

Dec. 1, 1959

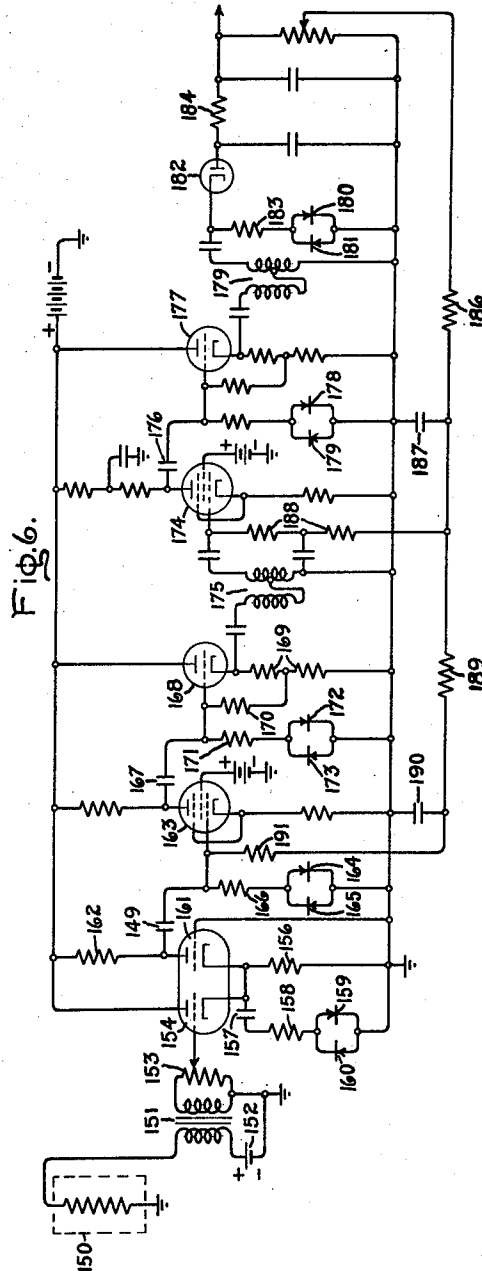
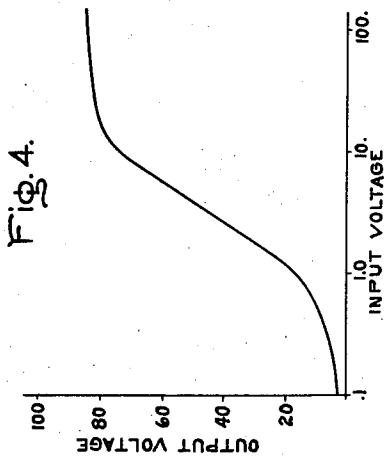
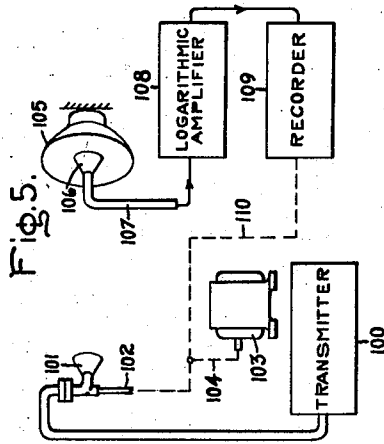
R. E. RICKETTS

