Aug. 9, 1932. F. GRAY 1,871,266

ELECTROOPTICAL TRANSMISSION

Filed April 8, 1930

FIG. 1.

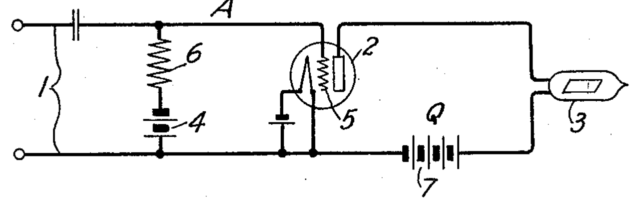


FIG. 2.

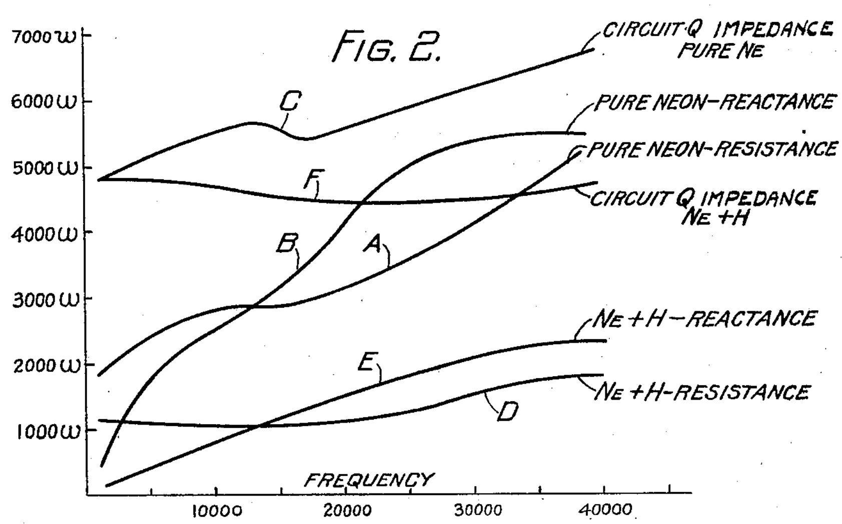
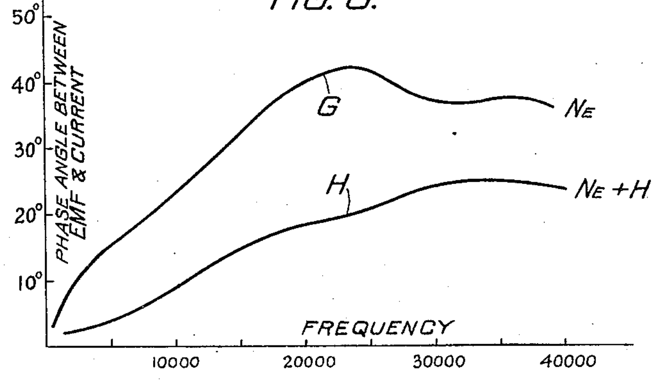


FIG. 3.



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ELECTROOPTICAL TRANSMISSION

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This invention relates to electro-optical transmission and more particularly to apparatus for reproducing an image.

At receiving stations of certain image producing systems heretofore proposed, image currents are supplied to a glow lamp containing a charge of pure gas of the helium group, for example, neon. The incoming currents modify the intensity of the light radiated by the lamp, which is viewed through a suitably apertured scanning member which is driven in synchronism with a scanning member at the transmitting station.

Considerable difficulty has been experienced in producing a well defined image at receiving stations which operate in the manner described above. In general the image is either blurred, ill-defined or distorted, because the intensity of the light supplied by the lamp fails to vary in accordance with, or synchronously with, the variations of the image currents, or the intensity is not reduced to the proper value when reduced current is supplied to the lamp.

The undesired conditions noted above are due to the fact that the lamp, because of undesired resistance and reactance characteristics, discriminates in favor of current components of certain frequencies lying within the frequency range used in television, and certain other signal systems; that it introduces a phase shift of the current components with respect to the corresponding applied voltages which is not proportional to frequency, and that there is a time lag of the light with respect to the current flowing through it which is evidenced by the presence of an after-glow.

An object of the invention is to overcome or minimize the disadvantages noted above, in a signalling system including glow lamps.

Another object of the invention is to improve the quality of the image produced at a television receiving station employing glow lamps.

Still another object is to provide means at a television receiving station to produce a sharply defined image of the subject scanned at a transmitting station.

A further object is to improve the frequency characteristics of glow lamps.

An additional object is to prevent light lag effects and particularly after-glow in the operation of a glow discharge lamp.

