May 11, 1943. W. R. KOCH 2,319,139

FACSIMILE SYSTEM

Filed Sept. 30, 1940

Fig. 1.

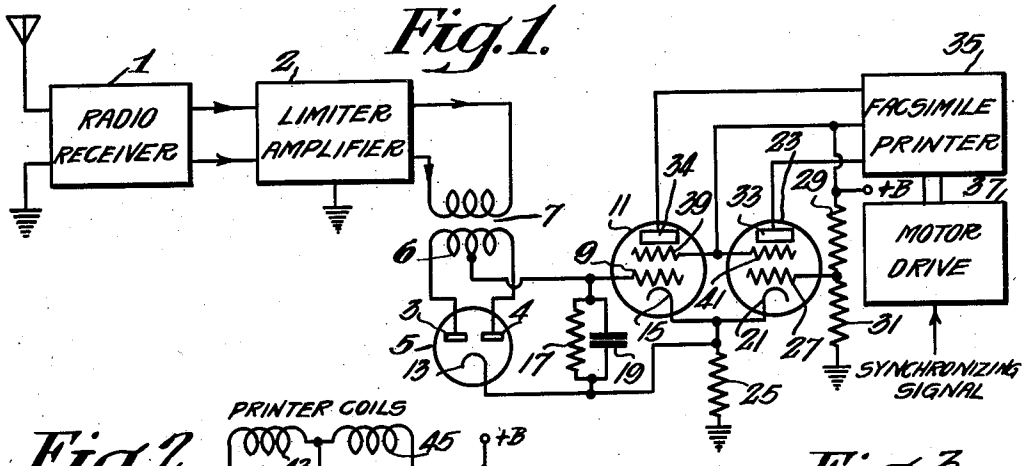


Fig. 2.

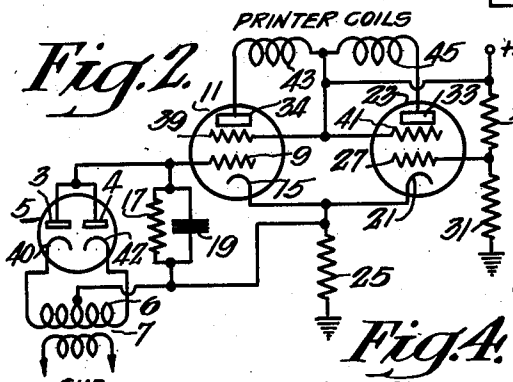


Fig. 3.

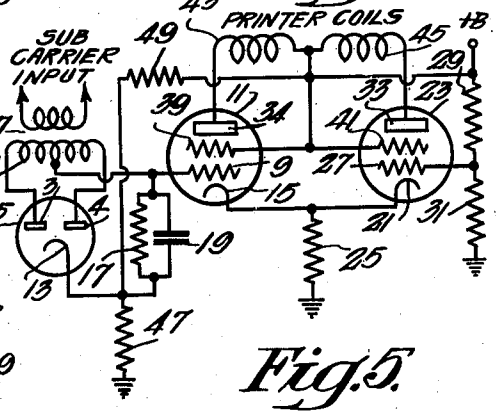


Fig. 4.

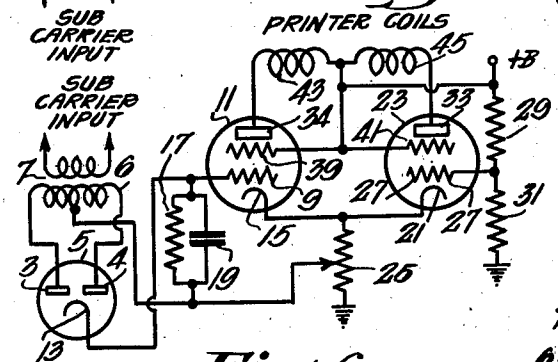


Fig. 5.

