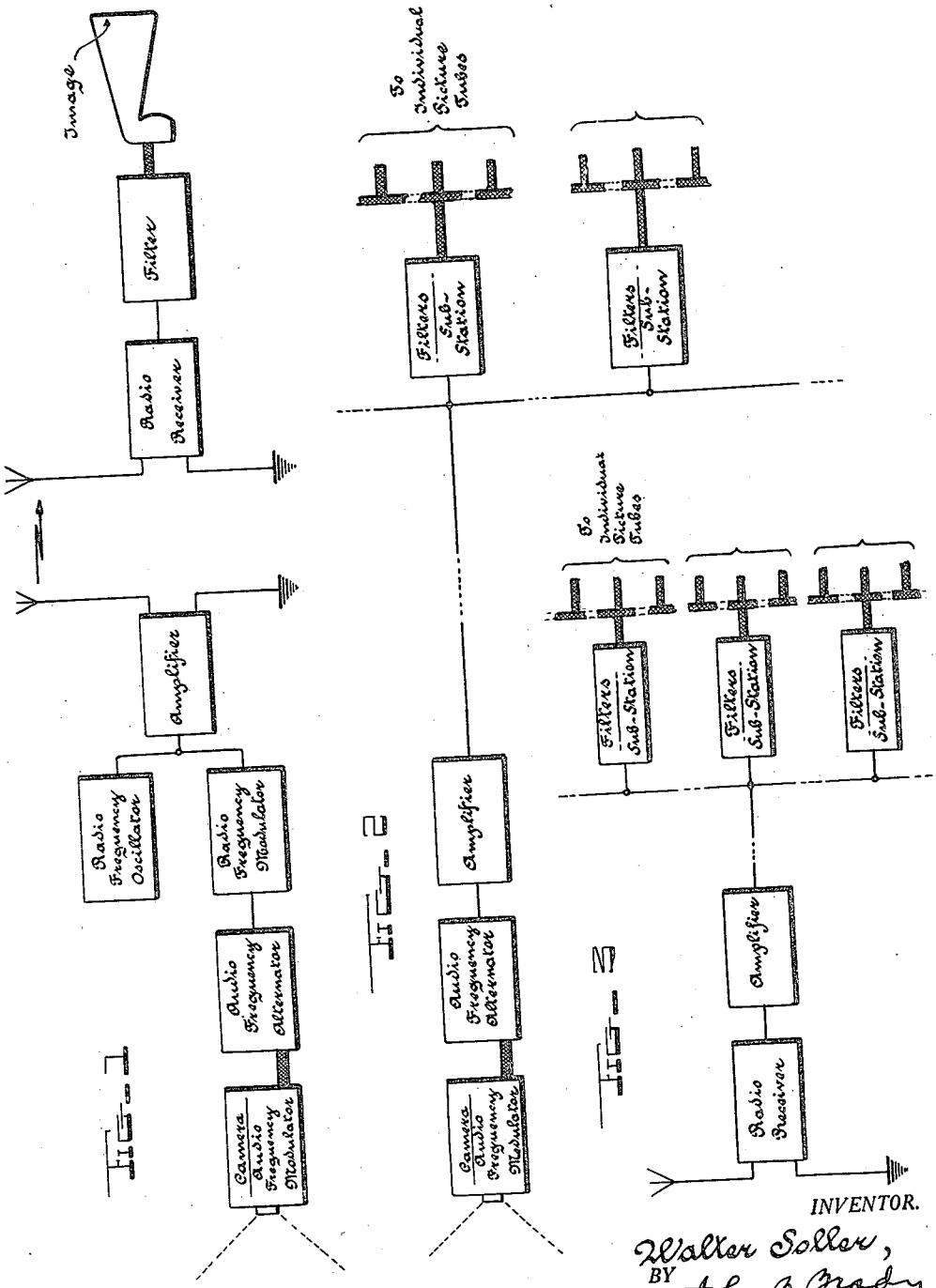
May 27, 1941. W. SOLLER 2,243,132

TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 1



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May 27, 1941. W. SOLLER 2,243,132

TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 2

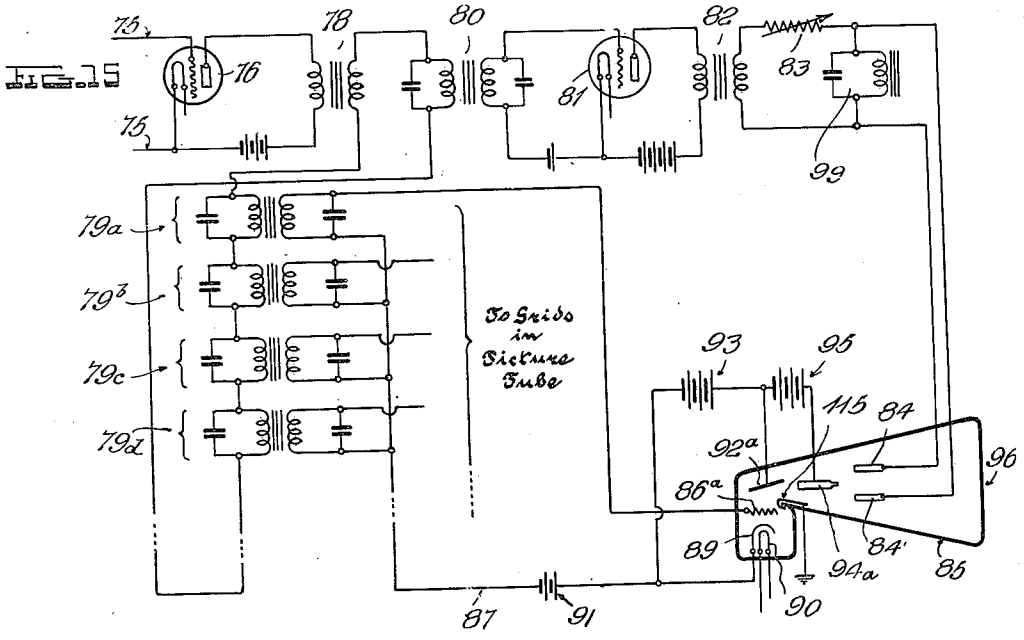
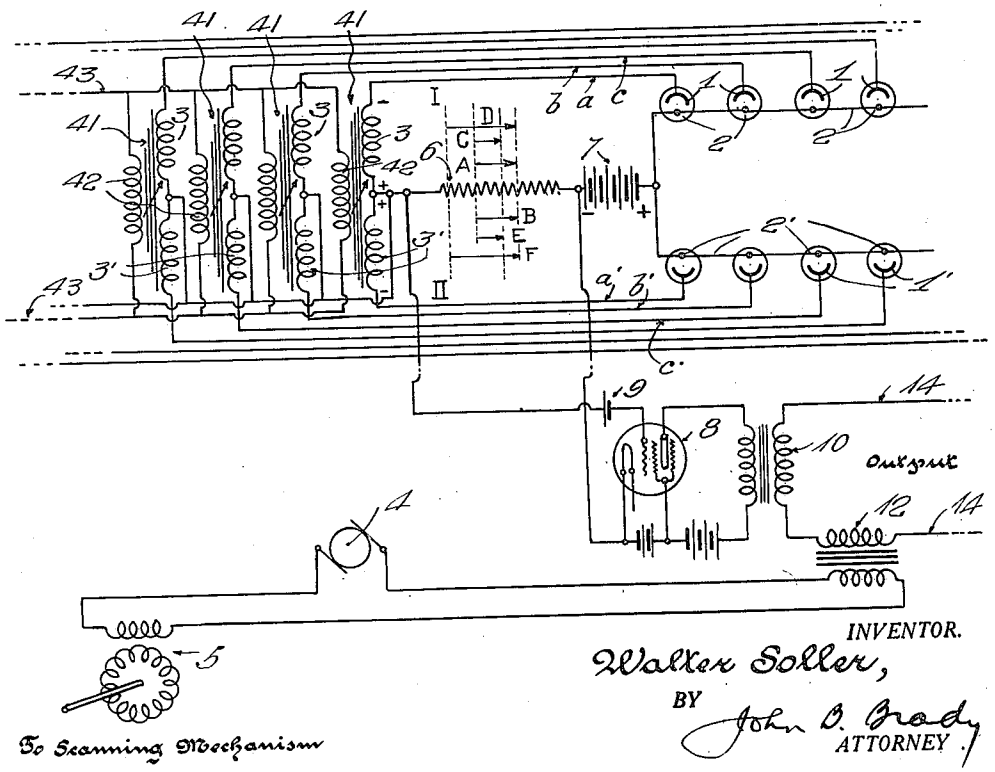