In one preferred embodiment of the invention, the above noted objects may be accomplished by providing a receiver comprising an amplifier for supplying image currents to a glow lamp having a gas charge comprising a mixture of inert gas and a small percentage of active gas.

Because of the use of the active gas, the resistance of the lamp is maintained substantially constant over the television frequency range, its reactance varies approximately linearly with frequency, and its impedance is lower than the impedance of a lamp charged with the same practically pure inert gas. The active gas also operates to substantially eliminate the light lag with change of current flowing through the lamp.

The present invention also contemplates including the glow lamp in an amplifier output circuit having an impedance which is constant over the television range and which is high compared with the impedance of the lamp, whereby the effect of the impedance variations of the lamp, upon the amplitudes of the different frequency components of the image current wave, is rendered substantially negligible.

A more detailed description of the invention follows and is illustrated in the accompanying drawing.

Fig. 1 is a schematic diagram of a receiving circuit embodying the invention and Figs. 2 and 3 illustrate curves, used to explain the invention.

Referring to Fig. 1, there is shown a circuit 1 for applying the incoming image currents to the input circuit of an amplifier.

Obviously the circuit 1, may be the termination of a line over which the image currents are transmitted or the output circuit of a high frequency terminal apparatus, if the image currents are transmitted as modulations of a carrier wave over a line or radio link.

The image currents are impressed upon the input electrodes of the space discharge tube amplifier 2, the output circuit Q of which includes a glow discharge lamp 3.

The input circuit of the amplifier includes a battery 4, for impressing a biasing potential upon its grid 5, and a resistance 6, for improving the operation of the tube 2, as an amplifier. Battery 7, supplies space current to the anode-cathode path of the tube 2, through the discharge path of the glow lamp 3.

The intensity of the light produced by the lamp 3, is caused to vary in accordance with the changing amplitudes of the amplified image current supplied by the tube 2.

In television systems the glow area of the lamp 3 is viewed through the apertures of a scanning member, which is driven in synchronism with a similar member at the transmitting station. The scanning members are operated at such a rate of speed that an image of the subject, scanned at the transmitter, is completely repeated at the receiving station in a period corresponding to the persistance of vision, i. e., from $\frac{1}{16}$ to $\frac{1}{20}$ of a second. The frequency range of the image currents is from very near zero to from 10,000 to 50,000 cycles per second, depending upon the size of the image, the scanning period and the resolution desired. Examples of television systems in which the circuit of Fig. 1 may be employed, or in which the glow lamps of this invention may be substituted for the ones shown, are those disclosed in application of F. Gray Serial No. 227,649 filed October 21, 1927 and application of J. W. Horton Serial No. 230,418 filed November 2, 1927.

The glow lamp 3, is provided with a gas charge comprising an inert gas and a small quantity of active gas. For example, the charge may comprise 99 to 90 per cent neon and 1 to 10 per cent hydrogen.

With regard to the alternating current components which flow through the glow lamp 3, the circuit of Fig. 1 may be considered as though the amplifier tube 2, were a source for supplying alternating current at an E. M. F.=E and had an internal resistance=R_0. That is, the internal output resistance of the tube 2, is equal to R_0 ohms.

The lamp 3, may be regarded as an impedance Z, comprising a resistance R, and a reactance X.

The absolute value of the impedance $Z=\sqrt{R^2+X^2}$.

In terms of the voltage drop V, across the lamp, the current through it at any frequency is

$$I=\frac{V}{\sqrt{R^2+X^2}}$$

and the phase angle between current and voltage is

$$\varphi_1=\text{arc tan}\frac{X}{R}$$

In the operation of the circuit of Fig. 1, current of any frequency flowing through the lamp 2, is

$$I=\frac{E}{\sqrt{(R+R_0)^2+X^2}}$$

and the phase angle between the current and E. M. F. is:

$$\varphi_2=\tan^{-1}\frac{X}{R_0+R}$$

For small values of

$$\frac{X}{R_0+R}$$

the phase angle is approximately

$$\varphi_2=\frac{X}{R_0+R}.$$

Referring now to Fig. 2 there are shown two sets of curves. One set, A, B and C relates to a discharge lamp charged with pure neon, and the other set, D, E and F to the same lamp, provided with a gas charge comprising 90% neon and 10% hydrogen by volume and at a pressure of a few millimeters of mercury.

According to curve A the resistance R of the pure neon lamp varies from about 1,800ω at approximately zero frequency to about 5,300ω at 40,000 cycles.

