

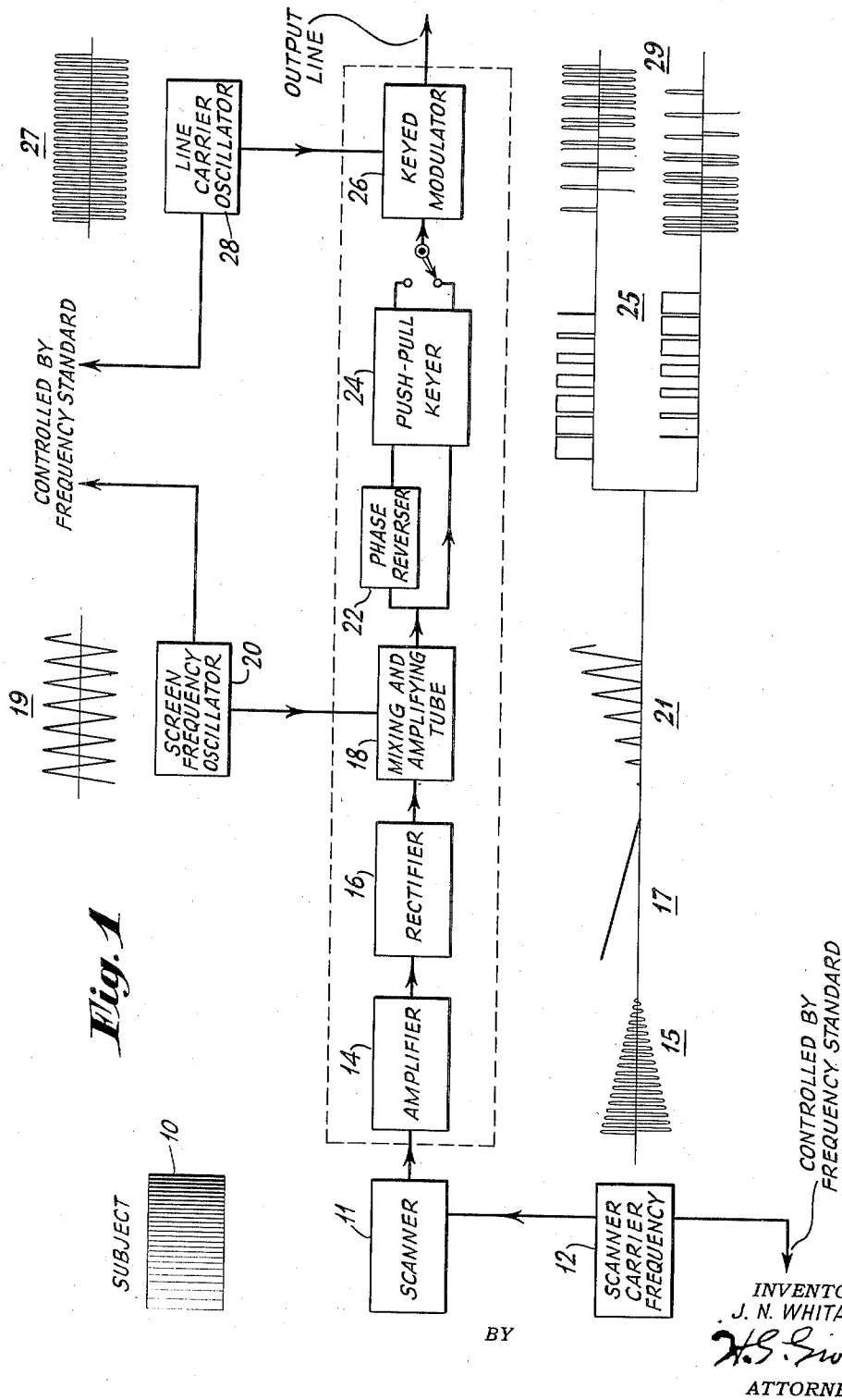
April 8, 1941.

