Dec. 28, 1937. LA VERNE R. PHILPOTT 2,103,793

FACSIMILE TRANSMISSION

Filed July 30, 1932

Fig. 1.

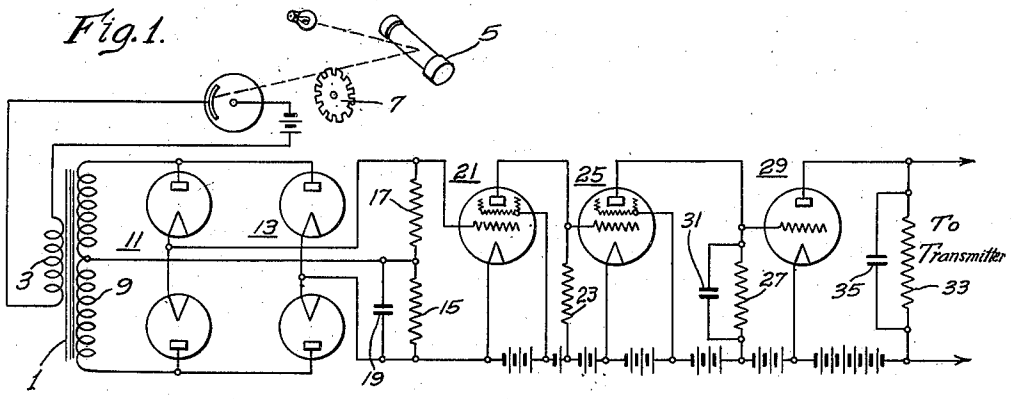



Fig. 2.

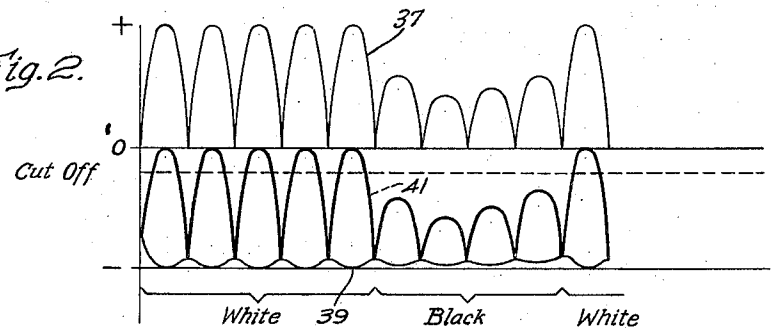



Fig. 3.

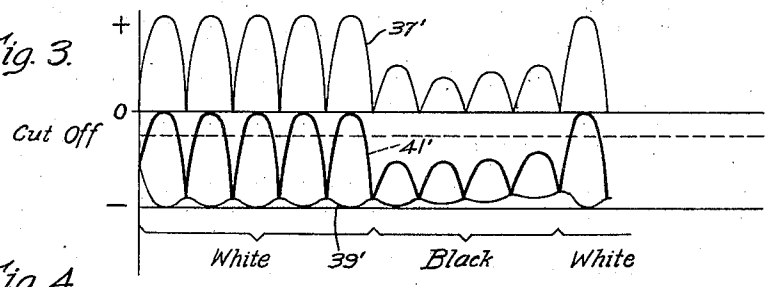
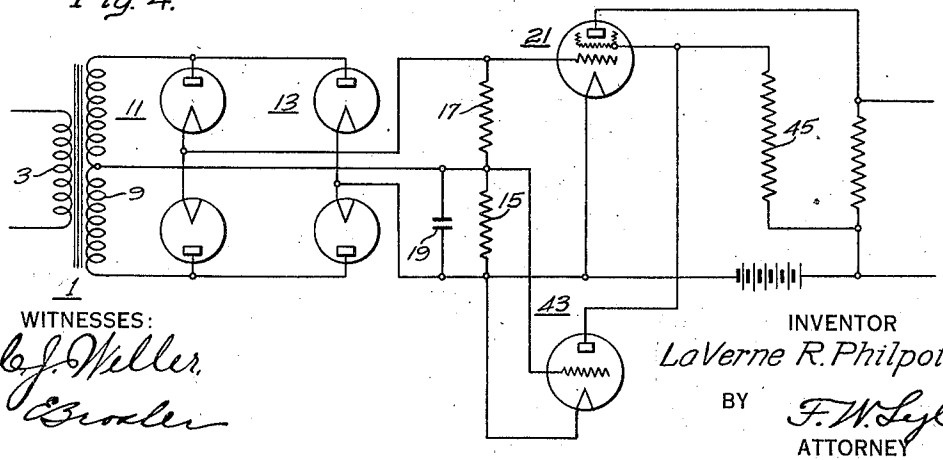



Fig. 4.




