

Feb. 3, 1931.

G. WALD

1,790,736

TELEVISION TRANSMISSION APPARATUS

Filed Aug. 30, 1929

4 Sheets-Sheet 1

Fig. 1.

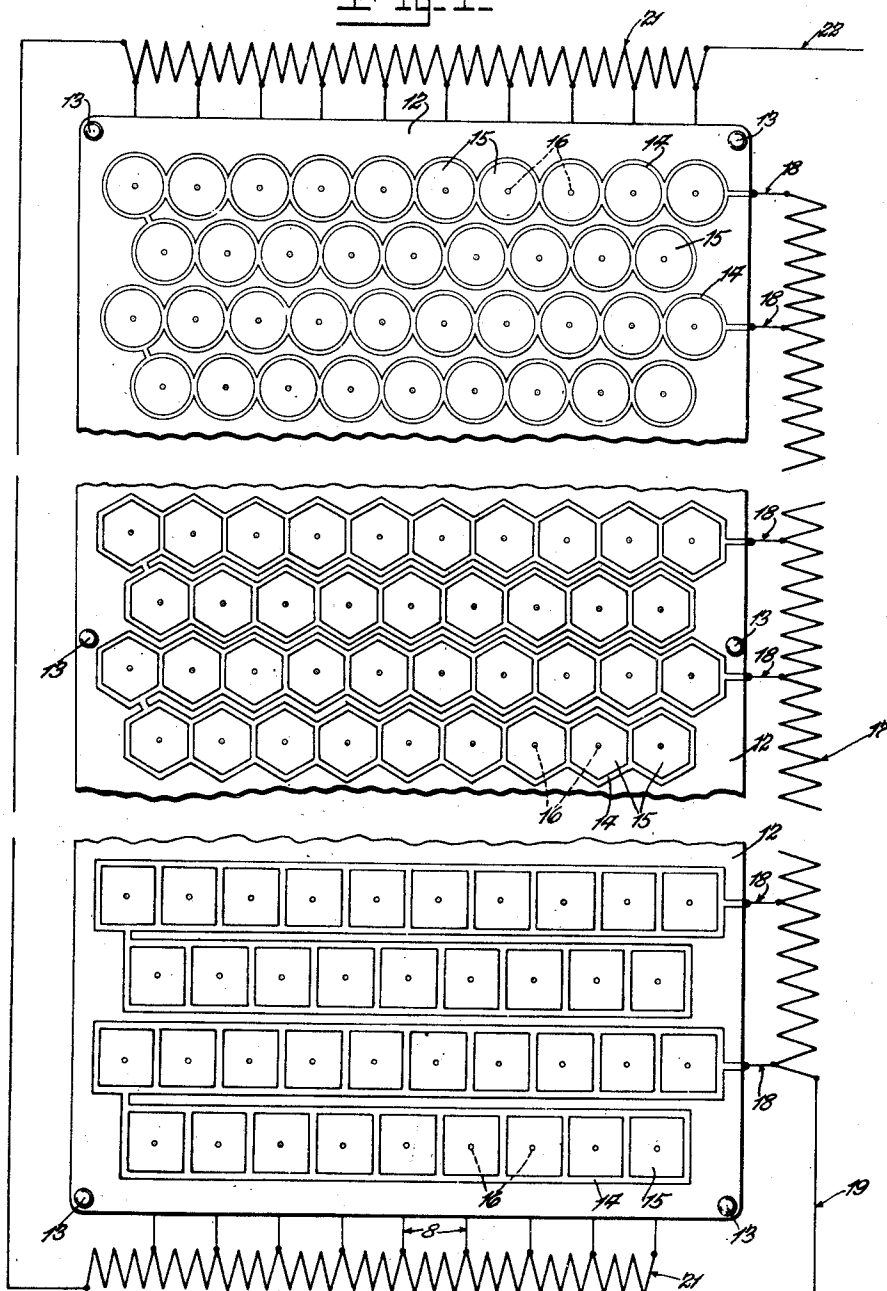
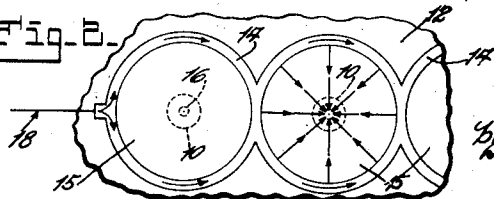


Fig. 2.



