

Oct. 22, 1940.

A. N. GOLDSMITH

2,219,149

TELEVISION SYSTEM

Filed Feb. 6, 1937

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Fig. 1

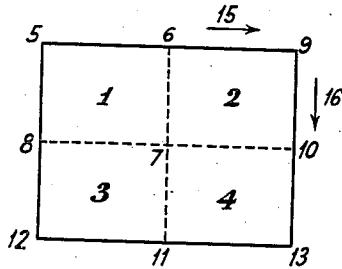


Fig. 2

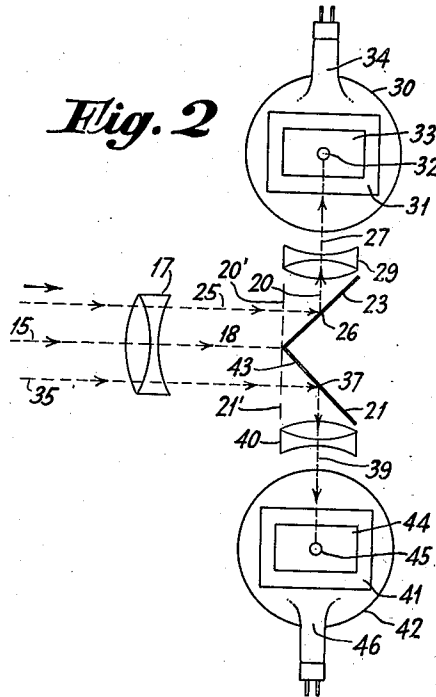
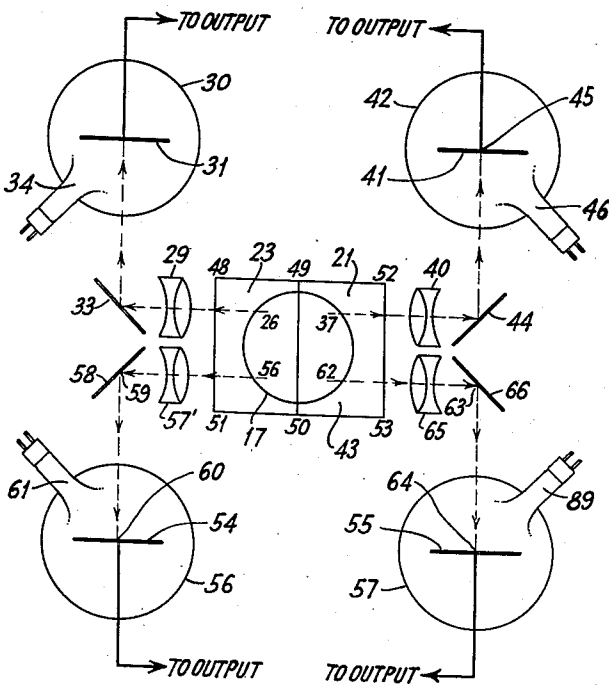


Fig. 3



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ATTORNEY

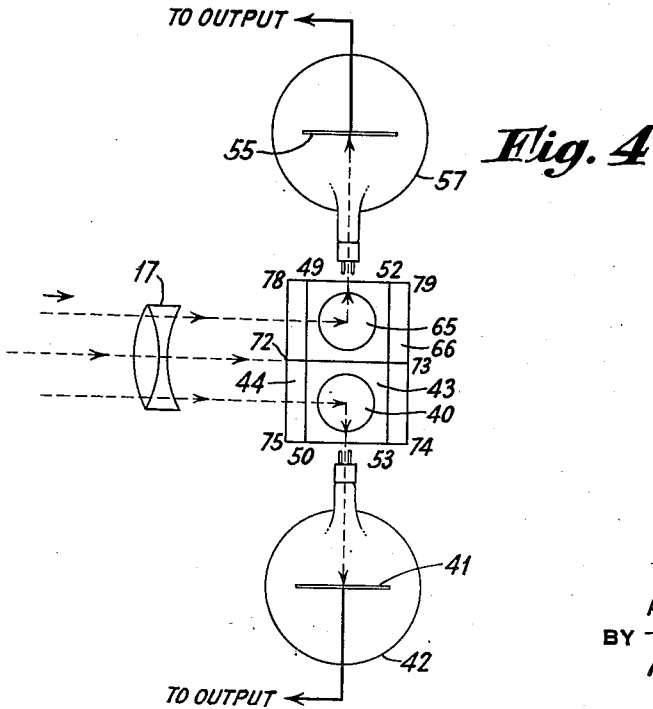
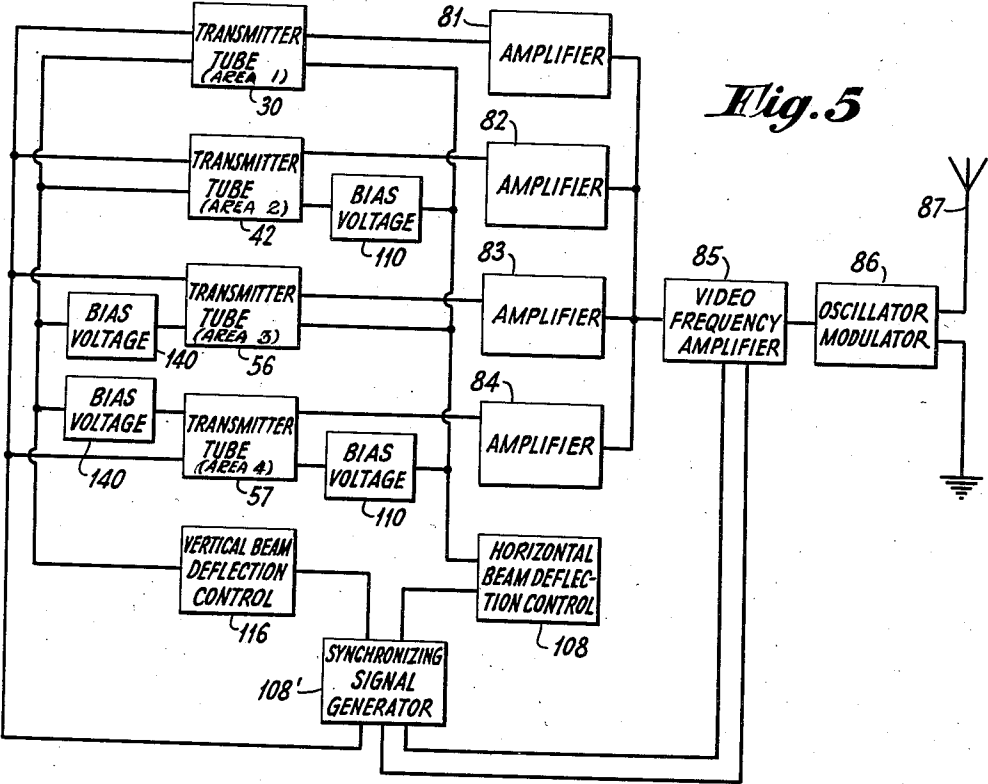
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A. N. GOLDSMITH

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Fig. 6

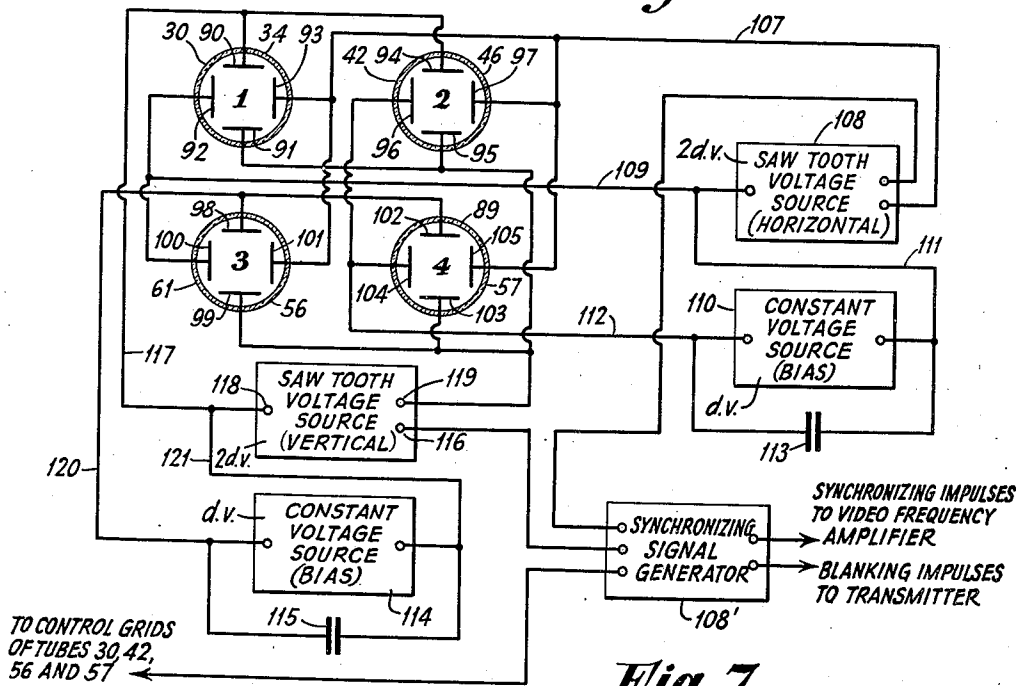
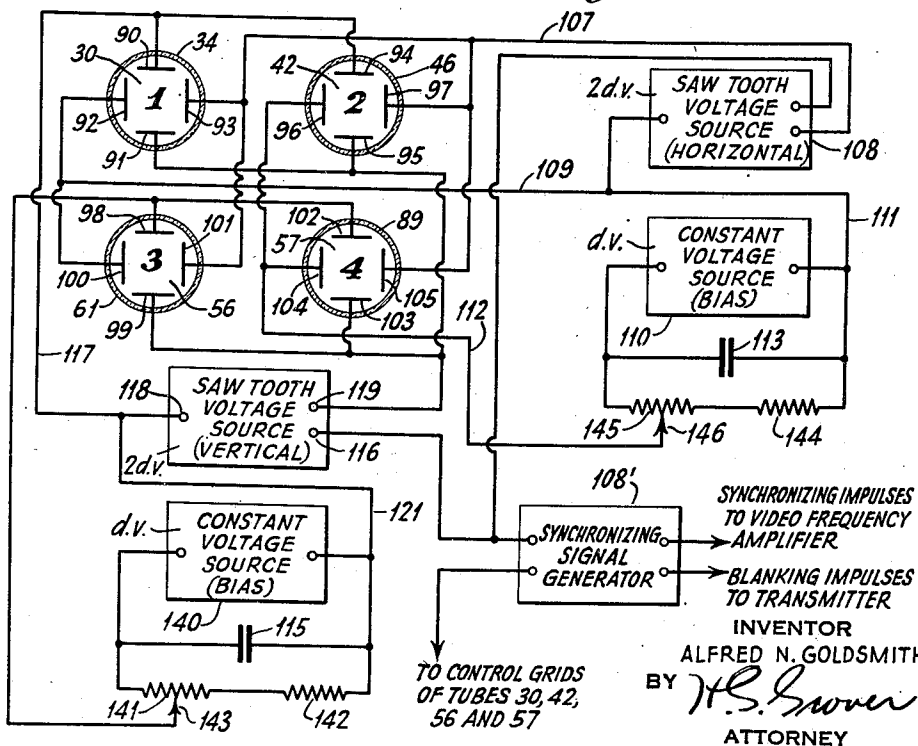


Fig. 7



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Oct. 22, 1940.

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Fig. 8

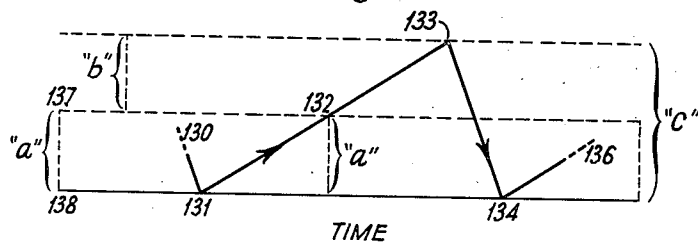


Fig. 9

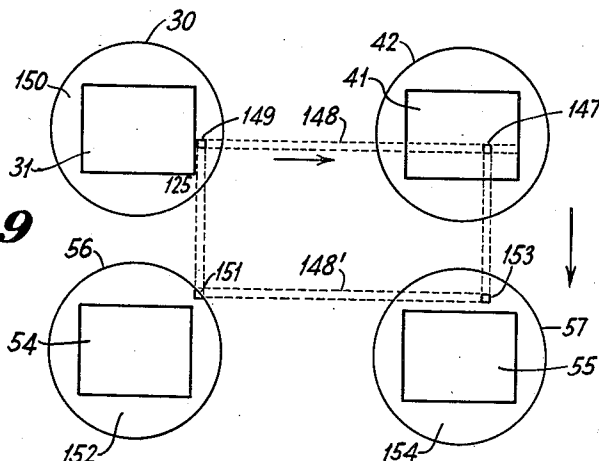


Fig. 10

LINE	FRACTIONAL PORTION	SCANNING TUBE	LINE	FRACTIONAL PORTION	SCANNING TUBE
1	$0-\frac{1}{2}$	30	361	$0-\frac{1}{2}$	56
1	$\frac{1}{2}-1$	42	361	$\frac{1}{2}-1$	57
RETURN-- BEAM OFF		42, 30	RETURN-- BEAM OFF		57, 56
2	$0-\frac{1}{2}$	30	362	$0-\frac{1}{2}$	56
2	$\frac{1}{2}-1$	42	362	$\frac{1}{2}-1$	57
RETURN-- BEAM OFF		42, 30	RETURN-- BEAM OFF		57, 56
3	$0-\frac{1}{2}$	30	720	$0-\frac{1}{2}$	56
3	$\frac{1}{2}-1$	42	720	$\frac{1}{2}-1$	57
RETURN-- BEAM OFF		42, 30	RETURN-- BEAM OFF--		
360	$0-\frac{1}{2}$	30	TO BEGINNING OF NEXT PICTURE		
360	$\frac{1}{2}-1$	42	1	$0-\frac{1}{2}$	30
RETURN-- BEAM OFF		42, 30	1	$\frac{1}{2}-1$	42

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Fig. 11

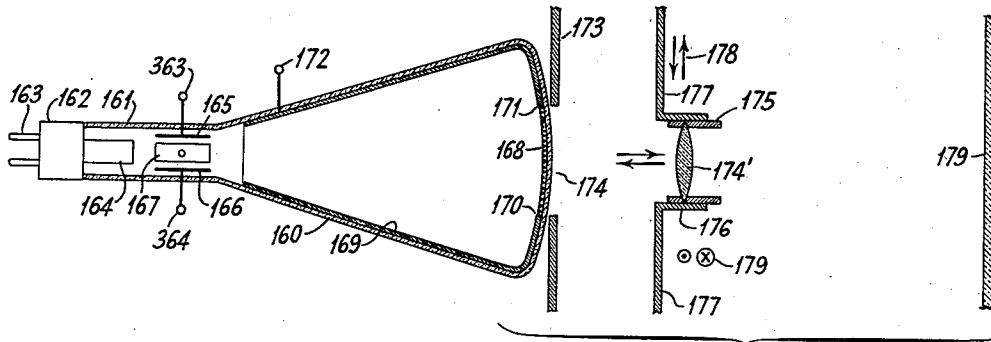


Fig. 12

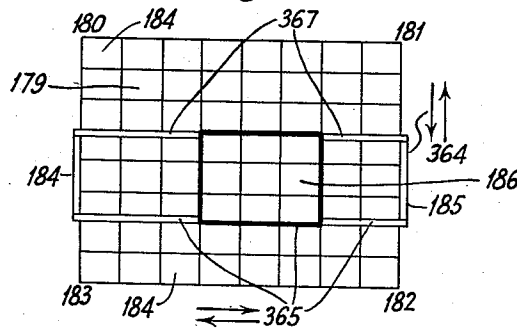
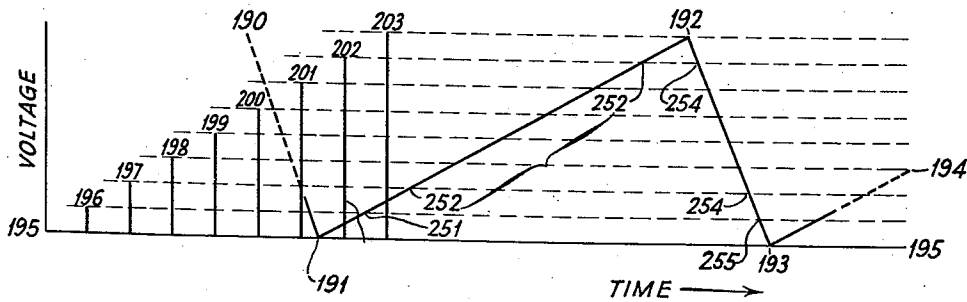


Fig. 13



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A. N. GOLDSMITH

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Fig. 14

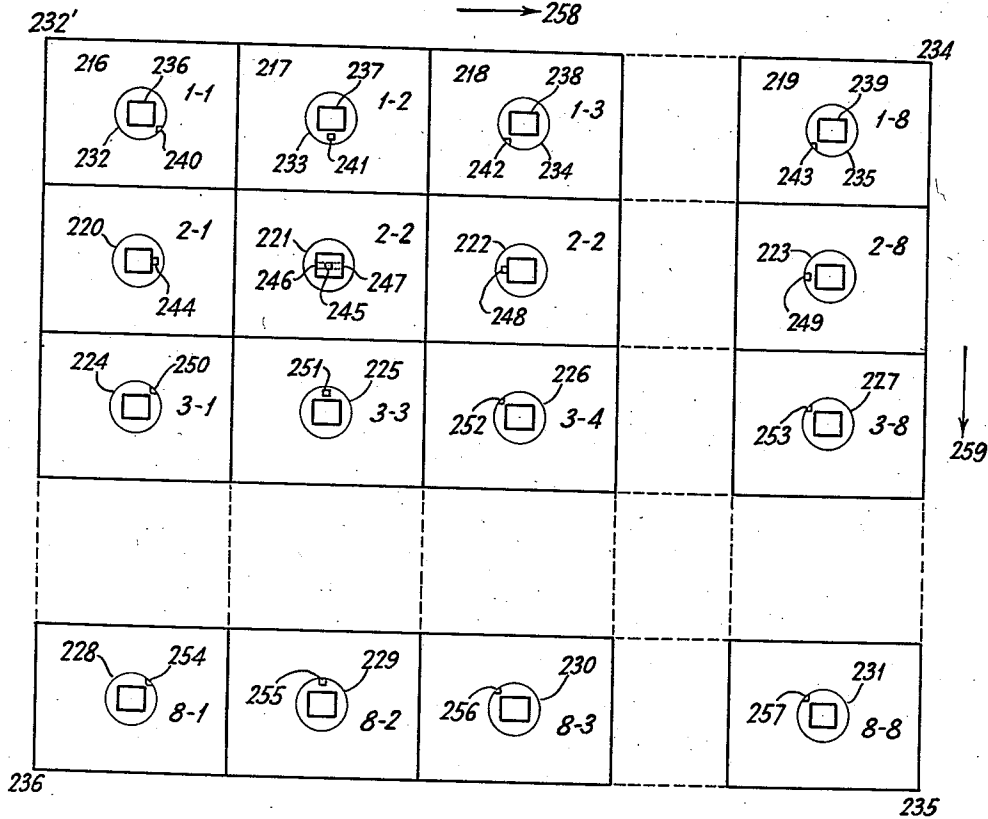
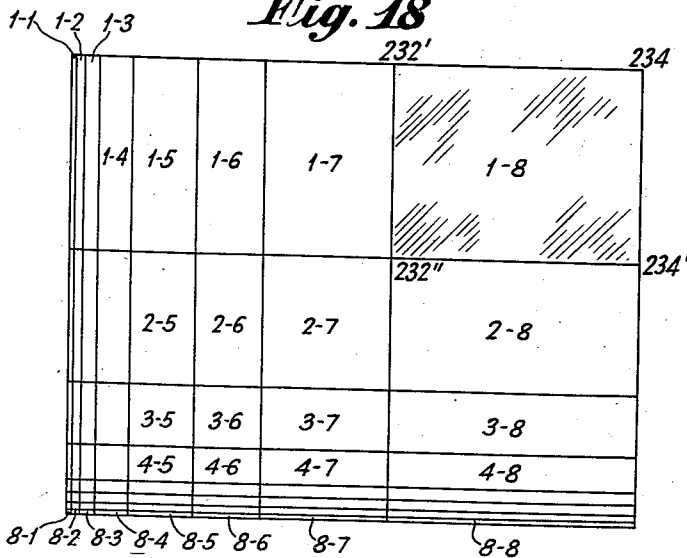