2,915,599

LOGARITHMIC AMPLIFIER

Filed June 6, 1952

2 Sheets-Sheet 1



Inventor:
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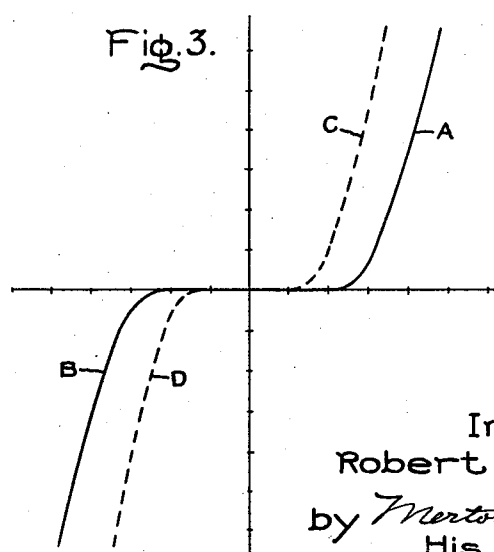
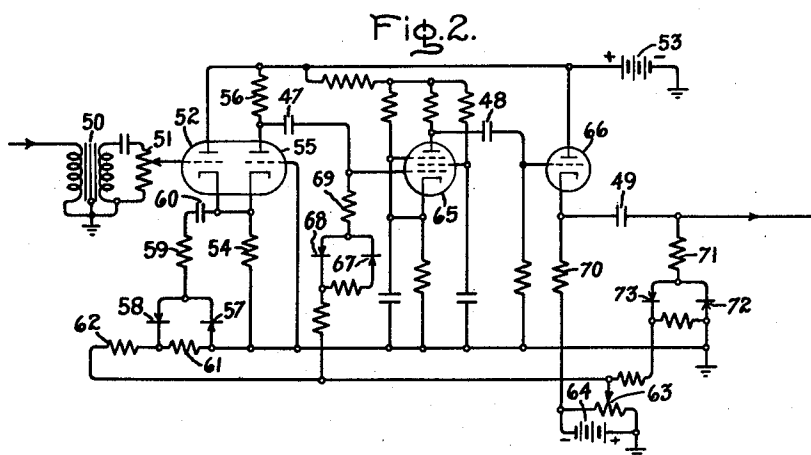
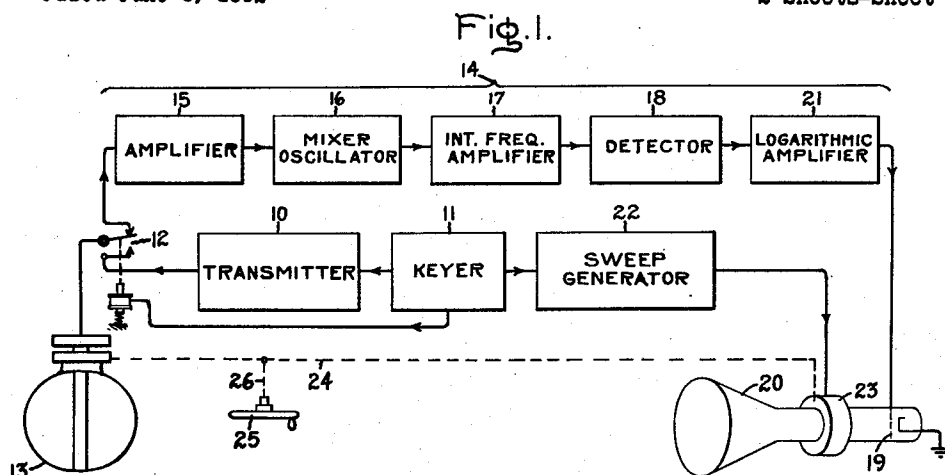
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R. E. RICKETTS
LOGARITHMIC AMPLIFIER

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Filed June 6, 1952

2 Sheets-Sheet 2



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2,915,599

LOGARITHMIC AMPLIFIER

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Application June 6, 1952, Serial No. 292,067

3 Claims. (Cl. 179—171)

My invention relates to wave-translating apparatus and, more particularly, pertains to an improved logarithmic amplifier, i.e., an amplifier exhibiting an input amplitude versus output amplitude characteristic which is of logarithmic form.

It is an object of my invention to provide an improved logarithmic amplifier which is simple and inexpensive to construct, and yet is entirely stable and efficient in operation.

Another object of my invention is to provide an improved logarithmic amplifier which affords amplitude compression of an applied wave without materially altering the general wave configuration.

