No. 676,006. Patented June 11, 1901.

A. MUIRHEAD.

RECEPTION AND RETRANSMISSION OF ELECTRICAL IMPULSES.

(No Model.) (Application filed Feb. 20, 1901.) 3 Sheets—Sheet 1.

Fig. 1.

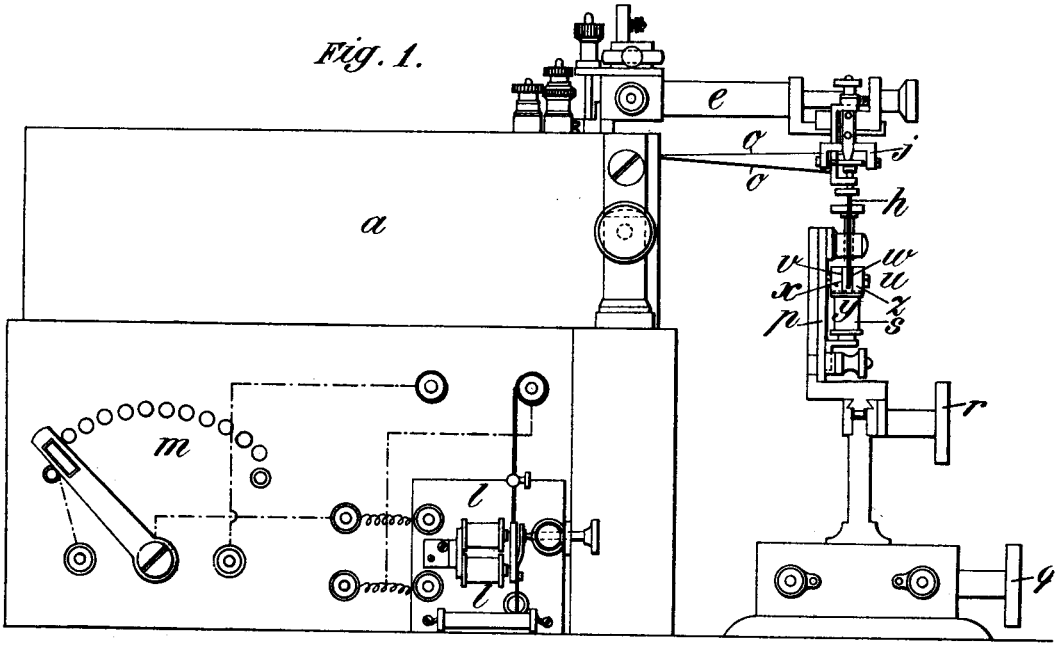

Fig. 2.

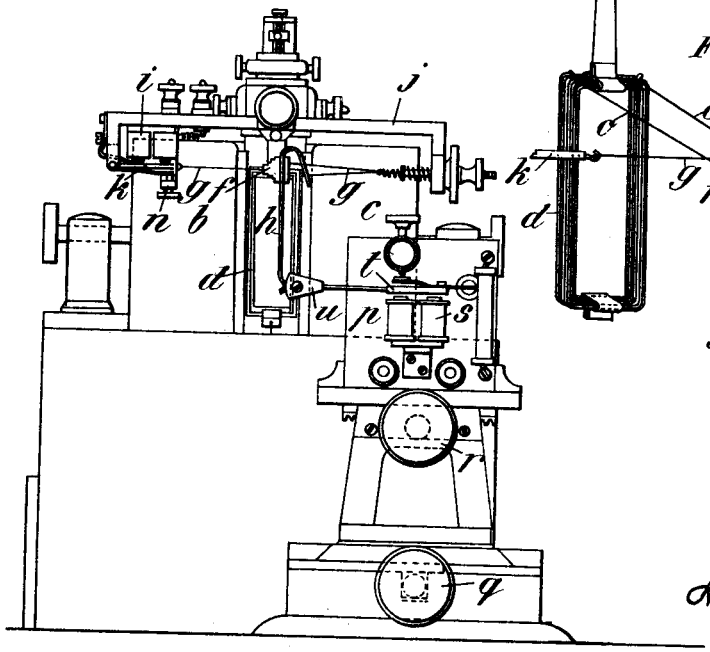

Fig. 3.

