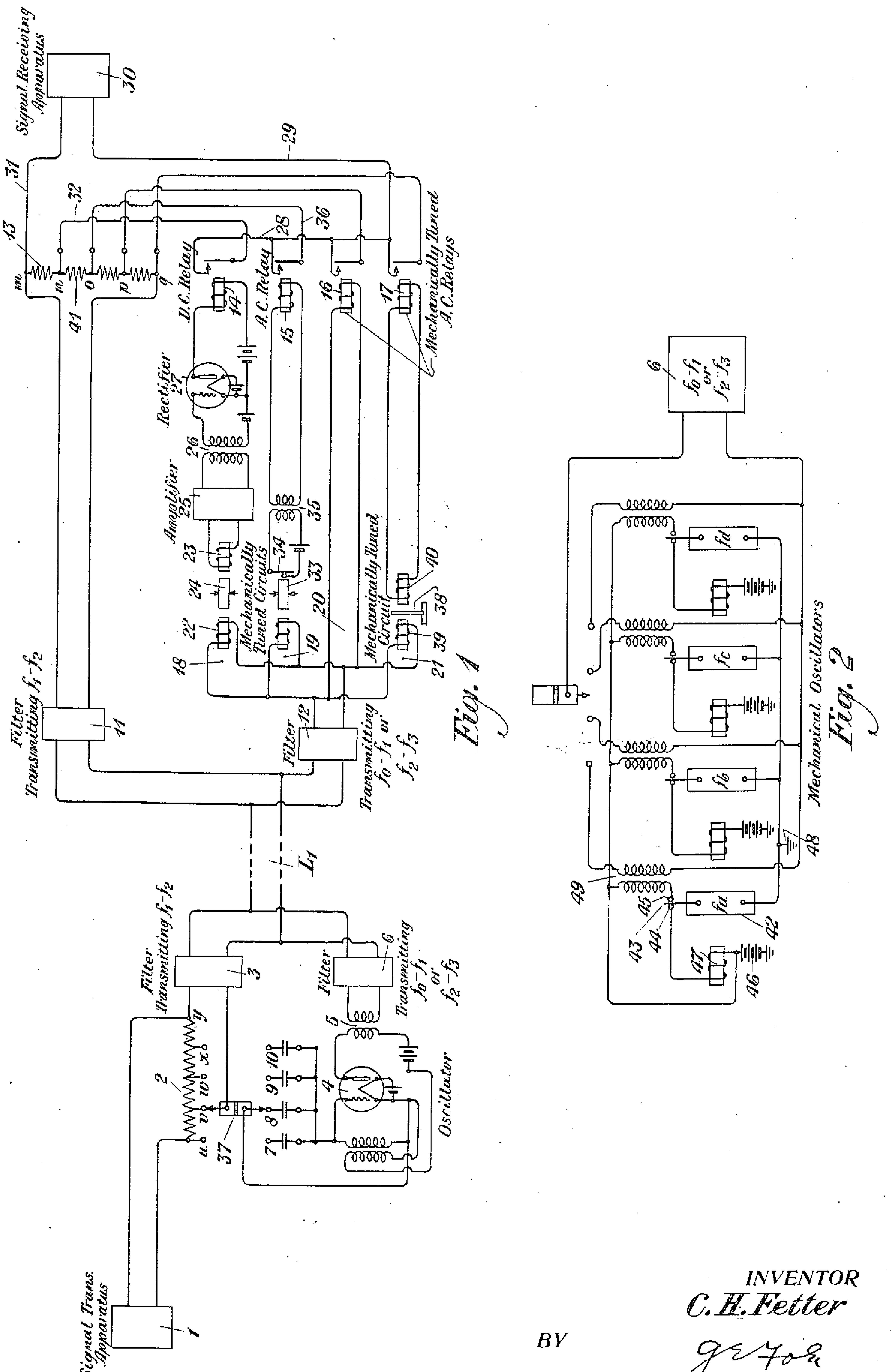
Oct. 7, 1930. C. H. FETTER 1,777,355

TRANSMISSION LEVEL CONTROLLING DEVICE

