wires are closed through the impulsing springs of the dial. The purpose in short-circuiting the receiver and transmitter is twofold: first, to prevent objectionable clicks in the receiver due to the succession of breaks in the telephone loop; and second, to prevent any variation in the resistance of the transmitter from affecting the resistance of the impulsing loop. The voltage induced in the circuit by the breaks and makes at the impulsing springs was of the order of 900—1,000 volts, necessitating the maintenance of a high standard of insulation resistance on the subscribers' lines and apparatus.

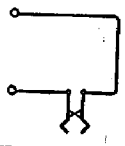

FIG. 14. IMPULSING CIRCUIT, 1913

On account of the difficulty in maintaining the somewhat critical adjustment of the shunt spring and its associated impulse spring, the shunt spring group was separated from the impulsing springs and each group was made up in a separate spring assembly. The mechanical operation of the shunt springs remained unaltered. This revision was made in 1918, when the circuit shown in Figs. 13 and 14 was used.

In 1922, the dial was re-designed and with the exception of the shunt spring assembly was the same as the standard dial introduced in 1924. The corresponding telephone circuit is shown in Fig. 15, from which it will be seen that the use of an

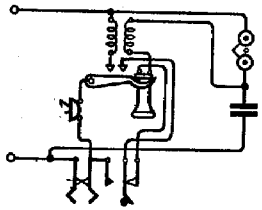

FIG. 15. SUBSCRIBER'S TELEPHONE CIRCUIT, 1922

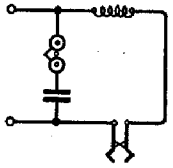

FIG. 16. IMPULSING CIRCUIT, 1922

induction coil provides for standard speech transmission. The 2μF condenser and magneto bell, together with one winding of the induction coil, are connected across the impulsing springs when the finger-plate is moved away from its normal position (Fig. 16). This portion of the circuit functions similarly to a spark quench circuit with the result that the voltage induced in the circuit during dialling is of the order of 400 volts. The magneto bell, however, tinkles in response to charge and discharge of the condenser and it is necessary to fit a bias spring to the bell hammer to overcome this.

Standard Telephone Circuit. The present standard circuit for subscribers' telephones is shown in Fig. 17, and the corresponding impulsing circuit in Fig. 18. The shunt spring assembly consists of four springs in place of the three used in the 1922 circuit. When the finger-plate is away from its normal position, i.e. "off-normal," the 1,000Ω coils of the magneto bell are shunted by the two windings of the induction coil; bell tinkling is consequently eliminated and the use of a bias spring made unnecessary. The impulsing springs are shunted by the 2μF condenser in series with the 26Ω winding of the induction coil, and this arrangement serves to prevent the voltage induced during dialling from rising above 200 volts; the arrangement functions similarly to a spark quench circuit. A three-way cord serves to connect the table telephone and the bell-set when the circuit is used for a telephone of this type.

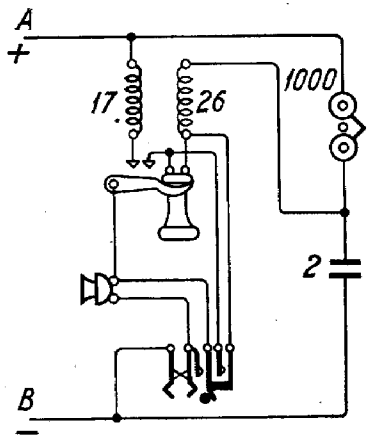

FIG. 17. FUNDAMENTAL CONNEXIONS OF SUBSTATION TELEPHONE

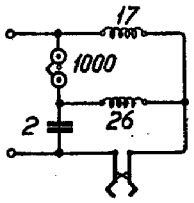

FIG. 18. IMPULSING CIRCUIT

Dial, Auto, No. 10. The present standard dial for use on subscribers' telephones connected to automatic exchanges of all types is known as Dial, Auto, No. 10.

The dial is defined as "a calling device arranged in the form of a rotatable disc for controlling automatic selectors or switches for the purpose of establishing a connexion." (1) The dial consists of a circular, rotatable, metal finger-plate, having

ten circular finger holes punched in it, rigidly fixed to a central spindle. The finger holes are equally-spaced round two-thirds of the outer annular ring of the plate (Fig. 19). The number ring, of white vitreous enamel on copper, is fixed to the case behind the finger plate in such a position that when this plate

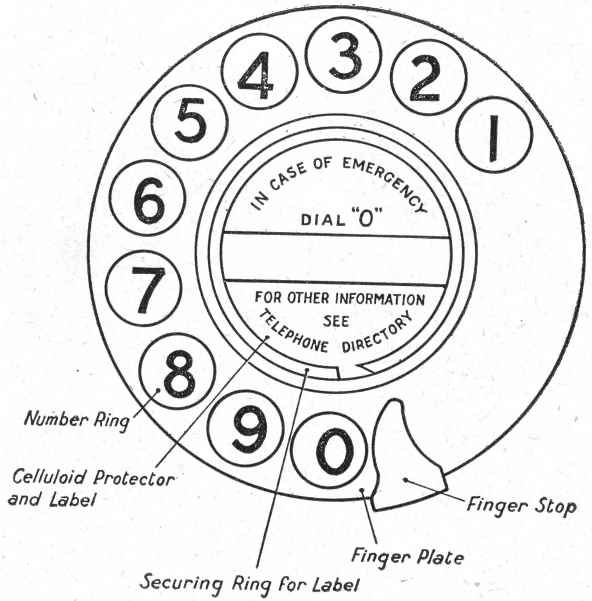

FIG. 19. FRONT VIEW OF DIAL

is in the normal position, the digits 1, 2, 3 . . . 0 are exposed through the finger holes. The figures are enamelled in black. Bent over the finger plate in a position adjacent to the digit 0 is a fixed finger stop. The central portion of the finger-plate accommodates a label giving instructions in the use of the dial, and bearing the telephone number of the instrument with which the dial is associated. The label is protected by a transparent disc, and both are held in position by a spring securing ring.

The dial has an overall diameter $3\frac{1}{8}$ in. and an overall depth of $1\frac{1}{8}$ in. There are no exposed screw heads to invite tampering by the subscriber or other unauthorized person. The diameter of the finger holes and the distance between the finger-plate and the number ring are so arranged that, whilst there is no difficulty in seeing the numerals and, for dials used in Director areas, the letters, the finger only enters the hole sufficiently far

to ensure easy dialling, and does not rub against the number ring behind. The normal finish of the finger-plate is either black enamel or stainless steel.

