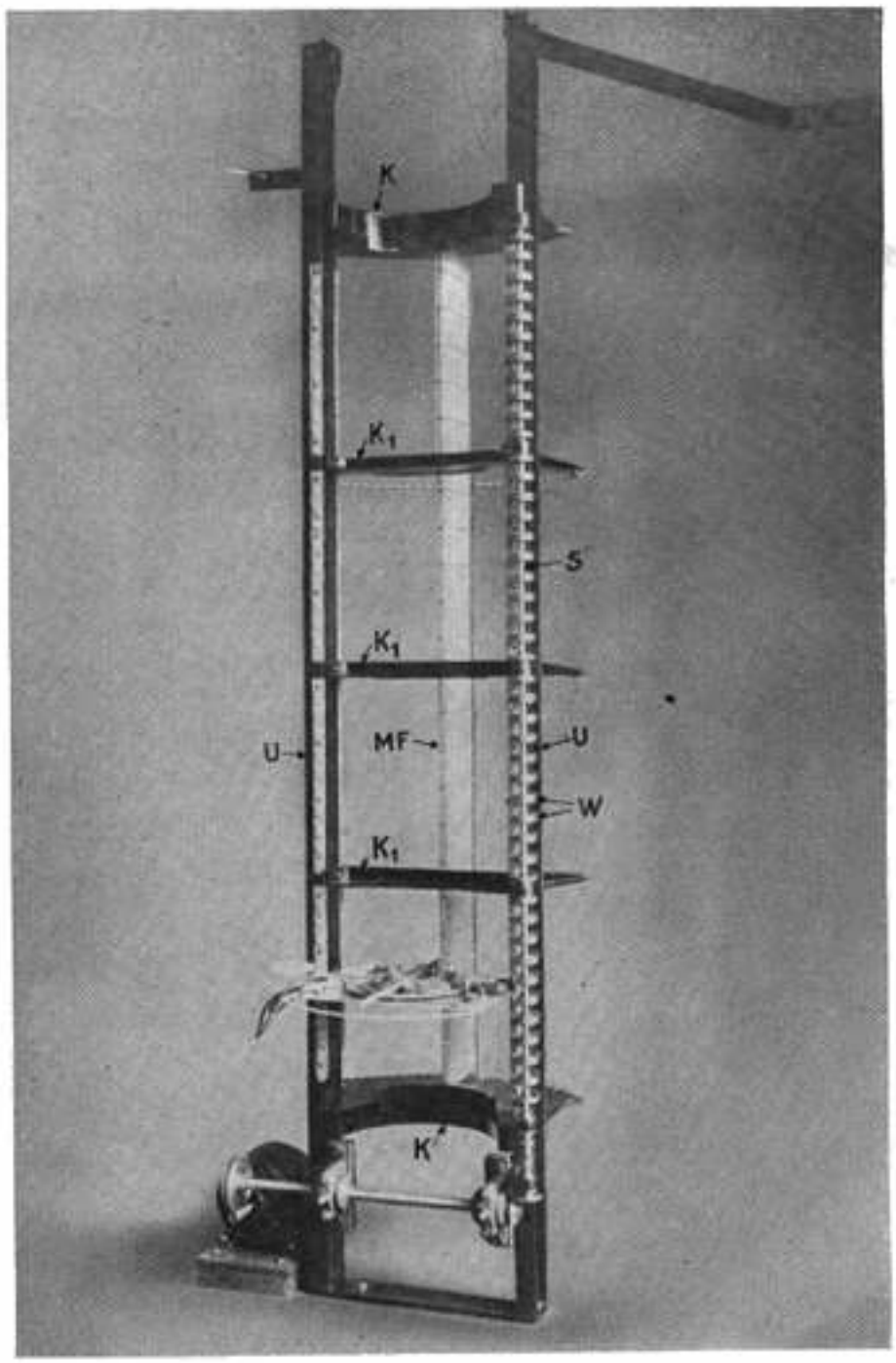
The L. M. Ericsson Automatic Switching System with 500 line selectors.

The L. M. ERICSSON full automatic telephone system is to be classified as a »power driven» system, inasmuch as the necessary selectors and sequence switches are mechanically propelled by rotating shafts continuously driven by small motors, common to a given number of racks.

The Ericsson system uses register sets, the function of which is to receive and register the impulses sent out from the subscribers' telephone instruments (or, in the case of a semi-automatic station, from an operator's keyboard) and to direct the group selectors and connectors to their correct positions. This directing is accomplished by means of revertive impulse control.

The chief characteristic of this system is that all selectors, i. e. the line finders, group selectors, and connectors, are of the same construction, except for some minor details, all having a capacity of 500 lines. Another feature of this system is the multiple, consisting of vertical, bare wires, forming so-called multiple frames.



R 5 Fig. 1. Selector rack for 40 selectors.

I. Description of the switching apparatus.

A. *The selectors.*

The selectors are mounted in racks accommodating 40, 50, 60 or 70 selectors. Figure 1 shows a rack for 40 selectors. Such a rack consists of two vertical channel irons connected both at the top and bottom by means of the brackets K. Additional brackets K_1 are inserted for each group of 10 selectors.

On the insides of the channel irons are fastened metal strips with horizontal notches into which the selectors are slipped and locked in place.

The vertical driving shaft is mounted in ball bearings on the right hand side of the rack and furnished with double, toothed drivers W one for each of the selectors.

The multiple consists of 25 multiple frames MF (fig. 1 shows such a frame in position) placed radially in relation to the selector's centre of rotation, as shown in fig. 2. Each multiple frame is composed of

vertical bare wires for 20 lines, held by strips of insulating material.

Fig. 2 shows in outline a selector rack with one selector, seen from above. A selector is shown in fig. 3. The main selector parts are:

Base plate	BP
Magnet coupling	MH—MV
Rim gear wheel	KR
Rotary disc	TS
Locking magnet for the same	CV
Contact arm	KA
Locking magnet for the same	CR.