WITNESSES:

E. J. Weller.

E. Crocker

INVENTOR

LaVerne R. Philpott.

BY F. W. Lyle.

ATTORNEY

Patented Dec. 28, 1937 2,103,793

# UNITED STATES PATENT OFFICE

2,103,793

## FACSIMILE TRANSMISSION

La Verne R. Philpott, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application July 30, 1932, Serial No. 626,851

8 Claims. (Cl. 178—7.1)

My invention relates to a communication system, more particularly to a keying system for use in transmission of facsimiles or the like.

Keying systems in use at the present time for the transmission of facsimiles, in black and white particularly, are so limited in their elasticity that several critical adjustments must be made manually to differentiate properly between black and white. These adjustments become quite critical when such material as typewriting is to be transmitted by reason of the fact that the typed letters vary greatly in the density of print and in the transparency characteristic of the inks used. Manual adjustment must also be resorted to, to compensate for changes in the potential of the supply source and whiteness of paper in addition to the adjustments referred to above.

These adjustments were occasioned by the fact that in systems of the prior art as known by me, a fixed bias potential was employed on the first amplifier, or keying tube and the signal potentials were algebraically added to this fixed bias to block the tube or render it more conducting depending on whether the signal represented black or white or vice-versa. Should the average signal level shift appreciably for any of the causes noted above, both black and white signal potentials will appear to one side of the bias potential with the result that the system will become inoperative unless some manual adjustment is made to compensate for the above changes.

According to my invention, I have provided a system wherein, after the initial adjustment has been made, all necessary changes or adjustments in the components of the system will be taken care of automatically, thereby eliminating the necessity for the many manual adjustments required in systems of the prior art.

It is accordingly one object of my invention to provide a system of the type referred to which shall provide rapid and automatic adjustment of the critical factors to compensate for uncontrollable variations in the components of the system, such as shift of line voltage, change of lamp brilliance, variations in the message paper, and differences in the character of the subject matter to be transmitted.

Another object of my invention is to provide a system of the type described which shall require practically no care in the operation thereof.

Additional objects of my invention will be disclosed in the following description taken in conjunction with the accompanying drawing, wherein:

Figure 1 is a view illustrating the fundamentals of my invention as embodied in a keying circuit for the transmission of facsimiles in black and white;

Figs. 2 and 3 are curves illustrating the operation of the circuit of Fig. 1 and the manner in which adjustments are automatically taken care of, and

Fig. 4 is a view covering a portion of the circuit of Fig. 1 in combination with an improvement thereto.

Broadly speaking, my invention accomplishes the above-mentioned results by establishing across the input circuit of an electron discharge device, series potentials, which are substantially equal in value but opposite in phase, during a steady condition of signal supply energy. When this supply energy momentarily drops in response to a signal, the potentials referred to are unbalanced to such an extent as to leave a predominance of negative potential on the grid of the discharge tube of a value sufficient to bias the tube beyond its cut-off point. This variation of grid potential will render the tube alternately conductive and non-conductive according to signals received. This alternating condition is amplified in subsequent amplifiers associated with the discharge tube and is employed to key a transmitter accordingly.

Many undesirable changes in the characteristics of the components of the system, which changes may be of a substantially permanent character, will result in affecting the series potentials across the input circuit of the discharge tube in substantially equal, but opposing amounts, and since the operation of the system depends upon a momentary difference between these opposing potentials, it will be readily appreciated that the operation of the system will be maintained unaffected regardless of the undesired changes noted above. Looking at it from another viewpoint, the black and white signal potentials will always appear on opposite sides of the cut-off value of potential necessary to block the tube upon which they might be impressed.

Referring more particularly to Fig. 1 of the drawing, I have shown a transformer 1, the primary 3 of which comprises a source of signal energy, and normally would be connected with some scanning means such as a rotating disc or cylinder, or scanning apparatus of the cathode-ray type either directly or through amplifiers. If a mechanical scanner such as the rotating

cylinder 5 or a disc be employed, chopper means 7 may be used to interrupt the scanning medium at a rate sufficient to impress upon the resultant current a frequency capable of being amplified through a transformer. The signal energy, therefore, will be in the form of an alternating current modulated according to characteristics of the subject to be transmitted.

