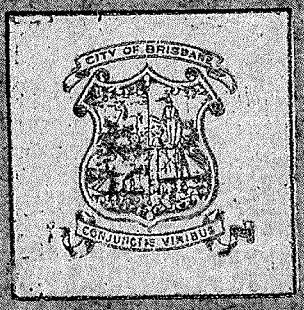


Brisbane Telephone System

Dec. 1929

Tel Box 1

6.

A MAJOR STEP in the modernisation programme of the Brisbane Telephone Service was completed at 2 p.m. on Saturday, 30th November, 1929, when Central and Paddington Automatic Exchanges were brought into service. Brisbane now has ten automatic exchanges to which are connected 85 per cent. of the subscribers' lines in the network.

The transfer of the many thousands of subscribers' and miscellaneous services from the former manual system to the new automatic exchanges and the simultaneous introduction of new trunk and toll exchanges was one of the most complicated works so far attempted by the P.M.G.'s Department in Australia.

Consistent with modern telephone progress, many entirely new features have been introduced and Brisbane citizens now enjoy a telephone service equal to that given in any other part of the world.

The World's first practical telephone instrument was produced by Professor Graham Bell in the year 1876, and the following year saw the establishment of the first telephone exchange. Queensland was not slow in taking advantage of a modern invention, and in 1880 was installed Brisbane's first telephone exchange, with 36 subscribers. The growth of Queensland's telephone system, although slow at first, has been remarkably rapid within recent years, and there are now 900 exchanges serving 50,000 subscribers.

The automatic exchange buildings in Brisbane were designed and erected under the supervision of the Commonwealth Works and Railways Department, and, in the case of the main exchanges, have been equipped with air conditioning plant for de-humidifying and cleaning the air in the apparatus room.

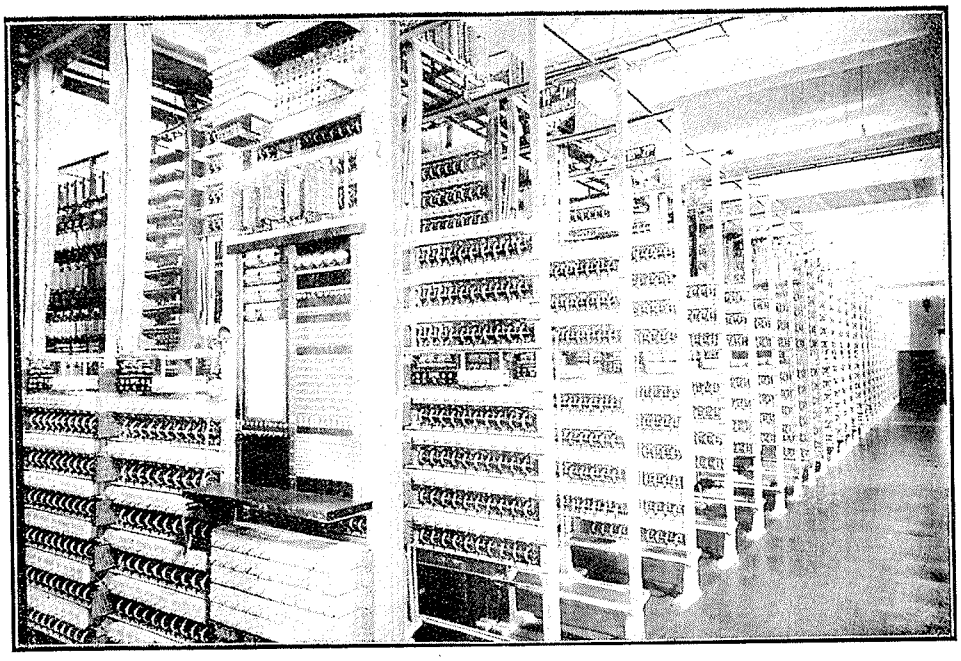
The whole of the automatic switching equipment in the various exchanges was supplied by Siemens Bros. & Co. Ltd., London, and the installation work was carried out by the Department's own officers.

With one of the finest and most up-to-date plants in Australia and with handsome new buildings with ample space for expansion, the Telephone Department in Brisbane is in a position to furnish the highest grade of service to its subscribers for many years to come.

The numbering scheme at present in use for the Brisbane Metropolitan Network is as follows:—

Central	B1000—9999
South	J1000—5999
Coorparoo	J6000—6999
Yeronga	J8000—8999
Bulimba	JY1000—1999
Paddington	F9000—9999
Albion	M1000—5999
Nundah	M6000—6999
Newmarket	M7000—7999
Sherwood	U7000—7999

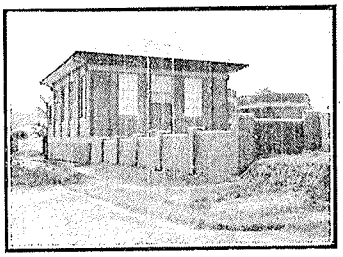
These dates in another way are corrected



PORTION OF CENTRAL MAIN AUTO. ROOM.

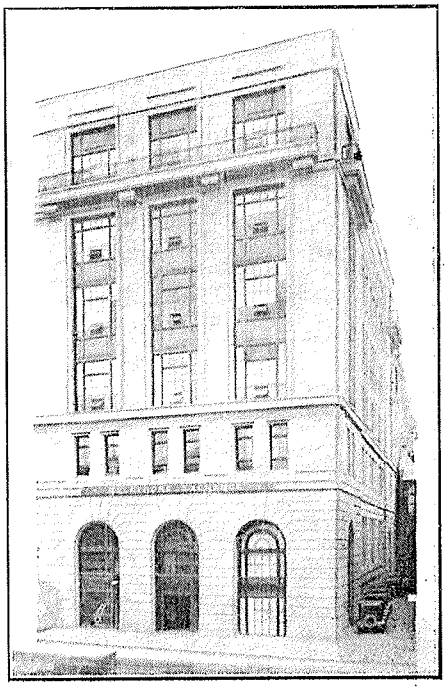
TRUNK SWITCH ROOM.

BRISBANE AUTOMATIC TELEPHONE EXCHANGE BUILDINGS, 1929.

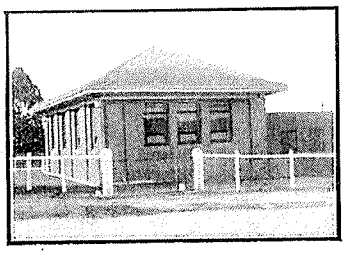


NEWMARKET.

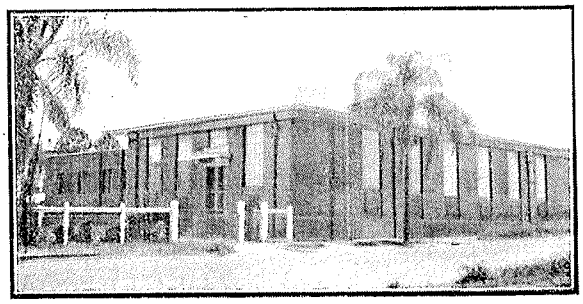
PADDINGTON.



CENTRAL

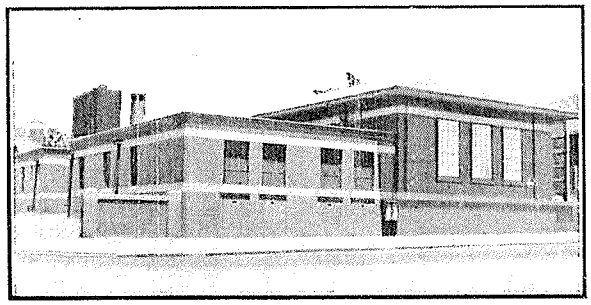


SHERWOOD

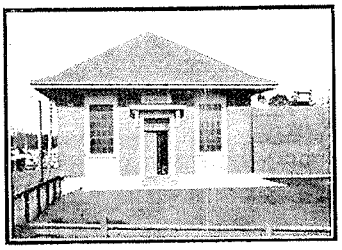


ALBION.

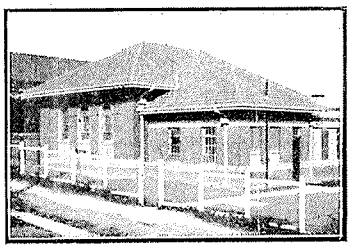
NUNDAH.



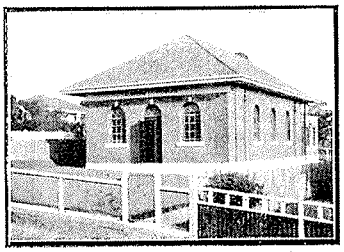
SOUTH



BULIMBA



YERONGA



COORPAROO

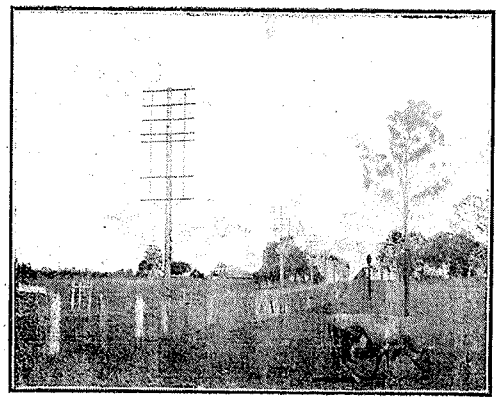
The new automatic equipment has been designed to operate in conjunction with equally efficient long-distance apparatus, which is also accommodated in the Central building.

Modern invention has made it possible for several telephone conversations and telegraph messages to be sent simultaneously over a single pair of wires, and the equipment installed in Brisbane embodies these latest developments.

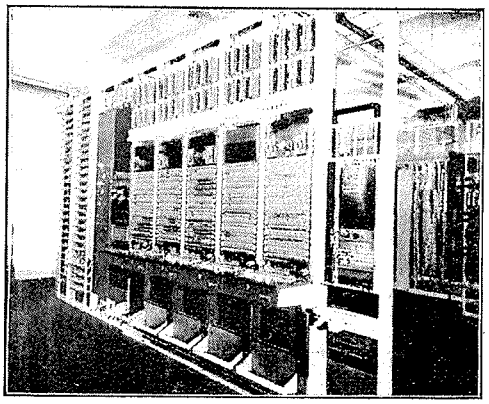
Incidentally, this increase in efficiency is reflected in the line construction, and the underground and overhead lines radiating from Brisbane are of an exceptionally high standard.

The ideal, already set by the Department, is to develop the long distance service so that ultimately a telephone subscriber in any part of Australia may be placed in communication with any other, whatever may be the distance of separation.

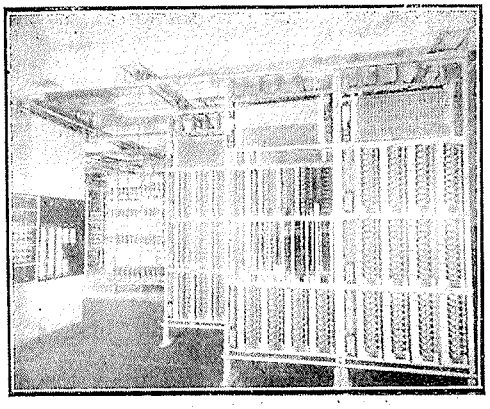
But who can foretell what the future holds! It would seem that the telephone engineer has already provided for the possibility that the world at large will be a common exchange and the trunk operator able to link up a girdle around the earth in a period of time compared with which "Puck's" forty minutes seems eternity.



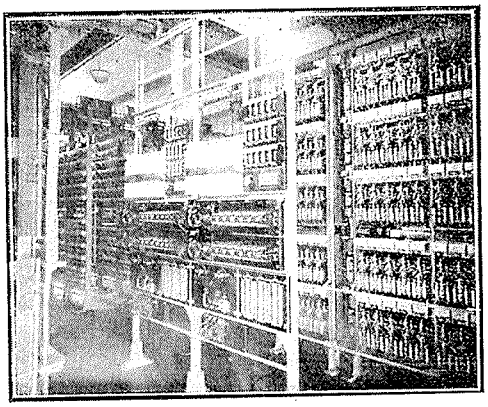
TYPICAL TRUNK POLE LINE.



TRUNK TEST BOARD.

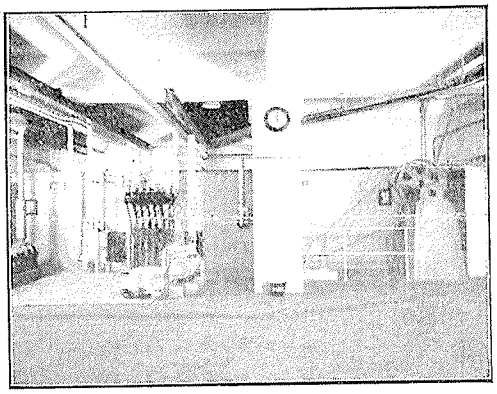


JUNCTION PRESELECTOR RACKS.

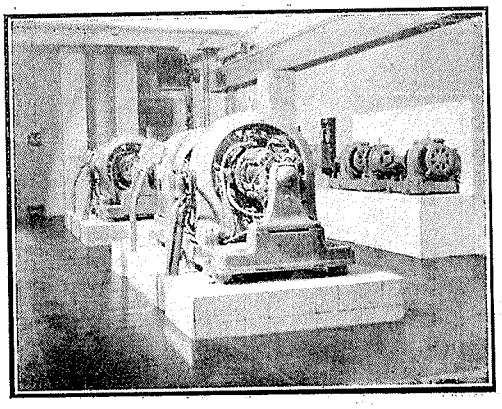


MOTOR INTERRUPTER RACKS.

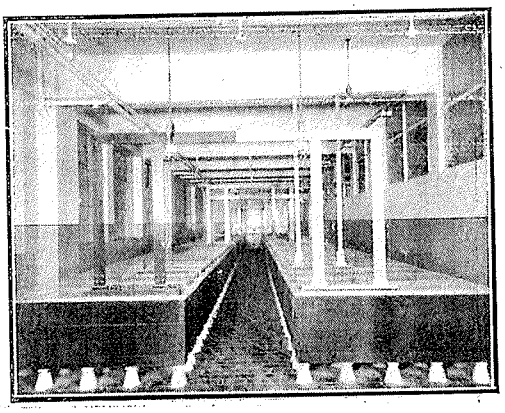
MAIN DISTRIBUTION FRAME AND TEST DESK.



AIR CONDITIONING PLANT.



40 K.W. MOTOR GENERATORS



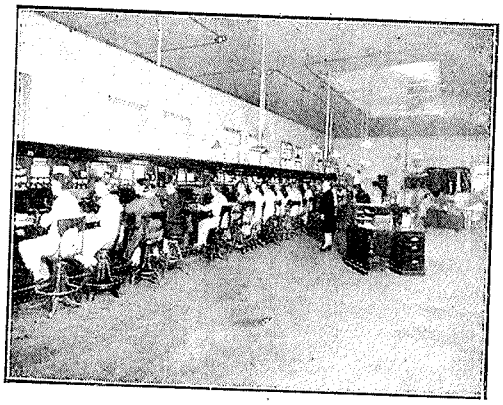
DUPLICATE 3000 A.H. BATTERIES.

This equipment has concluded its term of service to the public after functioning successfully for nearly twenty years.

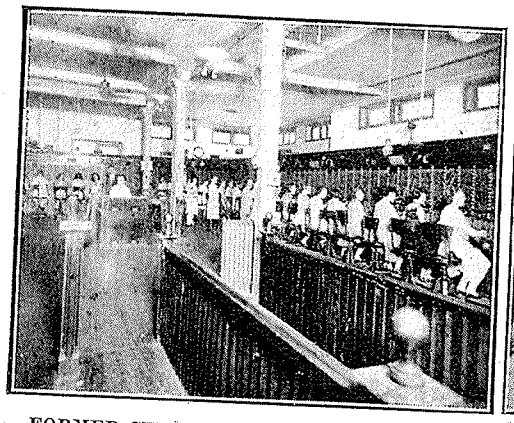
A staff of over two hundred girls was required to operate these boards, the service provided being one of the best of its kind in the Commonwealth.

The introduction of the automatic means that only a small staff is now required and many will miss the cheery "Number, Please" of the telephone girl.

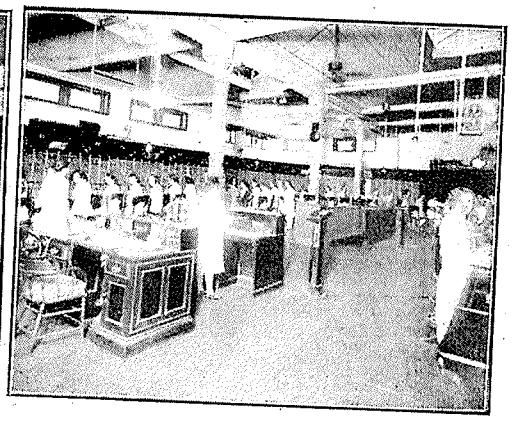
But no Public Telephone System would be complete without the "Hello" girl, and her patient voice may still be heard on "Information" and "Long Distance" connections.



FORMER TRUNK SWITCHBOARD.



FORMER CENTRAL MANUAL EXCHANGE.



ANOTHER VIEW OLD CENTRAL.

Siemens Bros. & Co. Ltd. Full Automatic Telephone System.

Paper read by
H. E. Humphries,
before the Postal Electrical
Society of Victoria,
January, 1920.

Siemens Brothers' Full Automatic Telephone Switching System as used in Public Exchanges.

