P W—B 2

B 2

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject :

TELEGRAPH CONCENTRATORS

ENGINEER-IN-CHIEF'S OFFICE
1919

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[*Continued on page iii of Cover.*

CORRECTION SLIP TABLE

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TELEGRAPH CONCENTRATORS

(B.2)

The following pamphlet in this series is of kindred interest:—

B.1. Elementary Principles of Telegraphy and Systems up to Morse Duplex.

TELEGRAPH CONCENTRATORS.

TABLE OF CONTENTS.

TELEGRAPH CONCENTRATORS.

INTRODUCTION OF THE SYSTEM.

The general extension of the telegraph system to outlying villages and country districts has led to the installation of a great many circuits which, although very necessary for the convenience of the public, are yet called upon to carry a comparatively small amount of traffic. When several such circuits radiate from a single transmitting centre, great advantage results from connecting the lines to " Switch Jacks " and indicators upon a suitable switchboard instead of appropriating a separate telegraph instrument to each line, and the Post Office therefore, in 1892, introduced for this purpose a form of " Concentrator Switch " constructed on similar lines to the telephone switches then in use.

Such a switch provides the means for connecting any line to one of a number of " Switch Working Sets " when a message has to be sent or received. Under the best conditions a very considerable economy in apparatus and office space can be effected in this way, with the further and very important advantage that the telegraphists are relieved from the necessity of keeping a watch upon several different instruments, and of moving about from one to the other.

All calls are received by the switch operator, who connects the calling line through to a disengaged working set, the telegraphist at which is thus put in communication first with one line and then with another without the necessity arising for a change of position.

At slack periods the whole of the messages dealt with can be confined to a few working sets, the labour of supervision being thus simplified and the despatch of the work expedited.

This facility for the concentration and effective supervision of staff has, in fact, led to the inclusion upon the switches of many lines which require the continuous use of a working set for two or three hours in the middle of the day.

The connection of such a line to a switch of course effects no saving of apparatus, since an additional working set must be added at the same time.

GENERAL DESCRIPTION.

The advantages of concentrator switches may be summarised thus :—

(a) Saving of apparatus sets due to the latter being based on the busy hour traffic load and not on the number of lines to be concentrated.

(b) Saving of table space.

(c) Concentration of supervision.

On a circuit which is concentrated the line is led through a jack to an indicator or indicating relay, and a call from the distant station energises the indicator or relay. The locals of the indicator or relay may be connected with either a bell or a lamp signal. To answer the call a two-way plug is plugged into the jack, and the arrangements are such that the tip of the plug connects the apparatus set with line whilst the " ring " of the plug completes a " clearing " signal circuit, which is normally disconnected at a press button forming part of the apparatus set. When the telegraphist at the apparatus set has cleared the traffic to and from the office which has been plugged through to the set at which he or she is working, the press button is operated and a battery current is sent through the indicating relay *via* the " ring " of the plug, thus giving the concentrator switch operator a clearing signal.

Telegraph circuits may be concentrated during both day and night, may be concentrated only during the less busy parts of the day and during the night, or, in consequence of their special character (*i.e.*, Machine Telegraphs, Special Wheatstone and other types of special circuits), may not be concentrated at all. In all large telegraph offices, apart from the usual small number of special circuits, all lines working to that office, after passing through the test box, are brought to a concentrator switchboard, of which there may be several in different parts of the office.

In the development of Telegraph Concentrator Switchboards, the following improvements have been effected :—

(a) The locals of the line relay close a lamp circuit which constitutes the calling signal.

(b) A pilot lamp is fitted by means of which a separate indication is given to the switch operator that attention is required at the switchboard.

(c) The Apparatus Working Sets may be used in connection with both C.B.S. and ordinary Morse circuits.

(d) The lamp jacks and relay strips permit of a more compact form of switchboard.

(e) By the use of an Electro-magnetic Indicating Key, the telegraphist at the Working Set, after giving the usual clearing signal, obtains an indication when the switch operator has withdrawn the plug at the switchboard.

From the following notes on the different systems in use the evolution of the Telegraph Concentrator Switchboard will be easily traced.

The arrangement of a circuit that is concentrated on the type of Switchboard equipped with Non-polarised Indicator Relays is shown in Fig. 1.

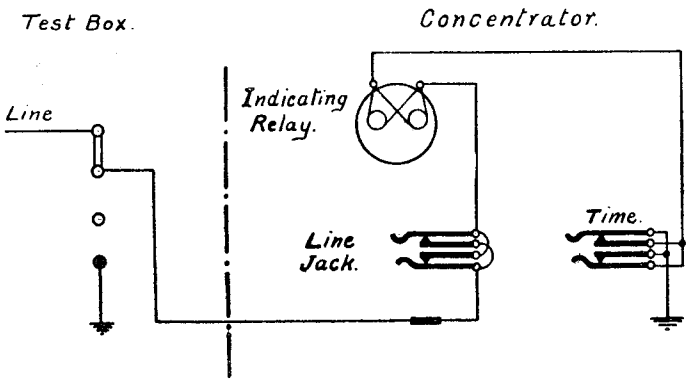


Fig. 1

The jack labelled " Time " in the diagram is the common connection to earth of all the concentrated circuits worked on the same system, *i.e.*, a separate time jack is provided for each different system, one for the D.C. Sounder circuits, another for the A.B.C. circuits, another for the single needle or D.P. Sounder circuits, and so on. The use of the time jacks will be explained later. In the case of central battery circuits the termination is somewhat different.

The concentrator may thus be regarded as arranged on the same lines as a telephone exchange switch, with this exception, that provision is not made for connecting the lines through to each other, but merely for connecting them through to suitable telegraph instruments by means of which telegrams may be sent or received.

For each group of circuits of the same type that is concentrated, a sufficient number of sets of apparatus of that type is provided which will suffice for the traffic of the " busy hour." The number of instruments provided with staff can be varied from time to time as the traffic requires, and during the night, or on Sundays, when messages are few and far between, one telegraphist can attend to a large group of circuits without moving from his seat.

Each set of apparatus terminates in a plug, as shown in Fig. 3, the plugs being arranged in a row on a plug shelf in front of the concentrator.

THE CONCENTRATOR.

The type of concentrator shown in Fig. 2 is now regarded as obsolete and is being replaced by more modern types.

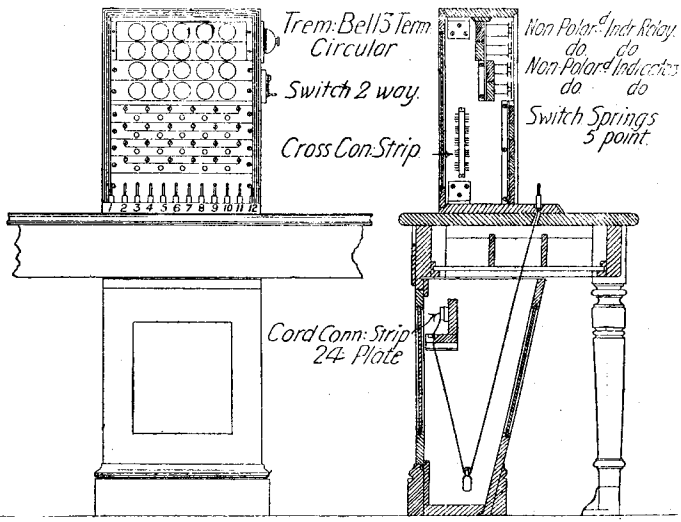


Fig. 2.

The wiring arrangements are given in Fig. 3.

The switch frames are made for 20, 40 or 60 lines respectively, and comprise 1, 2 or 3 panels. The illustrations (Figs. 2 and 3), show a concentrator of one panel. In large telegraph offices the number of circuits to be dealt with may necessitate the use of more than one concentrator. Provision is made for 12 instrument plugs for each panel, and there is space for four strips of five non-polarised indicating relays (with the coils joined in multiple), which are used for all classes of circuits except A.B.C. Non-polarised indicators are used for A.B.C. circuits. Cross-connection strips are fitted to which the lines

are led, and a trembler bell with a tumbler switch is provided for calling the attention of the operator when the concentrator is left unattended.

CONNECTIONS OF CONCENTRATOR SWITCH.
20 LINE.

