

BRITISH RAILWAYS

(WESTERN REGION)

G.W.R.

TECHNICAL DESCRIPTION

OF

THE RELAY AUTOMATIC TELEPHONE

SWITCHBOARD

MODEL No. 10.

IN USE AT:-

NEWTON ABBOT.

THE RELAY AUTOMATIC TELEPHONE COMPANY LIMITED.

RELAY HOUSE. STREATHAM HILL. LONDON S.W.2.

FOLDER NO.211.

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"RELAY" SWITCHBOARD. MODEL NO. 10.SECTION 1. GENERAL DESCRIPTION.

"Model 10" is a small Private Automatic Switchboard designed to deal with a maximum of ten telephones.

Outside the United Kingdom the switchboard is only supplied fitted for this maximum but at Home may be supplied fitted for seven telephones. In the latter case an extension to the full capacity of ten telephones may be readily made at any time, space and wiring being provided for the extra equipment required, which consists of nine relays arranged in groups of three.

The telephones employed in connection with Model No. 10 switchboards are specially designed for the purpose. They are of the well known and convenient handset table pattern, and are fitted with the Post Office standard dial-switches. The trembler bell, which is also of special design, is apart from the table set and is usually fixed to the wall.

Only two wires are required between the switchboard and each instrument, but an earth (the positive pole of the battery is earthed) must also be connected to each telephone. As the switchboard is essentially designed for small premises however, the nearest convenient earth in many cases, will be at the switchboard itself, and for this reason a standard triple conductor ^{CABLE} will normally be used to connect up the phones. The limit of line resistance is placed at ten ohms per wire, i.e. twenty ohms loop and ten ohms in the earth connection. This allows a run of two hundred yards of standard cable. In the unusual case of longer runs, other arrangements may be made.

Provision is made in the switchboard for two simultaneous conversations; practice proving this number to give satisfactory service to ten extensions. Where, however, a switchboard is likely to be exceptionally busy, it is possible

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Section 1 - (continued)

to add a small group of relays externally, to allow of additional simultaneous conversations.

To discriminate between successful and unsuccessful calls, "ringing tone" is heard by the successful caller, during such time as the called party's bell is ringing. It is easily recognised, being provided by the called party's bell itself. Silence after dialling indicated either the Recorder, both Feeds, or the called party to be "engaged". (see Section 3). An extension is engaged from the time its handset is lifted - or it is called - until its handset is replaced; thus, no more than two telephones can be connected together at any one time.

By replacing the handset on its rest, a call can be "cleared" (i.e. all apparatus released and returned to normal) at any time before the called party answers. A completed call, however, is not cleared until both parties have replaced their handsets.

An eight volt battery serves the switchboard and arrangements for charging from the power mains are provided.

SECTION 2. APPARATUS. Drawings - T.23 and T.3413.

(a) THE TELEPHONE.

The telephone comprises a hand combination microphone and receiver; the cradle which carries the handset when not in use, a dial switch - dial, for short, - and trembler bell. The cradle is commonly termed a "switch-hook" as it operates a set of contact springs when relieved of the weight of the handset. These contacts are necessary to disconnect the bell when answering a call and also to disconnect the instrument from the line when it is not in use. On T.3413 the switch-hooks are

SECTION.2 (Continued)

represented in the normal, i.e. depressed position.

The dial, when released after being pulled round, intermittently breaks a circuit between the telephone and the switchboard, thus signalling the latter a description of the extension required. Dials are represented on T.3415 by circles enclosing three pairs of contacts, numbered 1 & 2, 3 & 4, 5 & 6. The two outer pairs (1 & 2)(5 & 6) are normally "open" i.e. not touching, and are known as "off-normal" contacts because they make contact during any period in which the dial is not at rest.

The centre pair of contacts (3 & 4) known as "impulse" contacts, are normally closed; when, however, the dial plate is released after having been pulled round they are rapidly opened and closed from one to ten times according to the number dialled.

(b) THE RELAYS.

With the exception of five resistances, Model 10 switchboard is composed entirely of the Relay Co's standard relays.

Each relay essentially consists of -

(1) A "YOKE" of soft iron which is the frame or base upon which other component parts of the relay are mounted and which forms part of the magnetic circuit. The yoke may be individual to a relay or common to two or three relays.

(2) A "COIL" or electro magnet, consisting of a bobbin with a soft iron 'core' and brass cheeks, carrying one or more windings of enamel covered wire.

(3) An "ARMATURE" of soft iron which completes the magnetic circuit by bridging the open ends of the yoke and coil, pivoting on the knife edge of the former and, by moving up to the latter

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SECTION 2 (continued).

when the relay is energised operating -

- (4) one or more "SPRING BANKS". These are groups of flat springs carrying contacts which are closed or opened by the movement of the armature.
- (5) A "DISTANCE PINCE" of plated brass which is interposed between the armature and core to provide a fixed residual gap and so prevent the armature sticking up due to the residual magnetism in the iron circuit.

