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EDITOR — A. W. COLLETT

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A NEW 5 + 20 SUBSCRIBER ATTENDED PRIVATE AUTOMATIC BRANCH EXCHANGE

A. L. WEAVER, Exchange Systems Development Engineering Department

The Subscriber Attended P.A.B.X. described in Bulletin No. 22, *January*, 1951 *has successfully met the needs of business organizations for many years and has been modified from time to time to keep pace with new requirements.*

The P.A.B.X. described in this article is a new version designed to give more facilities and reduce maintenance.

THE Company's standard Subscriber Attended P.A.B.X. System for five exchange lines and 20 extension lines described in Bulletin No. 22 has been re-designed and the new version is now in production. Some of the new facilities provided are as follows :—

(*a*) Lock-out type extension line circuits to prevent switching equipment being held unnecessarily under P.G. and C.S.H. alarm conditions.

(*b*) The passing on of linefinder and exchange finder start conditions to a second circuit after a predetermined delay when the first circuit seized is faulty. This allows the call to be completed and prevents any uniselector driving continuously.

(*c*) The dialling of only two digits for extension calls and not as previously, two or three digits.

(*d*) The return of NU tone instead of busy tone when a spare or locked-out extension number is dialled.

(*e*) Right-of-way (intrusion) facilities are now included as a permanent feature.

(*f*) The safeguard against the loss of an exchange call during transfer.

(*g*) Transistor ringing and tone supplies.

(*h*) Test jack points to enable circuits to be busied manually.

As is implied by its title, the Subscriber Attended P.A.B.X. does not involve the use of a manually operated switchboard. Certain extensions are designated to answer calls incoming from the public exchange and transfer them to other extensions as required. Any extension may be so designated but the function is usually restricted to four or five extensions at the most.

In addition to the foregoing, any extension may be :—

(*a*) Allowed full access to the public exchange.

(*b*) Prevented from having direct access to the public exchange but permitted to receive transferred exchange calls.

(*c*) Allowed right-of-way (intrusion facility) on extension-to-extension calls.

(*d*) Allowed right-of-way when consulting another extension during a public exchange call or when transferring an exchange call to another extension.

Any extension may be fully barred, i.e. restricted to extension-to-extension calls only; this cannot of course be applied to the extensions designated to answer incoming exchange calls.

The exchange line circuits are normally arranged for working to either automatic or C.B. public exchanges. Simple internal modifications can readily be applied to convert the circuits for either C.B.S. or magneto working.

Access to the public exchange is gained by dialling a single code digit. The exchange line circuits can, if necessary, be arranged in two groups with an access code digit for each group.

Connection to an external telephone system other than the public exchange, with direct access from all extensions can be obtained by :—

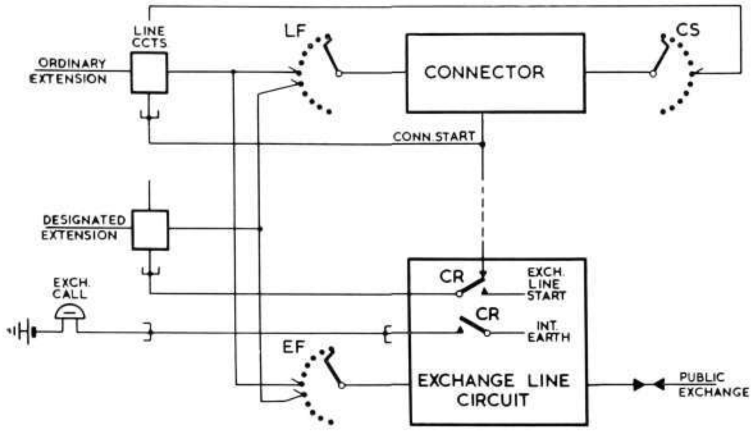

Fig. 1—Trunking and ' Start ' Outline

(*a*) Utilizing a second group of exchange line circuits, incoming calls being answered by the designated extensions.

(*b*) Replacing the second group of exchange line circuits with tie line circuits which allow direct ' in dialling ' to extensions.

Extension lines are numbered 20-39 whilst digits 8, 9 and 0 are available for allocation as access codes to exchange or tie line circuits.

Circuit Outline

Internal Call :—As may be seen from Fig. 1, when an extension removes the handset to originate a call, a start signal is routed to a free connector circuit to cause the linefinder (LF) to self-drive to the outlet associated with the caller's line circuit. At the same time, a thermal relay is activated in the connector circuit thus enabling the start signal to be passed to another free circuit after approximately 5 seconds should the first linefinder fail.

Normally the extension will be switched to the connector and dial tone returned within one second. It is therefore convenient to continue to use the thermal relay, arranged in this case to operate after approximately 20 seconds, as a guard against the caller failing to dial or causing the inter-train pause to be excessive. Should either of these contingencies arise, the connector is released and the caller's line circuit is locked out until the handset has been replaced. Switching equipment is thus prevented from being held indefinitely should a P.G. line fault occur.

When the requisite two digits have been dialled to position the connector switch (CS) on the required outlet, the called extension line circuit is tested. If the extension is already engaged, busy tone will be returned to the caller, but if the line circuit is locked out or the number dialled is spare, NU tone will be returned. When the called extension is found free, interrupted ringing current is applied to the line and the caller receives ring tone until the called extension answers.

At the end of the conversation, if the caller replaces the handset first, the connector is immediately released and the called extension line circuit is locked out until the handset is replaced. In the event of the called extension replacing the handset first, the thermal relay is again brought into use to enable the connector to be released and the calling line circuit locked out within approximately 20 seconds.

Intrusion. A right-of-way extension receiving busy tone after dialling may intrude on an engaged extension by dialling digit 1. This causes a speech path to be connected to the engaged parties and intrusion tone to be transmitted to indicate the presence of the third party.

If a private conversation is required, the engaged extensions should be requested to replace their handsets. The required extension will then be rung and the call proceeds normally.

Outgoing Exchange Call. Having removed the handset and received dial tone the originating extension dials the relevant code digit to gain access to an exchange line circuit. This positions the connector switch and, as shown in Fig. 2, enables relay EL to operate. This relay is interconnected with the EL relays of other connector circuits in a manner that permits only one to operate at a time. The arrangement prevents the possibility of a wrong connection when a second group of exchange lines or tie lines is equipped and calls to both groups occur simultaneously.

The operation of relay EL routes a start signal to a free exchange line circuit. Should there be no free circuit available the caller will receive busy tone, but normally the operation of relay EC prevents the return of tone. The exchange finder (EF) self-drives to the outlet associated with the calling

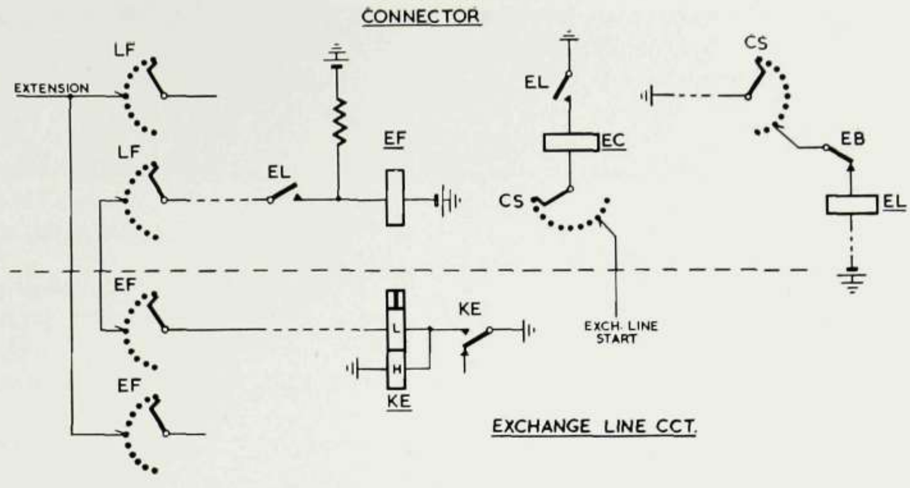

Fig. 2—Outgoing Exchange Call Switching Elements

extension's line circuit, the switch being arrested by the operation of relay KE. Relay EF in the connector also operates to cause the connector to release and when this has been proved the extension is connected directly to the exchange line circuit.

If the public exchange is automatic, dial tone will be returned and the required subscriber's number may then be dialled. Alternatively, if the public exchange is manual the appropriate signal is applied to call the operator.

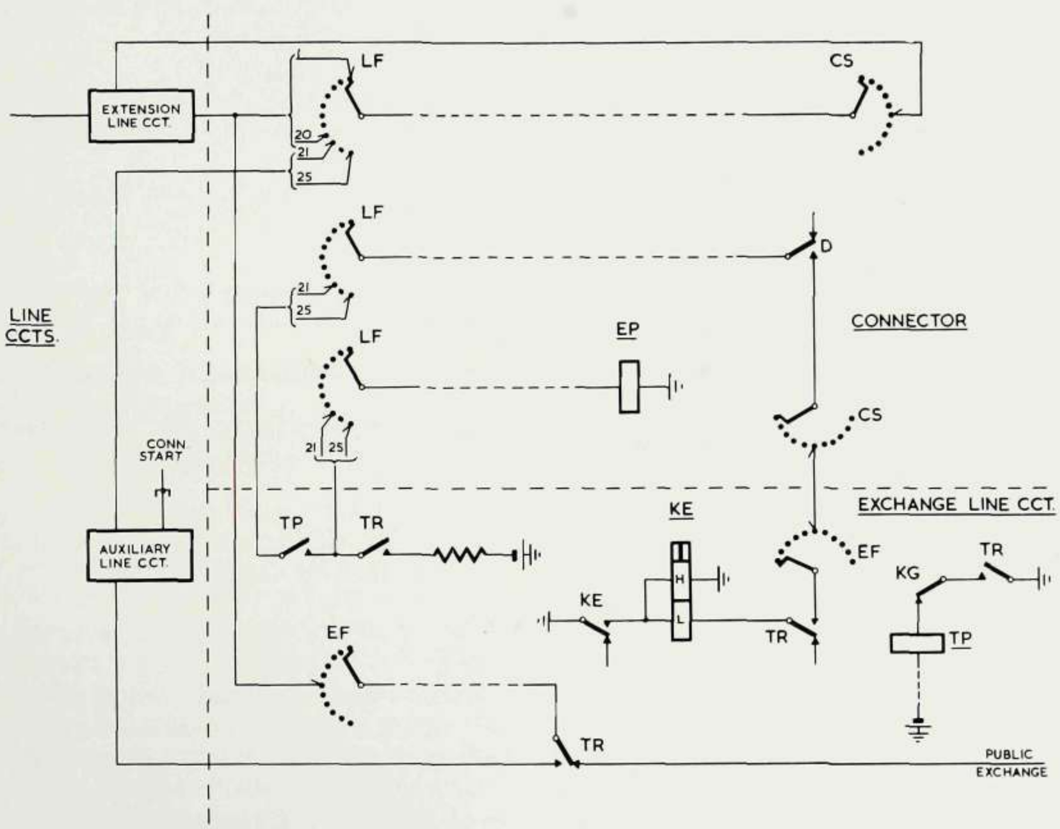

Fig. 3—Consultation and Transfer Switching Elements

Should a barred extension attempt an outgoing exchange line call, the operation of relay EB prevents EL operating and causes NU tone to be returned.

Incoming Exchange Call. On an incoming call, relay CR operates to ringing current from the public exchange. As shown in Fig. 1, bells are rung to attract the attention of the designated extensions and the first to answer causes the exchange finder (EF) to self-drive to the outlet associated with the line circuit concerned. The extension is thus connected directly to the exchange line circuit.

Consultation Call and Transfer. An extension engaged on an exchange call may consult, or transfer the call to, another extension. The extension instrument transfer button is momentarily depressed to cause relay TR to operate and divert the extension to an auxiliary line circuit. (Fig. 3). TR also connects a holding loop to the exchange line. A connector is seized and the required extension number dialled as for an internal call.

At the end of a consultation call the instrument transfer button is again momentarily depressed, relay TR releases and the connection to the exchange is re-established.

When the exchange call is being transferred the required extension having been obtained as for a consultation call the calling extension replaces the handset. Relay KG releases and, provided that no other transfer switching is taking place, relay TP operates. The exchange finder self-drives and is arrested on the required outlet by the operation of relay KE. The EP relay releases because of the low resistance shunting effect of KE and causes the connector to release; relay KG operates, TP and TR release and the transfer is complete.

An exchange call may be repeatedly transferred.

A right-of-way extension making a consultation or transfer call may intrude on an engaged extension in the manner already described; the ring and answer procedure must however be completed before the handset is replaced to transfer the call.

Exchange Finder Safeguard. A thermal relay is fitted in each exchange line circuit to prevent prolonged hunting of the finder. The circumstances in which this safeguard is used and the actions that result are as follows :—

(*a*) When an outgoing call is being attempted and the finder fails to locate the relevant outlet, the exchange start signal is passed to another free circuit.

(*b*) On an incoming call, if the finder fails to locate the required extension the call is diverted to the extension selected for mains-fail working.

(*c*) When a call is being transferred and the finder fails to locate the relevant outlet, owing to a circuit fault or to mis-operation on the part of an extension, the transfer is abandoned and the designated extensions are rung as for an incoming call. The re-establishment of the exchange call is thus ensured.

RINGING AND TONES

Continuous 25 c/s ringing current is generated by means of a transistor relaxation-type oscillator. A parallel-tuned transistor oscillator is used for the 400 c/s tone requirements. The absence of moving parts in the ringing and tone generators gives obvious advantages when compared with non-static devices. Less maintenance is necessary and radiated interference is virtually eliminated.

Interruptions are controlled by means of interacting relays and a miniature uniselector.

Following are details of the various tones and pulses.

Dial tone is obtained by feeding continuous ringing current via an attenuator network.

NU tone :—continuous, at 400 c/s.

Busy Tone :—400 c/s; 800 milli-seconds ON, 800 milli-seconds OFF.

Intrusion Tone :—400 c/s; 60 milli-seconds ON, 340 milli-seconds OFF, 60 milli-seconds ON, 1140 milli-seconds OFF.

Ring Tone is obtained by modulating the 400 c/s supply with the continuous-ring supply. The resultant tone is then interrupted in the sequence : 400 milli-seconds ON, 400 milli-seconds OFF, 400 milli-seconds ON, 1200 milli-seconds OFF.

Interrupted Ringing periods are the same as those for ring tone.

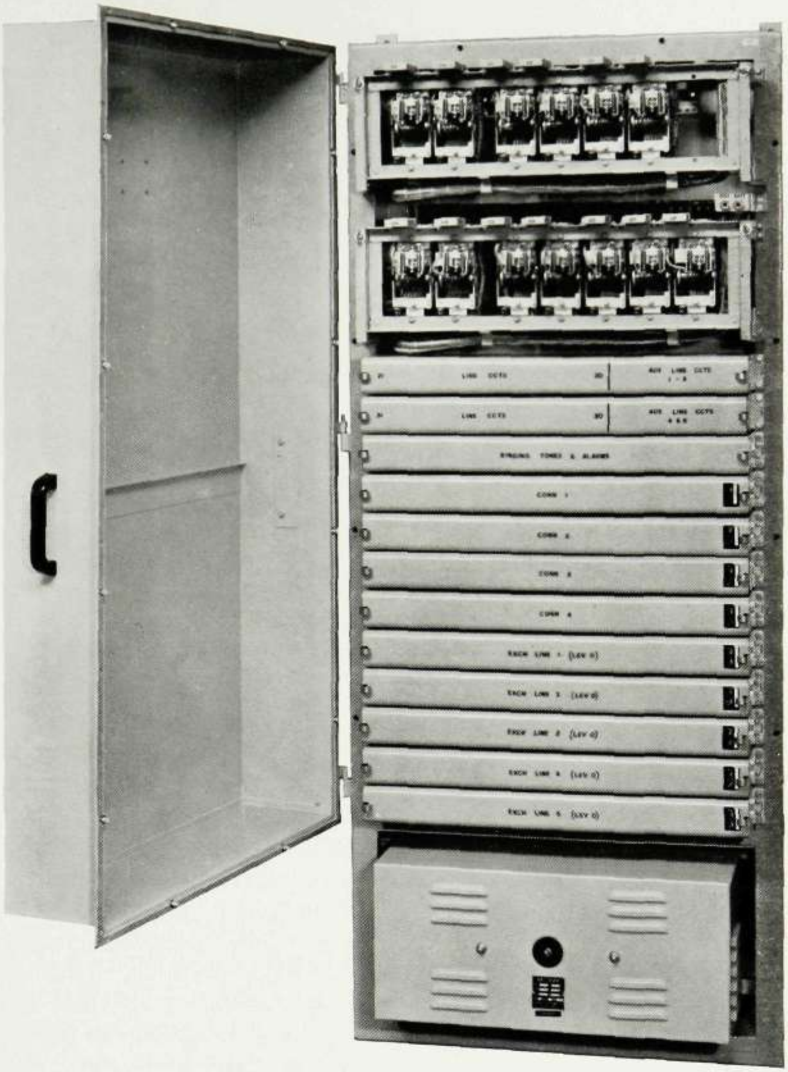

Fig. 4— 5 + 20 Unit with Battery Eliminator at the bottom

Interrupted Earth, which is applied to the bells associated with designated extensions when an incoming exchange call originates, has a periodicity of 800 milli-seconds ON, 800 milli-seconds OFF.

