

April 7, 1942.

K. B. ELLER

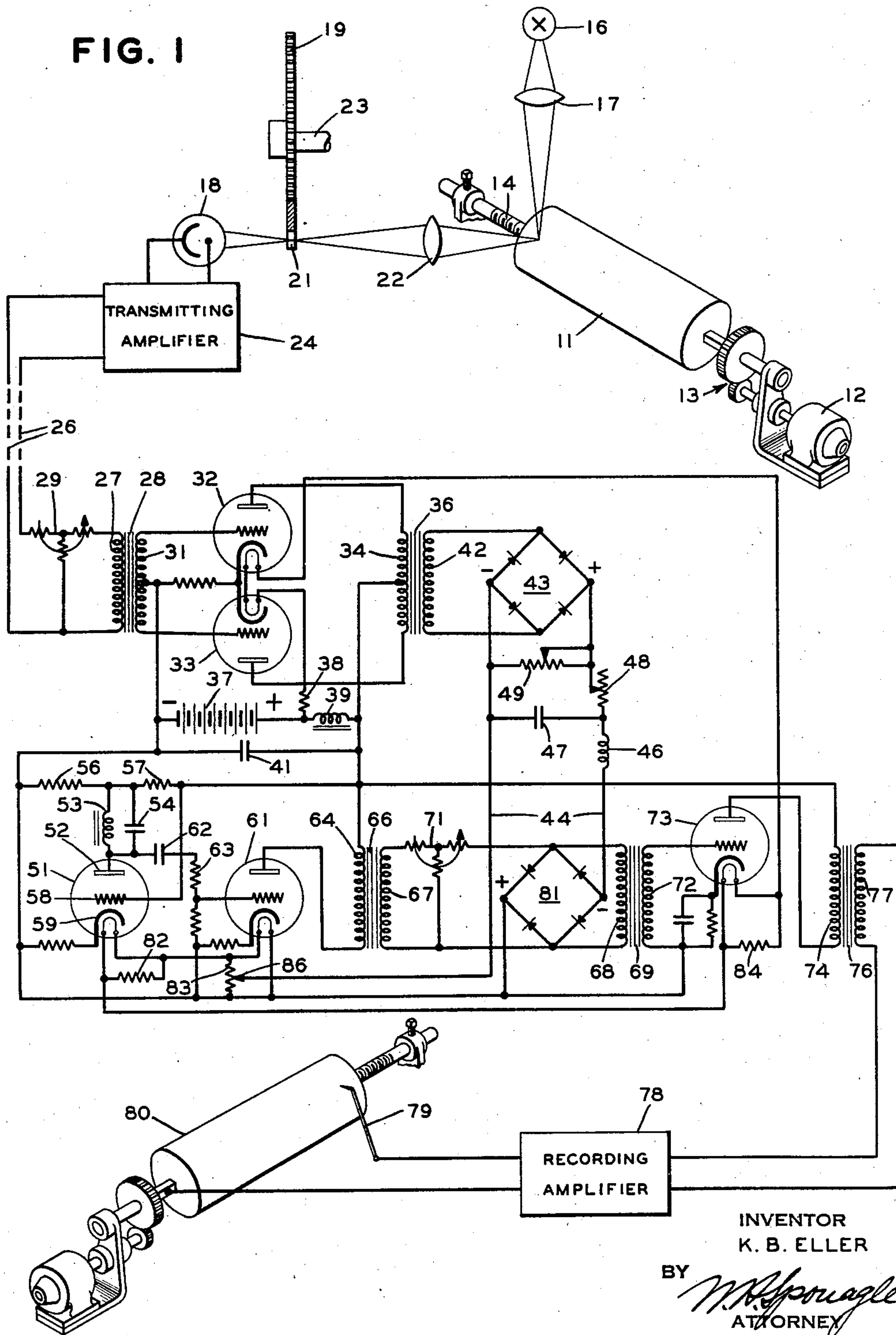
2,278,692

FACSIMILE SIGNAL INVERTER

