The Macadie Keysender

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WHILST there is ample evidence that the majority of subscribers prefer an automatic telephone system to a manual one, it has to be admitted that the labour of dialling presents an appreciable drag in the operating of a busy P.B.X. With a view to lightening this burden on busy P.B.X. operators the Post Office, some time ago, decided to develop a mechanical keysender which would be easier and faster in operation than the standard dial.

From a preliminary consideration of the subject and after examining earlier attempts to solve the problem, the following principles were laid down as a basis of the design :—

(1) The sender should be manually operated by keys of a typewriter pattern. It should be entirely mechanical in action and not involve any connexion to electric power supply for driving the mechanism.

(2) The sending of impulses to line should commence immediately the first digit is set up. This follows standard dialling practice, and is considered preferable to the alternative scheme of setting up the complete code before pressing a start key to send out the impulses.

(3) The speed and impulse ratio must comply with the specification for the standard dial, *i.e.*, speed 10 ± 1 impulses per second and impulse ratio (break percentage) 63 – 70%.

(4) The interval between digit trains should be 600 milliseconds.

(5) The size should be sufficiently small to permit of the sender being fitted to existing P.B.X. boards.

There was no dearth of ideas on which to base the design, and models on two alternative schemes were commenced, but at an early stage in the development it was decided to concentrate on a design evolved by Mr. D. Macadie, then a Staff Officer at the Post Office, Holloway Factory. In a few months, Mr. Macadie produced a model, constructed at Holloway Factory, which was considered a sound engineering solution of the problem. To ensure that the detailed construction would permit cheap and reliable mass production, further models were constructed by the General Electric Company, closely following the Post Office model. Improvements to lighten the pressure on the keys and to ensure greater reliability, were introduced during this second stage of the development.

The various models were tested by the Post Office Research Section and one of the final models was given a practical trial on the P.B.X. board at Dollis Hill, when, over a period of 16 months, it dealt with approximately 40,000 outgoing calls, with little or no maintenance attention and without showing any appreciable signs of wear.

The following extract from the Research Report on one of the later models is of interest :—

" It was found that the time required to deal with a call was 3 to 4 seconds. When using a dial and the normal dialling keys, 10 to 12 seconds were required. It will be realized that this leaves the operator free for the extra time, but she cannot use the sender again for about 6 seconds. The amount of wear on the moving parts due to 12,000 seven-digit calls is negligible. The impulse speed remained constant at 10.7 i.p.s. and the make percentage 32 throughout the tests. The tests made indicate that this type of sender is much less fatiguing than a dial and is preferred by the telephonist. The mechanism is necessarily more complicated than a dial, but the moving parts are very light and should not wear excessively. In cases where faults have occurred it has neither been difficult to find the trouble nor to put it right."

The Post Office is arranging to introduce the Macadie Keysender into service on rental terms and the mechanism has been coded as Keysender No. 5.

A general view of the keysender with the cover removed is shown in Fig. 1. The mechanism can be conveniently dissected into the following parts :—

- Frame and key lever Assembly.
- Code Storage Ring.
- Code Storage Mechanism.
- Impulse Mechanism.
- Internal Ratchet Restraining Pawl.
- Off-Normal Springs.
- Visual Indication Disc.

Before examining the detailed construction of the keysender it will be helpful to consider the principles on which it operates. In any type of keysender where the code is set up at a faster rate than it is sent out, provision must be made to store the code. In the Macadie Keysender the code storage device consists of a fixed circular ring carrying a series of steel pins held lightly friction-tight in holes drilled in the flange of the ring. A code is stored by pushing forward appropriate pins. The digit " *n* " is stored by pushing forward a pin spaced at an interval " *n* + 6 " pin spaces from the preceding projecting pin; for example, a series of " ones " is stored by pushing forward every " seventh " pin.

The impulses are sent out by interrupting a pair of impulse springs by the rotation of an impulse wheel, the speed of which is controlled by a governor. The impulse wheel, in addition to rotating about its own axis, rotates by a " sun and planet movement " about the main axis of the code storage ring, the relative angular velocities being such that a main axial rotation of one pin space coincides exactly with one complete impulse period. The main axial rotation causes a cam associated with the impulse springs to sweep over the face of the code storage ring, bearing against each projecting pin in turn. During the period of engagement between this cam and a projecting pin the impulse springs are lifted clear of the impulse wheel for a period of 6 impulses giving the inter-digit pause. As the interval between consecutive projecting pins for the digit " *n* "

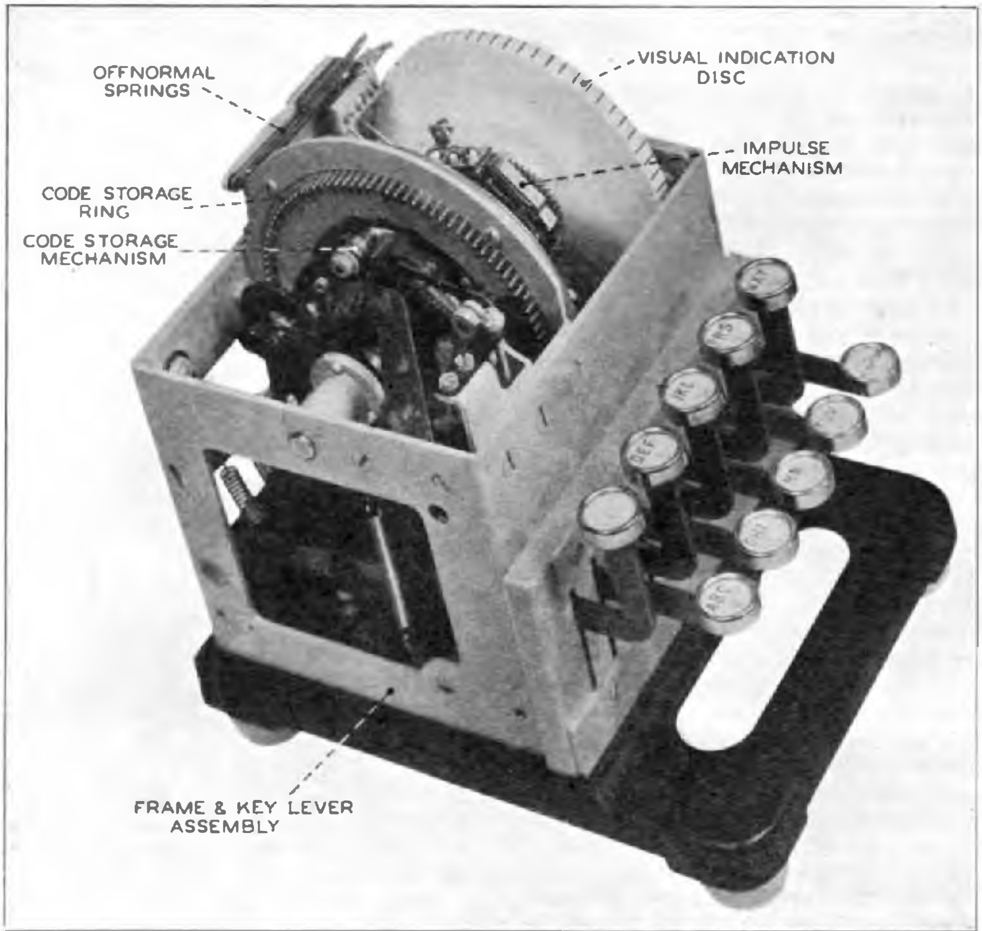

FIG. 1.—THE MACADIE KEYSENDER.

is " $n + 6$ " pin spaces, n impulses are sent out before the impulse springs are lifted. It is of course essential that the lifting of the impulse springs should occur during a " make period."

