

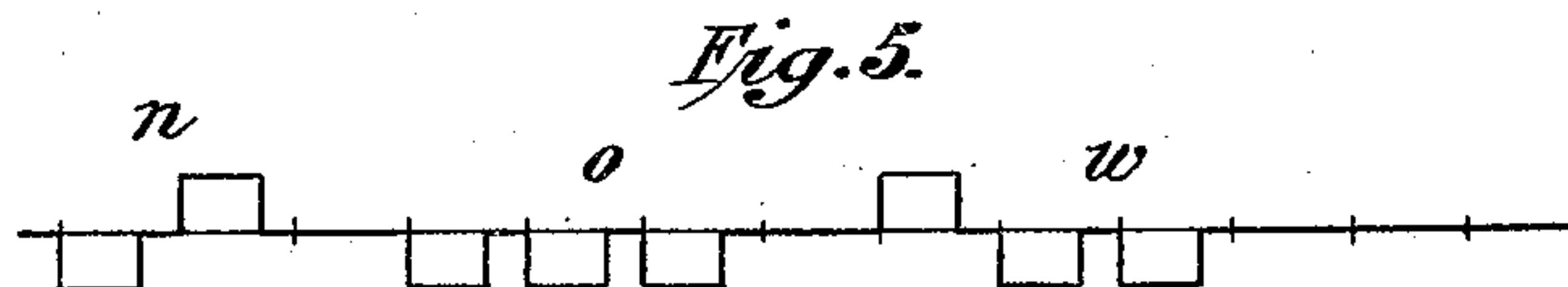
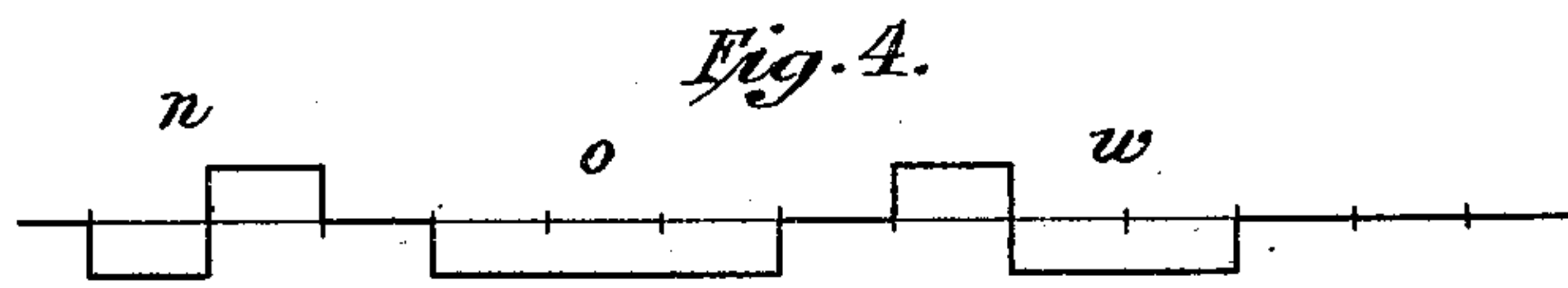
