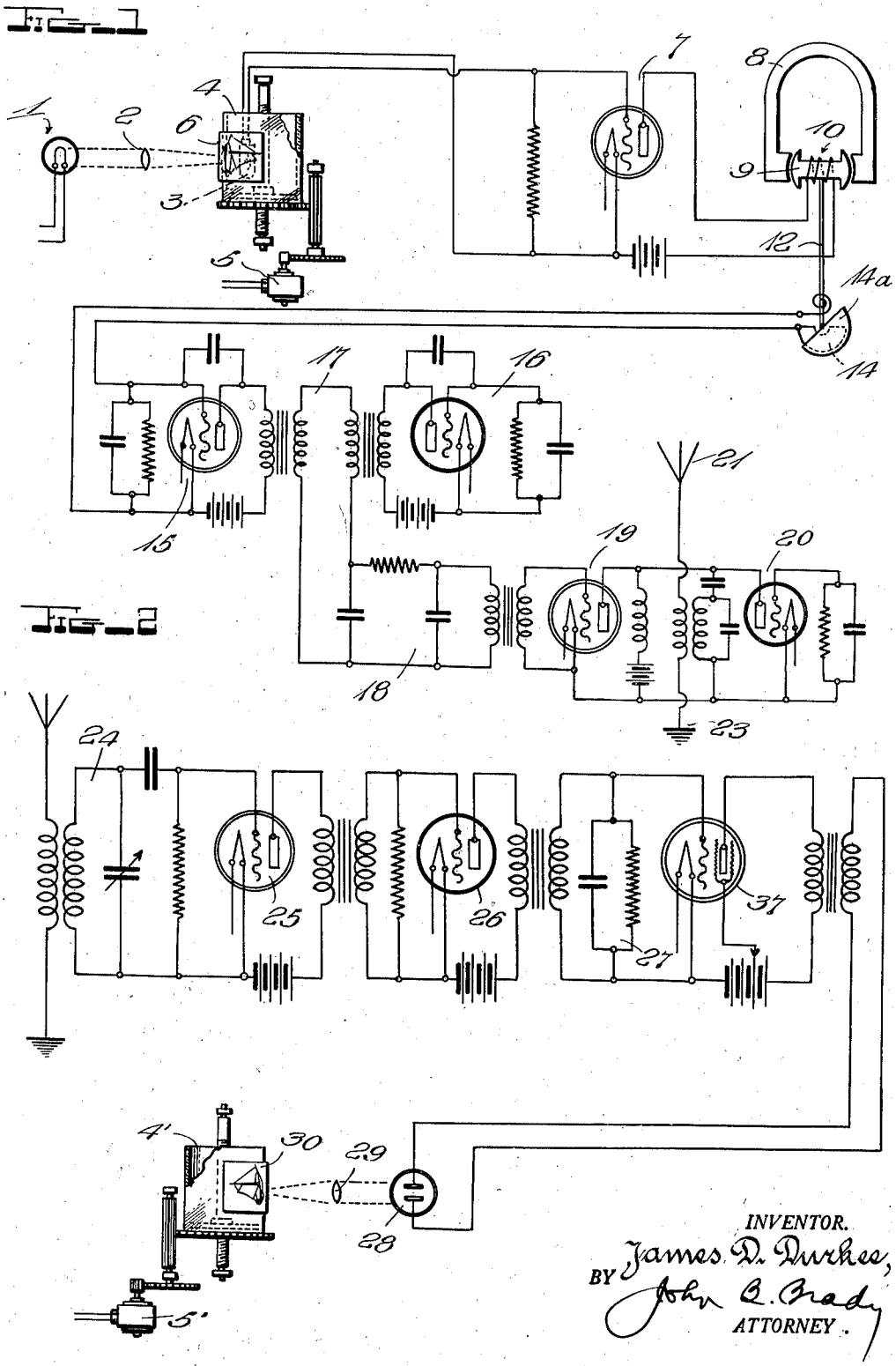
Feb. 20, 1940. J. D. DURKEE 2,191,057

FACSIMILE TRANSMITTING AND RECEIVING SYSTEM

Filed July 25, 1938 2 Sheets-Sheet 1



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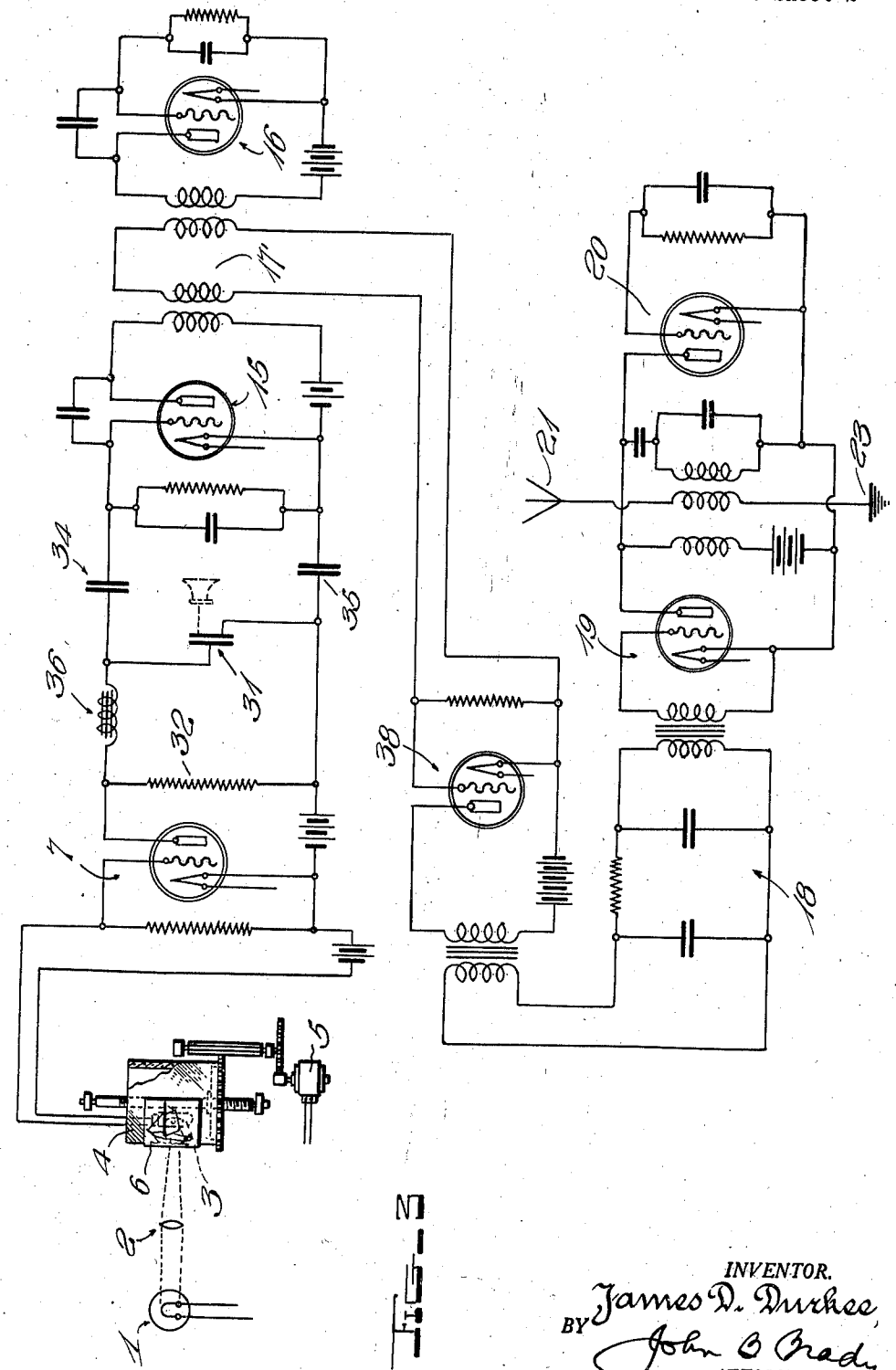


FIG. 2

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FACSIMILE TRANSMITTING AND RECEIVING SYSTEM

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Application July 25, 1938, Serial No. 221,223

9 Claims. (Cl. 178—7.1)

My invention relates broadly to the transmission and reproduction of facsimile pictures and more particularly to a frequency modulated audio frequency system.

