

April 2, 1946.

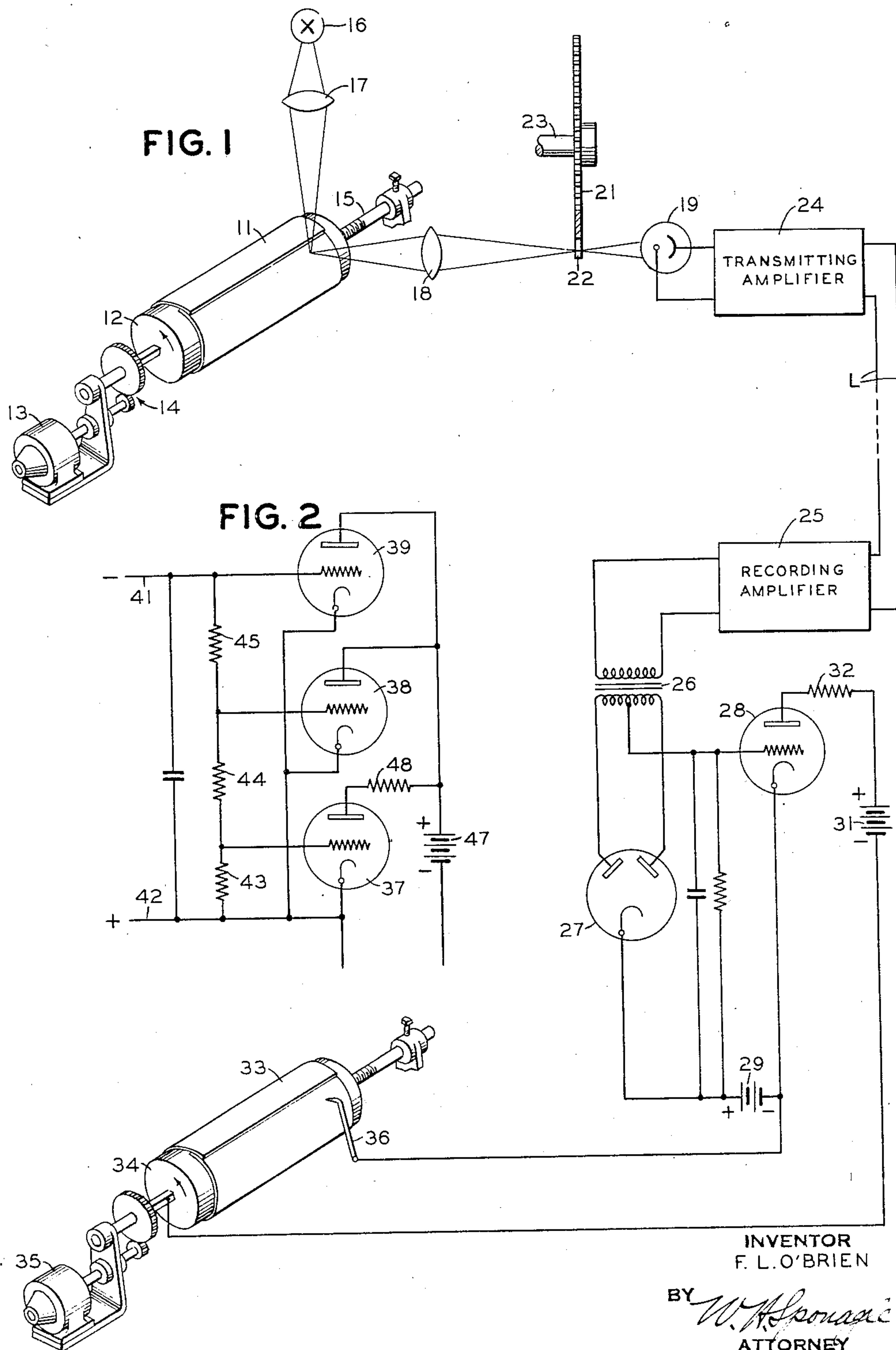
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FACSIMILE SIGNAL INVERTER