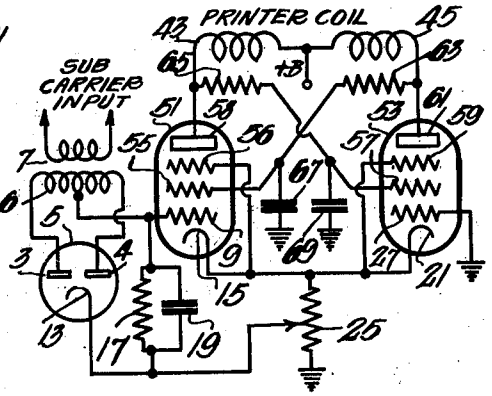
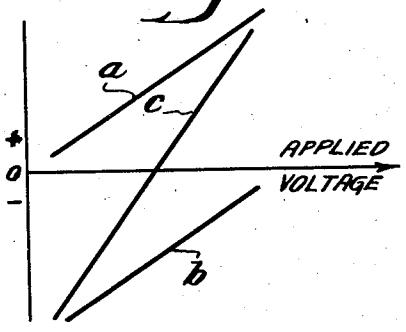


Fig. 6.



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2,319,139

FACSIMILE SYSTEM

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Application September 30, 1940, Serial No. 359,106

5 Claims. (Cl. 178—7.3)

This invention relates to facsimile systems, and more particularly to output amplifiers for facsimile printers.

The first requirement of a facsimile amplifier and the one most difficult to meet is that the lower frequency limit is not some definite frequency as in an ordinary audio amplifier, but is zero or direct current. If the image or copy being analyzed has a large black border, this border may require a number of solid black scanning lines to represent it and the signal passing through the amplifier may remain substantially constant for a number of seconds. An amplifier that did not include a direct current as a part of its frequency spectrum would not amplify such a signal properly. The upper frequency limit is much easier to meet, being generally much lower than that of the usual high quality audio frequency amplifier.

The simplest solution of the facsimile amplifier problem is a direct current amplifier in which the amplifier tubes are directly connected anode to succeeding tube control electrode and pure resistance coupling used throughout so that a lower frequency limit of zero is obtained. Such an amplifier, though extremely simple, has several serious disadvantages, which necessarily limits its use to specialized services. Drifting of adjustment, and fluctuations of supply voltage are main sources of trouble.

Several forms of self-regulating direct current amplifiers have been used, but these are generally very difficult to build or the initial adjustments are hard to make, or they do not regulate closely enough with very low input voltages which are usually present during the reception of facsimile signals.

According to this invention, an amplifier is provided whose output is not seriously affected by fluctuations in supply voltages or maladjustment.

The signal is impressed on a control electrode of one of a pair of electron discharge devices having a balanced output circuit. A portion of the signal is also fed to the cathode circuit of the other of the balanced output electron discharge devices through its cathode circuit.

The principal object of this invention is to provide a push-pull amplifier whose frequency range extends down to zero frequency.

Another object of this invention is to provide a stable direct current amplifier circuit.

Other and incidental objects of the invention will be apparent to those skilled in the art from a reading of the following specification and an inspection of the accompanying drawing in which

Figure 1 is a block diagram showing one form of this invention,

Figures 2, 3, 4 and 5 are circuit diagram showing other forms of this invention, and

Figure 6 is a graphical illustration of the results obtained through the use of this invention in any of its preferred forms.

Referring now in more detail to Fig. 1, the employment of one form of this invention is shown for the reception of radio facsimile signals. A radio receiver 1 supplies a limiter amplifier 2 with a facsimile signal which may be of the type in which an amplitude modulated sub-carrier is used. Such a sub-carrier has a frequency which, with its side bands, may be passed by the usual audio amplifier in a high quality radio receiver. For specific example, the sub-carrier may have a frequency of 2500 cycles.

