TECHNICAL INSTRUCTION
S 5

Studio Equipment Type A

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LIST OF CIRCUIT DIAGRAMS

STUDIO EQUIPMENT TYPE A

SECTION A

INTRODUCTION

In pre-war broadcasting it was customary to use particular studios for particular types of programme, and to use several studios in a single dramatic production. Because accommodation was limited during the war it became essential to use one studio for widely differing types of programme and to use many microphones in various parts of one studio, where previously a number of different studios would have been used.

Before the war all the amplifiers were battery-operated and it was convenient to place these, as far as possible, in a single control room, but during the war the *A* and *B* amplifiers were replaced by a single self-contained mains-driven amplifier situated in the studio cubicle, thus rendering the studio to a large extent independent of the control room.

The wartime arrangement had many advantages and when the design of post-war equipment was undertaken, it was decided to retain the idea of the self-contained *General Purpose Studio.* To this end the studio equipment Type A consists essentially of a control desk and two steel cabinets, all of which may be situated in the studio control cubicle. The larger of the two cabinets, known as the *Studio Control Cabinet,* contains all necessary amplifiers and rectifier units, and the other, the *Studio Supply Cabinet,* houses fuses and mains equipment.

In the design of post-war equipment a number of features new to the BBC were introduced; these include :—individual microphone amplifiers; automatic selection of *Line-up, Rehearsal* and *Transmission* conditions by operation of push-buttons; comprehensive echo facilities; group and independent faders; keys for substituting faulty amplifiers by spare amplifiers.

The new equipment has been made simple to operate and easy to maintain, even at the expense of some complexity in the circuits, and special attention has been paid to securing continuity of programme and rapid detection and elimination of faults. As far as possible the units have been standardised and may be used, with little modification, in a variety of places; for example, the same shelf assemblies and relay boxes can be used in the studio control cabinet irrespective of the size or complexity of the equipment.

Principal Features of Studio Equipment Type A

Individual Microphone Amplifiers

It was decided that every microphone and gramophone channel should include an amplifier before the mixer, this constituting a radical change from earlier BBC technique. The advantages of this circuit arrangement are as follows :—

(a) The low microphone output, which is very susceptible to interference, is raised to a high volume at the earliest possible point in the chain.

(b) Any noise introduced by the mixer is rendered much lower relative to the programme volume fed to it.

(c) Constant-impedance mixing can be employed. A feature of earlier broadcast chains was the loss of volume which occurred on any channel when other channels were faded up. Constant-impedance mixing eliminates this disadvantage but introduces a fixed loss of volume, which would be most undesirable without previous amplification. (See Appendix 1.)

(d) Microphone-correction units, which introduce a loss of volume, may be inserted between the amplifier and the mixer, still leaving the programme volume from the mixer high enough to retain the advantages enumerated above.

Push-button Control

To facilitate operation of the equipment, all switching operations necessary for lining-up the studio apparatus are performed by relays on depressing a single button on the control panel. Similar buttons are provided to connect the apparatus in the arrangement required for rehearsal and transmission conditions.

Echo Facilities

The circuit arrangement for the provision of echo is more flexible than in previous apparatus. Each programme channel is split into two by hybrid coils to feed the direct transmission channel and a separate echo channel. The relative programme volumes passing to each channel can be adjusted to give any of nine different ratios of direct sound to echo.

Group and Independent Faders

After the hybrid coils, the direct transmission channel is fed through a fader designated *Group Control*, after which a single independent microphone circuit is mixed in. This facility enables any given combination of microphone channels to be faded out in one movement of the group fader and a single independent microphone to be faded up for an announcement by a narrator, after which the previous combination of channels can be faded up again.

Basic Types of Studio Equipment Type A

There are five basic types of equipment, designated *Mark I* to *Mark V*, with the following facilities :—

Type	*For use in*	*Facilities*
Mark I	Small Talks Studio	3 channels.
Mark II	Small General Purpose Studio	5 channels.
Mark III	Small General Purpose Studio	5 channels. Group Control. Independent channel.
Mark IV	Medium General Purpose Studio	5 channels. Group Control. Echo facilities. Independent channel.
Mark V	Large General Purpose Studio	7 channels. Group Control. Echo facilities. Independent channel.

Most studio requirements can be met by the facilities of *Mark II*, *Mark V* or a larger (special) version of *Mark V* with more channels and, accordingly, production has centred around these three types. Of these, *Mark V* is regarded as a basic design and *Mark II* as a simplified version of it, obtained by the omission of certain facilities and a reduction of the number of channels. Similarly the special type is regarded as an enlargement of *Mark V*, a number of additional channels being provided.

This Instruction contains a detailed description of *Mark V* ; *Mark II* is described in less detail in Section G. Individual equipments in particular studios are not described unless they differ from the basic types, and the deviations from the standard design are described in Section J.

SECTION B

THE PROGRAMME CHAIN

Fundamental Programme Chain

As the complete circuit of the *Mark V* equipment is complex it is proposed to describe it with the aid of a series of simplified diagrams of gradually increasing detail until the full circuit is developed.

Fig. B.1 shows the fundamental programme chain from microphone to studio output, with all switching omitted. It consists of three *AMC/2* amplifiers in cascade (for details of the *AMC/2* amplifier see ~~ST.8, page 2~~ S.3 page 3) separated by balanced attenuators.

In the design of this equipment the average volume output of the ribbon microphone, Type AXB, was taken as — 80 db for speech input (this value being lower than is usually quoted in order that there should be some gain in hand). On orchestral music the output was taken as —50 db on maximum peaks and —105 db on minimum peaks.

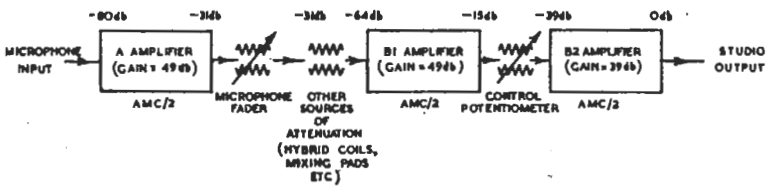


Fig. B.1 Fundamental Programme Chain

The first *AMC/2* amplifier, the *A*, raises the programme volume to —31 db, its gain being 49 db when the gain switch is set at 50 db. Next in the chain is the main mixer fader, Type *PB/1L1*, a constant-impedance balanced attenuator of the bridged-H type. (For details of this fade unit see Appendix 4.) When fully faded-up, this gives no loss of volume, but associated with it are a number of sources of attenuation, such as hybrid coils and mixing pads (not indicated as separate items in Fig. B.1) which give a total loss of 33 db and the programme volume at the input of the next *AMC/2* amplifier, the *B1*, is — 64 db. This is raised to — 15 db at the output of the *B1* amplifier. The average loss in the control potentiometer, Type *PB/2L1*, which follows next, is 20 db and the programme volume at the output of this is — 35 db. A further loss of 4 db occurs in a matching transformer situated between the control potentiometer and the *B2* amplifier. The latter has a gain of 39 db (with the gain control set at 40 db) and the programme volume at the output is zero.

The Programme Chain in Greater Detail

The Pre-mixer Jackfield

Fig. B.2 shows the chain of equipment between microphone and studio output in greater detail. Between the *A* amplifier and the main mixer fader is a jackfield enabling any microphone output to be fed to any channel. The output of the *A* amplifier is connected to the input of the main mixer fader via break-jacks, the inner contacts of which are normalled. Thus, in the absence of cross-plugging, each source is tied to a particular channel.

The Echo-mixture Switch

The main mixer fader is followed by a hybrid coil, which is a transformer with one primary and two secondary windings. This is designed to give great attenuation between the two secondaries, although both are closely coupled to the primary winding. (For the theory of the hybrid coil see Appendix 6 and ST.6, page 15.) This component splits the programme chain into two independent chains; one (the echo chain) feeds the loudspeaker in the echo room via a chain described later and the other (the direct chain) is mixed later with the output of the echo-room microphone to form the studio output. Both chains pass through an echo-mixture switch (Type *BBB/1Y1*) which follows the hybrid transformer. This switch is similar to a *two-channel fade unit* and takes the form of a Yaxley-type switch wired to form

two independent step-by-step attenuators of the bridged-H type, one in the direct and the other in the echo chain. The echo-mixture switches are located on the left-hand control panel of the desk and when turned fully anti-clockwise introduce infinite attenuation in the echo channel and no attenuation in the direct channel. In the middle position of the control knob no attenuation is included in either channel and the echo is equal in volume to the programme (50 per cent echo). When the control is turned fully clockwise infinite attenuation is introduced into the direct channel

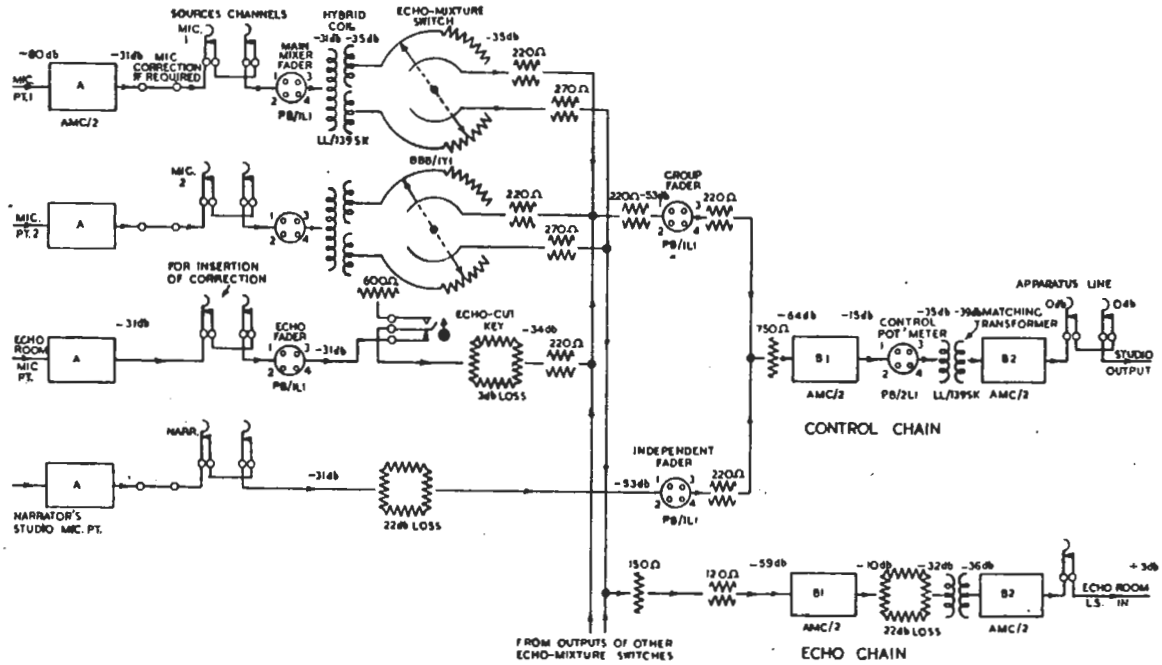


Fig. B.2. Programme Chain with all Switching omitted

and the programme consists entirely of echo (100 per cent echo). Intermediate positions are provided between these settings. Details of the echo-mixture switch are given in Appendix 5.

Mixing Circuits

All the programme channels, except that of the narrator's microphone, are split by hybrid coils as described above, and the direct chains are mixed with the amplified output of the echo microphone to form a single programme controlled by the group fader. Mixing pads of fixed resistors are introduced between the echo-mixture switches and the group fader to preserve correct matching. The resistor values are so chosen that the echo-mixture switches feed into a balanced load of 600 ohms and the group fader is fed from a source of the same impedance. An expression is derived in Appendix 1 for the value of padding resistor required and it is shown that this particular circuit arrangement introduces a volume loss of approximately 18 db.

The chain of equipment following the narrator's microphone is simpler than this because echo facilities are not required and the hybrid coil and echo-mixture switch can be omitted. The channel jack feeds into the independent fader via a fixed balanced attenuator of 22-db loss, which ensures that the programme volume at the input of the independent fader is the same as that at the group fader.

The output from the group and independent faders is mixed with the input to the *B1* amplifier and a further mixing pad is necessary. The theory is given in Appendix 1, where it is shown that the particular resistor values necessary for correct matching give a loss in volume of 11 db.

The *B1* amplifier is connected directly to the control potentiometer; no special matching arrangements are necessary because the output impedance of the *AMC/2* amplifier is equal to the input impedance of the *PB/2L1* potentiometer. The 600-ohm output impedance of the control potentiometer is matched to the 300-ohm input

impedance of the *B2* amplifier by a transformer. For standardisation the matching is achieved by the same transformer type used earlier in the chain as a hybrid coil. For details see Appendix 6. The transformer introduces a volume loss of 4 db.

The Echo Chain

The echo outputs of the echo-mixture switches are mixed by pads of fixed resistors and fed to the input of the echo *B1* amplifier. The *B1* amplifier is coupled to the echo *B2* amplifier by a loss pad followed by a 600/300-ohm matching transformer. The output of the *B2* amplifier is fed to the *MPA/1* loudspeaker amplifier in the echo room.

If any coupling exists between the echo amplifier and any of the channels feeding the echo loudspeaker, there is a possibility of "howl-back." The reason for the hybrid coils feeding the echo-mixture switches is now apparent; the great attenuation between the two secondary windings prevents this "howl-back".

The programme in the echo chain is not controlled and may have a great dynamic range. It is important, therefore, that the average programme volume fed to the echo room should not be too great, otherwise maximum peaks may cause serious overloading; on the other hand, the volume should not be too small or the signal-to-noise ratio may be poor. Between these two extremes there is a range of programme volume which can be satisfactorily fed to the echo room and any value within this range can be accepted since the gain control of the *MPA/1* amplifier has a range of 40 db. The attenuations of the pads at the input to the *B1* and the *B2* amplifiers are chosen to give an average programme volume of about + 3 db at the output of the *B2* amplifier. The attenuation of the loss pad between the echo *B1* and *B2* amplifiers is 22 db to correspond roughly with the average loss in the control potentiometer in the main chain. Typical values for the programme volume at various points in the chain are given in Fig. B.2. Although the values of these programme volumes may depart slightly from the figures given, the gains of the echo amplifiers must be the same as those of the corresponding control amplifiers since both chains are replaced on occasions by the stand-by chain.

In some installations the gain of the *B1* amplifiers is 39 db not 49 db as indicated in Fig. B.2. In these installations the average loss of the control potentiometer is reduced to 10 db to maintain the studio output at 0 db, but the levels in the echo chain after the *B1* amplifier are 10 db lower than in Fig. B.2, and the programme volume fed to the echo-room loudspeaker is — 7 db.

The circuit following the echo microphone is similar to that for any other microphone as far as the main mixer fader. After the *PB/1L1*, the chain includes a key mounted on the control panel and enabling the echo chain to be cut if necessary. This is followed by a 3-db loss pad included to simulate the loss of the hybrid coils in the other microphone chains, and after this the echo programme is mixed with the direct programmes from the echo-mixture switches.

This method of providing echo facilities is extremely flexible. By appropriate setting of the echo-mixture switches it is possible to arrange for any desired degree of echo to be superimposed on the output of any channel. If required, the echo can be gradually introduced or faded out of the main programme chain by rotation of the echo-microphone fader or it may be cut instantaneously by operation of the *Echo-cut* key.

The Complete Programme Chain

Fig. 1 shows the programme circuits of the *Mark V* equipment in full detail. Provision is made for nine [redacted] inputs, from microphones 1 to 6, from a gramophone bank (or an extra microphone), from the narrator's microphone and from the echo microphone. The order in which these are arranged is significant; to standardise the equipment as far as possible the third source is always the gramophone bank and the sixth source (in *Marks III, IV* and *V*), the narrator's microphone, and the microphone amplifiers associated with these are always in the same physical position in the studio control cabinet, irrespective of the number of sources. This facilitates location of any particular amplifier for maintenance purposes.

Replacing a Faulty A Amplifier

An *A* amplifier is provided for each microphone and, in addition, two spare *A* amplifiers, known as *Spare X* and *Spare Y* are included. The *A* amplifiers are numbered according to their position in the apparatus cabinet, No. 1 being *Spare X*, No. 2 *Spare Y*, No. 3 for microphone 1 and so on. If an amplifier in use develops a fault, it can be removed from circuit and replaced by *Spare X* or *Spare Y* by operation of a Kellogg key on the control panel. These keys operate relays which effect the change-over at the input and out-

put of each *A* amplifier. (Fig. 1.) One three-position key is provided for each of the nine amplifiers and it is normally in its central position ; if moved up, *Spare Y* is brought into circuit ; if moved down, *Spare X* is brought into circuit. The operation of the relay circuits is described fully in Section C, page 14. Safeguards are provided to prevent a spare amplifier being connected to two circuits simultaneously.

Anti-click Circuits

When one *A* amplifier is replaced by another, by operation of a Kellogg key, a click is superimposed on the programme if the input or output circuits of the two amplifiers are not at the same average potential relative to earth. To equalise the potential and eliminate clicks a centre-tapped resistance network is connected across the input circuits of all the *A* amplifiers and the centre points are connected together. Similarly, the centre points of networks included in the output circuits are also connected together. To avoid disturbing matching conditions these anti-click circuits have a resistance not less than ten times the input or output impedance of the amplifier ; the circuits are also accurately balanced.

Source and Channels

The change-over contacts at the output of the *A* amplifiers are followed by a panel where microphone-correction units may be included if necessary. Normally, no correction is required and the relay contacts are wired directly to the source jack.

Identification of Sources and Channels

As indicated in Fig. 1, the programme sources are designated by the symbols *MIC 1*, *MIC 2*, etc., *GRAM*, *ECHO* and *NAR*. The microphone amplifiers associated with these sources are also known by the same symbols, which are printed on strips underneath the amplifiers and also on ebonite strips mounted underneath the appropriate microphone amplifier change-over keys on the left-hand panel of the control desk. The source jacks are identified by a chart on the inside of the door covering the source-selection jackfield.

In certain installations, the programme sources include O.B. or S.B. lines or other studios in the same building ; such sources appear at the source jacks (where they are labelled *O.B.1*, *O.B.2*, *S.B.1*, etc., or by the studio number), at a suitable level for direct connection to a channel jack and no *A* amplifier is necessary.

The channels are distinguished by letters towards the end of the alphabet, except for the echo and independent channels which are designated *ECHO* and *IND* respectively. The letters used in the *Mark V* equipment are *S*, *T*, *V*, *W*, *X*, *Y* and *Z*. These letters appear above, or to the left of the fader controls on the centre panel of the control desk and, to distinguish the channel jacks, on the chart inside the door of the jackfield panel.

Thus each source has its identification and each programme channel between jackfield and associated fader on the control desk has its own particular code. The apparatus, as explained above, is so labelled that it is easy to distinguish the amplifiers and jacks of a particular source and the jacks and faders of a particular channel. The channel letter identification is necessary solely for initial setting-up of the equipment. As an example, if fader *T* is required to control the output of *MIC 3* (to which it is not normalled), the source jack *MIC 3* and channel jack *T* must be cross-plugged at the source-selection jackfield. In the absence of cross-plugging, the source jacks are tied to certain channel jacks.

During operation of the equipment, the operator is concerned almost entirely with the centre panel of the control desk and some indication is required there of the source to which any fader is connected, so that, in the event of a fault on a microphone amplifier, the correct change-over key can be instantly operated. This information is provided by inserting a peg labelled *MIC 1*, *GRAM*, *O.B.1*, etc., in a rubber grommet situated above, or to the left, of each fader control, near the channel identification letter and the short designation strip on which the programme engineer can write the use of the channel concerned (i.e., *Solo Artist*, *Piano*). In the absence of cross-plugging, these pegs bear the indications of the sources to which the channel jacks are normalled, and a plan of the normal tied positions is mounted on the top left-hand corner of the right-hand panel. If, say, *MIC 1* is cross-plugged to channel *T* at the jackfield, the peg bearing *MIC 1* is transferred to fader *T*. If any fader is not connected to a source, a blank peg is inserted in the grommet. Unwanted pegs are kept in spare grommets on the left-hand panel. Sources, whether local microphone points or O.B. or S.B. incoming contribution lines, are normalled to channels whenever possible, but all those for which no channel is available terminate at source jacks and must be plugged up when re-

quired. Pegs with designations for these additional sources remain with the blank pegs in the left-hand panel until the sources are plugged up.

If, on operation of a fader, it is noticed that the source is absent or faulty, the peg near the fader gives the code letters of the source concerned and shows whether it is a local microphone point, the gramophone bank or an outside source. Since each local microphone point has its associated *A* amplifier it is obvious, when trouble occurs on such a source, that the first action of the operator is to substitute the amplifier for one of the spare *A* amplifiers by operating the appropriate change-over key bearing the same code as the peg, but this cannot be done in the case of sources incoming via the local control room.

In some of the older Type-A installations, the channels are designated by colours, and coloured pegs are inserted in grommets near the channel faders and near the microphone amplifier change-over keys in order to identify them. Whenever cross-plugging is carried out, the pegs are moved appropriately. The letter code described above is, however, replacing the colour code.

The echo microphone has a source jack normalled to a jack feeding the echo channel but these are not provided to permit cross-plugging of the echo source to other channels or the echo channel to other sources (in fact, this must on no account be done) ; the echo microphone must always feed the echo channel. The jacks are provided solely to permit the insertion of a frequency-distorting unit (such as the *VCU/1*) in the echo chain when special effects are required.

The main mixer faders, echo-mixture switches and group faders have been described earlier, (page 4.)

B Amplifiers

Next in the chain are the *B* amplifiers which form three main chains known as the *Control*, *Stand-by* and *Echo* chains, each consisting of two *AMC/2* amplifiers in cascade. The stand-by chain can be substituted for either of the other two chains by operation of a Kellogg key on the control desk. A full description of the relay circuits effecting this change-over is given in Section C, page 14. Anti-click resistance networks are included in the input circuits of the *B1* amplifiers, but are not necessary at the output of the *B1* or *B2* amplifiers because of the greater programme volume there.

During *Rehearsal* conditions, when the *Talk-back* key is pressed, the control chain is connected between talk-back microphone and the studio and narrator's loudspeakers. The control-amplifiers are used for talk-back during rehearsal so that, if the studio output is fed to an office for any reason, the talk-back as well as the programme will be heard. Such an arrangement would, of course, be disastrous on transmission, yet it is sometimes convenient to have facilities for talk-back to an assistant in the studio during transmission. Under these circumstances when the control chain is required for the programme, the stand-by chain is used to amplify the output of the talk-back microphone, the output of the stand-by *B2* being fed to headphones always and to the studio loudspeaker when the microphones are faded out. (Section C, page 11.)

The output of the *B2* control amplifier forms the studio output and includes *Listen*, *Apparatus* and *Line* jacks. The studio output is also connected, via a break-jack, to the input of a monitoring amplifier *MNA/1* (for description see ST.8, page 9), which feeds the programme meter on the control desk. A jack is provided in a recess of the control desk to facilitate the connection of a portable programme meter. The a.f. output of the *MNA/1* is at zero volume and is connected to the studio and cubicle programme-selection switches mounted on the right-hand panel of the control desk, the programme being available at position 8 on both switches. (The programmes available on other positions of the switch are obtained from programme ring mains.) The output of the cubicle programme-selection switch feeds the cubicle loudspeaker amplifier via a circuit including a loss pad, the purpose of which is to insert 10-db attenuation in the loudspeaker circuit during the transmission talk-back conditions or when the *Loudspeaker Dim* key is pressed during use of the telephone, etc.

The output of the studio programme-selection switch feeds the studio loudspeaker, the narrator's loudspeaker and a number of jacks via relays.

The contacts of these relays enable the studio and narrator's loudspeakers to be connected either to the output of the monitoring amplifier or to the amplified output of the talk-back microphone. The switching operations are carried out automatically according to whether the apparatus is set up in *Transmission*, *Rehearsal* or *Line-up* conditions.

SECTION C

RELAY CIRCUITS

Introduction

Code Lettering of Relays

Most of the switching operations in the studio equipment Type A are carried out by relays on operation of keys on the control desk. The following is a description of the relay circuits.

To assist in determining the function of the various relays the following code is used :

Code letters.	*Position in Circuit.*
BZS	Signal buzzer in cubicle.
CAJ	Control amplifier *B1* input change-over.
CAO	Control amplifier *B1* output change-over.
CBJ	Control amplifier *B2* input change-over.
CBO	Control amplifier *B2* output change-over.
CBP	Control amplifier change-over.
CDM	Cubicle loudspeaker dimming.
EAJ	Echo amplifier *B1* input change-over.
EAO	Echo amplifier *B1* output change-over.
EBJ	Echo amplifier *B2* input change-over.
EBO	Echo amplifier *B2* output change-over.
GC	Green light (clear).
GO	Green light (operate).
LSO	Cubicle loudspeaker off.
MC	Mains cut.
MCO	Microphone change-over (talk-back).
MO	Mains off.
MNL	Monitor on line.
MXA/B/C	Microphone amplifier change-over.
MYA/B/C	Microphone amplifier change-over.
NLS	Narrator's loudspeaker.
RH	Rehearsal.
RO	Red light (operate).
RP	Red light.
SLS	Studio loudspeaker.
TB	Talk-back.
TN	Tone (line-up).
TNO	Line-up (tone operate).
TR	Transmission.
TTB	Transmission talk-back.
TTM	Transmission talk-back.
TTO	Transmission talk-back.
XL	Microphone amplifier *X* lock-out.
YL	Microphone amplifier *Y* lock-out.

The code letters for each relay are followed by a figure indicating the number of switching operations carried out. For example, code *CAJ/4* shows that this relay performs four switching operations and that these are concerned with the change-over connections at the input to the *B1* control amplifier. The four contacts of relay *CAJ/4* are lettered *CAJ1*, *CAJ2*, etc., and in the diagrams these are drawn for simplicity near the circuits they control and not necessarily near each other or the associated relay winding.

This method of drawing circuit diagrams involving a large number of relays is known as the " detached contact " method and, as will be seen, it greatly facilitates the breaking down of complex circuits to comparatively simple unit diagrams.

The Line-up Condition

General

The object of this circuit condition is to check the gains of the control and monitoring amplifiers and to provide a pre-transmission level check to the control or continuity room. The condition is obtained by depressing the *Line-up* key momentarily. The relay circuits switch on the apparatus, light the indicator lamp above the *Line-up* key, apply tone to the input of the *B1* control amplifier and short-circuit the control potentiometer.

In this condition the gain of the programme chain from the input of the *B1* control amplifier to the output of the *B2* amplifier is 84 db. This is made up of a gain of 49 db from the *B1* amplifier, 39 db from the *B2* amplifier and a loss of 4 db in the matching transformer between the two. Thus the tone applied to the input of the *B1* amplifier must be at — 84 db to give an output of zero level from the *B2* amplifier. The tone

received from the apparatus room is at zero level and the fixed attenuator shown in Fig. 1 has a loss of 84 db. The additional stage of attenuation is provided to give tone at a level suitable for applying to the input of an *A* amplifier for gain checking. The tone is available at a jack which is cross-plugged to the *Input Listen* jack of the microphone amplifier to carry out this check.

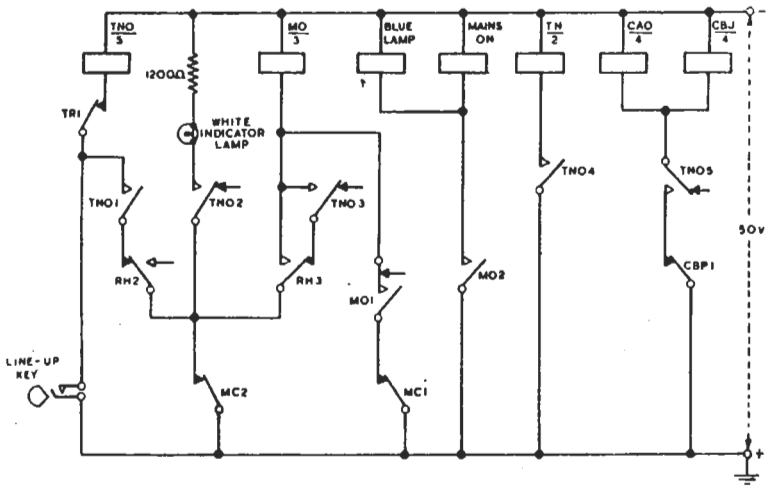


Fig. C.1. Relay Circuits, Line-up Condition

is energised via *TR1*. The relay operates and the following five switching operations occur :—

TNO1 closes and completes the 50-volt battery circuit through the relay winding, *RH2* and *MC2*, and locks relay *TNO/5*. Thus a momentary depression of the *Line-up* key is sufficient to operate the circuit.