Fig. 18



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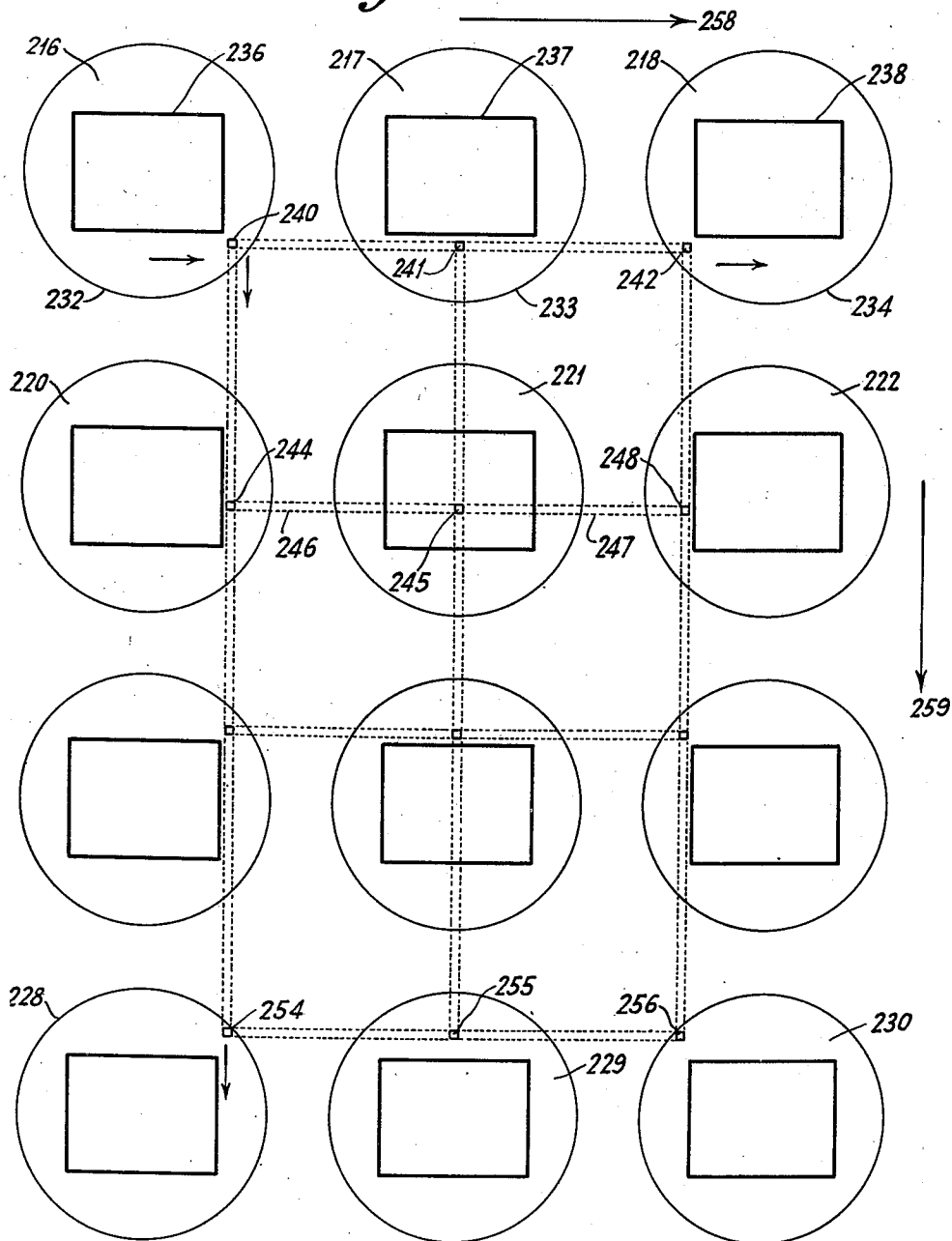
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Fig. 15



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Fig. 16

(CONTINUED)

COMPONENT SUB-PICTURE		PICTURE LINE	LINE SECTION	COMPONENT SUB-PICTURE		PICTURE LINE	LINE SECTION
TUBE ROW (FROM TOP)	TUBE COLUMN (FROM LEFT)	(FROM TOP OF PICTURE)	(FROM LEFT OF LINE)	TUBE ROW (FROM TOP)	TUBE COLUMN (FROM LEFT)	(FROM TOP OF PICTURE)	(FROM LEFT OF LINE)
1	1	1	$0 - \frac{1}{8}$	2	1	46	$0 - \frac{1}{8}$
1	2	1	$\frac{1}{8} - \frac{1}{4}$	2	2	46	$\frac{1}{8} - \frac{1}{4}$
1	3	1	$\frac{1}{4} - \frac{3}{8}$	2	8	46	$\frac{7}{8} - 1$
1	4	1	$\frac{3}{8} - \frac{1}{2}$	2	8 → 1	LINE RETURN-BEAM OFF	
1	8	1	$\frac{7}{8} - 1$	2	1	47	$0 - \frac{1}{8}$
1	8 → 1	LINE RETURN-BEAM OFF		2	8	47	$\frac{7}{8} - 1$
1	1	2	$0 - \frac{1}{8}$	2	8	90	$\frac{7}{8} - 1$
1	2	2	$\frac{1}{8} - \frac{1}{4}$	2	8 TO } 3 - 1 }	LINE RETURN-BEAM OFF	
1	3	2	$\frac{1}{4} - \frac{3}{8}$	3	1	91	$0 - \frac{1}{8}$
1	8	2	$\frac{7}{8} - 1$	3	8	135	$\frac{7}{8} - 1$
1	8 → 1	LINE RETURN-BEAM OFF		8	1	316	$0 - \frac{1}{8}$
1	1	3	$0 - \frac{1}{8}$	8	8	360	$\frac{7}{8} - 1$
1	2	3	$\frac{1}{8} - \frac{1}{4}$	8	8 TO } 1 - 1 }	PICTURE RETURN-BEAM OFF	
1	8	3	$\frac{7}{8} - 1$	1	1	1	$0 - \frac{1}{8}$
1	8 TO } 2 1 }	LINE RETURN-BEAM OFF		1	2	1	$\frac{1}{8} - \frac{1}{4}$

BEGINNING OF
NEXT FRAMEINVENTOR
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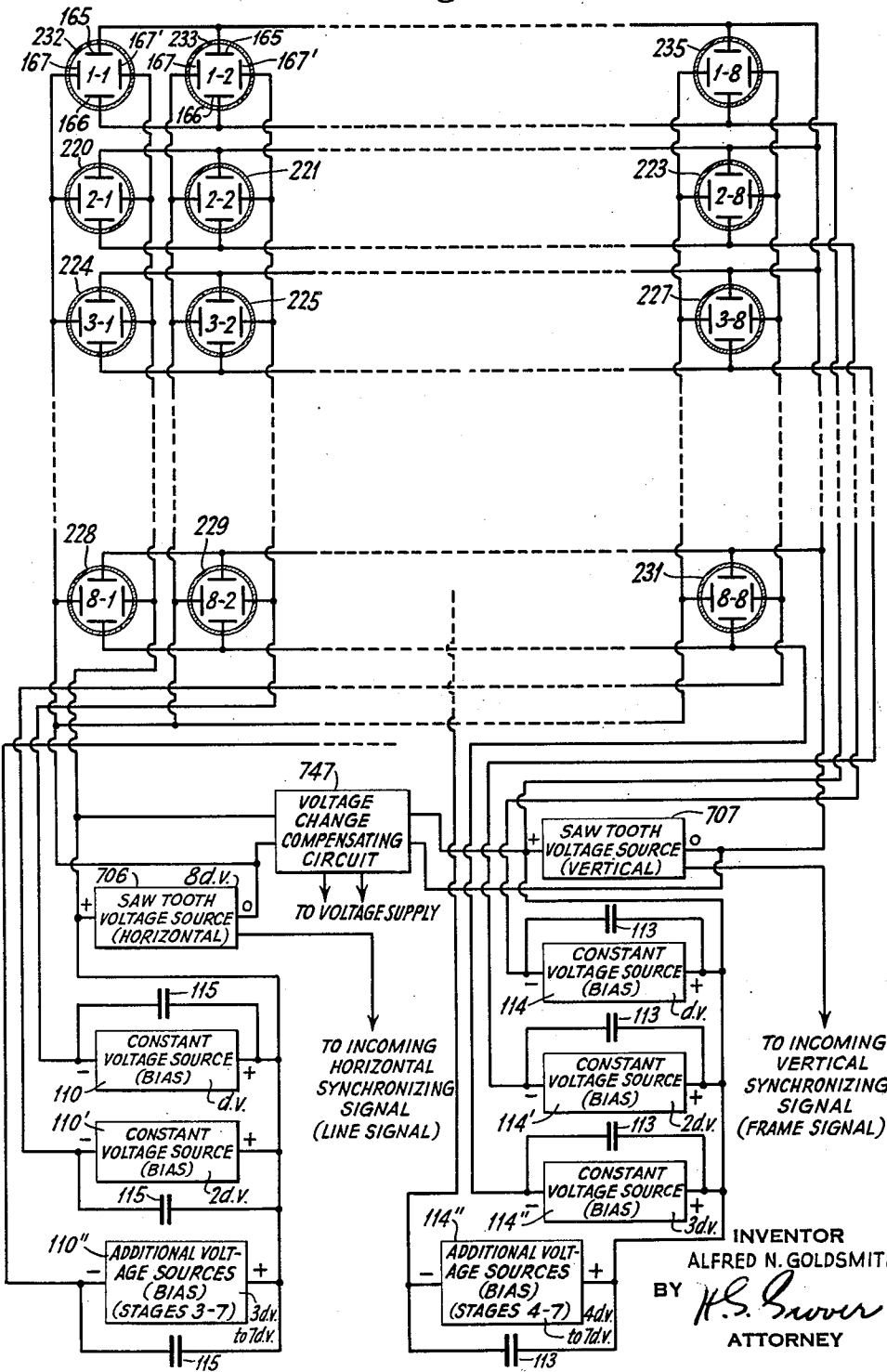
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Fig. 17



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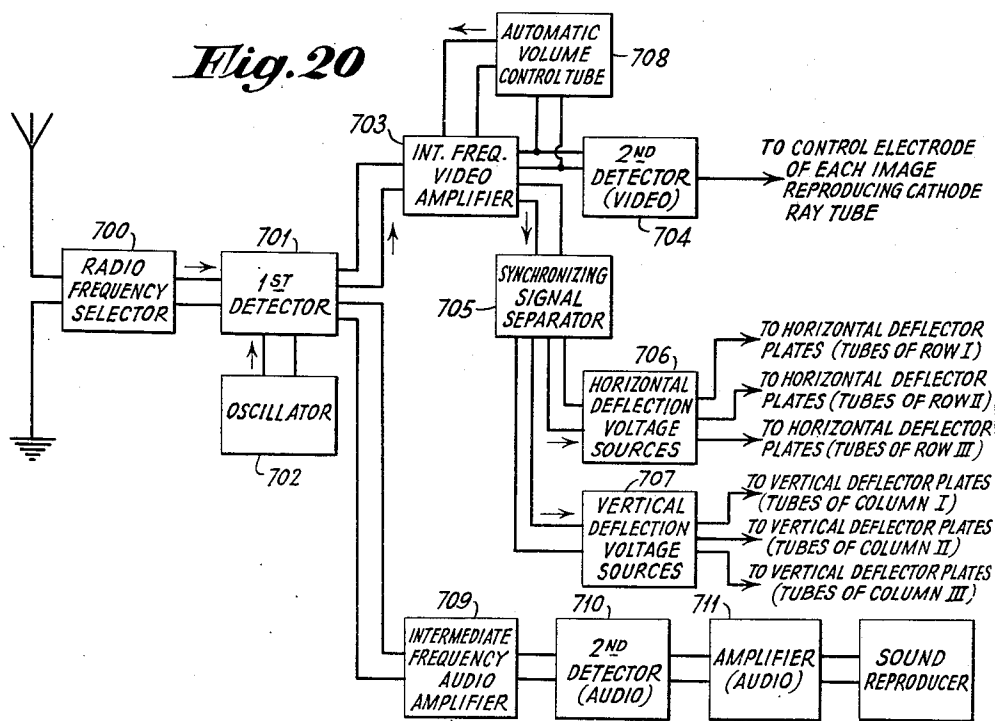
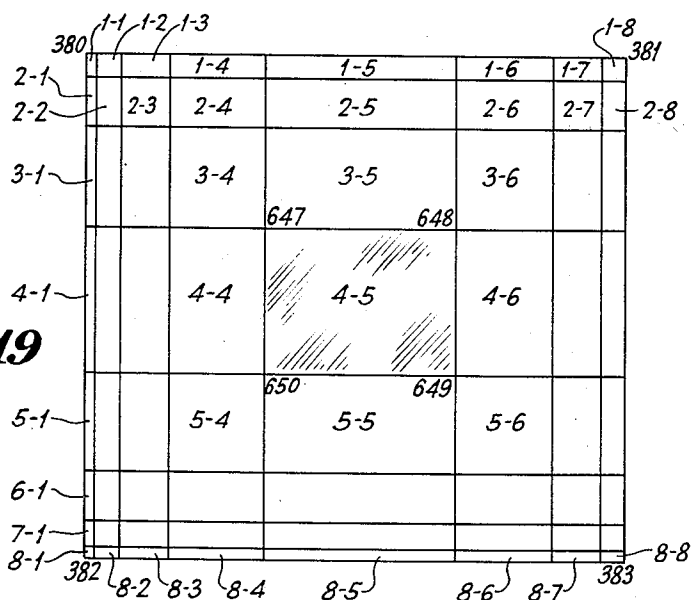
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Fig. 21a

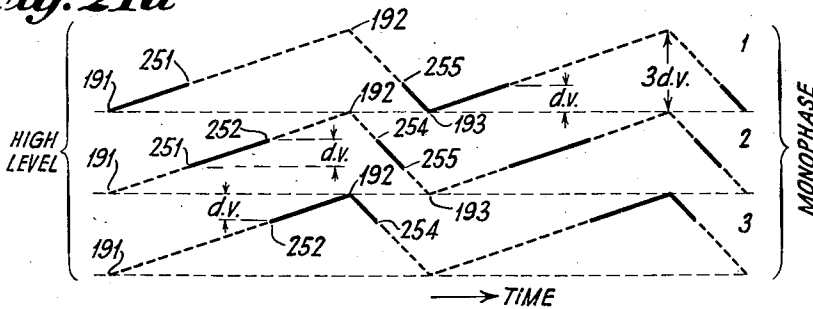


Fig. 21b

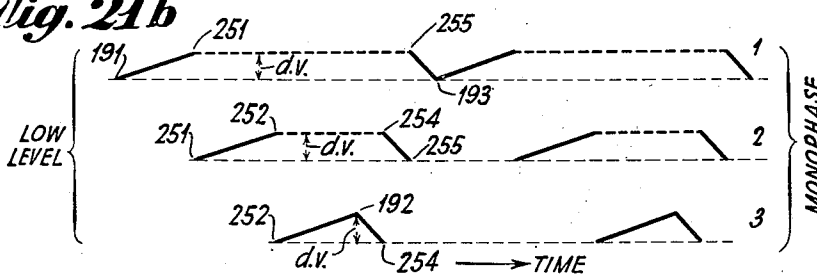


Fig. 21c

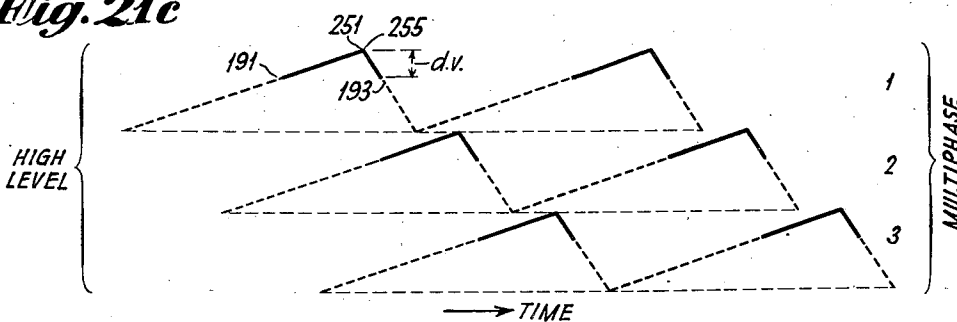
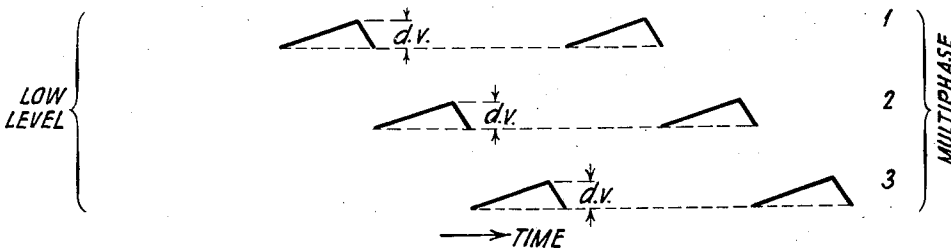


