

TELEGRAPHS.

TECHNICAL INSTRUCTIONS No. V.

GENERAL POST OFFICE,
LONDON,
AUGUST 1904.

THE HIGH-SPEED WHEATSTONE AUTOMATIC SYSTEM.

1. The automatic apparatus consists of three parts, the Perforator, the Transmitter, and the Receiver: but a Double Current Key, a Galvanometer, and a Sounder, are always required in addition, while a Rheostat and Condenser is also necessary in those cases where speeds in excess of 300 words per minute are desired; the Key and Sounder enable the telegraphist in charge of the circuit to obtain and give corrections and acknowledgments, or to work by hand when there is not sufficient traffic to demand automatic working, and the Galvanometer checks the condition of the Transmitter and Key and indicates the strength of the current arriving from the distant Office. Apparatus required.

The Galvanometer should be supplied with a double-wound shunt-resistance to carry off the extra current generated in the coils. Galvano-meter Shunt.

THE PERFORATOR.

2. The Perforator, which is shown in plan and front elevation by Figs. 1 and 2, is purely mechanical in its action. Groups of perforations, corresponding to the letters of the alphabet, are made by it in a slip of oiled paper, which is afterwards propelled automatically through the Transmitter.

The keys or plungers a, a_1, a_2 , Fig. 1, actuate five punches, 1, 2, 3, 4, 5, Fig. 2. When Key a

is depressed, it causes 1, 2, and 3 to perforate the paper in a vertical line, thus: $\begin{matrix} \circ \\ \circ \\ \circ \end{matrix}$; the depression of a_1 causes 2 only to punch, thus: \circ ; and the depression of a_2 causes 1, 2, 4, and 5 to perforate, thus: $\begin{matrix} \circ \\ \circ \end{matrix}$; a corresponding with a dot, a_1 with a space, and a_2 with a dash. The centre row of perforations acts as a guide to keep the paper in its proper place in the Transmitter, and as a rack by which it can be propelled. The perforations above and below the centre determine the number and order of the currents sent by the Transmitter.

Perforator
Action.

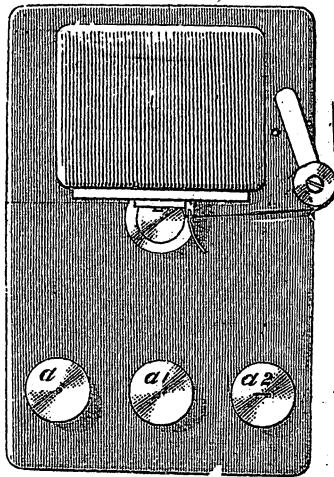


FIG. 1.

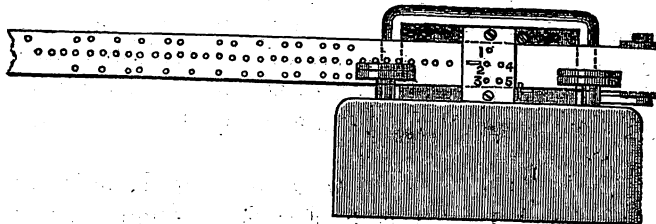


FIG. 2.

Fig. 3 shows the mechanism placed beneath the cover, and Fig. 4 shows the levers b , b_1 , and b_2 , which are pivoted in the block B under the base, and are connected respectively to the keys a , a_1 , and a_2 . The opposite ends of the levers project upwards through the base and terminate at the back of the mechanism (Fig. 3) near the ends of the five punches. Above and below the punches are two small rods, one of which is shown at c , Fig. 3. These rods are provided with steel spiral springs for withdrawing the punches after the depression of the keys. Spiral springs are also used to restore the keys and levers to their normal position after each operation.

3. *Action.*—When key a is struck the corresponding lever b is depressed; the opposite end of this lever pushes forward the punches 1, 2, 3 (Fig. 2), and the lever d (Fig. 3), which carries the smaller lever d_1 , and the pawl e . By this movement the three punches are forced through the paper slip, and perforations representing a dot are produced; and also d draws forward d_1 (to which the pin p acts as a fulcrum), and causes the pawl e to move back over one tooth of the star-wheel. When the key rises the punches are withdrawn, as already explained, by the spiral springs, c ; and the pawl, e , and its connecting levers are made to resume their normal position by the action of the strong flat spring, g ; so that the paper is pushed forward one space by the pawl, e , operating the star-wheel, f . There are similar movements when the two keys, a_1 , a_2 , are depressed, except that one punch only is actuated when a_1 is depressed to form a space, and four when a_2 is depressed to form a dash.

The lever h , Fig. 3, is connected, by means of a small rod passing through the base, to the lever, b_2 , and is only actuated when a dash is punched. Its function is to regulate the move-

ment of the pawl, *e*. When either a dot or a space is punched, the movement of lever *d*₁ is limited by the tail-piece of *h*, and the pawl moves over one tooth only of the star-wheel, pushing the slip one space forward; but when *a*₂ is depressed, the lever *h* is raised so that the movement of *d*₁ is not limited by *h*, but by the pin *l*, and the pawl accordingly moves over two teeth of the star-wheel, so that when the key rises the paper advances two spaces.

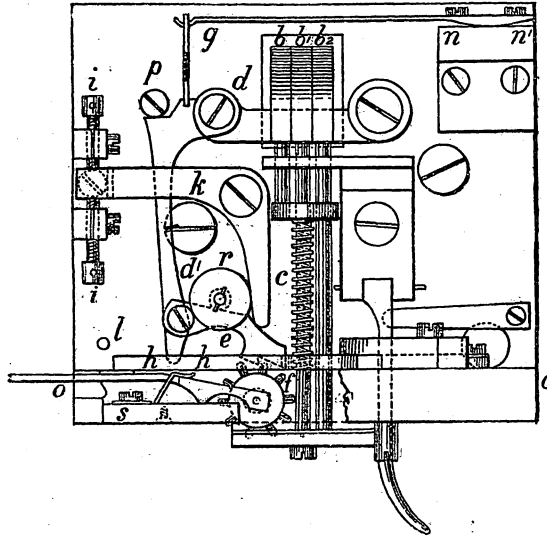


FIG. 3.

Adjustment
of Perfor-
ator.

