

2000 TYPE TWO-MOTION SELECTOR MECHANISM

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Figs. 2, 3, 4, 5, 17, 18, 19, 20 and 22 are appended to this pamphlet.

INTRODUCTION

The earlier types of two-motion selector mechanism follow the same general design but differ widely in detail from one manufacturer to another. Changes in selector circuit facilities have from time to time resulted in the addition of mechanically operated spring-sets and other devices to the mechanisms, and have increased the lack of uniformity and introduced difficulties in the specification of adjustments. Certain functions of a selector circuit are largely dependent on the adjustment of the mechanism, one example is the rotary stepping and testing circuit of a group selector, and on selectors fitted with the earlier types of mechanism faults have occurred because precise adjustment specifications cannot be given. The bearing arrangements for the wiper shaft also increase the fault liability; they allow the bottom end of the shaft to 'whip' during rotary action and consequently restrict to three the number of contact banks which can be associated with the mechanism.

The need to have a basic design which incorporated the mechanically operated spring-set operating devices resulted in the development and introduction of the Post Office 2000-type two-motion selector mechanism. A general view of a group selector employing a 2000-type mechanism is shown in Fig. 1.

All the earlier types of two-motion selector mechanisms are now known generally as 'pre 2000-type mechanisms' and are described in E.P. - Draft Series - Telephones 4/2.

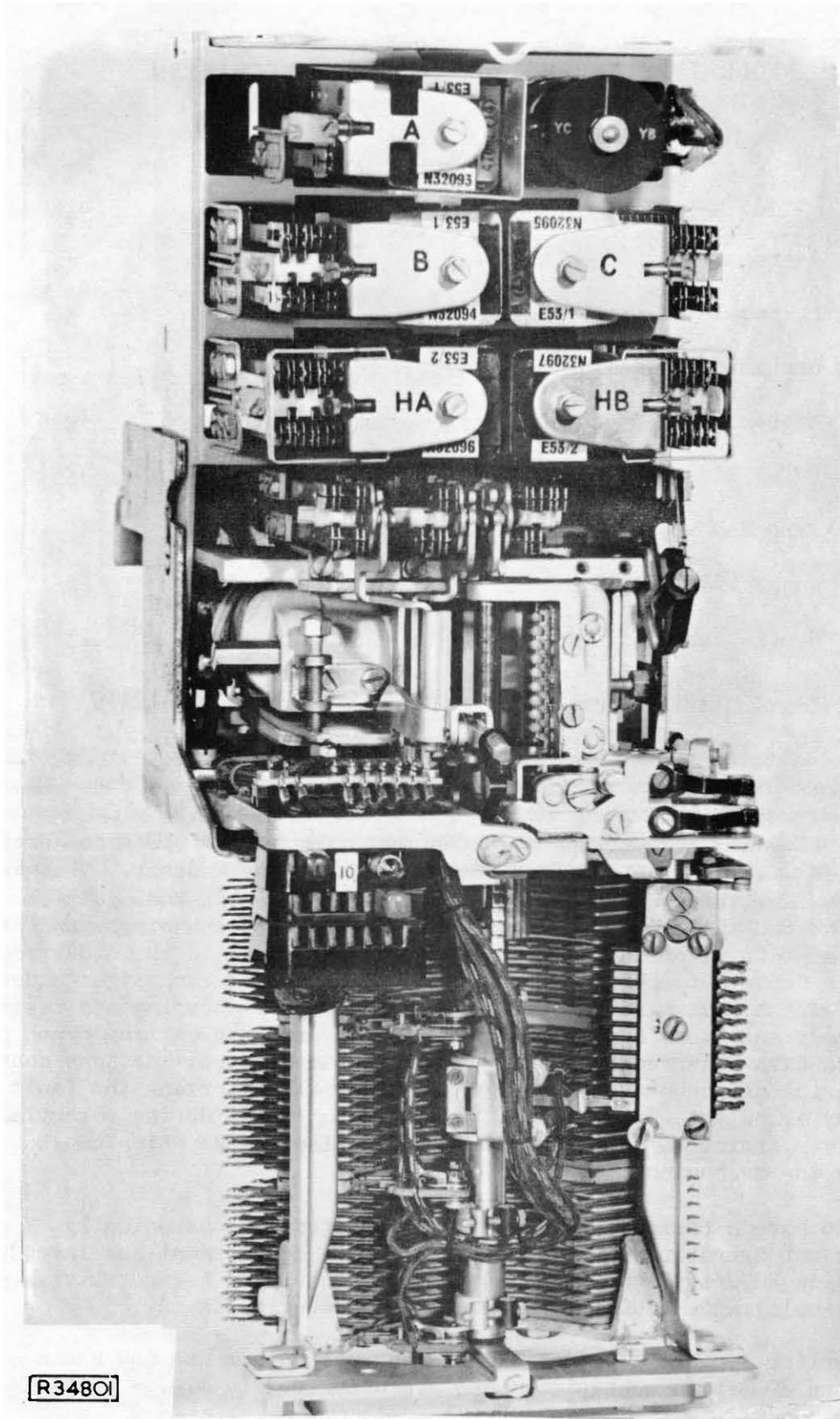


Fig. 1

2.

PRINCIPLE OF OPERATION

The mechanism is required to effect a connexion between a set of movable contacts, termed wipers, and one of 110 sets of contacts in an associated bank of contacts which is made up of 10 arc shaped layers, termed levels, each having 11 equally spaced sets of contacts. The levels are concentric with the carriage carrying the wipers, thus the wipers can be positioned on to any one set of contacts by two movements of the carriage,

- (a) a vertical motion which positions the wipers opposite the required level and
- (b) a rotary motion which positions the wipers on the required set of contacts in the selected level.

The 2000-type mechanism differs from all the other two-motion selector mechanisms in the method used to restore the wipers to the normal position. The rotary motion of the carriage is continued until the wipers are clear of the bank, at which point the carriage falls to the normal level and there rotates backwards, carrying the wipers underneath the first contact level back to the normal position.

The wiper carriage is moved in steps, each of which moves the wipers from one contact level to the next or one set of contacts to the next, by two electromagnet and ratchet devices. The essential components of the 2000-type selector mechanism are shown in Fig. 2 (appended).

The sets of wipers, vertical ratchet, rotary ratchet, rotary disk and cam are mounted on the tubular carriage which slides and rotates on the fixed shaft. A helical carriage-restoring spring is located between the hollow carriage and the shaft, and has one end secured to the carriage and the other to the shaft. In the normal position of the carriage the vertical ratchet is in alignment with the vertical pawl and detent, but the rotary ratchet is not in alignment with the rotary pawl and detent until the carriage has been raised at least one step.

The sets of wipers are raised to the required level of contacts by the appropriate number of operations of the vertical magnet armature. Each time the magnet is energized it causes the vertical pawl to engage the vertical ratchet and raise the carriage, and consequently the wipers, one level of the contact bank. The vertical detent engages with the vertical ratchet between each operation of the vertical magnet to support the carriage against the force of gravity and the tension of the extended restoring spring.

When the rotary armature is operated, its pawl engages with the rotary ratchet and causes the carriage to turn, thus moving the wipers on to the first set of contacts on the selected level. Subsequent operations of the armature cause the wipers to move from one set of contacts to the next. The restoring spring is wound up as the carriage rotates and between each operation of the armature the carriage is held by the rotary detent in engagement with the rotary ratchet. During the first rotary step the vertical ratchet moves out of engagement with the vertical detent but the carriage is prevented from falling by the rotary disk engaging with a slot in the comb plate.

The carriage is restored to the normal position by continuing the rotary stepping to a point which allows it to return to the normal level and then rotate backwards to the normal rest position. The rotary stepping continues until the carriage is at the 12th rotary position, the wipers are then clear of bank and the rotary disk is disengaged from the comb plate. The carriage is now free to fall and does so under the force of gravity and the tension of the restoring spring. At the normal level the rotary ratchet is disengaged from the rotary detent and the carriage rotates back to the normal position under the tension of the restoring spring; during this movement the wipers pass underneath the first contact level.

The release action is sometimes termed 'rectangular release'. It should be noted that once a selector has taken a vertical step it can only be released for subsequent use by being driven in the rotary direction beyond the end of the bank and so releasing.

MECHANICAL DETAILS

Construction

Three views of the mechanism showing the names of the main components are given in Figs. 3, 4 and 5 (appended).

The frame of the mechanism is a one-piece diecasting of an aluminium-silicon alloy and consists of an upper and lower platform joined by two members suitably shaped and drilled to provide a fixing point for the top of the stainless steel shaft and compartments for the two magnets. The various detents, armature stops and adjusting screws are arranged on the lower platform, and the mechanically operated spring assemblies on the upper platform.

The shaft is fixed and provides a guide for the tubular wiper carriage, thus eliminating any whip of the carriage during the rotary stepping motion. The rotary and vertical ratchets, the rotary cam and disk, and the wipers are fixed to the carriage, and the whole of this assembly is made as light as practicable to keep its inertia low and so make possible high operating speeds using low powered magnets. The vertical ratchet is of case hardened steel and is fixed by two screws to the leading edge of the hard brass rotary ratchet. A high frequency heating process is used to solder the rotary ratchet to the wall of the carriage. Each set of wipers is fixed to the carriage by a clamp so arranged that any set of wipers can be removed without disturbing the other sets. The portion of the carriage extending beyond the underside of the rotary ratchet is of a length to suit the number of contact banks associated with the particular mechanism.

The helical carriage restoring spring, because of the carriage's low inertia, assists both the rotary and vertical release movements. The spring is housed between the shaft and the inner wall of the carriage, and is secured at its upper end to the carriage and at the lower end to the shaft. The lower end fixing point is approximately a third of the way up the shaft to allow for the vertical travel of the carriage. Before the shaft is secured by the clamp it is given from 3 to 6 turns in an anti-clockwise direction, when viewed from the top, to pre-tension the spring; the carriage being, of course, held stationary during this operation.

The bottom bracket assembly provides a fixing for the lower end of the shaft and a bearing surface for the carriage. The anti-bounce plate is secured at one end only so that it can easily absorb the kinetic energy stored in the carriage at the end of the spring assisted vertical release movement. Without the plate there is a tendency for the carriage to bounce and jam the wiper tips against the 11th bank contact of level 1.

The majority of the piece parts are mild steel pressings which are case hardened to suitable depths where necessary.

The vertical and rotary magnet and armature assemblies are similar. The magnet has a single coil wound on a cast-iron core of generous proportions and having integral pole pieces. Eddy current losses are kept low by the high specific resistance of the cast iron. The large area of contact which the magnet core has with the selector frame facilitates the dissipation of heat generated during the magnet operations. The magnet armature is a plate of annealed Swedish iron riveted to a steel pressing forming the armature hinge at one end and the extension to carry the armature pawl at the other end.

Friction-locked Adjusting Screws

It has been found that the use of a locking-nut on an adjusting screw has the disadvantage that it tends to disturb the adjustment when the nut is being tightened. The friction-locking method, whilst facilitating adjustment, ensures that the adjustment remains stable in service. The rotary and vertical pawl front stop are friction-locked by a clamp-plate and locking screw as shown in Fig. 6. The armature restoring-spring adjusting screws are held in brackets of U formation as shown in Figs. 8 and 10, the limbs of which have been set outwards so that the

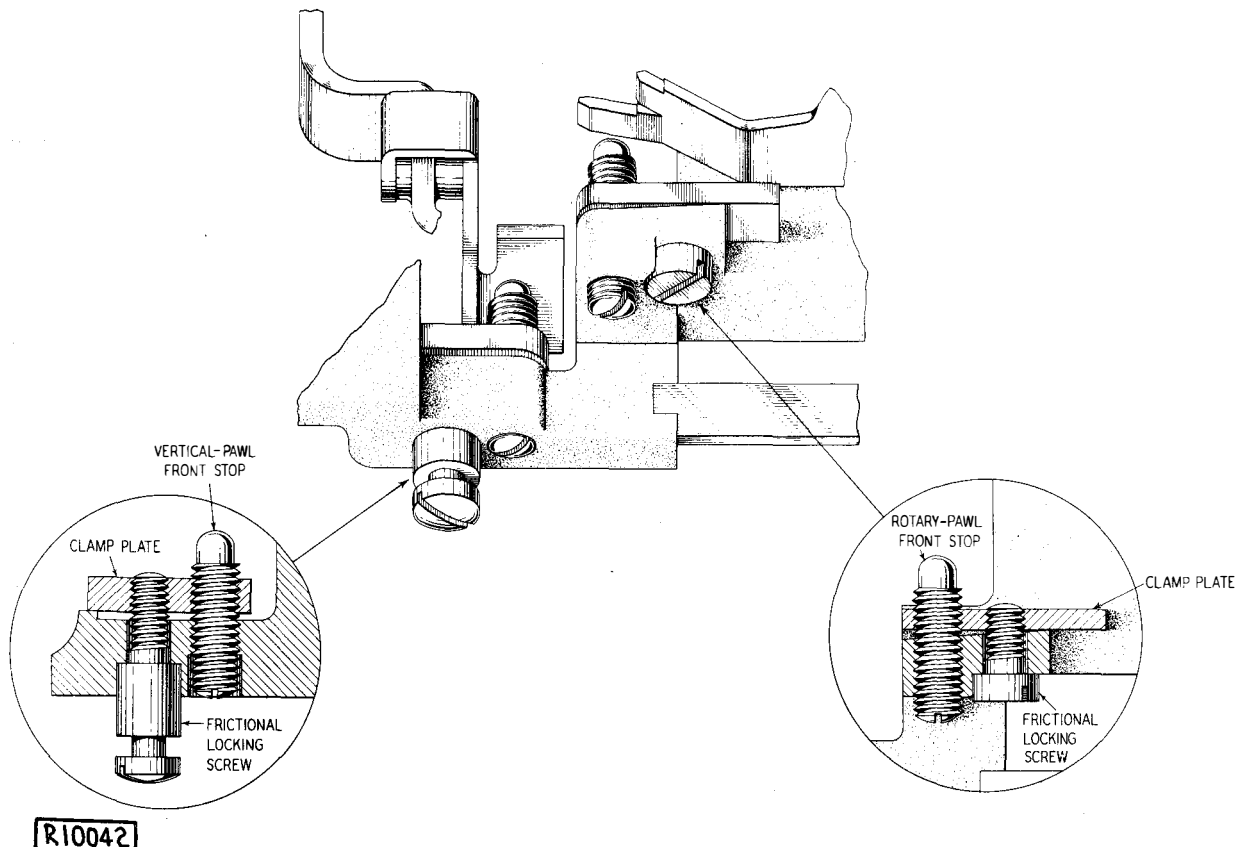


Fig. 6

threads are thrown out of pitch. When the adjusting screw is inserted, the limbs of the bracket are sprung inwards until the threads are in pitch, the screw is then held friction-tight by the outward tension of the limbs.

