Dec. 23, 1947. G. T. BAKER 2,433,256

TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

Filed March 6, 1943 7 Sheets-Sheet 1

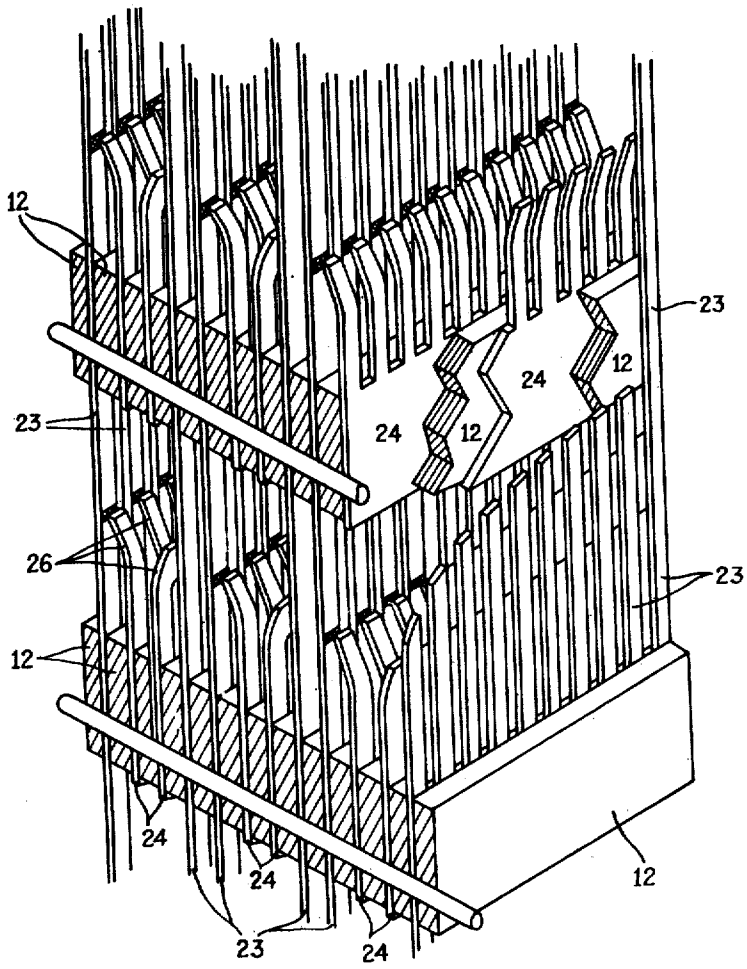


Fig. 1

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TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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Fig. 3.

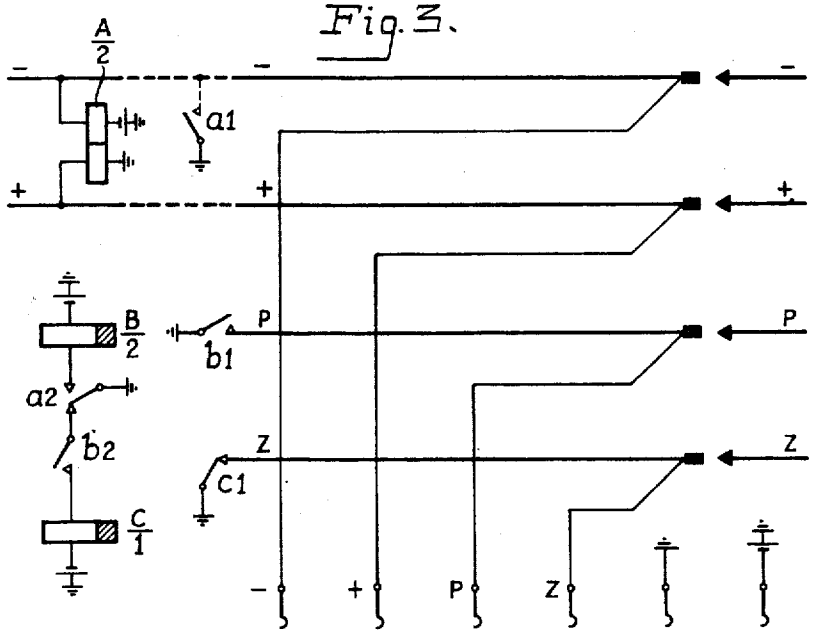
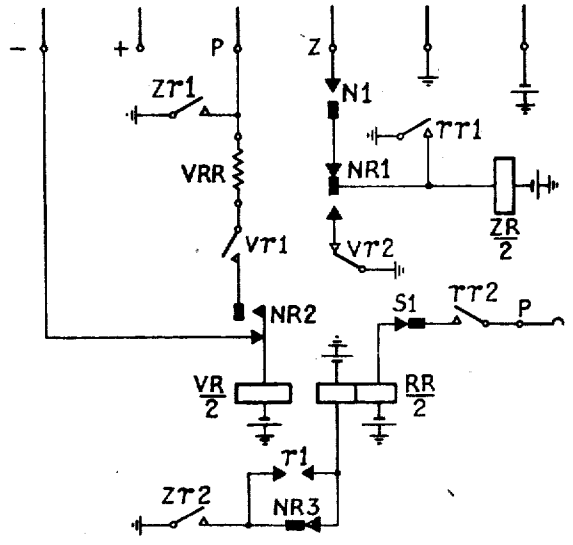


Fig. 2.



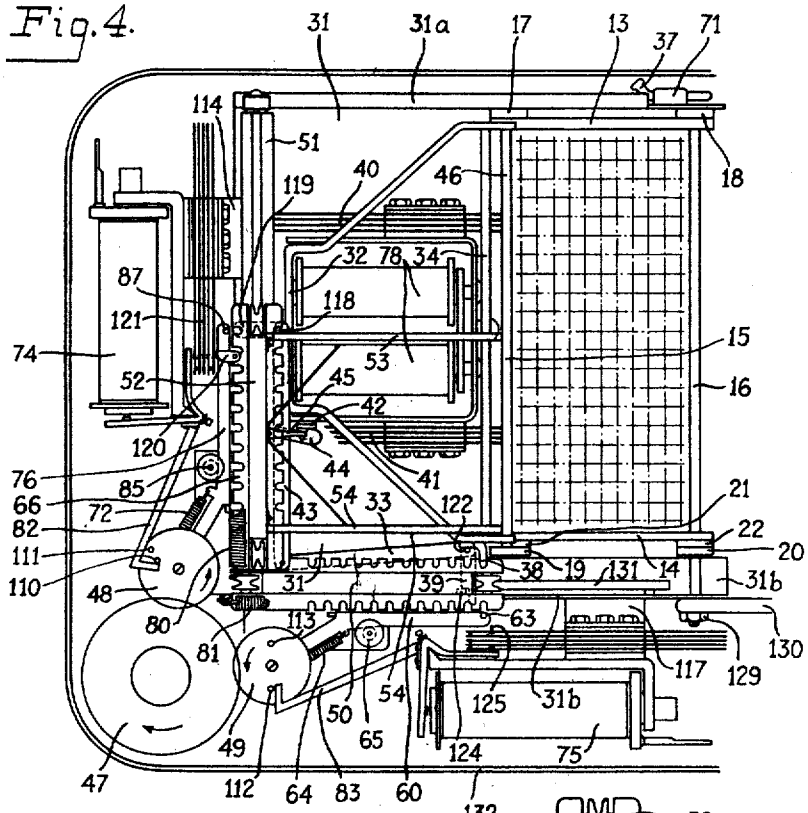
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Dec. 23, 1947. G. T. BAKER 2,433,256

TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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Fig. 4.



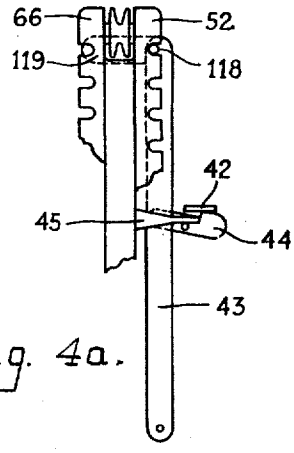


Fig. 4a.

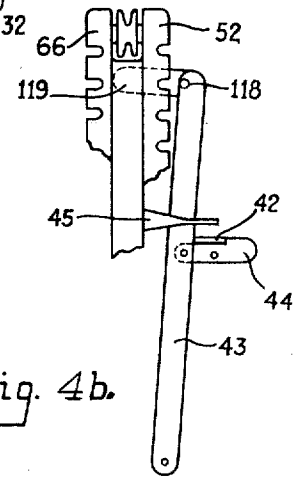


Fig. 4b.

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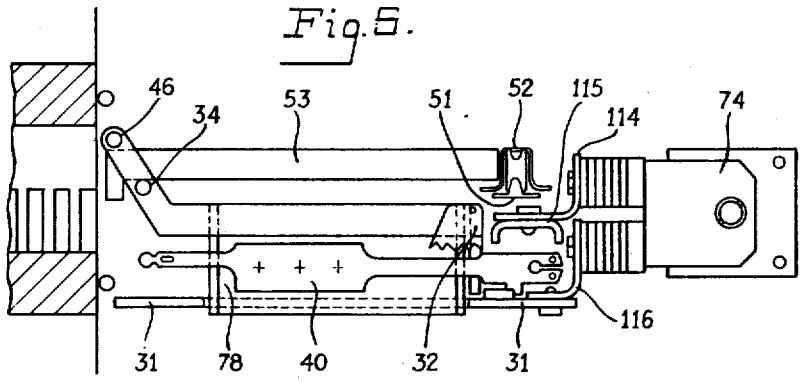
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Dec. 23, 1947. G. T. BAKER 2,433,256

TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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Fig. 5.



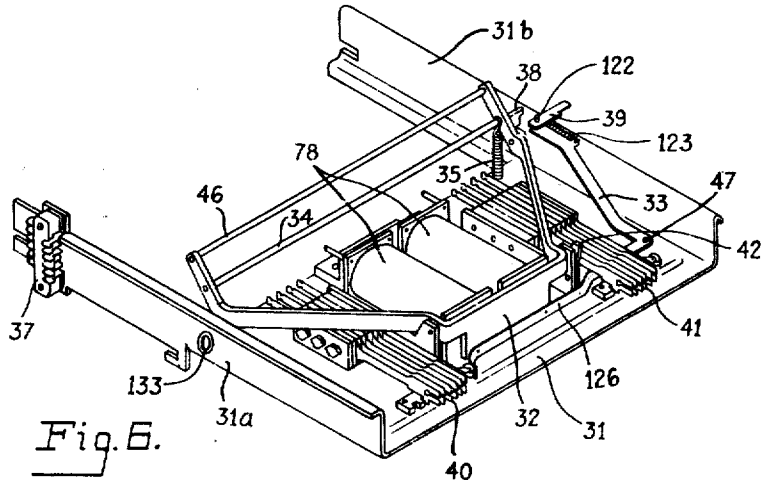


Fig. 6.

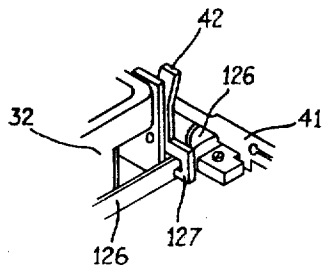


Fig. 7.

