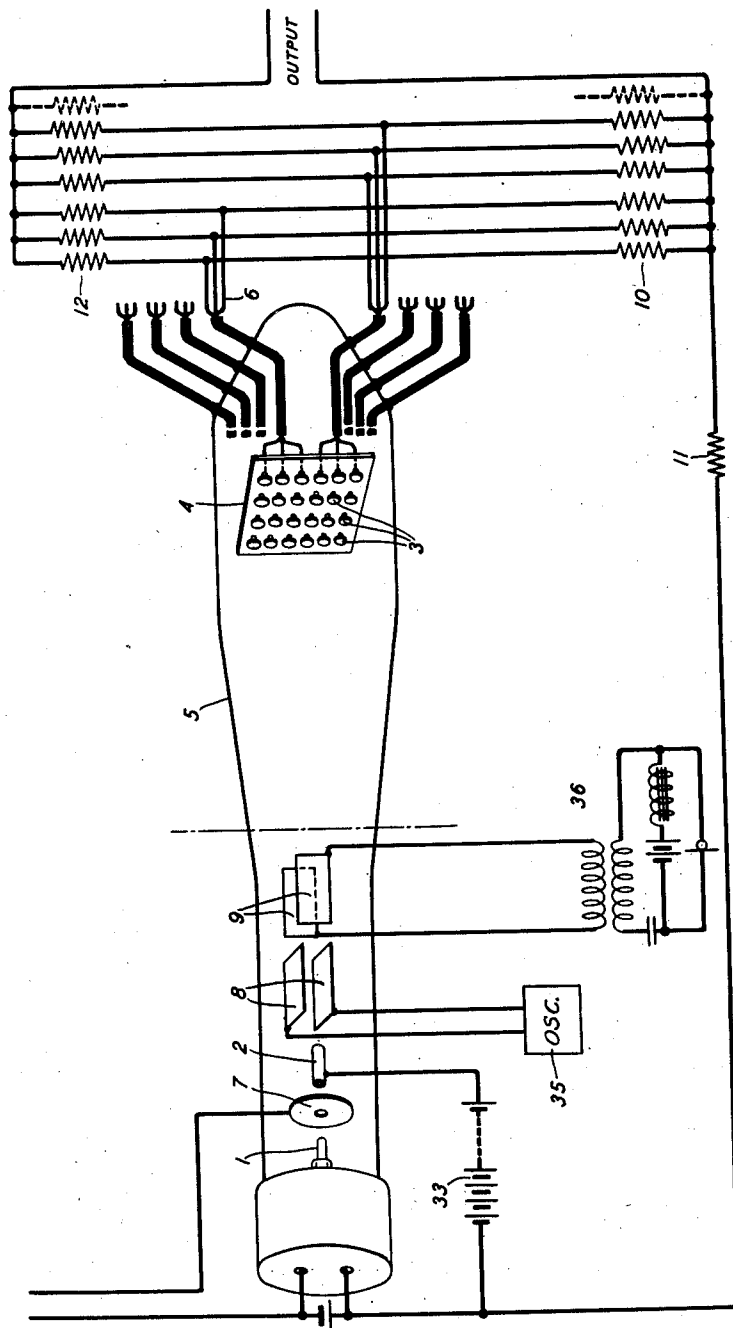


Feb. 6, 1934.