Limiter amplifier 2 is used to square up all signals and give the equivalent signal of a keyed tone. In addition a threshold control may be included in this limiter to reduce all background noises to zero. Thus the output will be either on at full value or off entirely, and no signals between these two values will be used. A description of a radio facsimile transmitter designed to broadcast such a signal and a more detailed description of a limiter amplifier may be found in an article entitled "Facsimile transmission and reception" by Maurice Artzt in Electrical Engineers Handbook published by John Wiley and Sons, Inc.

The signal is then fed between anode 3 and anode 4 of the full wave rectifying tube 5 through the push-pull secondary winding 6 of coupling transformer 7. The center tap in the secondary winding 6 is connected to the control electrode 9 of the amplifier tube 11. The cathode 13 of the rectifying tube 5 is connected to the cathode 15 of the amplifier tube 11 so that the incoming signal is fed between the control electrode 9 and cathode 15 of the amplifier tube 11. A resistor 17 and bypass condenser 19 are connected between the control electrode 9 and the cathode 15 to allow the accumulated electrons on the control electrode 9 to leak back to the cathode 15 and to complete the path for the current from the rectifier 15. The cathode 15 of tube 11 is connected directly to the cathode 21 of amplifier tube 23. This cathode circuit is provided with a resistor 25 connected to ground. There then results a voltage drop across resistor 25 in accordance with the impressed signal voltage due to the change in current drawn by the amplifier tube 11.

The resulting change in potential across re-

sistor 25 due to the change in current flowing therethrough causes the cathode 21 to change in potential in accordance with the impressed signal voltage. Control electrode 27 of tube 23 is maintained at a fixed potential with respect to ground by the B+ power supply and resistors 29 and 31, which resistors may be so chosen to provide a proper bias on the control electrode 27 with respect to the mean potential of the cathode 21. The "push pull" output signal is then taken from the anode 33 and anode 34 to supply the facsimile printer 35, which is driven by the motor drive 37. The motor is preferably kept in synchronism with the transmitter by using the same synchronizing signal as is used by the facsimile signal transmitter motor drive. The electron discharge devices 11 and 23 may take the form of three-element tubes or may be preferably of the plural electrode type including screen grids 39 and 41.

Upon the reception of a facsimile signal by the radio receiver 1, the limiter amplifier 2 passes an amplitude carrier to transformer 7. When the amplitude of the sub-carrier signal is great, a large amount of rectified voltage is impressed between the control electrode 9 and the cathode 15 driving the control electrode 9 more negative with respect to the cathode 15, thus allowing only a relatively small amount of current to flow through the amplifier tube 11. This relatively small amount of current produces a small voltage drop in the resistor 25 so that cathode 15 and cathode 21 are at a relatively small positive potential with respect to ground.

It will be remembered that control electrode 27 of amplifier tube 23 is maintained at a fixed potential with respect to ground so that during the period which the cathode 21 is at a relatively low positive potential with respect to ground, there will be a relatively small potential difference between the control electrode 27 and the cathode 21, causing a large current flow between the anode 33 and the cathode 21 of amplifier tube 23. This results in a push-pull output voltage which is required for driving the facsimile printer 35.

It is true that the large current flowing through the resistor 25 because of the large current in tube 23 tends to increase the voltage drop across resistor 25 such as to produce a degenerative effect, but this degeneration is not sufficiently large to be objectionable.

Like numerals refer to similar parts throughout the several figures.

Referring now to Fig. 2, another form of this invention is shown in which the modulated carrier input signal is fed through transformer 7 to rectifier tube 5 whose cathodes 40 and 42 are connected to opposite ends of the secondary 6 of transformer 7. The center tap of the secondary 6 of transformer 7 is connected to the cathodes 15 and 21 of the amplifier tubes 11 and 23, respectively. In this form of the invention both anodes 3 and 4 of the rectifier tube 5 are connected together and, in turn, connected to the control electrode 9 of amplifier tube 11.