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TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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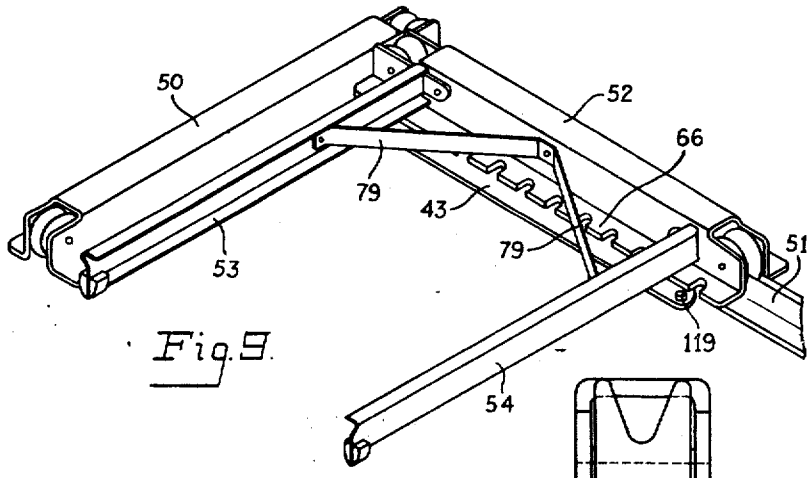
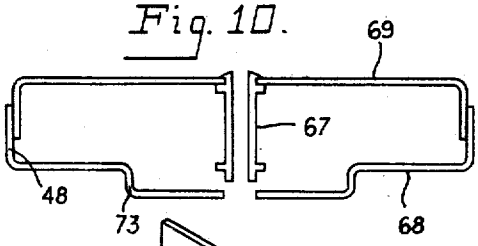


Fig. 9.

Fig. 10.



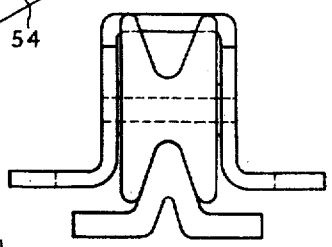


Fig. 8.

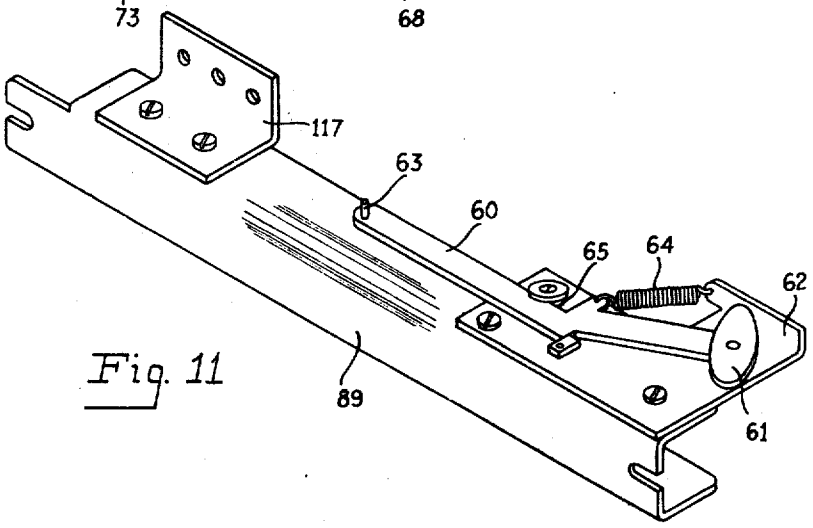


Fig. 11.

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TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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Fig. 12

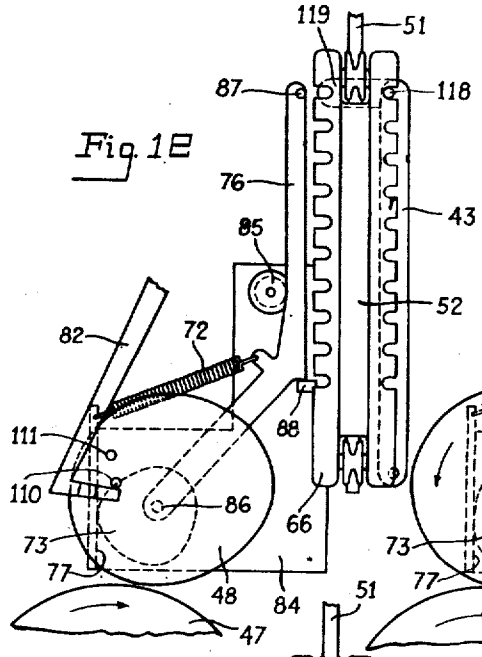


Fig. 12a

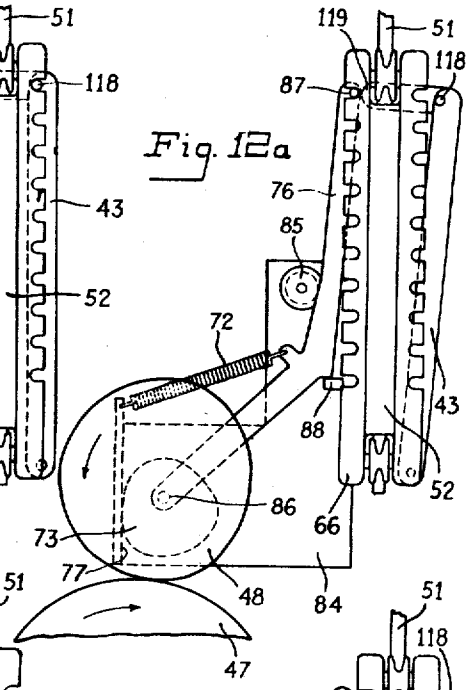


Fig. 12b

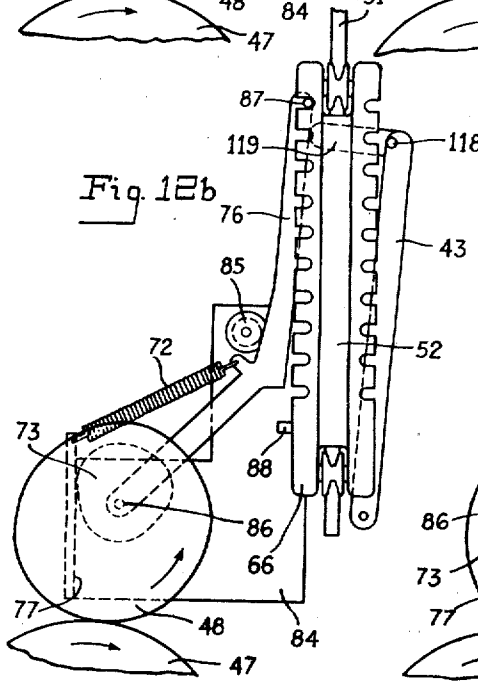
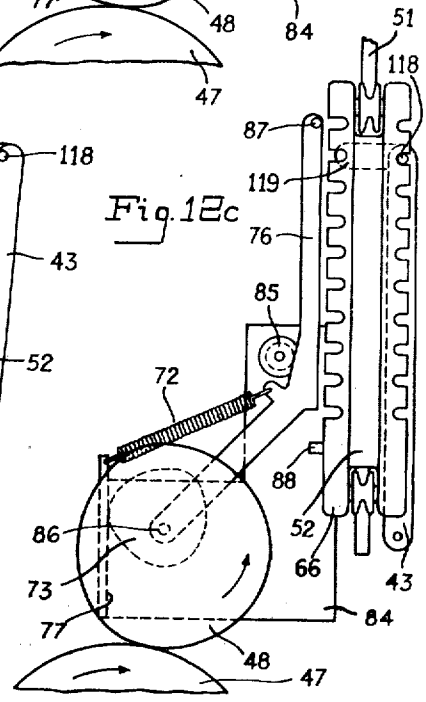


Fig. 12c



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TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

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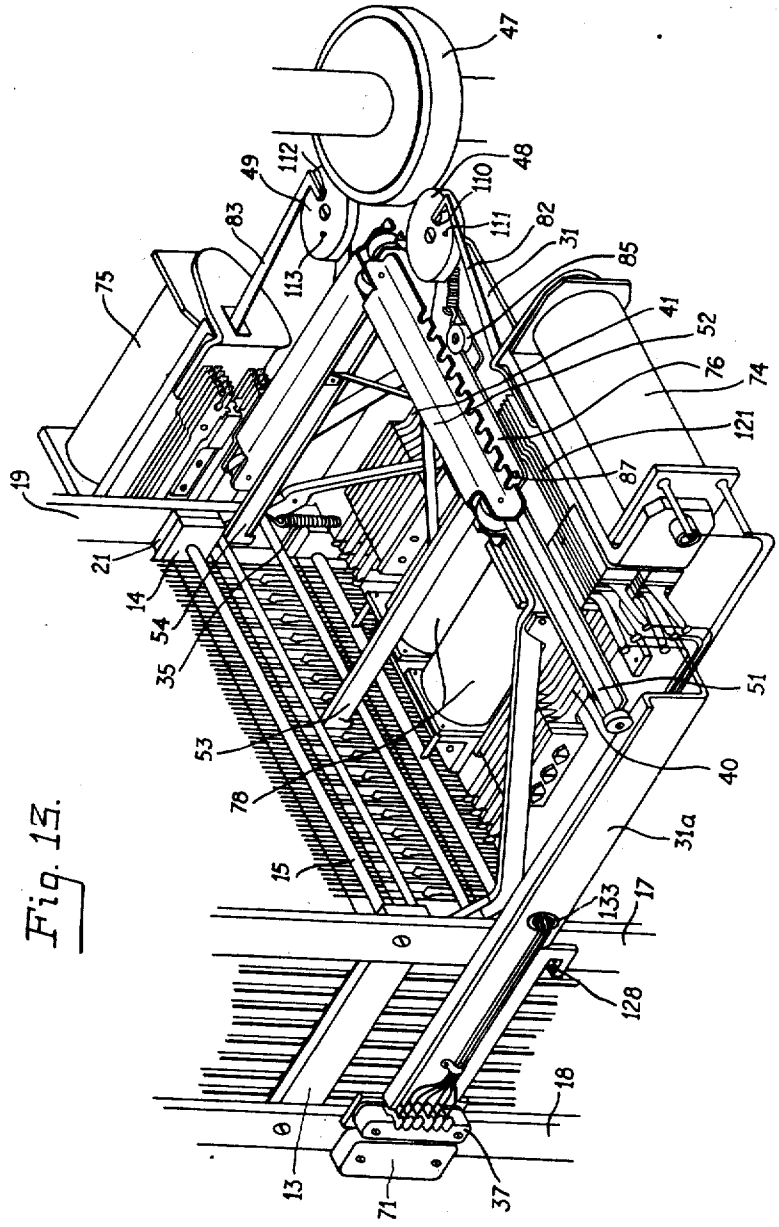


Fig. 13.

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Patented Dec. 23, 1947

2,433,256

UNITED STATES PATENT OFFICE

2,433,256

TWO-MOTION CAM CONTROLLED AUTOMATIC TELEPHONE SWITCH

George Thomas Baker, Liverpool, England, assignor, by mesne assignments, to Automatic Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

Application March 6, 1943, Serial No. 478,242
In Great Britain April 20, 1942

39 Claims. (Cl. 179—27.52)

1

The present invention concerns improvements in or relating to the construction of selector switches as used in automatic telephony, and the object of the invention is to provide a construction of selector switches which combines efficiency in operation, smoothness of running and compactness in design, so as to meet the fundamental requirements of an automatic telephone system in a very satisfactory manner.