4. *Adjustment.*—The machine is adjusted by means of the two screws, *i, i*, which act upon the bent lever, *k*. It must be so adjusted that 120 centre guide holes and 120 spaces are produced in exactly twelve inches of paper. The adjustment of the screws *i, i*, moves the lever, *k*, either inwards or outwards. If the end nearest the punches be moved towards them, then the perforations will be spread over a greater length of paper; but if it be moved away from the punches, the perforations will be closer together

and will occupy less paper. If a length of slip be taken containing 121 spacing perforations (which number may be obtained without counting by punching the word "telegraph" three Correct times, including the double space between the gauge. words, but no space after the last word), then the distance between the centres of the first and last holes must be exactly one foot. In other words, the distance between the centres of any two

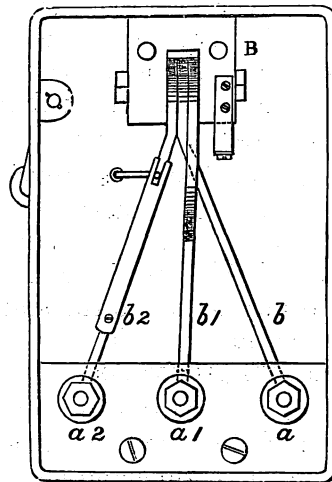


FIG. 4.

adjacent guide holes should be exactly one-tenth of an inch. Although a perforation more or less will not generally make any material difference to the working, it is important for high speed that the adjustment be accurate. In this connection it may be added that at offices where keyboard perforators have been introduced experimentally, the guide holes in the paper tape are previously punched to the exact standard, and transmitters inaccurately adjusted might fail to act with correct "slip," although workable with less accurately punched paper.

Keyboard
Perforators.

The flat spring, *g*, can be adjusted by means of the screws, *n*, *n*₁, and must exert sufficient

force to propel the paper freely after each depression of the keys. The vertical spring which carries the small grooved roller, r , is adjustable in a similar manner by means of two screws under the base. It should exert just sufficient force to cause the pawl, e , to drop between the teeth of the star-wheel. When the keys, a or a_1 , are depressed, the pawl should move freely over one tooth, and when key a_2 is depressed, it should be drawn back over two teeth of the star-wheel. If undue force be required to produce this action between the pawl and the star-wheel, then it will probably be found that the rubber ring under the head of the faulty key is a little too thick.

The star-wheel frame is provided with a tail piece, which projects outwards through the vertical plate, o , on the left-hand side. When paper is inserted this tail is pulled towards the operator in order to move the star-wheel out of the way, and as soon as the tail is released the wheel resumes its proper position.

The covers of perforators are hinged to the instrument, and fastened by means of a small spring bolt on the right-hand side of the cover.

The star-wheel mechanism may be removed by withdrawing three small screws in the plate s (Fig. 3), and carefully pushing the piece outwards. The star-wheel revolves in a groove filed in the brass piece, and it should be quite clear of the sides and bottom of the groove.

Where two screws are provided for adjusting, care should be taken always to release one before tightening the other, or the heads will probably be broken off or the cocks bent. Clamping screws also should be loosened before moving the adjusting screws which they clamp, and carefully tightened-up again when the adjustment is made.

A gauge half an inch wide and nine mils Paper thick should pass freely between the front plates. dimensions. The standard width of perforator paper is from 472 to 475 mils, and its thickness 4 to $4\frac{1}{2}$ mils.

THE TRANSMITTER.

5. The electrical mechanism of the Transmitter is shown in Fig. 5.

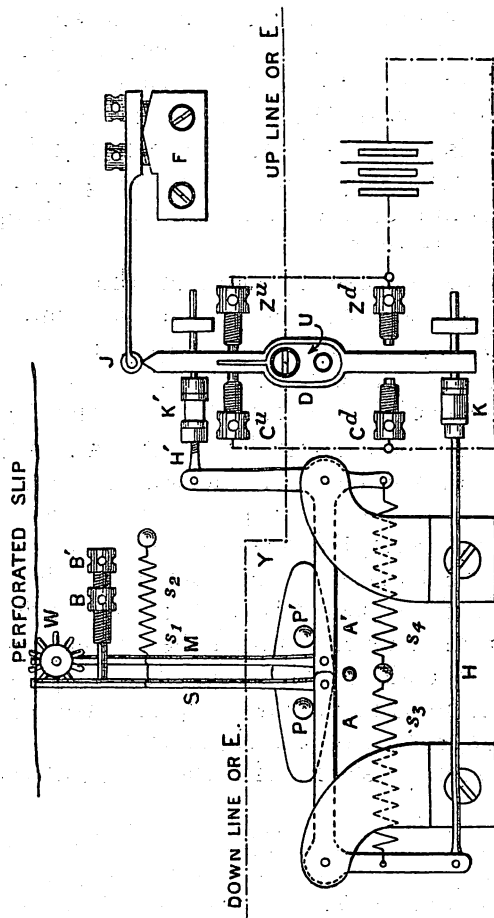


FIG. 5.

Transmitter
Action.

The contact-points marked C^d , C^u , and those marked Z^d , Z^u , are connected respectively to the positive and negative poles of the transmitting battery. Between these contacts plays the compound lever DU, the two parts of which, D and U, are insulated from each other, and are connected, as shown, respectively to "Down Line or Earth," and to "Up Line or Earth." The lever is so pivoted, and the contacts are so arranged, that when D makes contact with Z^d , U is in contact with C^u ; and when D moves against C^d , U is changed over to Z^u . Thus reverse currents are sent to Line. So long as the upper part of DU is to the left, a "spacing" current is sent to Line, and when it is to the right, a "marking" current is being sent. There are platinum contacts on the levers DU, opposite the contact-points.

Jockey
wheel.

A jockey wheel J, fitted at the end of a flat spring, presses against the upper end of the lever D, and so holds the compound lever firmly against the contacts; the lever cannot maintain the intermediate position shown in the figure.*

6. The bell-crank levers A, A^1 , which are pivoted on the front of the transmitter, are the means by which the required movements of the compound lever DU are effected. At the ends of the vertical arms of these levers are hinged the rods H, H^1 respectively, and at the ends of the horizontal arms are hinged the vertical rods S, M. The free ends of the rods H, H^1 pass freely through holes in the lever D, and work in brass bearings, shown to the right of the lever, so that they do not interfere with the action of the lever.

* *The function of the jockey wheel and spring is superseded, in the newer form of Wheatstone Transmitter, by a permanent magnet with pole pieces which attract and hold the compound lever to either side, exactly as in the case of the jockey wheel.*

Upon the rods, but insulated from them, are screwed adjustable collets, K, K¹. These will be again referred to when the action is described.

The rods S and M are kept in their normal position against the screws B, B¹ by means of light spiral springs s, s². The screws B, B¹, should be adjusted with special reference to the Standard gauge of slip. (See Paragraph 4.) The rods S and M pass on either side of a star-wheel W, which is of exactly the same description as that already referred to in the Perforator. The wheel W is driven by the mechanism of the transmitter.

Y is an ebonite beam, pivoted at its centre, and caused to vibrate by means of a small crank driven by the clockwork. Projecting from Y are two steel pins P, P¹, against which the bell-crank levers A, A¹ are nominally maintained by the action of the spiral springs s₃, s₄. Rocking beam.

The two spiral springs attached to the crank levers A, B are short, to prevent vibration being set up in the springs themselves.

The star-wheel revolves in a slot cut in a brass platform attached to the frame of the clockwork, and the two rods S, M work in similar slots on each side of that for the wheel.

The star-wheel is so geared that the upward movement of the rods S, M, if properly adjusted, takes place when the perforations in the paper slip come exactly opposite the ends of the rods. Star wheel.