Curve B indicates that the reactance X of the pure neon lamp varies from about 400ω at substantially zero frequency to about 5,500ω at 40,000 cycles.

Curve C, which relates to a 3,000ω circuit including the pure neon lamp, indicates that the total impedance of the circuit

$$\sqrt{(R_0+R)^2+X^2}$$

varies from 4,800ω at approximately zero frequency to about 6,600ω at 40,000 cycles.

Curves D, E, and F indicate variations of resistance R and reactance X of the lamp and total impedance

$$\sqrt{(R_0+R)^2+X^2}$$

of the circuit. D indicates that the resistance R varies from 1,100ω at approximately zero frequency to 1,800ω at 40,000 cycles. From E, it will be seen that the reactance X varies from 150ω at the lower frequency limit to 2,250ω at 40,000 cycles, and from F that the total impedance varies from 4,800ω at substantially zero frequency to 4,700ω at 40,000 cycles.

Fig. 3 includes curves G and H which indicate the phase angle between the applied E. M. F. and current, over the zero to 40,000 cycle range, for the two lamps referred to above.

As shown by curve G the phase shift in the pure neon lamp varies from 0% for direct current to about 42% at 22,500 cycles and 35% at 40,000 cycles.

For the lamp provided with a gas charge including 10% hydrogen, curve H indicates that the phase shift of the applied current with respect to the applied E. M. F. varied from zero, for direct current, to 24½% at 35,000 cycles and 23% at 40,000 cycles.

Thus, the presence of the active gas lowers the impedance of the lamp and makes it a smaller part of the total impedance of any circuit in which it is used, and the resistance of the lamp is made more nearly constant over the television range. Both of these factors result in a more uniform current response at the various frequencies. By lowering the reactance of the lamp, the active gas renders the phase shift more nearly proportional to frequency and, in a circuit of reasonably high impedance, gives a phase shift which is practically proportional to the frequency over the complete range. The curves show that this proportionality holds up to about 35,000 cycles for the improved lamps herein described when included in a 3,000ω circuit.

While many advantages result from the use of a small percentage of active gas in a charge of inert gas, it will be apparent that to secure the best results, it is necessary to use the lamp in a circuit having an impedance which is high compared with the impedance of the lamp.

Within wide limits, the impedance of the lamp is improved as the percentage of active gas is increased. However, since the presence of the active gas serves to reduce the brightness of the light produced, there is a maximum limit which should not be exceeded.

Under present conditions in television, not more than 5% of hydrogen should be used. As a matter of fact, the advantages of this invention are completely realized in a neon lamp having a hydrogen content of 1 or 2%.

In addition to improving the impedance characteristics of the lamp, the active gas effects a result of major importance in electro-otpical systems in that it prevents after-glow, i. e. the production of a glow within the lamp after the flow of image current through the lamp has ceased. The production of after-glow may be explained on the theory that, when an electron collides with an inert gas atom, the electron bounces away from the atom with practically no loss of energy. In a pure inert gas, electrons can thus lose their energy only very slowly and are consequently slow in recombining with positive ions. This residual ionization, or time lag in change of ionization, causes after-glow which makes the lamp act somewhat as an inductive reactance in an alternating current circuit and causes the image to be blurred.

However, when an electron collides with an active gas molecule it bounces away therefrom with very little of its initial energy. The presence of a small percentage of active gas in an inert gas, therefore, causes the electrons to lose their energy more rapidly than in a pure inert gas and causes them to recombine more quickly with the gas molecules, whereby after-glow is substantially obviated.

Quite independent of the above or any theory as to the cause of after-glow in the operation of glow lamps includuing a pure inert gas charge, it has been determined that this undesirable condition can be obviated by adding a small percentage of active gas to an inert gas charge.

There is evidence also that a lag in ionization occurs when current is applied or increased, and that this effect is reduced in the improved lamp herein disclosed.

The present invention provides a glow lamp having an inert gas charge to which active gas is added for the purpose of determining and controlling the response of the lamp when it is producing light i. e., under operating conditions; whereas heretofore active gas was introduced into a glow lamp for the sole purpose of lowering its starting or break down voltage.

While a definite circuit arrangement has been described and certain specific details have been given, it is to be understood that this was done merely for the purpose of completely and clearly disclosing the principles and nature of the invention. Its novel features will be defined in the attached claims.

Obviousy the present invention is applicable to sound recording, in which the distortion produced by the ordinary glow lamps including a pure inert gas charge, is applicable. The invention is of particular value for such use when the frequency range is wide, as in high quality recording.

