Sept. 7, 1926.

1,599,382

J. W. MILNOR

AMPLIFYING TELEGRAPHIC SIGNALS

Original Filed June 11, 1924 2 Sheets-Sheet 1

Fig. 1.

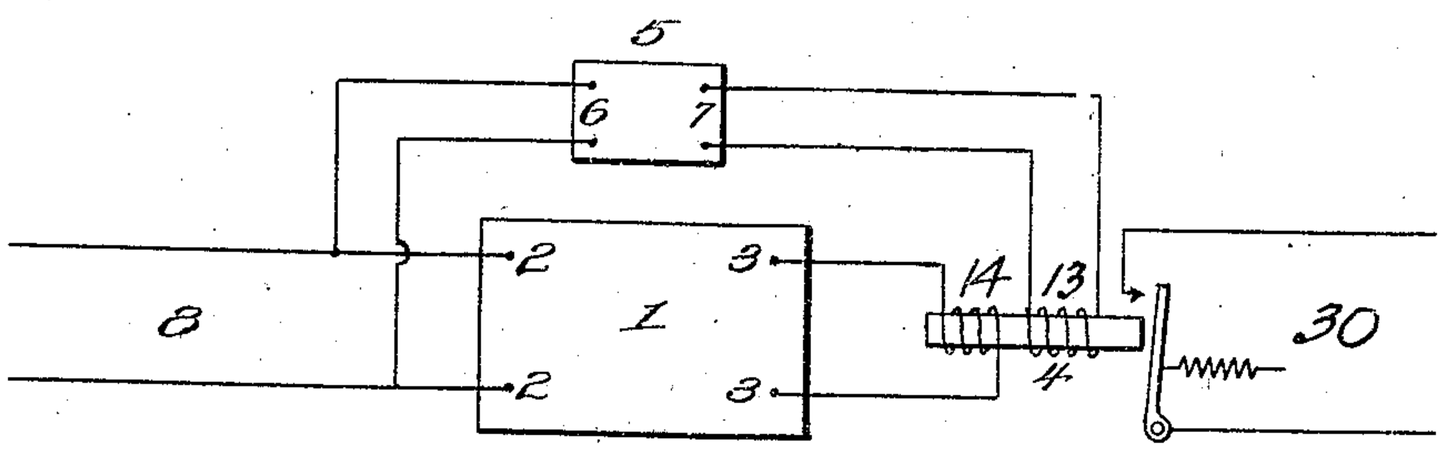


Fig. 2.