Mechanism Normal

When the mechanism is normal the weight of the carriage assembly is supported by the shaft clamp, and the rotary tension of the carriage restoring spring by the cam plate bearing on the comb plate. The shaft clamp is adjustable and the correct adjustment is such that there is a small clearance between the underside of the rotary disk and a lug on the comb plate. The rotary position is determined by the cam plate and the comb plate, neither of which are adjustable. The wipers are positioned on the carriage so as to be standing at the normal level, i.e. one level below level 1 on the contact bank, and outside the left-hand side of the contact bank.

A projection on the cam is engaged with the 'off-normal' spring-set operating lever to hold the spring-set operated; the other mechanically operated spring-sets are normal.

The vertical and rotary detents, although not engaged with their respective ratchets when the mechanism is normal, determine the vertical and rotary positions of the carriage at all other steps. The vertical detent is adjusted so that at each vertical step the rotary disk is opposite the appropriate notch in the comb plate, and that the carriage does not drop when the vertical ratchet leaves the vertical detent on the first rotary step. The rotary detent is adjusted so that it does not foul the rotary ratchet during the vertical action, the clearance between the detent and the ratchet tooth is made as small as possible. Correct adjustment of the rotary detent with the carriage at the normal rotary position ensures the correct position of the carriage at the other rotary positions. When appropriate, the detents are held in engagement with the ratchets by springs, Fig. 10, the force acting at the tip of each detent is approximately 140 grammes.

Vertical Stepping Action

The arrangement of the vertical magnet, armature, pawl and vertical ratchet

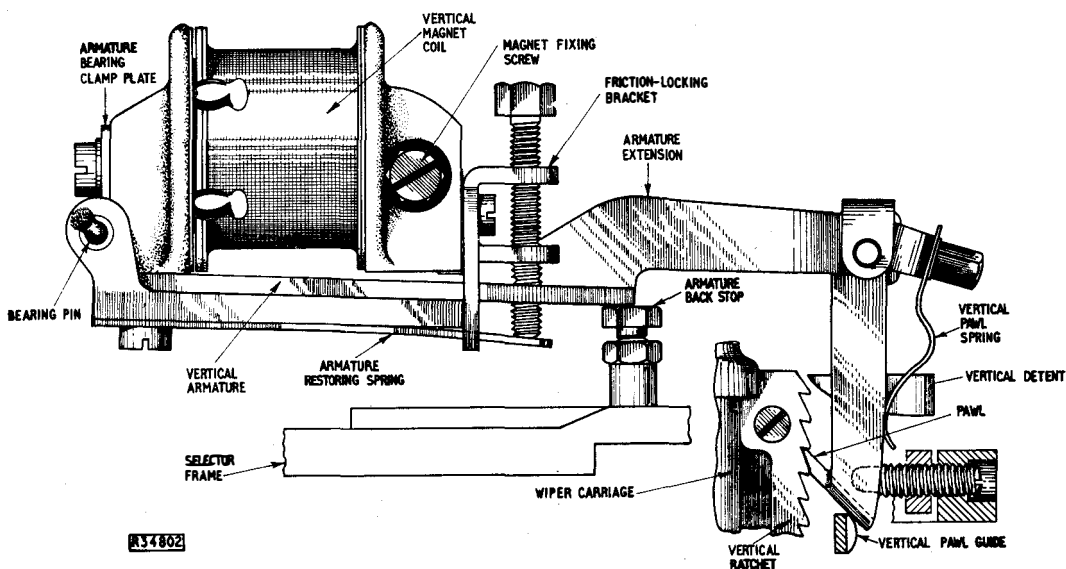


Fig. 7

when the carriage is at the normal position is shown in Fig. 7. The vertical armature is held firmly on the back stop by the tension of the flat steel restoring spring which has a tension of the order of 340 grammes, and the position of the pawl is determined by the adjustment of the back stop and pawl guide. The magnet is located in the selector frame by an extension of the tubular armature bearing pin, and a fixing screw which, after passing through a slot in the selector frame, engages with a movable plate. When the fixing screw is tightened both the magnet and plate are held firmly against the wall of the frame. The magnet is positioned so that when the armature is operated and the carriage is lifted one level of the contact bank, there is a small clearance between the underside of the appropriate detent tooth and the top of the detent.

When the vertical magnet is energized the armature is attracted and the pawl, under the influence of the pawl spring, is directed by the pawl guide into the root of the ratchet notch and lifts the wiper carriage. The detent slides over the first tooth of the ratchet, and just as it engages the next notch the pawl is wedged between the front stop and the vertical ratchet, as shown in Fig. 8, so arresting the vertical movement of the carriage. The armature, however, has not yet made contact with the pole faces of the magnet, consequently the armature extension is slightly bowed as the armature stroke is completed.

When the current ceases to flow in the vertical magnet coil, the armature straightens and restores to the normal position under the force of gravity and the tension of the armature restoring spring. The straightening of the armature imparts a flick action to the release movement and so shortens the armature release time. The vertical detent in engagement with a notch in the vertical ratchet holds the wiper carriage in the raised position against the force of gravity and the tension of the extended carriage restoring spring. Each set of

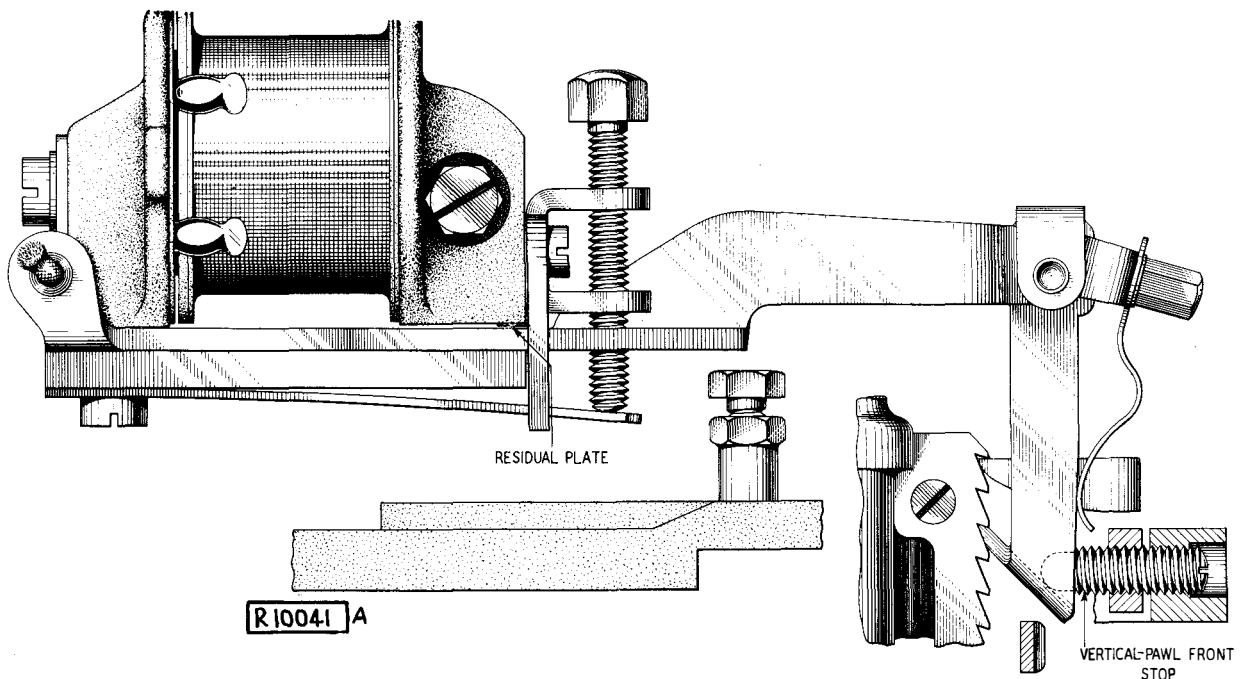


Fig. 8

wipers on the carriage is now positioned opposite the first level of its contact bank, and the rotary disk is opposite a notch in the comb plate as shown in Fig. 9. Further suitably timed pulses of current through the vertical magnet coil will cause the wiper carriage, and consequently the set of wipers, to be raised to any desired level on the contact bank. The carriage is supported at each level by the vertical detent engaged with the vertical ratchet notch.

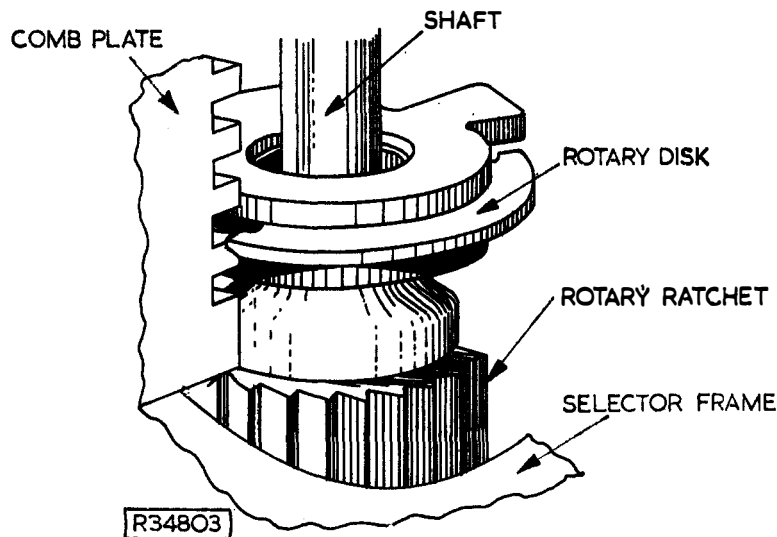


Fig. 9

Rotary Stepping Action

The rotary magnet arrangements, with the armature at the point where the pawl is wedged between the pawl front stop and the rotary ratchet at the first rotary step, is shown in Fig. 10. The mechanical arrangement is similar to that used for the vertical stepping, and the adjustment is similar in that the rotary pawl strikes its front stop just as the detent engages a ratchet notch and also slightly in advance of the rotary armature striking the magnet pole faces. The pawl guide is positioned so that, as the pawl moves forward, the tip of the pawl slides for a short distance along the long face of the ratchet tooth before engaging the root of the notch. The armature back stop is adjusted so that in conjunction with the pawl guide, the rotary pawl does not foul the rotary ratchet during vertical stepping.

During the first rotary step the vertical ratchet leaves the vertical detent as shown in Fig. 10, but at the same time the rotary disk enters the appropriate notch in the comb plate and supports the wiper carriage. The rotary disk is provided with a chamfered entering edge to prevent it jamming on the comb plate on the first rotary step.

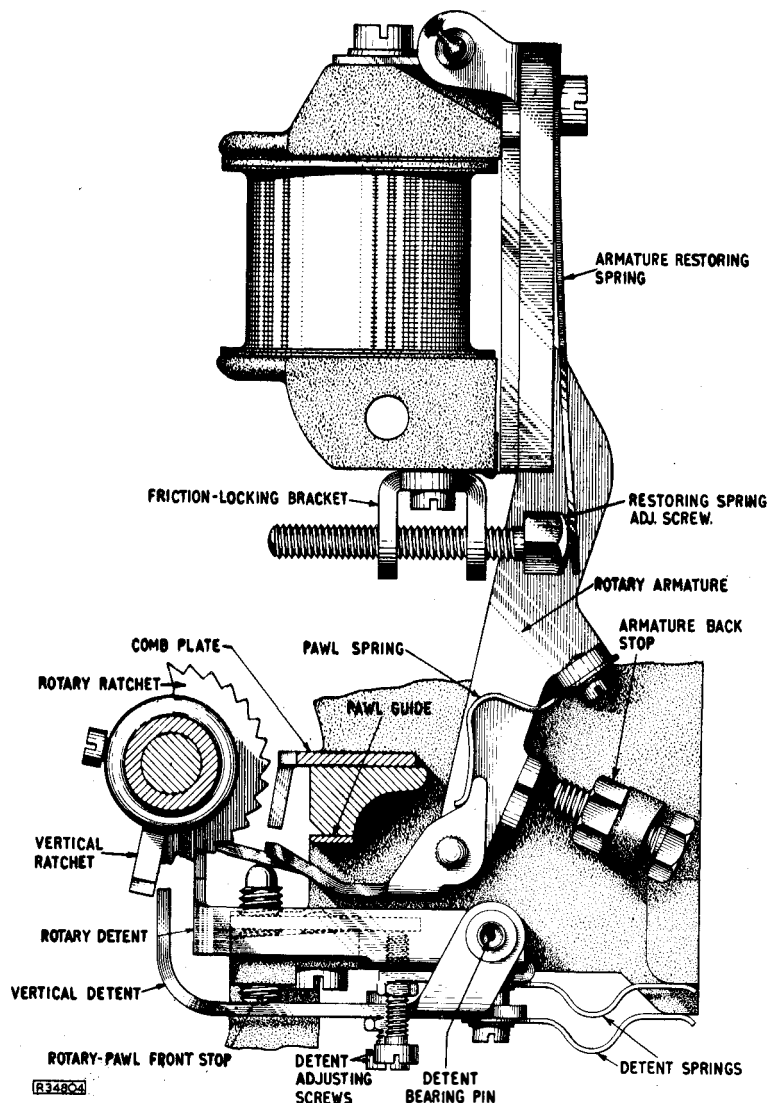


Fig. 10

The wiper carriage, and consequently the sets of wipers, can be positioned on to any desired set of contacts in the level by the appropriate number of suitably timed pulses of current through the rotary magnet coil. During the rotary stepping the weight of the carriage is supported by the rotary disk engaged with the comb plate. At each rotary step the carriage is held against the tension of the restoring spring by the rotary detent engaging with a notch in the rotary ratchet.