Filed Sept. 8, 1926 2 Sheets-Sheet 1



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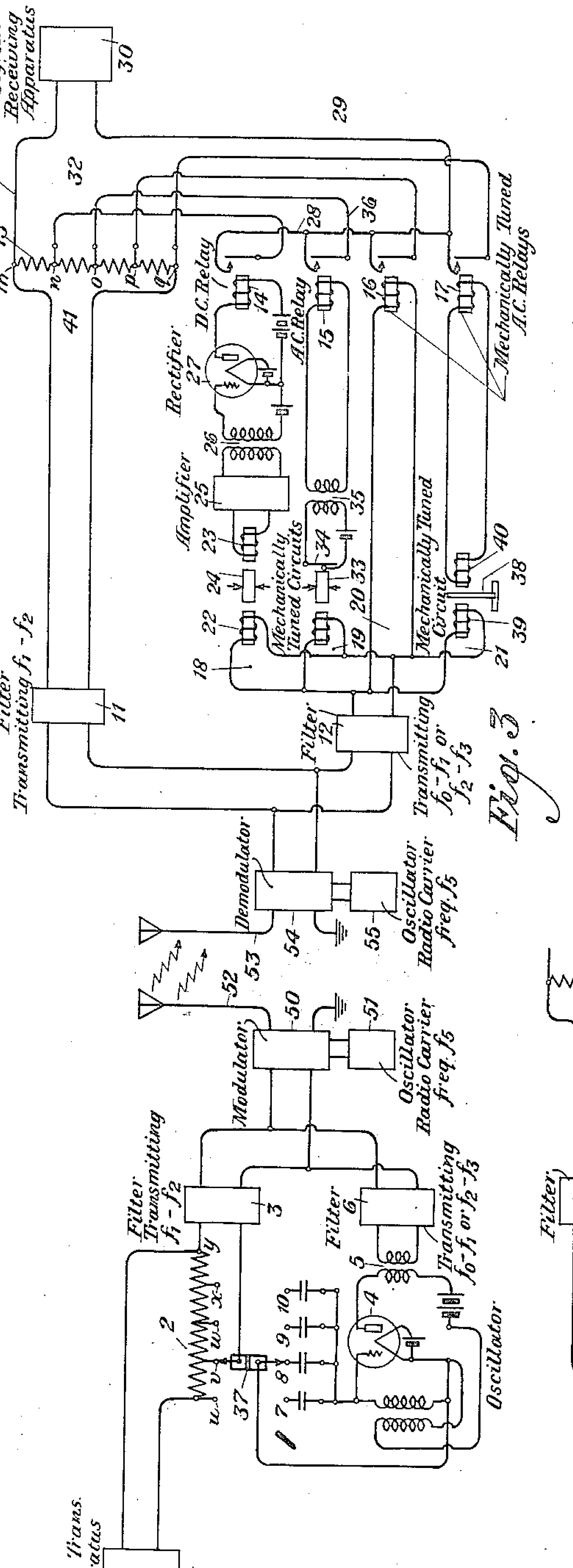