Mains Failure

The power supply for the P.A.B.X. equipment is usually fed from the mains via a suitable rectifier unit. Should the mains supply fail, the equipment will be out of service but contact with the public exchange can be maintained from selected extensions. These may be ordinary extensions within the P.A.B.X., provided that the public exchange is of automatic or C.B. type. Calls set up during a mains fail period are not disconnected when the power supply is restored.

Voltage and Line Limits

The equipment is designed to operate from a nominal 50-volts d.c. supply but will work satisfactorily over the range 45 to 55 volts.

Extension lines with a loop resistance of up to 800 ohms including the instrument may be connected to the system. The earth connection required for consultation and transfer facilities may be obtained locally or by means of a third wire to the P.A.B.X. equipment.

Exchange and tie loop resistance is independent of extension line limits; the equipment will function with a 1,000 ohm loop but this may depend upon the efficiency of the distant exchange equipment.

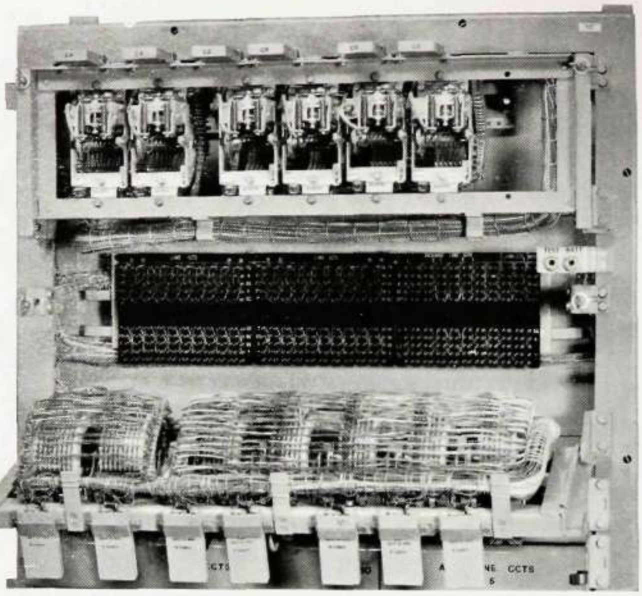

Fig. 5—Lower Uniselector Shelf swung down to expose connection strips

EQUIPMENT

As illustrated in Fig. 4, the equipment is mounted on a rack of pressed steel construction. The unit is approximately 5 ft. 9 in. (175 cm) high, 2 ft. 6 in. (76 cm) wide, and 1 ft. 2 in. (36 cm) deep when the outer cover is in the closed position. Two short angle brackets at the top enable the unit to be supported from a wall.

All the equipment is accessible from the front. The lower uniselector shelf can be opened as shown in Fig. 5 to reveal the connection strips, whilst the upper shelf is similarly hinged to enable the fuse panel to be exposed. The various circuits are strip mounted on jack-in type plates with the exception of the plates for the line circuits, but as the connections to these are formed into a looped cable arm, the plates can be withdrawn should it be necessary to gain access to the wiring side.

The hinged outer cover is of lift-off type and when closed, completely protects the equipment against dust, the rear cover being permanently sealed.

Power may be obtained from batteries and a suitable charger, but a mains rectifier unit which is adequate for most installations is usually provided and mounted at the bottom of the rack as shown in Fig. 4.

The stock unit as illustrated is fully equipped for 20 extension lines, 4 connector circuits (local links), 5 exchange lines and their associated auxiliary line circuits, and the ringing, tone and alarm relay set. However, a partially equipped version is also stocked, the rack being identical in size and appearance but equipped for 10 extension lines, 2 connector circuits, 3 exchange lines and the other common items. The upper uniselector shelf is not then provided but can be supplied complete with pre-formed cable and any other necessary equipment for intermediate requirements.

Apart from the extension instruments, the only other items of equipment are the d.c. bells to be fitted near the designated extensions, a small fuse alarm panel and an alarm extension panel, the last two items being optional.

Although many new features have been added to the system, every effort has been made to keep it as simple and economic as possible. Special consideration has been given to the maintenance aspect. Well-established types of apparatus, including heavy duty uniselectors, 600-type, 3000-type, and standard high-speed relays are employed. All items have full tropical finish, and p.v.c. insulated wire is used throughout; the maximum reliability is thus ensured even under the most stringent climatic conditions.

THE PRODUCTION OF TELECOMMUNICATIONS EQUIPMENT

Methods Employed by *Ericsson Telephones, Ltd.

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THE origins of the firm of Ericsson Telephones, Ltd., Beeston, Nottingham, date from 1898, when the Swedish organization founded by L. M. Ericsson established a sales branch in this country. Subsequently, in 1903, when the British L. M. Ericsson Manufacturing Co. was formed jointly by L. M. Ericsson & Co., of Stockholm, and the National Telephone Co., the Beeston factory of the latter firm was taken over. At that time, the factory site occupied an area of one acre, and the production of telephone equipment was begun with a labour force of 130. The firm was registered as a public company in 1912, and in 1926 the present name was adopted. Although the British company is now entirely independent of the Swedish organization, friendly connections are maintained.

The growth of Ericsson Telephones, Ltd., since its foundation, has paralleled that of the telecommunications industry, and today, the total area of the site at Beeston, where there are some 6,500 employees, is approximately 58 acres. Of this total, an area of more than 20 acres is occupied by factory floor-space, and 14 acres are available for future development. In addition, there are subsidiary factories at Basford (Nottingham) and Sunderland, where there are 250 and 1,000 employees, respectively. The three factories have a total floor space of 1,100,000 sq. ft. The products are exceedingly diverse, and include automatic and manual telephone exchanges; telephones and associated components; carrier equipment, for the connection of a large number of telephone circuits through a single pair of wires; remote control and signalling equipment; vibrators and power packs; totalizators; time recorders; light engineering assemblies; nucleonic and electronic instruments; cold-cathode valves, including dekatrons; and paints, enamels, varnishes and lacquers. The firm has also carried out extensive original development work on the PVC covering of wire, and now covers about 80,000 miles of wire per year.

FACTORY ORGANIZATION

Efficiently equipped and organized, on modern lines, the Beeston works are run on the basis of a "product group" system. Under this system, each of a number of different sections is responsible for the manufacture of a certain group of products, and each section is provided with all the necessary facilities for this purpose, so that it can function as a self-contained unit. In any given group, the products are such that the basic equipment and processes employed in the particular section concerned, are

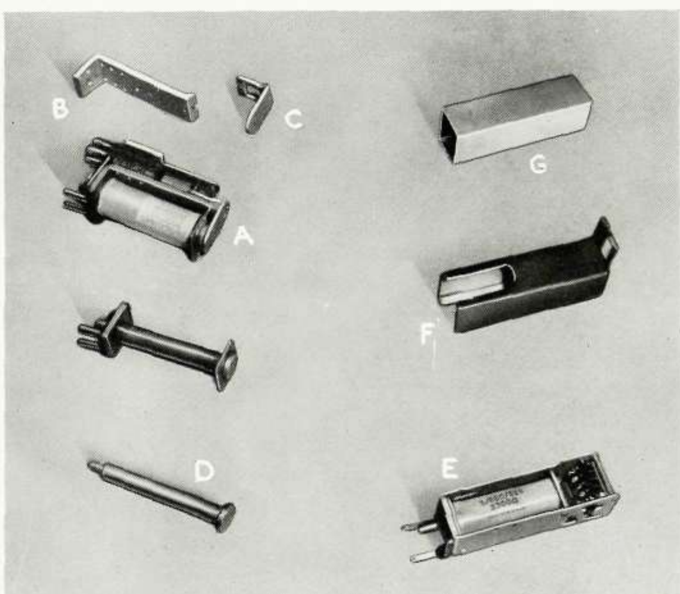

Fig. 1—Typical relay assembly, A, with yoke B, armature C, and core D. A meter assembly is seen at E, and the impact extruded case at F and G

*Trading also under the name 'Etelco Limited'

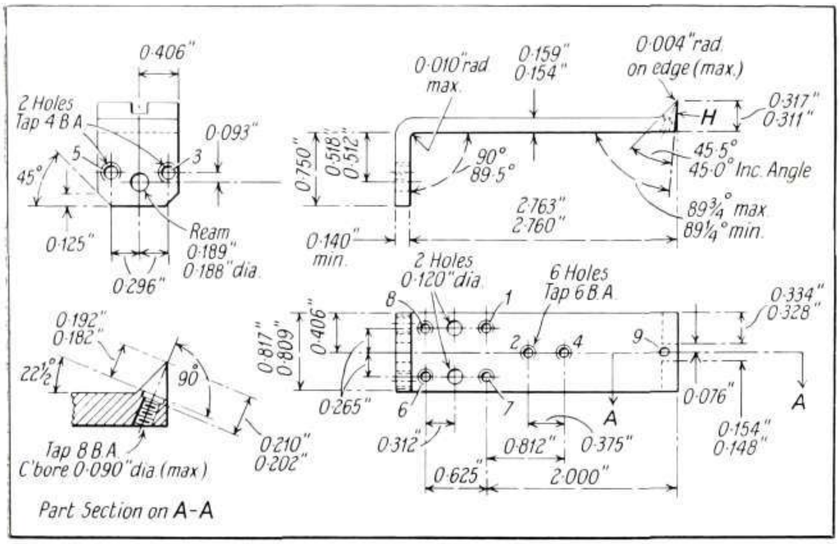

Fig. 2—Three views and a part-section of the relay yoke, showing the principal dimensions and the tolerances which are specified

common to as many of the various components as possible. Wherever it is desirable, however, special-purpose machines are employed in the sections, and in several instances, as will later be described, they are of the company's own design. With few exceptions, the work is conducted on a batch basis. The product group system, it may be noted, has been found to afford important economies, particularly in handling, as compared with the older practice of grouping machines, according to their functions, in large centralized shops.

An important branch of the firm's activities is the production of various types of relays, which are required in large quantities for use in automatic telephone exchanges. The output of these units is of the order of 20,000 per week, and an example is shown at *A* in Fig. 1, with some of the major components, including the yoke *B*, the armature *C*, and the core *D*. Another type of unit, also required in large numbers for similar duties, is the electromagnetic counter *E*. An impact-extruded aluminium case for this unit is seen at *F*, and another, at an intermediate stage of production, at *G*. Counters of this type are known as " meters ", and are employed to record, automatically, the number of calls made by each subscriber. The general quality and accuracy of both the units mentioned—and, indeed, of virtually all the firm's products—are of a high order, since they must conform to standards of performance and reliability laid down by the G.P.O. and similar authorities.

The principal dimensions and tolerances for the relay-yoke *B*, Fig. 1, are indicated in Fig. 2. These components are produced from electrical quality low-carbon iron strip, 2 in. wide and 0.146 in. thick, and since the latter dimension is critical, for tooling purposes, it is held within limits of ±0.0015 in. At the first stage, blanks 0.822 in. 0.826 in. wide, and 4.109 in. long, are produced from the strip, with a blanking tool set-up on a 75-ton Taylor & Challen, or a 70-ton Rhodes, crank-press. This tool is designed to locate the strip off-centre in relation to the punch, so that, initially, a series of blanks is cut on one side of the centre-line. When the end of the strip is reached, it is turned over, and passed through the tool again, so that a second series of blanks is cut on the opposite side. The same tool sets each blank to an angle of 1 deg., at a distance of $\frac{3}{4}$ in. from one end. This slight offset has been found essential to induce a flow of material in the required direction during a cold heading operation which follows, for forming the armature-fulcrum portion indicated at *H* in Fig. 2.

At present, it may be noted, it is the firm's practice to grind the edges of the work after cold heading, to ensure that the parts accurately fit the tools employed at a later stage, for piercing the holes. In these tools, the edges of the work are restrained, to minimize any bulging that may result from the piercing operation. Grinding is also necessary to remove any roughness of the sheared edges, which would tend to retain acid from the bath subsequently employed for dull chromium finishing. With the object of eliminating the grinding operation, the company is experimenting with special blanking dies, in which the upper edges of the die-aperture have a radius of $\frac{1}{32}$ in. Dies of this type have a burnishing action on the edges of the blank, and the results obtained have been encouraging.

Cold heading is carried out at the rate of 475 pieces an hour, on a 75-ton Taylor & Challen crank-press, with the tools shown in Fig. 3. The bottom die assembly comprises a circular bolster, in the centre

Fig. 3—The fulcrum portions of the yokes are cold headed at the rate of 475 an hour, on a 75-ton press, with the tools here shown

of which there is a conical bore with an included angle of 15 deg. Mounted in this bore, there is a pair of carbon steel split jaws of the design shown in Fig. 4. These jaws are of the same taper as the bore, and are fitted with inserts of Jonas & Colver's J.4V. cold heading die steel. The inserts are profiled to provide a central cavity of the same nominal cross-section as the blank, and of a depth somewhat greater than the finished length of the work. Towards the top of the cavity, the insert in one jaw has an inclined face, at an angle of 45 deg., which corresponds to that of the headed, fulcrum-portion *H*, Fig. 2. Above this face, the same insert is relieved, so that the cross-section of the upper portion of the cavity corresponds to the end elevation of the headed work.

The cross-section of the insert in each jaw approximates to an L-shape, and when the jaws are placed together in the bolster, the end of one limb of each abuts the inner face of the second limb of the other. With this arrangement, the parting lines of the tool cavity are at diagonally opposite corners of the work cross-section, rather than at the centre of each edge. Similarly, to ensure maximum support for the inserts, the parting faces of the jaws are offset, so that they lie in the same planes as the abutting faces of the inserts.

As may be observed in Fig. 4, there is a stepped cylindrical bore below the main cavity. This bore accommodates a loose plunger *J*, which serves to actuate an ejector-blade *K*, and the latter is free to slide in the lower portion of the cavity. These members are operated through the kick-rods *L*, Fig. 3, which are attached to the ram of the press. When the jaws are assembled in the bolster, they are located vertically in relation to each other by loose keys inserted in the tangential slots *M*, Fig. 4. Angular location of the jaws and cavity, relative to the punch, is effected by means of a finger that projects from the inner edge of the retaining-ring *N*, Fig. 3, which is screwed to the top of the bolster. This finger engages a corresponding recess provided in one of the jaws.

The punch, which is of the same material as the die inserts, is offset at a slight angle to the vertical. This offset, also, has been found necessary for satisfactory results, and the angle can be varied to suit slight differences in the work-material, from batch to batch. The punch is a fairly easy fit in the upper part of the die cavity, to allow for the offset. Initially, when the press ram is in the raised position, a cross-member attached to the lower ends of the kick-rods *L*, Fig. 3, is in engagement with the lower end of the plunger *J*, Fig. 4, so that the ejector-blade *K* is raised above the normal working level. A blank

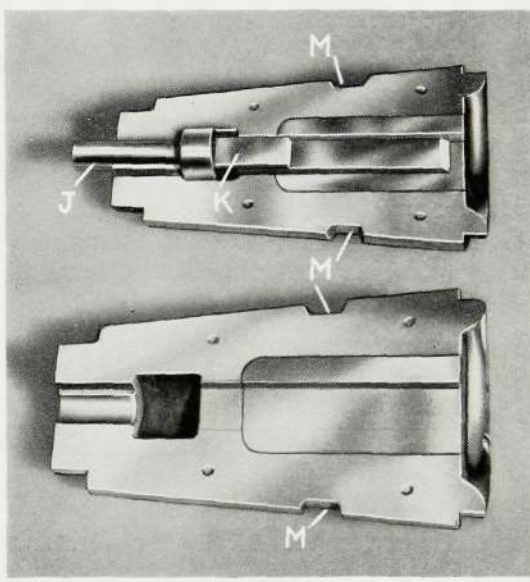

Fig. 4—A view of the tapered jaws for the cold heading set-up seen in Fig. 3, showing details of the inserts, and the arrangements for location and ejection of the workpiece

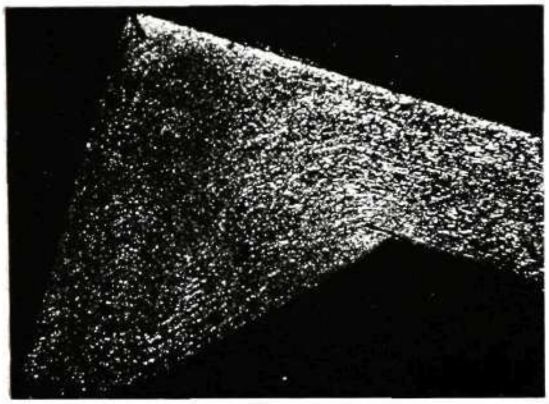

Fig. 5—An etched specimen, at 5 × magnification, showing the favourable grain formation obtained by cold heading

is inserted in the cavity with the offset portion uppermost, and with the lower end resting on the ejector-blade. The offset is arranged so that the inclination is towards that side of the cavity which forms the lip-portion of the head.

When the press is operated, and the ram descends, the ejector-blade is lowered to the working level, which is positively controlled by the shoulder of the plunger *J* engaging the step in the bore. The punch then engages the top of the blank, which is headed into the upper portion of the die cavity. At this stage, by virtue of the taper of the jaws and bolster, the walls of the cavity closely support the lower portion of the work, and minimize any tendency to bulge below the head. On the up-stroke, when the plunger and ejector-blade are raised by the kick-rods, the work is pushed upwards, so that it projects above the jaws. Over the final small amount of travel, the top of the plunger *J* is in contact with the top of the corresponding bore, and the jaws are thus displaced upwards, just sufficiently to free them in the taper, so that the work can readily be removed, and the next blank inserted.