Release Action

The first stage in the release of the selector mechanism is the stepping of the wiper carriage to a rotary position where the wipers are clear of the contact level. In practice this is effected by completing a circuit for the rotary magnet

coil through contacts, the rotary-interrupter spring contacts, which open when the rotary armature operates and close when the armature releases. The self drive circuit so formed causes the wiper carriage to be stepped to the 12th rotary position and so take the rotary ratchet out of engagement with the rotary pawl. During the next armature operate movement a projection on the pawl engages with the lug on the comb plate and prevents the armature from operating fully. The rotary interrupter spring contacts do not open and consequently the magnet remains energized and the pawl is held against the lug as shown in Fig. 11. The wiper carriage is held at the 12th rotary position by the detent engaged with the rotary ratchet in the normal way.

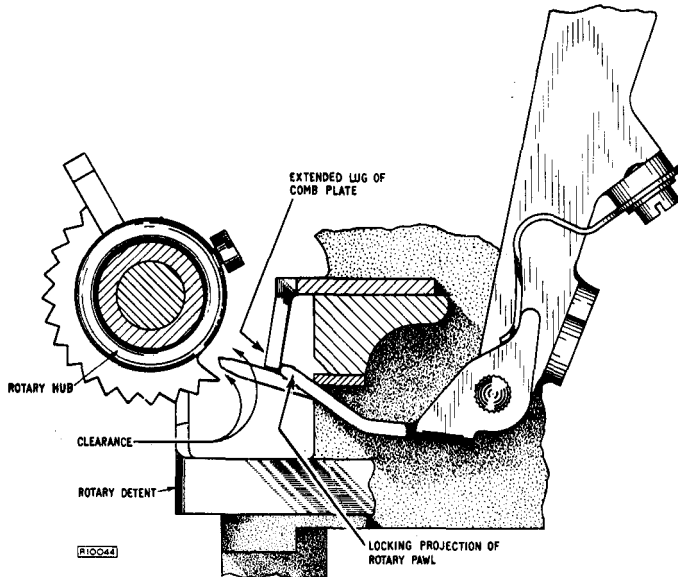


Fig. 11

When the carriage is at the 12th rotary position the sets of wipers are standing outside the contact bank levels and a slot in the rotary disk coincides with the comb plate. There is, therefore, no support for the wiper carriage which returns to the normal level under the force of gravity and the tension of the extended carriage restoring spring.

At the normal level the rotary ratchet disengages from the rotary detent and the rotary disk coincides with a notch in the comb plate. The tension of the carriage restoring spring causes the carriage to rotate back until arrested by the cam plate engaging with the comb plate, i.e., the normal position; the sets of wipers passing underneath the first contact level during this movement. The shock of the returning carriage is absorbed by the cam plate engaging with the operating lever of a mechanically operated spring-set just before the normal position is reached. A set of contacts on this spring-set is opened by the action of the operating lever and these disconnect the circuit for the rotary magnet coil, so allowing the armature to restore to the normal position.

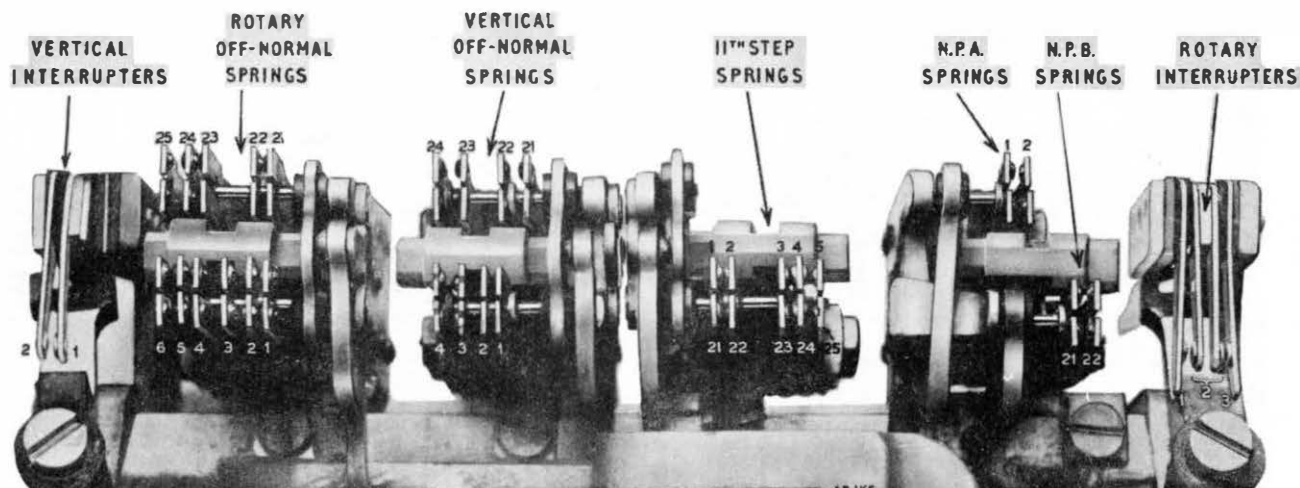
MECHANICALLY OPERATED SPRING ASSEMBLIES

General

The spring-sets of the mechanically operated spring assemblies fitted to the selector mechanism reduce the number of relays required in the control circuit and simplify the circuit arrangements. The type of assemblies described in this pamphlet follow the same basic design as those used on the P.O. 600-type relay, and have superseded the assemblies fitted to the earlier 2000-type mechanisms.

Operation of the assemblies is effected by two cam plates fitted to the wiper carriage above the rotary disk, which engage with the various operating levers at the appropriate points in the movement of the carriage. The main cam plate controls

the vertical off-normal (N), the rotary off-normal (NR) and the 11th step (S) assemblies, and the auxiliary cam controls the normal post (NP) assembly. The NP assembly can be in two sections, NPA and NPB, each of which can be operated independent of the other. The order in which the assemblies are mounted on the selector frame is shown in Fig. 12. Each assembly is mounted on a steel



R34805

Fig. 12

bracket, which is itself secured to the top of the selector frame by means of a single screw fixing at the front and a locating lug at the rear.

Spring-Sets

The contact springs are of 0.4 mm (16 mil) thick nickel silver and each spring has dome shaped twin silver contacts. When necessary platinum contacts are provided, a V-shaped notch is then cut in each contact tongue as a means of identification. Make, break, and change-over contact units, known as M, B, and C units respectively, can be fitted on any of the spring assemblies. The N, NR and S assemblies can each have up to 12 springs made up into 5 contact units; the NP assembly, however, can have only up to 6 springs, of which not more than 3 springs can be in the NPB section. When the NP assembly has only one section it can have up to 6 springs but not more than 2 contact units; if the section has 3 springs or less it is fitted in the NPB position.

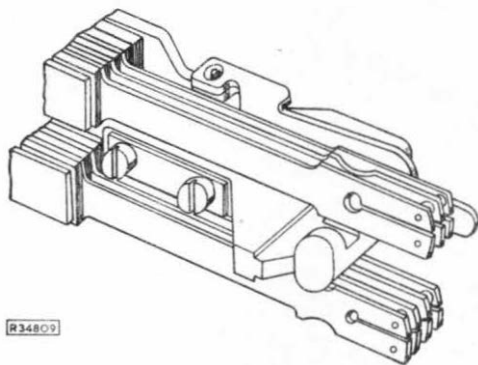


Fig. 13

The spring-sets are mounted on both sides of the buffer block as shown in Fig. 13, and are defined as right-hand and left-hand when viewing the assembly from the front and with the mounting bracket below the spring-sets. The left-hand springs are numbered from 1 upwards, and those on the right-hand from 21 upwards, i.e. normal relay spring-set practice. The numbering of a complete set of typical spring-sets is shown diagrammatically in Fig. 14. The arrows indicate the direction of movement of the various operating levers when the spring-sets are operated.

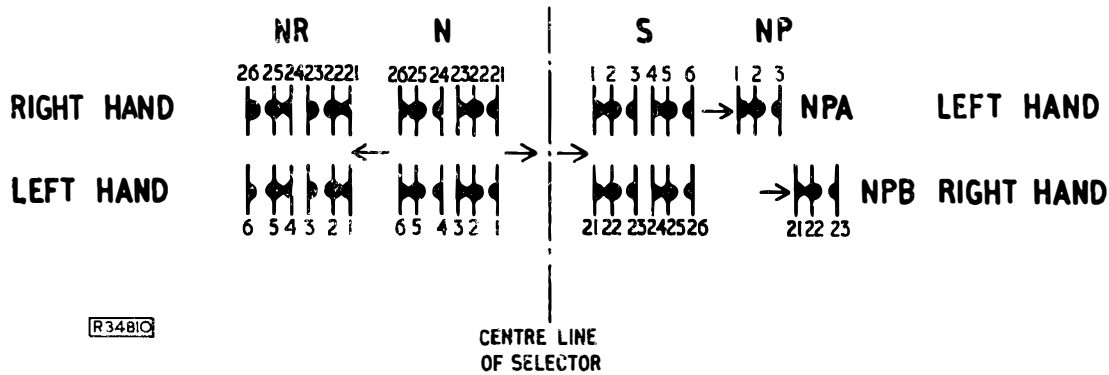
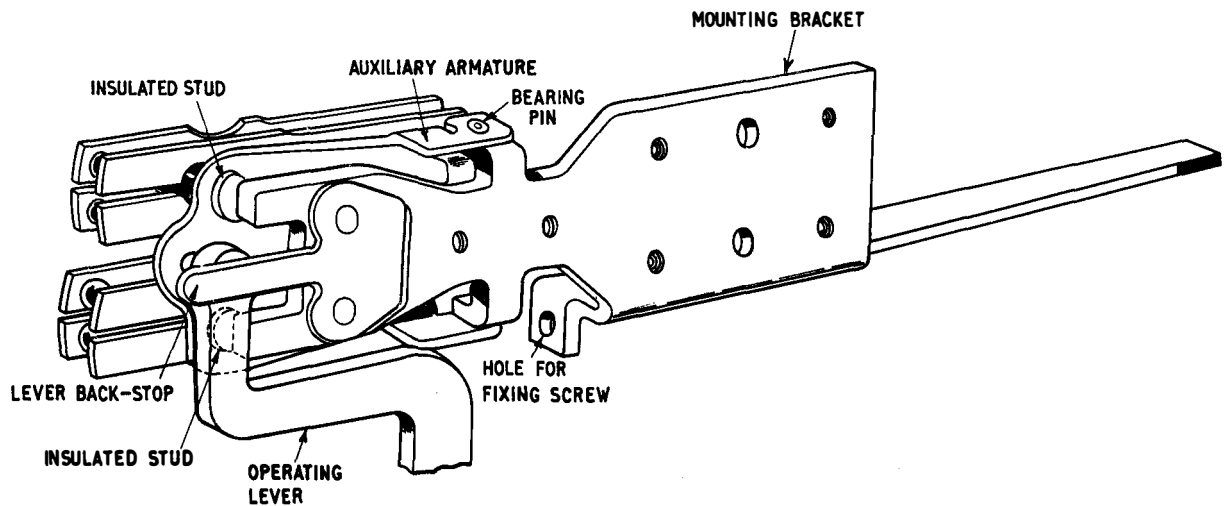


Fig. 14

Mounting Brackets

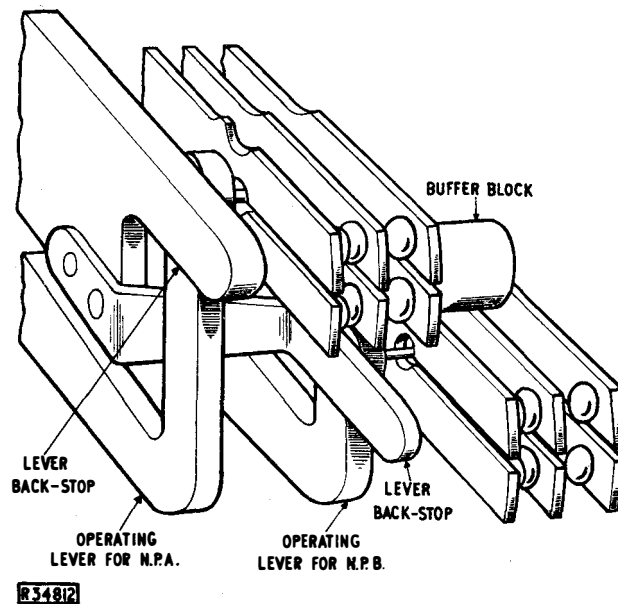
The mounting brackets used for the N, NR, and S spring assemblies are each provided with an auxiliary armature which is actuated by the movement of the spring-set operating lever. The movement of the auxiliary armature operates simultaneously the left-hand and right-hand spring-sets through two insulated studs which act on the spring lifting pins. The mounting bracket shown in Fig. 15 is suitable for the N and NR spring assemblies only; the bracket used for the S spring assembly is similar except that it is arranged so that the auxiliary armature moves in the reverse direction.