The corresponding energy of the induced current in the secondary 9 of the transformer is rectified through two full-wave rectifying arrangements 11 and 13 connected in parallel. The rectified energy through one of the full-wave rectifiers is impressed across a resistor 15 and the energy through the other parallel connected rectifier is impressed across a similar resistor 17 which is connected in series with the first resistor. The potentials across these resistors are so impressed as to be in opposition. A condenser 19 of relatively large value is connected across one of the above mentioned resistors 15.

These series connected resistors constitute the input circuit of an amplifier 21, preferably one of the screen-grid type, the plate circuit of which is directly coupled through a resistor 23 to another amplifier 25 also preferably of the screen-grid type to constitute a direct current amplifier. A similar coupling resistor 27 in the anode circuit of amplifier 25 comprises the input circuit to a discharge device 29 and is shunted by a condenser 31 which functions to smooth out or filter the current which may flow through this coupling resistor.

In the plate circuit of this last mentioned amplifier 29 is a resistor 33 comprising one of the elements in the grid circuit of one of the amplifying tubes of a transmitter. This last resistor may also be shunted by a condenser 35 if desired.

Anode, screen-grid, and biasing potentials for the various amplifier tubes may be supplied from a common supply source or a plurality of independent batteries suitably connected in the respective circuits may be employed.

The theory underlying the operation of my invention may be explained in the following manner.

Assume a uniform condition of signal energy supply, which condition would exist during a period when the background portion of a picture or typewritten message for example, is being transmitted for a period of time. The average potentials built up across the series connected resistors 15 and 17 would be substantially equal and opposite. By reason of the existence of the condenser 19 across one of the resistors 15, the potential across its associated resistor will be filtered, whereas that across the other resistor 17 will appear in impulses of half-wave duration. Therefore, the total potential across the input circuit of the first amplifier will vary between values representing zero potential on the grid and a value approaching the more or less steady potential across the condenser shunted resistor.

The resistors are so fixed in value that the value of potential approaching that across the condenser shunted resistor 15 will impress a negative potential upon the grid of the amplifier 21 of a value sufficient to bias it to beyond cut-off. Thus, during a steady condition of a signal energy supply source, the voltage on the grid of the amplifier will periodically render the tube conductive and non-conductive at a frequency depending upon the chopper speed. Should the signal energy change in response to a signal, such as when a dark portion of a subject is being scanned, the potential across the resistor 17 will drop for a period proportional to the length of time that the black portion is being scanned, but the potential across the other resistor 15 will not drop an appreciable extent in that time interval, which is normally a very short period of time, by reason of the fact that it is shunted by the condenser 19 which comprises an electrical energy storing means. This condenser is of such a value that its time of discharge is very much longer than any continuous period during which black may be normally transmitted. Consequently, during such periods, the potential across the condenser shunted resistor 15 will predominate and will maintain a cut-off bias potential on the amplifier until such time as a white portion of the picture is again presented to the scanner.

During conductive periods of the amplifier tube 21, current will flow in the plate circuit through the coupling resistor 23, causing an I. R. drop to be impressed upon the grid of the succeeding amplifier 25 of a value sufficient to block this tube, thereby rendering it non-conductive. The succeeding amplifier 29, therefore, will be rendered conductive by reason of the fact that no I. R. drop will be developed across its coupling resistor 27. Current will flow in the output circuit through the resistor 33 in said circuit, and since this resistor comprises one of the elements in the input circuits of an amplifier of a transmitter, it may be made of such a value as to block off the amplifier and render the transmitter incapable of sending signals.

During such periods when the amplifier tube 21 is in a non-conductive state, the condition of the succeeding amplifiers will be reversed from what they were when the tube was conductive. Thus, no current will flow through the resistor 33 in the plate circuit of the last amplifier 29 and the transmitter will be operative and capable of putting energy into the ether. Therefore, since the transmitter can be made operative or inoperative, at such times as when the first amplifier tube is made conductive or non-conductive, and since the condition of this first amplifier tube 21 changes in response to picture signals, it should be apparent that energy released by the transmitter will be characteristic of the signals impressed upon the amplifier tube from the scanning device.

Should the subject matter to be transmitted cover but a portion of the paper, it will be apparent from the above, that at the completion of transmission of the subject matter, the transmitter will become blocked and rendered inoperative and will continue to remain so, thus opening the radio channel at the transmitter frequency, for the use of other transmitters without interference.