This application is a continuation-in-part of my application Serial Number 37,578, filed August 23, 1935, for Facsimile transmitting and receiving system.

In picture transmitting systems wherein a radio frequency carrier current is modulated in intensity directly by the varying current from a light sensitive cell, the varying tones in the picture being transmitted are registered too sharply in the reproduced image, resulting in a facsimile of inferior quality.

One of the objects of my invention is to provide a system of facsimile reproduction in which the lights and shadows in the original picture are accurately reproduced.

Another object of my invention is to provide a modulating system wherein impact excitations of the carrier due to sharp changes in the intensity of the light focused on the photo-cell are eliminated from the modulator output, and the signal current caused to vary directly as the intensity of the light varies.

Still another object of my invention is to provide means for modulating a radio frequency carrier current by means of an audio frequency wave, the frequency of which is made to vary in accordance with the light intensity of successive points in a picture to be transmitted.

A further object of my invention is to provide an intermediate audio frequency oscillator the frequency of which is modulated in accordance with the variations in light intensity in a picture being scanned; the modulated audio frequency being employed to modulate the intensity of a radio frequency carrier current for transmitting by space radio or line wire the subject picture.

A still further object of my invention is to provide an audio beat frequency oscillator, the frequency of which is modulated by varying the frequency of one of the component frequencies, to modulate a radio frequency carrier current.

Still another object of my invention is to provide a translating system for detecting the frequency modulated audio wave and employing the modulations thereof to actuate a recording means by changing the intensity of a light source.

A still further object of my invention is to provide a filter device in the translating system responsive in uniformly varying effect over the band of frequencies over which the frequency modulation extends, the filter being effectively open to frequencies at the one extremity of the band of frequencies, and substantially closed to frequencies at the other end of the band.

Other and further objects of my invention reside in the circuits and arrangements hereinafter more fully set forth with reference to the accompanying drawings, in which: Figure 1 is a schematic diagram of the circuit connections in the transmitting system of my invention; Fig. 2 is a similar schematic diagram of the circuit connections in the receiving system of my invention; and Fig. 3 is a schematic circuit diagram of a modified form of the transmitter shown in Fig. 1.

The system of my invention involves frequency modulation within a relatively narrow audio band of a beat frequency resulting from the coaction of a plurality of high frequency oscillators. The frequency modulated wave is then employed, in the preferred form of my invention, to modulate a radio frequency carrier current whereby the modulations may be transmitted by space radio or line wire. At the receiver, the radio frequency carrier current is rectified, and the detected varying audio frequency currents are employed to energize a light source in intensity varying as the modulations of the audio frequency.

The system of my invention operates to transmit the light variations in successive minute portions of the subject picture. A scanning system at the transmitter and a synchronized system at the receiver are accordingly required. These may be of any of the types known in the art, the system of my invention being concerned primarily with the transmission of the varying color tones in the subject picture.

Referring to the drawings in more detail, Fig. 1 illustrates the transmitting arrangement of my invention. Reference character 1 indicates a constant light source focused by lens 2 on the light sensitive cell 3. A drum 4, carrying the film 6 which bears the picture to be transmitted is moved by suitable mechanical means, including a motor 5, so that the light beam from the source 1 passes through successive minute portions of the film, being varied in intensity with the density of the film and energizing the light sensitive cell 3 accordingly.

