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TELEPHONE, TELEGRAPH AND SIGNALLING ENGINEERS

ENGINE ROOM TELEGRAPHS, TELEPHONE AND PRIORITY FEATURES OF THE CENTRAL SCOTLAND CENTRALISED INDICATING SCHEME

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SYNOPSIS

A general outline of the Central Scotland centralised indicating scheme was given in Vol. I, No. 1 of this Journal, together with detailed descriptions of the operational features as regards circuit-breaker indications and the selection and transmission of meter readings. This article first deals with the control desk and miniature and wall diagrams and the general layout of the central indicating station. Then follow descriptions of the engine room telegraphs, telephone and priority features, the article concluding with some notes on the special means adopted to isolate the signalling apparatus from the signalling lines.

The various indicating facilities provided on the Central Scotland Electrical Scheme are divided into five groups, as follows, in order of priority.

(1) Changes in position of circuit breakers.
(2) Telephone communications.
(3) Changes in position of tap-changing switches.
(4) Engine-room telegraph signals.
(5) Meter readings.

Of the five groups of signals, (1) and (3) are non-selective, i.e. the displayed indications always correspond to the actual conditions and any change in circuit-breaker or tap-changing switch position automatically initiates an impulse train to correct the display and draw attention to the changed condition. The other three groups of signals are selective and involve the manipulation of selecting keys by an official at the central indicating station. In all cases the circuit arrangements are such that none but the particular selection intended can be obtained. This important safeguard is accomplished by cross-connections between seventeen contacts on one level of two uniselectors, one of which is first stepped a certain number of contacts and is followed by the stepping of the other uniselector a complementary number of times, whereupon a signal is automatically transmitted back over the line to complete the selection at the central indicating station.

The Central Indicating Station

The layout of the central indicating station, which is situated at Broomhill Grove, Glasgow, is shown in Figure 1, the principal items of equipment being as follows :—

(*a*) Central indicating board.
(*b*) Engineers' control desk—two positions.
(*c*) Main wall diagram.
(*d*) Manual telephone switchboard.
(*e*) Automatic signalling apparatus.

An illustration of the central indicating board was included in the earlier article by the authors, which appeared in Volume I, No. 1 of this Journal. This board contains fifteen panels, one for each of the generating stations and transformer stations. On the upper portion of the board is a diagram showing the complete 132,000 volts transmission line and including an indication of every oil circuit breaker and transformer. A red and green lamp are associated with each breaker, the red lamp glowing whilst the breaker is " closed " and the green lamp glowing when " open ". Immediately beneath the diagram panels are the meter panels, there being two instruments for each transformer station to indicate the true power and reactive kVA, a third instrument being provided to indicate the total load in the cases of generating stations. The two former instruments are of the

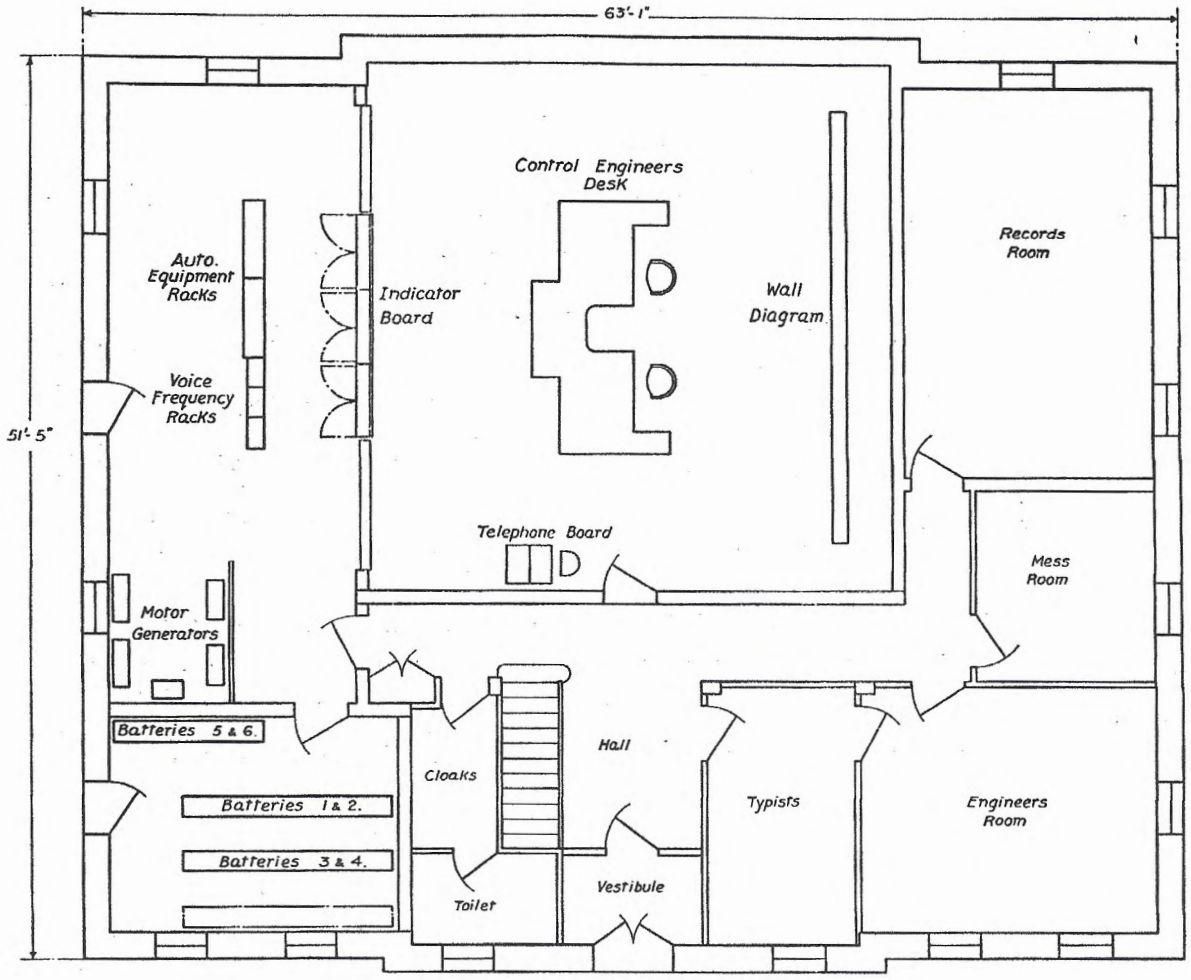


FIGURE 1

centre zero type in the case of generating stations and thus indicate either input to or output from the " grid ".

The lower part of the board contains the indicators for the transformer tap-change switches, each indicator comprising fifteen separate compartments having lamps for the fifteen operating positions. Immediately above the tap-change indicators are the three selecting keys for each station ; also, in the case of the generating stations, a set of seven lamps is provided for the engine room telegraph signals.

The engineers' control desk is shown in Fig. 2 and has accommodation for two officials, who are enabled to establish direct telephone communication with any station, or to interrupt and listen to conversations between the manual telephone switchboard and the distant stations. Each controlling officer is also provided with facilities for transmitting to each generating station any one of seven specific instructions, which are displayed and acknowledged on an engine room telegraph.

The diagram in the top centre of the control desk shows the generators, transformers, circuit breakers, isolating switches and transmission lines throughout the entire " grid ".