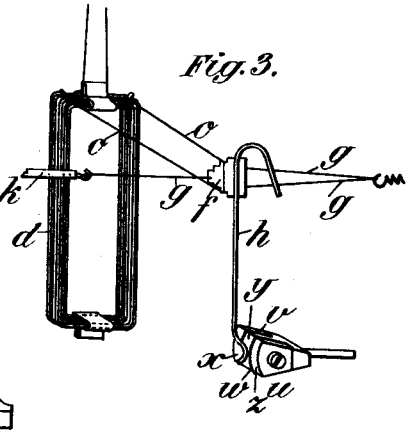

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Fig. 5.

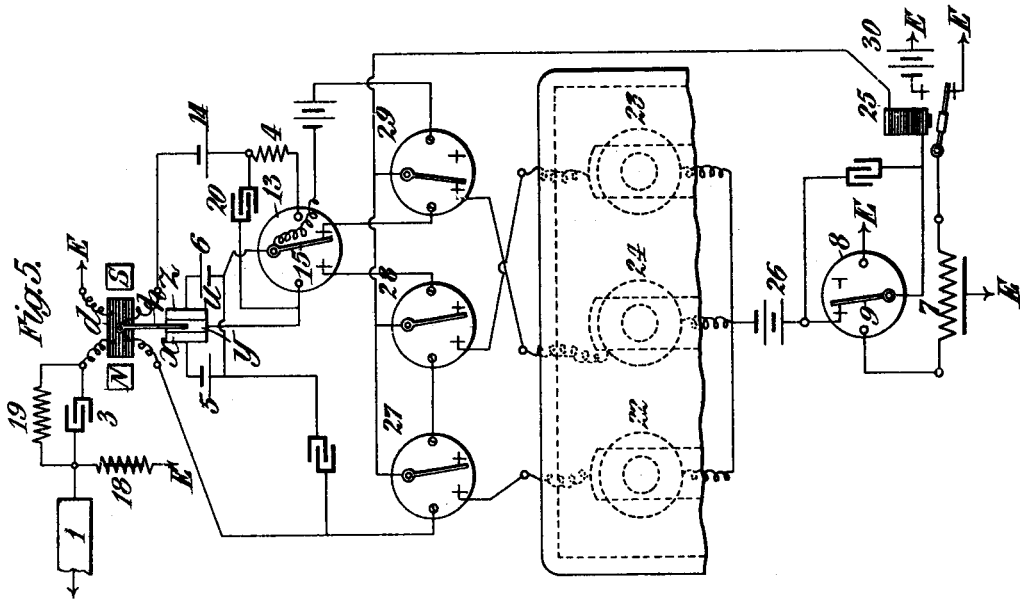

Fig. 4.

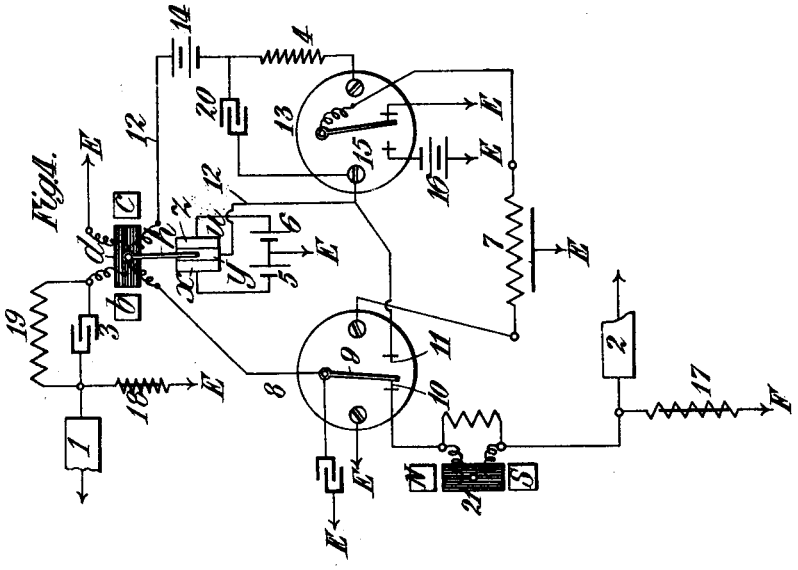

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Fig. 7.