In Fig. 2, I have pictured by means of curves the various potentials appearing across the series connected resistors and the manner in which these potentials vary in response to signals to affect in a representative manner the grid of the first amplifier tube.

The curve 37 on the positive side of the zero axis represents voltage variations across the resistor 17 during the scanning of first a white portion or background of a subject and then a dark or black portion. The irregularities in the peaks of the half cycles during scanning of the black portion of the subject are intended to represent the effect of non-uniformity in the dark portions of the subject, such as a typewritten character or the like.

The curve 39 on the negative side of the zero

axis represents the corresponding voltage variations occurring across the condenser shunted resistor 15. This being a filtered voltage, the curve accordingly shows filtered characteristics.

Since the operating potential appearing on the grid of the first amplifier tube is the algebraic sum of these opposing potentials, I have illustrated by means of the heavy curve 41 the variations occurring in the operating potential. Interpreting this curve, we find that during the transmission of white, the peaks extend above the cut-off value of the tube thereby rendering the tube operative to pass current during the intervals that the voltage varies above the cut-off value. If a small condenser were shunted around the resistor 17, the resultant voltage could be made to stay above the cut-off value during the transmission of white. In either case, the system would operate, the only condition to be satisfied being that the time constant of this small condenser across the resistor be materially less than the time required to scan a change in the black and white make-up of the subject to be transmitted and yet be sufficient to filter the potential at chopper frequency.

During transmission of black, the resultant voltage is maintained beyond the cut-off value regardless of varying characteristics in the ink or similar variations in the subject.

Therefore, while transmitting white, the first amplifier tube 21 will become operative, whereas during the transmission of black the first amplifier will be blocked and rendered inoperative.

Should any relatively permanent shift occur in the level of the signal energy, such as might occur when the voltage of the scanning circuit changes, or a change in lamp brilliance occurs, the operation of the system described by me above will not be materially affected.

Should the change be a gradual one to a lower value, the voltage across the condenser shunted resistor 15 will gradually drop to the new lower value of the supply level in step with the average voltage across the other resistor 17. During this change to the lower value the system will not be sensitive to the fact that a change was taking place in the signal level and no effect will be noticed on the reproduction at the receiver. At the new lower value of signal level, the operation of the system will proceed as usual.

Should the change, however, be a sudden one, that is, if the time within which the change took place is short compared to the time of discharge of the condenser, then the radio transmitter might be blocked for a few seconds until the condenser had sufficient time to reach the new lower average value of signal energy. However, this would not noticeably affect the received reproduction.

The curves illustrated in Fig. 3 are similar to those of Fig. 2 except that they represent a condition of operation at an appreciably lower signal level. It will be apparent from this figure that in spite of the fact that the potential drops represented by the curves 37' and 39' are smaller than those of Fig. 2, the values as represented by the difference curve 41' still bear the same relationship to the cut-off value of the amplifier tube as exists in Fig. 2, thus showing that the system will operate over a wide shift in signal levels.

If the change in the level of signal energy should rise instead of decrease, then practically no change will be noticed in the operation of the system as the condenser is adapted to charge at a rate very much quicker than the time necessary for discharge, and it will accordingly charge up to the new higher level practically in step with the change in signal energy supply level.

In the operation of the system described above, the large condenser functions as an averaging or storage means to fix a level with respect to signal fluctuations which appear across the unshunted resistor. This level will shift with changes in the average signal strength brought about by such causes as changes in supply voltage, lamp brilliancy, whiteness of paper, etc. and will be in such direction as to compensate for these changes.

The circuit of Fig. 4 will be identical to that of Fig. 1 except for the addition of a control tube 43 so connected that the condenser shunted resistor 15 will comprise the input circuit of the tube and a resistor 45 in the screen-grid circuit of the amplifier 21 will comprise an element in the plate circuit of the control tube. During the normal operation of the system, the voltage or potential across the condenser shunted resistor 15 is maintained substantially constant and the control tube will, therefore, remain substantially uniform in its condition. However, should the supply level change to a new permanent value, the potential across the condenser shunted resistor will change accordingly as described above and this change will occur on the grid of the control tube, thereby altering the condition of the tube. Should the change in level be such as to cause a drop in the voltage across the resistor 15, then the grid of the control tube will become less negative and more plate current will flow. This will result in a larger I. R. drop in the resistor 45 and consequently will mean a less positive potential on the screen-grid of the first amplifier tube 21, causing it to be blocked by less grid bias, so that if a high signal level appears across the shunted resistor, larger momentary signal drops are necessary to block it than when a lower steady signal level exists across the shunted resistor. Should the level of the supply source take a rise, then the grid of the control tube will become negative and the screen grid of the first amplifier tube will become more positive, thus requiring a larger negative bias to block the tube.