A Paper read by H. E. Humphries before the Postal Electrical Society of Victoria on 15th January, 1920.

SYNOPSIS.

Messrs. Siemens Brothers supply automatic switching equipment for installations of all sizes, from small ten-line private automatic exchanges to complete six or more figure public automatic exchanges. With the exception of a portion of the power plant, all of the substation and exchange automatic apparatus is manufactured from raw material at the Company's works at Woolwich, England.

The system and parts of the equipment to be described differs from the Siemens automatic switchboards, with which some of those present are familiar, and also from the exchanges which have been described in technical books and journals. Any such differences represent later practice.

It is not intended to devote any time to explaining the fundamental principles of automatic "trunk-seeking" systems, to which class the system to be described belongs, as members no doubt are sufficiently acquainted with such principles and practices at present in use to understand the description to follow.

DESCRIPTION OF APPARATUS.

Telephone Instruments.—Several types of telephones are manufactured for use on automatic switchboards, the foremost being wall and table types similar in finish to the Ericsson common battery telephones used by the Telephone Department in this Commonwealth. Figure 1 shows a standard automatic wall set. A neat and useful type of table set which is not yet in use in the Commonwealth is a single-piece hand-microtelephone set with a circular pedestal and base similar to that fitted on our standard type of table set. The hand-microphone, which is connected to the set by means of four insulated flexible conductors, normally rests in a horizontal position on a two-pronged switch-hook. On all table sets the circular bases are made sufficiently weighty and large in diameter to enable dialling to be done without it being necessary to hold the telephone pedestal. The receiver consequently can be held to the ear whilst dialling.

Waterproof mining and linemen's portable testing telephones are also fitted with calling dials when required for use on automatic systems.

The telephone circuit is the usual 17/26 ohm induction coil circuit and an "off-normal" change-over springset on the dial provides for the receiver circuit to be opened and the transmitter short-circuited during dialling.

To overcome the familiar trouble of the cord on hand-microtelephone sets breaking where it enters the handle just below the transmitter, a flexible steel spiral protecting spring is now fitted as an extension to the small tube to which the transmitter is attached, and through which the flexible cord passes. This spring prevents the cord from being sharply bent, and consequently prevents the tinsel conductors from being strained. This device obviates a large amount of trouble, which in the past has been one cause for not adopting this type of telephone more generally.

The calling dials are similar in principle of operation to those used on the automatic telephones in use in this State, viz., on their return to normal after being pulled off normal, the line circuit to the exchange is rapidly opened and closed the same number of times as that predetermined by the caller. The latest type of calling dial is very compact and simple, having a less number of parts and being more acces-

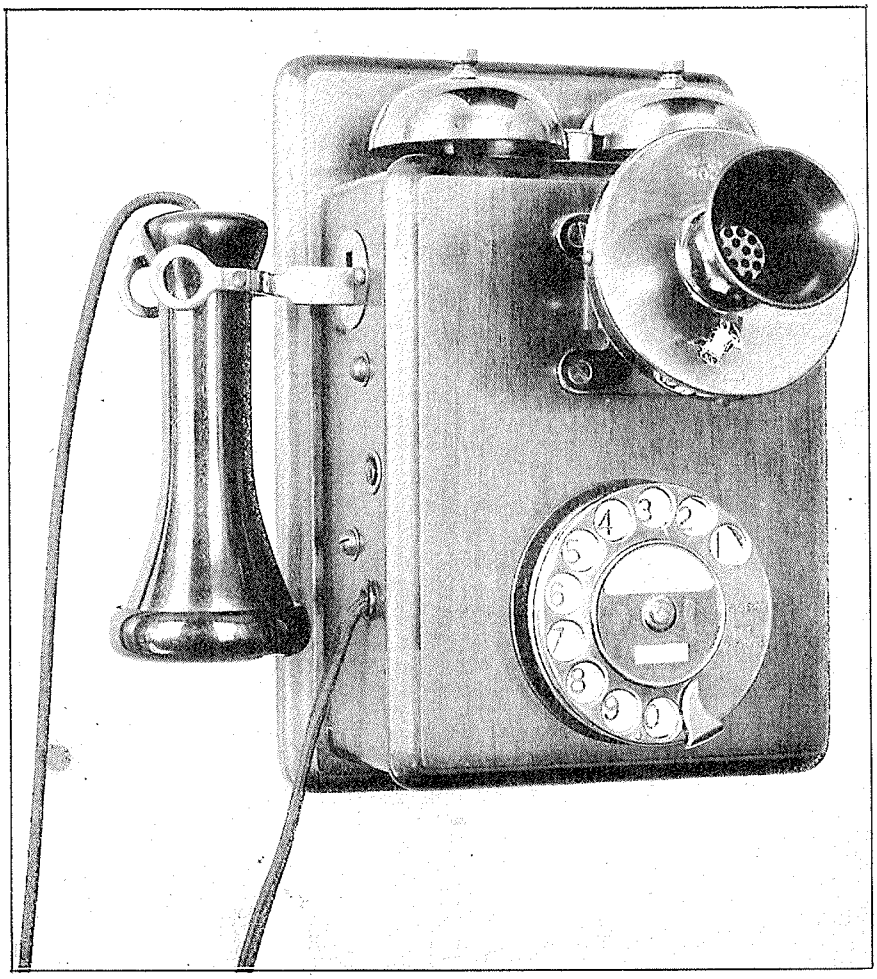


FIGURE 1.

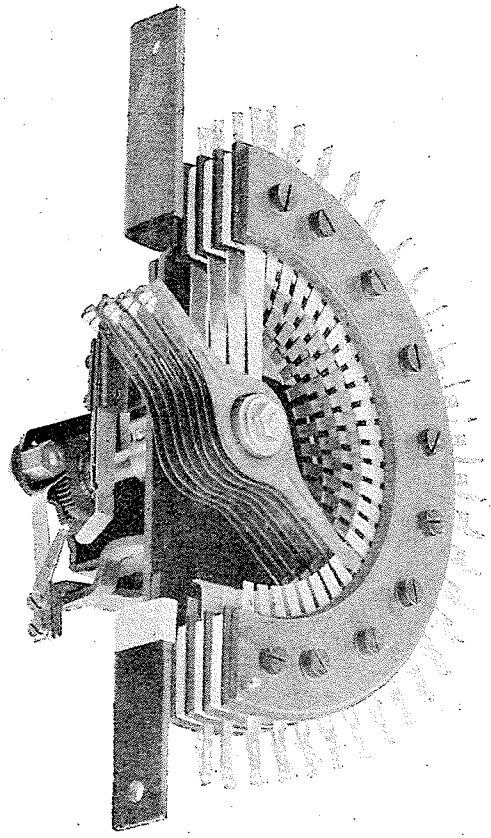
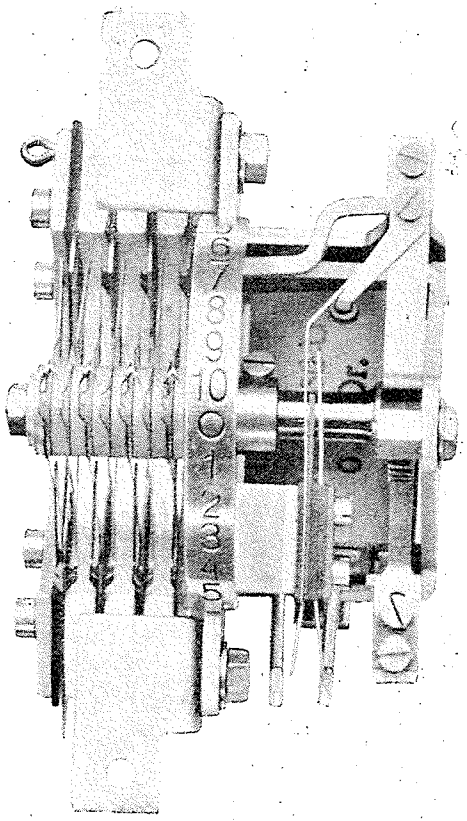


FIGURE 3.



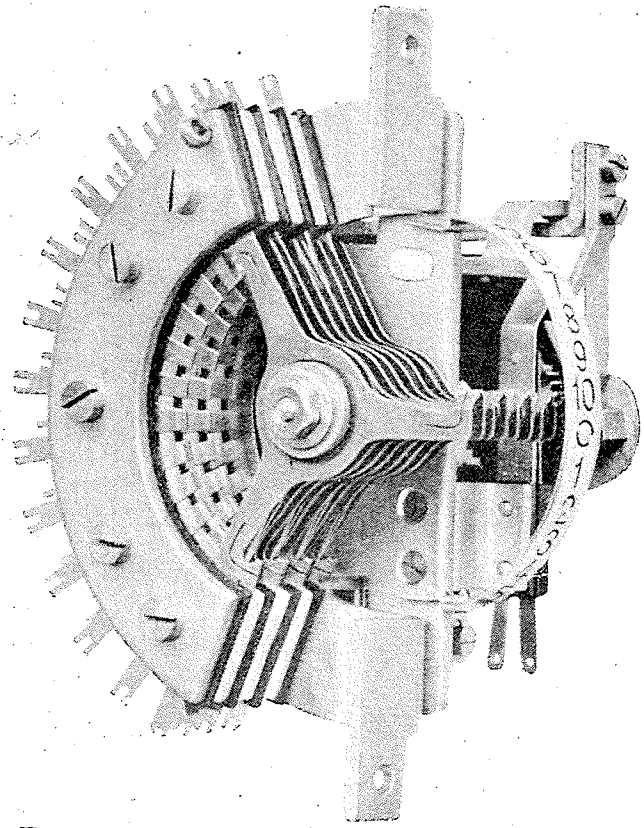


FIGURE 2.

sible for adjustment than the dials which up till recently were generally supplied by this Company. One special feature of these dials is that means are provided for insuring a definite "maximum pause" between successive trains of impulses. This prevents a train of impulses being transmitted before a switch is ready to receive them, and consequently wrong numbers due to the rapid manipulation of the dial are obviated. All dials are of china-bronze finish, and present a very neat appearance when in position on either a wall or table type telephone.

Preselectors.—Preselectors are switches capable of selecting a circuit in a comparatively small group of circuits by means of the rotary motion of a set of wipers in one direction. Two sizes of preselectors are in general use, each size having 11 and 26 sets of contacts in the arc respectively. These are illustrated in Figures 2 and 3 respectively. A description of the 11 part switch only will be given.

The bank of an 11 part preselector consists of 11 sets of contacts mounted to form an arc of approximately 120 degrees, the number of contacts in each set being dependent upon the circuit in which the switch is to be used. Ten of the sets of contacts represent ten outgoing trunks to the next rank of switches. The eleventh set of contacts are the "normal" contacts in switches to which the wipers return to normal after use. In cases where "normal" contacts are not required, such as on second preselectors, it is possible to have eleven outgoing trunks to the next rank of switches.

The wipers which search over the contacts are mounted on one end of a shaft, and are arranged in pairs to search over both surfaces of the respective arc contacts. This arrangement obviates end thrust on the shaft, and also permits sufficient pressure and contacting surface between the wipers and the contacts to eliminate microphonic action.

At the other end of the shaft is a ratchet wheel, and motion is imparted thereto by means of a spring steel pawl attached to the armature of the driving magnet. This magnet receives direct current impulses from contacts opened and closed by cams mounted on a separate interrupter machine. To prevent rotation of the switch in the wrong direction a spring steel retention pawl engages the ratchet teeth, and is adjusted to lock the arms in the exact position to which they are driven.

Each wiper set has three arms projecting at angles of 120 degrees, and the disposition of the arc contacts is such that immediately one set of wipers leaves the last set of bank contacts the following set of wipers engage with the first set of bank contacts. Connexion to the wipers is made by means of pairs of metal strips affixed to the arc assembly in the same way as the bank contacts themselves, but projecting sufficiently to contact at points on the inner surfaces of the pairs of wipers near the shaft. This arrangement allows positive contacting without appreciable friction.

In switches where a corresponding contact in each set is common on adjacent sets, a continuous metal segment is fitted, thus obviating the commoning of separate contacts and also reducing driving friction. An example of this is the off-normal contact on the fourth bank on first preselectors.

The special features and advantages of these preselectors are as follow:—

(*a*) The design of the mechanism is such that rapid and reliable selection can be made. Preselectors directly associated

with subscribers' circuits rotate at a speed of 50 steps per second, the time taken for a rotation over 10 trunks being one-fifth of a second. Fifty steps per second is not, however, the maximum speed at which it is possible to drive preselectors.

(*b*) The moving system is very light, but at the same time rigidity is maintained.

(*c*) Each time that a switch is taken into use, a set of wipers wipes over all of the bank contacts. In this way bank contacts are kept perfectly clean.

(*d*) The action of the driving magnet is positive, and tests taken have shown that there is no perceptible wear on the pawls and ratchet teeth over many times the average life of an automatic exchange.

(*e*) The provision of driving impulses from a source separate from the switch renders switch maintenance very low. The provision of impulses by means of motor-driven cams is absolutely reliable on account of the ratio of the make to the break period in the impulses being mechanically fixed.

(*f*) A preselector being a complete unit in itself and being operated by electrical impulses allows a maximum of flexibility. Preselectors can be mounted in groups of any size without the necessity for special mountings or fittings. As preselectors are mounted in panels of 10, the number of switches in a group having access to ten trunks can be increased from 10 in steps of 10.

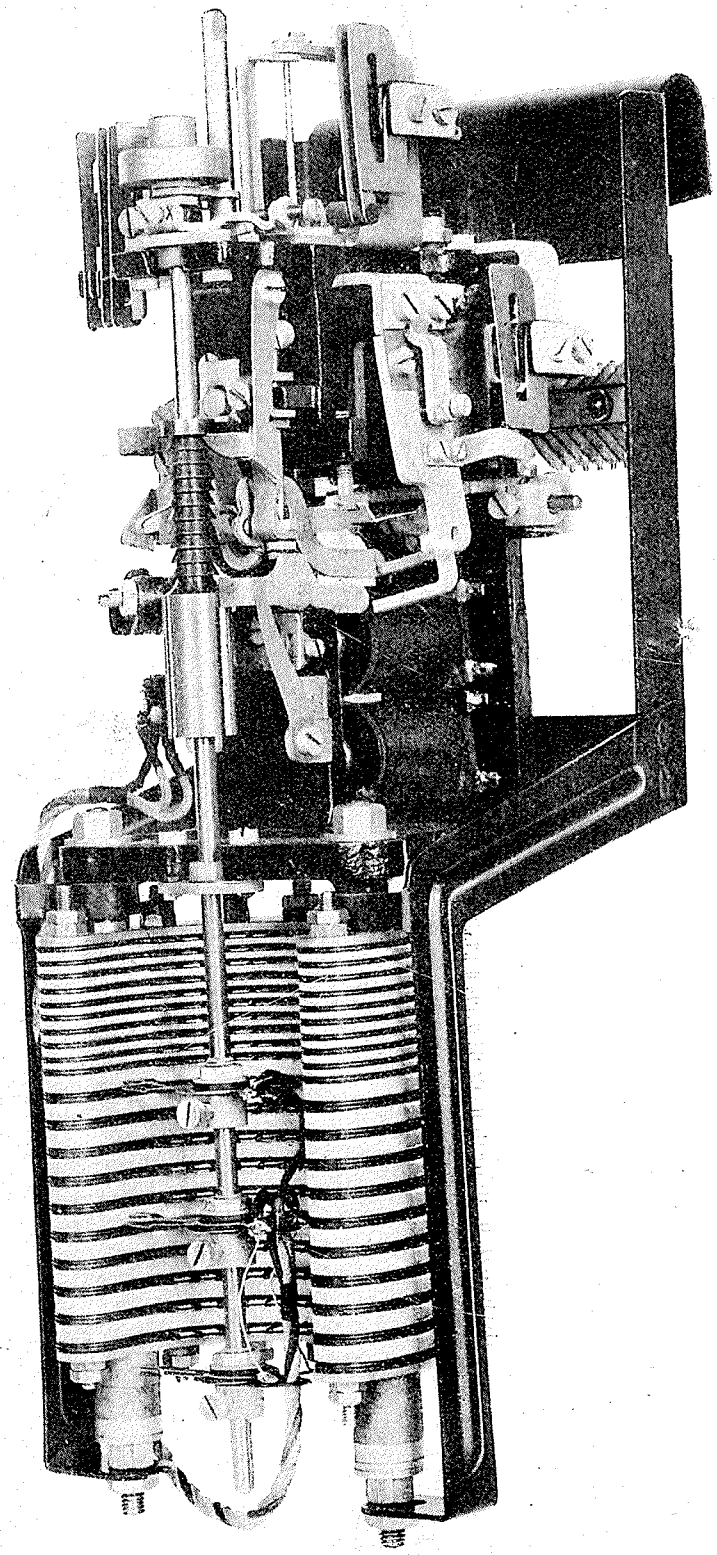
(*g*) The advantages of the method of wiring preselector banks will be referred to later on.

Each switch is provided with a curved designation strip which allows the number of the circuit on which the wipers are resting to immediately be ascertained.

Selectors.—Selectors are "pawl and ratchet" operated switches capable of connecting a set of wipers to any one of 110 sets of bank contacts. These bank contacts are arranged so that from a plan view of the assembly the rows of contacts are in the form of an arc, and from an elevation view each vertical and horizontal row of contacts is in a straight line.