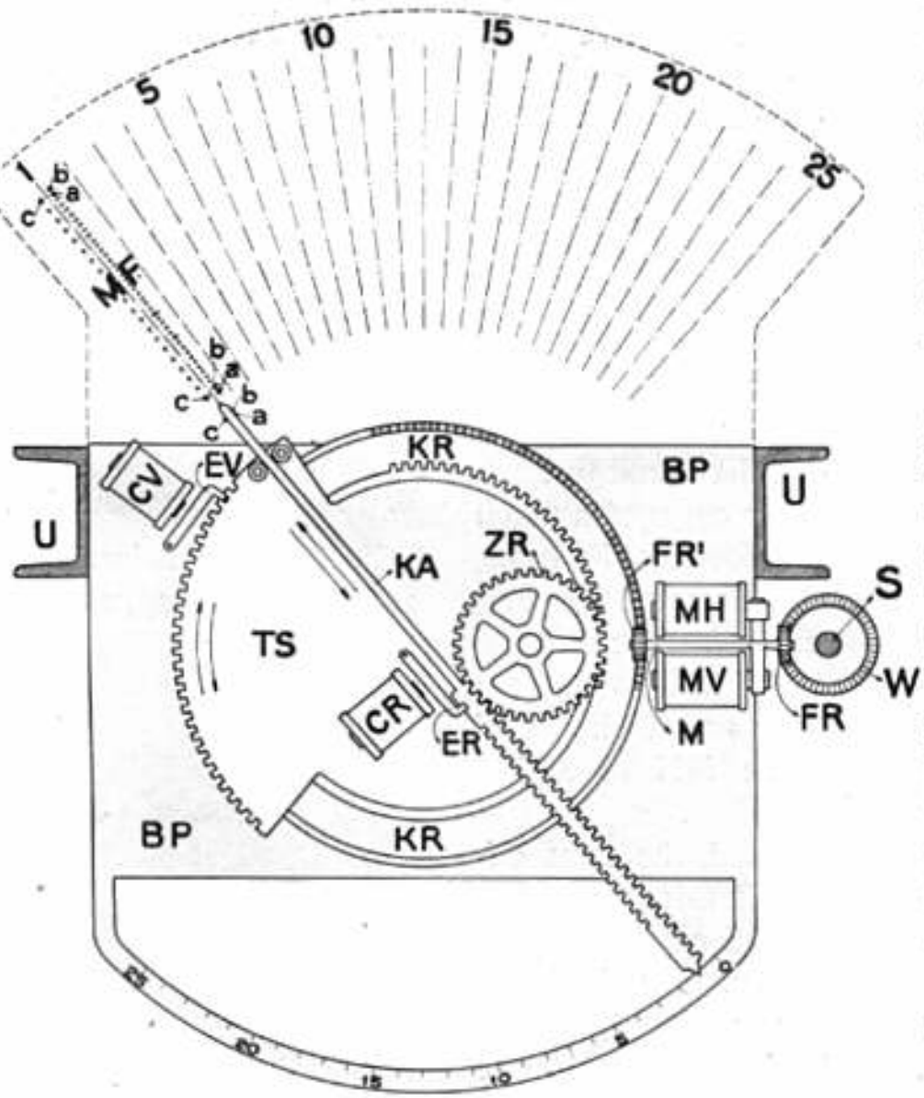
The magnet coupling, mounted directly on the base plate, has two magnet coils MH & MV. The shaft M, carrying the toothed wheels FR & FR_1, is run through the armature, which is common to both coils. The armature can be attracted by either the coil MH, giving it an upward movement, or the coil MV, giving it a downward movement. These movements cause the toothed wheel to be brought against either the upper or the lower driver W, thereby giving the shaft M a rotary movement in either the one or the other direction.

The function of the rim KR is to convey the movement from the wheel FR_1 to the rotary disc and the contact arm. The teeth on its outer edge gear into the wheel FR_1 and those on its inner edge gear into the wheel ZR, which is pivoted on the rotary disc TS, and whose function is to convey movement to the contact arm. The rear part of the contact arm is formed into a rack geared to the wheel ZR, as is shown in fig. 2. (ZR consists actually of two wheels, pivoted on the same shaft, the under one being geared to the rim KR and the upper one to the rack on the contact arm).

Movably mounted on the rotary disc TS is the contact arm KA, the front part of which is covered by an insulating sleeve of rectangular section, carrying the three selector contact springs, a, b and c. The contact arm has two different movements, namely, a rotary movement, in which it follows the turning of the disc around its axis, and a radial movement, by which it moves in to or out of a multiple frame.

The movements of a selector are controlled by means of the two locking or centering magnets CV and CR.

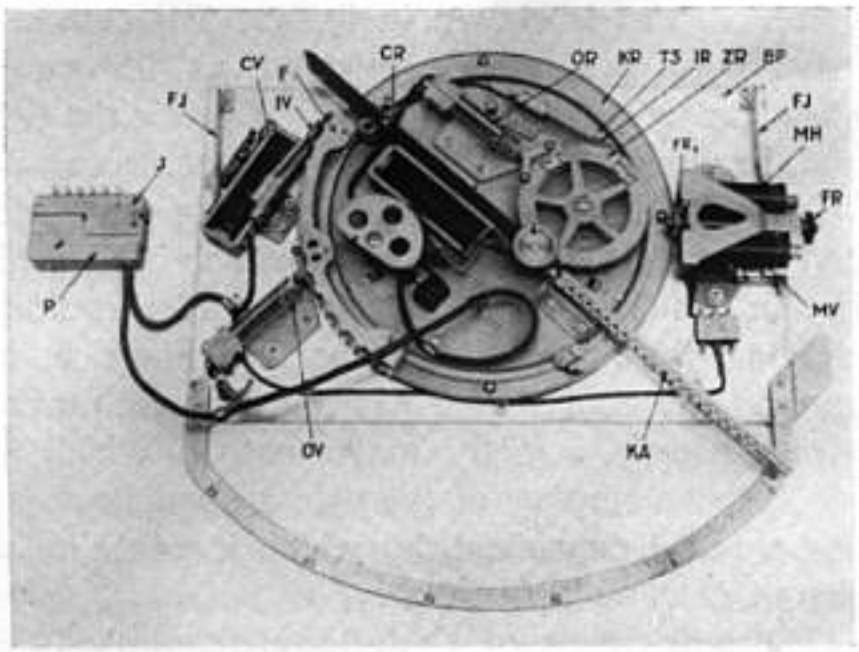
The magnet CV controlls the rotary movement of a selector, its armature being shaped to a dog EV, which fits into notches on the rotary disc, thereby locking it. The notches are spaced so as to exactly conform to the position of the contact arm in relation to the multiple frames. In fig. 2, for example, the contact arm is centred exactly opposite frame number 1.



R 12 Fig. 2. Working principle of a 500 line selector.

The magnet CR controlls the radial movement by means of its armature, which forms the dog ER, whose function it is to centre and lock the contact arm. This it accomplishes by striking into notches on the contact arm, corresponding to the positions of the 20 lines of a multiple frame.

The magnets MH and MV are furnished with the necessary current through con-



R 13 Fig. 3. Connector.

tacts located on the locking magnet armatures, when these latter are attracted. The two following cases can then occur:

(1.) If the locking magnet CV is actuated, the selector is released for rotation and the rotary disc, together with the contact arm, will start turning. This movement continues until the circuit through CV is broken and the dog engages a notch, thus locking the rotary disc, the current supply to the magnet coupling being simultaneously cut off. A left- or right-handed rotary movement is obtained depending on which of the magnet coupling coils MH or MV is energized.

(2.) If the locking magnet CR is actuated the contact arm is released for radial movement. This movement continues until the circuit through CR is broken and the dog engages a notch on the contact arm, thus locking the same, the supply of current to the magnet coupling being simultaneously cut off. The contact arm is either thrust into or withdrawn from a multiple frame, depending on which one of the magnet coupling coils MH or MV is energized.

As has already been mentioned, the three different types of selectors used in this system, i. e. line finders, group selectors, and connectors, are mainly of the same construction. The details in which they differ are as follows:

Each line finder is provided with a special test spring, mounted on the rotary disc (does not occur in fig. 3, which shows a connector), by means of which that multiple frame is found, in which an incoming call is located. The vertical front bars of the multiple frames in the line finder racks are, for this purpose, used as test bars, with which this test spring comes into contact during the line finder's rotary movement.