W. P. MASON
TRANSLATING DEVICE
Filed Aug. 16, 1930

1,946,223
4 Sheets-Sheet 1

FIG. 1



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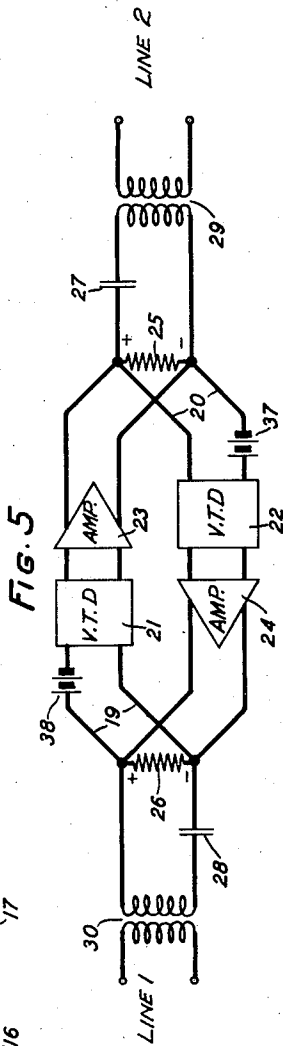
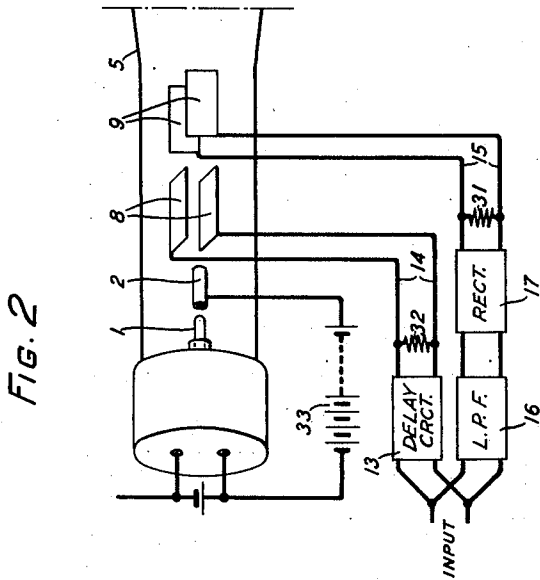
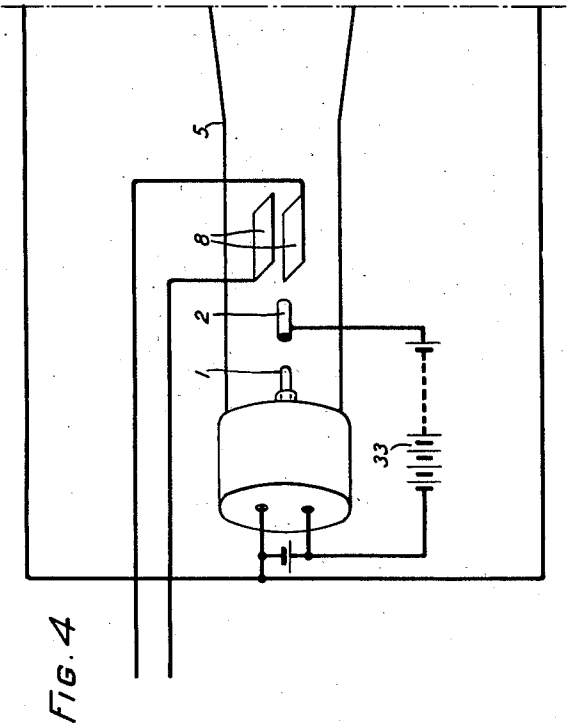
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4 Sheets-Sheet 2



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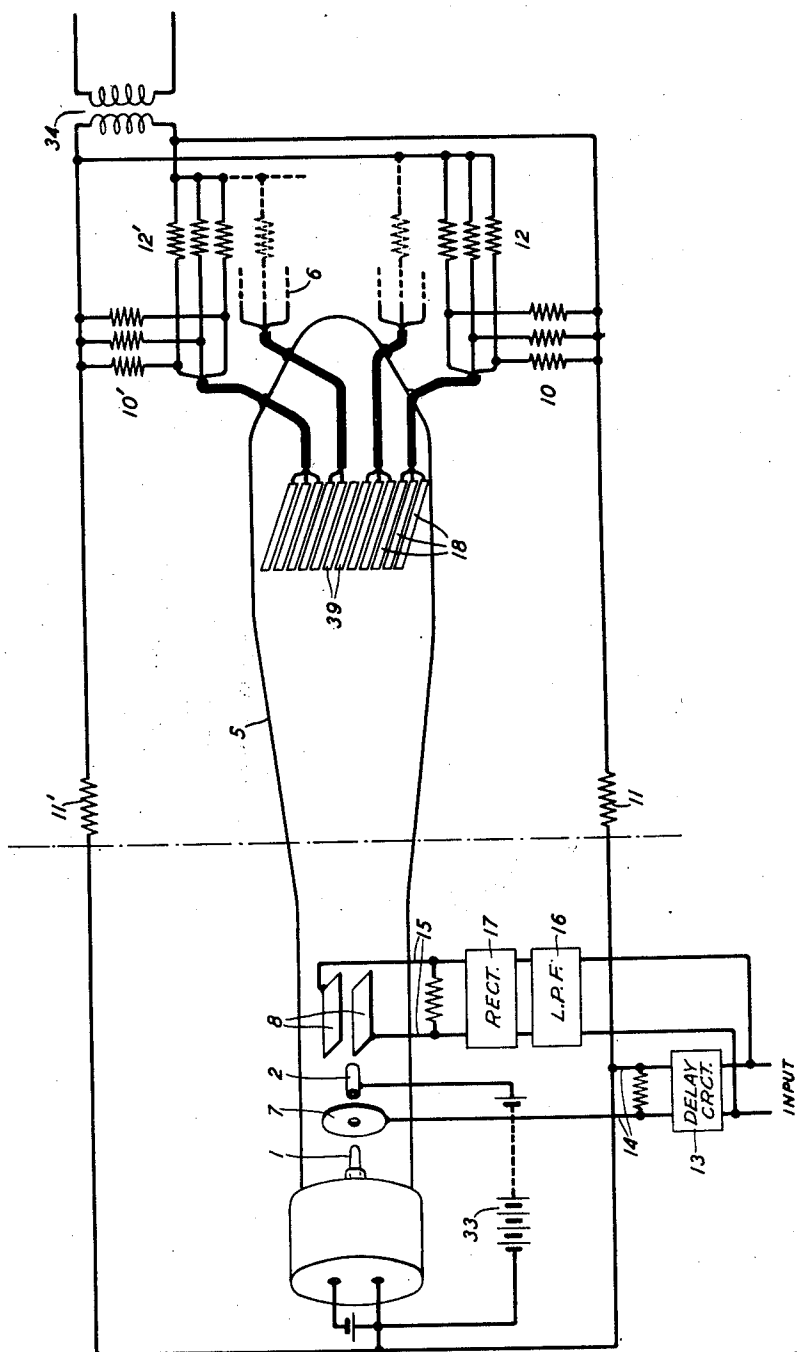
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1,946,223