This type of switch is used as a selector of any rank, which includes final selectors (or connectors). On final selectors, dial impulses, by means of which any one of 100 circuits can directly be selected, cause the complete wiper mechanism first to be lifted vertically to a position in which a set of wipers is in horizontal alignment with a row of bank contacts corresponding to the digit dialled. A second train of impulses then causes these wipers to be rotated in a horizontal plane so that they finally rest on a set of contacts corresponding to the two digits dialled. The switch mechanism of a final selector is shown in Figure 4.

On selectors of other ranks, the vertical selection is dial-controlled, but the horizontal selection is automatic, the wipers coming to rest on contacting with the centre of the first set of disengaged contacts in the level preselected. On these switches, any one of eleven contacts in each of the ten horizontal levels can be selected.



C 7540.—2

FIGURE 4.

The release of the wiper mechanism to normal is controlled by a release magnet which, by operating, knocks away the detents holding the wipers on to the selected circuit. The wipers first rotate to their normal vertical plane by means of tension imparted by a spiral spring and they then assume their complete normal position by force of gravity.

In very early types of switches a device was fitted on each switch for locking the detent mechanism into the position set by the release magnet on its operation at the release of a call. An improved circuit design, however, permitted the removal of this device, thereby increasing the simplicity of the switch design.

Siemens selector has many novel features, the foremost being the arrangement of the contact banks. In the latest type of switch, all of the bank contacts are contained in one complete bank assembly, separation of the contacts being effected by means of thin plates of ebonite separated by aluminium spacing pieces. The ebonite sheets project over the aluminium spacing plates thereby increasing the insulating area between adjacent horizontal rows of contacts. The whole arrangement effectively eliminates low insulation on the bank assembly, variations in the contact centres and the liability of bursting experienced with fibre.

The contact bank is divided into three sections, each section having associated with it a set of wipers. The top section consists of ten rows of eleven single contacts in each row and the middle and bottom sections of five rows of eleven pairs of contacts respectively. On the rows of contacts in the top section terminate the testing or "C" lines of levels 1 to 0 counting from the bottom level upwards. On the rows of contacts in the bottom and middle sections terminate the pairs of "A" and "B" lines of levels 1, 3, 5, 7, 9, 2, 4, 6, 8 and 0 counting upwards from the bottom level in the bottom section. The wiper assembly is such that each operation of the lifting magnet lifts the "C" or top set of wipers opposite to the level corresponding to the number of impulses transmitted to the switch line relay. The wiper assembly associated with the two lower sections is such, however, that one vertical impulse will bring the bottom pair of wipers, which correspond to the "tip" and "ring" of a plug in a standard manual C.B. system, opposite to number one level, whilst the middle set of wipers will be below level number two at a distance equal to that between two adjacent horizontal teeth on the ratchet drum. Two impulses of the lifting magnet will bring the middle set of wipers in horizontal alignment with the number two level, but the bottom set of wipers will be in alignment midway between levels numbers one and three. The corresponding "A" and "B" wipers in these two lower sets of wipers are commoned, and it will be seen that when one pair are on contacts the other pair are in space.

The reasons for this arrangement are as follow:—

(*a*) Congestion of wiring at the rear of the multiple contact bank is eliminated, and an inspection of the soldering can be made without interference to adjacent wiring.

(*b*) The increased space between the contacts permits quicker and neater wiring; wire similar to that in the relay forms is used, with the result that stable forms of high insulation resistance are obtained.

(*c*) The possibility of the wipers contacting with more than the correct pair of "A" and "B" contacts is eliminated.

(*d*) Thicker insulation can be fitted between the "A" and "B" contacts; greater immunity from low insulation circuits due to the deposition of metallic dust between the contacts is therefore permitted.

The switch consists of a smooth-finished iron frame supporting the lifting, rotating or drive, and the release magnets and their various associated movements. Each switch is provided with vertical "off-normal" contacts, and, where necessary, a special contact arrangement for use with a system of P.B.X. working, reference to which will be made later on. The operation of the release magnet also opens a pair of contacts which are for the purpose of making the switch test engaged until the wiper shaft is returned right home to normal. All special shaft-controlled springsets are of substantial make, and all contacts thereon are of platinum. No "side-switch" contacts are fitted, as the necessary circuit changes during the setting up of a call are performed by means of the switch relays.

To insure reliability of operation and ease of adjustment, the retention detents which engage the vertical and rotary ratchet teeth are separate and two arms on the armature of the release magnet effect separate release. One reason for this arrangement is that the vertical detent can be adjusted without affecting the adjustment of the rotary detent and *vice versâ*. Until the adoption of this improvement, adjustment had to be effected by bending the detent; it is now effected by means of an adjusting screw and a lock nut.

In combined vertical and rotary detents the rotation of the wiper shaft also causes the vertical detent to be partially withdrawn, and where the latter is at all out of adjustment, there is a possibility of the wiper shaft being dropped a level before the wipers enter the bank. With separate detents this trouble is overcome.

On selectors in which the rotary magnet is intermittently operated until a disengaged trunk is found, driving is effected by means of interrupted current at the rate of 25 steps per second, the reasons for adopting this principle of drive being the same as outlined in the description of the preselector. Each switch and bank is mounted in a pressed steel cradle, which is suspended on a steel rack. The cradle does not at any point come into direct contact with the rack, being separated therefrom by means of thick, spongy, felt washers. This method of switch suspension, besides having a very neat and orderly appearance, has the effect of entirely eliminating microphonic action between the switch wipers and bank contacts, and of considerably reducing the noise in an exchange due to switch action. On each first selector is fitted a lamp, which glows when the switch is taken into use.

Relays.—All relays are of the "flexible spring" type, and are mounted separately from the switches. Simple relay circuits, such as used in conjunction with subscribers' preselectors, are wired to permanently fixed mounting plates. In selector and similar circuits, in which the circuit is more complex and a comparatively large number of relays are subjected to constant use, the relays are mounted on removable mounting plates, as shown in Figure 5. These plates fit into

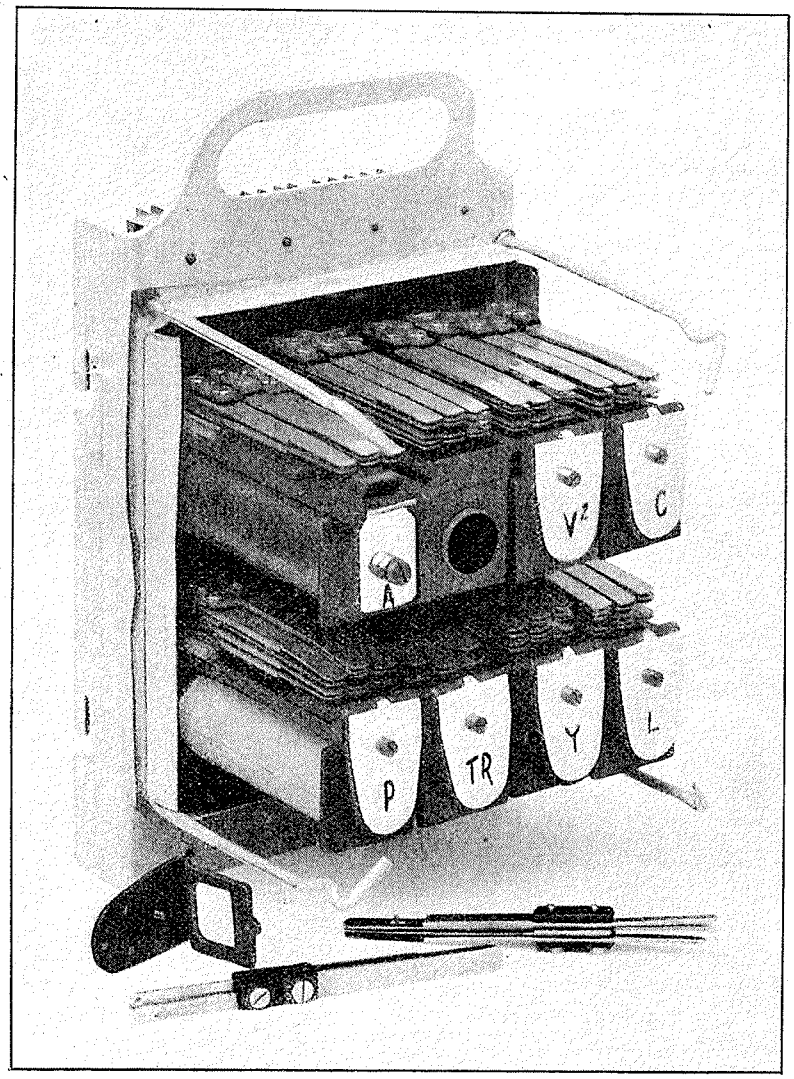


FIGURE. 5.

special mountings on the switch racks, and electrical connexions thereto are established by means of knife contacts.

Three general types of relays are used on automatic equipment, and are as follow:—

(*a*) Relay with the armature moving on a knife-edge. (This is the type most used).

(*b*) Relay with the armature moving on a non-magnetic metal spindle.

(c) Relay for use as an interrupter or for use in A.C. circuits.

In all three types, the airgap at the mounting end of the relay is reduced to a minimum by a drive fit between the core and the yoke.

In the first type, the armature, yoke, and the core are so shaped as to introduce a minimum of reluctance into the magnetic circuit. Special attention has been given to the design of the knife-edge on which the armature is suspended. Practically no mechanical friction occurs, and magnetic saturation at the knife-edge when the relay is operated is prevented by the large area of the magnetic circuit at that point. Consequently sticking at the knife-edge is prevented.

At the armature end of the core is spot-welded a soft iron button of approximately five times the cross-sectional area as the relay core. This button, in conjunction with the special design of the armature, practically prevents magnetic leakage, and thereby increases the power of the pull of the relay armature when operating. On account of the foregoing, increased tension between springsets normally in contact can be applied.

The relay springs are made up into small springsets consisting of various combinations of movements such as, for instance, a changeover set and a pair of break contacts or two pairs of make contacts. These springsets are self-contained, and when not mounted on the relay, are quite rigid, being held together by means of two small clamping screws. A springset is attached to a relay by means of a third screw which goes through the springset, through a small aluminium cradle and into a tapped hole in the iron yoke of the relay. Each aluminium cradle has three slots which will allow three springsets to be mounted on a relay, the slots being for the purpose of keeping the springsets in correct alignment. The advantages of this arrangement are—

(*a*) In the event of desiring to change a springset attached to a relay, it is not necessary to unsolder wires other than those attached to the springset.

(*b*) In the event of a relay winding developing a fault which necessitates the removal of the coil, such can be accomplished without unsoldering any of the wires attached to the springsets.

(*c*) On account of (*a*) and (*b*), repairs can be effected more quickly and neatness maintained by no interference being caused tc portions of the circuit not in trouble.

(*d*) The design of the springsets is such that there is very little possibility of the spring clamping screws becoming loose. Permanency of contact adjustment therefore can be maintained.

All springset contacts consist of platinum.

Contact springs consist of hard-rolled nickel-silver strips which in their normal position are always in tension against and consequently in contact with associated stiff metal strips which project to about two-thirds of the length of the flexible springs. These stiff metal strips also project beyond the back of the relay and are used as terminal points for the contact wiring. By being able to keep the flexible contact springs in a state of tension, positive contacting of normally "made" springs results. Excessive sparking at contacts also is prevented by spring vibration being damped by the stiff metal strips.

All relays are mounted on thin pressed steel mounting plates provided with flanges for strengthening purposes. This allows both rigidity and lightness and the weight of the switch-racks consequently is reduced to a minimum.

The second type of relay is similar in design to the type just described except that the armature is held in position by means of a brass spindle instead of a knife-edge and that a screw and lock-nut is provided for adjusting the length of the stroke and the airgap between the armature and the core when the relay is operated. By means of a pair of very thin brass washers the armature is prevented from touching the yoke at the points of suspension. The armature therefore is not "magnetically" in contact with the stationary portion of the magnetic circuit, this design being to allow rapid and complete demagnetization of the relay with a corresponding rapid and reliable operation of the armature. For these reasons this type of relay always is used to repeat impulses.

The third type of relay is similar to that just described in (*b*) except for the arrangement of the springsets. This relay is designed for two uses, firstly, to operate with alternating current and secondly, to be used as an interrupter. The springset assembly differs from that fitted to the two types of relays just described in that the flexible springs are attached to the lever of the armature and project towards the rear of the relay. These flexible springs make contact against rigid contact strips which project from the rear of the relay towards the armature. The effect of such a springset arrangement is that (*a*) with proper adjustment, it can be made to keep a contact continuously opened or closed (as desired) whilst energized by ringing current, such contacts to close or open if the relay winding circuit is opened and (*b*), with proper adjustment, it can be made to vibrate in the same manner as trembler bell. In either case the armature vibration is practically inaudible. In the former case the relay is used, for instance, to indicate failure of the exchange ringing current supply. The springset is adjusted so that the slight quivering of the armature due to the passage of ringing current does not cause the springset to close and thereby affect the alarm circuit. In the latter case the relay can be used, for instance, as an interrupter for generating ringing current for small private automatic exchanges. It also is used as an interrupter for driving preselectors on small automatic switching installations.

Here it might be mentioned that although the three types of relays which have been described are generally used throughout the automatic system, the necessity for the use of a 30/12000 ohm or similar manual type relay on junctions between manual and automatic exchanges may arise. The reason for particularly mentioning the 30/12000 ohm type

of relay is that it is of a special design embodying the following features which enable it to satisfactorily operate in conjunction with automatic equipment:—

(*a*) The relay is fitted with flexible contact springs which arrangement is the most satisfactory way of overcoming dirty contact trouble.

(*b*) When energized through the 12000 ohm winding from any standard manual C.B. cord circuit, the operation of the armature is positive. Vibration of the relay mounting cannot cause the armature to release and thereby affect the contact springs.

(*c*) The design is such that the same type of relay can be used over both long and short junction circuits. To prevent the armature from sticking after the low resistance winding has been in circuit on a short loop, the magnetic circuit is so designed that the flux therein cannot exceed a predetermined and fixed amount. Magnetic saturation at the pole face or knife-edge therefore is prevented and sticking cannot occur.

For automatic working, relays of the first type described only are rendered slow acting, this being accomplished in two ways, viz., by means of a copper sleeve or tube over the iron core and by means of a short-circuited winding. The former method is used in cases where the rapid operation of a relay is not necessary and varying thicknesses of the copper tube enclosing the iron core within the spool cheeks vary the speed of release. The provision of a copper sleeve also is sometimes made for the express purpose of retarding the operation of the relay. On account of the magnetic circuit of this type of relay having very small reluctance, the copper sleeves used do not have to be very large in order to fulfil their functions, and in consequence, more winding space is permitted. To illustrate the high efficiency of this type, very few slow-acting relays need to be provided with copper sleeves occupying more than approximately one-tenth of the total winding space. The latter method is used (*a*) where the rapid operation and slow release of a relay is required, this being effected by the short-circuiting of a winding after the relay is operated or (*b*), where the slow operation and rapid release of a relay is required, in this case, it being effected by a springset causing a winding of the relay to be short-circuited until fully operated.

An important feature is the means provided to exclude dust from the relays. All of the springset and coil terminals project through slotted rubber sheets clamped over punched holes in the mounting plates. In addition to this close-fitting covers are fitted over all relays, the type of cover used being dependent upon the circuit in which the relays are to be used.

On selector and similar circuits where several relays are mounted on a removable mounting frame associated with the switch, a black-enamelled stamped iron cover of appreciable thickness is provided and is pressed into position by means of specially shaped posts fitted to the relay mounting frame. The sides of the cover press firmly against an overlap of the rubber backing sheet, and by this means, dust is for all practical purposes excluded from the relays.

On line and cut-off and similar sets of relays which are mounted on permanently fixed plates, a smooth-finished dust-proof cover is fitted over each set of relays. A cover base, on which are pressed sides that

grip the removable cover by a sliding fit, is interposed between the relay and the plate and holds the rubber backing sheet firmly against the mounting plate.

The provision of individual covers has an advantage over a cover common to a plate of relays in that attention to one circuit does not necessitate uncovering more than one set of relays.

On relays constantly in use such as in the release magnet supervisory circuit, covers similar in design to but much smaller than those used on selector sets are fitted.

Except in special cases, retardation coils consist of relays minus the springsets. It is possible, therefore, to provide properly balanced transmission circuits in which both relays and retardation coils are used.

Subscribers' Registers.—On all measured service automatic switchboards which, up to the present, have been supplied by Messrs. Siemens Brothers, meters of the type which record one each time a successful and chargeable call is made, have been supplied.

The attention of the Company, however, has been directed for some time towards devising a more equitable method of charging for telephone calls. Efforts in this direction have resulted in the development of a system which takes into consideration the time occupied in successful and chargeable conversation and the class of service given. Reference to this method of call metering will be found in a paper entitled "Telephone Service in Large Cities," and read by Messrs. Laidlaw and Grinsted before the Institute of Electrical Engineers of Great Britain during May, 1919.

The former type of register referred to forms part of a local circuit on the first preselector and is controlled by relays which operate only when the called subscriber answers. On existing installations, these registers are wired in parallel with the holding windings of the subscribers' cut-off relays. The current flowing through the register when the circuit is in a "non-metering" condition is approximately 15 milliamperes but when registration is to be effected, this current is increased to approximately 130 milliamperes or nearly nine times the normal current.

The recording mechanism is not operated by means of a ratchet and pawl as is the usual practice but the movement of the armature causes rotation of a four-pointed star-shaped wheel geared to the shaft on which is mounted the recording mechanism. The construction of the armature and star-wheel is such that it is impossible for more than one to be registered at a time.

