THE POST OFFICE ELECTRICAL ENGINEERS' JOURNAL

VOL. 38 OCTOBER, 1945 PART 3

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Price 1/- net

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Recent Developments in W.D. Telephone Switchboards

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U.D.C. 621.395.33

This article gives a brief review of developments in W.D. telephone switchboards during the war and a more detailed description of the latest 10- and 50-line magneto boards.

Introduction

DURING the European and African campaigns from 1939 onwards the following switchboards were used :—

(*a*) *Switchboards U.C. 10-line and 6-line* are portable switchboards designed for mobile operations. The 10-line switchboard is suitable for use in divisional signals and the 6-line switchboard for battalion and artillery requirements. The switchboards are constructed on the unit principle and comprise an operator's unit, 10- or 6-line units and a common apparatus unit. Connections are made by double plug-ended cords which are carried, together with pulley weights, operator's microphone and receiver, etc., in a separate box. The complete 10-line switchboard weighs 47½ lb.

Each line unit includes a sensitive relay which operates via a bridge rectifier from either generator (17-25 c/s) or buzzer (300-700 c/s) signals. A current of about 1 mA is required to operate the relay, which lights a calling lamp supplied from a local battery.

Line fuses and lightning protectors are not included in the switchboard but are mounted in rigidly constructed frames known as " Frames. D and P, 10-wire." Two frames are required for 10 lines and weigh 18 lb. 14 oz. complete with carrying case.

(*b*) *Switchboards F and F* are designed for fixed exchanges and for field use. They are constructed on the unit principle to provide self-contained switchboards of 20- 40- or 60-line capacities. A maximum of three switchboards may be placed side by side to form a non-multiple exchange accommodating up to 180 lines. A teak case (Unit D) is used as a stand for the switchboard and a teak desk (Unit C) contains the operator's equipment, cords, keys and clearing indicators.

Five-line circuits are mounted on a framework (Units A and A/J). Units A are for magneto lines and Units A/J are for civil exchange lines. The exchange line circuits may be connected for any type of civil exchange by a plug and socket arrangement in the A/J Unit. Four Units A are mounted in a teak case with doors to form a Unit B, while three Units A and one Unit A/J are similarly mounted to form a Unit B/J.

A complete switchboard comprises a Unit C mounted on a Unit D. One Unit B/J and two Units B are mounted in that order on the Unit C, thus catering for five exchange lines and 55 extensions.

For transport Unit C packs into Unit D, forming a convenient load for two men, flush folding handles being provided for carrying. The doors of Units B and B/J close to provide protection during transport.

(*c*) *Switchboard, Command, 200-line,* is designed for use at Army Headquarters and is constructed on the unit principle for transportation in enclosed units. Five switchboard positions are provided, and the exchange caters for 180 extension lines and 20 exchange lines. The answering and multiple equipment is contained in a single unit (" A"), 9 ft. 6 in. long which extends over the whole length of the switchboard when installed. Each operator's keyboard and cord equipment is contained in a " Unit B." Unit C is a trestle on which the exchange is mounted. All units are constructed of waxed teak woodwork of substantial design, and Unit A, which weighs 750 lb., has a robust steel framework.

The face equipment of Unit A comprises hand-restored drop indicators which are mounted above the multiple jacks. There are three appearances of the complete multiple over the nine panels of the Unit. A Line Test Panel is also provided. The exchange line circuits work to any type of exchange.

In addition to the above Army switchboards, extensive use has been made for fixed installations of a number of Post Office boards, including Switchboards AT3796, P.M.B.X. No. 1A and standard sleeve control switchboards.

The above switchboards cover a large field of Army requirements. The extension of the war to the Far East led to the need for a 10-line switchboard which could be carried by one man through the jungle for fairly long periods. The weight of the Switchboard 10-line U.C. (47½ lb.) is too great, and this switchboard is not suitable for use in tropical theatres owing to the severe climatic conditions. A maximum weight of 25 lb. is reasonable, and to achieve this the new switchboard is designed to work with a field telephone as the operator's instrument. To avoid the use of a separate mounting to carry line fuses and protectors the switchboard itself is fitted with protectors. Buzzer calling is dispensed with and the switchboard is designed for generator signalling only. The equipment developed is known as Switchboard, Magneto, 10 Line (W.D.) ; further details are given in this article.