The perforated slip is kept in position on the star-wheel by a roller which is pressed into gear with the star-wheel by means of a spring. The position of this roller is so limited that it does not press upon the paper, but only prevents it from rising out of position. In it are gaps to keep it free of the rods S, M in their upward movement, and the central portion is toothed to gear with the teeth of the star-wheel. Paper roller.

7. *Action.*—When the transmitter trainwork is started, the rocking beam Y is set into vibration, and the pins P, P¹ move alternately up and down. When P rises, the horizontal arm of A is free to rise also, and the spring s₃ causes it to do so. The rod H is thereby moved towards the right, and the collet K therefore pushes the lower end of the lever DU towards the right also. The pin P¹ simultaneously descends, pressing A¹ down, and moving the collet K¹ clear of the compound lever. The pressure of the jockey wheel J ensures smart and decided action of DU. When pin P¹ rises in its turn, the reverse action takes place; H is moved to the left, so that K is clear of the lower end of the lever, and H¹ is moved to the right, so that K¹ pushes the upper end of the lever smartly to the right.

Transmitter
without
“slip.”

When the transmitter is running without slip this alternate motion, which, as has been already indicated, reverses the current sent to Line, takes place regularly without interruption, and a succession of simple reversals occurs, because the bell-crank levers, and the rods attached, are free to follow the alternate motion of the pins P, P¹.

Action with
unpunched
paper.

When unpunched paper is inserted, both the rods S, M are pressed downwards and the pins P, P¹ in their motion do not actuate the bell-crank levers A, A¹; the lever DU, consequently, does not move, and a permanent current is therefore sent to Line.

If now slip, perforated (say) with the letter
 ○ ○
 ○ ○ ○ (a) be inserted, then when rod M rises it
 ○ ○
 will be free to pass through the first upper hole, and the lever DU will be moved and will send a “marking” current; when the reverse movement of the rocking beam Y takes place, rod S will be free to pass through the first lower hole, and the

current sent by DU will be reversed: a *dot* will therefore have been sent. On the next movement of the rocking beam, M will be free to pass through the second upper hole, and the length of the "spacing" current is consequently precisely equal to that of the previous "marking" current (*dot*). The "marking" current being now on, when the rocking beam leaves S free to rise, it is prevented from so doing by the paper, which is not perforated below the second upper hole. In this case, therefore, the "marking" current is kept on until the rod S is again free to rise, which it can do through the second lower hole, and the current is then reversed. It will be seen that the "marking" current is therefore kept on during movements equal to two dots and the space between, and this is the recognised length of a dash. It is thus clear that when properly perforated slip is run through the transmitter, any required Morse signals—dots, dashes, and spaces—can be automatically sent to the Line.

Proportion
of dot and
dash.

8. *Adjustment.*—One end of the flat spring, which carries the jockey wheel J, is attached to a brass piece F, Fig. 5, which is in turn screwed rigidly to the frame of the clockwork. The upper side of F is V-shaped, and the tension of the spring is adjustable by means of the two screws which fasten it to its support. It should have sufficient tension to enable it to push the lever DU suddenly to the right or left when either of the collets K or K¹ pushes it beyond the centre of the jockey wheel.

The collets K and K¹ can be adjusted by being screwed forward or backward; their correct position may be found by running the transmitter with a blank slip, when the bar should remain unaffected, whether resting in its right or left position. The collets must, however, be sufficiently close to push the bar over the centre when

the slip is removed, so as to allow the jockey roller to complete the movement.

Spiral
springs.

In order to ensure reliable action at high speed, it is essential that the spiral springs s_3 and s_4 be strong enough to easily overcome the tension of the flat spring acting through the jockey wheel upon the lever. The amount of play allowed between the contact screw C^d and the lever D when it is resting on Z^d , or *vice versa*, is about 5 mils. The contacts C^n and Z^n should be adjusted to suit, so as to preserve similar distances with respect to the spring U.

Play of
lever.

The exact positions of the vertical rods S and M are regulated by the screws B, B', Fig 5; each of the rods should be so adjusted that it commences to enter a perforation in the slip when the left-hand edge of the perforation is sufficiently clear of the left-hand edge of the rod to allow it to pass through freely. If the screws P are screwed too much either way out of their correct position, the rods will catch against the edges of the perforation, and the mechanism will not act properly.

The springs s_1 and s_2 pull the rods S, M back against the screws P when they have become sufficiently withdrawn to be just clear of the slip. Although these springs are very light, they must be strong enough to cause the rods to return to their normal positions promptly.

Speed of
"slip."

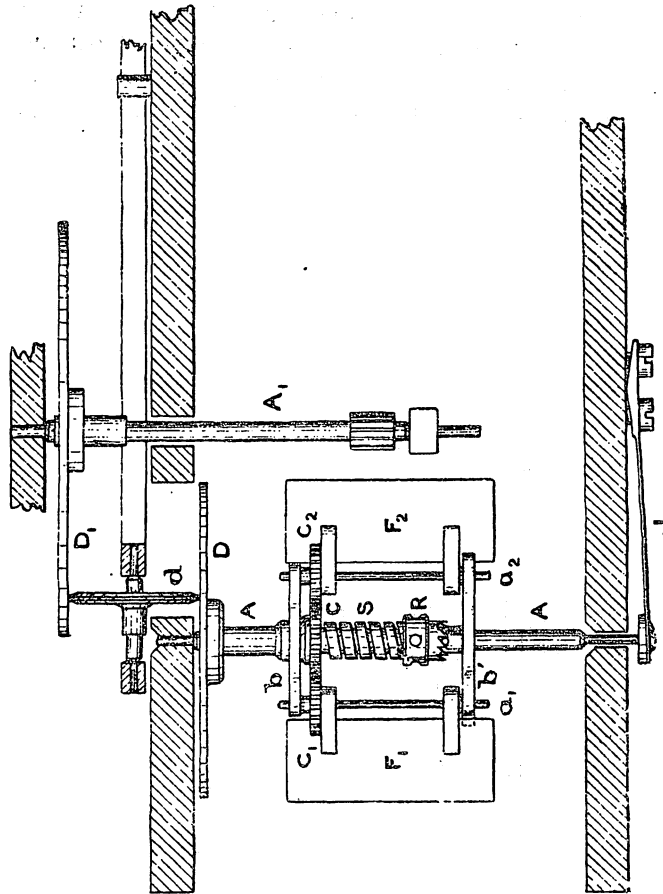
The speed of slip should range from not more than 7 to not less than 80 feet (400 words) per minute (*see* Speed table, p. 33). The thickness of the upper contact-arm U should not exceed 17 mils at the base and 12 mils at the top. The space between the paper roller and the platform, which is determined by the position of the stop-pin for the roller, should be from 8 to 10 mils wide. The tops of the vertical rods should be flat, and when in their lowest position they should

Adjustment
of vertical
rods.

be just level with the upper surface of the platform.

Good signals should be produced on the receiver with the coils joined in series (Fig. 14) when a punched slip is passed through at any speed from the lowest to the highest, the current employed being 17.5 milliamperes (*see* last para.

