Nov. 3, 1931. E. L. NELSON 1,830,173

RADIO TELEVISION SYSTEM

Filed June 23, 1927 2 Sheets-Sheet 1

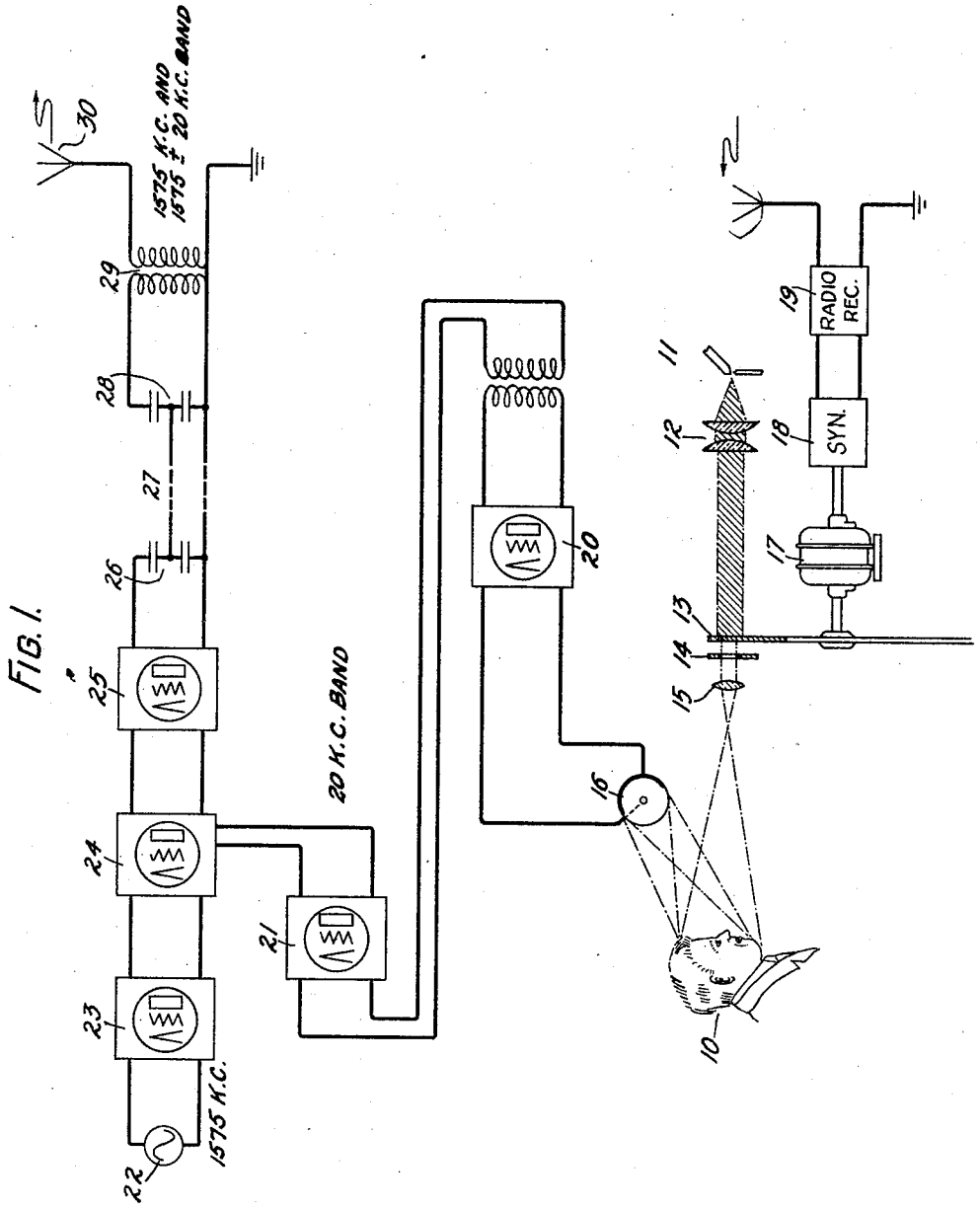

FIG. 1.