A wave-translating system in accordance with my invention comprises a cathode follower and a cathode-driven amplifier. The cathode follower and the cathode-driven amplifier have a common cathode impedance and are thereby electrically coupled together. Means are provided for applying to the cathode follower an input wave to be translated and the system also includes means for deriving an output wave from the cathode-driven amplifier that corresponds to the input wave. A circuit element having a non-linear or logarithmic input voltage versus resulting current characteristic is coupled to the common cathode impedance and thus the output wave varies as a non-linear or logarithmic function of variations in the input wave.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages, thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 represents, in block diagram form, a complete underwater sound echo-ranging apparatus, commonly referred to as sonar equipment and which includes a logarithmic amplifier that may embody my invention;

Fig. 2 is a detailed schematic diagram of a logarithmic amplifier constructed in accordance with my invention and which may be employed in the apparatus shown in Fig. 1;

Figs. 3 and 4 are graphs illustrating the operating characteristics of portions of the circuit shown in Fig. 2;

Fig. 5 illustrates a complete antenna-space-pattern plotter and represents another application in which a logarithmic amplifier may be employed; and

Fig. 6 is a detailed schematic diagram of a logarithmic amplifier which may be incorporated in the arrangement of Fig. 4 and which represents a modification of my invention.

Referring now to Fig. 1 of the drawing, the sonar apparatus there shown includes a transmitter 10 which, under the control of a keyer 11, generates pulses of supersonic energy. Keyer 11 controls the energization of the actuating coil of a mechano-electric relay 12 thereby to close the normally open contacts of a set of single-

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pole double-throw relay contacts for the duration of each generated pulse. Thus, the pulses of supersonic energy are supplied to a directional transducer 13 and pulses of a compressional wave are radiated into the water medium in which transducer 13 is immersed. Such compressional energy travels through the water and may impinge upon a reflecting surface of a remote object and, after reflection, returning pulses are intercepted by transducer 13.

Received pulses are supplied through the normally closed pair of contacts of relay 12 to a receiver 14 wherein after amplification in an amplifier 15, the pulses of supersonic energy are converted to an intermediate frequency by a mixer-oscillator stage 16. The intermediate-frequency pulses are amplified in an amplifier 17 and a detector 18 produces a demodulated pulse-type output wave which is supplied to control electrode 19 of a cathode ray indicator 20 through a logarithmic amplifier 21, the purpose and details of which will be described hereinafter.

As is generally well-known, the velocity of propagation of sound energy in water is substantially constant, and hence, the range of a reflecting object may be determined by measuring the total travel time of returning echo pulses. This measurement is performed through the use of an accurate time base sweep provided by a sweep generator 22 which may include any well-known form of circuit for deriving a highly linear sawtooth wave that is synchronized with the operation of keyer 11. The sawtooth wave is applied to the coils of a deflection yoke 23 that is supported for rotation about the neck of cathode ray tube 20. Thus, with the occurrence of each pulse of supersonic energy in transmitter 10, the electron beam projected toward the viewing screen of tube 20 is deflected radially from the screen center in a direction dependent upon the orientation of yoke 23 and at a rate proportional to twice the velocity of propagation of the energy radiated from transducer 11.

In order to derive target bearing as well as range information, transducer 13 is supported for rotation about a vertical axis and is mechanically coupled to deflection yoke 23 through suitable gearing, illustrated by a dash line 24. Of course, any well-known form of mechano-electric device may be interposed between transducer 13 and the deflection yoke in installations wherein the transducer and the yoke are located too far apart to permit the use of a direct mechanical connection. In any event, yoke 23 is rotatably synchronized with transducer 13 and rotates once for each revolution of the transducer.

A hand wheel 25 is mechanically coupled to transducer 13 through suitable gearing illustrated by an extension 26 of dash line 24. Thus, the azimuthal position of transducer 13 is under the control of hand wheel 25 and it is oriented by an operator so that the axis of maximum directivity intercepts a remote object. This is accomplished in accordance with well-known sonar techniques, a pair of head phones usually being coupled to detector 18 so that the operator may have both an aural as well as a visual presentation of reflected pulses.

Although a direct connection has been illustrated between hand wheel 25 and transducer 13, it is obvious that any known power assisted arrangement, for example, of the amplidyne type, may be suitably employed.

The output wave from logarithmic amplifier 21 of receiver 14 is applied to control electrode 19 with such polarity that received pulses increase the intensity of the electron beam projected toward the viewing screen of cathode ray tube 20. At the same time, the sweep wave from generator 22 deflects the electron beam from the

center of viewing screen 25 in a radial direction corresponding to the orientation of transducer 13. Thus, indications on the screen are produced which represent one or more remote objects. The distance from the center of the viewing screen to the indication is proportional to the range of the corresponding object and the bearing or azimuthal position of the object is defined by the angle subtended by a line intercepting the screen center passing through the indication and a vertical reference line through the screen center.