What is claimed is:

1. An electro-optical receiving system comprising a circuit, means for producing image currents in said circuit, and included in said circuit a glow discharge lamp having means for maintaining its resistance substantially constant over the frequency range involved and its reactance varying approximately linearly with frequency.

2. An electro-optical receiver comprising a glow lamp, a circuit including said lamp and having high impedance compared therewith, and means for maintaining substantially constant the resistance of said lamp over the frequency range involved.

3. A television receiver comprising a glow lamp, means for repeating image currents in a circuit including said lamp and having high impedance compared therewith, and means for causing the reactance of said lamp to vary proportionally with frequency over the frequency range involved.

4. A television receiver comprising a glow lamp, means for producing image currents in a circuit including said lamp and having high impedance compared therewith, said glow lamp including a charge comprising an inert

gas and a small percentage of active gas to render the combined impedance of the circuit and lamp substantially constant over the image current range.

5. A television system comprising a glow lamp, means for repeating image currents in a circuit which includes said lamp and has high impedance compared therewith, and means for causing said lamp to have a resistance which is substantially constant, a reactance variable substantially linearly with frequency and a phase shift proportional to frequency for currents in the frequency range involved.

6. An electro-optical system comprising a glow lamp, means for supplying to said lamp current extending over a wide frequency range, and means for causing the reactance of said lamp to vary substantially linearly with frequency for currents within said range.

7. An electro-optical system comprising a glow lamp, means for supplying to said lamp current extending over a frequency range including frequencies above 10,000 cycles per second, and means for causing the reactance of said lamp to vary substantially linearly with frequency for the current supplied by said means.

8. An electro-optical system comprising a glow lamp, means for supplying to said lamp current of a frequency range from below 10,000 cycles per second to at least 20,000 cycles per second, and means for causing the reactance of said lamp to vary substantially linearly with frequency for the current supplied by said means.

9. An electro-optical system including a glow lamp, and means for causing the reactance of said lamp to vary linearly with frequency when supplied with current having frequencies extending over a wide range.

10. An electro-optical system including a glow lamp, and means for causing the reactance of said lamp to produce a phase shift proportional to frequency for current supplied thereto, having frequencies extending over a wide range.

11. A circuit, a glow discharge lamp in said circuit and means for impressing upon said circuit signaling potentials having a wide range of frequency components for setting up light variations corresponding to said signaling potentials, said lamp having a gaseous filling comprising an inert gas and a small percentage of active gas, so that the combined impedance of said circuit and said lamp is substantially constant over said range of frequencies.

12. A television system comprising a space discharge amplifier, means for impressing an image current band on said amplifier, a glow discharge lamp included in the output circuit of said amplifier, said lamp having a gaseous filling of neon and less than 10% of hydrogen, the combined impedance of said output circuit and lamp being substantially constant over said image band range.

13. The combination with a glow lamp having a gas charge of inert gas and a small amount of active gas, and means for impressing upon a circuit including said lamp a variable electromotive force having freqeuncy components extending over a wide frequency range, whereby the impedance of said combined circuit and lamp is substantially constant and the response of said lamp is substantially proportional at each instant to the amplitude of the impressed electromotive force.

14. The combination with a glow lamp having a gas charge comprising at least 90% of inert gas and 10% or less of an active gas, and means for impressing upon said lamp a variable electromotive force having frequency components extending over a wide frequency range.

15. The combination of a glow lamp containing a gaseous filling comprising inert gas and an active gas, the proportion of the latter by volume being of the order of 10% or less, means for impressing upon said lamp variable potentials having frequency components extending over a frequency range of at least five thousand cycles per second.

16. The combination of a glow discharge lamp containing inert and active gas, the portion of active gas by volume being of the order of 10% or less, means for impressing a steady biasing potential upon said lamp and means for impressing upon said lamp variable potentials having frequency components extending over a range of at least twenty thousand cycles per second.

17. The combination with a glow discharge lamp having a gaseous filling comprising inert gas and hydrogen, the portion of hydrogen by volume being 10% or less, and means for impressing upon said lamp variable potentials comprising a wide range of frequency components.

18. The combination with a glow discharge lamp containing a gaseous filling comprising inert gas and hydrogen, the proportion of the latter by volume being 5% or less, and means for impressing upon said lamp variable potentials comprising a wide range of frequency components.

19. Means for producing a television image comprising a glow discharge lamp having a gaseous filling of inert gas and active gas, the proportion by volume of the latter being of the order of 10% or less, and means for impressing upon said lamp image potentials having frequency components extending over a range of twenty thousand cycles per second or more.

In witness whereof, I hereunto subscribe my name this 7th day of April, 1930.

FRANK GRAY.