A photograph showing some of the various types of dial supplied to various administrations is reproduced in Fig. 20.

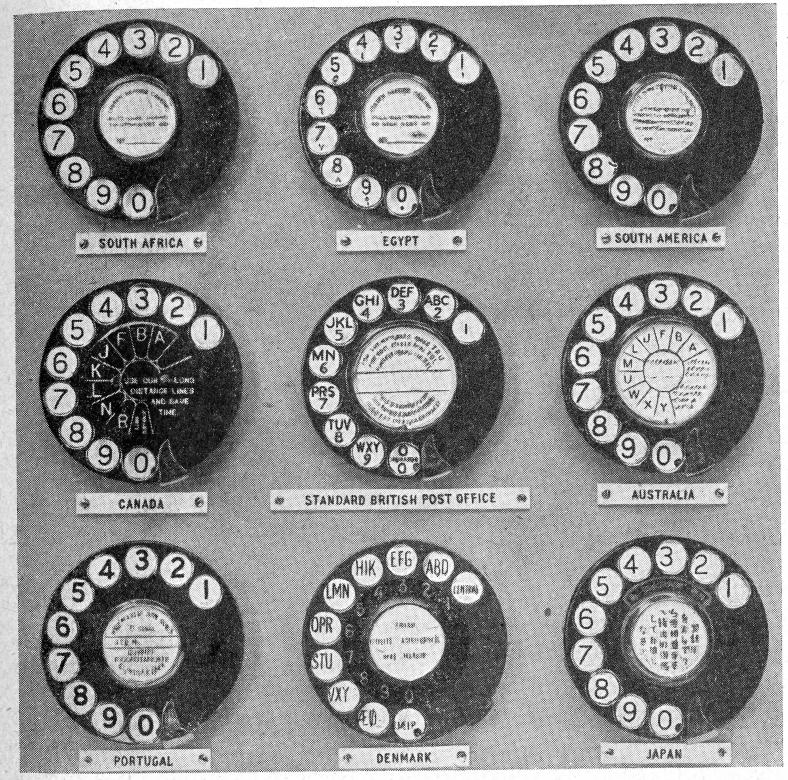

FIG. 20. SOME DIALS USED BY VARIOUS ADMINISTRATIONS

Siemens

Fig. 21 is a view of the front of the dial with the finger-plate and number ring removed. The main spring box, containing a flat clock spring, is fixed to the case, and one end of the main spring is secured to the box, whilst the other end is fixed to the central spindle. The stop screw serves to keep the spring in a partially-wound condition, and also to stop the rotation of the finger-plate and mechanism on their return to the normal

position. The main gear wheel is securely fixed to the central spindle and drives the governor gear, which is of the worm and worm wheel type so as to provide adequate speed control. A small helical spring is contained in the governor gear and forms the coupling between the small gear wheel and the worm wheel.

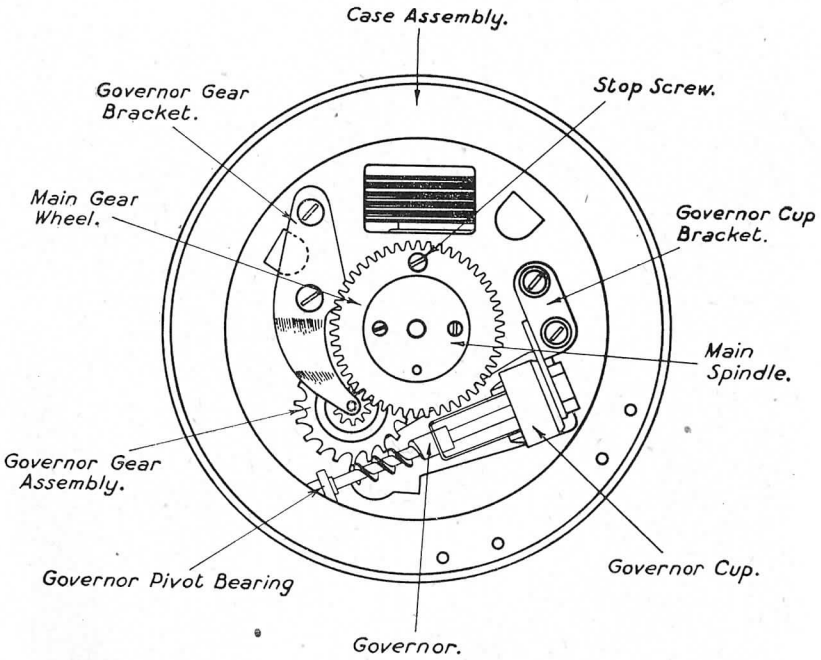

FIG. 21. FRONT VIEW OF DIAL, WITH FINGER PLATE REMOVED

The governor consists of two wings, each having a small weight at the free end. The weights are arranged to rub over the inner surface of the governor cup when they move outwards under influence of the centrifugal force set up by rotation. The friction so generated serves to limit the speed of the governor, and consequently the speed at which the mechanism of the dial rotates.

A view of the rear of the dial mechanism is given in Fig. 22. The impulse wheel is rigidly fixed to the central spindle and has ten slots in its periphery spaced at the same angular intervals as the holes in the finger-plate. The switching lever is fixed to the central spindle, and between it and the impulse wheel a slipping cam and assembly of washers are loosely fixed on the

spindle, as shown in Fig. 23. The spring-set consists of two groups of contact springs, the impulsing springs and the switching or shunt springs. In the normal position of the dial, the shunt springs are held apart by the switching lever, and the impulse springs are held closed by the impulsing lever which

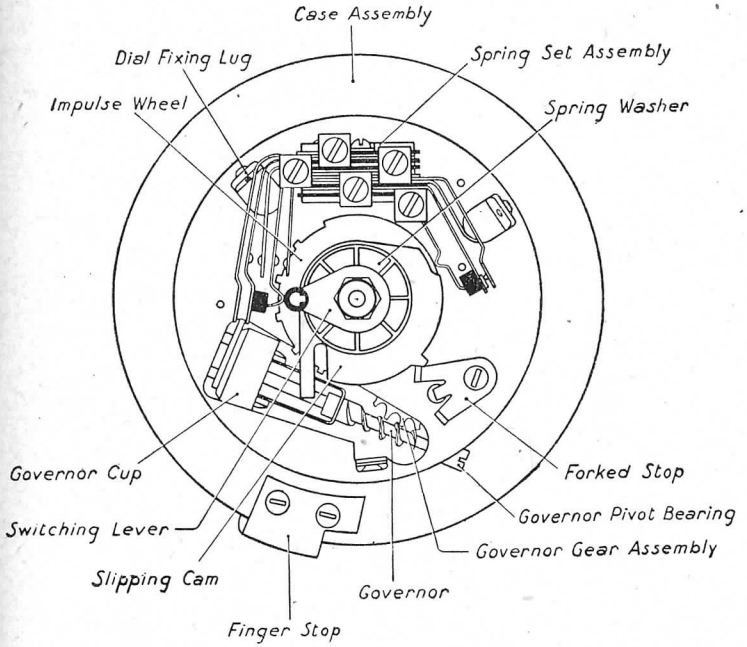

FIG. 22. REAR VIEW OF DIAL

rides on the outer edge of the impulse wheel. The connexions of the telephone circuit with the dial in this condition are shown diagrammatically in Fig. 17.

