MOBILE RECORDING UNITS, T.29 AND T.30

CONTENTS

LIST OF ILLUSTRATIONS

MOBILE RECORDING UNITS, T.29 AND T.30

General Description

Each van is equipped as a self-contained unit for continuous recording.

Behind the driver's cab there is a small studio with an observation window, equipped with a microphone and a loudspeaker. Behind this again there is a compartment occupying the greater part of the space in the body of the van which serves as the apparatus room. This contains two recording machines together with their associated amplifiers and control gear and the switchgear associated with the power supply circuits.

The recording machines are designed for cutting 100 threads to the inch at 78 r.p.m. and a hydraulic levelling device is provided for levelling the tables on which they are mounted. A neon light fed from an electrically maintained 50 c/s fork is used in conjunction with stroboscopic markings on the turntables for obtaining the correct speed of rotation. Where the material to be recorded will last less than four minutes the two machines can be connected for recording in parallel, but where it will last for more than four minutes continuous recording can be obtained by connecting them for use alternately, that is to say, for series recording. The machines are normally arranged to track from outside to inside although they can also be adjusted to operate in the reverse direction. A pick-up head with parallel tracking arm of the standard pattern is provided on each machine for use with the recording turntable for playing back the records, and provision is made for suitably modifying the amplifier characteristics so as to obviate the need for additional amplifier equipment.

The recording may be taken either from the studio or from one or more (up to four) microphones external to the van. Sufficient microphone cable in 100 yard lengths is carried to enable one microphone to be used up to 500 yards away from the van. Where however, more than one microphone is to be used the microphone connections are made via a 4-way mixer. The greatest distance from the van at which the microphones can be placed is 300 yards in the case of two microphones only, and 200 yards where 3 or 4 microphones are used. Provision is also made to enable programme or testing current to be received by line when desired.

A communication system provides for cueing in both directions by means of lights, between the microphone points and the mixer, and between the latter and the apparatus room on the van, and for telephonic communication using hand-ringing telephone sets between any two points of the system. The programme can also be monitored at the microphone and mixer points by means of headphones. The necessary communication units and telephone sets together with 500 yards of cable are carried in the van. Similar provision is also made for communication between the studio and the apparatus room. Furthermore, microphones are provided at the mixer point and in the apparatus room on the van so that during a rehearsal facilities exist for inter-communication utilising a talk-back circuit comprising the normal microphone and headphone circuits.

Separate sets of amplifiers are provided for the two programme channels. The amplifier units are mounted in separate frames provided with resilient rubber mountings by means of which they are attached to the racks. There are two racks installed on either side of the

General Description (*Contd*)

apparatus room each carrying the amplifiers associated with the machine installed on the same side. The apparatus on each rack comprises a supply unit, SHL/1, containing the necessary smoothing circuits, fuses, etc., a high gain amplifier DR/3 incorporating correction circuits which may be switched out of circuit when the amplifier is used for reproducing a record, and a power amplifier, DRP/3, for feeding the programme at the required level to the cutter head. There is also a loudspeaker amplifier, LSA/4, for monitoring and play-back purposes which can be used with either machine and can be transferred from one rack to the other as occasion requires.

The programme is fed to the cutter head via a control unit suspended from the roof over the turntables and incorporating the DR/3 amplifier gain control and the necessary switching, monitoring and sensitivity calibration circuits. Monitoring in the apparatus room can be carried out either on headphones or by loudspeaker. For play-back purposes, however, the loudspeaker in the studio is invariably used as this is a higher quality instrument. The reproducing pick-ups plug into jacks mounted on the forward bulkhead which are wired via the usual correction circuits to jacks on the apparatus racks adjacent to the DR/3 amplifier.

The inputs and outputs of the amplifiers are brought to jacks on the individual units and the programme wiring terminates on jacks mounted on the side of the racks in positions adjacent to the amplifiers to which connection is normally to be made. The necessary programme and monitoring connections are thus set up by the use of double-ended cords and plugs in the normal manner. The supply connections to the power units and thence to the various amplifier units are made by means of cords, using Niphan plugs and sockets. Any amplifier unit can thus be readily isolated by disconnecting the programme and supply connections, then by releasing a number of retaining screws the unit can be withdrawn from the front of its mounting for testing on the bench. Extension cords and connectors are provided to enable the supplies in each case to be extended to an amplifier undergoing test on the bench.

The talk-back and communication units are mounted near the recording machines on the forward bulkhead and the fork and line termination units on the cupboards at the back of the van. The benches are kept clear of apparatus and the covered space underneath is used for tools and spares. The field gear is stowed in the rear part of the apparatus room and comprises the microphone stands, communication units, mixer, telephone sets, cable drums, a folding table and chairs and a portable winch.

Except for the 12 volt supply for the relay and cue circuits and for the fork unit, which is obtained from the car battery, all the power supplies required for the operation of the equipment, including lighting, are obtained from a 100 volt 120 ampere-hour battery. This is carried under the floor of the van in two compartments, one on either side of the propeller shaft, accessible from the outside via flaps that can be raised. The H.T. and L.T. supplies for operating the amplifier equipment are obtained from motor-generator sets similarly housed, one on either side, in the rear of the batteries. The batteries may be charged either from a generator driven by the van motor or via a rectifier unit from an external source of A.C. or D.C., a length of cable being carried for making the necessary connections. The main charging and discharge boards and the lighting distribution board are mounted on the forward bulkhead of the apparatus room.

Programme Circuits

As has been stated, the recording may be taken either from the studio, from microphones external to the van or via a line.

The arrangement of the microphone circuits is shown in Figure 2†. The microphones employed are all of the S.T. & C. moving-coil type and require to be connected to the amplifiers through a transformer which steps up the microphone output impedance from 30 to 300 ohms. In the case of the studio the microphone is connected to a single channel fade unit incorporating the microphone transformer. Where a single external microphone is used, the microphone output is extended by connecting together an appropriate number of 100 yard lengths of microphone cable and the end connector is made fast in the socket on the line termination unit, LTU/1. The key on this unit should be thrown to the position in which its make contacts are closed so as to connect in circuit the microphone transformer provided in this unit. Where the recording requires more than one microphone these will be connected to the mixer, MX/17, and the output of the latter to the line termination unit but in this case, since the necessary transformer is incorporated in each of the mixer input channels, the key on the line termination unit is placed in its normal position so as to short-circuit the transformer on the unit. The talk-back microphone at the mixer point is connected, by throwing the talk-back key, in parallel with the mixer output via its transformer and the make contacts of the key.

The output of the line termination unit is connected in parallel with the output of the fade unit in the studio and of the talk-back microphone in the apparatus room (the latter via the make contacts of the talk-back key when thrown) to the microphone jacks. These are located one on each amplifier rack adjacent to the DR/3 amplifier input and are wired in parallel, see Figure 1†. Each of these jacks has a 600 ohm resistance connected across its inner contacts and, since the amplifier input resistance is 600 ohms, this arrangement ensures that regardless of whether only one or both amplifiers are plugged up, the microphone line will always be terminated by 300 ohms.

In the case of a programme incoming from an external line the connection is made via a balanced variable attenuator of the constant-resistance type, so as to enable the programme received from the line to be adjusted to the required volume for application to the amplifier input. A resistance network is provided in the output circuit of the attenuator which, in conjunction with the 300 ohms presented by the amplifier inputs, furnishes the required 600 ohms termination for the attenuator and the line. The attenuator is not, however, permanently wired across the microphone line because this would involve placing an additional load across the other microphones. When it is required, therefore, it must be plugged up by connecting a double-ended cord between the pair of jacks provided for the purpose.

A 5 MΩ resistance is connected on one side of the switches in the mixer and the studio fade unit, between the end of the fade resistance and the **off** stud, so as to maintain a connection between the secondary winding of the microphone transformer and the common microphone line even when the microphone is faded out, in order to prevent any difference of potential developing between these two points which might give rise to ' clicks ' when the microphone is subsequently faded up. The same purpose is served by the similarly connected 1 MΩ resistances provided in the talk-back circuits in the mixer and the van, the resistance in both cases being shorted out when the microphone is switched into circuit.

† *Fig.* 1 *attached to p.* 5 ; *Fig.* 2 *attached to p.* 6.

Programme Circuits *(Contd)*

Referring to Figure 1, there are two amplifiers associated with each cutter head. The DR/3 amplifier provides the necessary voltage amplification and frequency correction and the DRP/3 amplifier is a power amplifier. The correction applied in the DR/3 amplifier is of two kinds. The first reduces the low-frequency response so as to restrict the swing in the bass and prevent the cutter from breaking through the walls between adjacent grooves, and the second provides correction for the non-linearity of the particular cutter head in use. The latter is arranged as a self-contained unit, and when a cutter head is changed it is necessary to unsweat the associated correction unit in the DR/3 amplifier and substitute another having components of values specially chosen for the new cutter head. A key is provided on the front panel for cutting out both correction circuits so as to convert the amplifier to a straight characteristic for play-back purposes.

When **recording,** the DR/3 amplifier input is plugged up to the microphone jack and one of its output jacks to the tie-line providing connection to the DRP/3 amplifier input. One of the input jacks of the latter amplifier is plugged up to the jack at the other end of this tie-line, and its main output jack is plugged up to the tie-line feeding the cutter head via the control unit CU/3. Its monitoring output jack must be plugged up to the CU/3 headphone circuit. Connection must also be made between the second output of the DR/3 amplifier and the LSA/4 amplifier input, by plugging up these jacks to the tie-line provided and between the LSA output jacks and the lines supplying the van loudspeaker and the headphone circuit.

It will be observed that both recording channels are connected in parallel to the same input and, but for the fact that the correction to be provided in the DR/3 amplifier differs for each cutter head, it would have been possible to use a common DR/3 amplifier. In the event, however, of failure of one of these amplifiers the inputs of both DRP/3 amplifiers can be connected in parallel across the output of the DR/3 amplifier still working, by plugging up the spare input jacks of both DRP/3 amplifiers to the tie-line provided communicating between the two racks.

The DRP/3 amplifier input connection is completed in each case via the break contacts of a relay. In the normal position of the **DRP.1—DRP.2** key the operating circuits of both relays is interrupted so that if both channels have been plugged up the programme will be supplied to both cutter heads. If this key is thrown to either of the side positions the associated relay operates, disconnecting the programme input to one of the DRP/3 amplifiers. This key also controls the operation of the loudspeaker change-over relay. When the connections indicated above have been made, the LSA/4 amplifier input is connected to the travellers of the relay, the break contacts of which are connected to the output of the DR/3 amplifier on rack No. 1 and the make contacts to the output of the DR/3 amplifier on rack No. 2. The LSA/4 amplifier input is thus normally across the output of the DR/3 amplifier on No. 1 rack but is transferred to connection across the output of the DR/3 amplifier on No. 2 rack when the key is thrown to its **DRP.2** position, i.e. when only No. 2 channel is in use.