Local speed conditions.



of Section 16). "Marking" and "spacing" contacts of equal duration should be made for "reversals." This should be proved by the

needle of an induced galvanometer temporarily placed in circuit remaining at zero or moving equal distances on each side whilst the instrument is running at any speed.

9. An important part of the mechanism of the clockwork is the "fly" and its regulator, by means of which the speed of running is determined. The "fly" is so designed that the clockwork shall start at, as nearly as possible, the required speed. Its construction may be seen from Figs. 6, 7, 8, and 9. C is a toothed wheel fixed on an

Speed
Regulator.

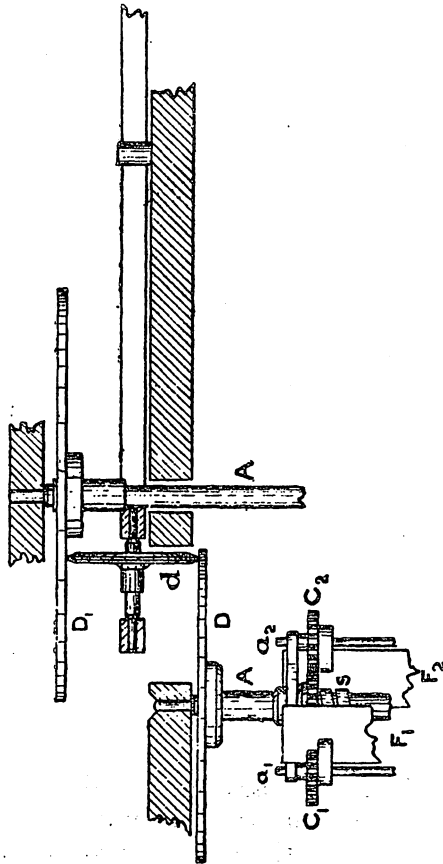


Fig. 7.

axle **A**, on which is also fixed the disc **D**. One end of the spring **S** is pinned to the wheel **C**, the opposite end being pinned to a small ratchet collet **R**, which admits of adjustment of the spring, so as to oppose more or less resistance to the expansion of the "fly" wings **F**₁, **F**₂. The wheel **C** gears with two similar wheels, **C**₁ and **C**₂, to which the "fly" wings are attached, and these two latter wheels are free to turn upon the axes **a**₁, **a**₂ which are fitted in the cross-pieces **b**, **b**¹ rigidly fixed upon the axle **A**.

The action of the spiral spring **S** is to turn **C**₁, **C**₂, and their wings, to the position shown by Fig. 8, in which position their motion is least retarded by the resistance of the air. When the clockwork is set in motion, the "fly" turns with the axle **A**, and the rapid rotation tends to cause the wings to extend in the direction of the arrows

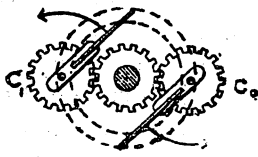


FIG. 8.

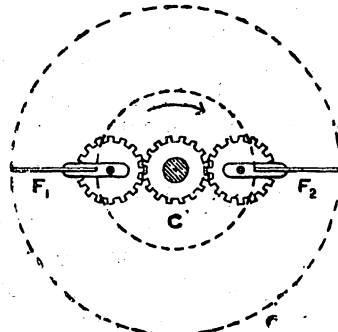


FIG. 9.

by centrifugal force, and to assume the position indicated in Fig. 9; the tendency being limited by the tension of the spiral spring **S**, and the speed of the "fly," being controlled by the increased or decreased resistance which the air offers to the motion of the wings consequent on the size of the circle which they describe; or, more correctly, the resistance offered by the air is proportional to the difference of the area of the two concentric

circles described from the centre of axis A to the inner and outer edges of the "fly" wings, as shown by dotted lines in Figs. 8 and 9.

10. The regulator provides the necessary mechanical connection between the trainwork and the "fly." It is shown in Figs. 6 and 7.

Action of
Receiver
discs.

A solid steel disc D, the outer surface of which is an accurate plane, is rigidly attached to the fly axle A. To the axle A_1 , which is directly in gear with the clockwork train, is also fixed a similar steel disc D_1 , and between D and D_1 is placed a small intermediate disc d , of German silver, having a polished periphery. The disc d is pivoted in a small brass frame, which can be shifted backwards or forwards by means of a lever projecting upwards from the back of the instrument; thus d can be made to gear with the edge of the disc D_1 and the inner surface of the disc D, as in Fig. 6, or it can gear with the inner surface of D_1 and the outer edge of D, as in Fig. 7. The disc d , and the intermediate d , are kept in close contact with D_1 by means of the jewelled spring J, Fig. 6, so that if the disc D_1 be turned by the clockwork, it will turn the connecting disc d , and the latter will turn the disc D and the fly-axle A to which it is rigidly fixed.

When the intermediate disc d is adjusted to the position indicated in Fig. 6, the disc D_1 tends to turn it rapidly, since there is a large circumference gearing against a smaller. Similarly the disc d tends to turn the disc D quickly; hence a comparatively slow motion of the axle A_1 will impart a quick motion to the axle A and the "fly." When, however, the position of d is as shown in Fig. 7, then the smaller circumference of D_1 , gearing by friction with d , and the latter gearing in the same manner with the larger circumference of D will cause even a quick motion of A_1 to impart a comparatively slow motion to A.

The instrument may be adjusted to run at any speed between the minimum and the maximum limits by means of the lever, which is pivoted to the framework of the instrument, and is connected to the moveable frame in which the small disc is pivoted. It will be noticed from this description that the faster the "fly" is driven the slower is the motion of the trainwork, and *vice versa*. In fact, the expansion of the "fly" in consequence of the speed at which it is driven acts as a brake upon the driving gearing.

The surfaces of the discs must on no account be oiled, and, should they accidentally become so, must be carefully cleaned, as slipping and consequent irregularity in running.

Absence of
grease.

11. The chains which carry the driving weight are made up of links which, as shown by Fig. 10, are cut V-shaped at their openings. This device allows of any two links being snapped together when held as shown by Fig. 11. Before a chain is joined, care must be taken to see that it is not twisted, as when the links are snapped together they cannot be separated except by breaking.

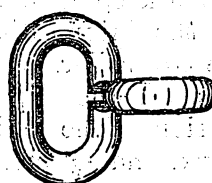
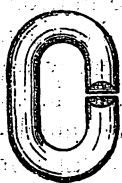


Fig. 10.

Fig. 11.

12. *Connections*.—A switch under the base of the transmitter cuts off the line and battery from the key when the transmitter train is running, and connects them to the electrical contacts of the transmitter. It is actuated by the starting and stopping lever.

Transmitter
Switch.

The actual connections employed for Simplex or Duplex working on the various classes of circuit will be found in the Diagram Book.

THE RECEIVER.