The magnetic circuit of the register and the various parts of the meter mechanism are designed to prevent failure of operation, over-registration, or sticking under proper working conditions. The armature is restored to normal both by gravitation and spring tension. The magnetic circuit has been designed to present the maximum reluctance when the armature is at its normal resting position, and for the reluctance rapidly to decrease as the armature moves to its operated position. On this account, once the armature commences to move, the magnetism increases to such an extent as to immediately cause full operation. Troubles of over or non-registration due to the registering movement being partially advanced from a previous and ineffective call are thereby eliminated. Apart from the initial adjustment of the tension restore spring, no provision is made for any further adjustments, as, once the register is assembled, no further adjustments are necessary.

The latter type of register referred to is operated on the principle of an ampere-hour meter, and is used in a local circuit on the first preselector in much the same way as an electric power meter is used in a power circuit. The advantages of a registering device of this kind will be apparent from the fact that the subscribers would be charged for the time occupied and the amount of equipment taken into use on a successful conversation. Provision is made for varying the recording speed of the meter according to the class of service rendered to the subscriber and also according to the hour of the day. For instance, a higher rate can be charged against a subscriber during the busy hours of the day than that charged during the slack hours. A further provision is that facilities can be provided for reducing the rate of recording on the meter after the connexion has been set up for a certain period. For instance, a subscriber can be charged at a certain rate for the first three minutes of successful conversation, with a reduced rate of charge for the use of the circuit after this period has elapsed.

In view of the fact that under this system of metering, the rate of charge can be reduced during the slack hours of the day, which may be, for instance, between 5 p.m. and 8 a.m., many subscribers would withhold conversations until the period of reduced charges. This would have the effect of reducing the number of calls in the busy hour, thereby allowing a saving in switch provision to be effected. Furthermore, as the duration of conversation is taken into consideration in the charging of calls under this system, there would be every tendency for subscribers to restrict the length of their conversations. A further saving in switch provision would thereby ensue. Apart from a saving in the capital cost of the equipment and the subsequent saving in maintenance through a smaller amount of equipment having to be maintained, still further reductions in maintenance would be effected by the switches receiving more work during the hours of light load. Switches lying idle for comparatively long periods are more likely to develop faults due to dirty contacts than switches in constant operation, as, in the latter case, troubles due to the deposition of dust would be minimized by the frequent moving of the contacts.

Condensers.—A noteworthy feature is the type of condenser mainly used throughout the automatic system. The dimensions of a two-microfarad condenser are $1\frac{3}{4}$ in. by 2 in. by $1\frac{3}{8}$ in., and for a half-microfarad condenser they are $1\frac{3}{4}$ in. by 2 in. by 9-16 in. The space occupied by one of these two microfarad condensers is 4.8 cubic inches, and an idea of its compactness can be gained by comparison with the 11.5 cubic inches of space occupied by a two-microfarad condenser of the type commonly used on manual common battery switchboards. Each condenser is contained in a very stout and neatly finished five-sided metal case, the terminals projecting through an insulating compound which forms the sixth side. This compound maintains practically the same degree of hardness through ranges of temperature experienced in practice and is non-hygroscopic. This latter feature, combined with the large insulating surface about the terminals, is largely responsible for the high insulation resistance obtained on these condensers.

Resistance Spools.—With the exception of those used in the power circuits, resistances are accommodated in two ways. Firstly, on a quantity of similar circuits in each of which a resistance is required

to carry up to a moderate amount of current, provision is made for such resistance to be wound non-inductively on a relay. Care is taken, however, in the allocation of these resistance windings in order to prevent electrostatic induction affecting transmission circuits and the cumulative effect of inductive and resistance windings causing relays to be overheated. This method possesses great advantages, as it allows conservation of equipment mounting space, simplification and economy in wiring and economy in apparatus.

Secondly, where it may be more economical to mount a resistance separate from a relay, and where such a course is necessitated by the resistance being required to carry a comparatively large amount of current, self-contained resistance spools are provided.

A type of resistance spool which has been supplied in the past with all automatic equipment is a mica-insulated spool similar to those supplied on manual common battery installations in this State. A great disadvantage of these spools, however, is that careless handling or inaccuracies in the spool terminal centres will cause the winding to be opened by the spreading of the brass clamping pieces. Rough handling of spools also will cause the mica to split and segregate. The company now has overcome these objections by the adoption of an entirely different type of resistance unit which has the advantage of not occupying more space than the older type of unit. This resistance unit is of very sturdy construction, and quite an appreciable effort would be required to open the circuit of the resistance winding.

Interrupter Machines.—Interrupted current for operating preselectors and the rotary magnets of selectors is supplied through cam-operated springsets controlled by a motor. First and second preselectors are driven at a rate of 50 steps per second, and all the other switches using motor-interrupted current, at the rate of 25 steps per second. Taking the case of a separate interrupter unit, as illustrated in Figure 6, the cams for driving preselectors consist of elliptical fibre discs mounted on a common shaft which is direct-coupled to the motor. The discs are separated by metal bushes of smaller diameter than, but of approximately the same width as, the cams. The interrupter springsets, each of which consists of two springs normally separated, are mounted vertically on opposite sides of the shaft; this arrangement permits of two springsets being controlled by one cam.

In each springset one spring is always pressing against the fibre cam, and it will be seen that the rotation of the cam will cause the spring to alternately move towards and away from the shaft. When this "travelling" spring is pressing against the cam at a point on its periphery through which the major axis passes, it is forced outwards sufficiently to be in contact with the "mate" spring, thereby completing the circuit to the driving magnet. As each pair of springs makes and breaks contact twice in each revolution of the cam, and as the motor rotates at a speed of 1,500 revolutions per minute, the number of interruptions per second is 50.

All interrupter contacts are approximately one-eighth of an inch in diameter and consist of tungsten. These two features reduce maintenance by the contacts maintaining a fixed adjustment over very long periods of wear and extreme ranges of temperature.

The springsets furnishing interrupted current at 25 steps per second are controlled by eccentric cams which only cause one interruption per revolution.

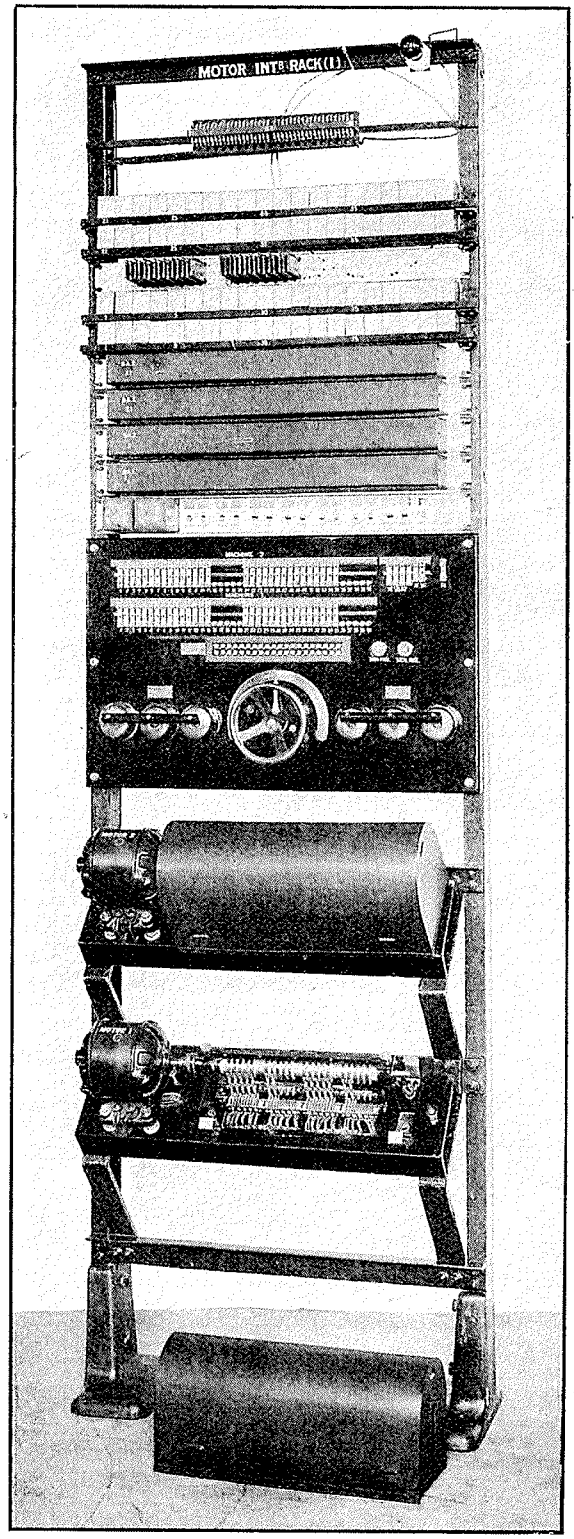


FIGURE 6.

To insure an even torque on the camshaft, the cams are staggered, so that the opening and closing of the contacts do not occur simultaneously. Special provision is made for the quick and easy removal of a springset, and when mounted on vertical racks the complete interrupter machine is permanently tilted on its mounting so as to facilitate contact inspection and adjustment.

Interrupter machines are supplied in duplicate, and switches are provided for connecting the driving power leads to the springsets on either machine. When in operation the machines make comparatively little noise.

TRUNKING PRINCIPLES AND METHODS OF HANDLING TRAFFIC.

Before proceeding with a further description of the apparatus, reference is necessary to the method of trunking employed. Subscribers' circuits terminate on fuses on the line side of the main distributing frame, from which they are jumpered to arresters and heat coils arranged in numerical order on the Exchange side of the main distributing frame. From this point they proceed in cable to one side of an intermediate distributing frame, on which also is terminated the cables from the subscribers' registers and the final selector bank contacts. They then are jumpered to blocks which are wired by cable to the first preselector racks. It therefore will be seen that the loads on the various groups of first preselectors can be adjusted without altering subscribers' numbers.

First preselectors are wired up in panels of ten switches, which have an outgoing multiple capacity of ten. The multiple of several panels of switches is then commoned up to form a row of first preselectors, the number of panels forming the row being dependent upon the traffic characteristics of the subscribers connected to the preselectors. For instance, five panels of switches, which would consist of 50 first preselectors, would allow ten outgoing trunks for 50 subscribers or 20 per cent. trunking. These preselectors are wired in racks accommodating 10 panels of switches or 100 subscribers' circuits.

Until recently, the outgoing multiple from the first preselectors was wired to second preselectors and the multiple from these latter switches was in turn wired to first selectors. By connecting the ten trunks leading from a row of first preselectors to ten-second preselectors, each of which had access to a different panel of first selectors, a subscriber could have access to 100 first selectors.

The reason for employing this method of trunking was to economize in first selector provision, the expense of providing second preselectors being a fraction of the amount saved by the consequent reduction in the number of first selectors.

A method of trunking now has been evolved which will permit the elimination of second preselectors, but at the same time effect economy in first selector provision as was originally effected by the use of second preselectors. First preselector multiple, therefore, is now wired direct to first selectors with the advantages of (*a*) reducing the capital cost of the exchange; (*b*) reducing the amount of equipment to be main-

tained; (*c*) conserving the exchange floor space; and (*d*) decreasing the time taken for a calling subscriber to be connected to a disengaged first selector.

The trunks from the first selector multiple lead to a distributing frame, and thence to second selectors in the same exchange or through the main distributing frame to selectors in a distant exchange or "B" positions in a distant manual exchange. The exchange local trunking then extends through the various ranks of selectors to the straight subscribers' connectors, or, in Siemen's nomenclature, the final selectors.

P.B.X. subscribers can be served in a number of ways, the following two ways being those most generally adopted. In the first method, connexions to P.B.X.'s are effected by means of special P.B.X. final selectors. Each selector consists of a digit switch and one or more discriminators, the former being an eleven-part preselector, and the latter being 26-part preselectors. Taking the simple case in which the average number of exchange lines in each P.B.X. is approximately 5, each digit switch would have associated with it two 25-part discriminators. In the case of the number of the P.B.X. which it is desired to call being, say, 3046, the digits 3, 0, and 4 would be received on a first, second, and third selector respectively, and the digit 6 would be recorded on the digit switch. On the digit switch stopping on its sixth contact, the particular discriminator, to the contacts of which are wired, *inter alia*, the various exchange lines of P.B.X. No. 3046, would rotate and select the first disengaged line of that P.B.X. If all lines were busy, a low-pitched, busy tone would be transmitted to the calling subscriber, whilst if a free line were found, the calling subscriber would be notified of the called subscriber's bell being rung by means of a high-pitched free tone in synchronism with the ringing of the distant bell. An important advantage of this scheme is that P.B.X.'s can be numbered consecutively. For instance, one P.B.X. may have five exchange lines, and be listed in the *Directory* as 2145, whilst another P.B.X. connected to the same exchange may be listed as 2146. The number of lines per P.B.X. is, of course, not restricted to five, being from one to a maximum of 25. It also is not necessary to accommodate the lines to one P.B.X. on consecutive contacts on the discriminator bank contacts. These exchange lines terminate on first preselectors situated anywhere on the first preselector racks, and originating calls are made in the ordinary manner.

The second method of dealing with private branch exchanges consists in making all final selectors of the type illustrated in Figure 4 available for P.B.X. working. In this system, (*a*) there can be one P.B.X. per level per final selector "hundred"; and (*b*) each P.B.X. can have a maximum of ten lines to the automatic exchange. Of course, a greater number of exchange lines could be provided per P.B.X., but the maximum number that can be made available for choice by dialling the P.B.X. "day" number listed in the *Directory* is ten.

The special features and advantages of this method are as follow:—

(*a*) No special racks or equipment are required other than an extra set of mechanical contacts on each final selector.

(*b*) The lines to a P.B.X. need not be arranged consecutively on a bank level. The final digit, however, always must be 1.

(*c*) If the first number of the P.B.X. is dialled, the final selector will automatically rotate until a disengaged line to the P.B.X. is found; or, if all lines are busy, an engaged signal will be transmitted to the calling subscriber.

(*d*) If a second or subsequent number in the P.B.X. group is dialled, free tone will be given if the line is free and busy back signals if the line is engaged.

(*e*) If calls are made to a straight subscriber's line intermingled with a P.B.X. group of lines, free tone is given on all calls in which the particular line called is free, and busy back signals when the particular line called is engaged.

For example, take the case in which the numbers of the lines comprising the P.B.X. group are 2101, 2102, 2103, and 2104 respectively. Assume that 2105 to 2108 inclusive are straight subscribers' lines, and that 2109 is a vacant number. Should it be decided to add another line to the P.B.X., the vacant number 2109 can be used. During ordinary day working, the number to be dialled when wanting the P.B.X. would be 2101. The final selector would then test the number dialled, and if it were engaged, would automatically rotate and search for a disengaged line to that P.B.X., at the same time passing over any disengaged or engaged straight subscriber's line between 2104 and 2109. If any number in the level other than 2101 were dialled, the switch would test for the condition of the circuit, but would not automatically rotate beyond the selected number. If in this particular P.B.X. it were necessary to be able to get into direct communication with, say, the caretaker after business hours, the caretaker's telephone forming an extension to the P.B.X. could be left plugged through to the main exchange on any line other than the first line. By these means, "night service" lines to P.B.X.'s can be supplied without the necessity for allotting special "night" numbers. This method of dealing with private branch exchanges does not necessitate any additions or alterations to the ordinary type of final selector multiple bank contacts.

When required, a special final selector in each "hundred" group is provided so that a trunk telephonist may enter an engaged circuit and offer a trunk call to the subscriber concerned.

To overcome the necessity for terminating each "hundreds" trunk offering final selector on a jack, and in order to obtain connexion to a subscriber by dialling his full number, an additional rank or ranks of switches are provided. These additional switches are standard final selector mechanisms, and respond to two trains of impulses from the calling dial. The switch circuit is specially designed, however, so that after two trains of impulses have operated the vertical and rotary magnets respectively, the circuit from the trunk board is extended through directly to the trunk offering final selector in the required "hundred." For instance, in a four-figure system of 3,000 lines capacity, there would be 30 trunk-offering final selectors, together with as many associated preliminary selectors as would be simultaneous trunk-offering connexions on the trunk switchboard. By arranging for both motions of the preliminary selector to be dial-controlled, a saving in switch provision is effected.

In the event of wishing to connect, say, subscriber number 2036 to a trunk line, a connexion would first be established through the ordinary

automatic switches, and if the wanted subscriber be engaged, the call would be released by the telephonist. The telephonist would then test for a disengaged trunk-offering circuit, and on such being found, would insert a plug into the jack and dial the required subscriber's number. The digits 2 and 0 would be recorded on the preliminary selector, and the wipers thereof connected to a trunk leading to the trunk-offering final selector in the "hundred" in which the subscriber's line is situated. The dialling of the digits 3 and 6 would complete the call. If the subscriber still were engaged, the telephonist would interrupt the conversation and ask him to hang up as a trunk call is waiting. The telephonist would then release the trunk-offering connexion, and set up a call through the ordinary switching channels.

Should the wanted subscriber restore his receiver to the hook whilst the trunk-offering connexion is being established, his line would automatically be made busy by the connexion of the final selector thereto. On finding his line thus disengaged, the call would be released and set up in the ordinary manner.

Although the connexion of a trunk-offering final selector to a disengaged subscriber's line will make it engaged, such a connexion to an engaged circuit will not alter the potential of the "C" line of a busy connexion on the final selector multiple.