J. N. WHITAKER
PHOTO-RADIO SYSTEM

2,237,645

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2 Sheets-Sheet 1



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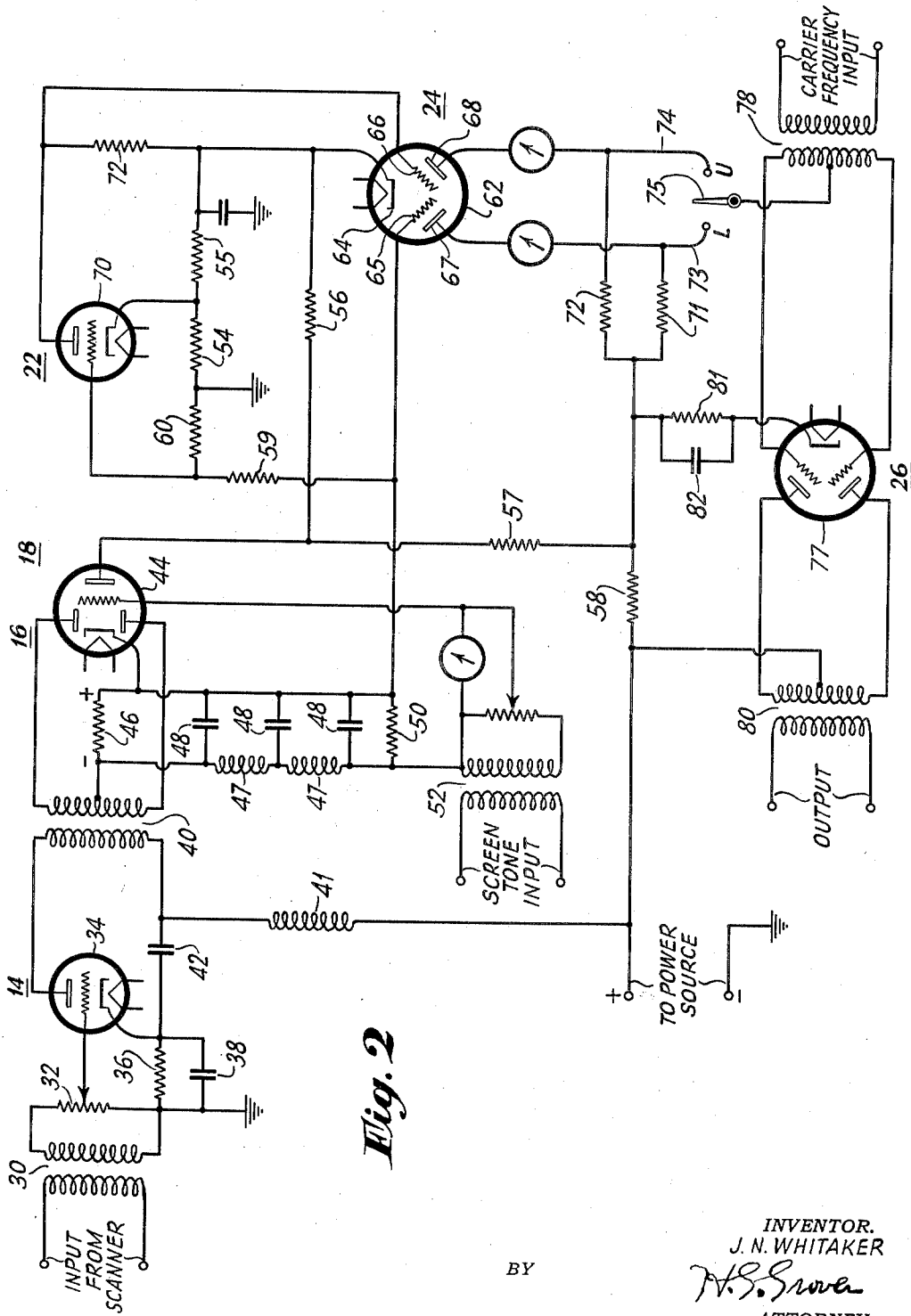
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2 Sheets-Sheet 2