The control unit CU/3, to which the main and monitoring outputs of the DRP/3 amplifier are connected, is equipped with an **on-off** key and an output meter. The meter which is of the metal rectifier type is connected across the cutter-head input in a filter circuit designed to discriminate against the higher frequencies and roughly counterbalance the effect of the

Programme Circuits (*Contd*)

correction applied in the DR/3 amplifier, so that the meter indication is more or less proportional to the volume applied at the input of the DR/3 amplifier. The filter has no appreciable effect on the characteristic of the cutter head because, whereas the input impedance of the latter is of the order of 2,000 ohms the minimum value that the shunt can have is about 50,000 ohms. The value of the resistance in series with the meter itself is made adjustable by means of a pre-set rheostat for purposes of calibration. The required adjustment varies with the sensitivity of the cutter head and the manner in which it is obtained is described later under the heading **Performance Tests.**

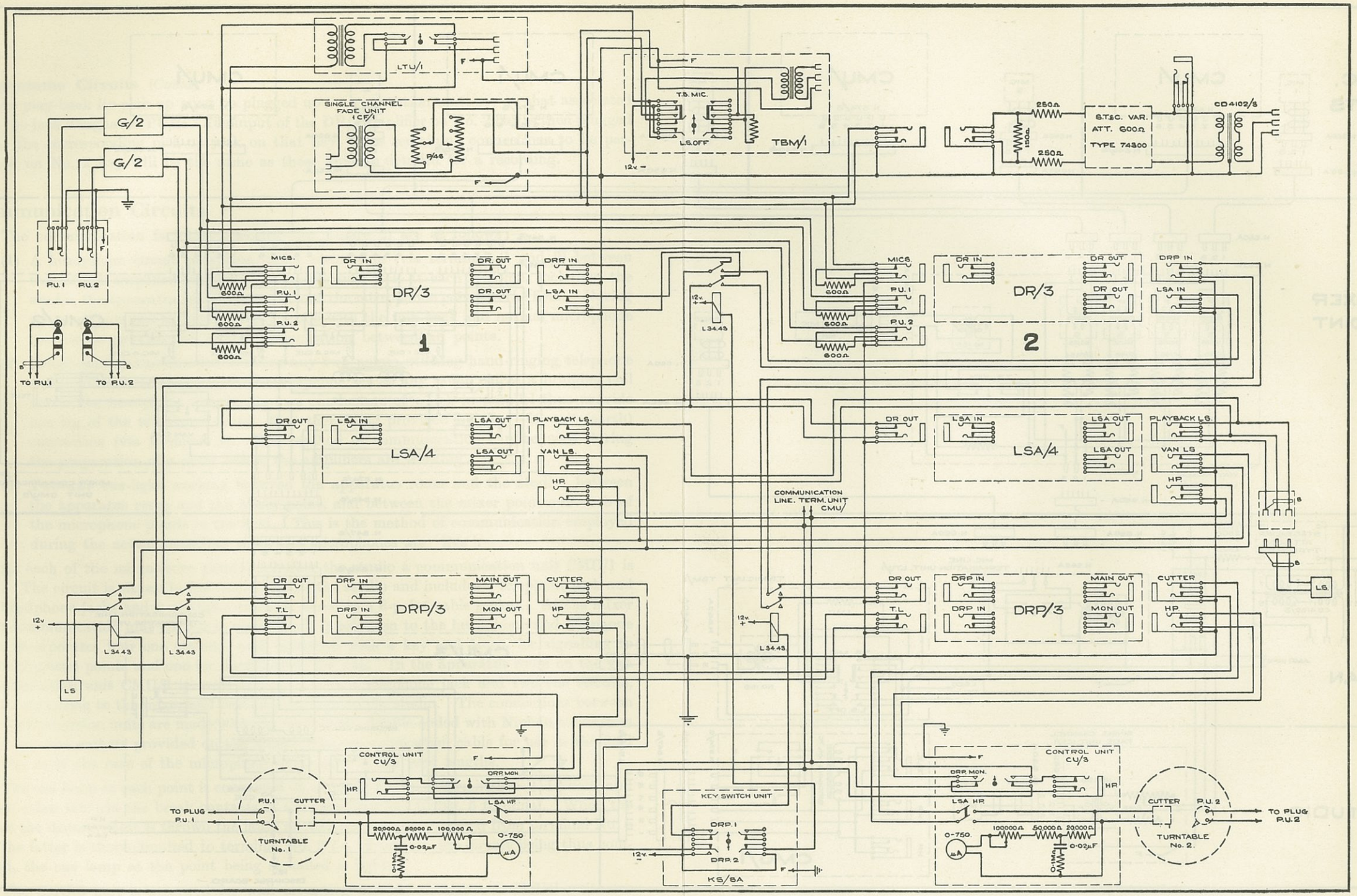
The volume applied to the cutter head is controlled by regulating the gain of the DR/3 amplifier. The potentiometer, P/4A, is connected between the first and second stages of the amplifier but is mounted beside the amplifier unit and is mechanically coupled to a duplicate control knob on the control unit CU/3. A Teleflex Remote Control coupling is used. The spindles of the potentiometer and of the control knob on the CU/3 unit each carry a pinion wheel which engages a wire wound in a spiral around flexible steel cable. The cable runs between the two controls in a brass conduit in which it is a good sliding fit. If the knob at either end is turned the pinion, engaging the spiral, pushes the cable along the conduit thus causing it to turn the pinion at the far end. The controls which thus rotate together have identical scales and always indicate the same setting.

A headphone jack is provided on the control unit for monitoring purposes and by means of a key can be connected either across the monitoring output of the DRP/3 amplifier or across the headphone output of the LSA/4 amplifier.

The talk-back unit in the apparatus room of the van is fitted with a 3-position key for controlling the talk-back microphone and van loudspeaker switching. The monitoring loudspeaker in the apparatus room is connected to the LSA/4 amplifier output via the break contacts of a relay, the operating circuit of which is interrupted while the talk-back key is in its central position but is completed when the key is thrown to either the **T.B. Mic** or **LS Off** position, so that the relay operates and disconnects the loudspeaker. To avoid the momentary howl that would result if the talk-back microphone and the loudspeaker were both live together, the talk-back key is adjusted to make the relay circuits early in its travel and the talk-back microphone circuit as late as possible, while the relay also is adjusted to break the loudspeaker circuit as quickly as possible.

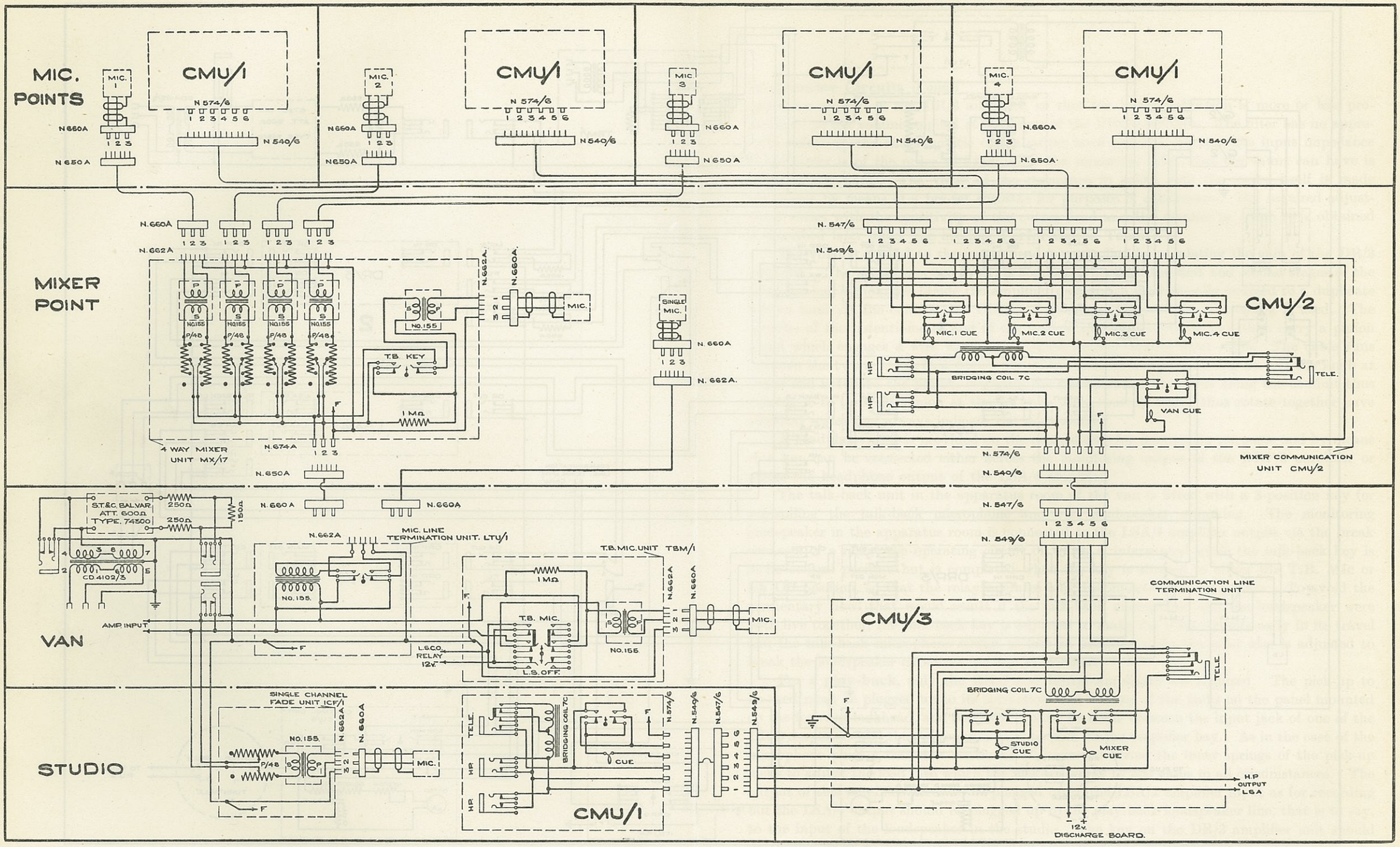
For a **play-back,** only the DR/3 and LSA/4 amplifiers are required. The pick-up to be used must be plugged up to its correction unit via one of the jacks on the panel mounted on the forward bulkhead, and connection must be made between the input jack of one of the DR/3 amplifiers and the appropriate pick-up jack on the amplifier bay. As in the case of the microphone plugs a 600 ohm resistance is connected across the inner springs of the pick-up jacks to adjust the load into which the pick-up works to 300 ohms in all circumstances. The output of this amplifier needs to be plugged up to the LSA/4 amplifier input as for recording but the LSA/4 output should be plugged up to the play-back loudspeaker line, that is to say, to the input of the loudspeaker in the studio. The key on the DR/3 amplifier unit should be thrown so as to switch the cutter-head correction out of circuit.

For '**dubbing**' from one record to another, one turntable will be used for playing-back the original record and the other for cutting the new record. If No. 1 turntable is being used



Drawing C 3827, Issue 3.

Figure 1. General Programme Schematic.



Drawing C 3836, *Issue* 4.

Figure 2. Microphone and Communication Circuits.

Programme Circuits (*Contd*)
for the play-back its pick-up must be plugged up to a correction unit, say to that associated with the jack designated PU/1. The input of the DR/3 amplifier on No. 2 bay is then plugged up to the corresponding pick-up jack on that bay. The remaining connections to be performed on No. 2 bay will be the same as those already detailed for a recording.

Communication Circuits

The communication facilities provided (see Figure 2) are as follows :—

(1) A headphone circuit providing direct connection (via terminals 1 and 2) between the LSA/4 amplifier output and a monitoring jack at each location, including the studio, the apparatus room, the mixer and the microphone points in the field. During rehearsal this can be used in conjunction with the talk-back and normal microphone circuits to provide full inter-communication between all points.

(2) Telephonic communication between any two points utilising hand-ringing telephone sets. The act of plugging in the telephone set at any point places a bridging coil across the headphone circuit, the two conductors of which in parallel thus provide one leg of the telephone circuit, the other being provided by the −12 volt (earth) connection (via terminal 3). This method of communication can be used during the preparation of a show before the amplifiers are working.