INVENTOR.
EDWARD L. NELSON
BY Otis Sprague
ATTORNEY

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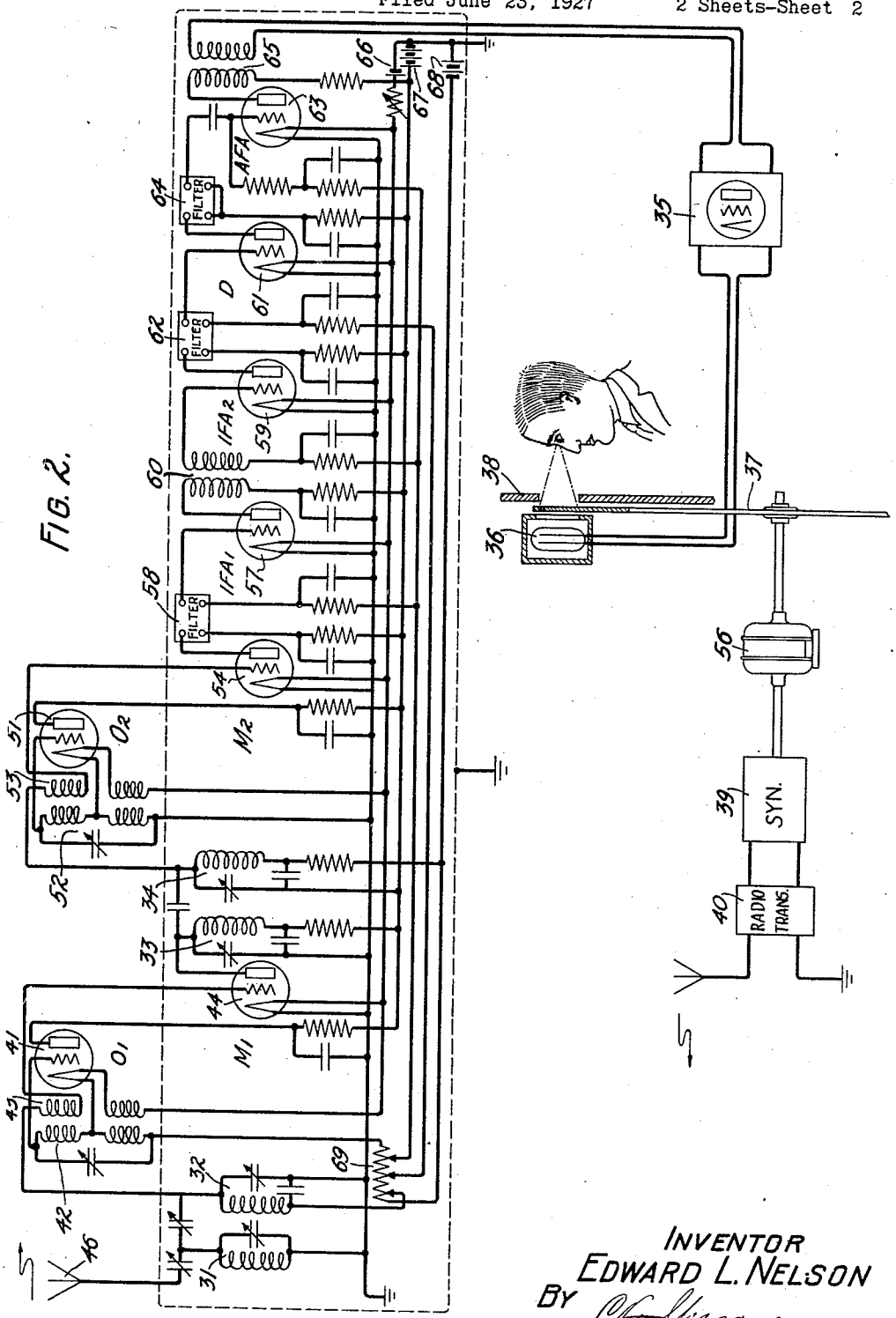

FIG. 2.

INVENTOR
EDWARD L. NELSON
BY O. B. Sprague
ATTORNEY

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UNITED STATES PATENT OFFICE

EDWARD L. NELSON, OF MOUNTAIN LAKES, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

RADIO TELEVISION SYSTEM

Application filed June 23, 1927. Serial No. 200,805.

This invention relates to electro-optical transmission systems and particularly to radio television.

The transmission to a remote point of an image of an object or scene is based upon the analysis of the object point by point in a time sequence and the transmission of waves having characteristics corresponding to the variations from point to point of the light and shade characteristics of the object. The transmitted waves are then utilized to control at a receiving point the formation of an image which is built up point by point in the time sequence corresponding to that of the analysis of the object.