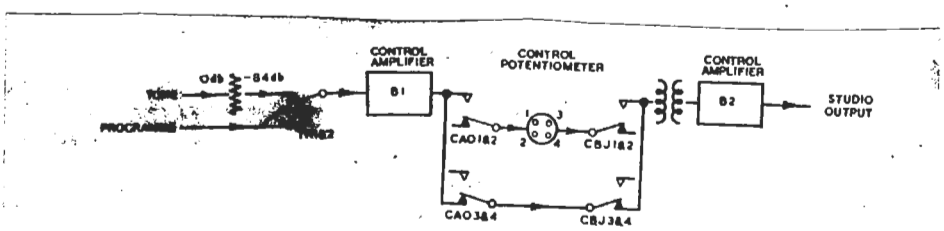


Fig. C.2. Programme Circuits, Line-up Condition

Operation of the Relay Circuits

The operation of the relay circuits controlling the *Line-up* switching may be followed from the complete diagram of all the relay circuits given in Fig. 2, or, more conveniently, from Fig. C.1 which illustrates the line-up relays only.

When the *Line-up* key is pressed, relay *TNO/5* is energised via *TR1*. The relay operates and the following five switching operations occur :—

TNO1 closes and completes the 50-volt battery circuit through the relay winding,

TNO2 completes the circuit of the indicator lamp over the *Line-up* key through a 1,200-ohm resistor. This resistor is included to limit the current through the lamp to 40 mA (6-V, 40-mA lamps are used throughout the equipment).

TNO3 energises relay *MO/3* via *RH3* and *MC2*. *MO/3* operates and performs the following three switching operations :—

MO1 locks relay *MO/3* in the energised condition by completing the battery circuit through *MO/3* winding and *MC1*.

MO2 switches on all mains supplies to amplifiers, loudspeakers and the studio blue light via a mains relay.

MO3 closes in the *Transmission* lamp circuit, but this circuit is broken during *Line-up* conditions by *TNO3*. Therefore, *MO3* performs no operation relative to the *Line-up* condition and is not shown in Fig. C.1.

TNO4 energises relay *TN/2*. When *TN/2* operates, the two contacts *TN1* and *TN2* transfer the input of the control *B1* amplifier to the line-up tone. (Fig. C.2.)

TNO5 energises relays *CAO/4* and *CBJ/4*. *CAO1* and *CAO2* perform no function relative to the *Line-up* condition but *CAO3* and *CAO4* transfer the output of the control *B1* amplifier directly to the primary of the 600/300-ohm matching transformer via *CBJ3* and *4* thus removing the control potentiometer from circuit. *CBJ1* and *2* perform no function relative to the *Line-up* condition. (Fig. C.2.)

The Rehearsal Condition

General

The circuit changes brought about by a momentary depression of the *Rehearsal* key are mainly concerned with the talk-back facility. The relays energised also switch on the green indicator lamp over the *Rehearsal* key, and, if the amplifiers and loudspeakers were previously off, switch these on. The conditions established in the talk-back circuit ensure that, when the *Talk-back* key is operated, the cubicle loudspeaker is silenced and the studio and narrator's loudspeakers are in circuit. The control *B1* and *B2* amplifiers are used, in cascade, for talk-back purposes, the control potentiometer being short-circuited as in the *Line-up* condition.

Operation of the Rehearsal Switching

The operation of the relay circuits can be followed from Figs. 2 or C.3 and C.4. When the *Rehearsal* key is pressed, relay *RH/4* is energised via *TR2*. The following switching operations occur :—

RH1 closes and locks *RH/4* in the energised condition, the circuit of the relay winding being completed through *TNO2* and *MC2*.

RH2 completes the circuit of the green indicator lamp via a 1,200-ohm resistor and breaks the locking circuit of *TNO/5*, so cancelling the *Line-up* condition (if this was set up before).

RH3 If the studio apparatus was switched off when the *Rehearsal* key was pressed, *RH3* completes the circuit of *MO/3*, which operates and is self-held by *MO1*. If the apparatus was previously in the *Line-up* condition *MO/3* will be already energised and locked.

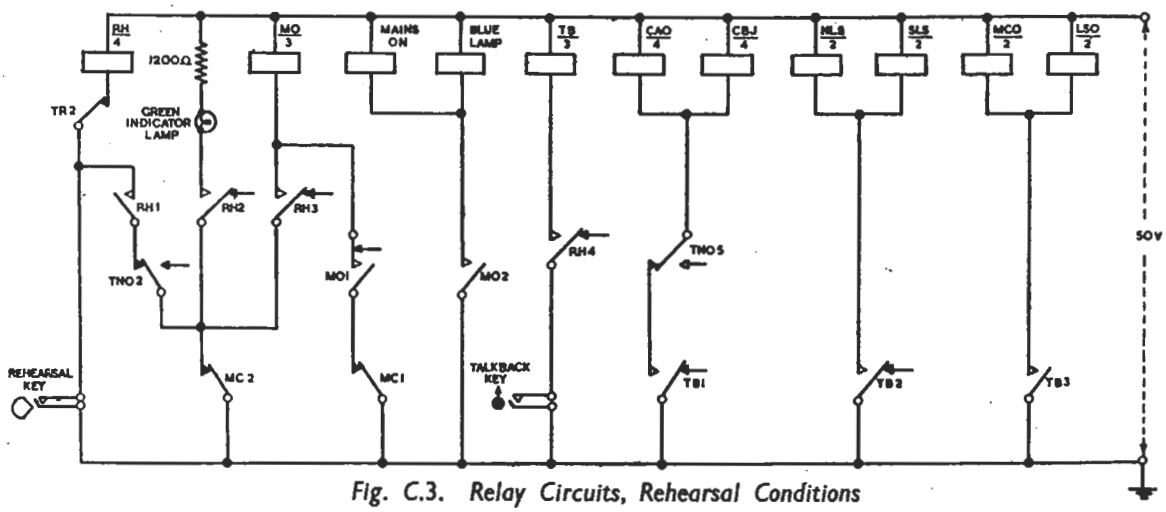


Fig. C.3. Relay Circuits, Rehearsal Conditions

RH4 prepares the circuit for *TB/3* to operate via the *Talk-back* key. When the *Talk-back* key is depressed, *TB/3* operates and functions as follows :—

TB1 closes, completing the circuits of *CAO/4* and *CBJ/4* via *TNO5*. These relays remove the control potentiometer from circuit as explained on page 10.

TB2 completes the circuit of relays *NLS/2* and *SLS/2*, the contacts of which perform the following functions respectively :—

NLS1 and *2* complete the line from the studio programme-selection switch to the narrator's loudspeaker input.

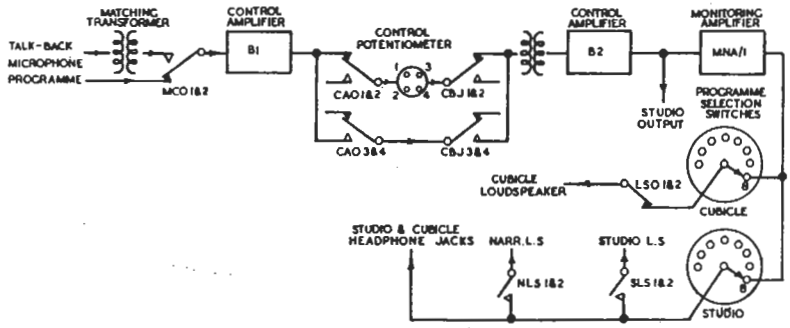


Fig. C.4. Talk-back Circuit, Rehearsal Condition

SLS1 and *2* complete the line from the studio programme-selection switch to the studio loudspeaker input.

TB3 completes the circuit of relays *MCO/2* and *LSO/2*, the contacts of which perform the following functions respectively :—

MCO1 and *2* transfer the input of the control *B1* amplifier from the output of the group and independent faders to the secondary of the talk-back microphone transformer.

LSO1 and *2* break the connections to the cubicle loudspeaker to prevent the "howl-back" which would occur if coupling existed between cubicle loudspeaker and talk-back microphone.

The Transmission Condition

General

In the *Transmission* condition the stand-by chain of amplifiers is used for talk-back purposes, the talk-back speech being audible on headphones only, unless all studio microphones are faded out, in which case it is also audible on the studio loudspeaker. Similarly, when the narrator's microphone is faded out, talk-back speech is audible on the narrator's loudspeaker. The apparatus is automatically switched to and/or locked in the *Transmission* condition when the studio red lights are switched on (page 13).

Relay Circuits in Detail (Figs. C.5 and C.6).

The apparatus is set up in the *Transmission* condition by a momentary depression of the *Transmission* key. This action energises relay *TR/4* via *RP1*. The functions carried out by *TR/4* are largely concerned with the cancellation of the *Line-up* and *Rehearsal* conditions and are as follows :—

TR1 opens and breaks the self-hold circuit of *TNO/5*, cancelling the *Line-up* condition, if this was previously set up.

TR2 opens and breaks the self-hold circuit of *RH/4*, cancelling the *Rehearsal* condition, if this was previously set up.

TR3 opens, breaking the circuit of relay *MC/2*. Thus when relay *TR/4* is locked in the energised condition by the red light signal from the control position, as explained under *Transmission Locking Circuit* (page 13), the contacts *TR1*, *TR2* and *TR3* make it impossible to switch the studio apparatus off or to the *Line-up* or *Rehearsal* conditions.

TR4 performs no useful function if the *Line-up* or *Rehearsal* condition was set up previous to operation of the *Trans-*

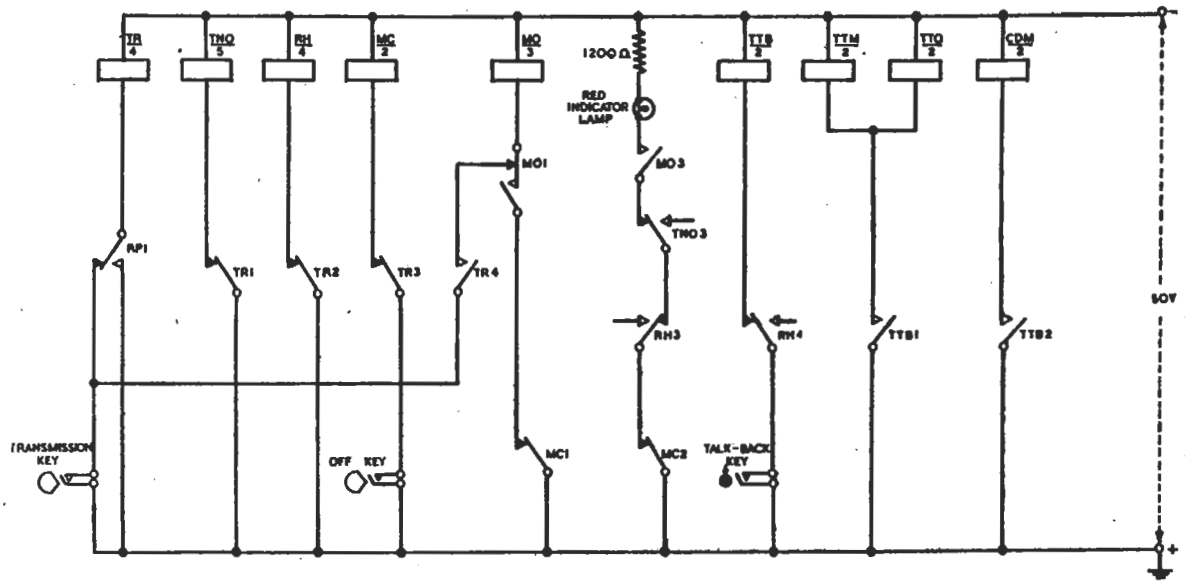


Fig. C.5. Relay Circuits, Transmission Condition

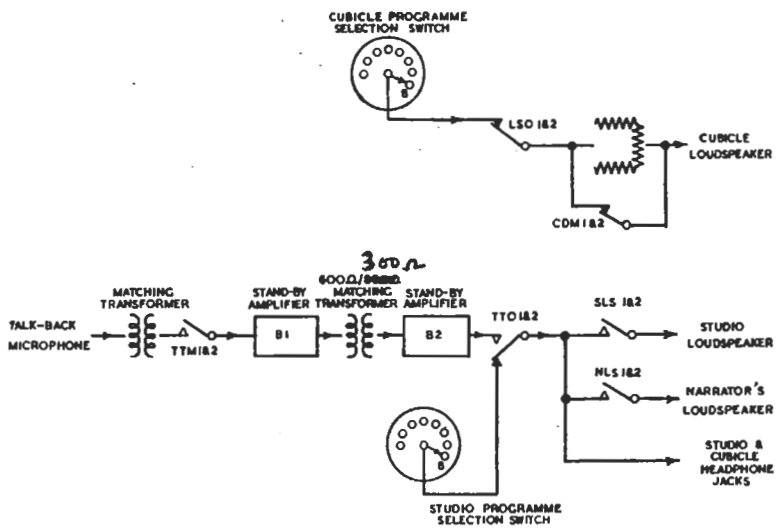


Fig. C.6. Talk-back Circuit, Transmission Condition

mission key, for *MO/3* will be already locked in the energised condition and the circuit of *TR4* is broken at *MO1*. If, however, the apparatus was off before the *Transmission* key is operated, *TR4* energises *MO/3* via *MO1* and the following operations occur :—

MO1 locks *MO/3* in the energised condition.

MO2 energises the mains relay and switches on all mains equipment.

MO3 operates the red indicator lamp above the *Transmission* key, the circuit being completed via *TNO3*, *RH3* and *MC2* (all now closed since *TNO/5*, *RH/4* and *MC/2* are unoperated).

TR/4 has no self-hold contact and therefore does not remain operated after release of the *Transmission* key. It is locked in the energised condition only when the studio red light is operated (see *Transmission Locking Circuit*).

Talk-back Circuit

During the *Transmission* condition, *RH/4* is unoperated and the *Talk-back* key is connected to *TTB/2* via the back contact of *RH4*. When the *Talk-back* key is depressed *TTB/2* operates and performs the following functions :—

TTB1 energises *TTM/2* and *TTO/2*.

TTM1 and *2* connect the input of the stand-by *B1* amplifier to the secondary of the talk-back microphone transformer.

TTO1 and *2* switch the studio-monitoring line (which feeds the studio headphones and the studio and narrator's loudspeakers) away from the programme-selection switch to the output of the stand-by *B2* amplifier. The connections to the loudspeakers, however, are broken by the contacts *SLS1* and *2* and *NLS1* and *2* respectively except when the microphones of the respective studios are faded out (see page 17). Thus in the *Transmission* condition the headphones always receive the talk-back speech, but the loudspeakers only when the microphonesare faded out.

TTB2 energises *CDM/2*.

CDM1 and *2* open and insert a 10-db loss pad in the lead to the cubicle loudspeaker, quietening this during talk-back speech.

Transmission Locking Circuit (Fig. 2)

When the appropriate studio signalling key on a control position is operated *RO/2* is energised. (See Appendix 3.)

RO1 operates the studio red light.

RO2 energises *RP/3*.

RP1 energises *TR/4*.

RP2 operates the central studio indicator in the control room.

RP3 is in parallel with *MO2* (Fig. C.3) and switches on all the mains apparatus if this is not already switched on.

Since *TR/4* is now permanently energised, *TR1*, *TR2* and *TR3* are all open and the *Line-up*, *Rehearsal* and *Off* keys are all ineffective. The apparatus is locked in the *Transmission* condition until the signalling key on the control position is released. If the studio has not been switched to any condition prior to operation of the signalling key, *MO/3* is not energised and release of the signalling key releases the mains switching and the apparatus reverts to the *Off* condition. If the *Transmission* key is pressed the red light above it is illuminated and the apparatus does not revert to the *Off* condition when the signalling key is released.

The Off Condition

Operation of Relay Circuits

The apparatus is switched off by a momentary depression of the *Off* (black) key. This energises relay *MC/2* via *TR3*. (Fig. C.7.)

MC1 opens, breaking the self-hold circuit of *MO/3*.

MO1 the holding contact of *MO/3*, opens.

MO2 opens, de-energising the mains relay and switching off all apparatus.

MO3 (Fig. C.5) opens, breaking the circuit of the red lamp over the *Transmission* key.

MC2 opens and breaks the self-hold circuits of *TNO/5* and *RH/4* to cancel the *Line-up* and *Rehearsal* conditions.

As explained, the *Transmission* condition cannot be cancelled by depression of the *Off* key as long as the signalling key on the control position is operated.

Main Amplifier Change-over

The stand-by *B1* and *B2* amplifiers can be substituted for the equivalent control or echo amplifiers by operation of a single Kellogg key on the control desk. When the latter is moved to the upper position, labelled *Spare to Control*, the control amplifiers are replaced; when it is moved to the lower position, labelled *Spare to Echo*, the echo amplifiers are replaced.

The relay circuits controlling the substituting of the stand-by for the control amplifiers are indicated in Fig. C.8. When the Kellogg key is operated, relays *CAJ/4*, *CBO/4*, *CBP/1* are energised directly and *CAO/4* and *CBJ/4* via *TNO5* and *TB1*. Fig. C.9 illustrates how the contacts of these relays perform the change-over. It will

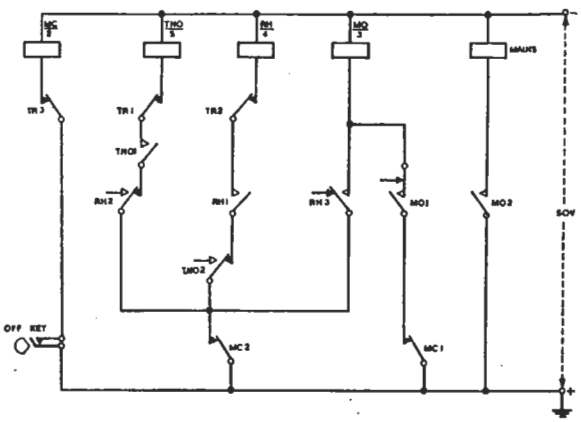


Fig. C.7. Relay Circuits, Off Condition

be noted that if relays *CAO/4* and *CBJ/4* are alone energised, the control potentiometer is inserted between the stand-by amplifiers, and the output of the control *B1* amplifier is applied directly to the matching transformer and the control *B2* amplifier. Thus, as far as the control chain is concerned, the control potentiometer is short-circuited. This circuit arrangement is set up in the *Line-up* condition by contact *TNO5* and in the *Rehearsal* condition by contact *TB1* when the *Talk-back* key is operated.

If the *Line-up* key is pressed when the control amplifiers have been replaced by the stand-by amplifiers, relays *CAO/4* and *CBJ/4* must be de-energised to short-circuit the control potentiometer, which is now included between the stand-by *B1* and *B2* amplifiers. The relay *CBP/1* is included to do this: when the amplifier substitution is effected contact *CBP1* is broken and if the *Line-up* key is pressed *TNO5* breaks, de-energising *CAO/4* and *CBJ/4*.

Under *Rehearsal* conditions the control amplifiers are used for talk-back purposes, the control potentiometer being short-circuited. If the amplifier change-over has been made, the control potentiometer must be short-circuited when the *Talk-back* key is operated. Relay *CBP/1* also achieves this: contact *CBP1* breaks when the amplifier change-over occurs and when the *Talk-back* key is operated *TB1* breaks, de-energising *CAO/4* and *CBJ/4*.

The relay circuits controlling the substitution of the stand-by amplifiers for the echo amplifiers are very similar to those given in Figs. C.8 and

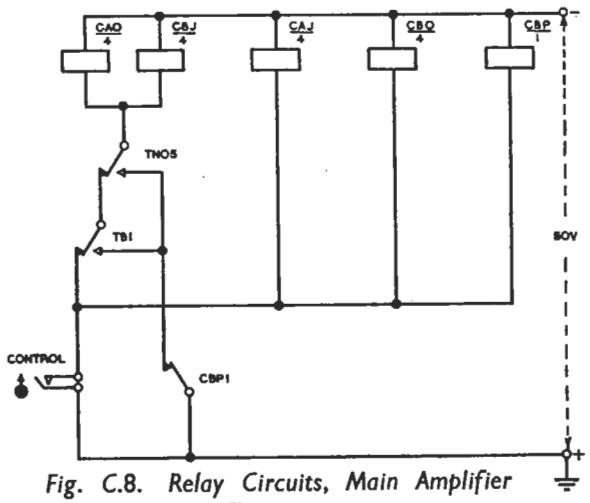


Fig. C.8. Relay Circuits, Main Amplifier Change-over

C.9. When the Kellogg key is moved into the *Spare to Echo* position it energises the four relays *EAJ/4*, *EAO/4*, *EBJ/4* and *EBO/4* which correspond with *CAJ/4*, *CAO/4*, *CBJ/4* and *CBO/4* respectively.

Microphone Amplifier Change-over

General

Any of the nine *A* amplifiers may be replaced by the spare amplifier *X* or the spare amplifier *Y* by the operation of a three-position Kellogg key, nine of which are arranged in a horizontal row on the left-hand control panel. When the key is moved to the up position spare *Y* is brought into circuit; when it is moved downwards the *X* amplifier is brought into use. Precautions are taken in the relay circuits to prevent double selection of the spare amplifiers.

Operation of the Relay Switching

The change-over keys are given the same numbering as the sources; for example, microphone point 1 is normally connected to the input of microphone amplifier 3 and change-over of this amplifier to the spare is controlled by key No. 1.

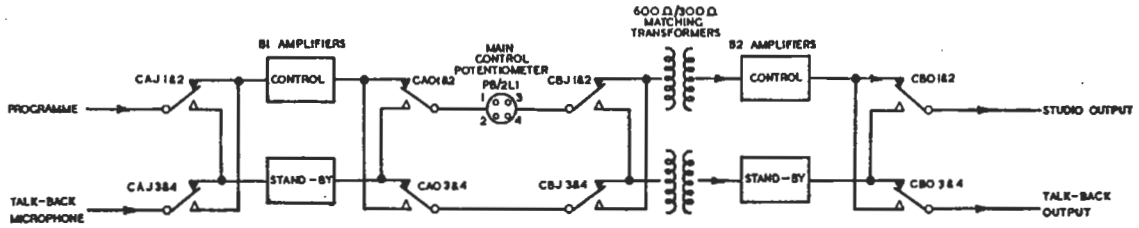


Fig. C.9. Programme Circuits, Main Amplifier Change-over

In normal operation of the equipment a letter code is used to distinguish the fader channels corresponding with particular keys since these can be interchanged by means of the cross-plugging facility. (See Section B, page 6.)

MXB1 locks *MXB/6* in the energised condition, the circuit being completed by the right-hand upper contacts of the key.

MXB2 and *3* transfer the output connections of microphone No. 2 from the input of No. 4 amplifier to the input of the *X* amplifier (see Fig. C.11).

MXB4 closes and operates relay *XL/1*. *XL/1* opens and prevents key No. 1 from replacing microphone ampli-

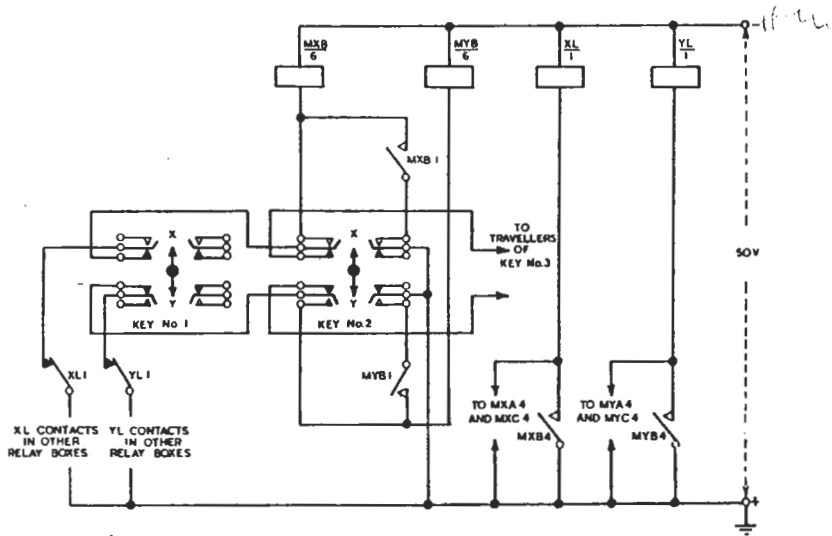


Fig. C.10. Relay Circuits, Microphone Amplifier Change-over

Suppose the amplifier connected to microphone point 2 is to be replaced by spare *X* (see Fig. C.10). To do this, key No. 2 is moved to the down position and the upper row of contacts in the diagram is operated. Relay *MXB/6* is energised via the contacts of change-over keys 1 and 2 and the relay contact *XL1*.

fier No. 3 by the *X* amplifier. As long as key No. 2 is in the *X* position its back contacts are open and keys Nos. 3, 4, 5, etc. are inoperative in the downward position. In the *Mark V* equipment there are three *XL/1* relays, designated *XL(A)/1*

XL(B)1, *XL(C)1*, each contained in a separate relay box. *XL(A)1* is opened by operation of any of the first three change-over keys; *XL(B)1* performs the same function for change-over keys 4, 5 and 6 and *XL(C)1* for keys 7, 8 and 9.

MXB5 and *6* transfer the connections of the source jack from amplifier No. 4 to the output connections of the spare *X* amplifier.

A similar sequence of operations occurs when the change-over key No. 2 is moved upwards to the *Y* position: relay *MYB/6* is operated and is

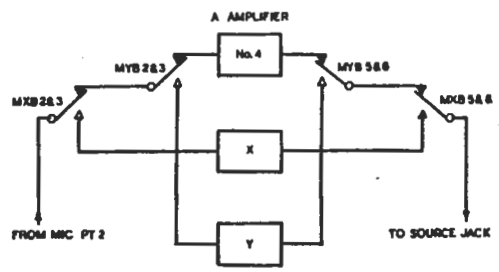


Fig. C.11. Programme Circuits. Microphone Amplifier Change-over

locked by contact *MYB1*. *MYB4* energises *YL/1* and prevents key No. 1 from operating on *Y* change-over. *MYB2, 3,* and *MYB5, 6* perform the switching operations shown in Fig. C.11.

Signal-light Circuit

When the signalling key on a control position is operated relay *TR/4* is energised, the *Line-up Rehearsal* and *Off* keys are rendered ineffective and the studio is locked in the *Transmission* condition until release of the signalling key. A detailed account of the signalling circuit is given in Appendices 2 and 3.

Studio and Narrator's Loudspeaker Circuits

General

It was explained on page 11 that the studio and narrator's loudspeakers are operated by the contacts of relays *SLS/2* and *NLS/2* respectively and that these are energised by one of the contacts (*TB2*) of relay *TB/3* which, in turn, is energised by the *Talk-back* key when the apparatus is in the *Rehearsal* condition.

The two loudspeakers can be silenced, when necessary, by operation of a key known as the *Studio Loudspeaker Cut-off* key on the control desk and, provided that this and the *Talk-back* key have not been operated, the studio loudspeaker is automatically switched on and off by rotation of the microphone and group faders. The independent fader similarly controls the narrator's loudspeaker. The arrangement is such that the loudspeakers are switched on when the faders are rotated fully anti-clockwise and off as soon as any one fader is turned clockwise. This precaution was taken to prevent any possibility of "howl-back." The gramophone fader and faders controlling sources external to the studio are not, of course, included in this circuit. By using the sleeve circuit of the source and channel jacks, provision is made for the interlock circuits to be automatically cross-plugged when microphone channels are cross-plugged.