Filed May 16, 1942

2 Sheets-Sheet 1



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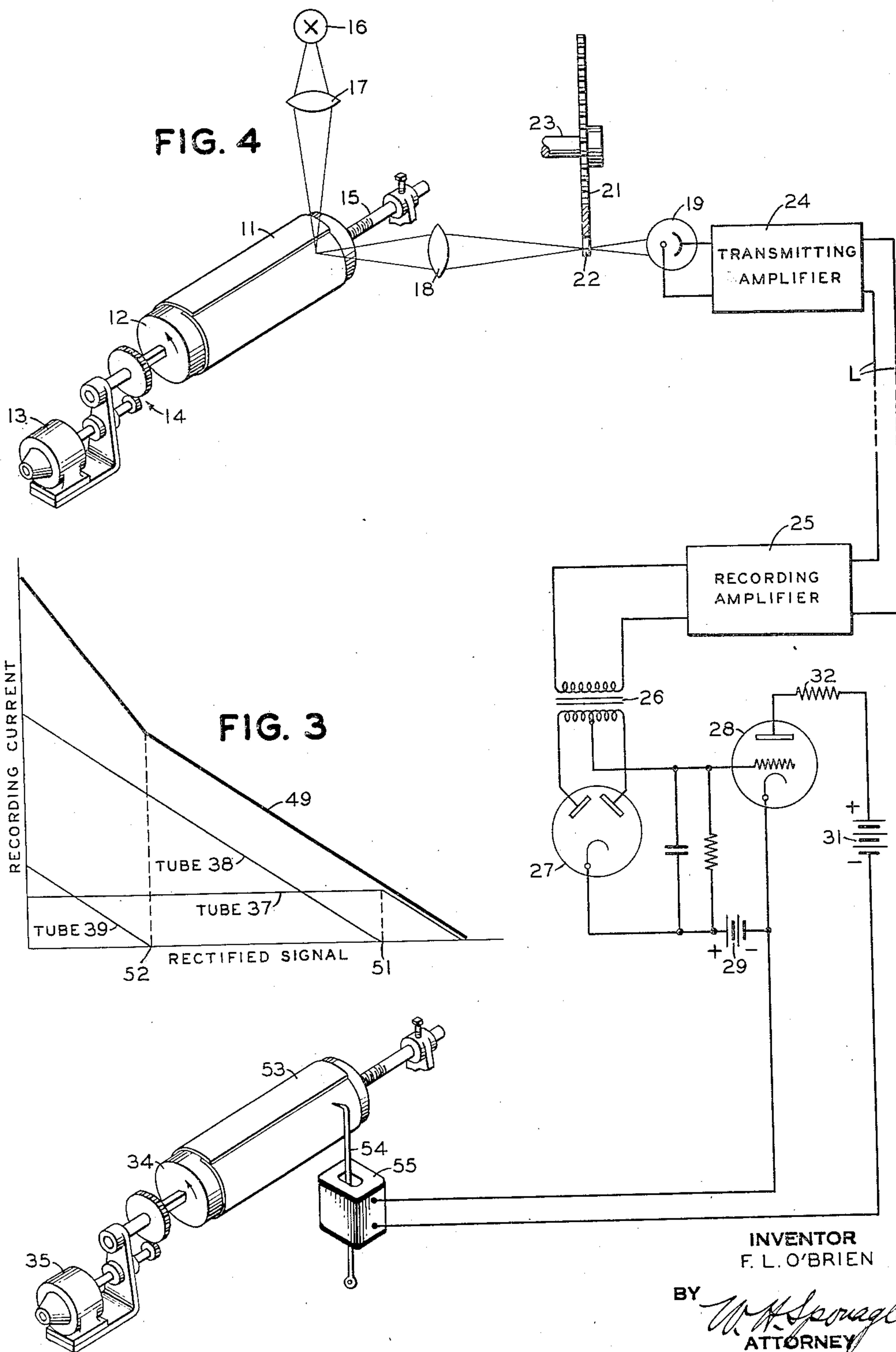
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UNITED STATES PATENT OFFICE

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FACSIMILE SIGNAL INVERTER

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11 Claims. (Cl. 178—6.6)

This invention relates to facsimile signaling systems and has particular reference to the recording of amplitude modulated signals representing graphic or pictorial subject matter.