SECTION 3. GROUPING OF RELAYS.

Excluding the charge cut off relay (C.C.O) which is only used when the battery is charged from the A.C.Mains via a rectifier, the total number of relays on a fully equipped Model 10 switchboard is forty-nine.

These relays are indicated on the circuit drawing T.3413, a key to which is provided by drawing T.23. A key to relay nomenclature will be found on T.3413.

The relays may be divided into three groups, Subscribers Apparatus, the Recorder and the Feeds.

- (a) SUBSCRIBERS APPARATUS. Associated with, and individual TO each line are one recorder connecting relay (RC), and one trunk connecting relay (TC) per Feed. RC serves to connect its line to the Recorder during the "dialling" or calling period. Either of the TC's will connect its line to a Feed during subsequent stages of a call.
- (b) RECORDER. This comprises impulse (I), guarding (G), testing (T), digit control 1 and 2 (DC1 and DC2) and the counting (C) and changeover (CH) relays. It's purpose is to select the line required according to the number dialled at the calling telephone and is available to only one line at a time. However, it is only in use

during

SECTION 3 (Continued).

the dialling period - a matter of seconds - at the end of which it is released and becomes available for other calls.

- (c) FEEDS. Two feeds are fitted on the standard Model 10. switchboard. Each comprises four relays, trunk marking (TM), ring^{-ING} (RG), ringing holding (RH), and feeding (F). A Feed is brought into use at the end of the dialling period and remains engaged for the duration of successful calls. It's first duty is to test the called line. If that line is busy the Feed will cause the release of all relays concerned with the call; if the line is free the Feed will connect the calling and called lines together, ring the latter's bell and, when the call is answered, provide speaking current to both transmitters and protect the conversation from interruption. The Feed will also cause the release of all relays concerned with a call which is abandoned by the caller replacing his received, whilst the called party's bell is ringing.

SECTION 4. CIRCUIT OPERATIONS. Drawings T.23 and T.3413.

This section contains detailed descriptions of the progress of calls under all possible conditions. Occasional references are made to the notes at the end of this section (4h) and it may be advisable to read them concurrently with these descriptions, as they concern not-too-obvious details regarding the characteristics and operation of certain relays.

The various conditions of calls to be considered are -

Successful calls - answered.

Successful calls - not answered, and abandoned by caller.

Call to engaged subscriber.

Call to subscriber whose handset is off the switch-

hook, or to a line which has no instrument fitted.
Call to a number for which the switchboard is not fitted.

Call when all feeds are engaged.

Call when the recorder is engaged.

In the following descriptions it is necessary to refer to individual springbanks on the various relays which are numbered (1) (2) (3) etc., For each associated relay, and described either as Normal - N, or Operated - OP.

The positive pole of the battery is always referred to as earth.

Frequent reference is made to:-

'G' earth - which is earth supplied via No.2 springset OP or G.

and 'Impulse earth' which is earth supplied to the recorder from G (No.1) OP via DC1 (No.3) OP and I (No.2) N, the circuit from DC1 (No.3) OP via I (No.2) N to the C and CH relays being known as the 'Impulse wire'.

(a) Successful call -answered.

- (1) Caller lifts his handset, operating the change-over contacts on the switch-hook.
- (2) The A wire is thus disconnected from the bell and connected to the B wire via the handset. No circuit is completed.

SECTION 4 - (CONTINUED).

Caller pulls dial round (see note 1), operating its off-normal contacts (1 & 2) and (5 & 6) and completing a circuit from negative via T (No.1)N, G.(No.3)N. RC(No.1) N. RC Coil TCs (No.4)N. B.Line, contacts (5 & 6) OP of dial which short circuits the hand-set, switch-hook contacts, contacts (1 & 2)OP of dial to earth.

- (4) RC operates and holds to the negative on RC (No.1)OP contacts, completing a circuit from negative via I coil DC2, (No.1)N. RC(No.2)OP impulse contacts (3 & 4)N of the dial, contacts (1 & 2)OP of dial to earth.
- (5) I operates and completes a circuit from neg. via GR. (See note 2), G. coil, I (No.1)OP to earth.
- (6) G operates and completes a circuit from neg. via CH1 coil CH1 (No.2)N, C1,5,9 (No.2)N, DC2 (No.4)N G (No.1) OP to earth.
- (7) CH1 operates, holds ^{via} CH1 (No.2)OP, CH2 (No.2)N. G(No.2)OP to earth, and completes a circuit from neg. via C4.8 coil C.4.8(No.3)N, CH1 (No.3)OP C1.5.9.(No.2)N. DC2 (No.4)N. G(No.1)OP to earth.
- (8) C4.8 operates, holds via C4.8 (No.3)OP ^{C1}~~CH~~.5.9(No.1) N, G(No.2)OP to earth, and completes a circuit from Neg. via GR, DC2 (No.6)N. C4.8(No.2) ^{OP}~~OP~~ DC1 coil, DC2 (No.3) N. G (No.2)OP to earth.
- (9) DC1 operates.