A novel feature of the impulse mechanism is that it has no zero position. It comes to rest on the completion of any call, in a position determined by the position of the last projecting pin and starts off again from this position to a new position, in accordance with any further code which is set up.

A restraining pawl is provided on the storage mechanism to cause the impulse mechanism to halt should it at any time catch up with the code setting and to bring the impulse mechanism to rest on completion of the code. This restraining pawl has to take up successive positions corresponding to each code pin operated, but must move from one position to the next after the operation of the code pin. This is achieved by attaching the restraining pawl to the storage mechanism by a helical spring. Normally the outer end of the restraining pawl is held in an internal ratchet mounted concentric with the code storage ring, and on the depression of a key the code storage mechanism steps forward, stretching the helical spring. On the release of the key the restraining pawl is kicked clear of the internal ratchet and jumps forward to its new position under the action of the stretched helical spring.

The code pin selection is effected by a marking arm on the storage mechanism, the marking arm being attached to a ratchet wheel which is stepped forward through the appropriate angle by the operation of any digit key. The marking arm, like the impulse mechanism, has no zero position but steps forward on each operation of a digit key. This continuous stepping forward feature enables the sender to be used, without modification, for codes of any number of digits, the only limitation being that the code shall not be so large, and set up so rapidly, that the code setting gets ahead of the impulse sending by more than one complete revolution. The accurate setting of the marking arm is of vital importance, and in the earlier models occasional overshooting occurred if a key was struck too violently. This defect has been overcome by allowing each digit key to travel beyond the angle necessary for correct setting. On the release of the key the ratchet wheel is allowed to return with the key, but at an early and definite stage of the return journey when all moving parts are travelling slowly, a locking pawl is snapped into engagement with the ratchet wheel. After the marking arm has been thus locked in its correct position, a striker pushes the marking arm against the selected code pin. The striker also knocks out the restraining pawl which limits the forward rotation of the impulse mechanism.

The depression of a digit key has thus to perform three main functions.

(1) On depression of the key—operate the storage mechanism ratchet wheel to set the marking arm in position and wind up the impulse mechanism spring.

(2) Just before the key completes its downward travel—release the locking pawl to allow the ratchet wheel to travel back a short distance. At a definite point on the return journey—snap the locking pawl into engagement with the ratchet wheel.

(3) After the ratchet wheel has been locked—operate a tripping lever to actuate the striker.

To perform these three functions, three rocking plates, a storage rocker, a locking pawl rocker, and a striker rocker, are mounted beneath the digit key levers and are operated by the digit key.

It should now be profitable to examine the detailed construction of the keysender.

Digit Key Assembly and Frame (Fig. 2).

The ten key levers KL are pivoted on a grooved bearing rod BR mounted in the rear of the frame and held in position by a plate SP. The key lever restoring springs S1 are attached to the spring grading bar SB. To even up the resistance to finger pressure over the whole range of keys, the grading bar is sloped at an angle so that the springs on the smaller digit keys have a higher initial tension. All the digit keys when operated travel through the same distance. The key pressures are light, being about 1 lb. 12 oz. Each digit key is provided with an adjustable shoe AS (Fig. 3) so that the point of engagement with the storage rocker RP1 can be accurately adjusted.

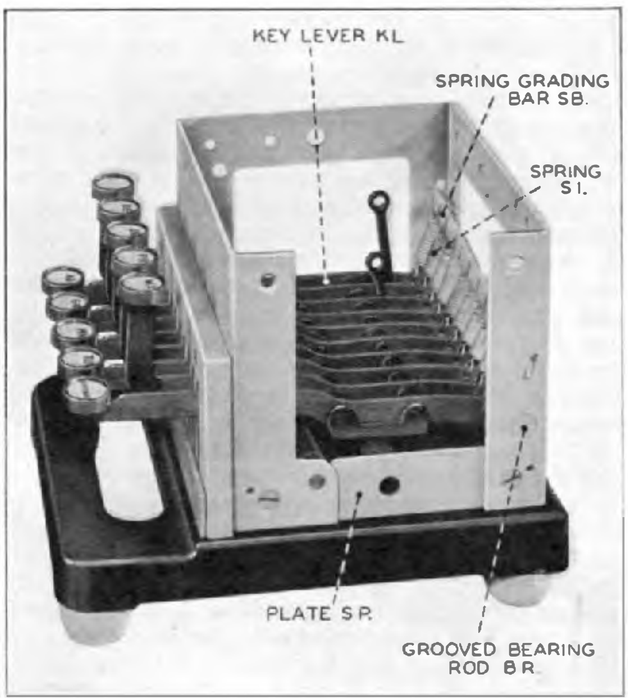

Fig. 2.—Digit Key Assembly and Frame.

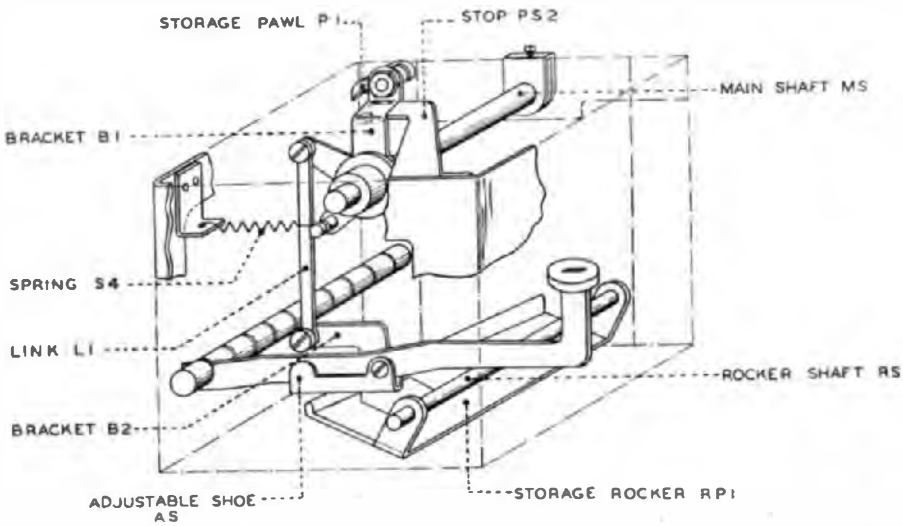

Fig. 3.—Code Storage Mechanism.

The three rockers, storage rocker RP1, locking pawl rocker RP3 and striker rocker RP2 rotate about the spindle RS (Fig. 4).

Code Storage Mechanism.

Storage rocker (Figs. 3 and 4).