When the finger-plate is moved away from its normal position, the switching lever moves away from the shunt springs, so allowing the two pairs of springs to make contact; the telephone circuit is thereby changed to the condition shown in Fig. 18. As the finger-plate moves round, the helical spring in the governor gear tends to unwind and prevents excessive rotation of the governor worm, which would otherwise drive the governor and retard the movement of the finger-plate. The slipping cam is held to the impulse wheel by the pressure of the spring washer, and rotates until the projection on the cam

strikes the forked stop. Further rotation of the cam is now prevented, and the continued rotation of the finger-plate causes the rotation of the main gear wheel, impulse wheel, and

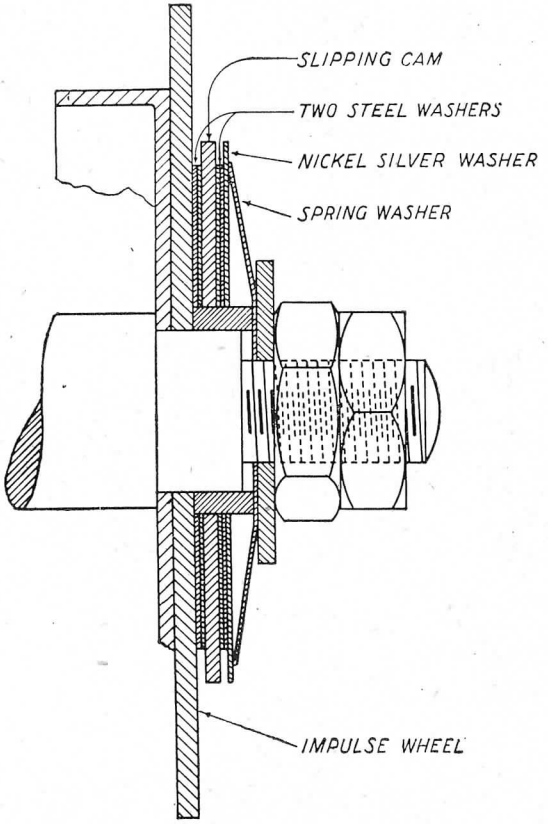

FIG. 23. ARRANGEMENT OF SLIPPING CAM AND WASHERS

switching lever only. When the clockwise rotation of the finger-plate is completed, the number of slots in the impulse wheel corresponding to the digit dialled have been exposed by rotation past the impulsing recess in the slipping cam. As the impulse lever rides on the periphery of the slipping cam, it is not affected by this movement of the impulse wheel, which takes place during the process of setting up a digit prior to its transmission.

Fig. 24 shows the state of the dial mechanism at the time

immediately prior to the removal of the finger from the finger-plate during the dialling of the digit 1. The governor has been omitted from the figure to simplify the drawing. Upon the removal of the finger the finger-plate, main gear wheel, impulse wheel, and switching lever return to normal, driven by the main spring. The slipping cam also rotates due to the pressure

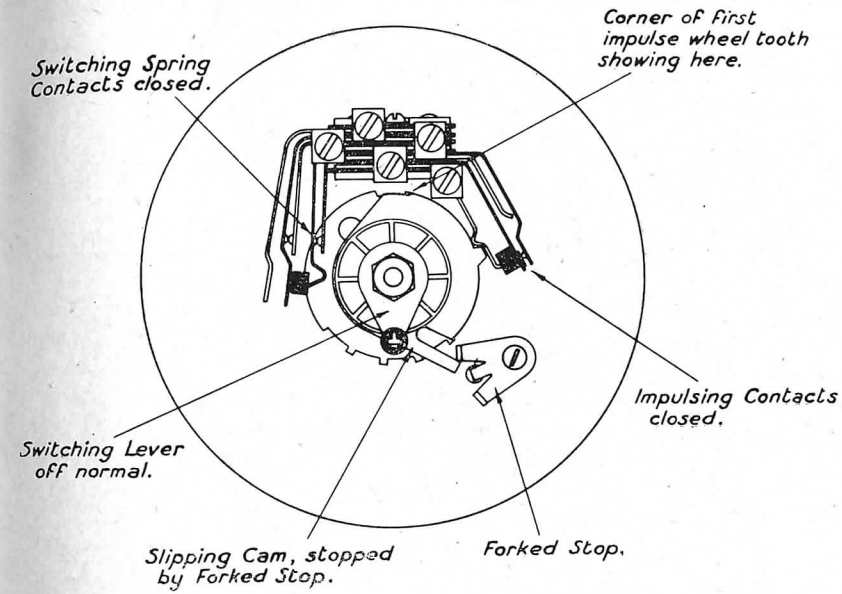

FIG. 24. DIAL MECHANISM IMMEDIATELY PRIOR TO REMOVAL OF FINGER ON DIALLING 1

exerted by the spring washer which clamps it to the impulse wheel. The helical spring in the governor gear now tends to wind up, thereby causing the governor to rotate at its maximum speed; the speed at which the dial mechanism returns to normal is so maintained constant. The impulse lever rides on the edge of the slipping cam until the small projection on the cam strikes the forked stop. The slipping cam is now in its normal position and the slots in the impulse wheel are exposed beneath the impulse lever, in the impulsing recess of the slipping cam. The lever now falls down into the first slot, so permitting the moving spring of the impulsing springs to break contact with the fixed spring. This position is shown in Fig. 25. The continued rotation of the impulse wheel causes the impulsing

contacts to be broken and made the number of times corresponding to the digit dialled, which, in the condition shown in Fig. 25, is the digit 1.