Particular care is necessary in the setting-up and servicing of the tools, to ensure that the volume of the headed material, as well as the optimum conditions for promotion of cold flow, are correctly maintained.

The former consideration is especially important, since even a small excess of material on the head can result in breakage of the cutters employed at a later profile-milling operation. As may be observed in Fig. 2, the maximum permissible radius on the working edge of the fulcrum is 0.004 in. This relatively sharp corner, and the vee cutter-profile necessarily employed, result in stress-concentrations sufficient to fracture the cutter, if the nominal cutting loads are slightly exceeded. Cold heading, it may be noted, in addition to affording a rapid and economical means of forming the components, provides a favourable grain formation. A typical specimen, etched to show this characteristic, is illustrated in Fig. 5, which is reproduced at an effective magnification of 5 ×.

Grinding the Edges of the Yokes

For the grinding operation on the edges, which at present follows heading, the components are set-up, 120 at a time, on the magnetic chuck of a Snow surface-grinder, as shown in Fig. 6. Slotted plates are provided, in which the components are packed diagonally, and backed-up by loose blocks. An 18-in. diameter segmental wheel is employed, which is run at 1,200 r.p.m., and is provided with segments of two grades, supplied by Abrasive Products, Ltd. Six of the segments are of grade C 24 PB, and the remaining two, of grade C 24 MB, the latter being somewhat harder. This mixture of grades is employed as the PB segments are slightly too soft for use alone. Approximately 0.020 in. of material is removed from each edge of the work, and the two stages are completed on 660 pieces an hour.

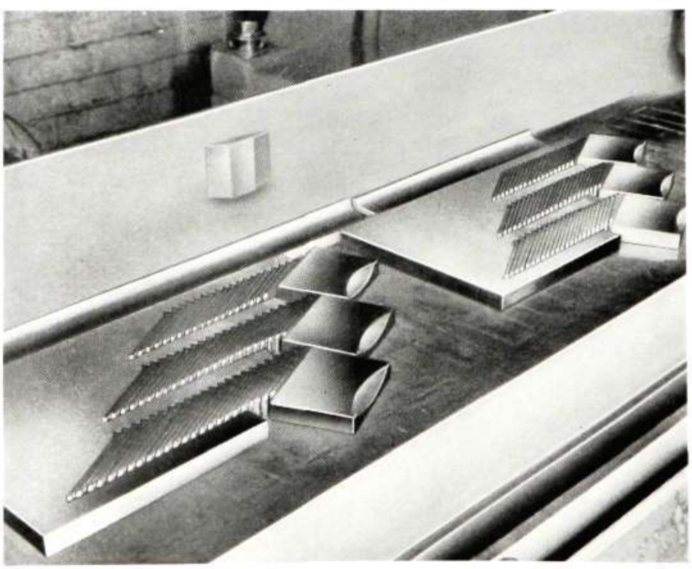

Fig. 6—At this set-up, on a Snow surface grinder, the edges of the yokes are ground, 120 at a time, on a magnetic chuck

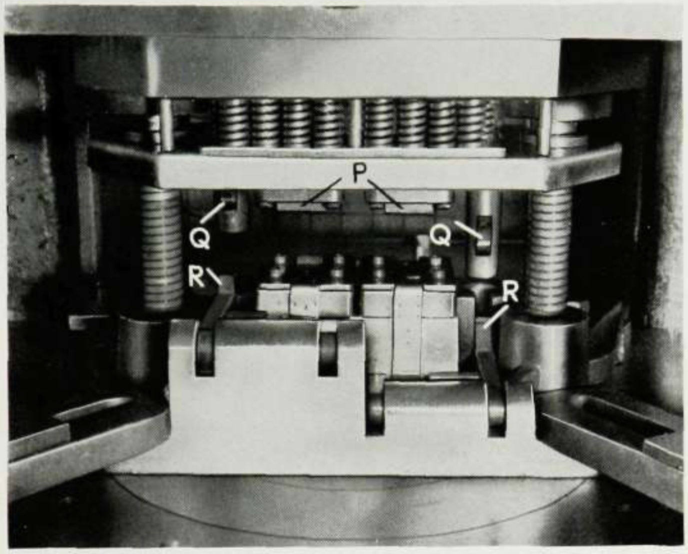

Fig. 7—Two-stage press tools, set up on a 70-ton Rhodes crank press, for piercing the holes in the long and short limbs of the yokes

The components are next barrelled for 20 min. in dry sawdust, after which a panel of the barrel is removed, a sieve is placed over the aperture thus exposed, and barrelling is continued for a further 20 min. In this way, a load comprising about 1,400 components is dried, de-burred and freed from sawdust.

Following this treatment, the 90-deg. bends are formed in the blanks, and the press-tools for this operation are set-up on a 70-ton Rhodes, or a 75-ton Taylor & Challen crank-press. These tools are of simple design, with a spring-loaded pressure-pad mounted in the die aperture. The blank is located on the pad by the edges, and by the lipped portion of the head, and when the press is operated, the work and pad are pushed into the aperture by the descending punch, and one edge of the aperture wraps the projecting end of the work round a corner and side face of the punch. This stage of the operations is completed on 525 workpieces per hour.

PIERCING THE HOLES IN THE YOKE

From Fig. 2 it will be observed that there are several holes in the component, two of which (in the lug) are tapped 4 B.A., and six (in the long face) 6 B.A. In addition, there is a reamed hole in the lug, of 0.188 in./0.189 in. diameter, for the attachment of the magnet core, and two holes of 0.120 in. diameter, in the long face, for attaching the contacts and their insulation, as seen at *A*, Fig. 1. All these holes are pierced on the two-stage press tools shown in Fig. 7, on a Rhodes 40-ton crank-press, the two stages being completed on 400 pieces an hour.

At the first station, at the left in Fig. 7, the long limb of the work is supported horizontally on the upper face of the die-plate, between a pair of edge-locating members, with the lug projecting downwards. In loading, the component is slid forward, to ensure that the inner face of the downwardly—projecting portion engages a locating face on the edge of the die-plate. The arrangements at station two are generally similar, except that a component, previously pierced in the long limb at station one, is loaded with the long limb projecting downwards, and with the lug between the edge-locating elements. When the press is operated, a locating block *P*, mounted on the spring-loaded stripper-plate, engages the heel of each component, so that the inner face of the vertical portion is held firmly against the locating face.

With continued descent of the ram, the stripper-plate engages the work, the springs are compressed, and the holes are pierced in both components simultaneously. At station one, the six holes subsequently tapped 6 B.A. are pierced 0.093 in. diameter, and the two 0.120- in. diameter holes are pierced actual size. At station two, the core hole is pierced 0.187 in. diameter, and the two remaining holes, which are subsequently tapped 4 B.A., are pierced 0.120 in. diameter. During the descent of the ram, the spring-loaded pawls *Q*, which are mounted in a pair of pillars attached to the punch plate, snap past the free ends of a pair of latch-type ejectors *R*, pivoted to the front of the bolster.

During piercing, there is inevitably a certain amount of lateral bulging of the work, so that it tends to be gripped between the edge-locating elements. Since the initial clearance is intentionally kept small —hence the necessity for the edge-grinding operation earlier described—these elements also constrain the edges, so that bulging is minimized. On the return stroke of the press ram, the work is first shed from the piercing punches by the spring-loaded stripper-plate, and with continued upward travel, the pawls *Q* engage and actuate the latch-type ejectors *R*, by swinging them upwards about their pivots. The ejectors engage the lower ends of the downwardly-projecting portions, thereby lifting the components from between the edge-locating elements at both stations simultaneously. Towards the top of the stroke, the pillars move clear of the ejectors, and the latter fall back to the horizontal position, as seen in Fig. 7. The components are left lying on the tops of the die-plates, in readiness for removal, and re-loading for the next cycle.

Despite the considerable thickness of the material, and the fact that, with the exception of the hole for the core, all the holes are of a diameter less than their depth, they are of a good standard for size and finish. The pin-type piercing punches, which are closely supported in " collapsible " sleeves, are made from Jonas & Colver's Novo steel, and the dies from a non-shrink steel, designated N.R.W., supplied by the same manufacturer. A feature of the tools is that the holes in the die-plates are 0.011 in. larger than the corresponding punches. Originally, a standard clearance was provided, but on the basis of experience gained over a period it was progressively increased to the figure indicated, which was found to give the best results. Considerable force is required to strip the work from the punches, and for this reason, the stripper-plate is backed by 40 springs which are made from square-section wire.

Setting and Countersinking

Referring again to Fig. 2, it will be noted that the tolerance on the internal 90 deg. bend angle of the lug is only ½ deg., and that the maximum permissible internal corner radius is 0.010 in. To ensure that the angle tolerance and radius are correctly maintained, the work is next set between simple vee press-tools, and a close-up view of these tools is shown in Fig. 8.

In the working faces of the lower tool, there is a series of short conical fixed punches, at positions that correspond to the tapping holes pierced at the preceding stage. When a component is loaded into the lower tool, it is located in relation to the punches by the profile, and by sliding it sideways against a pair of locating pegs. Thus, when the press is operated, the angle and corner radius are accurately set, and the holes in question are lightly coin-countersunk. With this set-up an output of 550 components an hour is obtained.

Although the countersinks are inevitably " pulled " slightly, because of the inclination of the tool faces, this is immaterial, since they are largely removed by the tapping operation which is subsequently performed.

They do, however, avoid formation of burrs at the tapping stage, and ensure that the various components seat correctly against the faces of the yoke, on assembly. Originally, the holes were countersunk on a drilling machine, but this additional operation has been eliminated by incorporating the countersinking punches in the working faces of the setting tools, as has been described.

Milling the Head Faces

For the next stage, at which the dimension from the inner face of the lug to the top of the head is " standardized ", two components are set-up at a time on a small Brown & Sharpe milling machine, as shown in Fig. 9. The air-operated vice is fitted with dovetail-profiled jaws, which serve to hold the work against a flat horizontal datum surface. Projecting beyond the jaws, on either side, there is an outrigger carrying a stop screw. The components

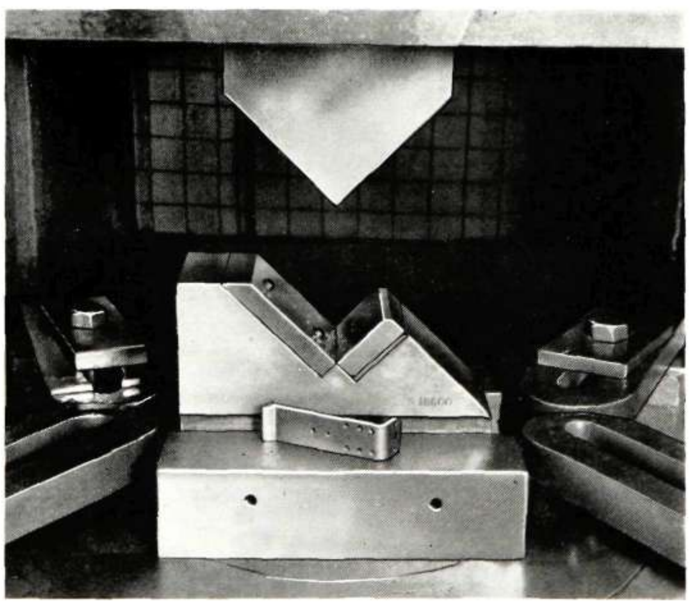

Fig. 8—The press tools here shown, for setting the 90-deg. lug angle, incorporate conical punches for coin-countersinking the pierced holes

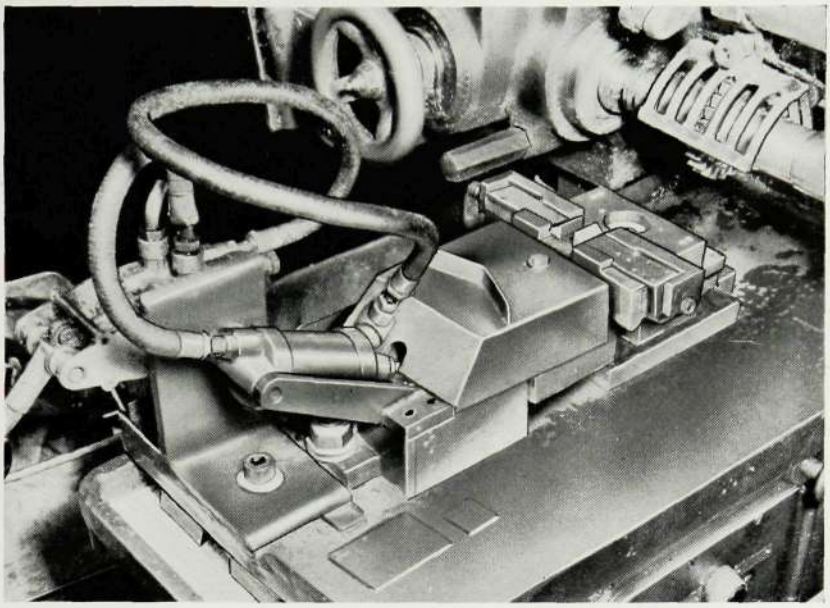

Fig. 9—Milling set-up, for "standardizing" the lug-face/head-face dimension, and "topping" the knife edges, on two components at a time

Fig. 10, on a Brown & Sharpe No. 12 plain miller. Two air-operated work fixtures are mounted at opposite ends of the table, so that one can be loaded while the other is in use. Each is designed to accommodate and locate two components at a time, the arrangement being generally similar to that employed for the preceding operation. In this instance, however, there is a separate vice for each component, in which the work is held at an angle to provide for cutter access, and the inner face of each lug is held against an adjustable screw top by an air-operated clamping lever *S*. The jaws and lever are controlled by means of the manually-operated valve seen in the right foreground, and it is arranged that the lever engages the work before the jaws. There is a similar valve for the second fixture, at the opposite end of the table.

are loaded into the vice with the heads pointing towards each other, and the lug of each is inserted between the stop-screw and a corresponding vertical datum face on the outer end of the horizontal supporting member. The inner surface of the lug is held lightly against the vertical datum face by the stop-screw.

A gang of four cutters, which are run at 345 r.p.m., is employed to machine the work at a feed of 18 in. per minute. The two centre cutters, which machine the end faces of the heads, are each of the side and face type, 3 in. diameter by $\frac{1}{4}$ in. wide, with 24 teeth. Each cutter removes approximately 0.025 in. of material from the face, depending on the accuracy of the heading operation. At the same time two 24-tooth slotting cutters, $\frac{1}{8}$ in. wide and $2\frac{3}{16}$ in. diameter, take light "topping" cuts along the fulcrum knife edges, for truing purposes, just sufficient to form narrow flats. This cut also standardizes the width of the end face of each head, and reduces the amount of material subsequently to be removed during finish-profiling. This stage is completed on 440 pieces an hour.

Finish-profiling of the knife-edges, to an included angle of 45 deg./$45\frac{1}{2}$ deg., is carried out with the set-up shown in

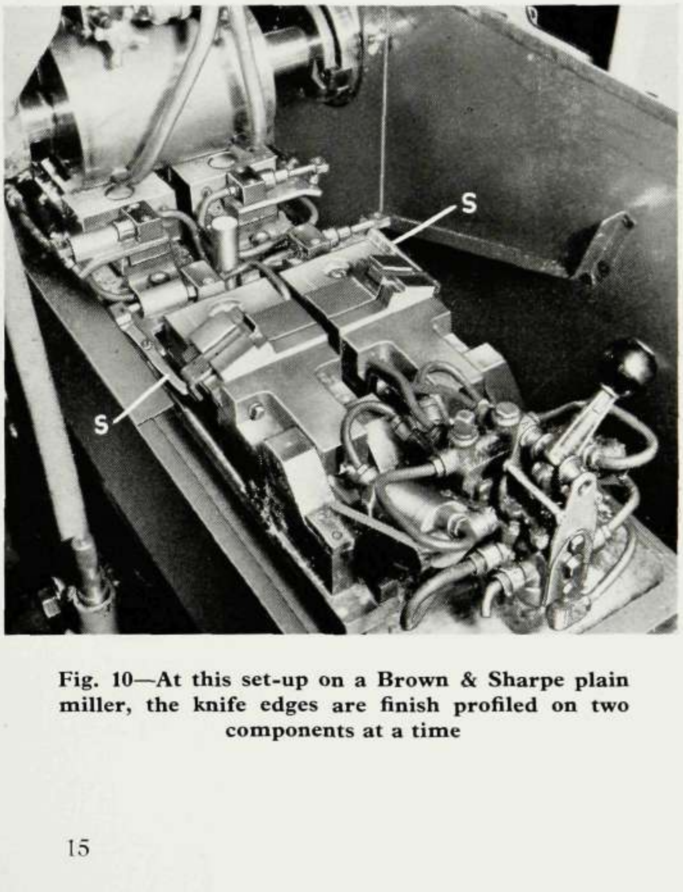

Fig. 10—At this set-up on a Brown & Sharpe plain miller, the knife edges are finish profiled on two components at a time

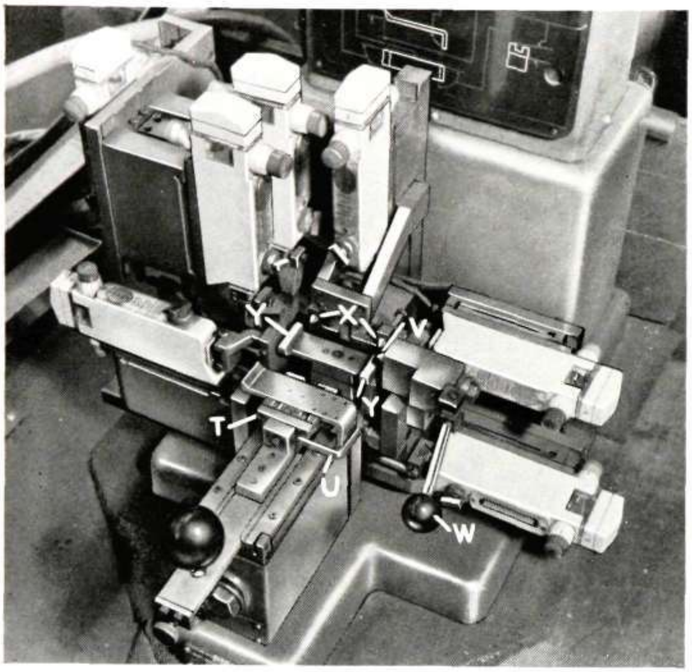

Fig. 11—Each component is checked on seven dimensions simultaneously, on the Sigma equipment here shown. The loading carrier T is seen withdrawn

A pair of form-relieved profile cutters, of high speed steel, each of 4.370 in. diameter, and with 18 teeth, is run at 500 r.p.m. When the table feed is initiated, the work is rapidly advanced to the cutters, and is then slowed automatically to a cutting feed of $7\frac{7}{8}$ in. per minute. Each cutter removes approximately 0.02 in. of material from each face of the head, depending on the accuracy of heading. In addition, it takes a light skimming cut, about $\frac{1}{8}$ in. wide, on the long face of the component, where it joins the inclined face of the head. This additional cut ensures that the corner-angle is sharp, and that the required working clearance for the armature, in the finished assembly, is maintained. At the end of the pass, the table stops automatically, and the components are unloaded during the next feed cycle in the opposite direction. Soluble-oil coolant is employed, and the stage is completed on 400 components an hour. To ensure that the knife-edge radii are maintained correctly, the cutters are checked twice weekly on an optical projector.