Inventor:
George H. Wald,
by R. P. Rappley & Kingsland,
His Attorneys.

Feb. 3, 1931.

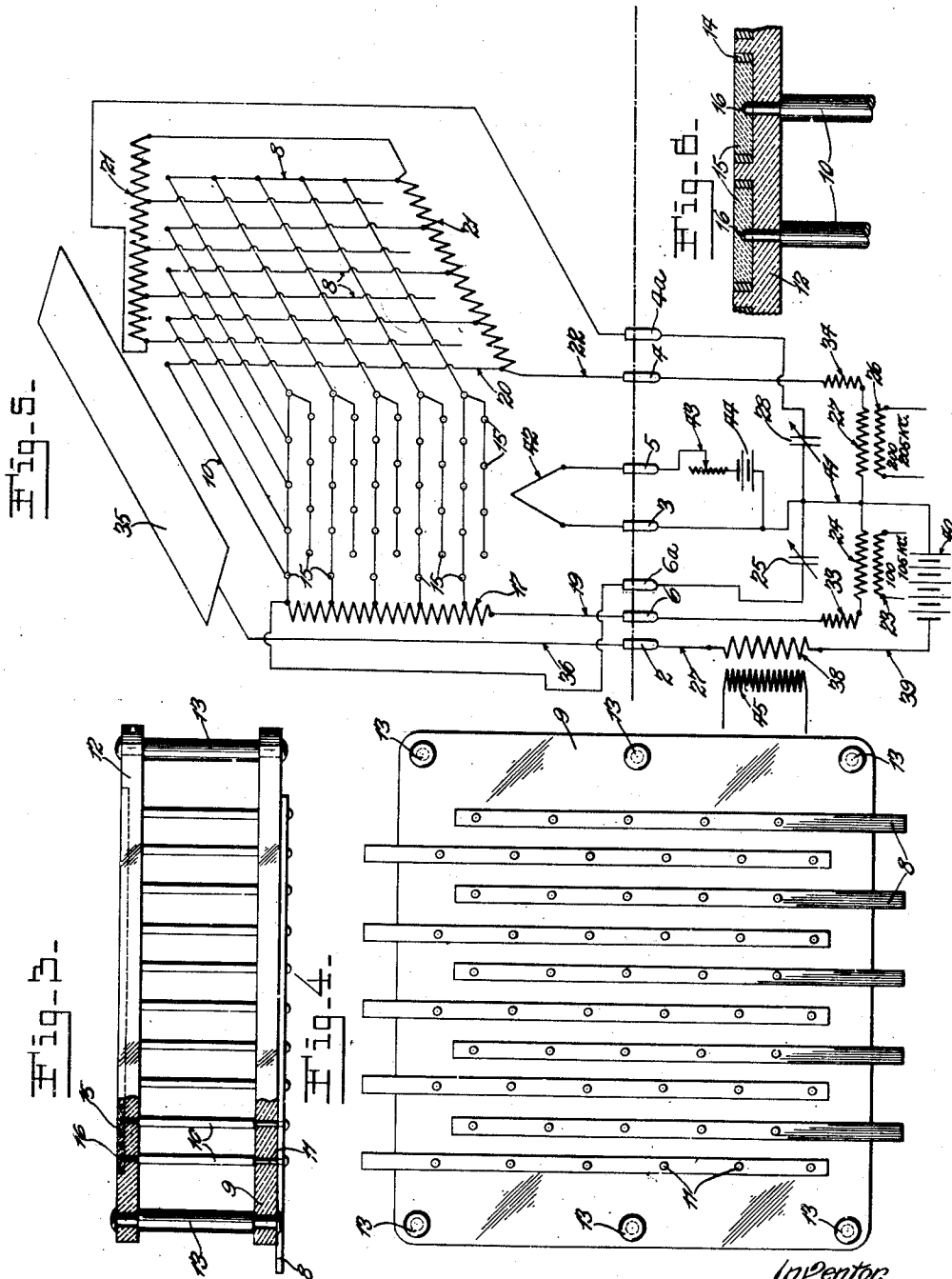
G. WALD

1,790,736

TELEVISION TRANSMISSION APPARATUS

Filed Aug. 30, 1929

4 Sheets-Sheet 2



Inventor:
George Wald,
by Rippey & Kingsland,
His Attorneys.

Feb. 3, 1931.