A further requirement arose for a magneto multiple exchange to replace the Post Office N.T.7 equipment which was obsolescent. The equipment was required for home and overseas military installations of a

static nature. The General Electric Company, Ltd., had developed a switchboard which, with certain circuit changes, met Army requirements. The equipment is known as Exchange, Magneto (W.D.) Unit Type " N " Positions and is described below.

Another exchange equipment developed by the Automatic Telephone and Electric Co. and the Signals Research and Development Establishment, in collaboration with the Post Office, is known as " Exchanges, C.B. Multiple, Unit Type, N Positions," and this will form the subject of a separate article.

Switchboard, Magneto, 10-Line (W.D.).

General

The switchboard is designed to work in the open in any part of the world. In tropical forest areas, such as Malaya, Burma and the East Indies, the rainfall is constantly heavy on most days in the wet season and the day air temperature may rise to 40° C. Relative humidities from 80 to 100 per cent. are common. Under such conditions of high humidity and relatively high temperature, fungus growth may be prolific. The main effects on electrical equipment are to promote the collection of moisture and produce a deterioration in the properties of insulating materials.

In desert regions as encountered in North Africa the air temperature may rise to 60° C. during the day and fall to freezing point at night. Perhaps the most severe hazard in such areas, however, is the dust and sand storms; the continual abrasion produced by swiftly moving particles may result in severe damage to equipment. Low extremes of temperature are reached in exposed arctic regions in Siberia, Alaska and North-Eastern Europe, where temperatures of −55° C. are relatively common.

The wide range of conditions which equipment must withstand imposes severe limitations in the choice of materials. The main components of the Switchboard, Magneto, 10-line have been designed specially for the job, and all materials have been carefully chosen and specially finished.

The general arrangement of the switchboard is shown in Figs. 1 and 2. A web-carrying strap, which is specially rot and fungus proofed is provided, and a small earth pin is attached to it during transport. The weight (including earth pin) is 23 lb., and the dimensions $14\frac{3}{4}$ in. × $9\frac{3}{4}$ in. × $5\frac{3}{4}$ in.

The outer case, which is shown closed for transport in Fig. 1, is constructed from No. 20 S.W.G. mild steel and is welded. All fixtures are welded to the case, so that apart from the main openings for the front and rear panels of the switchboard, it is sealed. The slot in the top of the case is a sliding fit for a field telephone (Telephone Set J or L), which is shown mounted ready for operation in Fig. 2. The front and rear openings are covered with lids, also made of No. 20 S.W.G. mild steel and provided with rubber gaskets $\frac{3}{8}$ in. square cross section, which fit tightly into channels in the lids. Each lid is secured to the case by a loose hinge and is closed by two brass captive screws which engage with tapped brass bushes secured to the inside of the case. When the lid is closed the gasket forms a sealed joint with a raised portion of the case. A plate of high grade synthetic resin paper laminated sheet engraved with brief working instructions is held in the front lid and a similar plate engraved with the circuit diagram in the rear lid. The front lid provides storage space for the cords when the switchboard is closed and the rear lid carries a small buzzer which is used as an alarm. The copper earth braid which is shown connected to the earth pin in Fig. 2 is wound round cleats on the rear of the case for transport and is covered by the rear lid when this is closed.

The circuit diagram of the equipment is given in Fig. 3. Each line circuit comprises a two-point jack; an indicator and a cord which is terminated in a plug. Protectors are connected between each line and the earth terminal of the switchboard.