Fig. 3

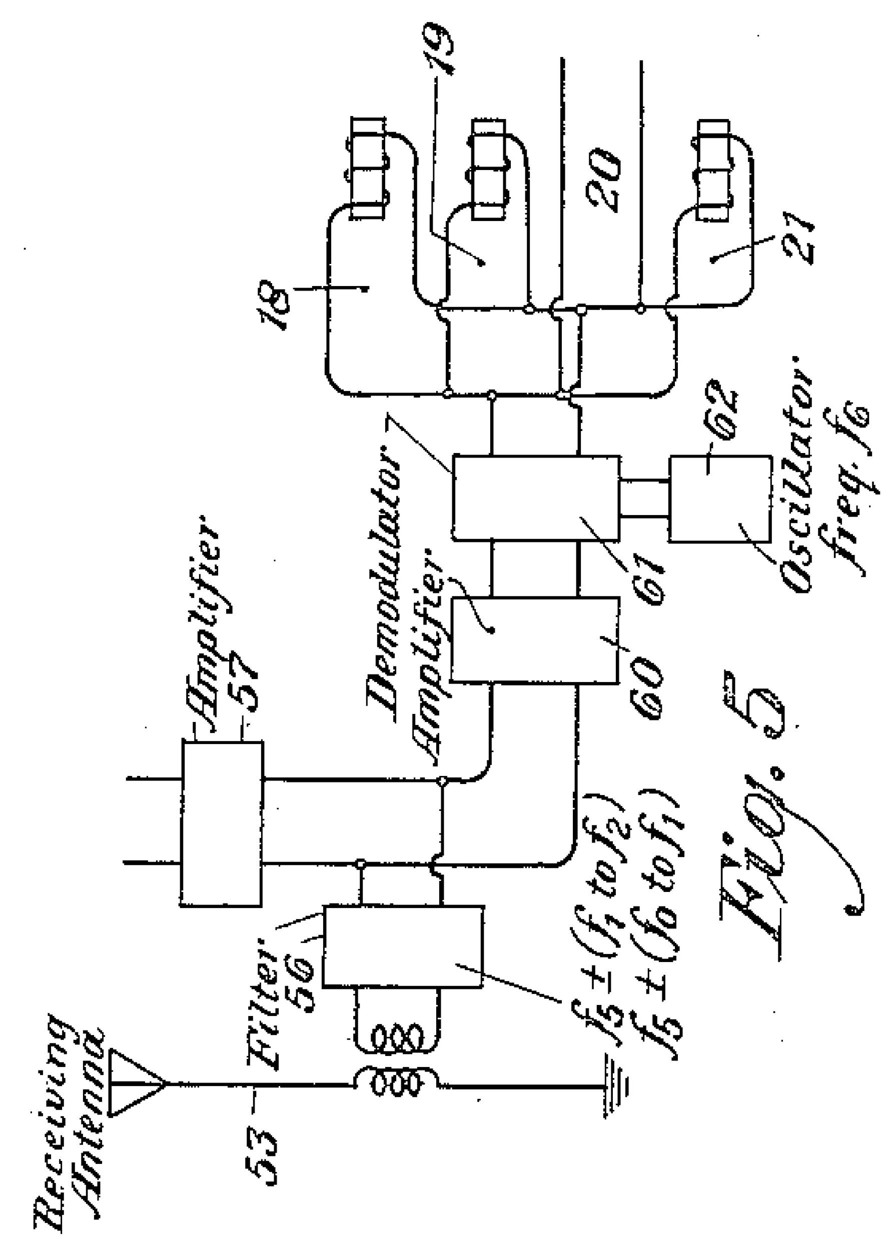

Fig. 5

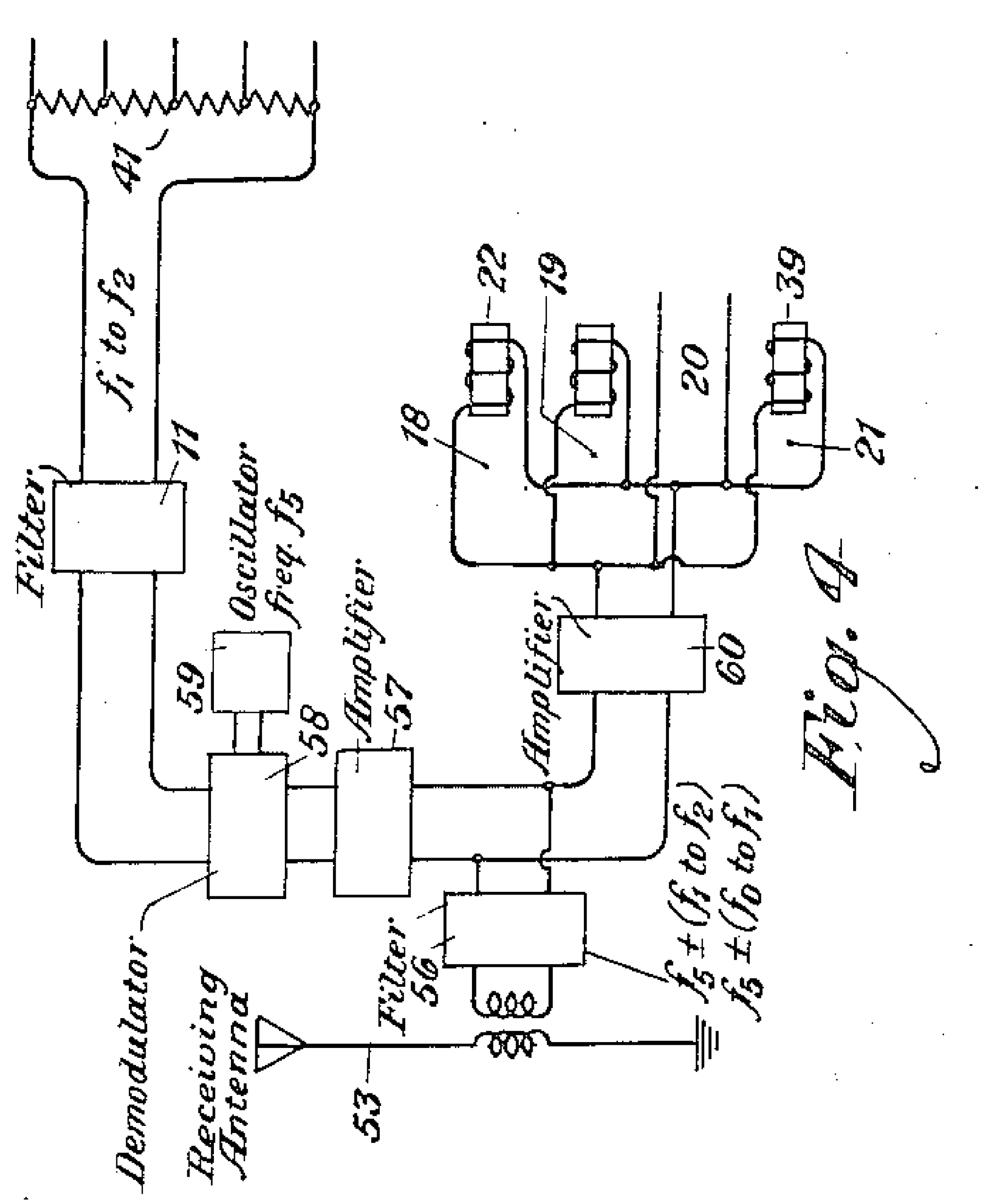

Fig. 4

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UNITED STATES PATENT OFFICE

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TRANSMISSION-LEVEL-CONTROLLING DEVICE

Application filed September 8, 1926. Serial No. 134,309.

This invention relates to transmission level controlling devices, and particularly to a system employing mechanically tuned circuits and devices for effecting the simultaneous operation of the gain-control devices at the sending and receiving ends of the transmission system.

It is of course well known to those skilled in the art that it is both desirable and necessary to control the volume of transmission simultaneously at both ends of a circuit, the change being effected by potentiometers arranged so that an increase or decrease in gain at the transmitting end produces a decrease or increase in gain at the receiving end, thereby maintaining constant the overall equivalent of the circuit. These changes result in keeping the transmission within a predetermined range, the upper limit of which represents the level that will tend to produce cross-talk or to overload the tubes, and the lower limit represents the noise level of the transmission path. The simultaneous regulation of the gain control devices at the sending and the receiving ends of a transmission circuit has, in certain of the systems of the prior art, employed a control current of a single frequency as shown in the patent to A. B. Clark, No. 1,565,548 that issued on December 15, 1925, or a plurality of frequencies as shown in the patent to I. G. Wilson, No. 1,704,850, dated March 12, 1929, which were transmitted from the sending end to the receiving end over a transmission circuit separate from the signal transmission circuit. Where a plurality of frequencies are employed as shown in the Wilson patent one frequency increases the gain at the receiving station, and the other frequency decreases the gain. In such systems it has been customary to use electrically tuned circuits or filters to select the frequencies transmitted over the common control circuit and to lead them into their respective circuits by which the gain control device at the receiving end is operated. While these selective circuits may each be tuned to permit the flow of maximum current at a particular frequency it is well known that they will permit current to flow at other frequencies lying on each side of the particular frequency the magnitude of the current depending upon the separation of the frequency from the point of resonance. Therefore in order to prevent the simultaneous operation of the terminal apparatus connected with two selective circuits it is necessary to space the control frequencies widely apart. This of course limits the number of steps of variations that may be derived from a limited range of available frequencies. Thus, for example, where a speech band, representing the frequencies between say 100 and 6,000 cycles, is transmitted, the frequencies from 0 to 100 cycles, and from 6,000 cycles upward, may be employed for control purposes. It is, of course, desirable to get the greatest number of control frequencies out of the range available below and above the speech frequencies.