When the impulsing contacts close at the end of the last break period, the switching lever opens the switching springs as the finger-plate comes to rest against the stop screw. The helical spring in the governor gear now unwinds and allows the

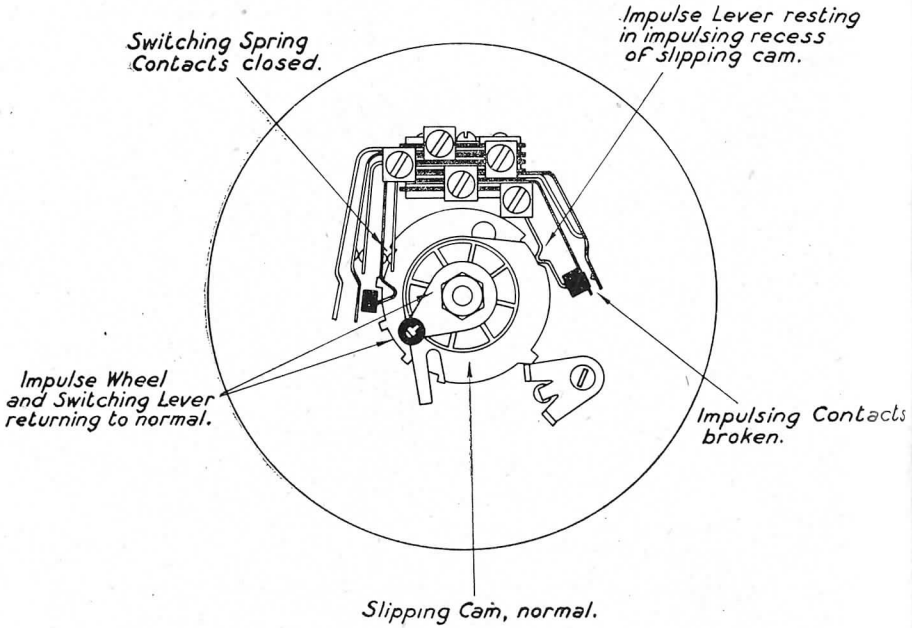

FIG. 25. COMMENCEMENT OF BREAK PERIOD AFTER DIALLING 1

governor to over-run slightly, so preventing any shock to the governor mechanism which would otherwise be given by the abrupt stop.

Lost Motion Period. From the foregoing description, it will be seen that a short period elapses between the removal of the finger from the finger-plate and the commencement of the break period of the first impulse, during which the slots on the impulse wheel are masked from the impulsing lever by the slipping cam. The purpose of this is to ensure that there shall be a short space of time, independent of any personal pause on the part of the person manipulating the dial, between the dialling of successive digits during which the selectors in the exchange are able to

perform any automatic actions which are not controlled by the dial and which have to be performed either before the reception of the first digit or during the interval between successive digits. This period is nominally 250 milliseconds (mS), and is known as the "lost motion period" or the minimum pause.

Standard Impulse. The standard impulse consists of a break period of $66\frac{2}{3}$ per cent, and a make period of $33\frac{1}{3}$ per cent. The

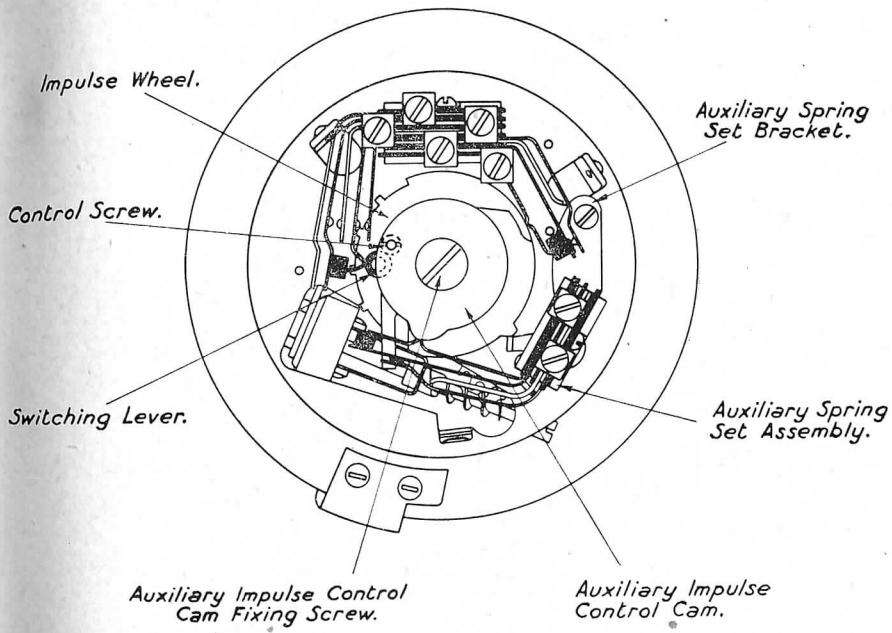

FIG. 26. DIAL, AUTO, NO. 11, SHOWING AUXILIARY SPRING-SET AND CONTROL CAM

standard impulse frequency is 10 impulses per second; thus, the duration of the break period is $66\frac{2}{3}$ mS, and that of the make period is $33\frac{1}{3}$ mS. These figures are usually rounded up and down to 67 mS and 33 mS, respectively. The permissible variation in impulse frequency is 9 to 11 impulses per second.

Dial, Auto, No. 11. The standard arrangement for call offices connected to automatic exchanges is the provision of prepayment multi-coin boxes. This device provides for the deposit of the fee before the call can be made, but in cases of emergency it is essential that the call office telephone shall be available to the public without the preliminary insertion of a fee. For a call

to an operator at the auto-manual switchboard associated with the automatic exchange, callers are instructed to dial the single digit 0. The dial used with the telephone is modified so that connexion can be made in such circumstances without the insertion of a prepaid fee. The nature of the circuit arrangements providing this facility is described on page 62, and an essential