FIG. 4



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May 27, 1941. W. SOLLER 2,243,132

TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 3

FIG. 5

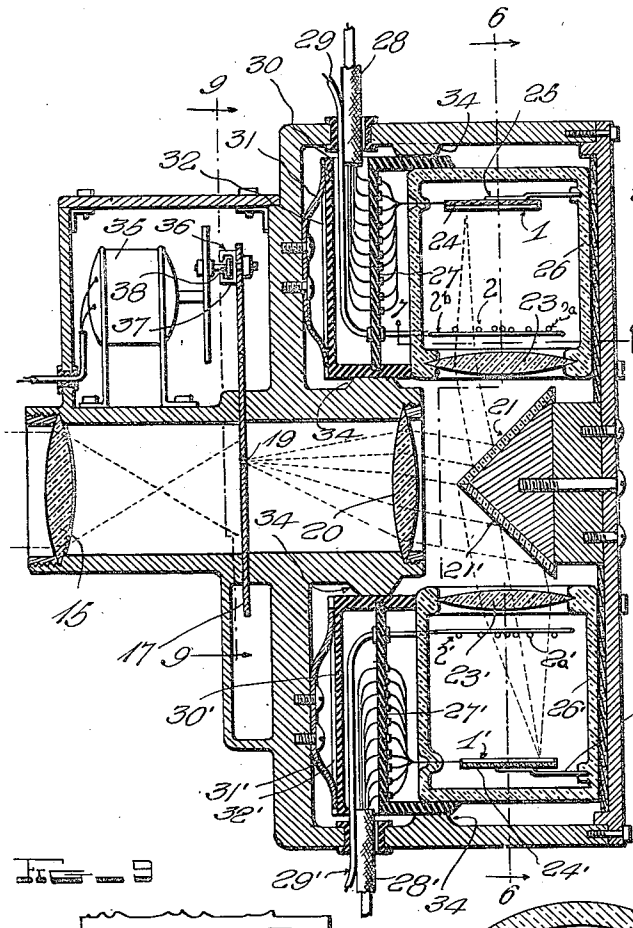


FIG. 6

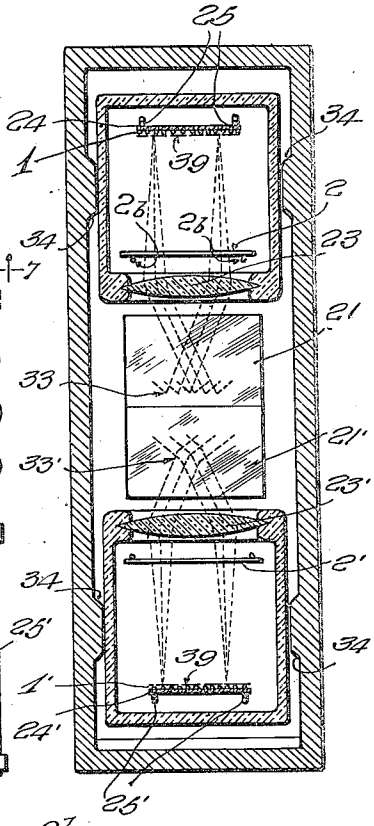


FIG. 8

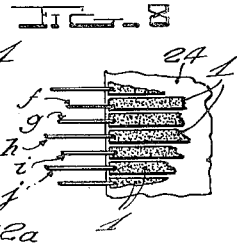
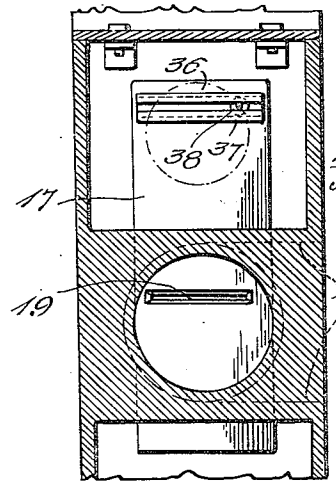


FIG. 9



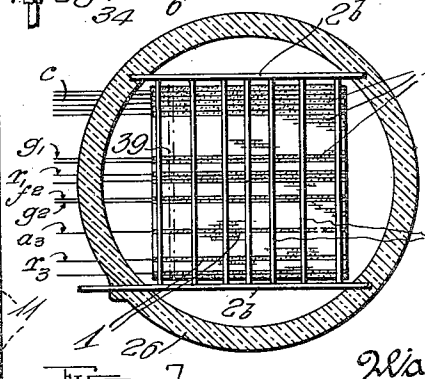


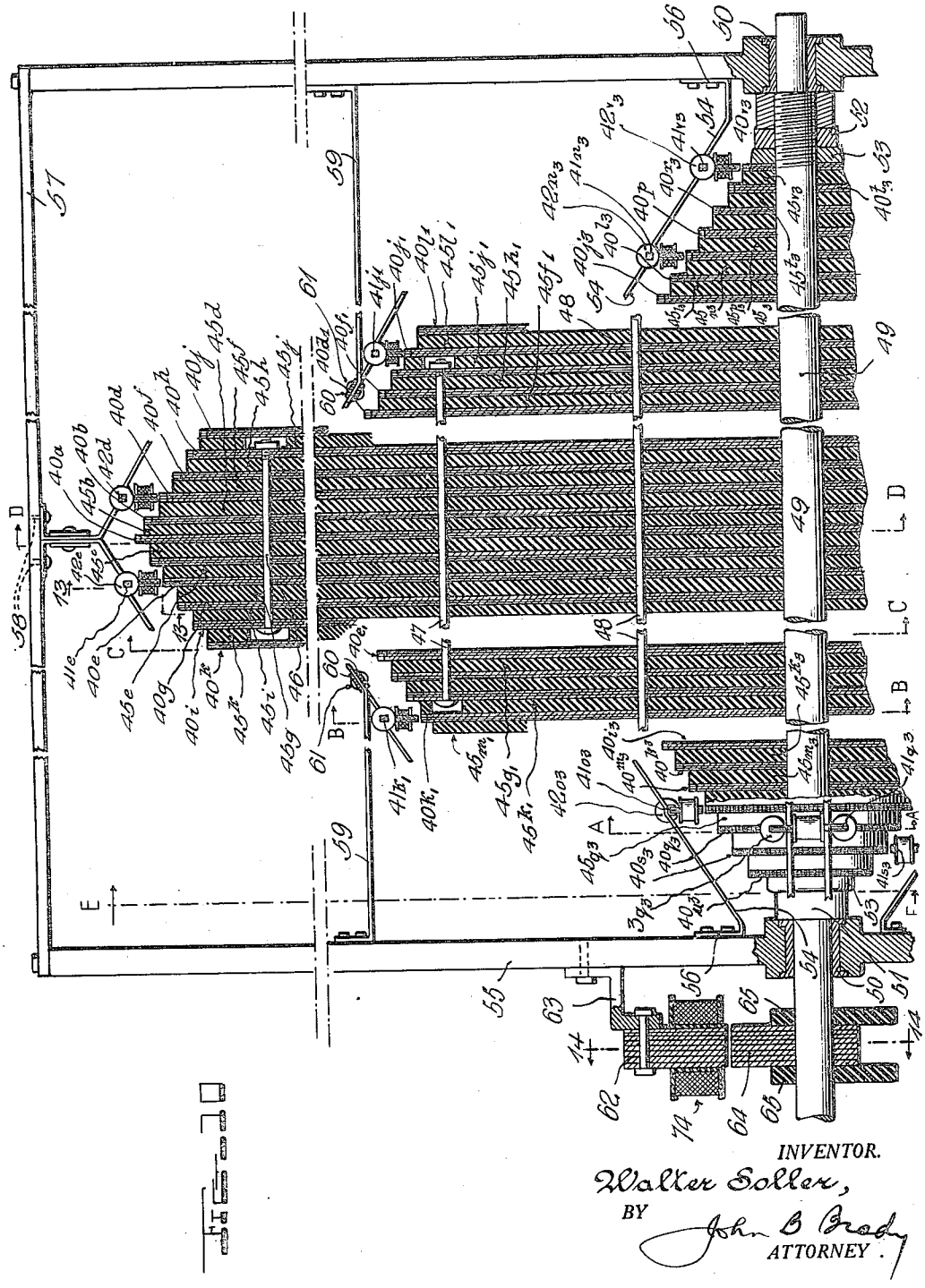
FIG. 7

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TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 4



