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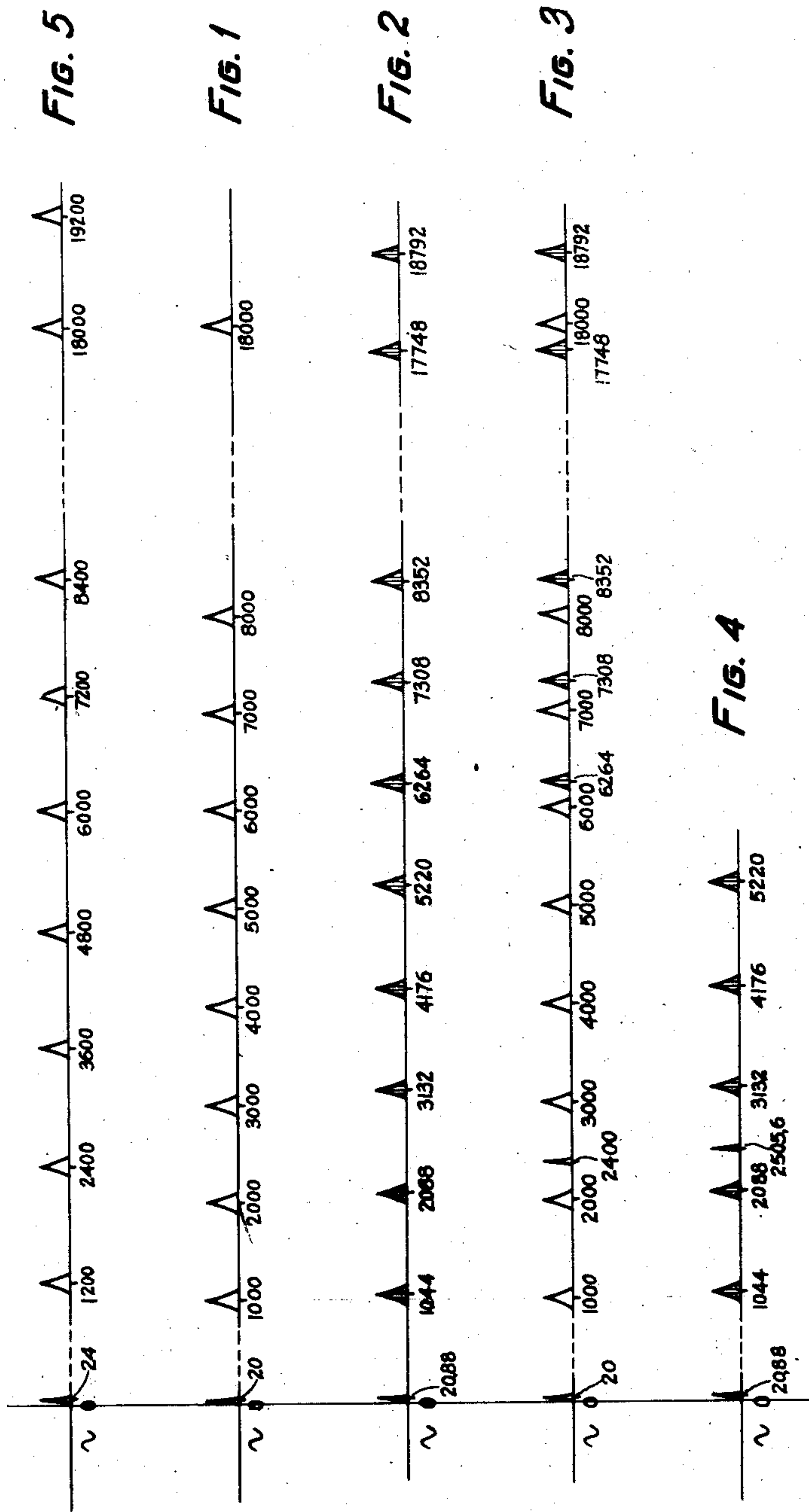
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1,769,919

ELECTROOPTICAL TRANSMISSION SYSTEM

Filed April 30, 1929

3 Sheets-Sheet 1



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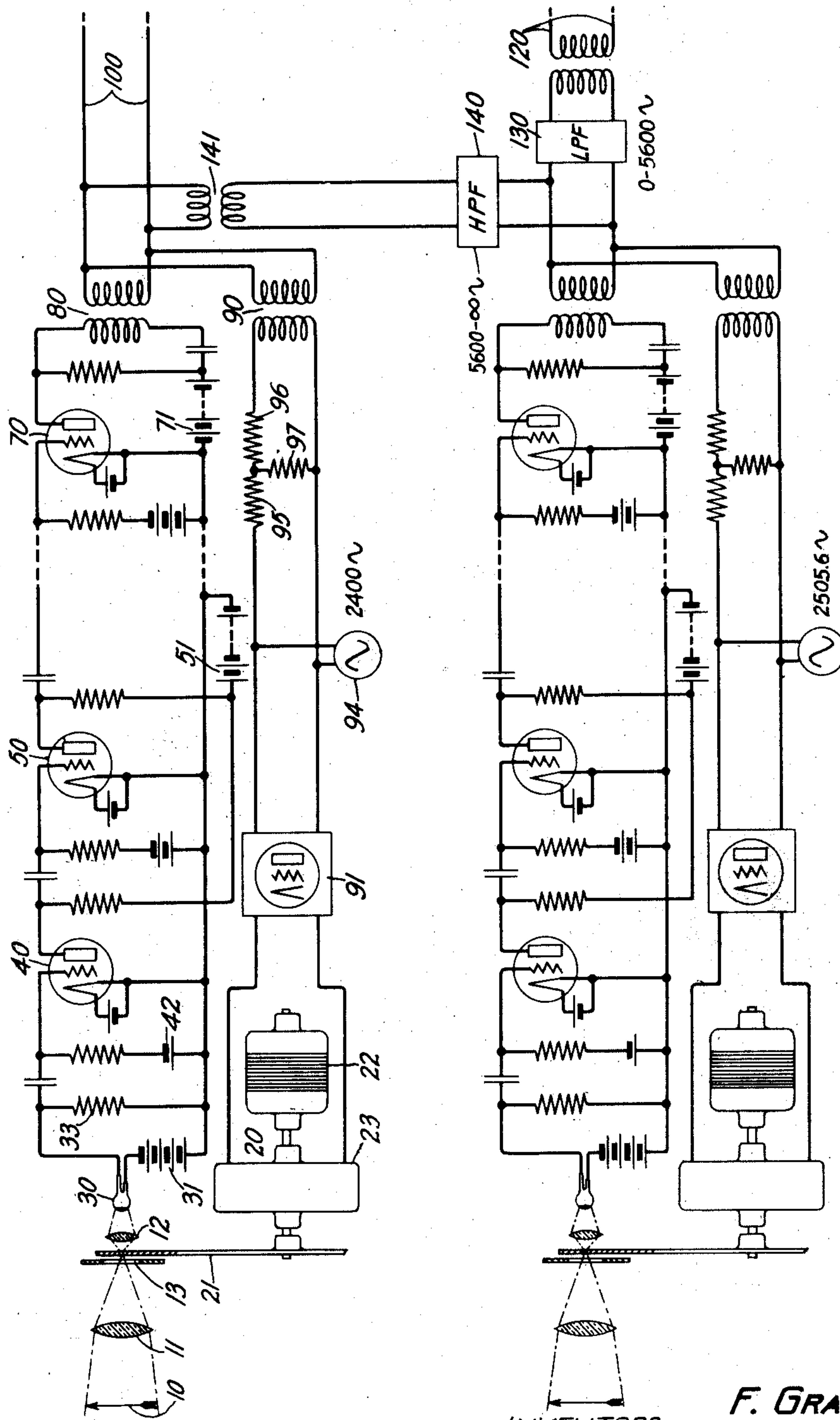
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FIG. 6