In order to produce a satisfactory image of a moving object it is necesary to transmit a band of waves of relatively great width—20,000 cycles per second, for example—and to reduce interference of all kinds to a low value. The elimination of interference and distortion when radio transmission is employed to transmit the image waves becomes a very difficult problem. Among the problems which had to be solved were the following: The transmitting antenna should be tuned to permit effective radiation, but the side band of the carrier is so wide that distortion in the outermost portions of the band is likely to occur. The receiving antenna should be tuned to eliminate interference but here again distortion must be guarded against. The photoelectric currents are very minute and the power radiated must be large, so that very great amplification must be resorted to at the transmitter, but this large amount of power introduces disturbances in the circuits carrying minute currents which are large compared with these currents. Prior to this invention there was, so far as applicant is aware, no known receiving system capable of eliminating disturbing wavs, which did not produce prohibitive distortion. The most nearly suitable circuit arrangement from the point of view of selectivity and band width was the so-called superheterodyne arrangement, but, due to the wilth of the frequency band, the usual type of radiofrequency input circuits employed with the superheterodyne could not be used.

In accordance with this invention, a system is provided which avoids the above mentioned difficulties. At the transmitting station the weak photoelectric currents are greatly amplified and used to modulate a carrier current of such high frequency that the distortion of the side band frequencies in the antenna circuit becomes negligible. This frequency may, for example, be 1500 kilocycles. At the receiver initial selectivity is obtained by coupling a local circuit containing resistance to the antenna thereby securing a widened resonance characteristic. The carrier frequency is then combined with a current from a local source of frequency very much higher so that the resulting "difference frequency" is much higher than the received carrier. This reduces the percentage width of the side band to such an extent that selectivity may be obtained in tuned circuits, without undue distortion and at the same time eliminates interference from the harmonics of the local source, which are of such high frequency as to be harmless. The frequency of the local source may be 6500 kilocycles, for example, in which case the difference frequency is 5000 kilocycles. After passage through highly selective circuits this latter current is combined with current from another local source for producing an intermediate difference frequency, which, after being selectively amplified, is detected to produce the image currents. The frequency of the second local source may be 5120 kilocycles, giving an intermediate frequency of 120 kilocycles.

The invention itself may be more readily understood by reference to the following detailed description in connection with the drawings, in which:

Fig. 1 shows diagrammatically a radio television transmitting station; and

Fig. 2 shows diagrammatically a radio television receiving station.

Referring to Fig. 1, there is shown a face 10 which represents the image to be transmitted positioned in front of the scanning apparatus. Light from a lamp 11 is focused into a pencil or beam of rays by the optical system 12 and directed against the surface

of a scanning disc 13 which is provided near its rim with a plurality of spirally arranged perforations. There is provided in front of the scanning disc a shield 14 having an opening of such width that as the scanning disc revolves the light coming through one perforation at a time will pass thereacross in an approximately horizontal line. The light coming through the opening in the shield 14 is focused by means of a lens 15 upon the face 10 and is reflected therefrom upon the sensitive surface of a photoelectric cell 16 which generates an electrical wave of characteristics depending upon the light and shade variations in the reflected beam. This scanning system and the reproducing scanning system outlined hereinafter are described in more detail in the copending application of F. Gray, Serial No. 181,538 filed April 6, 1927. The scanning disc 13 is driven by a motor 17 which is driven at such a speed as to cause the light pencils through the disc to completely scan the image about 18 times per second. Synchronizing apparatus 18 is provided for holding the motor and scanning disc in synchronism with the scanning disc at the receiving station, the synchronizing currents being transmitted over a radio channel and being received in the radio receiver 19. Obviously the synchronization of the scanning discs may be controlled from the transmitting station if preferred.

The electrical waves produced by the photo-electric cell 16 have components of frequency ranging from about 10 to 20,000 cycles per second. These waves are amplified in electric discharge amplifiers 20 and 21 and employed for modulating a radio-frequency wave in the radio transmitting circuit. The radio transmitter comprises a source of radio frequency waves 22 which may be an electric discharge oscillator, for example of the type described in Hartley Patent 1,356,763 of October 26, 1920, for generating a wave of 1,575 k. c. per second. The output of this source is amplified in an electric discharge amplifier 23 and impressed upon the input of an amplifying-modulator 24 of the constant current type described in Heising Patent 1,442,147 of January 16, 1923. The output of the image wave power amplifier 21 is impressed upon the anode circuit of the amplifying modulator 24 to modulate the radio-frequency waves in the manner described in the Heising patent. The resulting modulated radio wave is amplified in an electric discharge power amplifier 25 and impressed through the capacity coupling circuit 26 upon a transmission line 27 which connects the transmitter and the antenna. The other terminal of the line 27 is connected through a second capacity coupling circuit 28 and a radio frequency transformer 29 to the radiating antenna 30.