Fig. 21d



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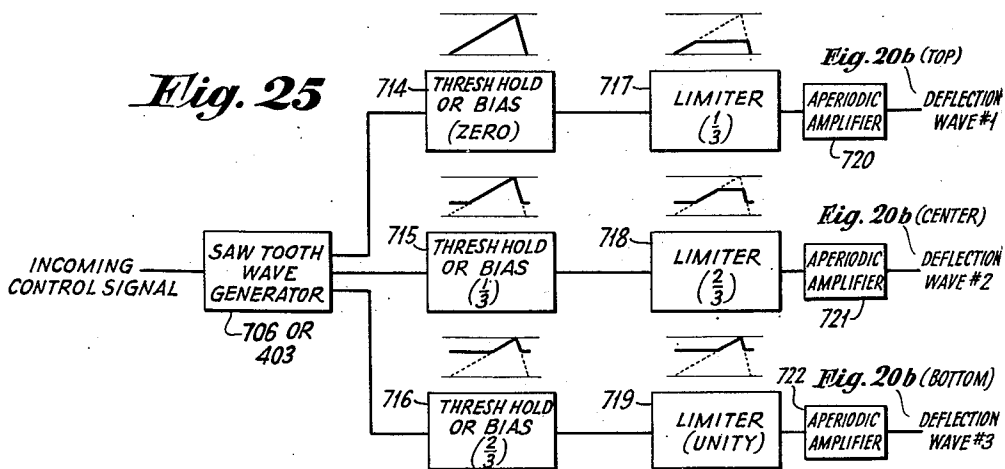
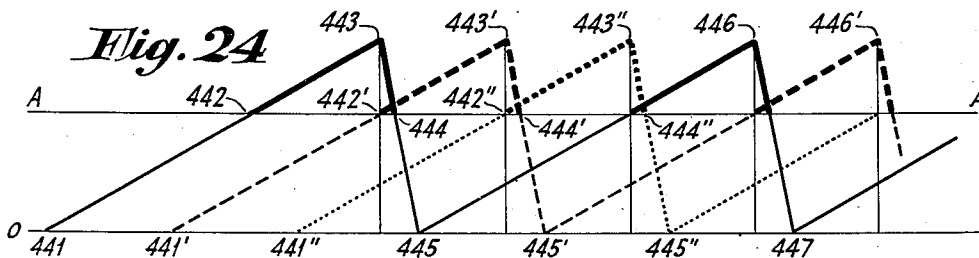
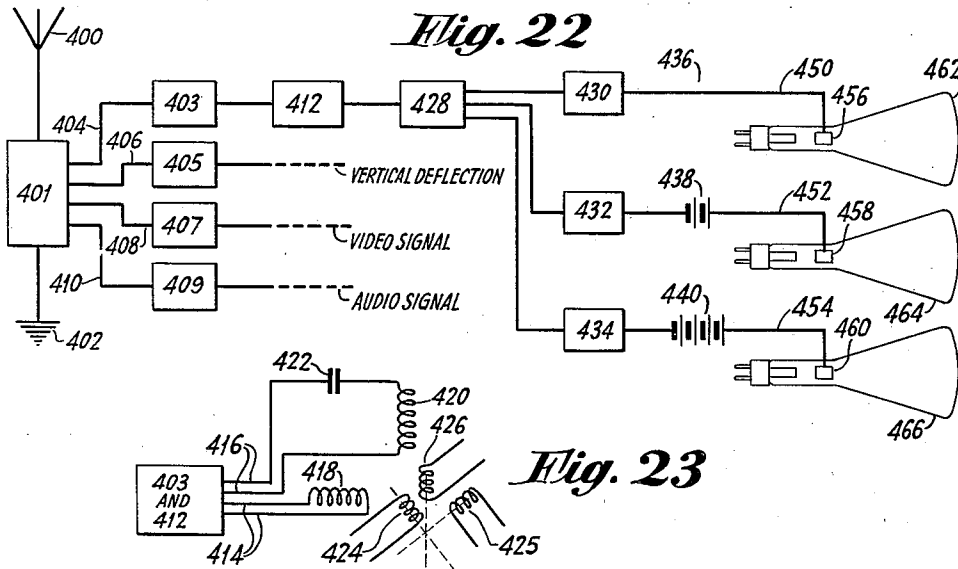
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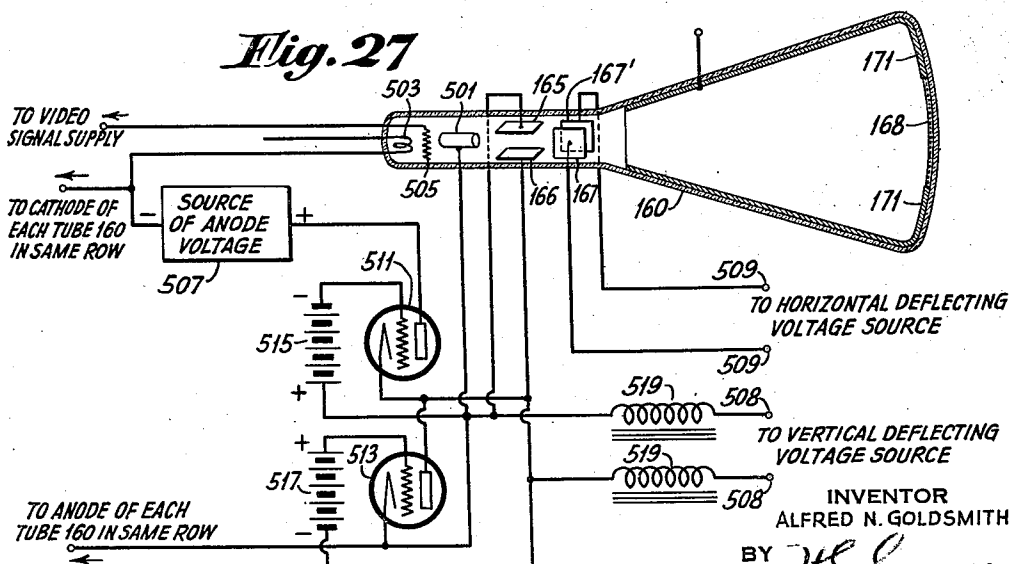
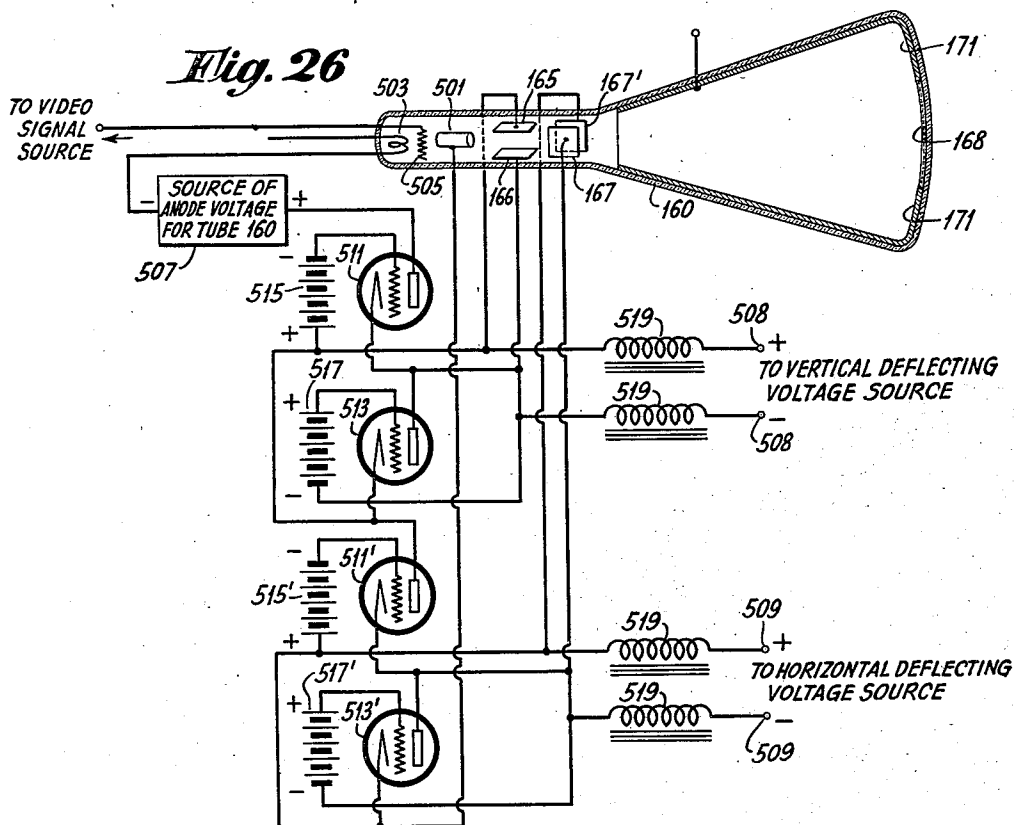
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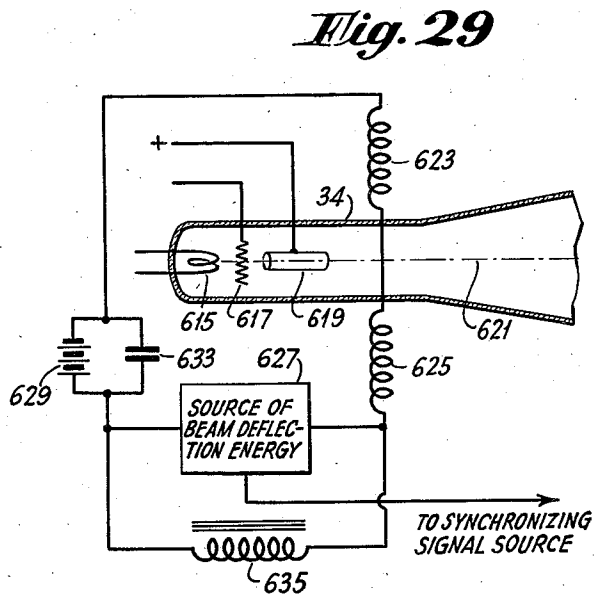
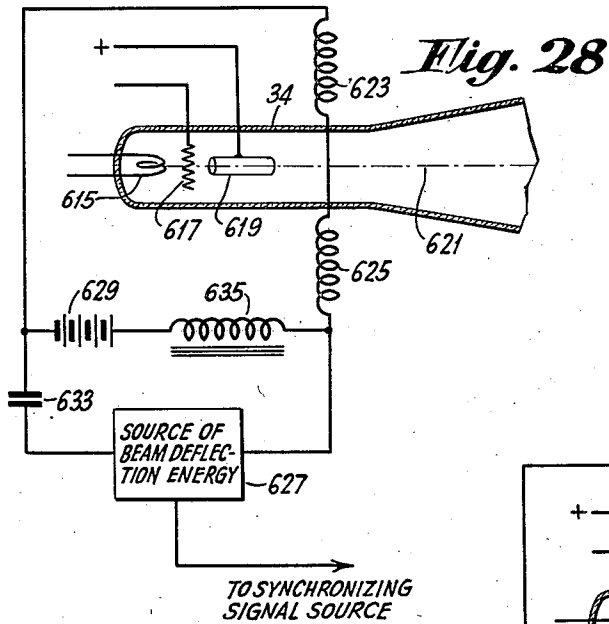
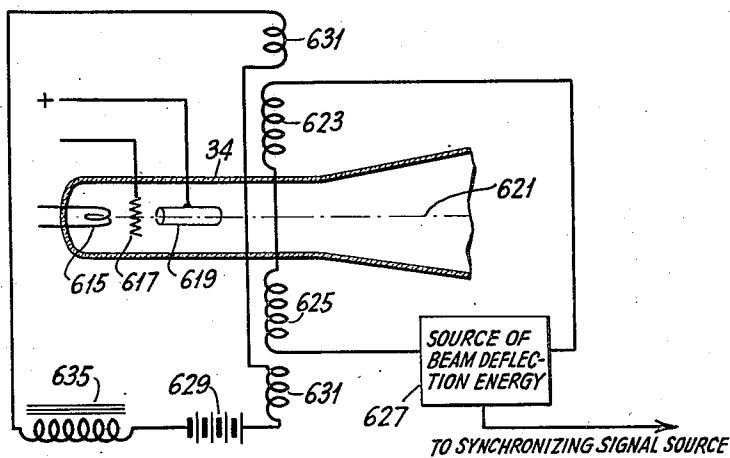


Fig. 30



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Oct. 22, 1940.

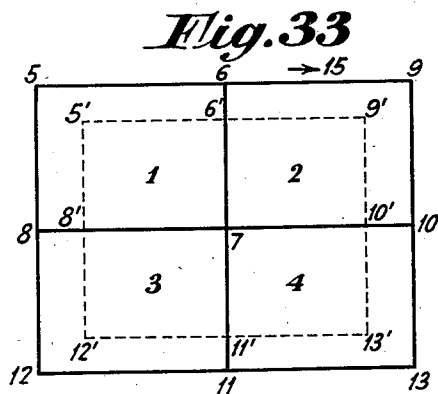
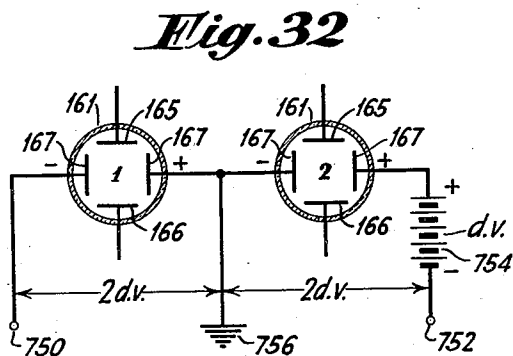
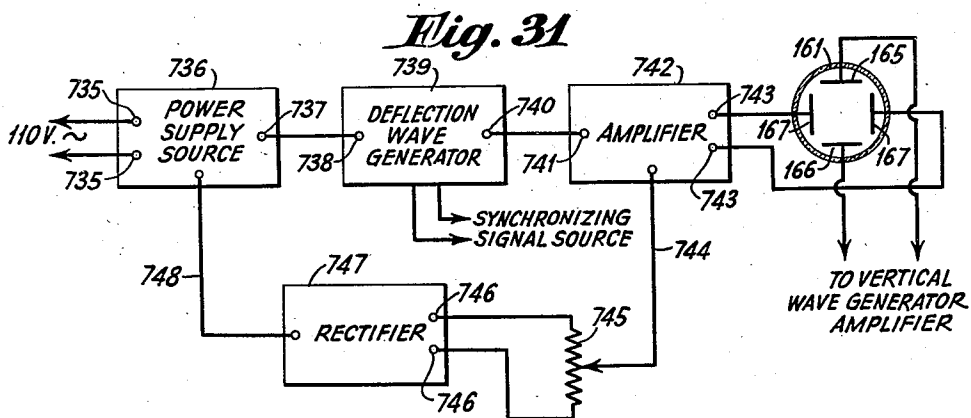
A. N. GOLDSMITH

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Fig. 34

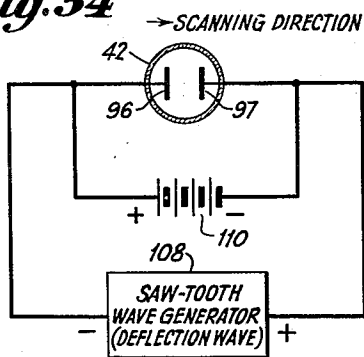


Fig. 35

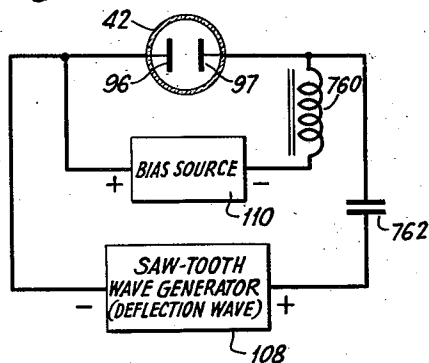


Fig. 36

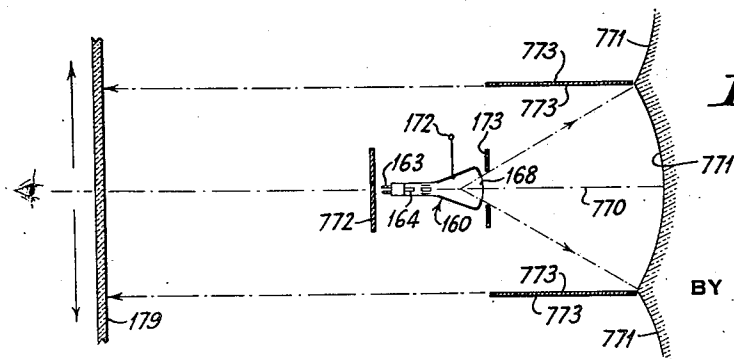
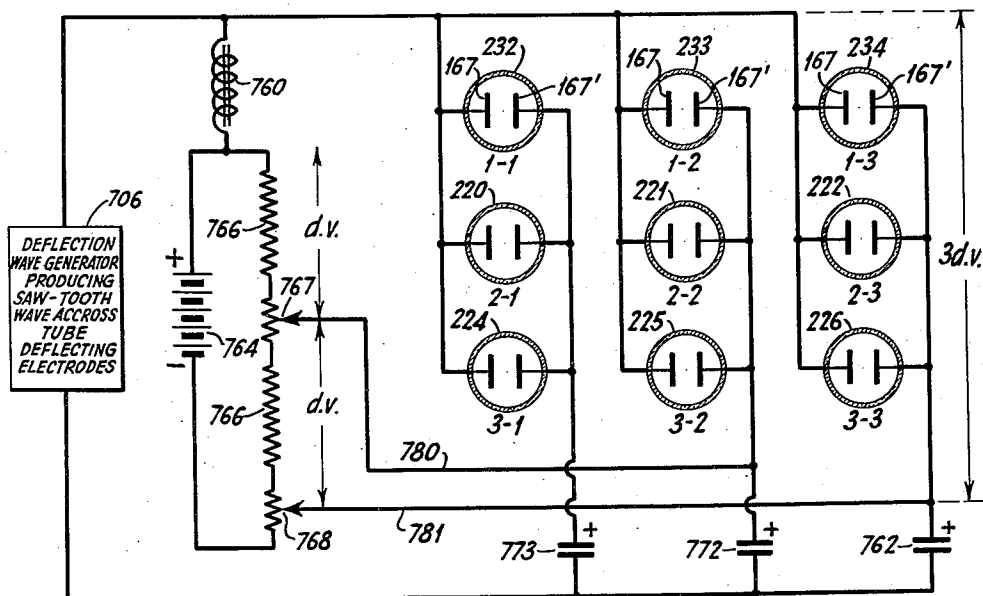


Fig. 37

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UNITED STATES PATENT OFFICE

2,219,149

TELEVISION SYSTEM

Alfred N. Goldsmith, New York, N. Y.

Application February 6, 1937, Serial No. 124,434

59 Claims. (Cl. 178—6.8)

The present invention relates to television systems and to both the transmitting and receiving portions thereof.

More particularly, the invention is concerned with ways and means and a method for producing at receiving stations images or pictures many times the size of the image or picture which can be obtained electronically by any of the now known present day systems.

The invention further is concerned with a method and apparatus for developing the video or image signals for producing pictures or images of the above suggested size, it being understood that such produced pictures shall have a produced detail or quality substantially increased over the detail producing qualities of any known and/or existing types of picture or image producing apparatus, irrespective of the character of such apparatus.

Further the invention is concerned with providing a method and apparatus for increasing the definition of television pictures beyond that which can be obtained by any known and presently existing types of television transmitting apparatus.

In the present day types of television apparatus and for the purpose of this consideration, reference will be made substantially only to the so-called "electrical" types of transmitter and receiver apparatus since these are now capable of providing maximum detail and definition. Both the size of the image ultimately produced at the receiver point and the degree of definition is determined largely by the character of the visual pick-up transmitting tube and the spot size of the cathode ray beam which is utilized as a scanning instrumentality, as is also the case in the receiver. The size of the image ultimately resulting at the receiver point is, according to the prior art systems, considered as a function of the size to which any practical electronic image reproducing tube may be built and the brightness of the spot formed by the cathode ray.

In present day types of television apparatus, and considering for the time being the aforesaid "electrical" types, an image of the subject at the point of transmission is projected upon a light receiving surface which is suitably photosensitized.

In one of the commonly known forms of television electronic scanners for transmitting stations such as that known by the trade name "Iconoscope," the image to be scanned is focussed upon a mosaic structure which comprises a plurality of electrically isolated photoelectric particles supported upon an insulating base, which

base, in turn, is supported by a conducting support member or signal plate. The light falling upon the isolated photoelectric particles causes photo-electrons to be emitted therefrom with the result that a corresponding distribution of electrostatic charges (a form of "electrical image") is accumulated upon the surface of the mosaic structure, as has already been described in numerous publications. The mosaic surface upon which the charges have accumulated is then scanned by a focussed cathode ray beam of a cross-sectional diameter corresponding in size to individual elemental areas into which the subject is assumed to be divided for scansion and rebuilding. During scansion of the charge image, there is produced in an external circuit a wave train of energy representative of the subject whose image causes the electrostatic charges (of related voltages) to build up or to be accumulated on the mosaic.

The signal transmitted may be developed either as a result of the change in potential of the signal plate under the scanning action of the cathode ray on the mosaic or the signal may be determined by the secondary emission from the illuminated side of the mosaic when secondary electrons are released under beam impact upon each charged photoelectric particle.

Various methods of scanning in such a system may be used and need not be discussed herein in detail, but reference to this electronic form of scanning may be found in the article published by Zworykin in the Journal of the Franklin Institute for January, 1934, Vol. 217, No. 1. It should be understood in connection with this type of system that the resultant image signals are due to the release of the charge accumulation on the mosaic structure during the time interval between successive traversals of each elemental section or area thereof by the scanning cathode ray beam and may develop in either manner above suggested. In the scanning process, the scanning beam may trace a pattern along a series of substantially adjacent lines, in which case the beam moves at a relatively slow rate across the assumed lines of the mosaic structure and returns at a relatively rapid rate to start the next line or path of scanning. In another form of scanning the pattern may be the so-called "interlaced" pattern where the so-called odd lines of the mosaic are first scanned and the so-called even lines are "skipped" during its scanning; during the next succeeding scanning the so-called "even" lines are scanned and the so-called odd

lines are skipped while the scanning cathode ray traverses the mosaic. If, for example, in this so-called "interlaced" pattern of scanning the resultant image to be transmitted is assumed to be of 343 line detail for example, the first scanning will include the 171½ odd lines with the first scanning starting, for example, at the upper lefthand corner of the mosaic and the last line terminating at the bottom of the mosaic midway between the lefthand and righthand edges thereof. The next succeeding scanning trace will then start at a point along the upper edge of the mosaic midway between the lefthand and righthand edges thereof, but will terminate in the lower righthand corner of the mosaic after the first half line and the succeeding 171 additional lines are scanned. In this way, each two scanned groups of 171½ lines portray, when pieced together, one complete scanned image. This formation of the image is known as the "odd line" interlacing method of scanning. However, a so-called "even line" method of interlacing the scanning pattern may also be used. In such even 342 lines of scanning may be assumed, and, in this case, the mosaic electrode will then be traced by the scanning beam along two series of scanning paths which each include 171 complete scanning lines with alternate lines being skipped between each traversal.

The method and system to be herein disclosed is also applicable to that type of electronic television scanning system wherein the light of the image falls upon a light sensitive surface which emits electrons which are accelerated toward an accelerating electrode whose central point is apertured. Behind the aperture of the accelerator electrode is located an electron collecting electrode. The collecting electrode is maintained at a highly positive potential relative to the photoelectric surface which is of the same general order as that of the accelerating electrode with respect to the photoelectric emitter surface. The collecting electrode may, where desired, be housed within a collecting target capable of emitting a great number of secondary electrons per primary electron to be collected by the target electrode. With a system of this type the entire bundle of photo-electrons moving from the photo-sensitive cathode toward the accelerating electrode is deflected electromagnetically or electrostatically in two mutually perpendicular directions so that the aperture in the accelerating electrode scans the elemental areas of the complete bundle of electrons.

Furthermore, the system to be herein described is applicable to those types of systems which are known as velocity modulation systems. In such systems, the rate of scanning the subject is assumed to be normally of some constant value for one predetermined condition of light and shadow on the subject, but with changes in the intensity of light and shadow to be represented, the velocity of the scanning is changed to values above and below the assumed normal value or the change in velocity may take place only in one direction from the assumed normal velocity.