TRANSLATING DEVICE

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4 Sheets-Sheet 4

FIG. 6

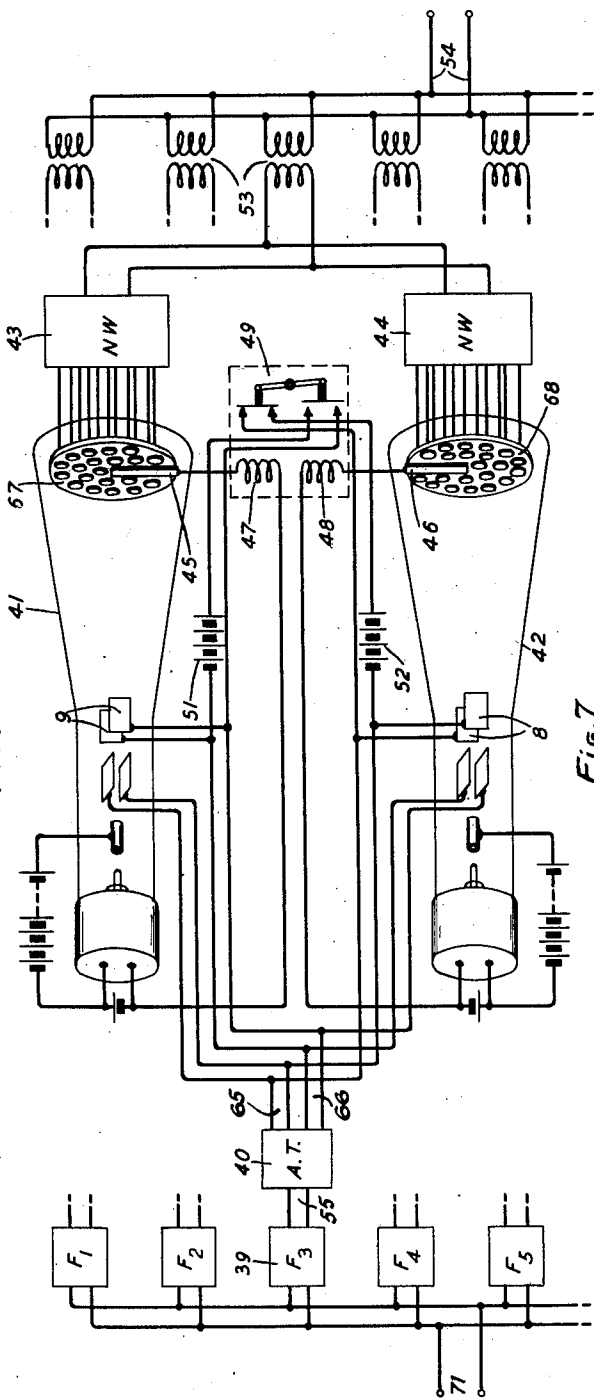
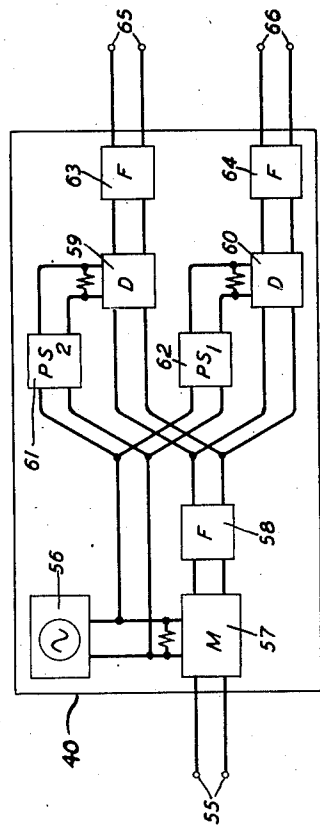