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2,237,645

PHOTO-RADIO SYSTEM

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6 Claims. (Cl. 178—5)

The present invention relates to a method of and means for transmitting intelligence, which is preferably in the form of a picture record, to a remote point where an electro-optical image or facsimile of the transmitted subject is to be reproduced. Generally, the invention is one which is capable of transmitting any type of intelligence, but it is particularly adaptable to the transmission of subjects which can be observed by the eye. These subjects, for example, may be pictures, copies of newspapers, financial statements, film records such as motion picture film with or without sound equipment, fashion plates, copies of fingerprints, drawings or other similar matter.

Briefly, the invention will herein be characterized as a constant frequency variable dot system by the use of which printed matter or like matter may be transformed into a series of electrical impulses which when received over a radio or wire line communication channel may be utilized for reproduction purposes. This constant frequency variable dot system of transmission consists essentially in the conversion of amplitude changes of a carrier or tone frequency into varying weight signalling or marking impulses which are transmitted at a constant frequency and amplitude so that the useful period of transmission which will at the receiving point correspond to marking periods, may have a value varying between zero and 100%.

In previously used systems for accomplishing the transmission desired, the lighter portions of the subject to be transmitted, that is, the portions of the subject varying in intensity between middle gray and white, for example, the marking periods are generally of constant duration while the spacing periods vary, and as the intensity of the light or shadow on the subject varies between middle gray and black, for example, the type of marking to reproduce these particular tonal values of the subject changes to a marking of variable duration and equal spacing between each marking representation. With this type of marking, to denote the lighter portions of the picture between middle gray and white, the relationship between the marking and the spacing periods may vary from equality of marking and spacing periods to as much as fifty times the time duration of spacing to the time duration of marking. Likewise for the darker portions between middle gray and black, the time duration of the marking impulses with respect to the spacing impulses may vary from equality to fifty times the time duration of the

spacing impulses. Thus it will be seen that in addition to varying the weights of the marking impulses the frequency at which these impulses are transmitted is varying, and with this type of equipment for transmitting records the variation in frequency range may be, for example, between 50 and 350 cycles per second.

In another type system which is known, the marking impulses are always at a constant frequency so that the number of marking impulses per unit time is constant, that is, the sum of the marking and spacing duration for any value of density is always constant but the marking duration depends upon the intensity of the subject at the point of scanning. Suppose, for example, that it is desired to transmit 150 dots per second and for a light portion of the subject the marking interval might be $\frac{1}{10}$ of this period or $\frac{1}{1500}$ of a second, then it is seen that the spacing duration would be $\frac{9}{1500}$ of a second. However, for a dark portion of the subject, the conditions might be such that the marking pulses occur for $\frac{7}{1500}$ of a second, whereas the spacing would be reduced to $\frac{8}{1500}$ of a second. In both of these cases it would be noted, however, that the sum of the marking and spacing time periods is always $\frac{1}{150}$ of a second, or if the 150 dots per second first assumed is the screen frequency, then it is seen that the sum of the marking and spacing impulses per time unit is always the reciprocal of the screen frequency.

In the use of this system in known apparatuses, a screen tone converter and amplifier has been used to convert the output from the scanning head into impulses of screen tone frequency and of varying duration in accordance with the light and dark values of the subject being scanned. In such systems some difficulty has been encountered inasmuch as the regenerative square wave amplifier will oscillate when the amplitude of the modulated scanner carrier plus the applied screen frequency is not sufficient to produce ample voltage changes in the control electrode circuit of the square wave amplifier. A system such as the one just described is shown and described in detail in the patent to Henry Shore and James N. Whitaker #2,033,245 of June 8, 1937.

The present invention relates to a material improvement over the system shown and described in the above mentioned patent in that the system has been substantially simplified and in that the tendency for the system to oscillate has been completely obviated by the omission of the regenerative square wave amplifier.