It has been found that by employing mechanically tuned circuits it is possible to employ control frequencies that are fairly close together in the frequency spectrum without causing interference at the receiving end of the circuit due to the simultaneous response of two or more of the control devices connected with the selective circuits employed.

It is the object of this invention to effect the regulation of the level of a transmission system by means of an arrangement employing mechanically tuned circuits and devices whereby the greatest economy of frequencies available for such control is effected.

This invention will be clearly understood from the following description when read in connection with the attached drawing of which Figure 1 shows schematically a form of embodiment of the invention; Fig. 2 is a detail illustrating the use of mechanical oscillators for producing the control frequencies; Fig. 3 shows the application of the invention to a radio signaling system; Fig. 4 shows in fragmentary form a modification of the receiving circuit in which the mechanically tuned devices operate at the received radio frequency; and Fig. 5 shows in fragmentary form a modification in which the control waves, as received, may be changed to any desired frequency for actuating the mechanically tuned devices.

In Fig. 1, 1 represents a signal transmission apparatus. This may be of any well known type capable of transmitting either voice or carrier frequencies. The output side of this apparatus is connected with the potentiometer 2 which controls the voltage impressed across the filter 3 which is connected between the potentiometer and the line L_1. This filter is arranged to transmit frequencies f_1-f_2, which, for example, may represent the speech band. Also connected with the line L_1 is an oscillator 4. The output side of the oscillator is connected by the transformer 5 with the input side of the filter 6. The other side of this filter is connected with the line L_1. The filter is capable of transmitting the frequencies f_0-f_1 and f_2-f_3, namely, the band of frequencies below the speech band and above the speech band. The oscillator is capable of producing any one of a plurality of frequencies, depending upon which of the condensers 7 to 10, inclusive, is connected with the input circuit of the tube.

The line L_1 at its receiving end is connected with two branches, one of which contains the filter 11, transmitting the speech band, and the other the filter 12, transmitting the control frequencies. The output side of the filter 11 is bridged across the potentiometer 13 having a plurality of taps taken therefrom which are connected with the armatures of the relays 14, 15, 16, and 17 of the branch control circuits at the receiving terminal. The number of branch circuits depends upon the number of control frequencies being transmitted from the sending end of the line. Four frequencies and four terminal circuits have been chosen for the purpose of illustrating this invention, but the number may vary in accordance with the requirements of particular cases. The branch circuit 18 is connected with the magnet 22 of the mechanically tuned circuit. This tuned circuit comprises magnet 22, which sets up in the winding 23 a voltage of predetermined frequency, which effect is brought about by the tuned bar 24. Both magnets 22 and 23 are permanent magnets. When, therefore, an alternating voltage is applied to coil 22 the end of the bar 24 adjacent to coil 22 will vibrate in accordance with the impressed voltage. This vibration will be transmitted mechanically and longitudinally through bar 24 and will, through the motion of the end of the bar adjacent to coil 23, set up a voltage in coil 23 of frequency corresponding to that of the frequency impressed upon coil 22. If the bar be of length equal to one half the wave length of the impressed frequency which it is desired to transmit, standing waves will be set up and the voltage induced in coil 23 will be a maximum. For frequencies other than that for which the bar is designed the voltage in coil 23 will be very much less. For example, if it is desired to transmit 10,000 cycles through a steel bar which will propagate longitudinally at say 500,000 cm. per sec., the bar would have a length of

$$\frac{500,000}{10,000\times 2}$$

or 25 cm. The vibration of this bar serves to vary the magnetic field of the winding 23 and causes a voltage to be set up across the terminals of this winding the frequency of which is the oscillating frequency of the bar 24. It has been found possible to construct bars that will vibrate within a very narrow range of frequencies so that a circuit employing such mechanically tuned devices is more highly selective than ordinary tuned electrical circuits. The mode of constructing mechanically tuned relays is set forth in detail in the patent to N. H. Ricker, 1,543,124 that issued on June 23, 1925. This patent not only describes in detail the theory underlying such relays, but also shows in Fig. 3 thereof how much more sensitive the mechanical relay is than a resonant electrical circuit. The said figure is described on Page 5 of Ricker's patent, lines 78 to 90.