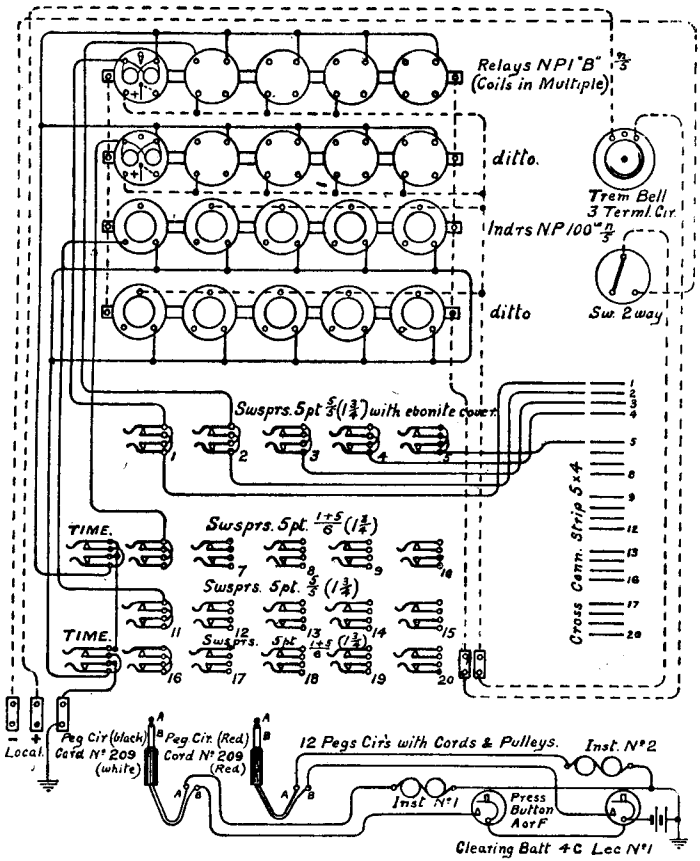


Fig. 3.

The N.P.I. Relay.—The non-polarised indicating relay is illustrated in Fig. 4, and consists of an electro-magnet, with

a soft iron armature, which passes under the left and over the right hand projecting core, from which it is held away by means of a spiral spring, the tension of which can be adjusted. A polarised soft iron needle is hung between the cores of the electro-magnet. The armature completes a local circuit through the right-hand contact screw shown in the figure. This screw has a platinum tip, while the left-hand screw is tipped with ivory. A green celluloid plate, engraved with the "code" of the circuit, is fitted in front. When a call is made the polarised needle swings from right to left and the local circuit is closed, thus ringing the bell if the tumbler switch is in the "on" position.

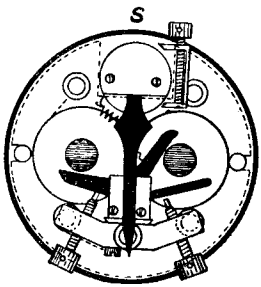


Fig. 4.
Non-polarised indicator relay.

The Drop Indicator.—The N.P. indicator used for A.B.C. circuits is of the well-known "drop-shutter" type (Fig. 3). Currents received on A.B.C. circuits alternate so rapidly that the needle of a N.P.I. relay would vibrate with so small an amplitude and so quickly that the signals might be overlooked; hence the necessity for a different type of indicator for A.B.C.'s. The dropping of the shutter closes a local circuit, and the bell rings.

Instruments.—Each instrument is connected to a circular plug joined up as shown in Fig. 3. Black and red plugs are fitted alternately. The cords are of the ordinary "two-way" telephone type, and it is customary to fit white and red cords alternately, so as to help the operator to trace cords rapidly and thus to ensure a prompt clearance as each circuit becomes disengaged. The clearing signal is given by the telegraphist pressing the button fitted at the instrument. This energises the N.P.I. relay, or N.P. indicator, and intimates to the operator at the concentrator that the instrument is available for a fresh connection.

Central Battery Circuits.—One of the earlier arrangements for Central Battery Omnibus circuits is shown in Fig. 5.

The lines, after passing through their respective jacks and indicating relays, are led through 3,000 ohms bridging coils to a common lead, which, in its normal position, connects up a battery of 80 volts positive. The switch in its other position connects this common lead to a special single current key, from which time is signalled from a battery of 120 volts—positive and negative. The fuse on the 80-volt connection is fitted with an indicator by which attention is called to a failure of the fuse,

CENTRAL BATTERY ARRANGEMENT (Telegraph)
FOR OMNIBUS CIRCUITS,
with Polarised Sounders at all Stations.
Explanatory Diagram.

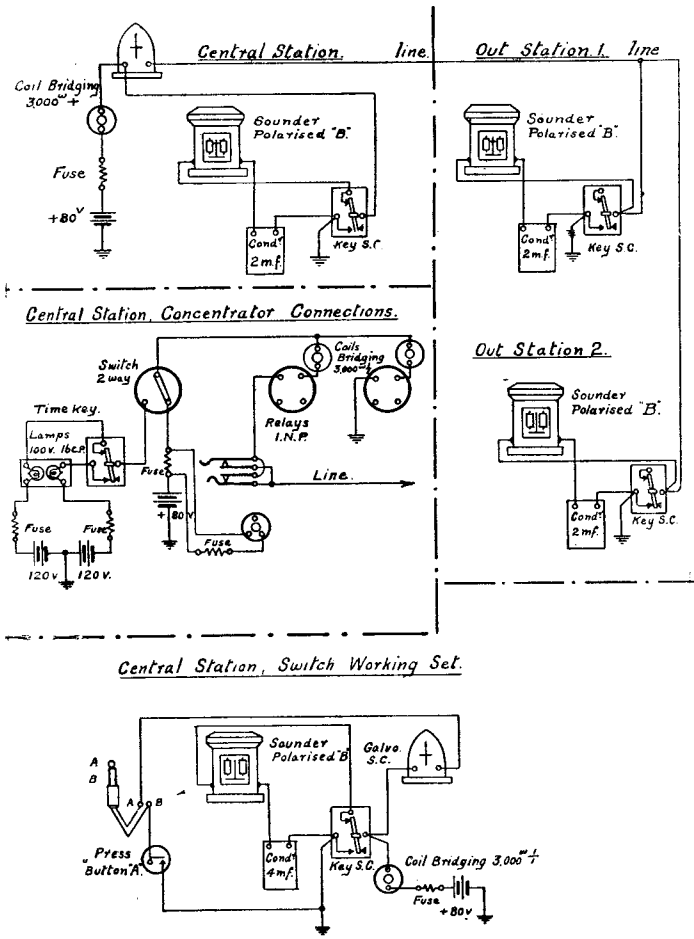


Fig. 5.

should that happen. The apparatus sets are joined up as shown in the diagram. When a set is plugged in, the line is cut off from the indicating relays and connected through the galvanometer and S.C. key to the 80-volt positive battery. The indicating relay is at the same time connected through the press button to earth, and as the battery connection through the two-way switch still remains, means are thus provided for a clearing signal to be given by the operator.

Grouping Circuits.—It is customary to group circuits of the same character as far as possible on the same panels and, similarly, to group together the plugs connected to instruments of the same type. Thus, in a three panel concentrator, the first panel might have, say, 18 C.B. sounder circuits with 7 plugs connected to 7 C.B. sounder instrument sets ; the second panel 20 double current sounder circuits and 10 plugs connected to 10 D.C.S. sets ; while the third panel might have 15 single current sounder circuits and 8 plugs connected to 8 S.C.S. sets. This grouping is, however, not imperative, so long as steps are taken to prevent confusion, and to ensure that the operator shall be in no doubt as to the character of the circuit calling or of the type of apparatus connected to any plug.

It will be observed that, in the grouping shown above, the whole of the available plugs are not joined up. It is usual to connect up only the number of working sets sufficient to carry the traffic of the busy hour. The number may be increased or reduced as the traffic requirements demand.

Adapting Circuits for Concentration.—In dealing with a group of circuits of similar character which it is desired to concentrate, the first step is to ascertain the conductor resistance of each circuit (line and apparatus, omitting the apparatus at the concentrator office). The circuit found to have the highest resistance is regarded as the " standard " for the group, and the resistances for all the other circuits are levelled up to within 25 per cent. of the " standard." This is done by placing resistance coils *in the receiving circuit* of the " out " terminal office. Thus, if the circuit having the highest resistance were 1,000 ohms, all the other circuits in the group to be concentrated would be levelled up to 750 ohms.

The object of levelling the conductor resistances is to ensure that the signalling currents from the concentrator office are similar in strength to the currents from the other offices linked up in the same circuit. It is obvious that each working set of apparatus at the concentrator must have a battery power adequate to work the longest line of all those concentrated. If the circuit resistances were not equal, or nearly so, the shorter lines would get much stronger signals than the long lines. Furthermore, intermediate offices would get currents of varying

strength according as to whether one of the sets at the concentrator or one of the " out " stations was signalling.

The resistance coil being placed in the *receiving* circuit at the terminal office in each case, the battery power at that office need not be increased ; but the power at each of the intermediate stations must be increased so as to work through the added resistance, and to ensure readable signals being received at all the stations in circuit. For example : a circuit consists of four offices, B, C, D and E (Fig. 6), joined up to a concentrator at A.

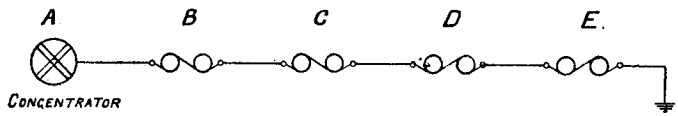


Fig. 6.