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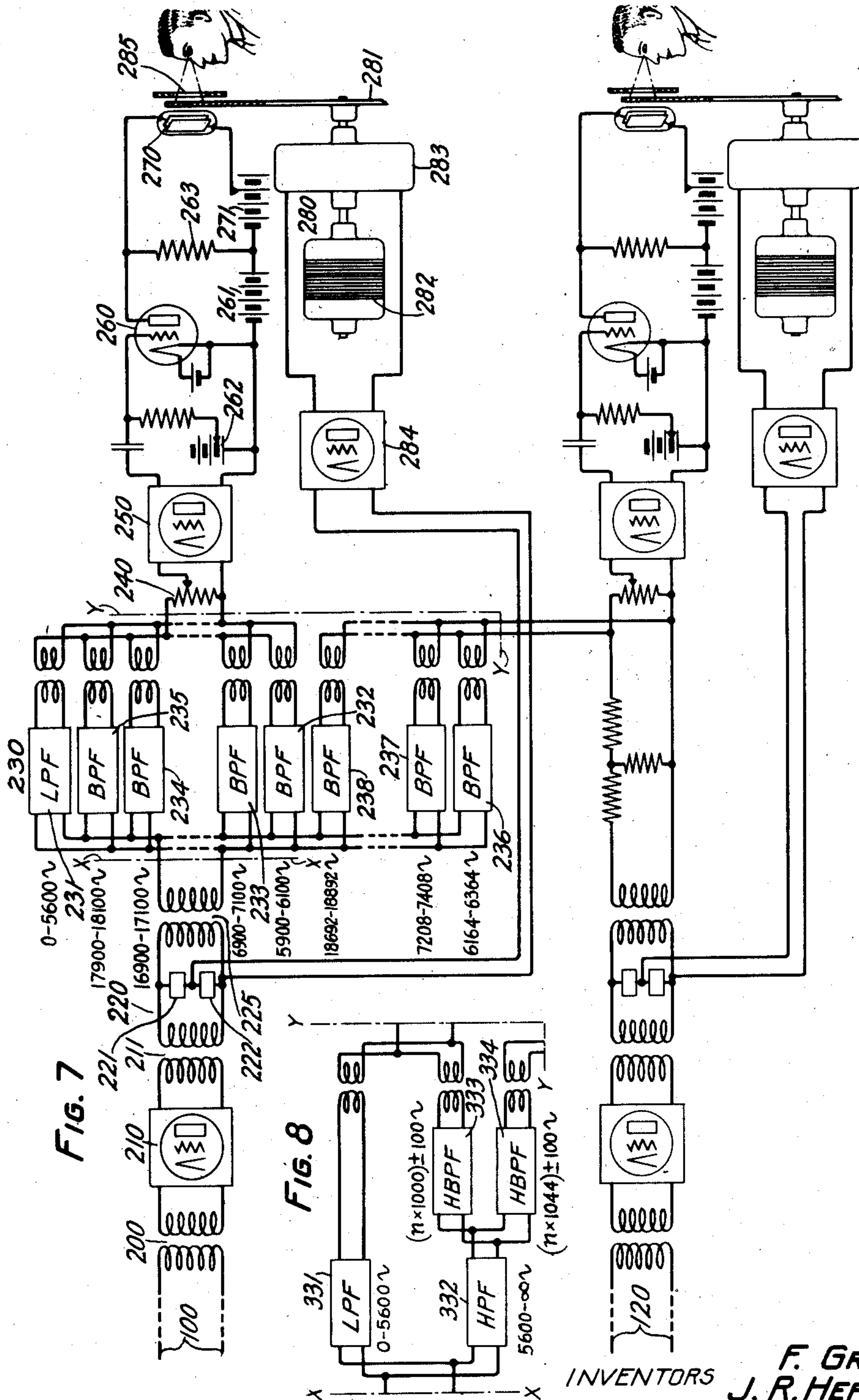
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ELECTROOPTICAL TRANSMISSION SYSTEM

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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ELECTROOPTICAL TRANSMISSION SYSTEM

Application filed April 30, 1929. Serial No. 359,211.

This invention relates to signaling and more particularly to television and high speed picture transmission and composite signal transmission.

5 An object of the invention is to improve the utilization of the frequency transmission band involved in signaling for such types of transmission as television and high speed picture transmission.

