·25
5	68Kc/S	2·36	12·7
6	66Kc/S	2·36	12·7
7	80Kc/S	2·43	15·6
8	114Kc/S	2·14	10·3
9	115Kc/S	2·14	10·3
10	72Kc/S	2·36	12·7
11	64Kc/S	3·72	19·0
12	104Kc/S	2·14	11·9

CMS 20061

ES/CMS 20062

ISSUE 4

CMA 30248

APPARATUS SCHEDULE				
R1 (ASS.1,2,3.)	180Ω	±5%	1/8W	HS.
R3 (ASS.1,2,3.)	75Ω	±1%	1/8W	HS.
R42 (ASS.1,2,3)	7·5KΩ	±1%	1/8W	HS
R44 (ASS. 1,2,3)	62·5Ω	±1%	1/4W	HS.
R45 (ASS.1,2,3)	75Ω	±1%	1/8W	HS
R55 (ASS.1,2,3)	5·1Ω	±5%	1/4W	HS
R46, R49 (ASS.3)	260Ω	±1%	1/8W	HS
R47, R50 (ASS.3)	60Ω	±1%	1/8W	HS
R48, R51 (ASS.3)	35Ω	±1%	1/8W	HS.
R52 (ASS.3)	115Ω	±1%	1/8W	HS
951-9572 R53 (ASS.3)	53Ω	±1%	1/8W	HS.
951-9532 R54 (ASS.3)	39Ω	±1%	1/8W	HS
TC41 (ASS.1)	CMZ 40403 /1			
TC41 (ASS.2)	CMZ 40403 /2			
TC41 (ASS.3)	CMZ 40403 /3			
C56. (ASS 1,2,3)	16μF	±20%	25V.	T.A

CMA 30015

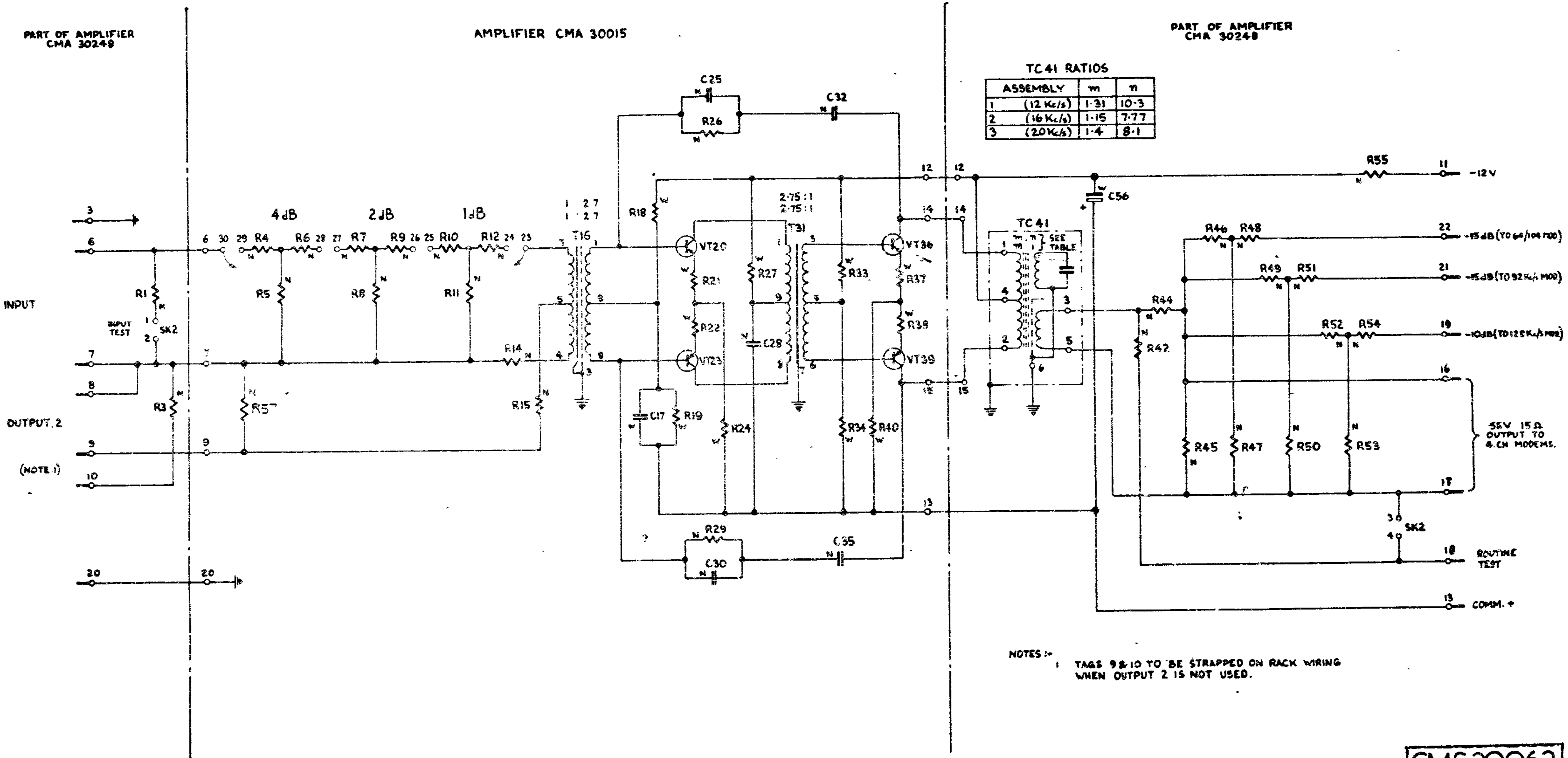
APPARATUS SCHEDULE					
R4, R6	16·9Ω	±1%	1/4W	HS	951-9693
R5	156Ω	±1%	1/4W	HS.	
R7, R9	8·2Ω	±5%	1/4W	HS	
R8	300Ω	±5%	1/4W	HS	
R10, R12	4·3Ω	±5%	1/4W	HS	
R11	680Ω	±5%	1/4W	HS.	
R15	91Ω	±5%	1/4W	HS.	
R14	75Ω	±5%	1/4W	HS.	
R18	820Ω	±5%	1/4W	HS.	
R19	330Ω	±5%	1/4W	HS	
R21, R22	47Ω	±5%	1/4W	HS.	
R24	220Ω	±5%	1/4W	HS.	
R26, R29	47kΩ	±5%	1/4W	HS.	
R27	100Ω	±5%	1/4W	HS.	
R33	390Ω	±5%	1/2W	HS.	
R34	150Ω	±5%	1/2W	HS.	
R37, R38	4·7Ω	±5%	1/4W	HS.	
R40	39Ω	±5%	3/4W	HS.	
C17, C28	1μF	±25%	150V	M.P.	
C25, C30	560pF	±5%	350V	S.M.	
C32, C35	0·01μF	±20%	200V	MP	
T16	TC 953422				
T31	TC 953421				
VT20, VT23	OC 72 (MULLARD)				
VT36, VT39	OC 28 (MULLARD)				
R57	180Ω	±5%	1/4W	H.S	

ASS	CMA 30248	CMA 30015	DESCRIPTION
6			
5			
4			
3	ASSEM. 3	ASSEM. 1	20 Kc/s CARR. AMP.
2	ASSEM. 2	ASSEM. 1	16 Kc/s CARR. AMP.
1	ASSEM. 1	ASSEM. 1	12 Kc/s CARR. AMP.