The circuit breakers and isolating switches are each represented by a small switch, the circular knob of which has a black line that completes the line of the diagram or is placed across it, depending upon whether the switch is in the closed or open position respectively. These small switches are hand-operated and control

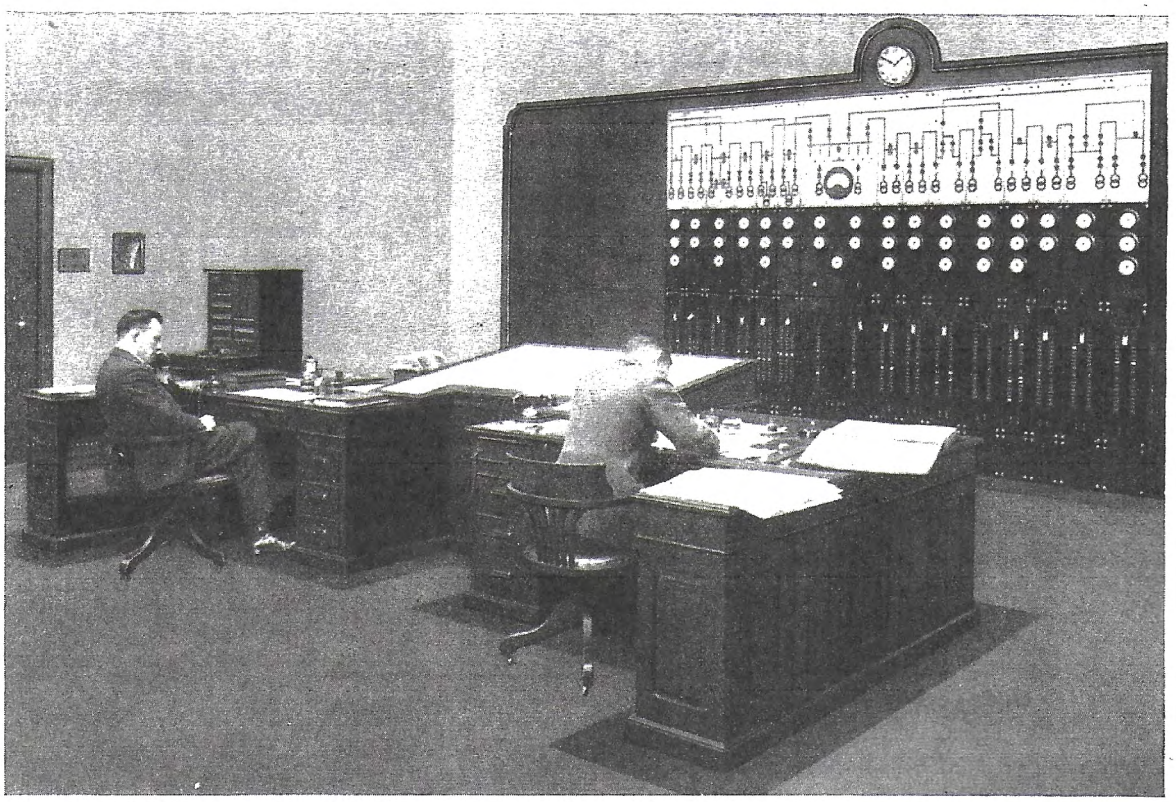


FIGURE 2

electro-magnetic indicators in the main wall diagram—see Fig. 3—which is a large scale copy of the control desk diagram. The indications of the two diagrams thus coincide.

The manual telephone switchboard in the central indicating station is for the purpose of extending calls between the Board's offices and any of the stations. Telephone calls may also be established directly with any of the stations from either of the control desk positions, which are also fitted with change-over keys enabling the controlling engineers to use the telephone instruments fitted on the central indicating board.

The manual switchboard is connected to the post office P.B.X. switchboard by means of a tie-line, which enables the "grid" telephones to be connected with the local extension instruments of the post office P.B.X.

The automatic signalling apparatus consists of A.T.M. Strowger telephone relays and uni-selectors (rotary switches), together with voice frequency rotary generators, thermionic amplifier-rectifiers and filter equipment for the more distant stations. Views of typical apparatus racks are shown in Figures 4 and 5.

CIRCUIT OPERATION.

As mentioned in the previous article in Vol. I, No. 1, of this JOURNAL, two methods of signalling are employed, namely, direct current signalling and multi-voice-frequency signalling. The former method is employed between the stations nearest to Glasgow, whilst the latter is used to the more distant stations, since in these cases the signalling wires pass through thermionic repeater stations. An outline of the circuit operation of both circuit breaker indications and the selective metering feature by means of voice-frequency

currents was also given in the previous article. Complementary circuit operations affecting telegraph signals, telephone calls and the priority feature will now be dealt with, also on the voice-frequency principle. It is considered unnecessary to include also a description of the direct current method of signalling, since in general this alternative method is simpler and merely employs the two-fold principle of positive and negative impulses in place of the three-fold principle of low, medium and high voice-frequencies.

Telegraph Signals.

These signals are selective in character and are initiated from the control desk at the central indicating station. Each controlling officer is provided with two circular dials, which enable any one of the following specific instructions to be displayed visually on the telegraph head in the particular generating station selected :—

(1) Control.
(2) Start-up.
(3) Raise kW.
(4) Steady.
(5) Lower kW.
(6) Shut down.
(7) Stand by.

The particular signal is selected by turning one dial, the particular station being selected by turning the other. When a common start key is actuated, the required signal is automatically transmitted to and displayed at the particular station, and corresponding signal lamps are caused to glow on the control desk and central indicating board immediately the signal has been correctly received and displayed. The displayed signal is acknowledged by the attendant simply rotating the pointer of the