Filed Feb. 16, 1940

2 Sheets-Sheet 1

FIG. 1



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FIG. 2

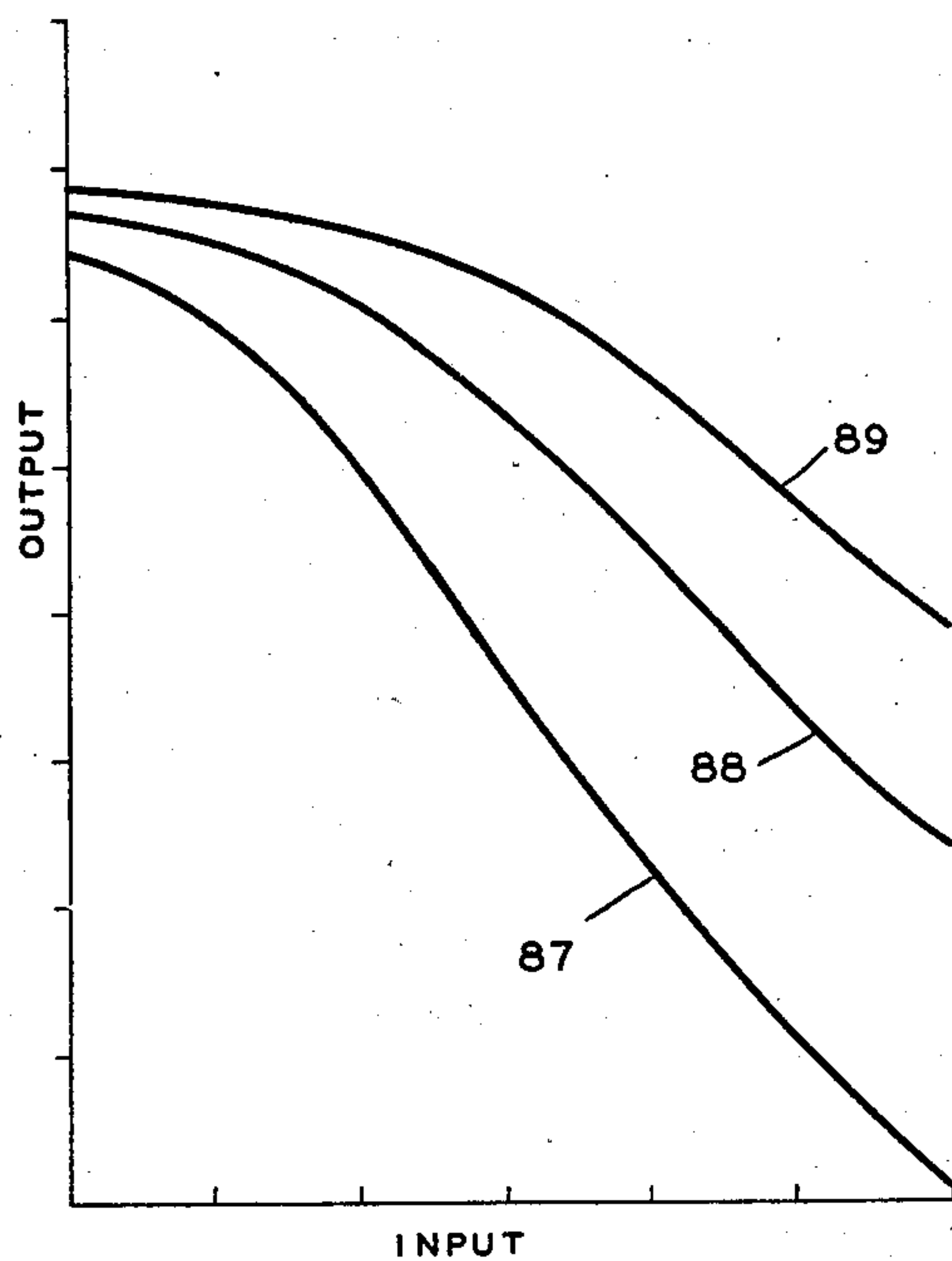


FIG. 3

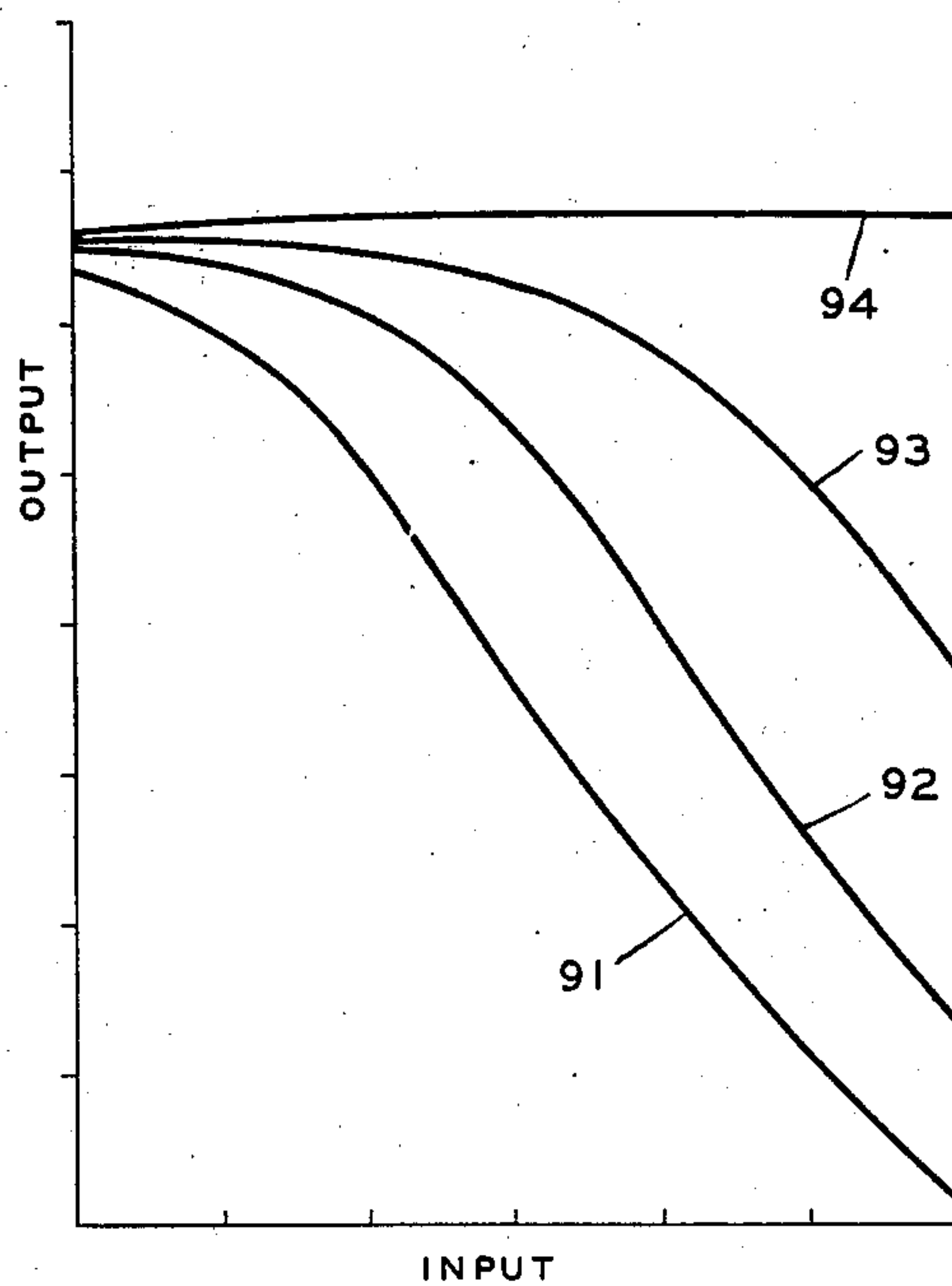
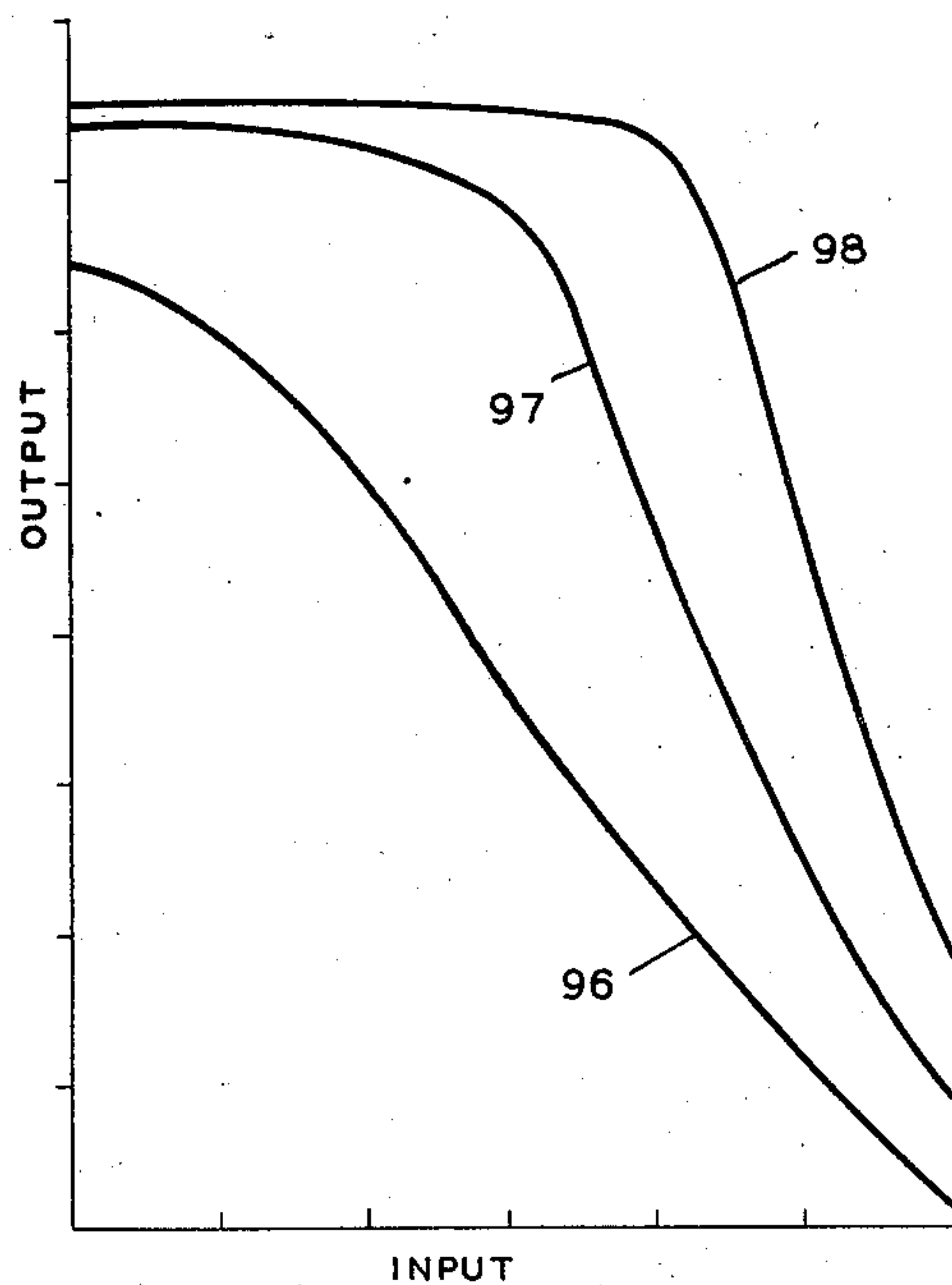