Operation of the Circuit

The relays controlling the narrator's and studio loudspeakers, *NLS/2* and *SLS/2* respectively, are connected to the 50-volt supply via 1,000-ohm resistors (Fig. C.12), which are included so that the relays may be de-energised by earthing points A and B. The sleeve circuits of plugs and jacks in conjunction with switches ganged with the microphone, group and independent faders, apply earths to points A and B to provide the facilities mentioned above.

Under normal conditions, when one or more faders have been rotated clockwise, point B is earthed by a connection obtained via the switches ganged with the fader controls, via contact *TB2* and one of the contacts of the *Studio Loudspeaker Cut-off* key. The studio loudspeaker is therefore silent, but it is brought into circuit automatically when all the faders are rotated fully anti-clockwise. When the *Studio Loudspeaker Cut-off* key is operated the battery earth is removed from *NLS/2* and *SLS/2* as well as from the fader switches so that both relays are unoperated and not under control of the fader switches. When the *Talk-back* key is operated under *Rehearsal* conditions, the battery earth is switched away from the fader switches by *TB2* to *NLS/2* and *SLS/2* directly, so that these relays are energised by the *Talk-back* key irrespective of the position of the microphone faders and of the *Loudspeaker Cut-off* key.

Each of the channel jacks has a change-over switch operated by the insertion of a plug and which, for channels normally connected to a microphone, in the absence of cross-plugging, connects point B to the associated fader switch. The latter is closed when the fader is turned

clockwise and connects point B to the group fader switch. This is closed by clockwise rotation of the control knob and connects point B to earth via the *Studio Loudspeaker Cut-off* key and *TB2*, de-energising *SLS/2* and silencing the studio loudspeaker. If the group control is rotated fully anti-clockwise, the earth connection to B is broken, *SLS/2* is energised and the studio loudspeaker is brought into circuit. Thus, when all microphone channels are faded out, *or* when the group fader is faded out, the battery earth is removed from point B, *SLS/2* is operated and programme is connected to the input of the studio loudspeaker.

The circuit controlling *NLS/2* is similar. The source jack of the narrator's microphone has a change-over switch which, when no plug is inserted, connects point A to the change-over switch of the *IND* channel jack and thence to the switch on the independent fader. When the latter is rotated clockwise, point A is earthed and *NLS/2* is de-energised, silencing the narrator's loudspeaker.

Sleeve Circuit

If a plug is inserted in, for example, *T* channel jack the change-over switch is operated, breaking the connection between point B and the switch of the associated *T* fader and rendering automatic loudspeaker control ineffective when that particular channel only is in use. This occurs when the gramophone or outside sources 1 or 2 are cross-plugged to any of the channel jacks. If, however, the source jack of any studio microphone is cross-plugged to any channel, the sleeves of the two jacks are connected together and this connection overrides the change-over switches on the jacks and connects point B directly to the fader switches.

Thus whenever there is a possibility of "howl-back," control of the studio loudspeaker by fader rotation occurs automatically, whether or not any cross-plugging has been carried out. If the only channel in use is connected to the output of a gramophone desk or to an outside source, the studio loudspeaker can safely be on when the channel is faded up, without any possibility of "howl-back,"

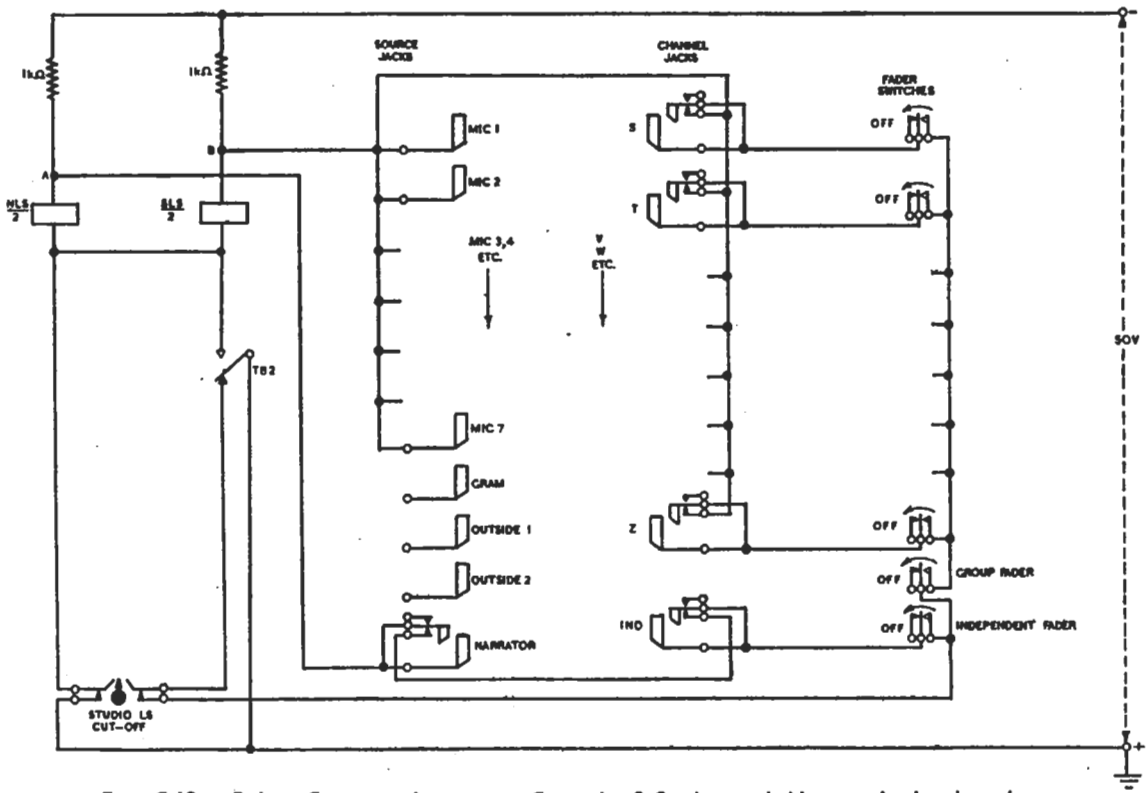


Fig. C.12. Relay Circuits, Automatic Control of Studio and Narrator's Loudspeakers

and automatic control of the loudspeaker is unnecessary.

In early installations the *NLS* and *SLS* relays had standard windings of 2,000-ohms resistance but in certain equipments it was found that clicks were heard on the programme when these relays operated. This was caused by the large change in p.d. across the relay winding when points A or B were connected to or disconnected from earth.

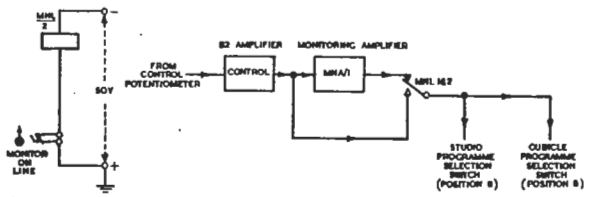


Fig. C.13. Relay and Programme Circuits, Monitor on Line Control

This difficulty was cleared by reducing the winding resistance to 50 ohms and connecting 1-μF capacitors across them.

The Stand-by Loudspeaker (Fig. 1)

If the cubicle loudspeaker amplifier fails and no headphones are immediately available, aural monitoring is still possible by use of a miniature loudspeaker, which can be connected across the output of the cubicle programme selection switch by operation of a key labelled *Stand-by Loudspeaker*. Since this loudspeaker is connected directly to the programme circuit and has no amplifier, the volume obtained is very weak.

Cubicle Loudspeaker Dimming (Figs. 1, C.5 and C.6)

The volume of the cubicle loudspeaker can be reduced by 10 db by operation of a key labelled *Cubicle Loudspeaker Dim* on the control desk. This energises relay *CDM/2*, the contacts of which insert a 10-db loss pad in the input to the loudspeaker amplifier.

Green Cue Lights (Fig. C.14)

Three cue lights are provided in the main studio

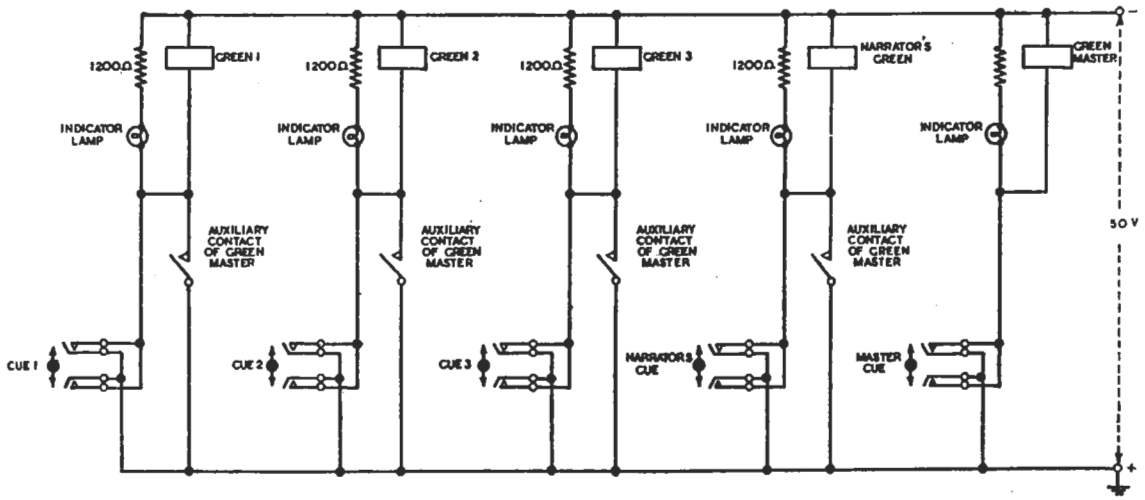


Fig. C.14. Cue-light Relay Circuit

Monitoring Circuits

No spare monitoring amplifier is provided in the equipment but if the *MNA/1* fails, the aural monitoring chain can be transferred to the output of the control *B2* amplifier by operation of a key labelled *Monitor-on-Line* on the control panel. This key energises relay *MNL/2*, the contacts of which effect the transfer as shown in Fig. C.13.

and one in the narrator's studio. Each can be switched on by a relay circuit controlled by a key on the control desk. A warning light situated above each key indicates that the cue light is on. All four cue lights can be simultaneously operated by means of a fifth (master) key on the control panel. The keys are non-locking in the down position and locking in the up position.

SECTION D

TELEPHONE EQUIPMENT (TYPE 2)

The control desk is equipped with two telephones, each housed in a recess at the side: one recess also contains the stand-by loudspeaker. Normally the control desk has a pedestal on the left-hand side and the stand-by loudspeaker is situated in the left-hand recess, but the desk can be manufactured with a right-hand pedestal if the cubicle lay-out makes this imperative, in which case the relative positions of the two recesses are reversed. The telephone instruments are independent, each having a separate line to the control room, but the buzzer is common. Each instrument is associated with a telephone-call key mounted on the right-hand control panel and which is pressed to make outgoing calls. Above each key is a white warning lamp, which is illuminated on receipt of ringing tone and indicates which telephone requires answering. Additional warning is provided by the white lamp on the cubicle wall and by a similar lamp on the studio wall. Arrangements are provided to render the latter ineffective under *Transmission* conditions, because it was found to have a disturbing effect on artists.

Each telephone instrument is supported on a cradle, which operates a multi-contact switch when the telephone is picked up or replaced. A telephone panel situated behind each recess contains the microphone transformer, choke, capacitors and relays. The left-hand panel differs from the other in that it contains both the telephone and the studio buzzers.

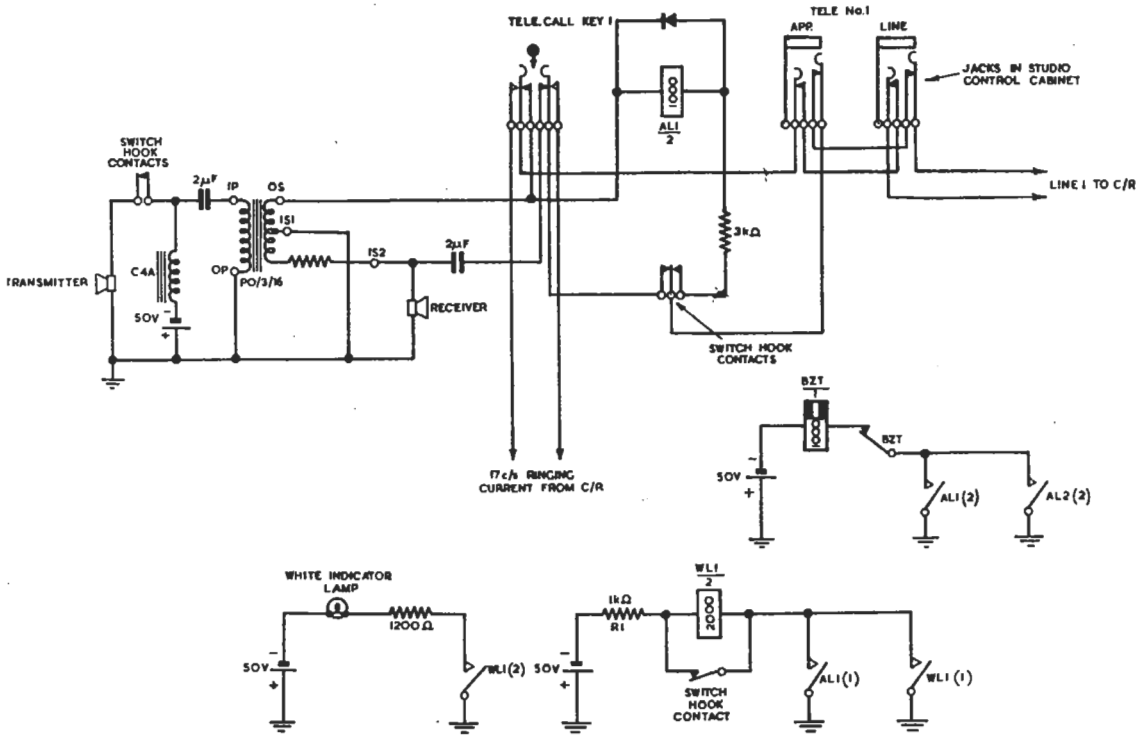


Fig. D.1. Telephone Circuit

The circuit diagram for one telephone is shown in Fig. D.1. When 17-c/s ringing tone is received on the incoming line it is fed via ~~[illegible] apparatus~~ a Line ~~jacks~~ break jacks, one of the contacts of the telephone call key, the switch hook contacts and a 3,000-ohm resistor to relay *AL1/2*. (The switch-hook contacts are shown in the positions taken up when the

cradle is raised ; when receiving a call the contacts are in the opposite sense.) *AL1/2* operates. The rectifier connected in shunt with *AL1/2* is provided to prevent the armature oscillating at 17 c/s, and a fuller explanation of this circuit is given later on this page.

AL1(1) completes the circuit of *WL1/2* via the 1,000-ohm resistor *R1*. *WL1/2* operates.

WL1(1) is a self-hold contact and keeps *WL1/2* in the energised condition after the ringing tone ceases and *AL1/2* becomes de-energised. There is a similar circuit for the other telephone, which includes relay *WL2/2* and contacts *AL2(1)* and *WL2(1)*.

WL1(2) energises the white indicator lamp above the telephone call key via a 1,200-ohm resistor. It also energises the cubicle white light via the *Cubicle White* relay and the studio white light via the *Studio White* relay. The circuit of the latter lamp is connected in series with an auxiliary contact of the studio red-light relay so that the studio white light is inoperative during transmission.

AL1(2) energises the buzzer in the control desk. The buzz lasts for the duration of the ringing tone as *AL1/2* becomes de-energised when the ringing tone ceases. The buzzer is also energised by contact *AL2(2)* of the other telephone.

When the telephone is lifted from the cradle to answer a call, the switch-hook contacts take the positions indicated in the diagram. The switching operations which occur are as follows :

1. Relay *WL1/2* is short-circuited and releases.
2. The incoming line is switched from relay *AL1/2* to the telephone transformer via a 2-μF capacitor.
3. The telephone microphone is connected to the 50-volt supply.

When the telephone is replaced on the cradle at the end of the conversation, these switching operations are reversed and the line is again connected to *AL1/2* which is de-energised. The apparatus is now ready to receive another call.

To make an outgoing call the telephone is lifted from the cradle and the appropriate telephone call key is pressed. By this means ringing current is applied to the line and operates the buzzer at the other end.

A.C. Operation of Relays

Relays can be operated from alternating current without appreciable loss in efficiency by connecting a small copper-oxide or selenium rectifier in parallel with the winding and a protective resistor in series. (See Fig. D.1.)

The action of the circuit may be explained as follows :—During half of each cycle the rectifier is non-conducting and current flows through the winding, establishing flux in the core. When the applied voltage falls, the flux collapses and generates an e.m.f. tending to delay the collapse. When the applied e.m.f. is zero the induced e.m.f. is large and in the right direction to drive current through the rectifier. When the applied e.m.f. reverses, the rectifier is conductive and its resistance is less than that of the relay winding, so that the p.d. across the relay is very small and nearly all of the applied e.m.f. is dropped across the series resistor. The relay thus behaves as though released with the winding short-circuited and the armature is so slow in moving that it does not return to the unoperated position before the next half-cycle commences, re-establishing the flux in the core. Thus the armature is held securely during the maintenance of the applied e.m.f. and does not oscillate at the mains frequency.

The only disadvantage of this use of relays is that they are a little slower in operation than on d.c.

SECTION E

THE CONTROL DESK

General Description

The control desk *SCD/5* (Fig. E.1.) is usually situated in the control cubicle immediately in front of the window between the cubicle and the studio. To give the operator an uninterrupted view through the window into the studio, the overall height of the desk is limited to 3 ft 3 in. There are many occasions on which more than one person is required to sit at the desk (for example, a producer may wish to sit alongside the programme engineer) and for this purpose the right-hand end of the table is unsupported. The carcase of the desk is in three parts, which are bolted together and any combination of control panels can be fitted to it.

Panel Mounting

The controls on the inclined face of the desk are divided amongst three panels. These are easily removable and, except for certain types of centre panel, are mounted so as to swing forward (as shown in Fig. E.2) to give easy access to the rear for maintenance.

The controls are assembled on the panels and wired remote from the desk and the " tail " of wiring is terminated on a tag block. After the panel has been fixed to the desk, the tag block is mounted in the lower part of the rear portion of the desk.

This feature has enabled a number of standard

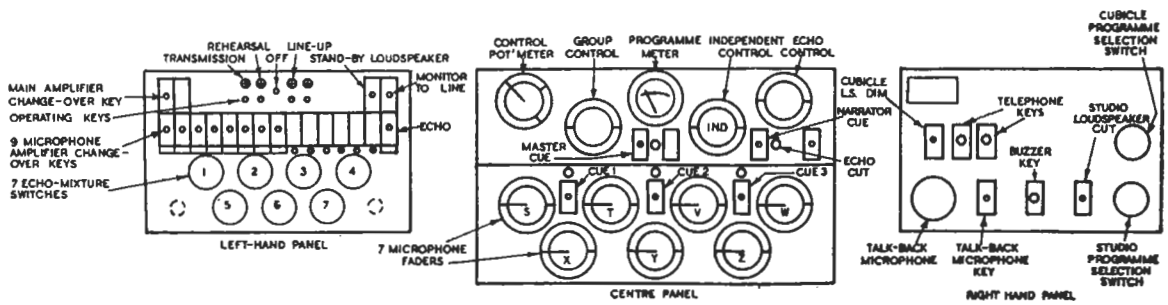


Fig. E.3. Grouping of Controls on Panels of Control Desk, Mark V Equipment

The height of the table from the floor (2 ft 4 in) was carefully determined to give the maximum of comfort to the operators particularly when the controls on the centre panel are being operated. The large number of controls required on the centre panel and the limitation of the overall height of the desk made it necessary to introduce the well in the table top, but this has increased working comfort by lowering the height of the more important controls and allowing the whole of the forearm to rest on the table when operating these controls. Two telephones to the control room are provided, one at each end of the desk, the right-hand one being located in a compartment let into the side and the other in a compartment at the front, which also serves to house the small stand-by loudspeaker.

types of panel to be designed which can be mounted, as interchangeable units, on the standard desk framework to cater for the needs of all types of studio. Except for special " outsize " installations, the centre panel is itself made up of various combinations of standard units, consisting of two sizes of control panel, two types of mixer panel, and a key- and lamp-panel. Various combinations of these are mounted one above the other and the different centre panel arrangements required for differing studio requirements are obtained by appropriate choice of these smaller panels.

The Grouping of Controls

The division of controls amongst the three panels is made according to their functions. As

shown in Fig. E.3, the centre panel carries the most important controls with which the programme engineer is concerned; these are the microphone faders, the main control potentiometer, the group and independent faders, the main echo control, programme meter, cue-light keys and indicator lamps, and the echo-cut key.

The right-hand panel carries the talk-back microphone and its operating key, the buzzer key, the *Cubicle Loudspeaker Dim* key, the *Studio Loudspeaker Cut-off* key, the telephone keys and the studio and cubicle programme selection switches. These are controls which the producer may wish to operate and are directly in front of him when he sits on the right-hand side of the programme engineer. The programme engineer also requires to use these controls and those which he requires most frequently, namely the talk-back microphone, its operating key and the *Cubicle Loudspeaker Dim* and the telephone keys, are situated on the left-hand side of this panel to be within easy reach. (See Fig. E.3.)

The controls on the left-hand panel are mainly of a pre-set nature, requiring adjustment at infrequent intervals. They are :—the keys selecting *Line-up*, *Rehearsal* and *Transmission* conditions, the *Off* key, the main amplifier change-over key, the microphone amplifier change-over keys, the stand-by loudspeaker key, the monitor-on-line key and the echo-mixture switches.

Fig. E.1. General View of Control Desk, Mark V Equipment

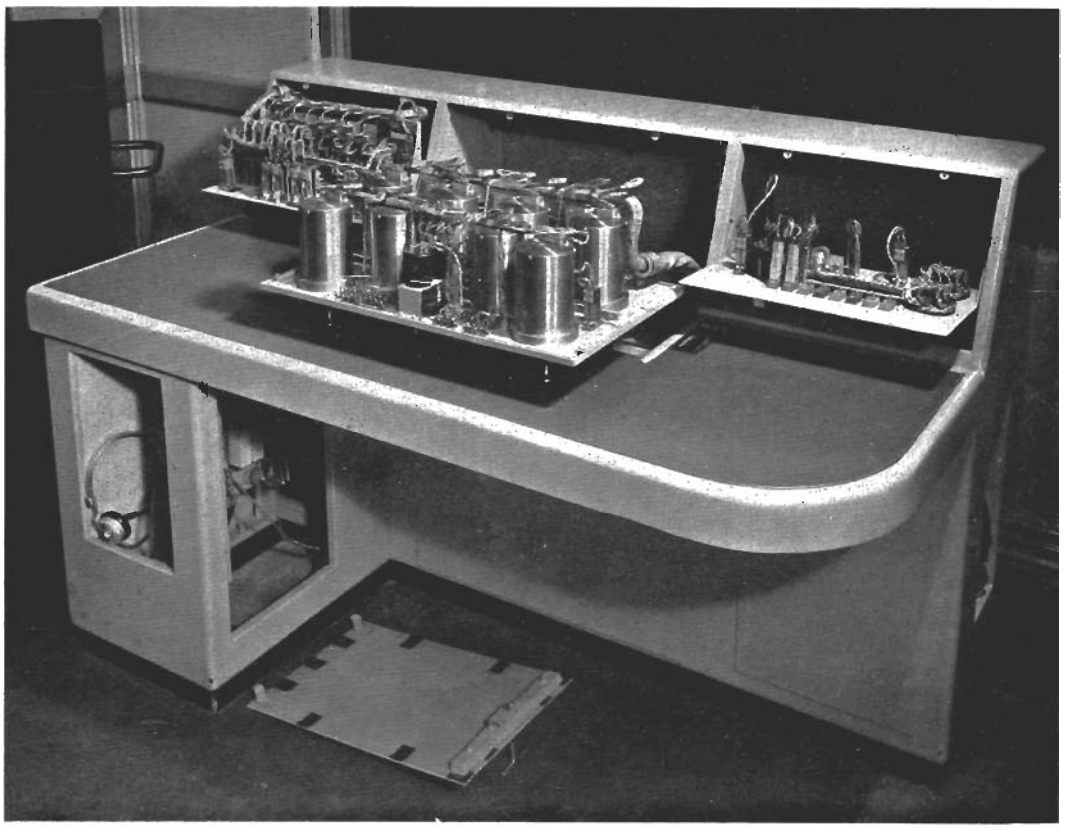


Fig. E.2. Control Desk, Mark V Equipment, with Panels swung forward or detached

SECTION F

THE STUDIO CONTROL CABINET AND THE STUDIO SUPPLY CABINET

The Studio Control Cabinet

General

All the amplifiers, mains units and relays of a studio equipment Type A are housed in a steel cabinet (Type *CT/1001*) 6 ft 6 in high, 3 ft wide and 2 ft deep, situated in the control cubicle or in a separate room nearby. The cabinet (Fig. F.1) is normally kept locked but access to the pre-mixer jackfield for cross-plugging purposes is possible through a non-lockable door at the bottom right-hand corner of the cabinet. A mains isolator is also located in this non-lockable compartment.

The amplifiers and other items of equipment are attached to shelves which are mounted on runners and can be withdrawn to provide easy access to the equipment for maintenance. Fig. F.2 shows some of the shelves partly withdrawn. To keep the centre of gravity of the cabinet low, the heavy mains units are situated at the bottom and the remaining shelves carrying amplifiers and relays are kept as low as possible.

For standardisation, the amplifiers and relays have been divided amongst the shelves as far as possible so that the same shelves may be used in any equipment irrespective of its complexity. For example, standard shelf No. 1 holds six *AMC/2* amplifiers and may be used as a bank of microphone amplifiers or as the control, stand-by and echo *B1* and *B2* amplifiers. Three No. 1 shelves are used in the *Mark V* cabinet. The shelves are manufactured, assembled and wired remote from the cabinet and the wiring to external apparatus is arranged in the form of two flexible "tails" terminating in tag blocks, one of which carries programme circuits and the other H.T. and L.T. supplies. When a shelf is fitted in the cabinet the blocks are mounted on uprights in vertical rows on each side of the cabinet near the front and are used for making the interconnections between the shelves, as well as for the cabinet-to-desk wiring.

No spare mains unit is provided, but the interconnections between amplifiers and mains units are so arranged that, when an amplifier acts as a spare for another, it is fed from a different mains unit. Thus if a mains unit fails, the operation for switching in a spare amplifier will restore the programme, except when more than two microphone channels are lost.

The cabinets complete with equipment are given type numbers between *SCC/1* and *SCC/5* depending on the *Mark*. For outsize equipment the cabinet is Type *SCC/6* with letter suffixes to designate minor differences which occur between individual equipments.

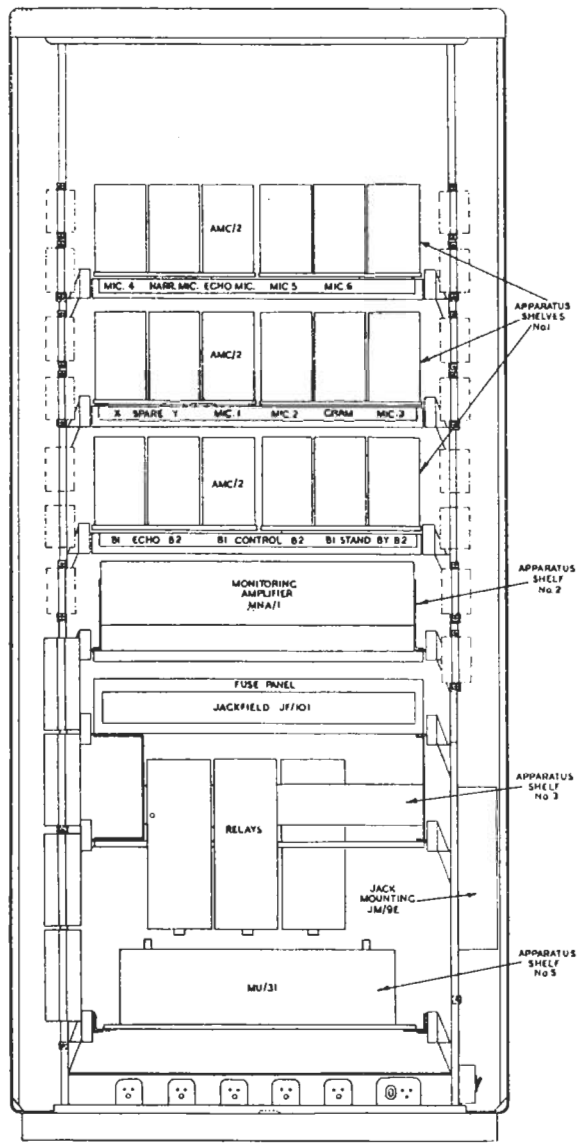


Fig. F.3. Shelf Arrangement of Studio Control Cabinet Mark V Equipment

The contents and purpose of each shelf will now be described, beginning at the top of the cabinet.