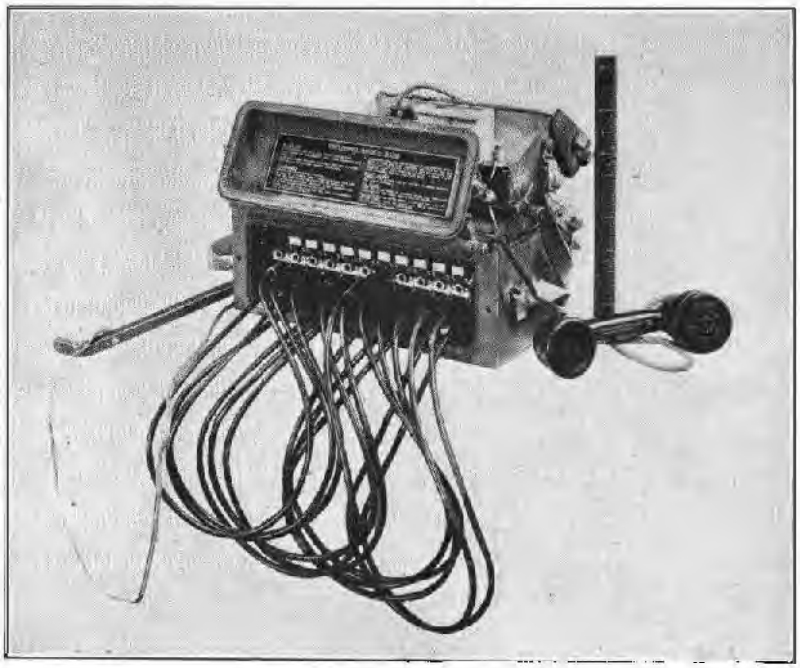

Fig. 2.—Switchboard, Magneto, 10-Line (Telephone Set Ready for Use).

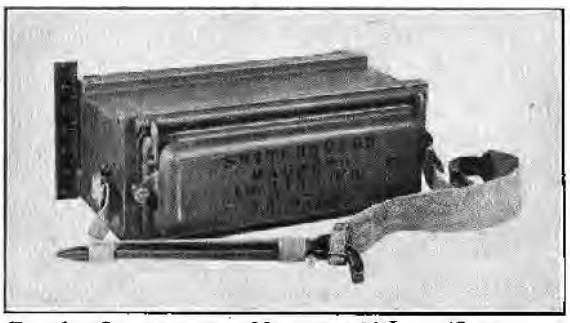

Fig. 1.—Switchboard, Magneto, 10-Line (Closed for Transport).

The indicator is connected permanently across the line so as to eliminate faults due to dirty contacts on the jack and to facilitate the design of the jack. The insertion loss due to a standard indicator across a 600 ohm circuit is 0·15 db. at 300 c/s, 0·1 db. at 500 c/s and less at higher frequencies. Since the line attenuation is lowest at low frequencies the effect of two drop indicators across a connection is negligible. The alarm contacts of the indicators are connected to two "Alarm" terminals on the

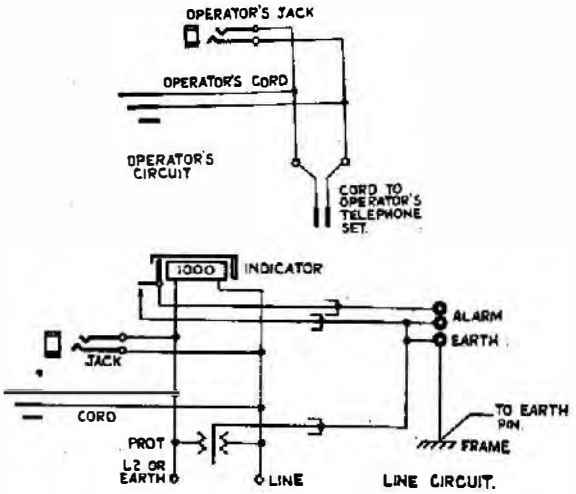

FIG. 3.—CIRCUITS OF SWITCHBOARD, MAGNETO, 10-LINE.

back panel and provide night alarm facilities when the buzzer, which is carried in the rear lid, is connected in series with one or two dry cells across the alarm terminals. Spare batteries carried with the field telephone are used for this purpose. The earth braid is permanently attached and is electrically connected with the case; a short end connects to the earth terminal of the switchboard and a 5 ft. length terminates in a tag for connection to the earth pin. The operator's circuit consists of a jack, single plug ended cord which is provided with a removable red rubber sleeve to distinguish it from the line cords and a telephone cord which is used to connect the switchboard to the telephone set.