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TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 5

FIG. 11

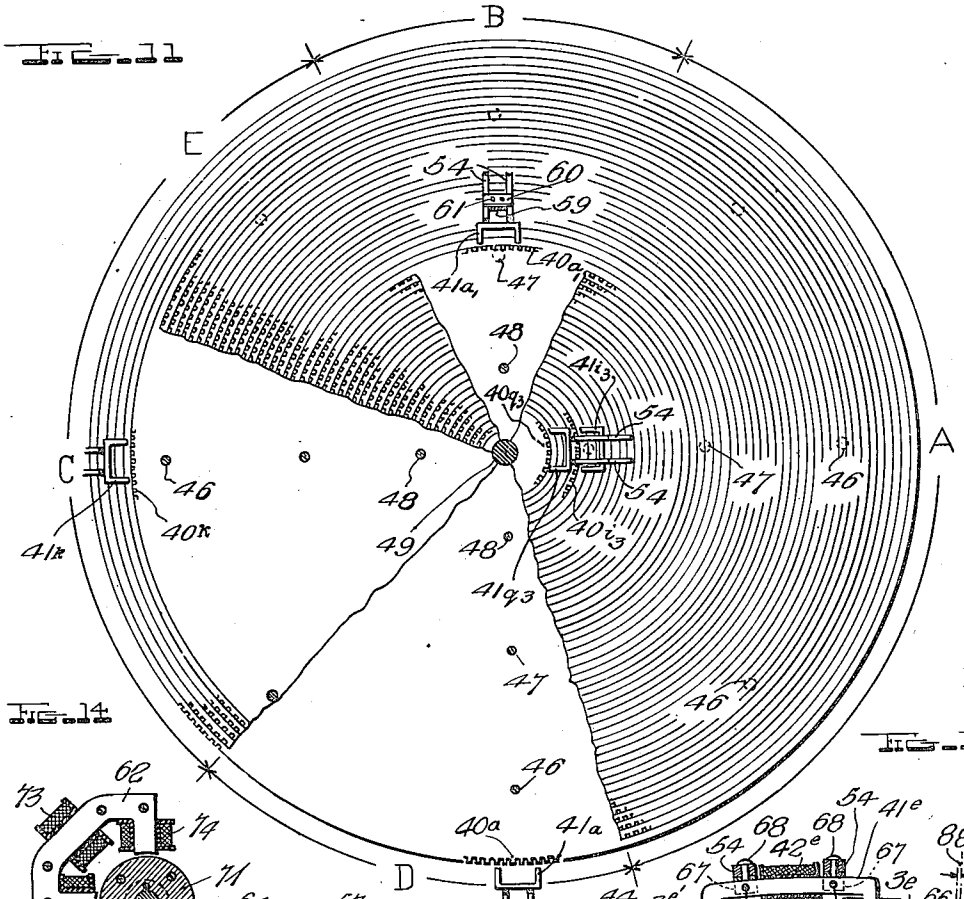


FIG. 14

FIG. 13

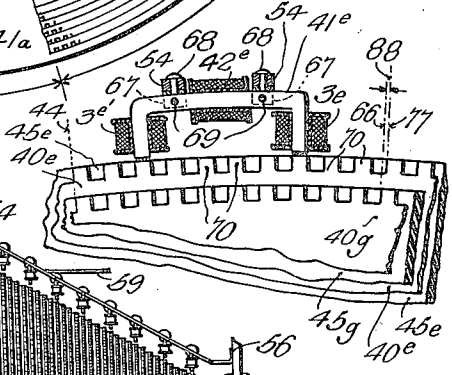


FIG. 12

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May 27, 1941. W. SOLLER 2,243,132

TELEVISION SYSTEM

Original Filed June 30, 1934 6 Sheets-Sheet 6

FIG. 16

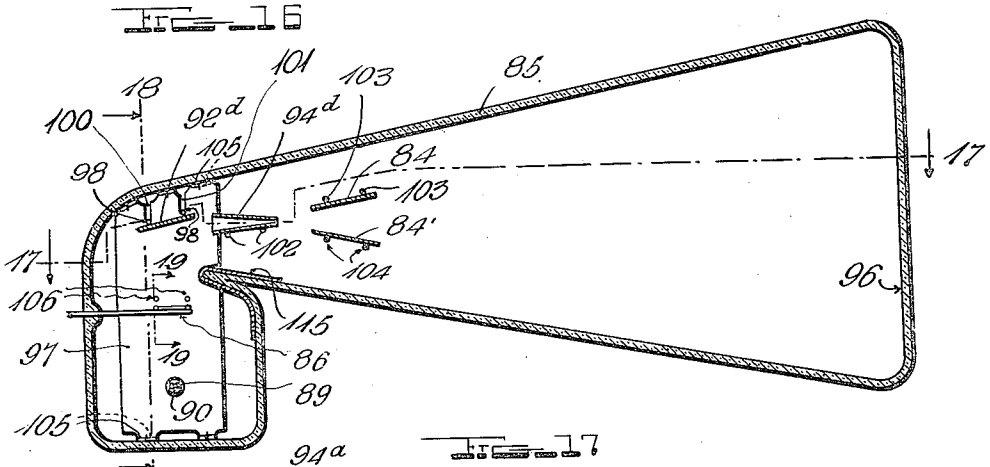


FIG. 17

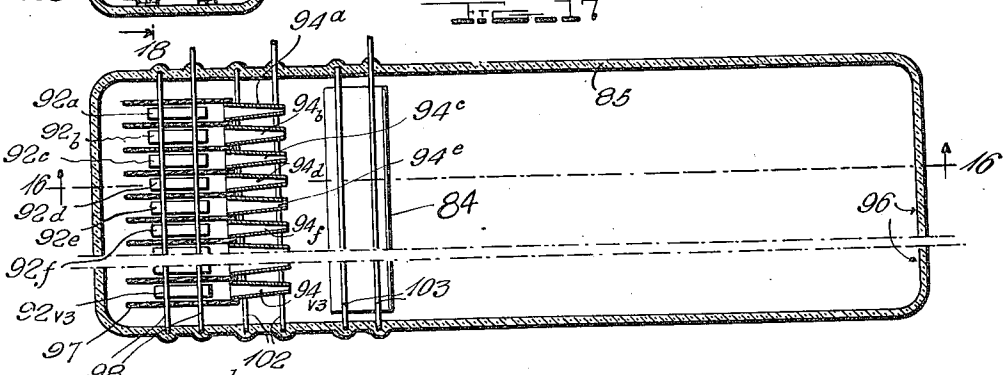


FIG. 18

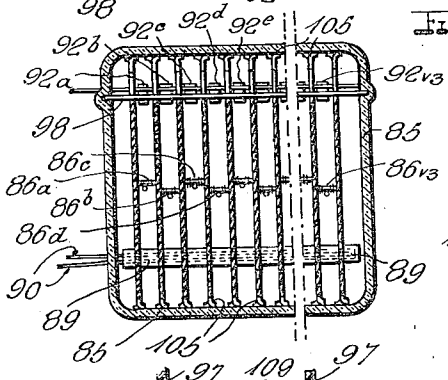


FIG. 19

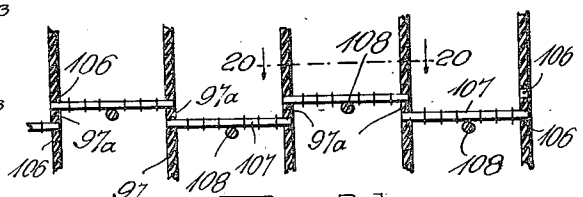


FIG. 21

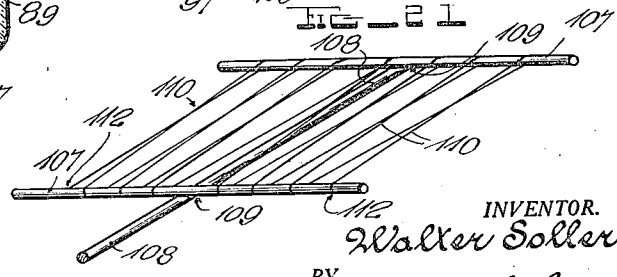
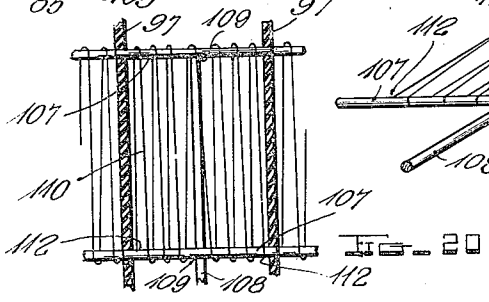


FIG. 20



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Patented May 27, 1941

2,243,132

UNITED STATES PATENT OFFICE

2,243,132

TELEVISION SYSTEM

Walter Soller, Cincinnati, Ohio, assignor of one-half to William H. Woodin, Jr., Tucson, Ariz.