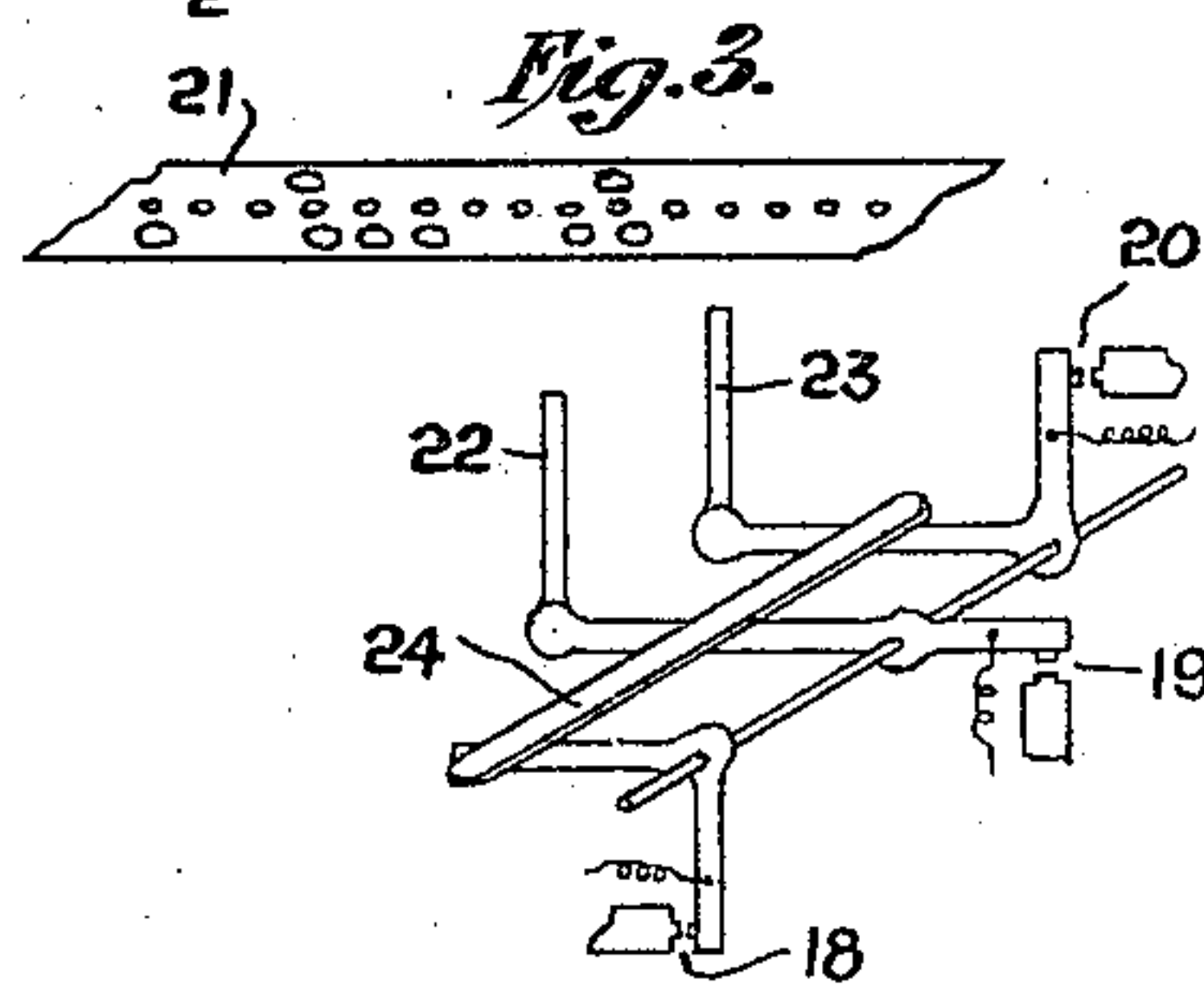
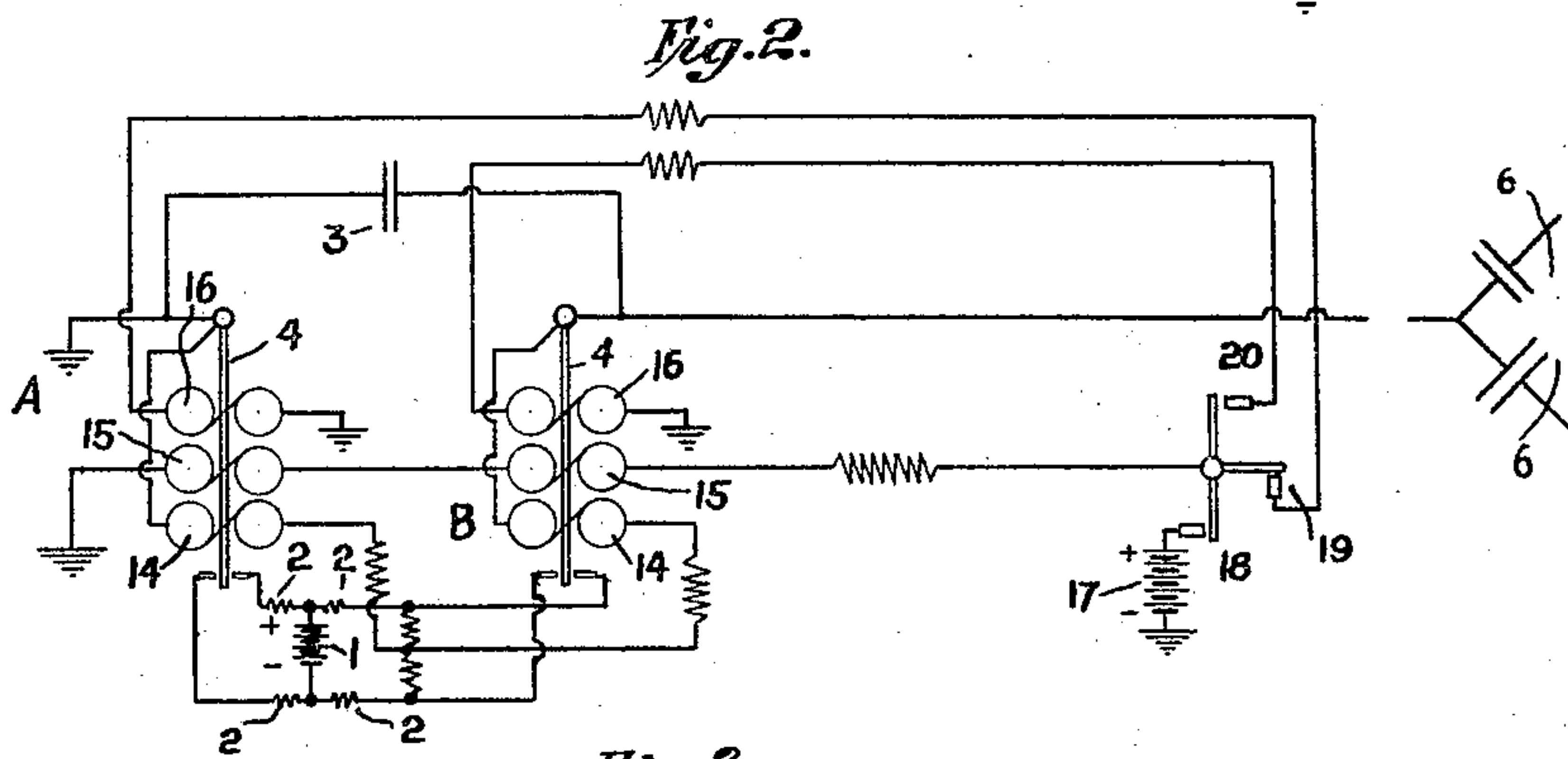