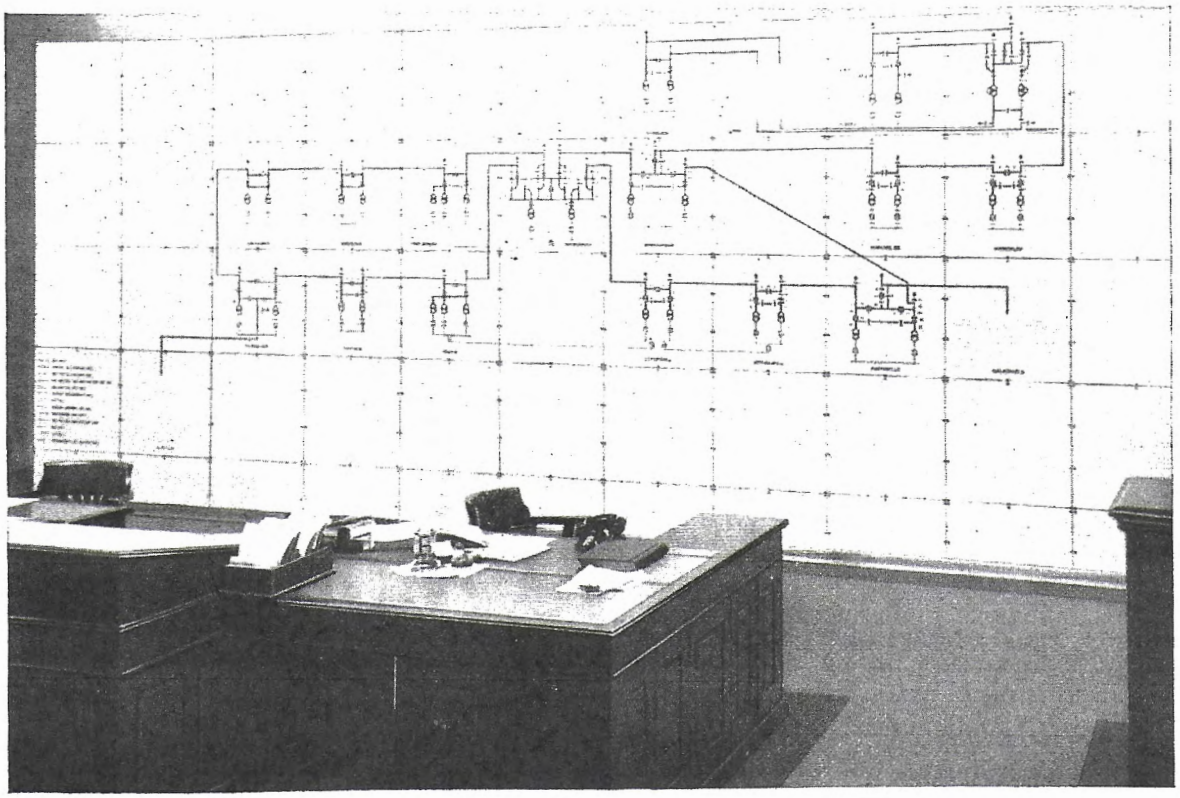
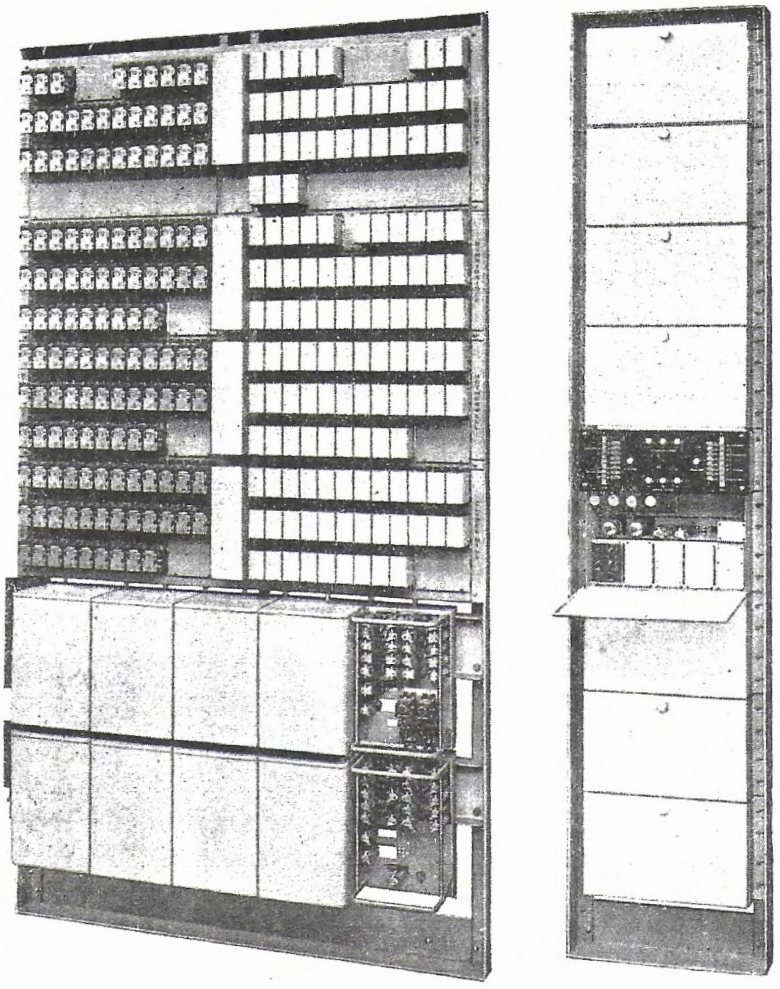


Figure 3

telegraph head—see Fig. 6—to the corresponding position and then pushing the handle inwards. This action cancels the signal and simultaneously transmits an impulse back to the central indicating station, where the corresponding lamps then also become extinguished.

N.B.—Since this article was compiled, a slight change is being considered, whereby the signal last transmitted can be continuously displayed at the Central Indicating Station. Under this arrangement, upon the transmission of a new instruction, the corresponding signal would "flicker" until acknowledged by the distant sub-station, whereupon the new signal would glow steadily and the previous signal be extinguished. This proposed modification is not, however, shown in the diagrams.

Figures 7 and 8 are schematic diagrams of the circuits employed in telegraph signalling. Assuming that the selecting dials are set as shown in Fig. 7, the actuation of the start key operates relay GT to mark the associated contact on bank 8 of rotary switch STA, which immediately commences to hunt. When the marked contact is reached, relay CO operates via its 4 ohms winding to connect the 1,000 ohms holding winding in series with the driving magnet of the rotary switch, which then ceases to hunt. The operation and locking-up of relay CO causes relay X to operate and lock-up to initiate the selective operation, the particular selection being marked, in the case assumed, on bank 3 of rotary switch B via bank 2 of rotary switch STA, the instruction dial and operated contacts CO to earth.



Typical Central Indicating Station Racks.

FIGURE 4

Relay U was also operated over the same circuit as relay X. The operation of relay U actuates relay V, which in turn disconnects relay U. These two relays, being slugged with copper, therefore interact at a steady rate of about ten operations each per second. The contacts of relay V are employed to step rotary switches B and C, which proceed step-by-step round their banks. Whilst rotary switch C stops with the operation of relay SW, explained later, to prepare a circuit for the lamp associated with the particular signal, rotary switch B steps until its wipers rest on the 24th set of contacts. Upon rotary switch B reaching the 24th contact, the circuit for relays U and V is disconnected and relay MR operates via operated contacts of relay X and wiper B4.

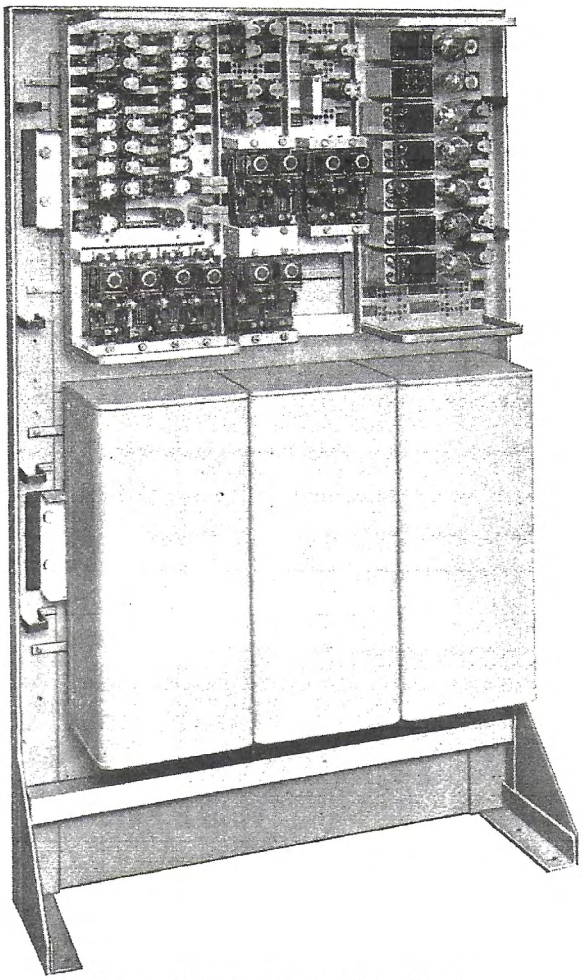
When relay X operated, current at 288 cycles was applied to