Application June 30, 1934, Serial No. 733,309
Renewed December 9, 1938

10 Claims. (Cl. 178—6.8)

My invention relates broadly to television systems and more particularly to a system for the transmission and reception of variations in light intensity by modulated signal energy.

My invention is directed to a complete television system capable of transmitting any stage performance, sports event, news feature, or the like, throughout the country, and receiving and reproducing the scene in any place having reproducing apparatus of the character hereinafter described. The system of my invention can be applied to any scene which can be photographed by a moving picture camera, and provides in place of recording films, two photo-electric retinas which transform the scene into electric current, which may be retransformed into a representation of the scene in every place having reproducing apparatus.

One of the objects of my invention is to provide in the transmission end of a television system means for transforming rapidly changing scenes into rapidly changing audio frequency currents which can be amplified in the ordinary way and sent over wires or broadcasted on a single radio frequency carrier.

Another object of my invention is to provide a television system adaptable for the dissemination of picture current over regular equipment now in use, that is, any national broadcasting system, telephone equipment, or short or long wave length radio transmitters, or any apparatus that accommodates electrical energy of audible frequency.

Still another object of my invention is to provide a system for receiving television signaling energy in which amplifying and filtering apparatus of high fidelity characteristics may be located in a number of sub-stations with only a simple form translating device required for connection to a distribution system emanating from the sub-stations for use in the home or reproducing location.

A further object of my invention is to provide a lens and mirror system for obtaining a pair of duplicate images for energizing a pair of photo-sensitive retinas to effect a push-push operation in the input circuit of a transmitter in a television system.

A still further object of my invention is to provide a system for utilizing a rectangular shaped element as a unit in scanning the whole of an object by reciprocative movement.

Another object of my invention is to provide a construction of alternator for generation of a plurality of different frequency currents for use as carriers and another current of a frequency suitable for operating a scanning system.

Still another object of my invention is to provide a construction of photo-sensitive retina for cooperation with uni-directional scanning.

A further object of my invention is to provide an efficient filter system at the receiving end of a television system for selectively isolating the several different frequency currents received from the television transmitter for producing an image at the receiver.

A still further object of my invention is to provide a self-contained, structurally fixed, translating device for rectifying the separate frequency modulated currents and utilizing the fluctuating currents thus obtained to synthesize the picture elements; to further utilize the unmodulated scanning frequency to control the movement of the scanning unit in synchronism with the shutter in the transmitting apparatus; and to translate the fluctuating currents obtained after rectification of the frequency modulated currents into fluctuating sources of light for reproducing an image.

A further object of my invention is to provide in the translating device at the receiving end of the television system, cathode, grid, and anode electrodes constituting the rectifying elements therein, the anode electrodes constituting also, sources of secondary electron emission and having in relation thereto formative anodes and deflecting plates to form and direct, respectively, point sources of cathode rays onto a fluorescent screen for effecting the reproduction of an image.

Other and further objects of my invention reside in the method of television transmission and reception and the apparatus and arrangements as disclosed more fully in the specification hereinafter following and set forth in the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration of the television system of my invention showing the arrangement of the parts of the transmitter and receiver in a radio broadcasting system; Fig. 2 diagrammatically illustrates the system of my invention employed in television transmission and reception over line wires; Fig. 3 shows an arrangement of multiple receiving circuits for a television receiving system; Fig. 4 is a schematic diagram of the electrical connections in the transmitter of my invention; Fig. 5 is a vertical longitudinal sectional view through the photo-electric camera of my invention; Fig. 6 is a vertical cross-sectional view of the camera taken on line 6—6 of Fig. 5; Fig. 7 is a detailed sectional view on line 7—7 of Fig. 5; Fig. 8 is a greatly enlarged detail view of a section of one of the photo-sensitive retinas; Fig. 9 is a detailed sectional view on line 9—9 of Fig. 5; Fig. 10 is a vertical longitudinal view, partly in section and partly in elevation, of the alternator employed to generate the several frequencies; Fig. 11 is an end view partly in elevation, on line E—E and partly in section on lines A—A, B—B, C—C, and D—D of Fig. 10; Fig. 12 is a general elevational view of the assembled alternator; Fig. 13 is a detailed en-

larged sectional view of one of the stator units taken on line 13—13 of Fig. 10; Fig. 14 is a detailed sectional view on line 14—14 of Fig. 10; Fig. 15 is a schematic diagram of the electrical connections in the receiving apparatus of my invention; Fig. 16 is a vertical longitudinal sectional view through the picture tube of my invention on line 16—16 of Fig. 17; Fig. 17 is a foreshortened horizontal sectional view on line 17—17 of Fig. 16; Fig. 18 is a foreshortened sectional side elevation on line 18—18 of Fig. 16; Fig. 19 is an enlarged detail sectional view on line 19—19 of Fig. 16; Fig. 20 is an enlarged detail plan view of the grid structure of my invention taken on line 20—20 of Fig. 19; and Fig. 21 is an enlarged perspective view of the grid structure employed in the picture tube of my invention.

The transmitter

The object to be televised is initially referred to a camera in which an image of the object is formed at the position of the shutter. This image is progressively scanned and divided optically into two identical images by means of lens systems and mirrors, as shown by the traces of light rays in Figs. 5 and 6. These two images are focused on two photo-electric retinas, each of which is comprised of a series of photo-sensitive strips shown at 1 in all figures of the drawings. I indicate in the drawings and throughout the specification, provision for one hundred such strips in each retina, but it is to be noted that more or less may be employed depending on the fineness and size of picture desired. A common anode is provided for each retina; and each strip, together with the common anode, forms a photo-electric cell. There are right and corresponding left photo-sensitive retinas having corresponding strips, the connections of which are marked *a* and *a'*, *b* and *b'*, etc. Right and corresponding left strips, which are units in the right and left photo-electric retinas, connect to corresponding coils on the same core of an alternator stator. A slit in a shutter exposes the same small area, a rectangular element of the image embraced by the slit in the shutter, on both right and left unit strips producing current modulations proportional to the light intensity on a small area of each strip. A true modulation proportional to the intensity of light on the small areas is thereby produced by the action of the current through the two areas and the corresponding alternator coils. Corresponding areas on all the 100 strips of both left and right retinas are exposed at the same time and similarly true modulations proportional to the intensity of the light on the exposed areas of these strips are produced. Each set of strips connects with coils on different cores of a composite stator and have a different frequency voltage applied to them. The common anodes are connected together, and, therefore, all the alternating currents of different frequencies combine into one complex alternating current passing through a resistance in series with the common anodes and center taps from the alternator coils.

As the slit in the shutter moves across the image, it progressively exposes different areas of the picture to the strips. The frequency of the voltage applied to each strip remains the same, but the light intensity is continually being varied according to the lights and shadows of the picture as the slit moves across the image. The image is thereby transformed into a complex alternating current of 100 or more modulated fundamental frequencies, which current I will call the picture current.

The movement of the shutter across the image in one direction gives one exposure. The shutter is operated through a Scotch yoke mechanism by a synchronous motor supplied with alternating current from a generator driven by the same shaft as the alternator that supplies the voltage for the photo-sensitive strips. The frequency of this source can be 60 cycles, thus giving 120 exposures a second with a shutter system driven by a two pole synchronous motor.

The voltage drop across the series resistance is the input to the first amplifier tube. This must be a very low input tube of the FP-54 type. A portion of the shutter operating current is introduced into the picture current after this first stage of amplification. If the picture is to be transmitted by radio, the frequencies supplied by the alternator should be kept to within 10,000 cycles so as not to have too large a band. For example, for a 100 strip retina camera, 3900 cycles to 9900 cycles in 60 cycle steps will provide the desired number and range of frequencies. This group of frequencies with continually varying amplitudes, together with a constant amplitude shutter frequency form, in combination, the complex output of the production end of the system. This can be transmitted by wire or by space radio, and it is actually a simpler wave than that being produced by an orchestra which is a relatively complex composition of frequencies.