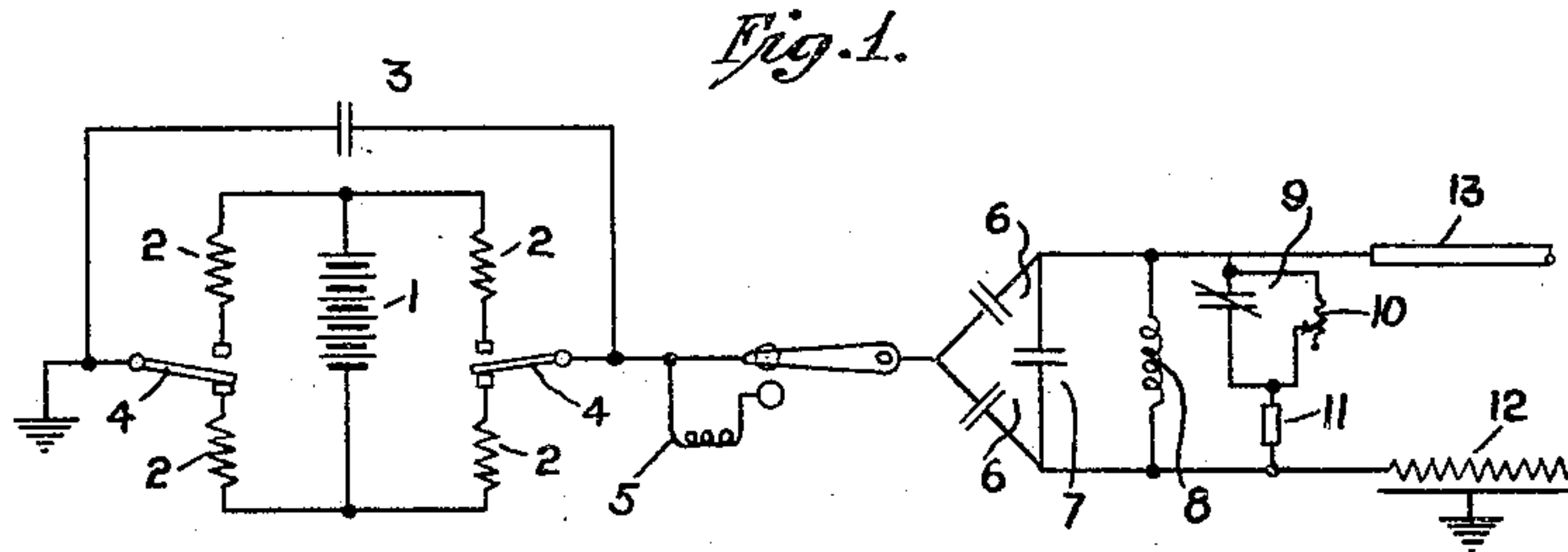
Dec. 19, 1922.