CARRIER SUPPLY AMPLIFIER

ES/CMS 20062

ISSUE 4



TC41 RATIOS

ASSEMBLY	m	n
1 (12 Kc/s)	1·31	10·3
2 (16 Kc/s)	1·15	7·77
3 (20 Kc/s)	1·4	8·1

NOTES :-
1 TAGS 9 & 10 TO BE STRAPPED ON RACK WIRING WHEN OUTPUT 2 IS NOT USED.

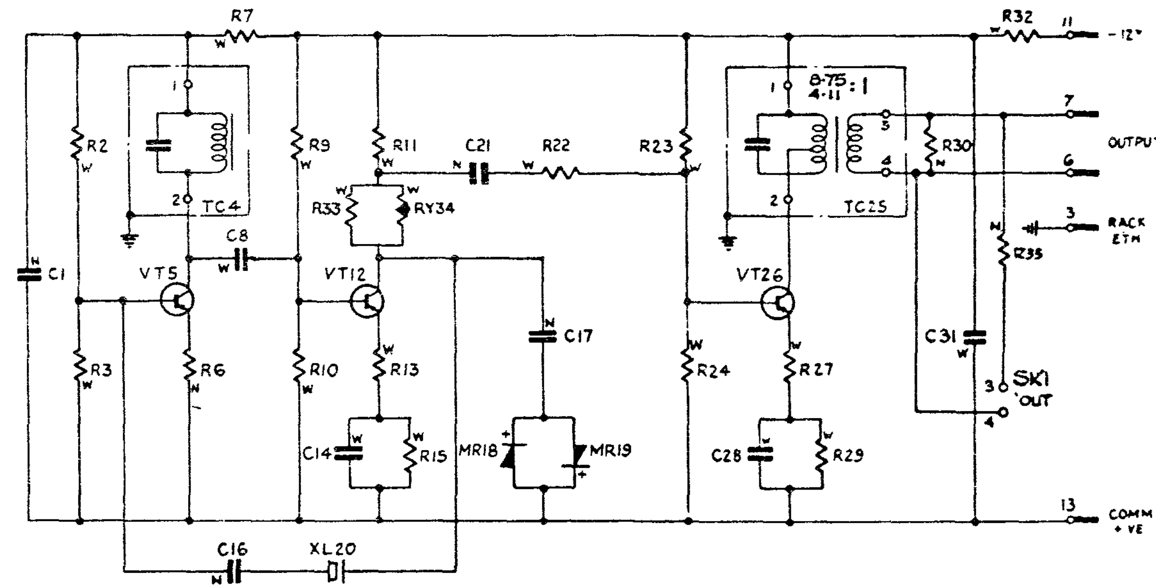
CMS 20062

3.825 Kc/s OSCILLATOR

ES/CMS30007 Issue 8

APPARATUS SCHEDULE					
R2	12K	± 2%	¼ W	HS	
R3	4·7K	± 2%	¼ W	HS	
R6	1K	± 2%	¼ W	HS	
R11	1·92K	± 1%	¼ W	HS	951-9475
R13	220Ω	± 2%	¼ W	HS	
R15	1·8K	± 2%	¼ W	HS	
R22	5·1K	± 1%	¼ W	HS	
R27	100Ω	± 2%	¼ W	HS	
R29	1·2K	± 2%	¼ W	HS	
R30(ASS.1)	82Ω	± 2%	¼ W	HS	
R30(ASS.2)	53Ω	± 1%	½ W	HS	951-9572
R7, R24	4·7K	± 10%	¼ W	C	
R9	18K	± 2%	¼ W	HS	
R10	10K	± 2%	¼ W	HS	
R23	8 2K	± 10%	¼ W	C	
R32	180Ω	± 10%	¼ W	C	
C1, C8	0·25μF	± 25%	150V	MP	
C14,17,21,28	0·5μF	± 25%	150V	MP	
C16	0·04μF	± 20%	200V	MP	
C31	1μF	± 25%	150V	MP	
VT5,12	OC44 (MULLARD)				
VT26	OC72 (MULLARD)				
MR18,19	5X640 (GEC)				
TC4	CMZ 40400/1				
TC25	CMZ 40401/1				
XL20	TC 94099				
R33	750Ω	± 1%	¼ W	HS	
RY34	L 94462 A				
R35	27 Ω	± 1%	¼ W.	H.S.	
R30(ASS3)	50Ω	± 1%	¼ W.	H S.	
R30(ASS4)	SELECTED ON TEST (NOTE 1)				
R30(ASS5)	200Ω	± 1%	¼W.	H S.	
R30(ASS.6)	120Ω	± 1%	¼ W	H.S	
SK1	TC 94282				

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.



NOTES:-

1 R30 TO BE SELECTED ON TEST FROM 22Ω 24Ω OR 27Ω ON ASS.4 ONLY.

6	9 CH. STACKABLE
5	12 CH. CABLE OR O/W W12H. C12G
4	6CH. RADIO. 12GA
3	3CH O/W W3C.
2	3 825 Kc/S OSC (3CHAN)
1	3·825 Kc/S OSC
ASS	DESCRIPTION

APPARATUS SCHEDULE

ES/CMS 30018.

Issue 3 5.10.61.