Chassis Assembly

The layout of equipment is seen in Fig. 2 and the chassis assembly is shown in the background of Fig. 4. The 18 S.W.G. mild steel front mounting plate carries the main components. The ten line cords and one operator's cord pass through rubber grommets at the bottom of the panel and the plugs are normally placed in "parking" sockets which are moulded in phenol-formaldehyde. Above the parking sockets are the jacks and indicators which are so designed that insertion of a plug into a jack restores the associated indicator by an auxiliary spring on the jack. The operator's circuit is on the left of the panel and no indicator is required in this position. Calls are normally answered by inserting the operator's plug into the jack of the calling line, but an operator's jack is provided for emergency use if the operator's cord fails. Unit construction has been sacrificed to achieve compactness, but the components of each line circuit are in one column. During transport the indicator shutters would tend to move about, and to prevent this a locking bar, which is spring loaded, is provided; it is readily moved from the locking to the working positions. The method of operation is standardised and is simple, but it should be observed that "conference" facilities are available, since any number of circuits may be connected together.

The terminal panel at the rear is $\frac{1}{4}$ in. thick synthetic resin paper laminate of the best electrical quality. A high resin content is essential to ensure that the material does not support fungus growth. The ten pairs of line terminals and the earth terminal are slotted so that Army line wires may be connected direct to them. A large size is used to facilitate operation with gloved hands in cold areas. The alarm terminals also are mounted on the terminal panel and the telephone connector passes through it. The holes seen above the line terminals are to facilitate adjustment of the indicators which are provided with a screw at the back to alter the sensitivity. This screw may be adjusted without opening the switchboard by passing a suitable screwdriver through the holes in the terminal panel.

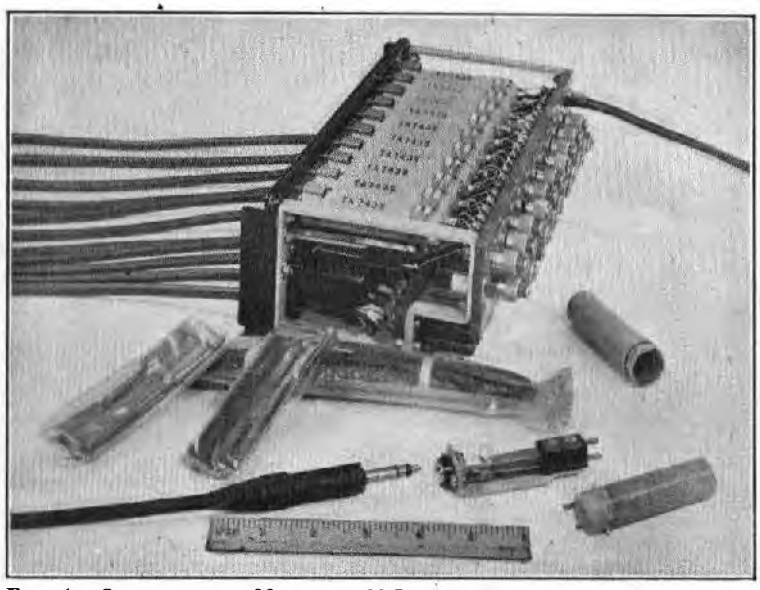

FIG. 4.—SWITCHBOARD, MAGNETO, 10-LINE. CHASSIS AND COMPONENTS.