G. WALD

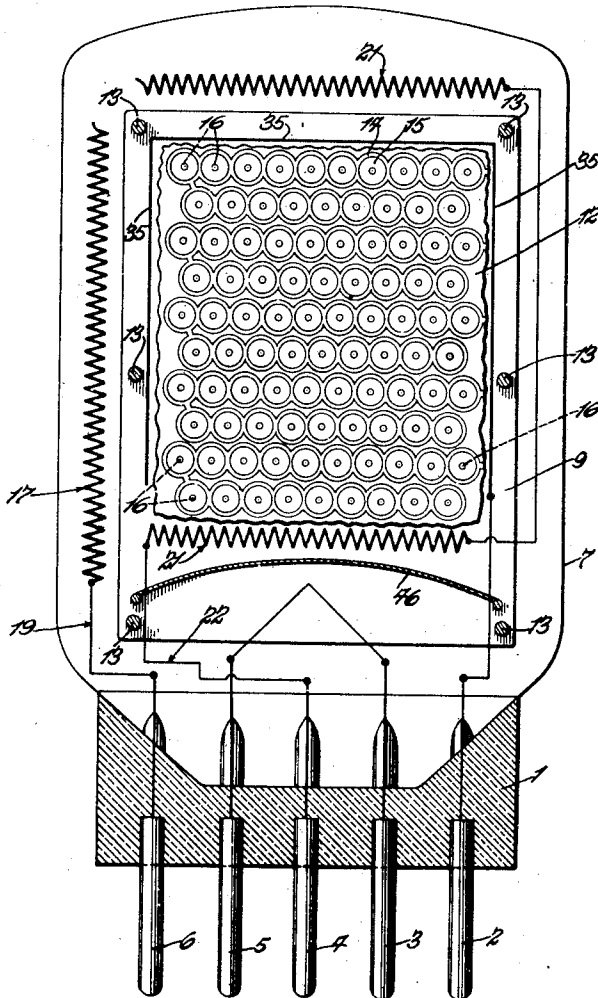
1,790,736

TELEVISION TRANSMISSION APPARATUS

Filed Aug. 30, 1929

4 Sheets-Sheet 3

Fig. 7.



Inventor:
George Wald,
by Nipsey & Kingsland,
His Attorneys.

Feb. 3, 1931.