The voltage set up in the winding 23 may be amplified by the device 25, if necessary, and, as amplified, impressed by the transformer 26 upon the rectifier 27. Connected with the output side of the rectifier is a direct current relay 14, which may be either biased or marginal so that it will not operate upon the normal plate current but will respond to abnormal currents produced by the incoming control signals. When relay 14 operates a circuit will be established from the contact of the relay over the conductors 28 and 29 to the signal receiving apparatus 30, thence over conductor 31 to and through that portion of the potentiometer between m and n, thence over conductor 32 to the contact of relay 14. It will be seen therefore that when this relay operates the voltage impressed upon the signal receiving apparatus 30 is the drop in potential between the points m and n of the potentiometer.

The branch circuit 19 is connected with a mechanically tuned circuit which differs from that shown in connection with the terminal circuit 18 in that the tuned bar 33 is in contact with the carbon button of the transmitter 34 so that vibrations set up in the bar 33 will produce variations of current in the circuit of the transmitter. These current variations flowing through the primary of the transformer 35 will produce an alternating current in the circuit with the secondary, which circuit includes an alternating current relay 15. This relay need not be tuned to the particular frequency of the tuned bar 33 inasmuch as the frequency selection will be made by the mechanical tuned circuit of which 33 forms a part. The operation of relay 15 serves to connect the receiving apparatus 30 across the points *m* and *o* of the potentiometer, so that the voltage drop across this portion of the potentiometer will be impressed upon the receiving apparatus.

The branch circuit 20 has connected therewith a relay 16, which is tuned to respond to the frequency represented by the setting of the control arm 37 at the transmitting station upon the contact connected with condenser 9. Relay 16 may be of any type, but a desirable form is that disclosed in the patents to Thompson, No. 1,555,893, dated October 6, 1925 and No. 1,692,961, dated November 27, 1928. The closing of the contact of this relay serves to connect the apparatus 30 across that portion of the potentiometer between *m* and *p*.

The branch circuit 21 is connected with a mechanically tuned circuit which differs slightly from those connected with circuits 18 and 19. The circuit connected with 21 employs a reed 38 whose frequency of vibration depends upon its mass and the stiffness at the point of support. This reed will respond to oscillations produced by the winding 39 and will serve to set up a voltage of the frequency to which it is tuned in the winding 40. This voltage serves to operate the relay 17 which connects the receiving apparatus 30 across the terminals *m* and *q* of the potentiometer.

It is desirable to point out that it is not necessary to have different forms of branch terminal circuits in order to effect the proper control of the potentiometer connected with the receiving apparatus. Four different types of terminal circuits have been shown to illustrate different ways in which frequency selection may be made by mechanical devices. It is of course obvious that each of the circuits 18 to 21, inclusive, may be equipped with the apparatus shown in connection with circuit 18. In that case selection of the desired frequency and discrimination against other frequencies are effected by the proper proportioning of the tuned bar 24. Likewise each of the branch circuits could be equipped in the manner shown in connection with circuit 19 or as shown in circuit 20 or 21.