Group selectors and connectors have always a definite starting position for the rotary movement. They are provided with a cam plate F, mounted on the rotary disc, which alternately closes and opens a group of switching springs IV, thus sending impulses back to the register.

The connectors are further provided with a switching group IR for the sending of impulses to the register when the contact arm is moving into a multiple frame. This switching group is actuated by means of a cam wheel, mounted under and on the same shaft as the toothed wheel ZR.

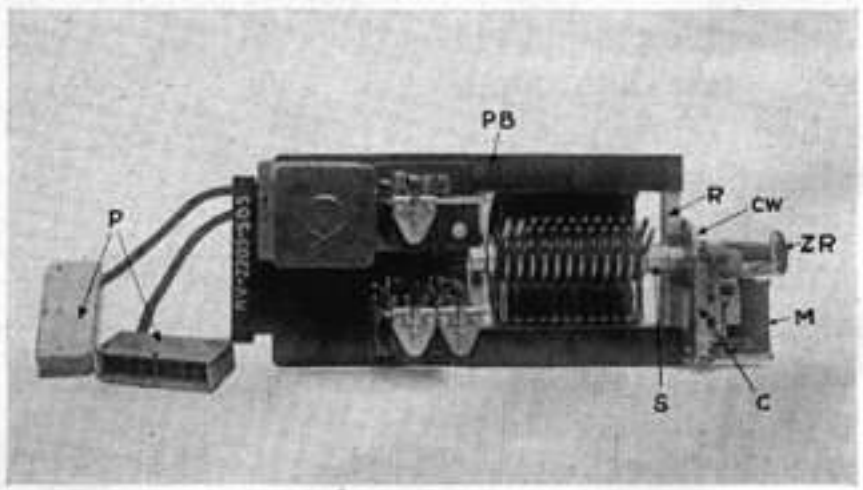
All selectors are furnished with two switching groups OV and OR, mechanically actuated in the extreme positions, one of their functions being to reverse the movements. OV reverses the rotary movement and OR the radial movement.

The connecting of a selector's wiring to the trunk lines is accomplished by means of an 18-point plug P, fitting into a corresponding jack J, mounted on the rack.

After being pushed into place in the rack, the selector is firmly locked in position by means of the two springs FJ.

B. *The sequence switches.*

Each selector is furnished with a sequence switch and relays, the appearance of which is shown in



R 14 Fig. 4. Sequence switch.

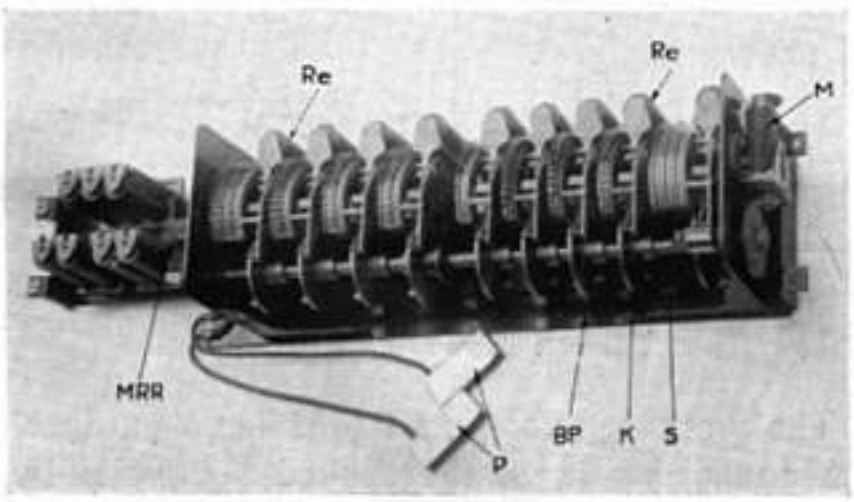
fig. 4. The contact bank consists of circular segments (the length of the arc being 1/3 of a full circle) in which metal contacts are embedded. Each segment has two rows of metal contacts, and a maximum number of 13 segments can be screwed upon a frame R, which, in turn, is screwed to a second framework BP. This framework BP acts also as a support for the sequence switch relays.

As a sequence switch of this type has 12 positions and 13 rows of double contacts, it follows that $12 \times 13 = 156$ different contact combinations are possible, but additional combinations can be obtained by making the bank contacts of different widths, so as to extend over more than one contact position.

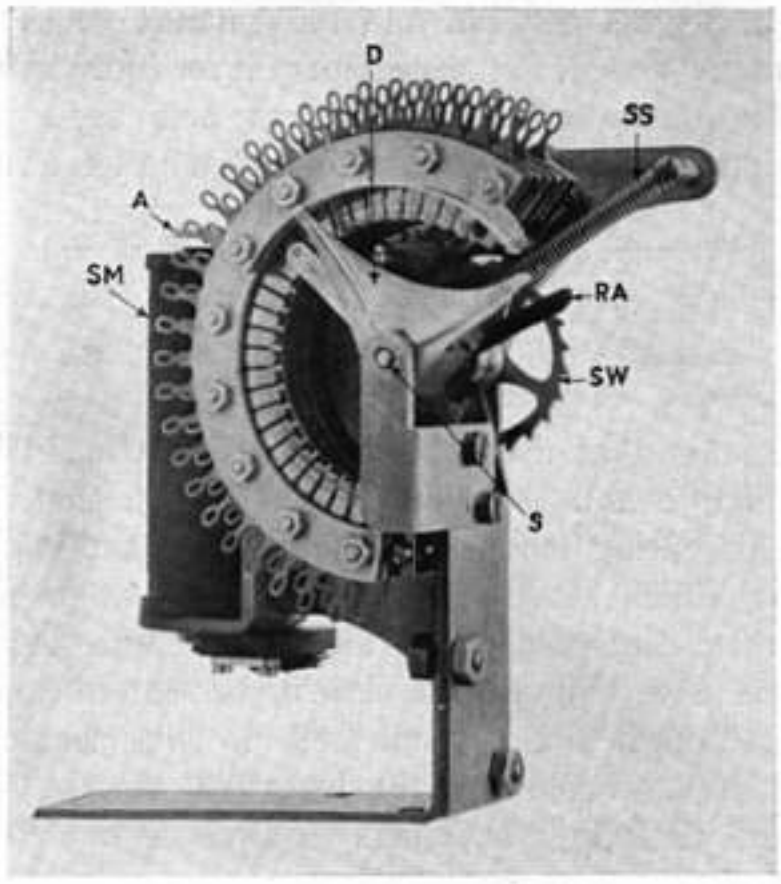
The sequence switches are power driven in the same manner as the selectors. M is the magnet coupling, with the toothed wheel ZR pivoted on its armature. The attracting of this armature causes ZR to engage a driving wheel mounted on the common driving shaft, the rotary movement being transmitted to the shaft S and the wiper arms.

Each sequence switch is furnished with an electrically controlled centering device, consisting of a cam wheel CW and the switching group C. Its function is to control the movements of the wiper arms by keeping the circuit through the centering spring closed until the wiper arms have reached the exact desired position.

Sequence switches are connected to the trunk lines by exactly the same method as selectors, i. e. by means of plugs P to jacks, which are mounted on the racks.