It is one of the objects of the invention to provide a novel form of signal inverter.

An additional object of the invention is to provide a signal translating device having "trigger" operating characteristics, by means of which it is particularly adapted for use as a graphic signal inverter.

Another object of the invention is to provide an electronic signal inverter which is adapted to operate at either one of two limits in response to signals of an undulating character.

A further object of the invention is to provide an electronic signal inverter having a non-linear operating characteristic to compensate for a non-linear response characteristic of an opposite sense of the recording medium employed.

In the present specification a "trigger" operating characteristic is defined as one by means of which there is produced either a marking or a non-marking effect in response to a signal which may vary in amplitude between two predetermined limits. An electronic device having a trigger operating characteristic produces a marking effect of uniform intensity in response to all signals below a preselected value and a non-marking effect in response to all signals above the preselected value.

According to one feature of this invention, an electronic discharge device is arranged so that, when it is conditioned for conduction by the control circuit thereof, the space current is limited to a predetermined maximum value. The input circuit of the device is normally provided with a relatively large fixed positive biasing potential which, when acting alone, conditions the device for maximum conduction of space current. The signals to be translated by the device are applied to the input circuit thereof as undulating direct current potentials in opposition to the biasing potential. It is preferable to amplify the control signals before impression upon the translating device so that there is considerable variation between the maximum and minimum limits thereof.

A better understanding of the present invention may be obtained from a consideration of a number of illustrative embodiments thereof which are to be described in connection with the accompanying drawings, of which:

Fig. 1 is a diagrammatic illustration of a facsimile system embodying the invention employed as a signal inverter, in which the record is effected

upon an electrosensitive paper by means of a stylus or electrode;

Fig. 2 is a modified form of a signal inverter embodying the instant invention particularly adapted for use for recording pictures or other subject matter having considerable variation in tone densities;

Fig. 3 is a graphical representation of the operation of the device of Fig. 2; and

Fig. 4 depicts an embodiment of the invention similar to that disclosed in Fig. 1 but used in connection with a percussion type of recording element.

In Fig. 1 a facsimile transmitter is shown diagrammatically. A sheet 11 carrying the subject matter to be transmitted is mounted upon a cylinder 12. The cylinder is adapted to be rotated in the direction of the arrow by means of a motor 13 coupled to the cylinder by reduction gearing 14 whereby a desired speed of rotation is secured. In rotating, the cylinder 12 is moved longitudinally by engagement with a stationary threaded shaft 15. The illustrated means for securing helical scanning of the sheet 11 is conventional, and it is contemplated that any other means for securing a scanning movement may be employed, since such mechanism forms no part of the instant invention.

The subject matter on the sheet 11 is scanned optically by focusing upon the surface of the sheet a spot of light derived from a source 16 by means of a lens system 17. Light is reflected from the sheet in accordance with the tonal densities of the elemental areas scanned and is directed by a lens 18 onto the light sensitive element of a photoelectric cell 19. Interposed in the beam of reflected light is a chopper or interrupter which is disclosed herein as a disc 21 having formed adjacent the periphery thereof a plurality of notches 22. The disc is mounted for rotation on a shaft 23, which may be driven in any convenient manner such as by the motor 13, for example. The speed of rotation of the disc and the number and spacing of notches are arranged so that the light beam is interrupted at any desired frequency. The potentials derived from the photoelectric cell 19 are of a pulsating character whereby alternating current is generated and modulated in accordance with the tonal densities of the subject matter to be transmitted. The amplitude modulated alternating current facsimile signals are amplified by a transmitting amplifier 24 and are transmitted over a pair of line conductors L to the receiving station.