Referring now to the systems for receiving scanned picture subjects, it is customary usually to provide (still assuming purely electronic types of image reproducing apparatus, although it is understood that mechanical forms may be used where desired) a cathode ray type device such, for example, as that known in the art under the trade name designation "Kinescope," wherein an

electron beam is produced to initiate on the tube end wall the luminous trace. The electron beam developed within a cathode ray tube of this type is projected longitudinally of the tube and focussed by suitably developed electrical fields and by suitably designed electrodes into a sharply defined spot which impinges upon a luminescent screen structure supported upon the inner surface of the tube end wall opposite the source from which the electron stream or cathode ray beam is developed. The developed electron stream is suitably influenced by the signals resulting from the transmitter to cause the resulting luminous effects upon the luminescent screen which portray the various intensities of light and shadow upon the original subject to vary as the beam is moved across the screen. The deflection of the beam, as in the transmitting systems, may be accomplished by suitable electrostatic or electromagnetic beam deflecting means or the combination of both, so that the beam or cathode ray traverses the entire luminescent screen according to the desired pattern of traversal, and this pattern may be the same as that described for the transmitting device.

The resulting intensity of the luminous trace produced by the beam bombarding the luminescent screen is determined in various ways, and among those commonly used and to which this invention is intended to be applicable are the so-called grid control, the varying area spot control, the velocity modulation systems, and the like.

Such systems of the prior art while generally capable of producing television images at receiver points of substantially satisfactory brilliance for small pictures to be viewed nearby in the home have not been found capable of producing large size images. Up to the present time, the maximum size of cathode ray tube which could be used at a receiver station and which would still approach a practical device has been a type whose luminescent screen diameter is of the order of 15" or less. Hence, the maximum size of the resulting optical image which could be produced on such a tube would be an image of rectangular shape having an aspect ratio of width to height of the ratio 4 to 3 which would fit within the 15" circle. The rectangular shaped subject is assumed in view of the current practice in the motion picture industry to provide rectangular shaped screen portrayals of actions, although it is obvious that a circular or a square formation of the resulting image could be realized. Such tubes as would produce an image of this size, which is not sufficiently large to be viewed by large sized audiences are, nevertheless, both extremely difficult to build and expensive to buy and, as well, are continually subject to possible breakage. Hence, for the most part, present day television is restricted to that size of reproduced image which can be placed within the boundaries of the so-called 9" cathode ray beam. But, in this connection it should be understood that this is not a limitation in the theoretical capabilities of the system, but rather a limitation in the practicability and the economical development of known systems. Even in cases where the so-called 12" tube is utilized with the resulting image pattern of the order of 7½ x 10", the image or picture produced upon the luminescent screen is still not sufficiently large for satisfactory large size demonstrations or sufficiently large to be viewed by large size audi-

ences. In fact, even for home usage the picture is usually considered too small to offer any substantial commercial possibilities unless it be of the order of at least 15" by 20".

Therefore, according to the present invention it is proposed to provide a system wherein it is possible to increase the detail or the definition obtainable in television pick-ups as well as to provide a system wherein the resultant image size may be substantially increased while providing even increased brightness and substantially little, if any, additional expense for the installation over that which it is considered will be necessary for large sized tubes. According to the present invention to be herein disclosed, it should be understood that any large screen television system should preferably be of such a type that large size pictures of the character herein referred to shall be obtained without any change in the general nature or characteristics of conventional television transmission. Further than this, large screen television should be capable of being carried out through the use of the now conventional types of cathode ray devices for reasons of economy, design, construction, shipping and usage.

In accordance with the present invention, however, it is proposed to provide a system wherein it is possible to increase the detail of definition obtainable in television pick-ups. It is also an object of this invention to provide a system which will not only increase the detail of definition to some extent, but will make it possible to transmit pictures for television purposes which have a detail which is substantially that of the currently produced motion pictures. It is further proposed in accordance with the present invention to accomplish the increased definition and detail with a single pick-up lens associated with the scanning instrumentality where the lens will be utilized so as to be without parallax or overlapping effects within the pick-up image.

Further, it is an object of the present invention to provide a system for increased detail and definition which can operate while using for scanning substantially any known type of electronic or mechanical scanning devices, for example, of the types above briefly described, and at the same time provide a conventionally produced and simply operating system for obtaining these effects by electronic scanning tube commutation where no mechanical moving parts are utilized and still obtain the increased detail and definition on an economically satisfactory basis.

It, of course, will be appreciated that with the approach of color television, that is, the television transmission of colored images on a commercial scale, it will be necessary to increase the effectiveness and detail of the picture severalfold since, in addition to the transmission of intelligence corresponding to the position and luminosity of each picture element, it will be likewise necessary to transmit an exact index of the colors of each element of the subject, and if trichromatic vision be assumed, the amount of effective detail to be transmitted for color therefore will be of the order of three-fold that required for black-and-white television.

A further object of this invention insofar as the transmitter end of the system is concerned, is that of providing a simple, effective, and reliable method by which a plurality of scanning tubes or other electronic scanning devices may be used simultaneously, and sequentially become

operative to scan and produce from the scanning image signals representative of the subject, and in such connection it is an object of the invention to provide ways and means by which independent scanning devices select separated areas or sections of the subject for analyzing purposes, and at the same time tubes or scanning elements not instantaneously effective in the transmission of signals are so arranged and utilized that power consumption is reduced to a minimum.

With respect to the receiver end of the system, the invention is intended to provide for the production of large television pictures in contrast to pictures of the sizes above noted; and in making reference to large television pictures, it is intended that the size of the picture shall be of the order of square feet through tens of square feet, and up to hundreds of square feet in contrast to the presently known size of pictures which are measured in the order of square inches, and still it is an object of the invention to provide these pictures of large dimensions in forms which will be of normal brightness and conveniently useable for theatre or home viewing at comfortable viewing distances.

A further object of this invention is to provide a television image reproducing system which will produce large and bright television pictures which shall also be of high detail and definition reaching, for example, from the present day types of pictures customarily considered of the order of between 300 and 400 lines per picture up to several times this amount of detail, for example, pictures having 700 to 800 lines, or even more.

It is a further object of the present invention to provide a system by which this increased size and detail in resulting picture can be produced while utilizing in the process only those present day types of tubes which are satisfactory for small size pictures and which can be constructed and sold cheaply, or to utilize tubes of even smaller size than those used at the present date, and still to provide a system wherein these results are accomplished with equipment purely electrical in its nature requiring no moving parts and requiring a minimum amount of maintenance and attendance.

It is a further object of this invention to provide a system for reproducing large size pictures, for example, on translucent screens (but not necessarily) in such a manner that if the television receiver of the nature to be herein described is utilized in the home for "deluxe home pictures," such a receiver can be viewed by the audience in any position without the interception of projected beams by members of the audience, and in the case of use for theatre installations on the stage, no equipment need be placed in the usual motion picture projection room, the entire equipment being such that it can be placed readily upon the stage of the theatre.

A further object is to provide equipment for producing large size television pictures which can be assembled so as to be shallow in the direction perpendicular to the plane of the viewing screen, and thus permitting its installation on shallow stages of theatres or any similar form for use in the home in reasonably compact cabinets.

A further object of the invention with respect to the receiver arrangement is to provide a series of receiving electron tubes of the cathode ray type, for example, which will each reproduce independent sectional portions of the view to be exhibited, and yet to provide a suitable arrange-

ment for matching on the viewing screen the different sectional portions of that view in such manner that there will be no discernible distinctions between a view reconstructed in sequentially produced sectional areas and a view of equal size produced as a unit.

A further object of the invention is to provide a system for securing large screen pictures which is entirely electrical and involves no moving parts or mechanical complications and to provide optical arrangements for producing component pictures which are of utmost simplicity in their nature and which can be manufactured and sold at a selling price little, if any, in advance of television systems using but a single image reproducing tube.

A still further object of the invention is to provide a television image producing system which will use only conventionally and present day types of equipment with minor structural and/or operating alterations, and at the same time to provide a resulting image which will, over its large area, be of a brilliance at least equal to the brilliance per elemental area of the present day types of small size television images.

A further object of the invention is to provide a television reproducing system wherein a plurality of separate television reproducing tubes produce different sections of the picture, and there is entirely electrical commutation between the various tubes, and sectional portions of the picture are assembled on different receiving tubes which are sequentially operated through suitable control of the electron beam deflecting systems.

It is also an object of the present invention to provide a receiver system capable of producing the types of large pictures, above referred to, which will operate with equal fidelity from the present single scanning tube transmitter of the transmitter systems now generally known or which will operate to provide increased detail where receiving signals transmitted from a transmitting system of the character herein described. In this way, it becomes obvious that an important part of this invention is the feature of providing a receiver with a multiplicity of image producing tubes which each produce a selected partial area of the complete image but which operate with complete control from the same signals which would control the complete image production on a single image producing tube.

Another object of the invention involves the use of a multiplicity of image scanning tubes for scanning partial areas of a complete picture after the formation upon the light sensitive scanning surface thereof of non-parallactic partial-images, which may result from an aerial image, for such consequent scanning.

Still a further object of the invention resides in the use of a plurality of image scanning tubes as well as image reproducing tubes which may be controlled through the use of suitable deflection bias controls in both horizontal and vertical directions of scanning so that the scanning beams are suitably retarded or triggered and become active in any desired sequence so that the partial images are scanned and/or reproduced according to a pattern equivalent to the now conventional scanning patterns.

A further object of the invention is that of providing suitable inter-connections of the deflection control systems of each image scanning or reproducing tube so that the sequence of op-

eration may be suitably regulated as above specified.

An additional object of the invention is that of providing suitable ways and means to produce large size television images through the use of partial-image area scanings at either or both transmitter and receiver while providing masking areas of suitable configuration and secondary emission properties to produce the desired type of reproduced electro-optical image.

Still a further object of the invention is to provide suitable means for conserving both tube life and power consumption by rendering inactive any tube not at the moment utilized in the system for producing or reproducing image or video signals.

A still further object of the invention resides in providing suitable ways and means for reforming the partial-image areas produced as an electro-optical image in each of a plurality of image producing tubes into a single large size electro-optical image capable of being produced upon a viewing screen with the partial-image areas in suitable relationship and accurate juxtaposition.

Another object of the invention is that of providing by means of a series of suitably positioned partial-image producing tubes a means to develop a large picture area from the several partial areas while providing suitable interlocks between the partial area image producing tubes to permit the sequential or selected operation of each to locate the several partial areas in proper space relationship in the complete area.

Still a further object of the invention is that of controlling the operation of the several partial-image producing tubes from the deflection control systems of each tube under the influence of a developed control deflection electrical means for controlling the electron beam deflection in each tube in sequence and at the same time providing flexibility of operation which may function either at high or low bias values on each tube deflection system or which may function from a single phase or multi-phase deflection control electrical wave formation.

Still another object of the invention is that of rendering tubes in the image producing system not at the moment effective in producing a partial area of the complete image area to be made inoperative so as to decrease power consumption and increase tube life.

A further object of the invention is that of providing a large size image producing system which will function equally well with electrostatic or electromagnetic beam deflecting systems or a combination of both and with all known types of intensity control systems for varying the resultant luminous spot intensity.

A still further object of the invention is that of providing an array or system of separate partial-image producing tubes which may as a unit be assembled in or as a part of any known and existing type of electronic television receiver apparatus so that when signals of the character transmitted from any of the aforementioned types of transmitter apparatus are received the produced image on the viewing screen will be many times the area of that of the usual and known receiver and will be formed from a series of juxtaposed partial-image areas.

An additional object of the invention is that of providing a system of concatenated partial-image producing tubes and their associated and controlling commutating circuits in such fashion

that the system constitutes a unitary electrical and optical equivalent of, or substitute for, a single conventional cathode ray tube (except for the greatly enhanced definition or size of the total image thus producible).

It is a further object of this invention to arrange for the automatic juxtapositioning in accurate registry of the partial areas which, in their totality, form the total picture.

Many other objects and advantages of the invention will, of course, be appreciated from a consideration of the following specification and claims in connection with the accompanying drawings wherein:

Fig. 1 shows schematically the area division of the complete image size as distributed to the several independent image scanning tubes;

Fig. 2 diagrammatically illustrates the arrangement for directing the light of the image subject to independent image scanning tubes, although this figure (like other figures of the drawings) is not intended to be drawn to scale;

Fig. 3 illustrates schematically a front view of the light distributing system of Fig. 2;

Fig. 4 represents a side view of the arrangements of Figs. 2 and 3;

Fig. 5 is a schematic diagram representing conventionally a transmitter wherein four suitably positioned image scanning tubes are arranged to scan partial areas of the complete scanned area and to supply the output signals resulting from scanning to the transmitter system;

Fig. 6 illustrates schematically one form of arrangement of the deflecting electrode control system for a plurality of independent image scanning tubes arranged to scan the subject by division into four juxtaposed partial-image areas;

Fig. 7 indicates a modification of the arrangement of Fig. 6;

Fig. 8 conventionally represents the wave form of the electrical energy used to deflect the cathode ray beam in the image scanning tubes of Fig. 6;

Fig. 9 schematically illustrates the position of the scanning spot of the cathode ray scanning tube of Figs. 2 through 4 over a plurality of the mosaic areas of the scanning tubes of the said Figs. 2 through 4;

Fig. 10 is a chart to illustrate the scanning pattern traced across the independent image scanning tubes;

Fig. 11 illustrates schematically the optical system for a single tube of the reproducer;

Fig. 12 diagrammatically represents the method for adjusting the areas of reproduction of the scanning pattern of any individual active tube in the reproducer system;

Fig. 13 diagrammatically represents the electrical wave formation used to deflect the cathode ray beam in the several cathode ray reproducing tubes at the receiver;

Fig. 14 represents diagrammatically the viewing ends of a large number of independent reproducing tubes used to re-assemble a complete picture;

Fig. 15 is a modification of a portion of the arrangement of Fig. 14 but shows only a part of the total number of tubes;

Fig. 16 is a chart to illustrate the operation of the receiver as compared with the operation of the transmitter shown by Fig. 10;

Fig. 17 illustrates one form of arrangement to control in sequence the beam deflection in the several tubes of the receiver arrangement;

Fig. 18 conventionally represents the scanning pattern trace when scanning a partial area in one extreme position in the composite area;

Fig. 19 represents a modification for scanning a different and more central area than that shown by Fig. 18;

Fig. 20 represents schematically a receiver system by which received signals may be reconstructed into electro-optical images;

Fig. 21 is a series of curves representing diagrammatically the wave formations serving to control the deflection of the developed electron beam in each of the partial area image producing tubes of the receiver. In this figure, curve *a* indicates the manner of operating with a mono-phase multi-bias high level system; curve *b* indicates the operational method for a mono-phase multi-bias low level system; curve *c* indicates the control utilizing a multi-phase single bias, high level control system; and curve *d* indicates the changes where a multi-phase single bias low level system of control is utilized;

Fig. 22 schematically represents a receiver system adapted to operate to produce beam deflection control as multi-phase control impulses for the reproducer tube deflection systems;

Fig. 23 is a schematic representation of a phase shifting arrangement for forming the multi-phase controlling electric waves for controlling the several partial image reproducing tubes;

Fig. 24 is a diagrammatic representation of the wave formations resulting in the several outputs of the phase shifter of Fig. 23;

Fig. 25 schematically indicates the energy output control for operating a low level system for single phase control as well as multi-phase control;

Fig. 26 is a diagrammatic showing of one form of arrangement for conserving power in a maximum degree on the cathode ray tubes not instantaneously usable in image scanning or reproducing;

Fig. 27 shows schematically a modification of the system of Fig. 26 but reduces the actual power saving from that saved by the arrangement of Fig. 26;

Figs. 28 to 30 each represent slight modifications of the arrangement of Figs. 6 and 7 and apply particularly to electromagnetic beam deflection systems.

Fig. 31 represents a simplified and automatic form of control with provision made to cause permanent juxtapositioning of the several partial images irrespective of voltage fluctuations tending to cause changes in the dimensions of the several partial or component areas which are scanned;

Fig. 32 shows schematically one suitable arrangement to maintain suitable juxtapositioning and matching of contiguous portions of a four tube partial-image scanning or reproducing system;

Fig. 33 shows diagrammatically the partial or component scanned areas (like Fig. 1) with the dotted outlines indicating the change in positioning of the partial areas with voltage changes on the deflecting electrodes deflecting the scanning beams;

Figs. 34 and 35 represent slight modifications for beam deflection wherein the biasing voltages are applied in parallel with the deflection voltages;

Fig. 36 represents a multi-tube arrangement wherein the biasing voltages are applied in parallel with the deflection voltages in accordance with the showing in Figs. 34 and 35; and

Fig. 37 represents a modification of the optical system of Fig. 11 in order to utilize reflecting members for producing juxtaposition of partial-image areas on the viewing screen.

5 If reference is now made to the drawings accompanying this disclosure for a further understanding of the aims and objects of this invention, it will be found that to understand more definitely the true nature of the desired results
10 it will be desirable to consider first a specific example of one system embodying this invention. However, it should be understood that this specific embodiment is purely illustrative and it is not intended that the example chosen shall
15 either represent a limit of the possibilities of the system nor place a limitation upon the type and character of the system to which the invention is applicable. Therefore, any values or parameters herein assumed for illustrative purposes must be
20 considered as being given merely to aid in the understanding of the true nature of the invention.

If it is assumed that the presently available average electronic television system for transmission is satisfactory for a 360 line picture (a convenient number which is close to the 343 line systems which have already been tested), it can be appreciated, with the picture to be reproduced having an aspect ratio of 4-to-3 for width and height, that the produced picture image
30 would be composed of 172,800 separate and distinct picture elements, neglecting elements used in line-return times. Accordingly, such a picture would have appreciably less definition
35 than the usual motion picture shown in theaters.

If it is assumed that a 720 line picture is to be produced in a television viewing screen such a picture should have equivalent line dimensions of 720 x 960 (that is, a 720 line picture having
40 the 4-to-3 aspect ratio) and would be composed of 691,200 separate picture elements. This latter picture would be substantially or reasonably the equivalent in entertainment value and audience satisfaction to the motion picture films projected
45 in theaters. From this example it will be seen that such a picture would contain four times the detail of the assumed 360 line picture and, therefore, such a picture might be considered as made up from four separate adjacent component pictures of the 360 line or 172,800 element variety.
50 This latter type of picture is readily obtainable with presently existing equipment.

It thus follows that a picture formed from four adjacent component pictures of the 360-line type, shown by Fig. 1 of the drawings, where
55 the component images 1, 2, 3 and 4 are assumed, may be developed where each of the partial areas is scanned by a separate and distinct scanning instrumentality of the type herein above suggested. The boundaries of these separate component images are indicated for the area 1 by the numerals 5, 6, 7 and 8; for the area 2 by the numerals 6, 9, 10 and 7. Similarly, for the
60 area 3, the boundary limits will be defined by the numerals 8, 7, 11 and 12; while for the area 4 the boundary limits included are included within the area included by the numerals 7, 10, 13 and 11.

From the foregoing, it can be seen that the
70 boundary of the entire picture area or image subject which is to be scanned by the several transmitting tubes comprises the entire area represented by all of that field of view within the boundary limits 5, 9, 13 and 12 and is thus formed
75 by juxtaposing and matching together all of the

several partial-image areas. The arrow 15 is intended to indicate the direction of horizontal scanning, while the arrow 16 indicates the direction of vertical scanning. As above suggested, this scanning action of the several areas may
5 be of either the sequential or the interlaced or other suitable pattern type, as desired.

If, now, it is assumed that each of the partial areas 1, 2, 3 and 4 is scanned by a separate scanning tube and each separate scanning tube
10 has its own optical system for picking-up the image areas 1, 2, 3 or 4 co-ordinated therewith, parallax effects of ordinarily known systems would substantially prevent the matching and smooth association and juxtapositioning of the
15 several partial areas without dividing lines of the four component or partial-images from the four separate scanning tubes assumed. Therefore, in order to scan a plurality of component image areas which will readily match at the receiver
20 and which will not exhibit line effects from the dividing line areas, an optical system for the purpose of obtaining a single image from a single lens which will divide the complete areas 5, 9, 13 and 12 into the four component areas so as to
25 provide four separate and non-parallactic images should be provided.

Making reference to Figs. 2, 3 and 4 of the drawings, one suggested form of such an optical system has been shown, although it is to be understood that other optically equivalent systems may be used. Considering first Fig. 2, there is shown the plan view of such an optical system which includes the showing of two of the four assumed image transmitting tubes. The image
35 of the complete area embodied by the several partial-image areas 1, 2, 3 and 4 is projected along a path 15 through the objective lens 17 which has the optical axis 15, 18 so that there is formed an aerial image of the object to be
40 scanned at the aerial image plane 20', 21'. In this arrangement, the reflecting surface 23, which may be a mirror or the hypotenuse of a glass right-angled or other suitably formed prism acting as an efficient reflector, collects a portion of
45 the light of the image passing through the objective 17, so that the light rays which strike the reflecting surface 23 are then projected typically along the path 25, 26, 27 through the auxiliary lens system 29 so as to fall upon the light
50 sensitive surface or mosaic electrode structure of the image scanning tube 30 (herein illustrated solely by a conventional showing). The lens 29 is so positioned as to focus the image rays which are reflected from the reflecting surface 23 upon
55 the photosensitive screen 31 of the image scanning tube 30, and thus the lens 29 will be understood to be positioned adjustably for the purpose of forming the said image on screen 31.