The cell 3 is connected in the input circuit of an electron tube amplifier stage 7, the output of which is fed to an electromagnetic device comprising a magnetic core structure 8 and an armature 9, on which is wound a coil 10 connected in the output circuit of the amplifier 7. The armature 9 is mechanically connected by means of shaft 12 with the movable section 14a

of a variable condenser 14 which is connected in the circuit of a high frequency oscillator 15 and operable to vary the frequency of the oscillations generated therein.

A similar high frequency oscillator 16 has its output coupled with the output of the oscillator 15 in the combining circuit 17. Oscillators 15 and 16 are preferably normally adjusted to operate at the same frequency and to produce a zero beat in the combining circuit 17. Oscillators 15 and 16 may, however, be adjusted so as normally to produce any desired fundamental beat frequency. The combining circuit 17 includes the secondaries of coupling transformers 11 and 22, the primaries of which are connected in the output circuits of the oscillators 15 and 16, respectively. As indicated in Figs. 1 and 3, these transformers, carrying high frequency currents from the oscillators, have a substantial amount of iron in the cores 11*a* and 22*a*, saturable at the high frequencies of the oscillators so that the transformers have non-linear frequency responsive characteristics. Connected in the series circuit 17, the secondaries of these transformers 11 and 22 comprise a combination having a non-linear characteristic, wherein the output currents of the oscillators 15 and 16 beat and result in a zero or low frequency beat wave to which the circuit 17 is linearly responsive. As the condenser 14 connected in circuit with oscillator 15 is varied by the electromagnetic means controlled by the variations of light on the cell 3, the frequency of the oscillations produced in oscillator 15 is modulated according to the light variations on the cell 3. The beat frequency, which is of audible magnitude, appearing in the combining circuit 17 likewise varies in accordance with the fluctuations in intensity of the light focused on the cell 3.

The combining circuit 17 is connected with a filter circuit 18 having the dual function of first excluding the higher fundamental harmonic frequencies of the component oscillations issuing from the oscillators 15, 16, and second of passing currents of beat frequency, within the band covered by the modulations introduced by the condenser 14, in varying intensities depending upon the instantaneous frequency of the wave. That is, the frequencies at one end of the band will be passed without diminution of the intensity of the current, while the frequencies at the other end of the band will be substantially suppressed and currents at those frequencies correspondingly diminshed, the current passed by the filter 18 decreasing uniformly with proportionate changes in the frequency thereof. In other words, the frequency modulations and the current passed by the filter vary in a straight line relation.

The filter 18 is coupled with an electron tube amplifier 19 so that the voltage on the grid thereof is directly proportional to the magnitude of the beat frequency and, accordingly, to the intensity of the light on the cell 3. The output of amplifier 19 is employed to modulate a high frequency carrier wave produced in an oscillator at 20, the modulation consisting of the beat frequency wave which varies not only in frequency but also in magnitude with the light intensity signal. The modulated carrier is fed to a radiating system including antenna 21 and ground 23.

At the receiver the modulated radio frequency carrier current is intercepted in the usual manner by tuning to the frequency of the carrier current, by means of the resonant circuit 24, Fig. 2, and rectified in the usual manner in a detector 25. The audio frequency modulations thus detected are amplified in the electron tube stage 26 and fed into an audio frequency band pass filter 27 which transmits currents of all frequencies within its range substantially uniformly. Further amplification may be obtained in the electron tube stage 37 from which the energy is fed to a source of light, such as a neon lamp, at 28, the intensity of the light produced thereby varying with the magnitude of the applied voltage. The light is focused by lens 29 upon the light sensitive film 30 which is fixed on a drum 4' driven by synchronized scanning means including motor 3'.

Assuming that the beat note produced at the transmitter in the combining circuit 17, Fig. 1, varies between 500 and 1000 cycles, a plurality of beat frequency oscillators may be connected for multiplex operation, each employing a range of frequencies independent from the others. A corresponding plurality of filter systems 27 may be provided at the receiver, each operative over a predetermined band in cooperation with the ranges of beat frequencies selected at the transmitters.