Dimensional Inspection

As the components are unloaded from the fixtures at the finish-profiling set-up, they are placed in a gravity chute that conveys them to an inspection station. Here, each is checked on seven dimensions simultaneously, on the Sigma equipment shown in Fig. 11. This equipment incorporates the required number of standard electrical comparator heads, fitted with gauging elements to suit the work, and each of these units operates a separate set of three signal lights. The latter are mounted on the cabinet that houses the associated electrical equipment, and each set comprises "plus" (green); "correct" (white), and "minus" (red). The comparator heads and gauging elements, it may be noted, are normally enclosed in a protective cover of Perspex. In Fig. 11, the equipment is seen with the cover removed, to enable details of the design to be observed.

To facilitate insertion of the work between the various gauging elements, the sliding carrier *T* is provided, which is pulled forward, to the position shown, for loading. The carrier is designed to locate the work by the edges of the long limb, and —loosely—by the outer face of the lug. It is mounted on leaf-spring hinges, so that it is free to "float" in a direction parallel with the axis of the slide, when it is advanced to the working position. Lateral "float" in a direction away from the lug locating arm *U*, is afforded by the freedom of the work to slide between the edge-locating elements.

Before the carrier is advanced to the working position, the spring-loaded conical centre *V* is withdrawn by means of the lever *W*. The carrier is then advanced against a stop, and in this position, the rear edge of the work engages the two screws *X*, which are mounted on a support that is spring-loaded towards the front, against another stop. As the carrier is advanced, the component slides on to a pair of horizontal supports *Y*, which lift it clear of those on the carrier. When the lever *W* is released, the side of the conical centre *V* engages the heel of the lug, so that the work is urged towards the left, and downwards. The inner face of the lug, near the bend line, is thus held in engagement with a datum pad on the right-hand side, and the long limb against the supports *Y*.

The various dimensions checked comprise that from the inner face of the lug to the end of the head (2.760 in./2.763 in., see Fig. 2) which is measured at two points on the width, so that an indication of

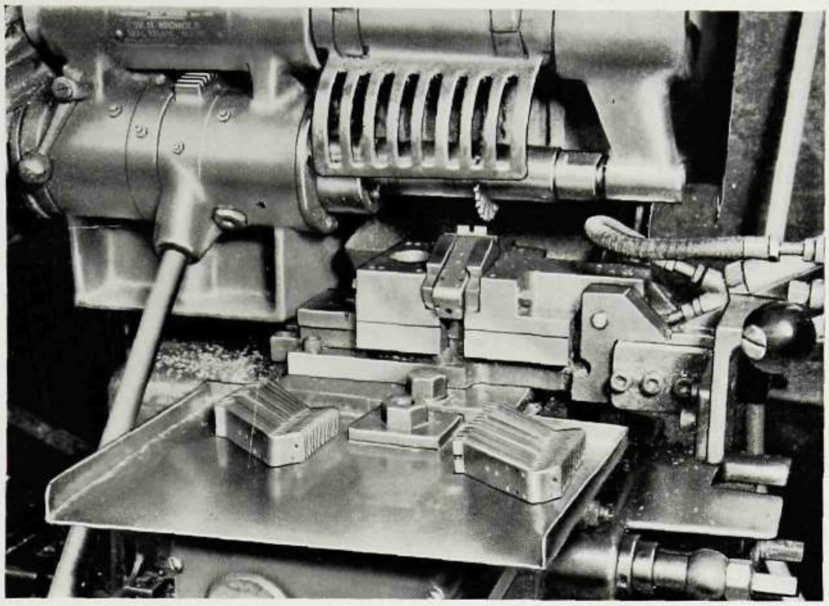

Fig. 12—At this set-up on a Nichols hand miller, the knife-edges are slotted at the rate of 650 an hour, with a high-speed steel side and face cutter

head squareness is also afforded; the knife-edge height above the long limb inner face at two points, and thus its parallelism with the limb face; squareness of the bend line to the edges of the long limb; and the 90 deg. lug angle at two points, to enable any twist to be detected. The rate of checking is such that the operator can easily keep pace with the output from the finish-profiling set-up, and, in addition, perform a deburring operation on the heel of the head, with the aid of a file which is attached to the bench-top.

Knife Edge Slotting and Drilling

Slotting of the knife-edges (see Fig. 2) is next carried out at the set-up on a Nichols hand milling machine, shown in Fig. 12, at which the output is 650 pieces an hour. An air-operated vice, with dovetail-profiled jaws, is employed to hold the work at the required angle of $22\frac{1}{2}$ deg., and during loading, the inner face of the lug is held manually against a locating stop, while the jaws are closed. The 3-in. diameter, 30 tooth, high speed steel Dormer side and face cutter, which is $\frac{5}{32}$ in. wide, is run at 520 r.p.m., and the 0.182 in./0.192 in. deep cut is taken at a single pass, the table being advanced and withdrawn by rapid movement of the feed lever.

For drilling the angular hole in the slot, which is subsequently tapped 8 B.A., the fixture shown in Fig. 13 is set-up on the table of a single-spindle drilling machine. The work is located laterally, on the inclined face of the fixture, by pegs that engage the edges, and longitudinally, by the profiled slot *Z* in the bushed drill-plate *A*. This plate is arranged to slide vertically, and is controlled by a pedal. When the pedal is depressed, the plate is lowered, and the slot engages the knife-edge. With the work thus located and clamped, the hole is drilled. Two air-jets, seen at the left, serve to keep the slot and locating face free from swarf. This stage is completed on 390 parts an hour.

Automatic Transfer Tapping Machine

Tapping of the various holes, to the sizes indicated in Fig. 2, is carried out on the 9-station Ericsson automatic transfer machine shown in Fig. 14, which is equipped with Hüller tapping heads. The components are loaded, all the same way round, and with

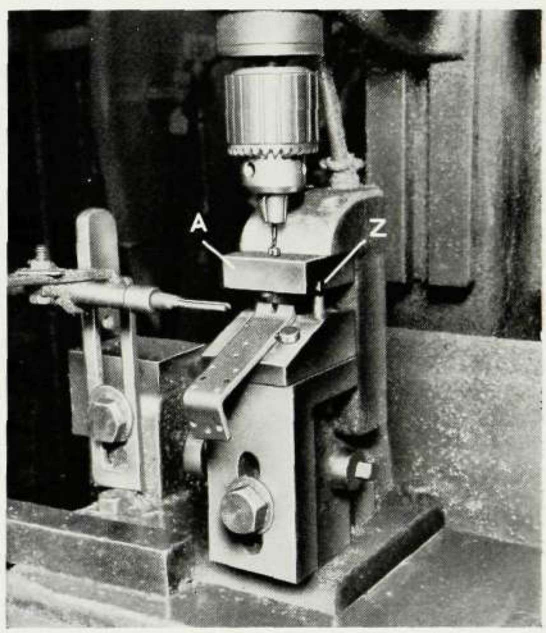

Fig. 13—With the simple pedal-operated fixture here shown, the inclined holes are drilled in 390 yokes an hour

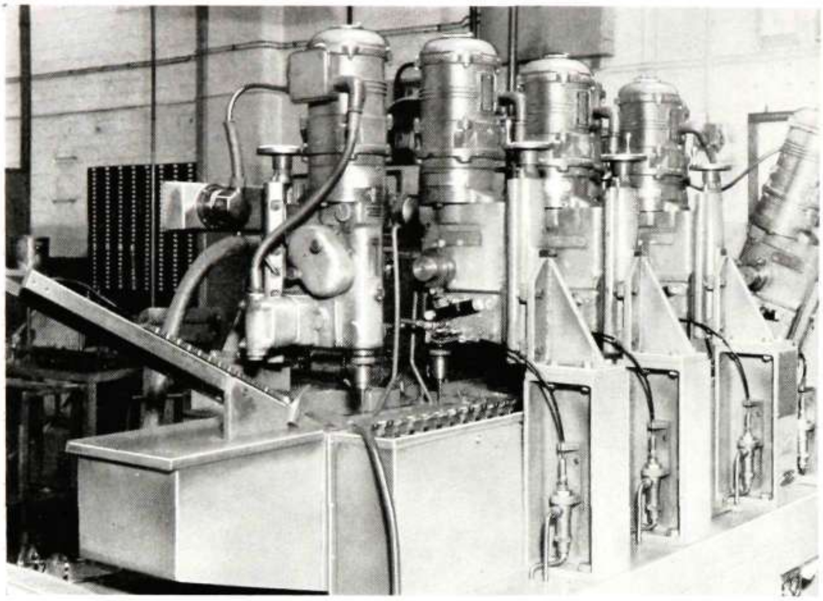

Fig. 14—The Ericsson 9-station automatic transfer machine, for tapping the holes in the yokes, is here seen from the input end

the lugs downwards, on the inclined magazine seen at the left. This magazine has a pair of guide-rails on the upper face, which support the under-side of the long limb, and another rail, on one side, engages the outer face of the lug, to locate the work laterally. Towards the bottom of the magazine, there is an air-operated detent and pusher mechanism, shown in Fig. 15, in which the first tapping station, and the transfer feed-bar *B*, may also be seen.

Designed to release one component at a time from the magazine, in unison with the motions of the feed-bar, the detent mechanism comprises a pair of upwardly spring-loaded plungers. These plungers are free to slide in a housing mounted on the underside of the magazine, and their upper ends pass through corresponding holes in the magazine face.

One of these holes is in a position immediately below the overarm *C*, Fig. 15, and the other a short distance beyond it. The lower ends of the plungers are coupled together through a rocker, so that when one is raised, the other is lowered. This rocker is operated, through a lost-motion linkage, by the ram of a horizontally-disposed pneumatic cylinder which also actuates the pusher *D*.

Feed Cycle

Initially, the plunger beyond the overarm is in the raised position, and the component at the bottom of the stack in the magazine rests against it. The next component, immediately above it, is beneath the overarm *C*, and over the retracted plunger. At this stage, the pusher *D* is in the advanced position, seen in Fig. 15. When the air-cylinder is energized, to retract the ram, the pusher is withdrawn towards the magazine, to a position well clear of the rails. Meanwhile, through the action of the rocker, the lower plunger is retracted, and the upper plunger is raised. The component at the bottom of the stack is thus released, and that above it is clamped against

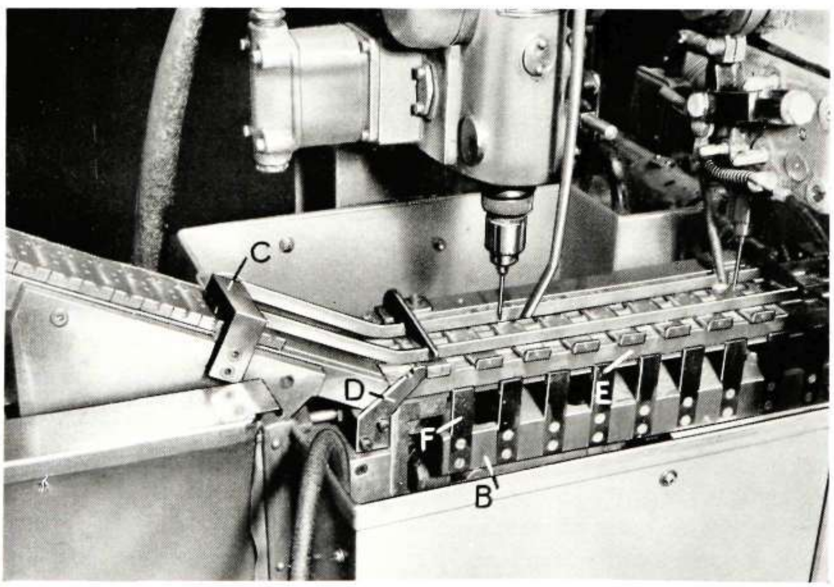

Fig. 15—In this view of the magazine and the first station, may be seen details of the detent and pusher mechanisms, and the transfer feed-bar B

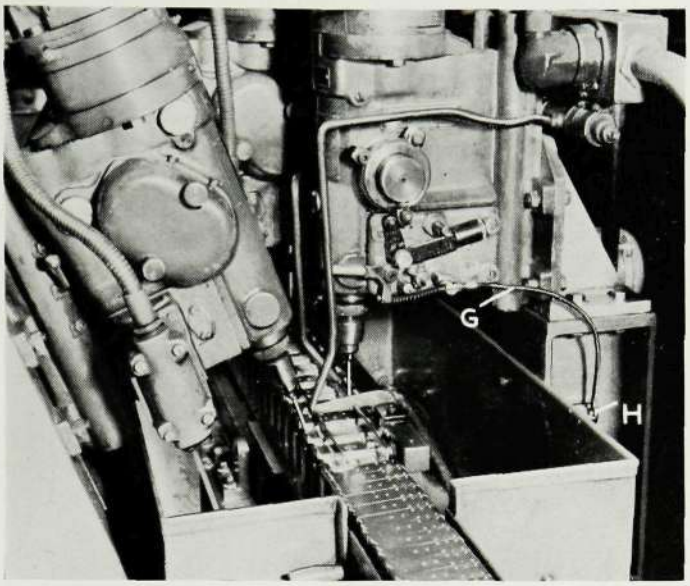

Fig. 16—A view of the 8th and 9th stations, at the output end, showing the cable and air-cylinder H, for initiating the tapping cycle at station 8

raised, so that the fingers enter the spaces between the components; and (4) traversed away from the magazine, through a similar distance. Thus, during stage (4) all the components on the rails *E*—including that previously released from the magazine, and engaged by the first vertical finger *F* during stage (3)—are advanced along them by a corresponding amount. In this way, the components are progressively fed through a total of 36 transfer positions, of which only nine, in line with the tapping heads, are working stations.

As each component is urged on to the main rails *E*, by the pusher *D*, the lug enters a gap between a datum face on the side of one main rail, and a side rail. On the inner surface of the latter, there is a series of formed flat springs, arranged end to end so that they are effectively continuous. These springs engage the outer face of the lug, near the heel, so that the inner face is held in contact with the datum face, and the work is thus located squarely across the rails *E*, throughout its passage along them. Originally, it may be noted, spring-loaded plungers were employed, but were found to wear rapidly. When the flat springs were substituted, they were found to afford a considerably longer useful life.

the overarm by the spring pressure of the upper plunger. As a safeguard against failure of the released component to slide down the remaining length of the rails, which could result in the accidental feeding of two components at a time at the next cycle, it is urged into motion by an air jet.

The tapping operations at the various stations on the machine take place simultaneously, and during this stage, the feed-bar *B* remains raised, so that the components previously fed are accurately spaced and located along the horizontal rails *E*, by the vertical fingers *F* of the feed bar. After a suitable dwell, to ensure that the released component has time to slide to the bottom of the magazine rails, the cylinder associated with the detent plungers and pusher is reversed. Consequently, the next component is unclamped from the overarm, and intercepted by the lower plunger. At the same time, the pusher advances against a stop, moving the released component along the horizontal rails *E*, until it is just touching the first vertical finger of the feed-bar.