In directing the light of the image along the
60 path 25, 26, 27, 32 (circle 32 is intended to show receding ray of light to the photosensitive mosaic 31 of the image scanning tube 30) there is positioned in the path of the light a reflecting surface 33 so that the light passing beyond the
65 objective 29 impinges upon this reflecting surface 33 prior to striking the photosensitized mosaic of the transmitting tube. It should be understood in this connection that one suitable form which the photosensitized mosaic or light sensitive electrode structure may assume is an electrode of the general character shown by the United States patent of Sanford F. Essig, No. 2,065,570 granted December 29, 1936, although it is equally apparent that the photosensitized
75

screen may be of any of the general types referred to in the opening portion of this disclosure. Similarly, the transmitting tube is assumed to be one of the type hereinabove referred to as having been described by Zworykin.

In the conventional form of apparatus exemplified by Fig. 2, the image scanning tube 30 is assumed to have an oblique stem 34 in which is positioned the electron gun structure, not shown, for developing a focussed electron beam or cathode ray pencil for the purpose of scanning the photosensitized mosaic 31, as has also already been described by Zworykin. Signals are produced by scanning the mosaic electrode in this type of system in known manner and result from neutralization of the electrostatic charges appearing upon the mosaic electrode and which in magnitude represent the corresponding elemental areas of the light image. Signal output may be taken directly from the signal plate of the mosaic electrode or may be the signals produced by secondary emission resulting from the scanning cathode ray striking the photosensitive mosaic electrode surface. Whatever the type of signal, that signal which is developed is transmitted through an amplifier system to a transmitting channel as shown more particularly by Fig. 5 which represents a conventional showing of the complete transmitter assembly and, as will be evident from what is to follow, there will thus be scanned, by means of the transmitter tube 30, a component partial (quarter, in the suggested illustration) image, such as the partial-image area 1 of the complete image areas 5, 9, 13 and 12. Similarly, the light of another quarter of the image, as shown by Fig. 2, is projected along the path 35, 37, 39, 45 through the copying lens 40 to the mosaic electrode structure 41 of a second image transmitting tube 42. This forms a second partial or component image, such as the image area 2 of the complete image areas 5, 9, 13 and 12.

Like the first partial or quarter area or component part 1, the second partial-image area 2 is also reflected from a reflecting surface 43 similar to the surface 23 so as to strike a reflecting body 44. The reflected light image is thus brought to focus by means of the adjustable objective 40 on the plane 45 on the photosensitive mosaic electrode. Within the neck portion 46 of the image scanning tube 42, there is also provided an electron gun structure (not shown) from which is developed a concentrated electron scanning beam for the purpose of scanning the mosaic 41 in the same manner that the beam developed within the scanning tube 30 scans the mosaic electrode 31. Thus, it will be appreciated, that two of the component or partial-image areas 1 and 2, for example, are properly subdivided and caused to influence the mosaic electrode structure of two separate image scanning tubes.

Due to the plan view showing of Fig. 2, the scanning tubes for the partial or component image areas 3 and 4 cannot be illustrated. Therefore, turning to the showing of Fig. 3, which is intended to be a view looking at the front of the set-up in the direction from which the light image shown by the arrow of Fig. 2 impinges upon the objective 17, the light of the image enters the objective perpendicularly to the plane of the paper. Upon passing through the objective 17 the light image impinges upon the reflecting surface 23, herein indicated as being within the boundary limits 48, 49, 50, 51 and from the reflecting surface 23 the light of the image, as

shown by Fig. 2, passes through the objective 29 to the reflector 33 and thus onto the mosaic electrode structure 31 of the transmitting tube 30. The light entering the objective 17 which follows the path 35, 37, 39 through the objective 40 is reflected from the reflecting surface 21, having the boundary limits 49, 52, 53, 50 to pass through to the reflecting surface 44 and onto the mosaic electrode structure 41 of the transmitting tube 42.

Thus, as is shown diagrammatically by Fig. 3, the two component or partial-image areas 1 and 2 are projected upon the mosaic electrode structures 31 and 41 of the tubes 30 and 42 respectively, and likewise the component or partial-image areas 3 and 4 of Fig. 1 are projected upon the mosaic electrode structures 54 and 55 of transmitting tubes 56 and 57, these being similar to tubes 30 and 42. The light image entering the objective 17 which is representative of the component or partial-image areas 3 and 4 of Fig. 1 passes through to the point 56, for example, on the reflecting surface 23. It is then reflected through an adjustable copying lens 57' to a reflecting surface 58, similar to the surface 33 so as to follow a path 56, 59, 60 at the termination of which the light image comes to impinge upon the mosaic electrode structure 54 of the image transmitting tube 56. The transmitting tube 56, like the tubes above described, also has a neck portion 61 wherein is provided a suitable electron gun structure, not shown, for developing a concentrated electron beam which when acted upon by suitable deflecting fields is caused to scan the mosaic electrode structure 54. Thus, the component or partial-image area 3 of Fig. 1 will be scanned and the signals which represent the light image upon the mosaic electrode 54 will be transmitted by means of suitable transmitting apparatus of the type to be described herein. Similarly, light of the partial or component area 4 which passes through the objective and onto the reflecting surface 43 will be redirected to pass along a path designated 62, 63, 64 to impinge upon the mosaic electrode structure 55 of the image transmitting tube 57. As the light representing the partial or component area 4 is directed along the path 62, 63, 64, it is passed through an adjustable copying lens 65, similar to the copying lens 40, and is reflected as focussed light rays upon the mosaic electrode structure 55 by means of the reflector 66, similar to the reflector 44.

From the above it will be appreciated that each of the four partial or component part areas 1, 2, 3 and 4 into which the complete image areas 5, 9, 13 and 12 are assumed to be divided, is directed by way of a single optical system so as to fall upon four distinctly separate electronic image transmitting tubes by means of a non-parallactic system. The light beam path for the corresponding partial quarter image can be limited as desired by opaque masks or apertures properly placed in the system. Such masking members, while not shown, define or limit in obvious manner the partial or component image dimensions on each of the four photosensitive mosaic electrode structures 31, 41, 54 and 55 as required. In case the edges of the partial or component images are not sharply defined but are shaded to a slight extent, this shading will have little or no detrimental effect on the complete system provided the shaded areas overlap in the entire re-constituted area.

In order to complete the graphic description

of the optical system of the scanning arrangement, Fig. 4 shows a side view of the arrangement of Figs. 2 and 3. In Fig. 4 the light of the image, as in Fig. 2, is passed through the objective 17 to strike the reflecting surface 43, indicated as being bounded by the boundary limits 49, 52, 53, 50; and the light reflected from this reflecting surface along the path 37, 39 of Fig. 2 is then passed through the objective 40 to strike the reflecting surface 44 indicated in Fig. 4. This light path is indicated as being within the boundary limits 72, 73, 74, 75 and the light image of the desired area thereafter impinges upon the photosensitive mosaic electrode structure 41 of the transmitting tube 42. Similarly, the image transmitting tube 57 is energized by the light passing through the objective 65 to fall upon the reflecting member 66 (indicated as being within the boundary limits 78, 79, 73 and 72) so that the finally reflected light image falls upon the light sensitive mosaic electrode structure 55 of tube 57, and another of the several partial or component image areas is thus translated, when the electrode 55 is scanned, into image or video signals.

In the foregoing description of the manner in which the complete image areas 5, 9, 13 and 12 are divided into its component parts or partial-image areas 1, 2, 3 and 4 by the non-parallactic optical system of Figs. 2, 3 and 4, the various parts of the system and the image transmitting tubes have not been described in any great detail due to the symmetrical structure making a description of a single one of these various parts adequate for the purpose. However, it should be noted in connection with the arrangements of Figs. 2, 3 and 4 that each of the component or partial-images has, in the illustrated case, one identical characteristic which is that each has the same "aspect ratio" which corresponds to that of the entire image area (and this will be assumed as being of a ratio of 4-to-3 for the horizontal to the vertical dimensions). By locating a suitable photosensitive mosaic electrode structure at the aerial image plane 20', 21', for example, on the plan view 2 of Fig. 2 and at 49, 50 of the side view, the outline of the complete picture is determined.

To summarize now the descriptions of Figs. 2, 3 and 4, it is a function of the arrangement of the optical system of these figures to produce from a suitably formed aerial image of a subject, a group of non-parallactic component or partial-images which should preferably, though not necessarily, each be of the same aspect ratio. Each of these separate component or partial-images is then focussed in suitable manner on the photosensitive mosaic electrode structure of a separate image transmitting tube. The mosaic electrode of each of the independent transmitting tubes is then connected to an output circuit, as more particularly shown by Fig. 5 wherein is represented a conventional connection to a transmitter circuit. The juxtaposibility of the partial-images is requisite, and is obtained as described.

As described by Fig. 5, the separate image transmitting tubes 30, 42, 56 and 57 (scanning the partial-image areas indicated on each diagrammatic showing) are preferably connected through separate amplifiers 81, 82, 83, 84 whose outputs feed a common video frequency amplifier 85. The output of the video frequency amplifier 85 is then supplied in conventional manner to the oscillator modulator component illustrated at

86. The resulting signal modulated carrier is transmitted by way of the radio link 87 or by a suitable co-axial cable to desired points of reception. The amplifier components 81, 82, 83 and 84 may, for example, be of the general character and description shown by U. S. Patent No. 2,045,315 issued to J. P. Smith, or an equivalent type amplifier capable of producing undistorted amplification throughout the desired frequency range. Where desired the output energy from each mosaic screen of the several transmitter tubes may be primarily amplified through the use of suitable secondary electron emission amplifiers of the character described by Zworykin, for example, in the Proceedings of the Institute of Radio Engineers for March, 1936, vol. 24, Number 3, pages 351 et seq. In any case, the outputs of the several transmitter tubes are connected either in parallel, series-parallel or in series, depending upon the forms of hook-up proving most adaptable to the constants of the thereto connected circuits into a common amplifier output such as shown by 85. In connection with the amplifier 85, it should be noted that this amplifier also should be one of such a character as to amplify in an undistorted manner and without phase shift a wide band of frequencies which will extend from the lowest frequencies such, for example, as the field or frame frequency of scanning up to the highest modulation frequencies. In this instance, also, this amplifier may be of the general type shown and described in the said patent to J. P. Smith No. 2,045,315 although other forms of wide band amplifiers may readily be substituted, the illustration being merely to show one form of amplifier which has been found satisfactory for the combination of apparatus claims herein described.

In order to provide for the scanning of the various component image portions which are produced on the various transmitting tube devices or tubes known and used under the trade-mark designation "Iconoscope," shown by Figs. 2 through 5 inclusive, the present invention involves still another fundamental feature which comprises the coordination of the scanning beam deflections in the various transmitting tubes. In this connection, if the usual and conventional types of deflecting circuits were used, it is obvious that the picture obtainable from the output amplifier of the transmitting tube mosaics would be a mere jumble consisting of the superposition of the four assumed component quarter images. Therefore, to overcome this possibility it is necessary to provide ways and means to adjust the position, time and phase of the respective scanning beam deflection forces, irrespective of whether electrostatic or electromagnetic deflection is being used, for the various image scanning tubes. For this purpose, it should be understood that each of the transmitting tubes 30, 42, 56 and 57 is provided with suitable electrostatic or electromagnetic (or a combination of both) deflecting systems suitably energized although the deflection systems have not been illustrated for the sake of providing clearness of illustration and avoiding possible complications in connection with the description of the optical system of Figs. 2, 3 and 4, and in this connection reference should be made to Figs. 6 and 7. With position, time and phase adjustments of the respective scanning beam deflections across the mosaic electrode structures of the various transmitting tubes properly adjusted, the four component quarter images may be scanned as if they were actual adjacent por-

tions of a single complete image of the usual sort on a single image transmitting tube screen, that is, referring again, for example, to Fig. 1, the normal scanning of the complete image areas 5, 9, 13 and 12 should determine the scanning of the component partial images 1, 2, 3 and 4. Each component image may be scanned with the full detail of which the corresponding individual image transmitting tube is capable.

Accordingly, by the arrangement shown by Figs. 6 and 7 of the accompanying drawings taken in connection with Fig. 8 showing the operational principle thereof and also Fig. 5 where the portions of Figs. 6 and 7 are schematically shown, ways and means are provided for adjusting the position, time and phase of the respective scanning beam deflection forces upon each separate image transmitting tube. In brief, this comprises impressing upon each deflecting element, that is, the electrostatic deflecting plate electrodes or the electromagnetic deflecting coils of the individual cathode ray image scanning tubes, depending upon whether electrostatic or electromagnetic methods are used, energy having two component values. One of these components is a deflecting component capable of deflecting the scanning beam for each scanning tube vertically or horizontally respectively by an amount equal to twice (still assuming the illustrative example of four partial-image areas given by Fig. 1) the distance necessary to cross the component or partial mosaic screen in the conventional manner of scanning. The second component is a constant individual negative deflecting bias, that is, a bias opposing the deflection in the normal direction.

Referring now for a moment to the showing of Fig. 1, for the horizontal deflectors of the quarter images 1 and 3, the negative deflecting bias will be zero. Similarly, for the vertical deflectors of the quarter images 1 and 2 of Fig. 1, the negative deflecting bias will be of a zero value. For the horizontal deflectors of the quarter images 2 and 4, there is provided a negative deflecting bias of sufficient value to prevent the scanning beam of the image transmitting tube co-ordinated with these particular elemental areas, as shown by Figs. 2, 3 and 4, beginning to move horizontally across the mosaic electrode structures of the transmitting tubes co-ordinated with these partial areas until just subsequent to the time when the scanning beam of the image scanning tubes coordinate with the component of partial image areas 1 and 3 has completed the traversal across those areas, as the case may be, depending upon which of the component or partial-images is being scanned; that is to say, the horizontal scanning of any line of the component area 2 is inhibited by negative deflection bias until the scanning of the first portion of this particular line has been completed for the image scanning tube scanning the component area 1. Similarly, with respect to the vertical deflection of the quarter images 3 and 4 a negative deflecting bias sufficient to prevent the scanning beam from beginning to move vertically across the picture illuminated portion of the image scanning tube coordinated therewith is provided until just after the scanning beam in the quarter image sections 1 or 2, as the case may be, shall have completed the vertical scanning or vertical motion for the partial images of the screens 1 and 2 respectively; that is, the vertical scanning of any portion of the component quarter image area 3 is inhibited by a negative deflection bias until the vertical

scanning of the higher portion of the picture contained in the quarter image area 1 has been completed.

In some instances, it will be found desirable to shield the non-active portion of the scanning tube mosaics, that is, the portions which are not necessary for the formation of the corresponding component or partial-image (in the illustrated instance a quarter image) by means of an internal conducting shield to provide the limiting dimensions for scanning. Such shield may be either grounded or maintained at some other convenient and substantially constant potential relative to the electron source. This has not been shown in detail by the drawings although it is readily apparent as to how the connection may be made. Thus, whenever the scanning beam in any given scanning tube is outside the quarter image scanning area of the mosaic it will impinge upon the conducting shield in question and there will be no scanning of the mosaic or output therefrom. For this purpose, the conducting shield of the surface should be free as nearly as possible of secondary emission and, thus, may readily be formed as a colloidal graphite surface or a metallic surface coated with material from which secondary emission either does not take place or less than one secondary electron per impinging of any primary electron is released. As above suggested, the opening of the shield permitting the passage of the scanning beam to the mosaic screen should have the same aspect ratio as the desired quarter image. In the example herein illustrated and selected for the purpose of illustrating the invention, each quarter image will, as previously suggested, have 360 horizontal lines and be composed of 480 picture elements (elemental areas) per scanning line. The scanning beam on each image transmitting tube mosaic electrode will be effective for scanning of the picture illuminated area on such a mosaic electrode one-quarter of the total time. The output from the video frequency amplifier 85 connected to receive the output from scanning of the four mosaic electrode structures of the separate transmitting tubes, still assuming the above example of four partial areas, will be used to modulate the television transmitter, whether for wire or radio transmission, together with the injected synchronizing signals, background control signals and the like introduced into the transmitter in a manner well known in the art.

Referring now more particularly to Fig. 6, there is shown one method of applying the negative deflecting bias on the deflector plates of the image scanning tubes. The deflection in Fig. 6 is assumed to be electrostatic although obviously electromagnetic systems may be used or a combination of electrostatic and electromagnetic. The image scanning tubes 30, 42, 56 and 57 are shown as arranged according to the pattern of Fig. 3 and the tubes are shown with a sectional view through the neck portions 34, 46, 61 and 89 respectively. Immediately ahead of and intermediate the base portion of the tube neck and the mosaic electrode structure, are arranged the complete deflecting electrode pairs. The tube 30, for example, is provided with vertical deflecting plates 90, 91 and horizontal deflecting plates 92, 93. Similarly, tube 42 is provided with vertical deflecting plates 94, 95 and horizontal deflecting plates 96, 97 while vertical deflecting plates 98 and 99 and horizontal deflecting plates 100 and 101 are provided for the tube 56. Similarly, tube 57 has vertically deflecting plate pairs 102 and

103 and horizontal deflecting plate pairs 104 and 105.

From what was above stated in considering Fig. 1 and the relationship between the biasing voltages to be applied to the image scanning tubes 30, 42, 56 and 57 for scanning the component or partial areas 1, 2, 3 and 4, it can be seen that with no horizontal biasing being required on the deflection system for scanning areas 1 and 3, the deflecting plates 92 and 100 may be tied together and similarly, since no vertical bias is required for the tubes scanning the areas 1 and 2, the vertical deflecting plates 90 and 94 of tubes 30 and 42 may be tied together. Likewise, since tubes 42 and 57 which scan the areas 2 and 4 must be biased for horizontal scanning, the horizontal deflecting electrodes 96 and 104 may be tied together and for the tubes 56 and 57 scanning the areas 3 and 4 since vertical bias is required the vertical deflecting electrodes 98 and 102 may be tied together. In each instance, the deflecting electrodes tied together are connected, as will be herein explained, to the source of sawtooth voltage 116 or 108 for deflecting the electron beam passing through the tube neck and projected therefrom toward the mosaic structure. All of the lower vertical deflecting electrodes 91, 95, 99 and 103 are tied together and similarly all of the right hand horizontal deflecting electrodes 93, 97, 101 and 105 are tied together assuming left to right and top to bottom scanning. For the purpose of providing horizontal deflection of the cathode ray beam, the horizontal deflecting electrodes 93, 97, 101 and 105 which are tied together are connected through a conductor 107 to one terminal point of the horizontal saw-tooth voltage wave source 108. The horizontal and vertical saw-tooth voltage wave sources 108 and 116, although operating at different frequencies, may be of any desired type and character such as a dynatron oscillator so connected as to develop a saw-tooth wave formation output, a grid glow tube and condenser combination, a blocking oscillator, or any other desired and known formation of appropriate deflecting voltages. To the horizontal deflecting electrodes 92, and 100, to which no bias need be supplied, a connection is made by way of conductor 109 to the terminal of the saw-tooth voltage wave source opposite from the terminal to which the conductor 107 is connected. In order, however, to provide suitable biasing voltage which must be overcome in order to produce any horizontal deflection of the electron beam within the tubes 42 and 57, there is provided a constant voltage source (any desired type such as a battery, for example) or bias 110 which has one terminal connected by way of the conductor 111 to the terminal of the saw-tooth voltage wave source with which the conductor 109 connects, and its opposite terminal connects by way of conductor 112 to the horizontal deflecting electrodes 96 and 104. In order to reduce capacity effects and to permit the undistorted passage of the deflector voltage, the constant voltage bias source 110 may be shunted by whatever combination of resistance, inductance and capacity, such as that conventionally illustrated by 113, is required.

The constant voltage source 110 may be of any desired type such, for example, as biasing batteries or the equivalent. In order to provide for the vertical deflection and for the biasing of the

system for scanning the lower component areas 3 and 4, a similar constant voltage source 114 shunted by a capacity 115 or other suitable bypass is provided in conjunction with the vertical saw-tooth voltage source 116. The tubes 30 and 42, upon whose vertical deflecting electrode system no bias voltage is applied have their vertical deflecting electrodes 90 and 94 connected by way of conductor 117 to one terminal 118 of the saw-tooth voltage source 116. The opposite terminal 119 of the saw-tooth voltage source connects to all of the vertical deflecting electrodes 91, 95, 99 and 103. In order now to apply to the tubes 56 and 57 the necessary vertical bias on the deflection system, the vertical deflecting electrodes 98 and 102 are connected together and connected by way of conductor 120 with the constant voltage source 114 (similar to source 110) and through conductor 121 back to the terminal 118 of the saw-tooth voltage source for vertical deflection. It thus can be seen that there is provided with the arrangement of Fig. 6 a convenient means for biasing and controlling the operation of sequentially related scanning for each of the tubes coordinated with the partial or component areas 1, 2, 3 and 4.