13. The Receiver is shown in elevation by Fig. 12.

The upper portion contains the clockwork. The ink reservoir, the adjusting screw, for the magnets (S), and the paper guides are attached to the front of the instrument. The lower portion contains the electrical mechanism. The instrument, practically, is an ordinary polarised relay, worked by the direct line current, and surmounted by a train of clockwork, which is driven by means of a weight; its speed of running is regulated by a "fly," expanding through a rotary motion, similar to that of the Transmitter.

The paper used in the Receiver is the ordinary Morse slip. On leaving the drawer in the base of the instrument (not shown in the figure) the slip is passed over a guide P, and then between two steel projecting pieces, *a* and *b*; which keep it in the right position to be marked by the inking disc, *m*. It then passes between the two rollers, Q and Q¹, which are for carrying forward the slip when the receiver train is in motion. The roller, Q, is turned by the clockwork, and Q¹ presses upon the slip by means of the spring R.

Ink wheels
and Ink-
wells.

The inking discs *m* and *d* are covered by a brass hood, G, fixed in position by means of the screw C. If the latter be slightly unscrewed (not removed), the hood G may be slipped off, and the discs *m* and *d* exposed for cleaning when necessary. The ink-well is secured in its place by the thumbscrew M.

The starting and stopping of the clockwork is effected by the lever K.

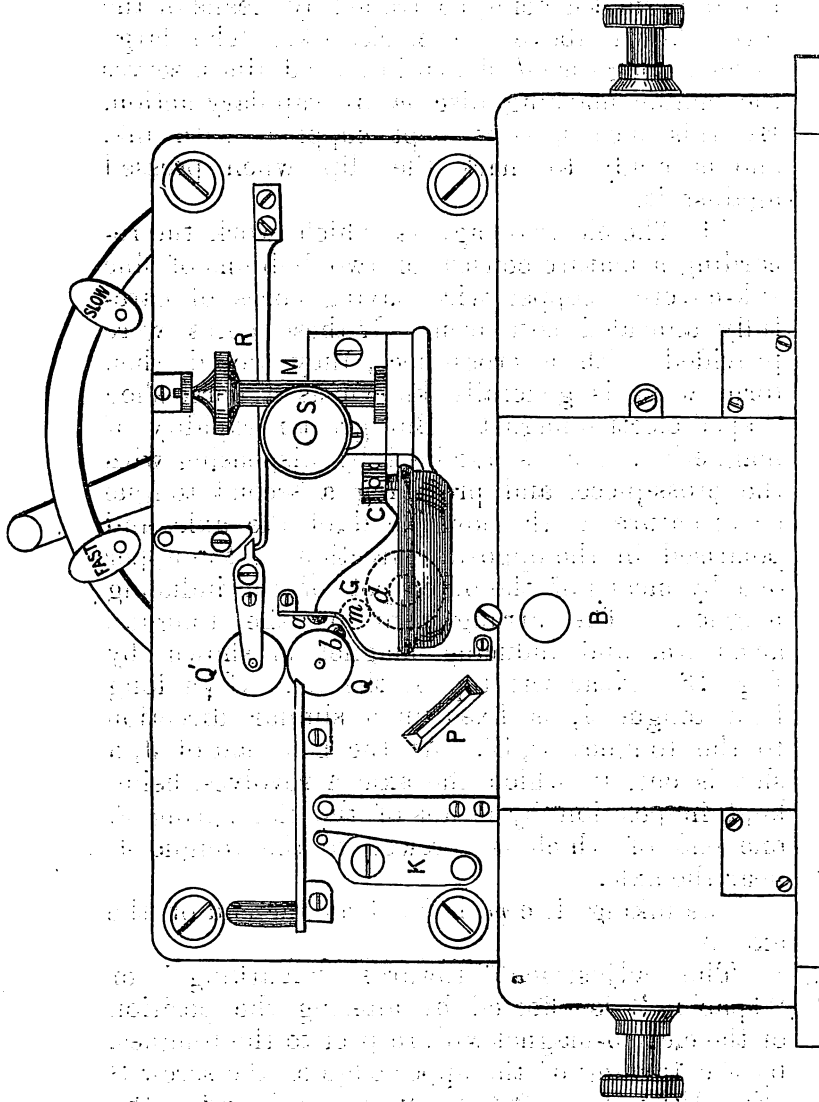


FIG. 12.

The clockwork gives rotary motion to the inking disc and its supply wheel, and also carries the paper slip forward at the required speed, the speed regulator being controlled by means of the lever shown above the clockwork. The large lower inking disc *d* shown in dotted lines, serves the smaller marking disc *m* by capillary action. By this means, *m* is kept supplied with ink, and is ready to mark the slip when pressed against it.

Receiver
Cores.

14. The electro-magnets which work the recording armature consist of two bobbins of fine silk-covered copper wire having cores of carefully annealed soft iron. If these cores were provided with a cross-piece, they would then form what is generally known as a horse-shoe shaped electro-magnet. But greater rapidity of magnetic action is obtained by dispensing with the cross-piece, and providing a second tongue or armature at the lower end of the axle, and polarised in the opposite direction to the upper one by means of the other pole of the inducing magnet. The arrangement of the tongues, armature, and inducing magnet is shown by Fig. 13. Near the top of the axle H, a long bent tongue J, is fixed in a similar direction to the tongues N¹, S¹. At the bent end of J, a slot is cut, in which the axle A revolves, being kept in position by means of the flat spring F, one end of which is screwed to the tongue J, near the axle.

Armatures.

The inking disc *m*, is fixed at the end of the axle A.

Adjustment.

The adjustment towards "marking" or "spacing" is effected by altering the position of the electro-magnet with respect to the tongues, by the turning of the upper edge of the screw S (Fig. 12) to the left for a "spacing," and to the right for a "marking" bias. To produce a bias

towards "spacing," the portion of the electro-magnet on the left hand side of the tongues is caused to recede, while the portion on their right hand is made to approach. This movement of the electro-magnet is reversed if a bias towards "marking" is required.

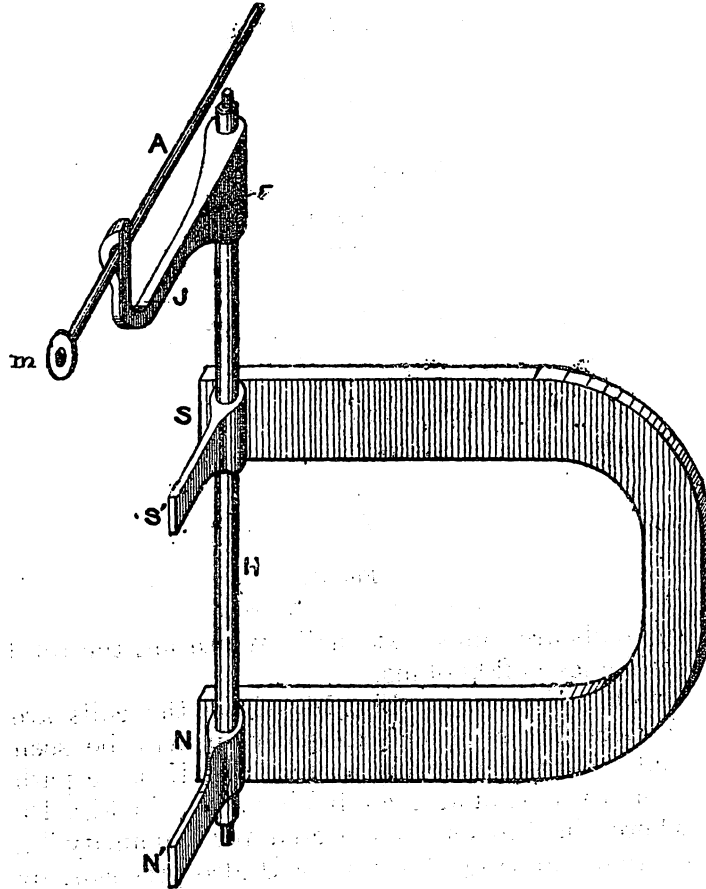


FIG. 13.