FIG. 4



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2,278,692

FACSIMILE SIGNAL INVERTER

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Application February 16, 1940, Serial No. 319,251

12 Claims. (Cl. 178—6.6)

This invention relates to facsimile telegraph systems and has particular reference to the control of the signals employed therein.

A convenient and efficient method of generating picture currents for transmission over a communication channel employing carrier frequencies utilizes a photoelectric cell in combination with a source of light. Light is reflected from the subject matter being scanned onto the photoelectric cell in proportion to the tonal densities of the subject matter. An interrupter or light chopper is interposed at some point in the optical system whereby a carrier frequency is generated and modulated in proportion to the amount of light which is reflected from the scanned subject matter. If the system includes a recorder which is operated in such a manner that marks are made in proportion to the amplitude of the signals applied thereto, a negative copy of the transmitted subject matter will be recorded. In order to produce a positive recording the generated signals must be inverted before being impressed upon such a recorder.

Hence it is a major object of the instant invention to provide an improved type of facsimile signal inverter.

For picture reception, in order to obtain exact reproduction of the transmitted subject matter, it is essential that the output of the signal inverter be proportional (or inversely proportional, depending upon whether a negative or positive recording is desired) to the input. It is also necessary that this proportionality exist throughout the entire range of signals from the minimum to the maximum.

It is, therefore, another object of this invention to provide a signal inverter having facilities for adjusting the response curve so that it has a linear characteristic throughout the working range.

Another type of facsimile service requires the transmission and reception of subject matter having tone values which are represented by signals having either a maximum or a minimum value. This class of subject matter includes printed or long hand copy, line drawings, etc. In order to record this type of subject matter it is necessary only to distinguish between maximum and minimum values of signal amplitudes. However, the degree of contrast between background and the marks made thereon varies appreciably. Therefore, in order to produce a legible reproduction of subject matter having variations in contrast between light and dark portions, it is necessary to be able to adjust the characteristics of the signal

inverter so that a substantial contrast is obtained in the recorded subject matter when only a small contrast exists in the original or transmitted subject matter. It is also desirable that a receiving system be adapted to make recordings having the same degree of contrast between the light and dark portions thereof from signals which are derived from scanned subject matter in which the contrast between the light and dark portions is great as well as from signals which are derived from scanned subject matter in which the contrast is small. It is apparent that if the response curve of the signal inverter has the same linear characteristics which are desirable for picture reproduction the recorder may be subjected to rather heavy currents when recording printed subject matter in which the contrast between white and black is great in the original copy.

Hence, another object of the invention is to provide a signal inverter having facilities for adjusting the response curve so that an expansion is secured in the "light" or non-marking region and saturation is obtained in the "dark" or marking region.

A further object of the invention is to provide a signal inverter having facilities for easily varying the character of the response curve throughout a substantial range.

Another object of the invention is the provision of means for translating facsimile signals from one carrier frequency to another.

The attainment of these and other more specific objects of the invention will become apparent from the following description which is taken in conjunction with the accompanying drawings, of which:

Fig. 1 is a circuit diagram of a facsimile telegraph system employing the novel signal inverter; and

Figs. 2, 3 and 4 illustrate typical response curves of the inverting apparatus.