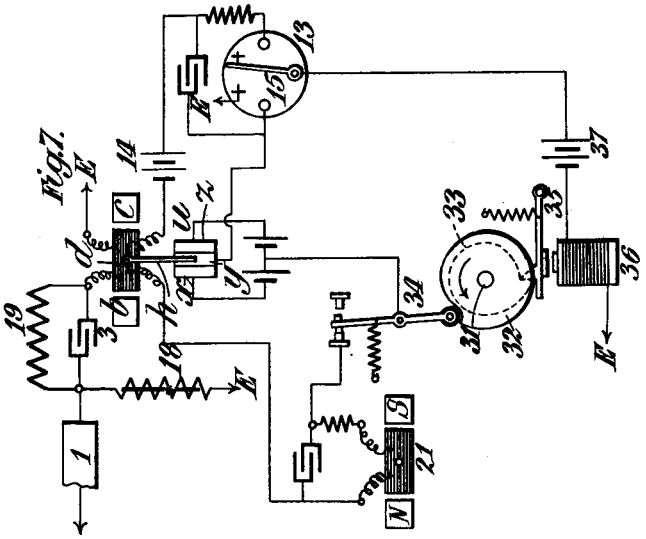
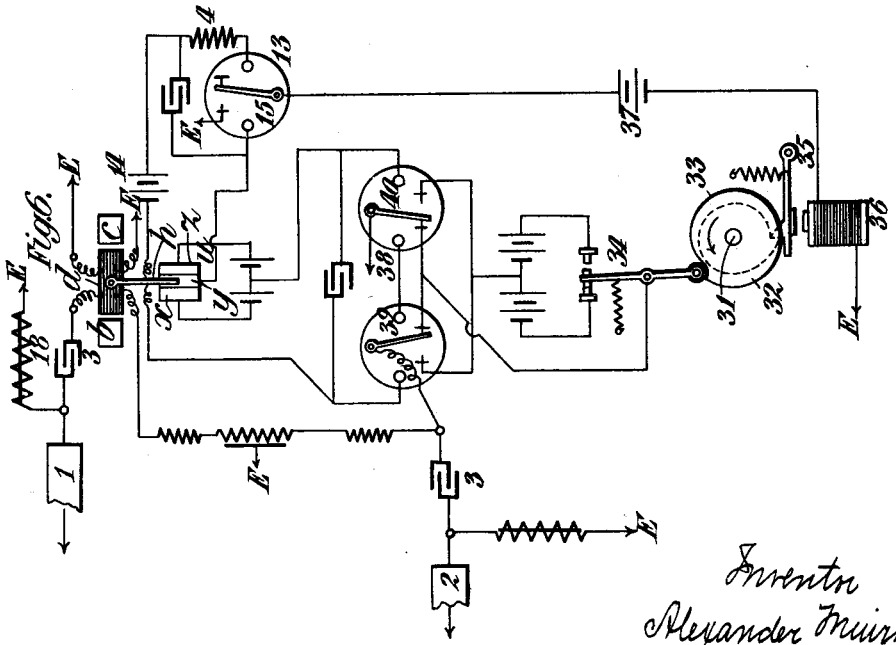


Fig. 6.



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UNITED STATES PATENT OFFICE.

ALEXANDER MUIRHEAD, OF SHORTLANDS, ENGLAND.

RECEPTION AND RETRANSMISSION OF ELECTRICAL IMPULSES.

SPECIFICATION forming part of Letters Patent No. 676,006, dated June 11, 1901.

Application filed February 20, 1901. Serial No. 48,150. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER MUIRHEAD, a subject of His Majesty the King of Great Britain, residing at Shortlands, in the county of Kent, England, have invented new and useful Improvements Relating to the Reception and Retransmission of Telegraphic Signals, of which the following is a specification.

My invention relates to the reception and retransmission of telegraphic signals, more especially in connection with submarine-cable or like circuits where the arriving impulses are of a feeble character. Such impulses are received upon a relay, the most usual form of which is analogous to a siphon-recorder; but the recorder-coil instead of operating an ink-siphon moves a contact-tongue upon or against relay-contacts, thereby making or breaking, as the case may be, either the retransmitting-battery circuit or a local-battery circuit, whereby in turn the retransmitting or equivalent contacts are made. The tongue that is moved by the recorder-coil usually makes contact with a metallic body which is divided by an insulating-partition into two battery-terminals, or sometimes two insulating-partitions have been employed, leaving a central or "zero" portion which has either been left insulated or merely carried to earth.