At the receiving station the signals are again

amplified by means of the recording amplifier 25, and the amplified signals are relayed by means of a coupling transformer 26 to a full wave rectifier tube 27. The rectified signals, which are undulating direct current potentials, are applied to the input circuit of an electron discharge tube 28 in such a manner that they tend to make the control grid of the tube negative with respect to its cathode. This feature forms the basis, in each modification, for the signal inverting action. The input circuit of the tube is biased by a battery 29 so that the grid is normally positive with respect to the cathode. Space current for the tube is derived from a source of direct current potential such as the battery 31, and the magnitude of this current is limited chiefly by a series resistance 32 rather than by the space impedance of the tube. The output circuit of the tube 28 is connected to the recording apparatus which operates synchronously with the transmitting apparatus. The recording medium is an electrosensitive sheet 33 mounted upon a cylinder 34 which is arranged for scanning movement, deriving its motive power from the motor 35. The recording circuit is connected in a suitable manner to the cylinder 34 and to a scanning electrode or stylus 36.

In considering the operation of the translating device, it should be borne in mind that large amplitude received signals represent light areas of the sheet 11 and that small amplitude received signals represent dark areas of the subject matter contained in the sheet 11. Since it is a characteristic of the recorder that marks are made on the recording sheet 33 proportioned in intensity to the value of the potentials of the recording circuit, any attempt made to employ the received signals for recording purposes would result in making a negative copy of the transmitted subject matter. Therefore, it is one of the functions of the translating apparatus to invert the received signals so that a positive copy may be made. It is assumed that in this case the subject matter is printed matter, a line drawing, or the like, in which case a distinction is to be made only between marking and non-marking signals without regard to the intensity of the marking signals. It is desirable oftentimes to make all marking effects of equal intensity.

In the absence of signals, the relatively large positive biasing battery 29 conditions the tube 28 for conduction. The size of the space current battery 31 and the value of the resistance 32 are such that the space current conducted through the tube is limited to a predetermined value throughout a considerable range of potentials applied to the grid of the tube. When direct current signal potentials, representing dark areas of the scanned subject matter, are applied to the input circuit of the tube 28, the recording current in the output circuit of the tube is controlled only by the biasing battery 29, since the signal potentials are small. In this case a marking effect is produced. When a signal representative of a light area is received, a large direct current signal potential is applied to the input circuit of the tube by the rectifier 27. As this signal potential increases in magnitude, it effects a decrease in the positive bias of the tube 28. No change is produced in the value of the space current of the tube, however, because of the arrangement thereof until the signal potential increases beyond a predetermined value. At this time the effect of the biasing battery 29 is completely overcome, and the grid of the tube 28 is

made sufficiently negative with respect to its cathode to interrupt completely the spaced current flowing in the recording circuit. Thus, in response to the large amplitude received signal, current is interrupted in the recording circuit and a non-marking effect is produced.

It has been found that in order to provide the tube 28 with a trigger operating characteristic a relatively large change in grid potential must be produced by a relatively small change in the level of the received signals. It is customary to express the signal level in terms of units which are the logarithms of power ratios or, in some instances, of voltage ratios. Because of the logarithmic relation, a unit change in the signal level corresponds to a much larger voltage ratio at high signal levels, than the voltage ratio corresponding to a unit change at a low signal level. Consequently, by providing considerable amplification in amplifiers 24 and/or 25, the change in the potential of the output of the rectifier tube 27 is relatively large when a unit change in the level of the signals is effected in the high signal level range. In practice, such a voltage change may, for example, be of the order of 50 volts. Thus, when the facsimile signals are increasing, but before the trigger point of the tube 28 is reached, the net grid voltage is sufficiently positive to produce the maximum space current. The next small increase in the level of the facsimile signals, for example, a one unit increase, produces a net grid voltage which is sufficiently negative to interrupt completely the conduction of space current in the tube.