1,439,633.

J. W. MILNOR.

METHOD OF AND APPARATUS FOR TELEGRAPHIC TRANSMISSION.

FILED SEPT. 17, 1918.



WITNESS  
*C. F. Haggerty*  
 C. F. Haggerty

INVENTOR  
*Joseph W. Milnor*  
 BY  
*H. M. Marble*  
 ATTORNEY



## UNITED STATES PATENT OFFICE.

JOSEPH W. MILNOR, OF NEW YORK, N. Y., ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## METHOD OF AND APPARATUS FOR TELEGRAPHIC TRANSMISSION.

Application filed September 17, 1918. Serial No. 254,401.

*To all whom it may concern:*

Be it known that I, JOSEPH W. MILNOR, a citizen of the United States of America, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in the Methods of and Apparatus for Telegraphic Transmission, of which the following is a specification.

My invention relates to a method of and apparatus for telegraphic transmission, particularly duplex telegraphic transmission, through lines of high static capacity, such as long submarine cables. By the term "lines of high static capacity" I mean lines such as it is substantially impracticable to operate by direct application of battery or other source of current to the line and by ordinary contact-making and contact-breaking relays at the receiving end; to the contrary, lines of high static capacity, as that term is employed herein, means lines which must be worked through condensers, and in which the current limitations are such that the receiving instrument must be of the nature of a siphon recorder, or similar very delicate receiving instrument, except as the nature of the receiving instrument may be affected by the so-called "cable magnifiers" which are now coming into extensive use.