The recorder is now ready to receive impulses from the dial and no further operations occur until the dial is released.

- (10) Caller releases his dial. Assuming the tenth extension (No.0) is to be called, the dial will be pulled round to its fullest extent and when released will send ten 'impulses' to the recorder. This means that the impulse contacts (3 & 4) of the dial will break and remake the circuit of I ten times. The resulting operations are as follows:-

Section 4 - (Continued).

- (11) FIRST BREAK - I releases (see note 3) and completes a circuit from neg. via C1,5,9 coil C1,5,9(No.4)N C3.7, (No.6)N C4.8 (No.5) OP to Impulse earth.
- (12) C1,5,9 operates and holds via C.1,5,9 (No.4)OP C2.6.0 (No.1)N G(No.2)OP to earth, completing a circuit from neg.via DC2 coil, C1.5,9 (No.3)OP G (No.1)OP to earth. C4.8 now holds via C.4.8(No.3)OP, C1.5.9 (No.1)OP to the impulse earth.
- (13) DC2 operates and holds via DC2(No.4)OP G(No.1)OP to earth. DC1 is now holding in a circuit from neg.via GR, I(No.1),N. DC2(No.5)OP. DC2(No.6)OP C4.8(No.2)OP DC1 coil, DC1(No.2)OP. G(No.1)OP to earth. The circuit for I is via DC1(No.1)OP instead of DC2(No.1)OP and RC is holding in a circuit from neg.via RC(No.1)OP RC coil, RC(No.3)OP, DC2(No.3)OP. G(No.2)OP to earth.
- (14) FIRST REMAKE - I operates (See Note3) and breaks the impulse earth, hence
- (15) C4.8 releases
- (16) SECOND BREAK - I releases and completes a circuit from neg.via C2.6.0 coil, C2.6.0(No.2)N. C1.5.9, (No.5)OP C4.8(No.4)N to the impulse earth.
- (17) C2,6,0 operates and holds via C2.6.0(No.2)OP C3.7(No.1)N G(No.2)OP to earth. C1.5,9 now holds via C.1.5.9(No.4)OP or C2.6.0(No.1)OP to the impulse earth.
- (18) SECOND REMAKE - I operates and breaks the impulse earth hence
- (19) C1.5,9 releases.
- (20) THIRD BREAK - I releases and completes a circuit from neg.via C3.7 coil (C.3.7(No.3)N, C2.6.0(No.3)OP. C1.5.9, (No.5)N. C4.8 (No.4)N to the impulse earth.
- (21) C3.7 operates, holds via C.3.7(No.3)OP C4.8(No.1)N G(No.2) OP to earth and completes a circuit from neg.via CH2 coil, CH1 (No.1)OP C3.7(No.2)OP G(No.2)OP to earth.

Section 4 - (Continued)

(21) Contd.

C2.6.0 now holds via C2.6.0(No.2)OP. C3.7(No.1)OP to the impulse earth.

(22) CH2 operates. CH1 is now holding via CH1(No.2)OP.

CH2 (No.2)OP. C3.7(No.4)OP G (No.2)OP to earth.

(23) THIRD REMAKE - I operates and breaks the impulse earth, hence

(24) C2.6.0 releases

(25) FOURTH BREAK - I releases and completes a circuit from neg.via C4.8 coil C.4.8(No.3)N. C.3.7(No.5)OP C2.6.0 (No.4)N to the impulse earth.

(26) C4.8 operates and holds via C.4.8(No.3)OP C1.5.9.(No.1)N.
G(No.2)OP to earth. C3.7 now holds via C.3.7(No.3)OP.
C4.8(No.1)OP to the impulse earth.

(27) FOURTH REMAKE - I operates and breaks the impulse earth, hence

(28) C3.7 releases and breaks the circuit for CH1. CH2
now holds via CH2(No.1)OP C3.7(No.2)N G(No.2)OP to earth.

(29) CH1 releases

(30) FIFTH BREAK - I releases and completes a circuit from neg.via C1.5.9 coil, C.1.5.9(No.4)N. C3.7(No.6)N C4.8 (No.5)OP to the impulse earth.

(31) C1.5.9 operates and holds via C.1.5.9(No.4)OP C2.6.0 (No.1)N. G(No.2)OP to earth. C4.8 now holds via C.4.8 (No.3)OP, C1.5.9(No.1) OP to the impulse earth.

(32) FIFTH REMAKE - I operates and breaks the impulse earth, hence

(33) C4.8 releases

(34) SIXTH BREAK - I releases and completes a circuit from neg. via C2.6.0 coil, C2.6.0(No.2)N C1.5.9(No.5)OP C4.8(No.4)N to the impulse earth.