In Fig. 2 is shown an arrangement embodying the principles of the invention which is adapted for use in a system for the reproduction of pictures or other subject matter having a substantially wide range of tone values. In this case three tubes 37, 38 and 39 are used and are arranged so that their output circuits are connected in multiple. The rectified signals potentials are impressed by means of conductors 41 and 42 upon a voltage divider comprising the series connection of three resistances 43, 44 and 45. The rectifier is connected to the voltage divider in such a way that conductor 41 is negative and conductor 42 is positive. The input circuit of tube 37 has impressed thereon that portion of the signal potential derived from the resistance 43. The input circuit of tube 38 has impressed thereon that portion of the signal voltage derived from resistances 43 and 44, and similarly the full signaling potential is impressed upon the input circuit of tube 39. The grids of all of these tubes are at cathode potential in the absence of rectified signaling potentials, and therefore under such conditions the tubes are conducting. Space current for the tubes is furnished by the battery 47. One or more of the tubes may be provided with current limiting facilities, such as a resistance 48, in series with the plate circuit of the tube 37.

In considering the operation of this device, assume that the direct current signaling potential is at a maximum value, corresponding with the scanning of the whitest portion of sheet 11. In this case the grids of the tubes 37, 38 and 39 have impressed thereon negative potentials derived from the voltage divider which are sufficiently large to render all of the tubes non-conducting. When a slightly darker portion of the sheet 11 is scanned, a small decrease in the value of the signaling potential is effected. The corresponding direct current potentials applied to the re-

spective tubes are decreased proportionately. The potentials which are applied to the tubes 38 and 39 are still sufficiently negative to prevent these tubes from becoming conducting. The decrease in the portion of the negative potential derived from the resistance 42, however, produces a potential upon the grid of the tube 37 of such a value that conduction begins. A small current is thus allowed to flow in the recording circuit whereby a light mark is made upon the recording sheet 33. As the signaling potential decreases still further in response to the scanning of darker elemental areas of the sheet 11, conduction of space current in the tube 37 is increased gradually until the limiting value is reached. This value is determined by the size of the battery 47 and the value of the resistance 48. At the point where this limiting value of space current is reached, potentials applied to the tubes 38 and 39 are arranged to be sufficiently negative to prevent either of these tubes from becoming conductive.

The production of recording currents corresponding to the lighter shades of the picture being reproduced by means of the tube 37 is primarily for the purpose of overcoming a relatively high threshold impedance of the recording paper. Where a single tube is employed in a recording circuit of this character, it is not ordinarily easy to operate entirely within the straight line portion of the characteristic plate current-grid voltage curve and at the same time produce disproportionate responses to the signals representing the lighter portions of the picture for the purpose of overcoming the threshold impedance of the recording paper. In such a case these lighter shades are either not reproduced at all or are reproduced with some lack of faithfulness.

Having operated and utilized the tube 37 for reproducing the lighter shades of the picture, the resistor 48 serves to limit the output current of this tube at a constant value as the signaling potential is further decreased. Substantially at the point where the limiting action is started, the tube 38 is conditioned for the conduction of a small current which is added to the current through the tube 37 so that the total current flowing in the recording circuit is correspondingly increased. This operation continues in a similar manner in response to further decreases of the signaling potential caused by the scanning of darker portions of the picture until the tube 39 is also conditioned for conduction to still further add to the current flowing in the recording circuit. In this case it is to be noted that there is no limiting of the current flowing in the output circuits of either of the tubes 38 or 39. The device is also arranged so that the tubes 38 and 39 operate at all times on the straight line portions of their respective characteristic curves. Consequently, after conduction is started in tube 39, the current flowing in the recording circuit is greater in proportion to changes of the signaling potential than it is before the beginning of conduction in tube 39. The purpose of such an arrangement is to compensate for the non-linear response characteristic of most recording papers employed in systems of this nature. It has been found that little distinction is obtained in the density of the recording marks made in the darkest portions of a sheet when the currents employed for making such marks are varied in the same proportion as in other portions of the recording range. Consequently, by using the arrangement of the instant invention, the current in the recording circuit is disproportionately in-

creased in the darker parts of the picture so that a compensation for the response characteristic of the recording paper is effected.