Although in the described arrangement, the vessel carrying the sonar apparatus is represented at the center of the viewing screen of tube 20, it is possible to produce an indication which moves in accordance with movements of the vessel. For example, the system disclosed in the application of K. H. Kingdon et al., Serial No. 494,564, filed July 13, 1943, now abandoned, and assigned to the present assignee may be employed for this purpose.

As is generally well-known, compressional wave energy is highly attenuated by the water medium through which it is propagated. At the usual supersonic frequencies employed in the sonar equipment illustrated in Fig. 1, this attenuation amounts to four decibels per thousand yards or, more generally stated, amplitude varies as the inverse square of distance. Consequently, the pulse wave amplitude supplied by detector 18 varies widely for remote objects at different distances within the operating range of the equipment.

If such widely varying pulse amplitudes are applied through a linear amplifier to control electrode 19 of cathode ray tube 20, remote objects at both short and extreme ranges could not be accurately displayed. For example, if the gain of receiver 14 is made high enough to permit the translation of pulses of small amplitude from objects at extreme ranges, then pulses from nearby objects would be of so great an amplitude as to cause abnormal operation of cathode ray tube 20 and the indications produced thereby would occupy too large an area of the viewing screen to permit accurate range and bearing measurements. On the other hand, if the amplification of receiver 14 is reduced to accommodate reflected energy from nearby objects, then reflected energy from objects at extreme ranges would not have sufficient amplitude to produce an indication on the viewing screen.

Thus, it is apparent that a translating stage having a non-linear input amplitude versus output amplitude characteristic, such as of logarithmic form, could obviate this difficulty. Logarithmic amplifier 21 serves this purpose by providing a large amplification factor for weak signals, however, as signal amplitude increases, a compression is effected and the amplifier operates with reduced amplification. In that way, pulses representing both nearby as well as extremely remote objects may be properly displayed on the viewing screen of cathode ray indicator 20.

Referring now to Fig. 2 of the drawing, there is illustrated a detailed schematic diagram of a wave-translating system constructed in accordance with my invention and which may be employed as logarithmic amplifier 21 of Fig. 1.

The output wave of detector 18 is applied to the primary winding of an input transformer 50, the secondary winding of which is shunted by the resistance element of a potentiometer 51. The movable arm of potentiometer 51 is connected to the control electrode of an electron discharge device 52 having its anode directly connected to the positive terminal of a source of B supply potential 53, the negative terminal of which is grounded. The cathode of device 52 is connected to ground through a cathode load impedance 54 and this device thus operates as a cathode follower, producing at cathode impedance 54 a replica of the wave supplied by detector 18, with no change of polarity.

The system further includes another electron discharge

device 55 having its control electrode directly connected to ground, its cathode directly connected to the cathode of device 52, and its anode connected to the positive terminal source 53 through an anode load impedance 56. Since cathode load impedance 54 is common to both devices 52 and 55, these devices are electrically coupled to one another and the cathode load impedance may be considered as being included in a coupling network by means of which the wave derived due to cathode follower action of device 52 is applied to the control electrode-cathode circuit of device 55, which operates as a grounded-grid cathode-driven amplifier. There is thus derived at anode load impedance 56 an output wave corresponding to the input wave.

The system also includes a circuit element, having a non-linear applied potential versus resulting current characteristic, included in the coupling network comprising impedance 54. This circuit element preferably comprises a pair of unidirectionally conductive, germanium diode rectifiers 57 and 58. The cathode of diode 57 is directly connected to the anode of diode 58 and these electrodes are connected through the series combination of a resistor 59 and a coupling condenser 60 to the common connection between the cathodes of devices 52 and 55. The anode of device 57 is connected to the cathode of device 58 through a resistor 61 and the junction of diode 58 with resistor 61 is connected through another resistor 62 to the movable arm of a potentiometer 63, the resistance element of which is connected to a source of potential 64 having its positive terminal grounded. There is thus provided a source of bias potential which is connected in shunt with resistor 61.