The coils are each wound with two wires, each having a resistance of 200 ohms, which are then joined for quantity inside the instrument

(Figs. 14 and 15), so that the resistance between U and D, and that between \bar{U} and \bar{D} is 100 ohms. When, therefore, by means of the links

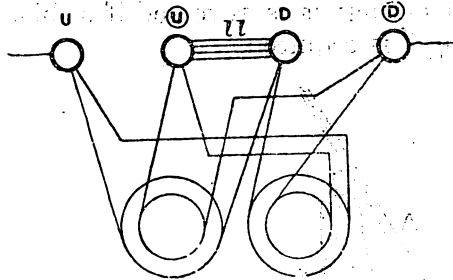


FIG. 14.
Series.

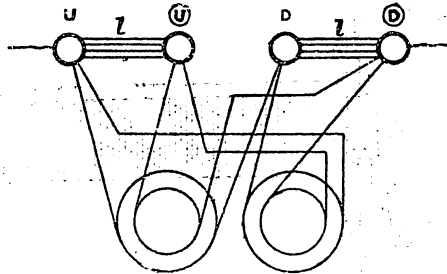


FIG. 15.
Duplicate Arc or "Quantity."

the coils are joined externally for series, the total resistance is 200 ohms.

Coil
Resistance.

On reference to Fig. 14, where the coils are connected for series externally, it will be seen that a current entering at terminal U has a path open to it around each bobbin; but, in Fig. 15, where the links are connected for "quantity," a current entering at terminal U also proceeds, by means of the link, to terminal \bar{U} , and it therefore has two paths around each bobbin open to it. The effect of this is to reduce the resistance of the instrument from 200 ohms to one-fourth, or

50 ohms, and so make it suitable at "Simplex" for short lines or lines with intermediate offices.

On long "Simplex" lines in wet or foggy weather, when the leakage of the line is considerable, it may become necessary to revert to "series" externally in order to obtain sufficient magnetic effect to produce good marks at a moderately high speed, but this should never be done on lines having intermediate offices except by arrangement with all offices in circuit.

Arrangement
of Coils for
various
Conditions.

15. The Receiver, like the Transmitter, is driven by a weight, and is arranged to run Morse slip at any speed between 8 and 60 feet a minute.

Speed of
Receiver.

The Instrument possesses a mechanical combination of click-wheel and bayonet joint, by means of which the clockwork and electrical portion (the "*Receiver Train*") may be detached from the driving part (the "*Receiver Motor*") without waiting for the weight to run down, or running the risk of damage by letting it down by hand. The construction of this arrangement is shown by Figs. 16, 17, and 18.

Train and
Motor
Connections.

Fig. 17 shows the bayonet joint which gears the clockwork with the weight. The long axle G is provided with a socket F to receive the end of the axle H (Figs. 16 and 17), projecting from the clockwork; near the end of this axle is fixed a strong pin A (Fig. 17), which gears behind a projection, B, and is held in that position by the action of the weight, which keeps the flat surface of the slot pressed against the pin.

The detaching gear is represented by Fig. 18. The teeth of the click-wheel D into which the pawl E is made to engage when required, are undercut in such a manner that when the pawl is placed in gear with the wheel it becomes locked. The normal position of the pawl E is, of course, away from the click-wheel; but, in order to

separate one portion of the instrument from the other; the clockwork is allowed to run, the pawl is thrown over, and is then pressed against the click-wheel by the spring C. By this means the weight is brought to a standstill and securely locked until the click-wheel is turned (by means

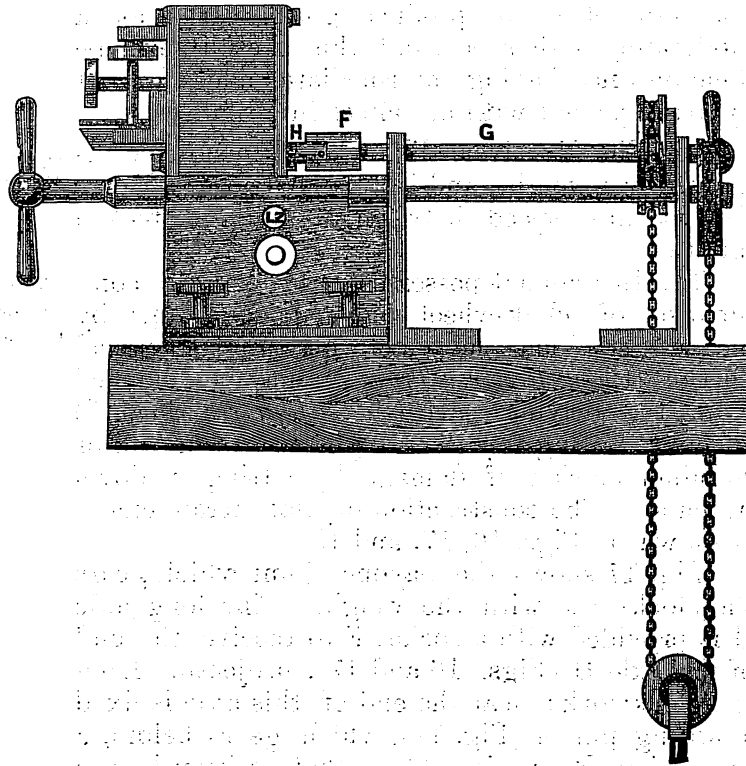


FIG. 16.

of a handle, shown at the right-hand end of the axle, G, Fig. 16), into such a position as to permit of the pawl being easily disengaged.

After the weight is stopped by E acting upon the click-wheel D, the axle H is carried forward by the momentum acquired by the clockwork into the position shown in Fig. 17, so that the pin A is clear of the projection B, and then, if the bind-

ing screws on each side of the clockwork portion are released, the parts may be easily separated.

Owing to the facility with which the Receiver Train can in this way be separated from the Motor, it is rarely necessary to remove the latter from the instrument table.



FIG. 17.