In Fig. 3 is a graphic representation of the operation of the device shown in Fig. 2. The output currents of tubes 37, 38 and 39 are represented by lines designated by the reference characters of the respective tubes. The heavy line 49 represents the combined output of all the tubes and is the current which flows in the recording circuit. When the rectified negative signal potential decreases to the value represented by the point 51, the current in the tube 37 is limited to a constant value, and current begins to flow in the tube 38. At the time when the signal potential is decreased to a value represented by the point 52, conduction of current is initiated in tube 39. Also at this point it is seen that the slope of the curve 49 changes so that further decreases in the rectified signaling potential cause much greater increases in the current flowing in the output circuit than similar decreases made previously.

Having reference to Fig. 4, there is shown a translating device having trigger and signal inverting characteristics similar to the device disclosed in Fig. 1. In this case, the recording is done on a sheet 53 which, for example, may be a mimeograph stencil. The recording element is a percussion element comprising a stylus member 54 which is adapted for movement into and out of engagement with the surface of the sheet 53 by an electromagnet 55. Such a device, shown herein diagrammatically, is of the type shown in greater detail in Patent No. 2,260,862, granted to F. L. O'Brien and P. H. Estes on October 28, 1941. The operation of the translating device is similar to that described in connection with Fig. 1.

The nature of the invention may be ascertained from the several embodiments disclosed herein, and it is contemplated that other modifications not specifically disclosed may be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a facsimile signal translating system, a source of undulating direct current potentials representing tonal densities of subject matter to be reproduced in facsimile, an electron discharge tube having a control grid and an anode, a recording circuit connected to said anode, a relatively large positive biasing potential connected to said grid for obtaining trigger action of said tube, and means to connect said direct current potentials to said grid in opposition to said biasing potential for producing currents in said recording circuit inversely related in amplitude to said direct current undulations.

2. In a facsimile system, a source of alternating current signals varying in amplitude inversely in accordance with the tonal densities of elemental areas of subject matter to be reproduced in facsimile, an electron discharge tube having a control grid and an anode, a recording circuit connected to said anode, a relatively large positive biasing potential connected to said grid for obtaining trigger action of said tube, means for rectifying said alternating current signals, and means for connecting said rectified signals to said grid in opposition to said biasing potential for producing currents in said recording circuit of a character to effect a positive reproduction of said subject matter.

3. In a facsimile signal inverting system, a source of amplitude-modulated alternating cur-

rent signals, an electronic relay having a control circuit and an output circuit, a recorder in series with said output circuit, means for strongly positively biasing said control circuit to render said output circuit in a condition beyond saturation of said electronic relay, means for rectifying said signals, and means for impressing said rectified signals upon said grid in opposition to said biasing means whereby large amplitude signals are required to render said output circuit non-conducting.

4. In a facsimile signal translating system, a source of alternating current signals modulated in two amplitude ranges, one above and the other below a predetermined value, an electron discharge tube having a control grid and an output circuit, means in series with said output circuit to limit the current flow therein to a predetermined maximum value, a relatively large fixed positive biasing potential for said grid, means for rectifying said signals, and means for impressing said rectified signals upon said grid in opposition to said biasing potential and means including said biasing potential and said rectified signals for rendering said tube non-conducting in response to said rectified signals within one of said amplitude ranges and conducting to the extent of said maximum value of output circuit current in response to signals within the other of said amplitude ranges.

5. In a facsimile system, a source of facsimile signals comprising unidirectional undulations, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having a non-linear response characteristic, a plurality of electron discharge paths each including a control grid and an anode, said anodes being connected to furnish recording currents to said sheet, means for impressing different increments of said undulations upon the respective grids and means controlled by said increments on said grids whereby the respective discharge paths are rendered operative at different signal levels to compensate for the non-linear response characteristic of said record sheet.