The conductor resistance (line and apparatus, but omitting apparatus at A) is 500 ohms. The " highest resistance " of any circuit in the group is 1,000 ohms, therefore a resistance coil of 250 ohms would be required in the receiving circuit at E, making the total resistance of the circuit A-B-C-D-E 750 ohms (75 per cent. of 1,000). The battery power at B, C and D would have to be increased.

The position of the resistance coil in a double-current sounder circuit is as shown in Fig. 7.

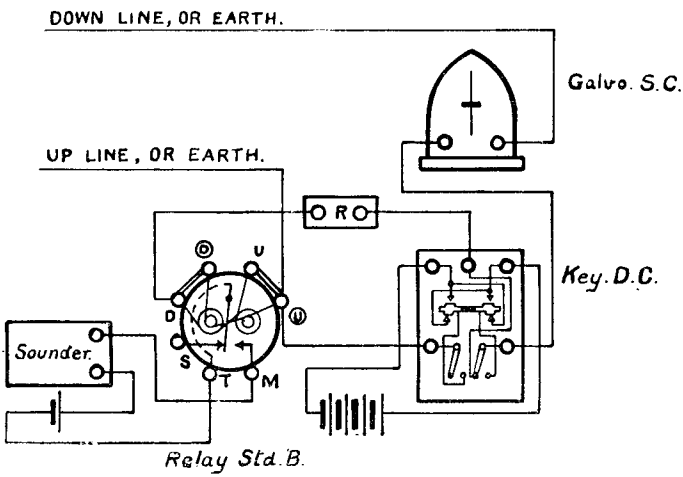


Fig. 7.

The next step is to arrange, as far as possible, for all the circuits to be joined up so that the office where the concentrator

is fixed is " UP " to all stations. If this were not done signals would be " straight " on some circuits and " reversed " on others, but by having the whole group of circuits joined up similarly any set of apparatus at the concentrator can be joined to any circuit, and signals will invariably be " straight."

In some cases, however, it is not practicable to arrange for all the stations to be " down " to the concentrator, and it then becomes necessary to fit a *plug reversing switch* at each set of apparatus at the concentrator which may be required to work on both " up " and " down " lines. The plug reversing switch is connected as shown in Fig. 8, which illustrates a D.C.S. set.

By tracing the current it will be seen that the connections of both the battery and the relay are reversed by altering the position of the plug.

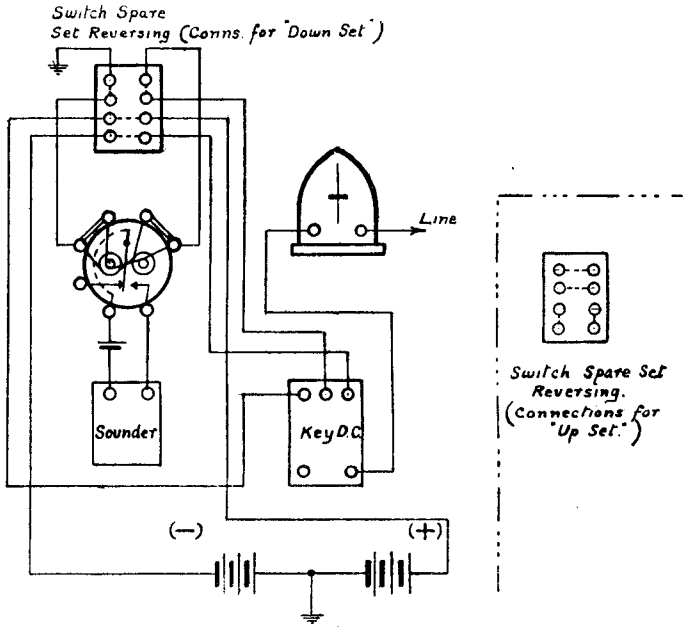


Fig. 8.

Circuits Concentrated at Night and Sundays only.—Certain circuits have sufficient traffic to necessitate their being connected throughout the day to their own sets of apparatus, which may be situated in a part of the instrument room a long distance from the concentrator. These sets, which may be duplex or quadruplex according to the amount of traffic

handled, are of the ordinary character and require no adaptation. At night and on Sundays the traffic on such lines is so small that it can easily be handled at one or other of the concentrator working sets. The lines are, therefore, taken to the concentrator, and are led through a plug key, as shown in Fig. 9.

CONCENTRATOR SWITCHES.

Arrangement of Telegraph Circuits connected to Concentrator Switches for Night and Sunday Working.

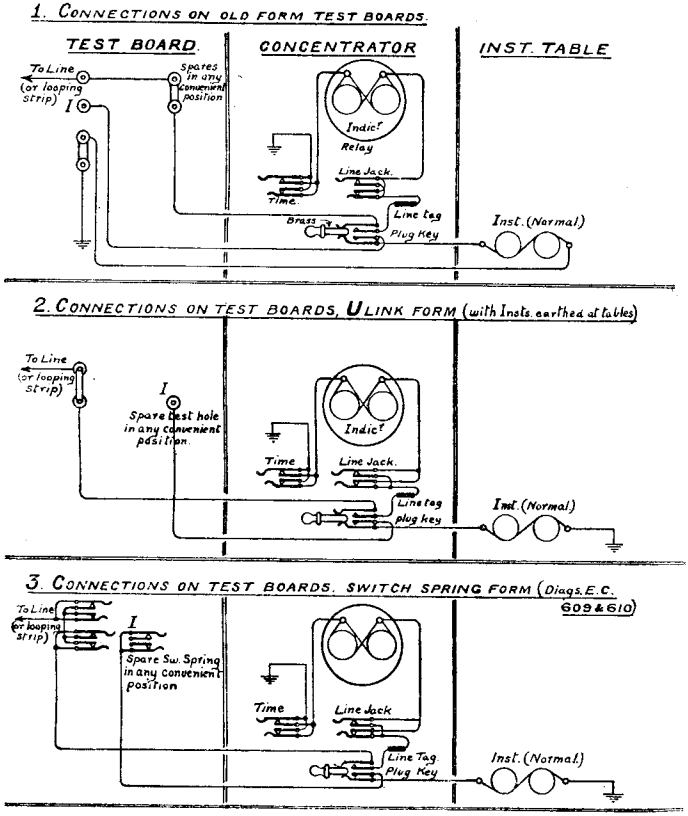


Fig. 9.

The plug keys are made up in strips of ten and are usually fixed below the strips of jacks. Each plug is of brass, and for night and Sunday working is withdrawn, thus disconnecting

the line from its normal instrument set and leaving it joined through to a jack and indicating relay on the concentrator. By the same operation the lead from the side of the instrument is joined through to a spare terminal or jack on the test box, thus leaving the instrument available for special arrangements. When the brass plug is in the position shown in the diagram (Fig. 9) the line is through to the " day " set of apparatus and the concentrator is cut out of circuit. This arrangement obviates the use of plugs and cords, and prevents the front of the concentrator being unnecessarily obstructed.

During very slack times—chiefly on Sundays—some of the working sets on the concentrator must be able to work on long or short lines as the traffic may necessitate. Thus a set at Birmingham may be required to transmit a message to Wolverhampton at one minute, to be followed by a message to Glasgow the next. To provide for this it is usual to connect two voltages to the key through a 6-terminal two-position switch, as shown in Fig. 10.

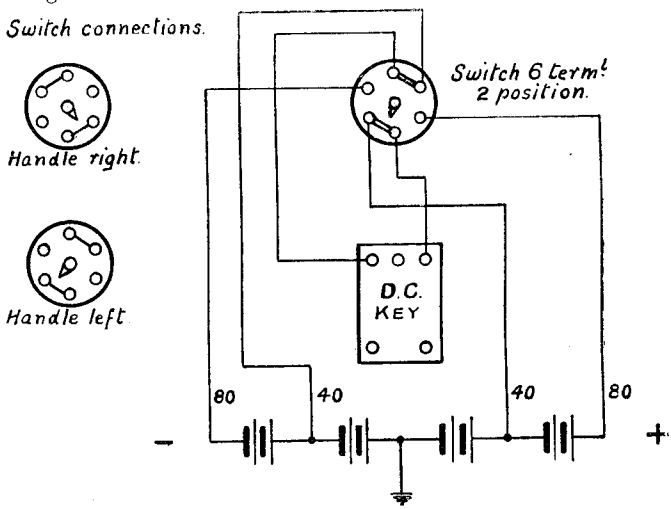


Fig. 10.

By turning the switch to the right a voltage of 80 is connected to the key, and with a switch to the left a voltage of 40 is joined up. If the higher voltage were used on short lines the needles of the galvanometers of the working sets might be injured by the violent oscillations. The switch is suitably labelled as a guide to the telegraphist.