In its general aspect, the facsimile system disclosed herein employs an optical scanning arrangement whereby facsimile signals are generated and modulated inversely to the tone values of the scanned subject matter. The apparatus employed for inverting the generated signals so that a positive reproduction may be made therefrom first amplifies and then demodulates the received signals. A local source of oscillations is provided and these local oscillations are impressed upon the input circuit of a second amplifier. A full wave rectifier is connected to receive the output of the local oscillator and, as arranged in the preferred embodiment of the in-

vention, the alternating current terminals of this rectifier are connected to the input circuit of the second amplifier. It has been found that a direct current voltage applied to the direct current terminals of the rectifier has the effect of decreasing the resistance of the alternating current side of the rectifier. Thus, a small direct current voltage applied to the direct current terminals of the rectifier acts as a shunt across the input circuit of the amplifier, thereby reducing the voltage which is applied thereto from the local oscillator. By applying the demodulated facsimile signals to the direct current terminals of the rectifier, which in this instance acts as a valve, it is seen that the potential of the local oscillations which is applied to the amplifier, will vary inversely with the amplitude to the received facsimile signals. Thus the output of the amplifier comprises alternating current signals which are modulated inversely to the received facsimile signals.

The invention is disclosed and described in conjunction with a facsimile telegraph system employing an optical scanning device. It will be understood that the instant invention is not limited to the specific combination of instrumentalities disclosed herein, but may be practiced in combination with substantially any form of facsimile scanning apparatus. Referring to Fig. 1 of the drawings, the subject matter to be scanned may be conveniently mounted on a drum 11. The drum is rotated at a suitable speed by means of a driving motor 12, which is connected thereto by means of a coupling device 13. Axial movement of the drum 11 is produced by a suitable advancing means 14 so that the entire message may be scanned. Light from a source 16 is concentrated by means of a lens 17 upon the surface to be scanned and is reflected into a photoelectric cell 18 or equivalent device. The spot of light which is projected upon the surface of the cylinder or drum 11 is thus caused to transverse the cylinder in a longitudinal direction as the cylinder rotates by reason of the axial movement thereof. The light which is reflected from the surface of the subject matter being scanned and which is incident upon the photoelectric cell 18 is interrupted by a shutter or light chopper 19. The shutter may be in the form of a disc as illustrated, which is provided with a series of equally spaced openings or notches 21 adjacent its outer edge. In cases where the reflected light is to be interrupted, a lens 22 serves to bring the reflected light beam to a focus substantially in the plane of the disc 19 so that it may pass through the openings 21 successively. The disc 19 is mounted upon a rotatable shaft 23 which may be driven in any suitable manner from the motor 12 or, if desired, from a separate source of mechanical power. The number of openings in the disc and the speed of rotation of the shaft may vary within wide limits depending upon the desired rate of scanning, the constants of the communication circuit employed between the transmitting and receiving stations and other factors. The output appearing across the terminals of the photoelectric cell 18 is of such a character that a negative copy of the scanned subject matter will be reproduced by the usual recorder employed in facsimile systems of this nature.

In cases where it is desired to make a positive record of facsimile signals generated as described, a signal inverter is employed, a novel form of which comprises the subject matter of the instant invention. Subsequent to the gen-

eration of the facsimile signals modulated in accordance with the tonal densities of the subject matter scanned as described, the signals may be amplified by means of a suitable amplifier 24 and transmitted over a pair of line conductors 26. At the receiving station the line conductors are terminated in a winding 27 of an input transformer 28. The signal level may be adjusted as desired by means of a T-pad 29. The secondary winding 31 of the input transformer is connected to the respective control grids of a pair of amplifier tubes 32 and 33. These tubes may be any of a number of types of tubes available for the purpose of amplifying signals within the voice frequency range. The tubes are arranged in the conventional push-pull connection by means of which their combined output is connected to a winding 34 of a transformer 36. A source of direct current potential 37 is used to provide the necessary power for operating all of the apparatus comprising the signal inverter. The heating elements of the various tubes are connected in series with one another and also with a current limiting resistor 38. Plate potential is supplied to the anodes of amplifier tubes 32 and 33 and to the anodes of certain of the other tubes from the battery 37 through a choke coil 39. A by-pass condenser 41 is also employed in conjunction with the power supply circuits and the choke coil for filtering purposes.

The amplified received signals are reproduced by induction in the secondary winding 42 of the transformer 36, and are connected to the alternating current terminals of a full wave rectifier 43. Therefore, the potentials which appear on the conductors 44 connected to the direct current terminals of the demodulating rectifier 43 represent the envelope of the modulated carrier current signals. An inductive device 46 is inserted in series with one of the conductors 44 and a capacitive device 47 is connected in shunt with these conductors and cooperate in a well known manner to filter out the carrier frequency from the demodulated signals. Two variable resistances 48 and 49, the former connected in series relation with one of the conductors 44 and the latter in shunt relation thereto, have a function to be described hereinafter.