Apparatus Shelf No. 1

Apparatus shelf No. 1 contains six *AMC/2* amplifiers. These are supported on guides, on which they are free to slide, when not connected up. Three amplifiers are carried on a platform, which is supported on rubber to minimise the effects of mechanical shock and consequent ringing noises superimposed on the programme. The H.T. and L.T. supplies, programme input and output connections are made to each *AMC/2* amplifier by a single multi-point plug which fits in a socket on the front panel. A faulty amplifier may be replaced in a few seconds.

Apparatus Shelf No. 2

Apparatus shelf No. 2 contains a single monitoring amplifier, Type *MNA/1*, mounted on vertical supports. One shelf of this type is included in every cabinet.

Apparatus Shelf No. 3

Apparatus shelf No. 3 carries the relays, the 50-volt fuse panel and a small jackfield used for test purposes. The relays are mounted in removable boxes or "sets" capable of accommodating 18 relays. These mountings are of the standard type widely used in automatic telephony. They hook or "jack" into position, the necessary electrical connections being made by a multi-point plug-strip which automatically locates with a socket-strip by the process of "jacking" the set into position. A useful feature of this design is that the socket-strip connections are arranged in pairs and the spring contacts of any pair can be so adjusted that they make together in a short-circuit upon removal of the relay box. In the event of a relay failure, the entire relay box is removed and replaced by a spare and the fault is then investigated at leisure. In case of dire necessity a relay box may be replaced during a programme; the paired connections are so arranged and adjusted that the studio output is maintained when the relay box is removed, although, of course, the facilities provided by the box are lost.

By suitable grouping of the relays in the boxes it is possible to meet the requirements of all sizes of Type A equipment by use of three different types of relay-box assembly. These are :—

Relay Box Type RLB/1

This box houses relays *TTM, TTO, MNL. TN, MCO, CAO, CBJ, CBO, CAJ, EAJ, EAO, EBO*, and *EBJ*. These are concerned with the talk-back circuit, monitoring and *B1* and *B2* amplifier change-over switching. Each cabinet includes one relay box of this type.

Relay Box Type RLB/2

This box houses relays *MO, TNO, TR, MC, RH, CBP, CDM, LSO, TTB, RP, TB, RO, SLS, GO, NLS*, and *GC*. These are concerned with the switching arrangements for the *Line-up*, *Rehearsal* and *Transmission* conditions. Each cabinet includes one relay box of this type.

Relay Box Type RLB/3

This box houses relays *MYA, MYB, MYC, MXA, MXB, YL*, and *XL*. These are concerned with the *A*-amplifier change-over switching. The number of relay boxes of this type required in a cabinet is dependent on the number of microphone amplifiers and hence on the size of the equipment. Cabinet *SCC/5* includes three boxes of this type.

Four types of apparatus shelf No. 3 are available, the type to be used in a particular cabinet depending on the number of type *RLB/3* relay boxes required.

Type of Apparatus Shelf No. 3	*Number of RLB/3 Boxes*	*Type of Cabinet*
Assembly *A*	1	*SCC/1*
Assembly *B*	2	*SCC/2* and *SCC/3*
Assembly *C*	3	*SCC/4* and *SCC/5*
Assembly *D*	4	*SCC/6A*, *SCC/6B*, etc.

The jack-strip on shelf No. 3 provides facilities for listening to the programme at the following points in the chain :—

Position in Chain	*Type of Jack*
Input to monitoring amplifier	*Apparatus, Listen*
Output of monitoring amplifier	*Listen*
Telephone	*Line, Listen*
Studio loudspeaker	*Line, Listen*
Narrator's loudspeaker ...	*Line, Listen*
Cubicle loudspeaker	*Line, Listen*
Echo loudspeaker	*Line, Listen*

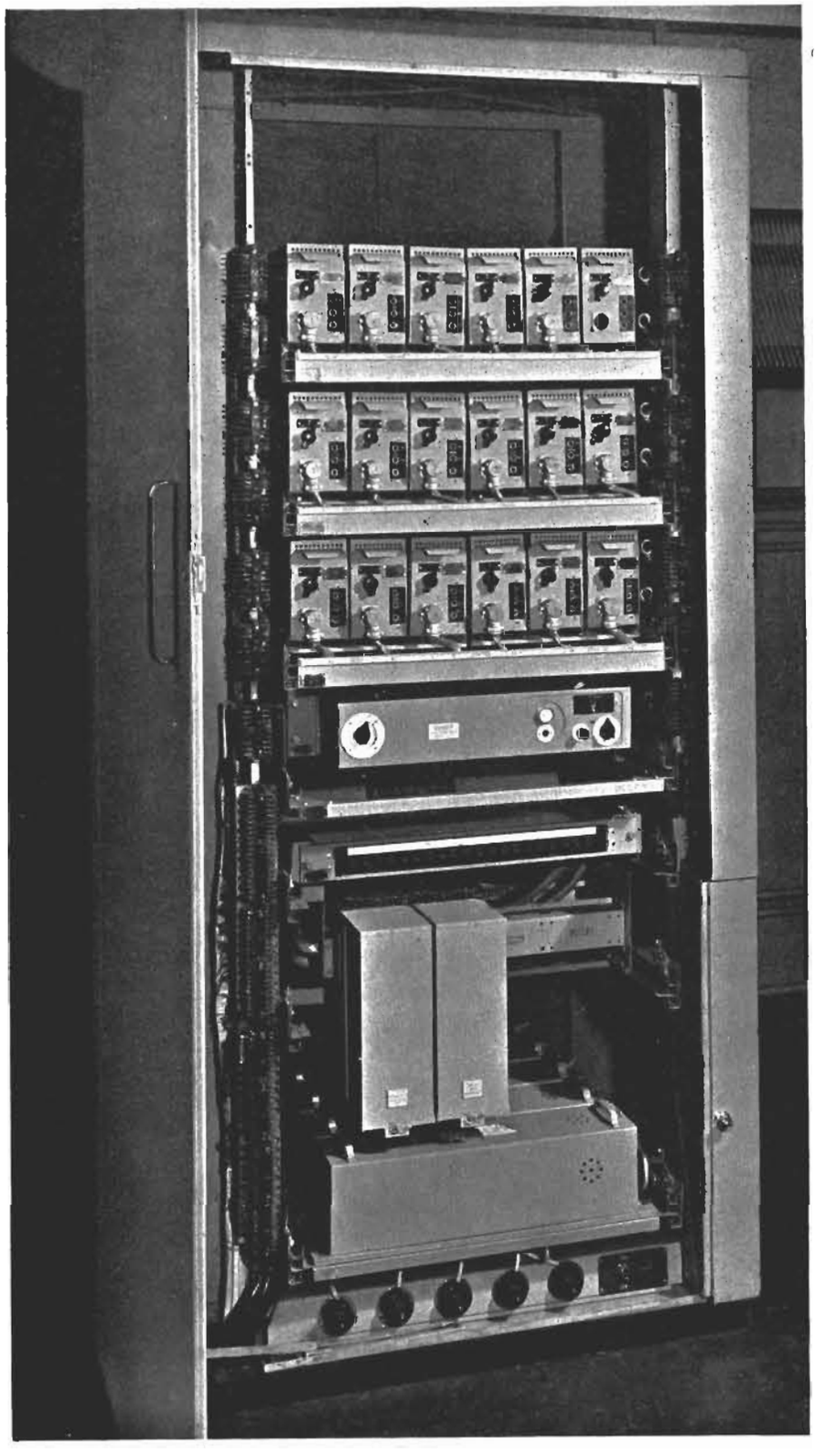


Fig. F.1. General View of Studio Control Cabinet, Mark V Equipment

INSTRUCTION S5

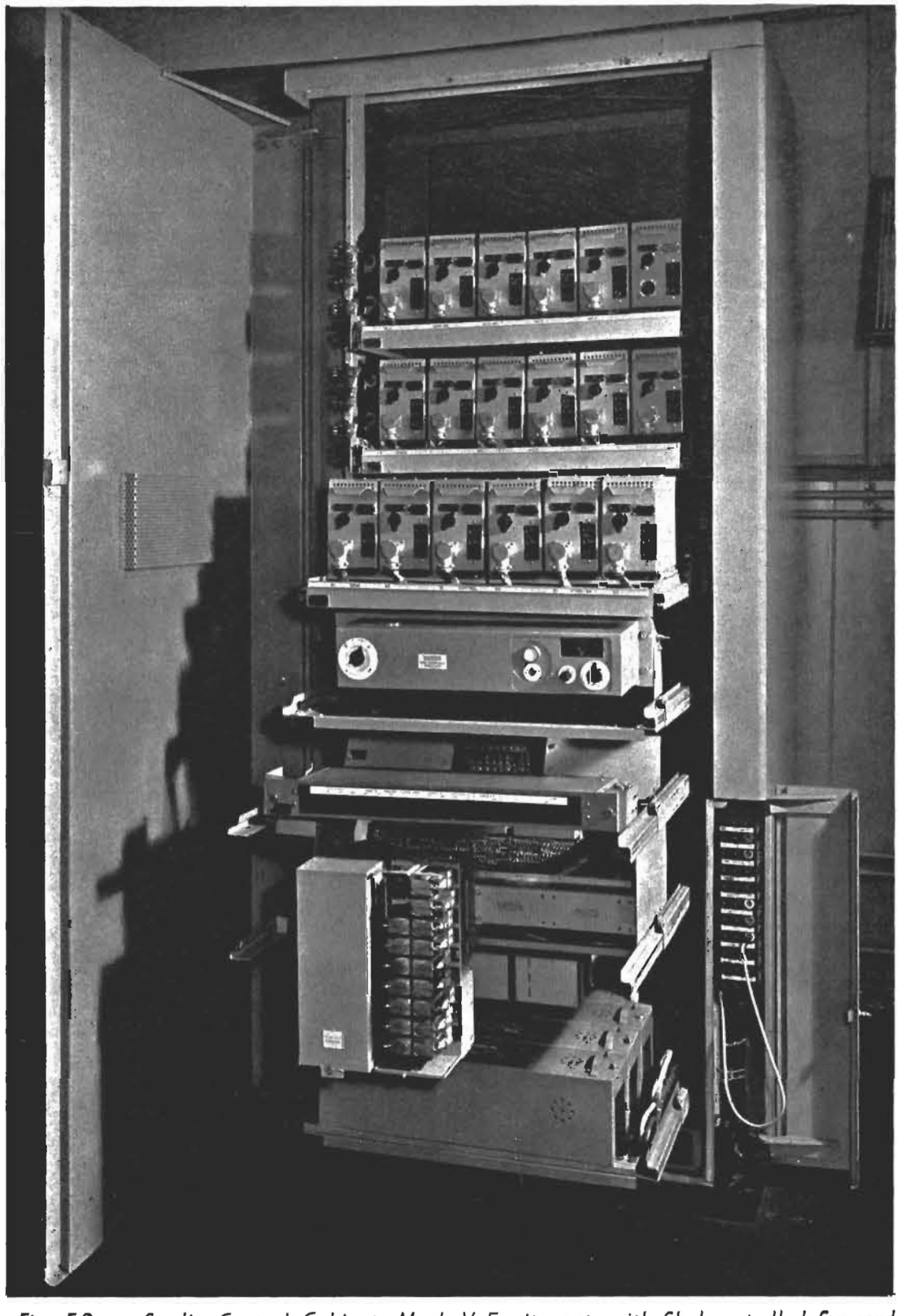


Fig. F.2. Studio Control Cabinet, Mark V Equipment, with Shelves pulled forward and showing Source Selection Jackfield

Two further jacks provide tone at zero level from the control room, which may be used for test purposes and tone at — 88 db used for testing microphone amplifiers.

Apparatus Shelf No. 4

This shelf contains mains units for supplying H.T. and L.T.to the equipment on the other shelves. Mains units Type *MU*/16 (for details see Technical Instruction ST.3, page 16) are used, their number depending on the size of the equipment as follows :—

Type of Apparatus Shelf No. 4	*Number of MU*/16*s*	*Type of Cabinet*
Assembly *A*	5	*SCC*/5
Assembly *B*	4	*SCC*/3 and *SCC*/4
Assembly *C*	3	*SCC*/1 and *SCC*/2

This type of shelf has now been superseded by shelf No. 5.

Type of Apparatus Shelf No. 5	*Number of MU*/31*s*	*Type of Cabinet*
Assembly *A*	2	*SSC*/1-5
Assembly *B*	3	*SCC*/6*A* and *SCC*/6*B*

Studio Control Cabinet SCC/5.

This cabinet houses the *Mark V* equipment and contains three No. 1 shelves, one No. 2, one No. 3 (assembly *C*) and one No. 5 (assembly *A*). The arrangement of the shelves is illustrated in Fig. F.3.

The Studio Supply Cabinet

All the mains isolators, contact breakers and mains relays of the Type A equipment are housed in a small steel cabinet (Type *CT*/*201*) usually mounted on the wall of the control cubicle. The equipped cabinet (Fig. F.4) is designated *SSC*/*5* for *Mark V* installations, and contains the following apparatus :—

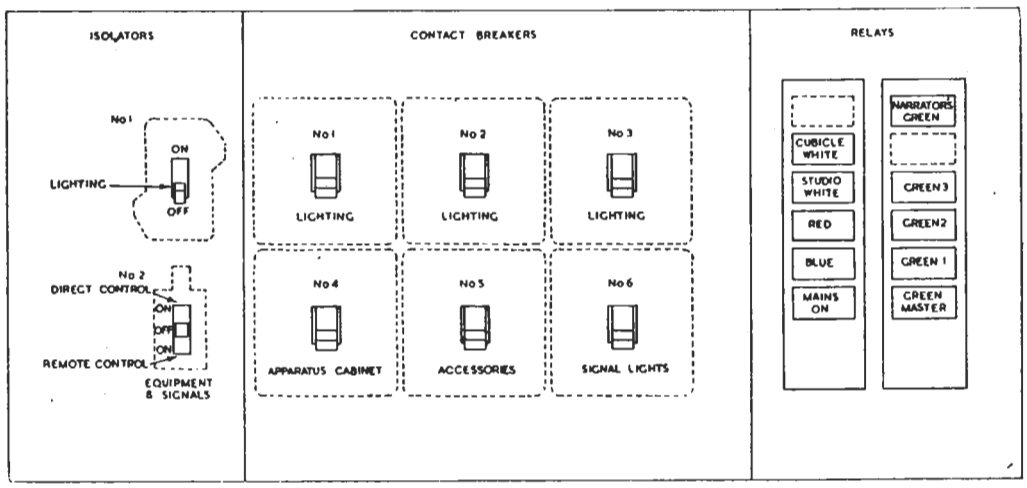


Fig. F.4. Component Arrangement, Studio Supply Cabinet, Mark V Equipment

Apparatus Shelf No. 5

This shelf contains mains units for supplying H.T. and L.T. to the equipment on the other shelves. Mains Units Type *MU*/31 (for details see Technical Instruction ST.3, page 21) are used, these supplying a greater output than the *MU*/*16s* used in apparatus shelf No. 4. Two versions of shelf No. 5 are available :

Two mains isolators, one controlling all lighting circuits and the other all equipment and signals.

Six contact breakers, three controlling lighting circuits, one controlling the supply to the apparatus cabinet, one controlling signal lights and the last controlling the supply for all remaining accessories.

Relays designated *Mains On, Studio Blue Light, Studio Red Light, Studio White Light, Cubicle White Light, Green Cue Lights* (three relays), *Narrator's Green Cue Light* and *Green Master Cue Light.*

The isolator controlling all equipment has three positions. When it is operated to the centre position, the mains supply is off; when operated to the down position, labelled *Remote Control,* the mains supply is fed to the equipment via the *Mains On* relay; when operated to the upper position, labelled *Direct Control,* the mains supply is fed directly to the equipment and the *Mains On* relay is ineffective. This facility was provided to enable the studio equipment to be used in the event of a failure of the 50-volt relay supply.

The studio and control cubicle white lights give indications that the telephone in the control cubicle requires answering. The small indicator lamps above the telephone keys show which of the two phones requires attention.

SECTION G

MARK II EQUIPMENT

General

The *Mark II* is a smaller version of the *Mark V* equipment, designed for use in small talks studios. No echo facilities or group fader are necessary. As shown in Fig. 3 there are five programme channels, four of which are normalled to microphone outputs, the remaining channel being normally connected to the output of the *A* amplifier which is fed from the gramophone bank. Altogether there are seven microphone amplifiers and, to secure conformity with the *Mark V* equipment, Nos. 1 and 2 are spares (either of which can be substituted for any of the remaining five on operation of the appropriate microphone change-over key), No. 3 is connected to *MIC PT.1*, No. 4 to *MIC PT.2*, No. 5 to the gramophone bank, and Nos. 6 and 7 to *MIC PT.3* and *MIC PT.4* respectively.

Mixing Circuits

Five channels are mixed in the *Mark II* equipment. If these are connected together by the method described in Appendix 1, the mixing pads should consist of 200-ohm series resistors in each leg of each channel and the mixing loss would be $20 \log_{10} \frac{1}{5} = 14$ db. To standardise the equipment and programme volumes, however, a shunt resistor is introduced at the junction point to simulate the resistance of three channels. The resistor has a value of $1040/3 = 330$ ohms. Thus 220-ohm series resistors are required in the mixing pads and the mixing loss becomes 18 db as in the *Mark V* equipment.

Although there is no group fader in the *Mark II* equipment, 220-ohm resistors are inserted at the point where it would be connected if included, to keep the programme volume at the input to the control *B1* amplifier the same as in other *Marks*. There is no independent fader but a fixed shunt 600-ohm resistor is included to simulate its resistance. This dummy circuit is mixed with the direct programme chain by series 220-ohm resistors and a shunt 750-ohm resistor as in the *Mark V* equipment, the volume loss due to this mixing pad being 11 db.

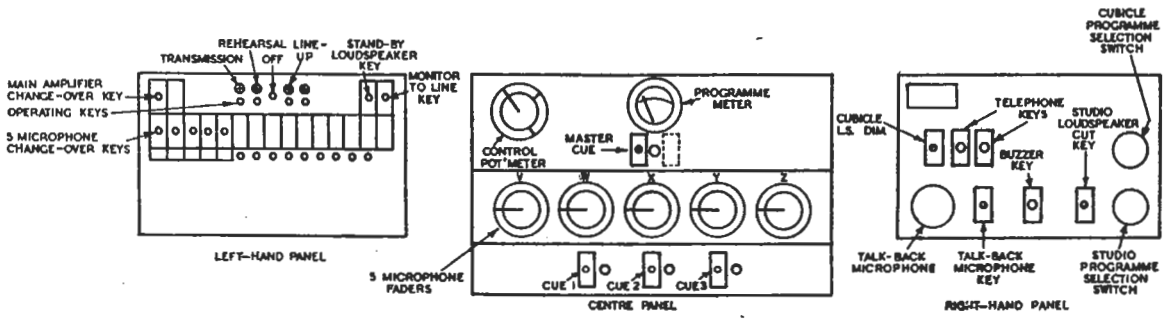


Fig. G.1. Panel Arrangement, Control Desk, Mark II Equipment

The relay circuits are shown in full in Fig. 4. They operate as described for the *Mark V* equipment in Section C. As there is no echo chain in the *Mark II* equipment, the main amplifier change-over key can only be operated so as to replace the control by the stand-by amplifiers. The relays *EAJ/4*, *EAO/4*, *EBJ/4* and *EBO/4*, which are mainly concerned with the substitution of the stand-by for the echo amplifiers, are included in the equipment, so that the standard relay box *RLB/1* is interchangeable in all *Marks* of equipment. The windings of these relays are not energised, and there are no references to contacts *EAJ1*, *EAJ2*, *EAO1*, etc., in Fig. 3.

The chief difference between the programme circuits of the *Mark II* and the *Mark V* equipment lies in the mixing circuits which will now be described.

The Control Desk

Fig. G.1 shows the arrangement of the controls on the desk *SCD/2*. The panels are made up of standard units, some of which are used in the control panels in other *Marks*.

The Studio Control Cabinet

The arrangement of the equipment in the studio control cabinet (see Fig. G.2) is similar to that in

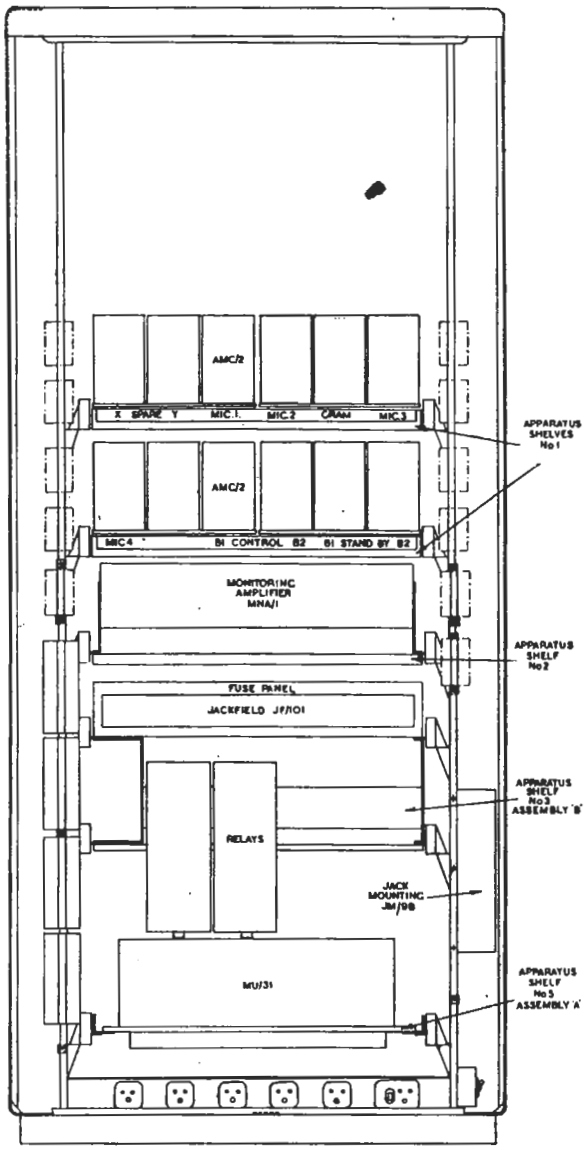


Fig. G.2. Shelf Arrangement, Studio Control Cabinet, Mark II Equipment

the *Mark V* equipment except that there are fewer *AMC/2* amplifiers and fewer relays. The cabinet contains the following standard shelves. (See Section F for details) :—

Two apparatus shelves No. 1. These contain a total of 12 *AMC/2* amplifiers, arranged in numerical order, one of which is a complete spare for physical substitution if required. Thus, as in the *Mark V* equipment, the first amplifier on the left on the upper shelf is No. 1, namely spare *X*, and the first on the left on the second shelf is amplifier No. 7 connected to *MIC PT.4*.

One apparatus shelf No. 2, containing the monitoring amplifier.

One apparatus shelf No. 3, assembly *B*, containing the jackfield and relay boxes. One relay box type *RLB/1*, one *RLB/2* and two *RLB/3* are required.

One apparatus shelf No. 5, assembly *A*, containing two *MU/31* mains units.

SECTION H

OPERATING INSTRUCTIONS

1. Switching On

Switch on the equipment by pressing the orange, green or red button, depending on whether *Line-up*, *Rehearsal* or *Transmission* condition is required, and check that the equipment is working normally. If all the facilities do not operate normally, check the mains switching as indicated below :—

1.1. Open the studio supply cabinet labelled *Lighting and Equipment Supply Cabinet* and check that all contact breakers and isolators are in the *On* position. Check that isolator No. 2, marked *Equipment and Signals* and situated in the bottom left-hand corner of the cabinet is in the down position marked *Remote Control.*

The studio supply cabinet is usually mounted on the wall of the control cubicle.

1.2. Open the small door at the bottom right-hand corner of the studio control cabinet and check that the tumbler switch below the jackfield compartment is in the *On* position.

The studio control cabinet may be situated in the control cubicle, or in an adjacent apparatus room ; at a permanent O.B. installation the studio control cabinet is sometimes in the local control room.

1.3. Check that the cubicle loudspeaker unit is plugged in and switched on at the amplifier itself and at the mains wall point marked *LS*. Check that the programme input to the loudspeaker unit is plugged in at the wall socket labelled *LS PT*.

1.4. Repeat 1.3 for the main studio loudspeaker unit.

1.5. Repeat 1.3 for the narrator's studio loudspeaker unit.

1.6. Repeat 1.3 for the echo-room loudspeaker unit.

2. Lining-up

2.1. Press momentarily the orange (*Line-up*) button at the top centre of the left-hand panel of the control desk. Check that the orange indicator lamp above the button is illuminated ; if it is not, proceed as in Section 11.9.

2.2. Allow an interval of 5-10 minutes for the amplifiers to warm up and check that the PPM reads 4. If it does not, proceed as in Section 11.9 (b).

3. To Carry Out a Rehearsal

3.1. Preliminary Operations

Check that all keys on the control desk panels are in their normal (centre) positions, that the cubicle and studio programme-selection switches are set to point 8 and that all the echo-mixture switches are set to position 1.

3.2. Switching On

Momentarily press the green (*Rehearsal*) button at the top centre of the left-hand panel of the control desk.

Check that the green indicator lamp above the button is illuminated ; if it is not, proceed as in Section 11.9.

3.3. Placing Microphones

Place the microphones in the main and in the narrator's studios in the desired positions. Note the socket designation numbers of the microphones employed and the specific use of each (e.g. soloist, orchestra, narrator, etc.). (This information is required in setting up the control panel.)

3.4. Placing Cue Lights

Place the portable cue-light stands in the main and narrator's studios in the desired positions. They should be connected to the cue-light extension sockets (at skirting level in the studios) having the same number as the cue

keys (on the control desk) by which it is desired to operate each cue light. The cue keys are numbered *CUE 1, CUE 2*, etc., and are situated on the centre panel of the control desk, the exact position depending on the size and type of the installation.

In Type-A equipment it is standard practice for those cue lights which are permanently fixed on the *studio walls* to operate only when the *Master* cue key is pressed.

3.5. Source Selection

Carry out any desired cross-plugging of sources and channels at the source jackfield as explained below. The source and channel jacks are accessible on opening the small door at the bottom right-hand corner of the studio control cabinet.

In the absence of any cross-plugging, each source is tied to a particular channel. A chart showing the tied sources and channels is mounted in the top left-hand corner of the right-hand panel of the control desk. The channel faders are situated on the lower half of the centre panel of the control desk and the channel code letters are stencilled above or to the left of each control knob. These channel code letters are merely a means of identifying each channel circuit between its input jack on the source-selection jackfield and the fader on the control desk associated with that circuit. If it is desired to change the normalled connections of sources and channels, cross-plugging at the source jackfield is necessary. To do this, note the letters of the channels and the numbers of the sources which are required to be tied together, and carry out the cross-plugging at the source jackfield. The output of the reproducing bank, O.B. and S.B. sources may be cross-plugged in the same way as microphone sources.

Interchange the source-numbered dollies and insert them in grommets near the channel faders to correspond with the cross-plugging carried out. This process is necessary to facilitate quick tracing of faults; if it is neglected and a fader develops a fault, there is no simple method of determining which microphone circuit and microphone amplifier change-over key are connected to the fader.

To indicate the use of the circuit connected to each fade unit insert slips of paper worded *Cast, Orchestra, Gram, Effects*, etc., in the holders above each fader. The use of each channel is decided by the positions of the microphone (see Section 3.3) to which the channel is connected.