The circuit includes facsimile printer coils 43 and 45. One terminal of the printer coil 43 is connected to the output of amplifier tube 11 while printer coil 45 is connected to the output of amplifier tube 23.

There is shown in Fig. 3 still another form of this invention in which the modulated sub-carrier is fed through transformer 7 to the anodes of the rectifier tube 5. The center tap in secondary 6 of transformer 7 is again connected to the control electrode 9 of amplifier tube 11. However, the cathode 13 of the rectifier tube 5 is connected to ground through resistance 47. The cathode 13 is maintained at a slightly positive potential with respect to ground through a voltage drop in resistor 47 caused by its connection to the +B voltage supply through resistor 49. This slightly positive potential on cathode 13 is required in order to maintain the control electrode 9 of amplifier tube 11 at a negative potential with respect to its corresponding cathode 15 which, as previously described, is maintained at a positive potential by a voltage drop across resistance 25.

It will be noticed that the principal difference between this form of the invention and those forms described above is that the rectified modulated carrier input signal is applied between the control electrode 9 of amplifier tube 11 and ground. It is true that increased degeneration is again experienced due to the drop in potential across resistor 25 in the cathode circuit of the amplifier tube 11 but this disadvantage is easily overcome by increasing the amplitude of the incoming signal.

Fig. 4 shows still another form of this invention. The rectified modulated carrier input signal is applied between the control electrode 9 of amplifier tube 11 and a variable tap on the cathode resistor 25. According to this form of the invention, cathode resistor 25 provides the necessary bias potential to the control electrode 9 with respect to its corresponding cathode 15 in addition to allowing cathode 21 of amplifier tube 23 to change its potential in order to produce a current through tube 23 opposite in phase to that current through tube 11 as previously described in more detail. Adjustment of the tap on resistance 25 may also be used to control the degeneration of the circuit which results from applying the voltage drop occurring across a portion of resistance 25 to the input circuit. Another fundamental difference between this form of the invention and those previously described is that an increase in the amplitude of the signal applied to the rectifier decreases the negative voltage on the control electrode 9.

Referring now to Fig. 5, a further modification of this invention is obtained by the use of push-pull output electron discharge devices 51 and 53. Tube 51 contains a cathode 15, control electrode 9, a screen grid 55, suppressor grid 56, and anode 58. Tube 53 includes cathode 21, control electrode 27, screen grid 57, suppressor grid 59 and anode 61. The screen grid 55 of tube 51 is connected to the anode 61 of tube 53 through resistance 63. Screen grid 57 of tube 53 is connected to the anode 58 of tube 51 through resistance 65.

As the control electrode 9 is made more negative in response to an increase in the amplitude of the modulated sub-carrier input signal, the plate current of the tube 51 is reduced. This causes less voltage drop through the printer coil 43 causing the screen grid 57 of tube 53 to become more positive. This, in turn, increases the plate current of tube 53, causing more drop through the printer coil 45 so that the screen grid 55 of the tube 51 becomes less positive. This tends to further reduce the plate current through tube 51 enhancing the effect of the signal voltage on the control electrode 9.

It is obvious that with tubes having a high mutual conductance and normal circuit con-

stants, an unstable condition would exist causing one tube to quickly take a minimum of current and the other tube a maximum. However, due to the degenerative effect of the cathode resistor **25** and to the voltage drop through the resistors **63** and **65** between the plates and connected screen grids of the opposing tubes, the operation of the circuit can be made very stable.

In order to secure the proper phase relations for the various signal components, a corrective element was added to compensate for the inductive effect of the printer coils **43** and **45**. In its simplest form, a satisfactory corrective circuit may be composed of small compensating capacities **67** and **69** connected between ground and screen grids **55** and **57**, respectively.

While in a preferred form of this invention, resistances **63** and **65** in the plate and screen circuits are equal, it is obvious that unequal resistances may be employed if it is desirable to secure a modified operating characteristic.