Section 4 - (Continued)

- (35) C2.6.0 operates and holds via C.2.6.0(No.2)OP C3.7
(No.1)N. G(No.2)OP to earth. C1.5.9 now holds via C.1.5.9
(No.4)OP. C2.6.0(No.1)OP to the impulse earth.
- (36) SIXTH REMAKE - I operates and breaks the impulse earth,
hence
- (37) C1.5.9 releases
- (38) SEVENTH BREAK - I releases and completes a circuit
from neg. via C3.7 coil C.3.7(No.3)N, ^CC2.6.0(No.3)OP
C1.5.9(No.5) N. C4.8(No.4)N to the impulse earth.
- (39) C3.7 operates and holds via C.3.7 (No.3)OP. C4.8(No.1)N
G(No.2)OP to earth, breaking the circuit for GH2. C2.6.0
now holds
- (40) GH2 releases
- (41) SEVENTH REMAKE - I operates and breaks the impulse
earth hence
- (42) C2.6.0 releases.
- (43) EIGHTH BREAK - I releases and completes a circuit from
neg. via C4.8 coil, C.4.8(No.3)N, C3.7(No.5)OP. C2.6.0
(No.4)N to the impulse earth.
- (44) C4.8 operates and holds via C.4.8(No.3)OP. C1.5.9(No.1)
N. G(No.2)OP to earth. C3.7 now holds via C.3.7(No.3)OP
C.4.8(No.1)OP to the impulse earth.
- (45) EIGHTH REMAKE - I operates and breaks the impulse earth,
hence
- (46) C.3.7 releases
- (47) NINTH BREAK - I releases and completes a circuit from
neg. via C1.5.9 coil, C.1.5.9(No.4)N C3.7(No.6)N C4.8
(No.5)OP to the impulse earth.
- (48) C1.5.9 operates and holds via C.1.5.9(No.4)OP. C2.6.0
(No.1)N. G(No.2)OP to earth. C4.8 now holds via
C.4.8(No.3)OP, C1.5.9 (No.1)OP to the impulse earth.

Section 4 - (Continued)

- (49) NINTH REMAKE - I operates and breaks the impulse earth, hence
- (50) ^C C4.8 releases
- (51) TENTH BREAK - I releases and completes a circuit from neg. via C2.6.0 coil, C.2.6.0(No.2)W. C1.5.9(No.5)OP. C4.8(No.4)W to the impulse earth.
- (52) C2.6.0 operates and holds via C.2.6.0(No.2)OP. C3.7 (No.1)W. G(No.2)OP to earth. C1.5.9 now holds via C.1.5.9(No.4)OP. C2.6.0(No.1)OP to the impulse earth.
- (53) TENTH REMAKE - I operates and breaks the impulse earth hence,
- (54) C1.5.9 releases
- (55) The dial has now completed its travel and its impulse contacts (3 & 4) remain closed, holding I operated. Whilst I is operated the slow releasing relay DC1 is short-circuited (see note 3), thus - Earth, I (No.1)OP DC2(No.5)OP, C4.8(No.2)W. DC1 coil, DC1(No.2)OP. G(No.1)OP to earth, hence, after a slight pause
- (56) DC1 releases (see note 4), breaking the circuit for I and completing a circuit from neg. via TM coil F(No.2)W, DC2(No.2)OP, DC1(No.2)W. G(No.1)OP to earth.
- (57) I releases and TM operates (see note 5). (The circuit for G is broken when I releases but, being slow to release, G allows the following operations (58 to 62), resultant upon the operation of TM, to take place before it actually releases).
- (58) The operation of TM completes three circuits:-
- (a) from neg. via calling party's TC coil, TM contacts OP calling party's RC(No.3)OP. DC2(No.3)OP. G (No.2)OP to earth. Calling party's TC operates. Calling party's RC now holds via RC(No.3)OP DC2 (No.3)OP G(No.2)OP to earth.
- (b) from neg via called party's TC coil (in this

Section 4 (Continued)

case No.0, TM contacts OP both TCs No.0 (No.1 contacts)

^{MARKING WIRE 0,}
N. CH2 (No.3)N. CH1(No.5)N C2.6.C(No.5)OP ~~as~~ C1.5.9

(No.6)N.C4.8(No.6)N. DC1(No.3)N. G(No.1)OP to earth.

TC No.0 operates and holds (see note 6) via TC(No.3)OP,
calling party's TC(No.3)OP, TM contacts OP, calling party's
RG(No.3)OP, DC2(No.3)OP. G(No.2)OP to earth.