3.6. Testing

With the aid of assistants in the main and in the narrator's studios, check the position and operation of every microphone and cue-light circuit it is intended to use. Remember that the group fader controls the output of all the channel faders with the exception of the independent fader. Thus to test a particular channel, the channel fader, the group fader and the main control potentiometer must all be faded up.

Check that the cubicle and studio loudspeakers give satisfactory volume when the PPM reading is between the normal limits and if necessary adjust the gain control of the loudspeaker amplifiers.

NOTE. The talk-back facility will be found useful in making the above tests.

4. To Use the Talk-back Facility

To talk to assistants or cast in the main or narrator's studio, hold the talk-back key down whilst speaking into the talk-back microphone.

NOTE. During *Rehearsal* conditions talk-back speech is heard on the loudspeaker and headphones in the main studio and in the narrator's studios but during *Transmission* conditions it is heard on headphones only, unless *all* the microphones in a studio are faded out when it is heard on the loudspeaker also in that studio.

5. Echo Facilities

With Type-A equipment, echo can be

superimposed on any source except that tied to, or plugged up to the independent channel. The degree of echo on each source can be pre-set to suit requirements by a 9-position switch. No echo is audible, however, until the main echo fader is faded up. To add echo to a particular channel, rotate the appropriate echo-mixture switch clockwise to give the desired degree of echo and fade up the main echo control fully.

The echo-mixture switches are mounted on the lower half of the left-hand panel of the control desk and are grouped in the same pattern as the channel faders on the centre panel. Any particular echo-mixture switch is always associated with the channel fader which has the corresponding position on the centre panel irrespective of any cross-plugging which may have been carried out.

NOTE. The echo-mixture switches have nine positions and the total volume is the same on all positions: in position 1 they give no echo; in position 5, 50 per cent echo and in position 9, full echo. Intermediate positions give intermediate degrees of echo.

Echo-cut Key

To introduce or cut echo instantaneously an echo-cut key is provided.

NOTE. After use, this key should be returned to the centre position as soon as possible but first the main echo control should be faded out.

6. To Silence the Studio Loudspeaker

Operate the *Studio L.S. Cut-off* key to the down position.

NOTE. This key also silences the narrator's loudspeaker.

7. To Quieten the Cubicle Loudspeaker

Operate the *L.S. Dim* key to the down position. This reduces the volume by 10 db.

8. To Use the Telephones

Two telephones are provided in the Type-A equipment; telephone 1 is located in the pedestal recess of the control desk and is provided solely for communication between the cubicle and the control room; telephone 2 is located in the recess at the side of the control desk remote from the pedestal and is provided primarily for communication to O.B. points, etc., contributing to a composite programme, the necessary plugging operations being carried out at the control room.

NOTE. If the cubicle loudspeaker is found distracting during use of the telephone it may be quietened as explained in 7.

(*a*) *To Make Outgoing Calls*

Lift the instrument from its cradle and momentarily press the associated *Tele Call* key.

The *Tele Call* keys are at the centre of the right-hand panel of the control desk.

(*b*) *To Receive Incoming Calls*

When the telephone buzzer is heard, or the cubicle or studio white lights are observed, note from the small white indicator lamps above the telephone keys which of the two instruments requires answering, lift this telephone from the cradle and speak.

NOTE. The *Studio* white lights are inoperative during transmission.

9. To Carry Out a Transmission

NOTE. The usual buzzer circuit arrangements are provided between studio, control cubicle and control room or continuity room for use at the start and close of transmission. One buzzer push is provided at the bottom centre of the right-hand panel of the control desk; others are situated in the studios.

9.1. To feed pre-transmission tone to the control or to the continuity room, press the *Line-up* button.

9.2. To give the studio and programme identification, put the equipment into the *Rehearsal* condition by pressing the green button and speak into the talk-back microphone.

9.3. To put the equipment into the *Trans-*

mission condition, momentarily press the red button.

If the equipment is in the *Line-up* or *Rehearsal* condition when the control room or continuity room operator presses the red-light signal key for the studio in question, the equipment is automatically transferred to the *Transmission* condition and is locked in that condition until the control-position signalling key is released.

10. To Switch Off

Press the black (*off*) button situated at the top centre of the left-hand panel of the control desk.

NOTE. This button is inoperative if a control-position signalling key appropriate to the studio is operated.

11. Fault Tracing and Remedy

It is assumed that the apparatus is switched on, that the PPM reads zero on no signal and that the cubicle and studio programme-selection switches are set to point 8.

11.1. No Signal from a Studio Microphone when the Channel is faded up.

Fade up a different channel to which another microphone has been connected. If this works satisfactorily, the fault may be due to :—

(a) Faulty microphone amplifier.
Check by changing over to spare X or spare Y microphone amplifier by operating the appropriate change-over key.
To do this, note the source code given on the peg alongside or above the channel fader and operate the microphone amplifier change-over key bearing this code to the up position labelled *Y* or to the down position labelled *X*.
NOTE. It is not possible to connect spare X or spare Y to two microphone circuits simultaneously ; when any change-over key is operated in either direction, all other keys are ineffective in that position. The microphone change-over keys are mounted in a horizontal row at the top of the left-hand panel of the control desk.

(b) Echo-mixture switch set to 100 per cent echo and echo fader faded out.
Check the settings of the echo-mixture switch and the echo fader.

(c) Microphone source plugged out or wrongly plugged up at the source-selection jackfield.
Check the cross-plugging at the jackfield.

(d) Faulty channel fader.
Check by cross-plugging the microphone to another channel or by exchanging the fader for another. To remove a fader, grasp the control knob firmly, at the same time pressing the clip underneath the knob upwards, and pull outwards.

(e) Faulty microphone.
Check by exchanging the microphone and lead for others in the studio.

11.2. No Signal from an O.B. or S.B. Source.

This may be due to :—

(a) Signal not leaving control room.
Check with control room.

(b) Faulty channel fader.
Check as in 11.1 (d).

(c) Faulty cross-plugging at the source jackfield.
Check the cross-plugging.

11.3. No Signal from the Reproducing Bank.

Proceed as in 11.1 (except for [e]). Check potentiometer settings on gramophone desk.

11.4. No Signal from a number (but not all) of Studio Microphones.

This is most likely to be due to a faulty mains unit supplying the microphone amplifiers. In this case two of the microphone amplifiers can be brought back into service by operating the appropriate microphone change-over keys, one to the *X* and the other to the *Y* position.

11.5. No Signal from any Microphone in the Main Studio.

Fade up the independent channel. If this is satisfactory, the fault may be :—

(a) Group fader faded out.
Check by fading up.
(b) Group fader faulty.
Check by changing fader for another fader not in use.

11.6. No Signals from any Source.
This may be due to :—
(a) Control amplifier failure.
Check by operating the *Spare to Control* key. This key is mounted at the top left-hand corner of the left-hand panel of the control desk.
(b) Control potentiometer failure.
Check by switching to the *Line-up* condition. If the apparatus operates normally in this condition, replace the control potentiometer by a spare channel fader.
A channel fader is not identical with the control potentiometer but may be used temporarily in place of it.

11.7. No Signals from the Cubicle Loudspeaker.
(*a*) *PPM and Headphones operating normally.*
This points to a fault in the cubicle loudspeaker amplifier. The *Stand-by LS* key should be operated to bring the small stand-by loudspeaker into circuit. As there is no loudspeaker amplifier the volume from the stand-by loudspeaker is very weak.
The *Stand-by LS* key is at the top right-hand corner of the left-hand panel of the control desk and the stand-by loudspeaker itself is mounted at the bottom of the pedestal enclosure.
(*b*) *PPM and Headphones not operating.*
This points to a fault in the monitoring amplifier. Transfer the cubicle loudspeaker amplifier directly to the studio output line by operating the *Mon on Line* key. This key is situated at the top right-hand corner of the left-hand panel of the control desk.
NOTE. PPM facilities cannot be restored until the monitoring amplifier has been replaced, and continuity room should be requested to monitor and control the programme until this can be done.

11.8. No Echo Facilities.
This may be due to :—
(a) *Echo-cut* key operated.
Check by restoring the key to normal position.
(b) Failure of echo-microphone amplifier.
Check by operating the echo-microphone amplifier change-over key to the *X* or *Y* position.
(c) Failure of echo *B1* or *B2* amplifiers.
Check by operating the *Spare to Echo* key. This key is situated at the top left-hand corner of the left-hand panel of the control desk.
(d) Failure of echo-mixture switch.
Check by cross-plugging the source to another channel.
(e) Failure of echo fader.
Check by replacing the fader by another not in use.
(f) Failure of echo-room loudspeaker amplifier or the power supply to it.
Inform control room.
(g) Failure of echo-room microphone.
Check by replacing the echo-room microphone and lead.

11.9. Power and Lighting Failure.
With Type-A equipment the a.c. mains supply to apparatus and room lighting is controlled by a number of contact breakers housed in the studio supply cabinet. These breakers are labelled according to the circuits they control, as follows :—
(i) *Lighting.*
(ii) *Signal Lights.*
(iii) *Accessories* (e.g. loudspeaker amplifiers, gramophone bank, etc.).
(iv) *Apparatus Cabinet.*
In addition, all room-lighting circuits are controlled by an isolator labelled *Lighting* and the supply to the signal lights, accessories and apparatus cabinet is controlled by a 3-position isolator labelled *Equipment and Signals*,

both isolators being situated in the studio supply cabinet.

It is normal practice for these breakers and isolators to be left in the *On* position, but should a failure occur it is the responsibility of the programme engineer to ensure that the particular breakers concerned have not tripped. If they have, they should be reset, and if they trip again, or fail to hold, control room should be informed immediately.

In addition to the a.c. mains supply, Type-A equipment also needs a 50-volt d.c. supply for operation of relays and indicator lamps and a failure of the d.c. supply, or the individual fuses, affects operation of the equipment. The 50-volt supply does not enter the studio supply cabinet and usually the supply to a particular floor is controlled by a contact breaker on that floor and contained in an iron-clad box in which the 50-volt supply to each studio suite is kept separate and is individually fused.

The following gives the procedure to be followed if a power or lighting failure occurs :—

(*a*) *Indicator lamp " dead."*

If the equipment operates normally it is likely that the indicator lamp has burnt out ; if the equipment is also " dead " this suggests a failure of the 50-volt supply, and control room should be informed immediately.

If this occurs the equipment can be restored to the *Transmission* condition by operating the isolator in the bottom left-hand corner of the studio supply cabinet from the position marked *Remote Control* to that marked *Direct Control*. This isolator cannot be moved from one position to the other in a simple motion but a pause is mechanically compulsory at the centre position. When this has been done, all relay-controlled facilities such as talk-back, amplifier change-over, etc., are absent.

(*b*) *Indicator lamps normal but no sound from loudspeaker.*

If the PPM is working this suggests that the *Accessories* breaker has tripped ; if the PPM is not working, the *Apparatus Cabinet* breaker has tripped.

(*c*) *Cubicle or Studio Lights " dead " (except emergency lights).*

If only a single lamp has failed it is most probable that the filament has burnt out ; if several lights have failed and the equipment is working normally, this suggests that one of the *Lighting* breakers has tripped.

(*d*) *Red, Blue, Green and White Signal Lights " dead."*

This suggests that the *Signal Lights* breaker has tripped.

(*e*) *All lights (except emergency lights) and equipment " dead."*

This suggests a failure of the incoming supply mains.

NOTE. The equipment cannot be used until the mains supply is restored but in every suite with Type-A equipment, the studio has an emergency microphone, the output of which goes directly to the control room without any intermediate equipment. Thus a simple programme might be continued by means of this single microphone but a complex one obviously could not.

SECTION J

PARTICULAR INSTALLATIONS

1. CAMDEN THEATRE INSTALLATION

The Camden Theatre installation may be regarded as a *Mark-V* type with 16 programme sources (which include two narrators' microphones, gramophone bank and two outside sources) and 11 channels (including the echo and independent channels). It is the largest installation possible, using the standard studio control cabinet and control desk, since the former has its full complement of amplifiers and the latter the maximum number of controls.

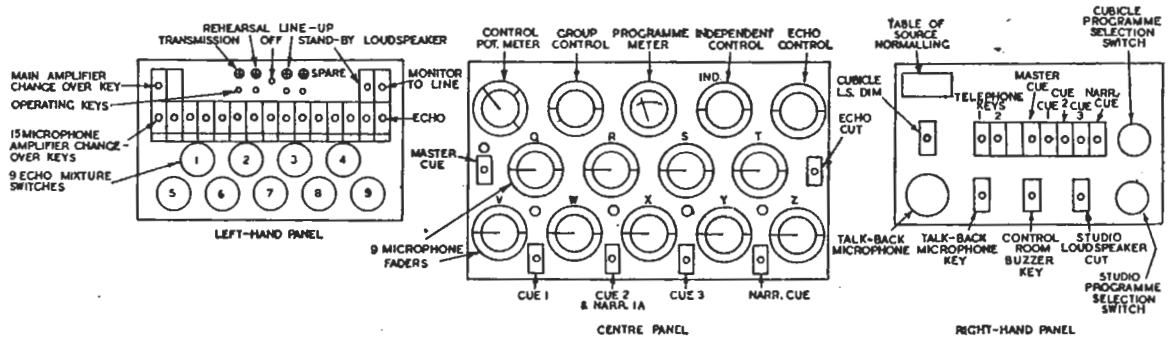


Fig. J.1. Grouping of Controls on Panels of Control Desk, Camden Theatre

Circuit Schematic (Figs. 5 and 6)

Apart from the additional complexity necessitated by the greater number of sources and channels, the circuit schematic (Figs. 5 and 6) is very similar to that of the *Mark V* equipment (Figs. 1 and 2), and the operation of the relay circuits may be followed from the description given in Section C.

There are, however, the following differences between Figs. 1 and 2 and Figs. 5 and 6 :—

(a) The Camden Theatre control room is fitted with 50-volt relays and the battery line from the control room to the studio-buzzer push is 50-volts positive in Figs. 5 and 6, compared with 24 volts in Figs. 1 and 2. A 1,000-ohm resistor is therefore included in the battery line in the Camden Theatre installation to keep the current to the normal value.

(b) As a precaution against clicks being superimposed on the programme, the *NLS* and *SLS* relay windings are of 50-ohms resistance instead of 2,000 ohms and 1-μF capacitors are connected across them. (See Section C, page 18.)

(c) As a further precaution against clicks, repeating coils, Type *LL/106SA*, are inserted in the echo and independent channels. The former is inserted after the 3-db pad following the *Echo-cut* key and the latter immediately after the independent channel jack.

(d) Studio 1A in the Camden Theatre can be used as an additional narrator's studio and the studio microphone point (formerly known as *MIC 10*) is now known as *NARR 1A*. Both narrator's loudspeakers are connected in parallel and the sleeve contact of *NARR 1A* source jack is connected to the sleeve of *NARR 1* source jack so that both narrators' loudspeakers are automatically silenced when either of the narrators' microphones are faded up, irrespective of the channel to which they are cross-plugged. The cue light in Studio 1A is connected in parallel with cue light No. 2 and is operated from key *Cue 2* on the control desk.

Studio Control Desk

The studio control desk is of the type with a left-hand pedestal and the arrangement of the

controls on the panels is illustrated in Fig. J.1. The grouping of controls follows the pattern of the *Mark V* equipment (Fig. E.3), but an interesting feature is the duplication of the cue keys on the right-hand panel, which provides increased operational flexibility.

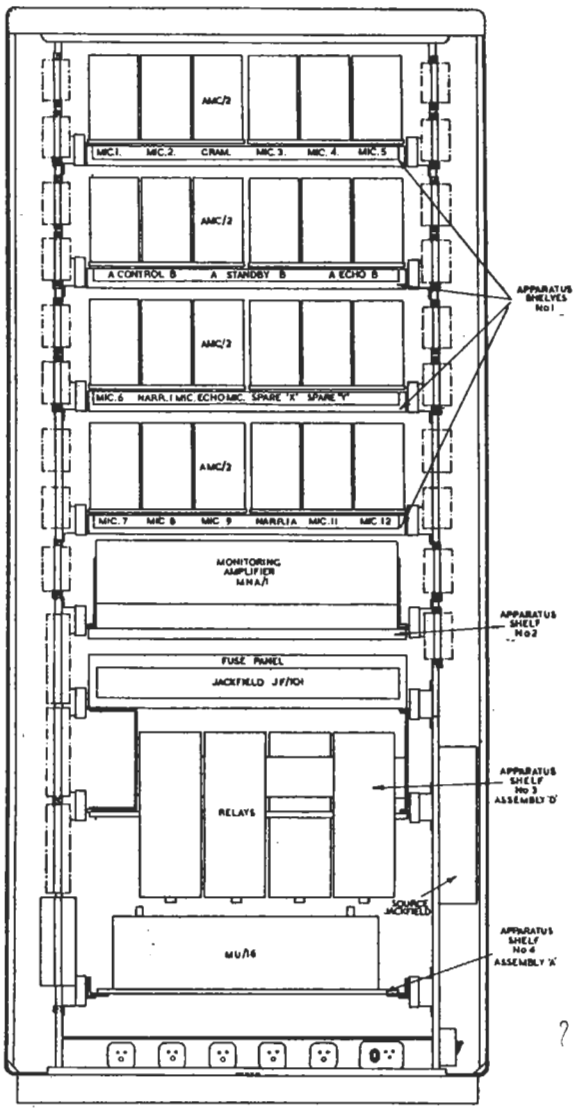


Fig. J.2. Shelf Arrangement of Studio Control Cabinet, Camden Theatre

Studio Control Cabinet

The studio control cabinet is known by the type number *SCC/6B* and the arrangement of shelves and amplifiers is illustrated in Fig. J.2. The upper half of the cabinet is fully occupied by four apparatus shelves, No. 1, each holding six *AMC/2* amplifiers, the functions of which are indicated in Fig. J.2. The extreme right-hand amplifier of the third shelf from the top is normally unused and is provided for physical substitution for any of the others. The lower half of the cabinet is fully occupied by an apparatus shelf No. 2, an apparatus shelf No. 3 assembly D and an apparatus shelf No. 4 assembly A. For details of the contents and function of these shelves, reference should be made to Section F.

2. SIXTH-FLOOR BROADCASTING HOUSE INSTALLATION

Studio 6A Equipment

This equipment, the block schematic for which is shown in Figs. 7 and 8, is a *Mark V* type which has been slightly modified so that Studio 6C may be operated remotely from it. There are nine fader channels instead of the usual seven, the two additional ones normally controlling the programmes received from two outside sources. There are two additional cue keys, one controlling cue lights in Studio 6C when the latter is linked to 6A, and the other one controlling a light in Studio 6A echo room, since the latter may also be used as a studio if necessary. The studio control cabinet is a standard type *SCC/5*, described in Section F, the additional relays required for the remote control of Studio 6C being housed in 6C control cabinet. Studio 6A control desk is more complex than *SCD/5* because of the additional controls mentioned above. The panel layout is illustrated in Fig. J.3.

Studio 6C Equipment

Studio 6C has a *Mark II* equipment to which a number of relays have been added to enable the equipment to be operated remotely from Studio 6A. Block schematic diagrams are shown in Figs. 9 and 10.

The output of Studio 6C, suitably attenuated, is available on the source jackfield of Studio 6A, and when this is cross-plugged to a 6A channel these relays are brought into circuit. Briefly, their function is to transfer control of the *Rehearsal*, *Transmission* and *Off* conditions and the signalling and monitoring circuits to Studio 6A. Full details of the operation of the remote control circuit are given below.

These additional relays are housed in a relay box Type *RLB/11* mounted in 6C Studio control cabinet, which, apart from this addition, is a standard type *SCC/2*. (See Section F.) The control desk of Studio 6C is also a standard type *SCD/2*. (See Section G.)

Remote Control of Studio 6C from Studio 6A.

Special arrangements have been made in the installations in Studios 6A and 6C whereby the apparatus in 6C can be operated remotely from the control desk of 6A. The necessary switching is carried out by relays contained in a special box, Type *RLB/11*, fitted on apparatus shelf No. 3 in the control cabinet of Studio 6C. The output of Studio 6C appears on a source jack on the jackfield of the 6A control cabinet and the transfer of control occurs when this source jack is cross-plugged to one of the 6A channel jacks.

If Studio 6C apparatus is switched on by operation of the 6C *Line-up, Rehearsal* or *Transmission* keys, *SP/2* operates via *RMS4* and *MO2* (Fig. 11) and contacts *SP1* and *SP2* break, preventing remote control of 6C from 6A.

SCCO3 connects 6C Cubicle-buzzer push and announcer's buzzer push in parallel with the equivalent 6A circuits.

SCCO4 connects *GO4* in 6C in parallel with *GO4* in 6A so that buzzers in both studios and both control cubicles all sound together. Thus when 6C is remote controlled, the buzzers in both studios and both control cubicles can be sounded by operation of any of the buzzer pushes in either studio or control cubicle.

RMS1, 2, 3 connect the *Rehearsal, Transmission* and *Off* keys respectively of the two control desks in parallel so that both studios are controlled simultaneously by operation of these keys.

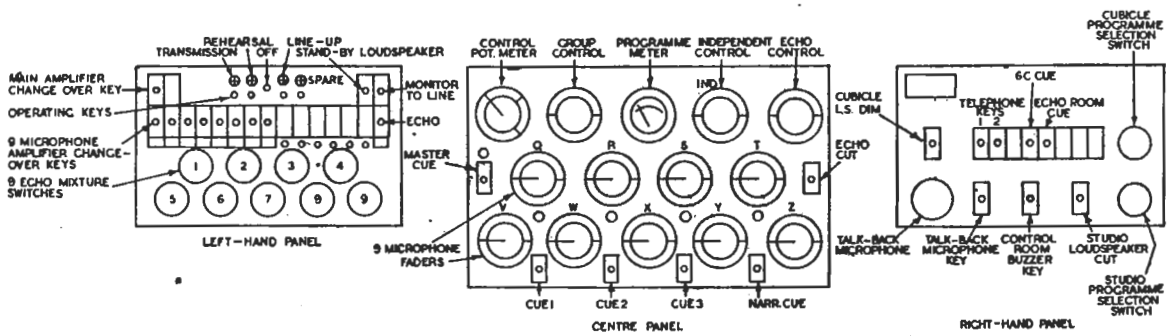


Fig. J.3. Grouping of Controls on Panels of Control Desk, Studio 6A Equipment, Broadcasting House

Suppose 6C source jack is cross-plugged (Fig. 11) to a 6A channel. Line *b* is earthed by the contacts of the source jack and this connection operates *SCCO/4, RMS/4, CLSCO/2* and *SLSCO/4* via *SP2* (provided that Studio 6C apparatus is switched off).

SCCO1 transfers the connections of 6C red light relay from *GO1* in 6C to *GO1* in 6A. Thus the two *RO/2* relays are connected in parallel and, when 6C is remote-controlled from 6A, both red lights operate together on receipt of a signal to 6A from the control or continuity room.

SCCO2 transfers the connections of 6C master green relay from 6C master cue key to a key labelled *6C Cue* on the right-hand panel of 6A control desk. Thus when 6C is remote controlled, operation of *6C Cue* key brings on all the cue lights in Studio 6C.

RMS4 breaks and isolates *SP/2* from the earth connection obtained via *RP3* and/or *MO2*. Thus *SP1* and *SP2* remain in the positions shown in Fig. 11, preventing cancellation of the remote control.

CLSCO1 and *2* transfer the input of 6C Cubicle loudspeaker from 6C Cubicle programme-selection switch and connect it in parallel with the headphone jacks of the 6A installation. Thus 6C Cubicle loudspeaker receives programme and talk-back speech from 6A (provided that the talk-back key in 6C Cubicle is not operated; this opens *LSO1* and *2*).

SLSCO1 and 2 transfer the studio loudspeaker of 6C from contacts *SLS1* and *2* of 6C and connect it in parallel with 6A headphone jacks via contacts *SLS(R)1* and 2. Thus provided

SLS(R)1 and *2* are closed, 6C Studio loudspeaker receives the studio output and talk-back speech from 6A.

SLS(R)/2 is operated via *SP1* from the sleeve circuit of 6C source jack. Under normal conditions, when the channel fader in 6A to which 6C is connected, or the group fader, is rotated clockwise, the junction of *SLS(R)/2* and the 1,000-ohm resister is earthed by a connection obtained via the switches ganged with the fader controls, one of the contacts of the loudspeaker cut-off key and contact *TB2*. Thus *SLS(R)/2* is de-energised and 6C Studio loudspeaker is silent, but it is brought into circuit automatically when either fader is rotated fully anti-clockwise and the earth connection is broken. For fuller details of this circuit see Section C, page 17.

If 6C source jack is not cross-plugged to any other jack, *SLS(R)/2* is permanently energised and *SLS(R)1* and *2* permanently made but the circuit is broken by *SLSCO1* and 2.

SLSCO3 and *4* transfer Studio 6C headphones from *TTO1* and *2* in 6C to *TTO1* and *2* in 6A and programme or talk-back speech originating in 6A can be heard on the headphones in 6C.

3. FOURTH-FLOOR BROADCASTING HOUSE INSTALLATION

Studio 4A Equipment

This equipment is a standard *Mark-II* type and the five sources are two studio-microphone points, the gramophone bank and two outside sources. Thus only two of the five channels have provision for automatic control of studio loudspeaker silencing by fader rotation.

4. VESTRY HALL (BIRMINGHAM) INSTALLATION

The equipment installed at the Vestry Hall Studio is a *Mark-V* type, which has been modified in the three respects listed under (*a*), (*b*) and (*c*) in Section J.1 on the Camden Theatre installation.

For circuit diagrams and descriptions reference should be made to earlier sections.

APPENDIX 1

MIXING CIRCUITS IN STUDIO EQUIPMENT TYPE A

General

Fig. 1.1 illustrates the method of connection used in the studio equipment Type A for mixing a number of programme circuits and maintaining correct matching conditions for all the apparatus involved. The latter are represented by blocks and the pair of terminals indicated on each may be regarded as the output connections of an amplifier or the input connections of a fader. In this method of mixing, fixed resistors are inserted in the input or output leads of all the channels, which are then connected in parallel. For simplicity, unbalanced circuits are considered in the following treatment.

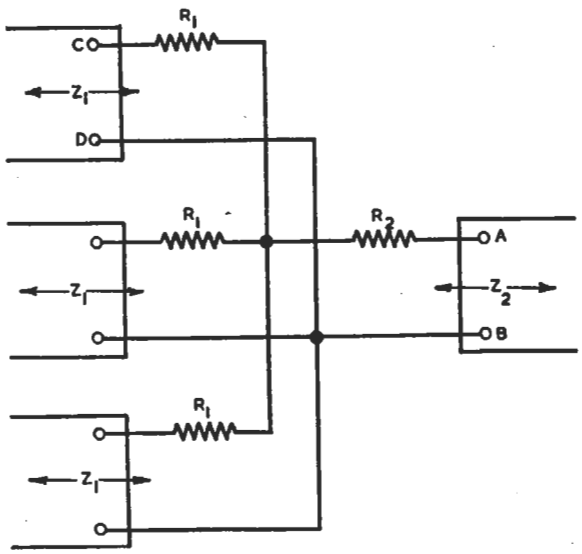


Fig. 1.1. Principle of Mixing Circuits

It is assumed that there are N channels of impedance Z_1 which are to be connected to a single channel with an impedance Z_2 equal to or less than Z_1. Matching is achieved by correct choice of values for R_1 and R_2.

