

TELEPHONY

A DETAILED EXPOSITION OF THE TELEPHONE SYSTEM OF THE BRITISH POST OFFICE

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Tones Provided in an Automatic Exchange. In order to give to subscribers a feeling of confidence in the performance of the automatic equipment it is desirable that they should be kept acquainted with the progress of the calls which they make. To this end, a system of distinctive tones is employed and these are four in number, as follows—

Dialling Tone. The function of the subscriber's hunter is to search for and seize a free first group selector in readiness for dialling. Unless the calling subscriber is informed when this has been done, he may dial before the apparatus is prepared, with the result that the impulses sent out before the exchange apparatus was prepared will be lost. To prevent this state of affairs from arising, a dialling signal is connected to the calling subscriber's line from the first group selector which is to be used for the call. This signal consists of a continuous tone having a frequency of 33 p.p.s. It is heard as a low burble in the telephone receiver and its reception indicates that dialling may be commenced.

Ringing Tone. When the calling subscriber has dialled the number of the called subscriber, the final selector tests the line, and, if it is free, connects an interrupted ringing current to the called subscriber's line. At the same time a tone is connected to the calling line, and it coincides with the ringing current in its cycle of interruptions. This tone is returned to the calling subscriber as an indication that the called subscriber is being rung. It has a frequency of 133 p.p.s., and, like the ringing current, it is connected for 0.4 second, disconnected for 0.2 second, re-connected for 0.4 second, and disconnected for 2.0 second, this sequence being repeated until the called subscriber replies, or the calling subscriber abandons the call.

Busy Tone. The final selector may find the called subscriber's line already engaged; the first or the second group selector may find all the trunks outgoing from the level over which it is testing, to be engaged. In either of these cases, a tone, known as the busy tone, is connected to the calling line to inform the calling subscriber of the position. This tone has a frequency of 400 p.p.s., and it is connected for 0.75 second and then disconnected for the same period, the cycle recurring until the calling subscriber replaces the receiver.

Number Unobtainable Tone. A calling subscriber may

dial a spare number, or one which is out of order or otherwise unobtainable for some reason, in which event a tone is returned to the calling subscriber to inform him of the fact. This tone, known as the number unobtainable tone, has the same frequency as the busy tone, viz. 400 p.p.s., but it is applied continuously.

The Private Wire. The testing of a trunk or a subscriber's line is carried out by using within the exchange a third conductor whose electrical condition is indicative of the state of the pair of wires forming the trunk or subscriber's line. This third conductor is known as the private wire, abbreviated to P-wire, or sometimes as the release trunk. It is the practice in "earth testing" circuits to indicate the engaged condition of a circuit by an earth connected to the P-wire, the free condition being indicated by either a battery connected to the P-wire or by leaving the P-wire insulated: in the case of "battery testing" circuits, the engaged condition is indicated by either a disconnected or earth-connected P-wire, the free condition being a battery-connected P-wire. In this respect, automatic practice contrasts with manual practice, for in a manual exchange the engaged condition is indicated by a potential on the third conductor, or S-wire.

As the through connexion must provide a pair of wires clear of all bridged apparatus except for the transmission bridge, the P-wire is used for holding the chain of selectors during the conversation. In addition, the P-wire may be used for effecting metering.

Metering Schemes. The calling subscriber's meter must be operated for each effective call made from the line. The standard practice of the British Post Office is to effect metering when the called subscriber replies. Two methods are in use; one is by means of a booster battery applied to the P-wire momentarily, in a similar manner to the method used in 22-volt C.B. manual exchanges; the other method is to utilize a battery reversal on the pair of wires forming the through connexion, for the purpose of operating the calling subscriber's meter over a fourth wire, necessitating an additional wire between the calling subscriber's line termination and the first selector.

Release of the Connexion. In a public automatic exchange, the calling subscriber controls the release of the selectors used in the chain of connexions on all calls except those to the automatic switchboard for the purpose of short distance trunk calls, inquiry, rural party line services, and long distance trunk

calls, i.e. calls to 0, 91, 93, and 94. In these cases, the operator answering the call controls the release of the connexion as soon as the plug is inserted in the answering jack.