The NP spring-sets are not operated by an auxiliary armature because the left-hand and right-hand spring-sets which form the NPA and NPB spring-sets respectively, need to be operated separately. Each spring-set is operated directly by the operating lever as shown in Fig. 16.



R34811

Fig. 15



R34812

Fig. 16

Operating Levers

Five operating levers are provided, one for each of the N, NR, and S spring assemblies and one for each of the two NP spring-sets. The levers are steel one-piece pressings and are either zinc-plated or cadmium-plated. All have two bearing holes, one at the upper end which fits over a phosphor-bronze bearing pin riveted

to the upper ledge of the selector casting and one at the lower end, which fits over a longer pin fitted at the bottom of the casting. The lower pin is threaded over a portion of its length, to permit adjustment of the lever position.

Vertical off-normal

The operating lever for the N spring-sets and its mode of operation is shown in Fig. 17 (appended). With the wiper carriage in the normal position, the projection of the cam plate is in engagement with the lower tongue of the operating lever. This causes the upper arm of the lever to bear upon the auxiliary armature and hold the spring-sets in the operated position. When the carriage is stepped off-normal in a vertical direction, the cam projection rises clear of the tongue, thus freeing the operating lever, and the spring-sets restore to normal under their own tension. The spring-sets remain in the normal condition until the final release of the mechanism.

It is important to note that, because the N spring-sets are operated when the selector mechanism is normal, and released when the wiper carriage steps off-normal the physical arrangement of the contact units is the reverse of that shown on the relevant circuit diagram e.g. M and B units on the circuit diagram are physically B and M units on the spring-set. This occurs because on circuit diagrams all spring-sets are shown in the unoperated condition.

When the carriage is returning on the normal level, the projection on the cam, which is approaching the tongue with an anti-clockwise movement, finally re-engages with the tongue and the spring-sets are re-operated. The re-engagement occurs approximately when the carriage is passing the third contact on the bank level.

Rotary off-normal

The operating lever for the NR spring-sets and its mode of operation is shown in Fig. 18 (appended). At the first and subsequent vertical positions of the wiper carriage a notch in the cam plate coincides with the flange of the operating lever, consequently the spring-set remains normal. When the carriage rotates at any contact level, the cam plate engages the lever flange. The operating lever moves until the operating edge of the flange is riding on the periphery of the cam plate, and this movement is transmitted through the lever and the auxiliary armature to operate the spring-sets. The relative shape and position of the lever and cam plate are such that the operation of the spring-sets is completed before the sets of wipers reach the first sets of contacts in the level.

During the rotary movement of the wiper carriage the operating edge of the lever flange is held against the cam plate by the tension of the spring-sets. When the carriage moves from the 11th to the 12th rotary position the step in the periphery of the cam allows the spring-sets to restore to the normal position. The operating lever back-stop, not shown in Fig. 18, prevents the lever flange from bearing on the cam during the vertical release movement.

At the normal level the cam plate is below the lower edge of the lever flange and so the spring-sets remain normal during the rotary release movement.

11th step

The operating lever for the S spring-sets and its mode of operation is shown in Fig. 19 (appended); the wiper carriage is shown at the 11th rotary position.

There is a clearance between the cam plate and the lever-operating surface during the vertical and rotary movements of the wiper carriage until just before the 11th rotary step. At this point the projection on the cam plate engages with the lever-operating surface as shown in Fig. 19 thus forcing the lever over. The movement of the lever is transmitted through the lever projection and the auxiliary armature to operate the spring-sets. When the carriage moves to the 12th rotary position, the projection on the cam disengages from the lever-operating surface and the spring-sets restore to normal under their own tension. During the rotary release movement the projection on the cam plate passes below the lower edge of the lever-operating surface. The S spring-sets are thus operated at the 11th rotary step, and remain operated only so long as the carriage remains in that position.

Normal post

An operating lever is provided for each of the NP spring-sets. The flange on each lever has 10 tapped holes as shown in Fig. 20 (appended), the spacing of the holes is the same as the spacing of the contact bank levels, and a level cam is fitted in the hole corresponding to the level at which the spring-set is required to operate. A series of level cams is available and they cover the range from operation at a single level to operation of the spring-set at 9 consecutive levels. A single level cam fitted to the NPB lever so as to effect operation of that spring-set when the carriage reaches level 5, is shown in Fig. 20.

The level cams are engaged by the tongue of an auxiliary cam assembly which is fitted to the wiper carriage, the complete assembly is shown in Fig. 21. The selector shaft passes through the bearing hole and the bottom projection fits around the carriage just below the rotary ratchet. The detachable bracket is provided so that the auxiliary cam can be fitted without removing the carriage from the shaft. The level cams shown in Fig. 21 effect the operation of the NPA and NPB spring-sets when the carriage reaches level 8. When the carriage is stepped vertically the auxiliary cam is lifted and at the 8th step the NPA and NPB steps in the tongue engage the level cams on each lever. The operating levers are forced over and the lever projections, Fig. 20, operate the spring-sets directly.

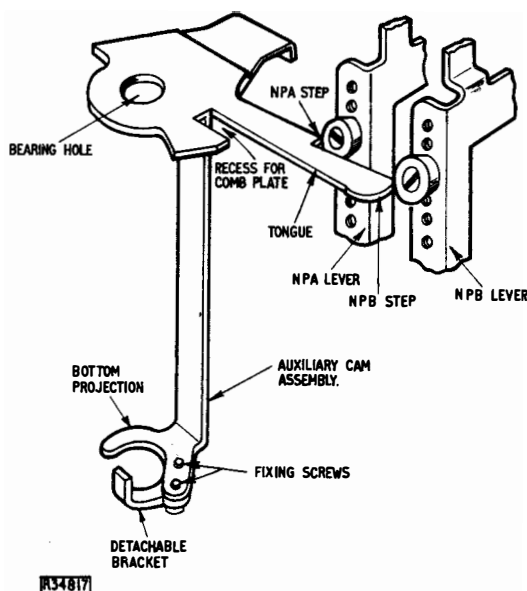


Fig. 21

or NPB spring-set is composed of a break contact unit only. The bias spring is fitted in the position taken by the make spring in a change-over unit and is tensioned to exert a pressure of approximately 30 grammes on the buffer-block.

The spring-sets release when the wiper carriage moves from the 11th to the 12th rotary position. The pin on the main cam plate, Fig. 20, engages the auxiliary cam, and as the carriage rotates the tongue is disengaged from the level cams so allowing the spring-sets to restore to normal under their own tension.

In the foregoing both the NPA and NPB spring-sets are operated at the same level, it should be appreciated that either or both spring-sets can be operated at any level.

VERTICAL AND ROTARY MAGNET INTERRUPTER SPRING-SETS

To obtain positive operate and release strokes of the magnet armature, the magnet interrupter spring-set, when used as the switching device in a self-interrupted stepping circuit, is required to disconnect the magnet coil circuit late in the operate stroke and to reconnect the circuit late in the release stroke. On the 2000-type selector mechanism these requirements are achieved by actuating the spring-set with an arm which is linked to an extension of the armature by a toggle mechanism.

The principle of the operation of the magnet interrupter spring-set is shown in Fig. 22 (appended). The operating striker is a U shaped extension of the magnet armature, and is in contact with the operating arm only during part of the operate and release strokes of the armature. The operating arm is stable in only the two positions shown in Figs. 22(a) and (b), that is with one or the other of the limbs of its forked extension bearing against the spring assembly projection under the tension of the loop spring. One end of the loop spring is free to rotate in a hole in the projection of the spring assembly, and the other end is held by its own tension in a groove in the fork. The tension is sufficient to move the operating arm over to its stop against the tension of the spring-set and to hold it in that position. In practice the tension of the loop spring is sufficient to withstand a pressure of 50 grammes applied to the side of the lever and in line with the loop spring.

The position of the operating arm when the magnet armature is normal is shown in Fig. 22a. The contacts of the spring-set are closed and the lever spring is clear of the operating arm. When the armature operates the operating striker engages the arm, which then turns on its pivot against the tension of the loop spring. The tension of the loop spring increases as the arm approaches the mid-point of its travel and is greatest at this point. When the arm passes the mid-point however, the tension of the loop spring aids the movement of the arm and consequently the movement is completed independent of the striker. As the arm completes the movement it engages the lever spring and opens the contacts as shown in Fig. 22b.

When the magnet armature restores, the restoring striker engages the operating arm and the arm and spring-set are restored to the normal position in a fashion similar to that described for the operate stroke. The points in the travel of the magnet armature at which the spring-set operates and restores are determined by the adjustment of the operate and restoring strikers. The operate striker does not engage the operate arm until late in the armature stroke, the remaining portion of the stroke need be sufficient only to carry the operating arm just past the mid-point. Thus it is possible for the armature operate stroke to be completed before the spring-set contacts are open. In a similar fashion the armature release stroke can be completed before the spring-set contacts close.

A rotary magnet interrupter, fitted with a break contact unit is shown in Fig. 23. The vertical magnet interrupter, Fig. 24 is similar except for the configuration of the lower part of the operating arm and the striker.

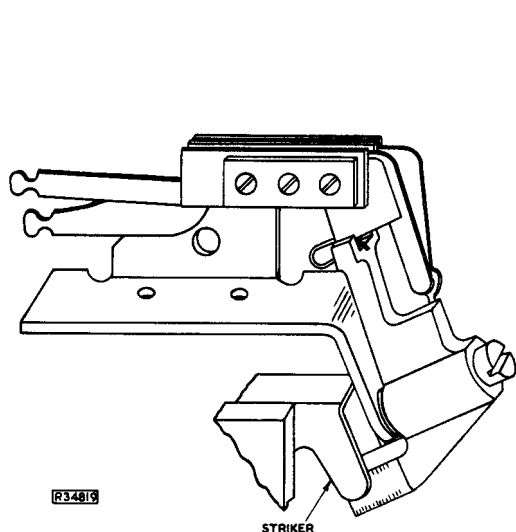


Fig. 23

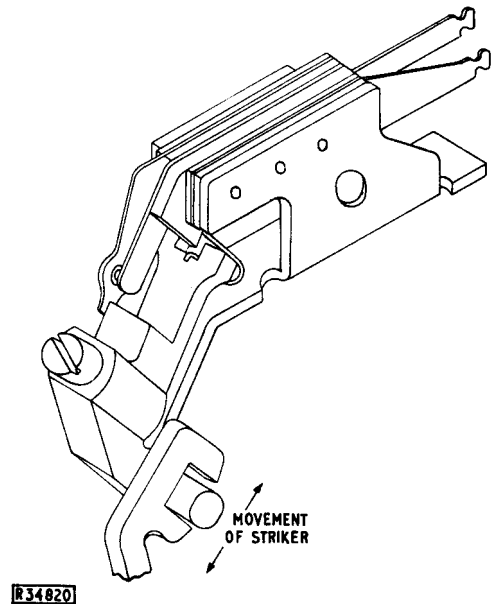


Fig. 24

The spring-set may consist of a single make, break, change-over or make-before-break unit. The spring-set assembly employed for the change-over unit is identical to that used for the make-before-break unit, the function being determined by adjustment.

The contact springs are of nickel silver; the stationary spring is 0.5 mm (20 mils) thick and the moving spring 0.25 mm (10 mils) thick. Each spring is fitted with a single platinum contact of large diameter. The stationary spring has sufficient flexibility to enable it to yield slightly under the impact of the moving spring, and after impact the two springs oscillate together for a short period, but without the contacts opening. The result is an almost complete elimination of contact bounce, together with improved contacting due to the rubbing action between the contacts.

The operating arm is a bakelite moulding, reinforced to render it proof against breakage as the result of the impact stresses imposed on it by the magnet strikers. The face of the arm behind the contact springs has a white surface to facilitate adjustment of the contact clearances. The pivot is a large diameter brass or steel bearing pin which screws into a tapped hole in the mounting bracket. The spring-set and the operating arm are mounted on a steel bracket which is screwed to the selector frame.

BANKS AND WIPERS

Banks

Line and private banks

A line or private bank consists of 10 arc-shaped levels of 11 pair of contacts suitably insulated from each other and clamped between two arc-shaped

mild-steel plates. The bank dimensions are the minimum consistent with reasonable manufacturing tolerances, and the working surfaces of the contacts are arranged on the arc of a circle having a radius of approximately 28 mm (1.1 in). The cross-section of a contact level is shown in Fig. 25. For normal purposes the contacts are of hard brass, but in certain cases nickel silver is

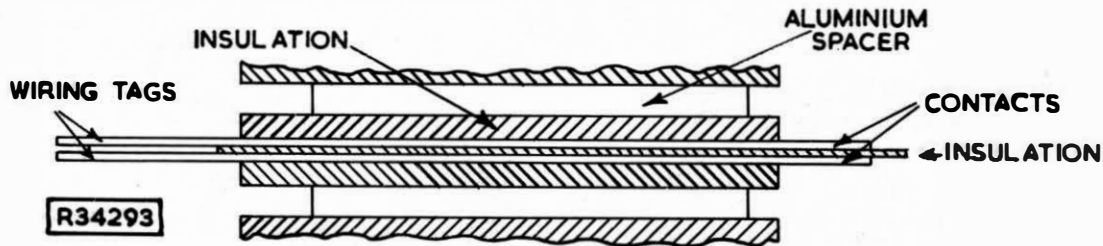


Fig. 25

used because of its hard wearing qualities. To facilitate construction, each arc of contacts is stamped out from a plate, in such a fashion as to leave each contact connected by its wiring tag to the remainder of the plate. When the bank is finally assembled and clamped the contacts are cut away from the rest

of the plate. The insulation consists usually of phenol-fibre plates, and the contacts are retained in position by either tacky oiled linen, varnish, or pips on the contacts which press into the insulation. Bakelite and P.V.C. are also used as the insulating material. The aluminum spacing plates act as electrostatic screens, and later issues of the banks have the plates bonded together by a thin copper ribbon to reduce cross-talk when the banks are used in speech paths. The complete bank is assembled under pressure and held between two steel plates by four counter-sunk screws. The use of counter-sunk screws enables the banks to be mounted closer together vertically than the pre-2000 type banks. The individual banks are held together by the two bank rods which secure the banks to the shelf cradle as shown in Fig. 26; two banks are shown in this figure.