R 15 Fig. 5. Complete register set for a 10,000 line system.



R 16 Fig. 6. Register unit.

The sequence switches are mounted on both sides of the rack, each side or panel accommodating 20 switches, with their fuses and alarm devices.

C. *The register sets.*

A register set is shown in fig. 5, the most important parts being:

The Base	BP
» Register units	Re
» Restoring mechanism, consisting of:	
A Magnet coupling	M
» Shaft S with discs	K
» Sequence switch	MRR

The relays with which a register set is equipped are mounted on the base BP, as shown at extreme left in fig. 5.

A register unit — shown in fig. 6 — is a step-by-step selector. The bank of contacts consists of circular segments of insulation (extending over slightly more than a half circle) in which the metal contacts are secured. The wiper arms are mounted on the shaft S, which also carries the ratchet wheel SW and the restoring arm RA. A register unit has 27 contact positions, i. e. the starting position 0, 25 positions from 1 to 25, and one extra position 26.

The ratchet device of the register unit consists

of a magnet coil SM and its armature A. The armature actuates an escapement lever (not visible in the illustration) which, in turn, acts as a releasing mechanism for the ratchet wheel SW.

R 17 Fig. 7. Line finder and group selector.

One end of the coil-spring SS is fastened to the frame and the other encircles the shaft S.

This spring tends to rotate the shaft and wiper arms, which movement, however, is counteracted by the escapement lever, which engages the ratchet wheel SW. Should an electric current now be led through the magnet coil SM, its armature will be attracted and the lever will release the wheel, allowing the wipers to advance one step. A renewed breaking of the current will readjust the lever, allowing the wipers to advance one more step. The wipers are thus advanced two steps for each full impulse (i. e. one closing and one breaking of the circuit).

D is an indicator, which shows the position occupied by the wipers.

The register units forming part of a register set are mounted on the base BP (fig. 5).

The shaft S with the discs K is made to rotate when the restoring magnet coupling is brought to engage the vertical driver shaft. The discs K are provided with studs which operate the restoring arms RA of the register units, thus restoring the wiper arms to the starting position, 0.

Register sets are also removably connected to the trunk lines in the same way as selectors and sequence switches, i. e. by means of plugs fitting into jacks mounted on the racks.

The register sets are mounted on either one- or two-sided racks, with 10 to 12 sets to each panel.

D. *The relays.*

The relays used in an automatic exchange are practically identical with the well-known Ericsson type. A few improvements have been adopted, however, such as the eliminating of all internal connections, all switching group and coil connections being carried out to soldering tabs. The advantage of being able to remove and replace coils and switching groups is hereby gained. The relay armatures have been re-designed so as to make them more sensitive and quick-acting. Special pains have been taken to obtain a correctly balanced pressure for the contact points.

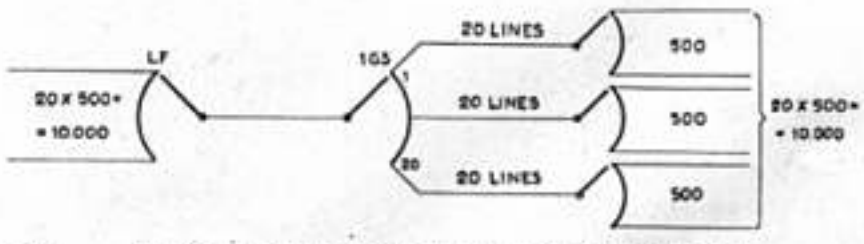
II. The building up of the system.

A. The extending of calls to the group-selectors, in the Ericsson automatic system, is accomplished by means of line finders. The subscribers' lines are brought together in groups of 500. Every such group is connected to the multiple in a line finder rack. The number of line finders necessary for 500 lines depends on the traffic (i. e. the number and average duration of calls during the busy hour) and usually varies between 30 and 50.

B. Each line finder is associated with a group selector, as shown in fig. 7, LF signifying a line finder and GS a group selector. Should 40 line finders be required, the corresponding group selector rack will also contain 40 group selectors. Trunks lead from the multiple frames in the group selector racks to connectors or to further group selectors.

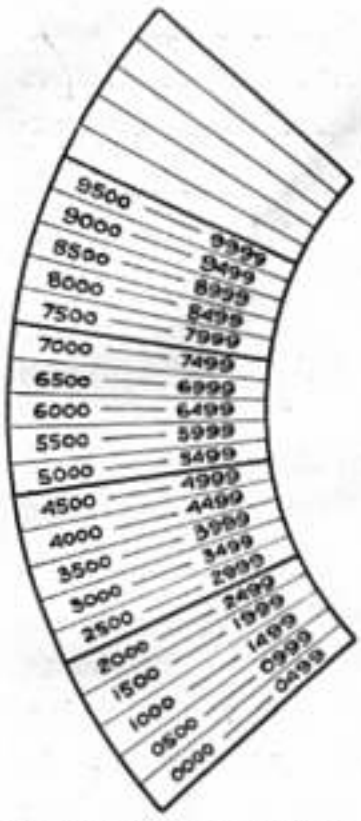
If the full capacity of the twenty five multiple frames of a group selector rack is utilized for trunks to connectors, a capacity of $25 \times 500 = 12{,}500$ lines is obtained. For practical reasons, however, it is not customary to use more than the first 20 frames for this purpose, the remaining 5 (21 to 25) being used for special lines.

A capacity of $20 \times 500 = 10{,}000$ lines is thus reached by the use of only one group selector, as shown in fig. 8.



R 18 Fig. 8. Schematic diagram for a 10,000 line system.

The group selectors in a 10,000 line plant direct the connecting in of the desired 500-group by means of the rotary movement, while the radial



R 19 Fig. 9. Numbering of multiple in a group selector rack.

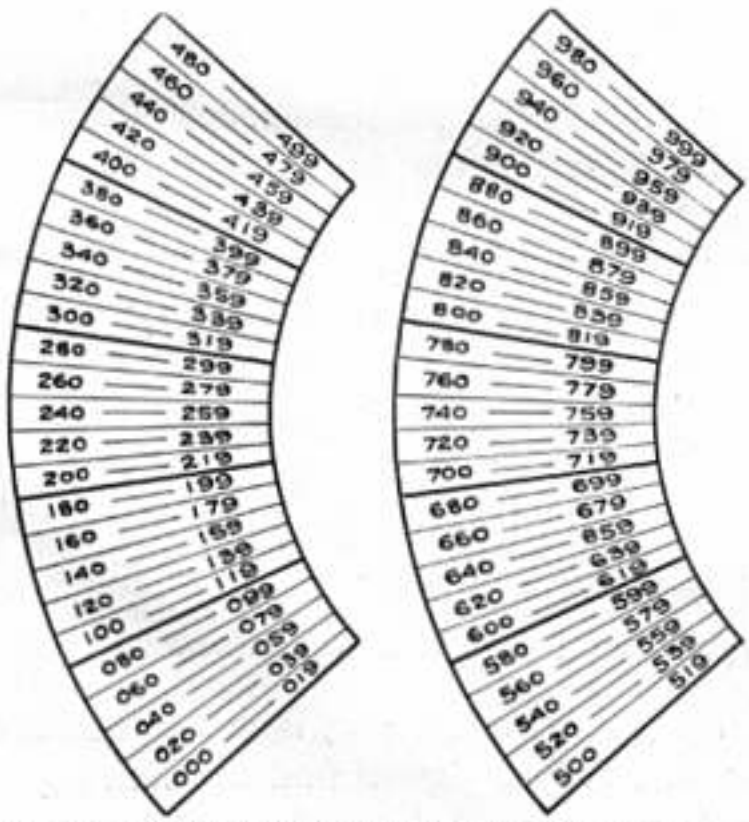
movement is utilized to search out a disengaged connector (that is, when the contact arm enters the multiple frame).