On completion of the tapping phase of the cycle, the feed-bar is traversed through a rectangular path, during which it is (1) lowered to the position seen in Fig. 15, with the fingers *F* clear of the underside of the workpieces; (2) moved horizontally towards the magazine, through a distance equal to the pitch of the vertical fingers (1.5 in.); (3) fully

The sequence in which the holes are tapped is indicated numerically in Fig. 2, and holes 1, 2, 4, 6, 7 and 8 are tapped by vertical heads, whereas 3 and 5, in the lug, are tapped by horizontal heads. The hole 9 is tapped by an inclined head, the cycle-time of which is 6.9 sec. This tapping cycle is the longest of the series, and therefore determines the cycle-time for the machine.

All the basic motions of the machine, including those of the detent mechanism, pusher, and transfer feed-bar, and those required for initiating the automatic cycles of the tapping heads, are pneumatically operated, and are controlled by a series of rotary cams, mounted on a common shaft. Driven by an f.h.p. electric motor through reduction gearing, these cams actuate a set of pneumatic valves. The transfer feed-bar is actuated by two vertical and two horizontal air-cyclinders, and the horizontal motions are damped hydraulically. For each tapping head, there

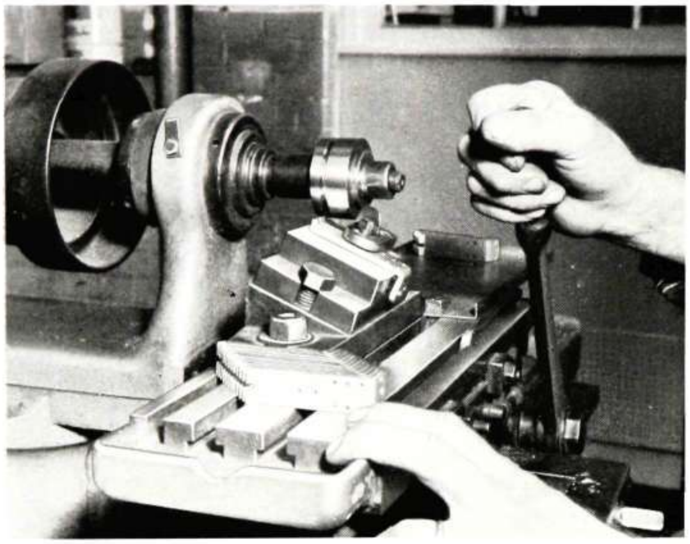

Fig. 17—Minor damage to the knife edges, sustained during handling, is rapidly removed by rollings, with this set-up on an obsolete milling machine

is an air-cylinder that trips the mechanical control for initiating the automatic cycle, through a Bowden cable, as shown at *G*, Fig. 16, in which stations 8 and 9 are viewed from the delivery end. The upper end of the air-cylinder, which is mounted on the column that supports the tapping head, may be seen at *H*.

Among various safety devices may be mentioned a pneumatic valve, situated near the delivery end of the machine, which is tripped at each forward stroke of the feed-bar. Should the feed-bar jam, so that this valve is not tripped, the tapping heads will not operate. To ensure that the machine is kept under observation at all times, and tap-breakages quickly detected, the capacity of the magazine is intentionally limited. This capacity is such that, between reloadings, the operator only has sufficient time to proceed to the delivery end, unload a batch of tapped components into a wooden tray, and return to the loading station.

Knife-Edge Rolling

During ensuing stages, at which the components are degreased, heat-treated, and dull chromium plated, it is virtually impossible to avoid a certain amount of minor damage to the knife-edges, in handling. Accuracy of the knife-edges is therefore restored, after chromium plating, by rolling, at the set-up shown in Fig. 17. The machine employed is an obsolete horizontal miller, with a lever-feed table. A hardened steel roller, suitably grooved, is mounted on the spindle, which is free to revolve, and the component, held on a simple inclined fixture is traversed under the roller by a single rapid stroke of the feed lever. In this way, any raggedness of the knife-edge is removed.

Impact-Extruded Meter-Cases

As mentioned earlier, the cases *F*, Fig. 1, for the electro-magnetic counting meters *E*, are produced from aluminium by impact extrusion. Each finished case is 3.6 in. long, and the external dimensions of the cross-section are 0.995 in./1.000 in., by 1.037 in./1.042 in. over the greater portion of the length. At the open end, the maximum permissible external dimensions are 1.015 in. by 1.057 in. The wall thickness is approximately 0.02 in. Internal major and minor cross-section dimensions are held within a tolerance of 0.005 in. and 0.006 in. respectively, and all internal corners are sharp. These cases were originally produced from brass, which necessitated the lengthy sequence of operations illustrated by the

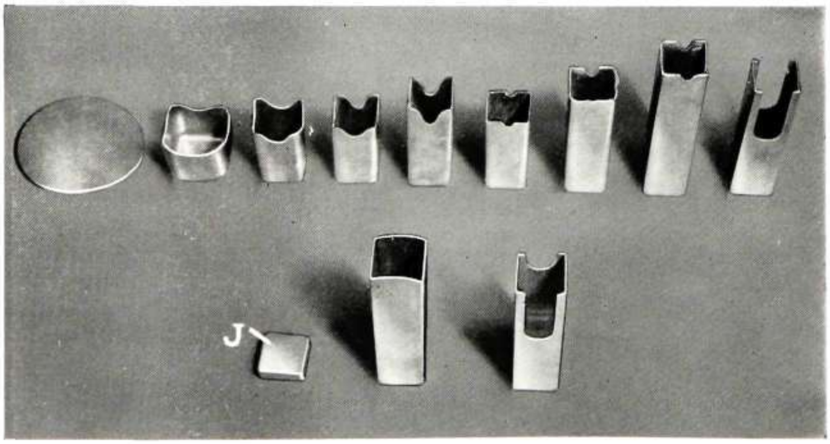

Fig. 18—(Above) Typical sequence originally required for producing meter-cases in brass. (below) Production stages for impact-extruded aluminium cases

top row of components shown in Fig. 18. This sequence involved blanking; cupping; two draws to increase the depth and reduce the cross-section; a reduction drawing stage to thin the walls and sharpen the corners; trimming the ends; two further reduction draws; and final trimming. After each draw, moreover, it was necessary to clean and anneal the work, and before the final trim, the bottom was planished to enable the correct trimmed length which was specified for the meter case to be maintained.

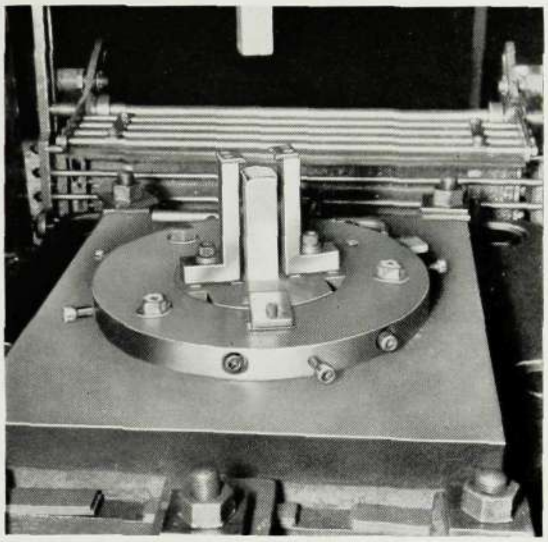

Fig. 19—Press-tools for impact-extruding the cans G, Fig. 1. The extrusion is stripped from the punch by the fixed claws

The stages for producing the cases from high-purity aluminium are seen in the bottom row in Fig. 18. Cans are impact-extruded at a rate of 270 an hour, on a 75-ton Taylor & Challen crank-press, from blanks *J*, which are prepared from 1 in. wide guillotined strip, by cropping and coining short lengths with the same press-tool. Coining, to 0.998 in. by 1.035 in. and 0.312 in. thick, is carried out to avoid the necessity for cutting any of the material to waste, and to ensure that the edges have a high finish, which has been found essential for satisfactory extrusion.

Tool Design

The extrusion tools are shown in Fig. 19, with a can still in position in the die. The punch, of Jonas & Colver's Z.A.Y. cast steel is parallel-sided, with a 0.02 in. radius on all corners, and a land measuring 1.001 in. by 0.961 in. by $\frac{1}{8}$ in. long, at the lower end. Above this land, all four sides are relieved by 0.001 in. On the bottom face, there is a raised rib in the form of a $\frac{1}{2}$-in. diameter circle, which encloses a raised grid of $\frac{3}{32}$ in. squares. The ribs of the grid are 0.003 in. high, and are provided to facilitate flow control. With the same object, the surrounding plain face of the punch is tapered from the periphery of the circle to the edges of the land, by 0.003 in., so that the face is in the form of a very shallow truncated cone.

The dies, which is of Jones & Colver's J.4V steel, has a recess measuring 1.038 in. by 0.998 in., by $\frac{7}{16}$ in. deep, with $\frac{1}{32}$ in. corner radii. A high polish is provided on the surfaces, and the sides are inclined outwards at an angle of 1 deg. A blank is placed in the recess, and when the press is operated, the material is extruded between the surfaces of the land, and the walls of the die, to the height seen in Fig. 19. On the up-stroke, the can is stripped from the punch by a pair of fixed claws, which are mounted on the die assembly. Operations subsequently carried out on the cans, to produce the finished cases, are identical with those originally employed on the brass cases. The latter, however, required shot-blasting to provide a key for the enamel finish, whereas the aluminium components are treated by the Pyluminizing process (The Pyrene Co., Ltd.).

Some further examples of the company's production equipment and methods will be discussed in a later article.

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JOINT ELECTRONIC EXCHANGE DEVELOPMENTS

ON Tuesday 10th November there was a Press showing of an experimental electronic exchange at the Post Office Research Station, Dollis Hill, London. The Postmaster-General, the Rt. Hon. Reginald Bevins, M.P. described the model as the first product of a joint venture between the Post Office and its five principal Manufacturers of telephone switching equipment. He explained that some three years ago an agreement was signed between the Post Office and these Manufacturers, as a result of which a Joint Electronic Research Committee (J.E.R.C.) was set up, with the Engineer-in-Chief of the Post Office, Brigadier Sir Lionel H. Harris, K.B.E., T.D., as Chairman. In pooling their research and development resources, the six organizations making up the Committee decided to undertake long-term studies on the best system to be employed and also to obtain practical experience in designing and operating exchanges using electronic equipment.

The experimental exchange at Dollis Hill will help in furthering both objects. Each member organization of J.E.R.C. has undertaken detailed study of a portion of the system and the individual parts are now working together in the experimental exchange. Both the multiplex and speech circuit equipment have been designed jointly by the Post Office and the General Electric Co. Ltd. ; the supervisory equipment by Ericsson Telephones Ltd. ; the register equipment by Siemens Edison Swan Ltd., and the translation, metering, line information and other equipment jointly by Automatic Telephone & Electric Co. Ltd., and Standard Telephones & Cables Ltd.

The common supervisory equipment, for which the Company has taken responsibility for design and manufacture, is shown under test in Fig. 1. It consists of a number of jack-in units which are of two main kinds ; magneto-strictive delay line units and logic units. The equipment has as its basic function a continuous observation of all calls from the time the connection has been established to its clearing down. Among the more straightforward

Photo by courtesy of the Postmaster General

Fig. 1—Testing the Experimental Electronic Exchange Supervisory Equipment

functions may be mentioned ringing the wanted subscriber and the application of ring tone to the calling subscriber, ring trip on answer and metering. The common supervisory equipment is also responsible for control of a number of the more complex facilities to be provided on the exchange and serves as a central co-ordinating link for many of the routining and testing operations.

As the Dollis Hill model has been set up to test the over-all functioning of a system rather than act as an engineered prototype, opportunity has been taken to introduce a number of experimental techniques in the design of the apparatus. The common supervisory equipment includes magneto-strictive delay lines some 900 μS long operating at 1 Mc/s repetition rate ; in this way a single set of equipment can supervise the operation of a complete exchange serving many thousands of subscribers. Similar techniques have been employed elsewhere in the exchange and it is by this extensive application of the principles of time sharing, using the high switching speeds possible with electronic devices, which leads to the suggestion that electronic telephone exchanges designed in this manner may ultimately have subsubstantial economic advantages over the electromagnetic system.

Although this model is not built as a public exchange it does provide facilities for telephone calls within the Research Station and also into the London public telephone system. Exhaustive tests are now being carried out and, upon completion, equipment for about 1,000 lines will probably be installed within two years for the public exchange at Highgate Wood, in North London.

HOW THE DOLLIS HILL MODEL WORKS

General

In existing telephone exchanges, one subscriber is connected to another by metallic contacts on relays and selector mechanisms. In this way, while the subscribers are in conversation, there is an actual direct metallic path from one to the other within the telephone exchange, and all the apparatus involved in this path is used exclusively by that conversation as long as the call continues.

Investigations into the field of electronics have shown that devices can be made which have properties similar to those of a switch in that they are either 'on' or 'off'. Among these switch-like components are various kinds of special valves, transistors and many other elements still in the research stage. These basic circuit elements operate either to allow currents to pass or to be obstructed and so have become known as 'gates'.

Early attempts to construct electronic telephone exchanges were based on the idea of replacing the electromechanical switches by suitable gate circuits and experimental models of systems of this kind have been demonstrated over the last ten years. Experience in the computor field, however, had some years ago established that with suitable choice of components, these gate circuits could open and close extremely rapidly ; whereas mechanical contacts require an appreciable fraction of a second to close and open, the electronic equivalent can do so over a million times as quickly.

Because of the limited operating speed of the mechanical system, all the apparatus involved in the conversation is required for the exclusive use of that conversation ; however, by taking advantage of the ultra high switching speeds available with electronic devices substantial economies can be made.

It is clear that if the gate circuits concerned are always in the condition allowing current to pass, then the electronic switching system is equivalent to the present system and may not offer any particular advantage over it. If however the gate circuits are opened and closed momentarily at intervals then a large number of conversations could use the common speech path by interlacing each one in the 'off' periods of the others. In this way can be achieved the desired economy of having a large number of speaking paths (i.e. conversations) sharing common apparatus. This process of interlacing speech paths in time sequence, the whole cycle being repeated fast enough for there to be no audible discontinuities, is known as time division and the equipment is called a time division multiplex system. With mechanical switches this process would produce a series of clicks and a disjointed effect on the speech ; by using electronic gates, the switching rate can be so speeded up that no audible effect can be detected.

Having interlaced the speaking circuits into a multiplex in this way it is necessary to be able to select the wanted one for each different pair of subscribers who are carrying on a conversation. This selection process is carried out by gate circuits connected between the common multiplex and the subscribers concerned ; if the gates were continuously open, all conversations would be overheard, but by opening and closing them only for the time at which the particular speech channel is available for the subscribers concerned, each will hear only the remarks of the other.

The multiplex cycle repeats 10,000 times per second and each speech circuit is connected for one millionth of a second, so that 100 speech circuits are available for each multiplex group. Many more than 100 subscribers can be connected to this group, however, as not all of them will be using the telephone at the same time, and in a typical electronic telephone exchange working in this manner, up to 800 subscribers could be connected in one group. If more than this number is required, several groups must be provided with additional gates to interconnect the groups.

Apart from the multiplex group apparatus which provides the actual speaking circuits, it is also necessary to include equipment to supervise the operation of the gate circuits, to register the wanted number of the subscriber being dialled, to translate the number being dialled into signals which operate the appropriate gate circuits and to record on a meter the cost of the call.

Additional Technical Information

Basically the exchange employs the principle of time division multiplex and switched highways for the ultimate connection, where each highway can carry up to 100 simultaneous conversations and sufficient highways are provided depending on the traffic of the exchange. The exchange lines are arranged in groups and each line in a group is connected by electronic gate circuits to the highway common to all lines in that group. Each highway in turn is able to be connected to any other, again by electronic gate circuits. These highways transmit speech and other signals to and from the lines in the form of amplitude modulated pulses. The number of lines in a group connected to a highway is several times the possible number of simultaneous conversations depending on the traffic originated by the lines.

Temporary Memories

Each connection on a highway uses a pulse channel transmitting one of a series of interleaved cyclically recurring pulse trains, typically of 10 kc/s repetition frequency. Lines are connected to channels by applying suitably timed pulses to the gate circuits. Magneto-strictive delay lines are used as temporary memories for storing the pulses which have been allocated to the subscribers' gates for connection to the highway and also for controlling the gates interconnecting the highways. Magneto-strictive delay lines are used as registers to receive information dialled by subscribers. They count and store the dialled pulses, obtain any translations which are necessary to route calls to other exchanges and transmit digit pulses when outgoing routes are established. Delay-lines also control the supervision of connections after they have been established. They connect tones to the calling lines and ringing to the called lines at appropriate times, detect answering and clearing and arrange for the metering of successful calls.

Use of Magnetic Drum

A magnetic drum is used as a semi-permanent memory. This drum carries all the information relative to all subscribers' lines and junctions and acts in this respect as the exchange library. Another portion of the drum co-operates with the register equipment by providing translation facilities for routing the call either to a local subscriber or to subscribers on other exchanges. Positions on the drum particular to each subscriber are used to record the accumulated total of unit fee registration debited against the subscriber and as such replace the individual electromechanical message registers provided per subscriber in existing systems. The accumulated total can be read from the drum as and when required for subsequent automatic accounting for the final subscriber's account.

Change-Over Prospects

It must be emphasized that this experimental installation does not imply an immediate and wholesale changeover of the public telephone system to electronic switching. There are still a number of hurdles to clear even with the time division system and investigation into the technical and economic merits of alternative electronic systems has yet to be completed. The decision, however, of the Post Office and the Manufacturers to plan a public installation of the system indicates their confidence in the progress so far made in this joint venture.