In the present system, signals of scanner carrier frequency which are modulated in accordance with the light values of the subject being scanned, are supplied to an amplifier tube which in turn supplies power to a rectifier, the output of which represents, in current and voltage, the light and dark values of the particular subject. A screen frequency of a constant value is then supplied to a mixing tube together with the output of the rectifier tube which results in the production of impulses of constant frequency but of variable intensity, the intensity being determined by the output of the rectifier tube in accordance with the light and dark values of the subject being scanned.

The output from the mixer tube is then supplied to a push-pull keyer through an appropriate phase reversal system in order to accomplish true push-pull operation of the keyer. The separate elements of the push-pull keyer are made conducting or non-conducting depending upon the length or amplitude of the output from the mixer tube, which impulses, as stated before, are of a constant frequency. The output of the push-pull keyer which comprises a series of impulses of constant frequency and constant amplitude but of varying lengths, depending upon the light and dark values of the subject, is then supplied to a modulator for modulating the line carrier frequency prior to transmission by radio or line channel.

It is therefore one purpose of the present invention to provide means whereby pictures or printed matter may be transmitted by transforming the light values of the subject into impulses of constant frequency but of varying duration.

Another purpose of the present invention resides in the provision of means whereby a simple and improved method of photo-radio transmission may be accomplished.

A still further purpose of the present invention resides in means whereby the subject matter to be transmitted by facsimile may be transmitted either negatively or positively.

A still further purpose of the present invention resides in the use of a push-pull keyer for operating a push-pull modulator in a photo-radio transmitting system.

Another purpose of the present invention resides in the provision of means whereby positive or negative transmission may be accomplished.

Still another purpose of the present invention resides in provision of means for selecting either positive or negative transmission, the means comprising a single-pole double-throw switch.

A still further purpose of the present invention resides in the provision of a circuit whereby negative or positive transmission may be selected by a switching operation without the necessity of changing any of the adjustments or parameters of the circuit.

Still further purposes and advantages of the present invention will become apparent to those skilled in the art from a reading of the following specification and claims, particularly in connection with the accompanying drawings, wherein like reference characters represent like parts and wherein:

Figure 1 is a diagrammatical showing to represent the sequence of the various operations of the present invention, and

Figure 2 shows a preferred system which is constructed in accordance with the present invention.

Referring now to the drawings, in Figure 1 is shown a subject 10, which varies in shading from light to dark or black. It is upon this subject that light is projected for reflection on to a light responsive element for producing current and voltage variations in accordance with the light values of the subject. The light responsive element is contained within the scanner 11 which is supplied with a scanner carrier frequency by the element 12, the frequency being controlled by a standard constant frequency. The output from the scanner is then directed to an amplifier 14 and the wave form of the energy supplied to the amplifier is such as that shown at 15 for a subject having the light values such as that shown at 10. It will be noticed by referring to the wave form 15 that the wave consists of an amplitude modulated wave, the carrier frequency of which corresponds to the scanner carrier frequency and the amplitude of which corresponds to the amount of light which is reflected from the subject. After the signals have been amplified, they are supplied to a rectifying device 16 where they are rectified, the output of this device being represented by the curve 17. It will be noticed by examining the wave form of the curve shown at 17 that it conforms to the envelope of the modulated scanner carrier frequency wave shown at 15.

The rectified signal is then directed to a mixing and amplifying device 18 upon which is also impressed a screen frequency of a wave form such as is shown at 19, and which is produced by a screen frequency oscillator 20, the oscillator being controlled by a constant frequency standard. The output of the mixing and amplifying device 18 is shown by the wave form 21 and it will be noticed by inspecting this wave form that the impulses occur at constant frequency but are of a varying amplitude, the darker the subject the greater the amplitude. It will also be noticed that the shape of each impulse wave corresponds to the shape of the wave form of the screen frequency as shown at 19, the amount of each wave used depending upon the amount of output from the rectifying device 16.