C. The connector makes the final connection to the desired number. The group of 20 which contains the desired number is sought out by means of the selectors' rotary movement, and the final connection is accomplished by means of the radial movement.

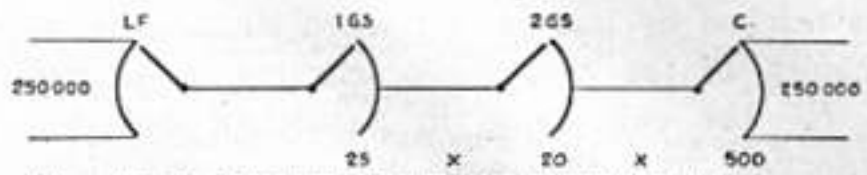
A connector multiple contains 500 lines, similar to the line finder multiple. Each group of 500 lines, therefore, has its connector rack, containing a certain number of connectors, their number depending on the intensity of traffic.

Fig. 9 shows the method of numbering the multiple frames in a group selector rack for a 10,000-line plant, while fig. 10 shows how connector multiples are numbered.

Each group of 1,000 occupies 2 frames in the group selector multiple, the first containing the 5 lower hundreds — from 0 to 4, and the second containing the 5 higher hundreds — from 5 to 9.



R 20 Fig. 10. Numbering of multiple in a connector rack.



R 21 Fig. 11. Schematic diagram for a 250,000 line system.

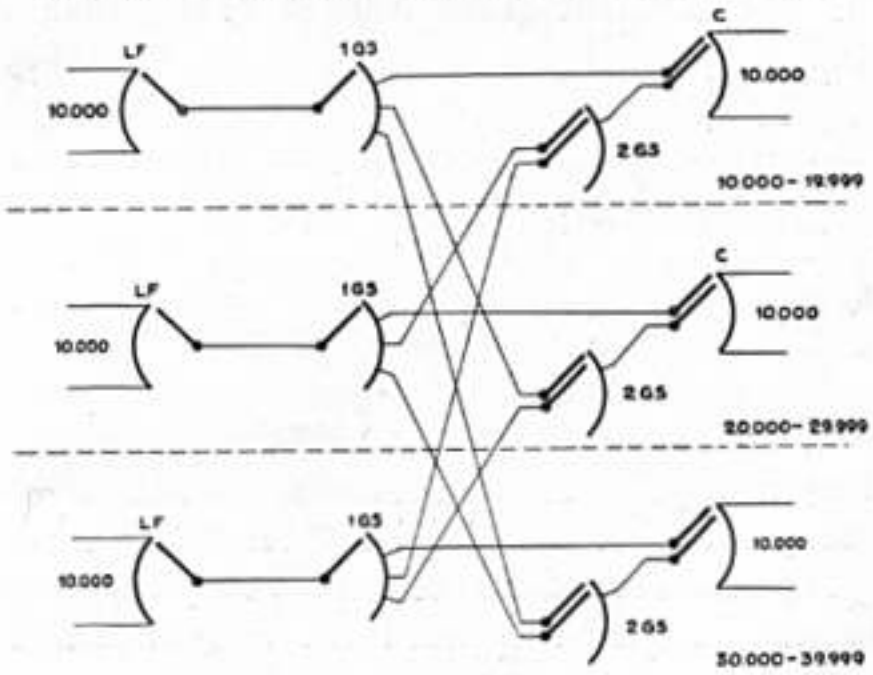
D. The capacity can be increased to $25 \times 20 \times \times 500 = 250{,}000$ by adding one more group selector, as shown in fig. 11.

Trunks are carried from the first group selectors 1GS to 25 ten thousands groups. These trunks end in second group selectors 2GS, the multiples of which are trunked to the connectors C of the respective five hundreds groups.

E. Another system, in which either one or two group selectors are used to complete the connections, is applicable to plants of from 10,000 to 60,000 lines. A schematic diagram of this system, for a plant of 30,000 lines, is shown in fig. 12.

The 30,000 lines are grouped in 3 ten thousands. The traffic between subscribers whose numbers are within the same ten thousands group is handled by one group selector 1 GS, since the multiple frames of the first group selector rack contain trunk lines to the 20 five hundreds corresponding to their own 10,000 group. Trunk lines from the multiple frames 21 to 25 proceed to the second group selector 2 GS, the multiples of which are in turn trunked to connectors.

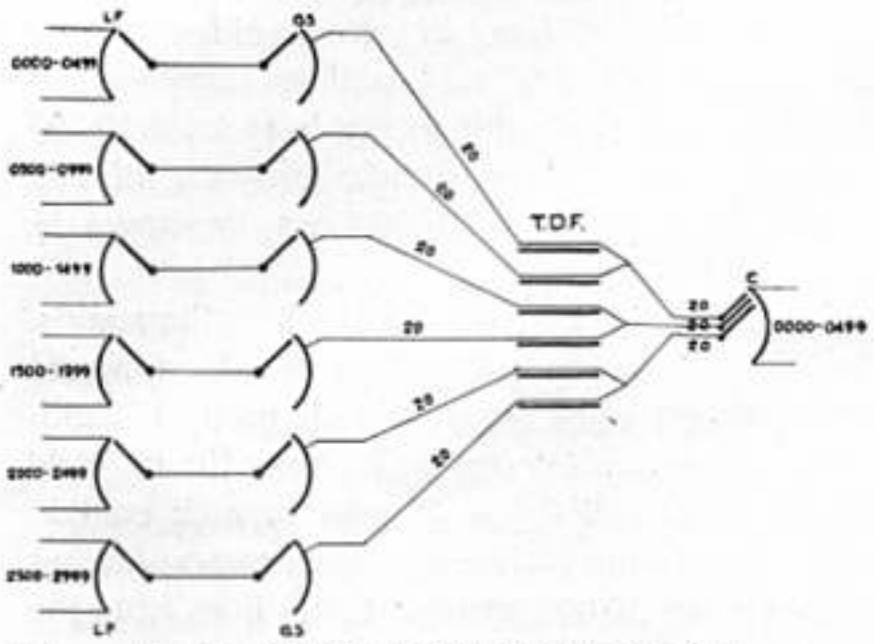
Thus, a capacity of $10{,}000 + 5 \times 10{,}000 = 60{,}000$



R 22 Fig. 12. Schematic diagram for a 30,000 line system.

is reached by this system when all the multiple frames of the first group selectors are utilized.