(6) from neg. via RG coil, TM(No.5)OP F(No.3)N to
earth, RG operates

(59)Two TCs (calling and called) associated with one feed
and RG in that feed are now operated. RG completes a
circuit from neg. via one coil of F, TM(No.4)OP, RG(No.3)
OP, RH coil to Earth. (Note: the current in this circuit
is insufficient to operate F). (See Note7)

(60)RH operates and completes a circuit from neg. via
FR, RH(No.1)OP one coil of F to earth.

(61) F operates. RG now holds from neg. via its coil RG
(No.1)OP called TC(No.2)OP, A line, impulse contacts
(3 & 4)N of dial, switch hook contacts, bell to earth.
(see note 8).

(62)Called party's bell commences to ring

The operations 58 to 62 inclusive are all
completed before-

(63)G releases, (See note 3) breaking the earth at (G1)
&(G2) and thus

(64)releasing all recorder relays that were still operated,
in this case, C2.6.0 and DC2, and also TM in the Feed
and the calling RC. The TC relays now hold from neg
via TC coils, TC(No.3)OP, HR, RG(No.4)OP. F(No.3)OP to
earth. RH now holds from neg. via RG coil, RG(No.1)OP,
calling TC(No.2)OP. A line, instrument, B line, TCs(No.4)
OP. TM(No.4)N. RG(No.3)OP. RH coil to earth.

(65)The ringing period has now commenced.

(66)The called party lifts his handset, thus disconnecting

(66) contd.

following circuit set up - Neg. via RG coil, RG(No.1)OP
calling and called TCs (No.4)²OP^{A LINES, INSTRUMENTS, B LINES, TCs (No.4)OP} all in parallel; TM
(No.4)N. RG(No.3)OP. RH coil to Earth. The resistance
of RH is such that the maximum current in this circuit
is insufficient to hold RG, hence

(67) RG releases. RH releases. F now holds from neg. via
one of its coils, RG(No.3)N. RG(No.2)N, both calling
and called lines and instruments in parallel via contacts
on TCs, OP. RG(No.1)N, F(No.1)OP. RH(No.1)N, other coil
of F to earth.

(68) This is the talking condition. The transmitters of both
instruments are supplied with talking current via the
coils of F.

(69) Release of connection

As F will hold in circuit with one line and instrument
only, it is not until both switch-hooks are down that-

(70) F releases and breaks the holding circuit for both TCs.

(71) Both TCs release, and all relays are now de-energised.

The foregoing describes the dialling of digit "9"
(ten impulses) because the fullest working of the recorder
is entailed. The result of dialling other digits may easily
be followed. Take, for example, the digit 7. Operations
will be as described in Section 4a up to and including the
Seventh remake (41) and its immediate result (42); i.e. up
to the point where seven complete impulses have been sent
by the dial. From this point, 55 and onwards will apply
in general, the main difference being that the Recorder
setting, i.e. the C and CH relays operated, will be such as
to complete the Marking Wire corresponding to the number
dialled, modifying 58(b) to that extent. If seven were
the digit dialled it will be seen that when marking takes

Section 4 (Continued)

place C3.7 would be the only C relay operated (see 39) and both CH relays would be down, hence 58(b) would read:-

"from neg. via called party's TC coil, (in this case No.7) TM ~~TM~~ contacts OP both TCs No.7 (No.1)N, marking wire No.7, CH1(No.4)N, C3.7(No.7)OP. C2.6.0(No.5)N. C1.5.9(No.6)N. C4.8(No.6)N. DC1.(No.3)N. G(No.1)OP to earth. TC No.7 operates and holds via TC(No.3) OP, calling party's TC(No.3)OP. TM contacts OP calling party's RC(No.3)OP. DC2(No.3)OP. G(No.2)OP to earth."

(b) SUCCESSFUL CALL, NOT ANSWERED AND ABANDONED BY CALLER.

Circuit operations up to and including the commencement of the ringing period are, of course, as described in 1 to 65. From that stage of the call, operations proceed as follows.

(72) Caller abandons the call by replacing his receiver, thus breaking the circuit for RH (See 64) at the switch-hook contacts.

(73) RH releases, breaking the circuit for ~~M~~ F

(74) F releases and breaks the holding earth for the TCs.

(75) Both calling and called TCs release, and the latter breaks the circuit which includes RG and the bell.

(76) RG releases and the bell ceases ringing. All relays are now de-energised.

(c) CALL TO AN ENGAGED SUBSCRIBER.

Again assuming "0" to be the wanted number-engaged, this time - operations as described in 1 to 57 all take place. Resultant upon the operation of TM (see 57) the calling party's TC operates as shown in 58a and RG operates as shown in 58c.

As line No.0 is already engaged, one of its TC relays is energised, breaking the marking wire "0". Hence, the other TC No.0 can NOT operate as was described in 58b.