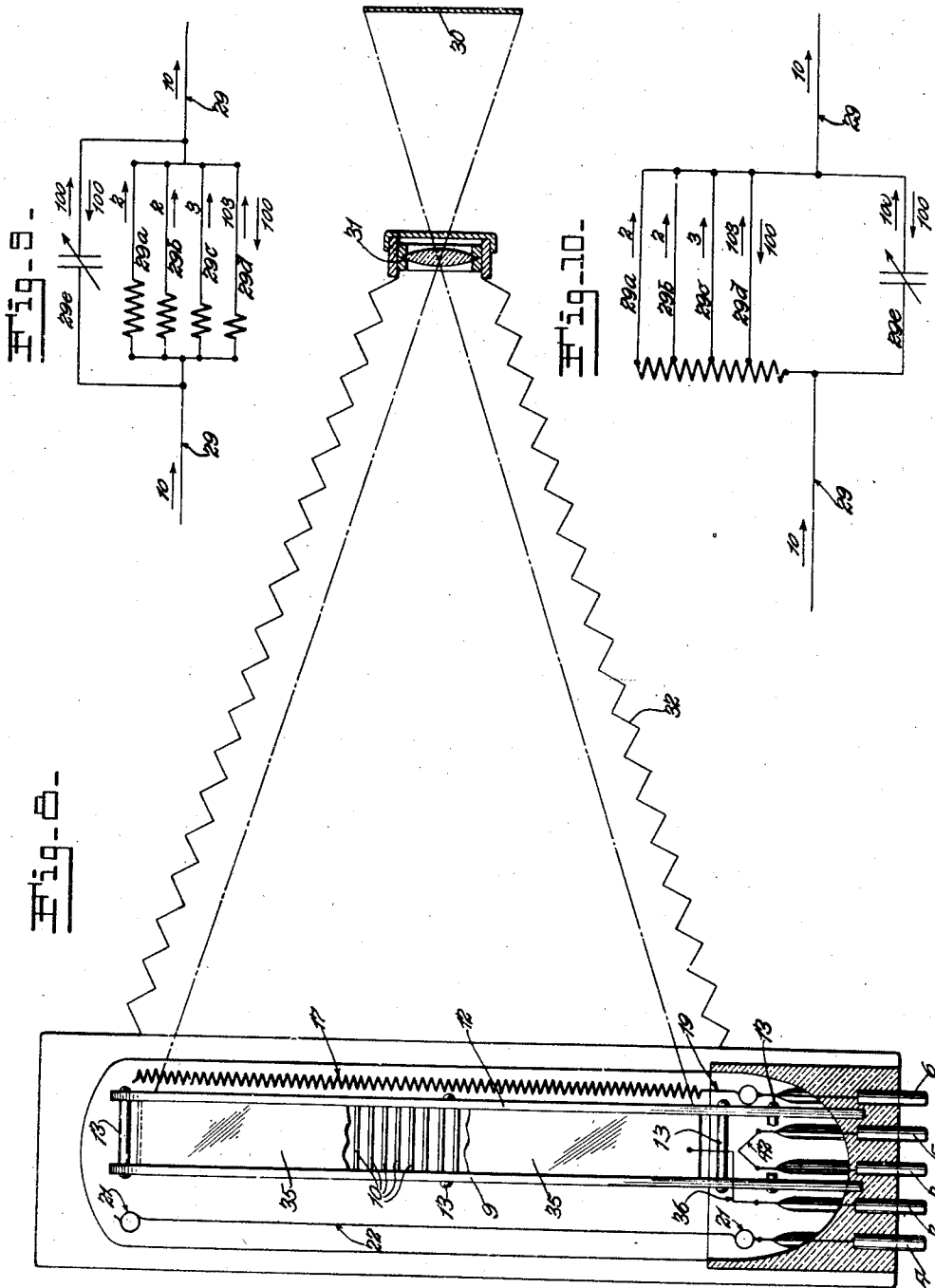
G. WALD

1,790,736

TELEVISION TRANSMISSION APPARATUS

Filed Aug. 30, 1929

4 Sheets-Sheet 4



Inventor:
George Wald,
by Ruppel & Kingsland,
His Attorneys.

UNITED STATES PATENT OFFICE

GEORGE WALD, OF BELLEVILLE, ILLINOIS

TELEVISION TRANSMISSION APPARATUS

Application filed August 30, 1929. Serial No. 339,333.

This invention relates to improvements in television transmission apparatus.

An object of the invention is to produce a television transmission apparatus, including a light-sensitive frame that will convert images into amplified electric current impulses that may be transmitted to a receiver for reproduction, by direct reflection of the image on the frame which is equipped with light-sensitive cells, whereby the electric current impulses are controlled by the variation in resistance resulting from the varying degrees of light reflected from the image.

The full scope and objects of the invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which

Fig. 1 is a composite illustrative view of the receiving frame illustrating optional forms of light-sensitive cells together with the electrical connections therefor.

Fig. 2 is an enlarged view of a pair of light-sensitive cells illustrating the current path therethrough.

Fig. 3 is a side view, partially in section, illustrating the construction of the grid rods in association with the light-sensitive cells and the elements whereby the light-sensitive cells are connected into the circuit.

Fig. 4 is a bottom plan view of the grid element.

Fig. 5 is a diagrammatic view of the grid element with the complete electrical circuits therefor.

Fig. 6 is an enlarged view, in vertical section, of a pair of light-sensitive cells showing the detailed association of the grid rods therewith.

Fig. 7 is a front view of the assembled receiving frame, portions being broken away to fully illustrate the complete construction of the unit and its connections.

Fig. 8 is a view, partially diagrammatic and partially in section, illustrating the side of the television receiving apparatus including the lens system for focusing the image on the receiving frame.

Fig. 9 is an illustrative diagram showing the alternating current parallel circuits and the current path in each.

Fig. 10 is a diagram further illustrating the principles of the circuits involved in the apparatus.

The sending apparatus includes a vacuum tube having a base piece 1 from which prongs 2, 3, 4, 4a, 5, 6 and 6a project, said prongs being connected at their inner ends with the internal leads of the respective circuits and their outer ends being adapted to contact with the external leads when the base 1 is mounted in a socket. The base piece 1 supports a tube 7 which is preferably shaped as shown in Fig. 7, being substantially rectangular in outline with the front and back walls spaced apart and the top and side walls rounded. The tube is thus substantially flask-shaped.