In cases where a separate signal source of impulses for providing deflection and synchronism is utilized, each of the saw-tooth voltage sources 108 and 116 may be supplied with an impulse at desired points in the scanning cycle in order that there may be no drift or variation in the rate at which the saw-tooth impulses are developed. Such a synchronizing source 108' may be of the general type described by J. P. Smith in U. S. application, Serial No. 8659, filed Feb. 28, 1935, now issued as United States Patent No. 2,132,655, or even of the type disclosed by A. W. Vance in U. S. application, Serial No. 727,091, filed May 23, 1934, now issued as United States Patent No. 2,105,870. The impulses developed in the source 108' then serve to control (as diagrammatically illustrated by Figs. 5, 6 and 7) the synchronization of the sources of saw-tooth voltages 108 and 116 and additionally serve to bias the image scanning tubes during return periods and still further serve to supply synchronizing and blanking effects in the signals transmitted. The manner of operation of the synchronizing signal generator has been fully described in the aforesaid Smith application and is herein illustrated merely in connection with its application to a completeness of this disclosure. The saw-tooth impulses developed from each source or resulting after passing through appropriately connected wave shaping circuits energized from the sources 108 and 116 are of the general formation shown by Fig. 8. Referring now to Fig. 8, the action resulting from the negative deflector bias above described is more pictorially illustrated. In this figure, numerals 130, 131, 132, 133, 134, 136 represent the general wave form of the deflector voltage active upon the tube deflecting plates. The ordinate value 137, 138 designated a , represents a voltage which is substantially one half that corresponding to the peak value obtained at the point 133 on the deflector saw-tooth wave, and this voltage is the negative deflector voltage or bias which is applied in series with the deflector plates 96, 97 and 104, 105, for example. As the deflector voltage rises from a zero value indicated at the point 131 to the value indicated at the point 132, 75

that is, the ordinate value a , for example, the scanning beam controlled by the plate pairs 92, 93 and 100, 101 at once moves fully across the mosaic electrode screen of the image scanning tube coordinated with the partial-image areas 1 and 3 except that it is prevented from doing so only so far as the quarter or partial area 3 is concerned by the fact that it is kept off the screen by the vertical negative bias on the vertical deflector controlling the scanning beam on the mosaic electrode structure of that tube coordinate with the image area 3.

As soon as the deflector voltage exceeds the value indicated by the ordinate a (that is, at the point 132) the following condition occurs: The scanning beam of the quarter image or component area 1 of Fig. 1 moves onto the conducting mask which delineates the outline of the active or useful area on the mosaic electrode structure. Therefore, this scanning beam has no further effect in producing the video frequency or the picture scanning signal output. Simultaneously, the scanning beam for scanning the electrostatic image produced by the partial or component area 2, which has been held on the conducting mask of the mosaic screen of the coordinated transmitting tube for this image and has, therefore, been inoperative in producing the video frequency output, now moves across the quarter or component part area in a horizontal direction so as to scan the remaining half of the given horizontal line. While this is occurring, the vertical deflector voltage has increased in the meantime by the amount necessary to move the scanning beam down one line on both the mosaic electrode structures of the scanning tubes 30 and 42 so as to scan the next horizontal line of the quarter or component areas 1 and 2, and the process above described for scanning the individual line is again repeated until the complete area is scanned. It is to be noted, as was already pointed out, that this action of the scanning beam on the transmitting tubes 30 and 42 assumes, as should be the case, that the vertical deflector plates of the scanning tubes 30 and 42 arranged to scan the areas 1 and 2, are connected in parallel across the full generator voltage of the saw-tooth voltage source 116; whereas the deflector plates for scanning the component areas 3 and 4 are also connected in parallel, but the pair of them are as well in series with the suitably bypassed negative vertical deflector bias applied from the source 114 so that these scanning plate pairs do not come into action until the vertical deflector bias, also obtained from a voltage wave of the general formation shown by Fig. 8, has risen to more than half of its maximum value and in the region designated by the ordinate value b between points 132 and 133.

Thus as the amplitude of the saw-tooth voltage wave for producing horizontal and vertical deflection of the scanning cathode ray or electron beam increases, and dependent upon the bias applied horizontally and vertically by the bias voltage sources 110 and 114 respectively, the partial areas or component parts of the complete subject which is scanned are determined. However, where the voltage changes, because, for example, of power supply fluctuations the deflection voltages may change accordingly, and the pattern area may tend to vary in size. Accordingly, this invention provides, as will later be explained, suitable compensation for establishing continuous matching of the patterns of the several partial areas in case such an effect occurs.

A modified method of obtaining negative deflector voltages, whether horizontal or vertical, as may be needed, is shown more particularly by Fig. 7. This modified method is similar to that shown by Fig. 6 except that the negative constant voltage source 140 is shunted not only by the bypass condenser 115 or other circuit combination necessary to pass undistortedly the deflector voltage, but also by the resistance combination 141, 142. This resistance combination comprises the constant resistance 142 and the variable resistance 141 which is tapped at point 143 in such fashion as to enable a desired fine adjustment of the negative vertical deflector bias voltage to be made. Similarly, the constant voltage bias source 110, normally shunted by the condenser or other suitable combination 113, is also shunted by both a fixed resistor 144 and a second resistor 145 which is tapped at a point 146 for the purpose of permitting substantially a vernier adjustment.

In the light of what has been above described, reference may be made to Fig. 9 of the drawings for a further understanding and description of the motion of the scanning spot on the four quarter-image mosaic scanning tubes 34, 42, 56 and 57. In Fig. 9 the relation of the spot for scanning with respect to the mosaic electrodes 31, 41, 54 and 55 of the image scanning tubes 34, 42, 56 and 57 respectively is shown. The horizontal scanning direction is indicated by the horizontal arrow whereas the vertical scanning direction is indicated by the vertical arrow. The various spots shown by the small squares on the figure with respect to the mosaic electrodes indicate the instantaneous positions of scanning. In showing this arrangement, it will be seen that the spot area 147 is upon the mosaic electrode 41 of the scanning tube 42, having followed the portion of the path of deflection indicated by 148 lying on mosaic 41. This instantaneous condition corresponds to a time period when the horizontal deflection voltage is approximately 80% of the maximum value $2c''$ shown by Fig. 8 and the vertical deflection voltage is approximately one third of this maximum value, it being understood, of course, that the general wave formation for the vertical and the horizontal deflection voltage is identical except insofar as the time period of the cycle of repetition is concerned. Therefore, only one wave form has been shown by Fig. 8 and such wave is assumed to represent both the horizontal and vertical deflection voltage.

The conditions and operational sequence in the four quarter-image scanning tubes may be described as follows: In the scanning tube 34 the scanning spot 149 having already swept across the mosaic electrode 31 as viewed in the figure has come to a position upon the conducting mask 150 which surrounds the mosaic structure and is thus inactive to produce or initiate an output signal. In the scanning tube 42, however, the scanning spot 147 has traced a portion of the scanning line 148 and instantaneously is impinging at the point 147 upon the mosaic electrode 41. Therefore, at point 147 the beam is active in the scanning operation and output signals are fed to amplifier 82 (see Fig. 5). In the scanning tube 56, in like manner, the scanning spot 151 having already moved across a horizontal path of direction 148' impinges entirely upon a conducting mask 152 of the scanning tube. The impinging spot 151 thus is not only to the right of the mosaic area 54, but is also above the mosaic area because the negative vertical deflector bias on the deflecting electrode system of tube 56 prevents the vertical

deflecting plates from moving the scanning spot down into the scanning area zone while scanning is taking place in either of tubes 34 or 42. This is because of the fact that the vertical deflecting voltage in the assumed instantaneous operational state, as above stated, is only approximately one-third of its maximum value and an amplitude of at least 50% of the maximum value of the vertical deflecting voltage wave is required to bring the scanning spot to the level of the active or mosaic area of either of tubes 56 or 57.

In similar manner, the scanning spot 153 of the scanning tube 57 is impinging upon the masking area 154 surrounding the mosaic electrode 55 and is, therefore, also inactive. In other words, it can be seen from the graphical analysis of Fig. 9 that only one image scanning tube can at any given time be active. Further, it is apparent that the image scanning tube which is instantaneously active is controlled in accordance with the bias voltage supplied to the deflecting electrode plate pairs (deflecting electrodes) of the several image scanning tubes. In the case already illustrated the horizontal lines are shown dotted adjoining the four scanning spots, three of which are inactive in the production of video frequency output at any given instant, as above explained. Fig. 9 is intended to show the direction in which the motion of the four scanning spots takes place and to indicate that the motion of the scanning spot of each of the several image scanning tubes is interlocked, so to speak, by the interconnection of the deflecting plate pairs for these tubes and by the application of the negative deflector biases.

By Fig. 10 a table is given to show the entire scanning operation in some detail and in actual sequence. The various lines of the subject are numbered from 1 through 720 (assuming a 720 line picture) and, as shown, the fractional portion zero to one-half of the first scanning line is scanned by the first scanning tube 30, whereas the second scanning tube 42 takes up the task of scanning the fractional portion of the first scanning line identified as one-half to one. Immediately thereafter the scanning beam is returned so as to start the second scanning line. However, at this time the scanning beam is suppressed or biased beyond cut-off conditions, as is known in the art, by applying biasing voltages to the control grid of each of the separate image scanning tubes. When the scanning beam returns to the lefthand margin of the mosaic electrodes illuminated by the partial-image areas 1, 2, 3, 4, so that the second line of the subject may be scanned the scanning operation is repeated and the first half of line 2 of the scanning is scanned by the scanning spot produced in tube 34 and the second half line portion of line 2 is scanned by the scanning spot developed in image scanning tube 42.

In the case above assumed, of course, it will be understood that sequential line scanning has been illustrated. However, if the system is operated for interlaced scanning (since there is no essential difference in the scanning action regardless of which method is used) line 2 of the picture will not be scanned immediately subsequent to line 1, but rather line 3; and, in any event, the order in which the several lines are scanned is identically followed out by the arrangement shown.

From the foregoing it will be seen that what has been produced is, in effect, the use of a large number of relatively small image scanning tubes to provide the effect of one extremely large scanning

tube. These small or quarter-image scanning tubes are rigidly interconnected electrically and suitably related in their sequential vertical and horizontal action through the negative deflector biases and the inter-connection of the pairs of deflector plates. Thus the scanning operation for the several partial-image tubes may be described as an interlocked sequence scanning or a triggered scanning action.

While the invention, so far, has been illustrated as applied to electrostatic deflection and to the use of negative deflector voltage bias, it will be appreciated that the same method of control is applicable to electromagnetic deflection methods through the use of suitable deflecting coils in place of the deflecting plate pairs. In this instance, the negative deflector magnetic field pairs are used, and biasing fields may be produced readily by feeding a direct current to the deflecting coils either in series or in parallel with the source of deflecting current (and the direct current connection being by-passed to permit the distortion-free passage of the deflecting currents), or by having additional constant field coils energized from an adjustable direct current source. In each of the above cases, the resulting field developed by the bias opposes the deflector current field and is suitably related in magnitude thereto as explained in connection with Fig. 8. It will also be appreciated that reversed electrostatic fields may be used for the purpose of practicing this invention where desired, and such fields may be developed from a large source of constant, although preferably adjustable potential, in such direction as to oppose the main deflector plate fields, and such reverse field plates may be located within or without the corresponding image scanning tubes.

Although the system so far described has been illustrated in connection with electrostatic deflection of the cathode ray beam, it is, as was above suggested, also possible to use, where desired, only electromagnetic deflection systems, or electromagnetic deflection systems in combination with the electrostatic systems. In addition, the electromagnetic systems likewise lend themselves to usage with the biasing systems of the previously described Figs. 5, 6 and 7 as well as with the forms of beam deflection control to be more completely described in connection with the receiver end of the system.

Figs. 28, 29 and 30 are directed to electromagnetic deflection systems and are applicable either to the transmitter end of the system or to the receiver end. While it is to be understood that these arrangements apply equally well to all image scanning tubes or image reproducing tubes, the deflection control is shown for a single tube only and in only one of the two directions of deflection, although the manner of connection with a plurality of tubes will be obvious in view of the arrangements shown by Figs. 5, 6 and 7 of the transmitter and also the arrangements shown in connection with the receiver. In these diagrammatic showings, the tubes 34, for example, of the transmitter (or tubes like 160 of the receiver—see Fig. 11) are conventionally shown in part. Since the large end of the tube envelope is, in each case, not material to an understanding of this portion of the invention, the neck of the tube is broken away.

In the neck of each tube 34 is positioned the tube cathode or electron emitter 615 (shown as a direct heater although obviously the well known

indirectly heated cathode may be substituted) and axially aligned with the cathode is the grid or control electrode 617 (usually in the form of an apertured disc) and the anode 619 (usually a tubular electrode member). In the case of the transmitter tube the grid is biased to cut-off by the synchronizing signal generator deriving so-called "return line" periods while in the receiver tubes the grid or control electrode is supplied with received video signals to control the image reproduction on the luminescent screen (not shown by Figs. 28 to 30).

In order to deflect the cathode ray beam 621 developed when suitable voltages are applied to the cathode and anode are the electromagnetic deflecting coils 623 and 625 for causing, when energized, the cathode ray to bend to sweep the luminescent screen. The coils 623 and 625 are supplied with current from the source of beam deflection energy or deflection wave generator and suitable associated tubes 627. The source 627 develops electrical energy of such wave formation as to force a saw-tooth current wave through the deflecting coils 623 and 625. Due to the impedance of the deflecting coils such a wave form of energy is usually an electrical wave having both a saw-tooth and an impulse component as is known in the art and described, for example, by A. W. Vance in United States application, Serial No. 544,959 filed June 17, 1931, now issued as United States Patent No. 2,137,039. The sources of beam deflection energy are usually controlled as to timing either by the received synchronizing signal in the case of the receiver (see Fig. 20) or by the synchronizing signal generator in the case of the transmitter (see Fig. 5).

The bias voltage to cause each independent image scanning or reproducing tube to be coordinated to a particular partial or component area (as in Figs. 6 and 7) is developed by means of a suitable source of direct or uni-directional current 629 which flows directly through the deflecting coils (Figs. 28 and 29) or through a separate coil 631 acting simultaneously with the main deflecting coils to control the path of the beam motion. (See Fig. 30.)

In one form of arrangement (Fig. 28) the direct current from the source 629 is blocked from the high frequency path by means of a suitable condenser 633 while the high frequency deflection voltage is blocked from the direct current path through the bias source by means of a choke coil 635. A slightly modified form of circuit is shown by Fig. 29 where the direct current and high frequency paths are in parallel and the high frequency is bypassed with respect to the bias voltage 629 by way of condenser 633 while the direct current bias is bypassed with respect to the source of beam deflection energy 627 by the choke coil 635.

Where separate deflection coils are used for biasing (Fig. 30) the arrangement is slightly modified and the direct current from the bias source is prevented from flowing in the circuit of the beam deflection energy by way of the A. C. connection because of the separated biasing and beam deflection circuits. The beam deflection energy flowing through deflecting coils 623 and 625 cannot be induced into the circuit applying the deflection bias by reason of the connection in the bias circuit of the high frequency choke coil 635 in series with the bias coils 631 and the bias source 629.

Systems for producing composite pictures or

scanning composite pictures formed from a plurality of juxtapositioned partial or component areas, naturally, require deflection of the developed cathode ray in two mutually perpendicular directions. This requires a mere duplication of the systems of Figs. 28 to 30 in connection with the deflection coils (not shown) for deflecting in a plane at right angles to the plane of deflection produced by coils 623 and 625. Where a combination of electromagnetic deflection and electrostatic deflection is utilized the circuits of Figs. 28 to 30 may readily be combined with those shown by Figs. 6 and 7 as well as that of Fig. 20.

Naturally, systems using a multiplicity of cathode ray image producing or reproducing tubes will be arranged in accordance with the form of arrangement conventionally shown by Figs. 5, 6 and 7 and also Fig. 17, for example, and the biasing value applied to the deflecting means for controlling the beam deflection on each of the separate or partial-image scanning or reproducing tubes will follow the above referred to modifications.

Reference may now be made to the receiver end of the system whereby large size picture areas may be produced. In this connection it should be borne in mind from the statement of invention above made and in accordance with aims and objects thereof above defined there should be provided as a part of the receiving instrumentality a device composed of a plurality of separate and distinct image reproducing tubes which will each produce scanning component parts of the resulting subject later to be matched together to produce a complete image subject. Reference will be made, for the purpose of describing the invention, to one specific form of device for a predetermined number of lines into which the produced picture is assumed to be divided. In connection with the receiver also it should be distinctly understood that while one form of transmitting system has been disclosed and a general form of receiver system will herein be described, the receiver system nevertheless to be of utmost practical value is adaptable to existing types of transmitting equipment. Therefore, the receiver device to be described is one of such type as to be capable of producing "large" size images of the character herein defined from the signals transmitted by the now existing types of transmitter equipment, as well as by the coordinated use of the transmitter equipment, described by Figs. 1 through 10 hereof.

Consequently, for the purpose of this disclosure the illustrative example which will be assumed for the purpose of description by no means represents the ultimate capabilities of the system but is convenient for use as an illustration of the operation. In connection with the scanning of a single component or partial-image area, such as the area 1 in Fig. 1, the system described for transmission was assumed to scan the area 1, as well as the areas 2, 3 and 4 with 360 lines of picture detail. Therefore, it will be assumed that it is desired to reproduce a 360-line picture of each of the component areas 1 of Fig. 1, (which, it will be appreciated, may be a complete view of a complete subject) with the size of picture ultimately to be produced at the receiver to be 6 feet high and 8 feet wide. The receiver system will be described herein with reference to a reproduced picture of such size for all of the component or partial-image areas. Either sequential line scanning or interlaced scanning can be used with equal effect in the picture reproduction with

resulting efficiency comparable to presently found results for each type of scanning. Following this analogy, of course, it will be appreciated that the description which is to follow would apply equally well to a composite reproduced picture of 720 lines, for example, which would have dimensions 12 feet high and 16 feet wide, for example.

If, now, the 360 line picture 72 inches high is assumed, it is appreciated that the width of each line into which the picture is to be divided upon reproduction will be 0.2 inch.

It is known in the art that if the line structure by which the picture of the reproducing system is recomposed is to disappear, the viewing distance should be about 1,900 times the width of the individual picture element or line. Thus, in the chosen example, the viewing distance would be of the order of approximately 31 feet, and for a television screen on the theater stage this, naturally, will be an entirely feasible and acceptable viewing distance when it is understood that all viewing distances in excess of 31 feet would, similarly, show no line structure in the produced picture image.

If, now, it is assumed in considering this invention further for the purpose of illustration that the large picture is assumed to have dimensions 6 feet by 8 feet (this resulting from the aspect ratio 1.33), then it can be assumed that this large picture is made from the projection on a translucent screen as a result of reproducing the partial or component images formed on sixty-four separate cathode ray image reproducing tubes, each of which partial-images will have the same aspect ratio as the finally produced large picture. So considered, each of the separate cathode ray image producing tubes would then produce a partial-image on the large screen and each of the partial-images would have height and width dimensions which would be one-eighth of the finally produced large picture, that is to say, $\frac{1}{8}$ th its area so that the dimensions of each of the partial-images would be 9 inches high and 12 inches wide.

The actual partial-image picture is formed on the luminescent screen of the assumed cathode ray image producing tubes. These tubes preferably are of the projection type cathode ray device, as disclosed, for example, by John C. Batchelor in copending application, Serial No. 584,924 filed January 6, 1932. Each of the separate projection type cathode ray tubes will produce an image of a size approximately $2\frac{1}{4}$ by 3 inches, and since its height and width relationship is assumed to be $\frac{1}{8}$ th the complete image, it can be seen that each separate projection type cathode ray image producing tube will produce 45 lines of the picture, and each line of the partial-image will then be 2.25 inches divided by 45, or 0.05 inch (1.27 mm.) in width. This value or fineness of definition, it will be appreciated, can easily be obtained in practice. Far finer line definition than above suggested is obtainable in practice, if needed.

Following the foregoing illustration, each of the component partial-images on the cathode ray image reproducing tubes scanned is intended to be projected by means of a suitable optical system, such as a relatively simple and inexpensive convex lens combination, onto the large translucent viewing screen. With the size of each partial-image being of the order of $2\frac{1}{4}$ inches by 3 inches and the projected image 9 inches by 12 inches, a simple calculation discloses that for a convex lens for projection would be placed at a distance at

7.5 inches from the cathode ray projection tube screen and approximately 30 inches from the large translucent viewing screen.