The output of the mixing and amplifying device 18 is then supplied to a push-pull keyer 24, one portion of the output being fed directly to the push-pull keyer and the other portion of the output being supplied thereto through a phase reverser 22 in order that the control electrodes of the push-pull keyer will be affected equally but in phase opposition. The separate halves of the push-pull keyer then supply wave forms such as are shown at 25 which comprise a series of impulses of constant frequency and of constant amplitude but having a duration as determined by the amplitude of the output of the mixing and amplifying device. These impulses are then directed to a keyed modulator 26 to which is also supplied a line carrier frequency of the form shown at 27 which is generated by a line carrier oscillator 22. The output of the modulator is then represented by the wave form shown at 29, which constitutes a series of impulses occurring at a constant frequency, each impulse consisting of a group of cycles at line carrier frequency and at a constant amplitude, the number of cycles in each group varying in accordance with the length of the impulses as supplied to the modulator by the push-pull keyer. The output from the modulator may then be transmitted by radio or by line channel to a remote station for

subsequent reception by a receiver which transforms such impulses into a reproduction of the original subject which was scanned.

Referring now to Figure 2, which shows a preferred form of the present invention, the signals as supplied by the scanner 11 are impressed upon the primary transformer 30, across the secondary of which is connected a resistance 32. This resistance is a potentiometer by means of which the intensity of the signals as supplied to the amplifier tube 34 may be controlled. The control electrode of the tube 34 is maintained at an appropriate negative bias with respect to the cathode by means of the resistance 36, across which is connected a decoupling condenser 38. The anode of the amplifier 34 is connected to a source of positive potential, the connection including the primary of transformer 40. A choke member 41 is also included in this connection, in order that the alternating component of the anode current may be by-passed to the cathode of the tube 34 by the condenser 42.

The ends of the secondary of the transformer 40 are connected to the anodes which form the diode portion of the duo-diode triode tube 44. The midpoint along the secondary is connected to the cathode of the tube 44 by way of a resistance 46. The diode portion of the tube 44 then operates as a full wave rectifier, the rectifier signal appearing across the cathode resistor 46.

The rectifier signal is then fed through a suitable filter network which comprises a series of chokes 47 and condensers 48, the filter terminating in a resistance 50. The rectified and filtered signal is then impressed upon the control electrode of the triode section of the tube 44, upon which is also impressed a screen tone. The screen tone is applied to the primary of the transformer 52, across the secondary of which is connected a resistance which operates as a potentiometer in order that the intensity of the screen tone as applied to the control electrode of the triode section of the tube 44 may be controlled. The anode of the triode section of the tube 44 is connected to a positive source of potential through the resistance 57. Impulses of screen tone frequency then appear in the anode circuit of the tube 44, the amplitude of these signals depending upon the rectified current as supplied by the diode section of the tube 44.

The resistances 54, 55, 56, 57 and 58 form a voltage divider for supplying the proper voltages to the various electrodes of the tubes of the circuit. The anode of the triode section of the tube 44 receives its positive potential from a point between the resistances 56 and 57. The cathode of this tube is connected to ground through resistances 59 and 60 in order that the anode current of the tube will cause potential drops to appear across these resistances. Therefore when current is drawn through the anode circuit of the triode section of tube 44, a voltage will appear across resistances 59 and 60 commensurate with the amount of the current drawn.

The push-pull keyer 24 comprises a duplex-triode tube 62 having a cathode 64, control electrodes 65 and 66, and anodes 67 and 68. The control electrode 65 is connected to the cathode of the duplex-diode triode 44, and the control electrode 66 of tube 62 is connected to a point between the resistors 59 and 60 by way of a phase reverser 22. The phase reverser comprises a triode 70, the cathode of which is connected to a point between resistors 54 and 55 and the control electrode of which is connected to the point be-

tween resistors 59 and 60. By so connecting the tube 70, the control electrode is maintained at an appropriate potential with respect to the cathode thereof and the voltage drops which appear across the resistance 60 as a result of anode current being passed by the triode section of the tube 44, are impressed upon the control electrode of tube 70 to cause anode current to flow in the tube 70 as the result of these voltage variations. The anode of tube 70 is connected through resistance 72 to a point between resistances 55 and 56 in order that potentials which appear across the resistance 72 as a result of the conductivity of tube 70, may be impressed upon the control electrode 66 of the tube 62.