If, in this case, the 36 "hundred" trunk-offering final selector already had been in use, lamp-flashing signals would have been transmitted automatically to the calling telephonist on the completion of dialling the digits 2 and 0 respectively.

Trunks to test desks, monitor's desks, &c., are usually taken off a level of the first selector, although these trunks can be connected to any rank of switch past the first selectors. Calls to these desks or over dead number or dead level circuits are not recorded against the calling subscriber.

Junction lines to manual common battery exchanges are terminated on special positions in the manual exchange. Each position is provided with a set of cords and associated supervisory lamps. Generally all such junctions are cord-ended. Take the case of a subscriber connected to an automatic exchange wishing to be connected to Manual 2345. If trunks to the manual exchange were wired to level number 1 on the first selectors, the subscriber would dial the digits 12345. The dialling of 1 would cause the caller to be switched on to a junction leading to the manual exchange, and the digits 2345 would be recorded on an intimator in front of a manual telephonist. Each intimator consists of a set of impulse-receiving devices, and a single number indicator common to the set of impulse-receiving devices. The number of these receiving devices to each position depends upon the number of subscribers simultaneously dialling, and usually comprises three sets. The number 2345 would be indicated on two blocks of lamps, lamp numbers 23 and 45 respectively glowing in each group. The number 23 lamp would indicate the stile strip number to be identified, and the number 45 would indicate the jack number in the group of subscribers' lines associated with the number 23 on the stile strip. Identification of the calling number further is facilitated by the lamps on the indicator

being in the same relative position as the jacks in each "hundred." The cord on which the number is to be set up is indicated by means of a signal on a supervisory lamp. Automatic ringing of the called subscriber would then commence upon the insertion of the junction calling plug into the particular multiple jack, and would immediately be cut off on that subscriber answering. Each cord circuit is provided with double positive lamp supervision. On purely C.B. systems, the registration of the call against the calling automatic subscriber only will be effected after the removal of the called subscriber's receiver from the hook.

The facilities just described will not be appreciated in Australia so much as in places like Egypt or India, where several languages are spoken. The present practice in such places is to employ telephonists capable of conversing in the various languages spoken, and telephonists, to have these qualifications, necessarily have to receive special training. Under the "intimator" system, the telephonist does not have to speak to the caller, and consequently need only to be able to converse with the exchange officers in charge.

On traffic to other manual C.B. or magneto exchanges where such conditions exist as to prevent the automatic registration of calls, facilities are provided for the registration of the call against the calling subscriber by means of the momentary depression of a register key by the manual telephonist.

The same conditions probably may necessitate the ascertaining of the wanted subscriber's number by speaking over the junction line, in which case the junctions can be made either plug or jack ended. Taking the former case, for instance, each junction would consist of a cord and plug, a "call and clear" junction lamp operating in conjunction with the alarm bell when necessary, a supervisory lamp associated with the calling side of the circuit, a register lamp to indicate registration or non-registration of a call, and a listening, ringing, and register key Inaudible registration of a call can be effected when both subscribers are listening on a connexion.

Calls from manual exchanges are handled in two ways, firstly, by means of automatic keyset senders or calling dials, or secondly, by means of special "B" positions at the automatic exchange equipped with a multiple and calling cords. In the method of handling calls by means of keyset senders, the number passed over the order wire is set up on a keyboard by the "B" telephonist. From this stage in the connexion the control of the call can be effected in three different ways. Firstly, the circuits can be arranged so that impulses are not transmitted until the "A" telephonist inserts a plug into the associated outgoing junction jack. Secondly, it is possible to arrange for the impulses to be sent out as soon as the complete number is set up on the keyboard. The control of the call is then automatically transferred to the "A" telephonist just prior to the transmission of the last train of impulses, and if that telephonist has not taken the call at this stage of the connexion, the switches already taken up are automatically restored to normal. Thirdly, the control of the call can be given to the "B" telephonist who is provided with a listening key and associated supervisory lamps on each junction circuit. In this case the call can be set up independent of the "A" telephonist, its release being fully under the control of the "B" telephonist.

Each "B" telephonist's position is provided with one keyset having control over a number of sending machines. The machines are housed quite separately from the keysets and are protected by means of glass-panelled dust-tight wooden covers.

Provision is made for the called automatic subscriber to transmit positive supervisory signals direct through to the manual "A" positions. In the event of the called subscriber being busy, both visual and audible busy signals are transmitted direct through to the "A" cord circuit. As it is understood that a number of improvements in the handling of this class of traffic are pending, no further reference will be made to the automatic sender systems at present in use.

In the method of handling incoming calls to automatic exchanges by means of Manual C.B. positions equipped with calling cords and multiple, the calls are extended through to the wanted subscribers in the same way as on ordinary Manual C.B. switchboards. The jacks are wired to the side of the I.D.F. to which also are connected the multiple wires from the final selector banks. The insertion of a plug into the multiple jack renders the line busy to final selectors and the operation of a subscriber automatically being called or originating a call causes the associated multiple jack to test engaged. The advantages of this method of handling calls are—

(*a*) Where the automatic equipment is replacing a manual multiple equipment, economy will ensue by using a portion of the replaced switchboard instead of purchasing keyset tables, keyset sending machines and additional switches necessary to carry the incoming junction traffic. Although the automatic selectors would be required subsequently on the conversion of the distant exchange to full automatic working, the keyset tables and sending machines only would be required until such conversion occurred.

(*b*) The absence of keyset senders considerably reduces the amount of equipment with which the maintenance staff has to become familiar.

(*c*) The time occupied in setting up a call under ordinary manual operating conditions is less than by means of keyset senders.

When provided with calling dials, party line subscribers can be connected to any first preselector and can originate calls in the same manner as straight line subscribers. Party line subscribers are signalled on the harmonic bell principle, the calling signals being transmitted either automatically or manually from one of the exchange miscellaneous desks. In the former case each party line subscriber would be allotted a different exchange number. The numbers of the parties on a single circuit need not be consecutive nor need they be confined to any particular "hundred" in the exchange. Special party line final selectors are not necessary, the selection of the correct ringing frequency being accomplished by a relay set jumpered between the final selector multiple and the party line.

When the correct calling frequency is selected manually, all outgoing calls to party lines are routed *viâ* a selector level to one of the exchange miscellaneous desks at which the connexion is completed.

When not provided with calling dials, party subscribers originating calls are answered from one of the miscellaneous desks, from which the calls are semi-automatically completed.

ACCOMMODATION OF APPARATUS.

General.—All switches and relays are mounted upon steel racks which are always accessible from both front and rear. The importance of such a design will be realized by those who have had to chase troubles in almost inaccessible places. Where possible, all equipment is laid out in the order in which the various switches are taken up in a call from subscriber to subscriber. Racks are supported on feet of a special design permitting a clear run for cleaning and sweeping under the racks and affording no opportunity for the accumulation of dust.

Registers.—Subscribers' registers of the impulse per call type are mounted upon separate racks in numerical order, and their appearance when in position is similar to that on standard common battery manual installations.

Preselectors.—Each rack of preselectors consists of ten panels of ten switches per panel and the associated relays. The relays are mounted beneath corresponding panels of switches. All wiring incoming to the preselectors is terminated on small terminal blocks mounted in alignment with the associated panels of preselectors or in alignment with the miscellaneous panel. The provision of accessible terminals on the racks greatly facilitates the work of the maintenance staff in testing subscribers' circuits. Wiring from the preselector multiple terminates on a special terminal arc at one end of each panel of switches.

Between the fifth panel of preselectors and the relays associated with the sixth panel of switches is mounted a miscellaneous panel on which is accommodated the fuses, test jacks, call routing charts and other miscellaneous rack equipment.

Each switch is provided with a removable number peg on which can be engraved the number of the subscriber connected thereto.

Selectors.—The number of panels of two-motion selectors (1st, 2nd, &c., or final), that can be accommodated on a rack depends upon the number of relays associated with each switch, but is either three or four panels of switches per rack. The relays corresponding with the switches are each mounted above the associated switch under a common cover. A miscellaneous panel is fitted in a manner similar to that on the preselector racks.

Wiring to switches terminates either on a terminal block or on a strip of test jacks associated with each panel of switches. Multiple wiring from each panel terminates on a connecting board which is mounted at the top of each rack. The terminals are so arranged on this board that the concentration of the levels in various panels can be accomplished by means of bare tinned copper wire straps.

Final selectors are supplied on racks accommodating three panels of up to fifteen switches per panel. Allowing a test selector in each panel,

it will be seen that on a "15 switch" rack as many as 42 simultaneous outgoing connections to 100 subscribers can be provided for on one rack of switches. This large number of switches in a "hundred" probably never would be required, but it is quoted to demonstrate the size that can be reached in final selector groups without it being necessary to common the switch bank multiple on separate racks.

Each selector is provided with a removable number peg on which can be engraved the circuit number.

Figure 7 shows a final selector rack as supplied to Port Adelaide. Although not representative of latest practice, it shows the general principles of switch layout that have been adopted.

Miscellaneous Circuits, Junction Relays, Etc.—Miscellaneous circuits, such as outgoing junction, incoming junction, and party line relays, are accommodated on steel racks similar in form to those on which switches are mounted. As most of these circuits are comparatively simple, the relays are mounted on permanently fixed mounting plates accommodating one horizontal row of apparatus per plate. Where the circuits are at all complex, the relays are mounted on removable mounting plates in the same manner as switch relay sets. Connections to the circuits are made *viâ* terminal blocks mounted at the top of the racks.

Keyset Sending Machines.—These machines are mounted on a cast metal base supported by four stout metal legs attached to each corner of the base. The base and machines normally are covered by a dust-proof glass and wood framework. The sides and top of the frame are hinged so that any particular machine can be attended to without having to remove the whole cover. Each keyset table usually accommodates twelve keyset machines. The associated relays (usually accommodated in removable sets), are mounted lengthwise below the base of the table on a framework supported by the metal legs of the table. Connections to the circuits are made *viâ* terminal blocks mounted above the relay sets.

Semi-Automatic Tables.—Semi-automatic tables for handling traffic incoming from manual exchanges contain a minimum of equipment, the apparatus mounted therein being only that required by the telephonists together with the necessary wiring and terminal blocks. The table framework consists of a polished mahogany cabinet and the keyshelf of polished red fibre. The tables are of ample size to permit operating either standing up or sitting down. There is also more than sufficient room for a telephonist to swing around in her chair without interference to telephonists operating on adjacent positions.

Tables are laid out back to back and the units so formed are mounted adjacent to each other.

Miscellaneous Desks.—The cabinet work of monitor's, information, test and complaint desks consists of mahogany. They all are similar in general design and are somewhat on the lines of the desks supplied with standard manual common battery equipment. All relays and similar apparatus under cover are mounted on plates attached to a swinging "gate" inside the desk. All such apparatus is normally kept from view by means of "lift-out" doors.

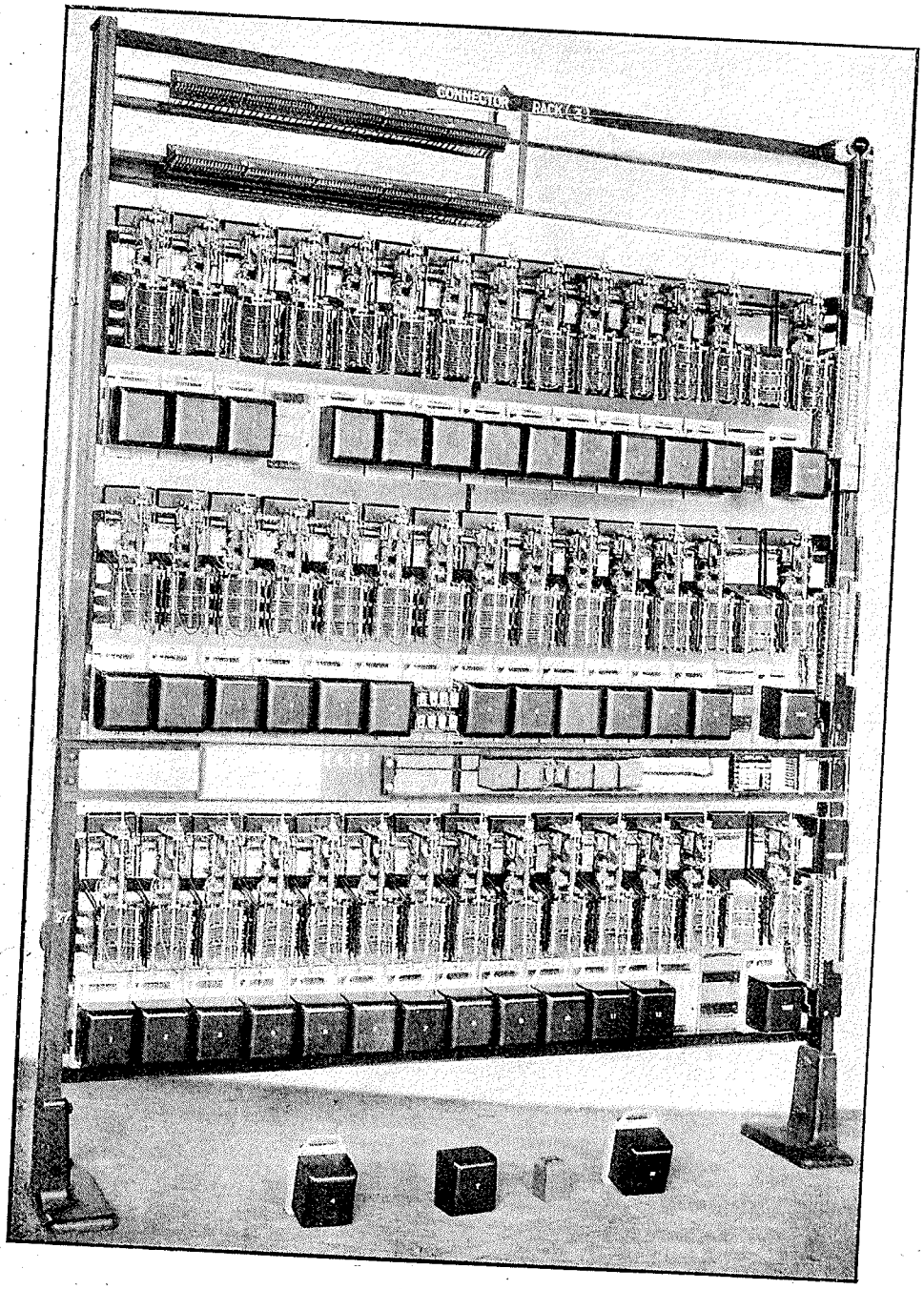


FIGURE 7.

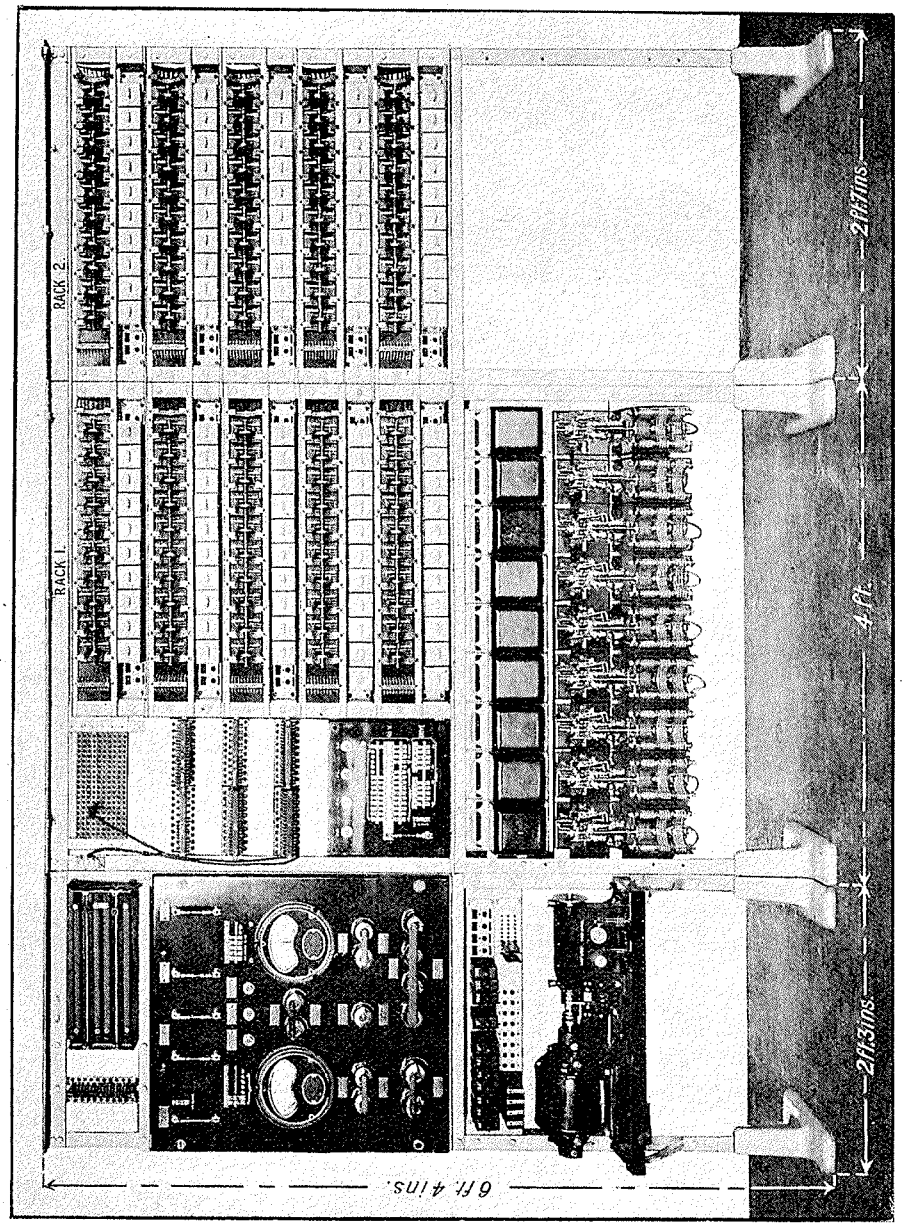


FIGURE 8.