According to one feature of the invention the contact-making arms of a selector are caused to move in two directions in substantially the same plane by a common rotating member having its axis substantially normal to said plane separate clutch mechanisms being provided to enable the rotating member to move the contact-making arms successively in the two directions.

According to a further feature of the invention the contact-making arms of a selector which are adapted to be moved across and into a bank of contacts are subsequently moved in a direction substantially normal to the plane of the first movement to cause pairs of contacts of a selected set of contacts to engage.

According to a further feature of the invention the step-by-step movement of the selector mechanism is effected by a roller having two cam surfaces one of which acts on a driving roller and the other of which acts on a fixed surface, whereby the first roller is given a movement in a close path to cause a tooth-engaging action to take place followed in succession by a tooth-driving, a tooth-disengaging and a restoring action to advance the selector mechanism one step.

According to a further feature of the invention an arm having a tooth-engaging member at one end and a double cam arrangement pivoted at the other is so arranged that the pivot of the double cam arrangement is given a movement due to the action of the two cams jointly on a fixed and moving surface respectively to cause the tooth-engaging member to move in a substantially rectangular path to enter, drive, and leave a tooth of the selector mechanism and return to its starting position, whereby the selector mechanism is advanced one step.

According to a further feature of the invention a selector switch mechanism, that is to say the operative part of the selector switch as distinct from the contact banks is adapted to be jacked into a contact bank having fixed and movable contacts comprising a horizontal frame carrying on one side an electromagnet and on another side at right angles to the first side a second electromagnet, the said electromagnets controlling the motion of contact-making arms in different directions from a common rotating shaft.

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The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawings, which correspond to similar figures in my copending application No. 478,245, filed March 6, 1943, now Patent No. 2,402,232, dated June 18, 1946, in which is disclosed a full description of the selector mechanisms and circuits, selector bank construction and cabling and mounting arrangements for a new and improved automatic telephone system with which the present invention has direct association.

Referring now to the drawings,

Fig. 1 shows an enlarged perspective part view of a rectilinear continuous bank showing the metal strip multiples and the precious metal contacts, a desired connection being effected by the appropriate operation of cordless contact-operating arms, conveniently referred to hereinafter as "wiper arms."

Figs. 2 and 3 together show the circuit of a ten-level ten-outlet per level group selector and the basic control circuit therefor.

Fig. 4 shows a reduced diagrammatic plan view of a cam driven two-stage selector and also the position occupied by the bank with respect thereto. Fig. 4*a* shows a plan view of the primary carriage release control mechanism with the carriage in its normal position, while Fig. 4*b* is a similar view of the conditions obtaining when the switch has completed the secondary release movement from the position to which it has been previously set and is about to commence its primary release movement.

Fig. 5 shows a part diagrammatic side elevational view of the two-stage selector and its associated bank and approximates its full size.

Fig. 6 shows a reduced perspective view of the selector chassis with the selector components assembled thereon.

Fig. 7 shows the slight mechanical modifications which are involved in meeting special release action requirements.

Fig. 8 shows an enlarged end view of one end of one leg of a carriage shown on its running rail, while Fig. 9 shows an enlarged perspective view of the primary and secondary carriages together with the wiper arms.

Fig. 10 shows an enlarged sectional view of the primary drive main and subsidiary cams, which, as shown, are integral with one another, while Fig. 11 shows an enlarged perspective view of the selector secondary drive arrangements from which, for the sake of clarity, the main drive cam is assumed to have been removed. The four basic stages of operation involved in driving the

selector primary carriage one step are shown in the four Figs. 12 to 12c inclusive.

Fig. 13 shows a reduced perspective view of the complete selector jacked in position adjacent the bank.

The two basic movements performed by the selecting switch wiper arms with respect to the contact bank are "across" and "in," and will be referred to as primary and secondary movements respectively, and being effected by primary and secondary main and subsidiary driving cams.

With regard to Fig. 4 it should be explained that it is partly diagrammatic and not in exact accordance with the exact construction. For instance, the driving cams are shown circular with a central pivot and overlapping the continuously operating roller, whereas the primary cam should be of the shape shown in Fig. 12 and should be pivoted eccentrically as shown. The secondary driving cam which is adapted to advance the secondary carriage through two steps per revolution is of the same size as the primary cam, but the shape of both this secondary cam and its subsidiary cam is modified accordingly, the shape of the subsidiary cam being on the lines indicated in the perspective view of Fig. 11.

A further point by which the selector shown in Fig. 4 differs from actual practice is that the primary cam is shown to be of the two-stage escapement release type while the secondary cam is shown to be of the single stage simple release type so that the former is only released and allowed to engage with the driving roller when the corresponding controlling relay releases after having been operated, while the latter is released and allowed to engage with the roller as soon as the secondary control relay operates. With the simple circuit arrangements to be described the selector is therefore only suitable for functioning in a group selecting capacity when it has to respond to trains of impulses for its primary direction of movement and when it has to self-drive in the secondary direction so as to perform a hunting operation. Both primary and secondary cams may be of the simple catch release type shown in connection with the secondary cam in Fig. 4 if the circuit arrangements are suitably modified.

Referring to Fig. 4 it will be seen that the power source for the operation of the selector is derived from a hard rubber roller 47, rotating on a common shaft at a constant speed, say 10 R. P. S. The primary and secondary driving cams 48 and 49 are each eccentric and pivoted so as to be just clear of the roller on its smallest radius. Each cam has a spring 72 or 64 associated with it which stores sufficient energy to give the cam a small rotational movement when a catch controlled by a control relay 74 or 75 is released. When a control relay has effectively released the catch the surface of the cam after a slight movement comes into contact with the roller which continues the rotation of the cam. As is later fully described, the pivot of the cam is moved away from the roller as the cam rotates, the pressure between the cam and the roller due to the load automatically preventing slipping. The pivot of the cam transmits its movement by a single member 76 or 60 direct to a carriage 50 or 52. A subsidiary cam integral with the main cam and operating upon a fixed surface causes the driving pin 87 to be moved in and out of engagement with the driving teeth thus avoiding ratchet and pawls and ensuring a constant lock of the carriage at all times. The contour of the main cam is such as to give constant acceleration and deceleration to the carriage thus reducing stresses to a minimum.

The switch is built up upon a chassis 31 on which the primary and secondary control relays 74, 75 are mounted, either directly or indirectly as will be later described. Two carriages are provided, a U-shaped primary carriage 52 (see Fig. 9), the two side arms 53 and 54 of which form the wiper arms, and an L-shaped secondary carriage 50, on the long arm 51 of which the primary carriage is adapted to run. Each of the carriages runs on rollers and is provided with a toothed driving member, the primary carriage being adapted to be moved step-by-step on a rail provided by the long arm of the secondary carriage and thus to carry with it the wiper arms 53 and 54, a state of balance therefor being maintained by the wiper arms which rest on a rail 34 positioned at right angles thereto and forming an extension of the release magnet armature 32 (see also Fig. 6). The secondary carriage is adapted to be moved step-by-step on rails provided by the chassis and thus to carry with it the primary carriage and associated wiper arms.

As an introduction to the operation of the switch it will be assumed that it is functioning as a final selector, i. e., both basic movements are controlled by dialled impulses.

In this case both primary and secondary cams will have to be of the two-stage release type or alternatively suitable circuit arrangements will have to be provided to allow of impulse control of single-stage release cams.

On receipt of the first train of impulses, the primary relay 74 responds and in a manner to be later described intermittently couples the associated driving cam 48 with the roller drive 47 with the result that a driving member 76 pivoted on the same pivot as the cam is given a reciprocating and rocking motion and its tip co-operates with the toothed driving member of the primary carriage 52 to advance it a number of steps corresponding to the number of impulses dialled and thereupon to set the wiper arms to a position opposite the required bank level. The release magnet 78 is then energised, whereupon rail 34 secured to the magnet armature 32 raises the wiper arms 53 and 54 slightly at their tips so as to cause these tips to clear the toothed combs 24 of the bank level into which they will be subsequently inserted. The banks consist of fixed contact members 23 extending from one side of the switch to the opposite side in the form of metallic strips and movable contact members, one for each fixed contact member in each switch which form the teeth of a comb 24, insulators 12 being provided between the comb plates and strips as illustrated in Fig. 1. The second train of received impulses is effective on the secondary relay 75 which in response thereto intermittently couples the associated driving cam 49 with the roller drive and the secondary driving member 60 is also given a reciprocating and rocking motion so as to cause the secondary carriage 50 to move a number of steps corresponding to the digit concerned and in so doing to carry with it the primary carriage and also the wiper arms mounted thereon. At the end of the second digit the wiper arm tips will be positioned over the required set of contacts in the bank and the release magnet is now de-energized to cause the

tips to lower into the contact sets opposite to which they are positioned in order to make firm contact between the incoming trunk and the selected outgoing trunk.

When the switch is to be released the release magnet is again energised and it will be understood that the mechanical conditions of the primary and secondary ratchet retaining pawls are made such as to allow the carriages to restore to their normal positions under local spring tension, the wipers travelling light as during the initial setting operation of the switch, since the wipers will have again been lifted clear of the banks on the energisation of the release magnet.

Consideration will first be given to the general assembly and construction of a selector switch bank and for this purpose reference should be had to Fig. 1.

A bank is formed by continuous strips **23** running the full length of the predetermined multiple and as shown in the part view of Fig. 1 these are clamped at opposite sides of selectors to form fixed contact members, the intervening space between the clampings forming the bank contacts for one selector. At the end of the multiple the strips **23** are fanned out to form wiring tags. That part of the bank multiple allocated per selector will subsequently be referred to as a selector bank so that Fig. 1 may be described as showing a part view of two selector banks in each of which are included three levels of two conductors each. A level of one bank is moreover assumed to have been broken away in order more closely to illustrate its construction. Each bank will be preferably of the 100 point type, that is to say, with ten rows or levels of ten sets of contacts, each set of contacts being formed on four strips and four combs **24**; on each level there will be provided in addition the usual eleventh step set of contacts for overflow busy indication purposes.

A multiple will usually comprise twenty such banks assembled together one above the other, the necessary multipling being inherently performed by virtue of the use of continuous strips **23** which connect with the outgoing trunks. The connecting function of the ordinary selector wipers and cords is taken by a set of comb plates **24** one of which is provided for each row of strips conveniently referred to as a level of each bank and having fingers **26** aligned with the various bank strips. Each finger of a comb plate such as **24** forms a movable contact member. All bank contacts are made of precious metal such as silver, and to make this a commercial proposition all the silver-base-metal junctions are made by rolling, this rolling operation being carried out in the stock before blanking.

The continuous strips are stamped from a metal sheet on which silver contact strips will have been previously rolled at right angles to the direction of the strips and at spacings of say 1½ inches, this distance representing the calculated vertical distance required between bank centres to accommodate the selector switches one above another. The comb plates are stamped from springy metal ribbon of suitable width and provided with a rolled silver edge of, say, about 20 mils width. The comb plate fingers are preferably each split with a saw cut (not shown) to give a twin contact effect and the plates are subsequently formed to give the requisite shape shown in Fig. 1.

