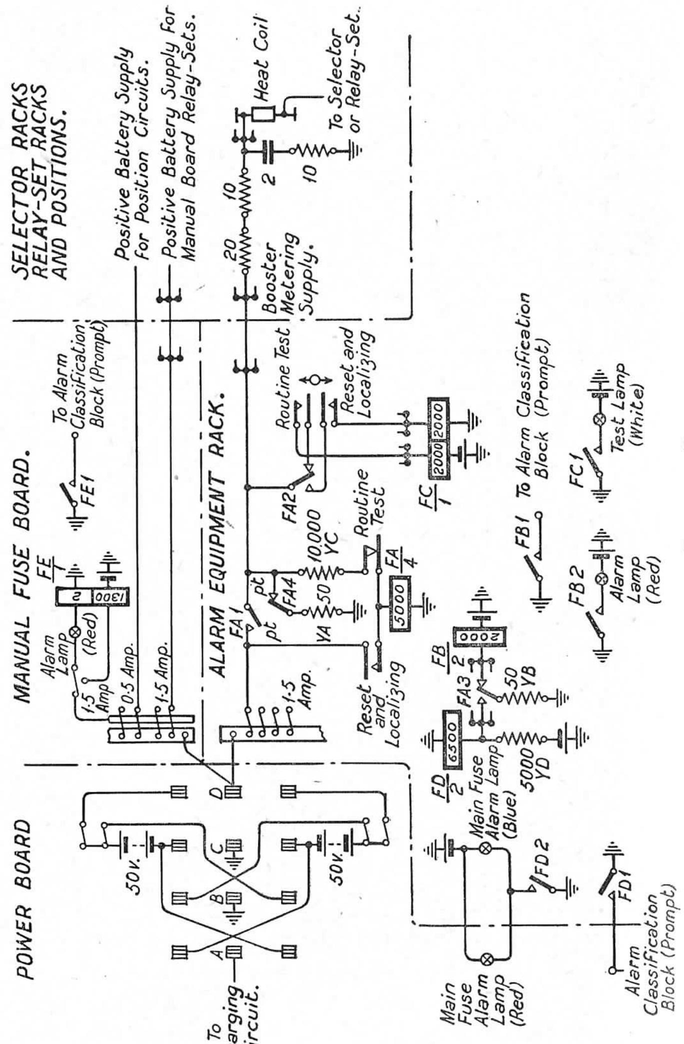

Fig. 130. Positive Battery Distribution

however, it is necessary to provide alarm conditions should a fuse serving the automatic apparatus blow, and at the same time the supply lead served by the blown fuse must be connected to earth to prevent the release of any connexions which may be connected to the metering supply during the time that the fuse is blown. Relay *FA* is normally operated through the 10,000 Ω spool and **FA1** to the positive battery through the fuse. When the fuse blows, relay *FA* releases; *FA*4 connects earth to the positive booster battery supply lead; *FA*3 removes the short-circuit from relay *FD* and operates relay *FB*; *FA*2 disconnects the localizing key. The circuit of the prompt alarm is closed and the fuse alarm lamps on the fuse panel and the power board, together with the main fuse alarm lamp (blue) glow.

Ringing Machines. The ringing current is furnished by a motor-driven generator or dynamotor. Two machines are provided, one driven from the public electricity supply mains and the other from the exchange battery, so that in the event of failure of the power supply the battery ringing machine may be brought into use; to minimize any possibility of delay, the change-over from the power-driven machine to the battery-driven machine is accomplished automatically.

The connexions of a typical battery-driven machine are shown in Fig. 131. In addition to the slip rings, the machine carries a series of commutators, which are used to provide—

(i) a tone of 400 p.p.s.;
(ii) a tone of 133 p.p.s.; and
(iii) a tone of 33·3 p.p.s.