The alternator is of the inductor type, arranged to produce all the frequencies required and connected to incorporate the push-push feature. As only extremely small currents are required, this arrangement will be adequate. A separate alternator, also of the inductor type but of larger capacity, for supplying current to the synchronous motor, is mounted on the same shaft.

Figs. 1, 2 and 3 show in block arrangement the units as combined in a number of workable systems. The camera constitutes a source of modulations for the audio frequencies generated in the composite alternator. The output of these two units is a complex audio frequency wave which can be employed to modulate a radio frequency carrier, which, in turn, is amplified and radiates energy, as shown in the left section of Fig. 1. Either long or short waves may be used. The receiver in Fig. 1 comprises the usual selective tuning apparatus and radio frequency rectifier or detector, obtaining in the output thereof the complex audio frequency wave. A filter system separates the several frequencies of which those modulated are then conducted to the rectifying section of the picture tube. After rectifying the audio frequency, the former modulation thereof becomes available for control of a source of luminescence at the image screen. The unmodulated frequency is employed to energize deflecting plates for synchronously synthesizing an image of the object initially scanned.

Fig. 2 shows the transmission of the complex audio wave, or picture current, directly over line wires to the filters at the receiving positions. Fig. 2 further shows a distribution system wherein main filters are located in substations and serve a multiplicity of picture tubes. Thus, all that is necessary to receive the images in the home or office is to become a subscriber to this system in much the same manner as telephony is now administered.

Fig. 3 illustrates how the distribution sys-

tem of Fig. 2 could be applied to the radio receiving apparatus of Fig. 1 for reception of extremely distant performances, for example, transoceanic events.

Referring in detail to Figs. 4–14 which illustrate the transmitting system, Fig. 4 is a schematic diagram of the circuit arrangement of the apparatus of my invention. Photo-sensitive strips are shown generally at 1 and 1', the common anodes at 2 and 2'. Conductors *a*, *a'*; *b*, *b'*; *c*, *c'*; etc., show the relation of right and left photo-sensitive strips with coils in the stator of a multiple alternator. These coils designated generally by 3 and 3' have terminals connected to conductors *a*, *a'*; *b*, *b'*; *c*, *c'*; etc., in the pairs, as shown. Coils designated generally by 42 are energized by direct current through leads 43 and provide a magnetic field in the cores, designated generally by 41, on which they are mounted together with the respective coils of the series 3, 3'. Alternator 4, which is driven by the shaft which drives the multiple alternator, supplies the power for the synchronous motor 5 which drives the shutter. The center connections from all pairs of coils in the multiple alternator are connected in common to a resistance 6, the other terminal of which connects through battery, or other source of direct current 7, if necessary, to both the anodes 2 and 2'.

Arrows disposed above and below resistance 6 indicates the manner of push-push modulation of the several frequencies. Instantaneous signs of the voltage induced in one of the series of coils 3, 3', are shown by the + and − signs adjacent the terminals thereof. The middle connection has a stable potential due to the balancing effect of the voltages at either side of the middle point. The battery 7 has the positive pole thereof connected with the anodes 2, 2', of the photo-electric units, and has a voltage equal to or greater than the peak voltage in the alternator coils 3, 3', so that the anodes are maintained positive with respect to the cathodes of the photo-electric cells at all times. The voltage across the resistance 6 due to the battery 7 may be represented in circuit I by the vector A, indicating the polarity and the magnitude thereof, and in circuit II by vector B; each vector representing the voltage of the battery 7. With instantaneous potentials as indicated, the coil 3 supplies a voltage across resistance 6 as represented by the vector C in circuit I, and coil 3', a voltage represented by vector E in circuit II. As the instantaneous voltages indicated are in the same sense in their respective circuits as the voltage of battery 7, light falling on the photo-electric cells will permit current to flow under the force of the sum of the voltages A and C in circuit I, represented by arrow D, and B and E in circuit II, represented by arrow F. Considering the condition with the phase of the voltages from coils 3, 3', 180° disposed, that is, with the voltages opposite in polarity with respect to the battery 7, the vectors C and E will be reversed, and, under excitation by light on the photo-electric cells, current will flow in the resistance 6 under the force of the difference between voltages A and C in circuit I, and B and E in circuit II. In either condition, however, the alternating component voltages C and E are in phase and act in push-push relation, the result being improved modulation by reason of the more definite response and greater signal intensity in the modulated output without sacrifice of simplicity and efficiency.

The system may be converted into one wherein the coils 3, 3', supply voltage to the resistance 6 in push-push relation, by a simple rearrangement of the elements disclosed.

The composite current through the resistance 6 includes the alternating currents from all the coils 3 as separately modulated by the corresponding photo-electric units. The input to the electron tube 8 is the potential drop across this resistance 6.

Bias potential to cause tube 8 to operate as an amplifier is provided by a battery 9. The output circuit includes transformers 10 and 12; transformer 10 amplifies and transmits the complex wave comprised of the several modulated different frequencies while transformer 12, the secondary of which is connected in series with that of transformer 10, amplifies and introduces into the output circuit 14 the current which drives the synchronous motor. The frequency of this current is unmodulated and is to be used at the receiving end to effect synchronism with the scanning at the transmitter.

Fig. 5 is a sectional view through the camera used in the system of my invention. Reference character 15 designates a convex lens which forms an image of the object at the position of the shutter 17. Slit 19 in the shutter 17 permits that portion of the image exposed by the slit to be refocused by lens 20, mirrors 21 and 21', and lens 23 and 23', on the photo-sensitive retinas 1 and 1' which are carried by insulating plates 24 and 24'. Light traces shown by dotted lines indicate how these images are formed. Mirrors 21 and 21' may be replaced by total reflecting prisms to obtain greater fidelity and efficiency of reflection and, therefore, a greater intensity of light on each photo-sensitive retina. Anodes 2 and 2' are grill structures of variously spaced elements 2*a* supported by rods 2*b*. Rods 25 and 25' support the insulated plates 24 and 24'. Glass envelopes 26 and 26' contain the retinas, 1 and 1', anodes, 2 and 2', and lens 23 and 23' and are exhausted to a high degree of vacuum. Conductors *a*, *a'*; *b*, *b'*; *c*, *c'*; etc., connect through terminals on insulating plates 27 and 27' to multiconductor cables 28 and 28'.

Anode connections 29 and 29' are connected to separate terminals on insulating terminal boards 27 and 27'. Insulating covers 30 and 30' are cemented to glass envelopes 26 and 26' and support the terminal plates 27 and 27'. Spring members 31 and 31' fixed to the frame engage grooves 32 and 32' in insulating covers 30 and 30' and with projections 34 from the frame structure serve to keep the glass envelopes 26 and 26' and the associated apparatus in alignment.

Synchronous motor 35 drives the shutter 17 in reciprocative movement by means of the Scotch yoke mechanism 36 which consists of channel member 37 fixed to the shutter 17 and roller member 38 operating in the channel member.

Fig. 6 is a sectional view on line 6—6 of Fig. 5 and indicates by the same reference characters, the same elements, as described hereinbefore. Fig. 6 further shows the light traces of a pair of points in the beam of light passed by the slit 19 in shutter 17 from the lens 20 which parallels all rays emanating from the slit 19, through their reflection at points 33 and 33' by mirrors 21 and 21', and subsequent focus at the photo-sensitive retina by lens 23 and 23'. Fig. 6 illustrates more clearly the beam character of the scanning element in contrast to the usual "ray", by showing the scanning beam by the dotted line

39 in position to embrace all the photo-sensitive strips 1, at the same time.

Fig. 7 is a sectional view on line 7—7 of Fig. 5 and further illustrates the relation of scanning beam 39 and photo-sensitive strips 1 as such that the beam embraces all the strips simultaneously and, in the scanning progression, continues to embrace all the photo-sensitive strips simultaneously. Fig. 7 also illustrates the structure of the anode 2 and the unequal spacing of the rod elements to secure a minimum of interference for the light rays converging on the retina.

Fig. 8 is an enlarged detail view of the retina 1 and insulating plate 24 showing the separate, insulated character of the photo-sensitive strips constituting the retina and the individual connection to each strip.

Fig. 9 is a sectional view on line 9—9 of Fig. 5 and illustrates the relation of the slit 19 in shutter 17 to the central opening in the frame structure.