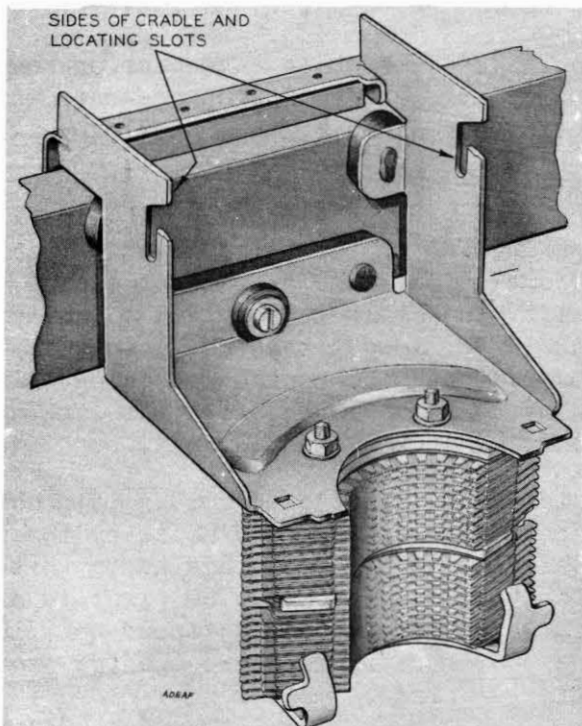


Fig. 26

This arrangement is comparatively rigid and the banks are not disturbed during withdrawal or replacement of a selector, also a special support for the bank is not required when a selector is not fitted in the cradle. The ends of the steel plate on the underside of the bottom bank are extended and bent up to form a fixing for the frame columns of the mechanism.

The wiper carriage and shaft arrangement allows more than 3 contact banks to be associated with the selector, in practice up to 12 banks have been used. Thus an additional contact bank can be provided for 2-10 line P.B.X. facilities instead of the auxiliary arc provided on pre 2000-type mechanism.

Vertical marking bank

When a vertical marking bank is required to be associated with the selector, the bank plate immediately below the bank cradle is replaced by the plate shown in Fig. 27. The vertical marking bank, also shown in Fig. 27, consists of eleven pairs of nickel-silver contacts set in bakelite insulation. It is attached by two screws to the small bracket which is pivoted on a vertical spindle. The bracket

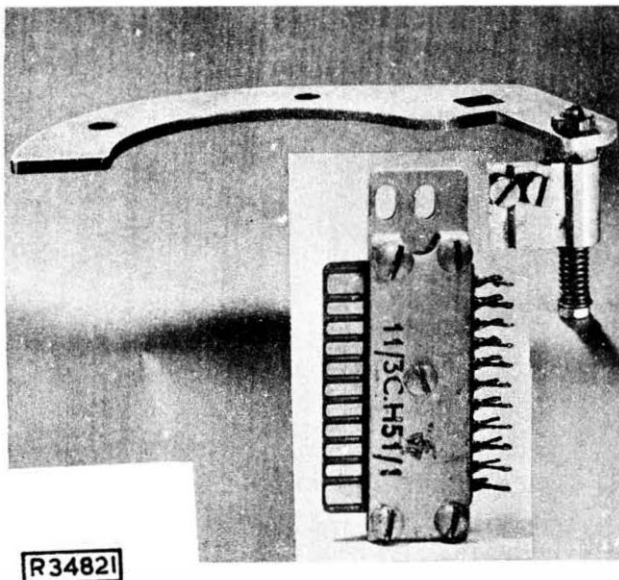


Fig. 27

plates holes were provided in place of the indentations.

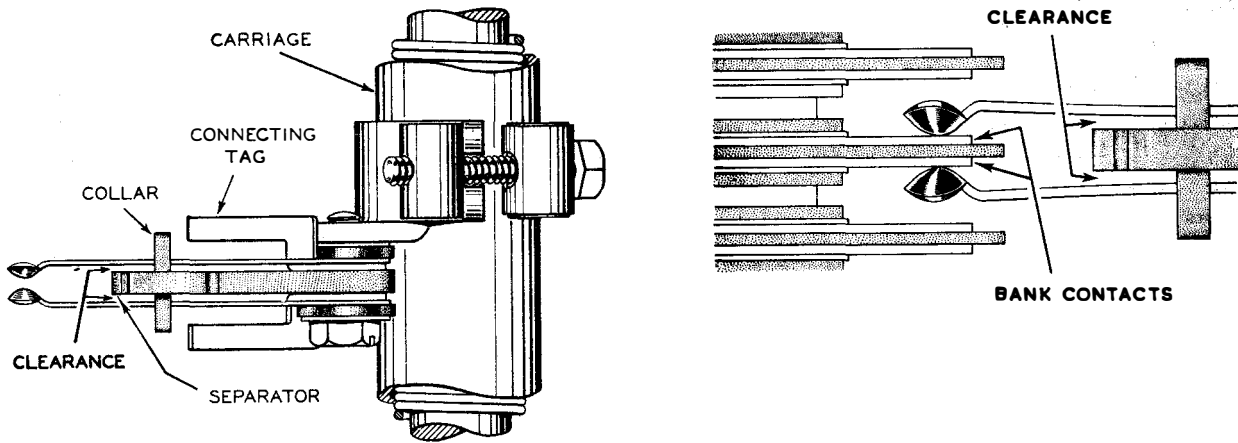
Wipers

Line and private wiper

A cross section of the type of wiper assembly used for the line and private contact banks is shown in Fig. 28 a plan view of the wiper resting on a bank contact is shown in Fig. 29. The two wiper blades are of nickel-silver, having an 18 per cent nickel content to enable the material to retain a given tension for a long period of time. The tip of each blade is pressed out to form a spoon shaped contact, and the blades are held parallel by a fibre collar located in notches a short distance back from the tips. The pressure exerted by the wiper blades on the bank

is held at the upper end of the spindle by the helical spring which is positioned between the underside of the bracket and the lower end of the spindle. The upper end of the spindle is threaded and is screwed into the projection on the bank plate and secured by a lock-nut. The projection on the bank plate is provided with indentations with which a domed extension of the bracket can engage, and be held in position by the helical spring. When the dome is engaged with the front indent, the vertical marking bank is in its normal working position where the bank contacts may be traversed by the vertical marking bank wipers. When the dome is engaged in the rear indent the bank is swung clear of the wipers to enable the selector to be removed from the cradle. On earlier type bank

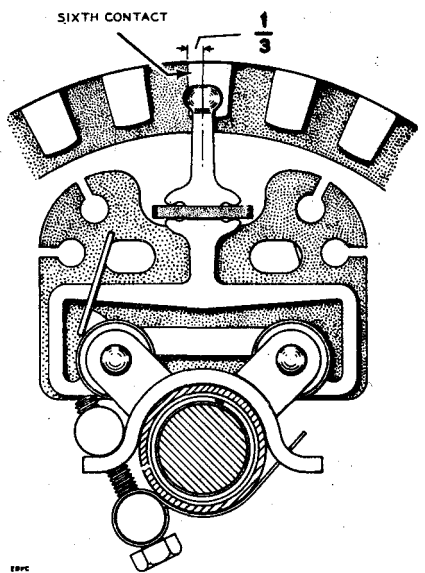
contacts is determined by the gap between the tips, in practice it is of the order of 0.4 mm (16 mils). Between the wiper blades, and extending through the fibre collar, is a rigid plate of insulating material. This plate is suitably drilled to provide ways for the flexible conductors, known as the "wiper cord", which connect the wiper blades to the control circuit of the selector. The wiper blades, insulated plate, and the necessary washers and insulated bushes are screwed to a bracket which is suitably curved to fit the wall of the wiper carriage. A spring steel clamp holds the bracket to the carriage and makes contact over the whole of its surface to prevent indentation of the tube.



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Fig. 28

Before the fibre collar is fitted to the wiper blades, each blade is set outwards from its root so that the wiper tips are 9.5 mm ($\frac{3}{8}$ in) apart and equidistant from the insulated tape. When the collar is fitted it holds the blades together to form a "balanced pair" as shown in Fig. 28. Should either blade be deflected by inaccuracies in the plane of the contact level the collar causes the other blade to follow, consequently there is no change in the gap at the wiper tips and the pressure exerted by the tips on the contacts remains sensibly the same. The deflexion of the blades must, of course, be within the limits imposed by the central insulated separator plate. The fibre collar in conjunction with the separator also reduces vibration of the wiper blades during the vertical stepping action and so decreases the possibility of the tips fouling the contact level on the first rotary step.



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Fig. 29

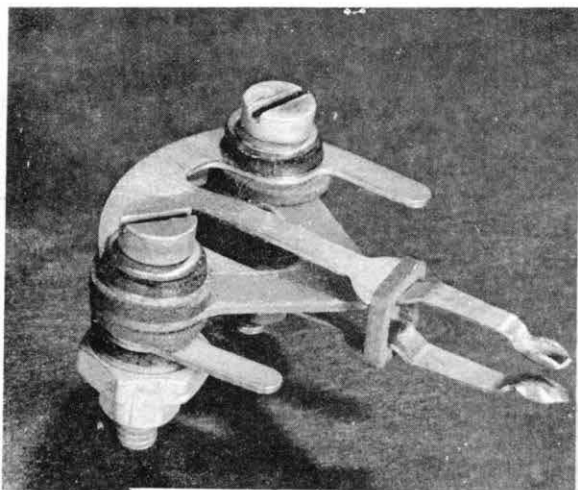
Theoretically the most satisfactory shape for a wiper tip is a truncated cone, and the tips of the wipers fitted originally to the mechanism were of this shape. Manufacturing processes, however, resulted in the tip taking up a rounded form with the metal thin at the tip of the cone. The latest design of wiper has a spoon shaped tip with the extremity cropped; during manufacture the metal in this type of tip thickens and so gives longer life to the wiper. The requirements of the tip of a wiper are as follows:-

- (a) To have sufficient depth so that the wiper, if poorly positioned, can climb on to the contact.
- (b) To have a shallow angle to reduce the outward force on the wiper blades when they enter the contact bank. The angle must, however, be sufficiently acute to avoid the tip bridging adjacent contacts.
- (c) To have a narrow width to enable the wiper to clear the sides of the bank when stepping and falling vertically.
- (d) A satisfactory shape should be retained for a long period despite wear.
- (e) The area of the contact should not be too great because the contact resistance decreases as the pressure per unit area increases.

It should be appreciated that the outward force mentioned in (b) must, if there is not to be excessive wiper bounce, be counteracted by the tension of the wiper blade. Thus the more acute the angle the greater the tension necessary to avoid bounce; the use of the fibre collar however, imposes a damping effect on the wiper blades and reduces the tension necessary to keep bounce within tolerable limits.

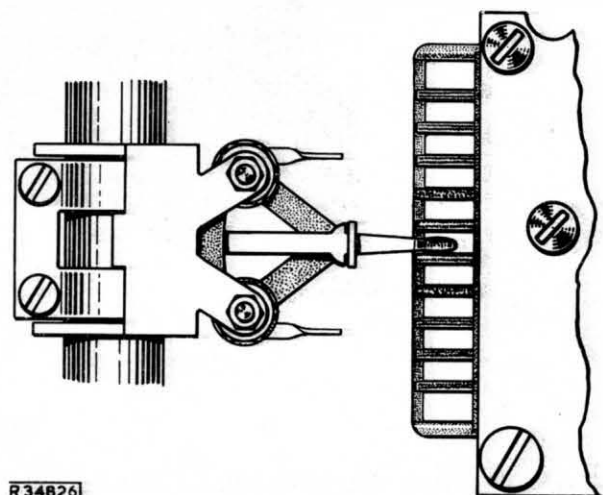
Vertical-marking wiper

The vertical-marking wiper is shown in Fig. 30. The wiper is attached to a bracket which is free to rotate horizontally on a locating collar fixed to the wiper carriage. The wipers thus rise and fall with the wiper carriage but remain stationary when the carriage rotates. The position of the wiper when the carriage is at the 5th vertical position is shown in Fig. 31.



R34822

Fig. 30



R34826

Fig. 31

The wiper is similar in construction to the line and private type. The blades are of nickel silver and are narrow in width beyond the fibre collar to limit the rise of contact pressure when the wiper tips pass over the raised insulation between adjacent bank contacts. The main function of the collar is to reduce the wiper bounce and so lessen the pitting and wear of the wiper tip. An earlier pattern wiper has a circular domed tip, and should the vertical stepping give rise to 'overshoot' disconnexion faults arise when the edge of the tip rides up on the bank insulation. The narrow tip on the wiper shown in Fig. 30 when positioned correctly, reduces the chance of disconnexions caused by overshoot to negligible proportions.