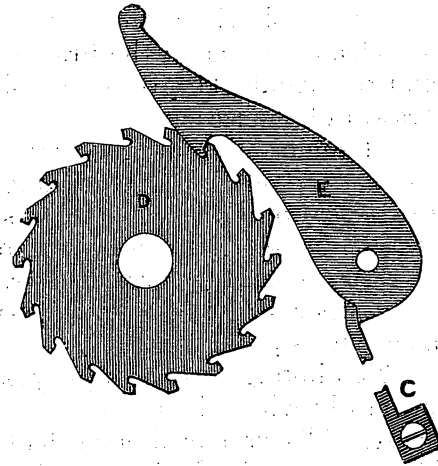


FIG. 18.

A mechanical alarm, which indicates when the Mechanical weight requires winding up, is now fitted upon ^{alarm.} the Motor.

16. *Adjustment.*—The permanent mechanical adjustment of the receiver is a simple matter, and only requires a little care.

By partly turning the screw at the top of plate B, Fig. 12, the plate, which is hinged at the bottom, can be let down, thus exposing two small adjusting screws with a projection from the lower tongue playing between them. The easiest method of adjusting is as follows:—

Allow the slip to run at the rate of about 15 feet per minute, then keep the tongue pressed gently against the left-hand screw; if a line appear on the slip, advance the screw until it is broken into dots; then withdraw the screw slowly

Receiver
adjustment.

until the line appears unbroken, when a further very slight withdrawal will ensure the necessary margin. The tongue should then be pressed gently against the screw on the right-hand side, the screw being advanced until a broken line (irregular dots) appears on the slip, when it should be slowly withdrawn until the slip runs out clean, and, as in the first adjustment, a small margin should be given by a slight further withdrawal of the screw.

It sometimes happens that the tongue, owing to a dirty state of the inking discs, requires a great deal of play between the screws. The effect of this is to considerably reduce the speed of working when the current is weak, and it is therefore important to keep the ink-well and the discs as clean as possible.

Standard
breadth of
marks.

The inking-disc, being dry, should pick up ink promptly when the train is set running at lowest speed. The standard breadth of marks is 16 mils. The standard thickness of Morse paper—an important matter in connection with high speed apparatus—is $3\frac{1}{2}$ mils. The coils of the magnets should be differential with 50 Daniell cells without external resistance, care being taken that the current is passed through the coils in both directions. With a properly adjusted Transmitter, the Receiver should work at a speed of at least 400 words per minute (the coils being in series), with 20 Daniell cells through 800 ohms external resistance, a condenser of 2 mf. capacity being joined across the resistance. (Figure of merit 17.5 milliamperes.)

Standard
thickness of
paper.

Figure of
merit.

Shunted
Condensers.

17. *High speed working.*—On cable circuits a shunted condenser of a suitable value is inserted at each end of the line; and on land lines where a speed of 300 words per minute and upwards is desired, shunted condensers are used at the receiving end of the line.

The general principle involved in the application of condensers at the receiving end of a line may be explained thus, so far as the electro-magnet alone is concerned:—

Every electro-magnet wound to a resistance R has its own coefficient of self-induction L , which determines the rate at which a current rises or falls, and the time constant is expressed by the ratio $\frac{L}{R}$. It is the time the current takes to rise from zero to its full strength. Time Constant.

If the two plates of a condenser of capacity K be shunted by a wire of resistance R_1 , then when a current flows, the condenser will be charged and the current will rise to its full value, and if the current stops, the condenser will discharge, and the current will gradually fall to zero. The time constant of such a condenser is KR_1 . This is exactly the reverse action to that which takes place in an electro-magnet, and by properly regulating the capacity of the condenser and the amount of resistance the action of one can be made to exactly counteract that of the other.

Now, if we connect up an electro-magnet and a shunted condenser in the way shown in Fig. 19, then, when the current commences to flow, the opposing electro-motive force set up in the coils of the magnet by self-induction is overcome by the current charging the condenser, and when Action of Condenser.

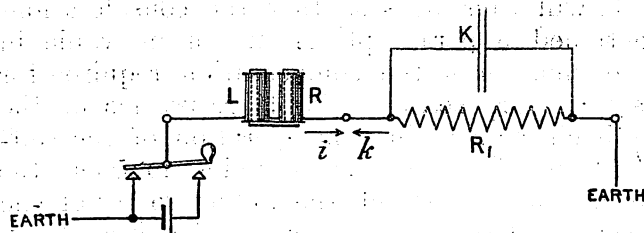


FIG. 19.

the condenser is charged, the current continues to flow through the shunt, but is weakened by its resistance. On the cessation of the current the self-induction of the magnet sets up an electromotive force tending to prolong the current in the direction (*i*) while the discharge from the condenser *K* is in the opposite direction (*k*). Hence these effects oppose and neutralise one another when the resistances *R* and *R*₁, and the capacity *K*, are properly adjusted.

Self
induction.

18. The self-induction of the receiver or relay may however, be compensated for, without using condensers, by joining the receiving instruments in series with a resistance the value of which is dependent on the self-induction of the receiving instrument, and increases with the maximum speed required. For example, an average Post Office Receiver in "series" with an added resistance of 12,000^Ω and a signalling voltage of 120, should give a speed of 400 words per minute, while the same receiver joined in "duplicate-arc," with a voltage of 60 and a resistance of 3,000, should be capable of recording signals at the same speed. The exact amount of resistance required differs with different specimens of the same form of receiving instrument, with different forms of receiving apparatus, and also with different Transmitters, the interval of "break" in the Transmitter and the resistance of the battery having a considerable influence.

Practical
conditions.

It will thus be seen that the considerations mentioned in paragraph 17 are of no value in the estimation of the compensation required for practical purposes, as while the resistance of the line itself acts against the operation of the self-inductive effects of the receiving magnet, the capacity of the line aids the inductive lag of the apparatus at the receiving end of the circuit.

19. On ordinary land lines, and with the Simplex present form of Post Office apparatus, the procedure for the attainment of maximum Simplex speeds should, as far as possible, be as follows:—
adjustments.

- (a) The receiving office should request the sending office to turn his key switch to "send" for a minute, the voltage in use being, as a general rule, 100.
- (b) The Receiver or Relay being connected in "series," the receiving office should then raise or lower his resistance in the compensating shunt Rheostat until 20° (or 8 milliampères) is indicated on the half-coil of the Differential Galvanometer.
- (c) Slip should then be run through the distant Transmitter, and the Receiving office should alter his Condenser values until the best results are obtained. The actual speed obtained, with the most accurate compensation, depends on the Capacity, Resistance, and Self-induction of the line, but generally speaking the higher the unit capacity of the line, and the lower the compensating shunt, the greater the amount of compensating capacity which will be required.*
- (d) If the receiving Relay or Receiver be joined in "duplicate-arc" the deflection on the half-coil of the Galvanometer should be adjusted to indicate 35° (16) and the required compensating capacity will then be found, for the same circuit, to be greater than in the case of "series" connections.