10 This invention is the result of the discovery that when an object or field of view is periodically scanned in a series of parallel lines and the light tone values of elemental areas are translated into electric current variations the energy is largely concentrated in a number of distinct bands of frequencies between which there is very little useful energy, and the position of the bands in the frequency spectrum is dependent upon the field scanning frequency and upon the line scanning frequency. The energy concentrations resulting from scanning an ordinary field occur in the regions of the field scanning frequency and some of the lower harmonics thereof and in the regions of the line scanning frequency and the lower harmonics thereof. These latter bands are made up of a plurality of frequencies the prominent ones of which differ by approximately the field scanning frequency. The bands may, for example, have a band width of approximately 20% of the line scanning frequency, in which case the low energy intervening gaps or valleys have a frequency band width of approximately 80% of the line scanning frequency.

This invention provides means for producing two or more different photoelectric currents in which the bands of energy concentration are made to occur at different frequency positions for each photoelectric current by separately scanning different line series of elemental areas of a field of view at different rates and for utilizing certain gaps in one of such composite currents for the simultaneous transmission of at least a portion of the other current or currents over the same circuit or medium.

50 In case the scanning frequencies are near together, as they would be in ordinary tele-

vision, two television transmissions which may be completely segregated at the receiving terminal are possible from the same station over a single low grade circuit and a single high grade circuit. Where substantially complete electrical segregation of the different television transmissions is not required at the receiving terminal a single high grade circuit may be used.

Simultaneous transmission from separate stations or simultaneous two-way operation is possible.

In systems in accordance with this invention the line scanning frequency and its harmonics follow an arithmetical progression, the harmonics being multiples of the line scanning frequency. Since the line scanning frequencies for the different photoelectric currents are different and their harmonics differ by a constant, the harmonics of one photoelectric current have frequency differences different from that of any other associated photoelectric current and certain of the harmonics which are common multiples of the line scanning frequency of the different photoelectric currents will therefore in general coincide. The different line scanning frequencies may be so chosen that coinciding harmonics will occur only with respect to very high unimportant harmonics which are eliminated by the filtering action of the line or other transmission apparatus or by special filters. This coinciding of harmonics inherently results in limiting the number of photoelectric currents that may be simultaneously transmitted without interference over one circuit. However, if some sacrifice in quality of the produced images is permitted this limitation is largely removed. Methods of operation under such conditions are subsequently described.

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

Fig. 1 is a typical current-frequency diagram of the energy concentrations resulting from scanning in a series of parallel lines an ordinary object at a line scanning frequency rate of 1000 cycles per second;

Fig. 2 is a typical current-frequency dia-

gram of the energy concentrations resulting from scanning in a series of parallel lines an ordinary object at a line scanning frequency rate of 1044 cycles per second;

5 Fig. 3 is a typical current-frequency diagram of the energy concentrations resulting from interweaving the energy concentration bands at the different frequencies shown in Fig. 2 above 6000 cycles into the gaps between the energy concentration bands in Fig. 1 and also a synchronizing current having a frequency of approximately 2400 cycles per second, all of which are transmitted over a single broad frequency band transmission circuit;

10 Fig. 4 is a typical current-frequency diagram of the energy concentration bands below 6000 cycles of Fig. 2 and an interwoven synchronizing current of approximately 2505 cycles per second, all of which are transmitted over a single narrow frequency band transmission circuit;

15 Fig. 5 is a typical current-frequency diagram of the energy concentrations resulting from scanning in a series of parallel lines an ordinary object at a line scanning frequency rate of 1200 cycles per second;

20 Fig. 6 is a general schematic representation of the transmitting terminal apparatus of a television system arranged in accordance with the invention for simultaneously generating and transmitting a plurality of television currents;

25 Fig. 7 is a general schematic representation of the receiving terminal apparatus of a television system arranged in accordance with the invention for simultaneously receiving and translating a plurality of television currents into images; and

30 Fig. 8 is an alternative arrangement of a filter network for separating different received television signals.

35 The typical current-frequency diagrams in Figs. 1 to 5 represent the general characteristics of the distribution of the energy concentrations of photoelectric scanning currents such as are shown for a more limited range of the spectrum in the joint copending application of Frank Gray and John R. Hefele, 45 Serial No. 337,132, filed February 2, 1929, showing typical photoelectric scanning current-frequency curves of a number of different objects both at rest and in motion. The current-frequency diagrams shown herein indicate the position of the energy concentrations at different frequencies in the frequency band or spectrum over a range up to approximately 19,000 cycles per second of different photoelectric currents generated in scanning 50 an ordinary object at three different line scanning rates. Current strength is indicated in the direction of the ordinate and frequencies along the abscissa. Fig. 1 and Fig. 2 are typical current-frequency diagrams of the principal energy concentrations resulting 55

from scanning in a series of parallel lines ordinary objects at field scanning rates of 20 and 20.88 cycles per second and at line scanning rates of 1000 and of 1044 cycles per second, respectively. The employment of different scanning rates causes the energy concentrations to occur at different frequency positions in the photoelectric current frequency spectrum as is shown by a comparison of the two diagrams. The positions of the energy concentrations resulting from these two different line scanning rates are within 200 cycles up to about 5000 cycles and from that point on up to about 19,000 cycles the relative displacements of the energy concentrations are not less than 200 cycles and consequently these higher frequency bands occupying distinctive positions may be interwoven and simultaneously transmitted over the same circuit without interference. Fig. 3 shows the frequency bands for the two photoelectric currents above 5600 cycles so interwoven and also the lower frequency bands for one of the photoelectric currents, namely, that having a field scanning rate of 20 cycles per second and a line scanning rate of 1000 cycles per second. All of the photoelectric current frequency bands shown in Fig. 3 and a synchronizing frequency of about 2400 cycles are sufficiently separated for transmission without interference over a single circuit and for segregation at the receiving station. The principal lower frequency bands below 5600 cycles resulting from the field scanning rate of 20.88 cycles per second and the line scanning rate of 1044 cycles per second and a synchronizing frequency of about 2505.6 cycles are shown in Fig. 4 and they must be transmitted over a separate circuit or have their frequencies displaced by means of a carrier to a range outside of that shown in Fig. 3 or to low energy gaps therein if they are to be transmitted without interference on the same circuit with the signal bands shown in Fig. 3.