The manner in which the system operates is as follows: Let it be assumed that the upper contact of the arm 37 is upon the point *u* of the potentiometer 2 at the transmitting end, and the lower contact is connected with the condenser 7. As thus positioned, the full signal voltage will be impressed on the line L_1, and similarly oscillations of a frequency determined by the condenser 7 and the inductance of the input circuit will also be transmitted through the filter 6 to the line L_1. At the receiving station, the signal frequencies will pass through the filter 11, and since the maximum signal voltage was impressed across the transmitting end of the line the maximum voltage will be impressed across the potentiometer 41 with which the receiving apparatus 30 is connected. The control frequency will pass through the filter 12 and will be impressed upon all the branch circuits but assuming that the apparatus connected with the circuit 18 is tuned to the control frequency being transmitted, that circuit only will respond. The rectified voltage will operate the relay 14, thereby serving to connect the receiving apparatus 30 across a small portion of the potentiometer, namely, that between the points *m* and *n*. As the signal voltage impressed upon the line L_1 is cut down by moving the arm 37 so that its upper contact touches *v* and its lower contact is connected with the condenser 8, a different control frequency will be generated and transmitted over the line L_1 which will operate only the selective apparatus connected with the circuit 19. This in turn operates relay 15 which increases the voltage impressed upon the apparatus 30 by connecting the latter across the terminals *m* and *o* of the potentiometer 41. In like manner the voltage impressed across the apparatus 30 will be increased as the signal voltage, impressed upon the line L_1 at the sending end, is decreased, the increase being effected by the transmission of predetermined control frequencies from the sending end and the response to highly selective mechanical tuned circuits or devices at the receiving end.

The arrangement shown in Fig. 2 represents a mechanical oscillator which may be substituted for the electrical oscillator shown at the sending end of Fig. 1. In Fig. 2 the element 42 is a tuned reed which will vibrate at a frequency determined by its mass and stiffness. This reed causes the vibration of a diaphragm 43 with which are connected the carbon buttons 44 and 45. Current from the source 46 will flow through the winding of the magnet 47, thence through the button 45, diaphragm 43, reed 42 to ground. As the reed vibrates it will cause variations in the current through the primary of transformer 49, the frequency of the variations being the same as the frequency of vibration. These current variations will produce an alternating current in the circuit connected with the secondary of the transformer, which current will be transmitted through the filter 6 to the branch terminal circuits at the receiving station. By employing a plurality of similarly constructed but differently tuned oscillators the required number of control frequencies may be produced.

While the invention has been disclosed as applied to a wire circuit it is of course equally applicable to a radio circuit by substituting transmitting and receiving antennæ for the line L_1, as shown in Fig. 3, and by employing apparatus well known to those skilled in the art for the production of the radio frequencies. In Fig. 3 the oscillations that pass through the filters 3 and 6 are impressed upon the modulator 50 that has an oscillator 51 connected therewith to charge the frequencies of the oscillations in order that they may be radiated from the antenna 52 to the antenna 53 at the receiving station. The received oscillations will be demodulated by 54 having a source of oscillations 55 of frequency f_5 connected therewith which frequency is the same as that produced by the oscillator 51. The band f_1-f_2 will be selected by the filter 11 and impressed upon the signal receiving apparatus, and the control band f_0-f_1 will be transmitted by the filter 12 to the control circuits.

The schematic arrangements which have just been discussed have a practical application, principally by virtue of the very great selectivity which it is possible to obtain in a mechanical system. This selectivity results from the fact that the operation of such a mechanical system requires appreciable time, that is, a small fraction of a second. For that reason, the arrangement is quite positive in its action in that any extraneous transient frequencies will have practically no effect on the system. It would, therefore, be practicable to operate such a pilot channel, for example, on a transatlantic radio circuit at a level which would require a very small output from the transmitters and at the receiving end might correspondingly fall well below the noise level as determined for signal transmission. However, even though the pilot channel control frequency were on the edge of the signal band, it would probably operate more satisfactorily and at the same time require very little output from the transmitting tubes, inasmuch as the band width required for the transmission of a suitable number of frequencies is very narrow.