The grid element is made up of a plurality of flat plates 8 preferably arranged in parallel series with the ends of each alternate plate offset, as shown in Fig. 4. The plates 8 are mounted on the back of a plate 9 of insulating material. A plurality of series of grid rods 10 extend at right angles to the plates 8, each of said rods having a reduced extremity 11 that passes through an opening in the plate 9, the rods of each series being respectively electrically connected to one of the plates 8.

A plate 12 of insulating material is spaced from the plate 9 and held in this adjustment by a plurality of spacing rods 13 connected respectively at their opposite ends with the plates 9 and 12. The plate 12 is of a non-transparent, insulating material, and constitutes the mounting for the plurality of light-sensitive cells and a plurality of series of conductors 14.

In Fig. 1 of the drawing optional forms of the light-sensitive cells are shown, the manner in which they are constructed is as follows: In the face of the plate 12 there are formed series of molded cavities in parallel groups in which are seated strips of stamped conductor members of the form and outline shown in the optional views in Fig. 1. In the upper broken panel of Fig. 1 is shown a series of intersecting circles arranged in parallel groups, the adjacent parallel groups being connected so that each conductor com-

prises a single conductor of two branches that lie parallel with each other. In the intermediate broken panel the outline of the conductors are shown as comprising a series of connected hexagons, the alternate branches being offset to interfit as shown in the drawing. In the lower broken panel is shown alternate series of offset connected squares.

It should be understood that whatever may be the form of the selected cell outline the cavities in the plate 12 are correspondingly made to accommodate the selected form. The cavities in the plate 12 are very shallow, approximately 1/100 of an inch deep, and the conductor strips 14 of either selected form are inserted in the cavities so that within the area defined by the contour of the conductor plates there remains a slight depression. In mounting the conductors in the plate 12 the cross dimension of each circle, hexagon or square is slightly greater than the cavities as originally formed in the plate 12, so that when the edges of the conductor strips are pressed into the cavities, a slight spring action will be exerted against the walls of the cavities to hold the conductors in place. After the conductors have been thus mounted the internal spaces defined by the conductors are filled with melted selenium, or other light re-acting material, and the surplus scraped or removed from the entire plate so as to leave the selenium or other material in a thin disc form, thereby forming the cell discs 15. After the discs have thus been molded, the material is annealed to approximately 180° C., thereby forming a permanent conductive variable resistance connector between the walls of each cell through which current flows under certain conditions hereinafter more fully explained.

Each of the grid rods 10 has an upper reduced portion 16 that extends through the plate 12 and terminates in respective ones of the cell discs 15, the point of each rod being embedded in such cell disc.

In assembling the grid element the grid rods are held in a template and the plate 9, with the suitably formed openings therein, is placed over the ends of the rods with the reduced portions 11 extending through the openings. The plates 8 are then assembled and the ends of the reduced portions 11 of the grid rods are flattened or riveted over to hold them in place. The template is then removed and the plate 12, provided with the suitably formed openings, is mounted over the opposite ends of the grid rods with the reduced portions 16, extending through said openings, and the spacing rods 13 assembled to clamp the plates 9 and 12 over the grid rods. The conductors 14 are then set in place in the cavities formed in the upper face of the plate 12, and the selenium or other light reactive material is moulded into the

cavities defined by the contour of the conductor plates 14, thus completing the grid element.

At one side of the conductors 14, and within the tube 7, is an induction coil 17. The separate conductors 14, comprising two branches, are tapped into the induction coil 17 at equidistant points through tap leads 18. The lower end of the coil 17 is connected by a lead 19 to the prong 6 in the base piece 1.

The plates 8 are respectively tapped in by tap leads 20 to an induction coil 21 formed in two branches, the lower end of said coil being connected with the prong 4 by a lead 22.

The grid circuits may be understood by reference to the diagram shown in Fig. 5. A variable frequency current is received on a primary 23. The frequency of the current, for example, is from 100 to 105 kilocycles. The current is impressed on the secondary 24. A variable condenser 25 functions to tune the secondary with the circuits for the conductor 14. This variable frequency, because of the balancing of the induction and capacity of the circuits, produces resonance in sequence in the separate conductors 14. That is to say, a circuit is so tuned that resonance will be produced in the upper one of the series of conductors 14 at 100 kilocycles frequency; and in the lower one of the series of conductors 14 at 105 kilocycles frequency, the frequency attained intermediate these two limits producing resonance in the intermediate conductors.