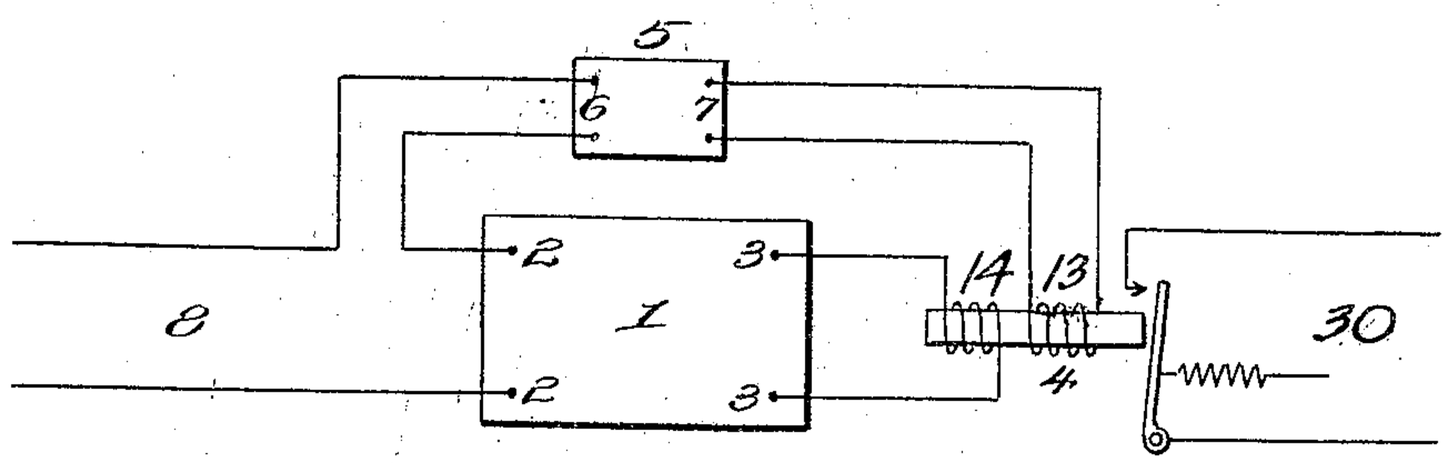
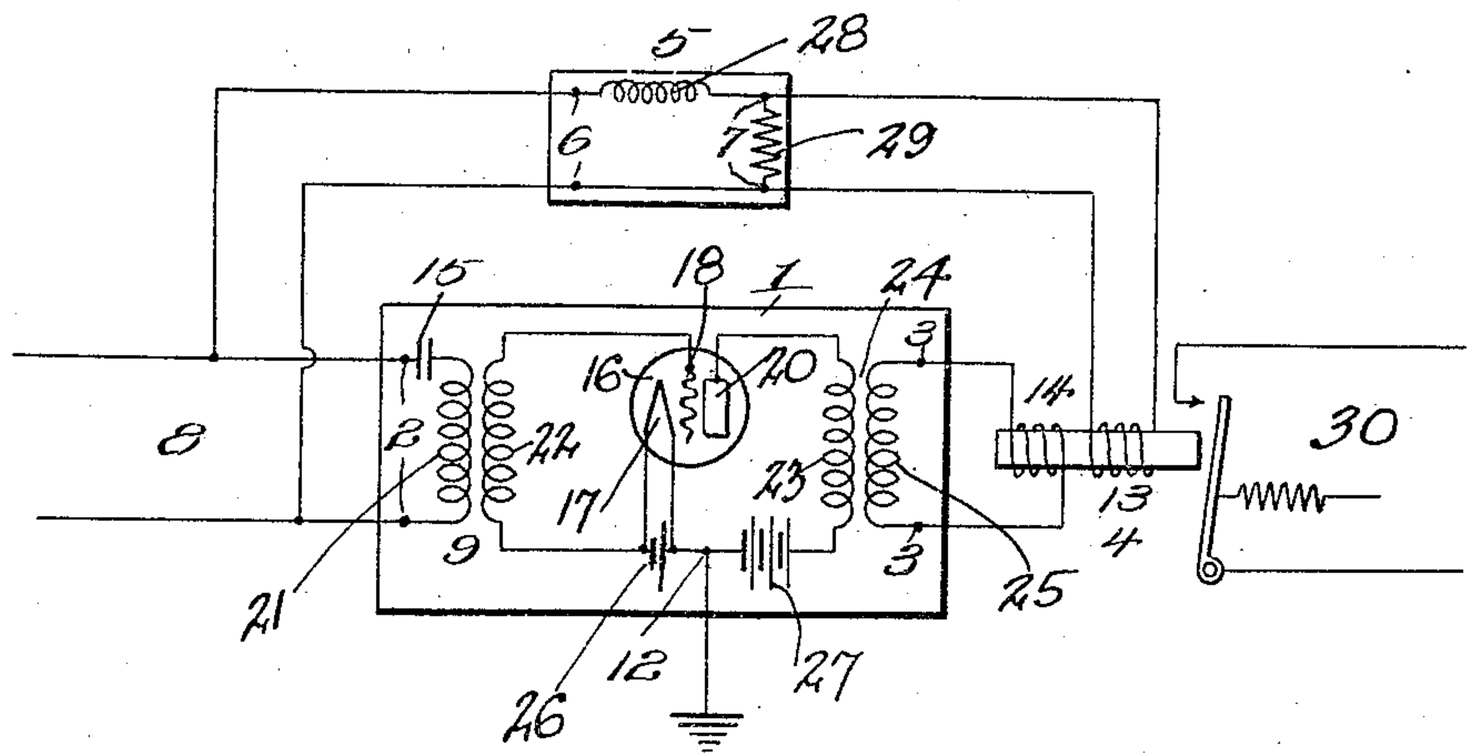


Fig. 3.