My invention comprises improvements in methods and apparatus for telegraphic transmission through such lines of high static capacity, whereby increased speed of operation, particularly in the case of duplex transmission, is obtained, and whereby greater energy is available at the receiving end for the operation of the receiving apparatus. My invention is particularly applicable when a cable magnifier is employed at the receiving end, but is independent of any particular form of magnifier; for example, the magnifier may be of the hot wire type, such as the well known Heurtley magnifier; or it may be a selenium relay or other instrument working upon the principle of movement of a beam of light across an electrically light-sensitive surface; or it may be a magnifier employing the so-called gas relay or audion, as set forth, for example, in my prior application Serial No. 212,331 and 212,332, filed January 17, 1918, now Patents No. 1,378,712, granted May 17, 1921,

and No. 1,415,382, granted May 9, 1922, respectively.

I find that the employment of a magnifier very greatly modifies conditions of cable transmission, making desirable the suppression of certain features which heretofore were thought desirable in cable transmission, and making desirable other features which perhaps would not be desirable if magnifiers were not employed. For example, before the employment of magnifiers, great attention was paid to the obtaining of the largest and best shaped signals possible at the receiving siphon recorder. It was not necessary as a rule to pay great attention to the matter of obtaining as nearly perfect duplex balance as possible, for the reason that at the speeds of transmission practicable without magnifiers, and under the conditions of transmission obtaining without magnifiers, it was usually possible to obtain, without great difficulty, a sufficiently accurate balance. But the introduction of magnifiers produces a quite different condition. When good magnifiers are used, the message capacity of a cable is practically limited only by the accuracy of the duplex balance obtainable; and any device which makes it possible to obtain a better duplex balance, or for any reason decreases the perfection of balance required, materially increases the message capacity of the cable.

As is well known, in the duplex operation of telegraph lines, there is employed, in addition to the main line itself, a so-called artificial line at each transmitting point, which artificial line is supposed to be a duplication, as to resistance and capacity, of the main line. In practice, however, it is found practically impossible to make the artificial line a complete representation, in an electrical sense, of the main line. For example, the main line has its static capacity well distributed throughout its length; yet this distribution may not be even, because the cable line may be built up of various sections, of differing construction; and from time to time the construction of the cable is affected by "patching;" i. e., the replacing of defective sections by new sections. Furthermore, leaks develop in cable lines from time to time, and, until repaired, greatly affect the distribution of capacity in the cable.



Furthermore, the resistance of the main line cable is changing constantly due to change of temperature, and for the obtaining of a perfect balance, constant corresponding readjustment of resistance of the artificial line would be required. It is, therefore, practically impossible to have an artificial line which at all times and under all circumstances absolutely duplicates, in an electrical sense, the main line.

I have found that conditions of operation, particularly when operating duplex, are much improved and a much higher speed of transmission is made possible by modifications in the method of transmission, and in the transmitting apparatus, whereby the rise of current and potential in the line, incident to the closing of the transmitter contacts, is made more gradual; in other words, what may be termed a "cushioning effect" is introduced between the source of current supply and the line; such cushioning being obtained by the introduction of relatively large resistances between the source of current supply and the line; the employment of such relatively large resistances being usually accompanied by the employment of a source of current supply of higher voltage than that commonly employed heretofore. It has not been unusual in ocean cable operation in the past to employ for current regulation relatively small resistances between the source of current supply and the line; such regulating resistances being usually of a few ohms only; but the cushioning resistances which I employ are of much greater value—for example, 50 to 150 ohms each; such higher resistances being usually employed, as above stated, in connection with higher current voltage. In one instance the voltage was increased about 60 per cent.

To further aid in the production of the cushioning effect, I also commonly employ a condenser shunted around the transmitter contacts.

The effect of the high resistance employed and the shunted condenser employed, as above referred to, is to smooth out the rush of current into the cable, which follows the closing of the transmitter contacts. By so smoothing out this rush of current, I find that the effect obtained with an actual imperfect balance between the cable and the artificial line, is practically the same as if that balance were nearly perfect; and thereby a much higher speed of operation is obtainable than would otherwise be practicable.

In addition I have found that improvement in conditions of transmission and reception may be obtained by changing the character of the signals sent by the cable transmitter, so as to increase the power available at the receiving end.