It is well known that whenever the transmission on a submarine telegraph-cable exceeds a certain rate depending on the K R—*i. e.*, the product of the capacity K and the conductor resistance R of the cable—the signals received at the distant end of the cable run into each other, with the result that the index of the receiving instrument (the siphon in the case of a siphon-recorder or the contact-tongue of a relay) does not return to the zero position between each signal. It has already been suggested to overcome this difficulty by "curbing" the receiver-coil to such an extent as to bring back its attached contact-tongue to zero for every impulse sent into the cable at the originating station.

My present invention, which is directed to the increase of the effectiveness of the relay-circuit in the retransmission of signals from one section of cable into another at intermediate stations or to the operation of perforators required for automatic transmission at terminal stations, consists, essentially, in introducing through the medium of the central section of the relay contact-body certain apparatus or arrangements in a local circuit whereby the retransmitted signals are improved or the perforator operated and whereby the effect of any prolonged contact made by the receiver-tongue is converted into the same number of separate impulses as those originally transmitted, notwithstanding the fact that the receiver-coil itself remains over on one contact during the whole period.

In the accompanying drawings, Figure 1 is a side elevation, and Fig. 2 is a front view, of a receiving-relay. Fig. 3 is a perspective detail view showing the recorder-coil, the aluminium cradle, the contact-arm, and the contact-body divided into three sections. Figs. 4 to 7 are diagrams of the apparatus and circuit connections, Fig. 4 showing one arrangement for reception and retransmission of signals and for correcting by electrical means the effect of prolonged excursions of the receiver-tongue, Fig. 5 showing the application of the invention to a perforator, Fig. 6 showing an arrangement for reception and retransmission of signals and for correcting by mechanical means the effect of the said prolonged excursions of the receiver-tongue, and Fig. 7 showing the simplification of the arrangement of Fig. 6 for reception only.

Referring first more particularly to Figs. 1 to 3, *a* is a magnet provided with adjustable pole-pieces *b* and *c*, in the field of which the coil *d* is mounted. *e* is a suspension-piece carrying the coil *d* and the aluminium cradle *f*, which is attached to stretched fibers *g*. *h* is the contact-arm, attached to the cradle *f*. *i* is an electromagnet mounted on the bridge *j* of the suspension-piece *e*, and *k* is its hinged armature, to which one end of the stretched fiber *g* is attached. When it is desired to vibrate the cradle *f*, the electromagnet *i* is energized through the vibrator *l*. *m* is a set of slide-resistances for regulating the strength of the current flowing through the coils of the vibrator *l* and the electromagnet *i*. When it is desired not to vibrate the cradle *f*, the armature *k* may be held in contact with the poles of the electromagnet *i* by the binding-screw *n*, or the latter may be used as an auxiliary adjustment of the arm *h* against its contact-surface. Fibers *o* connect the coil *d*

with the cradle f in the usual way. The contact-arm h oscillates or plays upon a contact-body, which may be a stationary, revolving, oscillating, or vibrating one. The drawings show a plate p, that is adjustable longitudinally and transversely by set-screws q and r, respectively, supporting a vibrator s. The armature t of this vibrator carries the contact-body u, which is consequently vibrated approximately at right angles to the plane in which the contact-arm h moves.

According to my present invention the contact-body u is divided by thin partitions v and w, of an insulating material, mica by preference, into three conducting-sections x, y, and z.

Having thus indicated the principal parts of the relay instrument, I will next proceed to describe the electrical connections and circuit arrangements with reference to the diagrammatic illustrations.

In all the applicable diagrams, 1 represents the cable from which for the purpose of this description it is assumed signals are about to be received, and 2 the one into which corresponding signals are to be retransmitted. 3 3 represent the condensers, which are usually placed between the cable and the receiving or sending apparatus. E E represent the earth connections, and 4 4 represent resistances inserted for the purpose of regulating the strength of the current flowing in the various circuits.