A set of interrupters is driven by reduction gearing from the main shaft of the ringing machine. Each interrupter consists of a cam and associated spring set. The cams revolve once in 3 seconds. The first three sets of interrupters are used for providing interrupted ringing current; the alternating current of 17 p.p.s. is connected for 0·4 second, the ringing lead is earthed for 0·2 second, ringing current is again connected for 0·4 second, and, finally, the lead is earthed for 2·0 seconds. This cycle of operations occurs in sequence, being displaced 1 second at each cam. The actual load on the ringing machine at one time is therefore only one-third of the total load on the exchange. The fourth spring set is associated with the busy back and is operated for 0·75 second and normal for the same period. The fifth spring set is only supplied on exchanges equipped with a motor start circuit, i.e. where the ringing machines are not run continuously; it is operated for 0·4 second and normal for 2·6 seconds. The sixth spring set supplies interrupted earth at busy speed, i.e. 0·75 second on, 0·75 second off.

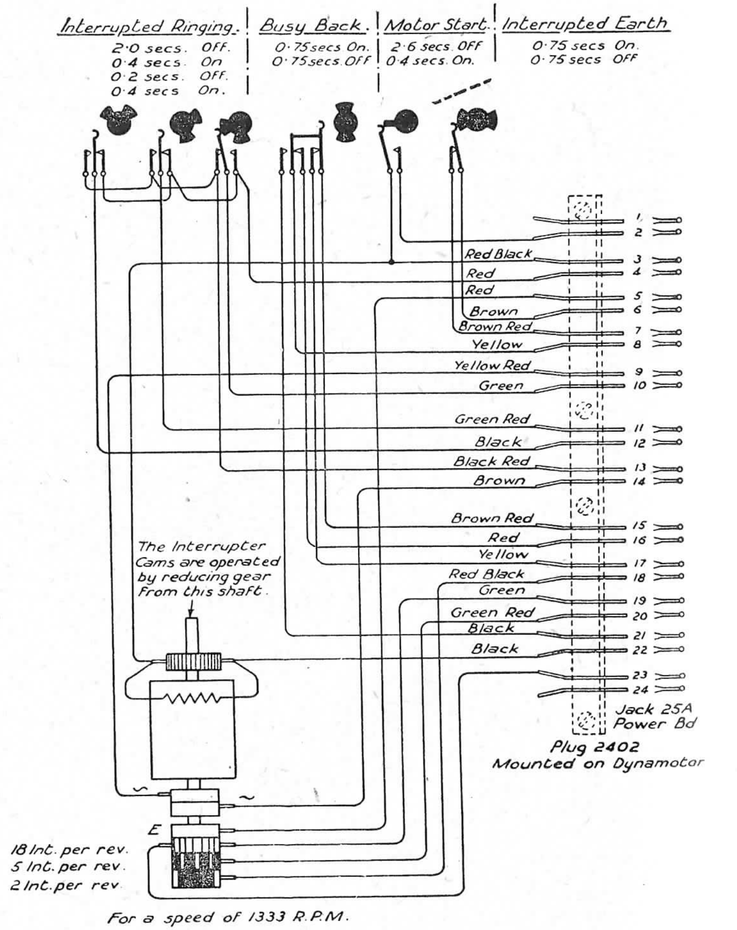

FIG. 131. WIRING OF TYPICAL RINGING DYNAMOTOR

Ringing and Tone Distribution. The frequency and interruptions of the ringing current have been stated on page 33, whilst the various tones required in an automatic exchange are set forth on that page. In large exchanges, the ringing machine is run continuously, and the following description and

diagrams show how the various tones, etc., are distributed to the apparatus.

Busy Tone and Flash (Busy Back). The circuit for the generation and distribution of busy back is shown in Fig. 132. Battery is supplied through a resistance, x, to a smoother unit and thence *via* one coil of a tone transformer to the 400 p.p.s. interrupter drum on the ringing machine and so to earth. The resistance, x, is adjusted to give a satisfactory volume of tone, and its value depends upon the equipment concerned. The smoother unit is provided so that as pure a tone as possible is obtained. The spark quench condenser and resistance connected to the transformer coil prevent sparking at the segments of