Each row of contact members in a bank is separated from its neighbour by an insulating plate **12** of a length equal to that of the comb plates and

of a thickness of say 50 mils to reduce possible cross talk to a minimum and at the same time to give ample room in the level for the insertion of the wiper arms. Since each strip will be clamped in each of the twenty banks through which they pass, it is not considered necessary to provide clamping bars which extend through the banks, and accordingly it will be seen from Figs. 4 and 13 and particularly from my co-pending application No. 478,241, filed March 6, 1943, that each bank of the multiple after assembly in a suitable jig will be clamped together by two horizontal clamp plates such as **13** and **14** which are secured against the bank by clamp rods such as **15** and **16**. The requisite spacing of 1½ inches between adjacent banks is secured by means of the four vertical members **17**, **18**, **19** and **20** which extend over the length of the multiple and which are secured at each bank by the two clamp rods provided individual thereto.

As will be described later each selector switch mechanism is adapted to jack into position against its bank in the manner shown in Fig. 13, with its wiper arms normally at rest at a distance equal to one level before the first level of the bank. To meet this requirement suitable packing pieces **21** and **22** (Fig. 4) are interposed between vertical bars **19** and **20** and the adjacent clamp bar **14**. From Fig. 4 it will be seen that the clamp rod **15** will be nearest to the selector switch mechanism and this will be of such a length as to finish off level with the vertical members **17** and **19** including its fixing nuts, or alternatively countersunk fixing screws may be used as in Fig. 13. The other clamp rod **16** will be of such a length as to extend for about ¾ of an inch at one end in order to provide suitable support for the bank multiple on the mounting upright.

In the development of the new automatic telephone system in which the selector according to the present invention forms a large part, mechanical and electrical design were both taken into consideration, and at this stage a preliminary circuit review will be introduced since some of the circuit aspects of the system had a very large influence on the final design.

It will, however, be appreciated that certain of the mechanical features are capable of being used independently of the circuit design and vice versa, the present invention aiming at showing how the two features of design may be combined with advantage.

It has been noted that one of the major differences between this selector switch and its prototypes is that the connecting function is now part of the bank and virtually divorced from the selector. It seems highly desirable to maintain this condition rigidly not only for selector simplification but also for talking efficiency. Hence all switching contacts must be kept out of the through wires and every selector must look like the right-hand portion of Fig. 3, from which it will be seen that the speaking path at each selector passes through neither relay contacts nor jack-in plug and socket joints.

In designing circuits to meet this condition the following guiding factors were taken into consideration:

1. It is extremely advisable that the holding and battery feeding bridge shall be in the first stage or at least in an early position in the train.

2. The avoidance of line contacts means that selectors provided with two or more sets of wiper arms and banks should not be provided as these need switching relays so that generally there will

be only one available outlet per step on any level such as on a 100 outlet (ten levels of ten outlets each) selector and it is proposed to use such a 100 outlet selector in the new system. The new selector drive arrangements may, however, enable a secondary movement search speed to be obtained, which will permit of fifteen or more outlets to be hunted over in a direct line. The use of such selectors also permits four wires to be used and this fourth wire is made use of to simplify subsequent circuit design. It also simplifies the circuit problems which arise when a feeding bridge is employed at any early stage in the switch train.

3. The use of the fourth wire opens up the possibility of avoiding the use of independent relays in the selectors. The primary and secondary magnets may be used as relays, since they can conveniently be of the same general design as the standard British post office type relays.

4. The necessity of eliminating an extra mounting means for relays enables the selector to assume whatever shape is most suitable for its own purpose and it is found that a flat type of construction with a height only of the order of 1½ inches is quite possible.

Every selector normally contains three basic relays usually designated A, B and C. The present circuits are such that these relays need be provided only once per train thus further justifying the use of 100 outlet selectors and effecting material economies in relays.

One of the problems created by employing the battery feeding relays at an early stage in the connection is that of impulsing. In this case the relays usually subject to impulse failure are concentrated in the first stage so no difference is encountered there. The magnets are subject to an initial extra repetition due to this cause, but in any case, this is met by the elimination of a repetition in the selectors themselves where the incoming impulses are delivered direct into the magnets instead of being repeated from an A relay. In addition to this, the magnets are self-correcting and will perform a single operation on one pulse however long or short.

Figs. 2 and 3 show the fundamentals of the new circuits. The combined primary magnet and relay VR is impulsed directly over the negative line, only one step being taken for each up and down movement of the relay.

The Z wire is used for primary/secondary changeover by the operation of the combined release magnet and relay ZR. This unit is of comparatively high resistance and hence little battery drain is involved in maintaining it energised until the completion of the secondary movement. Immediately this motion commences relay VR, which also serves as the switch holding relay, is maintained from the private and on its release at the end of the call re-energises the release magnet to initiate release of the switch.

The only controls to reach the selector come over the four incoming wires. All tones and common services are supplied at the battery feeding relays. Accordingly it would appear that only battery and earth connections are required in addition to the four control wires. Hence a six point test jack has been used in place of the usual U-point jack. Where selectors have to fulfill some special function this number would undoubtedly be increased but if the selector is definitely kept solely to its mechanical functions the number required is quite small.

A detailed description of these circuits will be made later after consideration has been given to the selector switch mechanism, for which reference should be had firstly to the plan layout thereof shown in Fig. 4. From this figure it will be noted that it has been possible to accommodate a two-coil release magnet **78** so that ample power is available to meet the requirements of both the switch release and wiper arm control functions which it is adapted to perform.

In Fig. 6 is shown a view of the pressed steel selector chassis **31** with the components assembled thereon. The manufacturing operations of the chassis consist of blanking and part forming, followed by a final forming operation, the latter being limited to the completion of the side lips. Upstanding portions in the centre of the chassis may be formed integral with the chassis **31** for the purpose of supporting certain spring sets, coils, and also the release magnet armature pivots or a "U" shaped sub-assembly could be provided having the advantages that:

(1) The springs can be assembled on the sub-assembly before mounting on the chassis and the use of an offset screw driver is avoided.

(2) An adjustment in the vertical plane can be provided if desired.

The end slot on the plug-ended arm **31***a* of the chassis is not required if this arm is located between the separators supporting the jack on the bank vertical member and both bank clamp rods are countersunk on this side of the bank.

As regards the assembly of components on the chassis the release magnet armature **32** will first be fitted and its pivot pins will be riveted in position; the two extension arms of this armature will have been previously linked by the wiper rails **46** and **34**, one of which, **34**, is connected to one end of a coil spring **35** which serves as the armature return spring. The release magnet and secondary off-normal spring sets **40** and **41** respectively may then be fitted, the usual buffer blocks for which will be secured to the base of the chassis. The secondary carriage retaining pawl **33**, together with its return spring (not shown), is riveted into place in such a manner that its rivet **47** serves as a pivot on which it can turn. This pawl is provided with a spring-loaded pivoted piece **39** at its head which pivots on the rotary ratchet pawl pin **122** and is used in conjunction with the rotary release as will be described later. Also attached at this stage to arm **31***a* of the chassis is the six point plug **37** which is adapted to engage with a jack secured to one of the bank vertical members when the switch is jacked into position.

Before referring to Fig. 9 which shows the primary and secondary carriages, it is desirable to point out that it was originally intended to grind and harden the lip shown on the right hand side **31***b* of the chassis in Fig. 6 but differential hardening especially of a piece this size is rather a difficult manufacturing operation and to avoid this a separate running rail of hard steel is employed say ⅛ of an inch thick by ½ an inch wide, as shown in Fig. 8 where it is designated **131**, with a top contour to suit the trolleys as described later, the corresponding upright **31***b* of the chassis side being finished straight and the rail is screwed to the inside. This change assists the manufacture of the chassis since the only sharp turn has been abolished. This permits of the use of a harder quality steel with consequently greater rigidity. The other lip which contacts a flat roller required no such modification.

Referring to Fig. 9 it will be seen that the L-

shaped secondary carriage comprises a short arm 50 and a long arm 51, the latter forming the running rail for the primary carriage 52 and its wiper arms 53 and 54. The rail 51 has a ridge to match the rollers, which ridge may be pressed up. Preferably if as is anticipated sufficient length of both this and the secondary running rail should be required then a special roller stock which would be cut off to the desired length would be used.

The wiper arms 53 and 54 are pressed from stiff steel of the order of 20 mils thick so as to form channel-shaped members. These arms are riveted to the member 52 and rigidity is provided by the bracing piece 79, riveted to the centre of the carriage and to the wiper arms at the point reached by the bank when the wiper is on the 11th bank contact.

Each contact operating tip is moulded on. One of the plastic resins, e. g., Bakelite, may be used for this purpose, or failing this, it may consist of two ebonite or like pieces riveted on. In either case the lower side of the wiper arm is flattened at the actual wiper tip to provide a central support.

Ordinary rubbing wipers (not shown) when required for instance for testing for a free outlet, lie along the flat part of the wiper arm on either side. They are made of any of the usual wiper materials, e. g., phosphor bronze, and are riveted to the wiper arm behind the tip. Such rivets include insulators, the inner pair of which are carried along the arm to prevent contact with the arm. The rear tags are carried to a second rivet about two inches behind the tip at which point the wiper cords are attached, thus obviating the need for the cords entering the bank.

The carriage return springs 80 and 81 lie alongside their respective carriages in each case on the outside thereof as shown in Fig. 4.

To keep the trolleys on the rails it is proposed to magnetise the latter. These are already of a hard steel and the trolleys and carriage provide an efficient return circuit. There should be no difficulty in obtaining the required retaining force.

There are components of the switch mechanism which have not yet been dealt with, or at least have only been mentioned generally, and the design and functions of the members involved will be better appreciated from the ensuing paragraphs which proceed step-by-step with the mechanical operations involved in the setting up and subsequent release of a group selector switch, i. e., with dialled primary movement and self-driven secondary movement.

Referring now to Fig. 4 the primary and secondary control relays 74 and 75 are of the British post office standard type with extensions 82 and 83 on their respective armatures for cam control purposes. As previously mentioned, on the secondary movement these controls take the form of a simple catch that is released when the relay is energised, but for the primary movement escapement control is provided necessitating one up and one down movement to cause release. On the primary driving cam 48 the co-operating part of the escapement catch comprises the two upstanding pins 110 and 111, while on the secondary driving cam 49 the co-operating part of the simple catch is either pin 112 or pin 113 which are spaced in 180 degrees phase relationship so as to allow of a half rotation only of the cam for each release of the catch, it being appreciated that the cam is designed so as to advance the secondary carriage two steps for every revolution. As previously mentioned the control relays are supported by brackets which form the top plates of the two spring build-ups on each relay. Two brackets are thus used per relay, one per build up, and on the primary relay the upper one 114 is supported by a channel member 115 (Fig. 5) extending across the chassis under the carriage rail 51 and the lower one 116 is secured to the floor of the chassis 31 itself. The secondary relay brackets, one of which is shown designated 117 in Fig. 4, are secured to a U-section angle piece 89 shown in Fig. 11 but not in Fig. 4 and the base of which is bolted to the side of the chassis, the side arms of the angle piece each supporting a bracket.

The problem of primary and secondary drives of the switch is essentially a dynamic one in contrast to the stationary elements which have already been discussed. Lightness of the moving parts is absolutely essential and with the construction about to be described the weight of the moving unit has been brought down to just over half an ounce.

The main improvement is that while in the construction according to the prior application two moving parts were employed one having a purely reciprocating motion, the other partaking in the reciprocating motion and having in addition a further rocking movement which causes the pawl tip to move in and out of the teeth, the construction according to the invention employs only a single piece 60 or 76 (Fig. 4) which has both reciprocating and rocking motion superimposed.