U.D.C.621.395.631.4

RINGING GENERATORS USING TRANSISTORS

J. Bird — Circuit Development Laboratory

This article briefly describes d.c. Invertor units using transistors that have been developed as ringing generators to replace several of the conventional ringing devices now in use. Some applications are discussed in relation to telephone instruments, switchboards and automatic exchanges and comment is made on future trends and development.

RINGING current is a basic requirement for signalling in any telephone system and the many devices that exist for its generation bear testimony to the effort made to suit the customer in his varied needs. Hand-operated magneto generators, battery-operated vibrators, sub-cycle generators operating from a.c. mains and power-driven rotary machines, in present use, have been designed to provide this essential facility and all have merits particular to their application.

The use of the latest junction transistors has now made possible the development and production of small static ringing-current generators that operate from d.c. sources of supply generally available with telephone equipment. These new devices, judged in terms of cost, electrical performance, freedom from maintenance, simplicity of design, size and convenience to the user, will prove their suitability as a replacement for many of the conventional devices now in use.

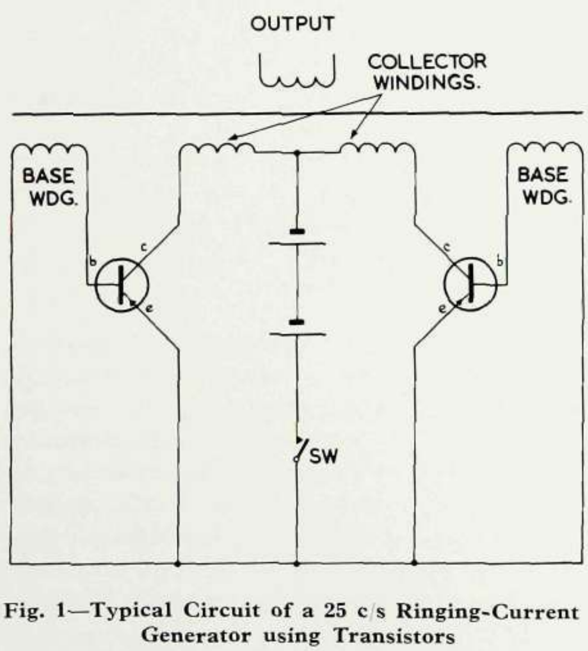

Fig. 1—Typical Circuit of a 25 c/s Ringing-Current Generator using Transistors

General Circuit Arrangement

Several different arrangements have been employed in the generators described, but in principle of operation they follow the circuit shown in Fig. 1.

Collector current begins to flow in both transistors when the battery supply is connected via SW. By design, it is determined that one of these currents will rise faster than the other to initiate the desired oscillation in the transformer windings. This current, rising in the collector winding, induces in the associated base winding an e.m.f. which causes base current to flow in the associated transistor in such a direction as to assist the formation of the collector current. At the same time, a similar e.m.f. induced in the other base winding is in such a direction as to cut off the transistor in the second half of the circuit. Current may now continue to rise in the collector circuit at a rate dependent on the collector winding inductance. Under these conditions the voltage developed across the operating transistor is very low, i.e. the transistor is in the ' bottomed ' state. Thus, almost all the supply voltage is developed across the collector winding to give the maximum voltage transformation into the transformer output winding.

Upon the collector current reaching the maximum value determined by the base current, the transformer flux ceases to change and the induced base winding voltage is reduced to zero. Reduction in the transistor base current results in a limitation of collector current with a consequent collapse of transformer flux and reversal of the induced voltages in the two base windings. The conducting transistor is rapidly cut off and collector current rises in the second transistor.

The cycle repeats in this manner at a frequency largely governed by the transformer inductance.

An essential characteristic of this circuit is that power can be delivered to the output without any appreciable power dissipation in the transistors.

For Use in Telephones

Over the years the magneto generator has given sound and reliable service, but a drawback in its operation is the necessity for manual rotation of the handle associated with its mechanism.

Here, in Fig. 2, is shown a ringing-current generator that operates by means of a press-button. Small and compact, the unit is located conveniently in a standard telephone instrument ; in this instance the intermediate telephone of an Intermediate/Extension telephone arrangement. The generator is supplied from the same local power source that provides direct current for transmission purposes and the output, derived on depression of the button mounted on the instrument, is capable of ringing an a.c. bell and an external bell (when fitted) over a line resistance of 1000Ω.

This unit has the advantage of being immune from electrical damage under certain conditions that can occur when a telephone instrument is undergoing maintenance or installation. For example, if the output were to be inadvertently short-circuited, or the input be reversed, no harm to the transistors would ensue. Furthermore, a reversal of the input would be immediately apparent since the ringing output would not be available in this instance.

The generator operates from a 6 to 9 volts supply and typical results obtainable are shown in the Tables.

Two 500+500Ω +2μF Bell Circuits in Parallel, connected in Series with 1000Ω Line

Input Volts	Input Average Current	Output Volts (Peak)	Current Per Bell (r.m.s.)	Frequency c/s
6	200 mA	85	7·5 mA	19
9	320 mA	150	12 mA	24

Two 500+500Ω Bells in Series with a 2μF Capacitor and 1000Ω Line

Input Volts	Input Average Current	Output Volts (Peak)	Load Current (r.m.s.)	Frequency c/s
6	170 mA	100	8 mA	21
9	220 mA	175	10·5 mA	28

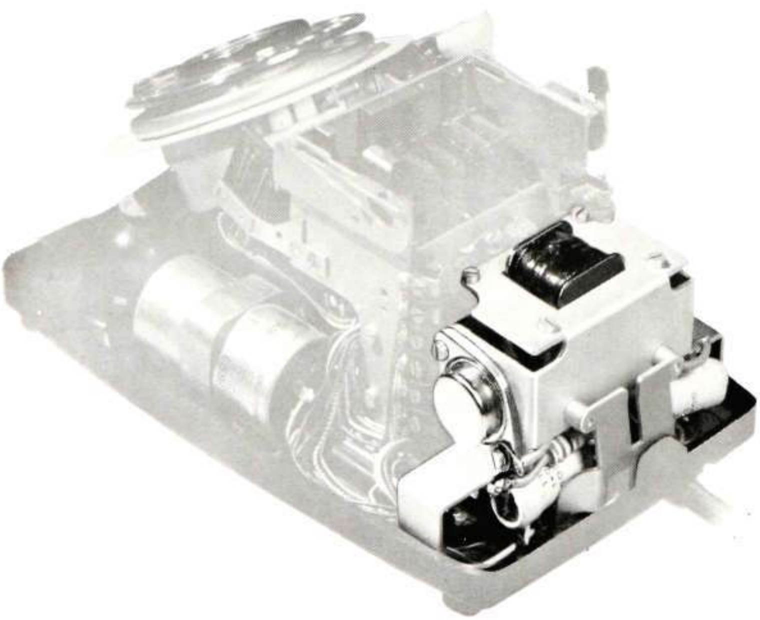

Fig. 2—25 c/s Ringing Current Generator in an Intermediate-type Telephone

Because of the diversity of existing power sources a single type of generator, such as this, is unlikely to supersede the magneto generator in all its applications. The probability is that a minimum number of types of unit will be developed and their final form will be largely influenced by particular requirements.

An immediate development is a unit for use in magneto telephone instruments. In this case a comparatively larger output is required and to minimize the current drain from cells generally used with local-battery instruments it is proposed to operate this unit from a supply exceeding 3 volts.

Fig. 3—25 c/s Generator operative from 12 volts d.c. for single-position switchboards

FOR USE IN SWITCHBOARDS

Whilst having a number of potential applications, the unit illustrated in Fig. 3 has been designed primarily as a power ringer for use in a single switchboard position. Capable of modification for differing input and output specifications, this device mounts on the standard magneto generator fixing centres and provides immediate replacement for the hand-generator when ' ringer-start ' contacts exist at the switchboard. The adaptability of the unit may be instanced where, in switchboards of new design, advantage may be gained by mounting the unit directly in the rectifier unit supplying power to the switchboard.

Two $500+500\Omega$ bells in parallel, each in series with a $2\mu F$ capacitor, can be operated by this unit. Alternatively, by the inclusion of a capacitor in series with the generator output winding, satisfactory operation of four bells, in series with a single 1·8 or 2 μF capacitor, can be achieved ; this arrangement conforms to a British Post Office requirement when telephones are used on extension lines in their Plan 1A arrangement.

A nominal 12V input is required for this unit. The higher voltages common to telephone equipment but outside the range of suitable transistors may be suitably limited by means of a voltage-divider chain. This latter arrangement may also be employed where wide ranges of voltages are encountered in exchanges supplied over power leads, but satisfactory operation of more than one bell circuit, in this case, is difficult to achieve at the extreme lower end of the particular range used.

Where the range of supply voltage is within the operating limits of available transistors it is possible to design more efficient units to operate directly from the supply and adequately encompass a wide voltage range. With this in mind a unit of the type shown in Fig. 3 operating nominally from 24 volts is under development.

The present method of operating switchboards with a power ringing supply, using the magneto generator as a standby, is likely to disappear for C.B. switchboards and be replaced by ringing generators using transistors. Standby ringing will also be generated by a spare transistorized unit for those rare occasions when accidental mechanical breakage occurs.

FOR USE WITH AUTOMATIC EXCHANGES

When power ringing for a suite of switchboards or multi-party lines is under consideration the unit illustrated in Fig. 4 is of greater interest.

This is a larger output 25c/s generator operating from a 50V d.c. source and is designed to replace vibrator and other ringing equipment in medium-size automatic exchanges. In addition to this ringing device, Tone units using transistors have already been supplied with ' Rurax ' exchanges and the generator itself, with a single phase, has operated without trouble or deterioration of output in a high calling rate 800-line exchange for several months.

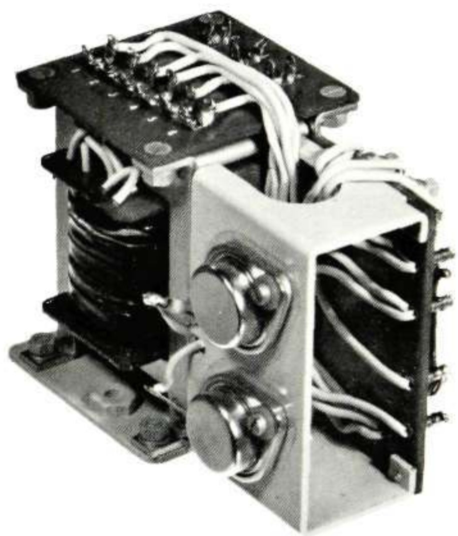

Fig. 4—25 c/s Generator operative from 50 volts d.c. for Auto Exchanges or suites of switchboards

The generator unit mounts in four B.P.O. standard '3000'-type relay spaces, either on a jack-in relay set base or strip-mounting plate. Alternatively, together with its input smoothing, it is available in a metal box for wall or base-board mounting. A typical use for this latter unit is at carrier terminals where, for reasons of space, it is impracticable to mount the device within the equipment.

The standard, set and achieved for this design, was that the unit should deliver 7 mA ringing current to a standard bell circuit comprising a 500+500Ω bell in series with a 2 μF capacitor, under the following conditions :

Input voltage	46V
Line resistance	1500Ω
Shunt across generator output	24 similar bell circuits in parallel
Exchange apparatus in series with line	Ringing trip relay and ringing return resistor

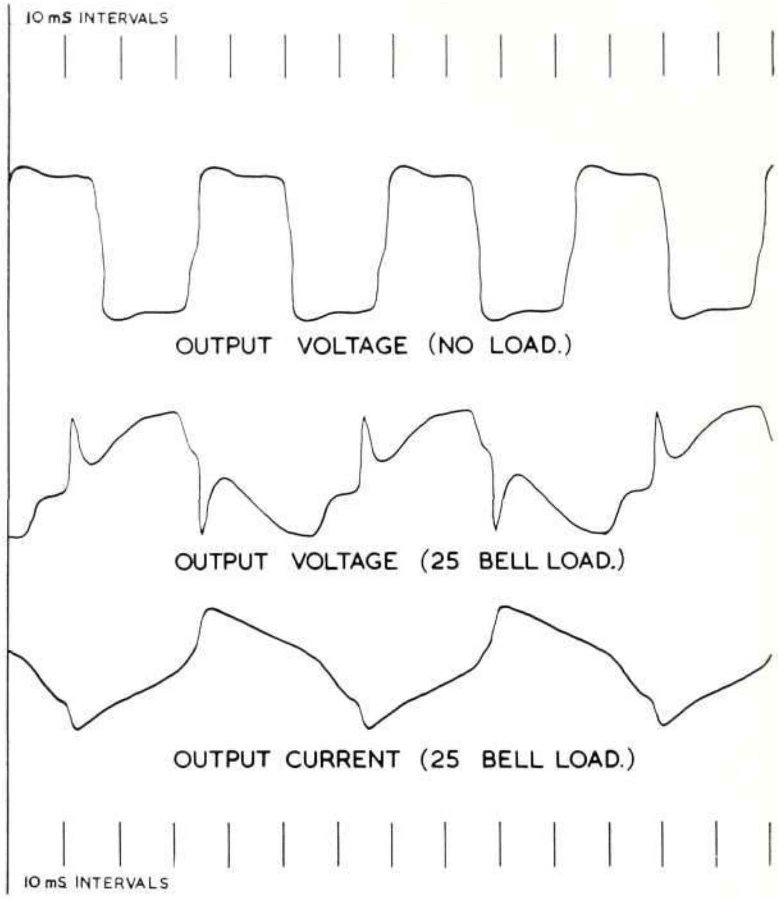

Fig. 5—Output Curves for the Generator in Fig. 4

The average input current on no load is 350 mA rising to 900 mA when 25 standard 500+500Ω bells are operated, each in series with a 2 μF capacitor, on a zero resistance connection. Fig. 5 shows the output current when the generator is so loaded.

Under certificate No. I.S. 1181 (Methane), this generator, comprising a modified transformer with a safety resistor in series with the output winding, gives an intrinsically safe ringing source and is fully approved by the Ministry of Power for use in telephone systems for mines.

To meet the need for a unit to function from the more usual manual switchboard supply of 24V, a device similar to that shown in Fig. 4 is now in an advanced stage of design. For this application it is not considered that so large an output will be required. Using the 7 mA ringing current standard decided upon for the 50V unit it is intended to operate 10 standard 500+500Ω+2 μF bell circuits in parallel, with one circuit terminating a 1000Ω line and, additionally, four 500+500Ω bells in series with a 2 μF capacitor.

Conclusion

Transistors have been in use for several years and experience suggests that static devices employing these components will have a long life. Since, in the devices described, the transistors are used in such a manner as to dissipate no appreciable power it is confidently expected that, except for mechanical damage, these devices will last as long as the equipments with which they are associated.

U.D.C.621.395.342

A SELECTOR BANK CLEANER

B. A. GREEN, M.I.Prod.E., M.I.E.I.—Apparatus Development Engineering Department

One of the many operations necessary in the preparation of automatic telephone exchange equipment before it is introduced into service is the cleaning of selector bank contacts. This article describes a motorized unit suitable for quick and efficient cleaning of the contacts of British Post Office types ' 2000 ' *and* ' 4000 ' *selector banks.*

IN the normal course of manufacture and installation, selector bank component parts are subjected to various processes and atmospheres which may contribute to the contamination of the surfaces of contacts. This contamination causes difficulty during the subsequent continuity testing operations at automatic telephone exchanges and various methods have been devised to overcome the problem. The efficacy of most of these methods has depended in the past on the skill and integrity of the person carrying out the cleaning operation, which is a tedious and monotonous task subject to human fallibility.

The bank cleaner described in this article has been developed to provide means for reliable and consistent cleaning by a process which is virtually independent of human fatigue and variability.

In essence, the cleaner is a jack-in type unit having a motor-driven shaft carrying cleaning segments which wipe over bank contacts a predetermined number of times. A general view of the unit is illustrated in Fig. 1.