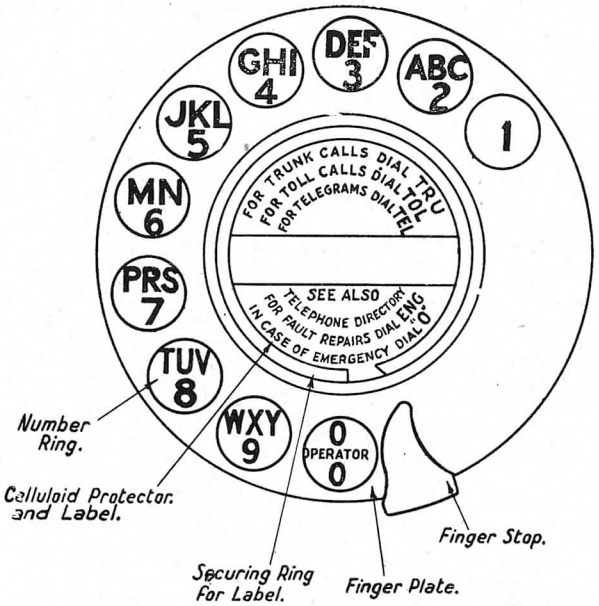

FIG. 27. DIAL USED IN DIRECTOR AREAS

feature is the additional spring-set provided in the dial as shown in Fig. 26. This dial is known as the Dial, Auto, No. 11, and consists of a No. 10 dial provided with an auxiliary impulse control cam fixed loosely to the spindle, and a control screw projecting from the auxiliary cam into the path of the switching lever. When the digit 0 is dialled, the switching lever moves round anti-clockwise as seen in Fig. 26 and on the last portion of the movement engages with the control screw, so forcing the auxiliary cam from engagement with the auxiliary spring-set. The springs change over and remain in this position until the finger-plate returns to its normal position, when the switching lever again engages with the control screw and forces the cam on to the operating lever of the auxiliary spring-set. The springs are thus opened during the whole of the period

during which the impulsing springs are being opened and closed by the teeth on the impulse wheel. The control screw is so placed that the action only occurs when the digit 0 is dialled. In some cases, the action may be required when the digits 8 or 9 are the first to be dialled; in this event, two control screws are used, the second being spaced so that the switching lever engages with it just prior to the completion of the movement when the digit 8 or 9 is dialled.

Lettered Dial. In Director areas, the dial number ring is engraved with letters as well as numerals; the reason for this provision will be apparent from Chapter VIII. Fig. 27 shows a front view of the dial used in such areas; the letters are engraved in black and the figures in red. Apart from the different instruction label in the centre of the dial, the instrument is the same as that described on page 39 *et seq.*

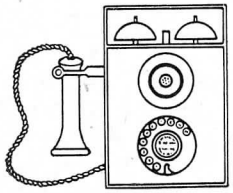

FIG. 28. TELEPHONE No. 121

Wall Instrument. The standard wall telephone is the Telephone No. 121, illustrated in Fig. 28. With the spread of the automatic system, it is desirable that the telephones used on automatic and C.B. manual systems should be interchangeable, and this telephone is the Telephone No. 121 C.B. with the

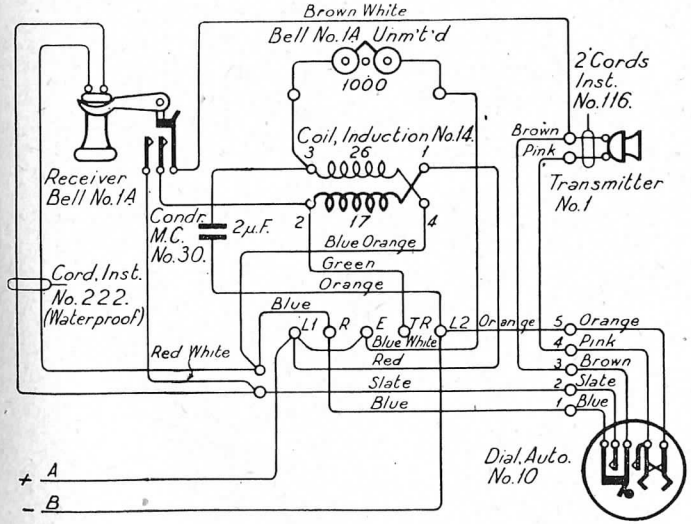

FIG. 29. WIRING DIAGRAM OF TELEPHONE No. 121

addition of a dial in place of the dial dummy used in the C.B. instrument. The dial is connected to terminals 1, 2, 3, 4, and 5; in the C.B. instrument, terminals 4 and 5 are strapped. It

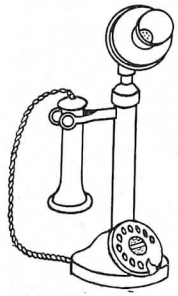

FIG. 30. TELEPHONE NO. 150

is thus a simple matter to convert a telephone from C.B. to automatic working. The wiring diagram of the instrument is given in Fig. 29.

Table Instruments. The standard table telephone is the Telephone No. 150. Here, also, the instrument is the same as

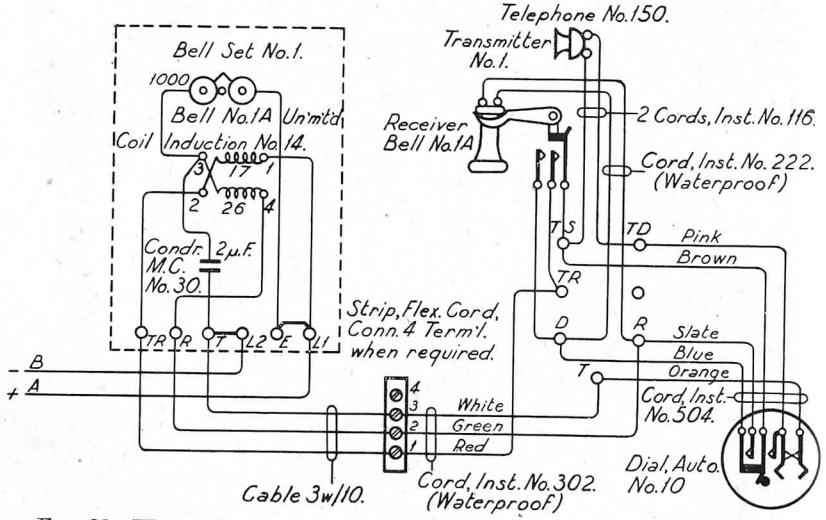

FIG. 31. WIRING DIAGRAM OF TELEPHONE NO. 150 AND BELL SET NO. 1

that used in C.B. systems with the addition of a dial. It is illustrated in Fig. 30 and a diagram of the connexions is given in Fig. 31. The dial is connected to terminals *TS*, *TD*, *D*, *R*, and *T*. A Bell Set No. 1 completes the installation.

Microtelephone Set. This instrument, Telephone No. 162, is the same as that described in Vol. I, except for the addition of a dial. Fig. 32 shows its appearance, whilst Fig. 33 is a wiring

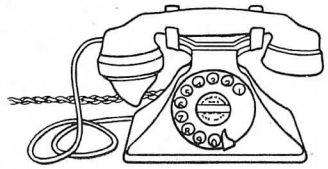

FIG. 32. TELEPHONE NO. 162

diagram of the telephone, which is used with a Bell Set No. 1 The dial is connected to terminals *T*, 1, 2, and 3.