the line to operate relay LO at the distant station, thereby preparing the medium and high frequency receivers to accept impulses. Rotary switch B reaches the 7th set of contacts in about three-quarters of a second, whereupon relay OP is momentarily actuated via the normal contacts SW, pulsing contacts U and wiper B4. Relay OP thus superimposes an impulse of 576 cycles upon the line. Remembering now that Instruction No 2 is being transmitted, it will be seen that the 18th contact of bank B3 is marked with positive, all the other contacts being un-marked. Consequently, as rotary switch B steps round, relay OP again operates to transmit an impulse of 588 cycles on each of contacts 8 to 17, whilst on the contacts 18 to 23 relay PP operates to transmit impulses of 1,440 cycles. It will be observed that the change-over is effected by the operation of relay SW, which operates and locks up when the wipers reach the 18th contact. Thus, in this case, the train of selecting impulses comprises eleven pulses of 588 cycles followed by six pulses of 1,440 cycles.

At the distant station relays L and AA operate respectively with each impulse of 588 and 1,440 cycles. Relay L controls the stepping of rotary switch S and relay AA controls rotary switch T. Thus the eleven pulses of 588 cycles step rotary switch S to the 12th contacts and the six pulses of 1,440 cycles step switch T to the 7th contact. Auxiliary contacts on relays L and AA become effective after the 9th pulse of 588 cycles via wiper and bank S to control the stepping actions of rotary switches ET and ER in the telegraph head, as follows :—

Immediately the 10th pulse of 588 cycles ceases, rotary switch S steps to the 11th contacts. When now relay L is operated by the 11th 588 cycles pulse, relay EP1 is operated via the 1st contact and wiper ER2, operated L contacts, bank and wiper S2 to positive. The operation of relay EP1 energises driving magnet ET in series with slow release relay SR and, when the 11th 588 cycles pulse ceases, rotary switch ET steps to the second contact. Before relay SR has time to release, the remaining six pulses of 1,440 cycles operate relay AA, which in turn operates relay EP2 six times and thus steps rotary switch ER to the 7th contact. The local selecting circuit is then completed and relays TG2, TG1 and H operate in series over the following circuit :—

Positive on wiper S3, 12th contact, windings of relays TG2 and TG1, wiper of ET1 on second contact, No. 2 set of make contacts in telegraph head, 7th contact and wiper ER2, 7th contact and wiper T2, winding of relay H and operated contacts CO to negative. Relay H operates to hold relay CO, via the operated contacts of relay LO, which remains held by 288 cycles remaining on the line from the central indicating station. Relay TG1 operates to close circuits for the alarm bell and the lamp of No. 2 telegraph signal via wiper ET3 on the second set of contacts. The operation of relay TG2 energises relay MF, which applies 588 cycles to line and



Typical V.F. Sub-Station Rack.
FIGURE 5

thus actuates relay B1 of the medium frequency receiver at the central indicating station. Relay B1 then closes the circuit for No. 2 signal lamp (12 volts) on the particular panel of the central indicator board, via the winding of relay PL, operated contacts ET, bank and wiper C3, operated contacts MR, normal contacts B2 and operated contacts B1. A circuit is also prepared for relay M, which controls the " Telegraph answered " lamp on the engineer's desk, but under this condition relay M is shunted by the lamp and therefore does not operate.

The attendant at the distant station acknowledges the signal by turning the pointer of the telegraph head opposite the displayed signal and then pressing the handle inwards. This opens the particular set of contact springs and thus releases relays TG2, TG1, H and CO and causes the local apparatus to return to normal. The releasing of relay TG2, in turn releases relay MF to remove 588 cycles from the line. Relay B1 of the 588 cycles receiver at the central indicating station thus releases to extinguish the No. 2 lamp on the central indicating board, thereby unshunting relay M. The latter relay then operates to light the " Telegraph answered " lamp and also operates relay TGA which sounds the buzzer.

The transmitted signal having thus been acknowledged, the engineer releases the start key whereupon the whole of the selective apparatus at the central indicating station returns to normal.

Telephone Calls.

As previously mentioned, telephone communications can be established from either the telephone switchboard or the engineer's control desk. Incoming calls are generally answered from the engineer's desk. To initiate a call, the call key, on either the engineer's desk or telephone switchboard, is momentarily operated to operate and lock-up relay TC. This makes the telephone contact on the selector marking bank of rotary switch B—see Fig. 7—and connects positive to the selection start wire to commence the selective operations. It is considered unnecessary to describe in detail the step-by-step selective operations, as these are generally similar to those previously given for telegraph selections. The selective train comprises eight impulses of 588 cycles and nine of 1,440 cycles, thus at the distant station setting rotary switch S on the 9th contacts and rotary switch T on the 10th contacts—see Fig. 8.

FIGURE 6

Referring now to Fig. 10, it will be seen that relay TE operates via wiper T3 on the 10th contact and operated contacts of relay H, which, it will be remembered, operates upon the completion of the selective operation. The ringing vibrator is also brought into operation and delivers ringing current of about 16 cycles via the secondary of the transformer and operated TE contacts to the plant house and control room telephone instruments in parallel, the ringing circuit being completed via normal contacts N, home contact and wiper of rotary switch P and normal contacts RSR to positive. When the attendant replies by lifting the receiver, relay R operates and in turn operates relay N, which locks through its own contacts and supplies current for speaking purposes. Assuming that the call was initiated from the telephone switchboard, by this time a plug will have been inserted in the jack and conversation can then proceed.

Referring to Fig 9 it will be seen that when the plug is in the jack, the " call in progress " lamp lights on the engineer's desk. If desired, the engineer can listen-in on established conversations by merely depressing the " listen " key or he can cut-off either the sub-station or the extension to the switchboard by actuating another key, having two operating positions. By actuating the " extension cut-off " key, the engineer causes the " busy " lamp to be displayed on the telephone switchboard.