Determination of Constants of the Mixing Pads

General

The resistance connected across AB is made up of the series resistor R_2 and the resistance of N channels each of internal resistance $(Z_1 + R_1)$. For accurate matching

$$Z_2 = R_2 + \frac{Z_1 + R_1}{N} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The terminals CD are connected to a resistance R_1 in series with another resistance composed of $(R_2 + Z_2)$ in parallel with $(N - 1)$ channels each of internal resistance $(Z_1 + R_1)$.
For accurate matching

$$Z_1 = R_1 + \frac{(Z_2 + R_2) \cdot \dfrac{Z_1 + R_1}{N-1}}{(Z_2 + R_2) + \dfrac{Z_1 + R_1}{N-1}} \quad \ldots \quad \ldots \quad (2)$$

From (1) and (2) it may be shown that

$$R_1 = \frac{2Z_1Z_2N - Z_1Z_2N^2 - Z_1^2}{Z_1 - Z_2N^2}$$

Putting $\dfrac{Z_1}{Z_2} = M$

$$R_1 = \frac{M^2 + MN\,(N-2)}{N^2 - M}\, Z_2 \quad \ldots \quad (3)$$

Substituting for R_1 in (1)

$$R_2 = \frac{N^2 - M\,(2N-1)}{N^2 - M}\, Z_2 \quad \ldots \quad (4)$$

Special Cases.

(a) When $Z_1 = Z_2$.

In the special case when $Z_1 = Z_2 = Z$, $M = 1$ and

$$R = R_1 = R_2 = \frac{N^2 - (2N-1)}{N^2 - 1} Z$$

$$= \frac{(N-1)^2}{(N+1)(N-1)} Z$$

$$= \frac{N-1}{N+1} Z \quad \ldots \quad \ldots \quad (5)$$

(b) When the Number of Channels is Small

Positive values for R_1 and R_2 are only obtained from expressions (3) and (4) respectively if N exceeds a critical value (N_c) given by $M + \sqrt{M^2 - M}$. To obtain accurate matching

when N is less than N_c, R_1 should be calculated for $N = N_c$, R_2 should be made zero and a shunt resistor equal to $\frac{Z_1 + R_1}{N_c - N}$ should be introduced in parallel with Z_2.

The mixing circuit then takes the form shown in Fig. 1.2.

Determination of Volume Loss of the Mixing Pad

General

This method of mixing introduces a loss of volume; to determine its magnitude consider

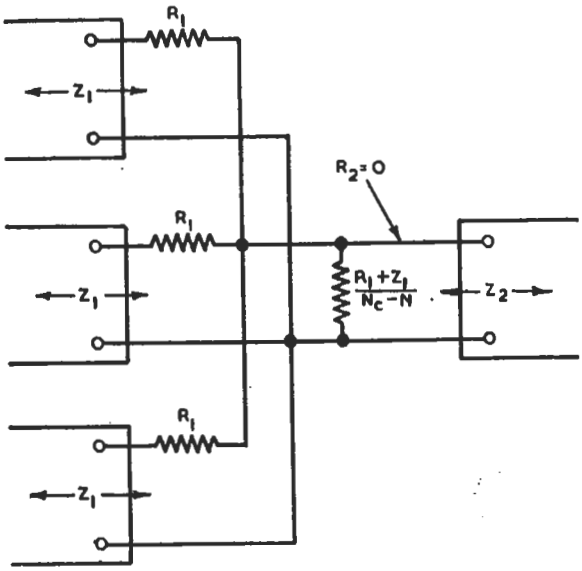


Fig. 1.2. Mixing Circuit used when $N < N_c$.

Fig. 1.3. Only two channels are shown specifically, the remaining channels being indicated as a shunt resistor of value X.

The attenuation between AB and EF is $\frac{E_3}{E_1}$ and this may be expressed

$$\frac{E_3}{E_1} = \frac{E_3}{E_2} \cdot \frac{E_2}{E_1}$$

(*a*) *Determination of* $\frac{E_2}{E_1}$.

Let the resistance of the network to the right of the dotted line in Fig. 1.3 $= Z_e$. Since the channel to the left of the dotted line is matched perfectly to its load:

$$Z_e + R_1 = Z_1$$

$$\therefore \quad Z_e = Z_1 - R_1$$

$$\frac{E_2}{E_1} = \frac{Z_e}{R_1 + Z_e} = \frac{Z_1 - R_1}{Z_1}$$

Substituting for R_1 from (3)

$$\frac{E_2}{E_1} = \frac{Z_1 - \frac{M^2 + MN(N-2)}{N^2 - M} \cdot Z_2}{Z_1}$$

$$= 1 - \frac{M^2 + MN(N-2)}{N^2 - M} \cdot \frac{1}{M}$$

$$= \frac{2(N-M)}{N^2 - M} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

(*b*) *Determination of* $\frac{E_3}{E_2}$

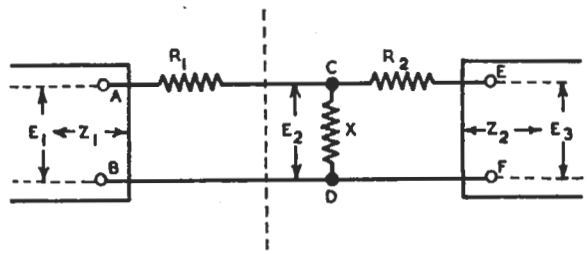


Fig. 1.3. Determination of Volume Loss in Mixing Circuit

From Fig. 1.3:

$$\frac{E_3}{E_2} = \frac{Z_2}{R_2 + Z_2}$$

Substituting for R_2 from (4)

$$\frac{E_3}{E_2} = \frac{Z_2}{\frac{N^2 - M(2N-1)}{N^2 - M} Z_2 + Z_2}$$

$$= \frac{N^2 - M}{N^2 - 2MN + N^2}$$

$$= \frac{N^2 - M}{2N(N-M)} \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

Combining (6) and (7)

$$\frac{E_3}{E_1} = \frac{E_3}{E_2} \cdot \frac{E_2}{E_1} = \frac{2(N-M)}{N^2 - M} \cdot \frac{N^2 - M}{2N(N-M)} = \frac{1}{N}$$

$$\therefore \text{ mixing loss} = 20 \log_{10} \frac{E_3}{E_1} = 20 \log_{10} \frac{1}{N} \quad \ldots \quad (8)$$

Thus the mixing loss is independent of the values of Z_1 and Z_2 and depends only on the number of channels mixed.

When N is less than the Critical Value.

Since $R_2 = 0$ for this case the volume loss of the mixing circuit shown in Fig. 1.2 may be calculated by the method from which (6) was deduced. The result is the same, if $N = N_c$.

$$\therefore \text{ mixing loss} = 20 \log_{10} \frac{2(N_c - M)}{N_c^2 - M} \quad \ldots (9)$$

Mixing Circuits in the Mark V Equipment

The Direct Chain

(*a*) *At the Input to the Group Fader.*

The method of connection shown in Fig. 1.1 is used in the direct chain of the *Mark V* equipment to mix the outputs of seven echo-mixture switches, and the output of the echo microphone with the input of the group fader. There are thus eight input circuits and one output circuit all of which have 600-ohms resistance. From (5) the value of resistor required in the mixing pads is given by

$$R = \frac{N-1}{N+1} Z = \frac{8-1}{8+1} 600 = 466 \ \Omega$$

To keep the circuits balanced, resistors of half this value should be included in each leg of all channels, but the preferred value of 220 ohms is used in practice.

From (8) the volume loss from the output of any echo-mixture switch to the input of the group fader is given by

$$20 \log_{10} \frac{1}{N} = 20 \log_{10} \frac{1}{8} = -18 \text{ db.}$$

(*b*) *At the Input to the B1 Control Amplifier.*

The circuit illustrated in Fig. 1.1 is used to mix the outputs of the group and independent faders (both of 600-ohms resistance) with the input of the *B1* control amplifier (300-ohms resistance). For this circuit $N = M = 2$ and hence $N < N_c$. As explained in Section 1, for accurate matching R_1 should equal its value for $N = N_c$, R_2 should be zero and a shunt resistor of value $\frac{Z_1 + R_1}{N_c - N}$ should be connected in parallel with Z_2.

$$N_c = M + \sqrt{M^2 - M}$$
$$= 3.414$$

$$R_1 = \frac{M^2 + MN(N-2)}{N^2 - M} Z_2$$
$$= \frac{2^2 + 2(3.414)(3.414 - 2)}{(3.414)^2 - 2} 300$$
$$= 424 \ \Omega$$

$$\text{The value of the shunt resistor} = \frac{Z_1 + R_1}{N_c - N}$$
$$= \frac{600 + 424}{3.414 - 2}$$
$$= 724 \ \Omega$$

To keep the output circuits of the faders balanced, R_1 takes the form of two 220-ohm resistors, one included in each leg; the shunt resistor is a 750-ohm component. From (9) the volume loss on

$$\text{mixing} = 20 \log_{10} \frac{2(N_c - M)}{N_c^2 - M}$$
$$= 20 \log_{10} \frac{2(3.414 - 2)}{3.414^2 - 2}$$
$$= 20 \log_{10} \frac{2.828}{9.66}$$
$$\simeq -11 \text{ db.}$$

The Echo Chain

As stated in Section B, page 5, the mixing circuit between the echo outputs of the echo-mixture switches and the echo *B1* amplifier must provide accurate matching of all apparatus and must introduce a loss of about 22 db. The circuit arrangement of Fig. 1.1 is used and it follows from expression (8) that 14 circuits must be mixed to give the required loss. As there are only 7 channels to be mixed, the impedance of the remaining 7 channels is simulated by a shunt resistor.

From (3) the value of R_1 is given by the following expression:

$$R_1 = \frac{M^2 + MN(N-2)}{N^2 - M} Z_2$$

in which $N = 14$ and $M = \frac{Z_1}{Z_2} = \frac{600}{300} = 2$

$$\therefore R_1 = \frac{4 + 2.14(12)}{14^2 - 2} 300$$
$$= 531 \ \Omega$$

To maintain balanced conditions 270-ohm resistors are inserted in each leg of the echo output of the echo-mixture switch.

From (4) the value of R_2 is given by the following expression :

$$R_2 = \frac{N^2 - M(2N - 1)}{N^2 - M} Z_2$$

in which $N = 14$ and $M = 2$.

$$\therefore R_1 = \frac{14^2 - 2\,(28 - 1)}{14^2 - 2} 300$$

$$= 220\ \Omega$$

To maintain balanced conditions 120-ohm resistors are inserted in each leg of the input connections of the echo *B1* amplifier.

The shunt resistor must have a value equal to that of 7 channels, each of 600-ohms resistance and each padded out with a 531-ohm matching resistor.

Its value is thus given by $\frac{600 + 531}{7}$ i.e., 162 Ω.

In practice a 150-ohm component is used.

APPENDIX 2

SIGNALLING BY SLEEVE CIRCUITS OF PROGRAMME JACKS

Origin of Method

The original *Standard Control Position* bay provided signalling circuits for a maximum of 20 sources by means of 20 keys and associated circuits on the bay. At large studio centres more than 20 sources were required on the control position, each provided with signalling facilities and, because of the limited space on the bay and the operational complexity which would result, the provision of further individual signalling circuits was considered undesirable. Instead, an alternative signalling circuit involving the sleeves of the source and channel jacks on the source-selection jackfield was developed. This enabled the signalling apparatus associated with a source to be selected simultaneously with the selection of the programme source. Only one signalling key and green light per channel need be provided, irrespective of the number of sources available for selection. The circuit was designed so that a single source may be selected on as many as eight control positions without affecting the operation of the signalling circuit. Normally a source is rarely required on more than three positions at the same time. This circuit is now used on the *Standard Control Position* bays used in Broadcasting House control and continuity rooms and elsewhere.

Operation of the Circuit (Fig. 2.1)

The studio jack is cross-plugged to the channel jack. To signal the studio the signalling key is operated to the down position. This completes a circuit from 24 volts positive, through a 400-ohm resistor, the contact of the key, the channel jack, the source jack, the back contact of *GO4* and the winding of *RO/3* to 24 volts negative. *RO/3* operates. There is also a parallel path to 24 volts negative from the channel jack through *ST/3* and a 1,000-ohm resistor, but the current in this path is too small to operate *ST/3*. This current is small because of the specially low resistance of the winding of *RO/3*: this winding and the 400-ohm resistor form a potential divider connected across the 24-volt supply when the signalling key is operated, and since *ST/3* is connected across the 10-ohm relay resistance, less than 1 volt is applied to *ST/3*.

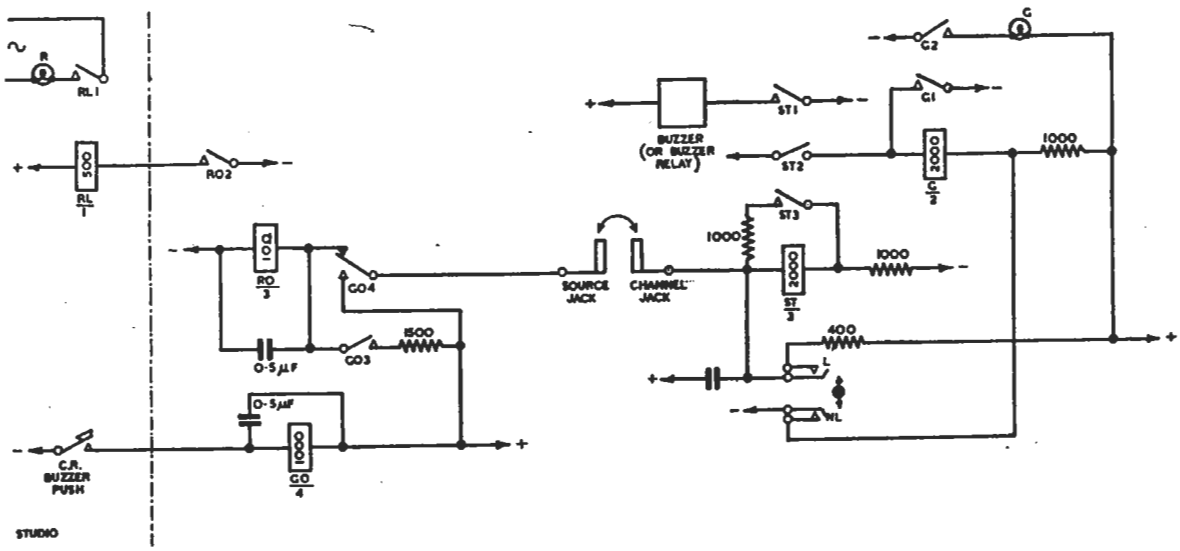


Fig. 2.1. Signalling by Sleeve Circuit of Programme Jacks

RO1 is not connected but is retained in the relay because its removal would modify the operating characteristics.

RO2 closes and operates *RL/1*. *RL1* switches on the studio red light.

RO3 closes and operates the central indicator in the control room. This is not shown in Fig. 2.1.

The signal from the control room is acknowledged from the studio by operation of the buzzer push energising *GO/4*.

GO1 } are not used.
GO2 }

GO3 makes (before *GO4* breaks) and completes a holding circuit for *RO/3* via a 1,500-ohm resistor to 24 volts positive. If *RO/3* is unoperated the current through this holding circuit is insufficient to operate this relay.

GO4 closes after *GO3* has made. The back contact of *GO4* breaks the operating path for *RO/3* and the front contact applies 24 volts positive to the source jack and channel jack sleeves to *ST/3* which operates.

ST1 completes the circuit of the buzzer or relay on the control position.

ST2 closes and operates *G/2* which self-holds.
G1 is the self-hold contact for *G/2*.
G2 operates the green light on the control position.

ST3 closes, inserting a 1,000-ohm resistor across *ST/3*. This is to prevent *ST/3* holding (via the signalling key when this is operated and the 400-ohm resistor to 24 volts positive) after *GO/4* is released.

The green light is cleared by operating the signalling key to the up position to short-circuit *G/2* by applying 24 volts negative to the relay side of the 1,000-ohm resistor.

APPENDIX 3

STUDIO SIGNALLING CIRCUITS IN STUDIO EQUIPMENT TYPE A

When the appropriate signalling key on a control position is operated, 24 volts positive is applied to the signal line (Fig. 3.1) which may or may not be the link between channel and source jacks (Appendix 2). A circuit exists between 24 volts positive and negative via the choke *L1*, the back contact of *GO1* and the relay *RO/2*. *RO/2* operates.

RO1 switches on the studio red light.

RO2 operates relay *RP/3*.

RP1 energises relay *TR/4*.

The switching operations carried out by the various contacts of relay *TR/4* were described in Section C. Briefly, they cancel the *Line-up* and *Rehearsal* conditions and render the *Line-up*, *Rehearsal* and *Off* keys ineffective.

RP2 operates the studio light in the control room central indicator by applying + 24 volts from the control room battery to the line to the central indicator.

RP3 switches on the studio blue light and all the mains equipment if necessary. If the equipment was previously in the *Line-up* or *Rehearsal* condition, the mains apparatus will already be switched on by *MO2*.

Buzzer Circuit

When the cubicle or the announcer's buzzer push is pressed, a buzz of approximately one second duration is sounded in the cubicle and at the control position and the green signal lamp on the latter is operated.

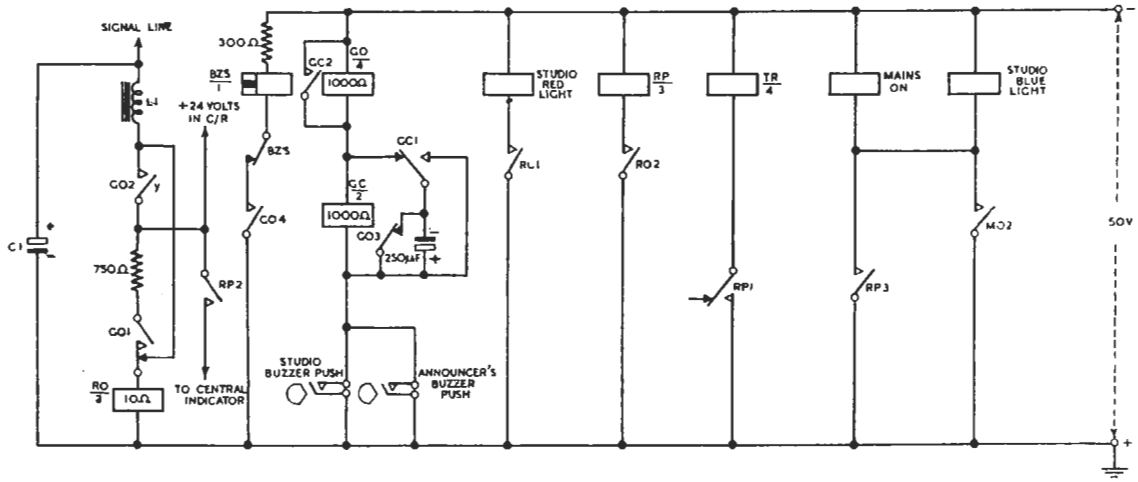


Fig. 3.1. Studio Signalling Circuit in Studio Equipment Type A

When either of the buzzer pushes is operated relay *GO/4* is energised, *GC/2* being short-circuited by *GC1* and *GO3*.

GO1 (make-before-break contact) closes, connects + 24 volts via 750 ohms to *RO/2*, and then disconnects the signalling line from *RO/2*. (The current in the circuit thus established is sufficient to hold but not to operate *RO/2*.)

GO2 (' y ' contact) now closes (i.e., after *GO1* has disconnected the signalling line from *RO/2*) and applies + 24 volts from the control room battery to the signalling line. At the other end of this line the relay controlling the green signalling lamp is operated and a buzzer is also sounded. (See Appendix 2.)

GO4 closes and completes the circuit of the buzzer *BZ/S1* in the cubicle.

GO3 opens and removes the short-circuit from relay *GC/2* which operates after an interval, due to the charging of the 250-μF

capacitor in parallel with the relay winding.

GC1 opens disconnecting the 250-μF capacitor from *GC/2* winding and discharging it by a short-circuit, in order to prevent it slugging the release of *GC/2*.

GC2 short-circuits *GO/4* and cancels the operations listed above.

GC/2 then remain operated until the studio-buzzer push is released and the duration of " buzzing " is limited effectively to approximately one second (made up of the delay due to slugged operation of *GC/2* and the slightly slugged release of *GO/4* due to the short-circuit of the winding).

Thus the prolonged operation of either buzzer push does not allow the signalling line to be engaged longer than one second and failure to receive a red-light signal from the control or continuity room is precluded. The circuit is, however, rapidly resetting (see function of *GC1*) and frequent operation of the buzzer push is possible.

APPENDIX 4

VARIABLE ATTENUATORS TYPES PB/1L1 AND PB/2L1

Attenuator Type PB/1L1

This type of variable attenuator is used in the studio equipment Type A for microphone, group and independent channel fading. It is a stud-by-

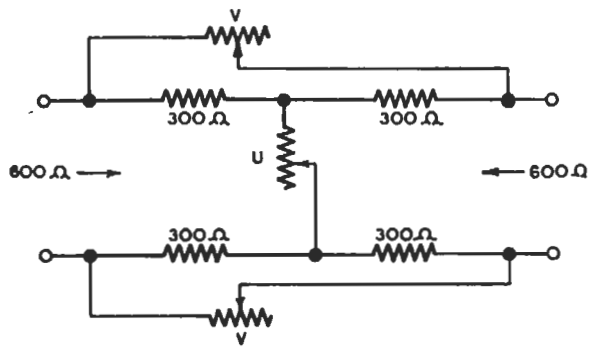


Fig. 4.1. Basic Circuit of Variable Attenuator PB/1L1

stud attenuator of the bridged-H type (Fig. 4.1) and is designed to have balanced input and output impedances of 600 ohms, irrespective of the setting of the control knob, this feature being necessary because the fader is used for constant-impedance mixing.

Fundamentally the circuit of the attenuator (Fig. 4.1) is composed of four series arms, each consisting of a fixed 300-ohm resistor, a shunt arm, U, variable in 20 steps and the bridging arms V, also variable in 20 steps. When the control knob is rotated fully anti-clockwise U = 0, V = infinity and the fader gives infinite attenuation: when the control knob is turned fully clockwise U = infinity, V = 0 and the fader gives zero attenuation. U and V contain 21 studs, as shown in the more detailed diagram of Fig. 4.2 and the maximum attenuation possible is 60 db. The loss between neighbouring studs varies from 2 db, when the overall loss of the fader is small, to 8 db when the total loss is great. The control shaft operates a change-over switch when rotated fully anti-clockwise; this serves to switch the studio or narrator's loudspeaker on and off (Section C, page 17).

The attenuator is a self-contained unit, built into a cylindrical screened housing which fits into a slightly larger screened housing fixed to the control panel, the necessary electrical connections being made automatically by a plug with eight contacts (Fig. 4.2) which fits into a socket at the bottom of the panel housing. A faulty attenuator may thus be replaced in a few seconds.

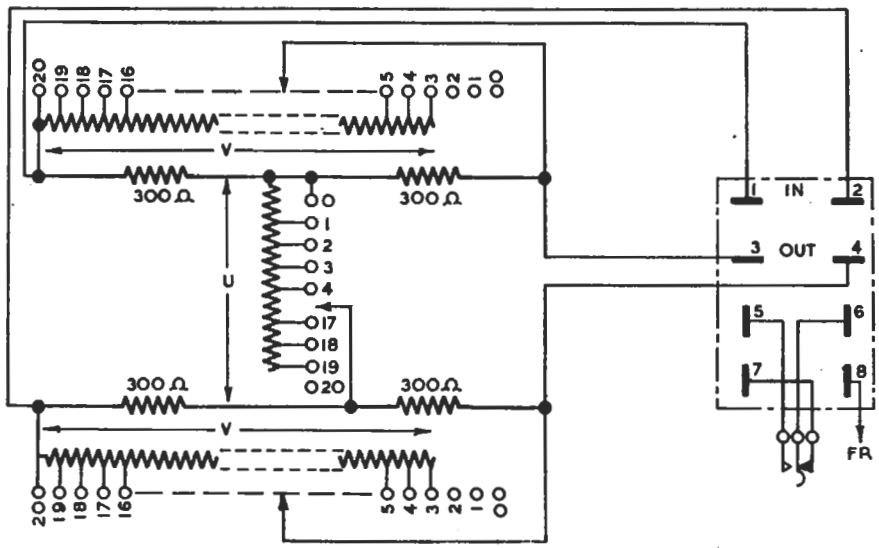


Fig. 4.2. Detailed Circuit of Variable Attenuator PB/1L1

The setting of the control knob is indicated by a black mask, attached to the control knob, which progressively uncovers a white scale as the knob

is rotated in a clockwise direction. This method of indicating the setting greatly facilitates quick determination of the extent to which the control has been rotated.

Attenuator Type PB/2L1

This is a variable attenuator of the bridged-H type, very similar in circuit and physical appearance to the *PB/1L1*, and is used as a control potentiometer in the studio apparatus Type A. The resistors U and V (see Fig. 4.1) have 31 studs and are variable in 30 steps, the maximum attenuation being 80 db (compared with 60 db for the *PB/1L1*) and the loss per stud varies from 2 db when the overall loss is small, to 5 db when the overall loss is large. When the control knob is rotated fully anti-clockwise the loss is infinite and in this position a change-over switch is operated as in the *PB/1L1*. The *PB/2L1* is housed in a screened container identical with that of the *PB/1L1* and, if a *PB/2L1* fails and there is no replacement at hand, it may be replaced temporarily by a *PB/1L1* and the service can be continued. (Similarly if a *PB/1L1* fails, it may be replaced by a *PB/2L1*.)

APPENDIX 5

ECHO-MIXTURE SWITCH. TYPE BBB/1Y1

This is a two-channel fade unit used in the studio equipment Type A to vary the ratio of echo to direct programme. Electrically it consists of two variable stud-by-stud attenuators of the attenuation in the echo chain and infinite attenuation in the direct chain (100% echo). The intermediate positions provide other ratios of echo to direct programme according to the table below.

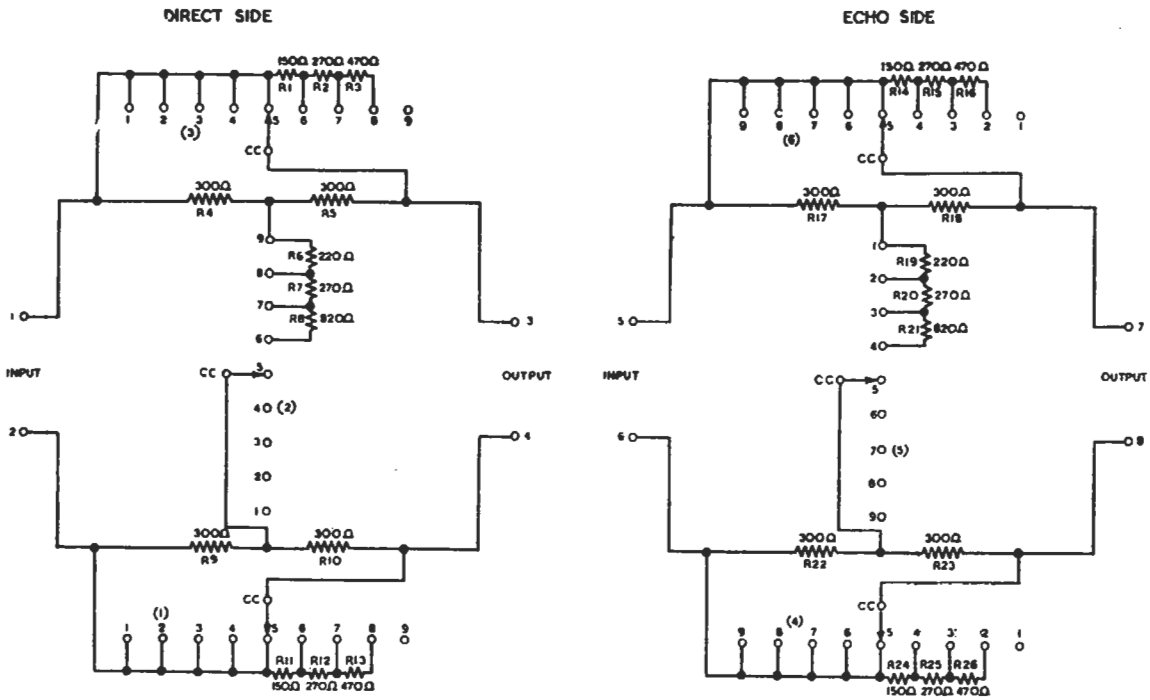


Fig. 5.1. Detailed Circuit of Echo-Mixture Switch. BBB/1Y1

bridged-H type, with a constant balanced input and output impedance of 600 ohms. The unit consists of a 6-bank, 9-position Yaxley-type switch (each attenuator occupying three banks) which are arranged to produce nine different ratios of echo to direct programme.