In spite of the fact that the radio equipment is separated from the antenna, being connected thereto by the line 27, much difficulty is caused by the radio frequency fields produced in the neighborhood of the radio equipment due to the relatively high amplification which must be employed with photo-electric cells. In order to minimize trouble of this nature the television terminal apparatus proper is located within a specially shielded studio. The walls, ceiling and floor of the studio are completely covered with No. 24 gauge sheet copper lapped about one inch and carefully soldered. The windows are covered with fine copper gauze. The door is covered with sheet copper which is carried around the edges so that in closing it makes a firm wiping contact with the surrounding frame. Circuits for lighting and miscellaneous power are led in through specially constructed transformers fitted with grounded copper shields between the primary and secondary windings. The circuits leading from the television transmitting apparatus to the radio transmitter are run in lead cables and brought into the room through suitable radio frequency filters enclosed in cable boxes attached to the copper sheathing. In order to avoid the possibility of the heavy current leads to the arc bringing in radio frequency energy and to eliminate noise and heat from the arc, it is mounted in a metal cabinet located outside of the room. This cabinet is grounded to the sheathing so as to protect the circular opening through which the light beam is projected into the room.

In the receiving station shown in Fig. 2, the modulated radio wave is received in a detuned antenna 46, selected by two capacity coupled tuned circuits 31 and 32 and impressed upon a modulator circuit M_1 to modulate the output of a 6,575 k. c. oscillator O_1. The resulting sideband centering about 5,000 k. c. is selected in the capacity coupled tuned circuits 33 and 34 and impressed upon the modulator M_2 to modulate the output of a 5,120 k. c. oscillator O_2 and produce an intermediate-frequency sideband centering about 120 k. c. This intermediate frequency wave is selectively amplified in the intermediate frequency amplifiers IFA_1 and IFA_2 and detected in the detector circuit D, the resulting image waves being amplified in the low-frequency amplifier AFA and impressed upon the television reproducing apparatus.

This reproducing apparatus comprises an electric discharge amplifier 35 the output of which is connected to a neon glow lamp 36 which is placed on one side of a scanning disc 37 similar to the scanning disc employed at the transmitting station. The operator views the reproduced image through a shield 38 having an opening of such size as to permit one aperture of the disc 37 to be viewed therein at a time. The disc 37 is driven by a constant speed motor 56 which also drives a syn-

chronizing apparatus 39 the output of which is employed for modulating a radio frequency wave in the radio transmitter 40 which is transmitted to the transmitting station to synchronously drive the transmitting scanning disc as hereinbefore described.

The oscillators O_1 and O_2 are of the type described in Hartley Patent 1,356,763 of October 26, 1920. Oscillator O_1 comprises a three-electrode discharge device 41 associated with a frequency determining circuit 42 inductively coupled to which is an inductance coil 43 which is connected to the grid of the three-electrode discharge device 44 employed in the modulator circuit M_1. Similarly, the oscillator circuit O_2 comprises a three-electrode electric discharge device 51, a frequency determining circuit 52 and an inductance coil 53 coupled therewith and connected to the grid of the three-electrode electric discharge device 54 employed in the modulator circuit M_2. The plate circuit of the device 54 is connected to the grid circuit of a three-electrode discharge device 57 through a filter 58 which, as is well understood in the art, may be designed to transmit the intermediate frequency side bands and to suppress waves of other frequencies. The plate circuit of the device 57 is connected to the grid circuit of another three-electrode electric discharge device 59 employed in the second intermediate frequency amplifier circuit through an interstage transformer 60. The plate circuit of the device 59 is connected to the grid circuit of a three-electrode electric discharge detector 61 through a second filter 62 similar to filter 58. This filter is designed to have a low input impedance at 120 k. c. to improve the action of detector circuit. The plate circuit of the detector 61 is connected to the grid circuit of a three-electrode electric discharge device 63 through a low pass filter 64 and the plate circuit of the amplifying device 63 is coupled to the input of the amplifier 35 through a transformer 65.

The electric discharge devices 41, 44, 51, 54, 57, 59, 61 and 63 are supplied with cathode heating current from a battery 66. with space current from a battery 67, and with grid biasing potential from a battery 68 with which there is associated a potentiometer 69 so as to provide the proper potentials. Condensers and resistances are employed in a manner well understood in the art for confining the direct and alternating currents to their respective paths.

The capacity coupled tuned circuits 31 and 32 serve to select the received radio waves to the approximate exclusion of interfering waves. However, it is difficult to provide for any high degree of selectivity by such arrangements since they must be designed to pass a 2.6% band, the radio sidebands being about 40,000 cycles in width. In accordance with the invention, the selected band is "beat up" to about 5,000 k. c. by the use of the oscillator O_1 and modulator M_1. At this frequency the desired sidebands require only a 0.8% band which can be readily obtained with a high degree of selectivity by the use of the capacity coupled tuned circuits 33 and 34. Thus it is possible to sharply discriminate against interfering waves without distorting the required wide band.