The primary 26 receives a variable frequency current of, for example, from 200 to 205 kilocycles which is impressed upon a secondary 27. A variable condenser 28 functions to tune the secondary 27 with the circuits for the plates 8. The secondary produces resonance in the plurality of plates 8 so that one end of the series responds at 200 kilocycles and the other end of the series at 205 kilocycles, with the intermediate plates being brought under resonance by intermediate frequencies.

In my Patent No. 1,754,491, granted April 15, 1930, I have shown a general system for transmission and reception of television in which there is employed synchronized variable condensers. It is my purpose to use that construction to energize the primaries 23 and 26, respectively, of the present application. Because full description of the construction of the condensers has been given in my said patent, it is unnecessary to repeat the construction here, suffice it to say that the transformer 23—24 of the present application corresponds to the transformer 54 of my said patent, and that the transformer 26—27 of the present application corresponds to the transformer 48 of my copending application. As a result of the operation of the synchronized variable condensers of the said patent there is impressed upon the primaries 23 and

26 of the present application synchronized bands of variable frequency.

Since all of the conductors 14 are tapped at equidistance across the coil 17, and all of the plates 8 are tapped at equidistance across the coil 21, it follows that resonance is produced at equidistance throughout the series of conductors 14 between the band of variable frequencies; for example, between 100 and 105 kilocycles, while resonance will be produced across all of the plates 8 at equidistance from each plate during periods, the sum of which is equal to the time that one of the conductors 14 is under resonance. Therefore, it follows that, while the incoming current on the secondary 24 passes from 100 to 105 kilocycles, all of the plates 8 are traced by resonance from top to bottom of the conductors 14.

In order better to understand the phenomenon which is the basis of operation of the apparatus reference may be made to the diagrams in Figs. 9 and 10, and to a brief consideration of the mathematics involved. The equation of a resonant condition must be such that

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f is the frequency of the current, L the inductance in henries, and C the capacity in farads. Now, by reference to Fig. 9, there will be found a main circuit 29 and a parallel circuit of branches 29a, 29b, 29c and 29d, each branch circuit having a progressively increasing inductance, and a branch 29e which includes a variable condenser. Let it be assumed that the alternating current is applied across this circuit, and that f has such a value that L of the branch 29d satisfies the resonance equation above given. Then, it follows that the values in amperes of the respective currents in the circuits will be as shown in the calculations above the arrows in the diagram (Fig. 9), and that the current flow will be in the direction indicated by the arrows.

In this case the inductive reactance causes a current to lead the E. M. F. by a phase angle of 90° , while the capacitive reactance causes the current to lag 90° . That is to say, due to capacity the current is 180° behind the current due to induction. Therefore, the current flow is in the opposite direction 180° electrically displaced. Again, by reference to the diagram it appears that the main circuit has 10 amperes going to the right; that the branch 29a has 2 amperes; the branch 29b has 2 amperes and the branch 29c has 3 amperes going in the same direction, while the branch 29d has 103 amperes likewise flowing in the same direction simultaneously with the current flow of 100 amperes in the opposite direction, and that in the branch 29e there is a current of 100 amperes in both directions.

The algebraic sum of the parallel circuits is $2+2+3+103-100+100-100=10$ in amperes, which is equivalent to the main circuit. In the branch circuits 29d and 29e 100 amperes flow in the opposite direction and, therefore, inductively and capacitatively, there is no wattage of energy. Ohmic-resistively, however, there is a loss in wattage equal to I^2R , I representing the current and R the ohmic resistance of the circuit. Assuming E equal to the applied E. M. F. we have

$$\frac{E}{R} = I,$$

that is the total E acting in the branch circuit divided by the ohmic resistance of the branch circuit produces a maximum current, it being understood that E is a composite of E due to ohmic, inductive and capacitive developments. Thus, it is seen in a branch circuit where resonance exists, that the ohmic resistance determines the maximum quantity of current in the branch.

The description has been made in regard to Fig. 9 but it will be understood that Fig. 10 substantially duplicates the diagram in Fig. 9, with the exception that in Fig. 10 the inductance is added to each branch in series by tapping one induction coil at different points, thus producing gradually increasing induction in the branches 29a to 29d. Therefore, since Fig. 10 represents principle of the grid circuit hereinbefore described, the phenomena of resonance with the mathematics involved may be understood from the foregoing description.