The movement of the storage rocker RP1 on the depression of a digit key is communicated to the storage pawl P1 (Fig. 3) *via* bracket B2, link L1, and bracket B1. The storage rocker is tapered so that for equal downward movements of the key levers the correct angular movement of the storage pawl for each digit is obtained. The storage pawl has an angular movement of 25° 12′ when storing digit " 1 " and of 56° 36′ when storing digit " 0." The storage pawl turns the ratchet wheel RW (Fig. 5) which rotates about the main shaft MS (Fig. 3). On the release of a digit key, the storage pawl P1 returns to stop PS2 (Fig. 3) under the pull of spring S4. The ratchet wheel is carried back for a short distance until the locking pawl is operated by the locking pawl rocker.

Ratchet Wheel (Fig. 5).

Front and back views of the ratchet wheel RW are shown in Fig. 5. The marking arm MA is attached to the ratchet wheel by the flat spring FS1, which allows the outer end of the marking arm to be pushed forward against a code pin when the pins CP are hit by the striker. The impulse mechanism restraining pawl P2 is attached to the ratchet wheel

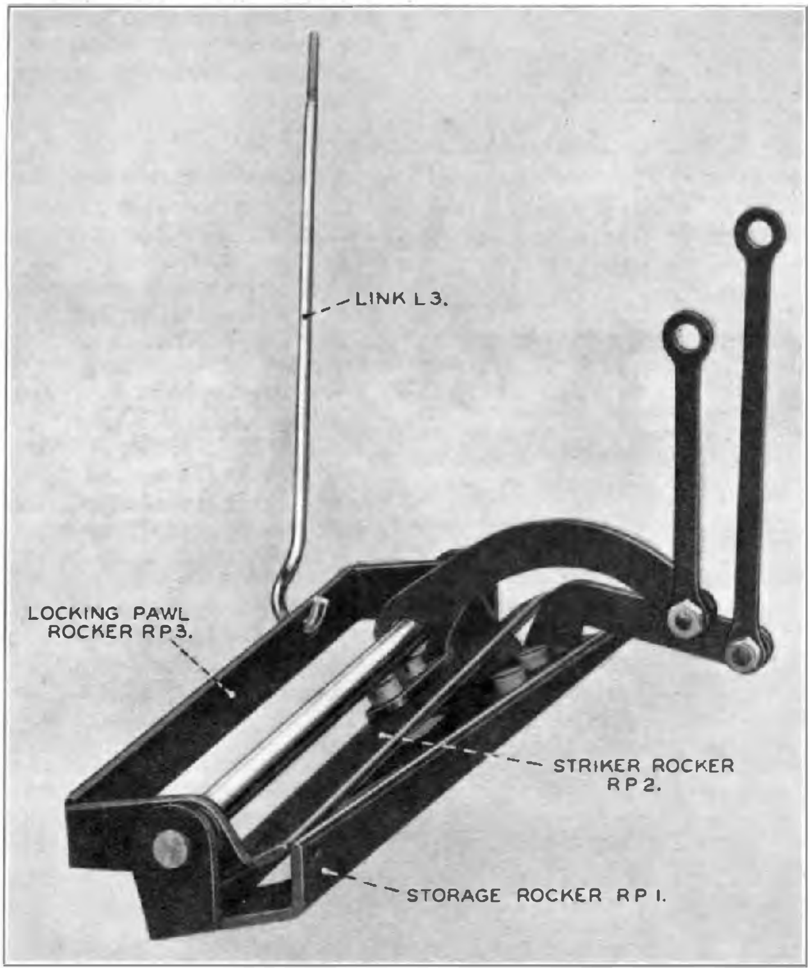

Fig. 4.—Code Storage Rocker.

by the helical spring S2. On the downward motion of a digit key, the ratchet wheel is stepped forward but the outer end of the restraining pawl being held in an internal ratchet (see Fig. 10) remains stationary and spring S2 stretches. The restraining pawl P2 is held against the marking arm MA by a flat spring FS2. In consequence, when MA is hit by the striker, the restraining pawl P2 is also pushed forward, is momentarily disengaged from the internal ratchet, and jumps to the new position of the ratchet wheel.

To eliminate bounce on the impact of the restraining pawl P2, stop PS1 is not rigidly fixed but is carried on a pivoted arm held in position against the rib of the ratchet wheel by a spring S6. The cone AP on the ratchet wheel is a forced release for the restraining pawl in the event of repeated partial operation of digit keys which might occur in playing with the keysender. The ratchet wheel steps forward on each depression but as the restraining pawl is only freed by a full operation of a key, spring S2 might be stretched an excessive amount but for the presence of AP which pushes the restraining pawl P2 clear of the internal ratchet should the ratchet wheel be turned through a large angle without releasing P2 in the normal manner.

The squared end of the bearing RB (Fig. 5), which rotates with the

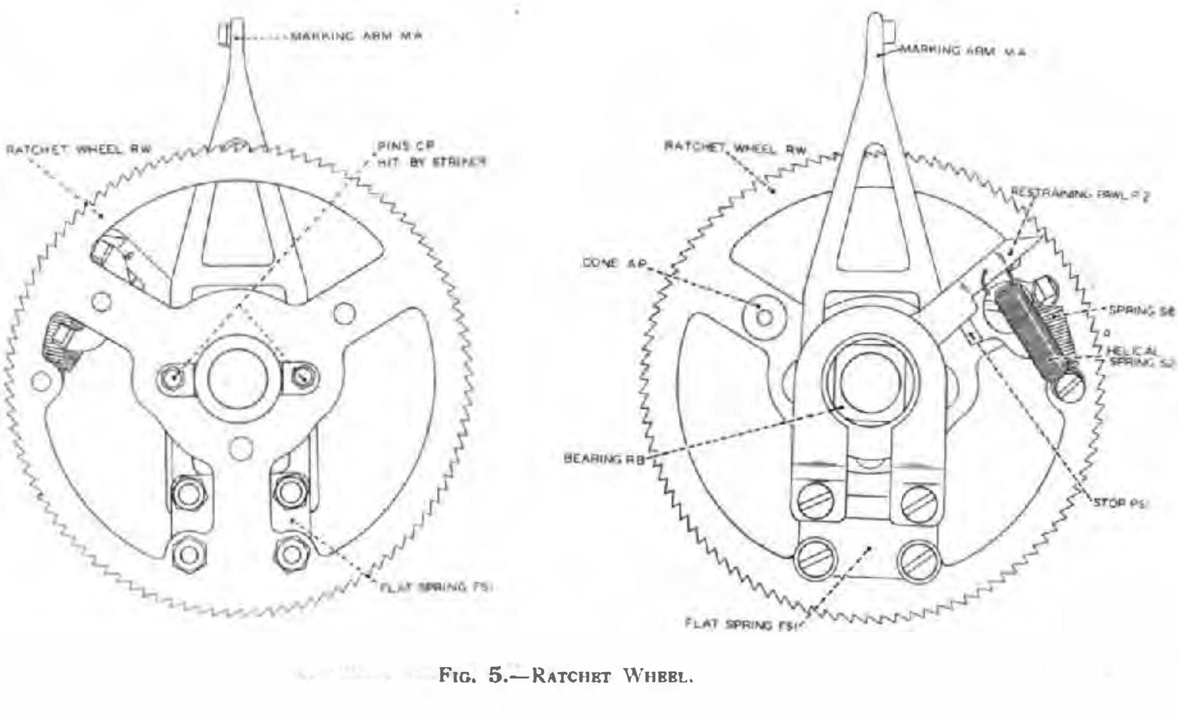

Fig. 5.—Ratchet Wheel.