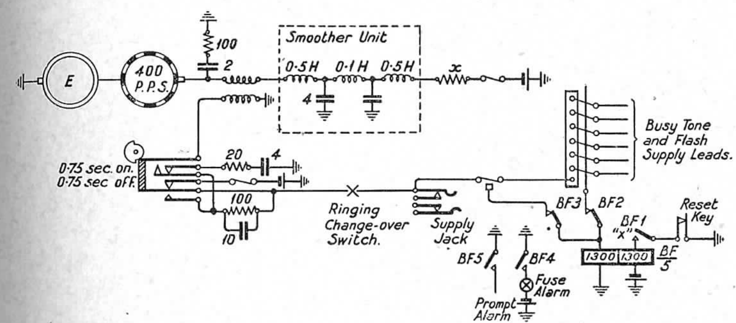

FIG. 132. DISTRIBUTION OF BUSY TONE AND FLASH

the interrupter drum. The tone from the secondary of the transformer is connected to the busy interrupter springs which are operated by the cam carried on the slow speed drum. With the springs normal, a battery is connected to the supply jack through the ringing change-over switch; when the springs are operated, the battery is removed and the tone substituted. The purpose of the condensers and resistances is to prevent any objectionable clicks during the change from battery to tone conditions.

The supply is distributed from the supply jack through a fuse board, and a fuse alarm relay is associated with the fuse panel to provide for alarm conditions in the event of a fuse blowing. The supply leads connect to the various racks requiring this type of supply, and connexion to the apparatus is made through U-links provided on each rack. The arrangements of the fuse alarm relay follow normal practice and need not be elaborated further.

Busy Hold. In the case of group and final selectors, and certain other apparatus, it is necessary to supply a busy hold battery during the flash periods of the busy tone, and the arrangements for this are shown in Fig. 133. The interrupter cam operates 180° out of phase with that for the busy back springs, and the supply passes through the change-over switch

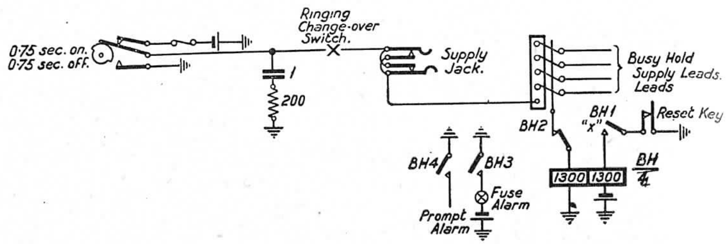

FIG. 133. DISTRIBUTION OF BUSY HOLD

to the supply jack. Thence, distribution is effected through a fuse panel, having a fuse alarm relay associated with it, and U-links on the apparatus racks.

N.U. Tone. The connexions of the circuit for the supply and distribution of number unobtainable (N.U.) tone are given in Fig. 134. There are two cases: first, the supply of tone to the

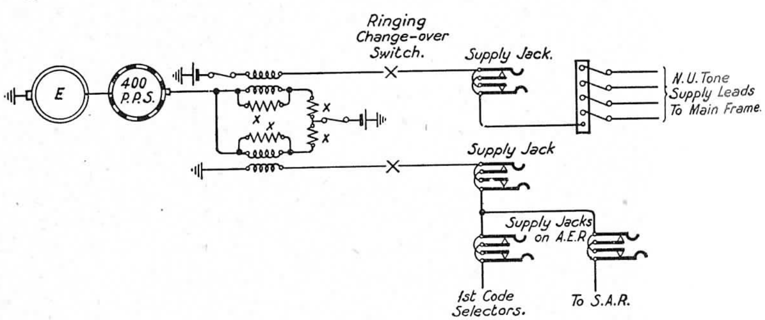

FIG. 134. DISTRIBUTION OF N.U. TONE

main frame; and second, the supply of tone to first code selectors and special apparatus racks. In the first case, the 400 p.p.s. interrupted battery is fed through the winding of a tone transformer. The secondary winding is connected to battery on one side, the other side being connected through the ringing change-over switch and supply jack to the fuse panel serving the main distribution frame. It will be noted that this tone is

superimposed on earthed battery, a point of importance in the operation of certain circuits to be detailed later. In the case of the supply to first code selectors, and special apparatus racks, this battery is not required, and hence a second tone transformer is used but the secondary winding is connected to earth. The resistances marked X in the diagram are adjusted to give a satisfactory volume of tone and their value depends upon the equipment. To prevent sparking at the brushes on the 400 p.p.s. interrupter drum, a spark quench circuit, not shown in the diagram, is connected to the tone transformer brush and consists of a 2μF condenser and 100Ω resistance connected to earth.