As is well known, in cable transmission in

the ordinary manner, current impulses of one direction denote dots of the telegraph code, and current impulses of the opposite direction denote dashes of that code. Normally, it may be said, there is no current to line; when a dot is to be sent, current of one polarity is put to line, and when a dash is to be sent, current of the opposite polarity is put to line. Between successive current impulses so put to line, of whatever direction, there is usually an interval of no current, termed the "curbing interval." The result is what are known as "curbed signals." In contradistinction to this old method of transmission, I find it better to entirely eliminate the no current interval between current impulses where dots and dashes succeed each other without intervention of regular spaces of the telegraph code. The result is what may be termed "block signals" as distinguished from the former "curbed signals." When two or more dots, or two or more dashes, succeed each other without intervention, one long impulse takes the place of the former successive impulses.

In cable working it is very essential to so shape a wave of current received through the cable that the various dots and dashes composing the letters may be distinguished one from the other. If magnifiers be not employed, the shape of these signals is improved by proper adjustment of the curbing interval commonly employed heretofore, as above mentioned, between impulses; and is also affected by the adjustment of magnetic shunts, receiving condensers, etc., at the receiving end of the cable. But where cable magnifiers are used, I find it desirable that the so-called refining or shaping of the cable signals be done at the receiving end; and to this purpose I do away with curbing intervals between the impulses, and by so doing make it possible to increase the energy transmitted through the cable; for in refining the signals at the transmitting end, by the employment of curbing intervals, and also in refining, at the receiving end, by means of magnetic shunts and receiving condensers, a large part of the energy of the signals is lost. Loss of energy at the transmitting end is particularly undesirable when the balance between the cable and the artificial line is imperfect. Loss of energy at the receiving end, incident to the refining of the received signals, is not so important, however, particularly when a suitable magnifier is in use, especially since there is at the same time a loss of energy of extraneous current (due to errors in balance) even greater than the loss of energy of the useful signals themselves. There is, therefore, a distinct gain to be made, when magnifiers are employed, by the elimination of the curbing intervals, and by the reduction of the detrimental effects of imperfect balance; these being comparative



improvements in so far as reduction of wasted energy and increase of speed of operation are concerned; the relations of these two improvements being so intimate, and their effects cumulatively so important, that it is impossible to distinguish in a practicable sense between improved results which can be laid definitely to the one improvement and improved results which can be laid definitely to the other improvement.

I will now proceed to describe my invention with reference to the accompanying drawings, in which I have illustrated, more or less diagrammatically, apparatus and a method of transmission embodying my invention as above outlined. In the said drawings:

Figure 1 shows, diagrammatically, transmitting and receiving apparatus at one end of a cable arranged for duplex operation; Figure 2 represents, diagrammatically, transmitting apparatus, including relay circuits, adapted for the operation of the telegraph keys of Figure 1; Figure 3 illustrates diagrammatically the application of the mechanism of the well known "Wheatstone" transmitter for the operation of the controlling contacts of the circuits of Figure 2. Figure 4 is a diagram illustrating transmission according to my improved method, without curbing intervals between impulses; and Figure 5 is a similar diagram illustrating, by contradistinction, the former method of transmission employed and embodying the use of curbing intervals.

Referring first to Figure 1: 1 designates a transmission battery, 2, 2 the cushioning resistances referred to, 3 the cushioning shunted condenser referred to, and 4, 4 the transmitter keys, which may be the armature levers of the relays shown in Figure 2. The battery 1 is connected, through the contacts of the transmitter keys, to the apex of the usual Wheatstone bridge arrangement of line and artificial line, the usual block condensers 6 being provided in two arms of this bridge, with a condenser 7 and inductive resistance 8 connected across the bridge, together with the additional shunted condenser 9 and resistance 10 in series with the magnifier 11 in the cross wire of the bridge. 12 designates the artificial line and 13 the main line or cable forming the other two arms of the bridge. It will be obvious that the resistance 2 and condenser 3 materially cushion the rise of potential in the line 13 and artificial line 12 upon the closing of the transmitter contacts 4; which cushioning has, as I have explained above, the effect of materially improving the conditions as to balance between the main and artificial lines; producing the effect of a much more perfect balance than actually exists.