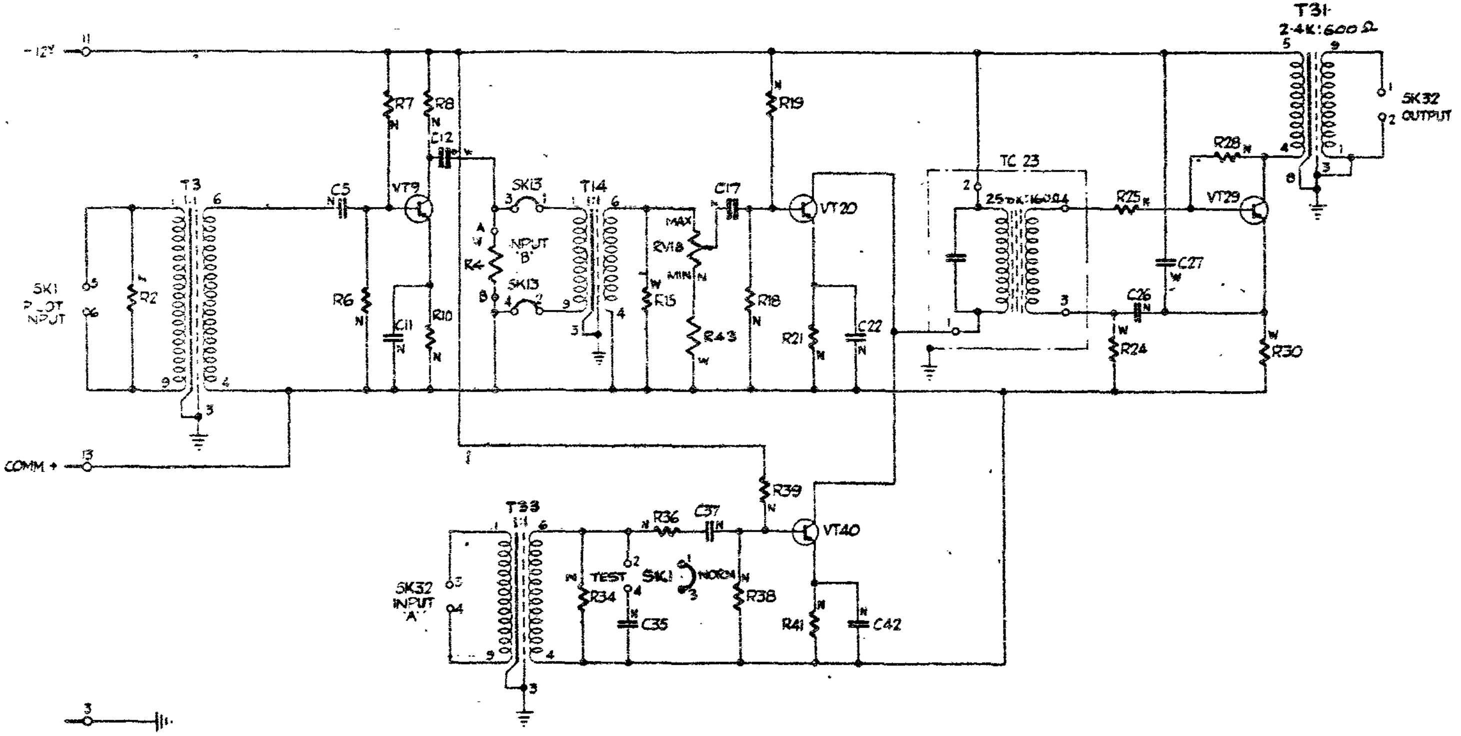
APPARATUS SCHEDULE					
R2	75Ω	±5%	¼W	HS	
R36	820Ω	±10%	¼W	C	
R6, R9	6.8K	±10%	¼W	C	
R7	27k	±10%	¼W	C	
R10 R30	2.2k	±10%	¼W	C	
R34	680Ω	±10%	¼W	C	
R18 R38	8.2k	±10%	¼W	C	
R19 R39	20k	±10%	¼W	C	
R21 R41	22k	±10%	¼W	C	
R24	3.3K	±10%	¼W	C	
R25	39Ω	±1%	¼W	HS	951-9572
R28	2.2K	±1%	¼W	HS	
R43	1K	±2%	⅛W	H.S.	
C5, 12, 22, 26, 27, 42	·04µF	±20%	200V	MP	
C11	25µF	±25%	50V	MP	
C7 C37	·02µF	±20%	200V	MP	
C35	·003µF	±20%	400V	MP	
SK1	TC 94254				
SK13, SK32	TC 94242				
T3	TC 953432				
T14, T33	TC 953205				
T31	TC 953211				
VT9, 20, 29, 40	OC44	MULLARD			
RV16	TC 72248				
TC23	CMZ 40402/5				
R4	2.7K	±10%	¼W	C	
R15	2K	±2%	¼W	H.S.	

NOTE:-
ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

SYNCHRONISING CIRCUIT

ES/CMS 30018

Issue 3 5.10.61.



TRANSMIT HYBRID CIRCUIT

ES/CMS 30024

Issue.4 30.11.61

APPARATUS SCHEDULE

ES/CMS 30024

Issue.4 30.11.61

ASS. Nº	DESCRIPTION.
2	FILTER & EQUALISER
1	TRANSMIT HYBRID

APPARATUS SCHEDULE				
R1, R3	28·8Ω	±1%	¼ W	H.S.
R2	83·5Ω	±1%	¼ W	H.S.
R7	15Ω	±1%	⅛ W	H.S.
T4	TC 953210			
T8	TC 953209			
F5	CMZ 40005/1			
E6	CMZ 40500/1			

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

ASSEM. 1 TO FIG. A
ASSEM. 2 TO FIG. B

FIG. A

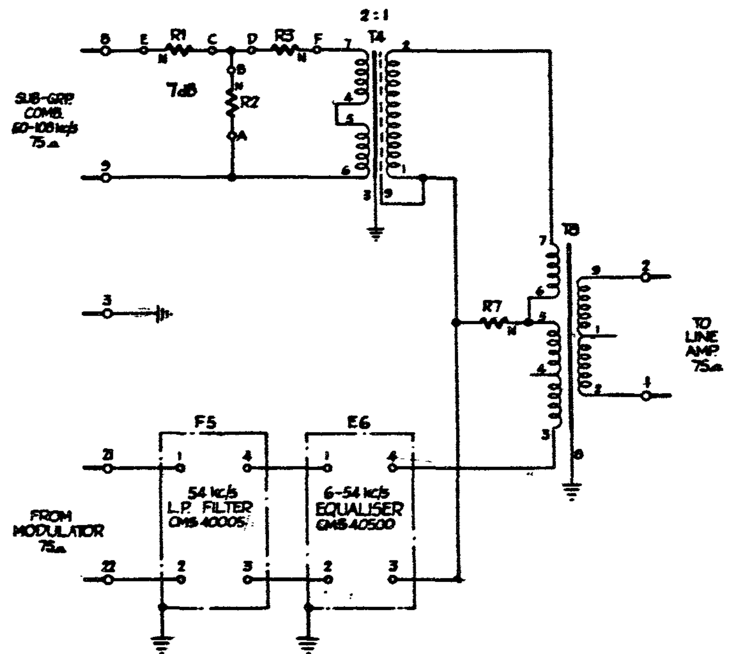
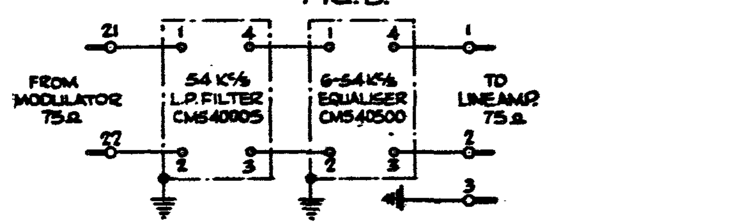


FIG. B.