A local source of oscillations is provided and includes an electron discharge device which is arranged so as to have a negative resistance characteristic. Such a device is the tube 51, having an electrode 52 which is arranged so that a secondary emission of electrons therefrom is produced. There is connected to this electrode an inductance 53 and a capacity 54 arranged in shunt relation with one another and connected to an intermediate positive potential through resistances 56 and 57, which are connected in series relation with one another and the combination connected to the source of potential 37 through the choke 39. An electrode 58 of the tube 51 is connected to the positive terminal of the source of potential 37 through only the choke 39 and is thus at a higher positive potential than the electrode 52. The cathode 59 of this tube is connected to the negative terminal of the source of potential 37. By reason of the above described connections, alternating currents are generated in the output circuit associated with the tube 51. The frequency of these alterations is determined by the relation between the values of the inductance 53 and the capacity 54. The output circuit from the local oscillator is derived in this instance from the secondary electron

emission electrode 52, and is coupled electrostatically to the input circuit of an amplifier tube 61. The coupling between the oscillator tube and the amplifier tube is obtained in a well known manner by means of a condenser 62 and a resistance 63. The amplified output of the tube 61 is impressed upon the primary winding 64 of a transformer 66 and the secondary winding 67 of this transformer is connected to a primary winding 68 of a transformer 69. Included in this connection is a T-pad 71 by means of which the signal level of the local oscillations may be controlled as desired. A secondary winding 72 of the transformer 69 is connected to the input circuit of an amplifier tube 73, which is provided with an output circuit including a winding 74 of an output transformer 76. The secondary winding 77 of this transformer is connected to the input circuit of a recording amplifier 78, the output circuit of which is connected to the recording stylus 79 and, in a suitable manner, to the drum 80 of the recording apparatus. This apparatus may be similar to the transmitting apparatus described hereinbefore for utilizing a recording blank which is mounted on a cylinder 80. The nature of this blank is such that marks or impressions are made thereon, having densities which are proportional to the current values applied between the stylus 79 and the drum 80.

A full wave rectifier 81 is connected with its alternating current terminals in shunt relation to the winding 68 of transformer 69. A plurality of copper oxide rectifiers arranged as shown are preferred for this rectifier. The direct current terminals of the rectifier 81 are connected to the conductors 44 so that the polarity of the terminals is opposed to that of the direct current terminals of the demodulator 43 with which they are respectively connected. The operation of the rectifier 81 as a valve by which the oscillations generated by the tube 51 are modulated inversely to the carrier current signals generated by the transmitting apparatus takes advantage of the fact that a small direct current potential impressed upon the direct current side of a rectifier of this type materially reduces the impedance of the alternating current side of the rectifier. Since the latter terminals are connected to the relatively high impedance of the transformer winding 68, a relatively small potential is impressed upon this winding when a relatively large direct current potential is impressed upon the direct current terminals of the rectifier, and vice versa. The direct current potentials which are applied to the direct current side of the rectifier 81 vary in proportion to the amount of light which is reflected from the subject matter being scanned by the transmitting apparatus. Hence, it follows that a relatively dark portion of the scanned subject matter is represented by a relatively small direct current potential which is applied to the direct current terminals of the rectifier 81. In this case the shunting action of the rectifier is relatively small, thereby allowing a relatively large potential to be applied to the input circuit of the amplifier 73. Since the recording apparatus is of such a nature that marks or impressions are made upon the recording medium having a tonal density in proportion to the amplitude of the output of the tube 73, a relatively dark recording will thus be effected. Similarly, a relatively light portion of the subject matter scanned by the transmitting apparatus is represented by a relatively large direct current potential applied to the direct current terminals

of the rectifier 81. The shunting action in this case is relatively large whereby the potential which is applied to the input circuit of the amplifier 73 is relatively small. The output of the amplifier is accordingly relatively small whereby a relatively light recording will be produced by the recording apparatus.

It has been pointed out in a preceding portion of the description that the heater elements of the various tubes included in the inverting apparatus are connected in series relation. In addition, the heater elements of the oscillator tube 51 and the amplifier tubes 61 and 73 are shunted respectively by resistances 82, 83 and 84. One terminal of the resistance 83 and one terminal of the heater element of the amplifier tube 61 are connected to the positive terminal of the rectifier 81 and to the negative terminal of the source of potential 37. The resistance 83 is provided with a sliding contact 86 which is connected to the negative terminal of the demodulator 43. By means of this sliding contact the negative terminal of the demodulator 43 and the positive terminal of the rectifier 81 may be connected directly together or, by suitably positioning the slider 86, a small potential may be introduced in this connection for a purpose to be described.

Adjustable resistances 48, 49 and 83 are for the purpose of adjusting the response curves of the inverting apparatus so that the desired characteristics may be obtained. The changes in the characteristics of the response curve effected by the adjustable apparatus provided therefor are shown in Figs. 2, 3 and 4.