The distant station calls the central indicating

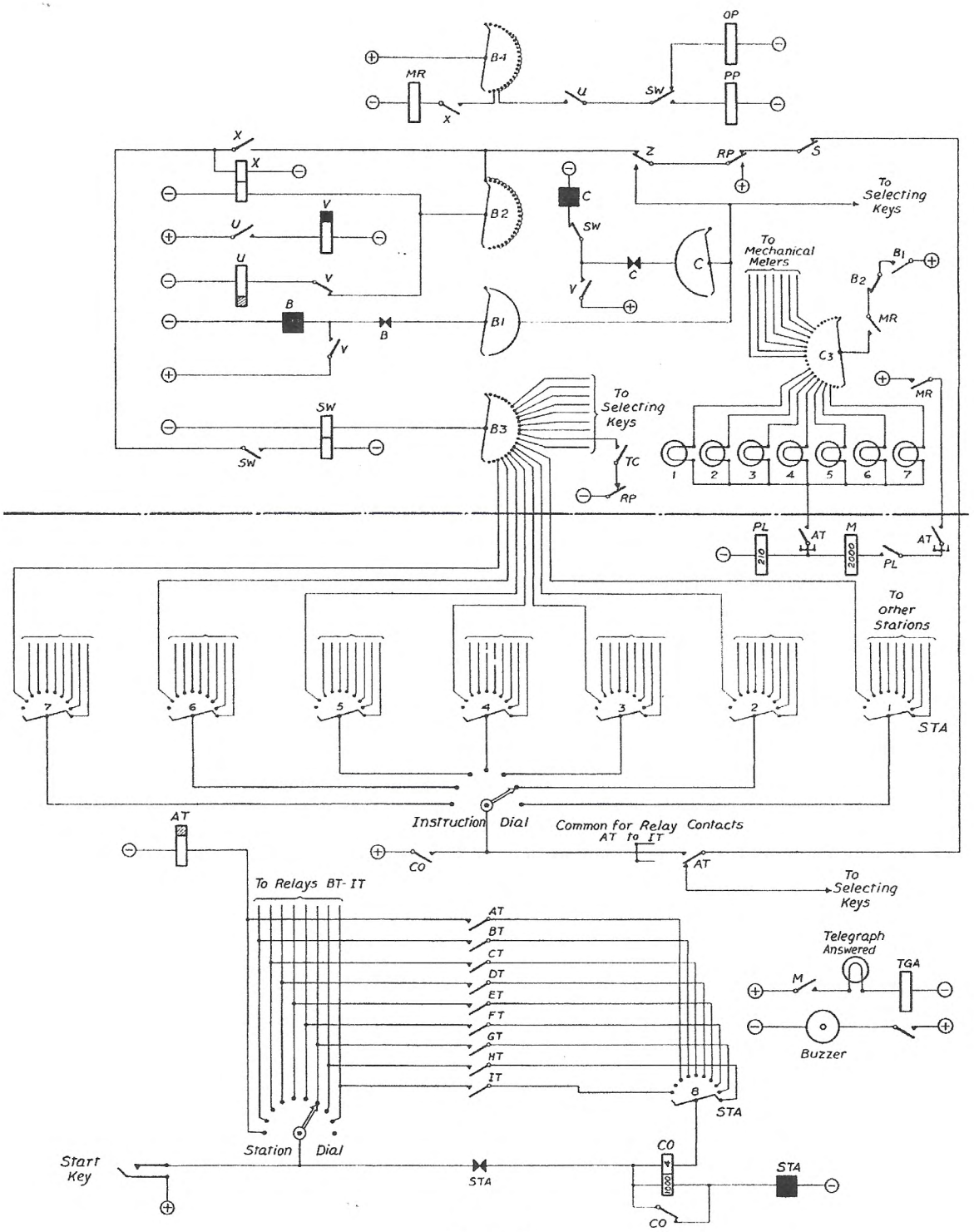

OP
PP
B4
MR
X
U
SW
Z
RP
S
To Selecting Keys
C
B2
V
B
B1
To Mechanical Meters
C3
MR
B3
TC
RP
PL
AT
M
2000
210
To other Stations
STA
Instruction Dial
Common for Relay Contacts AT to IT
CO
To Relays BT-IT
AT
BT
CT
DT
ET
FT
GT
HT
IT
Telegraph Answered
TGA
Buzzer
Start Key
Station Dial
1000
4

FIGURE 7

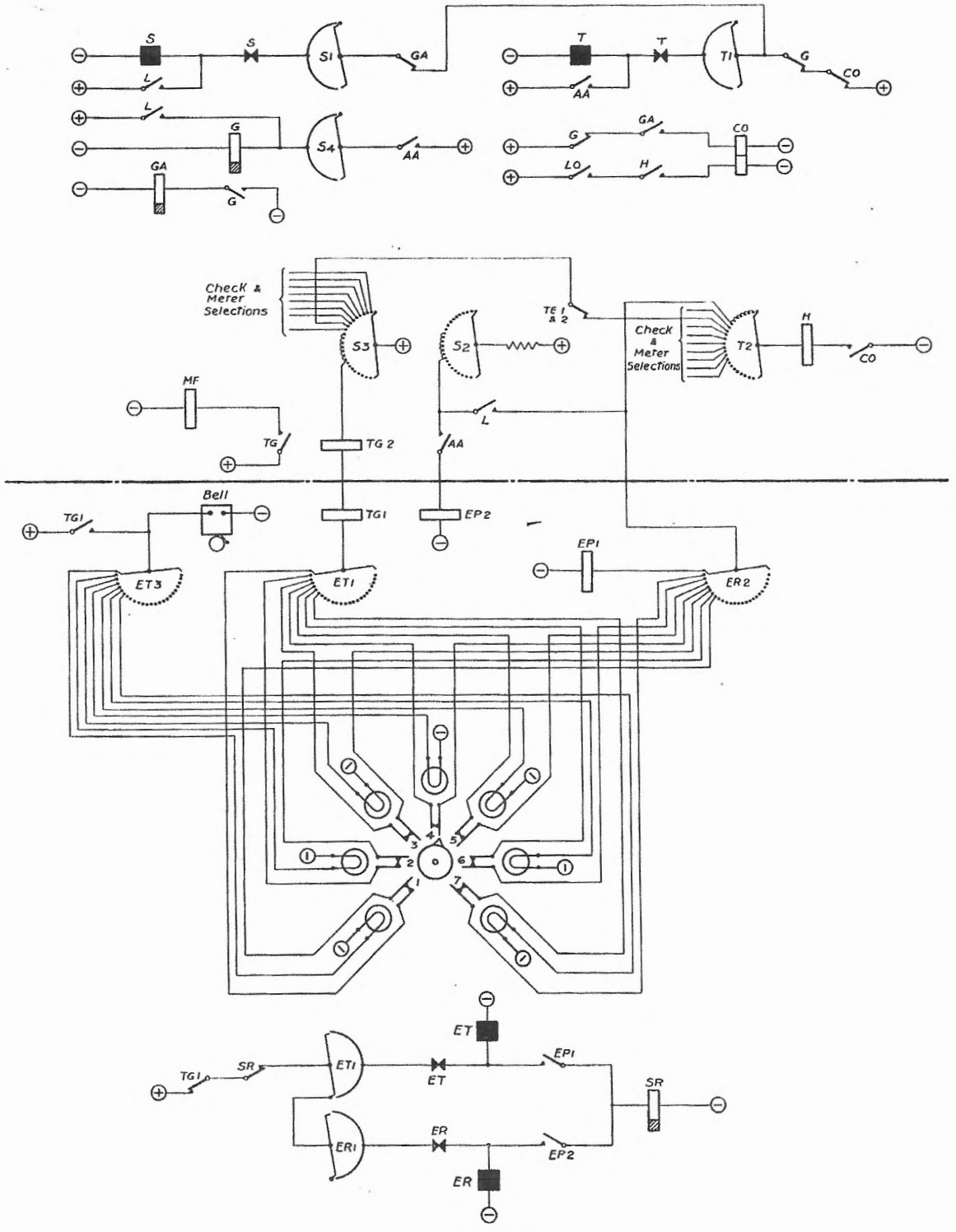

S
S
S1
GA
L
T
T
T1
G
CO
AA
L
G
S4
AA
GA
G
GA
G
CO
LO
H
Check & Meter Selections
S3
S2
TE 1 & 2
Check & Meter Selections
T2
H
CO
MF
TG
TG 2
AA
L
Bell
TG1
TG1
EP2
EP1
ET3
ET1
ER2
1
2
3
4
5
6
7
ET
EP1
TG1
SR
ET1
ET
SR
ER1
ER
EP2
ER