(3) Two-way cue-light working between the apparatus room and the studio, between the apparatus room and the mixer point, and between the mixer point and each of the microphone points in the field. This is the method of communication employed during the actual recording when the microphones are ' live '.

At each of the microphone points including the studio a communication unit CMU/1 is used. The circuit is shown in full in the case of the studio and includes a telephone jack and two headphone jacks and a cue light and key, wired to a 6-point cable socket. At the mixer point communication unit CMU/2 is used, which in addition to the headphone and telephone jacks incorporates four cue circuits, each equipped with a key and lamp, for signalling to the microphone points and one for signalling to the van. In the apparatus room on the van communication unit CMU/3 is used, equipped with a telephone jack and two cue circuits, one for signalling to the mixer and one for signalling to the studio. The connections between the communication units are made with six-cored cable, double-ended with Niphan connectors to fix into the sockets provided on the units. The communication cable for use in the field consists, as in the case of the microphone cable, of five 100 yard lengths.

The cue lamp at each point is connected on one side via No. 4 terminal to + 12 volts and on the other side via the break contacts of the signalling key to No. 5 terminal. When the key at the distant point is thrown the lamp at that point is disconnected from terminal No. 5 and the latter is short-circuited to terminal No. 3 (− 12 volts) ; the circuit being thus completed, the cue lamp at the point being signalled is lighted.

The CMU/3 unit is arranged for wall mounting but the CMU/2 and CMU/1 units are built into portable teak boxes provided with compartments for carrying the headphones, moving-coil microphones, and a short microphone lead.

Figure 2 attached.

Power Supply Circuits

The power supply for running the amplifiers and lighting, is obtained from the main 100 volt battery which is installed in two compartments behind the engine on either side of the propeller shaft and is provided with a 70 A isolating fuse in each lead. The battery may be charged either from A.C. mains via a rectifier unit or from a dynamo coupled to the driving engine.

The main charging and discharge switchboards are mounted on the forward bulkhead of the apparatus room, together with the lighting distribution board. The arrangement of the charging board is shown in Figure 3.

The dynamo is gear/chain driven from the power take-off side of the gearbox and is engaged when the engine is running by a separate lever in the driver's cab. It is rated at 2 kW, 15 A. for 1,500—2,200 r.p.m. and is of the compound-wound type.

An automatic regulator is provided for controlling the excitation of the dynamo so as to keep the charging rate from varying. It is of the over-compensating type and has four spring-loaded contact arms tuned to vibrate at a frequency of about 100 cycles per second. These make and break contacts by means of which resistances in series with the shunt field winding are alternately switched into circuit and short-circuited. The voltage of the generator output with the resistances in circuit is much less than the voltage necessary to maintain the charging current at the value required, and with the resistances short-circuited is much greater than this voltage.

The vibratory motion of the contact springs is sustained by an electro-magnet, the coil of which is connected, in series with a variable resistance, across the main charging resistance. When the relay contacts are closed, and the series field resistances short-circuited, the value of the field current, and therefore the charging rate, are rising. The ' pilot ' voltage, i.e. the voltage developed across the charging resistance, which is proportional to the charging current, increases and with it the current in the coil of the electro-magnet. At a certain value of this current the attraction of the electro-magnet on the contact arms will overcome the tension of the retaining springs and the contacts will therefore open. The adjustment is such that the four contacts open in succession and not all together. The removal of the short-circuits places the four series field resistances in circuit. The excitation is thus reduced and the charging current therefore falls and with it the voltage developed across the charging resistance. The current through the coil correspondingly falls until eventually the tension of the retaining springs overcomes the attraction of the electro-magnet and the contacts again close.

The cycle of operations just described is continuous, each cycle being completed in approximately 1/100 second so that, as stated above, the loaded relay contacts vibrate at a speed of approximately 100 cycles per second. The field coils have a high inductance designed to oppose rapid fluctuations of the value of the charging current and this therefore remains constant within very small limits.

While the load remains constant the series field resistances will be alternately in circuit and short-circuited for equal periods and the relay contacts will vibrate about a certain mean position. If, however, due to a change in the load, the charging rate tends to change, there will be a corresponding change in the mean value of the pilot voltage. When this happens the portions of the cycle during which the series field resistances are alternately in circuit

Power Supply Circuits *(Contd)*

and short-circuited will no longer be equal but will adjust themselves so as to provide a new average value of excitation, such as to maintain the value of the charging current unchanged. The mean position about which the loaded contact springs vibrate will therefore change in such a way as to provide the desired ratio between the two portions of the cycle in which the contacts are open and closed respectively. For example, if the equivalent resistance of the load falls, thereby tending to cause the charging rate to increase, the series field resistances will be short-circuited for less than half a cycle ; conversely if the resistance of the load rises so that the charging rate tends to fall, the portion of the cycle during which the series field resistances are short-circuited will be longer than that during which they are in circuit.

The regulator, it will be understood, is a voltage-operated device which acts in such a way as to maintain constant the mean voltage applied across the coil of its electro-magnet, but since this voltage is proportional to the voltage developed across the pilot terminals, the required condition can only be fulfilled by securing a constant current output from the generator. The regulator thus functions in practice as a current regulator. The average value of pilot voltage which the regulator will maintain can clearly be adjusted by suitably setting the variable resistance connected in series with the coil of the electro-magnet. In practice the value of the charging current can be pre-set to any value between 12 and 25 A.

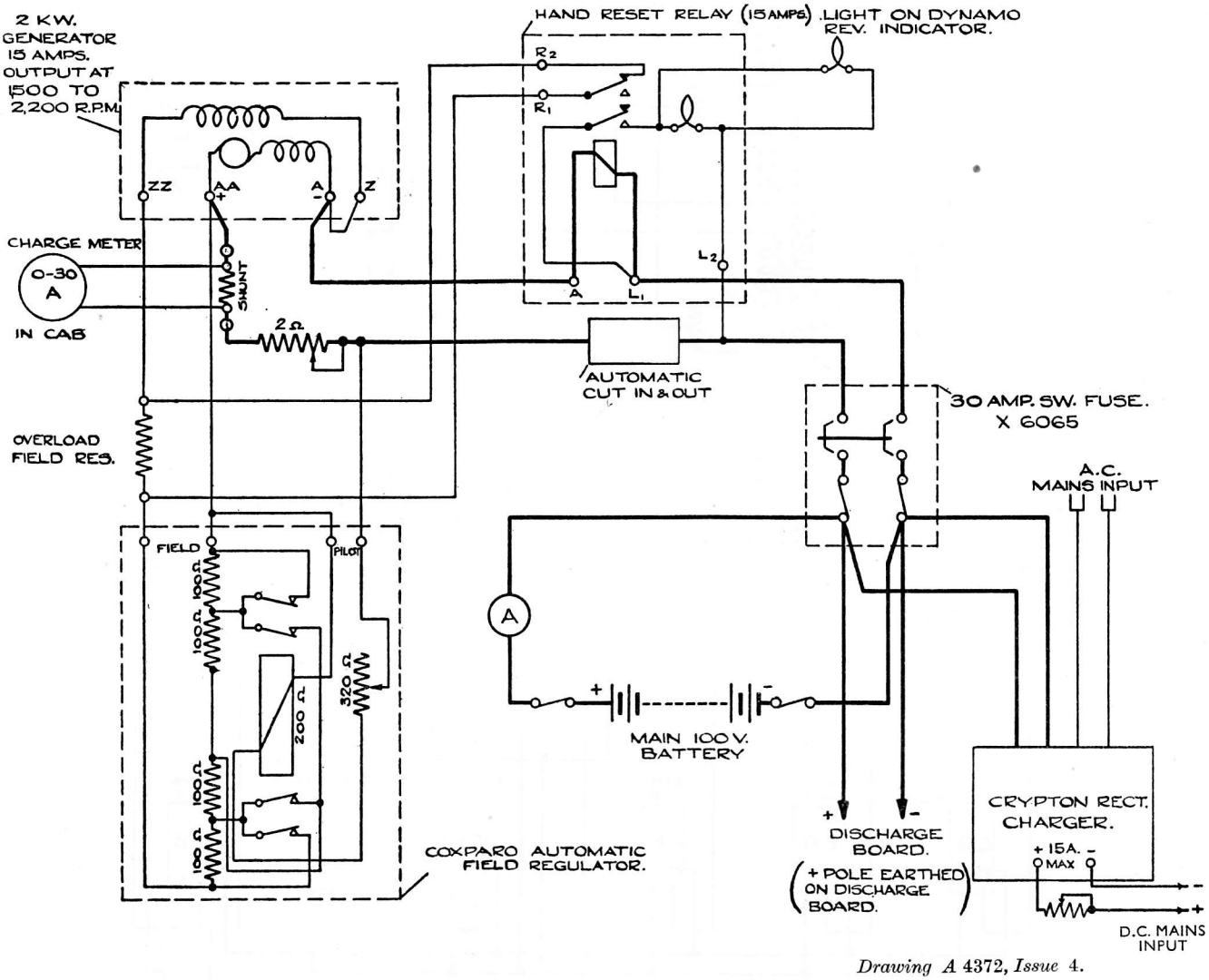
A current overload release is provided as a protection against excessive charging current. This takes the form of a relay with its operating coil connected in the charging circuit and with a resistance in series with the shunt field of the generator short-circuited over one pair of break contacts. When the current increases beyond the value for which the overload release has been set the short-circuit is removed and the excitation of the machine thus reduced to a safe value. At the same time the relay makes a circuit whereby lamps on the dynamo speed indicator on the dashboard in the cab and on the overload release itself are lighted from the main battery. This overload release is installed in the driver's cab and is reset by hand.

The remaining apparatus included in the charging circuit consists of an automatic reverse current cut-out, main contactor, and fuses in both sides of the circuit. The automatic cut-out completes the charging circuit whenever the generator voltage rises above the battery voltage and interrupts this circuit whenever the current reverses, that is, whenever the generator e.m.f. falls below that of the battery. A charging ammeter reading 0—30 A. is provided in the cab and is connected across a shunt included in the charging circuit. An ammeter connected directly in the positive battery lead is provided on the switchboard for indicating the charging or discharge current.

For charging the battery from A.C. mains a Crypton rectifier unit is used, the circuit of which is shown in Figure 4.