The curves shown in Fig. 2 illustrate the effect of varying the series resistance 48 through a considerable range of values while the shunt resistance 49 is maintained at its maximum value, and while the slider 86 of the potentiometer 83 is connected to the negative terminal of the power source 37 so that a direct connection is made between the negative terminal of the demodulating rectifier 43 and the positive terminal of the rectifier 81. Curve 87 illustrates the relation between the input and output of the signal inverter with no series resistance included in the output of the demodulator 43. The insertion of a series resistance in this circuit by means of the variable resistance 48 changes the slope of the response curve as shown by the curve 88. The curve 89 is obtained by still further increasing the amount of series resistance in the output circuit of the demodulator. It will be noted that all of these curves have somewhat the same characteristics. For example, there is in each a considerable portion in which the curve is substantially linear. The differences between the various curves is that for a given change in input an increasingly smaller change in output is obtained as the resistance in series with the output of the demodulator is increased.

The curves of Fig. 3 are obtained by adjusting the resistances 48 and 49 so that no series resistance is included in the output circuit of the demodulator 43 and the shunt resistance in this circuit is varied. The curve 91 is obtained under the same conditions as curve 87 of Fig. 2, that is, the series resistance is zero and the shunt resistance is a maximum and there is no opposing voltage introduced by the potentiometer 83. Therefore, curves 87 and 91 are exact duplicates thereby affording a comparison between the effects produced by the two types of adjustments. The curve 92 is obtained by reducing the value of the

shunt resistance 49. Curve 93 illustrates the effect of reducing the shunt resistance still further and curve 93 shows the result produced by short circuiting the output circuit of the demodulator 43. It may be seen that the curves 91, 92 and 93 have substantially the same characteristics as those shown in Fig. 2.

Hence it is evident that, by properly manipulating either one or both of the adjustable resistors 48 and 49, the characteristics of the response curve of the signal inverter may be modified in such a manner that the inverting apparatus will function to produce in its output circuit inverted signals by which an exact reproduction of the scanned subject matter may be made. Such characteristics in an inverter are highly desirable for the reproduction of subject matter such as pictures wherein the tonal density of the elemental areas varies gradually throughout a substantial range.

Fig. 4 illustrates the effect of including an opposing potential in the circuits connecting the demodulating rectifier 43 and the modulating rectifier 81. The curve 96 is obtained under conditions similar to those under which curves 87 and 91 of Figs. 2 and 3 respectively were obtained, that is, with the series resistance zero and the shunt resistance a maximum and the voltage obtained from the resistance 83 zero. If this voltage be increased by a relatively small amount a response curve having the characteristic shown by the curve 97 is obtained. A still further increase in the opposing voltage results in a response curve having the characteristics shown by the curve 98. It is seen from the curve 98 and, to some extent, from the curve 97 that, for values of the input signals below a certain level, the response curves have saturation characteristics. It is also seen that once the saturation point has been passed a relatively small increase in input produces a relatively large change in output. Inverting apparatus having these characteristics is desirable when transmitting and reproducing subject matter having only light and dark areas with no intermediate tone values. Where the original copy of the subject matter to be transmitted has a relatively small contrast between the light and dark portions thereof, the signals which are generated will vary to only a small degree in amplitude. If a satisfactory reproduction is to be made of such a faint original it is necessary that the contrast between the light and dark portions be increased before being applied to the recording device. It will be apparent from an inspection of the curves 97 and 98 that inverting apparatus is provided which is capable of transforming signals so that the subject matter may be recorded with the desired degree of contrast, since a relatively large change in the output is made by a relatively small change in the input of the signal inverting apparatus.

When the original subject matter contains dark portions from which little or no light is reflected, the signals derived therefrom are small in amplitude but when these signals are inverted there is not a corresponding increase in the inverted signal since it is evident from the curves 97 and 98 that a decrease in the input beyond a certain value produces little or no increase in the output. Thus the inverter is seen to possess the desired expansion characteristic in the "light" region and the saturation characteristic in the "dark" region.

Obviously, the novel signal inverter herein disclosed is not limited to use at the receiving sta-

tion, but may be employed with equal facility at the transmitting station if more convenient or if it is desired to invert the facsimile signals before they are transmitted over a communication channel. Also the communication channel employed need not be the pair of line conductors shown, but may comprise equivalent forms well known in the art such as radio frequency channels and the like. It is evident that there is no necessity that the frequency of the alternating current generated by the vacuum tube oscillator bear any relation to the frequency of the alternating current generated by the facsimile transmitter. Therefore, the novel circuit arrangements of the instant invention provide a convenient means for effecting a change of the facsimile transmitter generated frequency to any other frequency which may be more suitable for transmission and/or recording. It is also apparent that the auxiliary alternating current employed with the inverting apparatus may be derived from any convenient source and is not limited to the vacuum tube oscillator disclosed to illustrate the invention.