FIG. 7



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1,946,223

TRANSLATING DEVICE

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Application August 16, 1930. Serial No. 475,833

13 Claims. (Cl. 178—44)

This invention relates to an electrical translating device and circuits therefor.

It is an object of the invention to translate input waves into any desired one of a number of types of output waves for electrical transmission or control purposes.

Another object of the invention is to provide continuously operating switching means instantaneously responding to applied control forces.

In the prior art the structure of the cathode ray oscillograph is well known. In its usual form this device comprises a source of electrons, as a heated filament, an anode for causing the electrons to be drawn off in the form of a beam, and a sensitized screen which the impinging electrons make luminescent. Two sets of parallel plates are so positioned with respect to the electron beam and each other that potentials applied to the plates cause deflection of the beam in directions at right angles to each other. When continuously varying potentials are applied to these plates, there occurs a corresponding continuous deflection of the electronic beam, a luminescent trace on the sensitized screen marking the path traversed.

In accordance with the present invention, means which may or may not take the form of the cathode ray oscillograph structure, are provided for producing an electron beam and deflecting it in response to input waves. No sensitized screen is used. Instead, a plurality of conducting terminals are positioned in the path of the electrons, these being individually connected to a common output circuit through paths of different attenuation. As the electric current which this electron flow comprises is practically constant because of the high impedance of the discharge device, the output voltage at any instant will depend on the impedance of whatever attenuation path is associated with the output circuit. This in turn depends on the terminal to which the beam is deflected.

In an illustrative embodiment of the invention, an input wave applied to one set of deflecting plates produces a continuous deflection of the electron beam across the terminal structure, a plurality of attenuation networks being thereby successively connected to the output circuit as the beam passes from terminal to terminal. By properly selecting the attenuation network to be associated with each terminal, the amplitude of output voltage may be caused to vary in any desired manner as the beam sweeps across a number of terminals. Since the amount of deflection is directly related to the amplitude of the

input wave, it follows that the amplitudes of input and output waves may be made to bear any desired relation to each other. In a particular case, the relation might be one of direct proportion, so that the output wave appears of the same shape as the input wave. In another case the output amplitude might follow a square law or some other function.

The foregoing and various other embodiments of applicant's invention are contemplated and are hereinafter described in detail in connection with the drawings, in which

Fig. 1 shows an arbitrary distorting device connected to produce voice-modulated signals;

Fig. 2 shows a modification of the device of Fig. 1 adapted for use as a volume range compressor or expander;

Fig. 3 shows another type of volume compressor or expander, and also discloses a cross-talk suppression feature;

Fig. 4 shows a volume limiter using the device of this invention;

Fig. 5 shows diagrammatically a two-way voice operated repeater;

Fig. 6 shows a modification of the invention adapted to the reducing of a complex wave to a subharmonic; and

Fig. 7 is a schematic diagram of an angle translating element incorporated therein.

A more detailed picture of the arbitrary distorting device above described will be obtained from the following description, reference being had to Fig. 1.

Electrons produced by hot cathode 1 are caused to be drawn out in a fine stream by means of the positively biased, hollow, cylindrical anode 2. A few electrons, not striking the anode but continuing through its center, reach the opposite end of the tube where they may strike any one of the metallic terminals 3 mounted in the glass insulating support 4. Each terminal has a separate conductor 6 leading through the container 5 for connection to an external circuit. A control element or grid 7 is provided for regulating the amplitude of the electron stream in response to signals or other controlling potentials applied to it.