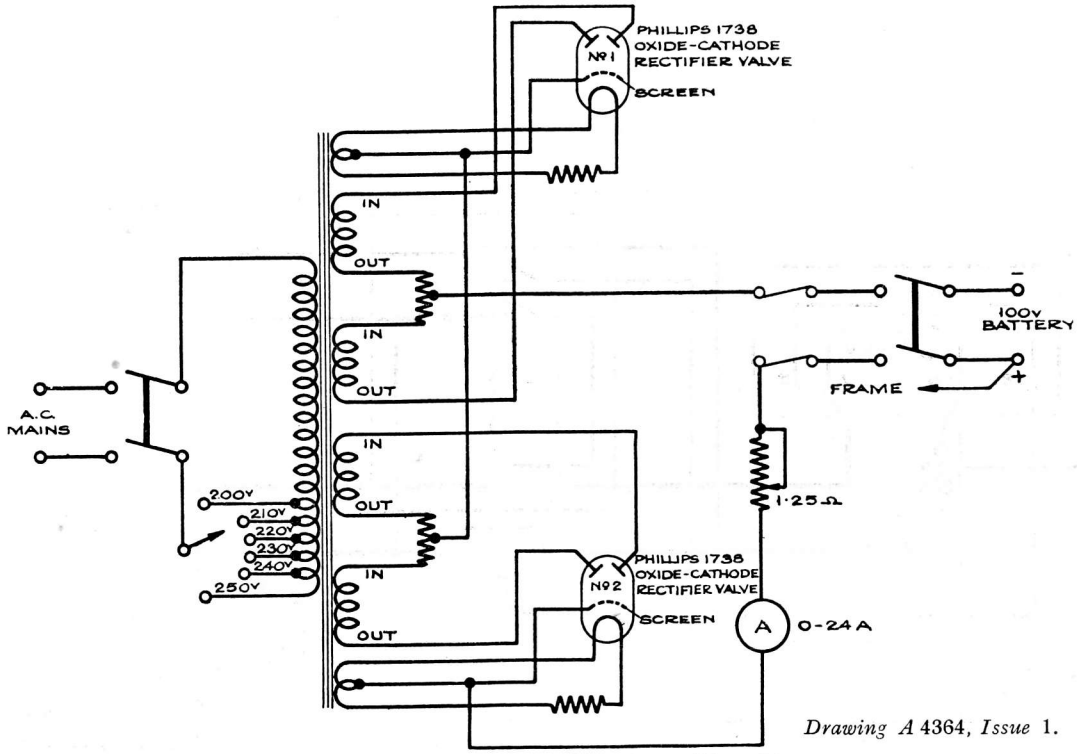
The schematic of the discharge board, BHL/3, is given in Figure 5 and the general schematic of the power wiring in Figure 7. The L.T. and H.T. supplies for the amplifiers are obtained from motor generator sets, one for each amplifier rack. All connections to the racks are made via double-ended cords with Niphan connectors. The circuit of the supply unit on the rack, SHL/1, is shown in Figure 6 which shows the input and output sockets. The cords and connectors are shown in Figure 7.

Referring to Figure 5, the positive pole of the 100 volt battery is taken to frame at the discharge board. The negative pole is connected via a 0—25 ammeter to the negative bus bar



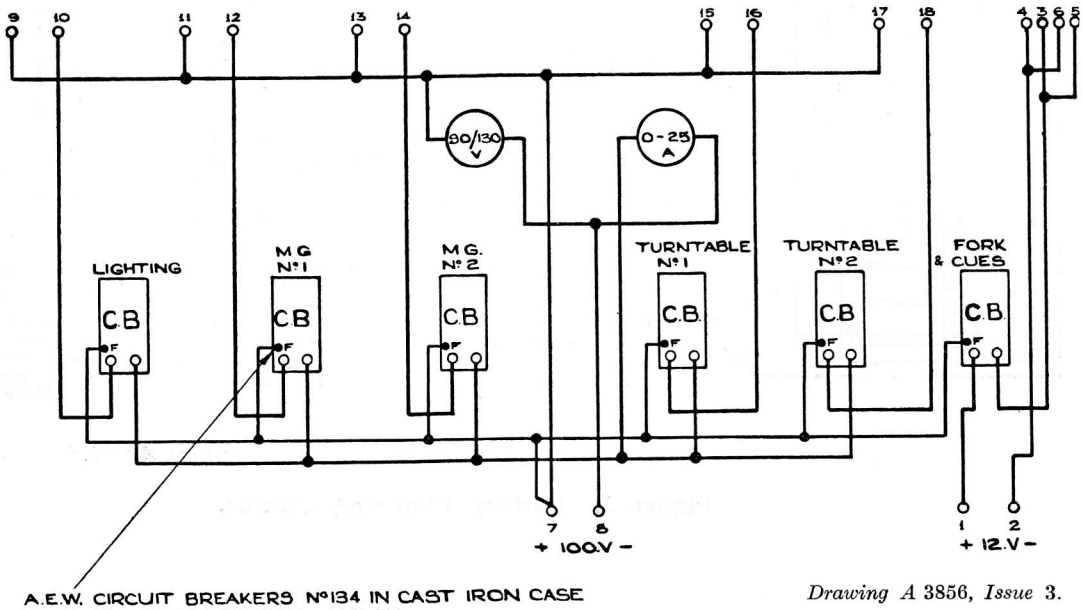
Drawing A 4372, Issue 4.

Figure 3. Battery Charging Circuit.



Drawing A 4364, *Issue* 1.

Figure 4. Crypton Charger Circuit.

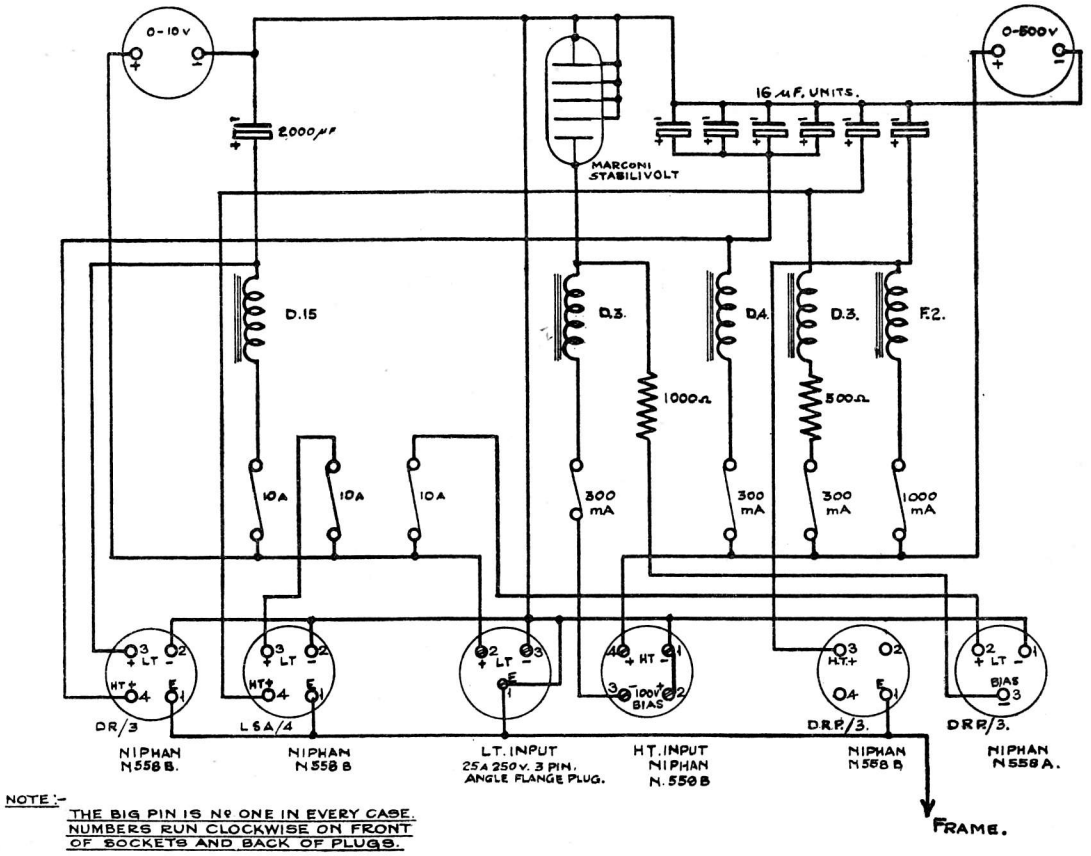


Drawing A 3856, *Issue* 3.

Figure 5. Battery Panel BHL/3.

Power Supply Circuits (*Contd*)

and the feeders to the various supply circuits are taken off through separate circuit breakers which are of the delayed thermal action type. A suppressed zero voltmeter reading 90—130 V is connected across the incoming supply. The power for driving the two turntables and for the lighting is taken direct from the 100 volt battery. From terminals 11, 12, and 13, 14 respectively, supplies are taken off not only for the motor of the motor generator sets but also for the field windings of the H.T. and L.T. generators and for the negative grid bias

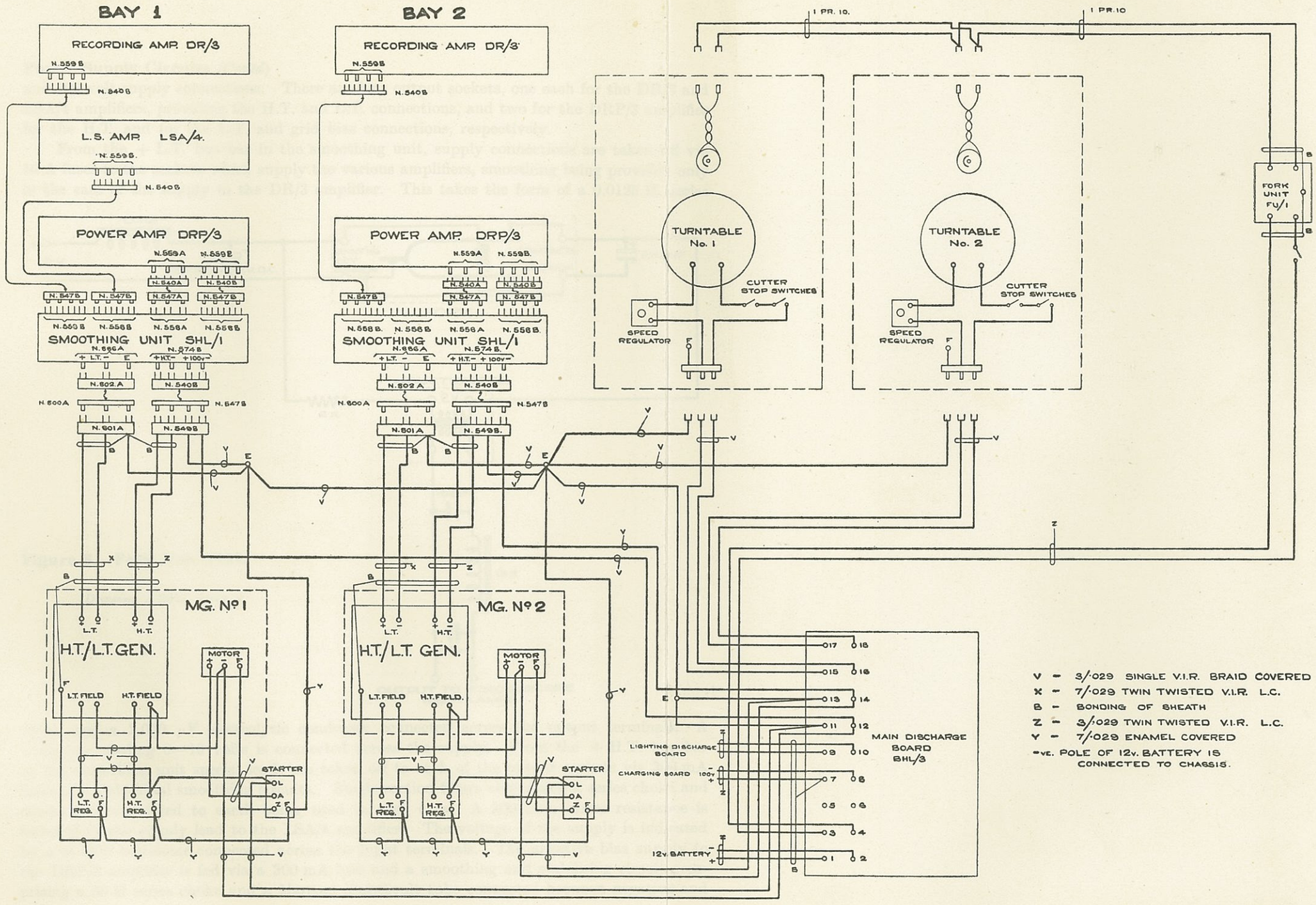


Drawing A 3784, *Issue* 3.