Fig. 10 is a vertical longitudinal view, foreshortened on both axes, partly in section and partly in elevation, of a preferred construction of alternator for the generation of the several frequencies employed in the system of my invention. Reference characters 40*a*, 40*b*, 40*c*, etc., designate toothed, laminated iron rotor sections constituting means for varying the reluctance of the flux paths between the poles of the several laminated U-shaped stator cores, 41*a*, 41*b*, 41*c*, etc. Magnetizing coils 42*a*, 42*b*, 42*c*, etc., supplied with direct current produce a magnetic field across the pole pieces of the stator cores 41*a*, 41*b*, etc., which passes into and out of the rotor sections 40*a*, 40*b*, etc., respectively. Thus, as the rotor revolves and the tooth or space portions pass the pole tips, the magnetic field is varied. By magnetically cutting the wires in coils 3*a*, 3*a'*; 3*b*, 3*b'*; etc., mounted on the pole pieces of the stator cores 41*a*, 41*b*, etc., this magnetic field generates an alternating voltage in the coils of a frequency depending on the rate of variation of the magnetic field. Insulation spacers 45*b*, 45*c*, 45*d*, etc., serve to support the teeth in the laminated rotor sections, to prevent jamming should one of the stator cores become misaligned and to separate the several magnetic fields to prevent interference therebetween.

The various sections are fastened together at different radii by bolts 46, 47 and 48 and supported on shaft 49 which is carried by bearings 50. The sections are secured on shaft 49 between collar 51 and nut 52 which is tightened to form a clamping fixture. Washers 53 are provided to prevent injury to the end sections 40v_3 and 40v_3.

The various stator cores are disposed in a double conical spiral arrangement around the rotor as is better shown in Figs. 11 and 12. Supporting rods 54 carry a number of the stator cores in fixed spacial relation to the rotor and are fastened at the ends to the side walls 55 at 56 and the transverse members 57 at 58. Supporting strips 59 are clamped to rods 54 by members 60 and rivets 61 and serve to brace the rods 54 and to maintain the alignment of stator and rotor elements.

Fixed to the shaft 49 and separate from the multiple alternator assembly, is an individual generator 4 of somewhat larger proportions, being of sufficient size to supply current to operate the synchronous motor to drive the scanning mechanism. This generator consists of a stator pole structure 62 mounted by bracket 63 to the side wall 55. The rotor member is comprised of a laminated iron section 64 of eccentric shape, for varying the reluctance of the magnetic path between the poles of the stator, and a pair of insulation members 65 fastened on either side of the laminated section 64 to counterbalance the eccentricity of the laminated section. The stator core carries a direct current magnetizing coil 73 and generating coils 74 and 74' in which an alternating voltage is induced by the variations in the magnetic field due to the rotation of the eccentric laminated rotor element 64, as is more clearly shown in Fig. 14.

Fig. 11 is a side elevation of the multiple alternator on line E—E of Fig. 10 and shows sections on lines A—A, B—B, C—C, and D—D of Fig. 10. The full elevation view on line E—E shows the stepped, concentric arrangement of the rotor sections to provide different linear speeds for the toothed peripheries of the various rotor sections. The section on line A—A shows the disposition of two representative stator cores 41i_3 and 41q_3 in their mutual relation and their relation to the rotor sections, 40i_3 and 40q_3. This relation provides on each set of supporting rods 54, a stator core assembly for every fourth rotor section. There are four such sets of supporting rods 54 disposed around the rotor and by proper selection of the initial pairing of stator and rotor elements, each rotor section will be provided with a corresponding stator assembly. This arrangement is more clearly shown in Fig. 12 in which, starting at the right of the illustration, the first rotor section has a corresponding stator supported by the upper rods 54, the second section has one supported by the front rods 54, the third has one supported by the lower rods 54, and the fourth has one supported by the rear rods 54, not visible in the drawing. The fifth section then will have a corresponding stator assembly supported on the upper rods 54 and so on for the whole of the structure. This separation and distribution insures magnetic distinction and facilitates construction.

The section on line B—B of Fig. 10, shown in Fig. 11, shows the stator core 41a_1, as representative of the series of stator cores supported on the upper rods 54. This sectional view also shows the mounting of the bracing strip 59 clamped to rods 54 by members 60 to which it is secured by rivets 61.

The section on line C—C of Fig. 10, shown in Fig. 11, illustrates stator core 41*k* as representative of the series of stator cores supported on the left rods 54, which are the rear rods not visible in Fig. 12.

The section on line D—D of Fig. 10, shown in Fig. 11, shows the stator core 41*a* as representative of the cores supported by the lower rods 54. This sectional view also shows the lower transverse member 57 and the mounting of the rods 54 thereon.

The distribution of binding bolts 46, 47 and 48 is shown in Fig. 11.

Fig. 12 further shows the relation of the generator 4 to the multiple alternator assembly and the general relation of the reinforcing strips 59 to the supporting rods 54 and the side walls 55.

Fig. 13 is a detailed sectional view on line 13—13 in Fig. 10, through a representative stator core unit which includes the core 41*e*, direct current magnetizing coil 42*e*, and alternating current generating coils 3*e* and 3*e'*. Supporting rods 54 are shown fixed to the core 41*e* by means

of saddle straps 67 to which rods 54 are held by rivets 68 and which, in turn, are secured to core 41e by rivets 69.

Rotor section 40e having teeth 70 is aligned with the core 41e and backed by the insulating spacing member 45e. The teeth are shown to be of an actual width of ⅛", in which case, for the curvature shown, there will be 161 teeth and 161 spaces in the circumference producing 161 cycles of flux change per revolution. If this machine is assumed to be rotating at 60 revolutions per second, the frequency generated in the coils 3e and 3e' will be 60×161 or 9660 cycles per second which would be suitable as a carrier for light modulations. To facilitate filtering and in order to minimize the band width required for a transmission system, a difference of 60 cycles between carrier frequencies has been assumed as a workable medium difference. Thus, at 60 revolutions per second of the rotor structure, a difference of one tooth and one space per section will produce the desired difference in frequency of 60 cycles per second. In order to further separate adjacent frequencies and to provide a balanced structure, the sections for adjacent frequencies are disposed on alternate sides of the center section which supplies the highest frequency. Thus, in Fig. 13, adjacent section 40g provides a frequency differing by 120 cycles from that provided by section 40e. From the radius 44 at which the teeth in sections 40g and 40e are aligned, to the radii 66 and 77, the distance 88 on the circumference indicates the increasing difference which amounts to the width of two teeth and two spaces in the complete circumference. The example assumed has provision for 100 carrier frequencies and the scanning frequency. Thus, 101 toothed sections are provided, 100 of which form a multiple alternator unit. In designating the several sections, the alphabetical characters are employed through a to z, a_1 to z_1, a_2 to z_2, and a_3 to v_3, making the total of 100 sections.

A frequency of 60 cycles per second is chosen for operation of the synchronous motor. Alternator 4, shown in section in Fig. 14, is, therefore, provided with a rotor 64 having one tooth 71 and one space 72 producing one cycle per revolution, or 60 cycles per second at 60 revolutions per second. The synchronous motor 35 having two poles, similar to the alternator, will revolve at 60 revolutions per second and effect 120 complete scannings every second which is more than sufficient number to maintain continuous vision. Core structure 62 of the alternator 4 carries direct current magnetizing coil 73 and alternating voltage generating coils 74 and 74'.

The receiver

The picture current, with the shutter frequency component, is received either by wire or through a broadcast receiver and amplified in the ordinary way. This current is then filtered out into the original frequencies. The current having the shutter operating frequency is amplified separately and provided with an amplitude control. The modulated frequencies are applied to a series of grids in the picture tube. These grids, together with a series of positively charged strips and a common cathode form a series of ordinary three electrode assemblies grouped together in the picture tube. The series of positively charged strips are electrically connected together and charged at the same potential, but separately associated each with an electrically separate grid.

These three electrode assemblies are operated at cut-off bias so that the currents in the positively charged strips are rectified and will be proportional to the modulations of the voltages applied to the grids. The positively charged strips become sources of secondary electron emissions and will produce secondary electrons in proportion to the electrons received from the cathode, the numbers of which are proportional to the light intensities which initiated the modulations. These sources of secondary electron emissions are, in turn, the electron sources for a series of cathode ray units forming the complementary part of the picture tube. Corresponding to each electron source is a guide anode. These guide anodes are electrically connected together and charged at a common higher positive potential than the secondary electron sources. This causes all electron streams, no matter of what intensity, to have the same velocity after leaving the anode. Common deflection plates can, therefore, be used as all of the electron streams will be deflected together. The shutter frequency voltage is applied to the deflection plates to cause these electron streams to deflect in synchronism with the movement of the slit in the camera at the transmitter.