Interrupter Machines.—In small exchanges the interrupter cams and springsets are controlled by the ringing machines, thereby obviating the provision of a separate interrupter unit, and reducing the amount of plant to be maintained. In larger plants the number of interrupter springsets which is required renders it necessary to control them by a separate motor. In such cases these machines are supplied in duplicate on a rack, together with the associated motor starting and contact change-over switches, miscellaneous equipment and terminal blocks.

In very large plants, meaning now about the range of 10,000 lines, interrupter racks are associated with and mounted close to the ranks of switches which they serve. Such a layout reduces installation costs, considerably simplifies wiring, and by the absence of a large number of single V.I.R. wires in the cable runs, enhances the appearance of the exchange wiring.

Selector Distribution Cabinets.—Variations in the traffic characteristics of the subscribers connected to an automatic exchange will often cause the routing of traffic in particular divisions of selectors to be overtaxed, with the result that a re-distribution of these switches is necessary. Where, for instance, first selectors are cabled direct to second selectors, a re-distribution of the second selectors over the first selector multiple may result in anything but a tidy appearance of the cable runs affected and the wiring at the first selector terminal boards. To provide, therefore, for such alterations, a selector distributing cabinet is supplied between ranks of switches where a re-distribution may become necessary. Apart from obviating alterations being made on the selector racks themselves, such a provision also increases the flexibility of the system and allows rearrangements of trunking to be done in the least possible time with a minimum of inconvenience.

These cabinets consist of steel racks fitted with terminal blocks and ebonite-covered jumper rings. The cabinets normally are totally enclosed by "lift-out" doors.

Figure 8 shows a front view of a 1918 model 100-line full automatic switchboard, this being the only illustration in the author's possession showing the more recent practice of the company. Though not similar in appearance to the racks used in large automatic installations, several of the points of note, such as the accessibility of all equipment from both front and rear, are illustrated.

Transmission.—With the exception of a small number of circuits operated by means of alternating current from the ringing machine, all telephone switching and directly-associated circuits operate on direct current at 60 volts pressure. Condenser transmission circuits are used, and on the latest equipment there is only one set of condensers, these and their associated battery-feed coils being situated on the first selectors. One advantage of dispensing with a battery feed on the final selectors is that where trunk line traffic is controlled from manual positions in the automatic exchange, no special battery-disconnect relays have to be provided on the final selectors, which, up till recently, has been this company's practice.

Battery feed coils consist of balanced windings each of 350 ohms resistance to direct current—see Figures 11 and 12.

The main reasons for the adoption of a battery pressure of 60 volts briefly are set out as follow:—

(*a*) A high voltage permits the use of battery feed coils of high impedance. The transmission loss at the battery feed apparatus consequently is less with a 60-volt system than would be were a lower voltage used.

(*b*) A large proportion of the total resistance in each circuit to a subscriber is in the battery-feed coils. The current supply to all telephones connected to the exchange therefore is more constant than on a system operating on a lower voltage, and consequently having a smaller amount of resistance in the exchange battery-feed circuits.

(*c*) As a result of the advantage outlined in (*b*), an excess of current on short loops is prevented, with the result that disagreeable loudness of transmission is eliminated.

(*d*) On long loops the high voltage allows a greater transmission volume than on a lower voltage system.

(*e*) The resemblance of the current variation to the transmitter diaphragm variation in a transmission circuit is greater with a high voltage and a corresponding high impedance battery feed circuit than with a lower voltage and a corresponding lower impedance system. Better articulation with a high voltage system therefore results.

(*f*) The use of small size cable conductors is permitted. This represents a large saving in a network wherein a large proportion of the subscribers' lines are routed *viâ* cable.

(*g*) The use of a high voltage permits very reliable relay and switch magnet operation.

Operating Limits and Switch Characteristics.—All circuits are designed to operate on very wide ranges of conditions. For instance, with the exchange battery pressure varying from 54 to 66 volts, a dialling speed varying from 7.5 to 14 impulses per second, a loop resistance varying from 1,000 ohms to no resistance, a line insulation resistance (wire to wire) as low as 15,000 ohms, satisfactory operation of any switch can be obtained under any combination of the foregoing conditions.

In addition to these wide ranges, provision also is made on installations of all sizes for the operation of the switch magnets to be unaffected by subscribers' lines of abnormal electrostatic capacity, and/or low insulation resistance. In a system where the selector line relay repeats the dial impulses directly to the switch-lifting magnet, for instance, the distortion of the line impulses by the line capacity will, in many cases, cause the wrong level to be selected. This is due to the combined inertia of the lifting magnet and the wiper shaft being so great that accurate response to the irregular operation of the line relay armature is not permitted. The result is that the level reached is lower than the level dialled.

Assuming that the dial speed is within the correct limits, the proper way to prevent this trouble is to keep the time of lift and the time of restore of the switch magnet armatures approximately equal. Any variation should be in the direction of making the "lift" period the

longer, as the apparatus to be lifted is of greater mass, and consequently possesses greater inertia than the apparatus in motion during the restore of the magnet armature.

In Siemens' latest first-selector circuit, a combined impulse repeating and translating device is interposed between the switch line relay and the switch lifting magnet. This device, which consists of a condenser and a relay, allows the ratio of the time of operation and release of the lifting magnet to be fixed, and entirely unaffected by excessive line capacity or low insulation resistance shortening the "de-energized" periods of the line relay during dialling.

As the repeating takes place from the first selector, there is no necessity for this special repeating device to be fitted on subsequent ranks of switches controlled through local first selectors.

A similar repeating circuit also is incorporated in all second or subsequent selectors on which incoming junctions are terminated.

The speed of operation of the preselecting switches renders it impossible for telephone subscribers to transmit impulses before the selectors are ready for their reception. To give an idea of the speed of these switches, take the case of a subscriber originating a call at the Port Adelaide Semi-Automatic Exchange. The following is a brief summary of the operations which occur from the removal of the receiver to the glowing of the lamp indicating the presence of a call on the semi-automatic positions (assuming that there is an immediately available circuit in each rank of switches for the passage of the call):—Line relay operates, first preselector rotates and selects a trunk leading to a disengaged second preselector, second preselector rotates (if necessary), and selects a disengaged relay repeater, relays on the first selector operate, keyset selector rotates (if necessary), and selects a disengaged keyset controlled from one of the semi-automatic positions, relays in the keyset circuit operate, lamp on semi-automatic position glows and indicates the presence of a call. This train of operations occurs so rapidly that in practically all cases where there is an immediately available circuit to a telephonist, the call lamp glows before the calling subscriber has the receiver to his ear. On this account it is necessary for the telephonists at the Port Adelaide Exchange to wait for a short period after the glowing of a call lamp in order to insure that the subscriber hears the exchange name being announced.

On the latest type of full automatic equipment the period occupied in preselection is much shorter than at Port Adelaide. The number of operations which occur prior to a first selector being ready to take impulses is very small, and is as follows:—Line relay on first preselector operates, first preselector rotates at 50 steps per second and selects a disengaged first selector, relays A, V, and E on the first selector operate in the order named. A conservative estimate of the average time required for this train of operations to occur is one-third of a second.

The special construction of the calling dial which was previously referred to, combined with the speed of rotation of the selectors and the time saved in automatic rotation due to rotated multiple on the selector banks, renders it impossible to dial a second or subsequent train of impulses before the selectors are ready to receive them. Tests made by dialling trains of single impulses as quickly as possible have proved this claim.

Throughout the system the links between the various switches test free only if they are connected to battery at maximum potential. By such design a faulty switch or relay set, rendered so by a dirty contact, and switches not ready for immediate use by reason of the wiper shaft not being right home to normal, are made to test busy.

In a recent design the links between the switches not only test free only when connected to battery but the design is such that in the case, for instance, of a preselector searching for a disengaged selector, (*a*) the testing or cut-off relay of the preselector will remain completely de-energized (unmagnetized) when its "C" wiper contacts with the "C" line of the engaged trunk; (*b*) the potential of the "C" line of the engaged trunk referred to in (*a*) will not be varied by being tested for busy or otherwise by the searching preselector; (*c*) as the result of (*b*), the cut-off relay of a preselector connected to a selector will not be shunted or its magnetism increased by the cut-off relay of another preselector momentarily contacting with the trunk in search of a free selector; (*d*) the cut-off relay of a preselector on finding a disengaged trunk, will operate and immediately make the trunk test engaged to other switches. The testing for a free circuit is solely done by the "C" wiper. Until connexion to a free circuit is actually made the "A" and "B" wipers are at zero potential.

Connexions to first selectors, rendered faulty by open circuit "C" trunks, are guarded against by such faults making the switch test busy. In the event, however, of a preselector engaging a selector, faulty by reason of either the "A" or "B" wires of the trunk being open, the circuit design is such that the preselector is released and caused to again rotate in search of a free selector. A call therefore cannot be held up nor can dialling be interfered with on account of a preselector "picking up an open or earthed trunk."

Switch Control.—Provision can be made for the immediate release of all two-motion switches on either party of a successful call hanging up his receiver. Assume that a call has been set up as follows:—Calling subscriber, first preselector, first selector, second selector, third selector, final selector and called subscriber. If, after successful conversation, the called subscriber hangs up first, the first and second selectors immediately will be restored to normal, following on which operation, the third and final selectors will release to normal. The second and subsequent selectors will then be available for other calls. The only apparatus now held up will be the first preselector and the first selector, and, as can be seen from Figure 11, the calling subscriber may dial up a second number without momentarily restoring his receiver to the hook.

Should the calling subscriber hang up first, all switches in the connexion will be restored to normal and the called subscriber will then take up a first preselector and a first selector. He then may dial up a number without restoring his receiver to the hook. Failure of the called subscriber to hang up after a predetermined interval of time will then operate the slow audible alarm and call the exchange mechanic's attention thereto. The switches released by the calling subscriber hanging up will immediately be available for further use.

In special circumstances, circuits embodying other well known methods of switch control can be installed.

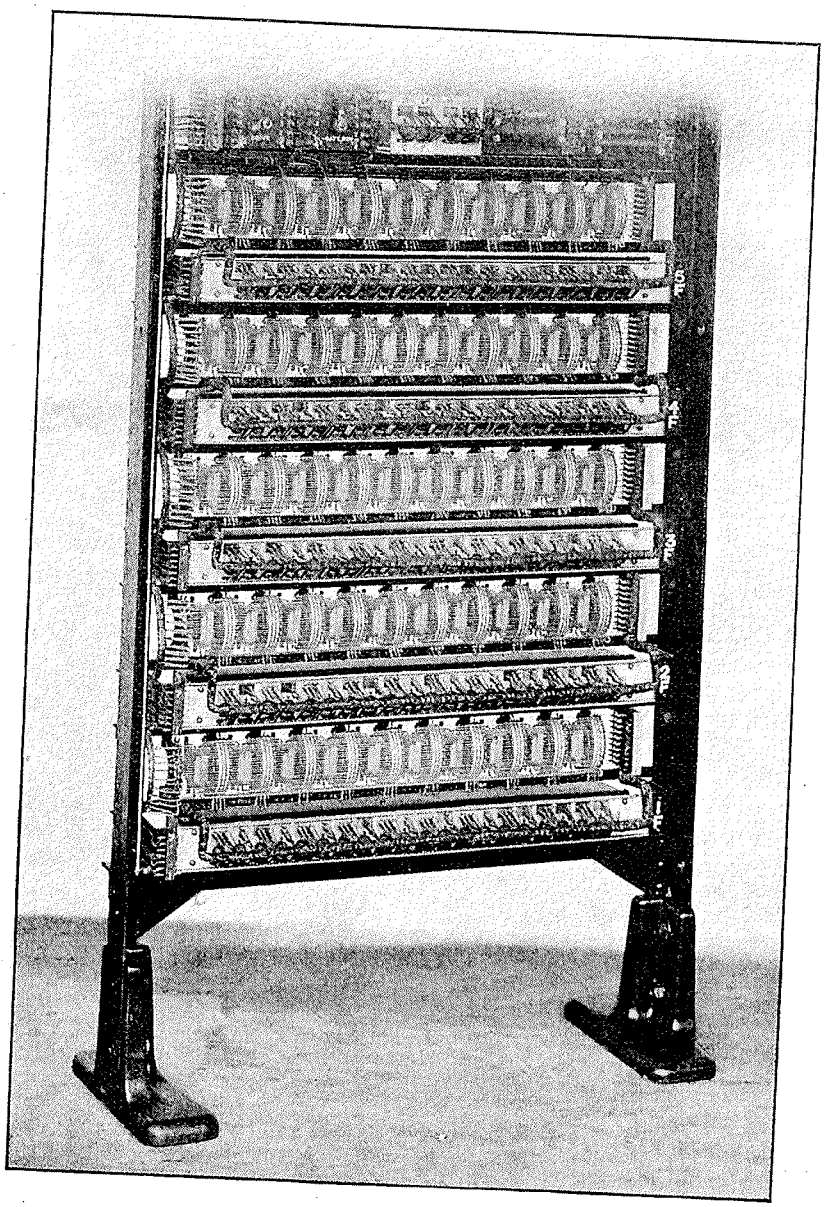


FIGURE 9.

Rotated Multiple.—Rotated multiple is extensively used throughout all ranks of switches. On first preselectors, a retrograde rotation is employed between panels comprising a row of switches. This feature is primarily intended to assist in the distribution of traffic to the first selectors, but it also decreases the time taken for a selector to be ready to receive impulses.

On selectors, both advancing and retrograde rotated multiple is used. In a panel of ten selectors, the multiple is rotated on each bank level between each switch, levels 1, 2, 5, 6, 9 and 0 having a retrograde rotation of one between each switch and levels 3, 4, 7, and 8 having an advancing rotation of one between each switch. One reason for the two directions of rotation is that the number of times that similar wires from the butt of the multiple forms to the switch bank contacts are closely parallel is reduced to a minimum. This feature minimizes both electrostatic and electromagnetic induction, and effectively eliminates crosstalk and especially the clicking noises due to the disconnexion of current in adjacent circuits. A rotated multiple between each switch also reduces driving to a minimum. It is not an uncommon sight to see all of the engaged switches in a rack of selectors resting on the number one contact of the various levels to which the wipers have been stepped. The maintenance and wear on driving magnets, their associated movements and driving pawls, and switch wipers is thereby reduced to a minimum.

Wiring.—For other than power circuit cabling, four sizes of cables are used, viz., 33, 42, 63 and 105-wire cable. One complete set of spare wires is included in each set of cable. These cables are light lead taped and braided similar to those in use in Departmental Exchanges.

Many novel features have been introduced into the wiring of the various portions of the equipment, the most noteworthy being that employed on the switch banks. The terminals of each bank contact on the preselector banks are staggered so that on a panel of 10 switches only corresponding multiple terminals become in horizontal alignment. Wiring is effected by means of bare tinned copper wire, there being thirty parallel wires in a multiple of switches each having ten outgoing three-wire trunks. The wire is laid into a slot in each terminal and then securely soldered. This makes the neatest possible arrangement, and allows the multiple always to be open for inspection. An example of this method of wiring is Figure 9, which shows the lower portion of the wiring side of a first preselector rack.

Selector levels are multipled with properly laced forms of No. 23 S.W.G. T.C. C.C. wire conforming to the departmental standard colour code. The butts of the multiple forms are arranged so that the wires from the butts to the corresponding levels are horizontal and straight, no slack wire being permitted. The butts of the multiple then are held in position by bands of webbing in the same manner as in common battery exchange multiple. The butts of all multiple wiring are coated with colourless shellac, thereby facilitating the removal of dust.

All wiring to relays and similar equipment mounted on permanently fixed mounting plates is effected by No. 23 S.W.G. T.C. C.C. wire conforming to the standard colour code. No slack wire is permitted between

the butt of a form and the terminals of the apparatus on the mounting plate, the wire being joined to the terminal in a straight line from the cable butt. All forms are neatly laced and coated with colourless shellac. This whole arrangement not only renders exceedingly neat work, but the forms are made very rigid, thereby increasing the immunity from breakage of the connecting wires.

Wiring on removable relay sets is made into a laced form which fits between the projecting springset and coil terminals and the mounting nuts at the rear of the relay set. The connecting wires are formed out directly opposite each terminal to which they are to be joined. Not more than a necessary fraction of an inch spare wire is permitted between the butt of the form and the terminals. All wiring on relay sets is done in standard code colours.

Power wiring amongst the apparatus on the switch racks is effected in two ways, viz., by V.I.R. insulated wire or by bare T.C. wire encased in black insulating tubing known by the name of itala tubing. The latter method permits very neat wiring, and is used on the racks where the power wire is to be run in a straight line.