By means of the plates 8, the electron stream may be deflected in one plane from its normally straight path, in accordance with the amplitude of a signal applied to the plates. A second set of plates 9 permits deflection in a plane at right angles to the first one, in response to the same or another applied signal. For any given combination of potentials applied to the controlling

plates the electron beam will be deflected to a definite spot on the terminal structure 4 and therefore to a definite terminal.

Upon striking a terminal, the electrons pass through one of the lead-in conductors 6 to the external resistances, which may assume a wide variety of forms and different schemes of connection. In the illustrative example of Fig. 1, the stream of electrons divides, part returning directly to the cathode 1 through one of the resistances 10 and through resistance 11; and part passing through one of the resistances 12, through the output circuit and back to the cathode. Resistances 10 and 12 are proportioned to the load impedance and to each other so that with the electron beam impinging on any particular terminal any desired fraction of the electron current may be diverted to the load. Because the internal impedance of the tube is very high compared with the impedance of its external circuit, the electron stream is of practically constant magnitude for given grid and anode potentials. With the beam on a given terminal the load current is a particular fraction of the electron current, and is therefore practically constant. Hence, by proportioning the various combinations of the external resistances, the load current may be made to vary in a predetermined manner as the beam is deflected from terminal to terminal. For instance, if a sine wave of voltage is applied to one set of plates, causing the stream to traverse a line of terminals, the output current will be sinusoidal also, or of triangular, rectangular or any desired wave shape depending on the proportioning of the various external resistors. If potentials are applied to both sets of plates the beam may be deflected over the entire area of the terminal structure, and for every combination of applied potentials the beam will be deflected to a particular terminal. The output current can therefore be made any function of the amplitudes of the two voltage waves.

If desired, a third variable, controlling directly the amplitude of the stream, may be introduced by means of the control element 7.

To prevent interruptions of the current when the beam crosses from one terminal to an adjacent one, the latter may be placed so close together that the gap will be substantially less than the diameter of the stream. The smoothness of the output wave is then limited only by the number of electrodes used.

While a particular structure and function have been used for purposes of illustration, the present invention is capable of embodiment in forms widely different from the ones described. It is to be understood that the resistance elements may be incorporated within the glass container, so that it would be necessary to bring out only the two output leads. The particular type of terminal structure and the arrangement of the terminals thereon shown in the diagram is not essential.

In Fig. 1 the two control voltages are shown as derived respectively from a source of voice signals 36 and a high frequency oscillator 35, which may be of the type disclosed in Hartley Patent 1,356,763, October 26, 1920. By the methods outlined above, the output current may be made any desired function of the amplitudes of the two waves. If the high frequency wave is to be modulated in accordance with a common method the output current may be made proportional to the product of the instantaneous amplitudes of the two waves. Undesired products of mod-

ulation, introduced by ordinary modulators, are not created by the present method.

Fig. 2 shows a modification of the arbitrary distorting device of Fig. 1 that may be used for compressing the volume range of speech or other complex signal waves. Through branch channel 14, the incoming speech waves are applied to one set of deflecting vanes 8. In another branch channel 15 all except the low frequency components of the speech wave, say below 500 cycles, are filtered out by low pass filter 16, which may be of the type disclosed in G. A. Campbell Patent 1,227,114, May 22, 1917. The low frequency waves that pass through are rectified by rectifier 17, which may be of any conventional type, and applied to the deflecting vanes 9 as a potential which varies substantially as the average energy level of each syllable.

The output current, as explained in connection with Fig. 1, may be made any function of these two voltages, one corresponding to the voice wave itself, the other corresponding to the average energy level of successive syllables. For purposes of volume compression, the attenuation networks are proportioned so that the voice wave is reproduced in the output circuit but with syllables of high energy level relatively reduced by the action of the control voltage.

The output current of the volume range compressor may be transmitted to a second discharge device and associated circuit similar to the first one except that the rectified low frequency current causes the signal to be reproduced with the syllables restored to their original energy levels. As the low pass filter 16 and rectifier 17 introduce some delay, delay circuit 13 is necessary to equalize the delay in the two channels 14 and 15. It may be of the form shown in H. D. Arnold Patent 1,565,302, December 15, 1925, or of any other suitable type.

Fig. 3 shows a volume compression system similar to that of Fig. 2, except that the voice signal operates directly on the amplitude of the stream through the medium of the control grid 7. The energy level of each syllable of the output current depends on what external attenuation network is in circuit. This, in turn, is dependent on the amount of deflection caused by the rectified low frequency signals applied to the deflecting vanes 8. As deflection occurs in only one direction, one row of terminals, shown in Fig. 3 as strips 18, is all that need be used. The delay circuit serves the same purpose as that of Fig. 2, namely, equalization of the delay in channels 14 and 15.