The picture formed on the fluorescent screen as the series of cathode rays deflect back and forth, is changing at the rate of 120 times a second in the example considered. Only a unit strip of the picture, corresponding to the portion the slit in the camera exposes, is produced at any instant, but this and the complete progressive scanning occur so much faster than the eye can follow that the impression of a complete picture or series of pictures is received by the eye. While the individual pictures do not move, a series of minutely different images will, at the proposed number of 120 a second, be blended into a smoothly moving picture. This result is due to the well known phenomena called "persistence of vision."

The secondary electron sources being long thin strips, can receive large numbers of electrons from the cathode and still form point sources of cathode rays by being placed almost in line with the direction through the anode. The sections in the picture tube will be disposed in exactly the same order as the photo-electric strips in the camera to which they are separately responsive.

Various methods of filtering are possible, e. g., some magnetostriction methods, resistance-capacity or inductance-capacity circuits depending on the magnitude of the frequency and the band width available; and various sources of frequencies may be employed such as the composite alternator shown or some arrangement of magnetostriction, piezo electric, or electron tube oscillators may be employed.

For other than radio broadcast transmission, higher than audio frequencies could be used. The alternator could be replaced by crystal oscillators, and the shutter frequency could be produced by heterodyning. In such a system, the filters in the receiving end could consist of crystal filters.

The more photo-sensitive strips and corresponding units throughout the system there are provided, the greater will be the lines per inch of picture width. Refined filtering and general precision of alignment will also improve the picture.

Fig. 15 is a schematic diagram of the electrical

connections in the receiving apparatus of my invention. The input 75 to amplifier tube 76 contains the complex audio wave. The output of tube 76 is further increased in transformer 78, the output of which is put through the series of filters 79*a*, 79*b*, 79*c*, etc., and filter 80. The output of filter 80 is the voltage of synchronizing frequency which is further increased in amplifier 81 and transformer 82. Variable resistance 83 controls the amplitude of the synchronizing voltage. Filter 80 comprising a choke coil and condenser further clarifies the synchronizing voltage which is then impressed on the deflecting plates 84—84' in the picture tube 85. The outputs of filters 79*a*, 79*b*, 79*c*, etc., connect to the inputs of the three-electrode assemblies in the rectifying portion of the picture tube 85. The output of filter 79*a*, as representative of these connections, is shown connected to grid 86*a*. A common connection 87 from one side of each of the filters 79*a*, 79*b*, 79*c*, etc., connects to the common cathode 89 which is brought to operating temperature by heater element 90. Source of biasing potential 91 is of such value as to cause the grids 86*a*, 86*b*, 86*c*, etc., to operate at cut-off points to effect rectification of the input voltage. Positively charged strips 92*a*, 92*b*, 92*c*, etc., represented by strip 92*a* in Fig. 15, are electrically connected together and charged at the same potential with respect to the common cathode 89 by source of potential 93. The electrons from cathode 89, on striking these positively charged strips 92*a*, 92*b*, 92*c*, etc., produce secondary emissions therefrom. Anodes 94*a*, 94*b*, 94*c*, etc., represented by anode 94*a* in Fig. 15, are more positively charged than strips 92*a*, 92*b*, 92*c*, etc., by source of potential 95 and, therefore, attract the electrons produced in the secondary emission. Anodes 94*a*, 94*b*, 94*c*, etc., form the electrons into point sources of electrons or cathode rays and project them as a flat beam between deflecting plates 84 and 84' on the fluorescent screen 96 constituting part of the end surface of picture tube 85.

Fig. 16 is a vertical longitudinal sectional view on line 16—16 of Fig. 17, and illustrates the structure which supports the several electrodes in the tube 85 and maintains them in fixed spacial relation. Insulating sheets 97 of mica or other material of good insulating properties, support the numerous grid assemblies 86 and the cathode 89. Transverse rods 98 of conductive material support and connect together electrically, the several first anodes 92. The rods 98 are fixed in the side wall of the glass tube 85. The first anode structure provides also for the uniform spacing of the insulating sheets 97 which have slots 100 and 101 to accommodate the rods 98. Secondary anodes 94 are of rectangular tubular cross-section and converging longitudinal section and serve to guide the electrons emitted from the strips 92 into point rays. Supporting rods 102 carry the several anodes 94 and connect them electrically together. The rods 102 are secured in the glass side walls as are the rods 98.

Deflecting plates 84 and 84' are supported in similar manner by rods 103 and 104 respectively. Connections are made to the several electrodes in conventional manner and led through the glass enevelope of the picture tube 85.

Grounded shield 115 is formed by metallic deposit on the surface of the glass or may be of other suitable form. This shield prevents electrons from the cathode 89 being attracted directly to anodes 94 instead of through the grids 86 to the first anodes 92.

Fig. 17 is a foreshortened horizontal sectional view on line 17—17 of Fig. 16. The disposition of the numerous strip anodes 92 and guide anodes 94 in relation to the insulating spacers 97 and the broad deflecting plate 84, is shown. Deflecting plate 84' is positioned directly beneath plate 84 on the far side of the electron or cathode beam. The proportions of the various elements are uniformly somewhat enlarged to clearly show the structure and arrangement thereof. It is understood that the nozzle ends of the guide anodes 94 are positioned as near each other as possible, or otherwise focused so as to form on the screen 96 a continuous luminous line by the partial blending of distinct adjacent luminous dots. The progression of the luminous line will be a smooth movement due to the smoothly varying electric current which promotes the scanning process. Thus, the picture produced will be a clear reproduction of the scene in the camera range.

Fig. 18 is a foreshortened vertical cross-sectional view on line 18—18 of Fig. 16 and shows the relation of the common cathode 89 to the individual grids 86 and strip anodes 92, with the insulating spacers 97 adjustably fitting the enclosure by virtue of the foot abutments 105. The grid structures 86*a*, 86*b*, 86*c*, etc., individual to each section are shown in more detail in Figs. 19, 20 and 21.

Fig. 19 is a vertical detail section view on line 19—19 of Fig. 16 and illustrates the alternate positioning of the grid structures as supported by adjacent insulating plates 97, in order to provide horizontal alignment of the grid structures with the strip anodes 92 and the cathode 89, but insulated support for individual electrical connection thereto. The vertical displacement between adjacent units has no effect on the control function of the grid and need be no greater than is necessary to afford sufficient structural strength in the section 97*a* between the holes 106 which receive the transverse rods 107 of the grid structure.

Fig. 20 is a further enlarged plan view of the grid structure as seen on line 20—20 in Fig. 19. Transverse rods 107 are lodged in apertures 106 in insulating spacers 97. Longitudinal rod 108 is spot welded to rods 107 at 109, holding rods 107 in spaced relation and serving as a connection terminal. Small size wire 110 is disposed in spaced turns around the transverse rods 107 and fixed thereto at points 112.

Fig. 21 is a perspective view of the assembled grid unit and shows the relation of the members described in connection with Figs. 19 and 20.

The system of my invention is particularly applicable to carrier current line wire operation. The television system of my invention can be practically employed on a large scale through a service company. In the cities, central stations having high grade filters, and distributing systems similar to the telephone system, may be employed. Only the picture tubes would be necessary in the subscribers' installations, and cables containing fine wire may lead to the units from the central stations. These cables are composites of fine, stranded, enameled wire as they provide only the small voltage required for excitation of the grids. The cathode connection is provided through the ground. Such a system would require a comparatively inexpensive unit for the home or office and would allow greater

refinement of filters and associated apparatus. The service company plan is practical for dissemination of television entertainment to the general public to whom a multiplicity of controls will always be a source of disappointment, discouragement and general antipathy towards television.

The splitting up of the image into the two images, as provided in my apparatus, is not essential and I may employ a single image falling upon a single photo-electric retina to control the transmission system. The means disclosed herein for obtaining an extremely rapidly changing electron source as is accomplished in the picture tube is a basic phenomena that has many uses and applications other than for television.