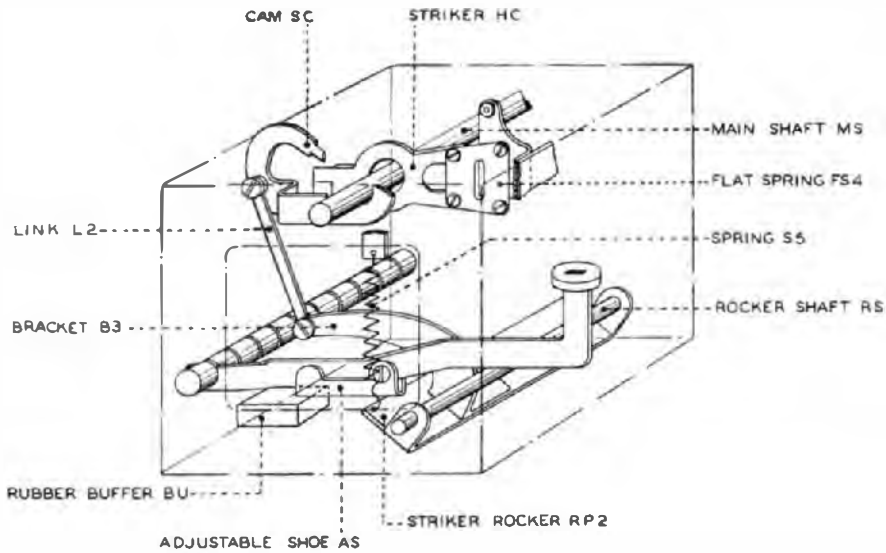

FIG. 6.—STRIKER MECHANISM.

ratchet wheel, engages in a D-bush anchored to the main spring driving the impulse mechanism thus winding up the impulse mechanism through the correct angle on each rotation of the ratchet wheel.

Striker Mechanism (Figs. 6 and 7).

On the depression of a digit key the adjustable shoe AS also operates the striker rocker RP2 (Fig. 6) pulling down cam SC *via* the intermediary of bracket B3 and link L2. The actual striker HC is attached to the frame by a flat spring FS4. The end of striker HC is so shaped that on the downward movement, cam SC passes in front of the striker pulling it away from the marking arm, but on the return journey SC passes behind the end of the striker and pushes it against the marking arm. This action which sets the code pin and releases the restraining pawl must occur after the ratchet wheel locking pawl has been snapped into position. In Fig. 7 the main shaft has been almost completely withdrawn.

Ratchet Wheel Locking Pawl (Fig. 8).

Towards the end of its downward movement, the key lever engages with the locking pawl rocker RP3 (Fig. 8), and, *via* link L3 and flat spring FS3, disengages locking pawl P3 from the ratchet wheel to allow the ratchet wheel to travel back on the release of the key. On the return journey of the key, spring S3 snaps the locking pawl back into engagement with the ratchet wheel.

Impulse Mechanism (Fig. 9).

Front and back views of the impulse mechanism are shown in Fig. 9. The impulse wheel IW, the impulse springs IS and the governor G are copied from the Post Office standard dial. T1 is the cam which bears against projecting code pins lifting the impulse springs clear of the impulse wheel for the inter-digit pause of 6 impulses. The stop pin DP bears against the restraining pawl and stops the rotation of the impulse mechanism on the completion of impulsing. The tailpiece T2 restores the code pins to normal, as the impulse mechanism sweeps round the face of the code storage ring. The last code pin operated at the end of a code is not, however, restored, as the rotation is stopped by the restraining pawl when T1 commences to engage with this last code pin. In consequence, any subsequent

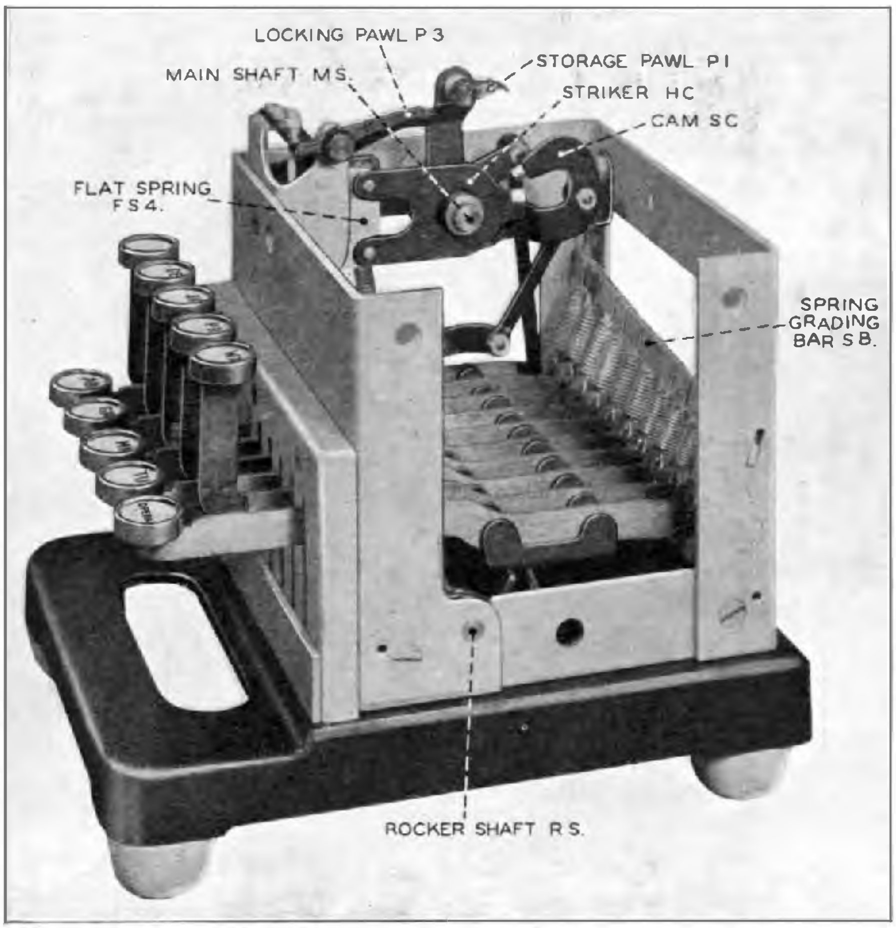

FIG. 7.—STRIKER MECHANISM.