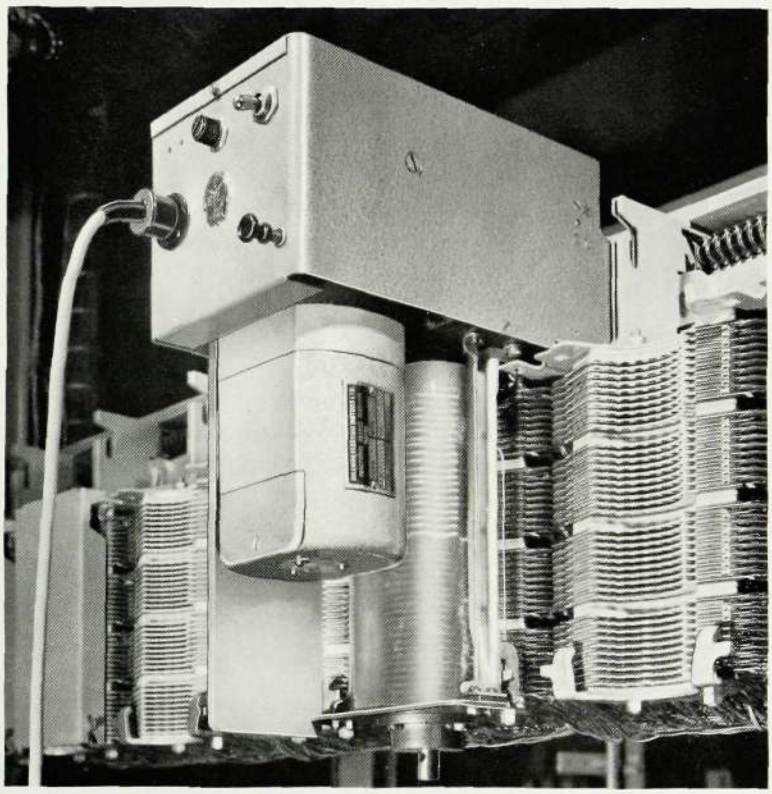

Fig. 1—View of the Bank Contact Cleaner in position for operation

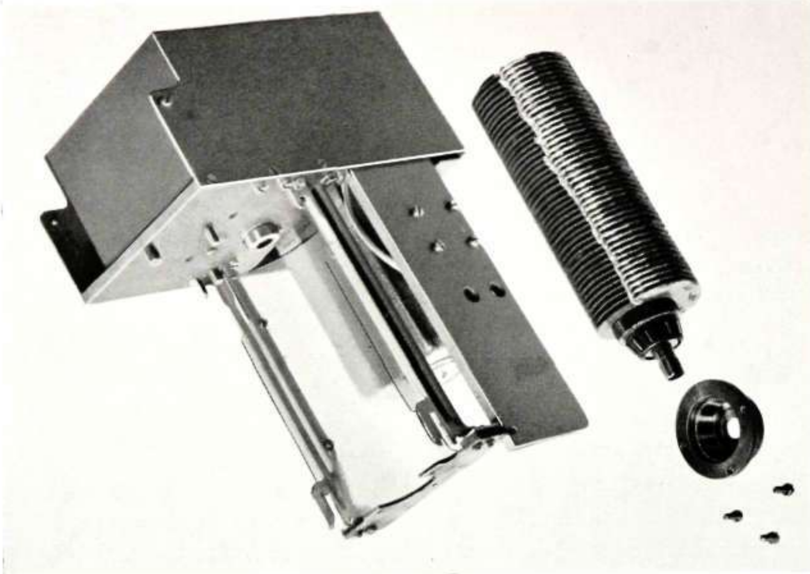

Fig. 2—Exploded view showing construction of Rotor

CLEANING MECHANISM

The cleaning mechanism is a rotor (Fig. 2), on the shaft of which are mounted two sections each comprising a number of fabricated discs, so spaced as to align approximately with the bank contacts. By means of Belleville-type washers, the discs are self-aligned with the particular level being cleaned.

One half the perimeter of each disc has radial slots through which cleaning tape is woven, the tape being secured by metal clips. The other half of the disc which is not used in the cleaning process, has a reduced radius to provide clearance between the disc and the selector bank. Thus, when the untaped side of the rotor faces the bank, the cleaner can be easily removed without risk of damaging the bank contacts or the cleaning segments.

During the cleaning operation the taped portions of each section are arranged to be on opposite sides as in Fig. 1 so that while the discs of one section are engaged in the bank, the discs of the other are free. This alternate engagement of the sections results in a more even distribution of the load on the motor.

The replacement of a soiled rotor by a clean one is a simple matter, since the rotor can be readily detached after removing three screws and disengaging the rotor from its driving shaft. Soiled tapes can be cleaned by moving the taped portion of the rotor through a bath of petroleum ether or a similar solvent which leaves no residue that might affect the bank contact surfaces.

DRIVING AND CONTROL MECHANISMS

The rotor is driven by a 50-volt a.c. motor through reduction gears and a tongued coupling at a speed of approximately one revolution per second. Supply to the motor is derived from a step-down transformer with tappings to accommodate the usual range of 50 c/s mains supply voltages.

Fig. 3 is a view of the control mechanism which may also be seen enclosed above the motor in Fig. 1. This section of the cleaning unit includes a socket for connecting the power supply, a power switch and fuse, and a non-locking button for starting the motor.

Operation of the control mechanism is effected by depression of the non-locking ' Start ' button which, in dis-engaging a mechanical latch, causes a micro-switch to operate and complete the motor circuit. The button is maintained in the operated position for approximately one second, during which time a cam on the rotor-drive spindle rotates to a position where it holds the latch out. A reduction gear, having a ratio appropriate to the number of rotor revolutions required and driven from a worm gear on the motor-driven spindle, turns a counting cam. This cam rotates one revolution for each cleaning cycle and during this period also holds the mechanical latch out.

The counting and rotor-drive spindle cams are slotted—the former may be seen in the forefront of Fig. 3—and when both slots are in alignment the mechanical latch drops back and releases the micro-switch to stop the motor. In this manner, the rotor

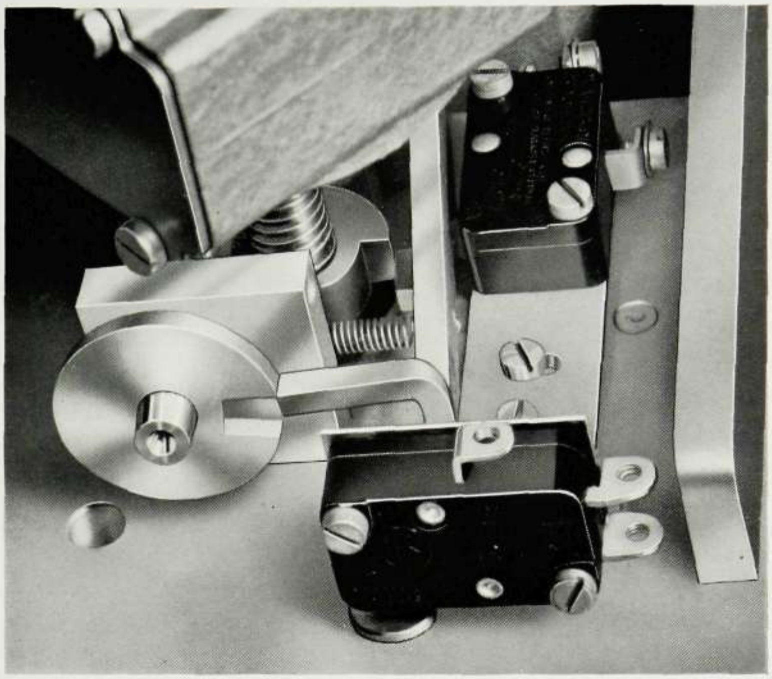

Fig. 3—Internal View of Control Mechanism

is arrested in the correct position with the upper section located clear of the bank. The lower section still in engagement with the bank is then rotated clear by first inserting a small lever in the hole at the bottom of the shaft.

Other Details

The mounting, designed to enable the cleaner to be jacked into position in a similar manner to a two-motion selector, consists essentially of two rigid plates at right angles to each other; one of these, a horizontal plate, provides means for mounting the control mechanism and the other, a vertical plate, serves to mount the motor. Standard frame extensions in conjunction with cradle location plates position the cleaner in correct relationship to the bank and engage with the existing location points of the bank and cradle.

A preliminary model has been in use in various parts of the world over the past two years and the knowledge gained shows that the use of a motorized unit not only ensures a great improvement in the quality of cleaning, but also results in a considerable saving in installation time. Observations reveal that with the motorized cleaner, twice as many selectors can be prepared and accepted for service in the time taken when manual cleaning operations are employed.

Designs have now been completed for the cleaning of B.P.O. types ' 2000 ' and ' 4000 ' selector banks for two, three or four bank selectors with or without vertical marking wipers.

U.D.C.621.395.49

A TRANSISTOR TYPE S + DX EQUIPMENT

A. P. Plumb — Carrier and H.F. Development Department

A demand exists for a single telegraph circuit to locations where a mains supply is not available or possibly unreliable and the traffic to be carried does not justify the provision of further line plant.

This battery operated Speech + Duplex (S + DX) Telegraph Equipment fulfils the demand in all respects.

DURING recent years the trunk communications in many of the less developed areas of the world have been modernized by the introduction of carrier and multi-channel radio systems together with the use of multi-channel v.f. telegraph equipment.

To complete the telegraph service it is necessary to transmit and receive telegraph messages between the trunk centres and remote locations often served by a magneto exchange. A mains supply is frequently non-existent or so unreliable as to prevent the use of orthodox valve equipment. The revenue possible from the telegraph service may not justify the provision of a further circuit to the central exchange, but the principle of S + DX working overcomes this problem and the use of transistors enables equipment to be operated from low voltage batteries.

To meet this demand our present range of S + DX equipment has been implemented by the addition of a further unit, the Type 17 with transistors, having a power consumption of 3 watts.

Operated from a low capacity battery or high voltage supplies this equipment provides for the simultaneous operation, without mutual interference, of speech and duplex telegraph over a common path. It is suitable for application to physical lines, radio links, or carrier communication circuits from which a 2-wire or 4-wire telephone circuit can be derived.

The addition of the telegraph channel is accomplished by suppressing a frequency band width of 500 c/s from the upper speech frequencies and using this section for telegraphy. This reduction of the speech band causes negligible loss in syllable articulation and scarcely affects the intelligibility of transmitted speech.

The system is flexible in that conversion from 2-wire to 4-wire working is effected by the simple positioning of U-links. Choice of either single or double-current telegraph working (low or high voltage) and the flexible arrangement of power supplies enables the installation of only the equipment needed for the initial demand.

Typical applications and power supplies of the system are shown in block schematic diagrams Figs. 1 and 2, the former showing a 12 + 12V terminal connected for use over a 2-wire line and the latter an 80 + 80V terminal for use over a 4-wire line or radio circuit. The optional power arrangements are, of course, applicable to both cases.

Telegraph Facilities

Low voltage 12 + 12V double-current working suitable for use over short d.c. loops requires no additional relays. The send current is approximately 6 mA and the maximum receive current output is 30 mA over a minimum loop resistance of 300 ohms.

When it is desired to operate a remote teleprinter with 80 + 80V working, a receive relay and a transistor power pack can be supplied and fitted within the casework. Resistors are included to enable the line current to be set to 20 + 20 mA.

It is also possible to provide for 40 mA single current working if this method of operation is required.

Basic Operation

Telegraphy

To enable the transmission of low-frequency d.c. telegraph signals over a non-physical circuit where no d.c. connection exists, these signals are converted

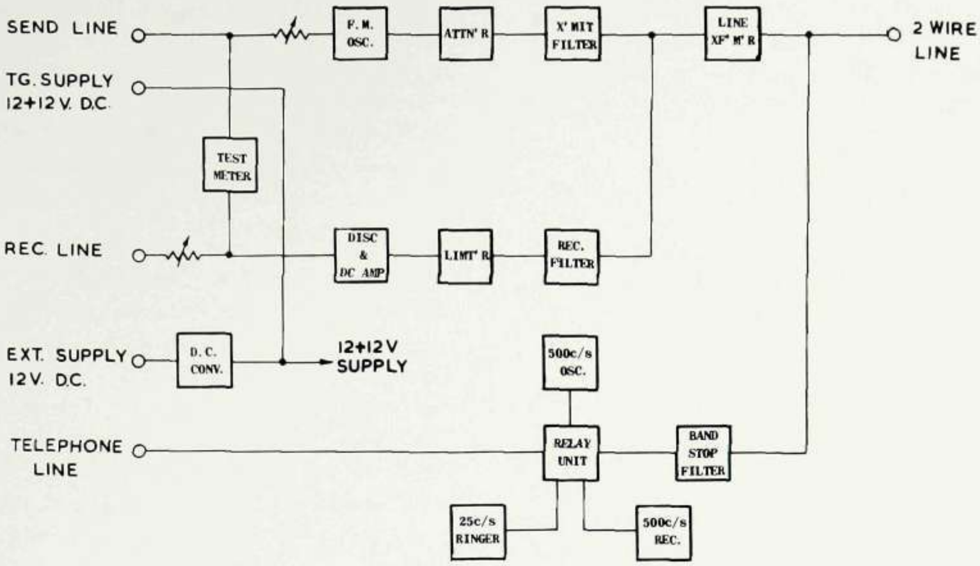

Fig. 1—Block Diagram of the FMT. 17 System, Two-wire Version

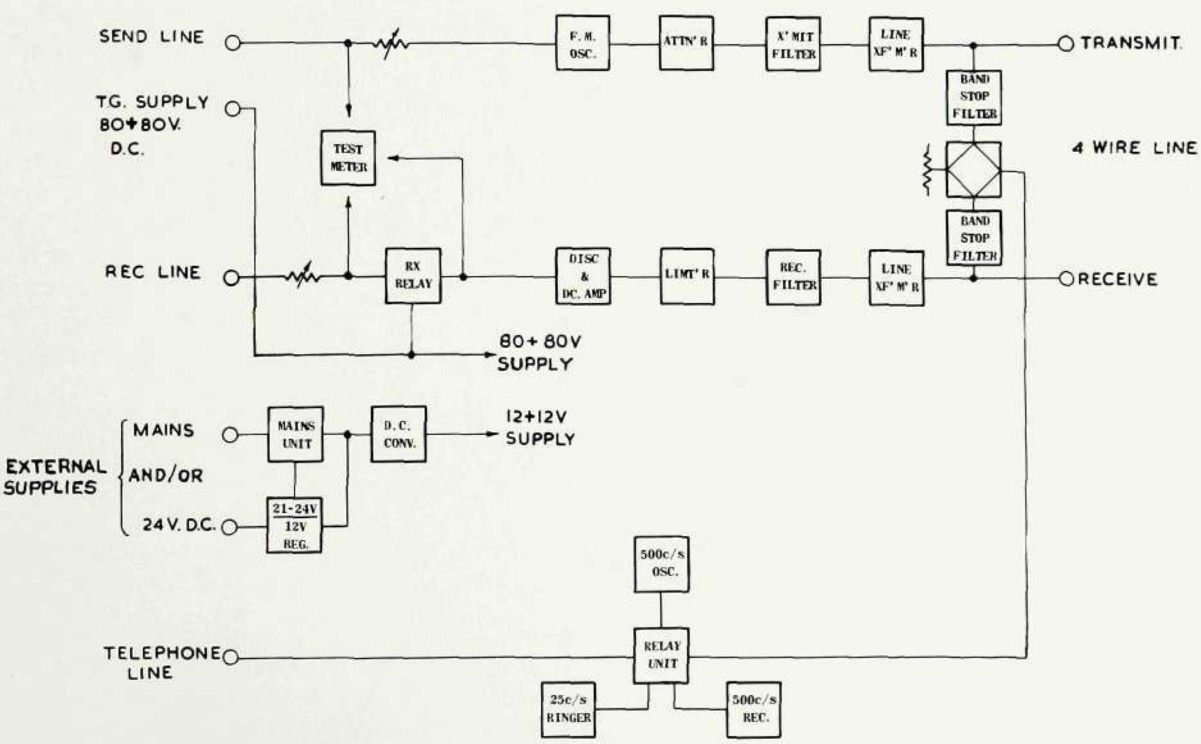

Fig. 2—Block Diagram of the Four-wire Version

to frequency-modulated signals of 1860 c/s for an 'A' station and 1680 c/s for a 'B' station. Direction of these transmitted frequencies is controlled by the transmit and receive band-pass filters at each terminal (see Fig. 1).

When d.c. signals are applied to the send leg, a modulated oscillator is caused to deviate ±30 c/s about the centre frequency. These upper and lower frequencies derived are transmitted to line via the attenuator, transmit band-pass filter and line transformer.

Consider now Fig. 1 as the distant terminal, since both terminals are identical apart from frequency allocation. The received f.m. telegraph signals enter a line transformer and a receive band-pass filter to operate the limiter unit. This unit is a device which presents a constant signal level to a discriminator unit in spite of variations in amplitude of level resulting from changes in line attenuation. The discriminator and d.c. amplifier convert the v.f. signals to normal d.c. signals and transmit them to the attached telegraph equipment.

Telephony

Referring again to Fig. 1; the telephone circuit operates via a relay unit and a band-stop filter which suppresses voice frequencies of 1520-2020 cycles; a transmission bridge in the relay unit isolates the d.c. circuit from line.

When a carrier-derived or radio circuit is employed, low frequency 17 c/s or 25 c/s magneto ringing originating from the switchboard cannot be directly transmitted over the channel. A relay is therefore provided in the relay set to respond to either of these frequencies of magneto ringing and cause the output of a 500 c/s oscillator to be switched to line by way of the band-stop filter.

Passing through a similar filter at the distant terminal, this v.f. tone from the oscillator is detected and converted to a d.c. signal by a 500 c/s receiver. This receiver is immune from all other incoming frequencies on the speech band. Operation of a relay in the relay unit by the d.c. signal then follows to switch an h.t. supply to a 25 c/s ringer which, on being energized, applies its output to the telephone circuit to actuate the telephone instrument bell.

It is to be noted that on short physical lines the 500/25 c/s ringing unit is unnecessary since the band-stop filter provides a metallic connection between the telephone and line circuit.