The growth of Central Battery Telegraph working developed

the need for a special C.B.S. concentrator switchboard at one or two of the larger offices, and the arrangements shown diagrammatically in Fig. 11 were brought into use. The concentrator working set is shown in Fig. 12.

PRINCIPLE OF C.B.S. LAMP SIGNALLING CONCENTRATOR.

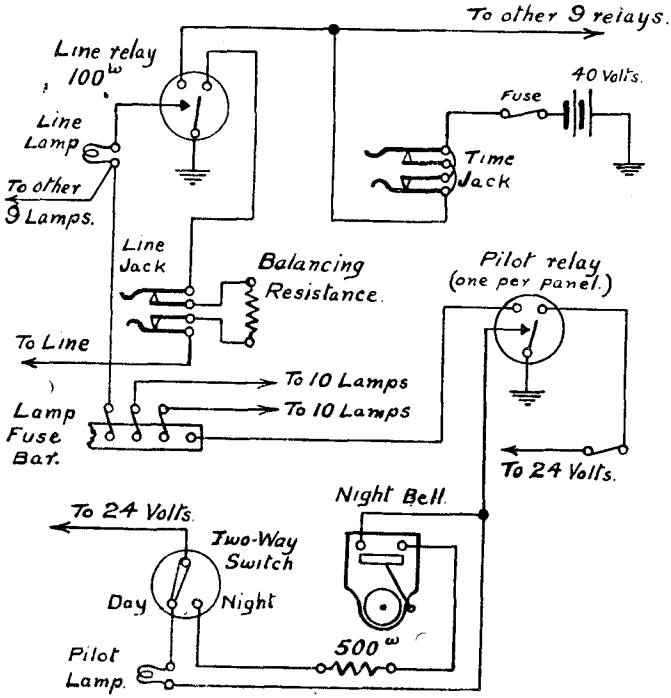


Fig. 11.

Attention is drawn to the following modifications of earlier C.B.S. practice :—

(1) The replacement of the inductive bridging coil (3,000 ohms) feed resistance with non-inductive feed resistance of 1,000 ohms (Fig. 12).

(2) The use of a low resistance (100 ohms) line relay in order that it may be possible to bias the apparatus against the currents flowing to line under conditions of low insulation where the wires are aerials of considerable length (Fig. 11).

(3) The provision of one Time Jack for each strip of ten circuits (Fig. 11).

(4) The introduction of glow lamps as a calling signal (Fig. 11).

(5) The use of a key E.M.I. on the concentrator working set to give " bothways " clearing signals (Fig. 12).

(6) The provision of one pilot lamp per panel (Fig. 11).

From Fig. 11 it will be seen the 40 volts negative battery on the concentrator is fed through the line relay and balancing resistance to line.

The depression of an out office key actuates the line relay. The local circuit of the line relay being closed, the line and pilot lamps glow.

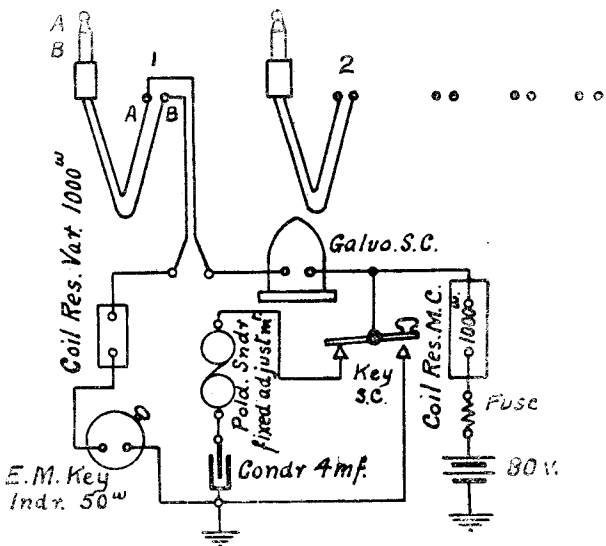


Fig. 12.

The switch operator plugs a working set (see Fig. 12) into the line jack, and signals are passed in the usual way. On completion of the traffic transactions, the telegraphist at the working set presses the E.M.I. key, which closes a circuit through the line relay and gives a clearing signal to the switch operator. When the latter pulls out the plug the armature of the E.M.I. key falls back, moving a disc indicator on the key, thus notifying the operator at the working set.

At this point it should be noted that the arrangements shown in Fig. 5 were modified to a considerable extent in consequence of the development of C.B.S. working.

These modifications are indicated in Fig. 13. Relay 18C is the same type of relay as that shown in Fig. 4, but the coils are wound to a resistance of (10 + 10) ohms.

CONCENTRATION OF C.B. & D.C. CIRCUITS.
(INDICATOR SIGNALLING.)
HEAD OFFICE.

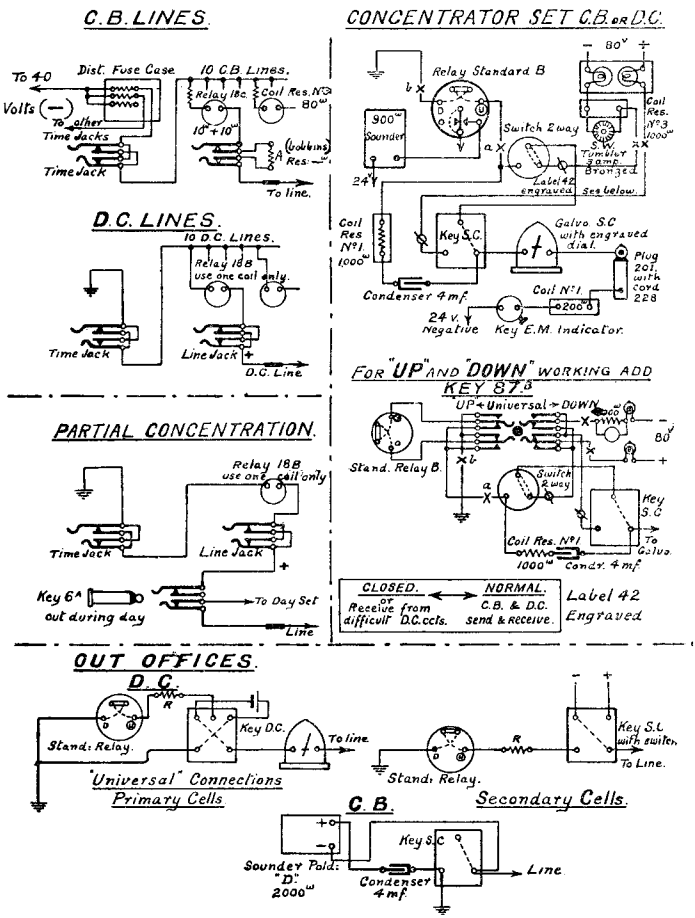


Fig. 13.

The only point that need be commented on is the use of a concentrator working set capable of working either C.B.S. or D.C.S. indiscriminately.

CONCENTRATOR LAMP SIGNALLING.

Front View.

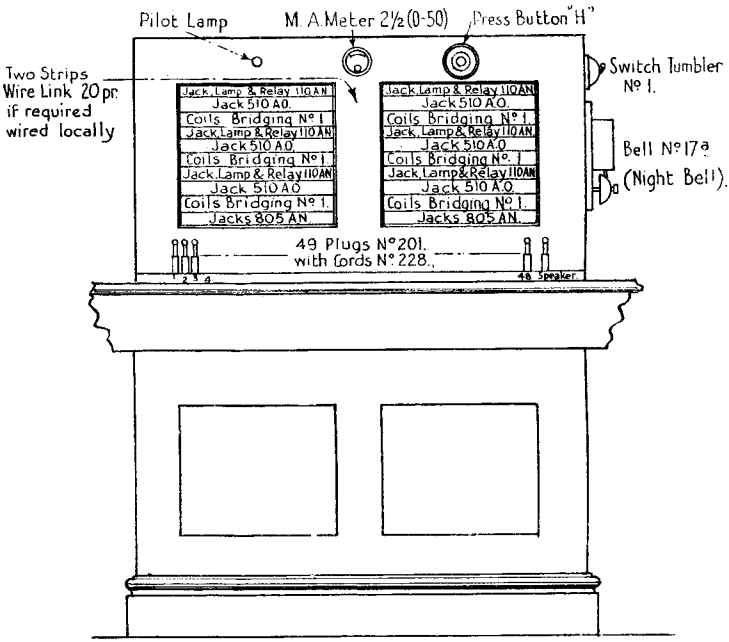


Fig. 14.