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Original Filed June 11, 1924 2 Sheets-Sheet 2

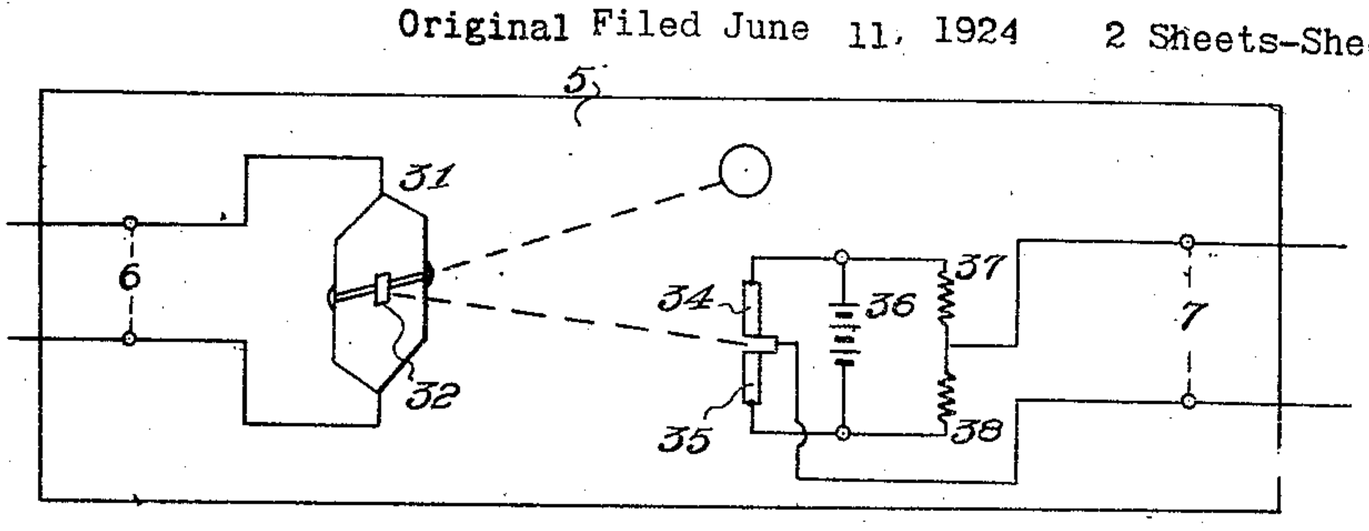

Fig. 4

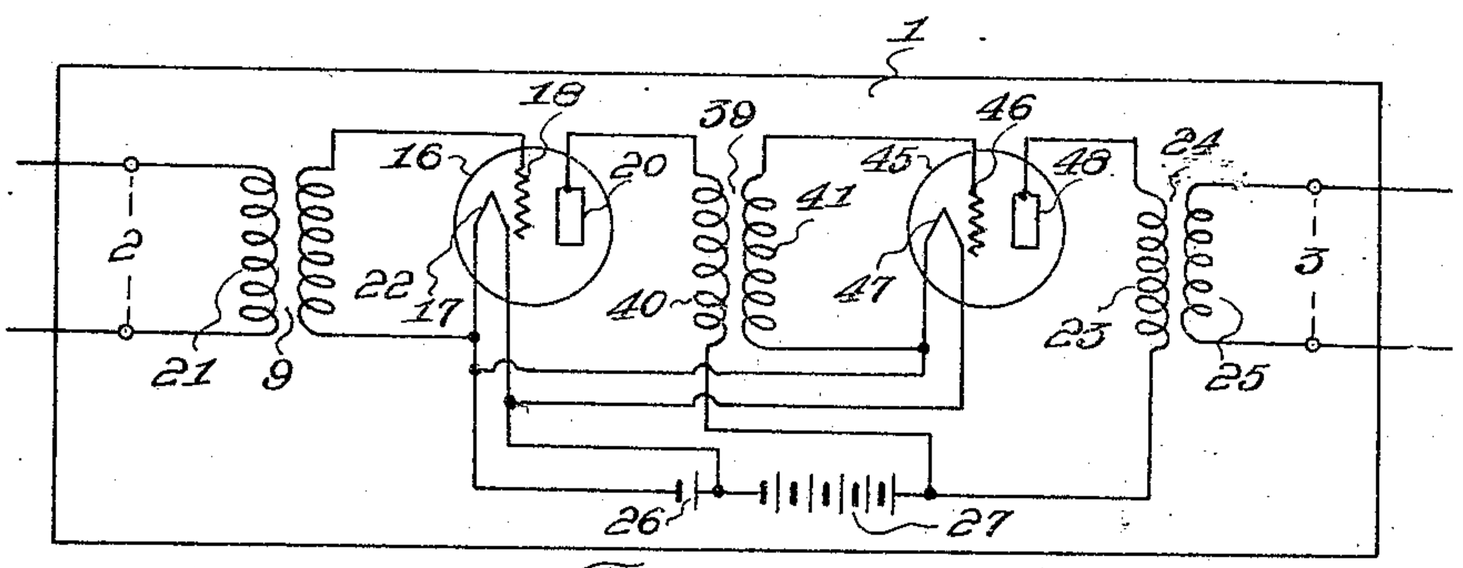

Fig. 5

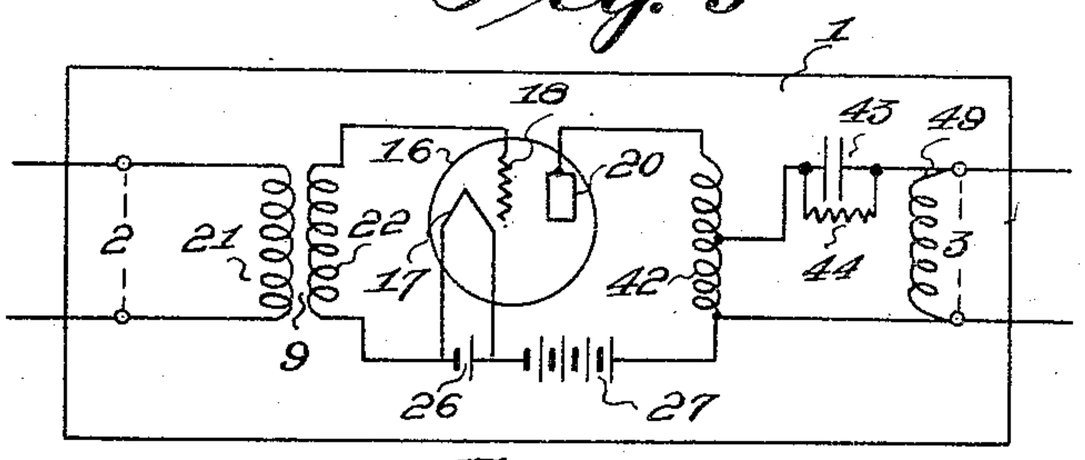

Fig. 6

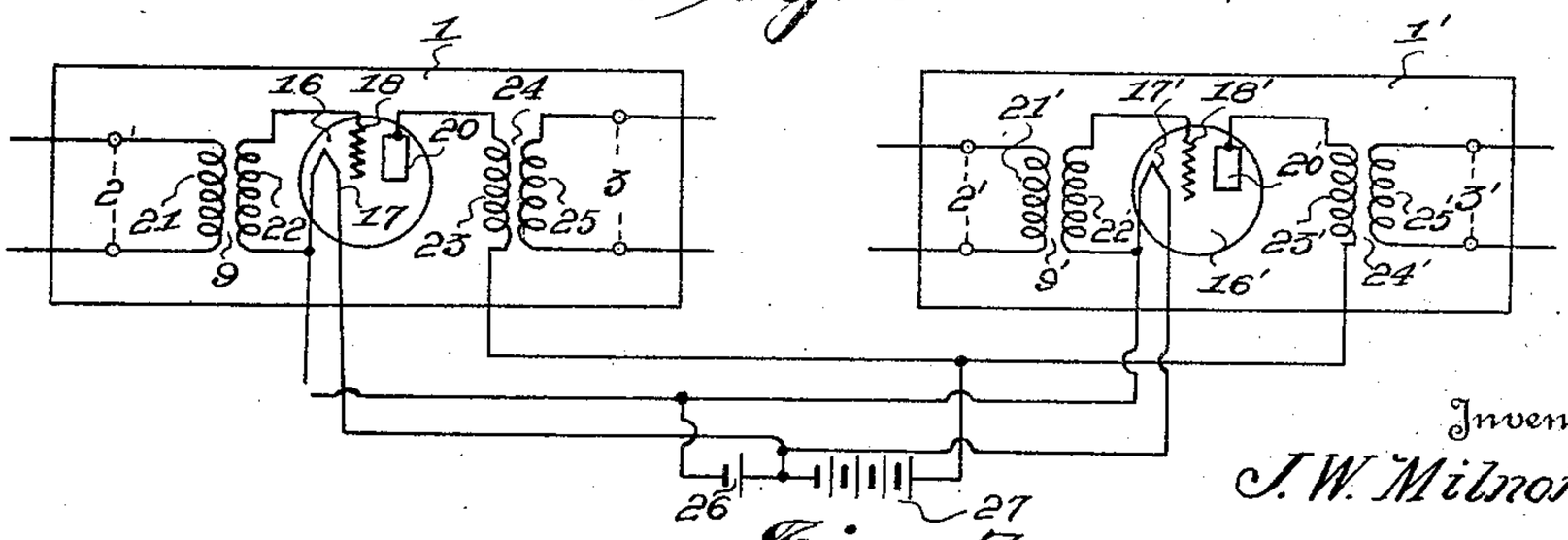

Fig. 7

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Patented Sept. 7, 1926. 1,599,382

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.

AMPLIFYING TELEGRAPHIC SIGNALS.

Application filed June 11, 1924, Serial No. 719,411. Renewed July 29, 1926.

My invention relates broadly to amplification systems for electrical currents and more particularly to a circuit arrangement for amplifying received telegraphic signals.

One of the objects of my invention is to provide an amplification system for electrical current particularly applicable to a system in which telegraphic signals from land lines or ocean cables are amplified or magnified through the agency of one or more electron tubes.

Another object of my invention is to provide an amplification system for line wire telegraphic operation where a plurality of components of the telegraphic signals may be efficiently impressed upon a responsive device.

Still another object of my invention is to provide a circuit arrangement for magnifying the feeble high frequency current components of telegraphic signals and causing them to actuate a responsive device while low frequency or direct current components of the signals are by-passed around the magnifying system to actuate the responsive device.