In one arrangement this invention employs the intervening wide gaps or valleys of low energy in a photoelectric current for the simultaneous transmission of other signals such as a second photoelectric current and synchronizing current insofar as they may be interwoven into mutually exclusive frequency positions as shown in Fig. 3. The very low frequency energy concentrations occurring in the region of the picture scanning frequency at about 20 cycles per second and the line scanning frequency and a few of its lower harmonics even though the rates of scanning for the plurality of photoelectric currents are different may not be sufficiently separated to permit all bands being transmitted without interference over the same circuit as heretofore explained. However, in a transmission arrangement employing two circuits, one of the circuits may be used to transmit only those frequency bands that 130

would cause interference, and consequently this circuit may be a comparatively low grade circuit having a relatively narrow frequency range provided the other circuit is a higher grade one having a frequency range sufficient for the full frequency band or spectrum of the photoelectric currents. In general, the arrangement provides for keeping the interwoven frequency bands of whatever origin of the proper width and positioning them in the gaps or valleys of low energy in a photoelectric current or currents and transmitting as many such separated bands over a single circuit as may be arranged to occupy separate frequency positions, thus making possible separation at the receiving station of the different frequency bands. Means for separately transmitting and translating into images the signal currents shown in the current-frequency diagrams of Fig. 3 and Fig. 4 are subsequently described and are illustrated in Fig. 6 and Fig. 7.

If a separate low grade circuit or a carrier current as described above is not used, more than one photoelectric current generated by separate rates of scanning may be simultaneously transmitted over the same circuit and made to produce images even though certain of the original energy concentrations do overlap. In the following several methods of confining the transmissions to one circuit are described. Fig. 5 is a typical current-frequency diagram of the energy concentrations resulting from scanning in a series of parallel lines an ordinary object at a field scanning rate of 24 cycles per second and at a line scanning rate of 1200 cycles per second. Comparison of this current-frequency diagram with that shown in Fig. 1 having field scanning rate of 20 cycles per second and a line scanning rate of 1000 cycles per second shows that energy concentrations which are functions of the line scanning rates of the two coincide at the common multiple frequency positions of 6000, 12,000, 18,000 cycles, etc., and that between these coinciding points the relative frequency displacements of the energy concentrations are not less than 200 cycles for all frequencies above the line scanning frequencies. The field or picture scanning frequencies are in the regions of 20 and 24 cycles per second in the diagrams shown in Fig. 1 and Fig. 5, respectively. In the region of the picture scanning frequencies and immediately above these frequencies certain of their harmonics will coincide. However, the positions of most of the energy concentrations may obviously be made to occur at different locations in the frequency spectrum by choosing different field or picture scanning rates and different line scanning rates as illustrated by comparison of the current-frequency diagrams. The photoelectric energy concentrations shown in Fig. 1 and Fig. 5 may be obtained by a scan-

ning disc having 50 uniformly distributed apertures and rotated at different field or picture scanning rates such as approximately 20 and 24 revolutions per second, respectively.

A plurality of photoelectric currents may be simultaneously transmitted over a single medium and translated into images. When two or more photoelectric currents having energy concentration bands which coincide at a few points, common multiples of the scanning frequencies, are simultaneously transmitted over the same circuit the chief problem is to segregate each photoelectric current and cause each to operate its proper terminal apparatus at the receiving station. Where frequency bands coincide separation after transmission over a common medium by filters is impracticable and the coinciding bands must therefore either be eliminated at the transmitting station or else the coinciding bands permitted to enter the receiving apparatus as interfering currents. The photoelectric currents generated by two different scanning rates such as shown in Fig. 1 and Fig. 5 have sufficient relative separation of their energy concentration bands to permit separation of all but a few of the coinciding bands above the line scanning frequencies, and the interference caused by the coinciding bands may not in many cases seriously affect the value of the produced image. A television signal may require no more than twenty-five of these bands and for ordinary fields shaped as those shown in the copending application referred to hereinabove, the photoelectric current signals need not include more than about eighteen energy concentration bands. For the scanning rates shown in the current-frequency diagrams of Fig. 5 and Fig. 1 the interference occurs at every 5th or 6th multiple of the scanning frequencies, respectively. Most of the low frequency harmonics in the regions of the field or picture scanning frequencies will be about 4 cycles or more apart and may be separated after transmission at the receiving station. However, certain of these harmonics will similarly coincide and cause interference. One method of partly eliminating the interference due to overlapping or coinciding bands is to suppress such bands in all or in all but one or in a part of all of the photoelectric signals at the transmitting station. This will leave all or all but one of the images without certain of its components depending upon the arrangement for eliminating overlapping bands. The loss may produce more or less distortion in the produced images but the different photoelectric currents can be separated at the receiving station and the images will in general be recognizable and may well serve certain purposes. A method of using signal currents in which the overlapping bands are transmitted to the receiving station may be

based upon the fact that a television signal received by a receiving apparatus badly out of synchronism gives a moving mottled or streaked field in which no image can be distinguished. Consequently two images can be scanned at different rates and the two signals superimposed for transmission over the same circuit and recognizable images can be produced without separating the two signal currents at the receiving station. If the mixed signal currents are allowed to operate two light sources behind two sets of moving scanning devices, respectively, each of which moves in synchronism and in phase with one of the two transmitting scanning devices, then the two receiving devices will reproduce the two original image fields, but each of these images will be reproduced on a moving mottled field resulting from the other television signal being out of synchronism. In an analogous manner, the widely separated bands of the two television signals can be separated by electrical filters and those bands which fall in the same positions of the frequency spectrum can simply be allowed to remain mixed and go to both of the receiving devices. The presence of a few superfluous bands in a television current generating an image will produce as above mentioned a moving mottled background but this effect will be less pronounced than in the arrangement above described in which none of the bands are separated before being impressed upon the receiving devices. The appearance of the mottled background may be less objectionable if the speeds of rotation of the different scanning discs are not exactly in the ratios of integral numbers due to the fact that a ratio of exact integral numbers may cause a superfluous band of frequencies to give stationary streaks in the field. A departure from such an integral relation will cause the streaks to move. It is therefore preferable not to use in the example given, exactly 20 and 24 revolutions per second of the scanning discs for the two different rates of scanning, but for example, 20 and $24 + \frac{1}{1500}$ revolutions per second. To be more exact the speeds of rotation should be such that the highest frequencies involved in the unseparated parts of the two signals do not bear an exact integral ratio to each other. As a matter of practical operation, such slight variations may normally occur and no special provision may be required for this variation.