While it would be possible to operate the transmission keys 4 by means other than

hereinafter described, or even to operate them by hand, yet the means shown for operating these keys, shown in Figures 2 and 3, is convenient and desirable. In Figure 2, the keys 4 constitute the armature levers of relays A and B, each relay having three windings, shown in Figure 2 as separate spools 14, 15, and 16, though it will be understood by those skilled in the art that instead of separate spools these windings might all be on the same spool. 17 designates a source of current supply for the operation of the relays, and 18, 19, and 20 are contacts, closed by the operation of the mechanism shown in Figure 3, for the transmission of dots or dashes; 19 being a contact closed for the transmission of dashes, 20 a contact closed for the transmission of dots, and 18 a grounding contact closed for the transmission of either dots or dashes. In Figure 3, 21 designates the perforated message tape of the Wheatstone transmitter, 22 and 23 designate the feelers of that transmitter, and 24 designates a member, operated by the usual cam mechanism of the Wheatstone transmitter, whereby the feelers 22 and 23 are alternately permitted to press against the paper strip 21 and then withdrawn therefrom. It will be apparent that as the feelers 22 and 23 are permitted to press against the paper strip, one or the other of such feelers will be permitted to pass through the strip if a perforation of the strip be opposite that feeler, and thereby a dot or a dash contact will be closed. The grounding contact 18 is opened and closed periodically at regularly recurring intervals whether or not the dot contact, or the dash contact, be closed. If the operating speed of the cable be 5 cycles per second, the contact 18 will close ten times in each second.

Normally, the armature levers 4 of relays A and B are held locked against the particular contacts with which such armatures happen to be in contact at the moment, by a small current from battery 1 through windings 14 which are in a high resistance circuit. Closing of the dash contact 19 closes circuit from battery 17 through contact 18 and contact 19 and winding 16 of relay A to return; also, from battery 17 through contact 18 and winding 15 of relays A and B to return; and as a result the armature of B is moved to the left (if not already at the left) while the armature of relay A is moved to the right (if not already at the right); for, the circuit of winding 16 being of lower resistance than of winding 15, exercises a preponderating influence on the armature of relay A. By the closing of contacts resulting from this movement of the armatures, the transmitting battery 1 is placed to line in a direction for sending a "dash" impulse.

If, on the other hand, "dot" contact 20 be closed, then circuit is completed from bat-



tery 17 through contact 20 and winding 16 of relay B, circuit being completed as before through windings 15 of the two relays; and as a result the armature of relay B is moved to the right (if not already there) while the armature of relay A is moved to the left (if not already there). As a result of the contacts thus formed by the armatures of the relays, the cable battery 1 is placed to line in a direction suitable for the transmission of a dot impulse.

As above stated, contact 18 is broken and closed periodically, whether or not either of contacts 19 and 20 are closed; and as a result the circuit through windings 15 of the two relays is broken and closed periodically; but during such periods of broken circuit, the locking circuit through windings 14 persists, holding the armatures of the relays in the positions occupied. One thing to be provided for in the obtaining of "block" signals from a mechanical transmitter is, the obtaining of the "zero" periods or "spaces," as for example, the spaces between letters, words and sentences, without losing the block character of the signals. This condition is provided for by the contact 18. If, now, in transmission, such a space occurs, contact 18 is closed by the action of the transmitter, while contacts 19 and 20 are prevented from closing, and circuit is completed from battery 17 through winding 15. As a result the armature of relay A is moved to the left (if not already there) and the armature of relay B is also moved to the left (if not already there). As a result the connection of the line to the cable battery through the line condenser is replaced by a connection to ground through the line condenser; and thus the spacing signal is transmitted.