The electron tube is especially convenient for magnifying signals of telephonic or radio frequencies. Difficulties are encountered when attempts are made to apply the tube for magnifying telegraphic signals because of the low frequency of operation, and particularly because it becomes desirable, if not absolutely necessary for the magnifier, to be able to pass not only alternating currents of low frequency, but direct currents as well. When applied for magnifying telephonic frequencies, an electron tube is usually operated in conjunction with intervalve transformers. A transformer for use with low frequency telegraph currents has a number of inherent disadvantages among which may be mentioned inefficiency and expensive construction. The transformer coupled multistage amplifier is limited to operation with alternating currents and will not pass direct currents.

In order to increase the amplitude of feeble direct currents, transformer coupling may be supplanted by a resistance method of coupling. However, resistance coupling is undesirable in many respects for it is inefficient and has a smaller voltage amplification per stage than is produced in inductively coupled circuits.

In the present invention, the electron tube is used for the magnification of the higher frequency components only, of the received telegraphic signals. The lower frequency components of the telegraphic signals and the direct current components are usually present in such strength that it is unnecessary to magnify them to any extent. The latter current is passed directly from the line into the apparatus or responsive device for reception or recording of signals, through a suitable impedance for controlling the signals.

My invention will be more clearly understood from the following specification by reference to the accompanying drawings in which;

Figure 1, is a diagrammatic illustration showing my improved amplification system for electron tubes where the by-pass circuit for the low frequency and direct current components of the telegraphic signals is parallel connected with the amplification circuit which transfers the high frequency alternating current components of the telegraphic signals;

Figure 2, is a diagrammatic illustration of the combination amplification system wherein the by-pass circuit is series connected in the input circuit of the high frequency amplifier; and

Figure 3, is a detailed wiring diagram showing the arrangement of an electron tube amplifier and by-pass circuit for the low frequency and direct current components of the signals.

Figure 4 is a diagrammatic illustration illustrating an alternate arrangement for the low frequency or direct current by-pass circuit of Figures 1, 2 and 3, embodying a magnifier of the selenium type.

Figure 5 illustrates another modification of my amplifier in which a plurality of electron tubes are employed.

Figure 6 is a diagram showing an arrangement of my amplifier in which the capacity, resistance and inductance are also used to shape the high frequency components of the currents.

Figure 7 is a diagram illustrating an embodiment of my invention in which I use a common battery for the cathode and space current circuits for a plurality of amplifiers.