Fig. 6 shows in curve *a* the current flowing through one of the printer coils such as coil **43**, curve *b* shows the current flowing through the other of the printer coils such as coil **45**. The resultant effective current through both the printer coils **43** and **45** is represented by curve *c*. This indicates a relatively large amplitude range through which this amplifier circuit will faithfully reproduce an incoming facsimile image signal.

If a frequency modulated sub-carrier is used, this invention may, of course, be similarly employed. Transformer **7** would then be of the frequency discriminator type in which a change in frequency of the sub-carrier would cause a corresponding change in the voltage applied between the control electrode **9** and its corresponding cathode **15**.

While several systems for carrying this invention into effect have been indicated and described, it will be apparent to one skilled in the art that this invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of this invention as set forth in the appended claims.

I claim as my invention:

1. In a picture-transmitting system including a balanced output circuit and a pair of discharge devices each having an anode connected to said output circuit and each discharge device having a control electrode and a cathode, the combination of a resistor having a terminal to which is connected the cathode of both of said discharge devices, a floating detector circuit for applying a signal between the control electrode of one of said discharge devices and said terminal, and means to normally maintain the control electrode of the other discharge device at a predetermined potential so that signal energy applied between said terminal and the control electrode of the first discharge device is also applied between the control electrode of the other of said discharge devices and said terminal through said resistor.

2. In a picture-transmitting system including a balanced output circuit and a pair of discharge devices each having an anode connected to said output circuit, an auxiliary electrode connected to the anode of the other of said discharge devices to cause the potential of each of said auxiliary electrodes to vary in phase with the variation of potential of the anodes in the other of the said discharge devices, a control electrode and a cathode, the combination of a resistor common to the cathode of both of said discharge devices, means for applying a signal between the control electrode of one of said discharge devices and a predetermined point on said resistor, and means to normally maintain the control electrode of the other discharge device at predetermined potential so that signal energy applied between the control electrode and said predetermined point on said resistor of the first discharge device is also applied between the control electrode of the other of said discharge devices and said predetermined point on said resistor.

3. A signal amplifier having a balanced output circuit, a pair of discharge devices each having an anode connected to said output circuit and each having a control electrode and a cathode, a resistor common to both of said cathodes, a circuit having no point of fixed potential for applying a signal between the control electrode of one of said discharge devices and a predetermined intermediate point on said resistor, and means to normally maintain the control electrode of the other discharge device at a predetermined potential so that signal energy applied between the control electrode and said predetermined point on said resistor of the first discharge device is equal to that applied between the control electrode of the other of said discharge devices and said predetermined intermediate point on said resistor.

4. A signal amplifier having a balanced output circuit including a pair of discharge devices, each having an anode connected to said output circuit and each having a cathode, a control electrode and at least one auxiliary electrode, a resistor common to both cathodes, means for applying a signal between the control electrode of one of said discharge devices and a predetermined point on said resistor, means to maintain the control electrode of the other discharge device at a predetermined potential so that signal energy applied between the control electrode and said point on said resistor of the first discharge device is substantially equal to that applied between the control electrode of the other of said discharge devices and said point on said resistor, and a connection including resistance between said auxiliary electrode and the anode of the other of said discharge devices to cause the potential of each of said auxiliary electrodes to vary in phase with the variation of potential of the anodes in the other of the said discharge devices.

5. A signal amplifier comprising in combination a pair of discharge devices each having a cathode, a control electrode, an anode and an auxiliary electrode, means for applying a signal between the control electrode and the cathode of one of said discharge devices, means for causing said cathodes to change their potential in accordance with said signal, means for maintaining the control electrode of the other of said discharge devices at a substantially fixed potential, and a connection between each of the auxiliary electrodes and the anode of the other of said discharge devices to cause the potential of each of said auxiliary electrodes to vary in accordance with the variation of potential of the anodes in the other of the said discharge devices.

WINFIELD R. KOCH.