Most any desired combinations of field or picture and of line scanning rates may be obtained by using scanning discs having the same or different numbers of apertures and rotated at the same or different speeds. However, other systems of scanning than those employing a scanning disc may be used to

generate equivalent different photoelectric currents.

The television transmitting station shown in Fig. 6 in general comprises terminal apparatus consisting of television scanning apparatus, current amplifying apparatus for the photoelectric current and synchronizing apparatus for two complete photoelectric transmitting units, each operated at different scanning rates. The two units are connected to a common output network so designed that currents covering a wide frequency range are passed to a high grade and currents covering a narrow frequency range are passed to a low grade transmission circuit, the frequency distribution of the energy concentrations for the two circuits being as shown in Fig. 3 and Fig. 4, respectively. An object 10 whose image is to be transmitted is periodically scanned in a series of parallel lines by the scanning apparatus 20. An image of the object is focused upon the viewing field of the scanning apparatus by means of a suitable objective lens system 11 and light from elemental areas of the image thus formed is directed by means of the lens system 12 upon the light sensitive cell 30. The scanning arrangement may comprise any suitable device, such as a rotating scanning disc 21 having a row of apertures spirally arranged. An opaque member having an aperture 13 is positioned between the lens 11 and the scanning disc and limits the size of the image field upon the scanning disc so that just one aperture in the scanning disc is exposed at any instant, the angular width of the aperture 13 being equal to the angular pitch of the apertures in the scanning disc. The scanning disc is driven at suitable speed by means of a driving motor 22. A synchronous alternator 23 mounted on the same shaft with the scanning disc 21 and the driving motor 22 is employed to maintain synchronism between the transmitting and the receiving scanning apparatus. The photoelectric current generated in the light sensitive element 30 is amplified by suitable vacuum tube amplifiers 40, 50, and 70. The output circuit of the light sensitive cell 30 contains a battery 31 and a resistance 33. Battery 31 causes current to flow through the resistance 33 which is carried by the changing excitation of the light sensitive cell. This results in a varying potential across the resistance 33, one side of which is connected to the grid and the other to the filament of the vacuum tube of the amplifier 40. Battery 42 is adjusted to apply a proper negative bias to the grid of the vacuum tube. The output of amplifier 40 is impressed upon the intermediate amplifier 50 whose output is in turn impressed upon succeeding amplifiers. Battery 51 supplies space current for these amplifiers. Any suitable number of stages of amplification may be employed.

The amplified photoelectric current on passing through the last amplifier stage 70, which is supplied with space current by the battery 71 is transmitted through the repeating coil 80 to the transmission line 100. Synchronizing current is generated by oscillator 94. The output circuit of this oscillator is connected with the synchronous alternator 23 through the amplifier 91 and with the transmission line 100 through the repeating coil 90. A network comprising series resistances 95 and 96 and shunt resistance 97 is connected between the input of the repeating coil 90 and the other elements in this circuit for properly matching and adjusting impedances to stabilize the operation of the synchronizing circuit. The television terminal apparatus shown in the lower half of Fig. 6 is identical with that shown in the upper half with the exception that the line scanning rate is different, the rate chosen being 1044 cycles per second instead of 1000 cycles. The oscillator generating the synchronizing current, as above mentioned for one of the units, has been chosen as 2400 cycles per second and that for the other unit 2505.6 cycles per second, which bear the same ratio to each other as the line scanning frequencies of 1000 and 1044 cycles per second. Other figures may be used but the ones chosen are such as to cause generation of frequency concentration bands, as shown in the current-frequency diagrams heretofore described and also permit the insertion of the two synchronizing currents in low energy gaps of the photoelectric currents. The low pass filter 130 has a cutoff frequency at approximately 5600 cycles per second and therefore passes to the transmission line 120 all currents up to 5600 cycles. High pass filter 140 also has a cutoff frequency of 5600 cycles and therefore passes all currents having a frequency above 5600 cycles to repeating coil 140 and to transmission line 100. This filter does not operate in the reverse direction. In this arrangement the operation of these filters is such that all signal currents below 5600 cycles generated by the second television unit are transmitted by transmission line 120 and all of the currents above this frequency are transmitted by transmission line 100. The transmission line 100 also transmits all signal currents of any frequency originated by the first television transmitting apparatus. Transmission line 100 must therefore have a wider frequency range than transmission line 120. If the transmission line 100 has a frequency range sufficiently beyond that required for the transmission of the signaling currents already assigned to it, the signals assigned to transmission line 120 may be stepped up by means of a carrier current to frequency regions beyond the other signals and all signals generated by the two television trans-

mitting units may be sent over a single pair of conductors.

The television receiving station shown in Fig. 7 in general comprises terminal apparatus consisting of filtering network for separating and routing the several received signal currents, current amplifying apparatus and synchronously operated television receiving apparatus for two receiving units. The two receiving units are connected with transmission lines 100 and 120, respectively, by the repeating coils 200. Suitable amplifying apparatus 210 is employed in each circuit. The amplified received signals are transmitted by the repeating coils 211 to the filter networks 220 which separates the synchronizing current from the other signals. This filter network contains shunt impedance elements 221 and 222. In the region of 2400 cycles the total impedance of these elements is so small in comparison with the impedance of the output sides of the repeating coil 211 or the input side of the repeating coil 225, that the synchronizing current is drained out of this circuit. In a specific case, impedances 221 and 222 may comprise inductance and capacity elements, respectively. One side of the local receiving synchronizing circuit which leads to the synchronous motor of the receiving scanning unit 240 is connected to one of the series arms of the filter network and the other side between the two impedances. The television currents are passed directly through the series arms of this network to the repeating coil 225 and into the filter network 230 which passes all frequencies of the order of 20 to 19,000 cycles. This network contains a number of filter elements connected in multiple to the incoming circuit. The output side of these filters are connected to two output circuits running respectively to the two television receiving units. The transmission line 100 as heretofore explained transmits all of the signal current for one television image and a large part of the signal current for the second television image, and these filters route each of the two television signals to their respective image producing units. The low-pass filter element 231 transmits frequencies up to 5600 cycles; band-pass filter 232 transmits a band of frequencies about 200 cycles wide in the region of 6000 cycles; band-pass filter 233 transmits a similar band in the region of 7000 cycles; and so on up to a band in the regions of 17,000 and 18,000 cycles which are transmitted by band-pass filters 234 and 235, respectively. This group of filters passes all photoelectric current for the television image having a line scanning frequency of 1000 cycles and also a synchronizing current of 2400 cycles. The output side of this group of filters is connected to the television translating apparatus through the potentiometer 240 used for regulating the in-