Fig. 3 shows a modified form of transmitter employing electrostatic means for varying the frequency of the component oscillator 15, in place of the electromagnetic control means and a variable condenser shown in Fig. 1. The electrostatic device 31 may be the operative unit of a condenser microphone, in which case the electron tube in amplifier stage 7 should have a high impedance output circuit. The plate voltage of the tube acts as a biasing potential on the condenser plates, and variations in the instantaneous voltage across a resistor 32 in the output circuit of the tube due to the variations in light intensity on the photoelectric cell 3 will be effective directly as changes in capacity. The condenser device 31 is coupled to the circuit of the high frequency oscillator 15 through condensers 34 and 35, and connected with the low frequency amplifier stage 7 by choke coil 36 in order to confine the high frequency currents from the oscillator 15 to the condenser plates. The condenser device 31 will thus be acted upon by the voltages across the resistor 32, and function, in place of the variable condenser 14 shown in Fig. 1, to modulate the frequency of the oscillator 15. A wider frequency band will be required using the circuit of Fig. 3 than is possible with that of Fig. 1, as the diaphragm of a condenser microphone will respond to frequencies as high as 10,000 cycles per second, but greater sharpness of definition in the facsimile will be assured.

A further modification of Fig. 1 shown in Fig. 3 is the provision of an electron tube stage at 38 operative as a detector wherein the oscillations from oscillators 15 and 16 beat. The outputs of the oscillators 15 and 16 are coupled by conventional transformer means to the circuit at 17' connected with the input of detector 38. The output of the detector is applied to the filter 18, as is the beat frequency output of the combining circuit 17 in Fig. 1, and the filter 18 functions as hereinbefore described to pass current in proportion to the beat frequency. The remainder of the circuit is similar to that of Fig. 1. The electron tube detector stage 38 may be provided in the arrangement of Fig. 1 in lieu of the non-linear transformer devices comprising the combining circuit 17 to effect the same results, if desired. It will be noted, however, that the filter

18 and its two-fold function are featured in both circuits and is an essential element of the system of my invention.

The transmission method of my invention produces a much wider degree of color tone variation than is possible with other methods, by reason of the smooth variation of the frequency of the audio modulation of the carrier, which results in no impact excitations such as result from direct modulation of the carrier. Freed from the impact excitations which extend over a relatively broad space in the frequency spectrum, the system of my invention is capable of transmitting a number of pictures in the band width heretofore required for the transmission of a single picture.

While I have described my invention in certain of its preferred embodiments, I desire that it be understood that modifications may be made by those skilled in the art, and that no limitations upon my invention are intended other than may be imposed by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In an image transmitting system, the method of transmitting variations of light intensity which comprises generating a beat frequency wave by the coaction of two independent oscillations, modulating the frequency of one of the independent oscillations and thereby modulating the beat frequency, regulating the amplitude of the beat frequency wave in accordance with the frequency of the same, generating a radio frequency carrier current, modulating the radio frequency carrier current by the beat frequency wave, detecting the modulated radio frequency carrier to reestablish the modulated beat frequency, employing the modulated beat frequency to vary the intensity of a light beam in accordance with the amplitude of the beat frequency wave, and recording the varying intensities of the light beam.

2. In an image transmitting system of the type described, the method of modulating a radio frequency carrier current which comprises initially modulating the frequency of an audio wave resulting from the coaction of a pair of high frequency oscillations, regulating the amplitude of the audio wave in accordance with the frequency thereof, and subsequently employing the audio wave to modulate a radio frequency carrier current.

3. In an image transmitting system of the type described, the method of modulating a radio frequency carrier current which comprises, generating a beat frequency wave by the coaction of two independent oscillations, modulating the frequency of one of the independent oscillations in accordance with color tone variation of a picture or object and thereby modulating the beat frequency, regulating the amplitude of the beat frequency wave in accordance with the frequency thereof, and employing the beat frequency wave to modulate a radio frequency carrier current.