The twenty pairs of protector carbons are mounted below the terminal panel. Nickel-silver springs which are held under the terminals make contact with the upper protector of each pair. A plate made of nickel-plated brass provides the common earth connection. Screw terminals, to which the line and telephone cords are connected by spade terminals, hold and make contact with an intermediate point of the springs. The systematic connection of lines is essential when using earth return circuits, and the top row of terminals is labelled "LINE" and the bottom row

"L2 or EARTH." To ensure correct connections inside the switchboard, both during initial assembly and during maintenance, 4 BA screw terminals are used for the ring connections, and 6 BA for the tip. Corresponding spade terminals on the line connectors are provided. The tops of the nickel silver spring contacts take the form of soldering tags and connections to the indicator coils and jacks are made from these points, using 14/·0076 stranded wire with slack between the spring and the indicator. The use of stranded wire with some slack in it is necessary to eliminate damage due to bumping and vibration, which all Army equipment is liable to encounter during transport.

Components

The main components used are shown in Fig. **4.** Conditioning at 60° C, 95-100 per cent. relative humidity revealed the following sources of insulation breakdown in standard telephone type jacks :—

(*a*) The use of laminated insulating wafers in the spring pile-up,
(*b*) Surface leakage from spring to spring on the outside of the spring pile-up,
(*c*) The existence of a short leakage path from spring to spring along the holes used for the fixing screws.

The connection of the indicator permanently across the line enables a two-point jack with no inner springs to be used and increases the distance between adjacent springs. The tip and ring springs are moulded in a block of high grade phenol formaldehyde and all metal parts have a high resistance to corrosion. A third spring which is coupled to the "ring" spring is so positioned that it automatically restores the indicator shutter when a plug is inserted in the jack.

The line connectors are carried in the front lid of the switchboard and must, therefore, be as small as possible. Braided cords are ruled out owing to the difficulty in making them mould and rot-proof and to the danger of erosion when they are used in a sandy or dusty environment. Rubber-covered cords are therefore used. Tests made on standard plugs indicated that low insulation resistance was caused mainly by leakage inside the plug. The outer cover is dispensed with and the body of the plug is moulded in rubber, which is bonded to the rubber sheath of the cord. The conductors are tinsel and each is rubber-covered.

The telephone connector is also rubber-covered, but 55/42 S.W.G. copper wire conductors are used. There is of course relatively little movement of this connector. The ends which connect to the field telephone are stripped and soldered to facilitate easy connection.

The indicator used is developed from the Army type MR3, which is of robust construction. The coil is constructed by winding on a polythene moulded bobbin and then moulding a layer of polythene over the winding to form a seal with the cheeks of the bobbin. After exposure to 10 damp heat cycles to Specification W.T. Board No. K110 the insulation resistance of six samples ranged from 11 megohms to 18,400 megohms.

The use of this type of protection, however, reduces the space available for winding, and the minimum number of turns for the tropical type (Indicator MR4) is 9,450 as compared with 12,150 for the normal type. The sensitivity is somewhat less, the A.C. ($16\frac{2}{3}$ c/s) operate voltage being 15 V instead of 12 V.

Two spare line connectors and 20 protector carbons are carried in a spares compartment in the case. Each line connector and each group of 10 protectors are provided with a polyvinyl chloride (P.V.C.) bag (Fig. 4)—which is heat sealed round the edges. The spares are thus protected from damp and fungus until they are actually required.

Luminising

To facilitate operation of the switchboard in the dark, luminous paint is provided on the indicator label holder underneath the label, which is moulded in a transparent material, such as methyl methacrylate, with the back concave to leave space for the paint and the front matt to allow it to be written on. The labels below the jacks are also treated with luminous paint. To make the luminosity independent of an external source of light, which would be required every 8 to 10 hours with phosphorescent paint, a radioactive paint which contains radium is employed. The radiation from the radium causes fluorescence of a suitable material in the paint, which is therefore luminous in the dark until one of the materials is used up. An effective life of two to four years is anticipated.

Performance

Comprehensive climatic and other tests indicate that the complete switchboard will stand up well to the most severe conditions it will encounter. The grade of the components is such that the chassis, out of the case, may be rinsed in water to clean out dirt and sand. It functions normally as soon as surface water has been removed.