Section 4 (Continued)

Operations proceed:-

- (77) RH operates as shown in 59
- (78) F operates as shown in 60, breaking the circuit for RG
- (79) RG releases (it is not held as shown in 61 because TC No.0 is not operated) and breaks the circuit for RH.
- (80) RH releases. F now holds in a circuit from neg. via one of its coils, RG(No.3)N, RG(No.2)N, calling TC(No.4)OP, B wire, calling instrument, A line, calling TC(No.2)OP, RG(No.1)N, F(No.1)OP, RH(No.1)N, other coil of F to Earth.

The above operations are all completed before:-

- (81) G releases (See 57), breaking G(1 & 2)OP and thus
- (82) releasing any G and CH relays that were still operated, in this case C2.6.0 and also the calling RG. TM is now held momentarily in a circuit from neg. via its coil, TM(No.³OP, RG(No.4)N, F(No.3)OP to Earth. DC2 is now held momentarily in a circuit from neg. via its coil DC²(No.4)OP, DC1(No.2)N, DC2(No.2)OP, TM(No.1)OP, ^{TM(N^o3)OP} RG(No.4)N, F(No.3)OP to Earth. Because the calling RG has released:-
- (83) The calling TC releases (having no holding circuit via HR because RG is de-energised, and TM operated), and breaks the circuit for F.
- (84) F releases breaking circuits for TM and DC2
- (85) TM and DC2 release.

All relays concerned with the call are now released, although the handset at the calling instrument is still off its rest.

The fact that nothing is heard in the receiver although dialling is completed indicates the engaged condition. The position is, in fact, as described in (2) and it is possible to dial afresh without depressing the switch-hook first.

- (d) CALL TO A SUBSCRIBER WHOSE HANDSET IS OFF ITS SWITCH-HOOK, OR TO A LINE WHICH HAS NO INSTRUMENT FITTED.

In both of these cases the fact that there is no bell connected to the A line (in the first case because the switch-hook contacts are operated) causes all relays concerned with either call to be released at the end of the marking period, i.e. the series of operations commencing with the operation of TM. The absence of ringing tone indicates the engaged condition to the calling party.

Circuit operations up to the marking period are as described in 1 to 60. When F operated, however, (see 61), the circuit for RG is broken and:-

(86) RG releases (it is not held as shown in 61 because the called A line is not connected to Earth via the bell) and breaks the circuit for RH.

(87) Subsequent operations are as described in 80 to 85 inclusive - with two exceptions:-

(a) In the case where the called party's receiver is off its switch-hook, F holds (see 80) via both calling and called TO contacts, lines and instruments in parallel.

(b) In either case, the release of the calling RG (See 82 and 83) causes the release of both TOs.

(c) CALL TO NUMBER FOR WHICH THE SWITCHBOARD IS NOT FITTED.

When a Model 10 Switchboard is fitted for seven lines only, three marking wires (usually Nos. 8, 9 and 0) are not used and although the actual wires are provided, they are laced up with their ends insulated, ready to be connected to the additional apparatus if and when it is fitted. The marking wire associated with an extension is broken (on a TO) if that extension is engaged, thus the operations resultant on a call to any of these numbers will be identical to those which would occur if the

subscribers apparatus associated with that number were fitted but engaged at the time of the call. (A description of such a call is given in Section 40).

(f) CALL WHEN ALL FEEDS ARE ENGAGED.

When a Feed is engaged the operating circuit for TM is broken by F (No.2) OP, hence, when all Feeds are engaged no TM will be operated when DC1 releases at the end of the dialling (See 56). The operations from this point will be:-

(88) I releases and breaks the circuit for G.

After a pause:-

(89) G releases, breaking G (Nos. 1 & 2) OP and thus

(90) releasing all recorder relays that were still operated, in this case G2.6.0 and DC2 and also the calling RC

(91) All relays are now released and conditions are as described in 85.

(g) CALL WHEN THE RECORDER IS ENGAGED.

The Recorder is only engaged during the dialling period, but it is possible that a second caller may pull his dial round during that period.

(92) Whilst the Recorder is engaged G is operated, thus when the second dial is pulled round a circuit is completed from neg. via T. Coil, RC(No.1)N RC coil of second calling RC, TCs (No.4)N B line, dial contacts (Nos. 5 & 6)OP contacts of switch-hook, dial contacts (Nos. 1 & 2) OP to Earth.

(93) T operates (owing to the comparatively high resistance of T, there is not sufficient current in the circuit to operate RC) and remains operated until the dial has returned to rest and its contacts Nos.(1 & 2)(5 & 6) OP are opened again.(See note 9)when

(94) T releases and conditions are as described in 85

* 18 *

Section 4 (Continued)

(h) NOTES

1. OPERATING THE DIAL.

The speed with which the relays concerned operate is such that it is impossible for a caller to pull round his dial - even if only to digit 1 - quickly enough to be able to release it before the operations described in 3 to 9 have taken place.

2. GR is provided to prevent the battery being short-circuited when I operates or releases and all three contacts (No.1) are momentarily touching.