The nature of the invention may be ascertained from the foregoing description of an illustrated embodiment, it being understood that changes in the invention herein disclosed may be made within the scope of what is claimed without departing from the spirit of the invention.

What is claimed is:

1. In a facsimile telegraph system employing amplitude modulated carrier current signals, means for demodulating said signals, a source of oscillations, an amplifier, means for impressing said oscillations upon the input circuit of said amplifier, a rectifier having its alternating current terminals connected to said input circuit, means for connecting said demodulated signals to the direct current terminals of said rectifier, and a utilization circuit connected to the output circuit of said amplifier.

2. A facsimile signal inverting system, comprising two rectifiers having unlike terminals of their respective output circuits connected together, an oscillator, means for connecting the facsimile signals to the input circuit of a first one of said rectifiers, means for connecting said oscillator to the input circuit of a second one of said rectifiers, a utilization circuit connected to said oscillator, and a resistance connected in shunt with said output circuits.

3. A facsimile signal inverting system, comprising two rectifiers having unlike terminals of their respective output circuits connected together, an oscillator, means for connecting the facsimile signals to the input circuit of a first one of said rectifiers, means for connecting said oscillator to the input circuit of a second one of said rectifiers, a utilization circuit connected to said oscillator, and a resistance connected in series with said output circuits.

4. A facsimile signal inverting system, comprising two rectifiers having unlike terminals of their respective output circuits connected together, an oscillator, means for connecting the facsimile signals to the input circuit of a first one of said rectifiers, means for connecting said oscillator to the input circuit of a second one of said rectifiers, a utilization circuit connected to said oscillator, and a source of direct current potential connected in series with said output circuits.

5. A facsimile telegraph system, comprising means for generating amplitude modulated car-

rier current signals representative of subject matter, means for demodulating said signals, a source of alternating current, a fixed impedance device connected to said source, a variable impedance device connected to said source to produce voltage changes in said fixed impedance device, means for utilizing said demodulated signals to alter the impedance of said variable impedance device, and means responsive to said voltage changes to reproduce said subject matter.

6. A facsimile signal inverting system, comprising two rectifiers having unlike terminals of their respective output circuits connected together, an oscillator, means for connecting the facsimile signals to the input circuit of a first one of said rectifiers, means for connecting said oscillator to the input circuit of a second one of said rectifiers, a utilization circuit connected to said oscillator, and filtering means including a condenser and an inductance connected to said output circuits.

7. In a facsimile telegraph system, means for generating facsimile signals comprising an amplitude modulated carrier current of one frequency, and means for translating said generated facsimile signals to a carrier current of a second frequency, said translating means comprising a source of carrier current of said second frequency, two impedances connected in shunt to said source, one of said impedances being a rectifier bridge, a demodulator for said generated signals, means for utilizing said demodulated signals to vary the impedance of said rectifier and thereby control the energy applied to the other of said impedances in accordance with said demodulated signals, and means for utilizing said controlled energy.

8. In a facsimile signal inverting system, a source of amplitude modulated carrier current signals, means for demodulating said signals, a source of oscillations, a rectifier, means including said rectifier and controlled by said demodulated signals for modulating in amplitude said oscillations inversely to said modulated carrier current signals, and a utilization circuit for said inversely modulated oscillations.

9. In a communication system, a source of amplitude modulated signals, a source of a limited supply of alternating current energy, a utilization circuit for said energy, a rectifier, and signal controlled means including said rectifier for diverting from said utilization circuit portions of said energy varying in amount in accordance with the amplitude of said signal modulations whereby the amplitude of said energy available for said utilization circuit is varied inversely to the amplitude of said signals.

10. In a communication system, a source of amplitude modulated signals, a source of a limited supply of alternating current energy, an alternating current utilization circuit for said energy, means for rectifying a portion of said energy, and signal controlled means for varying the amount of said energy rectified in accordance with the amplitude of said signal modulations to inversely vary the amplitude of said energy utilized by said utilization circuit.

11. In a communication system, a source of variable amplitude direct current potential, a source of alternating current potential, a utilization circuit coupled to said alternating current potential source, a rectifier bridge provided with a pair of alternating current terminals and a pair of direct current terminals connected to said source of alternating current potential, conductive means for connecting said variable amplitude direct current potential to said direct current terminals whereby the potential of said utilization circuit varies inversely to said variable amplitude direct current potential.

12. In a communication system, an alternating current potential, a fixed impedance connected to said potential, a rectifier having its alternating current terminals connected to the terminals of said impedance, a direct current potential connected to the direct current terminals of said rectifier, and means for varying directly said direct current potential to produce inverse variations of the alternating current potential for signaling purposes.

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