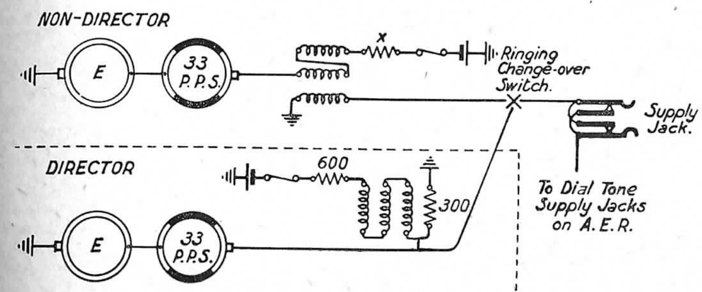

FIG. 135. DISTRIBUTION OF DIALLING TONE

Group Engaged Tone. Where group engaged tone is required on groups of outgoing junctions multipled over the auto-manual switchboard, the N.U. tone is used and the tone is tapped from the supply to the S.A.R.

Dial Tone. *Non-director Exchanges.* In the case of non-director exchanges, the dial tone is required to be earth-connected. Here, the arrangement shown in the upper portion of Fig. 135 is used, the resistance X being adjusted to give a satisfactory volume of tone. In *Director exchanges*, however, the tone is required to be connected through earthed battery and the arrangement shown in the lower part of the diagram is used. In both cases, the supply is taken through the ringing change-over switch and the supply jack; thence *via* supply jacks on the alarm equipment rack (A.E.R.) to U-links provided on the various apparatus racks.

Ringing and Ringing Tone. Ringing current from the generator slip rings is connected to the ringing fuse panel and thence to the various portions of the equipment calling for a continuous ringing supply. In each case, the supply is taken through a 660-ohm ringing resistance lamp, which for manual positions is fitted in the roof of the position, and for P.B.X. ringing leads is mounted on a panel adjacent to the fuse panel. The ringing and ringing return leads form a twisted pair, as indicated by the enclosing loop in Fig. 136; for manual switchboards and P.B.X. ringing leads, the ringing return is connected to earth, but for the test desk and the machine ringing the return leads are connected through earthed battery. Interrupted, or machine, ringing is generated by the interrupter cams carried