3. SLOW RELEASING RELAYS. G and DGI are slow releasing relays, that is, their armatures do not fall immediately the circuit for the coil is broken, but remain in the operated position for a short period. This effect is attained by providing a path for eddy currents, mainly by fitting a copper ring or 'slug' to the core and partly by short-circuiting the coil instead of merely disconnecting it.

It will be observed that when I is operated, G has a circuit from neg. via GR, G coil, I (No.1) OP to Earth and when I releases G coil is short-circuited by I (No.1) N. When I repeats impulses from a dial it never remains down long enough for G to release and thus G remains up during dialling. After DGI releases at the end of dialling, however, I releases permanently and G eventually releases, the time it takes to do so providing the "marking" period. (See 57 to 63).

When DGI and DGS are operated and I is down (See 13) DGI has a circuit from neg. via GR, I (No.1) N, DGS(No.5)OP, DGS(No.6)OP, G4.8(No.2)OP, DGI coil DGI(No.2) OP, G (No.1) OP to Earth.

Section 4 (Continued)

When I operates, however (See 14), neg. via GR is replaced by Earth and DC1 is short-circuited. During impulsing I is never operated long enough for DC1 to release, but at the end of impulsing (See 55), when the dial has come to rest, I remains operated and DC1 eventually releases.

4. IMPULSE EARTH 'MADE' ON DC1.

The Impulse earth passes over DC1 (No.3) OP for the following reason. At the end of impulsing DC1 releases, then I releases and G temporarily holds the recorder setting. (See 56 and 57). If DC1 did not break the Impulse earth when it released an extra impulse would be sent to the counting relays when I released.

A special adjustment to the contacts of DC1 is indicated on T.3413. The adjustment is required to prevent the slight possibility of relay I and DC1 'bussing' at the end of impulsing.

The 'buss' which is of very low frequency, may occur if, when DC1 releases at the end of impulsing, DC1(No.1)OP which holds I (contact 'A') breaks before the DC1(No.2)OP over which DC1 itself holds (contact 'B') thus:-

DC1 is short-circuited by I at the end of impulsing (55) and falls slowly. Contact 'A' breaks, I releases and completes the circuit for DC1 (13) before that relay has fallen far enough to break the circuit at contact 'B'. DC1 re-energises, I releases - and so on.

To definitely prevent this, contact 'A' must be adjusted so as to be the first to close when DC1 operates.

Section 4 (Continued)

5. 'SEARCH' FOR FEED.

The Marking period commences when DC1 releases after impulsing and passes earth via G(No.1)OP, DC1(No.2)N, DC2(No.2)OP to the TM relays (See 56). Actually all TM relays associated with disengaged Feeds commence to operate. The first, however, is adjusted to be a little quicker than the others and once it has operated TM (No.1) contact, the circuit for all other TMs is broken. If a third Feed is fitted the second TM is adjusted to be a little quicker than the third. Thus only one TM is operated at the commencement of the marking period - that associated with the first disengaged Feed.

6. Q BANK ON TO RELAYS.

On each TO relay are two pairs of contacts, TO (No.1) and TO (No.3), distinguished on T.3413 by the letter 'q'.

In practice these two pairs of contacts are mounted on one bank of springs (known as a q Bank) so arranged that when operated the make contacts close before the break contacts part.

TO (No.3) contacts complete a holding circuit for TO before TO (No.1) contacts disconnect the 'marking' (operating) earth, so preventing any possibility of TO releasing or 'buzzing' during the marking period. (See 58b).

7. THE OPERATING CIRCUIT OF RH is via one coil of F to neg. The resistance of RH is too great to allow F to operate when this contact is operated, and the arrangement is a matter of convenience in arranging contacts on RG and TM.

Section 4 (Continued)

8. RG HOLDING CIRCUIT.

RG holds in series with a called party's bell whilst it is ringing. The bell operates on the usual buzzer principle, breaking the circuit for its coils on a contact carried by its armature. To prevent the circuit for RG being broken by this contact the whole bell - contact and coils - is shunted by a resistance of 100 ohms.

9. USE OF RELAY T.

Whilst the Recorder is in use G(No.3)OP removes the short-circuit from T coil which will then form part of the circuit completed if a second subscriber pulls his dial round (See 4g). By arranging that T, once operated, prevents G replacing the short-circuit immediately the recorder is released, the second subscriber is still prevented from obtaining connection to the recorder. This is necessary since his dial may have already been released and sent one or more impulses at the time of the Recorder's release and if the Recorder were allowed to come into operation at that time it would receive less impulses than were sent by the dial.

SECTION 5. NOTES ON TESTING. Drawings T.23 and T.3413.

The following methods of testing various parts of the apparatus by pushing up the armatures of certain relays, may be of use in studying the circuit operations or in localising faults.