From a consideration of the description of Figs. 6 and 7, herein and bearing in mind the fact that the receiver system is generally adapted to follow the same operational characteristics as the transmitter herein described, except insofar as the present illustration assumes 64 complete projection type cathode ray reproducing tubes utilized to reproduce the entire image, then each tube should be arranged to function only $\frac{1}{64}$ th of the total time in the production of a projected partial-image. As in the transmitter system, during the time period not utilized by any one individual tube for scanning each complete image (that is, $\frac{63}{64}$ ths of the total time), the electronic scanning beam in each image reproducing cathode ray tube will be brought to rest on a relatively heavy internal conducting surface which is maintained at a suitable constant potential, as, for example, at ground connection. This was the case also in any one of the masking areas 150, 152, 154 and the like of Fig. 9. With the scanning beam falling upon the masking area the energy of the electron beam will be absorbed without objectionable secondary emission by the use of a suitable coating, such as a colloidal graphite, assumed for each conducting surface in question because of the fact that at best only reduced secondary emission can take place.

In addition, this conducting surface may also serve the additional purpose of an optical mask, although separate external optical masks may be used. This is done by limiting the size of the aperture provided to such a dimension as to mask the luminescent material upon which the partial-image is formed to a size $2\frac{1}{4}$ inches by 3 inches, which is the assumed size of each partial-image according to the illustrative example herein assumed. Each partial-image will then be produced on a separate cathode ray image reproducing tube and matched, as will herein be explained, with each other partial-image. Further, each partial-image which, (when considered with the aspect ratio of 1.33) will mean that the individual tubes will each produce 2,700 picture elements out of a total of 172,800 picture elements required for the 360 line picture, forms one $\frac{1}{64}$ th of the total picture.

Turning now more specifically to the construction of a receiver device for producing an electro-optical image according to the above conditions, reference first may be made to Fig. 11 of the drawings. Fig. 11 shows the general arrangement used in the production of a partial-image from a single cathode ray image reproducing tube. For a complete picture image it, of course, will be understood according to the assumed example, 64 such installations will be required. So constituted, the image producing cathode ray tube 160 (which is shown only in conventional form) has provided at the base of the neck portion 161 a suitable base 162 through the terminal points 163 of which suitable operating voltages may be supplied. The electron gun structure is conventionally illustrated at 164 and includes the usual directly or indirectly heated electron emitting cathode, a control grid, and an accelerating anode. Immediately ahead of the gun structure 164 and longitudinally spaced therefrom are the usual deflecting electrode pairs 165, 166 for vertical deflection of the developed cathode ray and 167 for horizontal deflection of the developed cathode ray. The electron beam or ray developed by the application of suit-

able voltages to the elements of the gun structure 164 then passes through the tube longitudinally so as to impinge upon the tube luminescent screen 168. Positioned so as to surround a portion of the screen material and to form a limiting mask thereabout, is conducting shield 169 which is metallic or conducting in nature and preferably coated with a colloidal graphite solution to minimize secondary electron emission under beam impact. The aperture or masking area of the size herein above assumed for limiting the area over which the partial-image may be produced is conventionally illustrated as including that aperture in the conducting shield which extends between the edges 170 and 171 in the plan view, it being understood that the horizontal dimensions are limited in the same manner as shown for the vertical dimensions. Suitable voltages may be applied to the conducting screen or shield 169 by way of the terminal connection 172.

Where desired a supplementary masking member 173 having an aperture 174' may be used in conjunction with the masking area provided by the apertured conducting shield. The masking member 173 serves to minimize the stray light in the system. The convex projection lens 174 is preferably mounted in a barrel 175 which enables back and forth focussing motion, as indicated by the arrows. The tubular member 176 which surrounds the lens barrel 175 is supported by an opaque shield member 177 arranged as indicated by the arrows 178 to be moved up and down vertically to carry the lens with it and as also shown by the arrows 179 to be moved in and out with respect to the plane of the paper, that is, the lens 174 should be positioned so as to be capable of motion in any direction parallel to the plane of the object and image (the luminescent screen partial-image and the large screen partial-image, respectively) and also capable of motion along its optical axis for focussing purposes.

The entire cathode ray tube assembly is connected flexibly and mounted so that it also can be moved back and forth along the optical axis of the lens by a small amount to permit compensation for slight differences of focal lens of the inexpensive projection lens system as commercially furnished, and assumed for purposes of illustration of this invention, or for other variations in the partial-image systems. Thus, the partial-image developed on the luminescent screen 168 of each of the tubes 160 may be brought into juxtaposition and accurate alignment upon the translucent or transparent viewing screen 179 when focussed thereupon by means of the lens system 174. In apparatus of the nature herein described, the various tube elements 160 which are each to produce a single partial-image are so mounted and adjusted relative to the viewing screen 179 that the partial area herein assumed as being composed of 45 lines of picture are caused to match on the viewing screen, and when viewed collectively to reproduce in enlarged manner the complete area represented by the sum of all of the partial areas.

A suitable and convenient method of adjusting the entire assembly is schematically illustrated by Fig. 12 where the screen 179 is indicated as being bounded by the boundary limits 180, 181, 182 and 183 and by the several lines traced across up and down between these boundary limits. It can be seen that 64 separate partial or component part image areas 184 have been provided. The large screen 179 is first swung aside or otherwise removed to leave available vertical support rods

180, 183 and 181, 182, each rod being just back of the image plane. A hollow cylinder 184 is arranged to slide up and down on the rod 180, 183 and may be clamped thereto in any desired position. Similarly, a second hollow cylinder 185 is arranged to slide upon the rod 181, 182. The upper ends of the two hollow cylinders 184, 185 are connected by a horizontal rod 367, while the lower ends are connected by a second horizontal rod 365 and over each of the horizontal rods is mounted slidably a hollow cylinder which preferably has the width of three partial-images. Similarly, the vertical slidable cylinders or sleeves 184 and 185 conveniently have a length of three times the height of a partial-image. Mounted over the horizontal rods is a smaller translucent screen 186 upon which may be produced a complete picture three partial-images wide and three partial-images high. It will be seen that this screen can be moved vertically or horizontally so as to cover any nine partial-images. Thus, the line of junction of each partial-image and those adjacent to it may be conveniently studied and adjusted for position, adjacency, matching, and maximum smoothness of the complete picture on the large screen which is to slide into position after the screen-carrying metal framework is removed from the field of view, for example, by sliding it up to a portion or prolongation of the vertical rods 180, 183 and 181, 182 above the complete picture area.

From the foregoing it can be seen that by this manner of adjusting and observing the partial areas of the resulting fields of view as produced by the impact of the electron beam or the luminescent screen of any one of the cathode ray image producing tubes 160 causing luminiscence on the screen 168, the areas may be easily matched by making suitable adjustments in the positioning of the tubes 160 relative to the lens, or of the lens relative to the tubes, or of both, and also by deflection voltage and deflection bias voltage adjustments.

In the previous embodiment of the optical system herein described in Fig. 11, the projection of a component or partial-image or picture area has been accomplished through a lens which forms an image thereof on the translucent viewing screen 179 upon which the component pictures are projected in juxtaposed positions, it is possible also to utilize other optical projection means for the same purpose. One means of this type is provided by the use of suitably positioned mirrors, either spherical or substantially spherical as described by Fig. 37. The several mirror surfaces should be so positioned that the reflected partial-image areas will be located in proper juxtapositioning for viewing.

Where a reflecting type optical system is used (as in Fig. 37) each separate image producing electron tube 160, on the screen 168 of which a partial-image is formed, is mounted with the optical axis 170 of a mirror 171 passing through the center of the image formed on the tube luminescent screen 168, it being understood that the optical axis should coincide with the longitudinal tube axis. The produced partial-image is suitably masked by a mask 173 so that only the useful portion of the produced partial or component part image is exposed to the mirror 171. Light passing from the partial picture on the cathode ray tube screen 168 is reflected from the mirror 171 and is brought to a focus on a translucent screen 179 placed perpendicular to the optical axis of the mirror and at an appropriate distance

therefrom. In this type arrangement the cathode ray tube 160 is positioned between the translucent screen 179 and the concave mirror 771 in contrast to the positioning explained by Fig. 11.

5 As an illustrative case for one suitable manner of positioning the cathode ray tube screen 168 may be located 9 inches from the mirror surface 771 and an image of three times the size of the original partial picture may be formed at the
10 corresponding distance of 27 inches from the mirror. Under these conditions, the focal length of the mirror is readily found to be $6\frac{3}{4}$ inches and the radius of curvature of the mirror (assumed spherical) is found to be $13\frac{1}{2}$ inches. To render
15 the system conveniently usable, it is necessary that the spherical mirror 771 have straight edges formed by planes parallel to the optical axis and parallel to the edges of the partial optical image. Accordingly, each mirror 771, viewed
20 along its optical axis, will have a rectangular outline having the same aspect ratio (assumed to be 4 to 3) as the partial-image on the cathode ray tube screen. To prevent leakage of light from adjacent tubes suitable shields 772 and 773 are
25 mounted in the system. Thus, one shield is mounted between each cathode ray tube and the translucent screen on which the total picture is formed. Alternatively, the tubes may be internally or externally blackened, as disclosed by
30 Zworykin and Batchelor Patent 1,988,469 of January 22, 1935, or the tubes may be shielded by an opaque body except over the active portion of the luminescent screen.

35 From each edge of each mirror there projects a flat blackened and light absorbing shield 773 which extends toward the tube in a plane parallel to the optical axis of a corresponding mirror. These shielding planes 773 are extended toward
40 the translucent screen for a sufficient distance to prevent light from any partial-image area on a cathode ray tube screen from reaching any mirror other than the one which projects this particular picture upon the translucent screen 179.

45 With this type system it can readily be appreciated that the same accurate juxtapositioning of all of the partial-images upon the screen 179 is obtained similarly to the optical method of Fig. 11. Slight adjustments may be made by moving the tube and/or mirrors relative to each other
50 and to the screen, as will be obvious and thus not specifically shown.

If the received video frequency voltages corresponding to the incoming or received picture signals were to be applied simultaneously to the control electrode of all of the partial-image reproducing tubes and if the synchronizing signals were to be applied to all of the vertical and horizontal deflecting electrode plate pairs of each of these tubes for the assumed case of electrostatic control, a useful large screen image would not be
60 obtained. Rather, there would be obtained a multiplicity of identical adjacent picture areas which would not add up, as should be the case to one large picture which represents the sum total of all of the component partial-images.
65 Therefore, as in the transmitter arrangements herein described, there is required at the receiver also a suitable means so as to interconnect and interlock and to retard the various vertical deflecting means and the various horizontal deflecting means respectively. In this way, each partial-image reproducing tube is optically active
70 in the partial-image production only at the proper times to contribute fully its proportion of the total picture and nothing else. The method and

means by which this is accomplished is one part of this invention. The principle of operation is more particularly depicted by referring to Fig. 13 of the drawings. In Fig. 13, numerals 190, 191, 192, 193, 194 and the lines drawn therebetween represent conventionally the usual saw-tooth voltage wave applied to the electrostatic deflecting plates of the tube for producing either the horizontal or vertical beam deflection. The maximum amplitude of such a voltage wave is indicated by the ordinate value between the points 191 and 192.

Still assuming the example wherein 64 separate cathode ray image reproducing tubes are utilized for the purpose of reproducing the image, by following an analogy of Fig. 8 (relating to the transmitter) it can be seen that a group of biasing voltages, varying each by $\frac{1}{64}$ th of the total amplitude of the voltage between points 191 and 192, shall be provided and suitably selected and applied to the beam deflecting electrode through suitable deflection circuits.

From this it follows then that the amplitude difference between points 191 and 192 of the wave 190, 191, 192, 193 etc. may be divided into eight
25 equal portions, and that the various fractions of the total voltage difference between points 191 and 192, selected by eighths, may be chosen and represented by the amplitude value between the level 195 (which is assumed for purposes of
30 illustration to be zero) and the levels 196, 197, 198, 199, 200, 201, 202 and 203. These voltages thus represented are then zero to $\frac{1}{8}$ th (the voltage between 195 and 196) zero to $\frac{2}{8}$ ths (the voltage between 195 and 197) and so on up to the
35 total or maximum voltage represented by the ordinate 195, 203, which is applied to all the deflector plates for a deflection in a given direction. Suppose, now, for example, that the deflecting voltage required to move the scanning spot
40 straight across the luminescent screen or partial-image area in the corresponding direction is represented by the voltage value 195, 196, that is, by $\frac{1}{8}$ th of the total direction, it is apparent that a similar voltage of only $\frac{1}{8}$ th the total voltage of
45 the saw-tooth wave 190, 191, 192, 193, etc., need be applied between the deflector plates of any one tube to deflect the scanning beam across that particular tube in order to scan the image producing plane thereof.

50 This succession or series of biases are, it is to be noted, in arithmetic progression since the difference between the bias on any one tube and that on the adjacent tubes is a constant quantity equal to the voltage required to deflect the spot
55 across any one tube. Thus the progression of bias voltage may be in sequence equal to 0, d.v., 2 d.v., 3 d.v. up to 7 d.v. for the eight column eight row array, for example, where d. v. represents the voltage required to deflect the scanning
60 spot across the screen in one direction in any one given tube.

Consider for the purpose of illustration only the horizontal deflection circuits and referring in this connection to Fig. 14, it will be seen that all
65 of the image reproducing tubes lying in the same vertical column as the tube 216 may have their horizontal deflecting plates connected in parallel and to the deflection voltage source. There will be applied to the horizontal deflecting electrodes
70 of these tubes not only the deflection voltage represented by the deflecting voltage wave shown by Fig. 13, but also a negative deflector bias which will oppose the deflecting electrostatic force applied across the deflecting electrode plates. 75

However, in connection with the first vertical column of image reproducing tubes shown in the vertical column beneath the tube 232, this negative deflecting bias will be of zero value because of the fact that the deflecting voltage wave is first induced upon these tubes insofar as horizontal deflection is concerned, and, therefore, the reproduced image is first produced upon the tube 232 or those tubes vertically beneath it with respect to the horizontal traverse of the image plane. To the horizontal deflecting plates of the image reproducing tubes lying in the vertical column next to the right of the tube 232, namely, the column 217 and those tubes immediately below the same, all of the horizontal deflecting plate electrode pairs may also be connected in parallel to the deflection voltage source. To the horizontal deflecting electrodes of these tubes there is also applied not only the deflection voltage but also the negative deflector bias voltage equal to the voltage represented by the voltage difference 195, 196 of Fig. 13 or, in other words, a biasing voltage of $\frac{1}{8}$ th the maximum deflection voltage (assuming an array or assembly panel to be built up from 64 separate partial-image reproducing tubes arranged in eight columns of eight rows each).

A condition similar to the preceding holds for those image reproducing tubes lying in the third vertical column to the left of Fig. 14, that is, the image reproducing tubes representing the partial-image indicated by 218 and those image areas immediately therebeneath except that the negative deflector bias in the case of the image reproducing tubes in the third vertical column is equal to the voltage represented by the ordinate 195, 197 of Fig. 13 or, in other words, is $\frac{2}{8}$ ths of the maximum deflection voltage. Similar conditions apply to each succeeding column of image reproducing tubes but with increases in the negative deflector bias voltage applied to each column by $\frac{1}{8}$ th of the maximum deflection voltage until the 8th and final column is reached, which is represented by the partial-image areas 219, and those tubes 223, 227, etc., immediately therebeneath vertically where the negative deflector bias voltage is equal to $\frac{7}{8}$ ths of the maximum deflector voltage for the column including tube 219, for example.

Suitable means for applying these horizontal negative deflector biasing voltages are provided in a manner very similar to that explained in connection with the transmitter portion of the system as was described in detail in connection with the description of Figs. 6 and 7. Like the system shown by Figs. 6 and 7, a precisely similar arrangement holds for the vertical deflection controls which are interconnected for each horizontal line and are then given a negative deflector bias voltage for line n from the top equal to $(n-1)/8$ ths of the maximum vertical deflector voltage, where n represents the number of the row of the tubes where the bias is to be determined, so that, for instance, for row 7 the value of n equals 7.

Considering, for example, the resulting image in the case of the horizontal deflection, it is clear that each vertical column of the image reproducing tubes comes into action, that is, has its scanning spots incident upon and optically visible in the arrangement of Fig. 11, in succession except as prevented by the action of the corresponding vertical deflection controls and each column of image reproducing tubes could be active in succession only $\frac{1}{8}$ th of the total time re-

quired to describe a horizontal line of the large picture. This system, however, must be modified as already indicated by the similar action of the negative vertical deflector bias and, as a result of this later action and by analogy to the system immediately preceding, it is clear that each horizontal row of image reproducing tubes comes into action or, in other words, has its scanning spots incident upon and optically visible in the arrangement of Fig. 11 in succession except as prevented by the action of the corresponding horizontal deflection control, and each row of image reproducing tubes can be active in succession only $\frac{1}{8}$ th of the total time required to move the scanning spot downward from the top to the bottom of the complete picture, which is again as it should be for the desired functioning of the arrangement.

The combination of the conditions mentioned immediately above leads to only a single one of the assumed sixty-four image reproducing tubes being optically active and contributing to the complete picture at any given time. It also leads to an orderly progression in the activity or operation of these image reproducing tubes in such fashion as to carry on the scanning of the entire picture in precisely the same fashion as if it were being produced by one very large image producing tube capable of producing a picture of such large dimensions. This is made clear by a consideration of Fig. 14 which shows the partial-image areas 216, 217, 218—219 in one horizontal row with image areas 220, 221, 222—223 in the adjacent horizontal row, as well as the complete picture area 232, 234, 235 and 236. Similarly, in vertical alignment the partial-image areas 216, 220, 224—228 form one vertical column while the partial-image areas 217, 221, 225—229 form the adjacent vertical column until the complete area 232', 234, 235, 236 has been formed.

In connection with each of the image reproducing tubes indicated as positioned within the partial-image areas 216, 217, 218, etc., the circle within each image area represents the luminescent end wall of each tube, and the rectangular portion within each circle represents the partial-image area produced by each separate tube as masked and determined by the window 174 of the masking area 173 shown by Fig. 11. In connection with each of the separate image reproducing tubes of Fig. 14, there is shown within the circle the scanning spot in an assumed momentary condition corresponding to only one optically active image reproducing tube, namely, that tube producing the partial-image area 221, it being assumed as the second tube down in the second vertical column and the second tube across in the second horizontal column of the partial image producing tubes. It will be seen that the spot or point 245 of the partial-image area 221 being instantaneously produced is substantially in the middle of the scanning line 246, 247 and approximately 50% of the way down this partial-image area. A portion of the partial-image screen areas are shown on a somewhat enlarged scale by Fig. 15 where like reference numerals represent like parts in Figs. 14 and 15. It can be seen, for example, that within the tube 232 functioning to produce the partial-image area 216 and masked by the masking window areas 236 that the spot 240 produced by the beam developed within the cathode ray image producing tube 216 is slightly to the right of and slightly below the masking window. This indicates that so far as the first vertical column of partial-image producing tubes (i. e. all tubes vertically aligned with tube 232 is concerned, it is not now scanning a useful part

of the total image area. The position of the scanning spot upon the masking area of this tube indicates that the partial-image intended to be reproduced by the tube 232 has been completely scanned. For the tube 233 having the picture producing area masked by the masking area 237 in order to produce the partial-image area 217 adjacent the area 216, the spot or electron beam developed within this tube is impinging at a point on the mask immediately below the lowermost portion of the screen area used to produce the image but the impact point is shown as midway between points of minimum and maximum deflection of a beam from this tube. This indicates an instantaneous useful operational state of one tube within the vertical column of tube 233. Upon inspection this is shown to be the tube 221.

In this way it can be seen from Fig. 15, taken in conjunction with Fig. 14, that the resulting spot on each of the image producing tubes of the first horizontal line of the pattern is beneath the screen area in a vertical direction of all tubes in the first horizontal row whenever a tube in the second horizontal row becomes active or useful in the production of a partial-image. Similarly, it can be seen that for each vertical row the spot has a position which corresponds to the instantaneous position of scanning in the horizontal path but that each tube is not always active in producing a partial-image by reason of the horizontal deflection bias applied to the system.

Considering now more particularly Fig. 15, where the spot 245 is substantially midway between the left and righthand edges of the masking area for the tube 221 and approximately 60% of the distance between the top and the bottom of the masking area, it is evident that the vertical deflection bias applied to all of the tubes in that horizontal row is of a value equal to $\frac{1}{2}$ of the total vertical deflection voltage required to move the scanning beam from the top to the bottom of the complete picture area. Therefore, all tubes in the second horizontal group of partial-image producing tubes may become active in sequence in accordance with the change in horizontal deflection voltage. Since the vertical deflection bias voltage for the tube in the second transverse row is greater than the zero bias value over which the tubes in the first horizontal partial-image area group would be active and since the deflection voltage in a vertical sense has not yet reached a value sufficient to overcome the $\frac{2}{3}$ and greater bias voltage applied to the tubes in the third and fourth and subsequent horizontal partial-image areas, the only tubes which can be active or respond to signals applied will be those tubes which have a vertical deflection bias of $\frac{1}{2}$ of the deflection voltage value in the vertical sense.