FIGURE 8

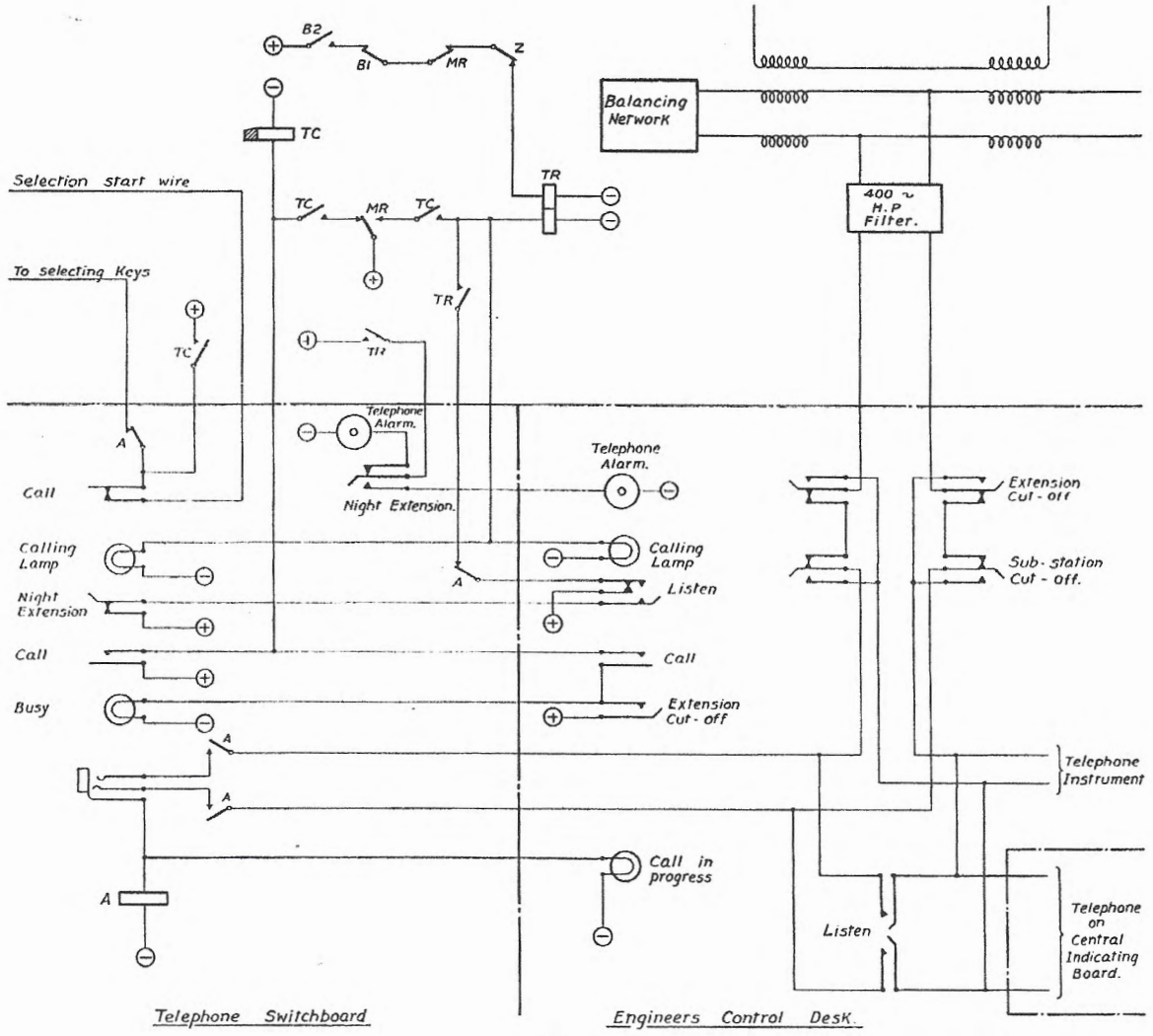


FIGURE 9

station by merely lifting the receiver in the plant house or control room, or, if the extension key in the control room is actuated, in the station office. This operates relay W, which locks up in series with the winding of relay R, which also operates. The operation of relay R in turn operates relay N, which locks up via its own contacts and supplies current for talking purposes.

With the operation of relay W, relays LF, TO and F and relay HF also operate. Relay F operates slow release relay E, which in turn opens the circuit and relay F, so that these two relays interact at a steady rate of about ten operations each per second. The contacts of relay E are employed to step rotary switch P, which proceeds to step its wipers steadily round its banks. Relay W remains held via wiper P2 until it reaches the 18th contact, when it releases, thus also then releasing relays L, F, TO, F, and relay HF, and causing rotary switch P to rotate its wipers to the "home" position. During the period, approximately $1\frac{3}{4}$ seconds, that relay W remained operated, relays LF and HF respectively applied 288 cycles and 1,440 cycles to the line, thus actuating relay B2 at the central indicating station. This causes relay TR to operate and lock up, thus lighting the calling lamps on the telephone switchboard and engineer's desk, also sounding the telephone alarm bell. Normally, incoming calls are answered from the engineer's desk by