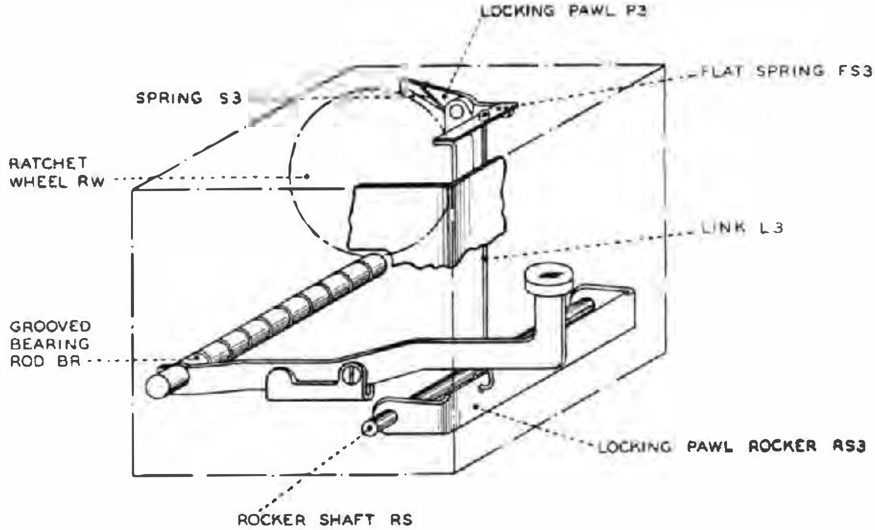

FIG. 8.—RATCHET WHEEL LOCKING PAWL.

code starts with a make interval. The impulse mechanism is carefully balanced about the axis of rotation by a cylindrical weight. The inner end of the main driving spring S is anchored to the D-bush.

Code Ring and General Assembly on Main Shaft (Fig. **10**).

Fig. **10** shows the code storage ring CSR carrying the code pins CP and fixed in the frame by mounting ring MR. The impulse mechanism is mounted on the main shaft. During assembly the stop pin DP is lined up with the restraining pawl on the storage mechanism and the impulse mechanism given a quarter turn in a backward direction before lightly engaging the D-bush on the impulse mechanism with the square on the ratchet wheel hub. The impulse mechanism is then given one and three quarter turns in a backward direction, winding up the drive spring S before pushing the impulse mechanism fully home with the stop pin DP bearing on the restraining pawl P2. The sun and planet movement consisting of the starwheel SW engaging on the internal gear IG is clearly shown. The impulse springs are wired to the collector rings CR and connexion made to fixed tags on the frame *via* wire brushes CB.

Off-Normal Springs (Fig. **11**).

This sketch shows the internal ratchet IR, the tip of the restraining pawl P2, and the stop pin DP on the impulse mechanism bearing against the restraining pawl. The internal ratchet is mounted in a ball bearing concentric with the code storage ring and is free to turn through the small angle determined by the slot and screw pin SL. The pressure of stop pin DP against the restraining pawl, due to the comparative large torque of the impulse mechanism drive spring, turns the internal ratchet in its ball bearing in a counter-clockwise direction holding the off-normal springs OS open *via* the strip link L4 and lever ●SL. Immediately the restraining pawl jumps forward when a code pin has been operated, the pressure on the internal ratchet due to the impulse mechanism spring is relieved and the off-normal springs push the internal ratchet in a clockwise direction until limited by stop SL, and in so doing close the off-normal springs.

On completion of impulsing, the impulse mechanism will again catch up with the restraining pawl and the pressure of stop pin DP on the restraining pawl P2 will again open the off-normal springs before bringing the impulse mechanism to rest.

Visual Indication Disc.

Attached to the impulse mechanism is a light disc with lines on its outer edge, Fig. **1**. This disc can

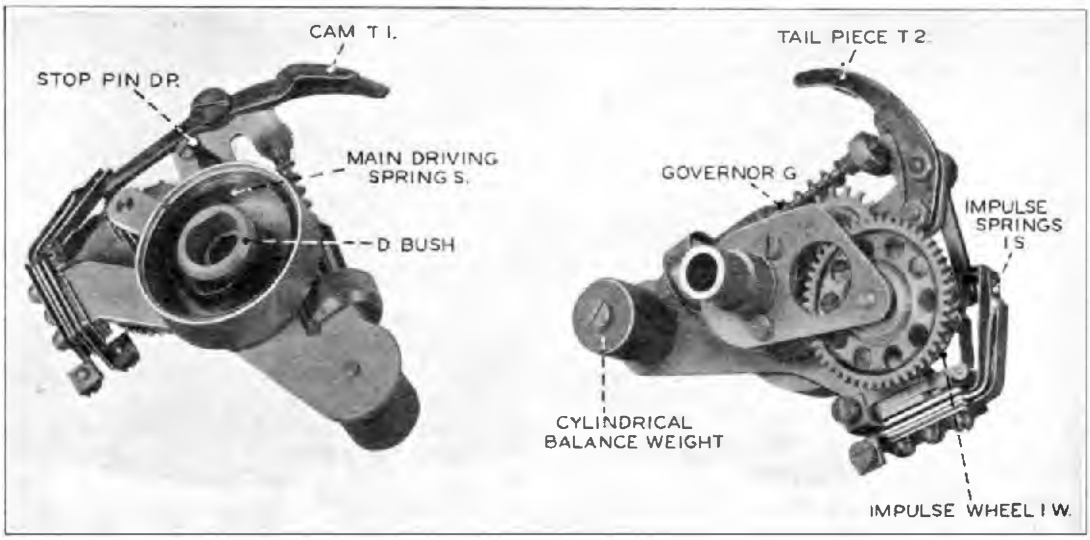

FIG. 9.—IMPULSE MECHANISM.