AMPLIFIER

ES/CMS 30026

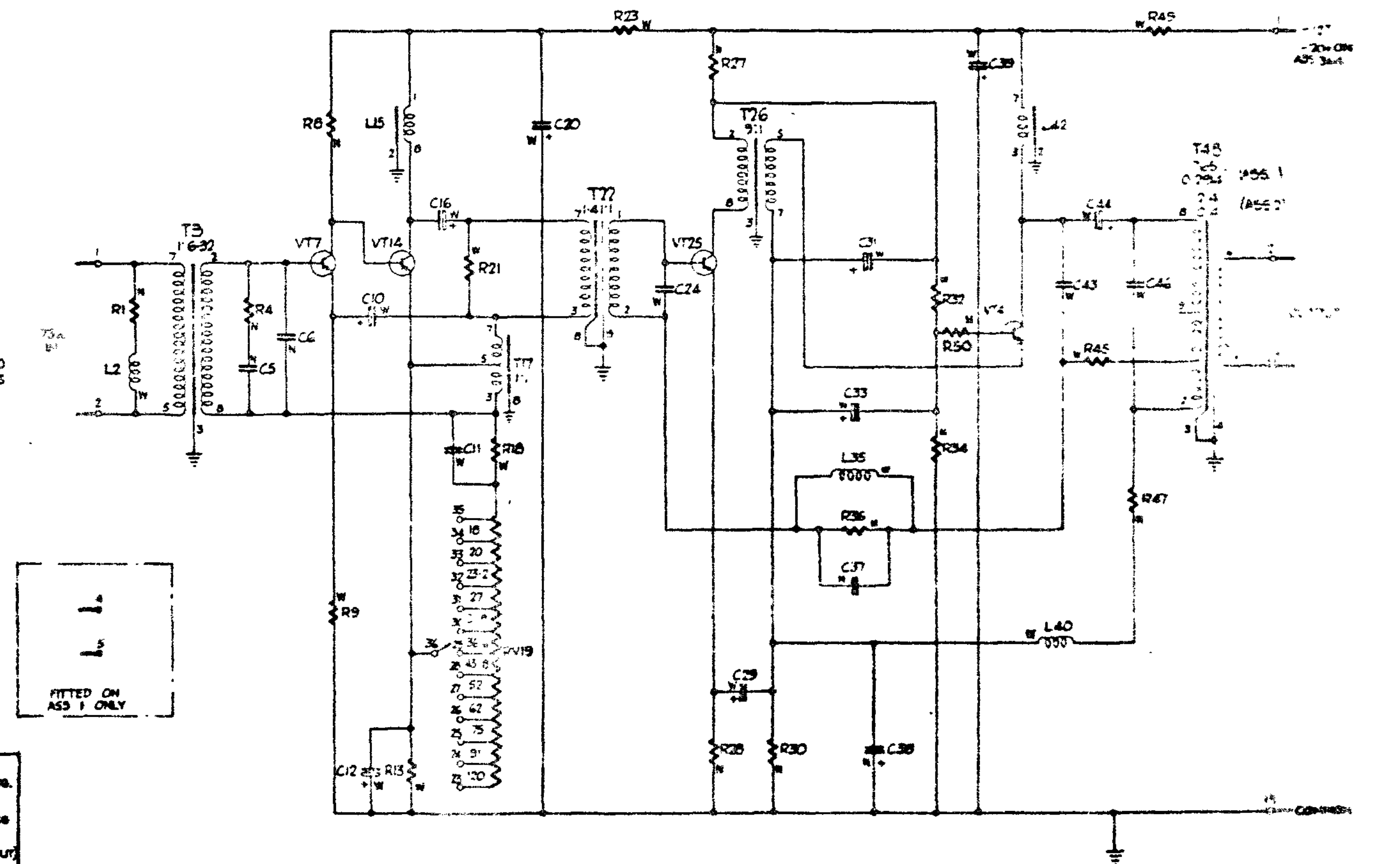
ISSUE 7. 29.4.65.

951-9549

	APPARATUS SCHEDULE				
	R1	104Ω	±1%	1/8W	H.S
	R4, R21	6·8k	±1%	1/8W	H.S
	R8, R3, R36	2·2k	±5%	1/8W	H.S
	R9	1·5k	±5%	1/8W	H.S
	R18	120Ω	±1%	1/8W	H.S
	R23	470Ω	±5%	1/8W	H.S
	R27, R28	1k	±5%	1/8W	H.S
	R30	390Ω	±5%	1/8W	H.S
	R32, R34	6·8k	±5%	1/8W	H.S
	R45	330Ω	±5%	1/8W	H.S
	R47	75Ω	±1%	1/8W	H.S
AS 1,2,5&6	R49	15Ω	±5%	1/8W	H.S
	C5	2200pF	±5%	200V	S.M
	C6	[illegible]	±5%	200V	S.M
	C31, C38	10μF	±20%	20V	S.T.
	C11	1500pF	±5%	200V	S.M
	C12	0·5μF	+50-20%	50V TCC	TA
	C16, 20, 44	8μF	±20%	12V TCC	TA
	R50	47Ω	±5%	1/8W	H.S
	C37	300pF	±5%	200V	S.M.
	C29	1μF	±20%	35V	S.T.
	C33	100μF	±20%	10V TCC	TA
	C39	4·7μF	±20%	20V TCC	TA
	C43 C46	200pF	±5%	200V	S.M
	T3	TC 852437			
	T17	TC 853433			
	T22	TC 853439			
	T26	TC 853440			
ASS.1,3,5&7	T48	TC 853441			
ASS 2,4,6&8	T49	TC 853442			
	L2	[illegible] 950752			
	L15	TC 950442			
	L35	TC 281605			
	L42	TC 853434			
	VT7, VT14, VT25	OC45	MULLARD		
	VT41	OC122	MULLARD		
	RV19A	TC 2713			
	RV19B	TC 2714			
	RV19C	TC 2715			
	L40	TC 281676			
	C34	170pF	±5%	200V	S.M
ASS.3,4,7&8	R49	390Ω	±5%	1/4W	H.S
	C10	2·2μF	±20%	20V	S.T.

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

ASS 4 & 8
AS ASS 2 FOR 20V WKG.
ASS 3 & 7
AS ASS 1 FOR 20V WKG
ASS 2 & 6
6-108 Kc/s AMP (75 Ω OUT)
ASS 1 & 5
6-108 Kc/s AMP (135 Ω OUT)
DESCRIPTION