The tube 70, because of its connection, therefore operates as a phase reversing tube and by its presence causes the grids 65 and 66 of the tube 62 to be operated in phase opposition in accordance with the current passed by the triode section of the tube 44.

The anodes 67 and 68 are connected to a point between resistances 57 and 58, the connections including resistances 71 and 72. Connected to each of the anodes 67 and 68 are a pair of conductors 73 and 74 which terminate at a pair of switch terminals for cooperation with a switch arm 75.

When either half of the push-pull keyer 24 is operating, a potential drop will be present across either the resistance 71 or 72, depending upon which half of the keyer tube is drawing current at the particular instant. This potential drop is applied to the grids of the push-pull keyed modulator 26 through the switch 75. The keyed modulator tube comprises a twin triode tube 77 which consists of a cathode, a pair of control electrodes and a pair of corresponding anodes. The carrier frequency which is to be utilized in transmitting the facsimile signals is impressed upon the primary of transformer 78, the ends of the secondary of the transformer being connected to the two control electrodes of the modulator tube 77. The switch arm 75 is connected to a midpoint along the secondary of the transformer 78. The two anodes of the tube 77 are connected to the ends of the primary of transformer 80, the anodes being maintained at a positive potential through connection to the midpoint of the primary. The secondary of the transformer 80 may be connected to an appropriate transmitting or antenna system, or it may be connected to a line channel for transmission of the modulated signals. The cathode of the tube 77 is connected to a point between resistances 57 and 58, the connection including a resistance 81 and a condenser 82.

The purpose of the switch 75 is to permit either positive or negative transmission since it may be seen that if the switch 75 is in the lower position marked "L", the transmission will be in a positive manner, that is, absence of signal input will result in no output signal and presence of signal input will permit an output to be present, whereas if the switch 75 is placed in the upper position marked "U" the transmission will be exactly the opposite, or in other words, negative, that is, the condition in which no signal input results in maximum signal output.

In order to describe the operation of the system, it will be assumed that a condition of no signal input exists. Under this condition, no voltage is applied to the plates of the diode section of the duo-diode triode 44, and therefore

no potential is present across either the resistance 46 or the resistance 50, and accordingly no grid bias is applied to the control electrode of the triode section of tube 44. The triode section of this tube will therefore draw plate current causing a voltage drop to appear across resistances 59 and 60. The presence of the voltage across the resistances 59 and 60 causes the control electrode 65 to be maintained at a positive potential with respect to its cathode and therefore permits this section of the push-pull keyer to conduct current. The control electrode of the phase reversing tube also receives a positive bias due to the potential drop across the resistance 60, which permits anode current to flow in the tube 70 and accordingly there appears a potential drop across the resistance 72. As the result of this, the control electrode 66 on the other half of the push-pull keyer will be at a negative potential with respect to its cathode by an amount sufficient to producing blocking thereof and accordingly there will be no current drawn by the anode 68 of the tube 62. The current from the anode 67 flows through the resistance 71 and causes a potential to appear thereacross which is impressed—assuming the switch 75 to be in the lower position—upon the control electrodes of the modulator tube 79 with the result that this tube is biased to cut-off and no current is passed therethrough.