Returning now to the light-sensitive frame hereinbefore described, it should be understood that the apparatus is so designed that an image 30 may be reflected through a lens system 21 connected with a bellows 32, so that the image in magnified form may be cast upon the area containing the light sensitive cells. As the resistance of the selenium is subject to the light shades reflected from the image, and as the ohmic resistance of each cell is the main ohmic resistance of its respective grid rod circuit, it follows that while each grid rod has some current in its circuit which varies with the resistance of its respective selenium cell, yet the total amount of all of the grid rod currents is less than the current in the grid rod circuit which is under resonance.

The current is then divided among all of the grid rod circuits. The current in the grid circuit under resonance is independent of the line voltage, but is dependent on the total voltage (ohmic, inductive and capacitive) in its branch circuit.

The normal current that flows through the conductors 14, except in such cell as may be under resonance which is brought about as above described, is through the path of least

resistance, namely around the metallic conductor member, and results in no impulses emanating from that portion of the frame. When a particular cell is brought under resonance the path of the greatly augmented current is no longer throughout the conductor strips, but is from the wall of the particular cell through the selenium disc, and through the corresponding grid rod. Since the resistance of the selenium disc is directly responsive to light and shade, the current that passes through the cell disc under resonance will vary within limits, as determined by the varying resistance resulting from the light and shade. This current passing through the grid rod is amplified. By references to Fig. 2 it will be seen the current path of a cell under resonance is clearly illustrated diagrammatically.

The means for amplifying the current comprises the usual three-electrode principle. The apparatus includes a plate circuit. The plate 35 is mounted in the tube and embraces three sides of the grid rod bank. The plate 35, in the form of a U-shaped strip, is mounted between the plates 9 and 12 and is connected by a lead 36 with the prong 2, which connects with a lead 37 through the primary 38 of the television output transformer. This plate 35 is covered outwardly with electrical insulating material so that the electronic flow from the filament will be through the grid rods 10. The circuit from the primary 38 is completed through a lead 39 to a source of power 40, the opposite end of the power element being connected with the common filament lead 41 which, in turn, connects with the prong 3 constituting one terminal of the filament 42. The opposite terminal of the filament 42 is the prong 5 which connects with the variable resistance element 43 in circuit with a filament source of power 44.

I have shown above where the filament 42, grid rods 10, and one side of the plate 35 are enclosed within the chamber formed (Fig. 8) by plates 9 and 12 and the outer insulative material on plate 35. It was also shown that an alternating current will flow through each grid rod 10 successively one after the other, corresponding to the resonance across the corresponding selector. From the circuits shown in Fig. 5 it will be seen that the current in the plate circuit, plate 35, 36, 2, 27, primary 38, 39, B-power 40, 41, 3 and filament 42, will likewise be an alternating current, like that induced in the grid rod 10, but amplified in magnitude. The amplitude of each alternating current wave will be that which the corresponding grid rod has at each instance. The current in the secondary 45 will then be an alternating current of variable wave length and of an intensity corresponding to current produced by the light and dark shades of the image focused on the light-actuated cells 15.

The impulses in the secondary television output circuit may be received by an apparatus such, for example, as that shown in my Patent No. 1,754,491, or in my copending application Serial No. 373,076.

In Fig. 1 I have illustrated various optional forms of the conductors 14 and of the cells embraced therein. The consideration that induces the preference for the form shown in the upper broken panel is that the current path is equal from the cell wall to the center of the cell disc at which point the grid rod is positioned. It has a disadvantage in that the space between the cell walls is dead space, unresponsive to light, and therefore the sensitive area is not coextensive with the reflected image. Due to the increased size of the image, this will have little practical effect on the television impulses generated by the apparatus. The middle broken panel in which the cells are in the form of hexagons has the very distinct advantage of minimizing the dead space, but results in a variable current path through the resistance discs. The connected squares shown in the lower broken panel respond closely to a straight line transmission of the image and has the advantage in that the dead space is considerably minimized. In practical operation the selection between the various forms of cells is optional.

It should be noted in connection with the use of the selenium material for the light reactive discs, that the usual lag, causing selenium to be discarded in connection with television, is not present in the instant apparatus, because the several selenium cells are under the influence of light and remain continuously reactive, and are not subject to instantaneous variations of light. The period of excitation of the several cells is so short in duration that the physical property of selenium is no disadvantage, but constitutes rather an advantage in that if there be a movement of the image the response in the selenium disc is not prompt enough to register the blurred line that would result if the selenium were instantaneously responsive.