Telegraphic signals of any description

may be considered to be composed of alternating currents of a range of frequencies. The frequencies of importance range from direct current (or a current of zero frequency) to a current at a frequency which is approximately twice as high as the fundamental or "dot" frequency of the telegraph signals. Ordinarily the low frequency components are passed through the telegraph line and system without great loss. The components of higher frequency become much weakened in transmission through the line and it frequently becomes quite important to provide apparatus which will increase the strength of the components of the line signals at the higher frequencies.

My present invention accomplishes this desired result by the provision of a network for the transfer of the low frequency or direct current components of the received telegraphic signals from the line to the responsive device. This network may be parallel or series connected with the input circuit of the electron tube amplifier, the energy dividing at this point and the relatively weak high frequency alternating current components of the signal passing through the electron tube amplifier to the responsive device.

Referring more particularly to the drawings, reference character 8 represents the line system from which weak telegraphic signals are received. Numeral 4 represents a receiving, relaying or recording device, hereinafter referred to as a responsive device, in which the magnified signals are received, and may be used either for operating local translating devices, such as sounders, printers, etc., or may be used for working or repeating into another line section. The electrical signal magnifier or amplifier is represented at 1 and may be of any type although as represented in Figure 3, an electron tube amplifier is particularly applicable in increasing the feeble received current to such an amplitude that the responsive device functions with accuracy. Numeral 5 represents an impedance network containing resistance, inductance and capacity in any desired combination for modifying the shape of the signals. In lieu of a network 5 a magnifier may be interposed in the circuit. That is to say, 5 might be a magnifier of the selenium type which is a relatively slow acting magnifier, while 1 might be a magnifier of the vacuum tube type. Of the current received from line 8, a portion is passed directly to receiver 4 through network 5. The remainder of the received current is passed through amplifier or magnifier 1.

The input terminals of the network 5 have been represented by reference numeral 6, while the output terminals are shown at 7. The current components of the higher frequency are magnified by amplifier 1 and passed into the responsive device 4. The action of responsive device 4 is therefore controlled partly by the lower frequency currents received through network 5, and partly by the higher frequency magnified current received through the amplifier 1. Responsive device 4 may control any desired circuit as represented at 30. The amplifier 1, in addition to magnifying the signal, may also contain resistance, inductance and capacity in any combination for shaping the signals. The electron tube amplifier used in the system may include a plurality of tubes, but for purposes of illustration, the amplifier has been shown as consisting of electron tube 16 having filament electrode 17, grid electrode 18, and plate 20. The line 8 terminating at 2—2, is electrically connected with the input circuit of the amplifier 1 by coupling coils 21 and 22 of transformer 9. Current of high frequency from line 8 will pass through condenser 15 and energize primary coil 21 of amplifier 1. Secondary coupling coil 22 is connected with filament electrode 17 and grid electrode 18, comprising the input circuit of the electron tube 16. The output circuit of the tube 16 includes primary winding 23 of coupling transformer 24, inductively coupled with secondary winding 25, having terminals 3—3, delivering the high frequency current component to the circuit of the responsive device 4, including winding 14. The cathode 17 is heated from battery 26 and space current supplied from battery 27. It will be understood that while only a single stage of electron tube amplification has been shown that any desired number of tubes may be used with a plurality of intervalve coupling transformers.

The network 5 may contain any desired combination of inductance, resistance and capacity, and for illustrative purposes it is shown as containing inductance 28 and resistance 29.

It will be observed that only direct current and alternating current of low frequency from line 8 will reach coil 13 of responsive device 4, through network 5, while current of higher frequency passes through amplifier 1 and is magnified and impressed upon winding 14 of the responsive device 4.

The amplifier circuit may be grounded as shown at 12, reducing the tendency of the system to oscillate. This is a particular feature of my circuit arrangement, the system being rendered non-oscillatory to all practical purposes. Where the line systems terminate in a telegraph office and employ a number of electron tube amplifiers connected in accordance with my invention, I am enabled to employ a common battery system for the cathode and space current circuits without undesired electrical reactions be-

tween the several circuits, as illustrated in Fig. 7.