Exchanges, Magneto (W.D.), Unit Type "N" Positions.

General Description

This exchange is designed for permanent installations of 50 to 300 extensions and 10 to 60 exchange lines. Each position ("Switchboard, position, magneto 10 + 50/60 No. 1") accommodates 10 exchange line circuits—which may work to magneto C.B.S. 1, 2 and 3, C.B. and automatic exchanges—and 50 extension circuits working to magneto telephones. The weight and dimensions are given in Table 1 :—

Table 1

Equipment	Weight lb.	Height in.	Breadth in.	Depth in.
Switchboard position ..	420	48	$26\frac{1}{2}$	$31\frac{1}{4}$
Multiple Unit	180	18	$53\frac{1}{4}$	17

An exchange may consist of one, two, four or six positions. A multiple unit (" Units, switchboard, magneto, multiple, 360 line, No. 1 ") is fitted over each pair of positions in four and six position exchanges. One and two position exchanges do not require a multiple unit. Fig. **5** shows two positions

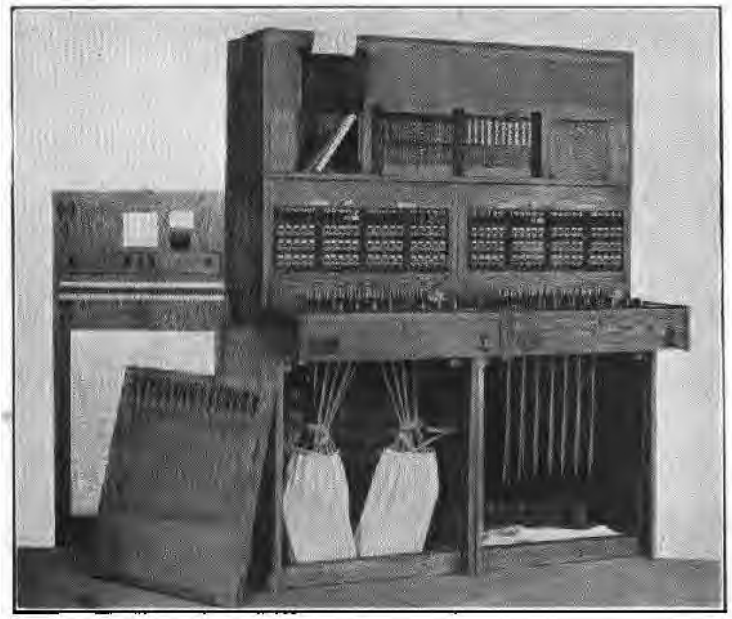

FIG. **5**.—SWITCHBOARD POSITION, MAGNETO 10+50/60, AND SWITCHBOARD UNIT, MAGNETO MULTIPLE, 360 LINE.

and a multiple unit which is fitted for illustration only.

Standard Post Office " Frames, M.D. 0/240", are used for the M.D.F. and the I.D.F. Table 2 shows the constitution of exchanges of various sizes.

TABLE 2

Extension lines	Exchange lines	Positions	Mult. Units	Frames 0/240		Rectifiers No. 38B	Battery Capacity
				MDF.	IDF.		
50	10	1	0	1	0	1	85 Ah
100	20	2	0	2	0	1	85 Ah
200	40	4	2	3	2	2	340 Ah
300	60	6	3	4	3	2	340 Ah

Constructional Details

The positions and multiple units are constructed of teak and the components have the normal tropical finish provided by the manufacturers for equipment which is to be used in protected places. The whole of the signalling equipment is mounted in the positions and no apparatus rack is required. The answering jacks are combined with Indicators MR3, which are jack restored, as already explained.

The key shelf is lower than is normal in multiple switchboards in order that ordinary chairs may be used by the operators. The cords, however, are of such length that each may reach the furthest jack in the multiple. This is made possible by the use of double-pulley cord weights. Each key shelf is equipped with 15 cord circuits, which include supervisory lamps, " dial and ring answer " keys and " speak and ring call " keys. A night alarm key, a position coupling key and a dial are also provided per position.