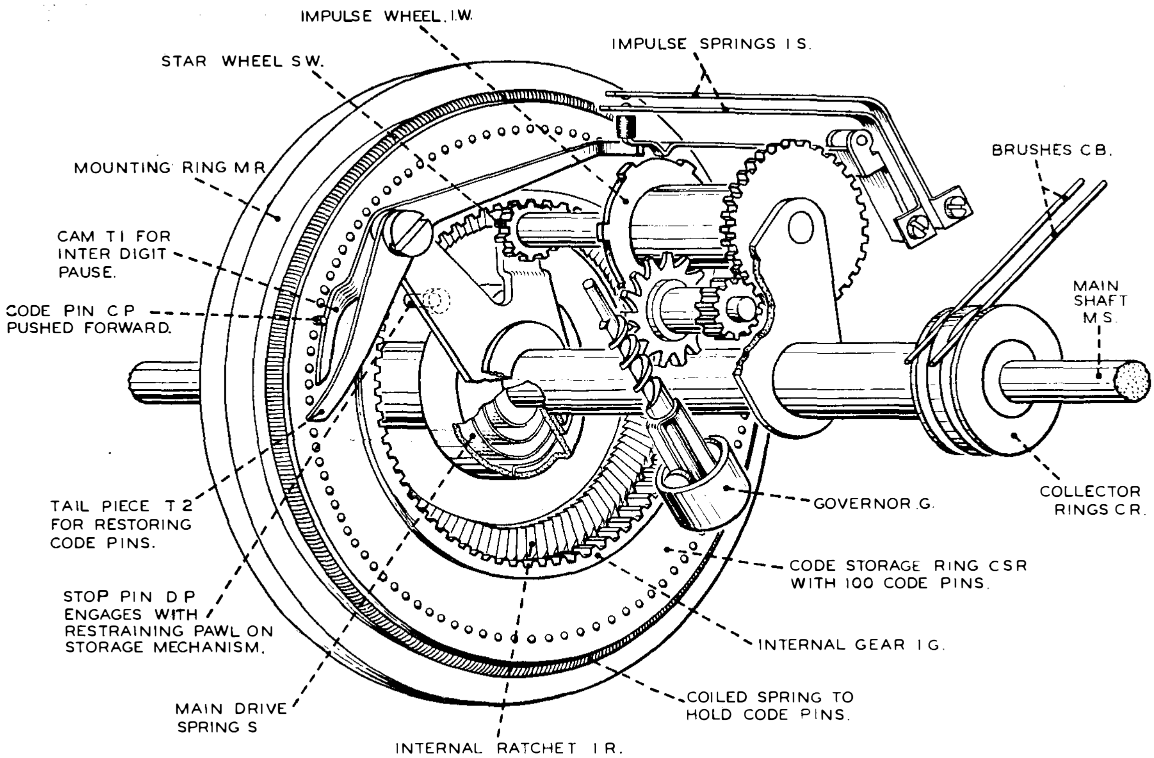

FIG. 10.—MAIN SHAFT ASSEMBLY.

be seen through a window in the cover and serves as a visual indication that the sender is engaged, and cannot be used for another call until the disc comes to rest.

Adjustments

The code storage ring in Keysender No. 5 has 100 code pins and as each depression of digit key 4 causes the marking arm to step $4 + 6 = 10$ code pin spaces, 10 depressions of digit key 4 will cause the marking arm to make exactly one complete revolution. This enables accurate adjustment of the adjustable shoe on key 4 to be made. Next key 3 is adjusted so that 10 depressions of key 3 ($10 \times 3 + 6$

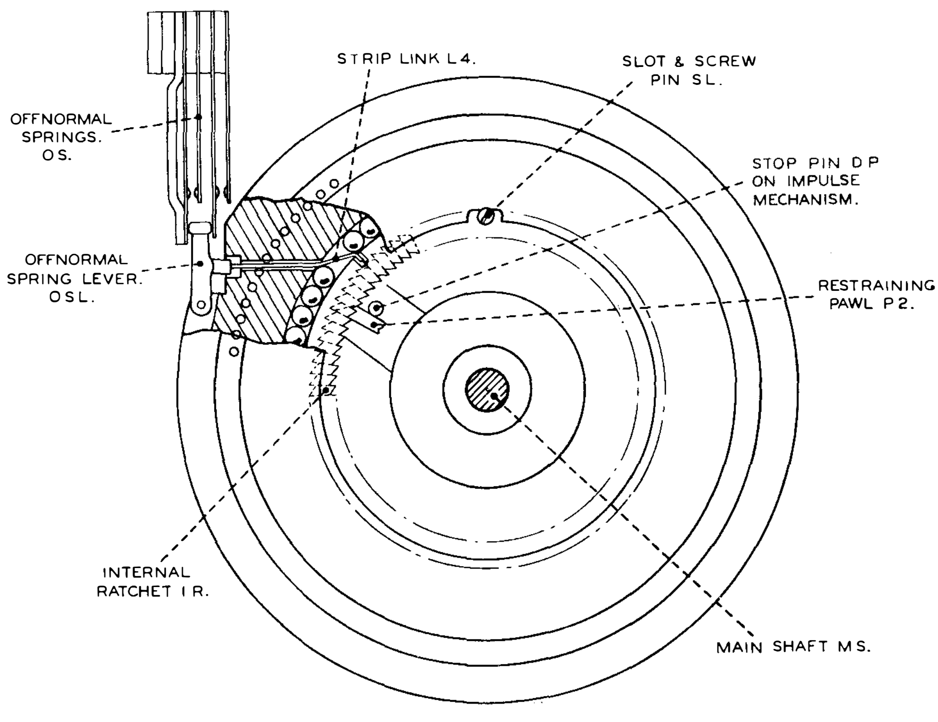

FIG. 11.—OFF-NORMAL SPRINGS.

steps) and 1 depression of key 4 give exactly one complete revolution of the marking arm.

By following this procedure for keys in the successive order 4, 3, 9, 10, 1, 7, 6, 8, 5, and 2, all ten keys can be quickly adjusted. The adjustment of keys can be checked by verifying that the marking arm makes one complete revolution by depressing the following keys, 1, 2, 3, 4, 5, 6, 7, 8, and 10, also by 1, 2, 3, 4, 5, 6, 7, 9, and 9.

A nut and screw adjustment is provided for accurately setting the time at which the locking pawl is operated.

Arrangements for fitting keysenders to P.B.X. boards.

It is quite probable that ultimately large P.B.X. boards will be designed to take mechanical keysenders, but this is not contemplated at present as keysenders will only be fitted in cases where the subscriber is willing to pay the extra rental.

For the practical trial on the Research Section P.B.X. at Dollis Hill a switchboard AT 1810 $\frac{10 + 50}{60}$ was modified by removing one cord circuit so that the keysender could be neatly housed at one end of the keyshelf. The exchange dialling keys were replaced by a strip of interlocked keys with make-before-break contacts and the board was wired to Fig. **12** and operated in the following manner. The operator plugs in to an exchange jack; on receipt of dialling tone, she presses the corresponding exchange line dial key and sets up the code on the keysender. The closing of the keysender off-normal dial springs operates relay A and connects the keysender to the exchange line. Immediately the code has been sent out, relay A restores and connects the exchange line through to the calling extension *via* the cord and conversation can commence immediately the connexion has been established.

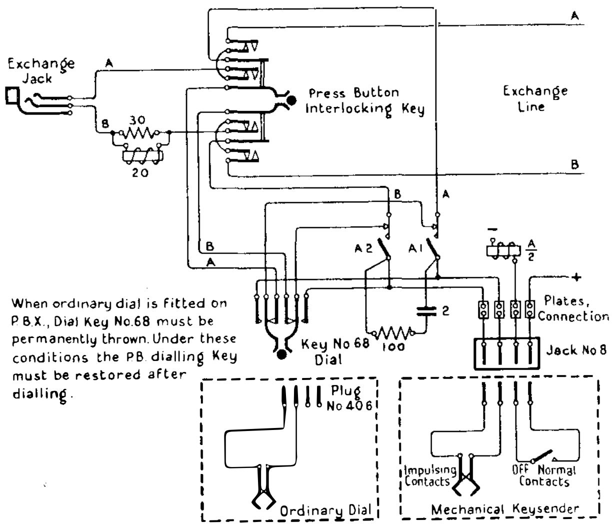

FIG. 12.—MODIFICATIONS TO CORD CIRCUIT OF SWITCHBOARD A.T. 1810 $\frac{10 + 50}{60}$

To make a subsequent exchange call, the press button dial key of another exchange line is depressed (after verifying that the keysender has completed the first call) thus connecting the A relay contacts and keysender to the new exchange line. Due to the mechanical interlocking of the keys, the dial key on the exchange line used for the earlier call restores and the connexion is maintained *via* the key contacts which, being make-before-break, do not cause any interruption to the conversation when operated. A dial key can be reset at any time if desired by operating a common reset key fitted to the dial key strip.