SUB-GROUP

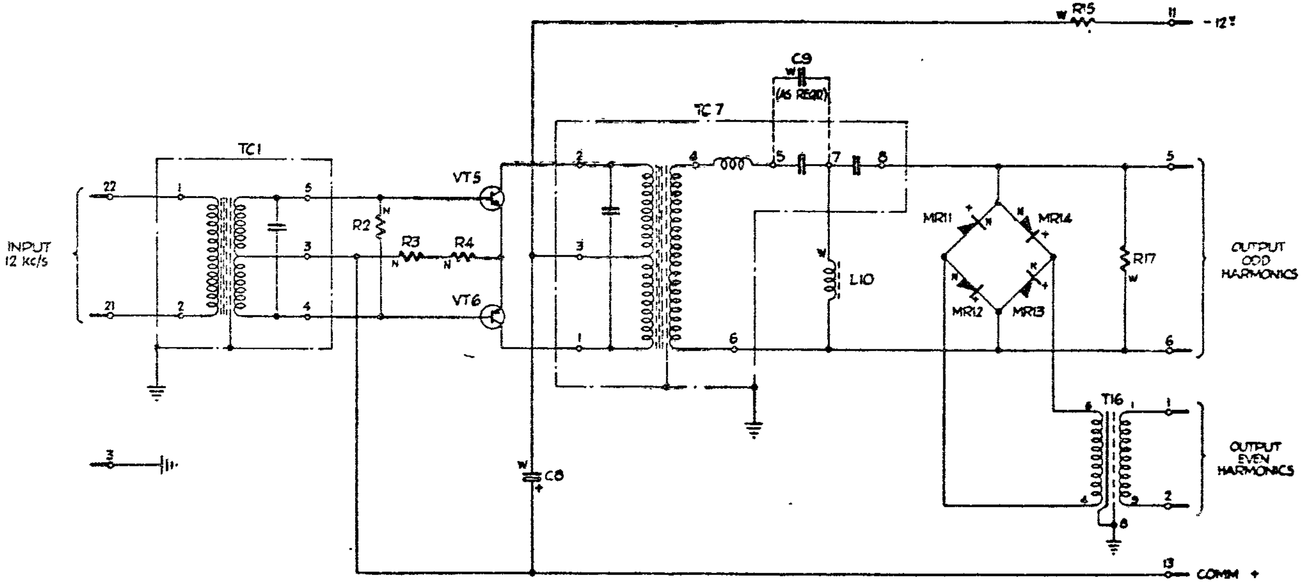
HARMONIC GENERATOR

ES/CMS 30034

ISSUE 5

APPARATUS SCHEDULE				
R2	8·2k	±1%	1/4w	H.S.
R3	49Ω	±2%		Cu W. W.
R4	51Ω	±1%	1/4w	H.S.
R15	56Ω	±5%	1/4w	H.S.
R17	600Ω	±10%	1/4w	C.
C8	8μF	±20%	12V	T.C.C. TA.
C9	TRIMMER	(DUB. SM22)		
VT5, VT6	OC 72 (MULLARD)			
L10 (ASS.1)	TC 281612			
MR11, 12, 13, 14	OA5 (MULLARD)			
T16	TC 953427			
TC 1 (ASS.1)	CMZ 40409/1			
TC 7 (ASS.1)	CMZ 40405/1			
TC 1 (ASS.2)	CMZ 40409/2			
TC 7 (ASS.2)	CMZ 40405/2			
L10 (ASS.2)	TC 281621			

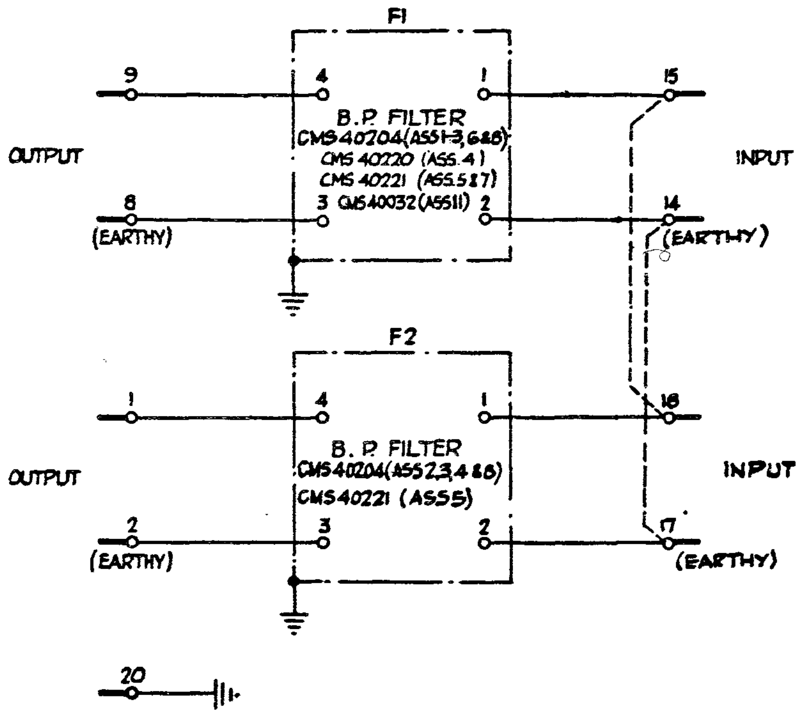
ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED.



CARRIER SUPPLY FILTERS

ES/CMS 30038 ISSUE 6.

APPARATUS	SCHEDULE	FREQ
F1 (ASS. 1)	CMZ 40204/1	60 kc/s
F1 (ASS. 2)	CMZ 40204/3	96 kc/s
F1 (ASS. 3)	CMZ 40204/2	84 kc/s
F1 (ASS. 4)	CMZ 40220/1	24 kc/s
F1 (ASS. 5)	CMZ 40221/1	80 kc/s
F1 (ASS 7)	CMZ 40221/3	180 kc/s
F1 (ASS. 6) F2 (ASS 3)	CMZ 40204/4	108 kc/s
F2 (ASS. 2)	CMZ 40204/5	120 kc/s
F2 (ASS. 8)	CMZ 40204/5	120 Kc/s
F1 (ASS. 8)	CMZ 40204/4	108 Kc/s
F2 (ASS 4)	CMZ 40204/4	108 Kc/s
F2 (ASS 5)	CMZ 40221/3	180 Kc/s
F2 (ASS 10)	CMZ 40204/2	84 Kc/s
F1 (ASS 9)	CMZ 40221/4	104 Kc/s
F1 (ASS 10)	CMZ 40221/4	104 Kc/s
F1 (ASS 11)	CMZ 40032/1	20 Kc/s



11	20 Kc/s FILTER
10	104 Kc/s & 84 Kc/s FILTER
9	104 Kc/s FILTER.
8	108 Kc/s & 120 Kc/s FILTER
7	180 kc/s FILTER
6	108 kc/s FILTER
5	80 Kc/s & 180 Kc/s FILTER
4	24 Kc/s & 108 Kc/s FILTER
3	84 kc/s & 108 kc/s FILTER
2	96 kc/s & 120 kc/s FILTER
1	60 kc/s FILTER
ASSEM	DESCRIPTION