Figure 6. Supply Unit SHL/1.

supply to the power amplifiers, DRP/3. The motor starter and the L.T. and H.T. field regulators are included in the positive lead, in each case. The 12 volt supply leads from the car battery, which is used for supplying the relays, cue lights and the fork unit FU/1, are also connected via a circuit breaker on the main discharge board.

The supply connections to each apparatus rack comprise + L.T. (6 V), + H.T. (420 V), grid bias (− 100 V) and frame (− L.T., − H.T. and + 100 V). Referring to Figure 6, on the SHL/1 unit there are two input sockets, one for the L.T., and the other for the H.T.



Drawing C 3826, *Issue* 3.

Figure 7. General Power Wiring Schematic.

Power Supply Circuits (*Contd*)

and 100 volt supply connections. There are four output sockets, one each for the DR/3 and LSA/4 amplifiers, providing the H.T. and L.T. connections, and two for the DRP/3 amplifier for the H.T. and for the L.T. and grid bias connections, respectively.

From the + L.T. bus bar in the smoothing unit, supply connections are taken off via 10 A fuses to the sockets which supply the various amplifiers, smoothing being provided only in the case of the supply to the DR/3 amplifier. This takes the form of a 0.0125 H. series

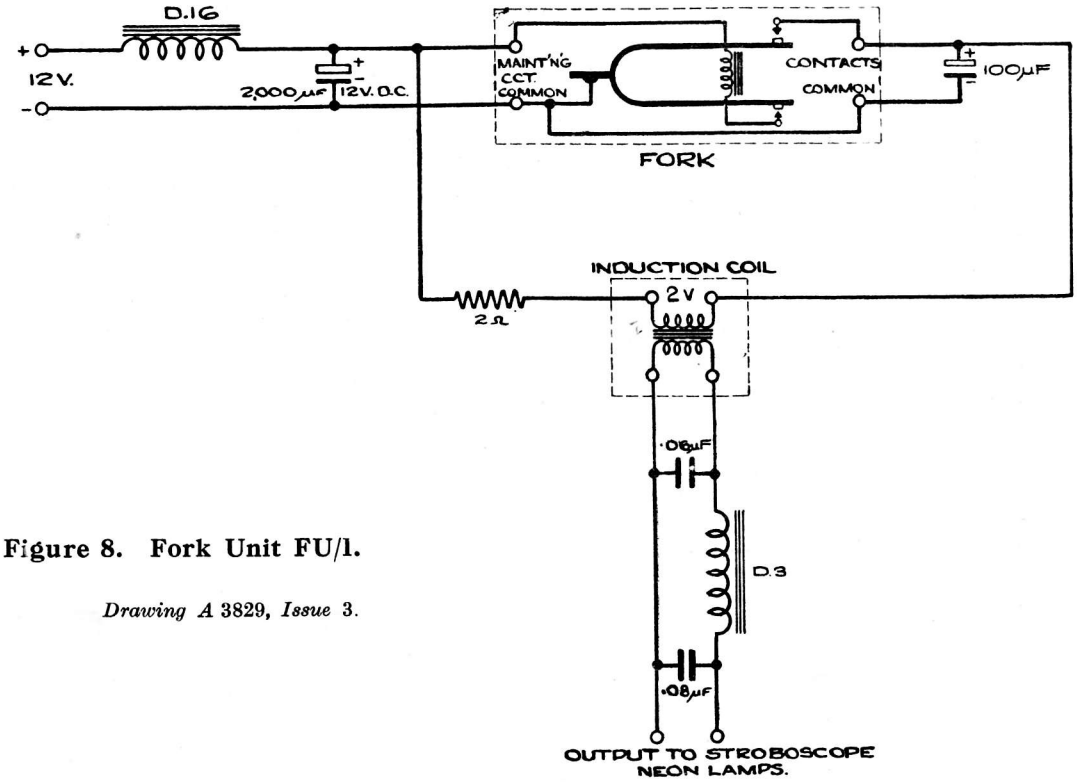


Figure 8. Fork Unit FU/1.

Drawing A 3829, *Issue* 3.

choke and a 2,000 μF electrolytic condenser connected across the output terminals. A voltmeter reading 0—10 volts is connected across the supply. From the + H.T. bus bar in the smoothing unit special leads are taken off to each of the output sockets via 300 mA fuses and individual smoothing circuits. Single section filters comprising a series choke and condensers connected to earth being used in each case. A 500 ohm series resistance is included in the supply lead to the LSA/4 amplifier. The voltage of the supply is indicated by a 0—500 voltmeter connected across the input terminals. The negative bias supply to the DRP/3 amplifier is fed via a 300 mA fuse and a smoothing and stabilising circuit comprising a 50 H series choke and a Marconi Stabilivolt tube connected between negative and earth.

The turntables are operated by a D.C. motor, the field and armature of which are supplied from the 100 volt supply. A series rheostat included in the negative lead functions as the

Power Supply Circuits (*Contd*)
speed regulator and is provided with an **off** position. The cutter stop switches which are automatically operated by a projection on the traversing carriage, when this reaches the extreme limits of the permissible traverse, are included in the positive lead.

The main D.C. supply from the discharge board and the A.C. supply for the neon lamps from the fork unit are brought to 3-pin sockets on the front bulkhead and are extended thence by flexible leads to a connecting block under each recording table to which the motor and lamp wiring is connected.

The arrangement of the fork unit, FU/1, is shown in Figure 8. The primary winding of the induction coil is connected, via one of the fork contacts in series with a 2 ohm resistance and the body of the fork itself, across the incoming 12 volt supply circuit. This includes a smoothing filter, comprising a 0.03 H choke in the positive lead and a 2,000 μF electrolytic condenser connected between positive and negative, designed to prevent interference from being fed back over the battery wiring. The fork makes and breaks its contacts 50 times a second, and thus provides in the secondary of the induction coil an A.C. of this fundamental frequency. The other contact of the fork is included in the maintaining circuit, making and breaking the circuit of the restoring electro-magnet, which is also fed from the incoming 12 volt supply. A 100 μF electrolytic condenser connected across the fork circuit provides for spark-quenching, while in the secondary circuit of the induction coil a filter is included for suppressing in the output all but the fundamental component of 50 c/s.

Recording Machine

The recording machines were supplied by the Marguerite Sound Studios Recording Company. They operate on the same principle as the machines used in the recording studios but the construction has been simplified in various ways.

The machine is illustrated in Figures 9 and 10† in which the various parts are numbered so that they may be identified by reference to the list accompanying the figures. Where parts appear in both figures the same reference number is used.

The principle of lateral recording is used in which a spiral groove is cut in the surface of a cellulose-coated metal disc and the programme record appears as lateral displacements of the groove about its mean position.

The recording machine consists essentially of a turntable (1) driven through suitable gearing by an electric motor and of a mechanism, mechanically coupled to the main drive, for traversing the cutter head over the recording blank.

The driving system is mounted under the main plate and is not visible in the pictures. It is arranged for driving the turntable at a speed of 78 r.p.m. and for traversing in either direction at a speed to provide for cutting 100 grooves to the inch.

A D.C. motor is used and is coupled to the main vertical driving shaft through a worm-reduction gearbox. The motor is mounted in a tray on a sorbo-rubber pad and is held in position by metal straps with sorbo-rubber pads inserted between the straps and the top of the motor. A flexible coupling is used for connecting the motor shaft to the worm-driven shaft of the gearbox. The turntable shaft is directly driven by the gearbox shaft through a flexible coupling and the driving shaft for the traversing mechanism is driven by means of a belt and pulleys from the turntable shaft.

† *Figures* 9 *and* 10 *attached to p.* 15.

Recording Machine *(Contd)*

The speed of the motor is controlled from the front panel by means of a series regulator, the control handle of which also serves as the main switch, the supply to the motor being cut off when this is in its extreme left-hand position. A neon lamp (5) is provided on the main plate of the machine in a torch-holder so that it illuminates the edge of the turntable on which stroboscopic markings in the form of equally-spaced dots are provided. The neon lamp is connected to the 50 c/s supply provided by the fork unit and the motor speed is adjusted by the regulator until the dots on the rim of the turntable appear stationary as they pass the lamp, which occurs when the turntable is revolving at 78 r.p.m.

The traversing carriage (6) which supports the cutter-head frame (18) runs on a track (7) with ' V ' shaped guides, rather like the bed of a lathe, and is made to traverse by the engagement of a half-nut (15) with a lead-screw (8). The lead-screw is driven through bevel gearing by a vertical shaft (10) which in turn is driven by the pulley. This shaft carries two bevel pinions (11 & 12) and is free to slide up and down sufficiently to enable either of the pinions to engage the wheel (9) on the end of the lead-screw, the drive being communicated to it by means of a spline on the shaft which fits into a keyway in the pulley. A lever (13) with a wedge-shaped cam (14) on the under-side is provided for adjusting its position, the shaft being held with its top in contact with the side of the wedge by a spring. When the lever is in its left-hand position the wedge is withdrawn and the shaft is lifted by the spring so that the lower pinion (11) engages the wheel on the lead-screw, which is therefore rotated in such a direction that the carriage traverses from back to front and the groove in the record is cut from inside to outside. When the lever is in its central position both pinions are disengaged When it is in its extreme right-hand position the driving shaft is depressed by the wedge. The upper pinion (12) is therefore caused to engage the bevel wheel on the lead-screw which is thus rotated in the reverse direction so that the carriage traverses from front to back and the groove is cut from outside to inside.

The half-nut (15) is held in contact with the lead-screw (8) by a spring, and a lever (16) with a toggle action is provided on the carriage, for lifting the half-nut clear of the lead-screw, to enable the carriage to be freely moved by hand. An alternative method of adjusting the position of the carriage by hand is to use the handle (17) provided in a clip on the main plate which can be attached to the front of the lead-screw. In this case the clutch lever (13) should be placed in the **neutral** position and the half-nut should be engaged.

The cutter-head frame (18) is attached to the carriage by means of a bolt (19) about which it hinges. Its other end is supported, when lowered into the working position, by a small wheel running on a raised track (20) ; the bracket carrying the wheel bearings is pivoted and an adjusting screw (21) is provided for setting the height at which this end of the cutter-head frame is supported.

The turntable (1) is slightly dished to ensure that when a disc (3) is clamped into position its edge will not be wavy but will press firmly against the rubber mat (2) that lies on the turntable. To provide that the cutter (27) will be perpendicular to the surface throughout the traverse, so as to maintain an even depth of cutting, the end-track (20) must be similarly inclined, but as the cutter is approximately half way between the horizontal traversing mechanism and the end-track the inclination of the latter towards the horizontal is made approximately twice that of the turntable surface.

Recording Machine (*Contd*)

The cutter head (22), which is carried between two pivots in the cutter-head frame, contains a moving armature system, the cutter holder (23) on the under-side of the head being carried by the armature. The depth of the groove is determined by the pressure applied to the point of the cutter and this can be adjusted as desired by suitably adjusting the position of the cutter-head pivots. The pivot shafts (24) are clamped to the sides of the cutter-head frame and are provided with slotted holes. The saddle (25) on the cutter head is provided with a number of pivot bearings on each side and with slotted holes for the fixing screws. There is also a pin (26) projecting from the end of the cutter head by means of which final adjustment of the suspension can be made by the use of sliding weights.

The position of the cutter-head pivots is adjusted so that the point of the cutter traverses the disc radially, and the height of the end of the cutter-head frame supported by the end-track is adjusted as mentioned so as to make the cutter perpendicular to the surface of the disc throughout the traverse. The depth of the cut is adjusted by suitably positioning the axis of suspension to obtain the appropriate pressure on the cutter point, to secure an average ratio of groove width to wall thickness of 1.5:1 (60% groove and 40% wall).