As signals are applied to the amplifier tube 34 a potential drop will appear across the resistances 46 and 50 as a result of current being passed by the rectifier portion of the tube 44, which, when applied to the control electrode of the triode section of tube 44 will operate to reduce the amount of current passed by the tube and the length, as well as the amplitude of the screen frequency impulses as they appear in the anode circuit of the tube 44 will depend upon the strength of the original input signal. These impulses are passed on to the grid 65 of the push-pull keyer 62, causing anode current to flow through the resistor 71 and at each instant that current is permitted to flow through this anode circuit, a corresponding reduction in the anode current of anode 68 is also present. The two halves of the push-pull keyer then operate alternately depending upon the presence or absence of current in the triode section of tube 44 and the length of time that one or the other half is conducting or non-conducting depends upon the amplitude of the impulses as supplied by the triode section of the tube 44. Therefore when a signal is impressed upon the system, and when the triode section of the tube 44 is non-conducting, there will be no current flowing through the resistor 71 and the anode 67. Because of the absence of current in this resistor the potential of conductor 73 will be more positive with the result that the control electrodes of the modulator tube 77 will be at such potential as to permit current to flow through the modulator tube, resulting in an output of modulated line carrier frequency. As previously stated, the length of time that the modulator tube is permitted to operate depends upon the amplitude of the current impulses as passed by the triode section of the tube 44, as may be seen by referring to the curve shown at 21 in Figure 1. As the signal input is increased less and less of the screen tone becomes effective due to a negative bias being applied to the control electrode of the triode section of tube 44 and the impulses transmitted as a result thereof will be proportionate-

ly shorter. Finally, when the signal voltage has increased to such an extent as to cause a complete cut-off of the triode section of the tube 44, then the opposite condition of a no signal condition will exist, and a steady and continuous output from the modulator tube will result. It must be kept in mind that this explanation of the operation of the system would be exactly reversed so far as the effect of the keyer tube on the modulator tube is concerned, if the switch 75 were placed in the upper or negative transmission position.

If it is desired to use negative transmission—in which case the absence of a signal would result in maximum output from the modulator tube—it is merely necessary to move the switch 75 from the lower position to the upper position and by so doing the modulator tube 77 is made to respond to voltage drops which appear across the resistance 72 rather than the resistance 71. These resistances, as may be seen from Figure 2, are connected to opposite halves of the push-pull keyer tube 62.

Although the applicant's system has been shown and described more or less specifically with respect to the type of tubes used, it is to be understood that other tubes might well be used to replace those shown in the drawings. However, since all of the tubes shown are variable, it is desirable that these tubes be used since the circuit may be materially simplified as a result thereof. By way of modification the tube 44 might be replaced by a half-wave or full-wave rectifier and a triode or pentode by making appropriate changes in the system and both of the tubes 62 and 77 might be replaced by separate triodes rather than resorting to the use of the combined tubes as shown by the figure.

Various other modifications and alterations may be made in the present invention without departing from the spirit and scope thereof, and it is desired that any and all such modifications be considered within the purview of the present invention except as limited by the hereinafter appended claims.

I claim:

1. A system for producing picture records comprising a discharge tube having a cathode, a pair of anodes, a control electrode and an additional anode, means for impressing push-pull alternating signal variations between said pair of anodes and said cathode for rectification thereby, means for applying a substantially constant alternating voltage of a predetermined frequency between said control electrode and said cathode, means for maintaining said additional anode positive with respect to said cathode, a load and filter circuit connected in the cathode circuit of said tube across which impulses are produced having a constant frequency corresponding to the said predetermined frequency and of an amplitude determined by the rectified signal variations, a push-pull keyer comprising a pair of thermionic discharge paths, means for rendering the discharge paths of said push-pull keyer alternately conducting and non-conducting for time periods determined by the amplitude of said impulses at the frequency of occurrence of said impulses, a carrier frequency modulating device, and means for controlling the operation of said modulating device in accordance with the conducting or non-conducting condition of the one or the other thermionic discharge path.