According to the arrangement shown in Fig. 4 the two outer sections x z of the contact-body u are connected to the two terminals of a split battery 5 6. 7 is a retardation-circuit one end of which is connected to earth through the coils of a local polarized relay 8, whose contact-tongue 9 plays between two contact-stops 10 and 11. By a wire 12 a local polarized relay 13, with a separate battery 14, is connected to the tongue h of the signal-coil d, and thus to the central section y of the contact-body u. The local relays 8 and 13 may be of the well-known "Post Office Standard Relay" or other convenient type. The contact-tongue h is connected to the second cable 2 through the tongue 9 and the limiting-stop 10 of the relay 8. The relay 13 is joined up with the separate battery 14 to the tongue h in such manner that when the latter is on the central section y of the contact-body u its tongue 15 puts the beginning of the retardation-circuit 7 to earth. On the deflection of the tongue h into contact with one of the outer sections x or z of the contact-body u a connection is made between the second cable 2 and the corresponding half of the split battery 5 6, and at the same time the tongue 15 of the relay 13 is deflected and the retardation-circuit 7 connected to the battery 16. After an interval of time, dependent upon the amount of retardation of the circuit 7, the tongue 9 of the relay 8, which is placed at the remote end of the retardation-circuit, is deflected and the second cable 2 allowed to discharge to earth through the self-induction shunt 17. This succession of deflections of the tongues 15 and 9 is repeated so long as the tongue h is upon one or other of the outer sections x or z of the contact-body u, and it is timed by adjustment of the retardation of the circuit 7 to suit the speed of transmission adopted. 18 is a self-induction shunt applied to the receiving-circuit, comprising the condenser 3 and the signal-coil d, as described in the specification of my application for Letters Patent Serial No. 700,394, for the purpose of eliminating the effect of earth-currents upon the zero of the signal-coil d. I find in practice at a speed constant of 500—*i. e.*, the ordinary speed of signaling—on cables having from two to six K R that the resistance of this shunt should be about the same as the signal-coil d and its self-inductance equal to the product of the square of its resistance and the capacity of the receiving-condenser 3. In carrying out this invention I sometimes find it advantageous to shunt the receiving-condenser 3 with a coil 19 of high resistance. A condenser 20 is put across the terminals of the transmitter 13 in series with a resistance 4 to steady the movements of the tongue 15. By inserting in an arrangement such as the present the coil of an ordinary direct-writing siphon-recorder 21 (suitably shunted) between the tongue 9 of the relay 8 and the second cable 2 a record of all signals that pass into the latter will be obtained. In this case the necessity of vibrating the siphon of the recorder 21 is avoided, there being sufficient power in the battery 5 6 employed to overcome the friction of the siphon on the recorder-paper. Moreover, on long cable-circuits the received signals on the siphon-recorder 21 are improved by the curbing action of the apparatus actuated in the local circuit of the recorder-coil relay, and such arrangement is of utility at a terminal station quite apart from the idea of retransmission. The insertion of a polarized relay 13, shunted with an adjustable condenser with separate battery 14 in that part of the local circuit which includes the central section of the contact-body x z in the manner above described, has also the effect of improving the spacing between the signals retransmitted by the apparatus, and, moreover, when the signal-coil d forms the receiving-circuit in a duplex system there is less "jarring" of the tongue of the local relay from imperfect duplex balancing than otherwise would be the case.

Fig. 5 illustrates the additions to be made to the local circuits when it is required to operate the three electromagnets 22, 23, and 24 of a perforator in connection with automatic transmission. The coils of the electromagnets 22, 23, and 24, which operate the three punches of the perforator, are inserted, together with an electromagnet 25 and battery 26, in the local circuits of the relays 27, 28, and 29, respectively. The tongue 15 of

the relay 13 is connected to the middle of the split battery 5 6 and also to one pole of the separate battery employed in connection with the relay 29. The coils of the two relays 27 and 28 are in series and connected up one terminal to the tongue *h* and the other to one of the fixed stops of the relay 13, the other fixed stop being connected to a terminal of the relay 29. The three tongues of the relays 27, 28, and 29 are connected to one terminal of the transmitter 25, the other terminal being connected to the tongue 9 of the relay 8 to complete the local circuit of the relays 27, 28, and 29 through the coils of the perforator-magnets 22, 23, and 24. The perforator-magnets 22, 24, and 23 operate what are called the "dot," the "central," or "spacing," and the "dash" punches, respectively, of the perforator.