1. SUBSCRIBERS APPARATUS.

(95) PUSH UP RG. This completes a circuit from neg. via I coil DO2(No.1)N, RG(No.2)OP, A wire, impulse contacts of dial (3 & 4)N, change-over contacts of switch-hook

Section 5 (Continued)

bell to Earth.

- (96) The bell rings and I operates, preparing the Recorder as described in 6, 7, 8 and 9.

2. FEEDS

- (97) PUSH UP TM, completing a circuit from neg. via RG coil TM(No.5)OP, F(No.3)N to Earth.
- (98) RG operates, completing a circuit from neg. via one coil of F, TM(No.4)OP, RG(No.3)OP, coil of RH to Earth.
- (99) RH operates (F will not operate in series with RH), completing a circuit from neg. via FR, RH(No.1)OP one coil of F to Earth.
- (100) F operates and breaks the circuit for RG.
- (101) RG releases and breaks the circuit for RH.
- (102) RH releases and breaks the circuit for F.
- (103) F releases and again completes the circuit for RG (97), which again operates RH - and so on, with the result that:-
- (104) R G, RH and F 'buzz'.

3. RECORDER.

PUSH UP I, which prepares the Recorder as in 96.

HOLD DC1 and G in their operated position and it is possible to send impulses into the Recorder at any speed desired by allowing I to fall back and then pushing it up again. In this way the action of the Recorder at each break and re-make may be examined at leisure.

If, after sending a number of impulses to the Recorder in this manner, I is held up - holding G and hence the Recorder setting - and DC1 is allowed to fall, marking to the associated line will take place, the condition of the Feed being as described in 59, 60 and 61.

Section 5 (Continued)

By allowing I to fall back all relays will be released.

SECTION 6. BATTERIES AND CHARGING ARRANGEMENTS. Drawings A.9465 and B.9514.

BATTERIES. A battery of eight volts is required to serve the standard Model 10 switchboard. Working at this unusually low voltage, voltage drop due to resistance in the battery and its leads must be avoided as far as possible.

For this reason it is desirable to use secondary cells, although the current consumption of the switchboard is small. These considerations led to the adoption of four 'Exide' D.F.G. type accumulators as the standard battery.

Arrangements for charging from A.C. or D.C. mains are provided.

CHARGING FROM A.C. MAINS. Drawing B.9514.

One standard battery is employed. It is permanently connected to the switchboard and also connected, via the break contacts of the charge-cut-off relay (C.C.O) to the output or D.C. side of a valve rectifier. The input or A.C. side of the rectifier may be connected to the A.C. mains by a switch (marked CHARGE) when it is desired to charge the battery.

The D.C. supplied to the battery from the rectifier is pulsating, or varying in intensity, at twice the frequency of the A.C. current. If the battery were on charge and a call set up in the switchboard, a hum corresponding to this frequency would be audible in the subscribers receivers.

Section 6 (Continued)

To prevent this occurring, the charge-cut-off relay (C.C.O.), is operated by all F relays (See T.3413) and breaks the charging circuit between the output side of the rectifier and the battery. Immediately the switchboard becomes free of calls and all F relays are at rest, C.C.O. releases and charging is resumed.

It should be noted that C.C.O. only breaks the output side of the rectifier, the input still being connected to the D.C. mains via the CHARGE switch. The rectifier, of course, contains a transformer which isolates the battery from the Mains.

CHARGING FROM D.C. MAINS. Drawing A.9465.

In this case it is necessary to employ two batteries in order that the switchboard may always be isolated from the Mains, which are directly connected to the battery on charge.

A charging resistance which takes the form of a lamp is employed to limit the charging current to the correct value.

The circuit is practically self explanatory. Each battery may be switched either to DISCHARGE, when it is connected to the Switchboard, or to CHARGE, when it is connected to the POWER SWITCH via the charging resistance. The POWER SWITCH disconnects the Mains from the battery switches when no battery is to be charged.

Each battery switch is provided with a centre 'off' position which entirely disconnects the battery.

To ensure that battery shall not be cut off from the switchboard care should be taken that there is always one of the battery switches in the discharge position; when it is necessary to take a battery off discharge the other battery should be switched to DISCHARGE first.

SECTION 7. CURRENT CONSUMPTION.

The average currents taken from the 8 volt battery under various conditions are listed below:-

<u>Condition</u>	<u>Current</u>
(a) Recorder prepared (See 3-9)	.6 amps.
(b) Marking period (See 56-62)	1.2 amps.
(c) Ringing period (See 65)	.4 amps.
(d) Talking period (See 68)	.18 amps.

Two or more of these conditions may occur simultaneously. The total current taken, of course, is the sum of the two corresponding figures given above. The maximum demand cannot exceed 1.6 amps (one subscriber Ringing and another Marking) unless a third Feed is fitted, giving provision for a third subscriber Ringing and so increasing the maximum demand to 2 amps. The Marking period is responsible for the greater proportion of these maximum demands which are, therefore, of extremely short duration.