An alternative method of connecting the keysender to a Switchboard B.E.C.B. multiple No. 9 is shown in Fig. **13**. In this arrangement, the ring-back key on each cord circuit is replaced by a combined ring-back and dial key. The operation is much the same as that previously described, but, as the dial keys are not mechanically interlocked, the operator has to restore the dialling key first brought into use before throwing a second dial key. In both schemes, the use of an auxiliary relay could be obviated by fitting make-before-break contacts on the keysender off-normal springs.

Development of the Design.

It is interesting and instructive to follow the development of any design from its inception to the final production stage, and a brief reference to the earlier Macadie models will illustrate the evolution of the design. In the first Macadie Model (Fig. **14**) the code storage device consists of a wheel the face of which is divided into compartments each capable of housing a steel ball 1/16 inch in diameter. Attached to this storage wheel is a ratchet stepped through " $n + 6$ " teeth on the operation of the " n " digit key. A supply of steel balls is stored in tube T, and one of these balls falls by gravity into the storage wheel compartment immediately opposite the lower end of this tube. A gate lever closing the end of this tube is held open in the unoperated position of all digit keys, by a radial arm which carries the ratchet stepping pawl. Immediately any digit key is depressed this arm is moved away from the gate lever which closes the gate and prevents a further fall of steel balls into compartments, until the return of the digit key to its normal unoperated position when the gate is again opened by the radial arm. The storage wheel being attached to the ratchet wheel is also turned through an angle " $n + 6$ " compartments on the operation of the " n " digit key but a steel ball is only fed into the last compartment on the return of the key to rest. Successive operation of digit keys in any order thus stores steel balls at the required digit spacing round the code wheel. The code wheel always rotates in a counter-clockwise direction viewed from the impulse mechanism side. The gear wheel GW is attached to the ratchet and storage wheel, and turns the frame of the impulse mechanism also in a counter-clockwise direction through an angle " $n + 6$ " impulses. The impulse mechanism carries a pair of impulse springs operated by teeth on the edge of the storage wheel and also a pair of shorting springs operated for a period of 6 impulses

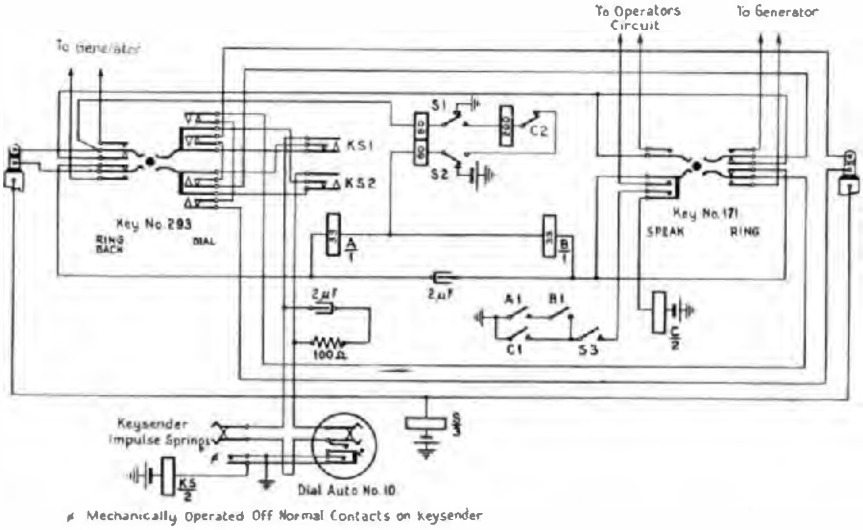

FIG. 13.—MODIFICATION TO CORD CIRCUIT OF SWITCHBOARD, B.E.C.B. MULTIPLE, NO. 9.

on passing any ball. The forward rotation of the impulse mechanism winds up the impulse mechanism spring which causes the impulse mechanism to rotate backwards generating continuous impulses except during the inter-digit pause when the shorting springs are operated. The motion of the impulse springs is thus an oscillating one. They are carried forward with the storage wheel on each depression of a key and run back to the zero position when impulsing. The actual motion is a combination of

FIG. 14.—FIRST MODEL KEYSENDER.

the two angular movements, a steady backward rotation relative to the storage wheel of 10 impulses per second and a forward movement with the storage wheel of " $n + 6$ " impulses on the depression of a digit key. The radial arm carrying the ratchet stepping pawl also acts as a restraining pawl to halt the impulse mechanism until the key is released on the first digit of any code and at any other time should the impulsing catch up with the keying. A steel ball is retained in its compartment until the storage wheel has made almost one complete revolution and is returned home to the tube T when brought opposite its upper end, being guided into the tube by the guide spring G.S.

The most serious defect of this first design is that due to the inertia of the moving parts fast operation of the digit keys results in errors in storage. To reduce the rate of keying to a safe speed, about 3 per second, a dashpot was added, but this increased the pressure necessary to operate the keys. In addition, the use of a large impulse wheel with sufficient teeth for the complete code was felt to be a weakness in the design if correct impulsing was to be obtained.

In the second Macadie Model, shown in Fig. 15, the code storage device consists of a horizontal wheel, but the balls have been replaced by steel pins as in the final model. A main drive spring at the foot of the main spindle is wound up every 20 calls by a few turns of the handle H. A warning notice " Wind " is displayed when rewinding is necessary. The main spring tends to rotate the storage wheel in a clockwise direction—viewed from above—but is prevented by a stop S, which bears against the pin last projected by the operation of a digit key. The digit key levers are so shaped that digit key " one " is immediately under a pin $1 + 6$ spaces away from the pin held by the stop S, and similarly for the other digit keys. The depression of digit key " n " thus pushes up a pin at an interval " $n + 6$ " spaces away from the stop. The depression of the key also withdraws the stop S from engagement with the pin previously projected, but the storage drum is prevented from rotating by the end of the digit key engaging with a tooth of a circular rack attached to the storage wheel. On release of the key, the end of the digit key is withdrawn from the rack before stop S returns and the storage wheel jumps forward " $n + 6$ " pin spaces when it is again held by the stop S. The rotation of the storage wheel also turns the impulse mechanism, winding up the impulse mechanism spring. The impulse teeth are cut on the edge of the storage wheel and on the backward rotation of the impulse mechanism impulses are sent out except when a cam attached to the impulse springs passes a projecting pin. This cam lifts the impulse springs away from the impulse teeth for an interval of six impulses. It was intended