The operation of the portion of the circuit described above may be more easily understood by referring to Fig. 3 which is a plot of voltage versus resulting current for the germanium diodes 57 and 58. Curve A illustrates the typical operating characteristic of diode 58 in the absence of a bias potential, i.e., a condition wherein the movable tap of potentiometer 63 is positioned at the grounded end of the resistance element. Since diode 57 is poled oppositely to diode 58, its characteristic curve B is shown in the opposite polarity sense in Fig. 3.

Although the diode rectifiers may operate in a suitable manner with zero bias, it has been found that a diode bias of approximately 0.15 volt in the positive or forward direction is preferable. Therefore, the movable tap of potentiometer 63 is adjusted to provide a current through resistor 61 which results in this bias and the actual operating conditions for the diodes 57 and 58 are represented by the dash curves D and C, respectively.

From an inspection of curve C-D, it will be observed that for undulating potentials at cathode resistor 54 of extremely small amplitude there is essentially no diode current flow. However, as the amplitude increases diode 58 conducts current during positive half cycles and diode 57 conducts current during negative half cycles. The amount of conduction in the diodes increases non-linearly with increasing input amplitudes. In other words, the impedance presented by the diodes in the cathode circuit of electron discharge device 52 decreases as the wave amplitude increases. Since the diode characteristics are of logarithmic form, the amplitude of the undulating wave that is developed in the cathode circuit of device 52 varies as a logarithmic function of variations in the amplitude of the input wave that is applied to this device.

The diodes may thus be considered to operate as a variable attenuator for compressing the undulating potential which is developed in the common cathode circuit. This undulating potential produces corresponding variations in the control electrode-cathode circuit of device 55 and the undulating potential which is derived at anode resistor 56 of cathode-driven amplifier 55 is similarly compressed.

Referring now to Fig. 4, the curve there illustrated is

a plot of input voltage amplitude of a sine wave of variable amplitude applied to transformer 50 versus output voltage amplitude derived at anode resistor 56, input voltage being taken to a logarithmic scale. It will be observed that this characteristic is essentially logarithmic over an amplitude range in the applied wave from 1 to 10 volts.

In order more closely to approximate the desired logarithmic characteristic in the wave translating system shown in Fig. 2, an additional translating stage is coupled to anode load impedance 56. This stage comprises an amplifier which includes a pentode-type electron discharge device 65 having its control grid circuit coupled by a condenser 47 to anode resistor 56 and its anode circuit coupled by a condenser 48 to the grid circuit of an electron discharge device 66 connected in a cathode follower circuit. A pair of oppositely-poled germanium diodes 67 and 68 are connected to the control grid of device 65 through a resistor 69 and are connected to potentiometer 63 in the same manner as are diodes 57 and 58. There is thus included a circuit element having a non-linear applied potential versus resulting current characteristic in the grid circuit of pentode amplifier 65.

The anode of cathode follower 66, of course, is connected to the positive terminal of source 53 and its cathode is connected to the negative terminal of source 64 through a cathode load resistor 70. The cathode of device 66 is coupled through a condenser 49 to a resistor 71, in turn, connected to another pair of germanium diodes 72 and 73. The circuit for these diodes is identical to the one provided for diodes 57 and 58.

The non-linear circuit elements in the grid circuit of amplifier 65 (diodes 67 and 68) and in the cathode circuit of cathode follower 66 (diodes 72 and 73) present respective circuit impedances which decrease with increasing wave amplitude. These circuit elements operate in the same manner as the one containing diodes 57 and 58 to provide additional compression for the wave translating system. Moreover, the screen potential of pentode amplifier 65 is established at a relatively low value so that for small signals the transconductance of device 65 is low while for signals of greater amplitude this parameter increases rapidly. This aids in producing a more nearly logarithmic characteristic by compensating for irregularities in the characteristic which may be caused by the diodes.

The resistance values of resistors 59, 69 and 71, which are connected to the several, respective diode circuits, are selected to provide a predetermined slope in the logarithmic characteristic of the translating system shown in Fig. 2. A further adjustment of the logarithmic characteristic may be made by regulating the bias for the several diodes by means of potentiometer 63 and thus the logarithmic function and the degree of compression may be controlled.