The size of the image to be transmitted by the apparatus does not necessarily correspond to the area of the frame. A 1" x 1" image may be reflected on a 10" x 10" frame, for example, by enlargement through a lens system. It is contemplated that by a sixty line to the inch picture, the cells shall be approximately one-sixth of an inch in diameter; that for a fifty line to the inch picture, approximately one-fifth of an inch. Thus, the plate may be ten times the size of the image.

When the distance from the lens to the frame is relatively large, provision should be made to maintain the intervening space under vacuum so that there will not be any reflection or refraction of the light rays reflected from the image. This, however, is unnecessary.

sary on smaller image transmission or on smaller frame construction.

While I have particularly described the construction of the cell as employing selenium, I contemplate any light reactive form of cell such, for example, as an electrolytic cell, or cathode ray cell, which would be responsive to the light reflected from the image.

I am aware that the invention may be modified in numerous particulars without departure from the spirit and scope thereof.

I do not limit myself unessentially, but what I claim and desire to secure by Letters Patent is:—

1. A television transmission apparatus comprising a frame composed of a series of conductors adapted to receive electrical impulses of varying frequency, light-sensitive varying resistance cells electrically connected with said conductors, a second series of conductors adapted to be excited by impulses of varying frequency, grid rods intermediate the respective cells and said second series of conductors, circuits for exciting said first named conductors, circuits for exciting said second named conductors, and means for bringing said circuits into resonance.

2. A television transmission apparatus comprising a frame composed of a series of conductors adapted to receive electrical impulses of varying frequency, light-sensitive varying resistance cells electrically connected with said conductors, a second series of conductors adapted to be excited by impulses of varying frequencies, grid rods intermediate the respective cells and said second series of conductors, circuits for exciting said first named conductors, circuits for exciting said second named conductors, means for bringing said circuits under resonance and thereby exciting the grid rods with electrical impulses of varying amplitude, and means for amplifying the impulses of the separate grid rods.

3. A television transmission apparatus comprising a frame composed of a series of conductors adapted to receive electrical impulses of varying frequency, light-sensitive varying resistance cells electrically connected with said conductors, a second series of conductors adapted to be excited by impulses of varying frequency, grid rods intermediate the respective cells and said second series of conductors, circuits for exciting said first named conductors, circuits for exciting said second named conductors, means for bringing said circuits under resonance and thereby exciting the grid rods with electrical impulses of varying amplitude, means for amplifying the impulses of the separate grid rods, and means for transmitting said amplified impulses for reception.

4. In an apparatus of the class described a light-sensitive frame comprising a series of metallic conductors, a plurality of light-sensitive discs embraced within the conduc-

tors and in electrical connection therewith, a circuit for exciting said conductors by varying frequency electrical impulses, a second series of conductors, means for exciting said second series of conductors by varying frequency impulses so co-ordinated that all of said second series of conductors will be excited while one of the first series of conductors is excited, grid rods connected with said light-sensitive cells at one end and with said second series of conductors at the other end and adapted to be energized when the circuits for said second series of conductors operate to bring a selected cell under resonance, and means for amplifying the grid rod impulses.

5. In an apparatus of the class described a light-sensitive frame comprising a series of metallic conductors, a plurality of light-sensitive discs embraced within the conductors and in electrical connection therewith, a circuit for exciting said conductors by varying frequency electrical impulses, a second series of conductors, means for exciting said second series of conductors by varying frequency impulses so co-ordinated that all of said second series of conductors will be excited while one of the first series of conductors is excited, grid rods connected with said light-sensitive cells at one end and with said second series of conductors at the other end and adapted to be energized when the circuits for said second series of conductors operate to bring a selected cell under resonance, means for amplifying the grid rod impulses, and means for transmitting said amplified impulses.

6. In an apparatus of the class described a rectangular frame comprising a plate of insulating material, a plurality of conductors set in said plate, said conductors being so formed as to provide cell spaces, light-sensitive material formed in discs and filling said cell spaces, means for exciting said conductors, a second series of conductors, means for exciting said second series of conductors, and grid rods extending from the cell discs to respective ones of said second series of conductors.

GEORGE WALD.