As illustrated in Fig. 5.1, in position 5 there is zero attenuation in both chains and the echo is equal in volume to the direct programme (50% echo). In position 1 there is zero attenuation in the direct chain and infinite attenuation in the echo chain (no echo). In position 9 there is zero

Attenuation in Decibels

Position	*Direct*	*Echo*
1	0	∞
2	0	12
3	0	7·5
4	0	3·5
5	0	0
6	3·5	0
7	7·5	0
8	12	0
9	∞	0

APPENDIX 6

TRANSFORMER TYPE LL/139SK

Transformer Type *LL/139SK* is used in the studio equipment Type A for two purposes: (1) as a hybrid coil following the echo-mixture switches and (2) as a matching transformer situated between *B1* and *B2* amplifiers. This appendix gives an explanation of the winding connections used for these two purposes.

The transformer has one primary and two secondary windings, all centre-tapped, and the tags are numbered as shown in Fig. 6.1. The turns ratio

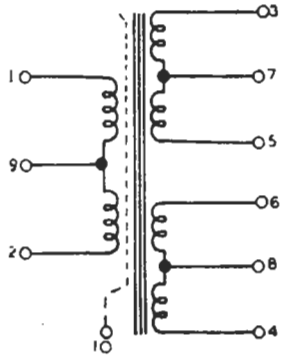


Fig. 6.1. Tag Connections of Transformer LL/139SK

between primary and either of the two secondary windings is $\sqrt{2}:1$.

When used as a matching transformer, the two secondary windings are connected in series by strapping 5 to 6 as shown in Fig. 6.2. The ratio of total secondary turns to primary turns is $\sqrt{2}:1$ and the impedance ratio is therefore 2 : 1, the value required to match the output impedance of the *PB/2L1* (or the *AMC/2* amplifier) to the input impedance of an *AMC/2* amplifier, i.e., 600 ohms to 300 ohms.

Fig. 6.3 shows the connections used when the transformer is used as a hybrid coil : tags 7 and 8 are bridged by a 300-ohm resistor, tags 3 and 4 form one output circuit and tags 5 and 6 the other. This circuit arrangement ensures that there is no coupling between the two secondary windings, although both are closely coupled to the primary. This may be understood from the following explanation :—If a signal is applied between 3 and 4 (Fig. 6.3) a p.d. is set up across 37, 84 and the 300-ohm resistor and, provided the turns ratio is correct and all circuits are correctly loaded, the p.d.'s across 37 and 84 together equal that across the resistor. As the two halves of each secondary winding are closely coupled, p.d.'s are developed across 75 and 68 equal but in the opposite sense to those across 37 and 84 respectively. Thus the p.d. appearing

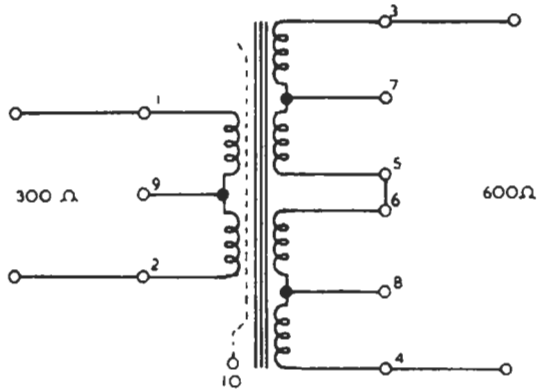


Fig. 6.2. Connections when Transformer LL/139SK is used for Matching

across 56, the other secondary circuit, namely the sum of those across 75, 68 and the 300-ohm resistor is zero. Similarly, because of the symmetry of the

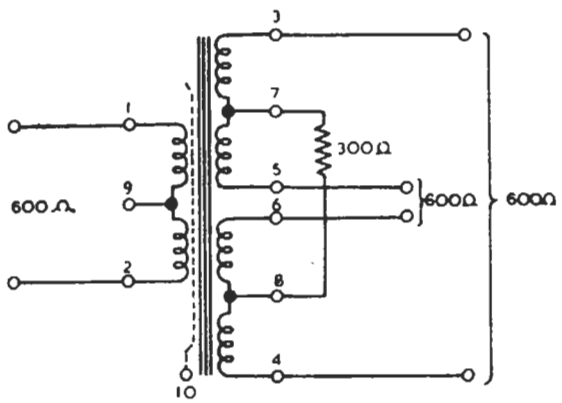


Fig. 6.3. Connections when Transformer LL/139SK is used as a Hybrid Coil

circuit, no p.d.'s appear across 34 when signals are applied between 56.

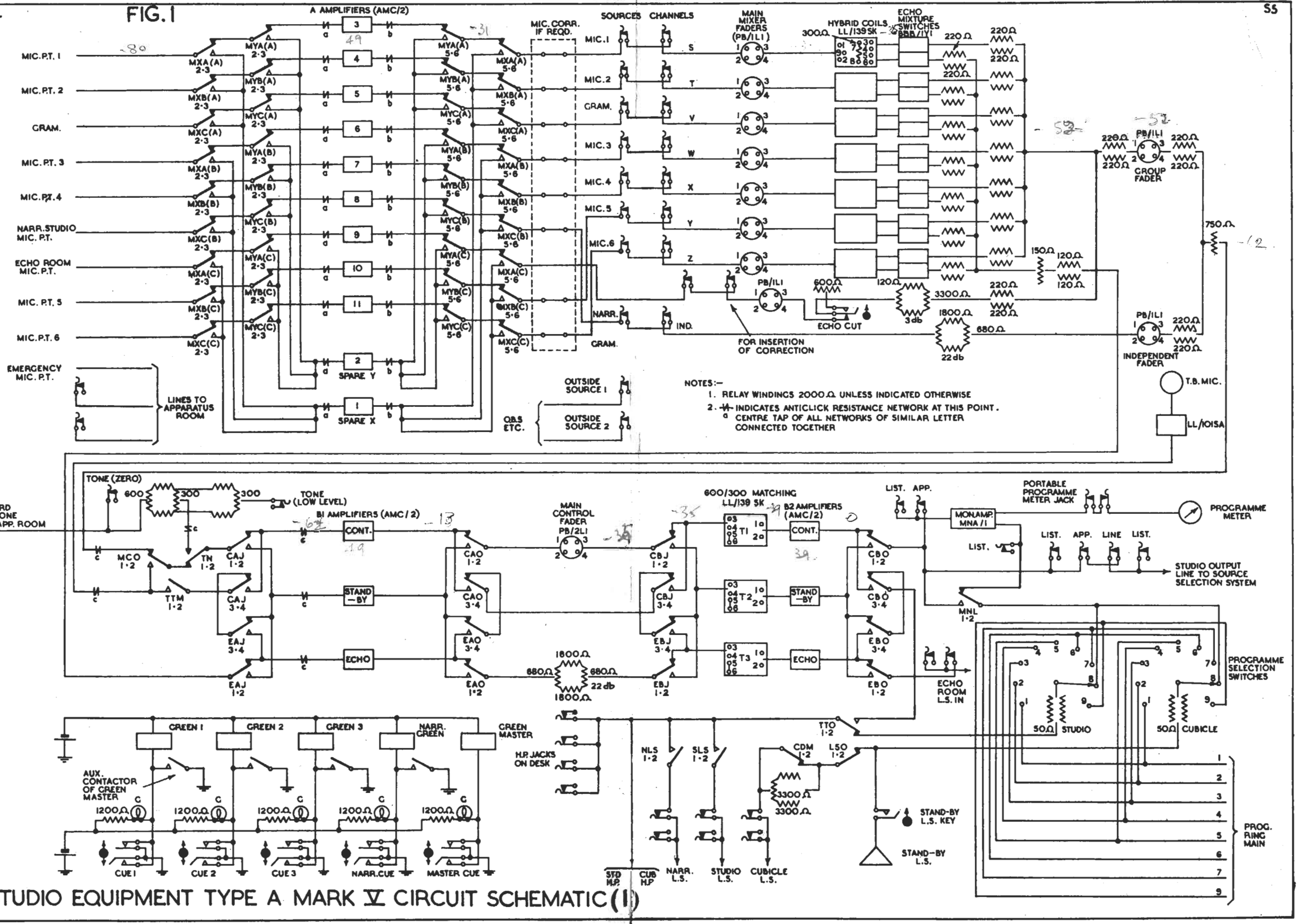
More details about the theory of the hybrid coil may be obtained from Technical Instruction ST.6, page 15.

NOTES

NOTES

INDEX

FIG. 1

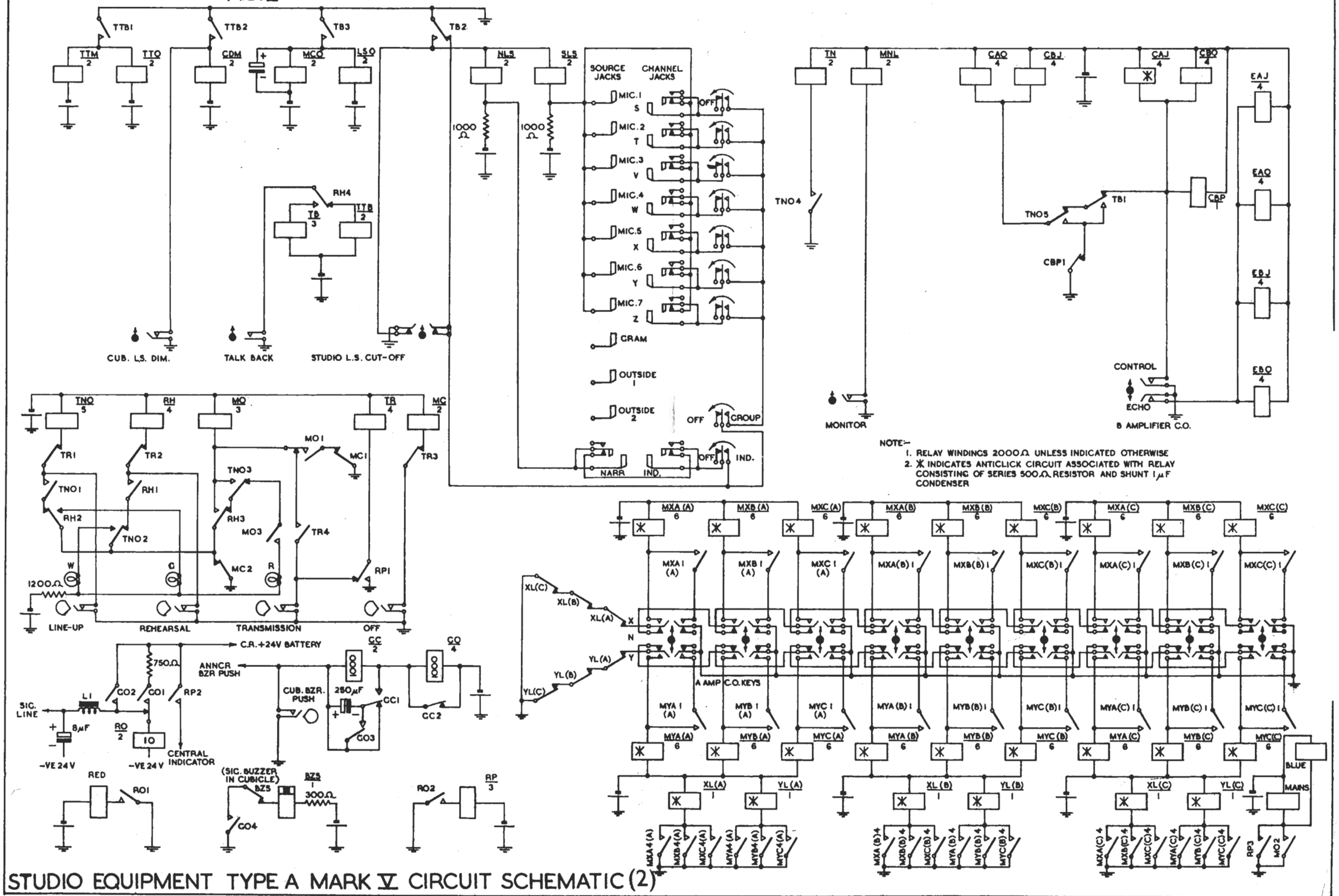


STUDIO EQUIPMENT TYPE A MARK V CIRCUIT SCHEMATIC (1)

F8/1825

74011A55/D J E

FIG. 2

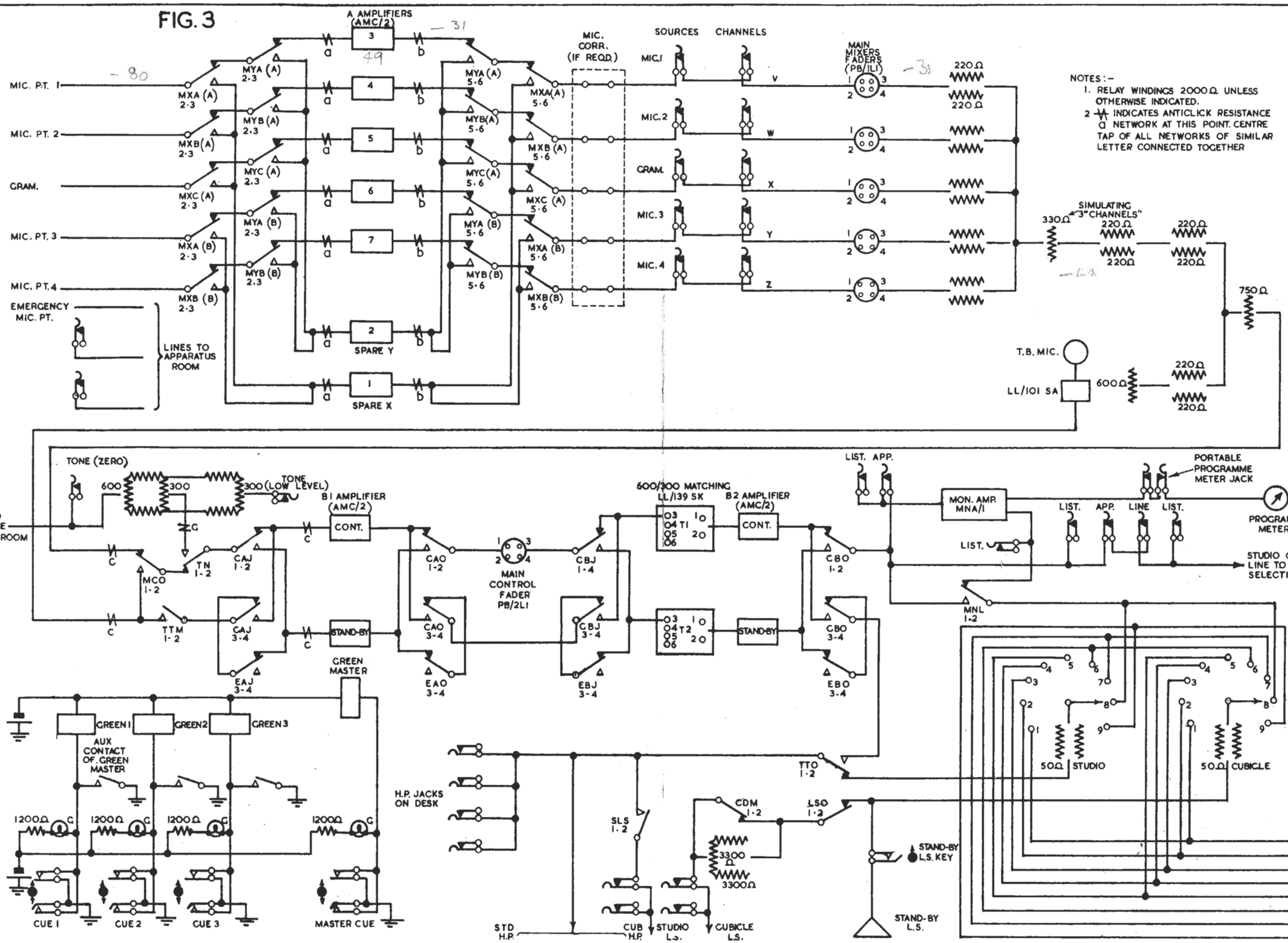


STUDIO EQUIPMENT TYPE A MARK V CIRCUIT SCHEMATIC (2)

SD/LF8/1822

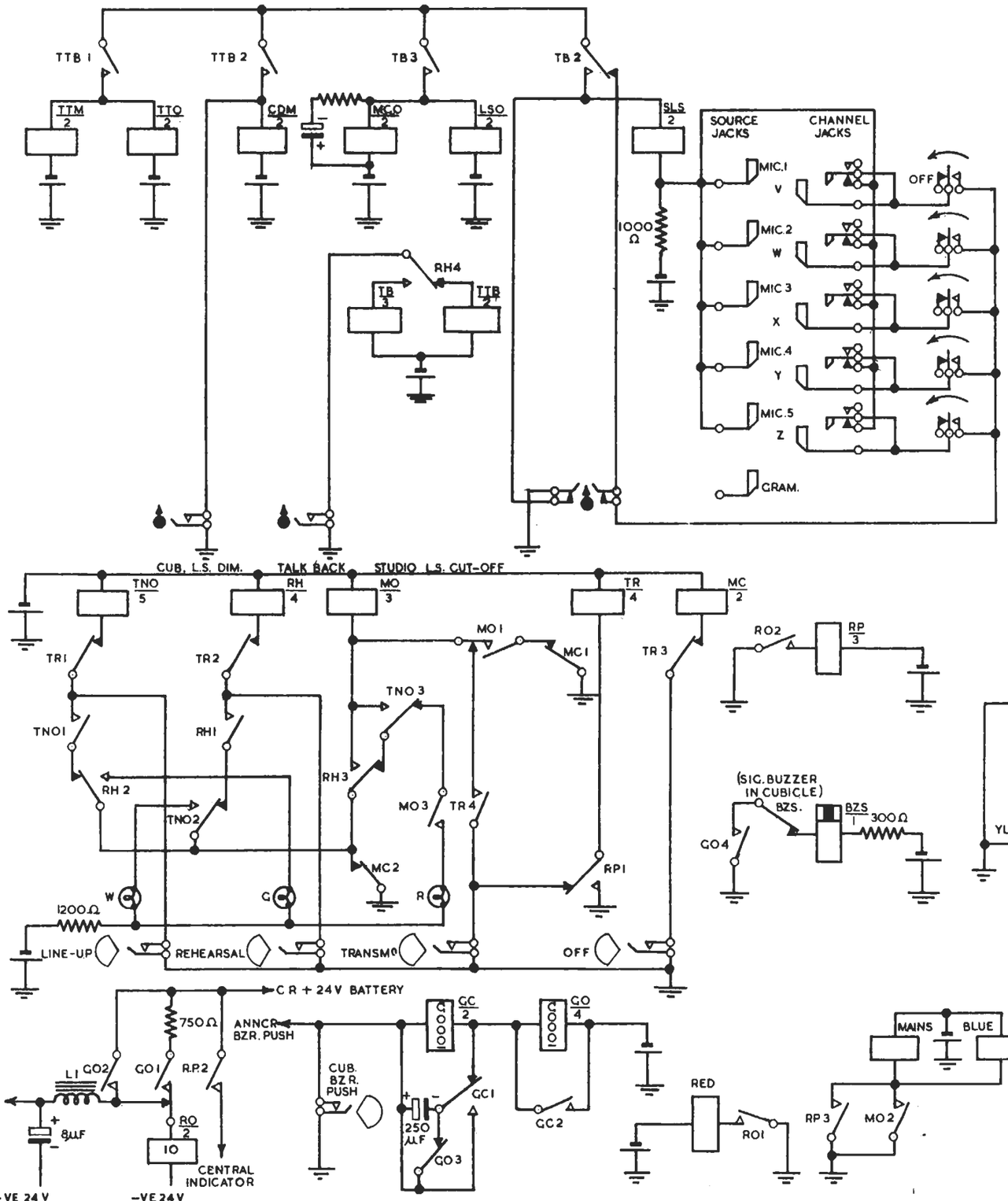
74004A/SS/AJP

FIG. 3



STUDIO EQUIPMENT TYPE A MARK II CIRCUIT SCHEMATIC (1)

FIG. 4



NOTES:-
1. RELAY WINDINGS 2000Ω UNLESS OTHERWISE INDICATED
2. ✳ INDICATES ANTICLICK CIRCUIT ASSOCIATED WITH RELAY, CONSISTING OF SERIES 500Ω RESISTOR AND SHUNT 1µF CONDENSER
3. INDICATES ANTICLICK RESISTANCE NETWORK AT THIS POINT. CENTRE TAP OF ALL NETWORKS OF SIMILAR LETTER CONNECTED TOGETHER

STUDIO EQUIPMENT TYPE A MARK II CIRCUIT SCHEMATIC(2)

FIG.5

'A' AMPLIFIERS

SOURCES | CHANNELS | MAIN MIXER FADERS PB/LI | HYBRID COILS LL/1395K | ECHO MIXTURE SWITCHES BBB/IYI

MIC.1 Q
MIC.2 R
GRAM. S
MIC.3 T
MIC.4 V
MIC.5 W
MIC.6 X
MIC.7 Y
MIC.8 Z
NARR. IND.
MIC.9
NARR 1A
MIC.11
MIC.12

MIC.1 MXA(A) 2-3 MYA(A) 2-3 MXA(A) 5-6 MYA(A) 5-6
MIC.2 MXB(A) 2-3 MYB(A) 2-3 MXB(A) 5-6 MYB(A) 5-6
GRAM. MXC(A) 2-3 MYC(A) 2-3 MXC(A) 5-6 MYC(A) 5-6
MIC.3 MXA(B) 2-3 MYA(B) 2-3 MXA(B) 5-6 MYA(B) 5-6
MIC.4 MXB(B) 2-3 MYB(B) 2-3 MXB(B) 5-6 MYB(B) 5-6
NARR. MXC(B) 2-3 MYC(B) 2-3 MXC(B) 5-6 MYC(B) 5-6
ECHO MXA(C) 2-3 MYA(C) 2-3 MXA(C) 5-6 MYA(C) 5-6
MIC 5 MXB(C) 2-3 MYB(C) 2-3 MXB(C) 5-6 MYB(C) 5-6
MIC 6. MXC(C) 2-3 MYC(C) 2-3 MXC(C) 5-6 MYC(C) 5-6
MIC.7 MXA(D) 2-3 MYA(D) 2-3 MXA(D) 5-6 MYA(D) 5-6
MIC.8. MXB(D) 2-3 MYB(D) 2-3 MXB(D) 5-6 MYB(D) 5-6
MIC.9. MXC(D) 2-3 MYC(D) 2-3 MXC(D) 5-6 MYC(D) 5-6
MIC.10 MXA(E) 2-3 MYA(E) 2-3 MXA(E) 5-6 MYA(E) 5-6
MIC.11 MXB(E) 2-3 MYB(E) 2-3 MXB(E) 5-6 MYB(E) 5-6
MIC.12 MXC(E) 2-3 MYC(E) 2-3 MXC(E) 5-6 MYC(E) 5-6

3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 (SPAREY) 2 (SPARE X) 1

EMERG MIC. PT. — CR. BAY J53

240Ω 240Ω 240Ω 240Ω

220Ω PB/LI 220Ω 220Ω GROUP FADER 220Ω

750Ω

3 db LL/1065A 22 db LL/1065A

PB/LI 220Ω INDEPENDENT 220Ω FADER*

ECHO FADER PB/LI

FOR INSERTION OF CORRECTION

T.B. MIC. LL/15A

05.1 6000Ω 600Ω — CR BAY J58

05.2 5000Ω 600Ω — J59

ZERO TONE L.L. TONE

300 0000Ω 930Ω 600Ω 350Ω 350Ω 300 0000Ω 930Ω

CR BAY 05/10A OUT J30

MCO 1-2 TTM 1-2 TN1-2

'B' AMPLIFIERS

CONTROL CAJ 1-2 CAO 1-2
STAND-BY CAJ 3-4 CAO 3-4
ECHO EAJ 3-4 EAO 3-4
EAJ 1-2 EAO 1-2

PO/2LI

32.4Ω

CBJ 1-2 CBJ 3-4 EBJ 1-2

600/300 MATCHING LL/1395K 'B' AMPLIFIERS

2 CONTROL
2 STAND-BY
2 ECHO

CBO 1-2 CBO 3-4 EBO 3-4 EBO 1-2

LIST. APP. MON. AMP PORTABLE P.P.M. JACK PROGRAMME METER

LIST. APP. LINE LIST. LIST.

600Ω STUDIO OUT TO C.R. BAY J65

MNL 1-2

ECHO ROOM L.S. LIST APP

PROG. RING MAIN

STUDIO CUBICLE

TTO 1-2

NLS 1-2 SLS 1-2 CDM 1-2 LSO 1-2

STAND-BY L.S. KEY STAND-BY L.S.

LINE LIST. H.P.

NARR. L.S. NARR. 1A L.S. STUDIO L.S. CUBICLE L.S.

GREEN 1 | GREEN 2. & NARR. 1A | GREEN 3 | NARR. L | GREEN | MASTER GREEN

AUX. CONTACT OF GREEN MASTER

1100Ω

CUE 1 CUE 2 CUE 3 NARR. CUE STD. 68 MASTER CUE

NOTES:-

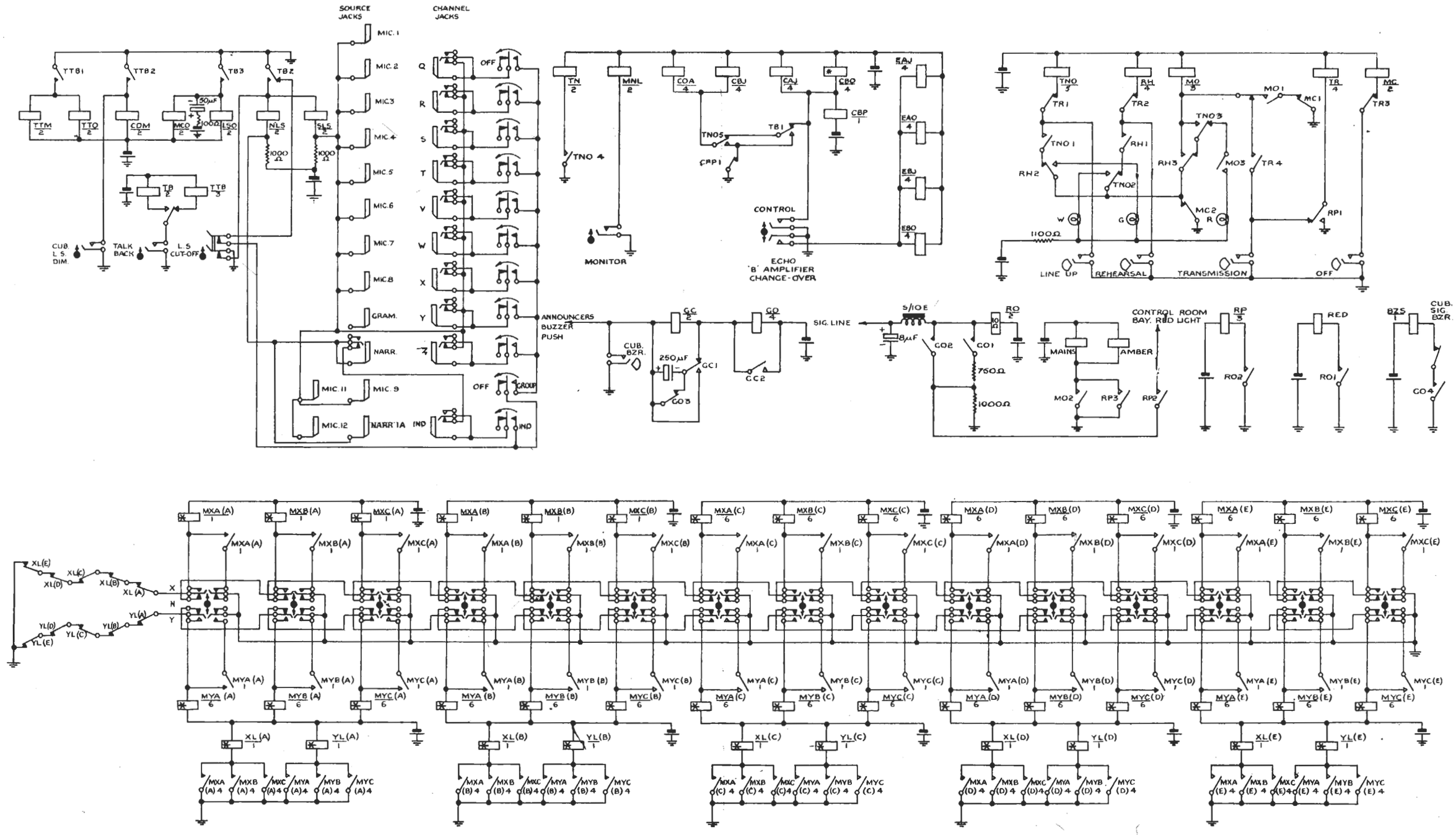
1. RELAY WINDINGS 2000Ω UNLESS OTHERWISE STATED
2. ⅓ INDICATES ANTICLICK RESISTANCE NETWORK AT THIS POINT, CENTRE TAP OF ALL NETWORKS OF SIMILAR LETTER CONNECTED TOGETHER.