In a particular embodiment of the above-described circuit which has been found to operate satisfactorily in practice, the following circuit constants were used:

Electron discharge devices 52 and

57	Dual triode type 12AT7
Electron discharge devices 65	Type 6BA6
Electron discharge devices 66	Type 6C4
Germanium diodes 57, 58, 67, 68, 72 and 73	IN69
Resistor 54	220 ohms
Resistor 56	56,000 ohms
Resistor 59	500 ohms
Resistors 81, 62	51 ohms
Resistor 69	10,000 ohms
Resistor 70	51,000 ohms
Resistor 71	6,800 ohms
Condensers 48, 49, 50	0.1 microfarad
Condenser 60	25 microfarads
Supply 53	+220 volts
Supply 63	-180 volts

Compression circuits heretofore employed usually depend upon many stages of compression so that a small percentage of compression per stage may be utilized in order to avoid distortion. In the circuit of Fig. 2, an extremely large degree of compression is achieved in the cathode circuit of cathode follower 52 because this stage provides a low-impedance driving source. This causes the diodes to operate very efficiently in compressing waves of large amplitude. As a result, although a greater ratio of attenuation is effected in one stage than heretofore possible, the envelope or general wave configuration of a wave of high amplitude is essentially preserved. Because of the great degree of compression, grounded-grid amplifier 55 always receives a relatively small signal amplitude, regardless of the amplitude of the input wave applied over transformer 50, and little or no distortion occurs in the grounded-grid amplifier.

Stated another way, the extremely low impedance achieved in the cathode circuit that is common to devices 52 and 55 causes the diodes to operate in an extremely logarithmic fashion since the degree of attenuation closely follows the configuration of the curves shown in Fig. 3. If, as in prior art arrangements, a high impedance circuit is employed, the diodes cannot operate in this manner.

It is thus apparent that a wave-translating system in accordance with my invention requires a fewer number of stages than heretofore required for a corresponding degree of compression. The system, therefore, is more simple and less expensive to construct and yet it operates efficiently to compress applied waves having amplitudes which may vary over a wide range without introducing serious amounts of distortion.

It has been found that unless a bias potential is applied to the diodes, they tend to change in forward resistance with variations in temperature. Moreover, the bias prevents electrolysis or chemical action due to high temperatures which is particularly noticeable in diodes not hermetically sealed. Therefore, the bias arrangement is an important factor in maintaining stable operation of the circuit shown in Fig. 2.

The resistors which connect each of the several pairs of diodes together, such as resistor 61, may be defined as balancing resistors. This is understandable if it is considered that the potential drop developed across resistor 61 produces the same, quiescent current through diodes 57 and 58. This causes each pair of diodes to exhibit similar applied voltage versus resulting current characteristics and, hence, not only is stable operation promoted, but that distortion which may result from non-similar characteristics is minimized.

The antenna pattern plotting system shown in Fig. 5 represents another application in which a logarithmic amplifier may be employed. A transmitter 100 supplies radio-frequency energy to an antenna 101, for example, of the horn type, that is mounted for rotation about a vertical axis on a rotatably supported carriage 102. A driving motor 103 is mechanically coupled to carriage 102 by a linkage 104 and continuously rotates the carriage and antenna 101.

The radio-frequency wave radiated by antenna 101 is intercepted by a parabolic reflector 105 and directed to the focal point thereof at which a horn-type antenna 106 is disposed. Antenna 106 is connected to a section of a wave guide 107 in which a bolometer (not shown) is positioned. Variations in the intensity of the intercepted radio wave, which define the space pattern of antenna 101 as it is rotated, produce changes in resistance in the bolometer. The bolometer is connected in the input circuit of a logarithmic amplifier 108, as will be apparent from the following discussion, the bolometer effectively demodulates the intercepted wave thereby to apply an undulation potential to the input of the amplifier.

The output of amplifier 108 supplied to a recorder 109 which may, for example, be of the type including a movable pen that is positioned in accordance with the ampli-

tude of the wave supplied by amplifier 108. A mechanical linkage 110 synchronizes movement of the recording paper (not shown) within recorder 109 with rotation of antenna 101 and, thus, the recording pen traces the space pattern of the antenna under measurement.

Since logarithmic amplifier 108 is employed, the recording paper utilized by recorder 109 may be provided with a logarithmic amplitude scale and in that way the size of the paper may be materially reduced as compared with a recording medium having a linear scale.