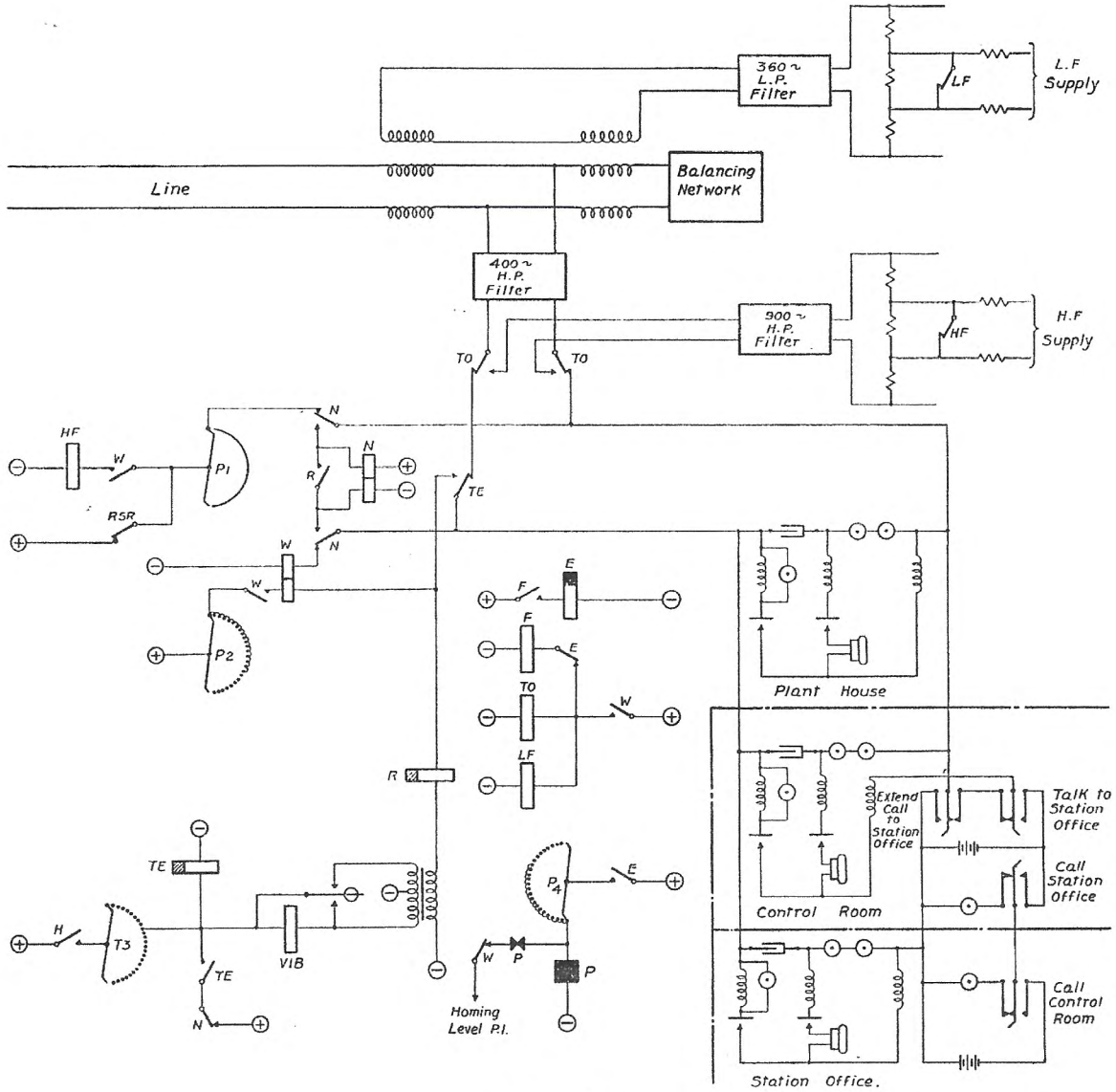


FIGURE 10

simply lifting the receiver, the listening key being momentarily " flicked " to release relay TR and thus extinguish the calling lamps. During the period that the telephone switchboard is attended, incoming calls are answered by inserting a plug into the jack.

PRIORITY FEATURE—CIRCUIT OPERATION—SEE FIGS 11 AND 12.

The function of the priority feature is to ensure that the various classes of signals are automatically transmitted in strict order of priority, which, as previously mentioned, is as follows :—

(1) Changes in position of circuit breakers.
(2) Telephone communication.
(3) Changes in position of tap-changing switches.
(4) Engine-room telegraphs.
(5) Meter readings.

Figures 11 and 12 are schematic diagrams showing the essential elements of the priority circuits at the central indicating station and sub-station respectively.

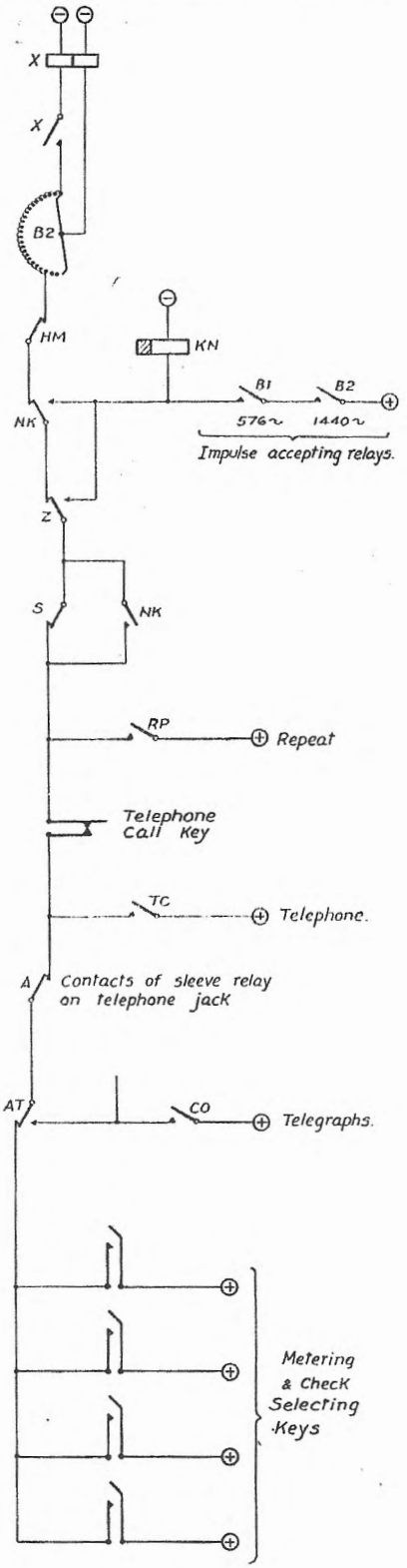


FIGURE 11

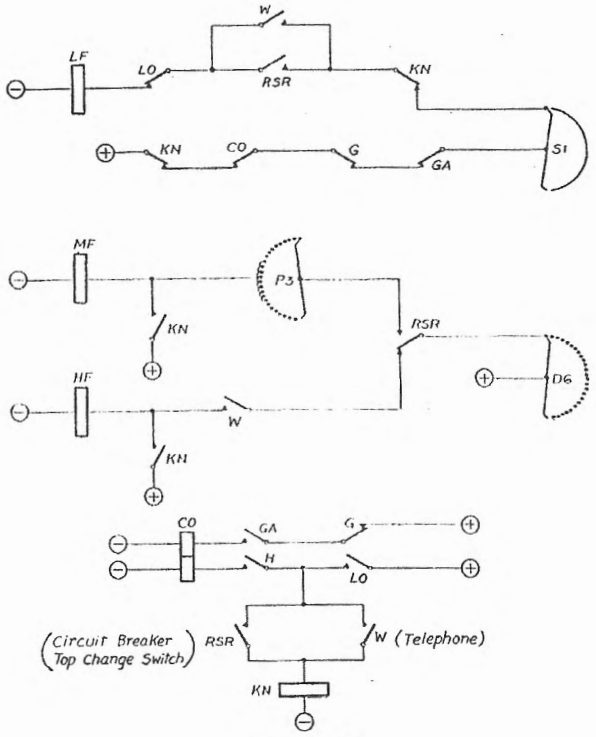


FIGURE 12

Referring to Fig. 11, relay X is the selection initiating relay, which operates and locks to the positive at the particular selecting key, or contact CO (telegraph), TC (telephone) or RP (repeat), operated. The selection initiating circuit is completed in series with the normal contacts HM, NK, Z and S. Whilst the whole of these contacts are not directly associated with the priority feature, it may be of interest to refer briefly to their functions. The HM contacts are always opened during the "homing" actions of the selecting uniselectors B and C and hence ensure that the process of establishing a selection cannot commence until both are on the "home" or starting contacts. Relay NK is the break-down relay which operates when both the medium and high frequency impulse accepting relays, B_1 and B_2, are actuated, due to the application of 576 and 1,440 cycles to the line at the sub-station, as explained later. Relay Z is slow releasing and is energised by the operation of either relay B_1 or relay B_2. As the transit time of the Z contacts is extremely small in comparison with the releasing time of relay NK, the latter relay remains locked up through its own contacts and restored Z contacts

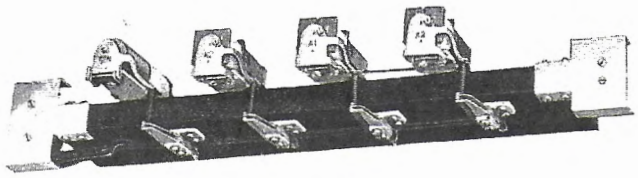


FIGURE 13

when relays B_1 and B_2 release. Mention may also be made of contacts S, which open when 288 cycles is applied to the line immediately prior to the actual transmission of circuit breaker pulses or the setting up of a telephone call initiated from the sub-station. Thus the operation of contact S ensures that the inadvertent operation of the telephone, telegraph and metering selecting keys does not interrupt the receipt of the incoming signals.