Referring to Fig. 11, the simplest drive would consist of a single strip joining the pivot of the main cam and the driving pin, but in the construction which is herein illustrated such a strip would foul the control relay armature retaining screw and the strip is bent accordingly to miss this screw. The movement is effected by the joint action of two cams, the driving cam which engages with the surface of the continuously rotating driving shaft or its equivalent and a subsidiary cam which engages with a stationary surface and while the driving cam is being rotated serves to deflect the end of the strip in a direction more or less normal to the direction of reciprocation.

The main component is the driving cam, which does the actual stepping of the selector. It is assumed that the cam moves in a straight line but in fact at each end of the stroke it is caused to move at right angles to the direction of travel under the influence of the subsidiary cam. This movement occurs when the cam contour is substantially flat and has the effect of starting to move the pin in and out of engagement while still travelling. If this is found to have any detrimental effect in practice a few degrees of flat will be allowed at the appropriate points.

The data used to design this cam was obtained as follows: The primary and secondary relays have been located as shown in Fig. 8 and if lines representing an imaginary cover 132 are drawn outside these relays, then the roller drive should fit inside this space. The continuation of the chassis line must be such that the roller must not interfere with the withdrawal of the chassis. Also the centre of the roller must be symmetrically aligned with regard to the two drives. These facts fix the roller diameter at say two inches.

If a line is drawn joining the roller centre and the driving pin when in the end tooth, the centre

of the driving cam preferably lies on this line. It follows that the mean effective diameter of the cam is something over an inch, say, 1.2 inches.

The minimum period available between two successive digits is normally taken as 450 milliseconds, this being fixed by the dial switch. Of this, 150 milli-seconds is allowed for the release of the "C" of digit-train relay, leaving 300 milliseconds to perform the automatic hunting operation. Hence 30 milli-seconds is available per step giving a hunting speed of 33.3 steps per second.

The primary stepping speed must be such as to be higher than that of the fastest dial likely to be encountered. In practice dials are assumed not to exceed 14 impulses per second, and allowing a margin the vertical speed should be about 16 per second.

It will be noted that this is about half the secondary speed, and since both cams function from the same roller and are required to be about the same over-all size, it follows that the secondary cam must perform two operations per revolution and the primary, one. That is to say, the secondary cam is provided with two pins diametrically opposite and the shape of the driving cam and subsidiary cam is modified accordingly. The subsidiary cam shown in Fig. 15 is designed for the secondary movement to work with two steps per revolution. Alternatively the cams may be adjusted in size.

The revolutions per second ratio between the primary cam and roller is about 0.6 giving the latter a speed of 9.5 revs. per second. Now in automatic telephony 10 impulses per second being the basic dialling speed is most widely used. Now if the shaft speed is made 10 revs. per second it can be used to provide any machine-made impulses required and many other advantages will be obvious. Hence the roller will preferably be two inches diameter with a speed of 10 revs. per second.

The primary speed will be made exactly half the secondary, giving a stepping time of 60 milliseconds. The usual division of an impulse in telephony is 66% for the operate stroke and the remainder for the release, and this ratio will be retained. Hence the forward primary stroke occupies 40 milliseconds and the return, 20 milliseconds. The secondary of course uses half these times.

In response to a train of dialled impulses the primary relay **74** responds and advances primary carriage **52** along the long arm **51** of the secondary carriage a number of steps corresponding to the digit dialled and thereupon sets the wiper arms carried by carriage **52** to a position opposite the required bank level. This is performed in the following manner.

From reference to Fig. 12 of the four operational views of the primary drive arrangement, Figs. **12**—**12***c*, it will be seen that the main primary driving cam **48** has integral therewith a subsidiary cam **73** constructed for instance in the manner shown in Fig. 10. The latter is urged by spring **72** against the case hardened runner **77** which forms part of the bracket **84** on which is mounted the case hardened pivoting roller **85** and which is conveniently secured to channel member **115** extending across the chassis as shown in Fig. 5. The roller **85** provides the main pivot of the driving strip and gives both a rolling and rocking point for the travel and rock of the driving member **76**. The driving strip **76** is

pivoted at one end on the same pivot **86** as in the main and subsidiary primary cams and at the other end carries a driving pin **87**, it being understood that the pivot **86** is independent of the bracket **84** so that the driving strip and cam assembly is maintained in position solely by being urged by spring **72** against runner **77** and roller **85**, spring **72** having a component of its pull lying between these supports so as to give pressure on each. In order to advance the primary carriage through one step the driving pin **87** is adapted to be given a substantially rectangular movement. The first stage is due mainly to the subsidiary cam being pressed against the slide plate **77** to cause the driving strip **76** to pivot about **85** and the pin **87** to engage with a tooth of the toothed driving member **66** as shown in Fig. 12*a*, the second stage which is due mainly to the main cam **48** due to its engagement with the roller **47** moving the pivot **86** away from the roller and so causing the pin **87** to advance the carriage driving strip **66** along the running rail **51** to the position shown in Fig. 12*b*, the third stage is the withdrawing of the pin from a ratchet after a complete step has been made to the position shown in Fig. 12*c*, due to the subsidiary cam and the runner and the fourth stage is the restoration of the pin back to the position shown in Fig. 12 due to the main cam and the roller.

In the normal position, i. e., with the main cam **48** held by the catch **82**/**110** the subsidiary cam **73** is on its maximum radius as shown in Fig. 12.

When the control relay **74** is operated on seizure of the selector, the catch **82** will move to the left away from the stop **110**, the amount of movement being such however that it will still remain in the path of the following stop **111**. Cam **73** thereupon rolls on slide plate **77** under pressure of spring **72** and cam **48** rotates with it for a short movement, further rotation being prevented by the engagement of stop **111** with catch **82**. This slight rotational movement brings the periphery of cam **48** a little nearer the roller **47** owing to its radius gradually increasing, but contact does not yet take place.

When the control relay releases in response to the first break impulse of an impulse train the catch **82** will restore to the position shown. In the engaging face of catch **82** a U-shaped recess is cut in such a position and of such size that the stop **111** will just pass through, and cam **48** will now continue to rotate forward under pressure of spring **72** until the increased angular movement brings it into contact with the driving roller **47** with which it will remain in frictional engagement for the remainder of the revolution.

The first effective stage in the rotational movement is reached when the subsidiary cam has moved from having its maximum radius in contact with slide plate **77** to where it comes to have its minimum radius in contact as shown in Fig. 16*a*. During this stage the pivot **86** will have moved to the left to cause the driving pin **87** to engage with the top tooth of the primary carriage **52**.

From this point onward the radius of cam **48** in contact with roller **47** continues to increase, while the radius of the subsidiary cam **73** in contact with slide plate **77** remains constant so that the driving pin **87** is given a movement in a direction along the path of the teeth of carriage **52** which is advanced one step when the position shown in Fig. 12*b* is reached. This completes the second effective stage.

For the third effective stage the radius of cam

48 in contact with the roller 47 then remains substantially constant, while that of cam 73 in contact with slide plate 77 rapidly increases so that the driving pin is withdrawn to the position shown in Fig. 12c.

The fourth and final stage consists of the driving pin being moved back to the position shown in Fig. 12 and is effected as the continued rotation of the cam 48 with its radius in contact with roller 47 decreasing proceeds. At this stage the toothed plate 66 is one step higher up than shown in Fig. 12.

On the next operation of the control relay and its subsequent release a second cycle of operations as described is performed to advance the carriage a further step and so on until the carriage together with the wiper arms which it carries have been set to a position opposite the required bank level.

Referring again to Figs. 4 and 12 it will be seen that lying along the primary carriage is a retaining pawl 43 which is attached by a pivot to the secondary carriage 50 and carries a case hardened retaining pin 118 at its free extremity which engages a tooth in the opposite side of the primary carriage to the driving teeth. At the free extremity of retaining pawl 43 there is provided a projection 119 at right angles thereto which passes under the carriage so that its tip will co-operate with an edge of the primary driving pawl 76. The receipt of an impulse causes the primary driving pin 87 to perform a rectangular movement as described and as the pin moves inward into engagement with the primary carriage ratchet the projection on the retaining pawl in engaging with the driving arm pushes the retaining pin 118 out of its tooth as shown in Fig. 12a. When the driving pin has completed its forward travel and carried with it the primary carriage through one step the retaining pawl and its projection assume the position shown in Fig. 12b, while when the driving pin withdraws at the end of its travel as in Fig. 12c the retaining pin 118 drops back in to the next tooth, the distances between teeth being such as to permit this to take place so that one is always in engagement. These operations take place for each impulse of the impulse train, and it will be seen that a positive lock is at all times maintained on the primary carriage by the driving pin or by the retaining pin so that overshooting cannot take place.

From reference to Fig. 4 it will be seen that a projection 120 is carried on the primary carriage 52 and this in the normal position of the carriage presses on the upper spring set 121 associated with primary relay 74. Springs 121 constitute the off-normal springs which change their position when pressure is removed, to produce suitable circuit operations as soon as the primary carriage 52 commences its first step. They are, of course, not affected by operation of the primary relay armature which is effective only on the lower spring set associated with the relay.

At the end of the impulse train the circuit arrangements are such that the release magnet 78 is energised, whereupon the rail 34 secured to armature 32 raises the wiper arms 53 and 54 slightly at their tips to cause these tips to clear the toothed combs of the bank level into which they will be subsequently inserted. One arm of the release magnet armature carries a projection 38 (Figs. 4 and 6), which normally drops into one of the retaining teeth of the secondary carriage; when the magnet is energised this is lifted upwards and out of the tooth. It serves to prevent the damage to the bank which would occur if the wipers could be driven in when they were not held upwards.

The secondary relay 75 is now energised to initiate a self-interrupted secondary driving movement, the circuit operations of which will be understood from the ensuing circuit description. The release of the catch 83 which forms an extension of the armature of relay 75 from engagement with pin 112 on the secondary driving cam 49 causes this cam to rotate and engage with the driving roller, whereupon the rotation of the main and subsidiary cam will proceed on the lines described in connection with the main cam 48 and subsidiary cam 73 under control of the driving roller and its local drive-engaging spring 64 until such time as relay 75 is released for instance when the outlet testing wiper which connects up therewith encounters a free outlet in the selected group in response to the step-by-step movement of the secondary carriage, which in being advanced carries with it the primary carriage and the wiper arms secured thereto.

The secondary carriage driving action is the same as for the primary carriage, the only difference being that cam 49 is adapted to produce a rectangular movement of the driving pin 63 for each half revolution it performs. A further difference, as previously mentioned, is that the rotation of the cam commences on operation of relay 75 and thereupon continues until such time as this relay releases and interposes its catch into the path of one or other of the rotating pins 112 or 113 according to which half-revolution of the cam is involved in the step concerned when the outlet testing wiper which connects up with control relay 75 encounters a free outlet. Fig. 11 shows an enlarged perspective view of the secondary driving arrangements in which, for the sake of clarity, the main driving cam is assumed to have been removed and which shows the essential shape of the subsidiary driving cam 61 which is adapted to engage with the case hardened runner 62, while the roller 65 serves as a pivot for the driving strip 60 carrying the driving pin 63.

As described in connection with Fig. 6, the secondary carriage retaining pawl 33 (Figs. 4 and 6) is attached by a pivot to the selector chassis and, as in the case of the primary retaining pawl 43, carries a case hardened pin 122 at its free extremity which engages into teeth in the opposite side of the carriage to the driving teeth. The projection 39 on this pawl passes under the secondary carriage in order to co-operate with the secondary driving pawl, but instead of being integral with the pawl as in the primary case it pivots on the pin and has a restoring spring 123 as shown in Fig. 6.