A cam (28) is provided for lifting the cutter off the record when required and operates by tilting the cutter head. A transverse bar (29) serves as a back-stop to check the movement of the cutter head when it is thrown up by the operation of the lifting cam.

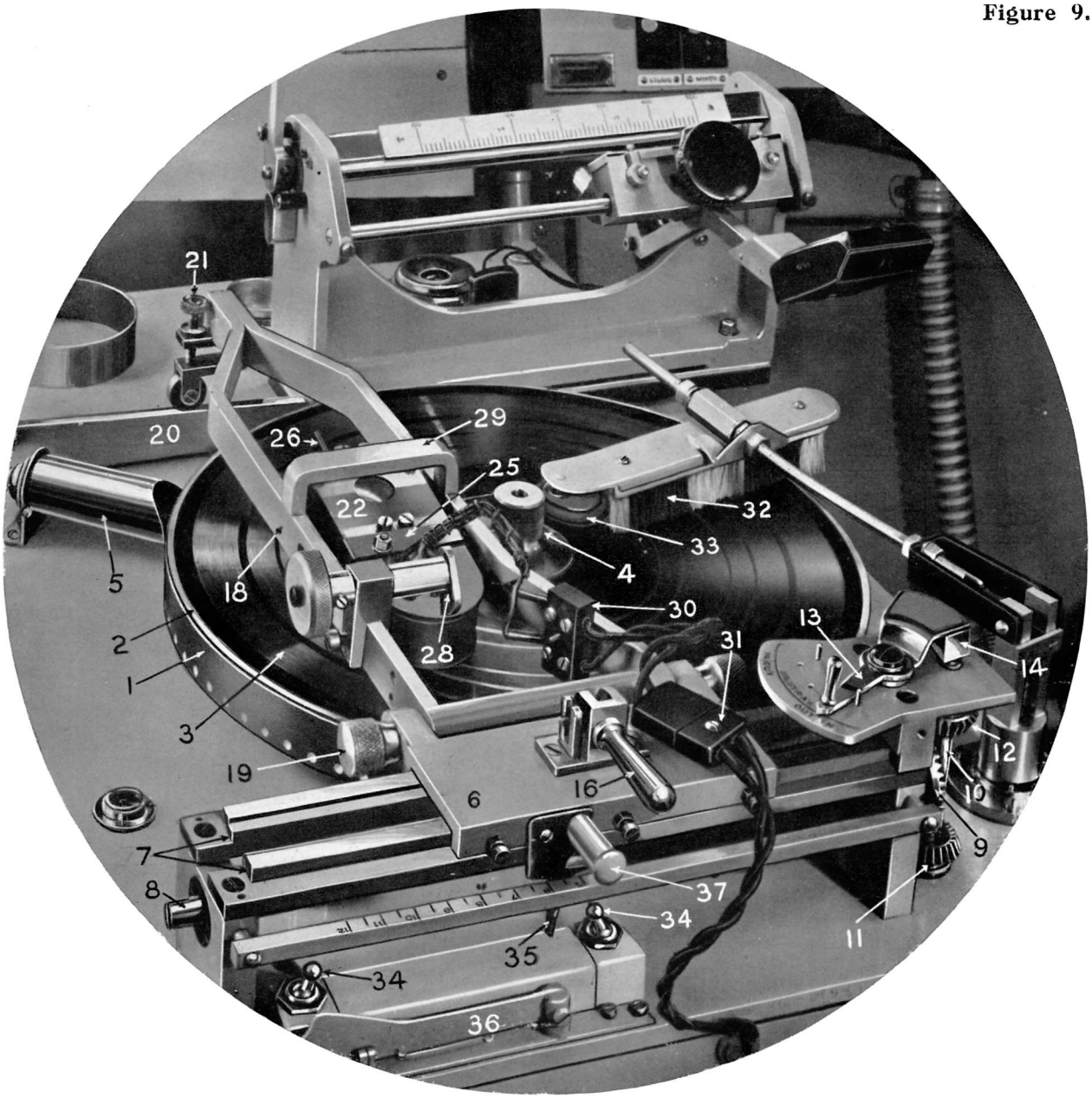
The connections to the cutter head are made via a connecting block (30) mounted on the cutter-head frame. This is wired to a two-way socket (31) which accommodates the plug terminating the input lead. The cutter consists of a round rod about $\frac{3}{4}''$ in length and $\frac{1}{16}''$ in diameter, with one side ground away at one end to approximately half the diameter to form a flat cutting face. The opposite side is also flattened slightly and at the end is ground off on each side at an angle so as to form a cutting point with an angle of approximately 90° in the middle of the cutting face. The cutter is inserted in its holder in such a way that the cutting face leads, that is to say, when the cutter is lowered into the working position the cutting face ' looks ' towards the right.

During the recording, the cutter removes a thread of material and it is found that if the cutter is placed in the head with the plane of the cutting face radial there is a tendency for the thread to clog the cutting point. The cutter is, therefore, inserted with its cutting face inclined a few degrees away from the radial direction towards the centre so that it tends to throw the thread in that direction. A brush (32) is provided for removing the swarf from the groove. The brush is mounted at the end of a pivoted rod and is provided with an eccentric (33), the rim of which is held in contact with the clamping boss of the turntable by a spring in the pivot support. As the turntable revolves the eccentric causes the brush to oscillate backwards and forwards over the surface of the disc being cut, thereby sweeping the swarf from the grooves and enabling it to collect at the centre.

To prevent the carriage from over-running, a pair of switches (34) controlling the main supply to the motor are provided on the carriage bed and are automatically operated by a projection (35) on the under-side of the carriage when it reaches either of its extreme positions, which are adjusted for a 13″ disc to permit of cutting between radii of 2″ and $5\frac{3}{4}''$. This gives a maximum playing time of about $4\frac{3}{4}$ minutes.

On the right of the traversing mechanism there is a lever (36) for cutting a ' run-out ' groove in the case of a record which does not occupy the whole of the cutting surface. To

Figure 9.



Disc Recording Machine

Figure 10.

REFERENCES

1. Turntable.
2. Rubber Mat.
3. Disc Recording Blank or Record.
4. Clamping Boss.
5. Neon Lamp Holder.
6. Traversing Carriage.
7. Carriage Track.
8. Lead Screw.
9. Bevel Wheel on Lead Screw.
10. Traverse Driving Shaft (*Fig.* 1 *only*).
11. Outwards Traverse Bevel Pinion (*Fig.* 1 *only*).
12. Inwards Traverse Bevel Pinion.
13. Clutch Lever.
14. Wedge-shaped Cam.
15. Half-nut (*Fig.* 2 *only*).
16. Lever for engaging or releasing 15.
17. Handle for manually operating Lead Screw (*Fig.* 2 *only*).
18. Cutter-head Frame.
19. Cutter-head Frame Hinge Bolt.
20. Cutter-head Frame End-track.
21. Cutter Angle Adjustment Screw (*Fig.* 1 *only*).
22. Cutter Head.
23. Cutter Holder (*Fig.* 2 *only*).
24. Cutter-head Pivot Shafts (*Fig.* 2 *only*).
25. Cutter-head Pivot-bearing Saddle (*Fig.* 1 *only*).
26. Pin for sliding weights.
27. Cutter (*Fig.* 2 *only*).
28. Cutter-head Lifting Cam.
29. Back Stop.
30. Connecting Block.
31. Plug and Socket (*Fig.* 1 *only*).
32. Swarf Brush.
33. Eccentric.
34. Mains Switches (*Fig.* 1 *only*).
35. Projection for operating 34 (*Fig.* 1 *only*).
36. 'Run-out-Groove' Lever.
37. 'Run-out-Groove' Stud (*Fig.* 1 *only*).

Recording Machine (*Contd*)

do this, the carriage is disengaged from the lead-screw when the end of the recording is reached (either by placing the clutch lever in the neutral position or by operating the half-nut release lever on the carriage) and the ' run-out ' lever is then raised so that it engages a stud (37) on the side of the carriage. The latter is then moved by continuing the upward movement of the lever until it reaches its extreme position, thereby cutting a groove which, when playing-back the record, will carry the needle quickly to the centre of the disc on the completion of the play-back.

A pick-up head with parallel tracking arm of the standard pattern is provided, for use with the recording turntable for playing back the records, the swarf-brush and cutter-head frame being raised for this purpose.

The machines are mounted on their pedestals by means of a compound hinge comprising two simple hinges mutually at right-angles, and are supported at two points, opposite the openings of the component hinges, by hydraulic rams. These each comprise a plunger ' C ' and a cylinder ' D ' (see Figure 11) mounted approximately vertically with their balled ends resting in hemispherical cups carried on the underside of the bed-plate of the machine and on an arm projecting from the pedestal near its base. A screw force-pump is used for operating the ram with its cylinder clamped to the front panel encasing the machine drive and its screw projecting from the front. Clockwise rotation of the screw forces the plunger of the pump into the cylinder and expels oil from the chamber ' B ' through the connecting pipe into the chamber ' A ', thereby causing the ram to rise, open the hinge, and tilt the bed of the machine. Conversely, counter-clockwise rotation withdraws the plunger of the pump and allows oil to be expelled from chamber ' A ', under pressure due to the weight of the machine, into chamber ' B ', so that the ram falls and the hinge closes. The arrangement thus enables the bed of the machine to be tilted in two directions mutually at right-angles so as to compensate for the slope and camber of the road. A spirit level is provided on the machine bed and the turntable is horizontal when the bubble viewed from above has been duly centred. In course of time a certain amount of oil is lost from the system past the rubber washers that sit on the tops of the ram and pump plungers, and it is necessary periodically to replenish the supply. For this purpose a filling hole with a screw cap is provided at the top of the cylinder of the ram. The procedure for carrying out this operation is detailed in the **Maintenance** section.

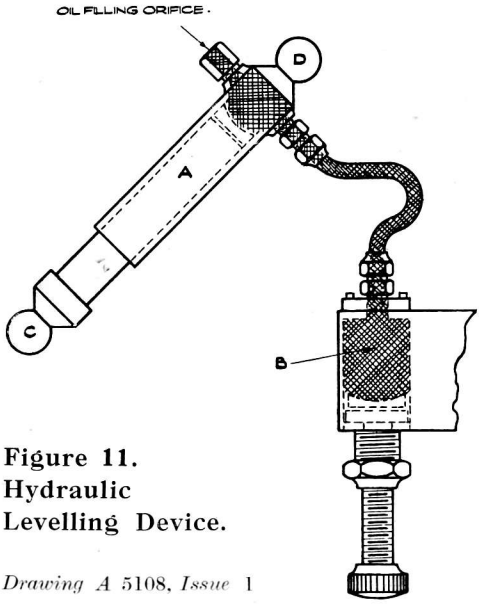


Figure 11. Hydraulic Levelling Device.

Drawing A 5108, Issue 1

Operation

Assuming that the machines are in adjustment and have been levelled and electrically lined-up, the procedure for **cutting a record** is as follows :—

(1) Close the fork power switch and the switch at the back of the fork unit and start the fork manually. The neon lights in the torch holders on the machine beds should then glow.

(2) Check that the starting rheostat on both machines is in its minimum position and then make the machine breakers on the main discharge panel. In cold weather run the machines slowly for a minute or two to help circulate the heavy oil in the gearbox and run up the turntables to the correct speed which will be indicated when the markings on the rim of the turntable appear to be stationary at that part adjacent to the neon light. (The speed will need to be watched since it is likely to vary slightly when the machine warms up.)