I have shown in Figure 4 a magnifier of the selenium type to be substituted for the network 5. 31 is a moving coil of the D'Arsonval galvanometer type, 32 is a mirror attached to or driven by the coil 31, 33 is light source including an optical system, 34 and 35 are selenium cells forming two arms of a Wheatstone bridge, 37 and 38 are resistances forming the remaining arms of the bridge, 36 is a battery connected across one diagonal of the bridge, with output leads 7 connected across the other diagonal of the bridge. The bridge is normally balanced so that with the light beam in its zero position no current flows in the output leads. The direct current and low frequency components of the telegraph signals will cause the coil 31 to deflect in one direction or the other depending upon the polarity of the signals. thus rotating the mirror 32 and deflecting the light beam 50, so that more of the light beam rests on selenium cell 34 and less on cell 35, or vice versa, depending upon the polarity of the signals. This causes the electrical resistance of cell 34 to decrease and of cell 35 to increase, or vice versa, thus unbalancing the bridge. Hence a current, which is an amplified reproduction of the low frequency and direct current components of the telegraph signals, flows in output leads 7. The characteristics of this magnifier are such that it is insensitive to high frequencies, and hence it will have a relatively unimportant effect on the high frequency components of the signals.

In Figure 5, I have shown an alternate organization for the arrangement 1, for amplifying the high frequency components in which a plurality of electron tubes are used, which includes, in addition to the arrangement shown in Fig. 3, the intervalve coupling transformer 39, with primary winding 40 and secondary winding 41; electron tube 45, having filament electrode 47, grid electrode 46 and plate 48. The action here is similar to that of the amplifier 1 of Figure 3, described elsewhere, except that, due to the use of a plurality of tubes, a higher degree of amplification is secured.

In Figure 6, I have shown the amplifier for the high frequency components of the signal currents in which the capacity 43, resistance 44 and inductance 49 also serve to shape the high frequency components. I have also shown the use of an auto-transformer 42 instead of the usual transformer, in the output of the electron amplifier.

In the operation of my circuit arrangement, the energy received over the line is divided, the relatively weak portions of the received signals being amplified, and other portions of the received energy not magnified but passed directly to the responsive device, the action of the responsive device being controlled partly by the current from the magnifier, and partly by the current taken directly from the line.

While I have described my invention in certain particular embodiments, it will be understood that modifications may be made and that no limitations upon the invention are intended other than are imposed by the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is as follows:

1. An amplification system for electrical signals having a plurality of differing current components, comprising in combination, a source of signal energy comprising components having different characteristics, an input circuit conductive to certain of said components, an amplifier connected with said input circuit, an output circuit connected with said amplifier, connections between said output circuit and a responsive device, and an electrically conductive circuit conductive to other of said components between said source of signal energy and said responsive device, whereby said amplifier operates to transfer current components of one characteristic to said responsive device while said electrically conductive circuit operates to transfer current components of differing characteristics also to said responsive device.

2. An amplification system for electrical signals having a plurality of differing components, comprising in combination, a source of signal energy comprising components having different characteristics, an input circuit conductive to certain of said components, an amplifier connected with said input circuit. an output circuit connected with said amplifier, connections between said output circuit and a responsive device, and means electrically conductive to certain of said current components to which said amplifier is non-conductive for also impressing a plurality of current components upon said responsive device.

3. A signal receiving system comprising in combination, a source of signal energy comprising components having different characteristics, a responsive device actuated by substantially all of said components, and a plurality of parallel electrical paths each responsive to differing current components of said signal energy connected between said source of signal energy and said responsive device, whereby a plurality of current components of said signal energy are caused to simultaneously actuate said responsive device.

4. A signal receiving system comprising in combination, a source of signal energy comprising components having different characteristics, a responsive device actuated

by substantially all of said components, a plurality of parallel electrical paths each responsive to differing current components of said signal energy connected between said source of signal energy and said responsive device, and means in one of said paths for increasing the amplitude of the current components therein, whereby all of said current components are caused to actuate said responsive device.

5. A system for receiving telegraphic signals having a plurality of differing current components comprising in combination a line circuit, a responsive device actuated by substantially all of the components of the received signals, an amplifier for increasing the effect of high frequency current components of said received signals upon said responsive device, and a separate circuit connected between said line circuit and said responsive device for also impressing low frequency and direct current components of said signals upon said responsive device.

6. A system for receiving telegraphic signals having a plurality of differing current components comprising in combination a line circuit, a responsive device actuated by substantially all of the components of the received signals, and a pair of circuits connected between said line circuit and said responsive device, one of said circuits operating to impress high frequency current components of the received signal upon said responsive device, and the other of said circuits operating to impress low frequency and direct current components of said signal upon said responsive device.