From Fig. 13 it will be seen that a Standard B Relay, having a coil resistance 1,000 ohms and a condenser 4 mf. connected in series with it, is connected between the bridge of the key and earth, and that 80 volts positive and negative (U.B.S.) are connected respectively to the front and back stops of the key. Normally, therefore, the 4 mf. condenser is charged by the

negative polarity and an earth or a positive current received from the line will discharge the condenser through the Standard B Relay in a marking direction. Clearly, within certain limits, this arrangement will work both C.B.S. and D.C.S. Morse. Provision is made, by means of a two-way switch, for joining the Standard B Relay direct to the line (that is to say for cutting out the 4 mf. condenser and 1,000 ohms resistance coil) when the line conditions are such as to render reception from a D.C.S. out-office difficult. The switch is used only for reception.

From the nature of this working set, it will be evident that for the D.C.S. Morse system, the marking current in each direction must always be a positive current from line, and this method of wiring out-office D.C. Morse sets is defined as wiring to " Universal Connections." See the diagrams under the heading of " Out Offices " (Fig. 13).

LAMP SIGNALLING CONCENTRATOR, C.B.S. AND D.C.S.

In 1913 a lamp signalling concentrator was introduced which accommodates both Central Battery and Double Current Morse circuits. This is an advance on the concentrator of the old pattern, and possesses some novel features. The general design is as shown in Fig. 14, and two sizes are manufactured to take 30 and 60 circuits respectively.

Lamp Jack and Relay.—A new type of line relay combined with a lamp jack has been designed which takes the place of the indicating relay in the concentrator already described. For D.C. circuits the relays are adjusted to work with a minimum current of about 5 milliampères, and for C.B. circuits the adjustments are generally such that they will not work with currents of less than 30 milliampères. The lamp jacks and relays are fitted in strips of 10.

Central Battery Circuit.—The arrangement for C.B. lines is as shown in Fig. 15.

For calling purposes the resistances of the circuits when the key of the most distant station is depressed should be levelled

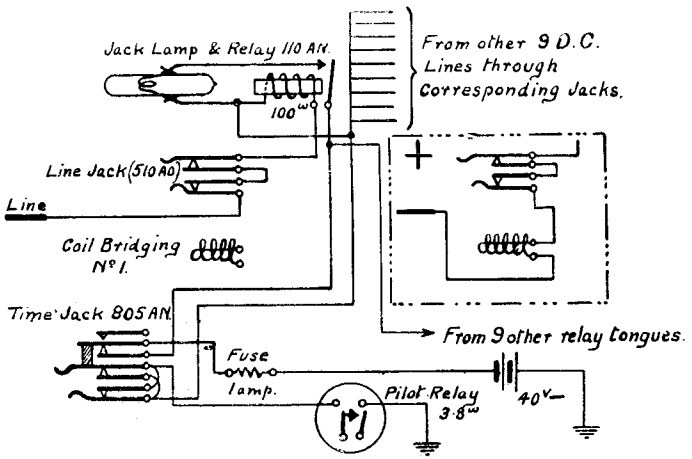


Fig. 15.

up to 1,000 ohms by the insertion of a bridging coil between the two inner springs of each line jack. These coils are supplied of the following resistance, *viz.* : 250, 500, 750 and 1,000 ohms, and are fitted on a strip immediately below

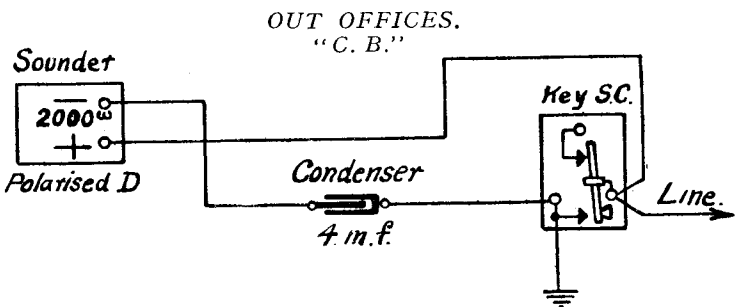


Fig. 16.

the corresponding jacks. The 40 volt *negative* battery is used as the normal power for the concentrator itself. The relay should be adjusted to respond reliably when the terminal

Office calls. The normal calling current is 36 m.a. (40 volts and 1,100 ohms).

The connections of the out office sets (C.B.) are as shown in Fig. 16.

The connections of a working set at the concentrator are as shown in Fig. 17.

DIAGRAM SHOWING WORKING SET JOINED THROUGH TO A LINE.

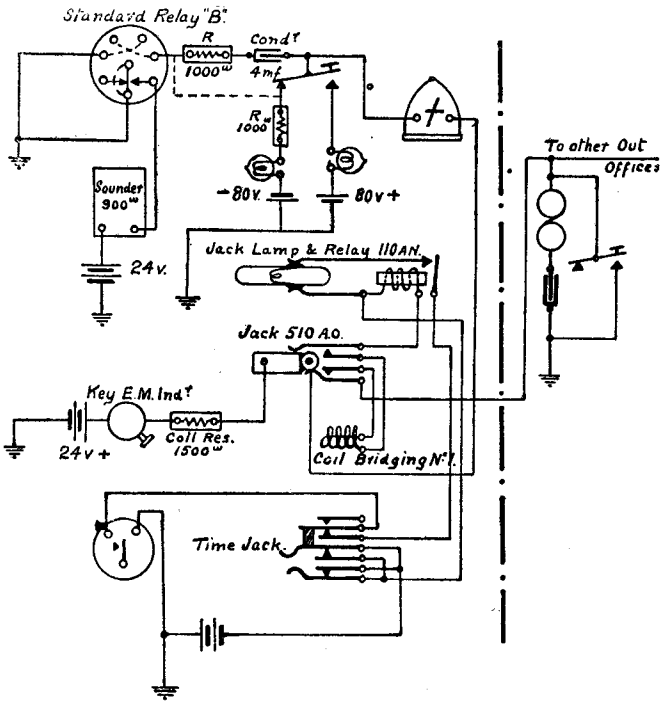


Fig. 17.

From an inspection of this diagram it will be seen that a negative voltage of 80 is connected to the line when the working set is plugged in, the voltage being supplied to the line from the working set *viâ* the tip of the switchboard plug. The out office uses this voltage when working to the head office.

Double Current Circuits.—Double current circuits are joined to the concentrator as shown in Fig. 18.

This requires that the battery and earth leads from the time jacks of each strip used for D.C. circuits shall be reversed. A *positive* current to line is used for marking at both ends, and the key and the relay connections shown are made to suit whether primary or secondary cells are employed. These connections are termed " Universal." 80 volts is the standard for the concentrator working sets.

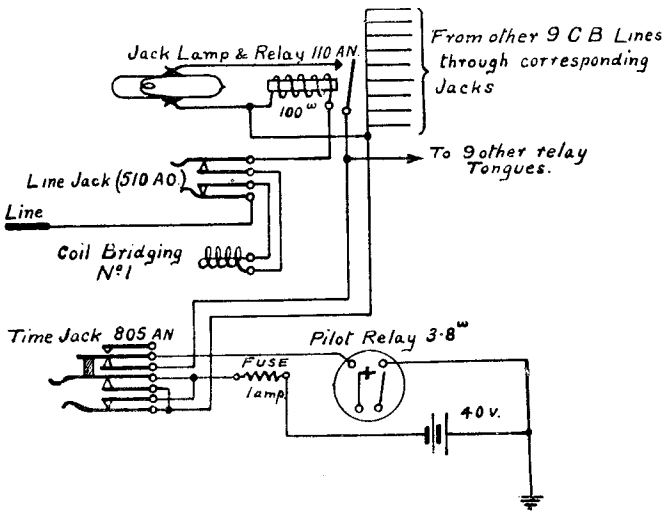


Fig. 18.

PARTIAL CONCENTRATION.

Circuits which are through to their own sets of apparatus during the busier hours of the day and are concentrated only during slack times, are joined up as shown in Fig. 19.

As shown in the diagram, the line is put through to its day set, or alternatively to the concentrator by changing the position of the wire link.

It is sometimes convenient and economical to use a concentrator working set for a circuit which is not controlled at the time by the switchboard operator. In such a case the ordinary concentrator arrangement is used instead of the arrangement shown in Fig. 19, and a plug connected to a convenient set is placed in the jack. The set chosen should be in such a position on the concentrator that the plug and cord will not hinder the operations of the switchboard operator.

D. C.
ARRANGED FOR PARTIAL CONCENTRATION.

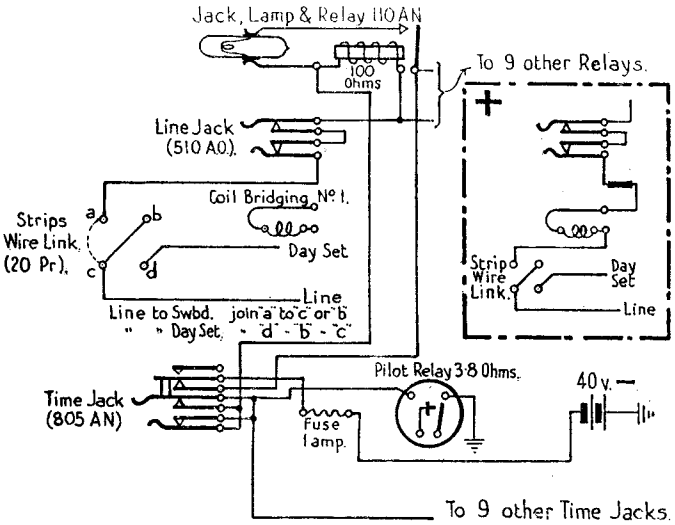


Fig. 19.