It will be seen that by the transmitting arrangement of Figure 2 the transmitting keys 4 are always thrown instantaneously from one side to the other and in such manner that, practically speaking, the transmission battery 1 is always to line in one sense or the other, curbing intervals being thereby eliminated.

In some cases I find it desirable to employ an inductive resistance 5 between the transmitting arrangement and the line and artificial line, as indicated in Figure 1; this in addition to the ohmic resistances 2 and shunted condenser 3.

It will be noted that according to my invention adjustments of apparatus, etc. for the purpose of shaping the signals, are to be made altogether at the receiving end; the condensers 7 and 9, inductance 8 and resistance 10, together with various features commonly provided in connection with the magnifier, or with the receiving instrument operated by the magnifier, or provided between the receiving instrument and the magnifier, affording ample opportunity for

the shaping of the signals. According to my invention, every effort is made to give the maximum power to the impulses transmitted, (while at the same time cushioning the transmission of these impulses into the line and artificial line, as above stated, to avoid troubles due to imperfect duplex balance), so that the impulses as received at the receiving end may be of as great power as possible.

I have shown diagrammatically in Figure 4 the uncurbed or "block" signals preferred to be used in cable transmission, as above described, and, in Figure 5, I have shown, by contrast, the same signals as transmitted by the ordinary or "curbing" method. In these figures I have shown characters *n*, *o*, and *w*, as transmitted by uncurbed signals and by curbed signals respectively. By comparison between Figure 4, showing the preferred method of transmission, and Figure 5, showing the hitherto common method of transmission by curbed signals, the distinction between the block signals and the curbed signals will be apparent.

What I claim is:

1. The method of improving the balance between the main and the artificial lines in the transmission of telegraphic signals through submarine cables and lines of high static capacity, which consists in transmitting the signals in block form, the impulses being unseparated from one another by curbing spaces, and cushioning the sudden rise of current.

2. The method of improving the balance between the main and the artificial lines in the transmission of telegraphic signals through submarine cables and lines of high static capacity, which consists in transmitting the signals in block form, the impulses being unseparated from one another by curbing spaces and interposing a non-reactive opposition to the sudden rise of current.

3. The method of improving the balance between the main and the artificial lines in the transmission of telegraphic signals through submarine cables and lines of high static capacity, which consists in transmitting the signals in block form, the impulses being unseparated from one another by curbing spaces, and restraining the sudden rise of current without reactive effect.

4. In a telegraph system, the combination with a submarine cable or transmission line of high static capacity, of means for nullifying the distorting effect of an imperfect balance between the cable and the artificial line, comprising means to transmit the signals in block form, and a non-inductive cushioning resistance interposed between the source of current supply and the cable of sufficient value to prevent the sudden rise of current.



5. In a telegraph system, the combination with a submarine cable or transmission line of high static capacity, of means for nullifying the distorting effect of an imperfect balance between the cable and the artificial line, comprising means to transmit the signals in block form, a non-inductive cushioning resistance interposed between the source of current supply and the cable of sufficient value to prevent the sudden rise of current, and a condenser shunted around the transmitting means.

6. In a telegraph system the combination with a source of current supply and a line, of means for supplying current of one sign or the other at will from said source to said line comprising two transmitting keys, electro-magnetic operating means for said keys comprising for each a holding winding and two other windings opposed relatively to each other and arranged the

one to exert a weaker influence than the other, and means controlling the flow of current through said relatively opposed windings and comprising two contacts arranged to be closed alternatively and at will and one controlling the stronger of the two opposed windings of the one key and the other the stronger of the two opposed windings of the other key, together with a third contact closed when either of the first two mentioned contacts is closed and controlling the weaker of the opposed windings of said two keys.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

JOSEPH W. MILNOR.

Witnesses:

ALAN STANDISH DANA,  
RANDOLPH LEDORN.