While I have shown the preferred form of my invention, I am aware that modifications may be made and, accordingly, I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

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

1. A method of television which consists in simultaneously modulating a plurality of currents of different frequencies by the variations of light intensity on a corresponding plurality of points constituting a narrow strip unit portion of an object to be televised, scanning the total object by the progression of said unit portion at a predetermined frequency across said object, combining the said modulated currents of different frequencies and current of said scanning frequency to form a complex wave, amplifying and transmitting said complex wave, filtering the several modulated currents of different frequencies and the current of said scanning frequency into separate channels at the receiving end, separately rectifying said filtered modulated currents, utilizing the varying currents resulting from said rectifications separately to control secondary electron emissions, amplifying the voltage of said scanning frequency and utilizing said voltage of said scanning frequency to control the deflection of all secondary electrons in synchronism with the progression of said unit strip across said object.

2. In a television system, means for producing a plurality of currents of different frequencies, means for modulating each of said currents by variations in light intensity, means for combining and transmitting said modulated currents, means for separating said modulated currents by virtue of their different frequencies, means for rectifying each of said modulated currents comprising a corresponding plurality of three electrode groups, insulating spacing members disposed between said groups, a common cathode constituting one of the electrodes, individually insulated grid structures constituting second electrodes, individually coactive anode electrodes constituting third electrodes, a common source of potential connected to said anode electrodes, means for biasing said grid structures with respect to said cathode at cut-off potential for effecting rectification of an external exciting voltage, means comprising said anode electrodes for producing a plurality of cathode rays varying in intensity in accordance with the modulations of said rectified voltage, and means for visually translating said cathode rays.

3. In a television system, means for producing a plurality of currents of different frequencies, means for modulating each of said currents by variations in light intensity, including means for scanning an object to secure a broader source of modulation, means for combining and transmitting said modulated currents, means for separating said modulated currents by virtue of their different frequencies, means for rectifying each of said modulated currents comprising a corresponding plurality of three electrode groups, insulating spacing members disposed between said groups, a common cathode constituting one of the electrodes, individually insulated grid structures constituting second electrodes, individually coactive anode electrodes constituting third electrodes, a common source of potential for said anode electrodes, each of said anode electrodes constituting a source of secondary emission of electrons in proportion to the modulation of the number of electrons received, said anode electrodes angularly positioned with respect to said first and second electrodes, a corresponding plurality of secondary anodes each comprising a tapered tubular member positioned in alignment with the horizontal projection of the emitting surface of the corresponding source of secondary emission, means for shielding said secondary anodes from electrons emanating from said common cathode, transverse rods fixed to each of said secondary anodes and supporting said secondary anodes in spaced relation, a common source of potential connected to said secondary anodes, the tapered tubular formation of said secondary anodes acting to direct said secondary electron emissions into a plurality of cathode rays, a pair of deflection plates positioned above and below said plurality of cathode rays and embracing all of said rays for controlling the angular movement of said cathode rays in synchronism with said scanning operation, and means for visually translating said cathode rays.

4. A television system comprising a multiplicity of photo-electric units each having an individual photo-sensitive element and an anode common to a plurality of photo-sensitive elements, an alternator assembly generating a plurality of voltages of different frequencies, each generating unit in said alternator including a pair of electromagnetic windings connected in series, the two terminals of said series connection connected to two photo-sensitive elements being subjected to light from the same point, a source of potential, a resistance element connected to the negative terminal of said source of potential, the positive terminal of said source of potential connected to said common anodes, the other terminal of said resistance element connected to the middle connection of said series connected generator coils, an electron tube amplifier circuit having input and output circuits, said input circuit connected to the terminals of said resistance element, a transformer, a primary winding of said transformer connected to said output circuit, a synchronous generator, a synchronous motor, a second transformer, a series circuit comprising a primary winding of said second transformer, said synchronous motor and said synchronous generator, secondary windings of both of said transformers connected in series circuit, the terminals of said last mentioned series circuit constituting the output connections for the system converting varied intensities of light into proportional electric currents, and means for translating said propor-

tional electric currents into varying sources of light.

5. In a television system, means for obtaining a pair of images, said means comprising a lens and mirror system including a first lens acting to form a first image of an object embraced by the scope of said first lens, a shutter having a rectangular shaped aperture disposed for reciprocative movement at the position of said first image, a second lens acting to parallel all rays emanating from the portion of said first image exposed by the aperture in said shutter, a pair of reflecting surfaces disposed in angular relation, the dihedral apex of said surfaces positioned centrally of said second lens parallel to said rectangular aperture in said shutter for permitting each of said reflecting surfaces to intercept and reflect a portion of the said rays as paralleled by said second lens, a third lens individual to each reflecting member, said third lens acting to focus said reflected parallel rays as second images of said object, a pair of photosensitive retinas positioned at the foci of said third lenses, said retinas constituting means for conversion of light energy into electric energy, transmitting means, and reception means capable of translating said electric energy into light energy.

6. In a television system, means for producing a plurality of currents of different frequencies, means for modulating each of said currents by the light intensity of a separate scanning point, means for scanning an object by a linear scanning element comprising all said scanning points, instrument means for combining said modulated currents, means for separating said currents by virtue of their different frequencies, means for producing a plurality of secondary electron emissions corresponding in intensity to the modulation characteristics of the separate currents, means for forming said plurality of secondary electron emissions into a corresponding plurality of cathode rays, means for deflecting all of said rays simultaneously in synchronism with the operation of said scanning means, and means for visually translating said cathode rays.

7. A method of television which consists in simultaneously modulating a plurality of currents of different frequencies by the light intensity on a corresponding plurality of points constituting a narrow strip unit portion of an object to be televised, scanning the total object by the progression of said unit portion at a predetermined frequency across said object, combining the said modulated currents of different frequencies and current of said scanning frequency to form a complex wave, filtering the several modulated currents of different frequencies and the current of said scanning frequency into separate channels at the receiving end, producing a plurality of secondary electron emissions corresponding in intensity to the modulation characteristics of the separate filtered modulated currents of different frequencies, and deflecting all secondary electrons under control of the current of said scanning frequency to simulate the object televised.

8. In a television system, a multiplicity of photoelectric units having photo-sensitive and anode electrodes, means for generating a plurality of voltages of different frequencies including individual center-tapped output circuits for the several voltages, the two end terminals of each output circuit being connected to two photosensitive elements subjected to light from the same scanning point, a resistance element connected between said anode electrodes in common and the center taps of said output circuits in common, currents from all of said output circuits modulated by the light intensities on the respectively connected photo-sensitive elements being combined in said resistance element, and output terminals connected with said resistance element.

9. A photo-electric receiving system comprising a plurality of frequency selective filter units disposed in series connection, an electron tube amplifier having the input thereof connected to the output of one of said filters; image producing means inducing a common cathode electrode, a corresponding plurality of grid, first anode, and second anode electrodes, a shield element positioned between said cathode and said second anode electrodes, a pair of deflecting plates positioned beyond said second anode electrodes, and a fluorescent screen aligned with said first and second anode electrodes and said deflecting plates; the output of said last mentioned amplifier connected to said deflecting plates, a source of potential, said second anode electrodes connected to the positive terminal of said source of potential, said first anode electrodes connected to said source of potential at a less positive potential and constituting independent sources of secondary electron emission, the negative terminal of said source of potential connected to said cathode electrode, one terminal of each of the outputs of the others of said filters connected in predetermined order to said grid electrodes, the other terminals of said outputs connected in common to said cathode electrode, and a source of bias potential connected between said common connection and said cathode electrode, the controls effected by the outputs of said filters acting to translate said modulated electric currents into light energy on said fluorescent screen through the medium of primary electron emission from said cathode and secondary electron emission from said first anode electrodes.

10. In a television receiving system, image producing means including a cathode electrode providing a primary source of electrons, a plurality of control electrodes associated with said cathode, a corresponding plurality of anode electrodes associated with said control electrodes and said cathode electrode, said plurality of anode electrodes constituting a plurality of secondary sources of electrons, a corresponding plurality of secondary anodes associated with said plurality of secondary sources of electrons, said secondary anodes acting to form said secondary electrons into a corresponding plurality of point rays, a pair of deflecting plates embracing all of said point rays of electrons, and operative to deflect all of said rays as a beam of electrons, a fluorescent screen positioned in the path of said electron beam and luminescent under the incidence of said beam, video signals means for individually varying the charges on said control electrodes to control the primary emission of electrons, and scanning signal means for varying the charges on the deflecting plates for controlling the deflection of said electron beam from the normal position thereof on said fluorescent screen.

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