The step shown on the pivoted projection 39 normally engages with a stop 124 (Fig. 4) attached to the chassis in such manner as to hold the pin 122 out of engagement with the holding teeth. When the secondary driving pin 63 engages with the first driving tooth to initiate a step of the secondary carriage the projection 39 is driven inwards away from the stop on the chassis and then as the driving pin moves forward in the direction of secondary motion, the free end of the projection moves about its pivot in the same direction so that when the driving pin backs out of the ratchet at completion of the step the projection in following in sympathy will over-

ride its stop and will so allow the retaining pin to drop into position to provide the positive lock feature described in connection with the primary movement.

Although not shown in the drawing, it will be understood that there is an extension piece on the long arm 51 of the secondary carriage 50 which normally engages with an operating roller for the secondary off normal spring set 41 (Fig. 6 and also Fig. 7 where it is shown partly broken away), whereby the latter is pressed when the carriage is in normal position and is released as soon as the carriage moves off normal to initiate suitable circuit changes.

As regards the secondary drive interrupter springs these will form the outer combination of the lower build-up of the secondary control relay 75 (Fig. 4) and their operating pin 125 will be adjacent the head of the driving strip 60. Hence when the driving pin moves into engagement and commences the forward driving movement the springs are allowed to make or break according to their function and to remain so until the driving pin withdraws at the end of the stroke. These springs are not used as interrupter springs in their normal accepted circuit sense, but simply indicates when the carriage is in motion. The only use that has been made of these in the circuits shown is to prevent the release magnet de-energising while the wipers are moving.

When the secondary motion is terminated by the release of the secondary relay the release magnet is de-energised to lower the wiper tips into the contact sets opposite which they have been positioned to effect the necessary connection between the incoming trunk and the selected outgoing trunk, while the stop 38 is again introduced into the retaining side of the secondary carriage ratchet.

From Fig. 7 it will be seen that the secondary retaining pawl 33 is in the form of a bell crank lever, the lower arm passing under the secondary off normal spring set 41 and engaging with a strip 126 attached to the release magnet armature, the end of strip 126 hooking behind the lever end of the pawl 33. When the magnet is de-energised the action of this strip is to withdraw the pawl and its pivoted head projection away from the secondary carriage so that the step on the projection will once again re-engage with the stop 124 (Fig. 4) on the chassis so that the retaining pin will be out of action with the secondary ratchet when the release magnet is subsequently re-energised to initiate release of the switch.

When this occurs the removal of the projection 38 from the secondary carriage entirely frees this carrige which thereupon rapidly restores to its normal position under control of the helical secondary carriage restoring spring 81 and carries with it the primary carriage.

The release of the latter has now to take place and this takes place as follows:

It will be seen from Figs. 4 and 4a that the primary retaining pawl 43 carries a spring-loaded pivoted piece 44 which is situated half-way down the pawl and this carries a similar step to the projection 39 on the secondary retaining pawl 33. In the normal position of the primary carriage the pivoted piece 44 engages with a small projecting arm 45 secured at right angles to and at the centre of the primary carriage by virtue of the contact between said arm and a pin secured in the pivoted piece 44. On the first primary step the arm will leave the pin but the piece 44 will not move since it will engage with the stop 42 affixed to the release magnet assembly in the manner shown in Fig. 7. Each time the retaining pawl 43 is moved about its pivot away from the retaining teeth of the primary carriage during the primary step-by-step movement, the outward movement performed by the piece 44 which moves in sympathy with the pawl 43 will be insufficient to cause the step thereon to engage behind the stop 42 so that during the primary stepping no locking action can be effected on the retaining pawl. When, however, the secondary carriage 50 makes a step and carries with it the primary carriage 52 and also the primary retaining pawl 43 which is pivoted on the secondary carriage, the movement involved by the first step will be sufficient to allow the step on the pivoted piece 44 to drop behind the stop 42.

Hence, after the secondary release has taken place as described above, the step comes into action as shown in Fig. 4b and disengages the primary retaining pawl pin 118 from the primary carriage so that this carriage will restore to normal under the tension of the associated helical restoring spring 80. The pivot piece 44 will then be disengaged by the projecting arm 45 on the primary carriage and which in the normal position of the carriage will engage with the pin secured in the piece 44.

On being disengaged from behind the stop 42 the pivoted piece allows the primary retaining pawl 43 to re-engage its pin in the primary toothed plate and the switch is mechanically ready for a subsequent setting operation.

Two further types of release are available for use on special circuits, one in which primary release takes place without any secondary movement, and the other, secondary release without involving restoration of the primary carriage.

For this function the stop 42 on the release magnet assembly is secured thereto by a pivot as shown in Fig. 7 and on the energisation of the release magnet the strip 126 secured to the magnet armature on moving inwards away from the extension piece 127 secured to stop 42 will allow the stop to rotate under pressure of a spring (not shown) about its pivot whereupon its top will move towards the primary carriage so as to give an effect equivalent to the movement of the secondary carriage off-normal. Hence when release after a primary movement only is required, the release magnet is energised as soon as the switch is moved off normal or at any time before the secondary movement has commenced. When the magnet is released stop 42 restores to its normal position and the primary pawl is therefore pulled out of engagement with the primary ratchet and the carriage thereupon restores.

For secondary release the same parts and adjustments are required. The release magnet circuit is completed through secondary off normal springs so that under ordinary conditions when the secondary carriage gets home the release magnet restores and pulls out the primary pawl so that the primary carriage now releases to restore the switch fully to normal. When secondary release only is required the release magnet is maintained via a subsidiary circuit so that on restoration of the secondary carriage the primary pawl is not pulled out and the selector can be further stepped in a primary direction and then in a secondary direction into another level.

Referring now to Fig. 10 which shows a sectional view of one form of main and subsidiary

cam assembly, say, that associated with the primary drive, it will be seen that the assembly comprises two pressings **68** and **69**, each of, say, 20 mil steel. One, **68**, which forms the outer surface of the main cam **48** on the subsidiary cam **73** is on one side while the other, **69**, is a force fit inside the outer one **68** and takes the other side. The two halves are also held together by the bronze bearing **67** which is dropped inside before the halves are pressed together and then spun over outside. Alternatively, the main and subsidiary cams might comprise a suitable moulded plastic. The pins **110**, **111**, **112** and **113** of the cams might consist of a piece or pieces pushed up at right angles from the side material of the cam or may comprise a pin or pins moulded in the cam if the moulded cam construction is adopted.

It has already been mentioned that instead of escapement control of a driving cam a simple catch construction could be utilised in conjunction with suitable circuit arrangements as previously described.

For instance, if a condenser was discharged into the controlling electromagnet, the electromagnet would only operate momentarily and restore to hold the drive until a fresh impulse is received. By this modification the primary and secondary cams can be identically controlled or alternatively if the controls differ as described the secondary movement can be controlled both by dialled impulses and by hunting to find an idle line of a group.

For the purpose of indicating when the secondary carriage has completed its full travel the springset nearest the chassis on the secondary control relay **75** will be utilised and will be operated by a suitable projection on the secondary carriage when this carriage reaches the 11th step position.

As regards the selector wiring, it is thought that this might be effected with preformed cables. This can be considered as starting at the plug **37** (Fig. 13) and entering the chassis through an ebonite bushed hole **133**. Immediately inside the chassis one branch will extend direct to the primary drive, while the other branch continues to the release magnet and the springsets located within the chassis, and it will also extend out through another bushed hole to cater for the secondary drive.

From Fig. 13 it will be seen that the switch plug **37** engages with a jack **71** which is screwed to the vertical bank member **18**. The jack **71** is mounted on two separators giving sufficient clearance between the jack and the vertical member to accommodate one arm of the selector chassis when it is slid into position. As regards the jacking-in and jacking-out of the selector, reference should be had to Figs. 4, 7, 11 and 13 and it should first be appreciated that the secondary drive including the control relay **75** is assembled on the U-shaped angle piece **89** (Fig. 11) and is readily detachable from the selector chassis, the control relay being electrically connected with the rest of the selector circuit via a branch of the preformed selector wiring cable. With the selector in position against the bank as shown in Figs. 4 and 13 the plug **37** at the end of chassis arm **31***a* engages jack **71** while an L-shaped shoulder piece on the same arm will engage a locating pin **128** (Fig. 13) in the bank upright **17**. The other arm **31***b* of the chassis is of substantially L section and will at its slotted end engage with the extended bank clamp rod **16** while the nut **129** (Fig. 4) will be tightened up to secure both the chassis arm **31***b* and also the bank (at this selector) to the supporting member **130** which connects with the relevant exchange mounting upright. Also engaging the clamp rod **16** at this point will be one slotted end of the angle piece **89** (not shown in Fig. 4), the other slotted end of which will engage a locating pin in the chassis arm **31***b*. Hence when it is desired to jack-out the selector it is first of all necessary to loosen off the locking nut **129** and then with one hand to hold the secondary unit in position while with the other hand the chassis is withdrawn. During withdrawal of the chassis the secondary unit can be tilted inwardly so that it will clear the roller drive and it can then be withdrawn as well, this unit and the chassis being, as previously mentioned, linked by the wiring cable. When the selector is to be jacked-in the opposite procedure is adopted so that the secondary unit is firstly manoeuvred into position and is followed by the coupled chassis after which the locking nut **128** is tightened up.

The carriage mechanism of the switch can be readily detached from the chassis for maintenance purposes. When rubbing wipers are employed this detachment may be obtained by employing a compact form of plug and socket in the circuit of the wiper cords.

A further point which should be noted is that although as at present described the wiper tips perform two linear movements at right angles to one another followed by a slight movement of rotation when a selecting operation is being effected, the invention also envisages the case where the last "push-in" movement is also linear and at right angles to the first two main setting movements.

Turning now to the circuit arrangements, certain of the principles have been already laid down, and to these another will be added. The group and final selectors are to be kept as simple and standard as possible, and all variations are to be made in the battery feed relay set which is jacked in as a separate unit and serves to control successive switches. Apart from the question of standardisation one of the main advantages of this type of layout is the fact that any new technique can be introduced without affecting the mechanical parts of the exchange. One example of this as is described later is shown in the introduction of the speed timing type of impulsing circuit (United States Patent No. 2,334,591 granted November 16, 1943, to Taylor and Baker) by means of which impulse-responding circuits are adapted to function independently of the ratio of received impulses, the separate time measuring functions of the ordinary B and C relays being combined into one timing function which simply measures the overall length of each impulse instead of the length of the separate parts thereof as hitherto. With the normal type of exchange layout it would be necessary to modify every selector in the exchange to introduce this feature. Now it can be incorporated or omitted merely by changing the first relay set. With the increased lengths of connection over which dialling is being effected and the more general use of A. C. methods, this point is very important.

Detailed circuit consideration of Figs. 2 and 3 will now be given and it will be understood that when the switch is to function as a group selector, i. e., with dialled primary movement and self-driven secondary movement, and is to be controlled from a simple control circuit such as that

of Fig. 3, then the primary driving cam will have to be of the two-stage escapement release type while the secondary driving cam will have to be of the single stage simple release type.