F. The connecting in parallel of the group selectors' multiples, and the connecting of the cables to the connectors is done in a traffic distributing frame. These frames are composed of two vertical angle irons furnished with tab strips to which the cable wires coming from the group selectors' multiple frames are connected and coupled in parallel so as to obtain an even distribution of connectors in relation to the amount of traffic. An example is illustrated in fig. 13. LF and GS are line finder and group selector racks for 6 five hundreds groups. Trunking to



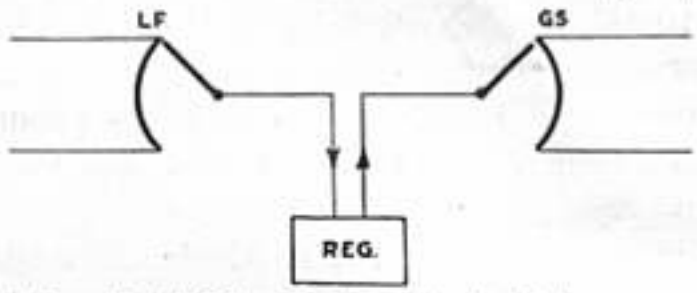
R 23 Fig. 13. Connection of group selector to T. D. F.

the traffic distributing frame is shown from the first multiple frame only, corresponding to the five hundreds group 0000 to 0499. Thus a 20-line cable is led from frame no. 1 in each group selector frame to the T. D. F. Suppose that traffic conditions necessitate the use of 60 connectors for 500 lines; the distribution can then be arranged as shown in fig. 13, for example, by parallel coupling the multiples in pairs, each pair with 20 trunk lines to the connector rack in question.

G. Connecting of the register sets.

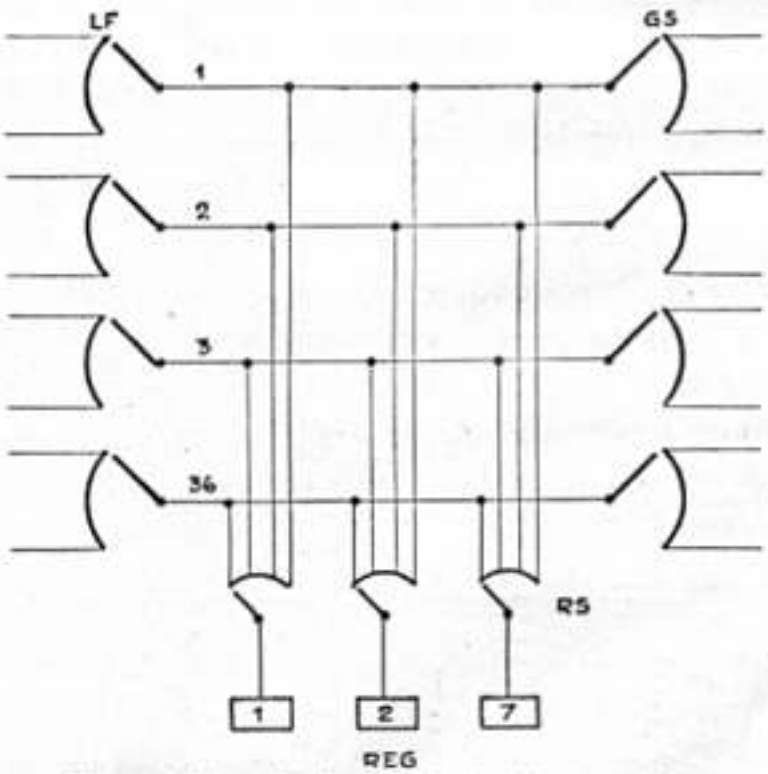
When a line finder is connected to a subscriber's line, a register set must also be connected for the purpose of directing the movements of the group selectors and connectors. Consequently, the register is placed between the line finder and group selector, as shown in fig. 14.

In view of the fact that a register set is engaged only as long as it takes the subscriber to dial the desired number and for the group se-



R 24 Fig. 14. Schematic diagram for line finder selector and register.

lectors and connectors to move to their respective positions, while line finders, group selectors, and connectors, on the contrary, are engaged as long as the conversation lasts, it is easily understood that it would be highly uneconomical to provide a register set for each individual line finder, especially as they are comparatively expensive and bulky devices. For this reason, only a certain number are allotted to each group of line finders, the number being determined by traffic conditions. Special selectors are used for connecting the register sets to the line finders. Two different principles can here be applied, clearly illustrated in figs. 15 and 16.



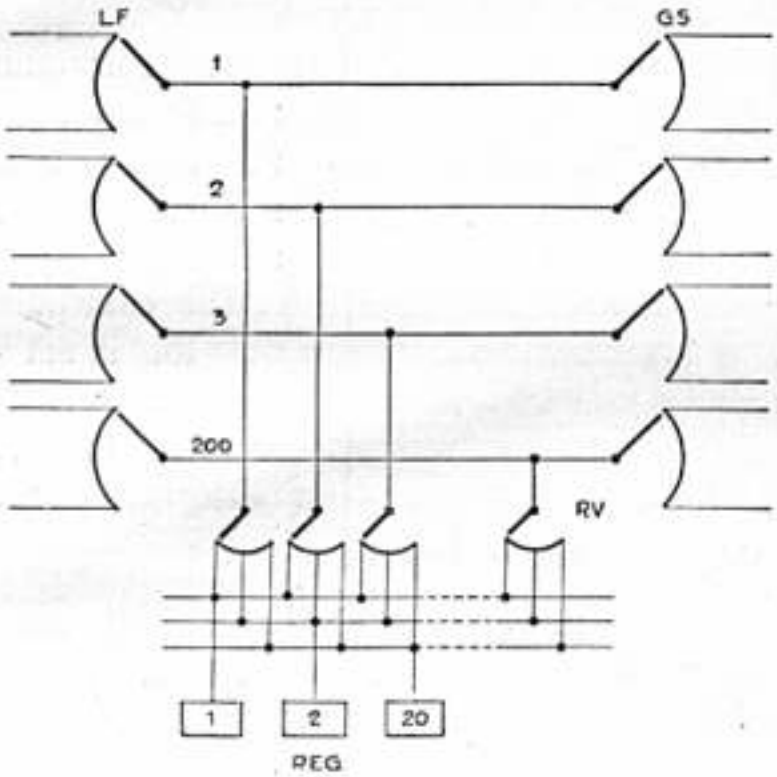
R 25 Fig. 15. Schematic diagram of circuit for connection of register by means of register finder.

In fig. 15 the connecting is accomplished by means of so-called register finders. Each register set is furnished with a register finder (the con-

struction of which corresponds to that of a sequence switch) accomodating 35 lines.

In this case, therefore, the line finders will form groups of 35. To each such group is alloted a certain number of register sets (6 to 9, depending on the traffic). A call entering such a group sets all the register finders RS belonging to disengaged register sets in motion, and the one that first finds the calling line finder LF is connected.

In fig. 16 the register sets are connected by means of register selectors RV, of which one is alloted to each line finder LF. The contact banks of these selectors — consisting of 20 contact



R 26 Fig. 16. Schematic diagram of circuit for connection o register by means of register selectors.

positions — are coupled in parallel and connected to 20 register sets. The number of line finders LF which can be connected to a group of 20 register sets depends on traffic conditions. (One group of 20 sets can, as a rule, be connected to the line finders for 3 or 4 five hundreds groups).