In Fig. 3 the central anode terminals are shown unconnected. This is in accordance with a further feature of the invention which discriminates against cross-talk and other interfering currents of small magnitude which make themselves objectionably manifest during intervals when no signal currents are being transmitted. In response to these small currents the beam will be deflected only a small distance from its central or neutral position, and if the unconnected anode terminal or terminals are made wide enough the beam will never reach the output circuit when noise currents alone are present. The amount of signal distortion introduced by the discontinuity of the output wave in this selected range of small amplitude is not sufficient to be objectionable. This feature is not limited to the particular circuit used for illustration but may be incorporated in any of those shown. For instance, when the beam is deflected in two directions as in the circuits of Figs. 1 and 2 instead of in one as in Fig. 3, it is

necessary to leave unconnected all the terminals within a selected small radius of the neutral position of the beam. Instead of leaving the terminals unconnected it is equivalent to connect them to the output circuit through paths of infinite or high attenuation.

The device of Fig. 4 may have the same type of electrode structure and output circuit as shown in Fig. 3. The grid 7, however, is omitted. This combination is designed in accordance with the procedure hereinbefore detailed so that signals of moderate amplitude are faithfully reproduced in the output circuit. The additional modification is made that the terminals to which the electron stream is deflected when excessively strong signals are applied, are connected to such resistance combinations as will limit the output current to a safe value or even make that current zero. In this form the combination may serve as an acoustic shock reducer.

Fig. 5 illustrates diagrammatically a repeater in a two-way communication system, channel 19 being adapted for amplifying signals transmitted from line 1 to line 2, and channel 20 being adapted for amplification of signals transmitted in the opposite direction. As the signal amplified in one channel is applied not only to the outgoing line but also to the input of the oppositely directed repeater channel, there is a strong tendency for a "singing" condition to be established, as is well recognized in the telephone art. In accordance with the present invention one channel is disabled upon the receipt of signals by the other channel.

Briefly, each repeater channel is arranged to impart to the line signals received by it a direct current component which is sufficiently large to disable the oppositely directed channel when the resultant signal is applied to it. Line signals, being transmitted through transformers, have no direct current component and when applied to the input of a channel do not disable it but are satisfactorily repeated. Thus each channel distinguishes between signals from its incoming line and signals from the oppositely directed repeater channel by the presence of a direct current component in the latter signals.

Referring now to Fig. 5, 21 and 22 are vacuum tube devices in accordance with Fig. 4, the deflecting plates 8 being connected to the input terminals of channels 19 and 20, respectively. The attenuation networks of each of these devices are proportioned so that the output current is equal to a constant plus a factor which is proportional to the deflection of the beam from one end of the terminal structure. The line signal and its direct current component are amplified by a direct current amplifier 23 and 24, respectively, which may be of the type disclosed in Arnold Patent 1,129,942, March 2, 1915, or any other suitable type, and are transmitted to the outgoing line. A condenser 27, 28, respectively in series with each transformer 29, 30, respectively, blocks the direct current component, which therefore passes through resistance 25, 26, respectively, but allows the alternating current, the line signal, to be transmitted to the outgoing line.

The vacuum tube device in the oppositely directed channel is subjected to the amplified signal, but because the latter now includes a large direct current component, the electron beam is swept off the terminal structure entirely, thus disabling that channel and precluding any "singing" action. As soon as the incoming line signals cease, the direct current component also dis-

appears, the beam returns to its original position and signals can then be received from either direction.

Because, even with no signals present, the direct current required by the amplifiers flows through the resistances 25, 26, respectively, biasing batteries 37 and 38 are used to neutralize the effect on the vacuum tube devices of the voltage drop in these latter resistances. As the central terminals corresponding to the neutral position of the beam, are unconnected, as shown in the drawings, the signal operated repeater of this invention has the desirable feature that it is not responsive to cross-talk or noise currents.

Fig. 6 illustrates a modification of the invention which is adapted to convert a complex wave, as a speech signal, to another complex wave in which substantially each frequency component of the original wave is represented by a wave of proportionate amplitude but of a subharmonic frequency.

The first step is to separate the incoming wave into a number of narrow substantially single frequency bands, and for this purpose band pass filters 39, which may be of the type disclosed in U. S. Patent 1,227,114, May 22, 1917 to G. A. Campbell, are provided. The output of each of these filters is passed to an individual translating device 40, which, as will be explained in connection with Fig. 7, converts the wave applied to it into two waves in phase quadrature with each other.