CAMDEN THEATRE. STUDIO EQUIPMENT TYPE A CIRCUIT SCHEMATIC.(1)

FIG.6

SD/LF10/2300

7401481/55/DJE



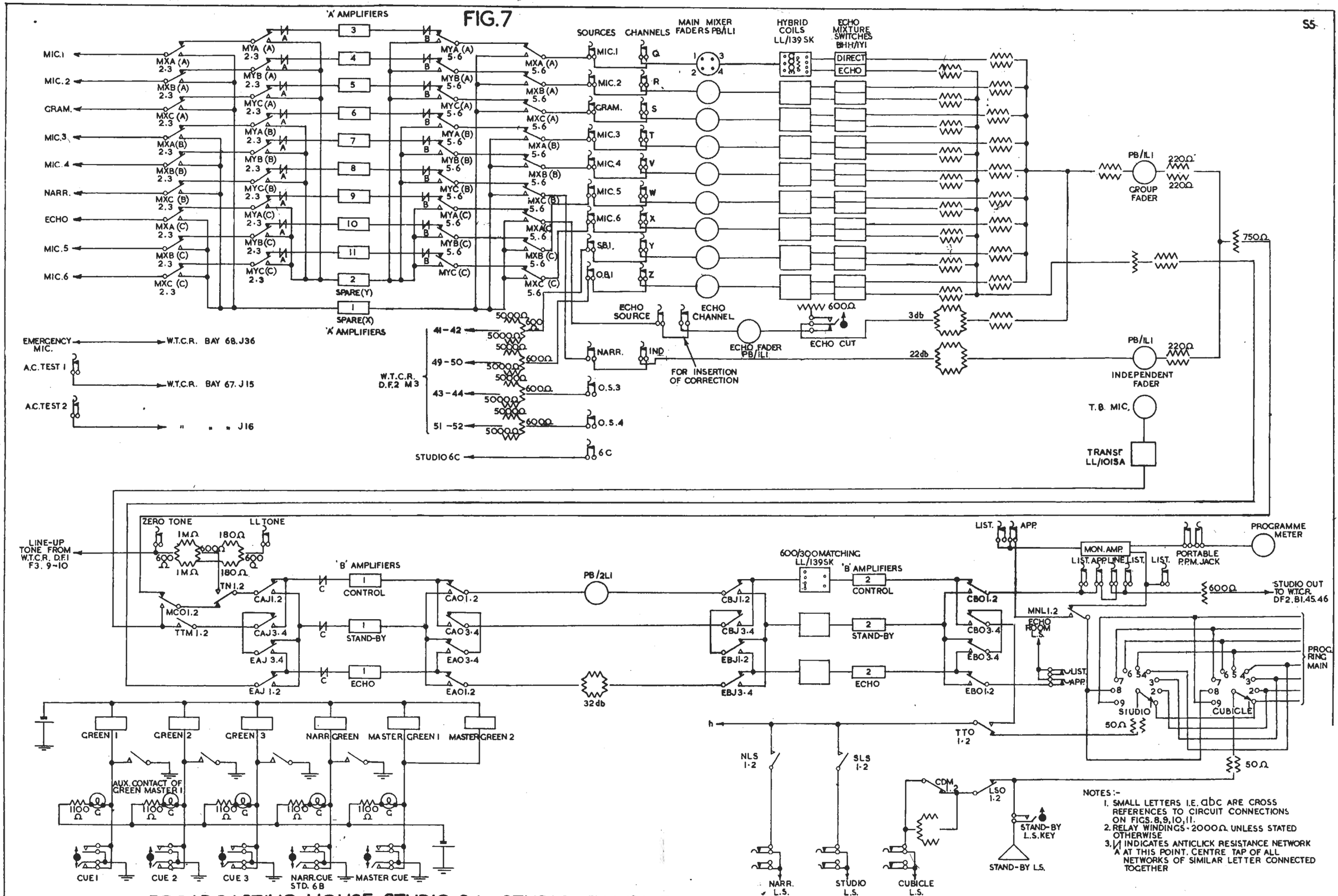
NOTES:-1 RELAY WINDINGS 2000Ω UNLESS OTHERWISE STATED
2 * INDICATES ANTICLICK CIRCUIT ASSOCIATED WITH RELAY CONSISTING OF SERIES 600Ω RESISTOR AND SHUNT 1µF CONDENSER.

CAMDEN THEATRE. STUDIO EQUIPMENT TYPE A. CIRCUIT SCHEMATIC (2)

SD/LF10/2744

74017C/S5/AJP

FIG.7



NOTES :-

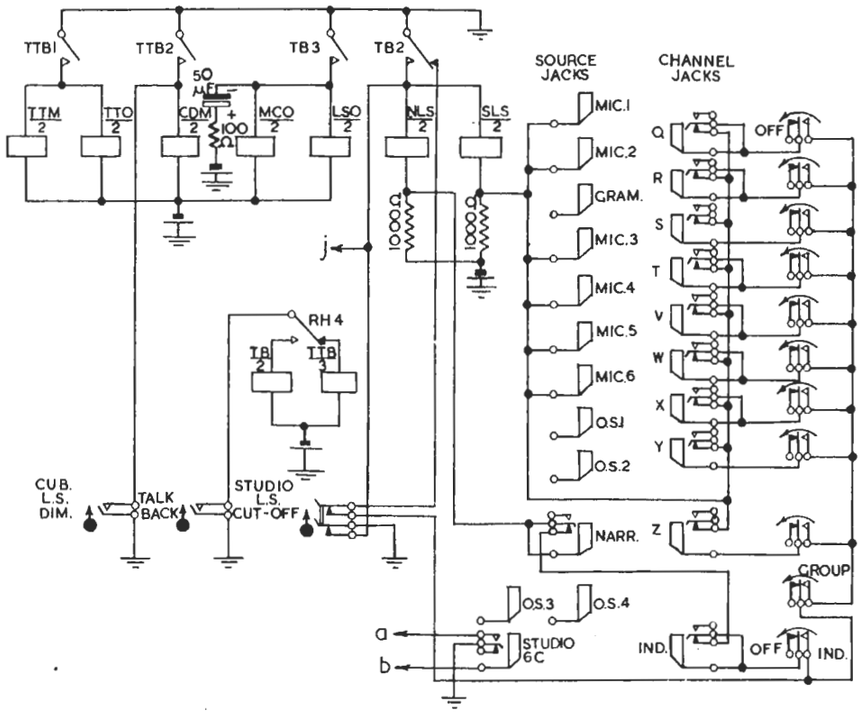
1. SMALL LETTERS I.E. abc ARE CROSS REFERENCES TO CIRCUIT CONNECTIONS ON FIGS. 8, 9, 10, 11.
2. RELAY WINDINGS - 2000Ω UNLESS STATED OTHERWISE
3. ⩘ INDICATES ANTICLICK RESISTANCE NETWORK A AT THIS POINT. CENTRE TAP OF ALL NETWORKS OF SIMILAR LETTER CONNECTED TOGETHER

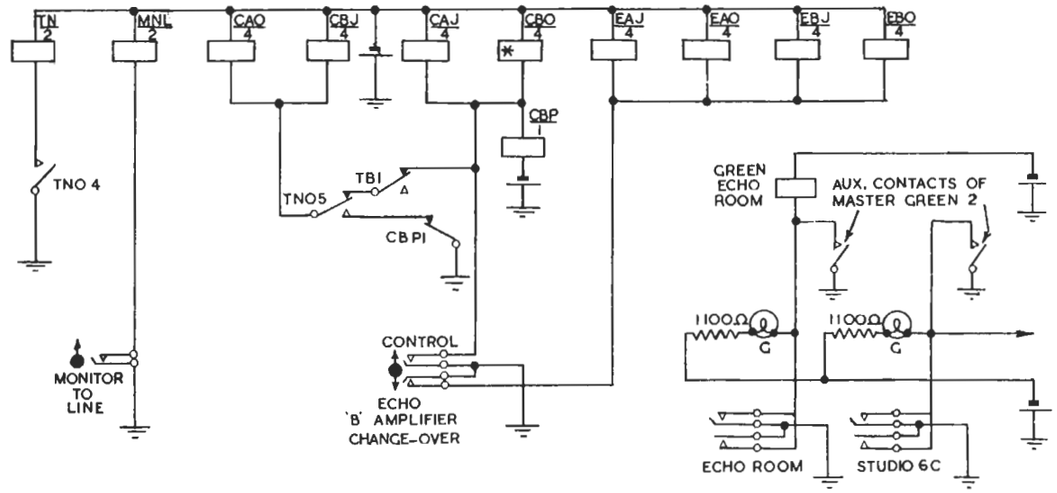
BROADCASTING HOUSE. STUDIO 6A. STUDIO EQUIPMENT TYPE A. CIRCUIT SCHEMATIC (1)

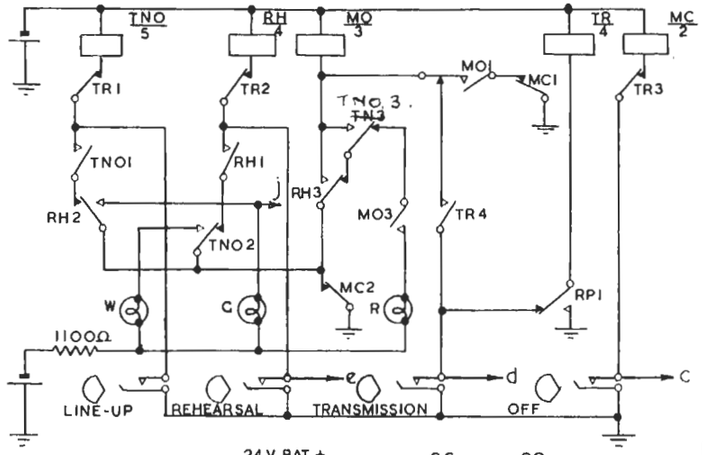
FIG.8

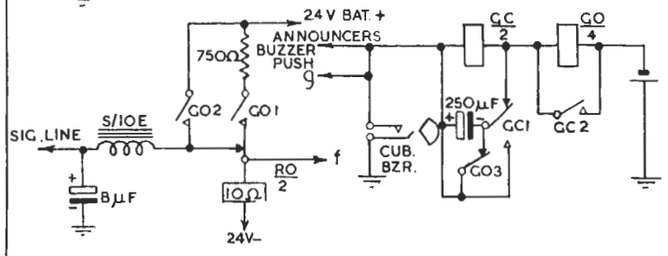
SD/LF10/2744

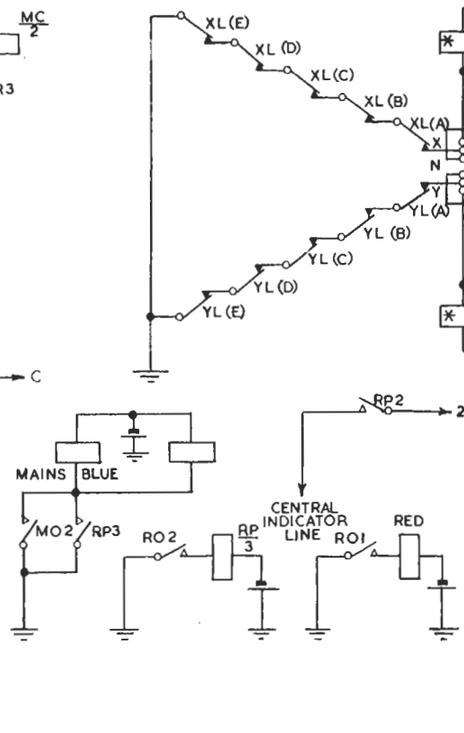
7401BC/S5/AJP

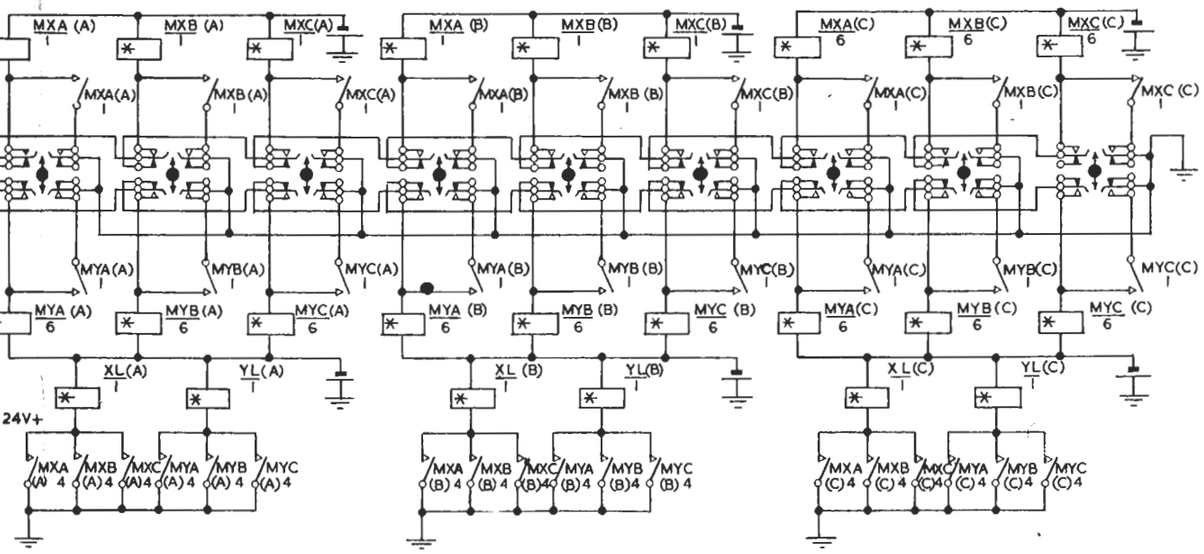


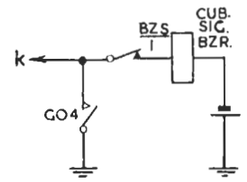








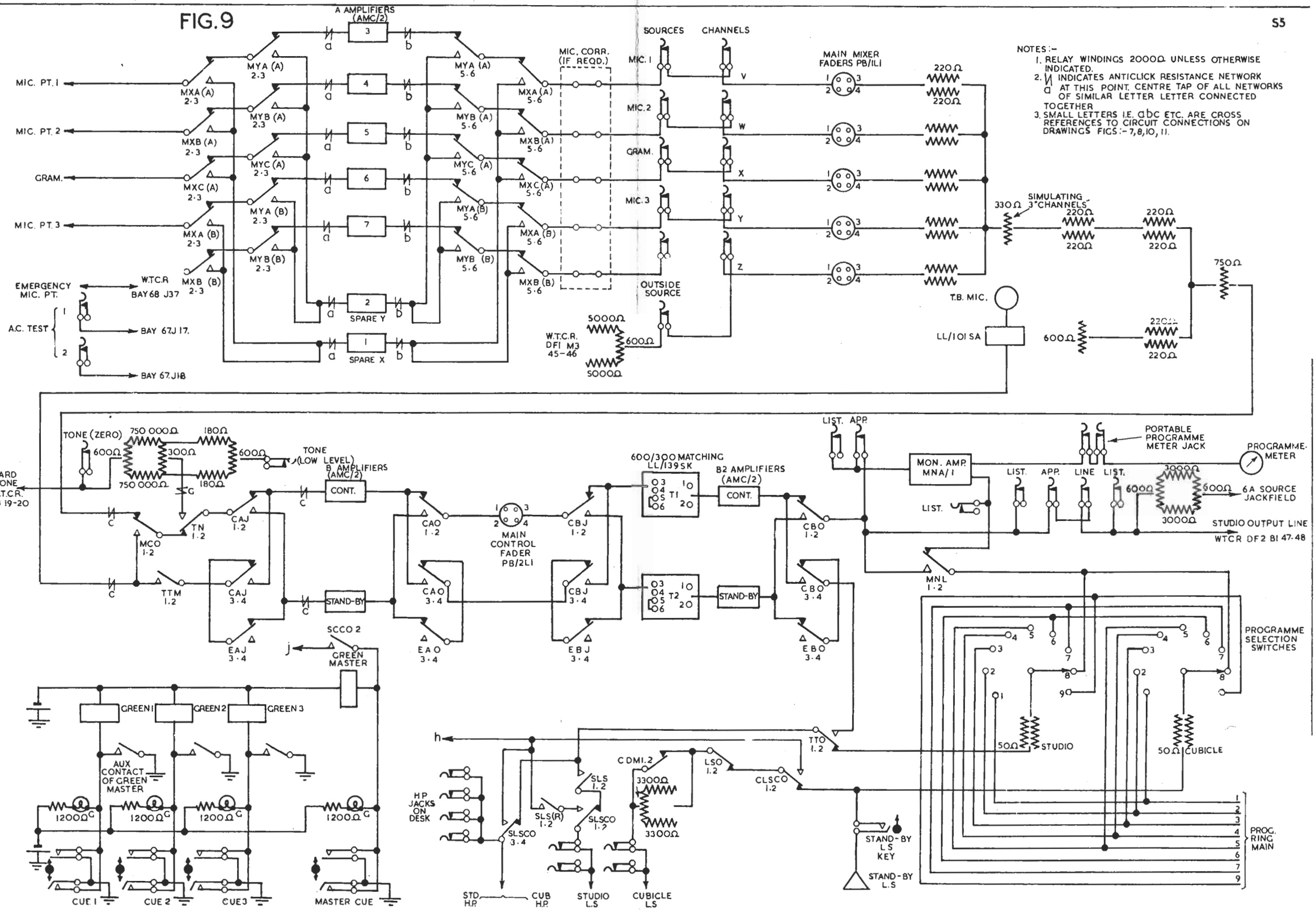




NOTES:-
1. SMALL LETTERS I.E. abc ARE CROSS REFERENCES TO CIRCUIT CONNECTIONS ON FIGS. 7, 9, 10, 11.
2. RELAY WINDINGS - 2000Ω UNLESS STATED OTHERWISE.
3. * INDICATES ANTICLICK CIRCUIT ASSOCIATED WITH RELAY, CONSISTING OF SERIES 500Ω RESISTOR & SHUNT 1μF CONDENSER

BROADCASTING HOUSE. STUDIO 6A. STUDIO EQUIPMENT TYPE A. CIRCUIT SCHEMATIC (2)

FIG. 9



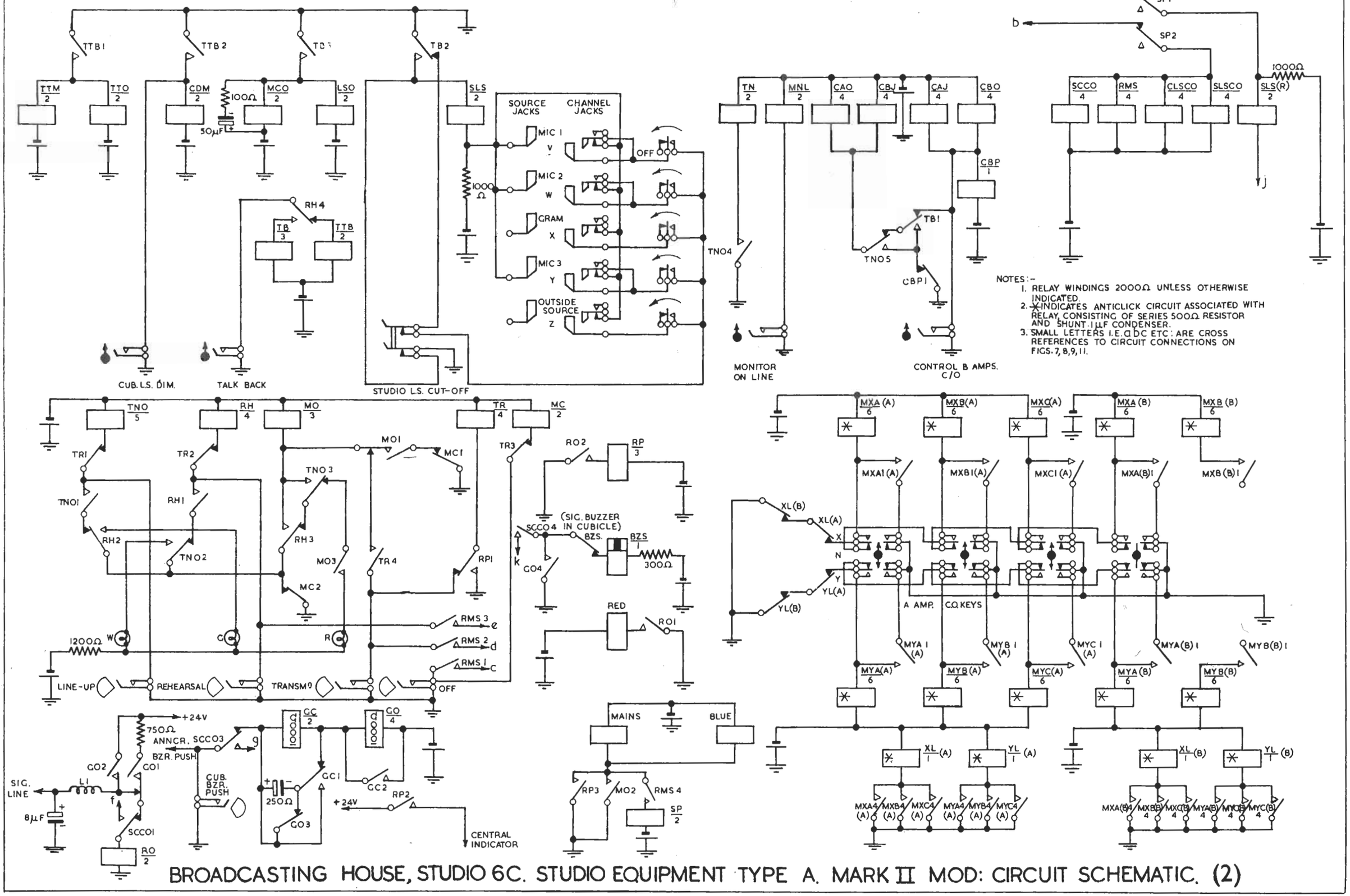
BROADCASTING HOUSE, STUDIO 6C. STUDIO EQUIPMENT TYPE A. MARK II MOD. CIRCUIT SCHEMATIC. (1)

FIG.10

S5

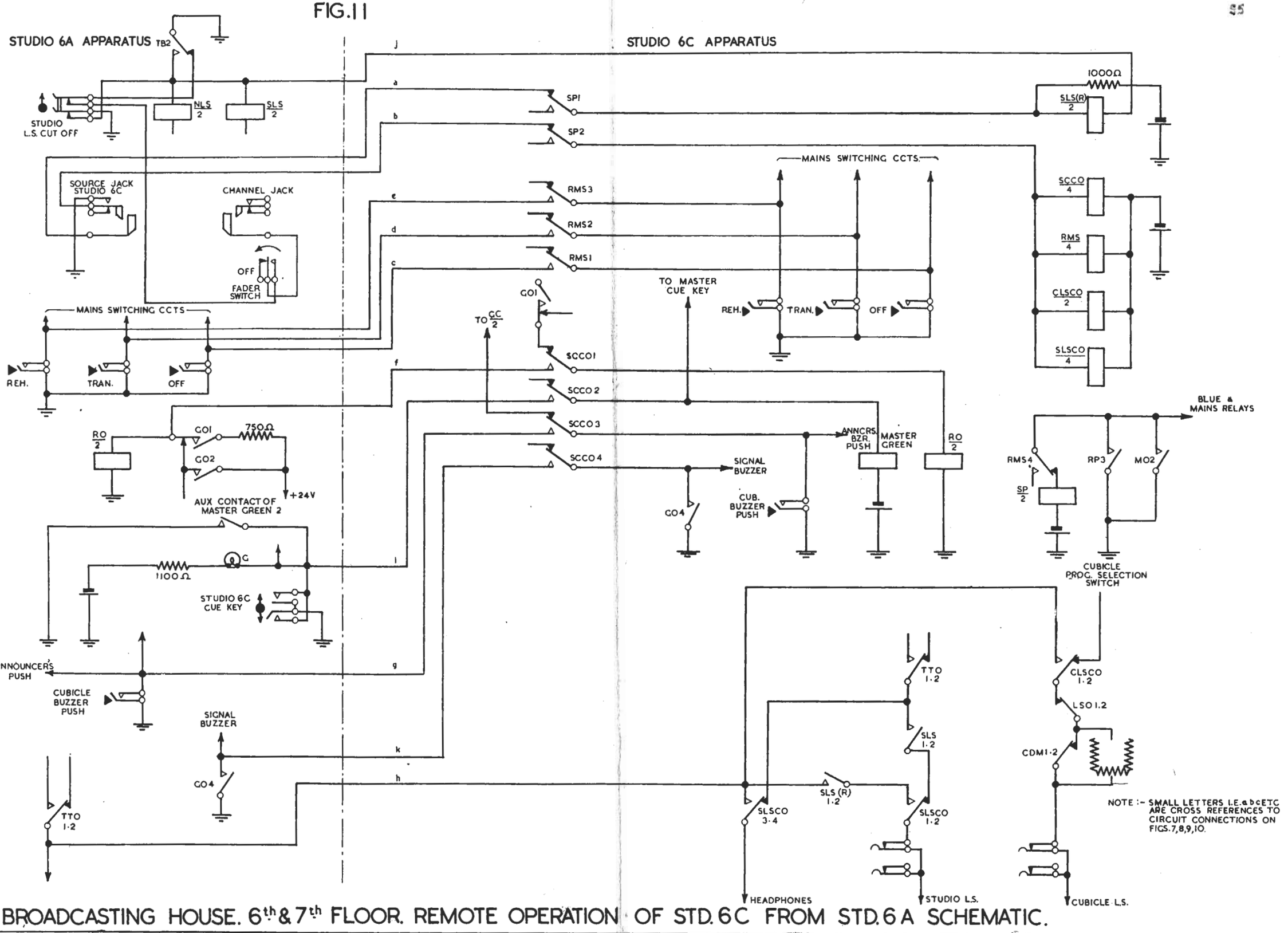
D/LFB/2745

74016C55/AJP



BROADCASTING HOUSE, STUDIO 6C. STUDIO EQUIPMENT TYPE A. MARK II MOD: CIRCUIT SCHEMATIC. (2)

FIG.11



NOTE :- SMALL LETTERS I.E. a b c ETC ARE CROSS REFERENCES TO CIRCUIT CONNECTIONS ON FIGS. 7, 8, 9, 10.

BROADCASTING HOUSE. 6th & 7th FLOOR. REMOTE OPERATION OF STD. 6C FROM STD. 6A SCHEMATIC.

74019B/55/AJP

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in Instruction S5 :—

_____

_____

Station..... *Date*..... *Signature*.....

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in Instruction S5 :—

_____

_____

Station..... *Date*..... *Signature*.....

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in Instruction S5 :—

_____

_____

Station..... *Date*..... *Signature*.....

ERRATA

To Editor,

Technical Instructions,

305, *St. Hilda's, Maida Vale.*

The following errors have been noted in Instruction S5 :—

_____

_____

Station..... *Date*..... *Signature*.....