JACKS AND WIRING

The selector is provided with a test jack which gives access to the principal wires of the control circuit and also enables the selector to be artificially engaged or 'busied'. The type of test jack fitted to the 2000-type selector is shown in Fig. 32 and its position on the selector can be seen by reference to Fig. 1. The test jack consists of slotted rectangular blocks of moulded ebonite housing 6 test springs, so that the complete jack is built up in multiples of 6 test points. The lamp jack is a similar moulding containing also a label holder and two test springs. The springs of the test jack are wired to appropriate points in the circuit and small metal connecting links with insulated

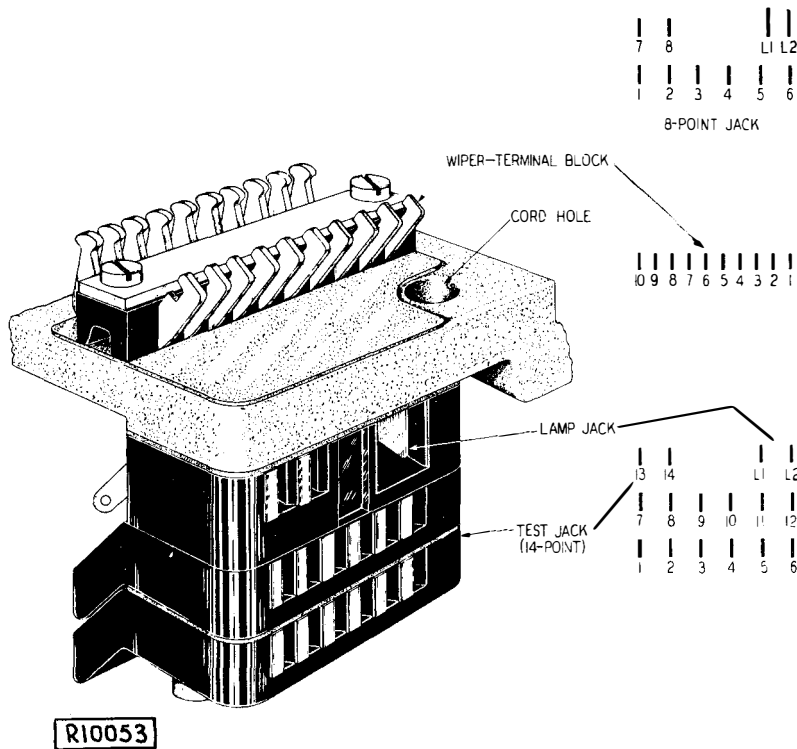
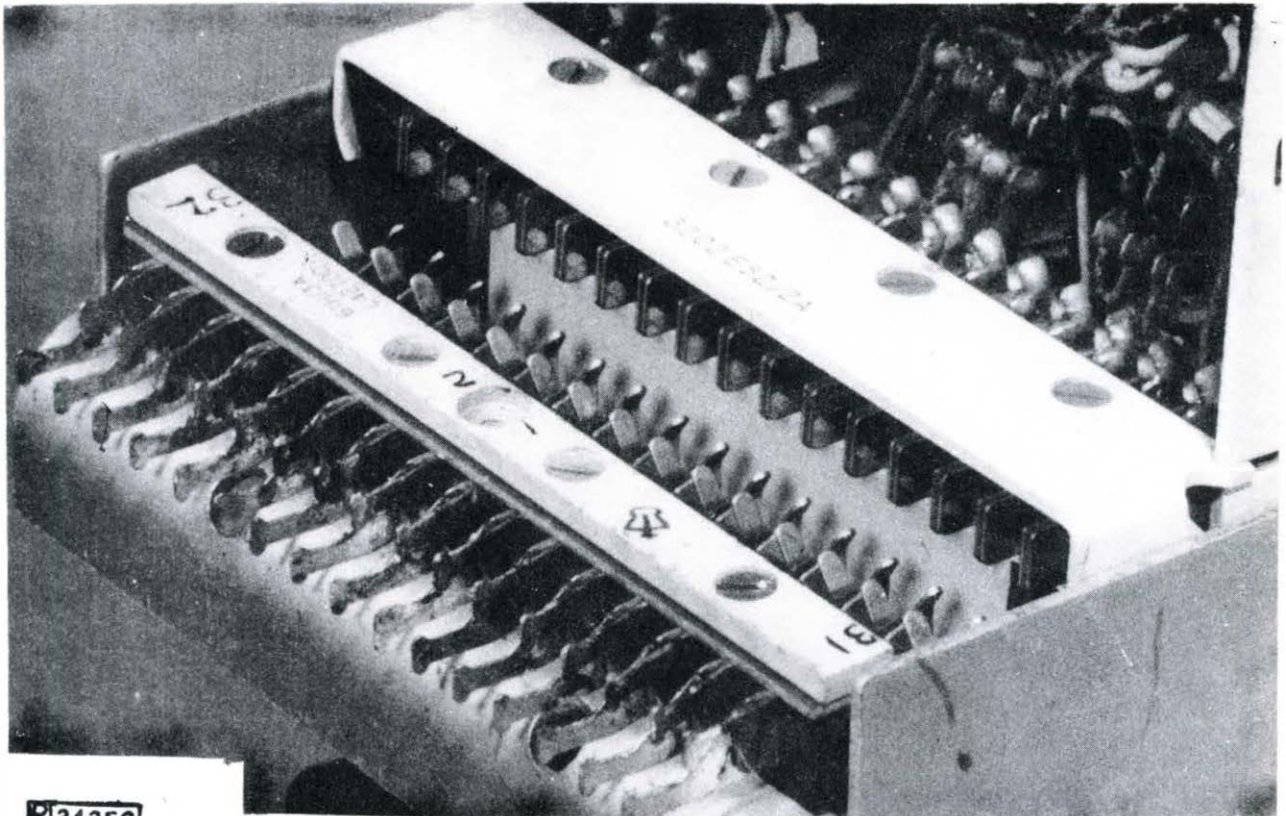


Fig. 32

handles are used for various testing purposes including 'busing' and opening the release-magnet circuit. The wiring, except that for the test jack and wipers, is confined to the rear of the selector base plate. The wire employed

is 0.5 mm diameter ($6\frac{1}{2}$ lb/mile) tinned copper suitably insulated. Wires of four different colours are usually used, namely white for negative battery, red for earth, blue-red for positive battery, and green for point-to-point wiring. The open method of wiring is employed, the wires being run singly in an orderly manner and lightly bound together. The selector wiring is terminated at the rear of the base plate on a multiple-way plug which makes connexion with a multiple-way jack on the selector shelf when the selector is in position on the rack. The permanent shelf wiring is terminated on the shelf jack; the connecting arrangements between the selector and the shelf are shown in Fig. 33. When viewed from the rear of the selector, the contacts of the



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Fig. 33

multiple plug are numbered 1, 3, 5 etc. to the right of a centrally positioned line, and 2, 4, 6 etc. to the left of the line. Springs number 9 and 11 make contact when the selector is removed from the jack, and in so doing busy the circuit.

CONCLUSIONS

The 2000-type selector mechanism has several advantages over the earlier type mechanisms, some important ones being:-

(a) Reduced size and mass. The selector frame is die-cast and is made from a 90% aluminum alloy. Its mass is about 284 grammes (10 ozs) as compared with the 0.907 kilogrammes (2 lb) of the pre-2000 type, sand-cast-iron selector frame. The vertical and rotary electromagnets are of the single coil pattern and are contained in the side recesses of the I formation frame; a release magnet is not required. The complete mechanism occupies about 70% of the space used by the earlier types of mechanism.

(b) Reduced Cost. The simplification of the frame casting and magnet arrangements, and the reduction in the number of different piece parts results in cheaper construction costs. This saving is augmented by savings in floor space because of the reduced dimensions of the mechanism.

(c) Greater magnet efficiency. The magnets, which are identical for the vertical and rotary functions, each consist of a single coil wound on an iron core of H formation. The armature is arranged parallel to the axis of the core and has a plate of annealed Swedish iron riveted to it to give a high flux density in a short time.

(d) Improved siting and method of mounting mechanically-operated spring-sets. All the mechanically-operated spring assemblies use a uniform type of spring, bracket, insulator and clamp plate. They are accessibly arranged across the top of the selector frame and each assembly is secured by a single screw and a tongue engaging a slot in the frame.

(e) Ease in removal and replacement of the selector. The selector rests in a pressed steel cradle which is fixed to the rack shelf, and is not directly connected to the contact banks. The contact banks are rigidly attached to the cradle and the removal from, and the replacement of a selector to the same cradle does not usually disturb the relative positions of the wipers and the bank contacts.

(f) Larger bank capacity. The selector shaft and wiper carriage arrangements, and the rigid construction of the contact banks, coupled with the increased efficiency of the selector magnets allows more than three contact banks to be associated with the selector.

(g) 2-10 line P.B.X. facilities. The use of a contact bank instead of an auxiliary arc allows for 2-10 line P.B.X. facilities on both groups of lines served by a 200 line final selector.

(h) Greater ease of adjustment. All minor adjustments to the mechanism can be made from the front and with the selector in situ.

END

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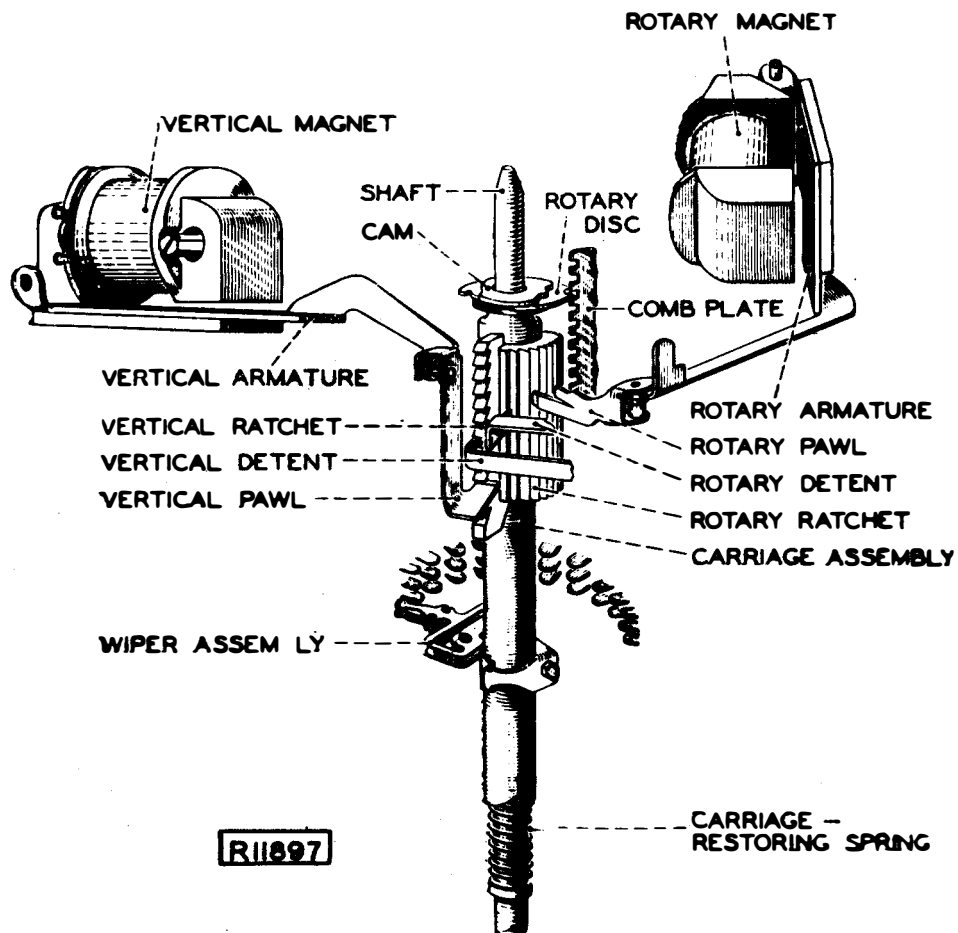
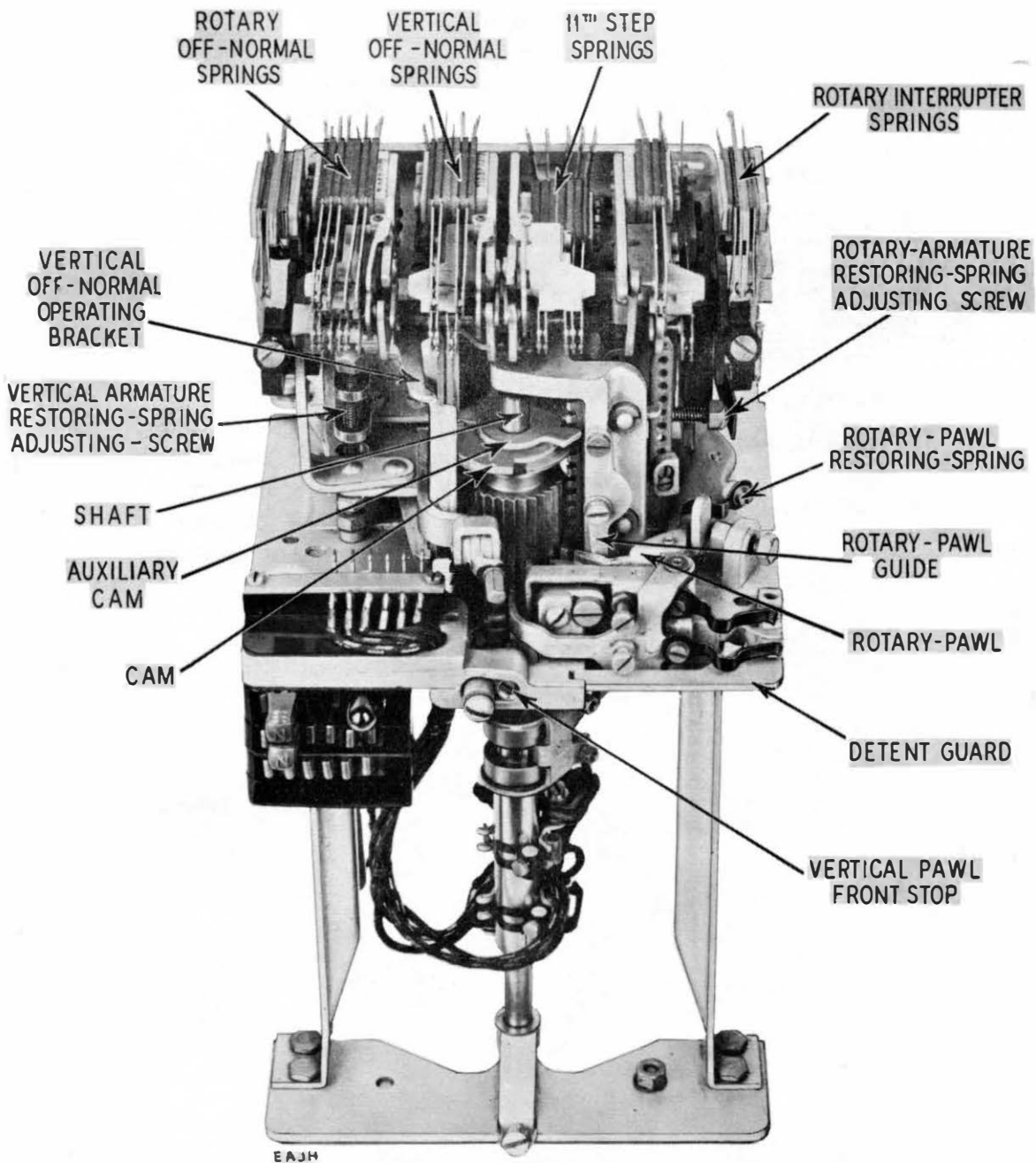