Discharge devices 41 and 42 may be of the same structure as that of Fig. 2, or slightly modified, as shown, by the substitution of a circular arrangement of the metallic terminals in their insulating supports. To the two sets of deflecting plates in each of these devices are connected the output channels of angle translator 40. With the forces acting on each electron beam now in both space and phase quadrature, the beam is caused to move about its neutral position in a circle, the radius of which is directly proportional to the amplitude of the applied wave. The output networks 43 and 44 to which the terminals in each circular path are connected, are so proportioned that as the beam moves through a complete circle, corresponding to a complete cycle of the applied wave, the amplitude of the output current rises and falls as a sine wave of half the frequency and of an amplitude proportional to the radius of the circle. Since during the next cycle the output current will again rise and fall as before, the output of each network is a succession of sine wave lobes. By a switching arrangement now to be described alternate current lobes in each device are suppressed, and the remaining lobes are combined in a common output circuit to form a perfect sine wave of half the frequency of the original wave.

In each discharge device 41, 42, the terminals in the radial row corresponding to zero output current, are united as a collector bar 45, 46 which is connected directly to one or the other of the actuating coils 47, 48 of relay 49 so that once in every cycle as the electron beam passes across that bar the current energizes the relay instead of passing into the network. Relay 49 is of such a type that as successive impulses are given it the armature moves from one position to an alternate position. With the armature in the position shown, a biasing potential, supplied by battery 52, is applied to the deflecting plates 8 of discharge device 42, causing the beam to be deflected entirely off the terminal structure and

thereby rendering the device inoperative. In its alternate position, the armature causes battery 51 to be connected across one set of plates 9 in the other discharge device 41, rendering it inoperative, and at the same time causes the bias to be removed from the first device 42.

By selecting the proper row of terminals to form the collector bar 45, 46, this switch over may be made to occur when the output currents of both networks are zero, so that one device will supply a positive lobe and then become inoperative while the other device supplies the negative lobe of a resultant subharmonic wave.

While a mechanical system for combining the output currents of the discharge devices has been described, any other means for accomplishing the same result may be substituted. As the output of a subharmonic producer of the type described can be similarly reduced in frequency, it is possible to obtain any even subharmonic of a given wave.

When the output of each of the filters 39 has been reduced in frequency by a subharmonic producer of the type described, the resultant waves are combined by means of transformers 53 and delivered to the terminals 54 which may be connected to a telephone line or other transmission medium.

To convert the complex subharmonic wave to its original form, the discharge device of Fig. 2 can again be used in conjunction with the angle translator of Fig. 7. In this case, the angle translator receives the whole band of frequencies, and only one discharge device need be used. Its output network is so proportioned that as the electron beam traverses a circle the output current goes through the amplitude variations corresponding to the required harmonic.

The angle translator 40 of Fig. 6 is shown in detail in Fig. 7 and its construction and operation will now be described. The incoming wave, applied at terminals 55 is combined with the carrier wave generated by oscillator 56 by means of a modulator 57, which may be the pure product modulator hereinbefore described or any other suitable type. If the signal wave be represented by $A \cos \omega t$ and the carrier by $B \cos pt$, the current from the modulator is

$$A \cos \omega t B \cos pt = \frac{AB}{2} [\cos (p-\omega)t + \cos (p+\omega)t].$$

Band pass filter 58 then removes one of the sidebands. If the upper one is selected, the current passed is

$$\frac{AB}{2} \cos (p-\omega)t + \theta,$$

where θ is the phase shift introduced by the filter 58. The lower side band, represented by the above expression, is applied to each of the demodulators 59, 60, which are also supplied with current from oscillator 56. Devices 61, 62, cause a shift in phase of the oscillator current passing through them, that caused by 62 being represented by ϕ_1 and that by 61, ϕ_2 .

The current output from demodulator 60 is then represented by

$$\frac{AB}{2} \cos [(p-\omega)t + \theta] B \cos (pt + \phi_1) =$$

$$\frac{AB^2}{4} [\cos ((2p-\omega)t + \theta + \phi_1) + \cos (\omega t - \theta + \phi_1)],$$

while that from the second demodulator 59 is

$$\frac{AB}{2} \cos [(p-\omega)t + \theta] B \cos (pt + \phi_2) =$$

$$\frac{AB^2}{4} [\cos ((2p-\omega)t + \theta + \phi_2) + \cos (\omega t - \theta + \phi_2)].$$

Identical filters 63, 64, remove the upper sideband from each demodulator output current, leaving

$$\frac{AB^2}{4} \cos (\omega t - \theta + \phi_1)$$

and

$$\frac{AB^2}{4} \cos (\omega t - \theta + \phi_2),$$

which are seen to differ by the phase angle $(\phi_2 - \phi_1)$. By proper adjustment of the phase shifters 61, 62, the angle $(\phi_2 - \phi_1)$ can be made of any desired value, 90° in the present case where it is used in conjunction with the subharmonic producing devices.