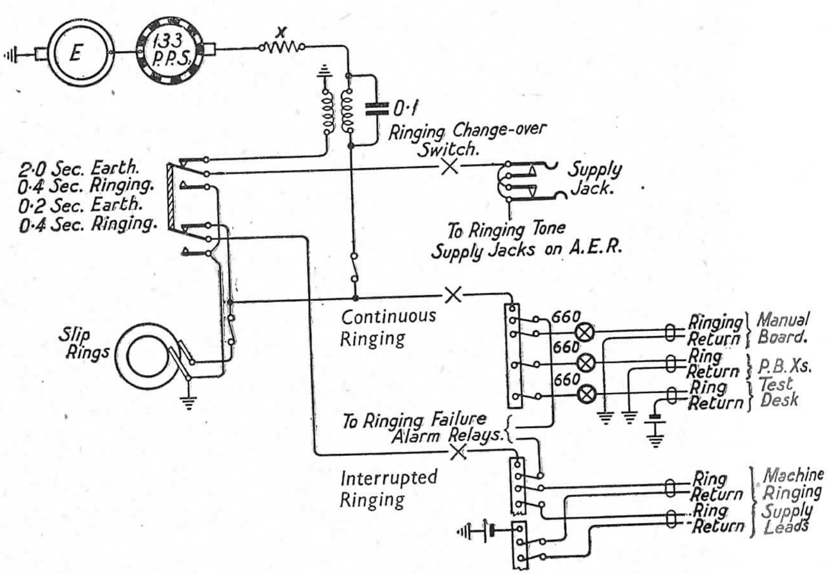

FIG. 136. DISTRIBUTION OF RINGING CURRENT AND RINGING TONE

on the slow speed drum of the ringing generator. These springs are provided in triplicate and during the two seconds earth period of one set, the other two sets provide their interrupted period in turn; the connexions of one set only are given in Fig. 136. Each of the three spring sets supplies approximately one-third of the exchange equipment, thereby enabling the load on the ringing machine at any given instant to be reduced to one-third of the total load and enabling a smaller ringing machine to be used than would otherwise be the case. In addition, the rather peremptory brrr—brrr——brrr—brrr of the machine ringing results in subscribers answering the telephone slightly more speedily than when ringing is at longer and more infrequent intervals.

The ringing tone is derived from the133 p.p.s. interrupter. Ringing current is tapped off and fed through one coil of the tone transformer and a resistance, *X*, to the interrupter drum. The resistance is adjusted to obtain a satisfactory volume of tone. The secondary winding is connected through interrupter springs and the ringing change-over switch to the supply jack and thence through supply jacks on the alarm equipment rack (A.E.R.) and *via* U-links to the apparatus. Previously, it was the practice to supply the ringing tone by superposing it upon the ringing current and then filtering it out through a small condenser in the selector or other apparatus; this had the disadvantage that no return circuit was provided for the tone, and by supplying tone separately and providing a return circuit in the apparatus, a much clearer tone is obtained.

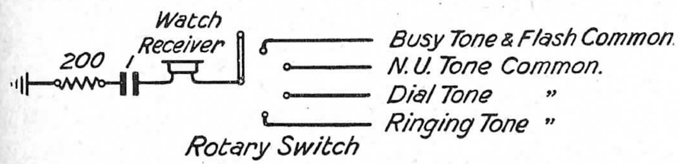

FIG. 137. TONE OBSERVATION CIRCUIT

Tone Observation. For observing the quality of the tone supplied to the exchange, a rotary switch and watch receiver are provided on the power board; these are connected as shown in Fig. 137, the actual connexion to the source of tone being made on the centre blades of the ringing change-over switch.

Flicker Signal. For the purpose of certain signals and timing operations required in automatic switching apparatus, it is necessary to supply a flicker signal consisting of earth and battery supplied alternately at 0·2 second intervals. The cam assembly on the ringing machine carries a cam designed to provide for this sequence of interruptions on its associated spring set and the arrangements for distribution are shown in Fig. 138. The output is connected *via* the change-over switch to the supply jack on the alarm equipment rack and thence to the supply jacks on the apparatus racks.

Interrupted Earth. This is similar to the flicker signal, except that the interruptions are made at busy speed, i.e. 0·75 second intervals. The connexions of the distribution circuit are shown in the diagram in Fig. 138.

Ringing Machine Start Facility. At small exchanges, the ringing generator is only run when and as required. To enable this to be done, a start circuit is controlled by all apparatus requiring a supply of either ringing current or any one of the four tones. The slow speed shaft of the ringing machine is provided with an additional cam and spring set arranged to open for a period of 0·4 second and close for 2·6 seconds. The connexions of the