In order to obtain sufficient amplification the selected band is beat down to about 120 k. c. and selectively amplified in the intermediate frequency amplifiers IFA_1 and IFA_2 after which the waves can be detected and the resulting image waves amplified by means of the usual low frequency amplifier circuits.

What is claimed is:

1. In a system for producing images of moving objects, means for producing image forming waves of a band of frequencies of the order of 20,000 cycles in width, means for generating a radio carrier wave of frequency of the order of 1,000 kilocycles or more, means for modulating said carrier wave in accordance with said image forming waves, means for radiating said modulated wave, means for selectively receiving said modulated wave, means for combining the received wave with another wave to produce a second modulated wave of the order of 5,000 kilocycles, means for selectively transmitting said second modulated wave to the substantial exclusion of interfering waves, means for combining said second modulated wave with another wave to produce a third modulated wave of the order of 120 kilocycles, means for selectively amplifying said last mentioned wave, means for detecting said selectively amplified wave to produce the original image waves, and means for producing an image from said reproduced band of waves.

2. In a system for producing images of moving objects, means for producing image forming waves of a wide range of frequencies, means for generating a radio carrier wave of frequency of the order of 1,000 kilocycles or more, means for modulating said carrier wave in accordance with said image forming waves, means for radiating said modulated wave, means for selectively receiving said modulated wave, means for generating a wave of frequency higher than said modulated wave, means for combining said wave with said modulated wave to produce a difference component of frequency higher than that of said modulated wave, means for selecting said difference component to the substantial exclusion of interfering waves, means for generating another wave, means for combining said last mentioned wave with said selected component to produce a second difference component of frequency lower than that of said first modulated wave, means for selectively amplifying said last mentioned

component wave, means for detecting said amplified component wave to reproduce the original image waves, and means for producing an image in response to said reproduced waves.

3. In a system for producing images of moving objects, means for producing image forming waves of a wide range of frequencies, means for generating a radio carrier wave of frequency of the order of 1,000 kilocycles or more, means for modulating said carrier wave in accordance with said image forming waves, means for radiating said modulated wave, means for selectively receiving said modulated wave, means for generating a wave of frequency higher than said modulated wave, means for combining said wave with said modulated wave to produce a difference component of frequency higher than that of said modulated wave, means for selecting said difference component to the substantial exclusion of interfering waves, means for amplifying and demodulating said selected wave to reproduce the image forming wave, and means for producing an image in response to said reproduced wave.

4. In a system for producing images of moving objects, means for producing image forming waves of a wide range of frequencies, means for generating a radio carrier wave, means for modulating said carrier wave in accordance with said image forming waves, means for radiating and selectively receiving said modulated wave with negligible distortion of the image side band, means for generating a wave of frequency higher than said modulated wave, means for combining said wave with said modulated wave to produce a difference component of frequency higher than that of said modulated wave, means for selecting said difference component to the substantial exclusion of interfering waves, means for amplifying and demodulating said selected wave to reproduce the image forming wave, and means for producing an image in response to said reproduced wave.

5. In a system for producing images of moving objects, means for producing image forming waves of a wide range of frequencies, means for generating a radio carrier wave, means for modulating said carrier wave in accordance with said image forming waves, means for radiating and selectively receiving said modulated wave with negligible distortion of the image side band, means for combining the received wave with another wave to produce a second modulated wave of the order of 5,000 kilocycles, means for selectively transmitting said second modulated wave to the substantial exclusion of interfering waves, means for combining said second modulated wave with another wave to produce a third modulated wave of the order of 120 kilocycles, means for selectively amplifying said last mentioned wave, means for detecting said selectively amplified wave to reproduce the original image waves, and means for producing an image from said reproduced band of waves.

6. In a system for producing images of moving objects, means for producing image forming waves of a wide range of frequencies, means for generating a radio carrier wave, means for modulating said carrier wave in accordance with said image forming waves, means for radiating and selectively receiving said modulated wave with negligible distortion of the image sideband, means for generating a wave of frequency higher than said modulated wave, means for combining said wave with said modulated wave to produce a difference component of frequency higher than that of said modulated wave, means for selecting said difference component to the substantial exclusion of interfering waves, means for generating another wave, means for combining said last mentioned wave with said selected component to produce a second difference component of frequency lower than that of said first modulated wave, means for selectively amplifying said last mentioned component wave, means for detecting said amplified component wave to reproduce the original image waves, and means for producing an image in response to said reproduced waves.

In witness whereof, I hereunto subscribe my name this 22 day of June, A. D. 1927.

EDWARD L. NELSON.