* *In very exceptional cases of very high line capacity (which have hitherto not existed in this country), very high received compensating shunt resistances and lower permanent currents are necessary, even in those cases where receiving apparatus similar to the present Post Office pattern is employed.*

- (e) On circuits having a considerable amount of capacity in proportion to the Conductor resistance, the addition of a shunted Condenser at the transmitting end of the line enables an additional increase of speed to be obtained.

Signalling
Condensers.

A Condenser in this position is called a "Signalling Condenser," and its value in micro-farads should be equal to the discharge value of the line at the sending end under its working conditions, the shunt being equal in ohmic resistance to the Conductor.

Signalling
Speed.

- (f.) The term "speed," as used here, does not refer to the true wave-speed of the line, but to the signalling value in "words per minute," under the disadvantageous conditions of the International Morse Alphabet, which necessitates signals of unequal length.

Speed
formula.

20. Although the capacity and resistance of a circuit are the main factors in the determination of speed, other factors modify the result considerably, but charts have been prepared showing the Simplex speed values of aerial and buried lines, on the following basis:—

The maximum Simplex speed in "words-per-minute" multiplied by the product of the total resistance and total capacity of the circuit (K.R.) is equal to 10,000,000 for iron aerial lines, 12,000,000 for copper aerial lines, and 18,000,000 for subterranean or submarine gutta-percha-covered cables.

Paper
Cables.

Paper cabling of all descriptions gives a smaller value than other forms of covered Conductors, although "screened" Conductors in paper Cable are more efficient than unscreened

paper insulated conductors even if the latter are used as a loop and are properly twisted.

All these figures are given on the assumption that the most accurate condensing compensation is employed.

21. The Duplex speed on any line is practically slightly less than two-thirds of the highest attainable Simplex speeds obtained with the most advantageous compensating arrangements. This proportion is stated with special reference to Post Office apparatus and conditions, and is applicable to both Wheatstone Bridge and differential methods of duplexing. Duplex.

It should be clearly understood, however, that Wheatstone Bridge connections should not be employed on long aerial lines, even if associated with cables, nor on any line on which it would not be beneficial to employ Signalling Condensers for Simplex working, if advisable from other points of view. Bridge Connections.

22. On some of the Duplex circuits between this country and the Continent, as well as on the Irish cables, the ordinary Duplex Coils forming the arms of the Wheatstone Bridge have been substituted, or supplemented, by coils wound on a closed magnetic circuit, so arranged that the sent current passes through the arms without any magnetising effect, but the received current meets with considerable inductive opposition, practically increasing the resistance of the arms for received current and throwing more of the initial current through the receiving instrument than would be available with ordinary Bridge connections. Magnetic Bridge.

On the decline or cessation of the received signal, the self-inductive action of the magnetic "arms" assist in neutralising or reversing the magnetic action of the receiving instrument.

Edison's
Magnetic
Leak.

On a few specially selected cable circuits Edison's Magnetic Leak is added, the amount and rate of the self-inductive action being carefully timed to suit each circuit by the addition of non-inductive resistances. This arrangement, being exceptional, does not call for a more detailed explanation.

TABLE for ascertaining the ACTUAL SPEED of TRANSMISSION on WHEATSTONE AUTOMATIC CIRCUITS.

Direction.—Pass 10 feet of perforated slip (representing 50 average words) through the Transmitter, and observe the time occupied.

Time Occupied.	Number of Words per Minute.	Time Occupied.	Number of Words per Minute.	Time Occupied.	Number of Words per Minute.
Seconds.		Seconds.		Seconds.	
5	600	24	125	56	54
5½	545	24½	122	57	53
6	500	25	120	58	52
6½	462	25½	117	59	51
7	429	26	115	60	50
7½	400	26½	113		
8	375	27	111	min. sec.	
8½	353	27½	109	1 1	49
9	333	28	107	1 3	48
9½	316	28½	105	1 5	47
10	300	29	103	1 6	46
10½	285	29½	101	1 7	45
11	273	30	100	1 9	44
11½	262	31	97	1 10	43
12	250	32	94	1 12	42
12½	240	33	91	1 13	41
13	231	34	88	1 15	40
13½	222	35	86	1 17	39
14	214	36	83	1 20	38
14½	207	37	81	1 21	37
15	200	38	79	1 23	36
15½	195	39	77	1 25	35
16	188	40	75	1 28	34
16½	182	41	73	1 30	33
17	177	42	71	1 35	32
17½	172	43	70	1 37	31
18	167	44	68	1 40	30
18½	162	45	66	1 43	29
19	158	46	65	1 47	28
19½	154	47	64	1 51	27
20	150	48	62	1 55	26
20½	146	49	61	2 0	25
21	143	50	60	2 5	24
21½	140	51	59	2 10	23
22	136	52	58	2 16	22
22½	133	53	57	2 23	21
23	130	54	56	2 30	20
23½	127	55	55		

Measurement of
High Speeds.

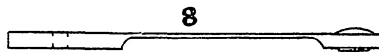
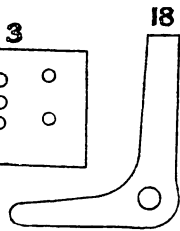
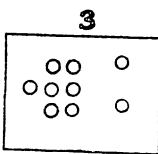
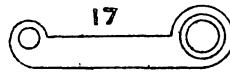
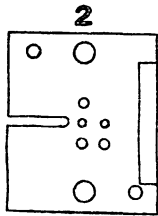
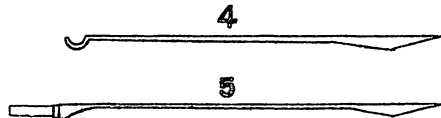
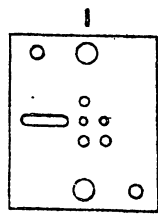
As at high speeds some difficulty is experienced in estimating intervals including half-seconds, a greater length of slip may be taken with a fixed time, (say) 25 seconds, when words per minute can be obtained in inches of paper, 10 feet of slip being equal to $10 \times 12 = 120$ words per minute, or 33 feet 4 inches equal to 400 words per minute.

AUTOMATIC PARTS.

Interchange-
able parts.

All the moving parts of the Perforator are very accurately made, so as to be interchangeable. The several parts are numbered as "Automatic Parts," which include also the Jewelled Pivot-springs for Receiver and Transmitter (Nos. 8 and 11), and they are supplied for purposes of repair under the several numbers, which are shown below.

1. Front Puncher-plate.
2. Back " "
3. Back Guide to Punchers.
4. Back spring acting on Star-wheel-Click Lever.
5. Vertical Spring on which Guide roller is pivoted.
6. Guide-roller.
7. Star-wheel.
8. Jewelled Pivot-spring of Receiver.
9. Star-wheel-Click Lever.
10. Star-wheel Click.
11. Jewelled Pivot-spring of Transmitter.
12. Lever regulating play of Star-wheel-Click Lever.
13. Centre-punch (for dot, dash, and space).
14. Top-punch (for dot and dash).
15. Bottom-punch (two of these—one for dot, other for dash).
16. Centre-punch (for dash).
17. Socket Lever.
18. Adjusting Lever (when required with cock and screws, say "complete").



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