intensity of the television signal. These signal currents may be further amplified by the amplifier 250. The circuits must be so arranged that the current through the glow discharge receiving lamp is at all times proportional to the illumination at the transmitting station in view of the well established linear relation between the intensity of the illumination resulting from the glow discharge and the current. The photoelectric signal wave as transmitted through the various amplifier circuits differ fundamentally from the initial current generated in the light sensitive cell in that the direct current component has been eliminated. This direct current component must be restored before the changes in light intensity at the receiving station will follow those at the transmitting station. The amplifier 260 provides means for making the necessary adjustment. The incoming photoelectric signal current whose intensity is adjusted by means of the potentiometer 240 is impressed upon the grid of the vacuum tube of the amplifier 260. The space current which is provided by the battery 261 is adjusted by the grid biasing voltage of the battery 262. Instead of connecting the glow discharge lamp and the vacuum tube directly in series, a resistance 263 is shunted across the output of the circuit of the vacuum tube across which is set up a potential proportion to the current through the resistance. The receiving lamp 270 is shunted across this resistance. In order to confine the operation of the vacuum tube of the amplifier 260 to the linear part of its characteristic, the biasing battery 271 is connected in series with the lamp so that current through the lamp will go to zero even when a finite current is flowing through the vacuum tube of the amplifier 260 and it is still on the linear part of its characteristic. For any strength of the alternating current television current determined by the potentiometer 240, the direct current component of the television current may be restored by adjusting the grid biasing battery 262 to such a value that the proper direct current flows through the receiving lamp 270. The viewing field in front of the receiving lamp is defined by the aperture 285 in an opaque plate positioned in front of the scanning disc 281 and in line with the receiving lamp 270. The annular width of the aperture 285 is such that just one aperture in the scanning disc appears at any instant, the annular width of this aperture being equal to the annular pitch of the apertures in the scanning disc. The scanning disc at the transmitting and the receiving stations are driven by the direct current motors and held in synchronism and in phase by the alternating current machines in accordance with well established practice. A typical synchronizing arrangement is shown in the patent of

H. M. Stoller et al. No. 1,763,909, issued June 17, 1930. The incoming synchronizing current of approximately 2400 cycles is passed by the filter network 220 to the amplifier 284 which in turn is connected with the synchronous motor 283 associated with the receiving apparatus 280. The energy for driving the scanning disc 281 is supplied by a driving motor 282, synchronism being maintained by the synchronous motor 283 whose input current is transmitted from the television transmitting station. The filter network 230 as so far described transmits television current for only one image, namely, that generated by a line scanning rate of 1000 cycles per second. A part of the television signal current for the second image generated by a different line scanning rate is also transmitted by the transmission line 100 and this portion of the second signal must be segregated and routed to the second television receiving terminal apparatus which is shown in the lower part of Fig. 7. For this purpose the filter network 230 contains a number of band-pass filters which transmit frequency bands approximately 200 cycles wide and which have mid-frequencies which are multiples of a line scanning frequency of 1044 cycles. The first of these band-pass filters 236 transmits such a band in the region of 6264 cycles, the second band-pass filter 237 transmits a band in the region of 7308 cycles and so on up to band-pass filter 238 which transmits a band in the region of 18792 cycles. The output circuits of these band-pass filters are all connected to the input circuit of the second television receiving apparatus and the energy concentrations of the television signal having frequencies in the regions of 6264 cycles and above are thus all received from transmission circuit 100, while the energy concentrations below this frequency are received over the transmission line 120. The terminal apparatus for producing the second image which is shown in the lower half of Fig. 7 is similar to that already described in the upper half of Fig. 7 with the exception that a filter network similar to network 230 is not required.

An alternative filter network which may be substituted for the filter network 230 is shown in Fig. 8. The dot-dash lines X—X and Y—Y in each of these figures indicate the point of connection of the input and output circuits. In the alternative arrangement the incoming signals are impressed upon a low-pass filter 331 transmitting all frequencies below 5600 cycles and upon a high-pass filter 332 transmitting all frequencies above 5600 cycles. The signal bands above 5600 cycles are impressed upon two harmonic band-pass filter networks capable of passing frequency bands of the desired width and which are harmonics of a fundamental frequency. The harmonic band-pass filter 333 passes frequency bands approxi-

5 mately 200 cycles wide and which have mid-
 frequencies which are multiples of 1000
 cycles, while the harmonic band-pass filter
 334 passes frequency bands about 200 cycles
 10 wide and which have mid-frequencies which
 are multiples of 1044 cycles. In other words,
 for example, the frequencies of the bands
 transmitted by these filters are $(n \times 1000) \pm 100$
 and $(n \times 1044) \pm 100$ cycles, respec-
 15 tively, n being any whole number. The low-
 pass filter 331 having a cut-off frequency of
 5600 cycles and the harmonic band-pass filter
 333 are connected to the television receiving
 apparatus operated by the television current
 20 generated by a line scanning frequency of
 1000 cycles, while the harmonic band-pass
 filter 334 which transmits all harmonics
 above 5600 cycles in the regions of multiples
 of 1044 is connected with the second tele-
 vision receiving apparatus, thus completing
 the partial television signal current directly
 transmitted over transmission line 120.