The multiple unit contains standard type jacks wired to connection strips and is constructed to fit over two positions as seen in Fig. **5**. A strip of linoleum is fixed above the jack field for pinning notices, and a pigeon-hole is provided on each side.

Each position is provided with spare lamps and fuses and a set of labels marked **50-99** (the answering indicators being labelled **0-49** as despatched) for use on the even-numbered positions. Space is left for the hundreds digit if required. These spares are carried on the rear panel of the position.

Two operator's jacks, connected in parallel, are provided on each position. One is Post Office " Jack No. 20 " and may be used with P.O. head and breast sets, the other is the standard Army operator's jack (equivalent to P.O. Jack No. 8).

During transport the cord weights are held in strong canvas bags which are anchored to the floor of the position.

Installation

The switchboard is designed for operation from a 24 V power supply obtained by rectification of the mains, using a " Rectifier No. 38B " with floating secondary batteries. It is possible, in the event of the mains failing, to use the operator's circuit with 3 V dry cells by altering a strap in the rear of the switchboard. Supervisory signals are not given during emergency working.

Ringing current is normally provided by a ringing vibrator which works from the exchange battery and has an output comparable with that of a hand generator. A hand generator (similar to P.O. "Generator No. 26A ") is fitted in each position as a standby.

" Cable, switchboard, enamelled " is used for cabling from the M.D.F. and I.D.F. to the multiples and to the positions. P.V.C. insulated wire is used for jumpering on the M.D.F. and I.D.F.

Facilities and Circuits

The main circuits are shown in Fig. **6**. The extension calls the switchboard by turning the generator handle, and the corresponding drop indicatoroperates. While a plug is in the jack relay SA is operated to the 400 ohm earth in the extension circuit so that when the handset is replaced on the extension telephone the release of relay A lights the supervisory lamp.

The exchange line circuit enables the switchboard to be connected to automatic, C.B., C.B.S. 2 or 3, and magneto exchanges or, by a change in the strapping, on a tag-strip at the back of the position, to C.B.S.1 exchanges. A slow releasing relay S operated by the auxiliary springs of its exchange jacks practically eliminates the possibility of false calling signals being given when clearing a connection. No supervision is provided on exchange line circuits.

Two groups of conference jacks are fitted above the answering jacks and indicators. For the purpose of setting up lengthy conferences without using up

the normal cord circuits, 30 double-ended cords are stored behind the kicking panel in such a manner that they are accessible to the operator. Conferences may be set up by means of these cords connected from the conference jacks to either the answering jacks or the multiple jacks. One normal cord circuit

in many respects than the conditions met in civil practice. The wide range of climatic conditions met and rough handling during transport necessitate the best possible finish to all parts and a sturdy construction. Poor lines, which are frequently unavoidable under battle conditions, unskilled labour