NOTES:-

1. FILTER F2 IS NOT FITTED ON ASSEMBLY 1, 6, 7, 9 & 11
2. DOTTED CONNECTIONS APPLY ON ASS 2 & 3 ONLY.

APPARATUS SCHEDULE

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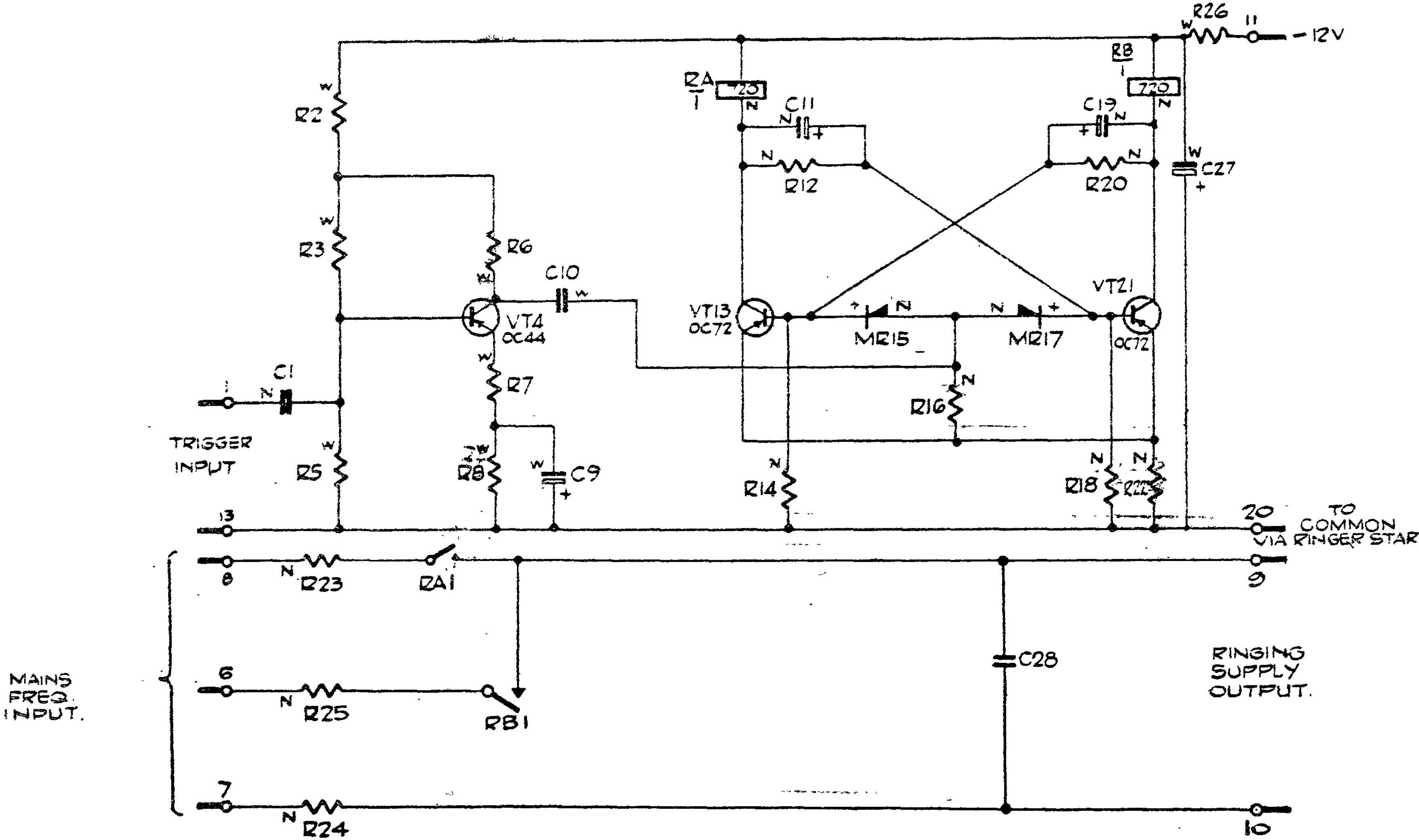
APPARATUS SCHEDULE	
R26 68Ω ±5% 1/4W	H.S
R2 330Ω ±5% 1/4W.	H.S
R3 10K ±5% 1/4W.	H.S.
R5 2·8K ±5% 1/4W.	H.S
R6 2·2K ±1% 1/4W.	H.S.
R7 39Ω ±1% 1/4W	H.S.
R8 1K ±1% 1/4W.	H.S
R12,R20 4·7K ±1% 1/4W.	H.S.
R14,R18 6·8K ±1% 1/4W	H.S.
R16 33K ±1% 1/4W.	H.S.
R22 68Ω ±1% 1/4W.	H.S.
R23-R25 250Ω ±5% 4.5W PAINTON 301A	W.W.
C1,C10 1µF ±25% 150V	M.P.
C9 100µF ±20% 6V	TCC.TA
C11 C19 50µF ±20% 12V	DUB TA.
VT4 OC44 (MULLARD)	
VT13,VT21 OC72 (MULLARD)	
MR15, MR17 OA95 (MULLARD)	
RA, RB TC99429	
C27 75µF ±20% 12V	TCC TA
C28 0·1µF ±25% 150V	M.P.

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED

RINGING GENERATOR

ES/CMS 30206   ISSUE 3



CMS30206

GROUP MODULATOR/DEMODULATOR

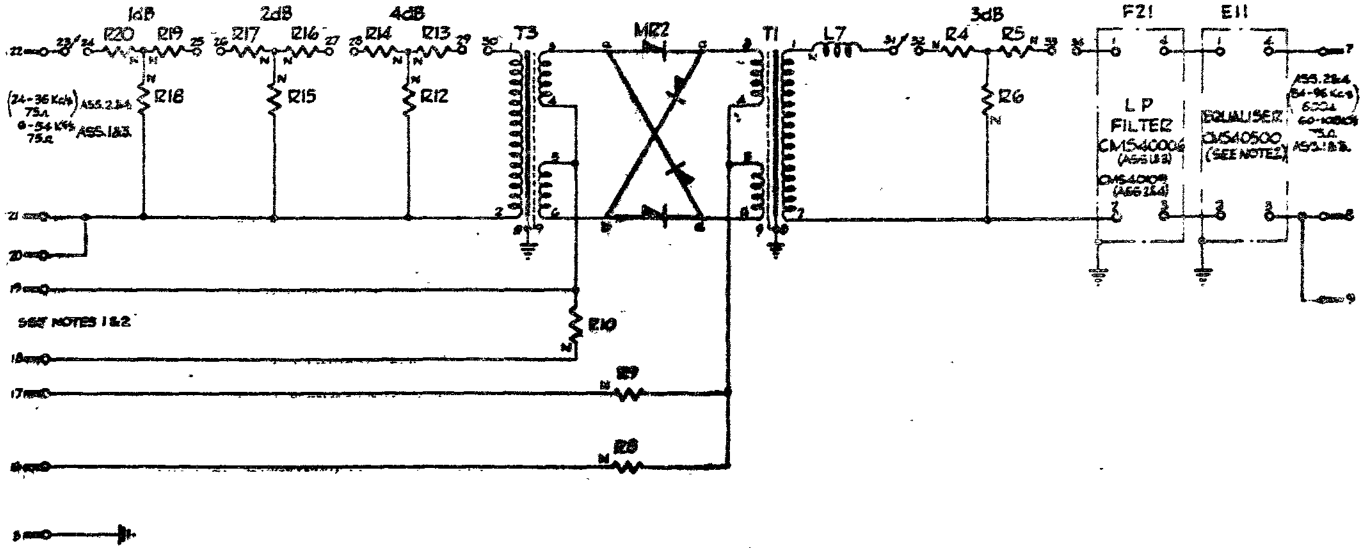
ES/CMS 30209

Issue 5 14.2.62.

APPARATUS SCHEDULE				
R4,R5(ASS.1&3)	13 Ω	±5%	¼W	H.S.
R6(ASS.1&3)	220 Ω	±5%	¼W	H.S.
R8(ASS.1&3)	15 Ω	±1%	¼W	H.S.
R9	50 Ω	±1%	¼W	H.S.
R10(ASS.1&3)	110 Ω	±1%	¼W	H.S.
R12	156 Ω	±1%	¼W	H.S.
R13, R14	16·9 Ω	±1%	¼W	H.S.
R15	300 Ω	±5%	¼W	H.S.
R16, R17	8·2 Ω	±5%	¼W	H.S.
R18	680 Ω	±5%	¼W	H.S.
R19, R20	4·3 Ω	±5%	¼W	H.S.
T1 (ASS.1&3)	TC953208			
T3	TC953207			
MR2	TC95266			
L7(ASS.1&3)	TC281614			
E11(ASS.1&3)	CMZ40500/2			
F21(ASS.1&3)	CMZ40006/1			
F21 (ASS.2&4)	CMZ40109/1			
T1 (ASS.2&4)	TC953227			
L7 (ASS.2&4)	TC281625			

951-9693

ALL RATINGS QUOTED ARE JOINT SERVICES TYPE APPROVED



NOTES:-

1. ASSEMBLIES 1&3 AT TERMINAL STATIONS CARRIER SUPPLY IS CONNECTED TO TAGS 19 & 18 WITH 18 STRAPPED TO TAG 17. AT FROGGING REPEATER STATIONS CARRIER SUPPLY IS CONNECTED TO TAGS 19 & 16.

2. ON ASSEMBLIES 2&4 THE 3db PAD IS NOT FITTED, STRAP ACROSS TAGS 31 & 34 ALSO E11 IS NOT FITTED, STRAP TAGS 1&4 AND 2&3. R8 & R10 ARE NOT FITTED. CARRIER SUPPLY CONNECTED TO TAGS 19 & 17.