TELEGRAPH ANCILLARY CONCENTRATORS.

The " Ancillary System," a further development of the lamp signalling concentrator, dispenses with the duty of switchboard operator and introduces into telegraph practice the principle of " team-working." For this purpose the lines are " series-multiplied " through a succession of concentrator panels and, where required, " engaged " lamp-signalling is provided.

In essentials the concentrator consists of a combination of three units, (a) the " home " section, a single panel, containing the line relays, time-jacks, etc.; (b) the " intermediate " section, consisting of one or more ancillary panels; and (c), the " last " or end panel, to which the incoming lines are joined. Two working sets, providing facilities for C.B. or D.C. working, are associated by means of jacks, plugs and cords with each panel of the concentrator, the total number of panels being determined by the number of working sets necessary in order to dispose of the concentrator traffic. Where, however, the number of panels exceeds eight, it is

necessary to divide the system into groups. For example an installation of 16 panels would comprise :—

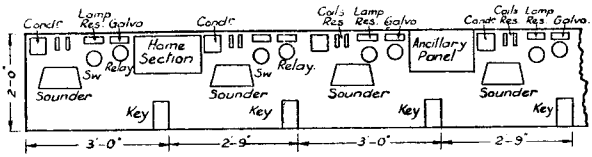
Group (1). 1 Home Section, 6 intermediate panels and 1 " last " panel.

Group (2). 1 Home Section, 6 intermediate panels and 1 " last " panel.

Fig. 18A shows the general layout of the apparatus, with two panels of the concentrator and their four associated working sets, in position. Fig. 18B is an explanatory diagram, with notes of the system, the Pilot and 6 D Relays being mounted on a separate relay rack, not shown in Fig. 18A.

ANCILLARY TELEGRAPH CONCENTRATOR SWITCHBOARD.

Telegraphists' Positions and Working Sets.
Layout of Apparatus on Instrument Room Table.



Connections of Concentrator Working Sets.

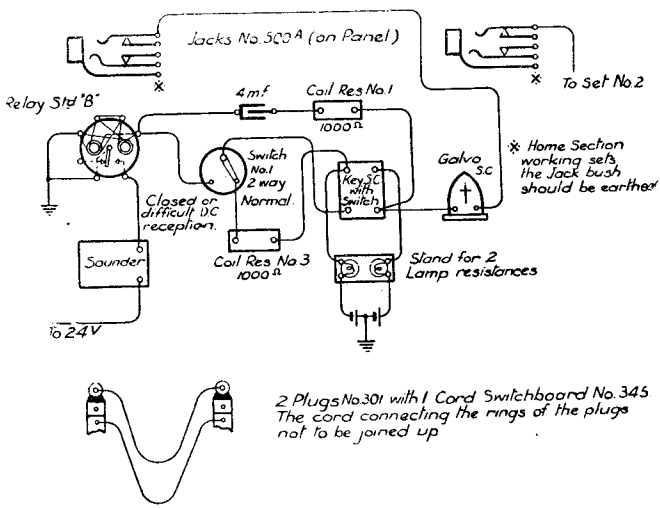


Fig. 18A.

TELEGRAPH ANCILLARY CONCENTRATORS

Explanatory Diagram.

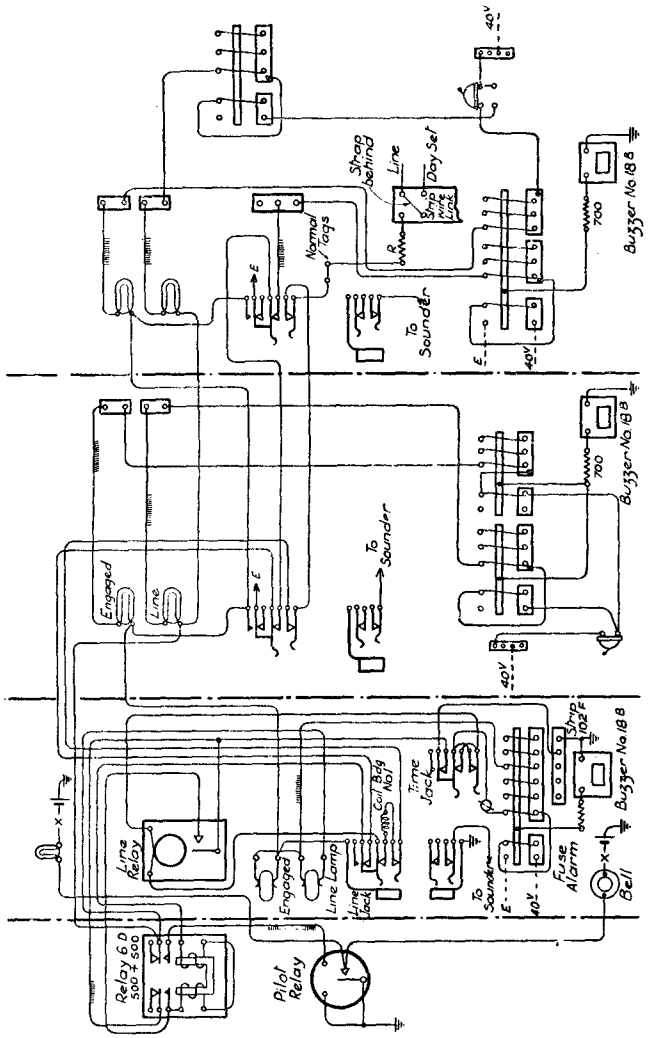


Fig. 18B.

At present this type of concentrator is designed for a maximum of 30 lines. The line relays, jacks, lamps, etc., are made up in strips of ten, one time-jack being provided for each strip of ten line relays. Eight-point jacks are used for the lines and four-point jacks for the telegraph sets, the necessary connections being made by means of three-way plugs and cords. Partial concentration of lines provided with " day " sets can be arranged for by leading the lines to a Strip, Wire Link fitted on the last panel.

The power layout calls for some consideration. Consequent on the termination of the lines on time-jacks, which are placed in the " home " panel, the line power for C.B. Offices is also led into this panel ; on the other hand, power with which to operate the Relays 6.D. from the contact stops of the line relays, must, in order to secure the necessary line-jack control, be led in at the last panel. The insertion of a plug into a line-jack cuts off the power from both line and 6.D. relays, extinguishing the " line " lamp and lighting the " engaged " lamp. Individual power for the lighting of the " line " and " engaged " lamps is provided on each panel controlled, with the exception of the " home " panel, by a pole tumbler switch so that panels may be closed down or opened as the traffic demands. The choice of Pilot Relay will depend on the number of line lamps installed, each of which takes about ·065 amps., since the whole of the current taken by these lamps will pass through the relay.

Briefly the operation of the concentrator is as follows :— The lines enter at the last section, pass through their respective concentrator jacks in " series multiple " to the relative line relays and are terminated on time-jacks to which is joined a 40-volt negative battery in the case of C.B. or an " earth " for D.C. circuits. The closing of the line relay tongue circuit, by the depression of an out office key, completes, *via* the upper springs of the line-jacks, the circuit for Relay 6.D. causing the line lamps to light up. The Pilot Relay circuit is also closed, ringing a bell and lighting the Pilot Lamp. The joining up of a calling line to a working set opens the line-jack springs, thus breaking the circuit of Relay 6.D. and extinguishing the line lamps. At the same time the " engaged " circuit is made and the necessary " engaged " lamps glow.

Engaged Lamps.—Three way Cords and Plugs (Cords, Switchboard No. 345 and Plugs No. 301) are required for earthing purposes.

Where the Coil Bridging, No. 1, of such resistance to level the Calling Circuit up to 1,000 ohms, would ordinarily exceed 200 ohms, the value of the Coil, Bridging to be fitted should

be ½ (1,000-line resistance) and the remainder ½ (1,000-line resistance) should be fitted in the line circuit at R.

The relays 6.D. 500 + 500 should be fitted separately on a suitable apparatus rack. See Diagrams T.G. 453, 454 and 473 for wiring details.

The number of working sets per Ancillary Panel is two (see Diagram T.G. 429 for the layout of apparatus on the instrument table and the connections of the working sets).

The lead from the Time Jack marked ø is shown connected for C.B. working. For D.C. working it should be connected to the earth strip (Strip, Conn. No. 102F).

Lines which are not permanently concentrated will locally be led through the Strip, Wire, Link, as shown.