Circuit Description

THE 25 *c/s RINGER* (Fig. 3)

The principle of operation is as follows:—

The balanced primary of transformer L1 (terminations 1-3) and transistors X1 and X2 form a push-pull, square-wave blocking oscillator with both

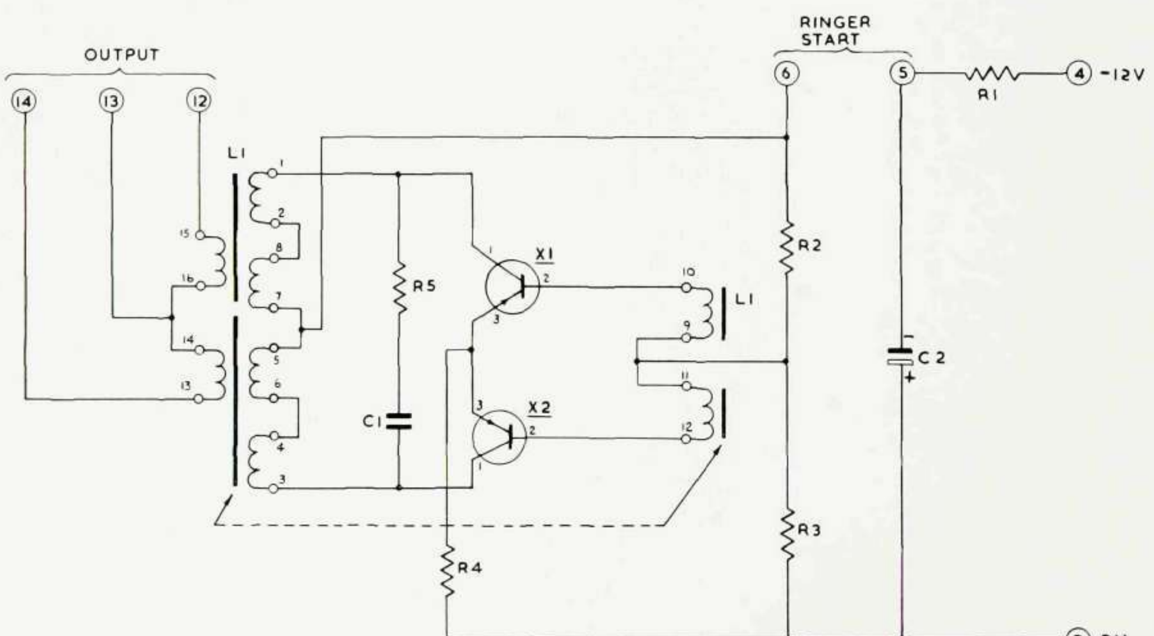

Fig. 3—25 c/s Ringing Current Generator Circuit using Transitors

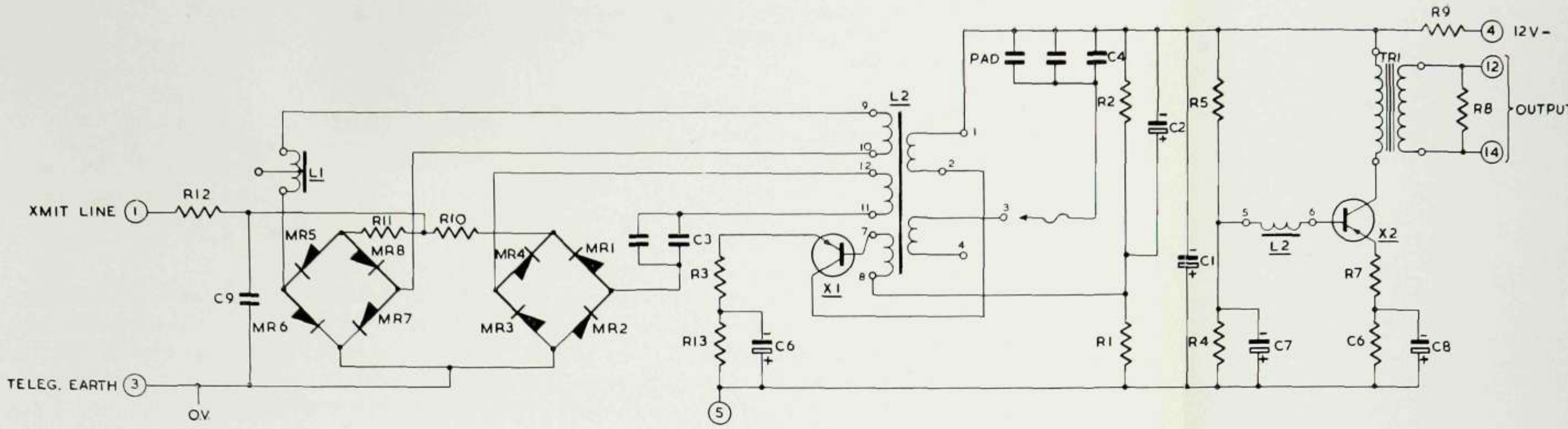

Fig. 4—Oscillator Modulator Circuit

transistors operating in the grounded emitter state. Positive feed-back to the base of each transistor is provided by means of the balanced secondary winding (terminations 10-12), to cause both transistors to bottom and cut off alternatively. Oscillations are initiated by the forward bias supplied by returning the centre-tap of the secondary winding (terminations 10-12) to the resistor chain R2 and R3. Capacitor C1 and resistor R5, being a simple quench circuit, protect both transistors from high voltage surges.

The 25 c/s output is fed from one or both of the output windings on L1 which are provided to meet specific requirements. Both windings combined are intended to work into relay sets having impedances in excess of 3000 ohms; use of one winding permits the satisfactory operation of low impedance bells.

OSCILLATOR — MODULATOR (Fig. 4)

The oscillator-modulator operates as follows :—

The complete unit employs two OC 71 transistors X1 and X2 operating in the grounded emitter connection. Transistor X1 serves to energize the oscillating circuit and X2 to provide a buffer amplifier stage between the oscillator and the output load.

Rectifier bridge MR1–MR4 in series with capacitor C3, and MR5–MR8 similarly connected with inductance L1, are joined in parallel across a d.c. telegraph transmit circuit and coupled by separate windings to the tuning inductance L2. The latter comprises four windings with variable tapping points 3 and 4 for the tuning capacitor C4, to enable frequencies 1680 c/s or 1860 c/s to be pre-set during production of the equipment. A simple filter, to eliminate unwanted harmonics, emanating from incoming d.c. telegraph signals is provided by resistor R12 and capacitor C9.

An incoming positive telegraph signal biases rectifier bridge MR5–MR8 to switch L1 in parallel with the tuned circuit. This results in an increase of 30 c/s in the carrier frequency. Conversely, a negative signal biases the other rectifier bridge MR1-MR4 to cause a 30 c/s decrease.

All frequencies caused to deviate in this manner are applied to the buffer amplifier X2 via winding terminations 5 and 6 on L2 and conveyed through transformer TR1 to output terminals 12 and 14, across which impedance correction for 600 ohms is provided by R8 resistor.

DISCRIMINATOR AND D.C. AMPLIFIER UNIT (Fig. 5)

Consisting of a frequency discriminating device with detector circuit, a v.f. amplifier and push-pull d.c. amplifier, this discriminating unit performs the reverse operation to that of the oscillator-modulator. The unit, as previously mentioned, is designed to amplify the frequency modulated v.f. signals received via the receive band-pass filter and limiter and to convert them into d.c. telegraph signals.

The v.f. amplifier employs two transistors X1 and X2, operating in the grounded emitter stage, which amplify the output signals under class ' A ' conditions and apply them to the primary windings of the frequency discriminator.

The discriminator has two parallel-tuned circuits, one L2 and C4 resonant above and the other L1 and C5 below the mid-band frequency. Hence, the incoming f.m. signals simultaneously tend towards resonance in one tuned circuit and away from resonance in the other in accordance with the modulated frequency. The voltages thus developed across each circuit, varying inversely in amplitude one from the other, are detected separately by the rectifiers MR1–MR2 and MR3–MR4 for upper and lower frequencies respectively. Both detected signals appear as pulsating d.c. and their polarities are applied in series aiding across potentiometer RV1 which forms part of a simple bridge circuit. The varying signal voltages produce d.c. voltage reversals across the output of the bridge circuit between the sliding contact of potentiometer RV1 (bias control) and the common connection between the two detector circuits.

When the mid-frequency signal is received by the frequency discriminator, the output from the bridge circuit is zero, since both detectors produce equal voltages of opposite polarity. Receipt of the upper-side frequency results in a voltage unbalance and a negative voltage appearing at the centre-tap of the potentiometer. Conversely, the lower-side frequency produces a positive voltage at the same point. Inductance L3 and capacitor C8 form a low-pass filter to prevent v.f. tones passing into the d.c. telegraph circuits.

Transistor X5 is a d.c. amplifier used to drive the push-pull stage X3 and X4. By design, X5 is slightly forward biased via L3 by the network R13 and potentiometer RV2 (balance control) so that the currents flowing through X3 and X4 are equal. Because of the resulting voltage drop of 12 volts across each transistor, the potential at terminal 8 equals that of the 12+12V battery centre-tap. Under this condition, which corresponds to the neutral position between ' mark ' and ' space ', no telegraph current is permitted to flow in the telegraph receive line.

When f.m. signals are received, the detector circuit provides positive and negative signals that cut-off and bottom X5 and X3 simultaneously. At the cut-off stage of X3, a forward negative bias to the base of X4 via R15 (MR5 high impedance) causes X4 to bottom and the —12 volt supply to be switched to the telegraph line. Conversely, when X3 is bottomed, the base of X4 receives a reverse positive bias via R16 (MR5 low impedance) causing X4 to cut off and the +12 volt supply to be switched to line.

Fuse FS1 provides protection for the output transistors X3 and X4 should the telegraph-receive line become short circuited to ground.

Overall Performance

On either 2-wire or 4-wire working, operation is satisfactory over lines having a characteristic impedance of 600 ohms. Line losses between terminals may vary from 0 db to 30 db and the maximum level of v.f. telegraph tone transmitted to line at —5 dbm may be reduced in steps of 1 db by suitable strapping on a 31 db attenuator.

The telgraph v.f. tone detector will operate, without adjustment, from incoming signals having levels varying from —5 dbm to —35 dbm.

In v.f. signalling over 2-wire lines the 500 c/s oscillator transmits to line at a level of approximately +1 dbm. When the hybrid transformer is connected for 4-wire working a loss of 4 dbs at 500 c/s is introduced at each terminal. The sensitivity of the 500 c/s ringing receiver may be adjusted to operate from tones down to a level of —40 dbm.

Distortion

Typical distortion figures are shown in the table below for 80 + 80V double-current telegraph working over a 2-wire line with variable attenuation. Indication is given of varying telegraph speed with ' mark ' to ' space ' ratios of 1 : 1 and 1 : 6 against line attenuation.

For basic 12+12V double-current telegraph working distortion figures are approximately the same.

Telegraph Speed	25 bauds		50 bauds		75 bauds	
Mark/Space Ratio	1·1	1·6	1·1	1·6	1·1	1·6
Line Attenuation	%	%	%	%	%	%
0 db ..	0·5	1·0	1·0	1·5	1·5	4·0
10 ..	0·5	1·0	1·0	2·0	3·0	4·0
20 ..	0·5	1·0	1·0	2·0	3·0	5·0
30 ..	1·0	2·0	2·5	3·0	4·0	6·0
35 ..	3·0	4·0	5·0	5·0	8·0	10·0

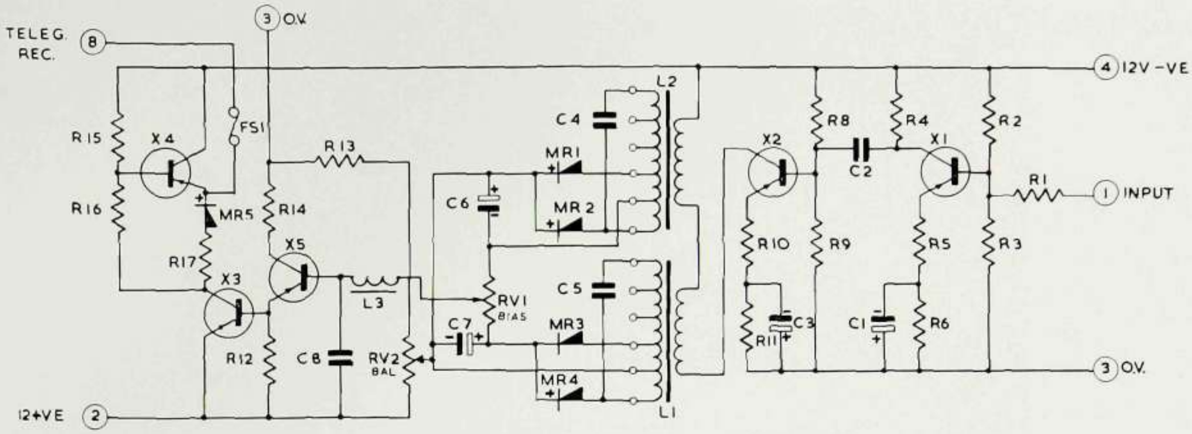

Fig. 5—Discriminator and D.C. Amplifier Circuit

EQUIPMENT FEATURES

Fig. 6 is a general view of the complete equipment for one terminal and Fig. 7 shows the apparatus with the cabinet removed. The termination is assembled on a unit basis. All units, protected from dust by robust metal covers retained by simple quick-release fasteners, are mounted on B.P.O. approved standard panel rails Type 51 within a hinged folding frame that slides into a metal cabinet. Cable connections are made by means of standard plugs and sockets, and all cable entries are located at the rear of the equipment. This construction combines simplicity of assembly with easy accessibility and facilitates replacement of parts.

Designed to operate in a wide range of climates (—10°C to +50°C) the equipment is fully protected against severe tropical conditions. Hermetically sealed filters are used throughout.

Fig. 6—S + DX Telegraph System FMT. 17 Terminal Equipment

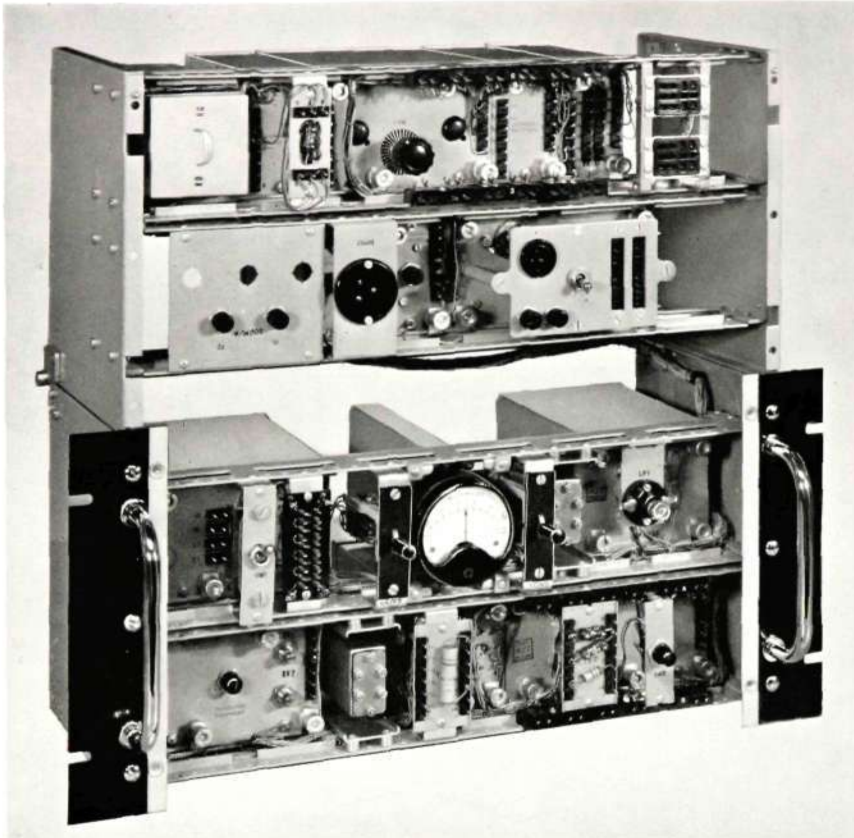

Fig. 7—Terminal Equipment with case off and rear equipment swung over

If desired the equipment may be rack mounted, in which case a metal dust cover is supplied in place of the cabinet.

Testing Equipment

To facilitate setting and lining up the equipment, all controls and test points are arranged on the front panel where a 50 mA centre-reading milliameter, when switched in either the ' transmit ' or ' receive ' telegraph circuit, indicates the magnitude and direction of the telegraph current; a ' Test Transmit ' key applies either ' space ' or ' mark ' signals.

Power Supplies

The equipment can be arranged to operate from any of the following supplies and their application may be seen by again referring to Figs. 1 and 2.

(*a*) Directly from a —12V d.c. positive-earthed supply with a current not exceeding 200 mA.

(*b*) A —21V or —24V d.c. supply by using a regulator unit designed for the equipment.

(*c*) A mains unit, working from standard a.c. mains supplies of 90–250 volts, 40-60 cycles. This unit incorporates a relay to switch a standby battery in and out should mains failure occur. Standby supplies may be provided by any of those indicated in (*a*) or (*b*) above.

For low voltage 12 + 12V telegraph working, power is derived internally from the equipment, but should 80 volts be required to operate a teleprinter magnet a suitable supply unit is available.

Power consumption per terminal, irrespective of any of the above sources used, is small. Operating from a —12V supply the equipment consumes approximately 2·5 watts and when supplied from a.c. mains, approximately 3 watts.

Conclusion

The main features that characterize this equipment are, high electrical performance, low power requirements, flexibility in application, ease of installation, special construction and finishes. All are associated with complete reliability of operation resulting from the considerable experience gained by the Company, over the years, in the manufacture of this type of equipment.