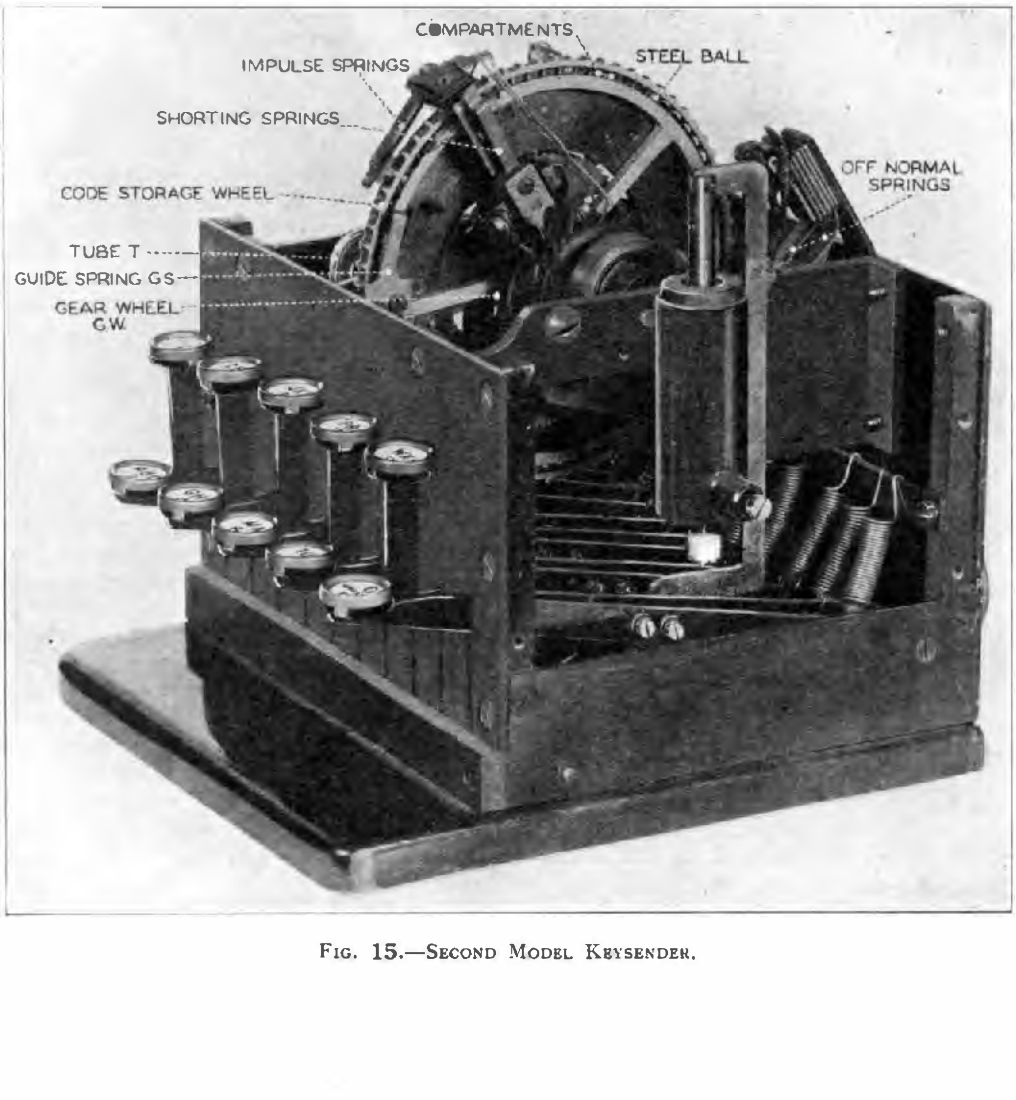

Fig. 15.—Second Model Keysender.

in this design to commence sending out impulses on the release of the first digit key just as in Model 1, but the impact of the storage wheel against the stop so distorted impulses that a start key was added as an afterthought. The impulse mechanism is now locked to the storage wheel until the depression of the start key, when it is released and runs back sending out the code stored. In use, therefore, the whole code is set up before depressing the start key. The model was designed on the basis that it would be operated in the same manner as Model 1 and in consequence the number of pins in the code wheel are insufficient and a slight enlargement of the model would be necessary to deal with the longest codes.

Future Developments.

There has been considerable diversity of opinion as to the need for a mechanical keysender, some authorities contending that it was better to lighten the P.B.X. operator's load by providing through dialling from extensions. The development of a mechanical keysender by the Post Office was started in August, 1929, and the final Macadie Model was completed at Holloway Factory in March, 1930, but the effect of trade depression on calling rates had reduced the complaints from P.B.X. operators and the view that through dialling from extensions was an adequate remedy gained ground. It has recently been decided, however, to provide mechanical keysenders both for P.B.X. operators and, if desired, for individual telephones, in cases where the subscriber is willing to pay the additional rental. The first supplies, which are being manufactured by the General Electric Company, should be available in August. The question, therefore, whether such a device is wanted by the public will shortly be no longer one for theoretical discussion, but one to be determined by the acid test of experience. If the view that there is a public demand for a device simpler and faster to operate than a dial is borne out by experience, further developments and improvements in design and in particular a considerable reduction in size will no doubt follow.

It may be advisable to mention one or two suggestions which have already been considered but not incorporated in the present design.

Key Interlocking. It would have been comparatively easy to fit an interlocking device to prevent the simultaneous depression of two keys, but the expense was considered unwarranted. If two keys are operated simultaneously in the present design, only the larger digit is stored.

Cancel Key. It has been considered unnecessary to provide a cancel key. To cancel a call the plug must be withdrawn for a short period and the keysender allowed to run down until it has discharged any code stored. As a rule this will require about two seconds and should in practice not represent any appreciable loss in time.

Inter-digit pause. When the keysender was designed, an inter-digit pause of 600 milliseconds was the accepted standard for the relay senders fitted in connexion with Keysender B-position working. There has been a tendency recently to propose a longer interval and 800 milliseconds has been suggested, although it is possible using a standard dial to have inter-digit pauses of the order of 450 milliseconds. Judged from practical trials of the Macadie Keysender, lost calls due to an insufficient inter-digit pause are a very rare occurrence. Whilst the basic design of the keysender can be adapted to provide any required inter-digit pause, an increase in this interval would necessitate an increase in size and slower operation, and is therefore to be deprecated. The main object of providing a keysender is quickness of operation and to slow down all calls to secure a very slight reduction in the number of times an engaged condition is encountered is surely unwise, particularly as the standard dial is likely to suffer equally from this alleged defect. The Post Office has at present under consideration a new design of two-motion selector which, amongst other advantages, has a faster hunting speed and this appears to be the correct line of development if the number of calls lost due to insufficient hunting time is appreciable.

Number of Code Pins. It has been suggested that the number of code pins in the storage ring should be increased. This matter was carefully considered when the design was being evolved in view of the importance of making the keysender small in size and it was decided that 100 pins were sufficient. The longest code likely to be encountered is WOOlwich 0009 which involves a total of 110 pin spaces ($5 \times 16 + 2 \times 15$). As impulses are sent out immediately the 1st digit key is released, keying will have to be at the rate of 5 per second before overlapping occurs. It was considered that the combination of such a long code and such a high speed of keying is a highly improbable coincidence which may be ignored.

The future will show whether or not the Macadie Keysender is the forerunner of designs which may eventually replace the dial on an extensive scale. Those who are apprehensive because the mechanical keysender is somewhat more complicated than the standard dial should take courage in the thought that it is not nearly so complicated as an ordinary watch which is carried in the pocket and has to work twenty-four hours each day, much more onerous requirements than the keysender will be required to meet.

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