DISTRIBUTION OF STANDARD TIME.

The observance of standard time throughout the United Kingdom is based upon a system of time signals having their origin in Greenwich Observatory and transmitted over the telegraph wires of the country. The Mean Time (Solar) clock at the Observatory is provided with contacts arranged to send an hourly signal to the Central Telegraph Office in London, where it is received upon a relay which forms a part of a set of apparatus known as the Chronopher. The local circuits of this Main relay operate a number of other relays by which the signal is transmitted to sundry renters in London and which ring bells, etc., fixed in the various administrative and operative departments of the group of buildings associated with the General Post Office headquarters.

The Chronopher includes a number of switching relays, to the tongues of which telegraph circuits between London and various large provincial telegraph offices are connected. These offices are Edinburgh, Glasgow, Leeds, Manchester, Liverpool, Newcastle-on-Tyne, Birmingham, Cardiff, Bristol, Chatham, Norwich and Dublin. Normally, the tongues of the switching relays connect the lines to the telegraph apparatus in the Central Telegraph Office, but, when the coils of the relays are energised by currents which are sent from the Control Clock associated with the apparatus, namely from 8h 58′ 30″ to 9h 1′ 30″ and again at 12h 58′ 30″ to 13h 1′ 30″, the tongues are disconnected from the apparatus leads and bunched on the tongue of the Main Transmitting Relay. This causes a positive current to be sent to all the offices concerned, which is the preliminary signal or warning that the time signal is about to be received. The Greenwich signal moves the tongue of the Main relay to its other contact and transmits a negative current to the Provincial stations. This current constitutes the time signal, which is thus transmitted to the Provinces at 9 and 13 o'clock.

DISTRIBUTION OF MEAN TIME—SKELETON DIAGRAM.

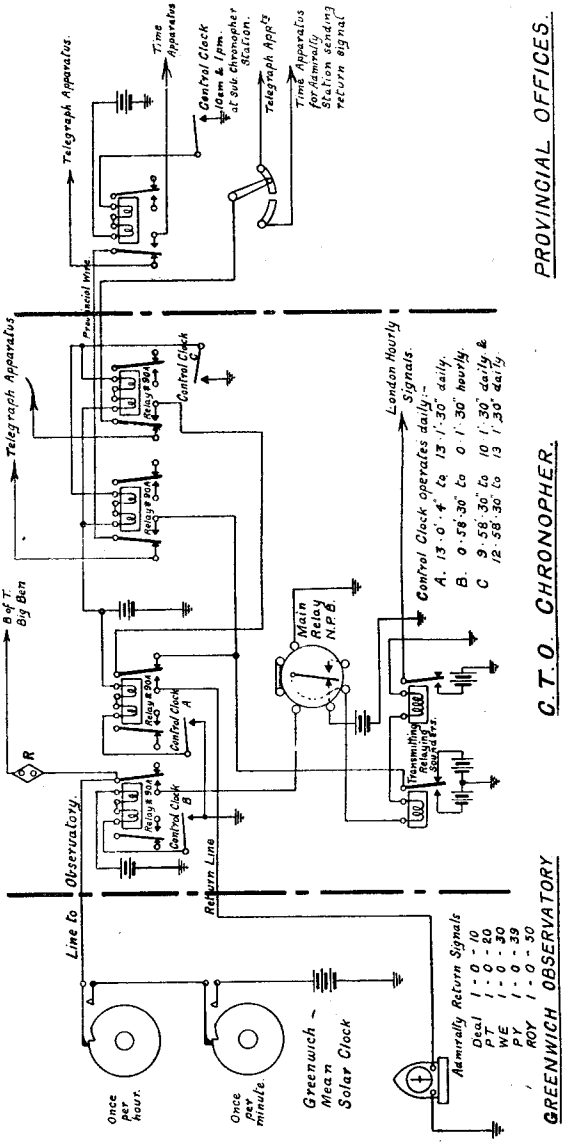


Fig. 20.

Fig. 20 illustrates the apparatus in skeleton form. The system as illustrated is somewhat more complicated because of the necessity for the provision of additional apparatus whereby return signals transmitted from certain naval stations are repeated through to Greenwich over a second circuit in order that the Observatory may check the time keeping of the clocks at those stations.

The Chronopher control clock, upon the accuracy of whose time keeping the correct switching depends, is automatically synchronised every hour by the hourly signal from Greenwich.

At each of the provincial offices referred to, a somewhat similar apparatus is installed but on a very much smaller scale. Switching relays, transmitting relays and a control clock performing identical functions are installed, but here provision is made for the division of the relays into groups for the 9 and 13 o'clock signals respectively, because, as a rule, only one or other signal is required by subscribers. The sub-chronopher provides for the transmission of the signals to other minor offices which also have subscribers connected to them, as well as for the transmission of the signals to subscribers in its own town. The apparatus is shown in Fig. 21 and the particular type of control clock shown associated with it in Fig. 22. The control clock is electrically driven, automatically synchronised by the time signals, and performs its switching functions by means of springs which are moved into contact with others by the passage of rotating cams.

At the end of the chain of offices from which renters may be served, hand switching is provided for, as illustrated in Fig. 23. The connections take various forms to suit the differing conditions which may be met with, as explained in the figure, the underlying principle of the system throughout being that a subscriber's circuit shall be connected to earth except for the brief period of time in which the signal is due to arrive, in order to prevent false signals being transmitted, the hand switches not being turned until the preliminary or warning signal is seen upon the galvanometer.

The subscribers' circuits are all bunched on one galvanometer which is connected to the local contacts of the relay and, because these circuits are thus connected in parallel, it is invariably stipulated that the standard resistance of a subscribers' apparatus shall be not less than 200 ohms. Because of the interruption to telegraph traffic during the passage of the signals, it is arranged to interfere with as few wires as possible for the purpose. The 4-bar switch shown in Diag. B of Fig. 23 thus enables Intermediate Offices to be served or 2 circuits, normally terminated at an office, to be connected together periodically for time signal purposes. As a general rule, any

DISTRIBUTION OF GREENWICH MEAN TIME.

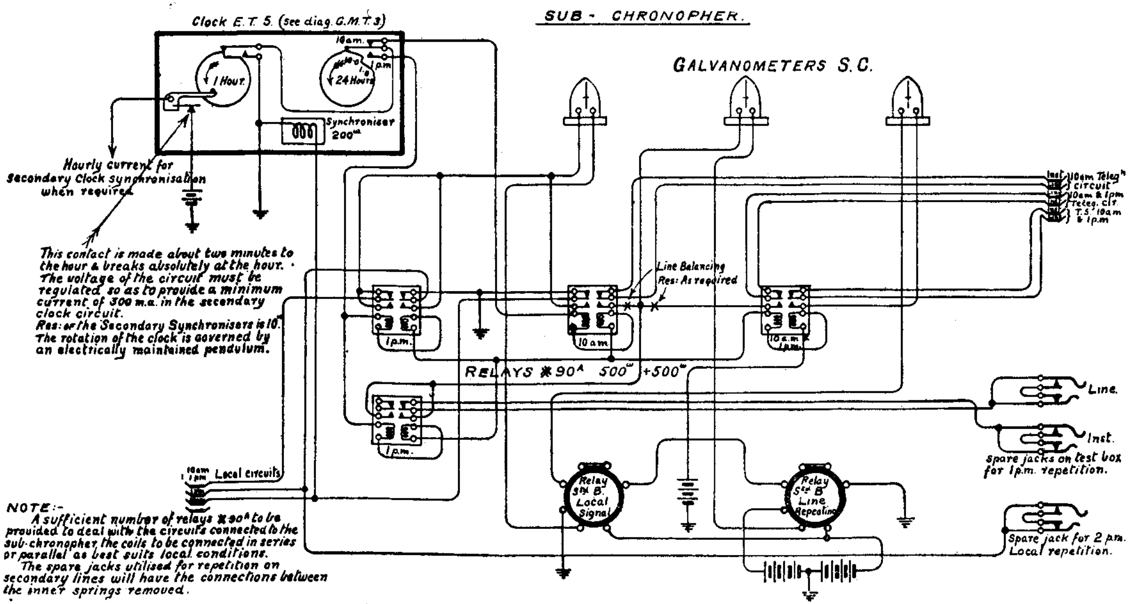


Fig. 21.

CLOCK ELECTRICAL TIME SWITCHING.