7. A system for receiving telegraphic signals having a plurality of differing current components comprising in combination a line circuit, a responsive device actuated by substantially all of the current components of the received signals, a pair of circuits connected between said line circuit and said responsive device, one of said circuits operating to impress high frequency current components of the received signal upon said responsive device, and the other of said circuits operating to impress low frequency and direct current components of said signal upon said responsive device, and means interposed in one of said circuits for increasing the amplitude of the current component therein.

8. A system for receiving telegraphic signals having a plurality of differing current components comprising in combination a line circuit, a responsive device actuated by substantially all of the current components of the received signals, a pair of circuits connected between said line circuit and said responsive device, one of said circuits operating to impress high frequency current components of the received signal upon said responsive device, and the other of said circuits operating to impress low frequency and direct current components of said signal upon said responsive device, and means interposed in said first mentioned circuit for increasing the amplitude of said high frequency current components upon the responsive device.

9. A system for the reception of telegraphic signals having components of differing characteristics comprising in combination a line wire circuit, an electron tube amplifier having input and output circuits, a responsive device, connections between said line wire circuit and the input circuit of said amplifier for impressing high frequency current components of said signals thereon, connections from the output circuit of said amplifier to said responsive device and separate means connected between said line wire circuit and said responsive device for impressing low frequency and also direct current components of said signals upon said responsive device.

10. A system for the reception of telegraphic signals having components of differing characteristics, comprising in combination a line wire circuit, an electron tube amplifier having input and output circuits, a responsive device, connections between said line wire circuit and the input circuit of said amplifier for impressing high frequency current components of said signals thereon, connections from the output circuit of said amplifier to said responsive device, and an impedance circuit connected between said line wire and said responsive device for transferring low frequency and direct current components of said signals upon said responsive device.

11. A system for the reception of telegraphic signals having components of differing characteristics comprising in combination a line wire circuit, an electron tube amplifier having input and output circuits, a responsive device, connections between said line wire circuit and the input circuit of said amplifier for impressing high frequency current components of said signals thereon, connections from the output circuit of said amplifier to said responsive device, and a circuit containing a plurality of electrically conductive elements connected between said line wire and said responsive device for transferring low frequency and direct current components of said signals upon said responsive device.

12. A system for the reception of telegraphic signals having components of differing characteristics, comprising in combination a line wire circuit, an electron tube amplifier having input and output circuits, a responsive device, connections between said line wire circuit and the input circuit of said amplifier for impressing high frequency current components of said signals thereon,

a connection from the output circuit of said amplifier to said responsive device, and a network connected between said line wire circuit and said responsive device for transferring low frequency and direct current components of said signals upon said responsive device, whereby said responsive device is operated simultaneously by all of said current components.

13. The method of receiving telegraphic signals which consists in receiving a plurality of current components of the telegraphic signals over a line, dividing the current components thus received into two sets, amplifying one set of current components and causing them to actuate a responsive device and impressing the other set of current components directly upon said responsive device.

14. The method of receiving telegraphic signals which consists in receiving a plurality of signal current components of varying degrees of strength over a line, dividing the weak current components of said telegraphic signals from the stronger current components thereof, amplifying the weak current components and impressing them upon a responsive device and directly impressing said stronger current components upon said responsive device.

15. The method of receiving electrical signals having a plurality of differing current components, which consists in dividing the current components received, amplifying and modifying the wave shape of one set of said components and causing them to actuate a responsive device and also impressing another set of said current components upon said responsive device.

16. A signal receiving system as set forth in claim 4, one of said paths containing means for shaping the wave shape of the current components passing therethrough.

17. A signal receiving system comprising in combination, a source of signal energy, comprising components having different characteristics, a responsive device actuated by substantially all of said components, a plurality of parallel electrical paths each responsive to differing current components of said signal energy connected between said source of signal energy and said responsive device, and means in more than one of said paths for increasing the amplitude of the current components therein, whereby all of said current components are caused to actuate said responsive device.

18. A signal receiving system as set forth in claim 4, one or more of said paths containing means for shaping the wave shape of the current components passing therethrough.

In testimony whereof I affix my signature.

JOSEPH W. MILNOR.