APPARATUS SCHEDULE

ES/CMS 40903 Sh. 1

Issue 6 8.11.61

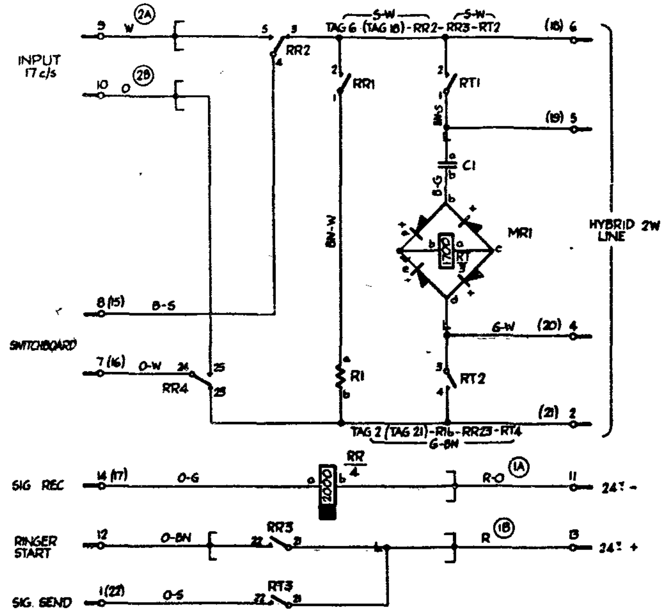
APPARATUS SCHEDULE				
R1	600Ω	±1%		H.S.
C1	2µf	±25%	250V	M P
MR1		TC 95251		
RELAY RT		JRJ 603 CB-ZR		
RELAY RR		JRJ 1013 A1-ZR		

ASS.	DESCRIPTION
3.	RING DOWN RELAYS (2ND CIRCUIT)
2.	RINGDOWN RELAYS (1ST CIRCUIT)
1.	RINGDOWN RELAYS (1ST & 2ND CIRCUITS)

RINGDOWN RELAY CIRCUIT

ES/CMS 40903 Sh. 1

Issue 6 8.11.61.



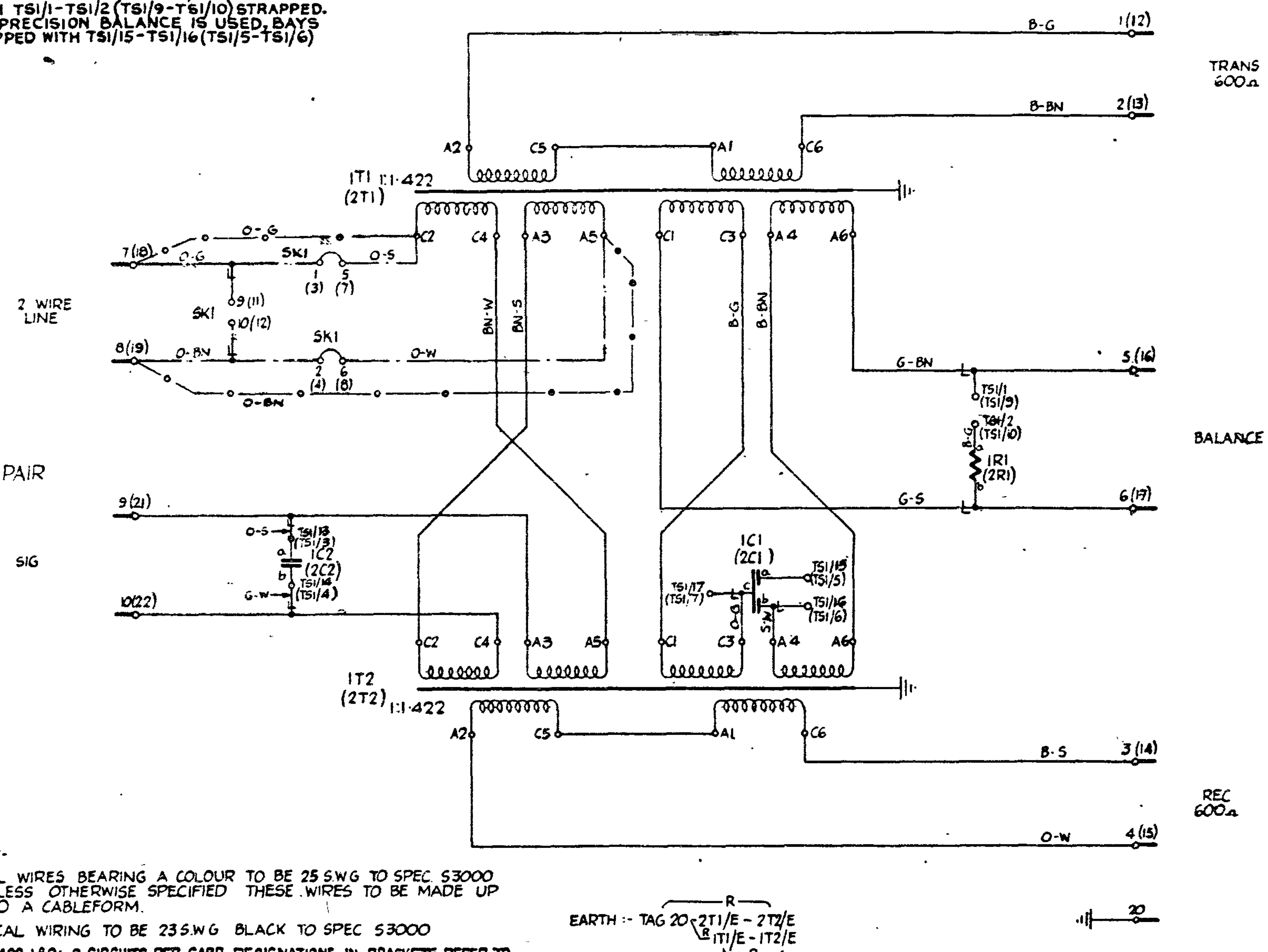
NOTES:-

1. ALL WIRES BEARING A COLOUR TO BE 25 S.W.G. TO SPEC. 53000 UNLESS OTHERWISE SPECIFIED. THESE WIRES TO BE MADE UP INTO A CABLEFORM.
2. LOCAL WIRING TO BE 25 S.W.G. BLACK TO SPEC. 53000
3. ADJACENT TAGS TO BE STRAPPED WITH 25 S.W.G B.T.C.
4. TWO CIRCUITS PER CARD. TAG NUMBERS IN BRACKETS REFER TO THE SECOND CIRCUIT.
5. ON ASSEM. 2. THE SECOND CIRCUIT IS NOT CALLED FOR
ON ASSEM. 3. THE FIRST CIRCUIT IS NOT CALLED FOR
ON ASSEM. 2 TAGS 15-18 & 16-21 ARE TO BE STRAPPED.
ON ASSEM. 3 TAGS 8-6 & 7-2 ARE TO BE STRAPPED.

ENGINEERS NOTE:-

WHEN A NOMINAL BALANCE IS USED, BAYS WILL BE SHIPPED WITH TS1/1-TS1/2 (TS1/9-TS1/10) STRAPPED. WHEN A PRECISION BALANCE IS USED, BAYS WILL BE SHIPPED WITH TS1/15-TS1/16 (TS1/5-TS1/6) STRAPPED.