Referring now to Fig. 6, which illustrates in detailed schematic form, wave-translating apparatus which may be employed in logarithmic amplifier 108 of Fig. 5, a bolometer 150, shown as a resistance, is connected in a series circuit including the primary of an input transformer 151 and a source of potential 152. The changes in resistance of bolometer 150 caused by variations in amplitude of the received wave energy cause corresponding variations in the flow of current through the primary winding of the transformer 151 and, as a result, there is developed in the secondary winding of the transformer a corresponding potential which is applied via a potentiometer 153 to the control electrode of an electron discharge device 154.

The anode of device 154 is directly to the positive terminal of a source of anode supply potential 155, the negative terminal of which is grounded. Its cathode is grounded through a cathode load resistor 156 and is connected through the series combination of a coupling condenser 157 and a resistor 158 to a pair of germanium diodes 159 and 160 which are connected in back-to-back relation. A ground connection to the diodes completes the cathode circuit for device 154.

Cathode resistor 156 is also in the cathode circuit of an electron discharge device 161 having its control electrode grounded and its anode connected to the positive terminal source 155 through an anode resistor 162. There is thus provided a cathode follower 154 connected in cascade relation with a cathode-driven amplifier 161 and including the diodes 159 and 160 in a common cathode coupling circuit. With the exception of the biasing arrangement illustrated in Fig. 2, this portion of the circuit is essentially identical to that described hereinbefore and the amplitude of the undulating potential which is derived at anode resistor 162 is logarithmically related to the amplitude of the input potential supplied to the control electrode of device 154. This provides the same type of compression which is described in connection with the circuit shown in Fig. 2.

Anode resistor 162 is coupled by a condenser 149 to the control grid of a pentode-type electron discharge device 163 having oppositely-poled germanium diodes 164 and 165 and a resistor 166 connected in shunt with its grid circuit. The output of pentode amplifier 163 is supplied over a condenser 167 to the control grid of an electron discharge device 168. Device 168 has its anode connected to the positive terminal source 155 and its cathode grounded through a resistor network 169. The grid of device 168 is connected through a grid resistor 170 to a tap of network 169 and the grid further is connected to ground through a resistor 171 and a pair of oppositely-poled germanium diodes 172 and 173. Thus, because of the inclusion of diodes 164, 165, 172 and 173 and because of a relatively low screen potential provided for device 163, the device 163 may be considered as being included within an additional translating stage which exhibits a non-linear input wave amplitude versus output wave amplitude characteristic.

This stage also includes a pentode-type electron discharge device 174 having the output of cathode follower 168 supplied to its grid circuit via a band-elimination filter 175. This filter serves to attenuate frequency components within a small band which includes that frequency due to rotation of antenna 101 of Fig. 5. The output of pentode amplifier 175 is supplied over a con-

denser 176 to the control grid of an electron discharge device 177 which is connected in a cathode follower circuit similar to the one in which device 168 is included and having oppositely-poled germanium diodes 178 and 179 connected in shunt with its grid circuit. The output of cathode follower 177 is supplied to the input of another band elimination filter 178 having a characteristic similar to filter 175. The output of filter 178 is shunted by a circuit including another pair of oppositely-poled germanium diodes 180 and 181.

As pointed out in connection with circuit shown in Fig. 2, the portion of the translating system shown in Fig. 6 including devices 154 and 161 exhibits a characteristic which is approximately logarithmic in form. The additional translating stage including devices 163, 168, 174 and 177 provides a non-linear input wave amplitude versus output wave amplitude characteristic which together with the approximated function of the preceding stage effects a substantially logarithmic over-all characteristic for the system of Fig. 6. This, of course, is required in order to produce accurate recordings on the logarithmic paper in recorder 109.

The system also includes an automatic gain control circuit which is associated with the additional stage for modifying the over-all characteristic of the system. This circuit includes a diode rectifier 182 having its cathode connected to filter 179 at the point at which a resistor 183, extending from diodes 180 and 181, is connected. The anode of diode 182 is connected to a filter network 184 which, in turn, is connected to a potentiometer 185. There is thus provided means coupled to cathode follower 177 for deriving a control potential which varies in accordance with variations in amplitude of the wave applied to the system of Fig. 6.