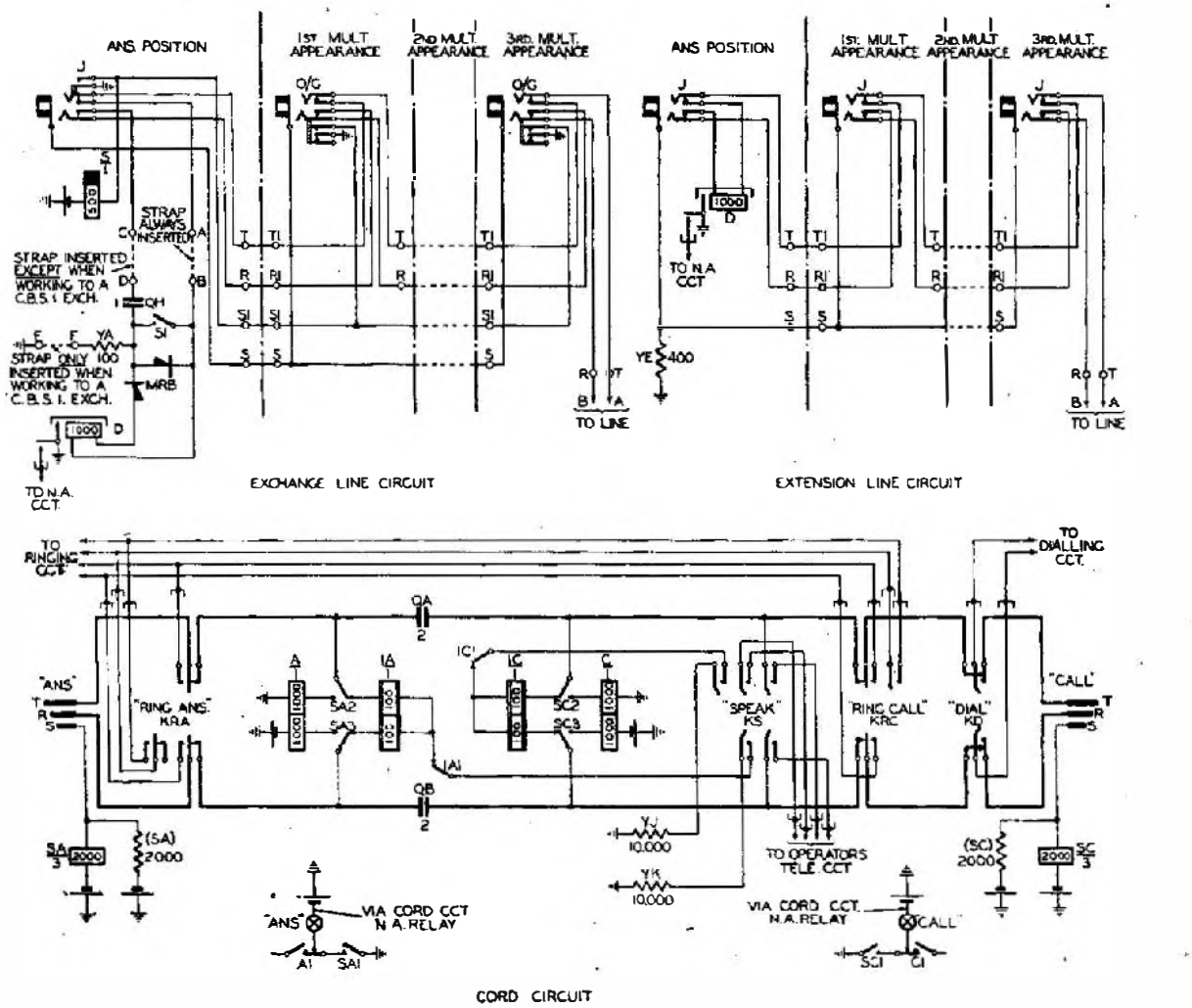

FIG. 6.—MAIN CIRCUITS OF W.D. MAGNETO MULTIPLE EXCHANGE.

at least must be used for each conference for supervisory purposes. Two conferences may be set up simultaneously on each position.

When the Night Alarm key is operated an audible signal is given whenever an indicator operates or a supervisory lamp glows. The same audible signal is given if a fuse blows (irrespective of the Night Alarm key), but a visual signal is also given. Temporary operation of the Alm. Dis. key stops the bell but leaves the fuse alarm lamp glowing until the fuse is replaced.

Conclusion

In conclusion it is stressed that W.D. conditions of use of communications equipment are more varied for installation and varied accommodation impose further limitations in design. When portability is necessary requirements become conflicting and an agreed compromise may be the only solution.

Acknowledgments are due to the Telephone Manufacturing Co., Ltd., who first put the Switchboard, Magneto, 10-line (W.D.) into production and effected improvements in the design, and to the General Electric Co., Ltd., who developed the Switchboard, Position, Magneto 10 + 50/60 No. 1 and the Unit Switchboard, Magneto, Multiple, 360 line No. 1 and provided the photograph in Fig. 5. The authors wish also to thank the Chief Scientific Officer, Ministry of Supply, for permission to publish this article.