25 The different frequencies used in describ-
 ing this system as adopted for two separate
 circuits are typical and are used primarily
 to facilitate the description. Obviously dif-
 ferent scanning rates may be selected and
 the frequency range of the television current
 is not necessarily limited to a range of from
 30 20 to 20,000 cycles and also different fre-
 quencies from those mentioned may be used
 for the synchronizing channels. An essen-
 tial requirement is that the energy concen-
 tration bands in the different signals have a
 35 proper separation so that the bands of one
 signal may be inserted in the low energy
 bands or gaps of the other signal currents
 thus making the energy concentrations of the
 different signal currents occur at mutually
 40 exclusive frequency positions as far as pos-
 sible.

The arrangement shown in Figs. 6 and 7
 employs two transmission channels as all
 energy concentration bands are kept sepa-
 45 rated in transmission, but as heretofore ex-
 plained, a plurality of television signals may
 be transmitted over the same circuit pro-
 vided separation of the images at the receiv-
 ing terminals is effected only by a difference
 50 in scanning rate, or the two signals are sepa-
 rated by filters with respect to all but the
 interfering frequencies which are allowed to
 pass into the receiving circuits, or the inter-
 fering frequency bands of the signals are
 55 eliminated at the transmitting stations.
 With the first and second of these plans the
 low pass filters 130 and the high pass filter
 140 shown in Fig. 6 are eliminated and the
 output circuit of both transmitting units are
 60 connected to a single transmission circuit.
 While in the third plan filter networks are
 employed to eliminate coinciding or inter-
 fering energy concentration frequency bands.
 If the line scanning rates are, for example,
 65 1000 cycles and 1200 cycles, such as shown in

the current-frequency diagrams of Fig. 1
 and Fig. 5, the interfering frequencies occur
 at 6000, 12,000, 18,000 cycles etc., and either
 such frequencies could be eliminated from
 both signals or from only one, in the latter
 70 case arranging the elimination to alternate
 between the two signals thus limiting the
 6000 band in one signal and the 12,000 band
 in the other and so on. When only one trans-
 mission circuit is used for a plurality of tele-
 vision signals and separation of the images
 75 at the receiving end is effected entirely by a
 difference in scanning rates, the filter net-
 work 230 of Fig. 7 is eliminated and all tele-
 vision signal currents are impressed upon the
 80 receiving lamps of both of the terminal units.
 If the second and third plans are used the
 filter network 230 is retained and each tele-
 vision current is separated as far as prac-
 ticable before being impressed upon the re-
 85 ceiving lamps. Each of the synchronizing
 currents may either be generated at the trans-
 mitting station and transmitted therefrom
 and separated at the receiving station as de-
 scribed or a single synchronizing current
 90 may be transmitted and harmonics generated
 therefrom for controlling the different re-
 ceiving units. Further description of modi-
 fications for using only one transmission cir-
 cuit are obvious from the earlier general de-
 95 scription of the principles involved and the
 detail description of the system shown in
 Figs. 6 and 7.

The operation of each of the principal ele-
 ments of the system has been described in
 100 more or less detail in the foregoing descrip-
 tion of the apparatus. In the general opera-
 tion of the system as a whole, the light tone
 values of line series of elemental areas of the
 objects or fields of view are translated into
 105 different and distinct photoelectric currents,
 each having energy concentrations in nar-
 row frequency bands at various predeter-
 mined separated frequency positions in the
 photoelectric current spectrum. A plurality
 110 of such photoelectric currents are interwoven
 either in part or completely, together with
 such other signaling currents as may be re-
 quired such as synchronizing currents and
 all transmitted over a plurality of transmis-
 115 sion circuits or a single transmission circuit.
 If the energy concentration frequency bands
 which are transmitted over a single circuit
 have such frequencies as to be mutually ex-
 120 clusive, then all signals at the receiving sta-
 tion may be separated and impressed upon
 their respective translating devices by means
 of electrical filters. If energy concentration
 bands having frequencies which are not mu-
 125 tually exclusive are transmitted over the same
 circuit, the received signals cannot be elec-
 trically separated and the produced images
 contain some distortion caused by such inter-
 fering currents, though as heretofore pointed
 out, in many cases, such interference is not
 130

serious. Filter networks at the receiving station are desirable for segregating the various energy concentration bands to permit directing the signal currents to their respective receiving elements so that each band acts as if it had been kept separate throughout its transmission. The direct current and very low frequency components may be eliminated before transmission and restored by local means at the receiving stations, as explained in the description of the system.

This invention in general utilizes the low energy gaps or valleys in the photoelectric signal current and makes possible the utilization of the transmission medium at a greater efficiency and also makes possible the direct transmission of all signal currents necessary for the operation of a plurality of photoelectric current transmissions over a single transmission circuit. The television transmission may be from a plurality of scannings at the same station or different stations and all in the same direction over the transmission line or from different stations and in opposite directions. Any plurality of scannings at the same station may be of separate objects or of the same object such as might be required for stereoscopic transmission, or even for color transmission where suitable filters or other color selective elements are used with a plurality of channels at both the transmitting and receiving stations. For two-way operation over the same transmission medium, an associated transmitting and receiving station is employed at both terminals.

What is claimed is:

1. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, separately scanning other line series of elemental areas at a different scanning frequency to produce a second similar composite current, and simultaneously transmitting said currents.

2. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, separately scanning other line series of elemental areas at a different scanning frequency to produce a second similar composite current, and simultaneously transmitting said currents over the same transmission medium.

3. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components

of large amplitude, separately scanning other line series of elemental areas at a different scanning frequency at the same station to produce a second similar composite current, and simultaneously transmitting said currents.

4. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, separately scanning other line series of elemental areas of interposed portions of the said field of view at a different scanning frequency at the same station to produce a second similar composite electric current, and simultaneously transmitting said currents.

5. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, separately scanning at different stations line series of elemental areas of different fields of view at different scanning frequencies to produce additional similar composite currents, and simultaneously transmitting the said currents over the same transmission medium.

6. The method of signaling which comprises successively scanning line series of elemental areas of a field of view having different tone values, producing from said scanning a composite electric current containing one or more groups of frequency components of large amplitude, separately scanning at a different station line series of elemental areas of a field of view at a different scanning frequency to produce a second similar composite current, and simultaneously transmitting the said currents in opposite directions over the same transmission medium.