4. In an image transmitting system, means for transmitting variations of light intensity which include a beat frequency oscillator comprising a pair of individual oscillation generators, and means for combining the outputs of said generators to produce an oscillation of beat frequency; means connected in one of said oscillation generators and controlled in accordance with color tone of a picture or object for varying the frequency of said one oscillation generator, the frequency of said beat frequency oscillation being modulated accordingly; and an audio frequency filter system connected with said combining means and adapted to pass current in proportion to its frequency within the range of said filter system.

5. In an image transmitting system, a source of energy comprising separate oscillator circuits, means for modulating the frequency of one of said oscillator circuits in accordance with the lights and shades in the image transmitted, the frequency of the other of said oscillator circuits being constant, transformer means in the output of each of said oscillator circuits and having non-linear frequency responsive characteristics in the range of frequencies of said oscillator circuits, said transformer means having secondary windings connected in series and constituting a combining circuit, said constant frequency and said modulated frequency being combined in said combining circuit to produce a beat frequency of a relatively low value and variable in accordance with the initial modulation of the first said oscillator circuit, a filter system connected with said combining circuit and operative to pass current of the beat frequency in proportion to its frequency, and means for modulating a carrier current in accordance with the output of said filter system.

6. In an image transmitting system, means for modulating a carrier current in accordance with the lights and shades in the image transmitted, which include a beat frequency circuit fed by separate oscillator circuits, the frequency of one of said circuits being varied by the light intensity signal while the frequency of the other of said circuits is constant, said beat frequency circuit comprising the secondary windings of separate transformer means coupled with said oscillator circuits and having non-linear frequency responsive characteristics in the range of frequencies of said oscillator circuits, and a filter system operative to pass currents of the modulation beat frequency issuing from said beat frequency circuit in proportion to the frequency thereof.

7. In an image transmitting system, a beat frequency oscillator constituting means for relieving a carrier current of abrupt changes in modulation due to impact excitation of a photo-cell by sharp changes in the light intensity signal thereon, said beat frequency oscillator comprising separate oscillator circuits, the frequency of one of said circuits being varied by the light intensity signal while the frequency of the other of said circuits is constant, and transformer means connected in the output of each of said oscillator circuits and having non-linear frequency responsive characteristics in the range of frequencies of said oscillator circuits, said transformer means having secondary windings connected in series and constituting a combining circuit, said constant frequency and said modulated frequency being combined in said combining circuit to produce a beat frequency variable in accordance with the initial modulation of the first said oscillator circuit exclusive of the results of impact excitation of the photo-cell by reason of the operation of the first said oscillator circuit with respect to the second said oscillator circuit in said combining circuit.

8. In an image transmitting system, a beat frequency oscillator interposed between photo-electric modulating means and a carrier modulating circuit, said beat frequency oscillator including a combining circuit inductively coupled with sep-

arate oscillator circuits and having a non-linear frequency responsive characteristic in the range of frequencies of said oscillator circuits and a linear frequency responsive characteristic in the range of the beat frequencies, the photo-electric modulating means being arranged to modulate the frequency of one of said oscillator circuits in accordance with color tone variation of a picture or object, and means connected with said combining circuit for translating variations in the beat frequency into current variations for said carrier modulating circuit.

9. In an image transmitting system, photo-electric scanning means, a source of alternating current controlled in frequency by said scanning means in accordance with light intensity in the object scanned, and means for regulating the amplitude of the alternating current from said source in accordance with the frequency thereof, said current of variable frequency being employed to modulate a carrier wave and the amplitude variations of said current being adapted to control the intensity of a light beam for producing an image of the object scanned.

JAMES D. DURKEE.

CERTIFICATE OF CORRECTION.

Patent No. 2,191,057. February 20, 1940.

JAMES D. DURKEE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 74, claim 4, after the word "tone" insert variation; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 2nd day of April, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)