III. Functioning of register set.

The mechanical construction of a register set has already been described under II--C. When considering its functions, a register set may be divided in two parts, namely the registering part, which receives and »registers» the numbers dialled from the subscriber's telephone (or, in the case of a semi-automatic exchange, the numbers called from the operator's keyboard), and the controlling part, which directs the proper setting of the group selectors and connectors.

The schematic diagram of a register set for a plant with subscribers' numbers of four digits (0000 to 9999) is shown in fig. 17.

A. Registering part of the register set.

That portion of the register set which registers the numbers consists of:

The impulse relay R_1.

The main function of this relay is to receive the impulses which are sent out by means of the subscriber's dial D. Simultaneously with the connecting of a register set to a subscriber's line, a circuit from earth over the subscriber's line and telephone, and through the impulse relay R_1, to battery, is closed, resulting in the actuation of the relay R_1. The dialling of a digit creates a train of circuit breaks or impulses, causing the relay R_1 to be released as many times as the circuit has been interrupted in the dial. (The number of circuit breaks corresponds in this case to the dialled digit. The figure 1 will cause the circuit to be interrupted once, the figure 2 twice,etc., and the figure 0, lastly, will cause the circuit to be interrupted 10 times.)

The restoring relay R_2.

The function of relay R_2 is to restore the register to normal after a connection is completed. This relay is constructed so as to be slow-releasing only. It is attracted through the contact a) in the relay R_1 at the same moment that the register is connected to a subscriber's line, and retains this position until the connection is completed. Owing to its slow releasing, relay R_2 remains attracted during the impulsing of relay R_1.

The controlling relay R_3.

The relay R_3 controls the movements of the control switch SOR_1. It is a slow acting relay similar in design to R_2, and is, for this reason, attracted once for each train of impulses sent, that is, once for each figure dialled.

The control switch SOR_1.

This apparatus is similar in construction to a register unit, described under II-C, and its function

is the successive connecting in of the units Re1 to Re4. Its magnet is energized over a contact in the controlling relay R3.

The registering units Re1 to Re4.

The object of these units is to register the dialled numbers. They are successively connected in by the controlling switch and take the positions which correspond to the dialled numbers.

Re1 is in circuit when the thousands digit is dialled.

Re2 is in circuit when the hundreds digit is dialled.

Re3 is in circuit when the tens digit is dialled.

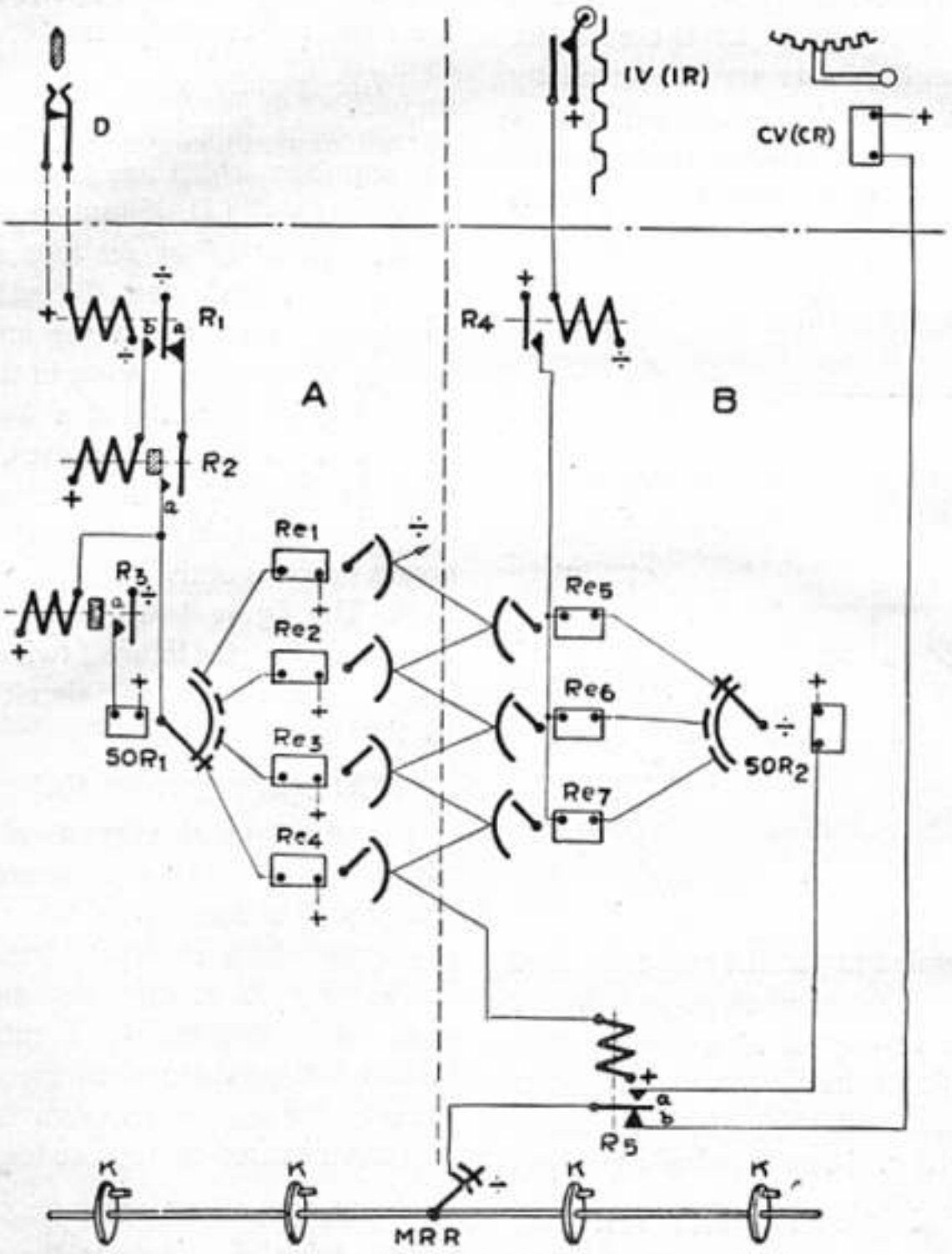
Re4 is in circuit when the units digit is dialled.

B. Controlling part of the register set.

This part of the register set is composed of:

The revertive impulse relay R4.

The function of this relay is to receive the impulses sent out by the group selectors during their rotary movement and by the connectors during their rotary and radial movements, and repeat them to the controlling units Re5 to Re7. These impulses are generated over the impulse contact IV (IR), and correspond in number to the number of steps which the selector and connector movements have advanced.



R 27 Fig. 17. Schematic diagram of register.

The stop relay R5.

The relay R5 cuts off the starting current to the group selectors and the connectors and serves also to close the circuit to the magnet of the control switch SOR2.

The control switch SOR2.

The function of this control switch is to successively connect in the controlling units Re5 to Re7.

The controlling units Re5 to Re7.

The controlling unit Re5 is set by the rotary movement of the group selector,

The controlling unit Re6 is set by the rotary movement of the connector,

The controlling unit Re7 is set by the radial movement of the connector.