Fundamental Circuits. In each of the above instruments, the fundamental connexions are those shown in Fig. 17 whilst the connexions during dialling are shown in Fig. 18.

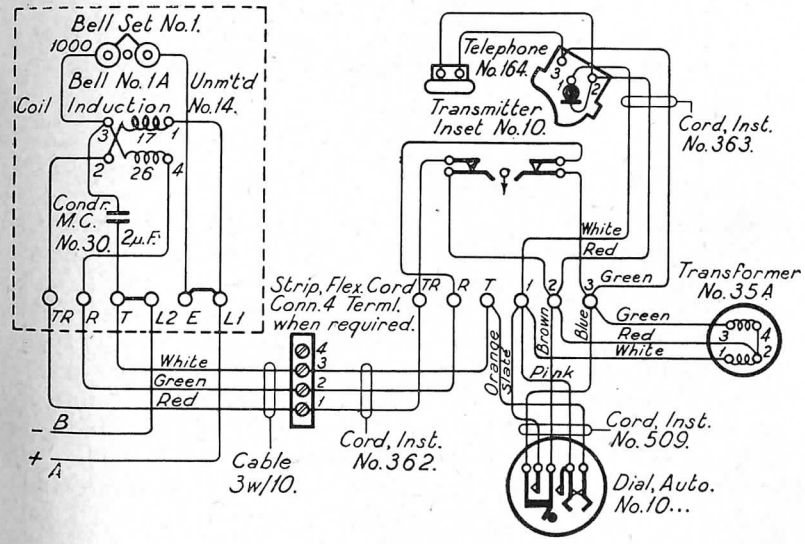

FIG. 33. WIRING DIAGRAM OF TELEPHONE NO. 162 AND BELL SET NO. 1

EXTENSION WORKING

To meet the varying requirements of subscribers requiring extension facilities, the Post Office has standardized various arrangements of apparatus which cater for the majority of cases encountered. These arrangements are known by a Plan No.

and, in general, they are applicable to all telephone systems. Details of the arrangements and the facilities provided by the various Plan Nos., will be found in Vol. I, page 313.

The following pages deal with those Plan Nos. which are most commonly used, and the arrangements required for automatic telephone systems are described.

Extension Plan No. 1. This provides for the connexion of one or two instruments as extensions from a main telephone on which all incoming calls are received. The extension stations

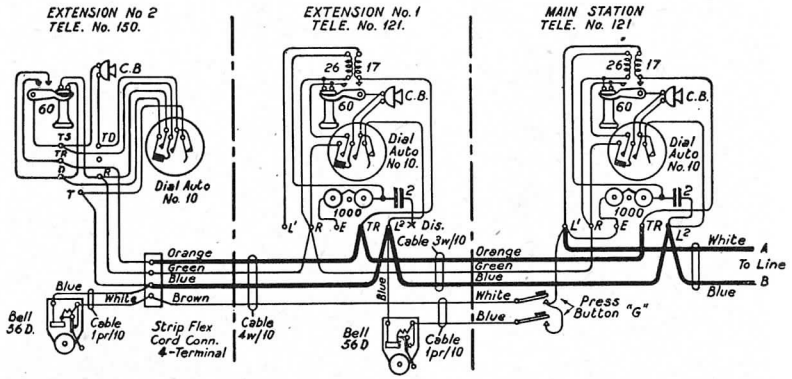

FIG. 34. EXTENSION PLAN NO. 1—WIRING DIAGRAM

are called by trembler bell actuated by means of press buttons at the main station. In Fig. 34, which is a wiring diagram of an arrangement providing for two extension stations, a wall telephone is shown at the main and one of the extension points and a table telephone at the other extension station. Any type of automatic telephone can, of course, be used at any point on the installation. The operation of a press button connects the associated trembler bell across the *A* and *B* wires, and the bell operates from the central battery at the exchange. The bells used (Bell No. 56D) have coils of 100 ohms resistance and the contacts are shunted by a non-inductive resistance of 1,200 ohms. The purpose of this is to provide a shunt path for the e.m.f. induced in the coil during the operation of the bell, so preventing the fluctuations in the line current from being sufficiently great to be audible to the calling subscriber.

Where a table instrument is used as an extension telephone, the induction coil at the main station is used during conversation.

The apparatus required for the installation shown in the diagram is—

Main Set. Telephone No. 121. Two press buttons *G*.
Extension 1. Telephone No. 121. (Bell disconnected.) Bell No. 56D.
Extension 2. Telephone No. 150. Bell No. 56D.

Extension Plan No. 3. It is often desired that an extension station may speak without the possibility of the conversation being overheard at the main set located, say, in the general

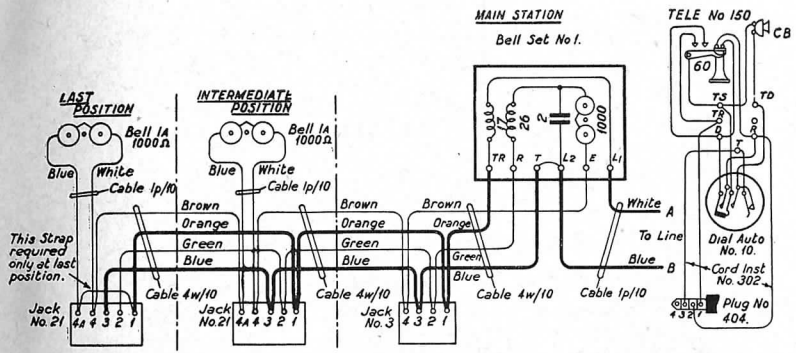

FIG. 35. EXTENSION PLAN NO. 4—WIRING DIAGRAM

office. The principle of the arrangement consists in placing both telephones in parallel on the exchange line through a six-point, two-position switch, which, when moved to the secrecy position, cuts off the main instrument. Both instruments are provided with their own induction coil and condenser, and, since failure to restore the secrecy switch prevents calls from being received at the main set, the switch connects the magneto bell in the extension telephone when operated, so that incoming calls will be received on this instrument until the switch is restored.