This control potential is applied over the movable tap of potentiometer 185, a resistor 186, which is included together with a shunt condenser 187 in a decoupling network, and over a resistance network 188 to the control grid of pentode 174. The control potential is also applied over resistor 186, a resistor 189, which is included together with a condenser 190 in another decoupling network, and via a grid resistor 191 to the control electrode of pentode 163. The system thus includes means for applying the control potential to each of the pentode amplifiers 163 and 174. Since this potential increases in a negative sense as the wave amplitude increases, automatic gain control action is effected in a known manner.

In operation, by adjusting the movable tap of potentiometer 185, the amount of gain control action may be regulated. In that way the slope of the logarithmic, input versus output characteristic may be varied to some extent.

The output wave of cathode follower 177 of Fig. 6 is demodulated by a rectifier 182, and the undulating components, other than those due to the antenna pattern are attenuated by filter 184. The resulting unidirectional potential which appears at the upper end of the resistance element of potentiometer 185, representing the variations in the wave energy produced by rotation of antenna 101 (Fig. 5) compressed in logarithmic fashion, is applied to recorder 109.

The same advantages enumerated in connection with Fig. 2, apply to the use of the diodes 159 and 160 in the cathode circuit of devices 154 and 161 and hence need not be restated. Moreover, the use of the additional stage of compression (including devices 163, 168, 174 and 177), incorporating automatic gain control, in combination with the excellent compression characteristics of the preceding stage (including devices 154 and 161) produces an overall input versus output characteristic which approaches a logarithmic function more closely than heretofore possible.

While I have shown particular embodiments of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may

be made, and hence, it is contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. A system for logarithmically amplifying a range of large and small amplitude signals comprising a cathode follower, a cathode driven amplifier, a common cathode circuit electrically coupling said cathode follower to said cathode driven amplifier, means for applying said large and small amplitude signals to said cathode follower, a first circuit having an impedance which varies inversely with applied signal amplitude connected across said common cathode circuit for logarithmically compressing said large amplitude signals substantially without compressing said small amplitude signals, a second circuit similar to said first circuit for logarithmically compressing said uncompressed small amplitude signals and said logarithmically compressed large amplitude signals after amplification by said cathode driven amplifier, an additional signal amplifying stage having a nonlinear input signal amplitude versus output signal amplitude characteristic which complements said previously mentioned signal compression and amplification to provide a substantially logarithmic amplification characteristic for said system.

2. In combination, a cathode follower circuit, a cathode driven grounded grid amplifier circuit, a common cathode resistance electrically coupling said cathode follower circuit to said cathode driven amplifier circuit, means for applying large and small amplitude signals to said cathode follower circuit, a first compression circuit comprising a pair of oppositely poled diodes coupled across said common cathode resistance for logarithmically compressing said large amplitude applied signals substantially without compressing said small amplitude signals, said cathode driven amplifier circuit responsive to said compressed large amplitude signals and said uncompressed small amplitude signals for providing amplified output signals, a pentode type amplifier, a second compression circuit comprising a pair of oppositely poled diodes responsive to said amplified output signals for providing logarithmically compressed output signals, means responsive to said logarithmically compressed amplified output signals for providing logarithmically amplified versions of said first mentioned small and large

amplitude signals comprising said pentode amplifier biased to amplify large amplitude signals to a larger extent than small amplitude signals.

3. An arrangement for logarithmically amplifying a range of large and small amplitude signals comprising first means for compressing the amplitude of said large signals substantially without compressing said small amplitude signals to provide first output signals, said first means comprising a cathode follower circuit, said cathode follower circuit comprising an output cathode load resistance in parallel with a pair of oppositely poled unidirectionally conductive devices, second means responsive to said first output signals developed across said cathode load resistance for amplifying said first output signals to provide second output signals, said second means comprising a grounded grid amplifier, third means for compressing the amplitude of said second output signals to provide third output signals comprising a pair of oppositely poled unidirectionally conductive devices, fourth means for amplifying said third output signals to provide fourth output signals whose amplitudes bear a logarithmic relationship to the amplitudes of said first mentioned large and small amplitude signals comprising a pentode amplifier biased to exhibit a non-linear input signal amplitude versus output signal amplitude characteristic.

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