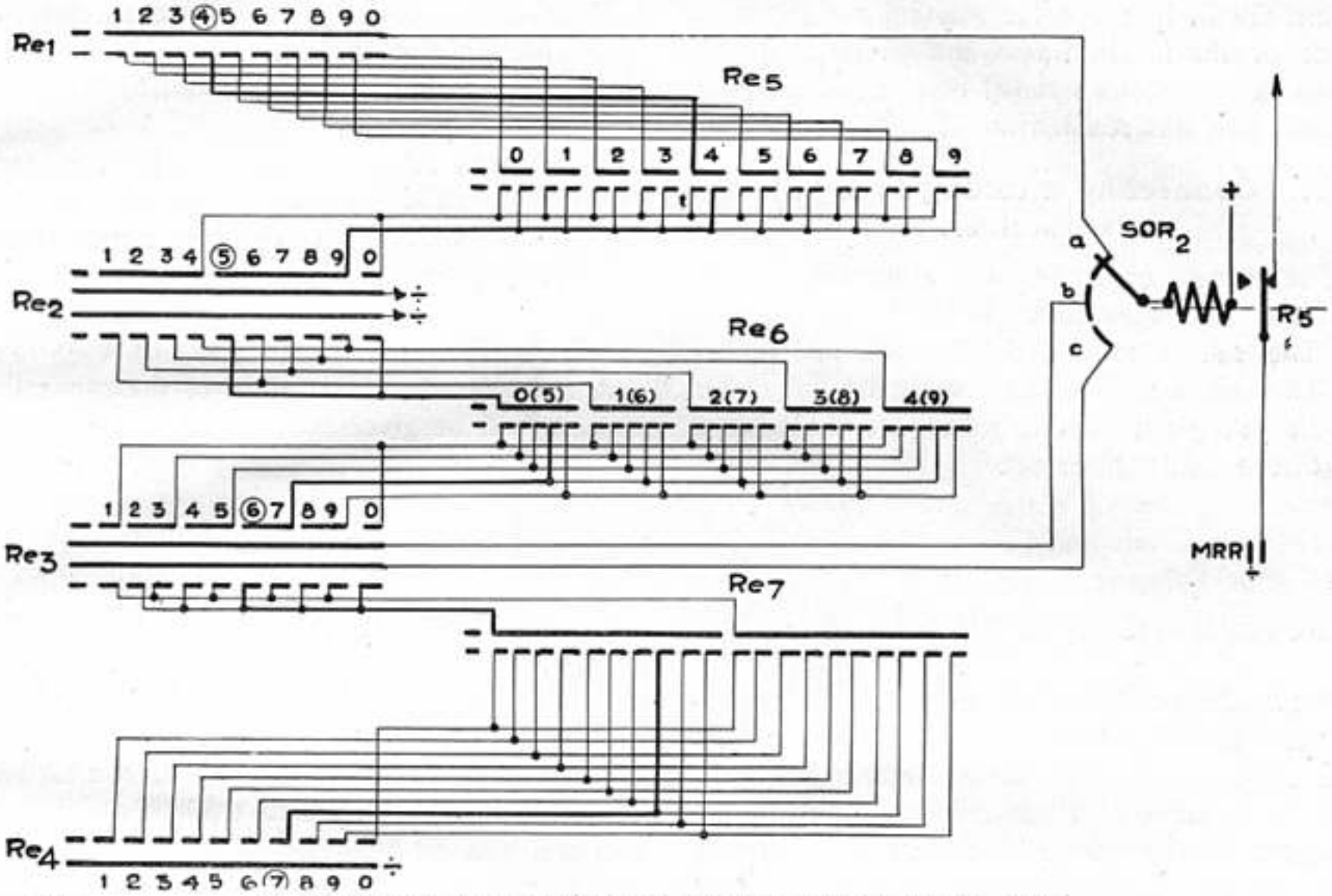
These controlling units, which receive their impulses from the revertive impulse relay R4, exactly follow the selector movements, for example, when the rotary movement of a group selector has advanced 11 steps, the controlling unit Re5 has also been advanced 11 steps, etc.

The restoring mechanism with discs K has a sequence switch MRR connected to its shaft, one of whose functions is to connect in the battery for starting the group selectors and connectors.

The setting of the group selectors and con-

nectors is accomplished by means of so-called revertive impulse control. When a sufficient number of digits has been dialled and registered by the registering units Re_1 to Re_4 (the two first digits for a four-digit numbering system), the sequence switch MRR is reset so that battery is connected in for starting the group selector. The centering magnet for rotary motion CV is energized (over a special relay which, for the sake of simplicity, is omitted in fig. 17), whereby its armature releases the rotary disc and simultaneously closes the circuit to the magnet coupling. Impulses are sent out to the register while the group selector is rotating, whereby the controlling unit Re_5 is properly set. When the selector movement has advanced a number of steps corresponding to the first two figures in the dialled number (the thousands and hundreds figures), a circuit is closed over the registering units Re_1—Re_3—Re_2 through the relay R_5, which hereby attracts its armature and breaks the selector-starting current at the contact in R_5.

The principle of setting for the connectors is the same as for the group selectors. The setting of a group selector, as has already been mentioned, is determined by the first two digits of a four figure number, the first digit determining the thousands group while the second digit determines whether the switching shall be directed to a five hundreds group of a low or high hundreds figure. This principle of setting is also made evident by the numbering of the group selector multiples, as shown in fig. 9.



R 28 Fig. 18. Connection between the registering and the controlling register-mechanisms.

The rotary setting of a connector is determined by the hundreds and tens figures (see fig. 10). It may here be noted, that the low hundreds figures 0, 1, 2, 3 and 4 are equivalent to the high hundreds figures 5, 6, 7, 8 and 9.

The radial setting of a connector, lastly, is determined by the tens and units figures.

Fig. 18 shows how the connection is made between the registering units Re_1 to Re_4 and the units Re_5 to Re_7, which control the correct setting of group selectors and connectors, so as to accomplish translation from the decimal system to a system corresponding to the grouping of lines in the group selectors and connectors. Suppose that the number 4567 has been dialled. The circuit a) attracts the stop relay R_5 and stops the group selector in front of the tenth multiple frame, circuit b) stops the rotating connector in front of the fourth frame, and circuit c), lastly, stops the connector's radial movement when the contact arm has reached line 7 within the frame.

IV. Connecting a calling to a called subscriber.

The process of establishing a speaking circuit between two subscribers is shortly as follows:

A. The call is connected to an idle line finder.
B. The call is connected through the line finder and a register selector (or register finder) to a disengaged register set.
C. The number called is registered within the register set.
D. The group selector is set to its rotary position.
E. The contact arm of the group selector enters the multiple, hunting an idle connector.
F. The connector is set to its rotary position.
G. The connector is set radially.
H. The register set is restored to normal after having completed its function.
I. The connector is testing to see whether the desired number is free.
K. A ringing current is sent out to the called number.
L. The called subscriber answers, thereby breaking the ringing circuit.
M. The selectors are restored to normal when the call is cleared, the call being recorded on the calling subscriber's service meter.

A more detailed description of the connecting process will be given in a future article.

G. G.