(3) The cutter-head frame corresponding to the correction unit in circuit in the DR/3 amplifier should be mounted on the carriage of each machine and a new cutter inserted in the holder. The cutter-head frame should be raised, the clamping screw slackened and a new cutter inserted in the holder so as to bottom in the hole. The cutting face should be turned so that it faces downwards and slightly towards the centre. The clamping screw should then be tightened with a small screwdriver, care being taken not to overstrain it. A new cutter should be used for each record. (If a screw should be broken off, the cutter head should be immediately taken out of service. No attempt should be made to drill out the broken screw.)

(4) Close the main breakers associated with the motor generators and with the field rheostats in their minimum positions, run up the motors on their starting resistances. The output voltages from the generators should then be adjusted by means of the field regulators and the voltmeters on the supply units, SHL/1, to 5 volts L.T. and 420 volts H.T. These positions are indicated by a red line on the meters. The L.T. supply to the amplifiers should then be switched on and any necessary compensation to the L.T. output voltages from the generators made by readjusting the field rheostats. About 30 seconds should be allowed to elapse before H.T. to the various units is switched on and once again any drop in voltage should be compensated for by adjusting the appropriate field rheostat.

(5) It is assumed that where external microphones are to be used they will have been run out and that the necessary connections to the line termination and communication units will have been made and the circuits tested out. The following connections should be carried out with double-ended cords.

DR/3 amplifier input to microphone jack.
DR/3 amplifier output to DRP/3 input (tie line).
DR/3 amplifier output to LSA/4 input (tie line).
DRP/3 amplifier input to DR/3 output (tie line).
DRP/3 amplifier output (main) to cutter input.
DRP/3 amplifier output (Mon) to H.P. input of CU/3 unit.
LSA/4 amplifier input to DR/3 output (tie line).
LSA/4 amplifier output to van loudspeaker input.
LSA/4 amplifier output to main H.P. circuit input.

Operation (*Contd*)

(6) The clamping boss on the turntable shaft should be removed and a recording blank placed in position on the turntable on top of the rubber mat with the recording surface upwards. The boss should then be replaced and pressed down firmly so as to clamp the blank and rubber mat tightly against the dished top of the turntable. With the ' raise-lower ' knob in the **raise** position the cutter-head frame should be lowered so that the free end is supported by the end-track. The carriage should then be run forward by hand until it is in the extreme forward recording position (that is to say, until the projection on the carriage reaches the forward trip switch but of course does not operate it). The lever on the carriage should be lowered so as to engage the half-nut and the swarf brush lowered on to the disc.

The recording blanks should remain sealed in their tins until immediately before use and should be stored away from heat. If they are exposed to air for a long period before use they will become too dry and the record will be noisy.

(7) The **DRP/1—DRP/2** key should be operated appropriately according to whether one or both machines are to take the recording. The clutch lever should be placed in the extreme right-hand position for tracking from outside to inside, and, after two or three revolutions of the turntable, for taking up the back-lash of the traversing mechanism, the cutter should be lowered on to the recording blank. The appropriate cue should now be given to the studio or to the mixer, according to the source from which the programme is being taken, and the cutter input then completed by means of the key on the CU/3 panel and the programme faded up. Throughout the recording the volume should be regulated so as to peak to 500 on the output meter during loud passages.

The precise order in which the foregoing operations to commence cutting a record are carried out will depend somewhat upon the circumstances. For example, if part out of the middle of a show is to be taken, the cutter head should be lowered only on receipt of the cue from the mixer or the studio and the programme faded up at the appropriate moment as judged on the loudspeaker or headphones.

(8) At the end of the record the programme should be faded out and the cutter-head input circuit interrupted by operating the **on off** key on the CU/3 panel. The clutch should be moved into the **neutral** position and the half-nut disengaged by raising the lever on the carriage. The cutter-head frame and the swarf brush should then be raised and the clamping boss removed. The disc can then be removed with the motor still running, by gently working the finger tips between it and the rubber mat. A clean blank can then be fixed on the turntable in readiness for a new recording.

(9) After the swarf has been removed the finished record is placed on the bench and subjected to vaseline treatment in order to ensure lubrication of the record and to prevent the cellulose drying out. The vaseline should be worked well into the grooves of the record. The surplus vaseline should then be removed and the record polished with clean muslin, using a brisk circular movement but without applying great pressure. The bench, the vaseline and the polishing material must be kept clean and free from dust.

Operation (*Contd*)

(10) Where **series recording** is to be used, the second machine should be prepared in the manner detailed in (6), but since the two machines may be required to record in parallel for a few seconds during the change-over the **DRP/1—DRP/2** key should be thrown to its central position.

(11) For **dubbing** from one record to another the cutter-head frame and swarf brush of the turntable to be used for the play-back should be raised and its pick-up plugged up to one of the gramophone correction units, using the jacks provided on the forward bulkhead. The input of the DR/3 amplifier associated with the other machine should then be plugged up to the corresponding pick-up jack on its amplifier rack. The remaining connections between the amplifiers on this rack will be the same as for recording and the preparations for the recording should be carried out in the manner outlined above.

The precise procedure will depend upon the circumstances. The **DRP/1—DRP/2** key should be thrown to the position corresponding to the machine used for the recording. Both turntables should be running and the pick-up should be lowered a little before the passage to be re-recorded is reached, the cutter head on the machine recording should be lowered but it should not be faded up until the passage is actually about to commence.

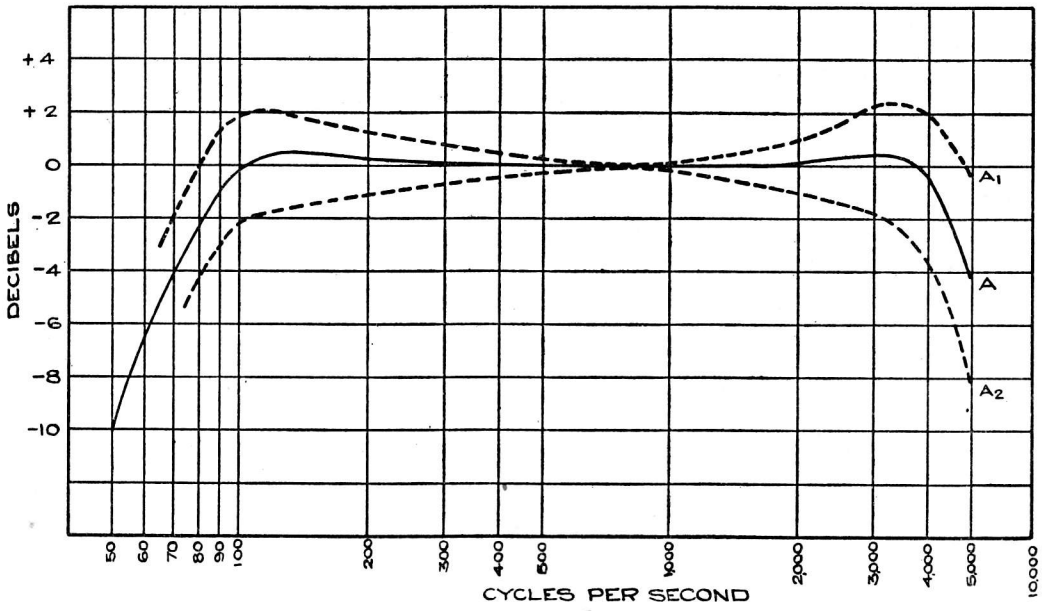
(12) For a normal **play-back** the swarf brush and the cutter-head frame of the turntable to be used should be raised and the record placed in position. The pick-up should be plugged to a gramophone correction unit by means of the jacks provided on the forward bulkhead, and the input jack of the DR/3 amplifier on the rack associated with this machine should be plugged up to the corresponding pick-up jack. The key on the amplifier panel should be thrown so as to cut out the correction circuit. The output of this amplifier should be plugged up to the LSA/4 amplifier input and the output of the LSA/4 amplifier should be plugged up to the play-back loudspeaker in the studio. If desired, the cue circuit can be used for signalling from the studio when the pick-up should be lowered.

(13) Upon the completion of the recording the cutter-head frames should be unbolted from the carriages, the hinge-bolts being replaced and the frames with the cutter heads in position suspended in the shock-absorbing mountings provided for transport.

Performance Tests

The performance tests are designed to provide a routine check on the sensitivity of the cutter heads and the frequency response characteristics of the recording and reproducing channels as a whole.

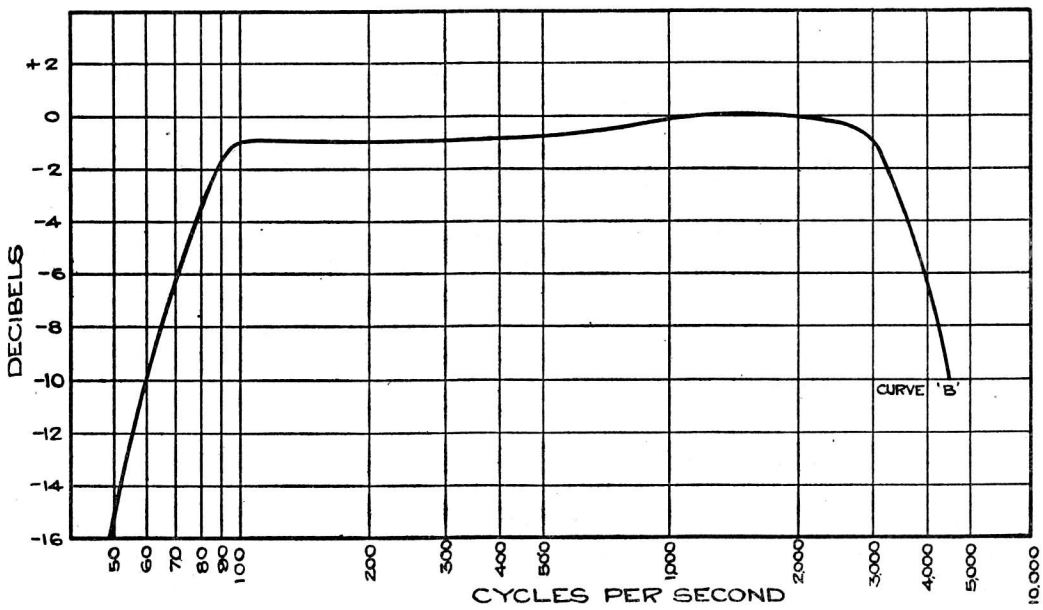
The sensitivity tests applied to the cutter head comprise two separate tests, namely for Standard Sensitivity and for Working Sensitivity. The former is designed to check the performance of the cutter head in order to determine whether it conforms to the minimum sensitivity requirements and is performed like the frequency response tests as a matter of maintenance routine once a week or whenever there is any doubt regarding the overall quality



Drawing A 5228, Issue 1

'A' = Standard curve with Pick-up Curve 'B' from XTR.22.
A_1, A_2 = Upper and Lower Limits.

Figure 12. Overall Frequency Response Characteristic.



Drawing A 5229, Issue 1

Figure 13. Pick-up Frequency Response Characteristic.

Performance Tests (*Contd*)

obtained from the equipment. The latter is a working adjustment and is designed to determine the appropriate adjustment for setting up the zero of the cutter-head meter to compensate for any slight change in sensitivity of the cutter head that may have occurred since the cutter head was last in use. It is performed immediately prior to starting up the machine whenever a recording is to be made.

For the purposes of the performance tests a source of tone and means of measurement are necessary. They are therefore normally carried out when the recording van is at B.B.C. studio premises so that the tone can be supplied by line from the tone source in the control room and the necessary measurements made by the use of measuring equipment provided in the control room. In the case of the sensitivity tests, however, where only 1,000 c/s tone is required, a source for emergency use in the field is provided by the standard test record *XTR*.27.