When a subscriber calls the control relay set or group of Fig. 3 is associated with the calling line via any suitable apparatus which might conveniently be of the line finder type. Relay A therein operates, whereupon the selector switch permanently associated with the control relay set is prepared for operation by the extension of earth forward over the negative and P leads. The earth on the negative lead operates the primary control relay VR, corresponding to relay 14 in the foregoing description, which at contacts *vr1* prepares a locking circuit for itself on to the private P. The armature extension on relay VR allows the associated driving cam to rotate slightly to the second stop position and when relay A drops at the beginning of the first impulse relay VR releases in turn and frees the driving cam. Under local spring pressure it rotates further and engages with the roller and thereupon completes a revolution independently of the control relay VR as already described. On the next and subsequent impulses of the train the primary carriage is operated in a similar manner to cause it to advance a number of steps corresponding to the digit dialled and it will be noted from Fig. 3 that relays B and C are held operated throughout the train by virtue of their slugs, the B relay guarding the connection and maintaining the P lead earthed while the C relay maintains the Z lead open to prevent the premature operation of the release relay ZR which is connected up to the Z lead on the first primary step due to the mechanical operation of the switch off normal contacts N1.

At the end of the first impulse train relay C releases after its slow release period and energises relay ZR which lifts the wipers clear of the bank level in question and at contact *zr2* provides an operating circuit for the secondary control relay RR. This relay in operating locks relay ZR at contacts *rr1* and also releases the catch on the secondary driving cam which engages with the roller. In this case the catch arrangement between the extension of the secondary relay armature and the driving cam is not of the escapement type, so that the motion continues until halted by the release of the relay RR and the consequent interposing of the tip of the extension armature into the path of the stop on the driving cam. The local drive-engaging spring periodically assists in maintaining the motion when the main cam passes through the position illustrated in Fig. 12. The secondary carriage advances step-by-step and carries with it the primary carriage and the wiper arms secured thereto are caused to enter step-by-step into the selected bank level. On the first secondary step the secondary off-normal contacts NR1 and NR2 are mechanically operated so that the holding circuit of relay VR is transferred to the P lead at contact NR2 and is locked for the remainder of the call via resistance VRR.

At the end of each secondary step the operating circuit of relay RR is broken by the interrupter contacts *r1*, which it will be understood are made during the engagement of the secondary driving pawl with the secondary ratchet, but when this occurs it will be noticed that the second winding of this relay will be connected over a rubbing test wiper P on to the corresponding lead of an outgoing trunk. If such a lead is busy an earth potential will be encountered thereon so that relay RR will remain held and the secondary carriage will step on to the next set of outlets.

When a free set of outlets is encountered the P wiper will not encounter any earth potential and the interrupter contacts *r1* on opening will cause relay RR rapidly to deenergise and the catch on its armature will thereupon fall into position to halt the secondary movement when the cycle of movement of the cam is completed.

Relay ZR is now released and causes the wiper arms to drop so that the tips thereof will lower into the set of selected bank contacts to press the movable contacts against the fixed contacts in the contact bank and so causing the calling party and the battery feed relay set to be switched through to the succeeding selecting stage, which may be either the final selector stage or another group selector stage. If the latter the operation will be the same as previously described. If the former the operation of the battery feed relay set will be as described except that it will function twice while the circuits will be appropriately modified from those shown in Fig. 2. More detailed circuits are described in my Patent No. 2,402,232, above referred to.

If the calling party should now hang up, relays A and B in the control relay set will release and the removal of earth from the P lead will release relay VR, whereupon an operating circuit for relay ZR is re-completed via contacts *vr2* and NR1. The wipers are again lifted clear of the bank and as previously described, the primary and secondary carriages are now freed to restore to normal under local spring tension. The mechanically operated springs restore to normal and at contact NR1 relay ZR is released to render the selector ready for further use.

As regards the succeeding selector, on seizure its primary control relay will have been operated over the negative lead and on release of relay A the control relay is released and initiates a single primary step. When relay B releases relay C releases following relay B and the selector release relay is energised and operates the secondary control relay whereupon a self-driven secondary movement commences. When a free outlet is encountered or when the 11th step position is reached where contacts equivalent to contacts S1 (Fig. 2) are operated the secondary control relay releases to stop the drive and in turn releases the release relay. The release relay in restoring opens the holding circuit for the primary control relay which has been held during the secondary movement and the latter in restoring re-energises the release magnet whereupon the switch restores to normal in the same manner as has been described for the preceding selector.

If all outlets on a level should prove to be busy the wipers will advance to the 11th step position in which position the 11th step contacts S1 will be mechanically operated and will open the circuit of relay RR to halt the secondary motion in the same manner as for a free outlet so that the switch will contact the control relay set through to the 11th set of bank contacts. It will be understood that the 11th step positive contact is permanently earthed so that earth will be extended back over the positive lead to the control group which in response thereto will initiate the return of a busy tone to the calling party in a manner discussed in the previously mentioned application. If an overflow for the level is to be provided this could be connected to the 11th step P contacts and the contacts S1 in operating could be in the form of a changeover combination

adapted to extend earth forward over the rubbing P wiper to operate the overflow meter in this condition.

The advantages of the new invention are set out below. The ratchet and pawl hammer drive of the decimal step-by-step selector has been replaced by a very smooth drive. Not only have all the violent accelerations and sudden stops been removed but also the sharp edge driving pawls, jamming operation and the like. The performance of this selector should in the matter of wear be immeasurably superior to its predecessors. This point would be greatly assisted by the increased bank tolerances, the primary movement has been doubled, the secondary control margin greatly increased. Hence a greater amount of variations can be allowed before things begin to fail. The directness of the mechanism should be noted. All mechanical springs are operated without the use of levers. This fact again increases the possible tolerances. Ample power is available and it is no longer necessary to work as near to predetermined limits as hitherto in order to get a desired performance.

With regard to talking efficiency which is the thing the subscriber is essentially interested in, all bank contacts are made of silver instead of base metals. Ample pressures and dual contacts are provided. These contacts moreover are self-aligning and cannot shift with regard to each other and so cause microphonic noises. The circuits also have been so designed as to reduce the contacts in the speech path to a minimum. In a normal 10,000 line exchange there are about 24 contact points in the talking circuit neglecting the preselector or finder stage. In the proposed system this number is reduced to 10.

Two other points of importance are space saving and battery drain. In the space of a 10'6½" rack where normally 90 10/10 selectors are mounted, 300 of the proposed selectors can be fitted. In a 10,000 line exchange case considered, 38 racks were required to mount the group and final selectors. With the selectors described herein only the space occupied by 19 racks is required. Even under the most adverse cases considered the percentage space saving was very high and in many cases exceeded 50%.

From a manufacturing point of view the selector has much to recommend it. Amongst other things are the greater tolerances mentioned earlier, the fewness and simplicity of parts involved. The selector can be divided into several sub-assemblies for construction flexibility and a large number of the parts are already standardised.

From an exchange maintenance point of view a further improvement might be incorporated in the switch construction which would further enhance its value. Briefly, the switch cover could form an integral part of the switch and within which a short individual roller drive would be located. To this drive would be coupled a pinion which would slightly project from the switch in such manner as to engage with a corresponding pinion on a common motor driven driving shaft when the switch is jacked into position. The short roller drive within each switch would thus be in continuous rotation so long as the switch is jacked in position and would be coupled up by the friction driving cams in the same manner as coupling is effected with the common driving roller. The advantage obtained is that each switch could be a sealed unit which would be sold to a customer as such, and which, if anything went wrong, would be returned to the manufacturer for repair or re-adjustment where the best possible arrangements for adjustment and/or repair would be available. This feature would have particular appeal in the case of private automatic exchanges where skilled maintenance personnel and suitable maintenance equipment are not ordinarily available. The sealed cover arrangements would furthermore provide an effective remedy against unnecessary wear and trouble which results from the ingress of dust and abrasives which is always likely to occur when maintenance and equipment is performed on site, as is usual at present.

I claim:

1. In an electrical switch, a movable contact making member, a rotating driver, and transfer means between said driver and said member for causing said driver to move said member step by step in each of two directions in a plane perpendicular to the axis of rotation of said driver, thereby to bring said member into contact making position.

2. An electrical switch as claimed in claim 1, wherein said transfer means moves said member step by step under the control of spaced apart electrical impulses, and wherein said transfer means causes said member to execute each step in a shorter period of time than the interval between successive ones of said impulses.

3. In an electrical switch, a movable electrical contact making member, a rotating driver, transfer means between said driver and said member for causing said driver to move said member step by step in each of two directions in a plane perpendicular to the axis of rotation of said driver, said transfer means including a clutch mechanism for communicating the motion of said driver to said member during movement of the latter in one of said directions and another clutch mechanism for communicating the motion of said driver to said member during movement of the latter in the other of said directions.

4. In an electrical switch, a movable electrical contact making member; a rotating driver; transfer means between said driver and said member for causing said driver to move said member step by step in each of two directions in a plane perpendicular to the axis of rotation of said driver; said transfer means including a clutch mechanism for communicating the motion of said driver to said member during movement of the latter in one of said directions, another clutch mechanism for communicating the motion of said driver to said member during movement of the latter in the other of said directions, and means whereby at least one of said clutch mechanisms temporarily ceases to communicate the motion of said driver to said member near the end of each step taken by said member under the control of that clutch mechanism.

5. In an electrical switch, a movable contact making member, a rotating driver, and transfer means between said driver and said member for causing said driver to move said member step by step in each of two directions parallel to a particular plane, and means for then moving said member in a direction substantially perpendicular to said plane.

6. In an electrical switch, a movable contact making member occupying a particular position, and mechanism for imparting to said member four successive movements thereby to bring said member into contact making position, each said movement beginning where the immediately pre-

ceding movement ended and taking place along a path transverse to such preceding movement.

7. In an electrical switch, a movable contact making member having a normal position, mechanism for moving said member from said normal position in a particular direction to a second position, then moving said member from said second position in a direction substantially perpendicular to said first direction to a third position, and then moving said member from said third position in a direction substantially perpendicular to each of said first two directions, thereby to bring said member into contact making position, said mechanism including a rotating driver operative to supply the power for moving said member in two of said directions.

8. An electrical switch as claimed in claim 7, wherein the movement of said member each of two of said directions comprises a step by step movement.

9. An electrical switch as claimed in claim 7, wherein the movement of said member in at least one of said first two directions is a movement for a variable distance.

10. In an electrical switch, a movable contact making member having a normal position, continuously operating source of mechanical power, transfer mechanism for causing said source to move said member from said normal position for a variable distance in a particular direction to a second position, other transfer mechanism for then causing said source to move said member from said second position for a variable distance in a direction substantially perpendicular to said first direction to a third position, and means then operated to move said member from said third position in a direction substantially perpendicular to each of said first two directions, thereby to bring said member into contact making position.

11. In an electrical switch, a movable contact making member occupying a particular position, mechanism for moving said member from said position in a particular direction to a second position, then moving said member from said second position in a direction substantially perpendicular to said first direction to a third position, then moving said member from said third position in a direction substantially perpendicular to each of said first two directions to a fourth position, and then moving said member from said fourth position in a direction substantially perpendicular said third direction, thereby to bring said member into contact making position.

12. In an automatic switch for completing an electrical circuit over any contact in a coordinate field of contacts, a movable carriage, a continuously operating source of mechanical power, transfer mechanism for causing said source to move said carriage first longitudinally and then laterally in a particular plane to select any contact in said field, a member carried by said carriage, and means operated after a contact has been selected for moving said member in a direction transverse to said plane to complete an electrical circuit over the selected contact.