It is possible to operate these mechanically tuned circuits within certain limits at the carrier frequencies involved in transatlantic radio of, for example, 60 kilocycles. It is, therefore, possible to have the control frequency source at the sending end a low frequency source and instead of converting it back into low frequency at the receiving end, it could be used directly to operate these circuits, as shown in Fig. 4. In the arrangement shown, the filter 56 will pass the signal band and the control band transmitted by the carrier f_5. The signal oscillations as amplified by 57 would be beaten in the demodulator 58 by oscillations of frequency f_5 produced by 59. The filter 11 would pass the signal band f_1-f_2 to the signal apparatus. The mechanically tuned devices connected with the control circuits 18, 19, 20, and 21 would respond if properly designed and adjusted to the control oscillations at the radio frequencies. Furthermore, it would be possible by having a beating oscillator on the output of the pilot channel filter to allow the receiving end circuits to operate on any range of frequencies desired independent of the frequency range at the source. The use of such an arrangement, which is shown in Fig. 5, might make it easier to design receiving apparatus as far as frequency is concerned.

In Fig. 5 the received oscillations as amplified by 60 would be beaten in the demodulator 61 with oscillations of the frequency f_6 produced by 62. By choosing the magnitude of the frequency f_6 it is possible to make the control oscillations resulting from demodulation meet the frequency requirements of the mechanically tuned devices connected with the branches 18, 19, 20, and 21.

While the invention has been disclosed in a particular form, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a signaling system characterized by the provision of means for maintaining constant the overall transmission equivalent, the combination with a transmission circuit of a source of control oscillations, connected with the said transmission circuit, and having means to vary the frequency at will, a source of signal oscillations also connected with the said transmission circuit, the said connection including means to vary at will the voltage applied by the said source of signal oscillations to the said transmission circuit, means to simultaneously control the said frequency varying means and the said voltage varying means, a plurality of receiving circuits also connected with the said transmission circuit, one having means to select the signal oscillations and means to receive the selected signal, the others having mechanically resonant means to select the control oscillations and means responsive to the latter oscillations to control the voltage of the selected signal oscillations applied to the signal receiving apparatus.

2. In a signaling system characterized by the provision of means for maintaining constant the overall transmission equivalent, the combination with a transmission line of a source of signal oscillations, a source of control oscillations differing in frequency from

the said signal oscillations, both sources being effectively connected with the said line to send signal and control oscillations thereover, means to vary the voltage of the signal oscillations applied to the said line and simultaneously to vary the frequency of the control oscillations, and a receiving circuit also connected with the said line having branch circuits, one having means for the selective reception of signal oscillations and the other for the selective reception of control oscillations, the signal branch circuit including a filter to transmit the signal oscillations thereto, a signal receiving apparatus and a potentiometer to control the voltage of the signal oscillations as applied to the said signal receiving apparatus, the control branch circuit including a filter to transmit control oscillations thereto, a plurality of mechanically tuned devices each responsive to oscillations of a fixed frequency that differs from the frequencies to which the other devices are responsive, and a plurality of relays, each controlled by one of said tuned devices to effectively connect said signal receiving apparatus across a portion of the said potentiometer.

3. In a signaling system characterized by the provision of means for maintaining constant the overall transmission equivalent, the combination with a transmission line of a source of signal oscillations, a source of control oscillations differing in frequency from the said signal oscillations, both sources being effectively connected with the said line to send signal and control oscillations thereover, a potentiometer connected between said source of signal oscillations and the said line and so related to the source of control oscillations that the frequency of the latter will be varied with changes in the setting of the potentiometer, a signal receiving circuit also connected with the said line including signal receiving apparatus, a filter adapted to pass the signal oscillations, a plurality of mechanically tuned devices each responsive to a particular frequency of the said control oscillations and means responsive to the operation of the said tuned devices to control the voltage of the received signal oscillations as applied to the said receiving apparatus.

4. In a signaling system characterized by the provision of means for maintaining constant the overall transmission equivalent, the combination with a transmission line, of a source of signal oscillations effectively connected with the said line, the connection including means to control the voltage applied to the said line, a source of control oscillations, the frequency of which may be varied at will also effectively connected with the said line, and a receiving circuit connected with the said line including signal receiving apparatus, filtering means to separate the signal oscillations from the control oscillations and to apply signal oscillations to the said receiving apparatus, a plurality of mechanically tuned devices, each responsive to a particular control frequency, and means controlled by the said tuned devices to govern the voltage of the selected signal oscillations as applied to said signal receiving apparatus.

In testimony whereof, I have signed my name to this specification this 7th day of September, 1926.

CHARLES H. FETTER.