Where the tone is supplied from an adjacent B.B.C. control room, the line will be terminated at the van on the variable attenuator unit which should be plugged up to the microphone input. The 600 ohm output of the tone source (TS/5) should be used and its gain control should be set for maximum output (approximately + 25 db.). The attenuator should then be set to introduce a loss sufficient to reduce the level of the incoming tone across the microphone jacks to approximately − 60 db. to correspond roughly with the normal microphone output level. From the microphone jack the tone is applied to the cutter head via the normal recording channel, the level actually applied to the head being controlled, as in the case of a programme, by means of the DR/3 amplifier volume control.

The sensitivity and frequency response tests on the cutter head are made by cutting a record and measuring the output level obtained when the record is played back. In the case of the sensitivity tests only a single frequency, namely 1,000 c/s, is used and the level obtained from the record is compared with that obtained from the test record *XTR*. 27 when played back under similar conditions. For the Standard Sensitivity test the standard portable meter provided is used in place of the normal monitoring meter for adjusting the level at which the tone is supplied to the cutter head. In the case of the frequency response tests a number of test frequencies is used and the record is played back with a standard B.T.H. pick-up followed by an A/8 amplifier terminated with 600 ohms, and the output is measured with a test programme meter or amplifier detector. The results are plotted and the curve obtained is compared with a standard curve giving the ideal frequency characteristic and the permissible tolerances.

The frequency response of the pick-ups is measured by using each to play-back the standard multiple frequency record *XTR*. 22 and measuring the level obtained at each frequency in the output of the DR/3 amplifier operating as a straight amplifier, using the standard portable meter. The curve obtained by plotting the results is then compared with the standard curve giving the ideal pick-up frequency characteristics. No test is provided for measuring the actual sensitivity of the pick-ups because in general any serious depreciation in sensitivity would be accompanied by severe distortion of the frequency response characteristic.

As stated, where sensitivity tests have to be carried out in the field, the test record *XTR*. 27 itself can be used as the source of 1,000 c/s tone for making the comparison record, the

Performance Tests (*Contd*)

necessary connections being those for ' dubbing ' from one record to another described in the section of **Operation.** For comparing the levels the monitoring meter connected across the cutter head can be used.

Measurement of Standard Sensitivity. The standard portable cutter-head meter provided should be connected across the cutter-head leads on the machine, and a band cut using 1,000 c/s tone adjusted to provide a reading of 500 on the standard meter. The level recorded should then be compared with that of the standard test record *XTR.* 27 and the ratio of the readings obtained expressed as a difference in decibels. The figure obtained will be a measure of the absolute sensitivity of the cutter head ; thus if the two levels are equal the head is said to have *zero sensitivity.* Any cutter head of which the sensitivity as determined by the above tests is less than — 8 db., should be rejected and withdrawn from service.

It should be observed that whenever a cutter head is changed the appropriate correction unit should be substituted for the correction unit previously in use in the DR/3 amplifier.

Adjustment of Working Sensitivity. A band should be cut on 1,000 c/s tone adjusted to give a reading of 500 on the monitoring meter and compared with the standard test record *XTR.* 27. If the levels differ by more than $\pm$ 0.5 db. the level applied to the cutter head should be changed accordingly and a new band cut and compared with the test record *XTR.* 27. For example, if the level of the band first cut (with the monitoring meter reading 500) is 2 db. less than that obtained from the test record *XTR.* 27, the input level must be increased (either on the attenuator or on the gain control) by 2 db. The process should be repeated until the level recorded equals that of the test record *XTR.* 27 within the permissible tolerance. The monitoring meter should then be adjusted by means of the recessed screw in its side to read 500 on the level of tone being applied to the cutter head, which is then said to be operating at zero Working Sensitivity.

Frequency Response Characteristic. Before taking an overall frequency characteristic the cutter head should be adjusted to operate at zero working sensitivity as described above.

Starting at $4\frac{1}{2}$" radius, bands of tone, each lasting 10 seconds and with a five seconds interval between each, are cut in the order indicated at frequencies of 1,000, 5,000, 4,000, 3,000, 2,000, 1,000, 500, 200, 100 and 50 c/s. These discs are now measured and the results plotted. The resultant curve should approximate to curve ' A,' Figure 12, to within the degree of tolerance indicated by curves ' A_1 ' and ' A_2 '. Heads having a frequency response characteristic lying outside these limits should be rejected, but before rejecting a cutter head it is advisable to take at least two check runs using different cutters and replays with at least two different needles.

If a head is seriously lacking in bass a test should be made to see if the coils are earthing to the casing. If this is found to be so, the bottom plate of the head should be carefully removed and the earth cleared. Absolutely no other adjustment should be attempted.

Although the cutter heads used on the two amplifiers are found to have frequency response characteristics lying within the permissible limits, yet if the divergence is in opposite directions so that there is more than 2 db. difference between them at 3,000 c/s and 4,000 c/s, they should not be worked together as a pair, and one of them should therefore be changed.

Performance Tests (*Contd*)

Calibration of Pick-Ups. The pick-ups are tested by playing back the standard test record *XTR.* 22 and measuring the frequency response. The curve obtained by plotting the results should approximate to curve ' B ', Figure 13. Where the pick-up response departs from this curve the overall frequency response of the combined recording and play-back channels will correspondingly differ, assuming an ideal characteristic for the cutter head, from curve ' A ', Figure 12.

Maintenance

Battery Charging

(*a*) **From A.C. Mains.** See that the D.C. switch X6065 is in the **off** position and connect one end of the charging cable to the A.C. input terminals on the charging switchboard and its other end to the A.C. mains.
Adjust the switch on the rectifier to the correct A.C. input voltage ; switch on the mains to the rectifier and make the switch on the rectifier itself. Allow 30 seconds for the heaters of the rectifiers to warm up and then close the battery switch on the rectifier unit. Adjust the charging current by means of the rheostat on the rectifier to give the required charging current (up to 15A) which will be indicated on the ammeter provided on the rectifier unit.

(b) **From D.C. Mains.** See that the D.C. switch X6065 and all switches on the Crypton charger are in the **off** position. Connect the charging cable to the D.C. source and in series with the resistance supplied. The free ends of the cable should then be connected in the proper sense to the two terminals marked **15 A max.** on the front of the Crypton charger. (*N.B. these terminals are always ' live '.*) Switch on the mains and by means of the resistance and the ammeter on the main charging panel, adjust the charging current to 15 A.

(*c*) **From Van Engine.** When the van motor is running, the charging generator can be started up by engaging the special gear-lever provided in the driver's cab. The D.C. switch X6065 on the charging switchboard should then be closed and the charging rate adjusted by means of the charging resistance on this switchboard. The automatic regulator keeps the charging current sensibly constant at all safe dynamo speeds over 1,200 r.p.m. The hand-reset overload trip in the driver's cab increases the field resistance to a safe value in the event of the current exceeding the setting of the trip. The upper limit of dynamo speed is marked with a red line on the dynamo revolution indicator as 2,800 r.p.m.
The batteries should receive normal maintenance, e.g. periodical topping-up and extended charging periods, in accordance with the maker's instructions. The isolating fuses should normally be removed when the battery is receiving attention.

Fitting a New Cutter Head. The following are the essential requirements as regards mechanical adjustment when fitting a new head in the cutter-head frame.

(i) The cutter point when traversed across the disc should follow a radial line.
A radial line should be scratched on the back of a disc and the disc, with the back upwards, should be clamped on to the turntable with the radial line parallel to the

Maintenance (*Contd*)

traversing screw. To ensure this the head should be lowered and traversed across the disc and the turntable rotated as necessary in order to make the inscribed line parallel to the traverse. The cutter head should then be moved by sliding the cutter-head pivots in the slots in the cutter-head frame until the cutter point when lowered rests on the inscribed line. This should then give the correct setting for the radial direction.

(ii) The suspension should be adjusted to secure a ratio of groove width to wall thickness of 1.5/1 (60% groove and 40% wall).
This condition can normally be secured by adjusting the pivots to a suitable pivot bearing in the saddle mounted on the cutter head, and by sliding the cutter head relative to the saddle, for which purpose the holes of the fixing screws have been slotted. Finally, the position of the sliding weight on the arm attached to the cutter head can be adjusted if necessary to complete the adjustment.
Every time the position of the suspension is altered it is important before making the trial cut to ensure that the cutter head works freely in its pivots without undue side play, that the cutter is traversing radially, see condition (i), and that the nuts clamping the saddle and the pivots are duly tightened.

With each cutter head a special correction unit for the DR/3 amplifier is provided. Consequently when a cutter head is changed the correction unit labelled for use with that cutter head should be used. To change a correction unit the DR/3 amplifier must be removed from its rack. The leads marked 'A', 'B' and 'C' should be unsweated and the three screws in the base which hold the unit in position withdrawn. The new unit should then be fastened in place and connected in circuit by re-soldering the connections.

Adjustment of Fork Contacts. The contacts of the fork in the fork unit should be arranged to give equal opening and closing times. The best way of carrying out this adjustment is with the aid of a cathode ray oscillograph, but if this should be inconvenient the adjustment may be made so as to secure the sharpest stroboscopic vision.

Amplifiers. Details of the amplifiers with their performance limits are given elsewhere, see **Division 3.**

Replenishing Fluid in Hydraulic Levelling Devices. If it should be found impossible to screw in the operating handles sufficiently to level the turntables in their extreme positions, the fluid will need to be replenished in accordance with the following procedure.

Unscrew the operating handle until the piston of the force pump is fully withdrawn and the ram is at its lowest. Then tie the two ends of the ram with stout string or wire so that the plunger cannot come out of the cylinder and gently screw in the operating handle until the string or wire is placed under a slight strain. The object of tying the two ends of the ram together is to prevent the rubber washers resting on the piston heads from falling over and allowing air to enter the system when the pressure is removed from the ram. The machine should then be lifted and the ram removed and replaced by one of the mechanical supports provided. The nut retaining the force pump should be released and the whole assembly removed.

Maintenance (*Contd*)

The cylinder of the ram should be placed in a vice and held in the position shown in Figure 11 with the force pump hanging loosely below it. The cap should then be removed from the oil-filling orifice and Lockheed fluid then introduced, a small quantity at a time, until the cylinder and pipe are full. The presence of air in the system would cause the ram to become springy and allow the turntable to vibrate during recording. Consequently, while the filling is in progress the force pump (cylinder ' B ') should be agitated to and fro in order to prevent air from being entrapped and vigorously shaken for some time after the cylinder is full in order to release any small bubbles that may still be adhering to the internal surfaces. A piece of wire inserted at the orifice may be found of assistance in removing some of the smaller air bubbles. When all the air has been expelled the cap should be restored and the ram replaced on the machine. The string or wire holding the plunger in the ram can then be removed.

Lubrication and General Maintenance. The motor generators should be examined and cleaned at least once a week, and once a month the grease caps should be replenished with suitable grease. The dust covers should be taken off when running so as to ensure adequate ventilation. If ever it should be necessary to take out a generator, care should be taken when replacing it to see that the sorbo rubber pad under the bed plate extends over the edges of the supporting tray.

The recording machines should be kept scrupulously clean and free from dust. The lead screw and the slide of the cutter-head carriage should be oiled after cleaning with thin sewing-machine oil or oil of the ' 3 in one ' type. The gearbox should be periodically topped up with oil, using Mobiloil ' C ' in the Summer and Mobiloil ' B ' in the Winter.

A little grease should periodically be applied to the threads of the remote control gear connecting up the DR/3 volume controls on the CU/3 panel and on the amplifier unit itself.