Extension Plan No. 4. To avoid the use of extension circuits and switches, a table telephone is connected to a plug, and jacks are fitted in the various rooms where it is required to use the telephone (e.g. dining-room, study, and bedroom). A bell-set and a jack are fitted in the position to be most used, and a magneto bell in each of the other positions. The magneto bells are, however, short-circuited until the plug is inserted. If the main bell, which is permanently in circuit, is audible from an

extension point, there is no need to provide a magneto bell at the extension. The telephone may thus be carried to and connected in whichever of the rooms the convenience of the moment dictates. The wiring diagram for a typical installation is shown in Fig. 35. With the plug in one of the extension jacks,

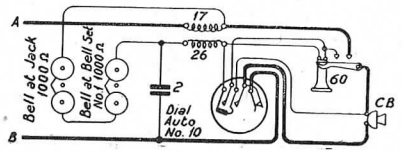

FIG. 36. CONNEXIONS MADE BY PLUG IN INTERMEDIATE OR LAST JACK

the connexions are as shown in Fig. 36.

The apparatus required is—

Main Point.	Telephone No. 150, Bell Set No. 1, Jack No. 3 Plug No. 404.
Extension Point.	Jack No. 21, Bell No. 1A (if the bell at the main is inaudible from the extension point).

Extension Plan No. 7. The arrangements so far described do not provide for intercommunication between extensions and, where this facility is required, recourse must be had to switchboards. It is, however, possible to provide intercommunication between the main telephone and one extension by the aid of a Bell Set No. 20 (Fig. 37). The conditions which the arrangement must fulfil are—

(i) Main set connected to exchange.
Extension connected to extension bell at the main set.

(ii) Main set connected to extension.
Exchange line connected to extension bell at main set.

(iii) Main set connected to extension.
Exchange line held.

(iv) Exchange line connected through to extension line.

These conditions are effected by the four positions of the switch in the Bell Set No. 20, and are shown in skeleton in Fig. 38. The bell-set consists of a 4-position switch, an indicator-relay (Relay No. 257A with coils of 50 Ω resistance), a Generator No. 4C, a Bell No. 1A, a 2μF condenser, and a 1μF condenser. A two-cell battery is provided to furnish speaking current on calls between main and extension.

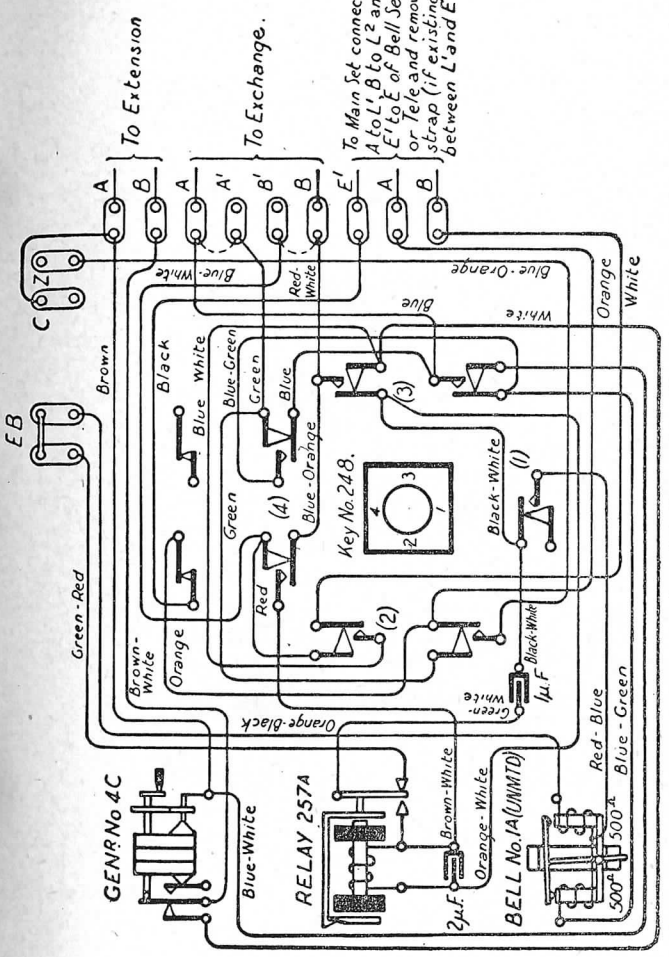

FIG. 37. BELL SET No. 20

Position of Pointer.	Groups of Springs Actuated.
1	All normal
2	2 and 3
3	1, 2, and 3
4	4

The indicator-relay is shunted by a 2μF condenser, and the magneto bell in the main telephone is disconnected by a contact of the indicator-relay when the switch is in the through position. By these means, a circuit clear of any bridged apparatus is provided, with the result that the bell-set does not introduce any appreciable distortion of dialled impulses.

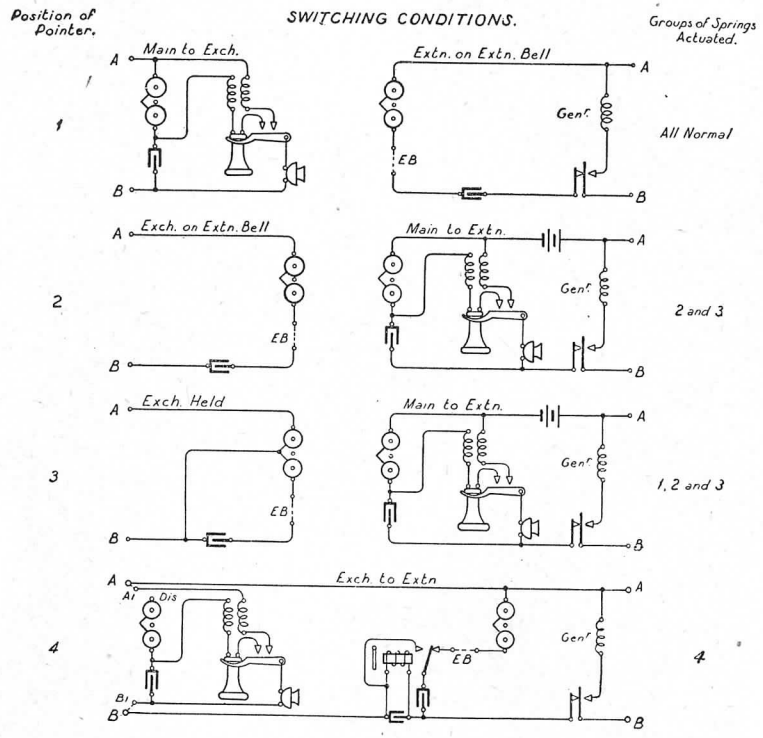

FIG. 38. CONNEXIONS MADE BY 4-POSITION SWITCH

The generator used at the extension instrument for calling the main is connected in series with a 2μF condenser, the combination being known as a Generator No. 4CP. The necessity for the condenser arises from the fact that should the generator handle be turned when the switch is in the through position, the indicator-relay would be operated by the current flowing round the loop provided by the armature of the generator when brought into circuit by the operation of the cut-out springs, whereas it is necessary that this relay should be released in

order to connect the magneto bell at the main for the reception of the ring from the extension.