7. The method of transmission which comprises concurrently generating by different rates of scanning and transmitting a plurality of photoelectric image currents representing the light tone values of elemental areas of a corresponding plurality of fields of view each extending over a wide band of frequencies, and concurrently transmitting the said currents at least in part over the same transmission medium.

8. The method of transmission which comprises concurrently generating by different rates of scanning and transmitting a plurality of photoelectric image currents representing the light tone values of elemental areas of a corresponding plurality of fields of view each extending over a wide band of frequencies, concurrently generating non-image currents and concurrently transmitting

said currents at least in part over the same transmission medium.

9. The method of characterizing and com-
positely transmitting a plurality of photo-
electric currents, each of which is generated
by successively scanning elemental areas of
an object whose image is to be produced
which comprises scanning for each photoelec-
tric current generated a different number of
elemental areas of a field in the same period
of time and transmitting the said photoelec-
tric currents over the same transmission me-
dium.

10. An electro-optical system comprising
terminal transmitting and receiving appara-
tus, a transmission medium interconnecting
said terminal apparatus, and scanning means
for scanning fields with different resolutions,
respectively.

11. An electro-optical system comprising
terminal transmitting and receiving appara-
tus, a transmission medium, scanning means
for scanning different portions of an image
at different fundamental frequencies, respec-
tively, and means for impressing the result-
ing photoelectric currents having different
fundamental frequencies and harmonic fre-
quencies thereof upon the transmission me-
dium, the different fundamental frequencies
and harmonics thereof at least in part occu-
pying different frequency positions in trans-
mission.

12. A two-way electro-optical system com-
prising terminal transmitting and receiving
apparatus, a transmission medium, and
means for generating a television current by
scanning a field of view at each terminal at
different rates, thereby causing the funda-
mental frequencies and most harmonics
thereof of the television currents generated
at two interconnected terminals to be so dis-
placed that the energy components of the
television current generated by one scanning
apparatus falls in frequency positions be-
tween the energy components of the other
television current.

13. A transmission system comprising
means for generating by different rates of
scanning a plurality of image currents cor-
responding to the light tone values of ele-
mental areas of a corresponding number of
fields of view, the essential frequency compo-
nents of each of said currents being distrib-
uted over a wide frequency band and largely
occupying substantially mutually exclusive
frequency positions in the image current
spectrum, and means for concurrently im-
pressing upon a common transmission me-
dium the said essential frequency components
of the said plurality of image currents.

14. A transmission receiving system com-
prising means for concurrently receiving a
plurality of photoelectric image currents, the
essential frequency components of said cur-
rents in part at least occupying mutually ex-

clusive frequency positions representing the
light tone values of elemental areas of a cor-
responding plurality of pictures or objects
and occupying a wide band of frequencies,
and non-image currents having frequency
components occupying non-interfering posi-
tions with respect to said image currents,
means for separating said image currents
and said non-image currents, and means for
separately utilizing said currents.

15. A television receiving system compris-
ing means for concurrently receiving a plu-
rality of television image currents, the es-
sential frequency components of each of said
currents occupying mutually exclusive fre-
quency positions and extending over a wide
band of frequencies, and synchronizing cur-
rent occupying a frequency position differ-
ent from that of the essential frequency com-
ponents of said image currents, means for
separating said synchronizing current from
said image currents, image producing means
for utilizing said image currents in the con-
current production of a plurality of tele-
vision images, and means for utilizing said
synchronizing current to control said image
producing apparatus.

16. A transmission receiving system com-
prising means for concurrently receiving a
plurality of image currents representing the
light tone values of elemental areas of a pic-
ture or other object, the essential frequency
components of said currents occupying mu-
tually exclusive frequency positions in the
image current spectrums and extending over
a wide band of frequencies, and non-image
currents respectively occupying different
frequency bands from those occupied by the
essential components of the said image cur-
rents, and means for selecting and directing
each of said currents into a separate channel.

17. An electro-optical system comprising
means for successively scanning elemental
areas of an object or field at a given rate and
generating photo-electric signal current hav-
ing concentrations of signal energy at a given
fundamental frequency and at multiple fre-
quencies thereof, means for successively scan-
ning elemental areas of a second object or
field at a given rate different from that for
said first object or field and generating photo-
electric signal current having concentrations
of signal energy at a given fundamental fre-
quency and at multiple frequencies thereof
occupying frequency positions largely dif-
ferent from those occupied by said first men-
tioned signal current, means for transmit-
ting all of said signal currents over the same
transmission medium, and means for sepa-
rating the components of the different signal
currents from each other.

18. A photoelectric signaling system com-
prising means for successively scanning a
plurality of fields of view having different
tone values, said means comprising apertured

scanning discs, each aperture of which scans a line of one of said fields, means controlled by each of said scanning means for generating a composite electric current containing groups of frequency components of large amplitude which are harmonics of the field scanning frequency, means for causing the field scanning frequencies and the harmonics thereof generated in scanning each different field of view to occupy at least in part different frequency positions, means for separately generating other currents having a frequency range outside those of said groups, and means for simultaneously impressing all of said currents upon the same transmitting medium.

19. A multiple field television system comprising means for successively scanning a plurality of fields of view having varying light tone values, said means comprising scanning elements for successively scanning line series of elemental areas of said fields at different rates, light sensitive means cooperating with said scanning elements, means including said scanning means and said light sensitive means for generating for each of said fields distinctive composite electric currents containing groups of frequency components of large amplitude, each of which are harmonics of the different field scanning frequencies, said groups also containing harmonics of the different line scanning frequencies, means for generating a television synchronizing current having a frequency range outside of the components of those of said groups, means for simultaneously impressing all of said currents upon the same transmitting medium, means for translating all of said composite currents into light, and means for producing images from each of said composite electric currents comprising scanning means operating at the same field scanning and the same line scanning frequencies as those scanning the different fields of view when generating the said composite currents.

In witness whereof, I hereunto subscribe my name this 24th day of April, 1929.

FRANK GRAY.

In witness whereof, I hereunto subscribe my name this 23rd day of April, 1929.

JOHN R. HEFELE.

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