It will thus be seen that no provision is made for control by the called subscriber, and, to guard against the possibility of the called subscriber's line being held engaged by a calling subscriber after the former has replaced the receiver, the calling subscriber failing to do so also, an alarm is given after this condition has persisted for three minutes. This alarm is known as the "Called Subscriber Held," abbreviated to C.S.H. alarm.

In private automatic branch exchanges, provision is made for the release of the connexion by the first party to replace the receiver on the termination of the conversation. This facility is known as "first party release."

REFERENCES

1. British Standards Institution Publication No. 204; Definition No. 9215.
2. *Ibid.* Definition No. 9629.

Ringling Machines. The ringling 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 ringling 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 ringling 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 ringling current; the **alternating current of 17 p.p.s.** is connected for 0·4 second, the ringling lead is earthed for 0·2 second, ringling 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 ringling 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 ringling 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.

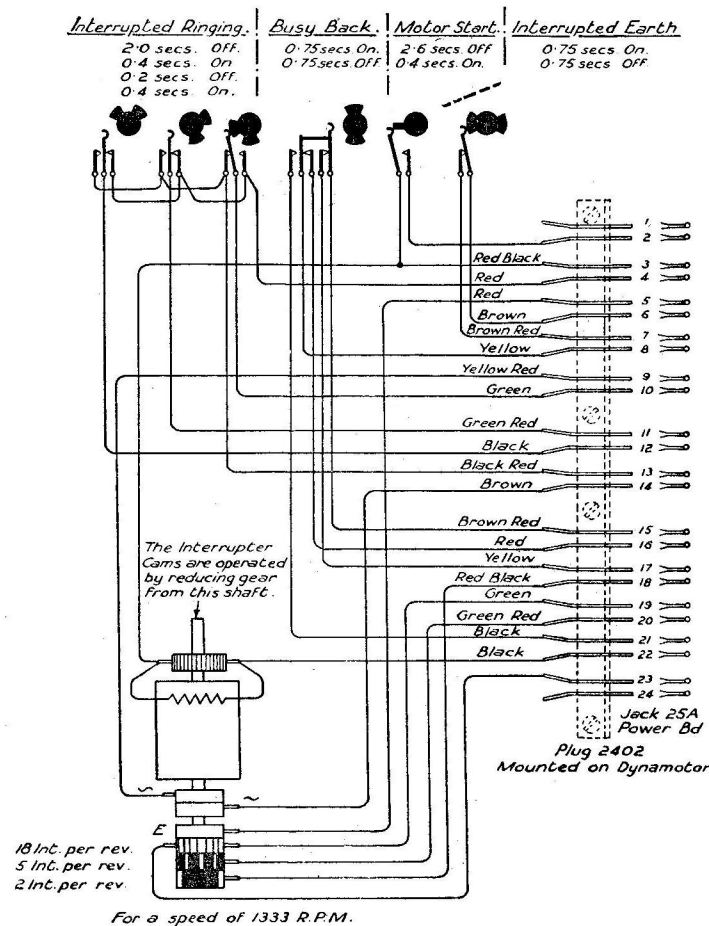


FIG. 131. WIRING OF TYPICAL RINGING DYNAMOTOR

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

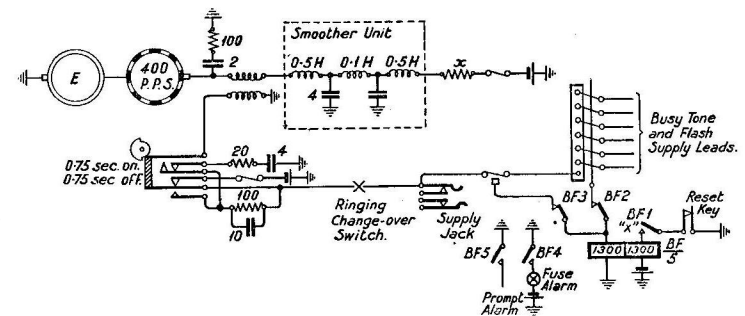


FIG. 132. DISTRIBUTION OF BUSY TONE AND FLASH

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 ring 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