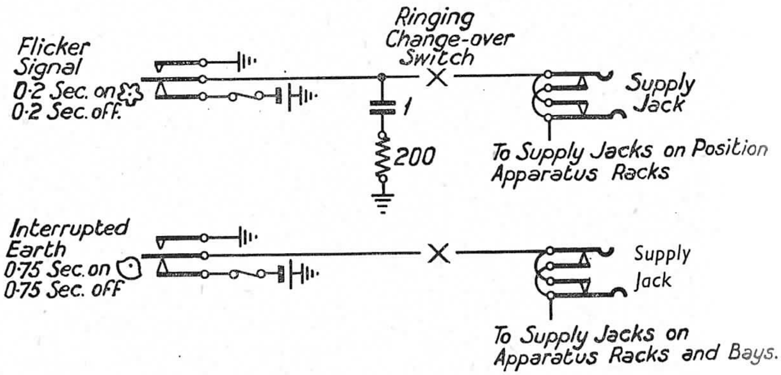

FIG. 138. DISTRIBUTION OF FLICKER SIGNAL AND INTERRUPTED EARTH

motor start circuit are shown in Fig. 139. When earth is applied to the start wire, relay *MS* is operated and locks through **MS1** to earth at the cam springs; **MS2** and **MS3,** which are both platinum contacts, close the circuit of the ringing machine. The machine starts up, and ringing current and tones are supplied to the exchange equipment so long as earth is maintained on the start wire. When this earth is removed, the motor continues running until the 3-sec. cam springs are opened; relay *MS* is then released and the motor circuit is broken. The purpose of the 3-sec. cam springs is to prevent damage to contacts *MS*2 and *MS*3 by ensuring that, having operated, relay *MS* is retained for a sufficient length of time to permit the motor to gain speed and so reduce the current flowing. This prevents a momentary earth on the start wire from causing the release

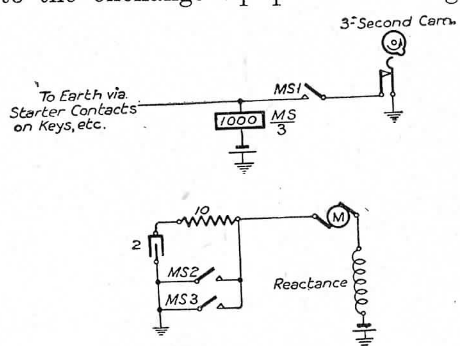

FIG. 139. ELEMENTS OF MOTOR START CIRCUIT

of relay *MS* at a time when the motor is taking a heavy starting current. In addition, a spark quench consisting of a 2μF condenser in series with a resistance of 10Ω is connected across *MS*2 and *MS*3. When the motor slows down, the momentum of the armature is enough to carry the 3-sec. cam past the springs and permit them to close in readiness for the locking circuit of relay *MS* when earth is next applied to the start wire.

Ringing Failure Alarm and Change-over Equipment. The standard arrangement for automatic exchanges provides for a

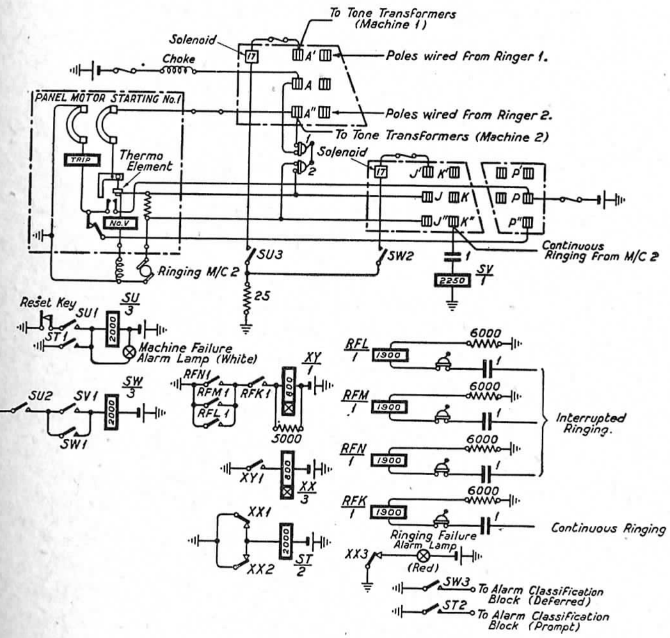

FIG. 140. RINGING FAILURE ALARM AND CHANGE-OVER CIRCUIT

ringing machine driven from the public electricity supply mains and a stand-by machine driven from the exchange battery. In the event of failure of the power-driven machine, the change-over to the battery-driven machine is accomplished automatically and a deferred alarm is given. Should the battery-driven machine fail, a prompt alarm is given. The arrangements for the change-over and alarm conditions are shown in Fig. 140. Relays *RFK*, *RFL*, *RFM*, and *RFN* are supplied with ringing current from the first distribution fuse on the fuse panels associated with continuous ringing, and machine ringing to each of the three sections of the exchange respectively. Under normal conditions, these relays are operated by the ringing current, *RFK* continuously, and the other three relays in turn during their respective ringing pulses. A switch is included in series with each relay to provide for testing the alarm and change-over equipment in respect of each relay. The operated contacts of these four relays maintain the circuit of relay *XY*, which is slow-releasing and retains over the 0·2 sec. earth period of the machine ringing. **XY1** operates relay *XX*, which is also slow-releasing; **XX1** and **XX2** disconnect relay *ST*, whilst **XX3** disconnects the ringing failure alarm lamp.