Spark-quenchers.—Spark-quenching devices are provided for all contacts breaking heavy current in circuits of high inductance. One method of spark-quenching commonly employed is a condenser and "timing" resistance connected in series across the contacts to be protected.

An ingenious method is employed for quenching the spark on contacts which control the automatic rotation of switches. In the case of second pre-selectors, for instance, on each switch is fitted a pair of mechanical contacts which close when the driving magnet is almost fully operated. These mechanical contacts are wired in parallel with the pair of relay contacts which control the disconnexion of interrupted driving current. As soon as the switch "testing" wiper touches against a disengaged bank contact, this relay immediately operates and opens the circuit through the drive control springs, but the circuit of the drive magnet is not opened, as the mechanical contacts at this period are closed, due to the drive magnet still being held locked by current flowing through the interrupter machine springs. The relay contacts therefore open when no current is flowing through them.

The disconnexion of the current through the interrupter machine springs a fraction of a second later then causes the drive magnet to release, thereby unlocking the circuit at the mechanical contacts. These contacts, it will be seen, also break when no current is flowing through them.

In this circuit the only point where a spark is likely to occur is at the interrupter springset, but pitted or dirty contacts are safeguarded against by the provision of a "condenser and resistance" quencher, the use of tungsten contacts and the burnishing of these contacts by their constant hammering together by the continuously rotating cams.

A similar method of spark-quenching also is adopted on the rotary drive of all except final selectors.

Fusing.—Main fuses, mounted in a fume-tight cabinet as near to the batteries as convenient, are interposed between the accumulators and the battery change-over switches on the main power board.

Continuous current power for the switchracks is fed from the battery change-over switches by a copper busbar, which is supported by special white porcelain insulators mounted above the racks. Connexion to each rack is made by a short length of insulated cable leading from the busbar to an enclosed main rack fuse which is rated from about 10 to 15 amperes, according to the apparatus to be served. From the "rack" side of the fuse a power cable leads to one or more polished slate fuse panels accommodating 1.2 ampere mechanical alarm fuses.

Driving current is fed through an enclosed main fuse to mechanical alarm fuses associated with the interrupter springsets. From the interrupter machine, rack "drive" power leads are fed to small fuse panels similar to those supplied for C.C. power.

As an example of the fuse distribution on the automatic switchracks, each panel of ten switches on a first selector rack has associated with it a fuse panel of ten 1.2 ampere continuous current fuses and ten 1.2 ampere interrupted current fuses. On the rack, associated with the miscellaneous equipment, there is also a panel accommodating fuses for the miscellaneous circuits such as the fault alarm and group control circuits.

Continuous current power to miscellaneous racks accommodating such as outgoing junction relay sets, is distributed from a large miscellaneous fuse panel equipped with mechanical alarm fuses.

Ringing power is supplied through alarm fuses mounted on the main power board. A resistance lamp, also mounted on the main power board, is interposed between the final selector racks and the fuses.

The insulated part of all mechanical alarm fuses consists of mica. The identification of a melted mechanical alarm fuse is provided for by a small glass bead projecting when the fuse melts. All enclosed fuses are contained in fibre cases to each end of which are rigidly attached stout connecting logs. All heavy current fuses are contained in white porcelain holders provided with "knife" contacts.

Fault Alarm System.—The following is a list of the faults which are brought under notice by means of the exchange alarm apparatus:—

(*a*) 60-volt main fuse on rack melted.
(*b*) 60-volt branch fuse on rack melted.
(*c*) Interrupter fuse melted.
(*d*) 75-volt ringing fuse melted.
(*e*) Failure of ringing machine.

These five faults immediately bring the visual and audible alarm apparatus into operation on their occurring.

(*f*) "Permanent glow," (P.G.) fault.
(*g*) Selector shaft sticking.
(*h*) Interrupter contacts permanently making.
(*i*) Interrupter contacts permanently open.

The visual alarm signal only is brought into operation immediately on any of these four faults occurring; if, after a pre-arranged interval of time, the fault is still in existence, the audible alarm is brought into operation.

The exchange equipment is divided into sections, the number of such sections varying according to the size of the plant. The alarm circuits

on the racks forming a section are grouped together to control associated section lamps and common audible alarms. These section lamps and audible alarms are multiplied in prominent positions in the exchange, and are accommodated in small lamp cabinets mounted so the lamps can easily be identified. When a fault occurs, the alarm bell calls attention to its existence, and the section lamp which is glowing indicates which section is affected.

A five candle-power red alarm lamp is fitted at the top of each rack, and by glowing it indicates which rack in the section is affected.

On each rack is fitted a small set of switchboard lamps, each lamp being associated with a particular circuit. The glowing of one of these lamps indicates the particular circuit on the rack which is at fault.

The time lag device consists of a springset and a slowly rotating cam which is controlled by the ringing machine. Only one time lag device per exchange is required. This arrangement is more reliable than relay controlled springsets as the cam control permits sufficient pressure to be exerted against the springs to insure immunity from imperfect contacting.

Group Alarm Circuits.—Group alarms are provided to indicate, *inter alia,* (*a*) when all trunks from a row of preselectors are simultaneously engaged; (*b*) when all switches in a panel of selectors are simultaneously engaged, and (*c*) when all switches of a panel of final selectors are simultaneously engaged. Facilities also are provided to intimate to a calling subscriber when all trunks leading to the next rank of switches are in use. For instance, if all outgoing trunks on a selector level are engaged, the wipers rotate to and stop on the eleventh set of contacts on that particular level of the switch bank. "Busy back" signals are then transmitted from this last set of contacts. Such contacts, however, could be wired to lamps and jacks on one of the exchange miscellaneous desks. In the latter case the glowing of the lamp would indicate the presence of a call which would be answered, and, if desired, could be completed by means of a hospital cord circuit and a hand dial.

Visual signalling apparatus associated with the group alarm circuits is concentrated, and is mounted in a suitable cabinet where required.

The indication of all switches in a panel being simultaneously engaged is effected in a manner different to that with which members are most familiar, viz., a set of series contacts which, when all are closed, complete a circuit through a relay. A group alarm circuit consists of a relay having an inductive and a non-inductive winding, both of comparatively high resistance. These windings are connected in series, the free end of the inductive winding being connected to positive battery and the free end of the non-inductive winding to negative battery. The group alarm contacts each consist of a pair of "break" springs, and the corresponding springs in all of the circuits to be included in the group are multiplied. One multiple wire is connected to positive battery, and the other multiple wire to the point where the two relay windings are joined. It will be seen that until all of the group contacts are operated and thereby opened, the inductive winding of this group relay will be short-circuited.

This latter method possesses several advantages, the four foremost being that—

(*a*) wiring is simplified;

(*b*) grouping additions and alterations are considerably facilitated;

(*c*) in the event of a group contact developing an open circuit due to such as dust, the group alarm circuit is not rendered inoperative as would be the case were such a fault to develop on the first-mentioned system, and

(*d*) where removable relay sets are employed in the circuits forming the groups, the removal of a set automatically affects the group alarm circuit in the same way as a relay set being rendered busy by being taken into use.

Call Tracing Facilities and Designation of Apparatus.—All apparatus is designated so that it immediately can be identified from charts or circuit diagrams. In addition to this complete designation scheme, a special facility is provided by each preselector having a removable ivorine number peg on which is engraved the Exchange number of the subscriber connected thereto. On each preselector and selector rack, with the exception of the final selectors, is provided a chart for the purpose of facilitating the forward tracing of calls. On tracing a call, reference to this chart will immediately allow the particular switch in the next rank of switches to be ascertained without having to exert mental effort to consider such as slip multiple. On all racks, with the exception of first preselectors, is also provided a chart for the backward tracing of calls.

Testing Facilities.—In addition to a Test Desk, reference to which cannot be made in this paper, facilities are provided for the quick and easy testing of all apparatus. Facilities are provided by means of C.B. jacks and plugs for testing onwards from any selector, the testing being done from a portable cabinet containing such devices as slow and fast calling dials. Preselector circuits and onwards can be tested by a shoe which fits over the terminals on the "incoming" connecting blocks on the preselector racks. A small number of multiple jacks are provided on each rack for the purpose of observing any particular stage in the making of a test call. For instance, it is possible to be at the second selector rack and, by means of one of the portable test sets, originate a call from a predetermined first selector. This obviates the necessity for the services of two mechanics in such types of tests.

A test selector is provided for each "hundreds" final selector panel and is controlled from the test desk. The No. 99 circuit in each final selector "hundred" is also wired through a "break" jack. By this means, routine tests can be made through the flexible wiper connecting cord to a point past the final selector wipers.

On impulse sender tables associated with junctions from manual exchanges, keys are provided for making any of the impulse senders test engaged. On the sending machines, keys also are provided for connecting each sender to a small set of test switches mounted close to the impulse machines. Facilities are provided for the testing mechanic to speak directly to the "B" position telephonist who can set up

predetermined numbers which can be observed by the testing officer in all stages of the switch and impulse sender operations without moving away from the keyset machines.

Non-locking keys are provided in the group control circuits associated with first selectors. These keys are for making routine tests on the group alarm circuits.

The portable cabinets used for testing the various switches are of convenient size and substantial make and are provided with facilities for being suspended from a storage rack when not in use and for being mounted and transported on a two-wheeled carriage when in use. The cabinets when mounted on the carriage are horizontally in alignment with the testing officer's shoulders. All relays, resistance spools, &c., in the set are enclosed by the cabinet, the only apparatus visible being the keys, jacks, lamps, ivorine number plates, &c.

Removable relay sets can be tested out of their normal position on the switchracks, this being done by means of the portable cabinets just described together with a small testing rack consisting of switches representing 1st, 2nd, and final selectors and their associated sets of relay knife contacts. The relay set to be tested is fitted into the appropriate holder on the test rack and tested in the same manner as on the main switchrack. The advantages of this facility are—(*a*) the small test rack can be mounted in a well-lighted position such as in front of a window, thereby facilitating maintenance, and (*b*) a testing mechanic need not hold up a trunk in order to carry out a test on a particular set of relays. Here it may be pointed out that in the event of a relay set being found defective, a spare set can be substituted and the switch made available for further use within, say, for a large public exchange, fifteen seconds after the discovery of the trouble. This includes the time of a mechanic to walk to and from the shelves on which the spare relay sets are stored. The actual operation of changing the relay set need not occupy more than about three seconds.

Power Plant.—Continuous current at approximately 60 volts pressure is provided from either of two sets of 30 accumulators. No end or counter-E.M.F. cells are supplied as the apparatus is designed to operate reliably on voltage variations within the permissible voltage variations of the accumulators. No special battery provision is necessary for metering purposes. Charging is effected by means of a continuous-current generator direct-coupled to a C.C. or A.C. motor as may be required. An ordinary commercial direct-current generator is supplied, the provision of a special telephone type generator having a multi-segmented commutator not being necessary. The control and protecting equipment is similar to that used on Common Battery installations.

Ringing current for straight line services is supplied by direct-coupled motor-alternators where the driving power is alternating and by a dynamotor where the driving power is continuous. To each ringing unit is direct-coupled a shaft controlling the busy-back and motor control interrupter cams (when the latter are employed), a ringing distributor and a time lag cam for use in conjunction with the delayed audible alarm. On small installations the springsets and cams furnishing interrupted driving current also are controlled by the ringing machine.

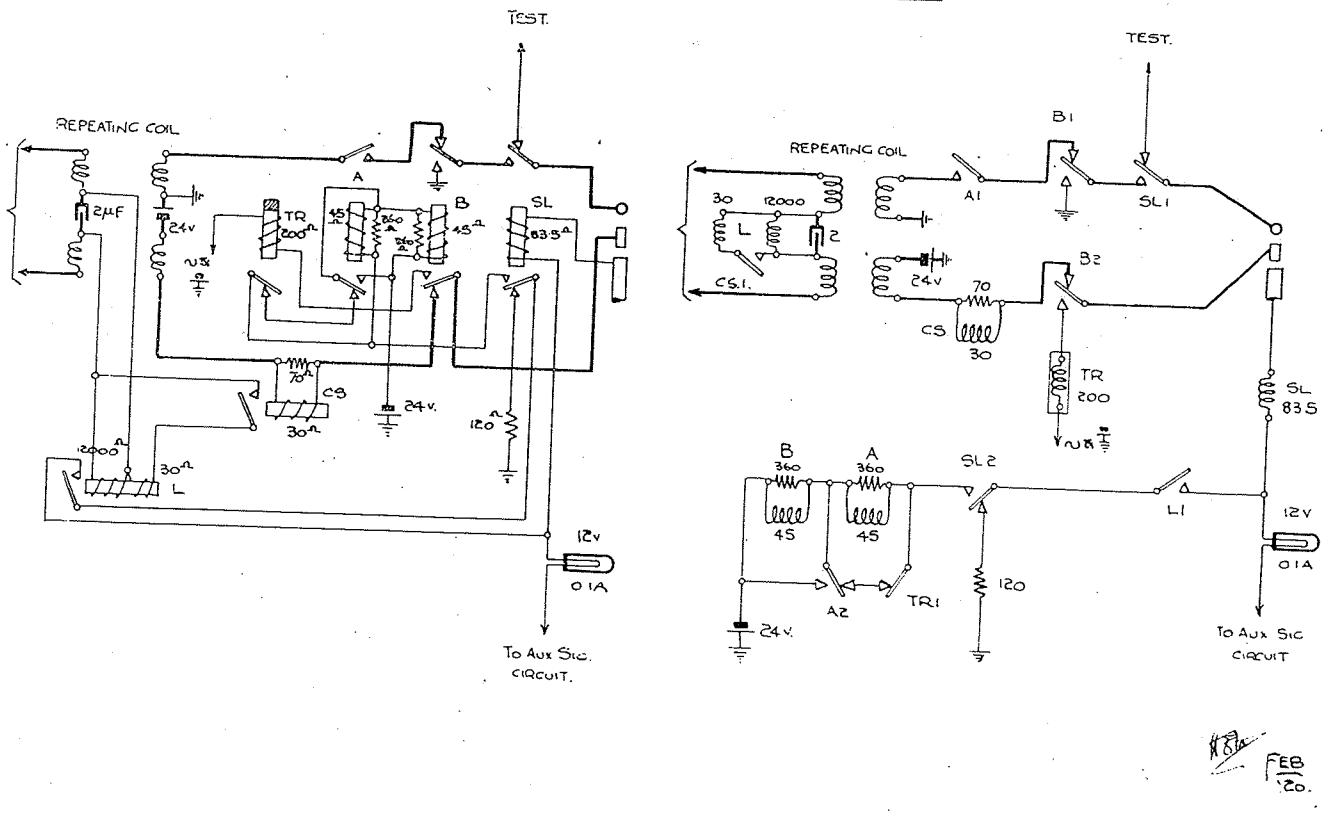

SECTION.1.
SECTION.2.
TEST.
REPEATING COIL
2µF
24v
TR
200Ω
A
B
45Ω
SL
83.5Ω
70Ω
CS
30Ω
24v.
120Ω
200Ω
30Ω
L
12v
0.1A
To Aux Sig. circuit.
B1
A1
SL1
30
12000
L
2
CS.1.
B2
70
CS
30
TR
200
SL
83.5
B
360
45
A
360
45
SL2
L1
A2
TR.1
120
24v.
12v
0.1A
To Aux Sig circuit
FEB '20.

FIGURE 10.

Reduction gearing for use with the slow-speed cams consists of a combination of bevel, straight and worm gearing and is contained in a totally enclosed gearbox. All gears are continuously lubricated.

The failure of a ringing machine is indicated on the exchange fault alarm system.

Ringing machines are supplied in duplicate except on small private automatic exchanges where duplication is not warranted.

Ringing current for party lines is supplied from a harmonic converter contained in a dust-proof cabinet. These sets are provided in duplicate.

"Busy back" and "free" tones are supplied from a ringing generator or an interrupter motor, the tones being generated in auxiliary shunt-excited windings incorporated in the machine.

The power board consists of highly polished black slate slabs. All fittings are copper-plated and lacquered on non-contacting surfaces. Leads from the various power equipment are brought on to busbars or fuses on the power board and from there distributed to the equipment to be served.

Circuit Diagrams.—In schematic circuit diagrams Messrs. Siemens Bros. have made a striking departure from the usual method of depicting electric circuits. All relay contacts are shown dissociated from their respective relays, but are designated in such a manner as to render their identification easy. All relays are designated by means of capital letters, such as A, B, V and X, and where, for instance, there may be two similarly lettered relays in a circuit, these relays are differentiated by means of index figures such as V^2 and V^3, but referred to as "V two" and "V three". Contacts number 2 and 4 of these relays would, for instance, be shown as $V^2 2$ and $V^3 4$.

To see the advantage of this method of depicting circuits, refer to sections 1 and 2 respectively of Figure 10. The former shows a keyless ringing circuit with which, no doubt, most of those present are more or less familiar. In this case the contacts are shown against their controlling relays. The latter shows the same circuit drawn in Siemens' style. Apart from the absence of a large number of crossing lines, which tend to make any simple circuit appear more or less complicated, this latter style of circuit layout shows each sub-circuit in the main drawing quite separate, and allows the functions of the various pieces of apparatus to be more easily seen and clearly understood. For instance, it can be seen at a glance how the operation of contact TR1 removes the short-circuit from relay A and how, by the change-over of contact A2, the subsequent release of contact TR1 does not again affect relay A. Furthermore, it is not necessary for any one, who even may not be familiar with the circuit, to "trace it through" to see how either relays A or B act as a shunt to the 12-volt supervisory lamp after the call is set up and whilst contact L1 is closed.