In the schematic diagram, Fig. 12, which shows the circuit elements at the sub-station, the contacts LO are always operated during the process of setting-up all selections, and also during the time that a selection remains set up, except a telephone call. It will be remembered that relay CO also remains locked up in series with H contacts operated on all selections, the telephone selection excepted. Relay RSR operates whenever a change in position of circuit breaker or tap change switch occurs, whilst relay W operates when a telephone call is initiated at the sub-station.

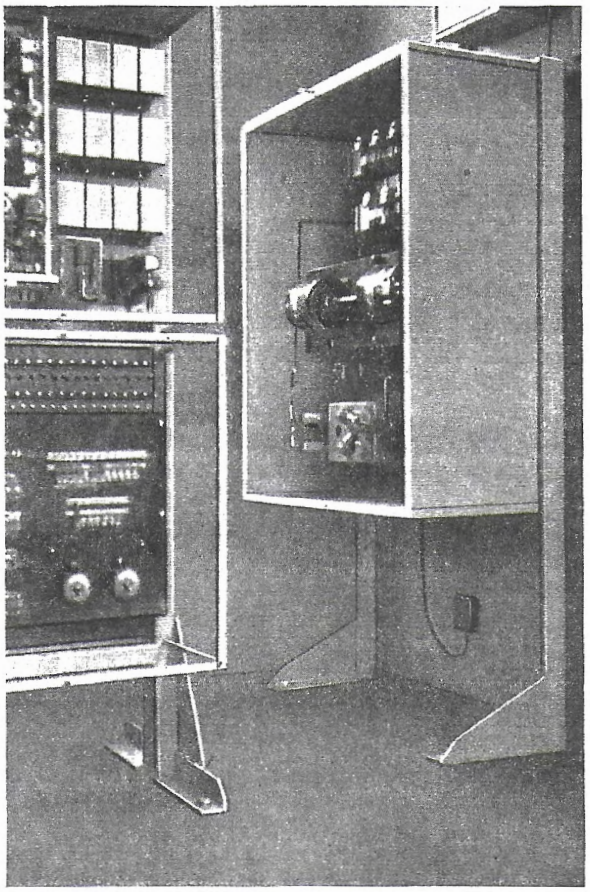


FIGURE 14

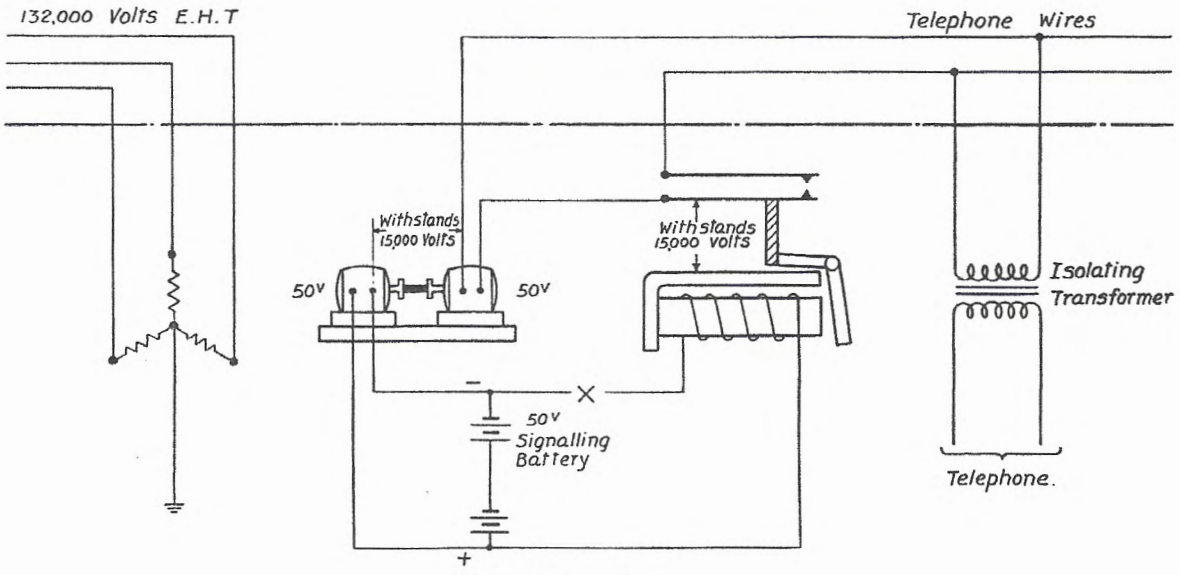


FIGURE 15

As regards changes in position of tap-change switches, over which telephone communications have priority, the circuit arrangements are such that the transmission of these signals is delayed until an existing telephone connection is cleared down. This is accomplished by taking the tap-change signal start circuit via the normally made contacts of relay N, which remain operated so long as a telephone connection is established.

Assuming now that either a telegraph or metering selection is established and that a circuit breaker trips or a telephone call is initiated at the particular sub-station, then relay RSR or relay W operates via operated LO contacts and in turn operates relay KN. The latter operates relays MF and HF which respectively apply 576 and 1,440 cycles to the line and thus operate relays B1 and B2 at the central indicating station. Referring now to Fig. 11, it will be seen that relay KN operates and prepares a locking circuit for itself, whilst relay X is released. The releasing of relay X removes 288 cycles from the line at the central station end and this releases relay LO at the sub-station, thus also releasing relays CO, KN, etc., and causing the apparatus at both ends to restore to normal. Whilst the releasing of relay KN at the sub-station removes 576 and 1,440 cycles from the line, relay RSR or relay W remains operated to initiate the setting up of the required signal in the manner previously mentioned.

Line Isolation

Special precautions are taken to ensure that the pair of signalling and telephone wires, which are included in the underground cable network of the British Post Office, shall not under any circumstances be affected by earth faults in the E.H.T. grid mains. As regards the more outlying stations, the signals for which are transmitted by voice-frequency impulses, adequate protection is ensured by the use of isolating transformers, designed to withstand 15,000 volts between windings. On the other hand, for the stations actuated by D.C. impulses, on which a 50 volts supply and the windings and contacts of various relays have to be in direct metallic contact with the line, special line isolation equipment—see Fig. 14—is provided. This equipment includes a small motor-generator, the motor of which is driven from the battery supplying the remainder of the signalling apparatus, and a number of line isolating relays. The latter are shown in Fig. 13, from which it will be seen that the contact springs are specially insulated from the heelpiece and coil, being designed to withstand safely a break-down test of 15,000 volts. The output from the small motor-generator is at 50 volts and, neither polarity being earthed, its employment for direct metallic connection with the line for the transmission of signals ensures that the potential of the line wires is not affected by changes in the potential of the power network main earth.

The coupling between the motor and generator is designed to withstand 15,000 volts.

Fig. 15 shows the elements of the line isolating equipment supplied for the stations signalled by D.C. impulses. It will be observed that, in the event of a line fault on the E.H.T. mains causing a relatively dangerous change in the potential of the main earth, the signalling wires are in no wise affected.

For permission to publish the above we are indebted to the Central Electricity Board.