Should the power-driven machine fail, or any one of the separate ringing supplies fail, the release of the associated ringing fail relay disconnects relay *XY*, which releases and disconnects relay *XX*. This relay also releases and closes the circuit of relay *ST* and the ringing failure alarm lamp. **ST1** closes the circuit of the ringing failure alarm lamp and relay *SU*; **ST2** closes the prompt alarm circuit. Relay *SU* locks through **SU1** and the reset key; **SU2** prepares a circuit for relay *SW*; and **SU3** closes the circuit of the solenoid of one of the knife-type change-over switches. The blades of this switch are engaging with the upper set of contacts and a weight is normally held away from the operating arm; when the solenoid is operated, this weight is released and, in falling, withdraws the blades from the upper contacts and changes them over to the lower ones. When this occurs, the solenoid is disconnected and the battery-driven ringing machine is started up. When this machine is running, relay *SV* operates from the continuous ringing current supplied by the machine and **SV1** closes the circuit of relay *SW* which, at **SW1,** locks through **SU2**; **SW2** closes the circuit of the solenoid of the second knife switch, which is thereby tripped and changed over. The left-hand blade short-circuits the resistance included in the armature circuit, this resistance being four times the armature resistance; the increase in the current flowing through the armature causes the battery-driven machine to speed up. **SW3** closes the circuit of the deferred alarm.

Meanwhile, the resumption of the ringing supply re-operates relays *RFK*, *RFL*, *RFM*, and *RFN* with the result that relays *XY* and *XX* re-operate. Relay *ST* releases and *ST2* disconnects the prompt alarm. The ringing failure alarm lamp is disconnected by **XX3.** Thus, the white lamp on the power board glows to indicate that ringing has been changed over satisfactorily, and a deferred alarm is given to call the attention of the maintenance staff to the occurrence.

Should the battery-driven machine fail to start, relay *SV* will not operate and, consequently, relay *SW* remains unoperated. The prompt alarm is given by **ST2** and the ringing failure alarm lamp remains glowing. Similarly, should the battery-driven machine fail after having changed over satisfactorily, the release of one of the ringing fail relays results in these conditions also.

Two tumbler switches are provided so that the battery-driven machine may be run for maintenance purposes. The switches are interlocked in such a manner that No. 1 can be on when No. 2 is off, but No. 2 cannot be on should No. 1 be off.

Impulse Machines. Certain automatic apparatus, such as directors and senders, requires to be provided with trains of standard impulses in order that they may connect these to line, as required, for the purpose of controlling automatic selectors. These impulses are generated by impulse machines, of which there are two types in use: first, a motor-driven rotary type; and, second, a reciprocating type operating with a trembler bell action.

The rotary type consists of a long spindle mounted horizontally and having ten pairs of fibre cams clamped to it. These cams control ten pairs of impulsing springs, one in each pair supplying the standard or "loop" impulses. The cams associated with the loop springs project for two-thirds of the circumference of the spindle, and they open the springs for two-thirds of a revolution and allow them to close for the remaining portion. The other springs of each pair are associated with the circuit responsible for counting the number of loop impulses transmitted to line and the impulses generated at these springs are known as "magnet" impulses, since they control a driving magnet associated with the counting mechanism. The cams associated with the magnet springs project for only one-third of the circumference, and the springs consequently deliver impulses having 66 per cent make and 33 per cent break. The relation between the loop and magnet springs forming a pair is shown in Fig. 141. One impulse machine normally serves eight directors or senders.

The spindle and cams are rotated by a $\frac{1}{8}$ h.p. battery-driven motor, which is started by a motor start relay whenever any