2. A system for producing picture records comprising a discharge tube having a cathode, a pair

of anodes, a control electrode and an additional anode, means including a cathode load resistance for impressing push-pull signal variations between said pair of anodes and said cathode for rectification thereby, means for applying an alternating potential of substantially constant frequency and amplitude across said control electrode and said cathode, means for maintaining said additional anode positive with respect to said cathode to produce at the cathode end of the cathode load resistance impulses of constant frequency but of an amplitude determined by the rectified signal variations, a push-pull keyer comprising a pair of thermionic discharge paths, means responsive to the produced impulses for rendering the paths of said push-pull keyer alternately conducting and non-conducting for time periods determined by the amplitude of said impulses and at the constant frequency of occurrence of said impulses, a carrier frequency modulating device, and means for selectively connecting said modulating device to the one or the other of said discharge paths whereby the operation of said modulating device may be controlled by the conductive or non-conductive condition of the selected path.

3. A facsimile transmitting system comprising a discharge tube having a cathode, a pair of anodes, a control electrode and an additional anode, means for impressing push-pull signal variations between said pair of anodes and said cathode for rectification, means for applying an alternating voltage of a predetermined frequency between said control electrode and said cathode, means for maintaining said additional anode positive with respect to said cathode, a cathode load and filter circuit connected in the cathode circuit of said tube across which impulses of said predetermined frequency and of an amplitude determined by the rectified signal variations are produced, a pair of electronic discharge paths, means including a phase inverter tube for controlling the conductivity of one of said paths, means for controlling the phase inverter tube and the conductivity of the other of said paths by the produced impulses to produce, by the discharge paths, additional impulses of the said predetermined constant frequency and of constant amplitude but of a duration determined by the amplitudes of the first named impulses, a carrier frequency modulating device, and means for controlling the operation of said modulating device in accordance with the said additional impulses as supplied by the one or the other of said discharge paths.

4. A facsimile transmitting system comprising a discharge tube having a cathode, an anode, a control electrode and an additional anode, means for impressing alternating signal variations across said cathode and anode for rectification thereby, means for applying an alternating voltage of a predetermined substantially constant frequency across said control electrode and said cathode, means for maintaining the said additional anode positive with respect to said cathode, a load impedance in the cathode circuit of

said tube across which a first series of impulses of the said predetermined constant frequency but of varying amplitude and time duration, in accordance with the rectified signal variations, is produced, a pair of electronic discharge paths, means including a phase inverter device for differentially controlling the operation of said paths to produce a second and a third series of impulses of constant frequency and amplitude but of a duration determined by the amplitude of said first series of impulses, a series of carrier frequency oscillations, and means for modulating said oscillations in accordance with said second or said third series of impulses.

5. A system for producing picture records comprising a discharge tube having a cathode, a pair of anodes, a control electrode and an additional anode, means for impressing alternating signal variations between said pair of anodes and said cathode for rectification thereby, means for applying an alternating voltage of a predetermined substantially fixed frequency and of a substantially constant amplitude between said control electrode and said cathode, means for maintaining said additional anode positive with respect to said cathode, a load impedance connected in the cathode circuit of said tube across which impulses of constant frequency and of an amplitude determined by the rectified signal variations are produced, an electronic keying device comprising a cathode, a control electrode and an anode, means for applying said impulses to the control electrode of said device to produce impulses of said constant frequency and of a substantially fixed amplitude but of variable duration in accordance with said signal variations, means including a load circuit for maintaining the anode of said keying device positive with respect to its associated cathode, and a carrier frequency modulating device responsive to the voltage drop across said load circuit.

6. A facsimile transmitting system comprising a discharge tube having a cathode, a pair of anodes, a control electrode and an additional anode, means for impressing alternating push-pull signal variations across said anodes and said cathode for rectification thereby, means for applying an alternating voltage of a predetermined frequency across said control electrode and said cathode, means for maintaining said anode positive with respect to said cathode, a load impedance and a filter network in the cathode circuit of said tube across which a first series of impulses of constant frequency but of varying amplitude and time duration in accordance with the rectified signal variations are produced, an electronic discharge device, means for controlling the operation of said device to produce a second series of impulses of constant frequency and amplitude but of a time duration determined by said first series of impulses, a source of carrier frequency oscillations, and means for modulating said oscillations in accordance with said second series of impulses.

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