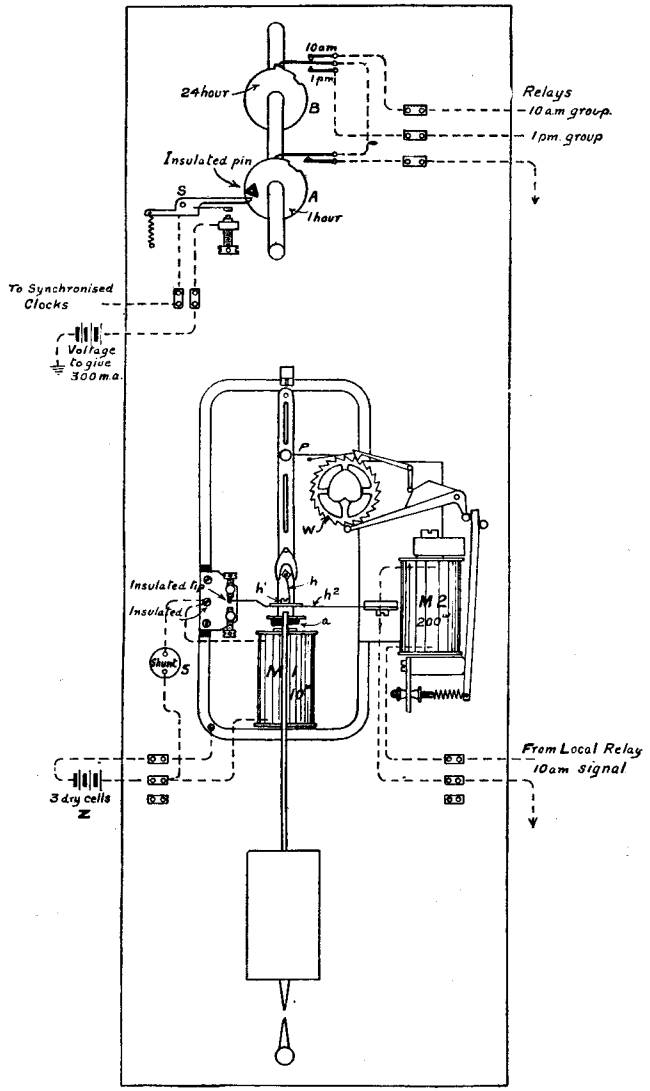


Fig. 22.

town having one or more subscribers is connected to a sub-chronopher station, and only a few of the important circuits radiating from London are interfered with.

It will perhaps be useful to follow in detail the whole of the operations involved in the transmission of the time signal in the order in which they occur.

First, the control clock at the main chronopher, acting at one minute and a half before the hour, causes the switching relays at the C.T.O. to be energised. The lines radiating to the sub-chronopher offices are thus connected to the relay by which the time current is transmitted, and the positive current or preliminary signal is sent out. At one minute before the hour the control clocks at the sub-chronopher stations act in the same way, disconnecting the telegraph sets ordinarily used on the circuits over which the time signal is received and transmitted, and connecting up the transmitting relay at the time apparatus to the lines radiating to the local offices served from the sub-chronophers. At two minutes before the hour the three-bar or four-bar switches at the local offices are turned by hand, thus cutting off the ordinary telegraph sets used ; then when the " preliminary " current is received on the galvanometer the switch is turned to " Time," thus joining up the standard relays by which the signal is received and repeated.

All is now ready for the passage of the signal, and this state of affairs continues until the exact hour. At the precise moment the Mean Solar Clock at Greenwich sends the signal. This is received at the Main Chronopher where the Main relay causes the relaying sounders to reverse the current momentarily, and this reversal constitutes the distributed time signal. At the sub-chronopher stations the reversal of the current from the main chronopher causes the transmitting relays to act in the same way, and the signal passes out to the stations connected to the sub-chronopher. At one minute past the hour in the case of the sub-chronophers, and at one and a half minutes past the hour in the case of the main chronophers, the control clocks cause the switching relays to operate so as to restore normal conditions, *i.e.*, the telegraph sets are reconnected to their respective lines, and ordinary traffic is resumed. At the distant offices served from the sub-chronopher apparatus the switches (three-bar or four-bar) are restored by hand to their normal position.

The arrangements briefly outlined above provide only for the transmission of the time signal to the more important telegraph offices and to towns where subscribers to the time service are located. But every telegraph office in the country—however unimportant or remotely situated—receives the time signal at 9 a.m. daily (except on Sundays), transmission being

DISTRIBUTION OF GREENWICH MEAN TIME.
TIME APPARATUS FOR LOCAL OFFICES.

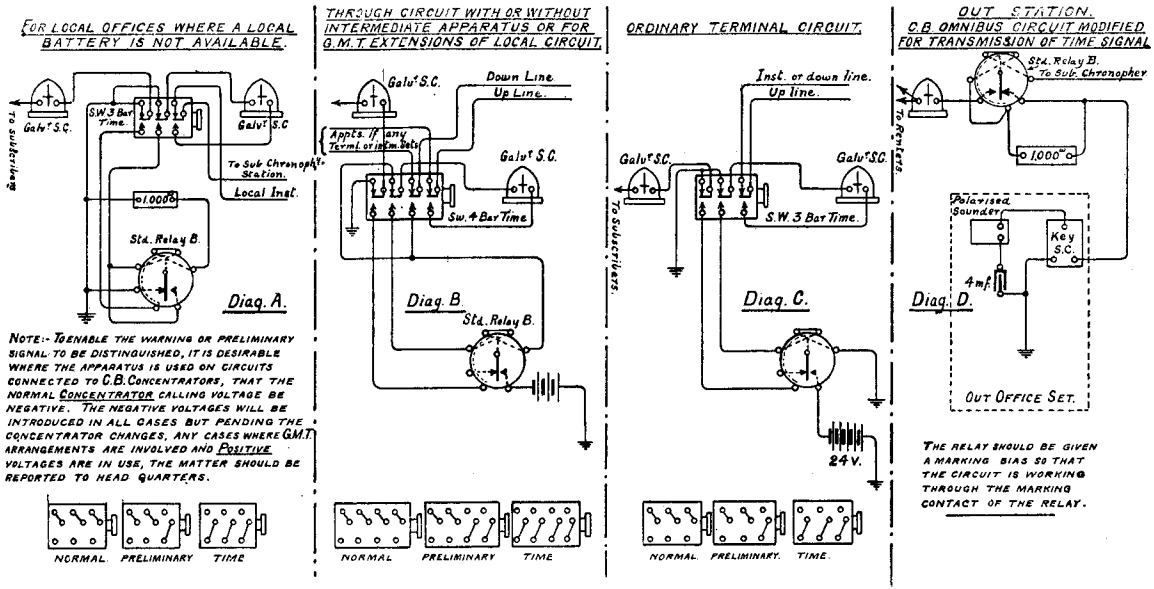


Fig. 23.

effected by hand. In the case of offices connected to concentrator switches the signal is transmitted from one or more sets of apparatus at the concentrator. All lines brought to a concentrator (with the exception of C.B. Sounder circuits) are led through a time jack. At the latter point they can be connected in parallel (" bunched ") by the simple operation of plugging in a set of apparatus at the time jack, thus permitting a signal to be sent by hand over all the " bunched " lines simultaneously.

In the case of C.B. sounder circuits a reference to Fig. 5 will show that in the older type of concentrator a special time key is provided, and the turning of a two-way switch causes the lines to be " bunched " and connected to the key. More than one key may be required, as it is customary to group not more than ten lines on one time key. The reason is that the current flowing out on a larger group of lines in parallel would probably blow the fuse in the battery lead. Thus in a concentrator with 40 C.B. Sounder circuits there would be four time keys and switches, and four operators would be required to transmit the signal (or two operators assuming that they use both hands).

In the case of C.B. omnibus out stations, Diag. D of Fig. 23 will be found to be self-explanatory.

Any lines which happen to be connected to a set of apparatus at the concentrator, and over which ordinary traffic is passing when the time signal is about to be transmitted, have the signal sent from that set of apparatus, *i.e.*, they are not included in the lines bunched on the time keys or jacks. All other lines have the signal sent from the set (or sets) of apparatus to which they are connected in parallel.

The usual procedure in a large telegraph office is for an officer to stand at the time apparatus, or sub-chronopher (if a sub-chronopher station) and on receipt of the preliminary signal strike a gong or call out " Time." (In very large instrument rooms several gongs fixed in various parts of the room are operated electrically by a press button fixed beside the sub-chronopher apparatus). Traffic is then suspended on all lines except those on which the time signal has not to be transmitted, and the word " Time " is signalled from the sets of apparatus provided for the purpose. When the momentary reversal of current, which constitutes the time signal, takes place, the officer at the time apparatus or sub-chronopher again strikes the gong or calls out " Nine." The word " nine " is quickly signalled on all lines concerned.

At the smaller transmitting centres, where time apparatus is not fixed, a similar procedure is adopted, the preliminary and time signals being transmitted by hand, or in the case of

telephone-telegraph circuits spoken over the line. In this way every telegraph office is supplied with the daily 9 a.m. time signal, and if ordinary care is observed at the centres where the signal has to be transmitted by hand, the time occupied in transmission to even the most remote office can be measured by a few seconds. The automatic transmission of the signal through the main and sub-chronophers is practically instantaneous.

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