13. In an automatic switch for completing an electrical circuit over any contact in a coordinate field of contacts, a movable carriage, mechanism for moving said carriage first longitudinally and then laterally in a particular plane to select any contact in said field, a member carried over a series of contacts in said field by said carriage during said lateral movement, means operated before said lateral movement to move said member a certain distance in a direction transverse to said plane whereby, during said lateral movement, said member clears the contacts over which it is moved, said last means operated after said lateral movement to move said member in the opposite direction transverse to said plane thereby to complete an electrical circuit over the selected contact.

14. In an electrical switch, a horizontal rectangular frame, two electromagnets carried by said frame respectively along two non-parallel sides of said frame, a contact making member movably supported upon said frame, a rotating driver, transfer means controlled by one of said electromagnets for causing said driver to move said member step by step in one direction, and other transfer means controlled by the other of said electromagnets for causing said driver to move said member step by step in a different direction, thereby to bring said member into contact making position.

15. In an electrical switch, a plurality of groups of contacts, each contact including a movable conductor and a stationary conductor, a plunger having a normal position, mechanism for moving said plunger in one direction to select a group of contacts and then moving it in a different direction to select a particular contact in the selected group, and means for finally moving said plunger in a third direction to engage the movable conductor of the selected contact and move it into electrical connection with the stationary conductor of the selected contact.

16. An electrical switch as claimed in claim 15, wherein said mechanism derives its power from a rotating member, and wherein each of said first two movements of said plunger is in a plane perpendicular to the axis of rotation of said member.

17. An electrical switch as claimed in claim 15, wherein said mechanism derives its power from a rotating member, wherein each of said first two movements of said plunger is in a plane perpendicular to the axis of rotation of said member, and wherein said final movement is substantially parallel to said axis.

18. In an electrical switch, a plurality of groups of contacts, each contact including a movable conductor and a stationary conductor, a plunger having a normal position, mechanism for moving said plunger step by step in one direction to select a group of contacts and then moving it step by step in a different direction to select a particular contact in the selected group, and means for finally moving said plunger in a third direction to engage the movable conductor of the selected contact and move it into electrical connection with the stationary conductor of the selected contact.

19. In an electrical switch, a plurality of groups of contacts, each contact including a movable conductor and a stationary conductor, a plunger having a normal position, mechanism for moving said plunger step by step in one direction to select a group of contacts and then moving it step by step in a different direction to select a particular contact in the selected group, said mechanism including means for causing said plunger to execute each step with constant acceleration and deceleration, and means for finally moving said plunger in a third direction to cause the movable conductor of the selected contact to move into electrical connection with the stationary conductor of the selected contact.

20. In a switching system, a plurality of paralle elongated stationary conductors, a plurality o

groups of movable contactors, each group including a different contactor for each stationary conductor, means supporting the different groups of contactors at regularly spaced intervals along the length of said stationary conductors so that each contactor is adjacent its individual stationary conductor, different mechanisms corresponding respectively to the different groups of contactors, and means for operating each mechanism at times first to select any contactor in its associated group and then to move the selected contactor into engagement with its individual stationary conductor.

21. A switching system as claimed in claim 20, wherein each of said groups of contactors is divided into a plurality of subgroups, and wherein said selective operation of any mechanism comprises a movement in one direction to select a particular subgroup in the group of contactors associated with that mechanism and a subsequent movement in a different direction to select a particular contactor in the selected subgroup.

22. A switching system as claimed in claim 20; wherein all of said mechanisms are operated by power derived from a common rotating shaft which is parallel to said elongated conductors.

23. In a switching system as claimed in claim 20, a support for said conductors and said contactors, and means including a jack for detachably securing each of said mechanisms to said support.

24. In a switching system, a plurality of groups of elongated primary conductors, all of said conductors being parallel and each group thereof occupying a plane parallel to the planes occupied by the other groups, a plurality of groups of secondary conductors, each of said secondary conductors being transverse to the length of said primary conductors and each group of secondary conductors being substantially in a plane parallel and adjacent to the plane occupied by a particular group of primary conductors, each secondary conductor having different integral portions corresponding respectively to different primary conductors in the adjacent group, and mechanism operated first to select any one of said portions and then to move the selected portion into engagement with its corresponding primary conductor.

25. In a switching system, a plurality of groups of elongated primary conductors, all of said conductors being parallel and each group thereof occupying a plane parallel to the planes occupied by the other groups, a plurality of groups of secondary conductors, each of said secondary conductors being transverse to the length of said primary conductors and each group of secondary conductors being substantially in a plane parallel and adjacent to the plane occupied by a particular group of primary conductors, a contact making member, mechanism for moving said member in one direction to select a particular secondary conductor and moving it in a different direction to select a particular primary conductor, said member effective after it has been moved in both of said directions to complete an electrical circuit between the selected primary and secondary conductors.

26. In an electrical switch, a movable contact making device, a continuously operative driving member, a fixed surface, a transfer member having a pair of cams rotatably supported thereon, means for slidably and rotatably mounting said transfer member so that one of said cams engages said surface and the other of said cams engages said driving member, said two cams cooperating to impart to said transfer member under control of said driving member a cyclic movement, and means controlled by said transfer member upon such cyclic movement for driving said contact making device step by step.

27. A driving mechanism as claimed in claim 26, wherein said two cams comprise a single unitary rotatable member.

28. In an electrical switch, a movable contact making device, a transfer member having a pair of cams rotatably supported thereon, a fixed surface, a moving surface, means for movably supporting said transfer member so that one of said cams engages said fixed surface and the other of said cams engages said moving surface, said moving surface effective to rotate said other cam, means whereby the rotation of said other cam is communicated to said one cam, said two rotating cams cooperating to impart to said transfer member a cyclic movement, and means controlled by the cyclic movement of said transfer member for driving said contact making device step by step.

29. In an electrical switch, a toothed member to be driven, a continuously operating driver, a fixed surface, a transfer member having a pair of cams rotatably supported thereon, means for slidably and rotatably mounting said transfer member so that one of said cams engages said surface and the other of said cams engages said driving member, said two cams cooperating to impart to said transfer member a movement such that a certain portion thereof travels in a substantially rectangular path, said portion effective to move said toothed member step by step by entering each tooth in turn, moving said member one step, leaving that tooth and returning to a point adjacent the next tooth, and a contact making member connected to said toothed member and moved thereby step by step.

30. In a driving mechanism as claimed in claim 29, a detent cooperating with said toothed member to prevent retrograde movement thereof when said portion of the transfer member is not in a tooth, and means controlled by the entry of said transfer member into a tooth for releasing said detent.

31. In an electrical switch, a movable contact making device, a transfer element carrying a member rotatably mounted thereon; a rotating drum; a pair of spaced apart supports occupying fixed positions with respect to the axis of rotation of said drum; yieldable means tending to maintain one surface of said transfer element in engagement with one of said supports, tending to maintain one surface of said rotatable member in engagement with the other of said supports and tending to maintain a different surface of said rotatable member in engagement with said rotating drum; said drum being effective to rotate said member, and said surfaces of said member being so configured as to impart to said transfer element a predetermined movement with respect to said supports; and means controlled by said transfer element upon such movement for driving said contact making device step by step.

32. In an electrical switch, a movable contact making device, a transfer element carrying a member rotatably mounted thereon; a rotating drum; a pair of spaced apart supports occupying fixed positions with respect to the axis of rotation of said drum; a single spring applying such a force to said transfer element that it tends to maintain one surface of said transfer element

in engagement with one of said supports, tends to maintain one surface of said rotatable member in engagement with the other of said supports and tends to maintain a different surface of said rotatable member in engagement with said rotating drum; said drum being effective to rotate said member, and said surfaces of said member being so configured as to impart to said transfer element a predetermined movement with respect to said supports; and means controlled by said transfer element upon such movement for driving said contact making device step by step.

33. In an electrical switch, a frame, a contact bank supported by said frame, said contact bank including a plurality of sets of contacts arranged in parallel rows, each contact set including a movable conductor and a stationary conductor, contact operating mechanism including a movable member, means for detachably mounting said mechanism as a unit upon said frame so that said member occupies a predetermined position with respect to said contact bank, means in said mechanism for moving said member from said predetermined position in a direction transverse to the length of said rows thereby to bring said member to a position adjacent the end of any particular one of said rows, other means in said mechanism for then moving said member in a direction parallel to said particular row to a position adjacent any particular one of the contact sets in that row, and still other means in said mechanism for then operating said member to cause it to apply a force to the movable conductor of said particular contact set thereby to move said movable conductor into engagement with the stationary conductor of said particular contact set.

34. In an electrical switch, a frame, a contact bank supported by said frame, said contact bank including a plurality of contacts divided into groups and subgroups, different switch mechanisms corresponding respectively to the different ones of said groups, means for detachably mounting each switch mechanism as a unit upon said frame in operative relationship to its corresponding group of contacts, a continuously rotating driver supported by said frame so that it is common to all of the switch mechanisms thus mounted thereon, a movable member in each switch mechanism, means in each switch mechanism for at times causing said driver to move that mechanism's member longitudinally to select any particular subgroup in the group of contacts corresponding to that switch, and means in the same switch mechanism then operated to cause said driver to move that mechanism's member laterally to select any particular contact in said selected subgroup.

35. In an electrical switch, a frame, a contact bank supported by said frame, said contact bank including a plurality of contacts divided into groups and subgroups, different switch mechanisms corresponding respectively to the different ones of said groups, means for detachably mounting each switch mechanism as a unit upon said frame in operative relationship to its corresponding group of contacts, a continuously rotating driver supported by said frame so that it is common to all of the switch mechanisms thus mounted thereon, a movable member in each switch mechanism, means in each switch mechanism for at times causing said driver to move that mechanism's member in one direction to select any particular subgroup in the group of contacts corresponding to that switch, means in the same switch mechanism then operated to cause said driver to move that mechanism's member in another direction to select any particular contact in said selected subgroup, and means in the same switch mechanism then operated to move said member in still another direction to complete an electrical circuit over said selected contact.

36. In an electrical switch, a movable contact making member having a normal position, a driver moving continuously at a uniform speed, transfer mechanism for causing said driver to move said member step by step from said normal position for a variable number of steps to a second position, other transfer mechanism for then causing said driver to move said member step by step from said second position for a variable number of steps to a third position, each said transfer mechanism including means for determining the size of the steps taken by said contact making member.

37. In an electrical switch, a movable carriage, a contact making member movable upon said carriage, a driver moving continuously at a uniform speed, transfer means for communicating the motion of said driver to said carriage thereby to move the carriage in a certain direction, and other transfer means for communicating the motion of said driver to said contact making member thereby to move said member on said carriage in a direction transverse to said first direction.

38. In an electrical switch, an electrical movable contact making member, a rotating driver, means including a cam engageable with said driver for moving said contact making member step by step in one direction, and means including a second cam engageable with said driver for moving said contact making member step by step in another direction.

39. In an electrical switch, an electrical contact making member movable in steps, a continuously operating driver, a pair of cams, means for causing one of said cams to intermittently engage said driver at times and for causing the other of said cams to intermittently engage said driver at other times, means controlled by one of said cams upon each engagement thereof with said driver for moving said contact making member a step in one direction, and means controlled by the other cam upon each engagement thereof with said driver for moving said member a step in a different direction.

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