APPARATUS SCHEDULE					
R1	600Ω	±1%	½W	H S	
C1	0·5μF + 0·5μF	±20%	350V	M P	MATCHED PAIR TC 68506
C2	1μF	±20%	350V	M P	
SK1	TC 94247				
T1, T2	TC 952601 (2 OFF TC 952600)				



NOTES :-

1. ALL WIRES BEARING A COLOUR TO BE 25 S.W.G TO SPEC. S3000 UNLESS OTHERWISE SPECIFIED. THESE WIRES TO BE MADE UP INTO A CABLEFORM.
2. LOCAL WIRING TO BE 23 S.W.G BLACK TO SPEC S3000
3. ON ASS. 1 & 2:- 2 CIRCUITS PER CARD. DESIGNATIONS IN BRACKETS REFER TO SECOND CIRCUIT. ON ASS. 3:- 1 CIRCUIT PER CARD ONLY.
4. ON ASS. 1. WIRING SHOWN THUS —·— APPLIES.
   ON ASS 2 & 3 WIRING SHOWN THUS —o— APPLIES.

APPARATUS SCHEDULE

ES/CMS 40907 SH.2.

Issue 6 16.8.62

	APPARATUS SCHEDULE				
	C5	500 μF	-20% +50%	25V	ELECT.
	MR1, MR2	ZR 21		(FERRANTI)	
	MR4	TP 25L 2211			
	L3	TC 950503			
	VT 12	OC 29		(MULLARD)	
	VT 14, VT15	OC 28		(MULLARD)	
	F550-F553				
	C49	60 μF	±20%	25V	TCC T.A.
	R6	2·2K	±5%	¼W	H.S.
	R11	3·3K	±5%	⅓W	H.S.
	R13	680Ω	±5%	¼W	H.S.
	R17 A&B, R18 A&B	2Ω	±5%	3W	(PAINTON 306A)
	R20	470Ω	±5%	¼W	H.S.
	R22 R28	1K	±5%	3W	(PAINTON 306A)
	R23	39Ω	±10%	¼W	C
CMZ 40806/1 MC1	R24	82Ω	±10%	¼W	C
	R25	150Ω	±10%	¼W	C
	R26	330Ω	±10%	¼W	C
	R27	680Ω	±10%	¼W	C
	C9	1μF	±25%	150V	M.P.
	C21	8μF	±20%	12V	TCC T.A.
	MR8	OAZ 204		(MULLARD)	
	VT 7, VT10	OC72		(MULLARD)	
	R29, 33, 37, 41, 45	270Ω	±1%	3W	(PAINTON P406)
CMZ 40805/4 MC2	R30, 34, 38, 42, 46	156Ω	±1%	3W	(PAINTON P406)
	R31, 35, 39, 43, 47	39Ω	±1%	3W	(PAINTON P406)
	C32, 36, 40, 44, 48	33μF	±20%	6V	TCC T.A.
	R55, R57, R59, R61, R63	11·6K	±1%	¼W	H.S.
	R56, R58, R60, R62, R64	560Ω	±1%	¼W	H.S.
	R65	18·4K	±1%	¼W	H.S.
	R66	550Ω	±1%	¼W	H.S.
	SKG7	TC 94272			

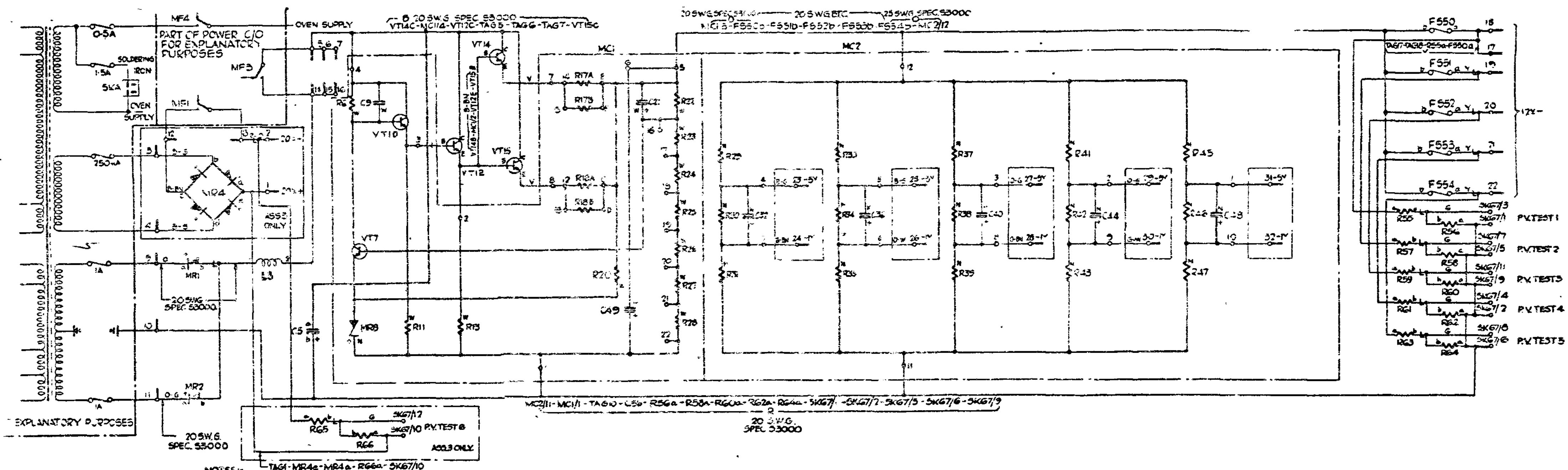
ALL RATINGS QUOTED ARE
JOINT SERVICES TYPE APPROVED.

4	2·2AMP -1V & -5V BIAS
3	2·2AMP -1V & -5V BIAS WITH 20V
ASSEM	DESCRIPTION

POWER SUPPLY UNIT.

ES/CMS 40907 SH2.

Issue 6 16.8.62.



NOTES:-

1. ALL WIRES BEARING A COLOUR TO BE 23 S.W.G TO SPEC 53000 UNLESS OTHERWISE SPECIFIED. THESE WIRES TO BE MADE UP INTO A CABLEFORM WHICH SHALL BE OF SUFFICIENT LENGTH TO ALLOW ACCESS TO PRINTED CARDS MC1 & MC2 AND TRANSISTORS VT14 & VT15 FOR MAINTENANCE PURPOSES
2. LOCAL WIRING TO BE 23 S.W.G. BLACK TO SPEC. 53000.
3. ADJACENT TAGS TO BE STRAPPED WITH 23 S.W.G. B.T.C. UNLESS OTHERWISE SPECIFIED.
4. WHEN STANDBY BATTERY WORKING IS NOT USED STRAP TAGS 5,6,7,14,15 & 16 ON ASS.4. AND TAGS 5,6,7,14,15 & 16 AND TAGS 12 & 13 ON ASS.3.
5. ALL RED WIRES TO BE 20 S.W.G. SPEC. 53000.
6. MR4, RG5 & RG6, AND ASSOCIATED WIRING ARE FITTED ON ASS. 3 ONLY.
7. ALL YELLOW WIRES TO BE IN 20 S.W.G. SPEC. 53000.