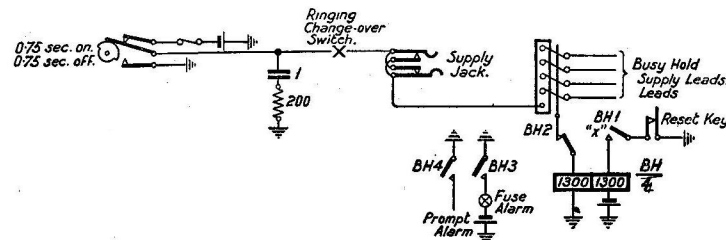


FIG. 133. DISTRIBUTION OF BUSY HOLD

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

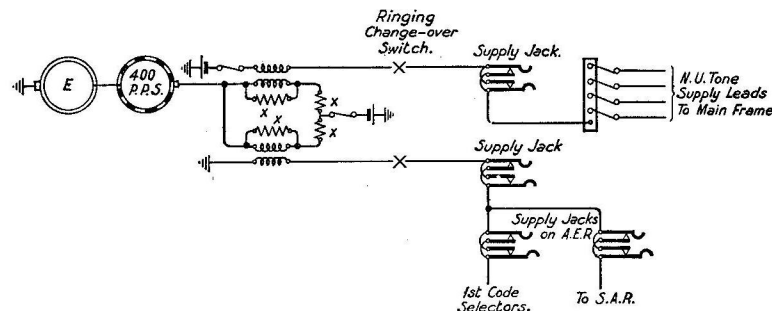


FIG. 134. DISTRIBUTION OF N.U. TONE

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 $2\mu\text{F}$ condenser and 100Ω resistance connected to earth.

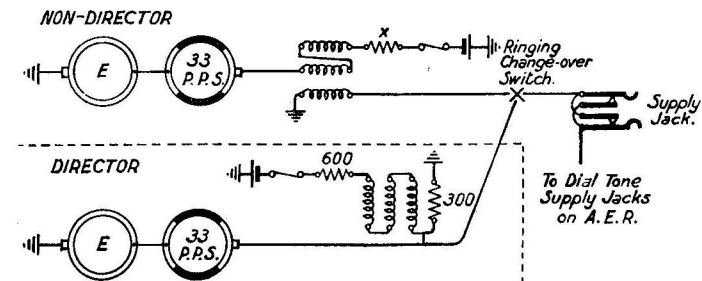


FIG. 135. DISTRIBUTION OF DIALLING TONE

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

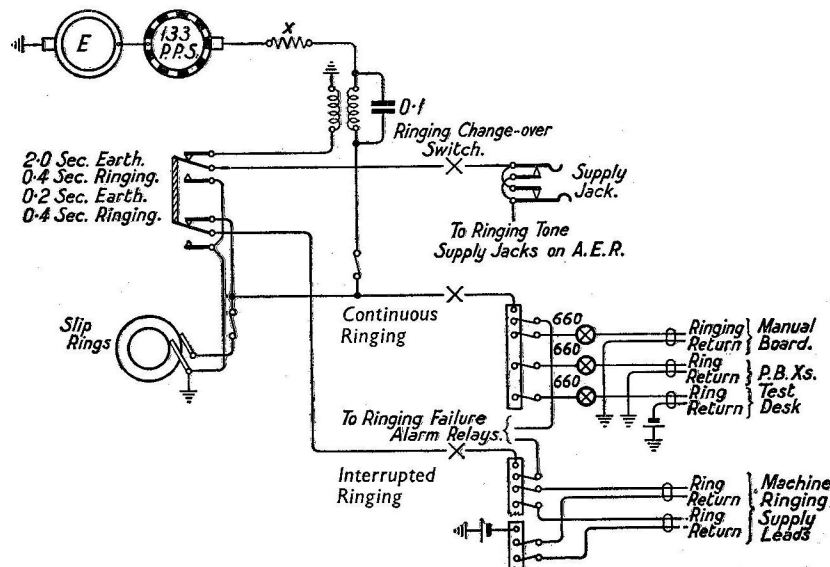


FIG. 136. DISTRIBUTION OF RINGING CURRENT AND RINGING TONE

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 the 133 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.