While a preferred embodiment has been illustrated for the purpose of describing the invention, it is to be understood that a wide variety of embodiments are within the spirit of the present invention, the scope of which is defined by the following claims.

What is claimed is:

1. A source of electromotive force, a plurality of networks of different, fixed attenuation, means to produce an electron stream selectively to associate said source and said networks, an output circuit in common to said networks, means successively to associate said networks with said source to produce a current in said output circuit varying in accordance with the attenuation of said successively connected networks, said last mentioned means being adapted to control said electron stream.

2. In combination, a space discharge device comprising means for producing an electronic stream, means for deflecting said stream in one plane under control of an applied signal, means for deflecting said stream in another plane under control of another applied wave, and a plurality of discrete terminals upon which said electronic stream may impinge, and means comprising paths of different and fixed attenuation for connecting said terminals to an external circuit.

3. A source of electromotive force, means to produce a directed electric discharge, a plurality of different impedance networks associable with said source through said discharge, means responsive to input signals acting on said discharge to selectively, variably associate said source of electromotive force and said networks, said networks being of such attenuation that the amplitude of the resultant current determined by their successive association with said source of current is a function of the input signal amplitude.

4. Means to produce an electronic beam, means to deflect said beam as a function of the amplitude of input signals, a plurality of electrodes in the path of said beam, a plurality of circuits connected to said electrodes and adapted to be completed successively through said beam, said circuits containing resistors of different magnitudes, the currents therein being functions of the amplitude of said input signals.

5. A space discharge device comprising means for producing an electronic stream, means for deflecting said stream in one plane in response to an applied signal, and a plurality of terminals upon which the deflected electronic stream may successively impinge, individual circuits for connecting said terminals to an output circuit, and impedance networks in said individual circuits whereby said output current is made a function of the signal applied.

6. In a transmission system, a space discharge

device in accordance with claim 2, control means associated therewith, means comprising a low pass filter and a rectifier for associating a source of voice waves with said control means, means comprising a delay circuit for associating the same source of voice waves with other control means, means comprising impedance networks connected in an output circuit whereby input signals of high amplitude are transmitted with an attenuation different from that suffered by signals of low amplitude.

7. In combination with a system wherein the relative levels of signals of high and low amplitude are altered, a discharge device in accordance with claim 2, means comprising a delay circuit for associating the output of said system with control means comprising deflecting elements in said discharge device, means comprising a low pass filter and rectifier for associating said output with other control means in said device, and networks in the output circuit of said device whereby the relative strength of signals of high and low amplitude is restored.

8. A space discharge device in accordance with claim 2, means for applying a signal voltage to deflecting means therein, and means comprising a group of unconnected terminals about the neutral position of the beam whereby signals below a selected amplitude are not transmitted.

9. A combination comprising a source of electromotive force and means for selectively, variably associating a plurality of networks therewith in response to input signals, said networks being so proportioned as to produce zero output current for input signals below a selected amplitude.

10. A combination comprising a source of electromotive force and selective means for successively associating a plurality of attenuators therewith in response to input signals, said selective means associating said electromotive force and said networks only when input signals of an amplitude above a selected value are applied.

11. A source of electromotive force, a plurality of paths of different, fixed transmission equivalents, an output circuit in common to said plurality of paths, means to produce a directed electric discharge for selectively associating said source and said paths, means acting on said discharge successively to associate said source and said paths for producing an output current varying in accordance with the transmission equivalents of said successively connected paths, said last mentioned means causing deflection of said directed discharge.

12. A transmission system comprising a combination in accordance with claim 11 and means for deflecting said directed discharge in response to signaling waves, the transmission equivalents of said plurality of paths being such that said signaling waves are transmitted with a reduced range of amplitude.

13. In a transmission system in which the amplitude range of signals is reduced, a combination in accordance with claim 11 and means for deflecting said directed discharge in response to said signals of reduced amplitude range, the transmission equivalents of said plurality of paths being such that the amplitude range of said signals is increased.

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55 130

60 135

65 140

70 145