The indicator-relay is of the pendent armature type and is provided with a copper sleeve on the core. The armature actuates a single change-over spring-set and an indicator attachment, consisting of a balanced aluminium lever which moves an aluminium flag into position behind a rectangular window. The indicator-relay was designed by Messrs. Siemens Bros. to meet the following conditions (2)—

1. The relay contacts shall not break when an extension is rung from the exchange over a line of zero loop resistance with maximum generator E.M.F. and lowest resistance ringing circuit in use.
2. The signal shall operate with the current over a line of maximum loop resistance with a minimum P.D. on the main exchange battery.
3. Having operated as in (2) above, the relay shall retain during dialling at minimum speed, i.e. the bell in the bell-set shall not tinkle.
4. When disconnected the relay shall release after operation, as in (2) or (3), on a line of 10 Ω loop resistance and with maximum P.D. on the main exchange battery.
5. The relay contacts shall not break when the extension station rings the main by hand generator in series with a condenser, the switch being in the through position.

Since the magneto bell at the main station is disconnected when the switch is in the through position, it is necessary that any extension bell required at the main station shall be connected in series with the magneto bell of the bell-set. Terminals are provided to enable this to be done.

The switch pointer on the bell-set normally remains at Position 1, and a ring from the exchange is received on the bell of the main telephone. The extension is connected to the magneto bell of the bell-set, so providing for the receipt of a call from the extension telephone. The generator fitted in the bell-set is provided for calling the extension instrument.

In Position 2, springs 2 and 3 are operated. The exchange line is now connected to the magneto bell in the bell-set and the main telephone is connected to the extension line; a 2-cell primary battery is included in the circuit to provide current for speaking. Calling in both directions is by generator, and a call from the exchange is received on the magneto bell of the bell-set.

In Position 3, springs 1, 2 and 3 are operated. One coil of the magneto bell is connected across the exchange line to provide for the retention of the loop while the main telephone is connected to the extension line. The necessity for this condition arises when the main telephone receives an inquiry which necessitates consultation with the extension before replying.

In Position 4, springs 4 only are operated. The extension instrument is connected directly to the exchange line, but the Relay 257*A* is inserted in series with the *B*-wire. At the conclusion of the conversation, when the extension telephone receiver is replaced, the circuit is disconnected and the indicator, which has been operated while the call was in progress, falls back to normal. This is known as a negative clearing signal to distinguish it from a positive clear, which may be defined as a signal which is operated to give the clearing indication. Failure to restore the switch to normal involves the receipt of any subsequent ring from the exchange on the bell-set and also on the bell at the extension.

The Bell Set No. 20 provides for both secrecy and non-secret conditions. With Plan No. 7, the conditions are non-secret and terminals *A* and *A*1, and *B* and *B*1 are connected by straps; this connects the main station telephone across the line when the extension is connected through to the exchange (*vide* Fig. 37). Plan No. 7A provides for secrecy, and the two straps are omitted to provide this condition.

Extension Bells and Buzzers. In all the telephones illustrated, an extension bell can be connected in series or in parallel with the magneto bell of the telephone by removing a strap between two terminal connexion plates in the circuit of the magneto bell and connecting the extension bell thereto; these connexion plates are usually marked EB1 and EB2. Loud sounding bells are often required in yards and workshops; in such circumstances, an indicator (No. 3701 AN) is connected in place of the extension bell, and the local contact of this indicator is included in the circuit of a Bell No. 19A, which has a 12-in. gong and requires a 5-cell primary battery. When the calling signal is required in situations where the sound of the bell is masked by the noise of running machinery, as in factories and power-houses, a motor-car type hooter is employed; when an electric power supply is available, the electric horn, Buzzer No. 19B, is worked from a battery of five small secondary cells which are kept charged by a current of from 20 to 30 mA

supplied from the power mains through suitable resistance lamps. In other circumstances, Buzzer No. 19A is used, and is driven from a battery of two small secondary cells which are kept charged by a battery of five WK1 Leclanché cells connected to them through a resistance of 100 Ω.

When the extension bell is not required to ring continuously

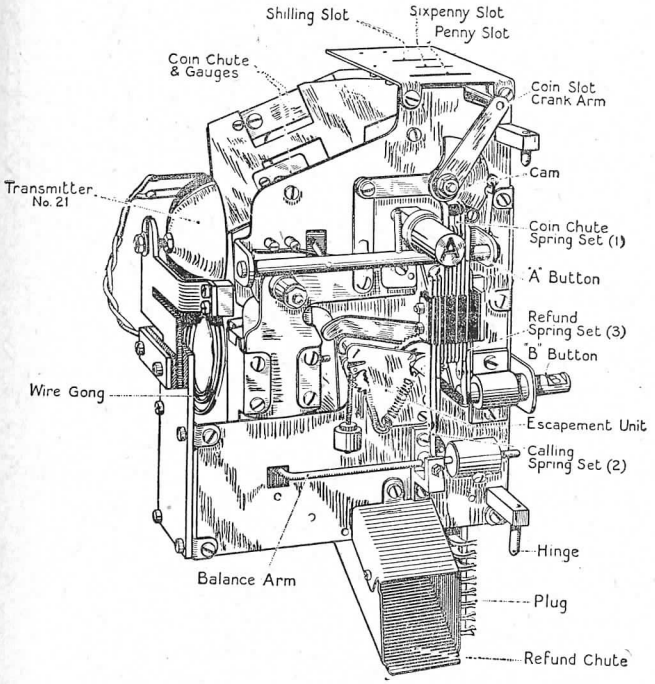

FIG. 39. PREPAYMENT COIN BOX MECHANISM

from the receipt of a call until attention is given at the telephone, a relay 56*A* (1,900 Ω) is connected in place of the indicator. The extension bell is operated by the relay contacts and, as the relay responds to the ringing currents and then restores to normal, the extension bell rings in synchronism with the rings received on the magneto bell at the main telephone. Such extension bells are termed non-continuous ringing bells.

CALL OFFICES

Prepayment Call Offices. The standard arrangement for a call office in an automatic exchange area is the provision of a