To fully appreciate the value of Siemens method of depicting circuits, comparisons should, however, be made on a more complicated circuit, such as the final selector in which there are a large number of sub-circuits and relay contacts.

This method of drawing circuits is particularly invaluable to the maintenance man, as in the event of trouble being reported on, say, a

selector circuit, reference to the diagram immediately will disclose the various possible sources of the trouble. Under the method of showing the contacts associated with the controlling relay, it would be necessary to trace through the circuit for the possible causes of the fault, whereas under the other method, these possible causes would be shown grouped together, and quite separate from the other unaffected parts of the circuit.

The style of drawing will also appeal to those who are interested in the design of telephone circuits. The design of a circuit to meet a set of conditions is very seldom accomplished by the drawing of a single diagram but usually entails making an appreciable number of diagrams before the right circuit is decided upon. By setting out the drawings in this manner a large amount of tedious repetition is obviated, portions of the circuit which will meet requirements not having to be re-drawn each time. The actual drafting also occupies less time, which enables a train of ideas to be followed up much quicker than by the method shown in section 1 of Figure 10.

Siemens Bros. supply a full and comprehensive set of diagrams and bound descriptions with their equipment. As an example, on the Port Adelaide installation, which consisted of the erection of semi-automatic equipment to handle traffic to and from 1,000 subscribers' lines, approximately 200 drawings and circuit diagrams were supplied.

All wiring diagrams show the equipment exactly as the wires are connected to the equipment terminals as viewed from the side on which the wires are soldered. The sizes and colours of all wires used are shown on the wiring diagrams.

All drawings and diagrams are foolscap or multiple of foolscap in size.

Time renders it impossible to deal at length with more than one of the electrical circuits, and therefore it is proposed to refer only to that circuit of most interest, viz., the first selector with the impulse-translating device.

Refer to Figure 11. In this diagram the apparatus necessary to give effect to the special features of switch control and impulse translation only are shown, all circuit details, such as "registering" contacts, group-alarm contacts, and the "shaft sticking" relay being omitted.

Take the case in which an automatic subscriber wishes to call, say, subscriber No. 6244 connected to the same automatic exchange.

Upon the caller removing his receiver from the hook, the associated line relay on the first preselector will operate and cause the preselector arms to move from their normal or home positions, and search for a trunk leading to a disengaged first selector. The moving of the pre-selector arms off normal will cause the associated bank contacts on the final selector multiple to test engaged.

After a disengaged trunk is found, the pre-selector cut-off relay will operate and, (*a*) will disconnect the interrupted driving current from the preselector driving magnet; (*b*) will disconnect the "A" and "B" lines leading to the caller from the preselector line relay, and connect them through to the first selector; and (*c*) will make the trunk selected test busy to other switches.

Simultaneously with the operation of the cut-off relay, the winding of the A relay in the "C" line circuit of the first selector is energized and relay A is operated. Contact A1 energizes relay V, which operates. Contact A2 effects no circuit changes at this stage.

Contact V1 connects a resistance in parallel with the winding of relay A as, at a later stage in the call, this winding will be open-circuited. Contact V2 energizes relay E *viâ* contacts Y1, winding of E, contacts B2 and F1 and guard resistance. Relay E operates. Contact V3 closes, but effects no circuit changes at this stage.

Upon relay E operating, contact E1 opens the "C" winding of relay A as this relay is to be used for receiving impulses. Relay A, however, remains operated as, by this time, the calling subscriber's circuit is looping the "A" and "B" windings of the A relay. Contact E2 changes over and prepares the circuit of the lifting magnet H. The caller now dials the first train of impulses.

The first open circuit from the calling dial causes relay A to release. Contact A1 opens, but relay V does not release during dialling on account of being fitted with a copper sleeve. Contact A2 releases, and the condenser MF receives a charge. The closing of the subscriber's loop after the first open circuit now causes relay A to be re-energized, and on contact A2 closing, the charge in condenser MF discharges through relay B, which operates. Contact B1 opens. Contact B2 removes the short-circuit from relay F which immediately operates. Contact B3 effects no circuit changes during the first train of impulses.

Contacts F1, F2, and F3 close, but cause no immediate circuit changes by their operation.

Relay B now releases, due to the dissipation of the charge in condenser MF. Contact B1 in releasing, closes the circuit of the lifting magnet which operates. The shaft is moved one step in a vertical direction, thus operating the vertical off-normal contacts designated K on the diagram. Contact K1 opens and guards against the subsequent energization of the third or "C line" winding of relay A. Contact K2 prepares the circuit of the release magnet M. Contact B2 places a short-circuit across relay E; this relay, by reason of the short-circuit, does not immediately release.

The second open-circuit from the calling dial again causes relay A to release. The changeover of contact A2 charges condenser MF, which again discharges through relay B upon the re-energization of relay A. Contact B1 opens the circuit of the lifting magnet, which releases the pawl in readiness for lifting the shaft another step. Contact B2 removes the short-circuit from relay E, which had not released during such a short period on account of its winding being directly short-circuited at contact B2.

Relay B, in releasing, due to the dissipation of the charge in condenser MF, re-energizes the lifting magnet.

The charging of condenser MF, due to the potential of 60 volts being applied by the closing of contact A2, is practically instantaneous, and for this reason the length of time that the A relay is in the unoperated state between successive impulses can be very small compared to the period of energization between such successive impulses. The ratio

of the period of energization to the period of de-energization of the lifting magnet H depends upon the respective fixed characteristics of condenser MF and the relay B, and this ratio therefore is both fixed and independent of the dialling circuit characteristics affecting relay A.

On the completion of the first train of impulses, relay E finally releases due to being permanently short-circuited. Contact E1 releases but the circuit through the third winding of relay A is now open at K1, a contact which opened at the first vertical step of the shaft. Contact E2 breaks the circuit of the lifting magnet and closes a circuit through the rotary magnet D and the battery interrupter.

The shaft wipers now rotate in search for a trunk leading to a disengaged second selector and on such a trunk being found, relay C operates. Contact C1 breaks the circuit of the rotary magnet and short-circuits the high resistance winding of relay C, thereby making the circuit test engaged to other selectors. Contacts C2 and C3 extend the "A" and "B" wires of the first selector through to the second selector.

The remaining trains of 2, 4 and 4 impulses respectively are now repeated over the "A" wire through to the second and final selectors by means of contact B3 on the first selector.

On the called subscriber answering, relay Y operates. Contact Y1, in opening, causes relay F to release. Contact Y2 removes the short-circuit from the "A" winding of relay Y thereby providing a balanced transmission circuit. Contact Y3 opens to guard against the premature short-circuiting of relay C.

Contact F1, in opening, effects no circuit changes at this stage. Contact F2 removes the short-circuit from the high resistance winding of relay C and prepares for certain release conditions. Contact F3 changes over and prepares the circuit of the release magnet M.

Conversation now ensues. Battery is now fed to the called subscriber's telephone through the windings of relay Y on the first selector.

In the event of the called subscriber first restoring his receiver to the hook, relay Y releases. Contact Y1 causes relay E to operate. Contact Y2 closes. Contact Y3 short-circuits the low resistance winding of relay C, which after a short time releases. Disregarding relay E for the moment, contact C1, in releasing, opens the circuit over the "C" wiper to the second selector thereby restoring that switch to normal. The releasing of the second selector in turn causes the final selector to be restored to normal. The back contact of C1 also closes a circuit through the release magnet M of the first selector and releases the switch wipers to normal. The release magnet circuit is broken at contact K2 when the shaft return right home to normal. Contacts C2 and C3 in opening prevent interference to other circuits when the wipers are in motion.

The restoration of the calling subscriber's receiver to the hook first will de-energize relay A, which in turn will release relay V. Contact V1, in opening, allows the first preselector to rotate to its home position. Contact V2 causes no circuit changes. Contact V3 opens and releases the second selector and the C relay on the first selector. The release of relay C will now cause the switch wipers to be released in the same manner as previously described.

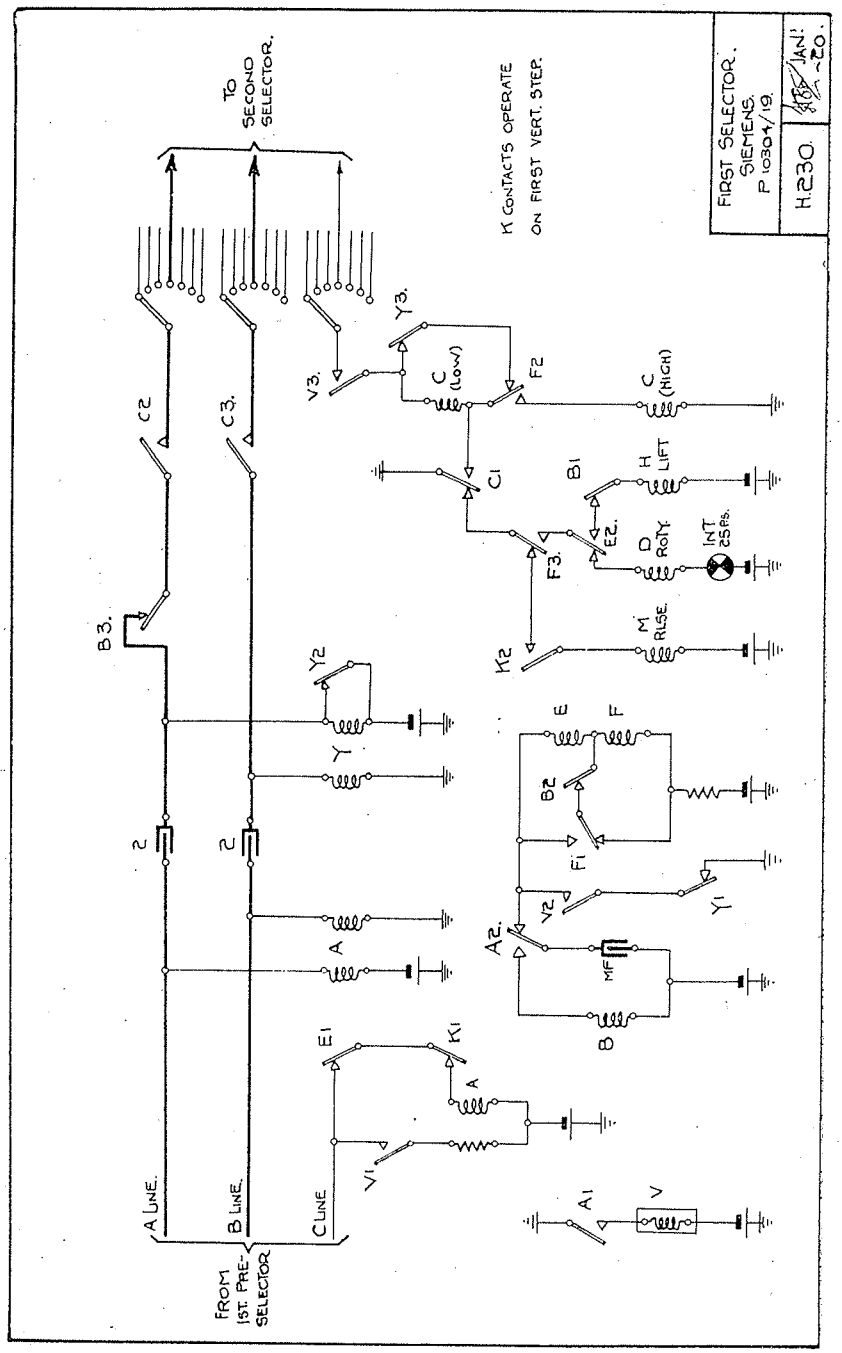

FIRST SELECTOR.
SIEMENS.
P 10304/19.
H.230.
JAN! 20.
K CONTACTS OPERATE
ON FIRST VERT. STEP.
TO
SECOND
SELECTOR.
FROM
1ST. PRE-
SELECTOR
A LINE.
B LINE.
C LINE
C2
C3.
B3.
V3.
Y3.
C (LOW)
F2
C (HIGH)
C1
B1
H
LIFT
E2.
D
ROTY
INT
CONTS.
F3.
K2
M
RLSE.
Y2
Y
E
F
B2
F1
Y1
V2
A2.
MF
B
A
E1
K1
V1
A1
V

FIGURE 11.

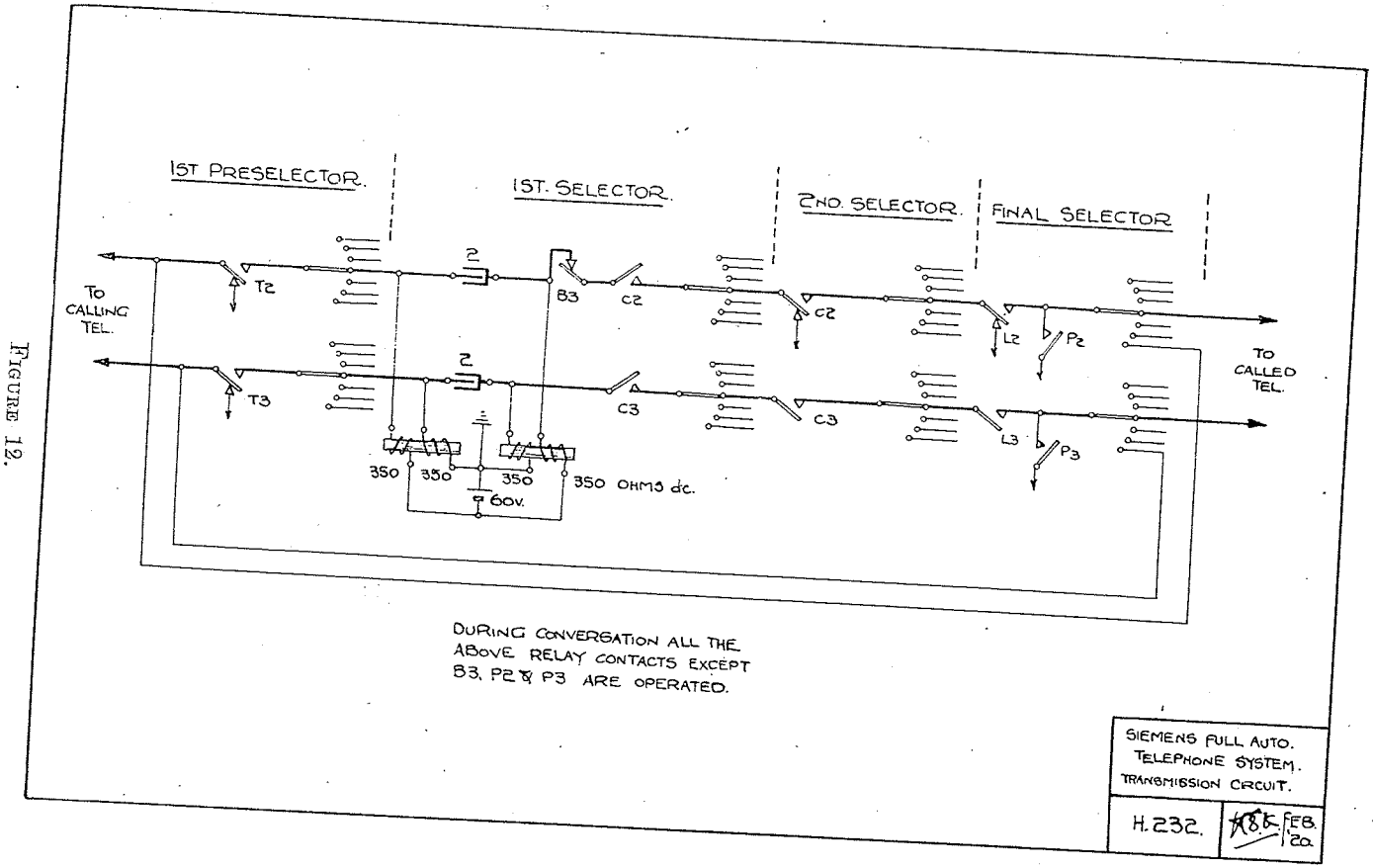

1ST PRESELECTOR.
1ST. SELECTOR.
2ND. SELECTOR.
FINAL SELECTOR
TO CALLING TEL.
T2
T3
2
2
B3
C2
C3
C2
C3
L2
L3
P2
P3
TO CALLED TEL.
350
350
350
350 OHMS dc.
60V.
DURING CONVERSATION ALL THE ABOVE RELAY CONTACTS EXCEPT B3, P2 & P3 ARE OPERATED.
SIEMENS FULL AUTO. TELEPHONE SYSTEM. TRANSMISSION CIRCUIT.
H.232.
A.S.C. FEB. 20

FIGURE 12.

The second selector, in releasing, will in turn release the final selector. The opening of the circuit through the called subscriber's cut-off relay then follows and the loop from that subscriber will cause a disengaged first selector to be taken into use. The called subscriber can then proceed to dial up a number in the ordinary manner.

A study of the impulse repeating circuit will show that if a calling subscriber removes his receiver from the hook and then replaces it without operating the telephone dial, the first selector wipers will remain at normal and not step up one, and momentarily take into use a trunk leading from the first level of the first selector. Intermittent "P.G." troubles and the accidental operation of telephone switch-hooks or exchange line keys on cordless private branch exchanges therefore will not bring into operation any switches other than first pre-selectors and first selectors.

Figure 12 shows the transmission circuit of a local automatic connexion of a four-figure system. All relay contacts shown thereon are depicted in their normal mechanical position.

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