It will thus be apparent from the above description that I have disclosed a system capable of fulfilling the objects of my invention. The system, when adjusted for one set of conditions, is thereafter self-adjusting and automatic in its operation and will, without the necessity of manual adjustments, compensate for permanent shifts in the characteristics of the components of the system.

While I have disclosed my invention in great detail, it should be apparent that various changes might be made thereto without the exercise of invention. I, therefore, do not desire to be limited in my protection to the above details except as is necessitated by the prior art and the appended claims.

I claim as my invention:

1. In combination, a source of signal energy, an electron discharge device having a circuit comprising a pair of resistors in series arrangement, means for rectifying potentials derived from said signal energy supply and establishing said rectified potentials across said resistors, the potentials thus established across said resistors being substantially equal but opposing during the absence of signals from said source, and

means for unbalancing said potentials at such times as the condition of said source changes in response to signals, said last means comprising an electrical energy storing means connected across one of said resistors.

2. In combination, a source of variable energy, an electron discharge device having a circuit comprising a pair of series connected resistors in series with two of the electrodes of said discharge device, means for establishing substantially equal but opposing potentials across said resistors and means for unbalancing said potentials an amount sufficient to bias said discharge device beyond the cut-off point in response to changes in energy supply of short duration, said means maintaining substantially equal balance of potentials during energy changes of long duration.

3. In combination, a source of signal energy, an electron discharge device having a circuit comprising a pair of series connected resistors in series with two of the electrodes of said discharge device, means for establishing substantially equal but opposing potentials across said resistors, said electron discharge device then being rendered conductive, and means for unbalancing said potentials in response to signals an amount sufficient to render said discharge device non-conductive, said means comprising a predominance of capacitance across one of said resistors compared to that across the other.

4. In a facsimile transmission system, a scanner for testing point by point the subject of which a facsimile is to be transmitted and delivering potentials corresponding to the brightness thereof, a keyer, and means therebetween for delivering to the keyer a potential corresponding to the difference between the average potential received from the scanner and the momentary received potential corresponding to the brightness of any one point of said subject, said means including an averaging device comprising a reactor and a resistor.

5. In combination, a source of signal energy, an electron discharge device having a circuit comprising a pair of impedances in series arrangement, means for rectifying potentials derived from said signal energy source and establishing said rectified potentials across said impedances, the potentials thus established across said impedances being substantially equal but opposing during absence of signals from said source, and means for unbalancing said potentials at such times as the condition of said source changes in response to signals, said means comprising an electrical energy storing means connected across one of said impedances.

6. In a system for the transmission of facsimiles or the like, an electron discharge device having an input circuit comprising a pair of similar impedances in series, an energy storing element in shunt to one of said impedances, means for producing periodically varying energy modulated according to a subject of transmission, and means for rectifying said modulated energy, the last said means having two direct current output circuits, said output circuits being connected respectively to said similar impedances for effectively impressing the resulting rectified modulated energy across said series conducted impedances to produce opposing potentials therein.

7. A view-transmission device comprising a source of light, means for energizing a photo-sensitive device by a light-beam caused to vary by scanning the view to be transmitted, means for deriving from the output current of said photo-sensitive device a voltage which is proportional to the mean value of said current averaged over periods long compared with the substantially instantaneous variations thereof produced by scanning said view, an electrical discharge device having an input and an output electrode, and means for impressing on said input electrode a voltage proportional to the difference between said voltage and another voltage which is proportional to the substantially instantaneous variations of said output current.

8. A view-transmission device comprising a source of light, means for energizing a photo-sensitive device by a light-beam caused to vary by scanning the view to be transmitted, means for imposing on said light-beam periodic fluctuations which are more rapid than the variations resulting from said scanning, means for deriving from the output current of said photo-sensitive device a voltage which is proportional to the mean value of said current averaged over periods long compared with the substantially instantaneous variations thereof produced by scanning said view, an electrical discharge device having an input and an output electrode, and means for impressing on said input electrode a voltage proportional to the difference between said voltage and another voltage which is proportional to the said instantaneous variations of said output-current.

LA VERNE R. PHILPOTT.