Fig. 2



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Fig. 3

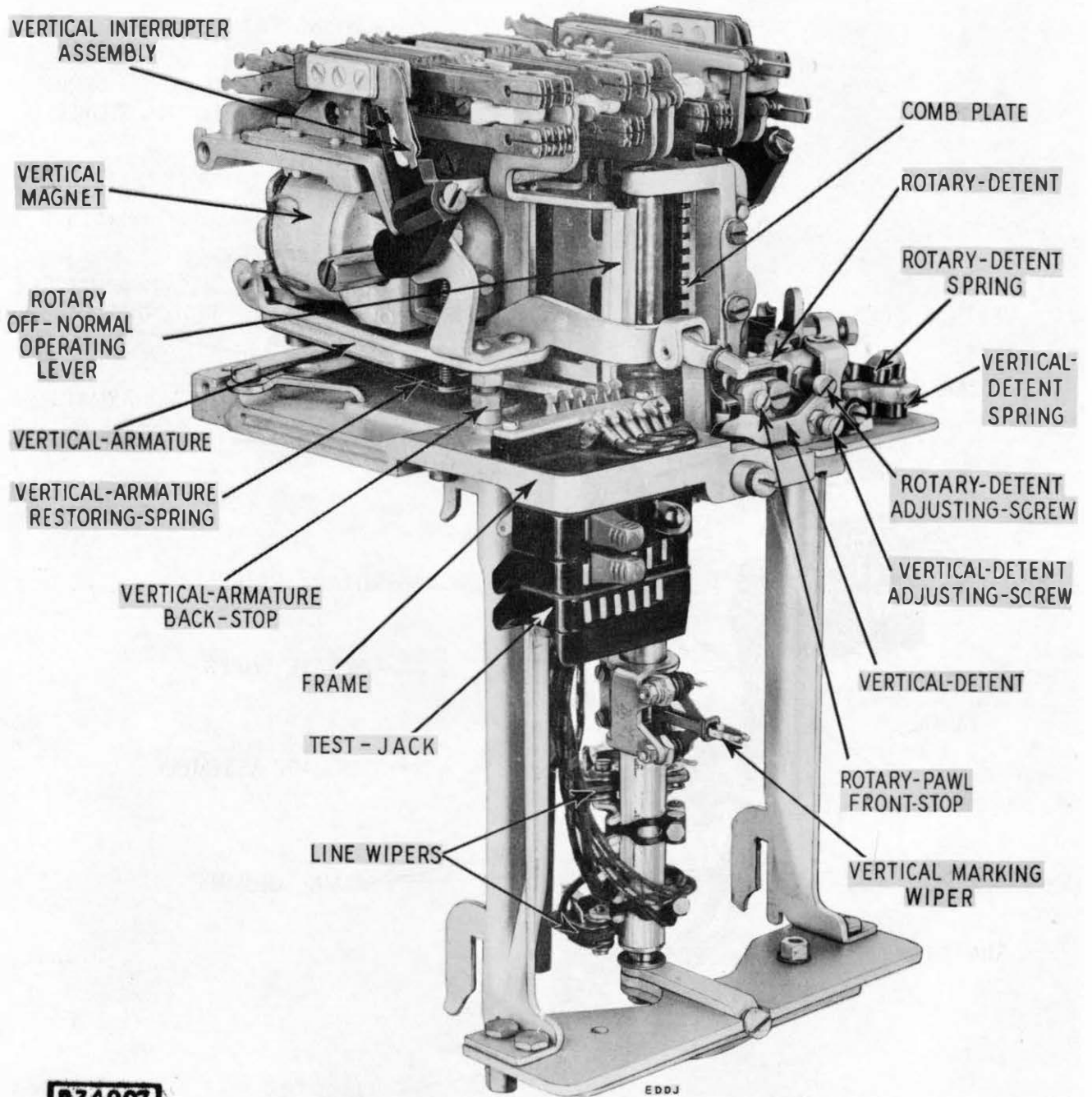
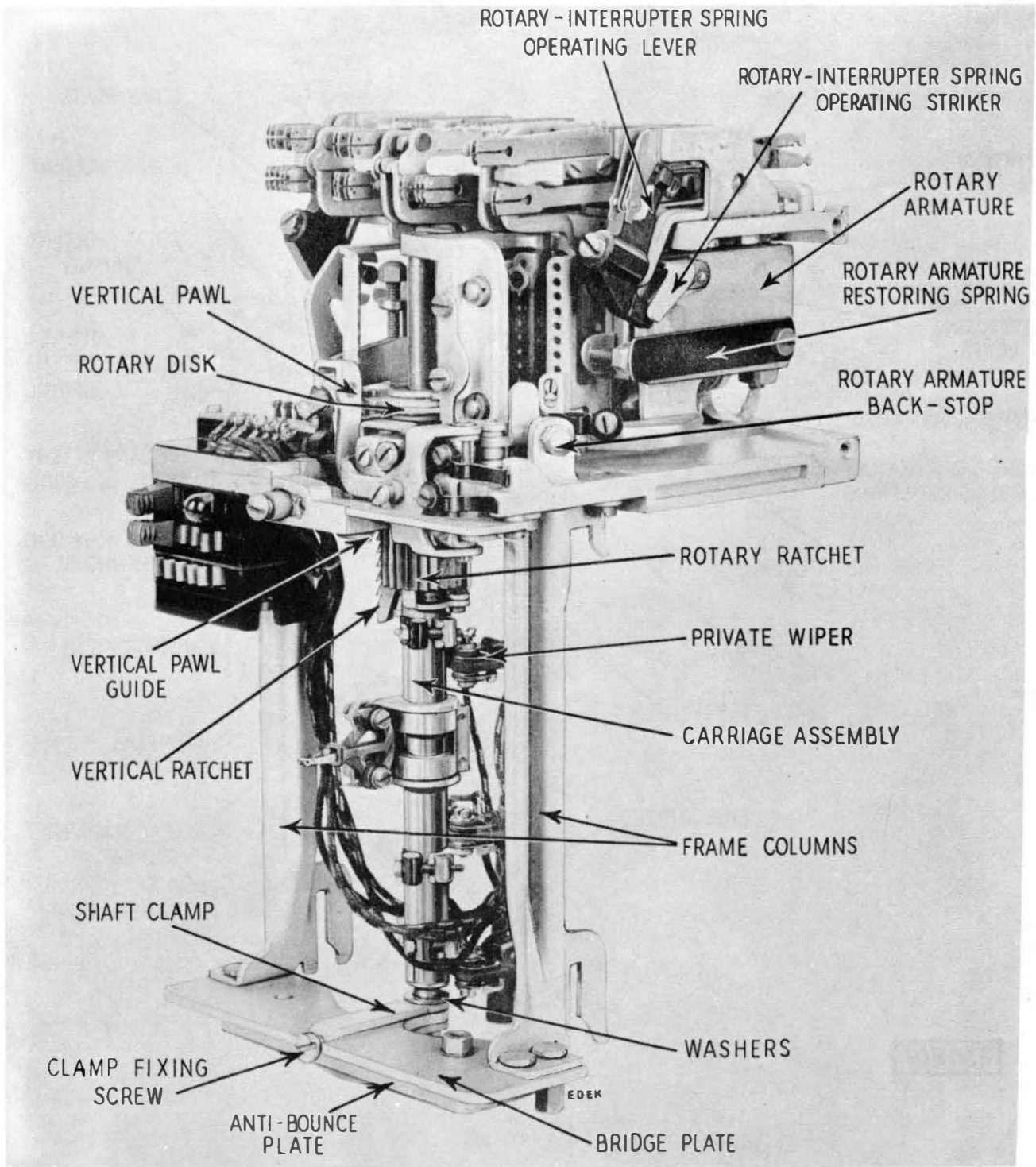


Fig. 4



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Fig. 5

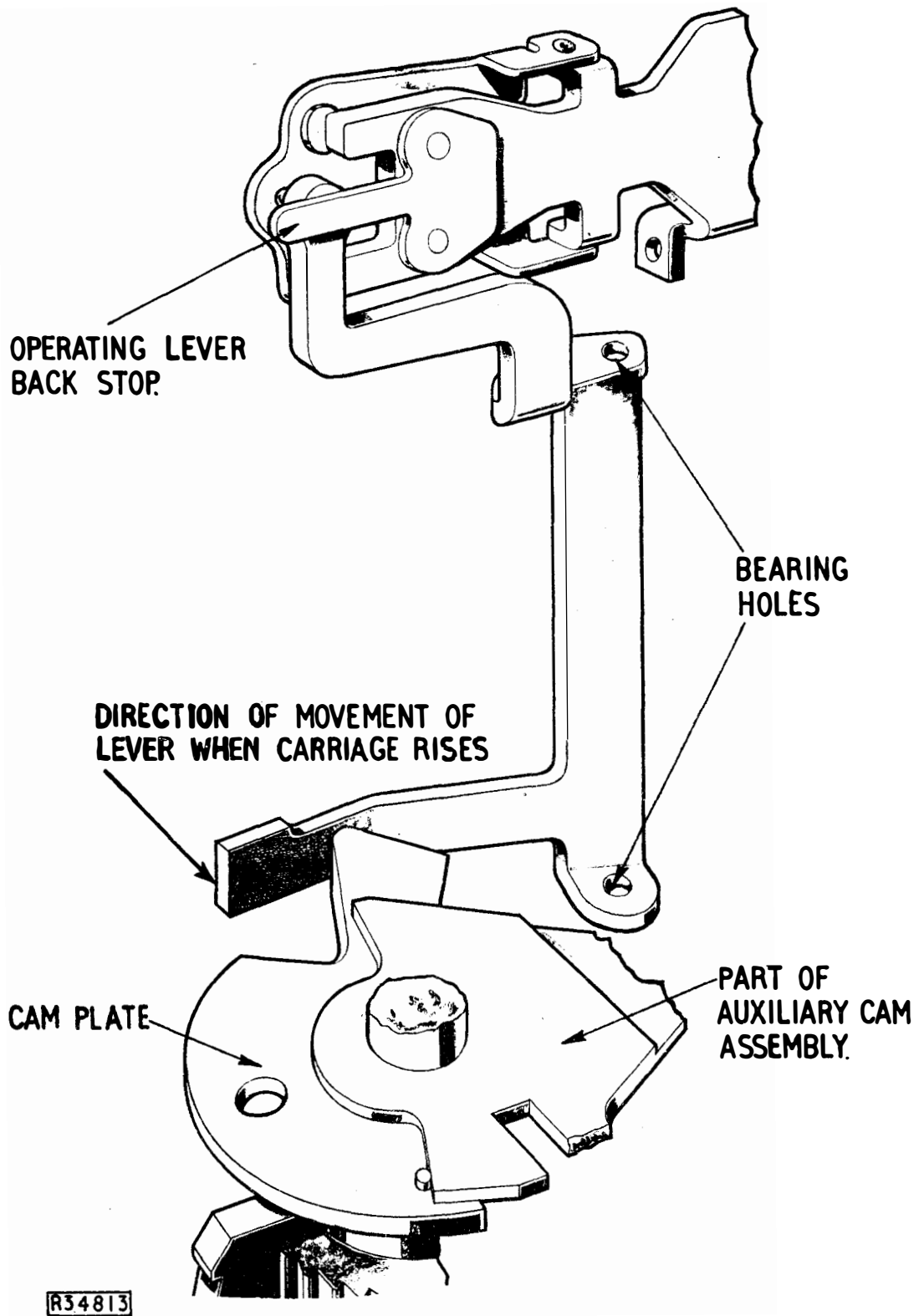
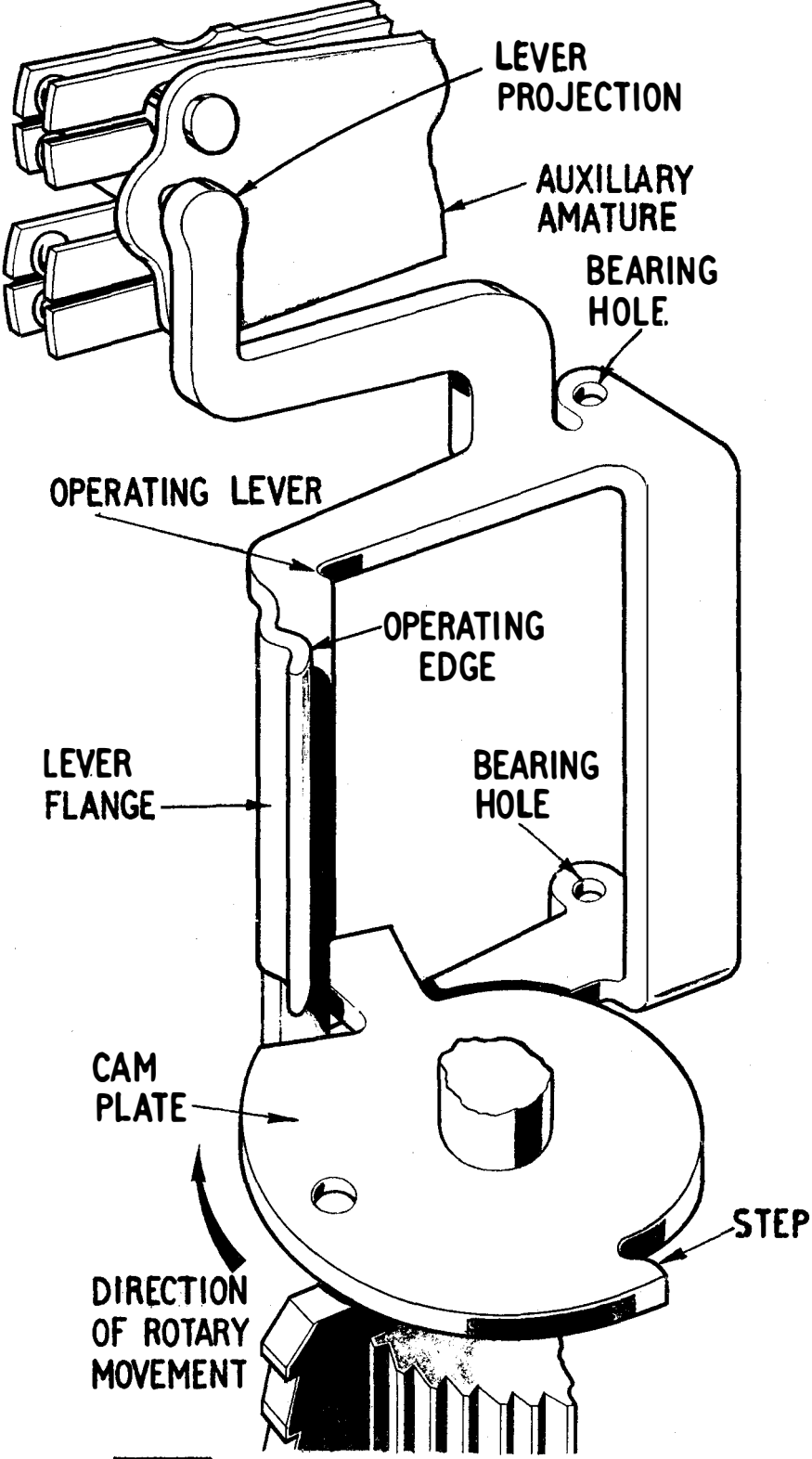