The operation of the above arrangement of apparatus is as follows: When no current is being received from the cable, the contact-tongue *h* rests on the central section *y* of the contact-body *u* and keeps the circuit of the relay 13 closed, thus holding the tongue 15 against that stop which closes the circuit of the relay 29, the result being a current from the battery 26 through the coils of the perforator-magnet 24 and the electromagnet 25. The armature of the electromagnet 25 when attracted applies the battery 30 to the retardation-circuit 7, and after an interval of time dependent upon the amount of retardation of the latter circuit the tongue 9 of the relay 8 is deflected and the circuit of the perforator-magnet 24 and electromagnet 25 interrupted. This succession of operations takes place as long as the tongue *h* rests on the middle section *y* of the contact-body *u*, the result being the perforation of a succession of central holes in the perforator-tape. Whenever a current arrives from the cable 1, the tongue *h* is deflected into contact with the section of the contact-body *u* which corresponds to the received current in direction—say, for example, the section *x*. Directly the tongue *h* leaves the central section *y* the circuit of the relay 13 is broken and the tongue 15 moves into contact with the stop which is connected to one terminal of the two relays 27 28, and thus the circuit of the latter is completed through the battery 5 and the section *x* of the contact-body *u*, the result being the closure of the local circuit of the relay 27, which includes the coils of the perforator-magnet 22 and the electromagnet 25. The relay 28 is not now actuated, as it is polarized in such direction as not to be responsive to current from battery 5. The circuit of the perforator-magnet 22 is interrupted periodically, as before, as long as the tongue *h* is in contact with the section *x* of the contact-body *u*, the result being a succession of perforations on the "dot" side of the tape, one perforation for every attraction of the armature of the perforator-magnet 22. A similar succession of operations of relay 28 takes place on the deflection of the tongue *h* onto the section *z* of the contact-body *u*.

In lieu of the retardation-circuit 7 and the relay 8 at the remote end of it I may employ the curbing-lever mechanism described and diagrammatically illustrated in the specification of Letters Patent No. 577,534, granted to me.

In Figs. 6 and 7 of the drawings accompanying the present specification, 31 is a shaft either frictionally driven from the shaft of the motor, such as is usually employed to drive the paper in connection with the siphon-recorder receiving instrument, or driven by the intermediary of ratchet-wheel and pawl mechanism. Upon this shaft 31 are mounted two cams 32 and 33, one, 32, adapted to actuate the curbing-lever 34 and the other, 33, (shown in broken lines,) intended to engage with a detent 35. An electromagnet 36 releases the detent 35 whenever the tongue 15 of the relay 13 is deflected onto the stop which closes the circuit of the battery 37—*i. e.*, on the deflection of the contact-tongue *h* into contact with one of the outer sections of the contact-body *u*. The speed of the motor is kept constant by means of a suitable governor and is regulated to correspond with the rate of transmission adopted. In Fig. 6 the curbing-lever 34 is connected to the back-stops of the line-transmitter 38 and is arranged when the detent 35 is released to oscillate between the two stops which are connected to the terminals of the split line-battery. In this figure two relays of the post-office type are shown joined up together as the transmitter, the two tongues 39 and 40 being the line and earth levers, respectively. On the arrival of a current from the cable 1 the tongue *h* of the coil *d* leaves the central section of the contact-surface *u* and comes into contact with one of the outer sections thereof, whereupon the corresponding lever 39 or 40 of the local transmitter 38 is deflected into contact with the middle of the split line-battery. At the same time the tongue of the relay 13 is deflected and the circuit of the battery 37 closed through the electromagnet 36, thus withdrawing the detent 35 from the cam 33. The shaft 31 is thereupon revolved by the motor and continues to revolve as long as the detent 35 is kept withdrawn during each revolution, reversing the split line-battery, and thus bringing about the retransmission of a succession of curbed signals corresponding to those sent from the original station. Fig. 7 illustrates a simplification of this arrangement which is employed when it is merely required in accordance with this invention to improve the signals on a siphon-recorder receiving instrument and not to retransmit into another section of cable. The cam 32 through the curbing-lever 34 in this

case breaks the circuit of the siphon-recorder 21 to allow the siphon-marker to return to zero at the end of the period of a signal.

What I claim, and desire to secure by Letters Patent of the United States, is—

In combination, in a telegraphic receiver, a tongue operated through the received impulses, a contact-body upon or against which said tongue makes contact divided into three conducting-sections the two outer of which constitute the terminals of a split battery, a local relay and battery included in a circuit completed through said receiver-tongue and the central conducting-section of said contact-body, and apparatus in the local circuit of the local relay serving to convert into the correct number of separate impulses the effect of any prolonged contact made by said receiver-tongue.

In testimony whereof I have hereunto subscribed my name.

ALEXANDER MUIRHEAD.

Witnesses:
A. F. SPOONER,
J. S. WITHERS.