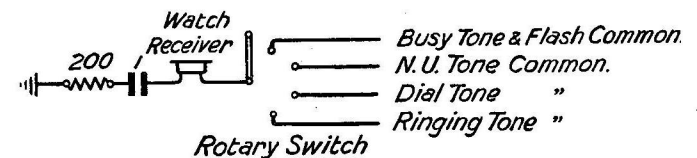


FIG. 137. TONE OBSERVATION CIRCUIT

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

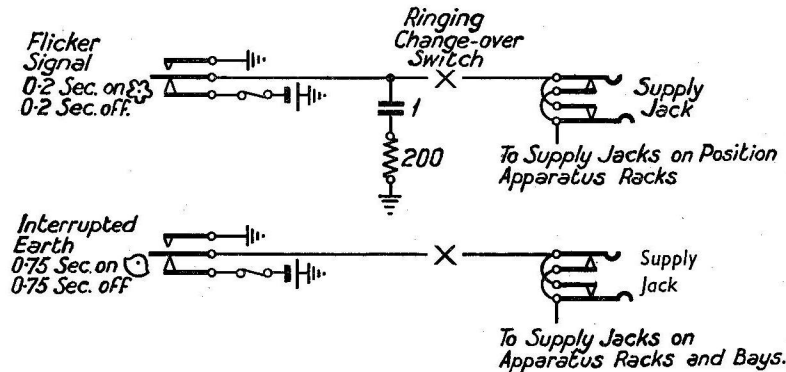


FIG. 138. DISTRIBUTION OF FLICKER SIGNAL AND INTERRUPTED EARTH

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 *MS2* and *MS3* by ensuring that, having operated, relay *MS* is

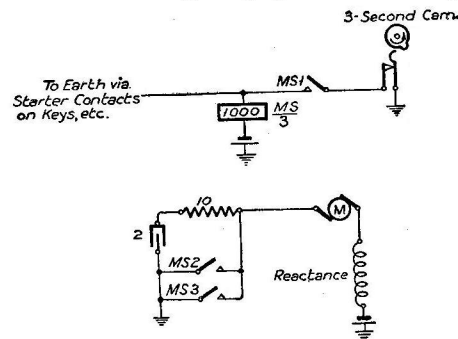


FIG. 139. ELEMENTS OF MOTOR START CIRCUIT

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

of relay *MS* at a time when the motor is taking a heavy starting current. In addition, a spark quench consisting of a $2\mu\text{F}$ condenser in series with a resistance of 10Ω is connected across *MS2* and *MS3*. 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

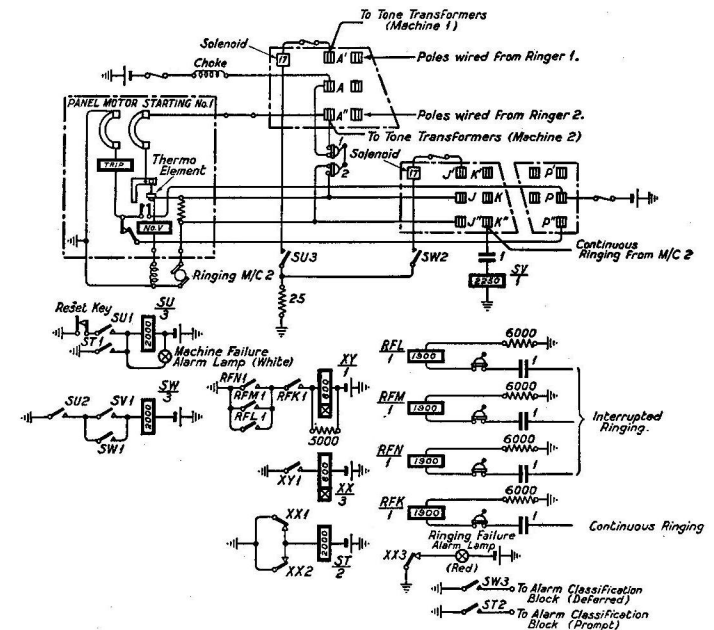


FIG. 140. RINGING FAILURE ALARM AND CHANGE-OVER CIRCUIT

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