Fig. 17



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Fig. 18

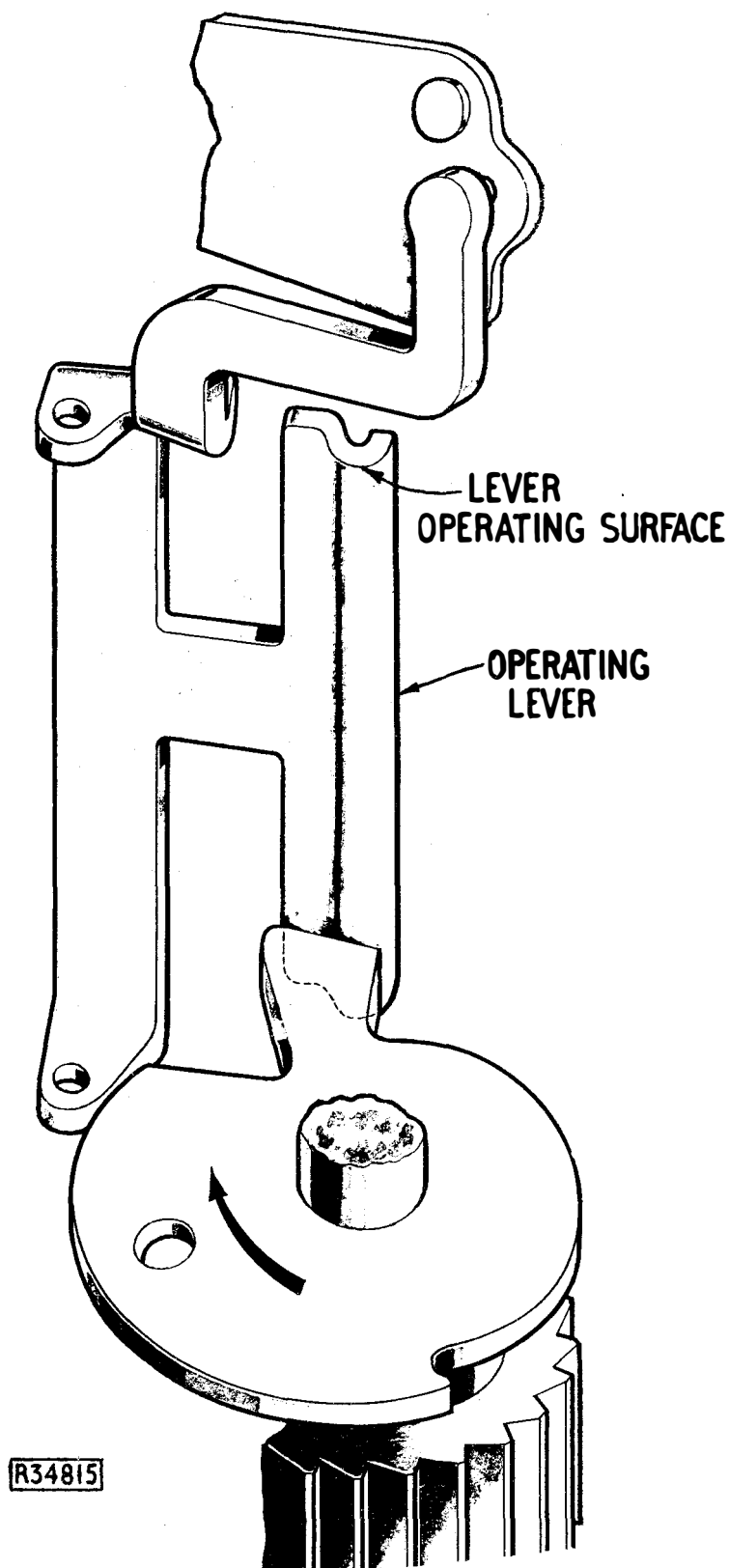


Fig. 19

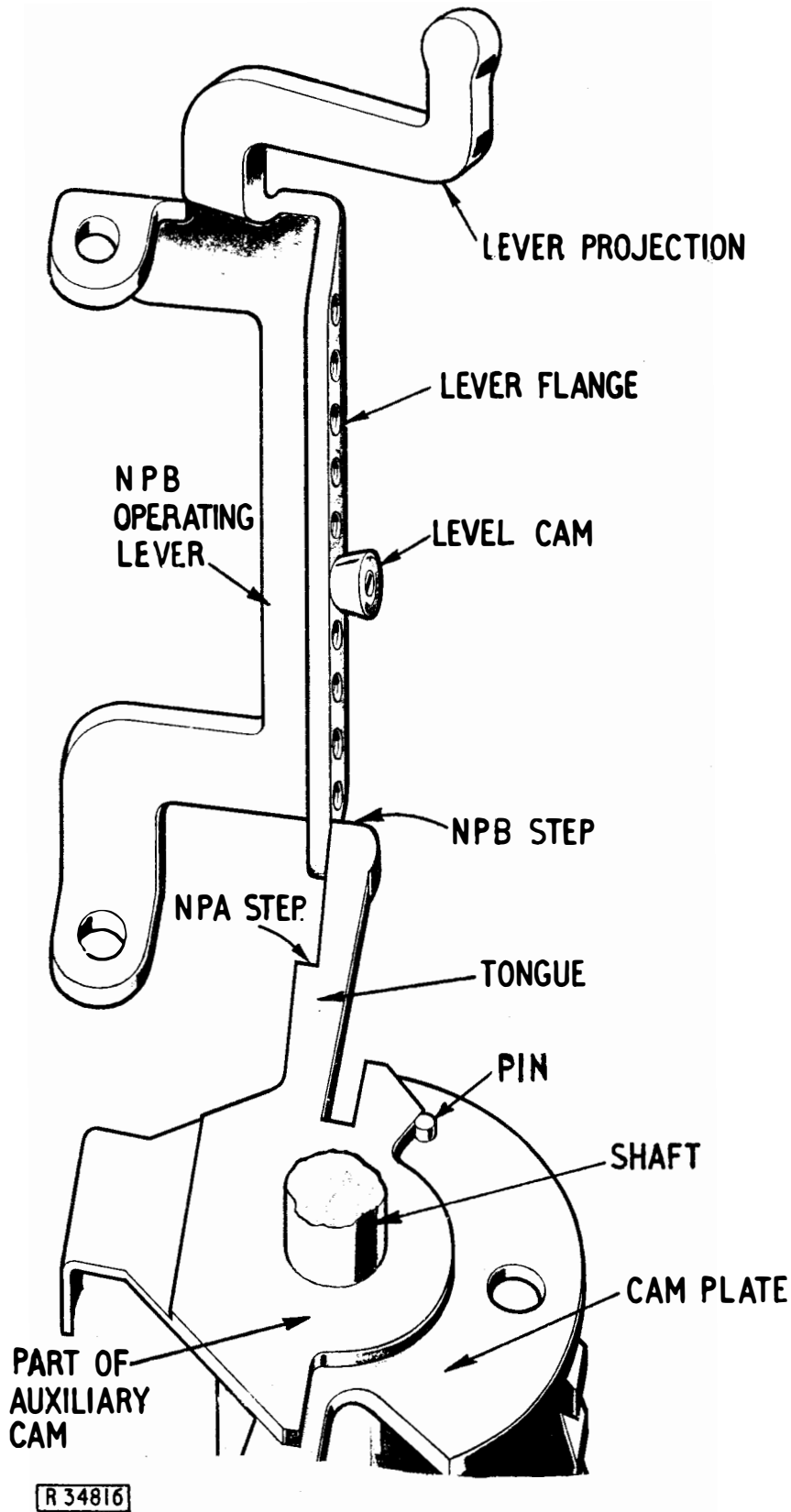


Fig. 20

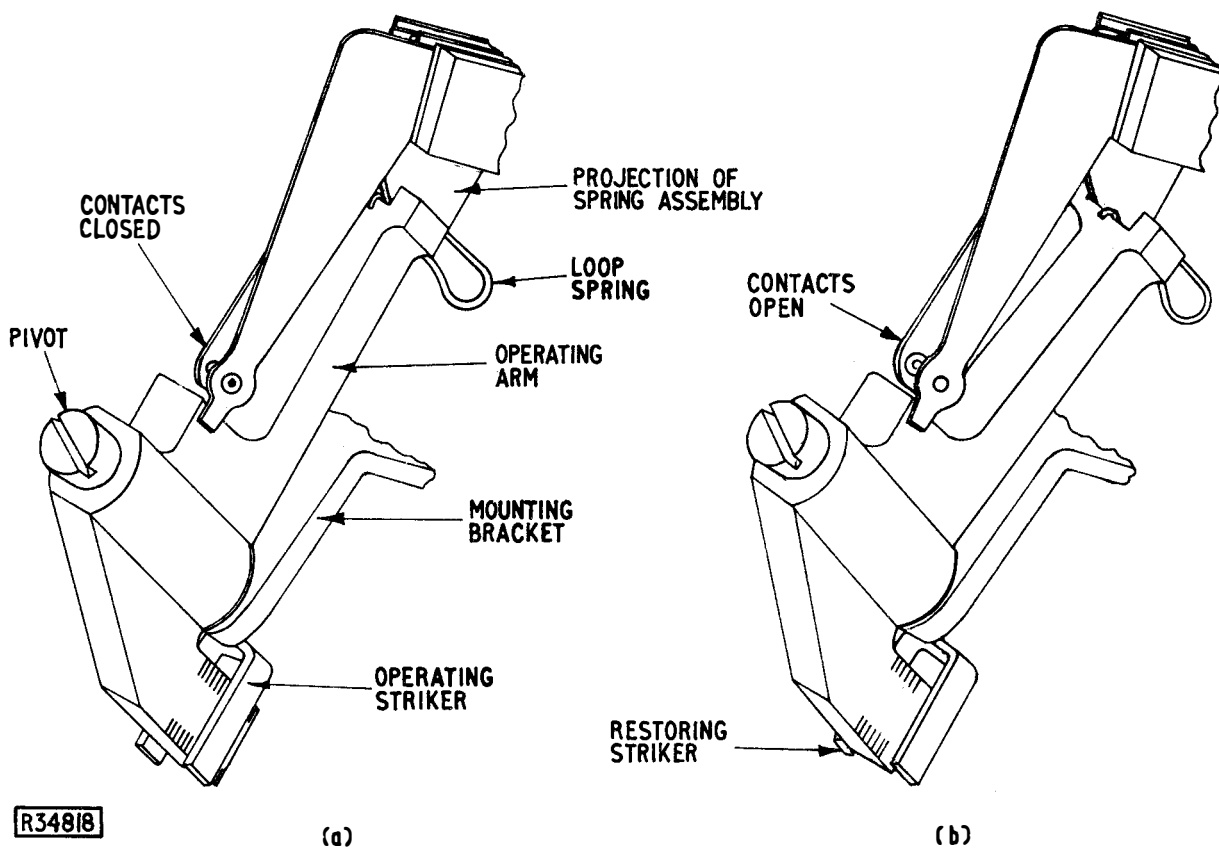


Fig. 22