6. In a facsimile system, a source of alternating current signals modulated in amplitude in accordance with elemental areas of a picture, a rectifier, means including said rectifier for converting said alternating current signals into unidirectional undulations, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having a non-linear response characteristic, a plurality of electron discharge tubes each having a control grid and an output circuit, said output circuits being arranged in multiple and connected to apply recording currents to said record sheet, means for limiting the space current in one of said tubes, and means for applying different increments of said unidirectional undulations to the respective tubes whereby said tubes are rendered operative successively to compensate for the non-linear response characteristic of said record sheet.

7. In a facsimile system, a source of alternating current signals modulated in amplitude in accordance with elemental areas of a picture, a rectifier, means including said rectifier for converting said alternating current signals into unidirectional undulations, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having a non-linear response characteristic, a plu-

5 rality of electron discharge tubes each having a control grid and an output circuit, said output circuits being arranged in multiple and connected to apply recording currents to said record sheet, means for limiting the space current in one of said tubes, and means for applying different increments of said unidirectional undulations as negative biases to the grids of the respective tubes whereby said tubes are rendered operative successively to compensate for the non-linear response characteristic of said record sheet and to effect an inverse relationship between said undulations and said recording currents.

8. In a facsimile system, a source of unidirectional undulations representing tonal densities of elemental areas of a picture, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having a non-linear response characteristic, a plurality of electron discharge tubes each including a control grid and an anode, said anodes being connected in multiple to apply recording currents to said record sheet, a voltage divider connected to said source of undulations, and means for connecting the respective grids of said tubes to different negative polarity points of said voltage divider whereby said tubes are rendered operative successively to compensate for the non-linear response characteristic of said record sheet.

9. In a facsimile system, a source of facsimile signals comprising variable amplitude potentials, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having a non-linear response characteristic, a plurality of electron discharge paths, each including a control grid and an anode, said anodes being connected to furnish recording currents to said sheet, means for impressing different increments of said potentials upon the respective grids and means controlled by said increments on said grids whereby the respective discharge paths are rendered operative at different signal levels to compensate for the non-linear response characteristic of said record sheet.

10. In a facsimile system, a source of facsimile signals comprising unidirectional undulations, a record sheet capable of color changes by the passage therethrough of electrical recording currents, said sheet having non-linear response characteristics at both ends of the recording range, a plurality of electron discharge tubes each having a control grid and an output circuit, said output circuits being arranged in multiple and connected to apply recording currents to said record sheet, means for applying different increments of said unidirectional undulations to the respective tubes whereby said tubes are rendered operative successively in response to deviations of said undulations greater than a predetermined small amount to compensate for the non-linear response characteristic of said record sheet at one end of said recording range, and means responsive to a relatively small predetermined deviation of said unidirectional undulations to supply a small recording current to said sheet before any of said tubes is rendered conductive to compensate for the non-linear response characteristic of said record sheet at the other end of said recording range.

11. In a facsimile system, a source of facsimile signals comprising unidirectional undulations, a record sheet capable of color changes by the passage therethrough of electrical recording cur-

rents, said sheet having non-linear response characteristics at both the light and dark ends of the recording range, a plurality of electron discharge tubes each having a control grid and an output circuit, said output circuits being arranged in multiple and connected to apply recording currents to said record sheet, means for limiting the current in the output circuit of one of said tubes to a predetermined relatively small maximum value, means for applying different increments of said unidirectional undulations to the respective tubes whereby said tubes are rendered operative successively in response to said

undulations, means including the last to be operated one of said tubes to compensate for the non-linear response characteristic of said record sheet at the dark end of said recording range, and means including said tube having a limited output current responsive to a relatively small deviation of said unidirectional modulations to supply said predetermined small recording current to said sheet before any of said other tubes is rendered conductive to compensate for the non-linear response characteristic of said record sheet at the light end of said recording range.

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