Similarly, considering the horizontal deflection voltages, all the tubes in the first vertical column forming the first vertical column of partial-images having the resultant spot of impact of the electron beam moved beyond the righthand edge of the image reproducing area because of the fact that the horizontal deflection voltage when causing any tube in the second vertical column to become active or to reproduce an image is greater than that zero value of bias by an amount greater than that required to deflect the electron beam in the first vertical column to the righthand edge of the image reproducing area. Since the bias applied to the tubes in the second vertical column is equal to a value of $\frac{1}{2}$ of the total horizontal deflection voltage, it is evident that any tube in the second vertical column

of partial-image producing tubes can become active to the influence of the horizontal deflection voltage except as modified by the previously stated conditions for vertical deflection. Similarly, since the tubes in the third vertical column have applied thereto a biasing voltage equal to $\frac{2}{3}$ of the total value of the horizontal deflecting wave, none of these tubes can become active until the amplitude of the horizontal deflecting voltage wave is of a value greater than that represented by the ordinate value 195, 197. Thus, as shown by Fig. 15, the biasing value for the image producing tube 221 to become active is of a value equal to the ordinate value 195, 196 in both the horizontal and the vertical direction.

From the foregoing the general conclusion to be drawn is that the combination of interconnection of the horizontal deflection plates of each vertical column of image reproducing tubes with the negative horizontal deflection bias of increasing value on each successive column starting from zero from the first column and increasing to $\frac{7}{8}$ ths on the maximum horizontal deflection voltage for the 8th column, and for each of the vertical deflection plates of each horizontal row of image reproducing tubes with a vertical negative deflection bias of increasing value on each successive row starting from zero bias for the top row and increasing to $\frac{7}{8}$ ths of the maximum vertical deflection voltage for the bottom row will lead to only a single image producing tube contributing to the rebuilding of a complete picture at any instant. The result is that the entire assembly or array of partial-image reproducing tubes is caused to function in sequence and, in effect, to function as if it were one large normal scanning image reproducing tube.

The table of Fig. 16 is intended as illustrative of the procedure of scanning a single frame of the complete picture. Starting with the top line of the component sub-picture or partial-image, corresponding to the image producing tube 232 of Fig. 14, the lefthand $\frac{1}{8}$ th of the first picture line is scanned by this tube. Continuing on the top line of the picture but passing into the second portion of the first scanning line produced by the tube 233 of Fig. 14, there is scanned the portion $\frac{1}{8}$ th to $\frac{2}{8}$ th of the first picture line, that is, the second eighth of the first complete picture line. This action continues right across the top row of the image producing tubes until the eighth righthand image producing tube is reached, after which the scanning beam is returned in the same fashion but extinguished by well known means of return line elimination to the beginning of the second line which is again produced by the image reproducing tube 232, and the process is continued as indicated in the table of Fig. 16 through the scanning of an entire frame of the complete picture. In this way, it can be seen that each image reproducing tube contributes $\frac{1}{64}$ th of the total picture, though not sequentially, after which the process or cycle is repeated.

In this connection, it should be noted that while each image reproducing tube contributes a $\frac{1}{64}$ th part to the complete picture (assuming 64 separate tubes) during the scanning of the assumed 45 successive horizontal lines of the complete picture (assuming again a complete 360 line picture divided into the several image reproducing tubes), the entire picture is in fact produced actually or potentially in distorted form within each separate image reproducing tube.

The manner in which the deflection voltages are supplied to the several tubes for producing

the partial-images in the assumed 64 tube array described in connection with Figs. 14, 15, and 16 is more particularly exemplified by the diagrammatic illustration of Fig. 17. This figure should be read also in connection with the showing of Fig. 13 where, as above explained, the ordinate value of the deflection voltage 195, 196 considered for horizontal deflection will be effective within the partial area 1—1, while the ordinate value 196, 197 of the deflecting wave will be effective in the partial area 1—2, and, for example, the ordinate voltage value 202—203 of the deflecting wave will be effective in the partial-image area 1—8. The diagrammatic showing of Fig. 17 however may be considered together with the arrangement described by Figs. 6 and 7 for the transmitting tube system since the system, it will be noted, closely approximates that of Fig. 6 relating to the transmitter except that the number of tubes in the complete array has been increased from four to sixty-four.

Referring now more particularly to Fig. 17, it will be seen, as was explained in connection with Figs. 6 and 7, that all of the deflecting plate electrode members 167 for horizontal deflection are connected together and connect to the zero or negative side of the saw-tooth voltage source 706 for horizontal deflection (assuming left to right scanning), and that the righthand horizontal deflecting electrode members 167' for each column of tubes are also connected together and that these electrode members connect successively to the negative terminal of successive constant voltage bias sources 110, 110', 110''. It was above explained in connection with Fig. 6 that the amplitude of the output saw-tooth voltage wave from the saw-tooth voltage source 706 (analogous to the source 108 of Fig. 6) is of an amplitude equal to the voltage amplitude required to deflect the developed electron beam within any one tube from one edge portion of the screen to the edge portion directly opposite multiplied by the number of tubes in the same row or column. Accordingly, with a 64 tube array, where the tubes are assumed to be arranged in 8 columns of 8 tubes each, it will be appreciated from the showing in Fig. 13 that if the voltage required to deflect the beam from one edge of the screen to the other for the partial area 1—1, for example, is represented by the deflection voltage (d. v.) value 195—196 (Fig. 13) that the amplitude of the output from the source 706 will be equal to 8 d. v.

Consequently, different values of bias are assigned to the bias sources 110, 110', 110'' as indicated, it being understood, however, that bias element 110'' is (in actual practice) in the form of several separate bias elements like 110 but is herein shown in merely conventional manner.

Similarly, the saw-tooth voltage source 707 for providing the deflection of the cathode ray in the vertical plane and which deflection voltage is to be applied between the deflecting electrode plates 165—166 of each tube also develops a deflection voltage of an amplitude 8 d. v. but at a frequency lower than that of source 706. Like the sources of bias 110, the constant voltage sources of bias 114, 114', 114'', etc., are of progressively increasing value as indicated. Each constant voltage bias source for both vertical and horizontal deflection is shunted by a condenser element 115 or 113 in the same manner as described in connection with Fig. 6.

For the vertical deflection of the cathode ray beam, the upper deflecting plate 165 of each tube

is connected to the zero or negative terminal of the saw-tooth voltage source and the lower deflecting electrodes 166 of each tube are connected together row by row so that the tubes of the first row have no bias applied in the vertical direction, the tubes of the second row have a vertical bias d. v. applied, while the tubes of the 8th row, for example, have a vertical bias 7 d. v. applied in the polarity indicated. The saw-tooth voltage sources 706 and 707 for producing the deflection voltage for deflecting the developed cathode ray beams in horizontal and vertical directions are suitably controlled, as more particularly indicated by Fig. 20, from incoming synchronizing signals representing both the line and the frame frequency. Suitable compensating means for compensating for voltage changes such as will be explained in more detail in connection with Fig. 31, for example, are provided at 747.

Having now described the manner in which the electron beam of each reproducer tube is deflected by the description relating to Fig. 17, reference may now be had to the manner in which the produced partial image areas appear. By Fig. 18 there is shown the partial-image as produced within the eighth or right-hand uppermost image reproducing tube of the series shown by Fig. 14. The useful partial-image which is not covered by the optical mask or masks is undistorted and is shown as that portion of the complete image embodied within the boundaries 232', 234, 234' and 232''. Since the horizontal negative deflector bias voltage on this image reproducing tube is of a value equal to $\frac{7}{8}$ of the amplitude of the saw-tooth deflecting voltage wave, as above explained, the scanning line never reaches to the right of the line between points 234 and 234'. The scanning spot, however, does pass over a region to the left of the line between points 232', 232'' producing there the inactive or optically unused partial-image pictures represented by the first seven partial-image producing tubes of the first horizontal line of the image producing tubes shown by Fig. 14. Somewhat similar, since the vertical negative deflector bias on this partial-image reproducing tube is of zero value, the vertical frame 1—8 (also bounded by the loci 232', 234, 234' and 232'') is the first produced during the downward motion of the scanning beam of the complete picture. After this portion of the complete picture has been produced, the portions represented by the partial-image producing tubes immediately therebeneath in the vertical column are produced each narrower than the preceding in a vertical but not a horizontal direction because of the non-proportionality of the vertical scanning beam motion and the vertical deflecting force in this region.

The remaining portion of the picture produced by this separate image producing tube comprising such typical portions as the distorted pictures 2—7, 3—6, 4—5, etc., are indicated in the figure and are all optically unused in the formation of the complete picture. In the designations applied to Fig. 18, the first numeral of each separate area represents the horizontal row of partial-image areas and the second numeral represents the vertical partial-image area so that the area shown in undistorted form by the designation 1—8 represents the first horizontal column and the eighth vertical column. Similarly, the distorted area 1—7 represents the first horizontal column and the seventh vertical column, and likewise the distorted area 3—8 represents

the third horizontal column and the eighth vertical column.

A somewhat similar condition is illustrated by Fig. 19 which shows the picture produced within that image reproducing tube which is at the junction of the fourth horizontal row and the fifth vertical row, so that it bears the locus, indicia 4-5. This tube produces behind the unmasked portion of this partial-image scanning tube the partial-image identified 4-5 as bounded by the bounding limits 647, 648, 649 and 650. This partial-image is undistorted, but all other and optically unused and masked partial-images are distorted, as indicated. The actual distortion varies in arrangement and size from the areas 5-5 and 3-5 which are only vertically distorted and areas 4-4 and 4-6 which are only longitudinally distorted to the distortion in two dimensions which is to be noted for areas such as 3-2; 3-3; 2-6; 3-1; and 3-3 for example, for the reasons set forth in describing Fig. 18. The main difference between the cases shown in Figs. 18 and 19 is that the horizontal negative deflector bias in Fig. 19 is less than in Fig. 18, being of a value equal to $\frac{1}{4}$ of the maximum horizontal deflector voltage, but the vertical negative deflector bias in Fig. 19 is greater than in Fig. 18, being equal to $\frac{1}{4}$ of the maximum vertical deflection voltage. This enables the production of the partial-images lying above and below and to the right and to the left of the partial image area 4-5 on at least some of the tubes. The actual distortions of the unused image portions within a given tube may be straight or curvilinear; but since they are unused, this is of no significance.

In any event, it will be appreciated, of course, that the large size areas 1-3 of Fig. 18 and 4-5 of Fig. 19 are intended to represent the areas of view uncovered by the aperture or window 174 of the masking screen 173 for the instantaneously active partial reproducing tubes. The remaining areas of each of Fig. 18 adjacent the active areas, such as 1-3 of Fig. 18 and 4-5 of Fig. 19, are illustrated in greatly exaggerated sizes for the purpose of explaining more clearly the invention. It should be understood that in actual practice, the combined width of the areas 1-1, 1-2, 1-3, 1-4, etc., through 1-7 of Fig. 19, for example, and the combined height of all of the areas 2-3, 3-3, etc. through 8-3 of the same figure will actually be compressed very greatly so that the total width and height of these areas will be only of the order of 10 to 20% the width and height of the complete unmasked area of the image reproducing tube instantaneously active. The same is true of Fig. 19 which shows in illustrative form the general size relationship of the reproduced distorted areas adjacent a more centrally located large area reproduced at any desired time period from one of the receiver tubes having a locus corresponding to the location 4-5 of Fig. 19.

A complete receiving system is diagrammatically shown by Fig. 20 and while this figure makes a schematic representation of the entire receiver, it should be understood that the various parts and elements thereof should be considered as related to the aforementioned Carlson patent, as well as other patents and applications mentioned herein, insofar as each mentioned applies to the receiver. In addition, for a complete understanding of Fig. 20 reference should also be made to the remaining figures of the drawings forming a part of this disclosure.

Referring now more particularly to Fig. 20, the

signals transmitted from the transmitter of Fig. 5 and reaching the receiver of Fig. 20 by way of a radio transmitting link or by way of a suitable cable, for example, that known as the "co-axial" cable, are brought to a radio frequency selector 700. This radio frequency selector may be a radio frequency filter or bandpass selector, suitably tuned, as explained in the Carlson patent, or, where desired, may be a radio frequency amplifier having an amplification factor equal to at least unity. In many instances, the radio frequency amplifier is desirable in order to preclude all possibility of re-radiation from the system which would be detrimental where more than a single transmitting station is sending out radio signals simultaneously with the transmission of the signals to which the receiver system of Fig. 19 is tuned.

The output from the radio frequency selector 700 is fed to the first detector 701 of the system into which also there is introduced the frequency developed by the local oscillator 702, and the output from the detector and intermediate frequency is then divided and a portion of the output energy supplied to the intermediate frequency video amplifier 703. Uni-control of the selector, oscillator and detector timing is preferred. The video and synchronizing signals are then to be separated in the output from this amplifier 703. After suitable amplification, the video signals are directed through the second detector 704 and the output of this detector suitably amplified, if desired, is supplied to the control electrode of each separate image reproducing cathode ray tube.

Where image reproduction is produced other than by amplitude modulation or intensity control of the cathode ray beam in the separate image reproducing devices, such, for example, as in a system where velocity modulation of the rate of traversal of the luminescent screen of the image reproducing tubes by the cathode ray beam is utilized, the energy output from the second detector 704 may be used with or without further amplification to control the rate of beam deflection, in which event the intensity of the developed cathode ray beam would be uncontrolled.

Should an automatic volume control system, such, for example, as shown by the Carlson patent, be desirable, the automatic volume control tube may be represented conventionally at 705.

The synchronizing signals separated from the video signals by the synchronizing signal separator 706 are then further divided and the horizontal or line control synchronizing signals or impulses (following each line of picture) are supplied to the horizontal deflection voltage source 706 and the vertical or frame deflection control signals or impulses (following each frame of picture) are supplied to the vertical deflection voltage source 707. Such arrangements may be, as above described, the known types of blocking oscillators, for example, as described by Tolson in United States Patent No. 1,999,378 or its Reissue No. 20,338 and also British Patent No. 402,629, and associated circuits or their equivalents and, as indicated by the drawings. The output from the horizontal deflection voltage source 706, as well as the output from the vertical deflection voltage source 707, is supplied to the deflection control electrodes (assuming an electrostatic system) of the various partial-image reproducing tubes of the system, as shown more particularly by Fig. 21.

The audio signals forming a part of the output of the first detector 701 are directed to an inter-

mediate frequency audio amplifier 709, as is also disclosed in the Carlson patent above mentioned. The amplifier intermediate frequency audio signals are next detected in the second detector 710 and are then further amplified in an amplifier 711. The amplified audio frequency energy actuates a sound reproducer 712. Automatic volume control may also be utilized according to known principles on the audio channel, although this has not been illustrated.

In connection with an understanding of this invention, it should also be appreciated that in many instances, the areas forming the borders of the image reproducing tube for reproducing any one section of the complete pattern of partial areas need not be reproduced at all. This is because of the fact that the scanning beam in each image reproducing tube serving to produce the partial-image area for each different section of the complete reproduced view may so operate that the electron beam which causes normally the luminescent trace or pattern across the luminescent viewing screen, such as the screen 168 of the tube 160, (Fig. 11) may be suppressed or cut-off. Thus, as soon as the path of traverse in horizontal and vertical directions of the beam of the then active image reproducing tube completes the partial area to be represented thereby, there will be no active electron beam to impinge upon the edge portions of the particular tube. It will be seen that great economy of power may be had because each separate image reproducing tube is active or, in other words, is developing a stream of electrons to form the scanning beam only at such times as it is usefully engaged in reproducing a useful portion of the complete image area. At all other times no beam will be active. This suppression of the electron beam may be accomplished in various ways, and for instance may be controlled through the use of a suitable biasing source normally biasing each image reproducing tube to a cut-off position except at the time when the image reproducing tube is usefully engaged in reproducing a partial area of the complete viewed area.

In the system of operation previously described, the anode voltage is continuously applied to each image producing tube in the array. Anode or beam current will flow in such circuits of each image producing tube in accordance with the value of the instantaneously applied video frequency or modulation voltage. This modulation voltage controls the beam intensity in the electron gun of each tube. It is desirable, although in no way essential to the operation of the system above described, to cut-off the beam current by removing effective anode voltage except when each individual image producing tube is restricted to producing the immediately useful partial-image area with which it is coordinated. Accordingly, as soon as the deflection voltage actually applied to the deflecting electrode plates of each image producing tube reaches the value which deflects the electron beam and the resultant scanning spot onto the unmasked portion of the screen of the image producing tube, full anode voltage must be applied. Similarly, as soon as the deflection voltage on the plates of the same image producing tube reaches a greater value, such that the scanning spot leaves the useful and unmasked screen area, the anode voltage should be removed completely from this image producing tube. In practice, a certain tolerance of leeway below the initial value, above mentioned, and above the final value, above mentioned, for the

deflection voltages may be selected for the points at which the control of the application or removal of anode voltage upon the image producing tube becomes effective. This control insures full coverage of the screen area for the time period useful in producing the partial-image area but, at the same time, renders each separate image producing tube inoperative for all time periods not useful in producing each separate partial-image area.

The anode voltage may conveniently be removed from each individual image producing tube, as herein described, during periods not useful in the complete image production through the use of two pairs of two tubes each arranged in series, where each pair of tubes is under the control of the deflection voltage in one of the two directions of deflection. These tubes may be identified as the thermionic load control tubes. The first of these control tubes of each pair is a "threshold" tube which permits anode (accelerator electrode) voltage to pass therethrough whenever deflection voltage applied to the corresponding associated image producing tube deflecting plates reaches the minimum useful value. The second of these control tubes of each pair is a "limiter" tube which cuts-off the anode (accelerator electrode) voltage of the associated image producing tube whenever the deflection voltage applied to the deflecting plate electrodes exceeds the maximum useful value.

From the foregoing statement it will be apparent that the number of "control" tubes should equal four times the number of separate image reproducing tubes.

One form of apparatus to accomplish the maximum degree of power saving is shown by Fig. 26 with a modification by which lesser total power can be saved being disclosed by Fig. 27. Each of these figures assumes electrostatic deflection of the cathode ray beam (for simplicity of illustration) but it will be apparent that the principle of operation is equally applicable to electromagnetic deflection, or to a combined electrostatic-electromagnetic system. Likewise, the control system for the beam cut-off is applicable either at the transmitter end of the system or at the receiver end of the system and, therefore, the showing by the drawings of a receiver type tube must likewise be considered merely illustrative.

Referring now to the drawings (first to Fig. 26 for high degree power saving) the electron beam developed within the tube 160 is produced by the development of a voltage difference supplied between the tube first anode 501 and the cathode 503 (forming together with grid 505—all conventionally shown—the electron gun 164 of Fig. 11) by the source 507. The beam deflecting electrode pairs 165, 166 (vertical beam deflectors) and 167, 167' (horizontal beam deflectors) are connected at terminal points 508 and 509, respectively, with the source of deflection voltage to sweep the developed electron beam across the luminescent screen area 168 and the shield or masking area 171.

Serially connected between the cathode 503 and the anode 501 are the source of anode voltage 507 and the two control tubes 511 and 513. The series connection is provided by connecting the positive side of the source 507 to the anode of tube 511 and then connecting the cathode of this tube to the anode of the next tube 513 which has its cathode connected to the anode of tube 511'. Each tube 511' and 513' is connected similarly 75

to tubes 511 and 513. There is applied to the control grid electrode of all tubes 511, 513, 511' and 513' a suitable bias voltage from sources 515, 517, 515' and 517' respectively. It will be noted that each of the sources 515 and 517, as well as 515' and 517', are poled oppositely with respect to the two control tubes which are connected therewith. For example, tubes 511 and 511' have the bias sources 515 and 515' connected to the positive side of the vertical and horizontal deflecting voltage source connected at 508 and 509. Likewise, tubes 513 and 513' connect with the negative side of the vertical and horizontal deflecting voltage sources connected at terminal points 508 and 509. The vertical and horizontal voltage sources also connect with the deflection electrodes of the image reproducing tubes 160 so that the electron beam passing through the tube anode 501 toward the screen 160 is deflected across the screen and upon the masking area 171. At the same time that increasing voltages are applied to the deflecting electrode pairs 165, 166 and 167, 167' the changes in voltage at terminal points 508 and 509 are effective upon the thermionic control tubes 511, 513, 511' and 513' connected thereto. The choke coils 519 serve to prevent any considerable A. C. from the deflecting voltage source flowing through the series capacity of the thermionic tubes. In such a case the saving in anode power may be expressed by the formula

$$P. S. (\text{power saving}) = \frac{n-1}{n}$$

where n equals the number of separate image producing tubes in the complete array, so that, neglecting power "on" period for short period where the scanning beam is impinging upon the masking area due to the selected degree of tolerance permitted, the saving on a 64 image reproducing tube array would be $\frac{63}{64}$ of the total anode power of the image projecting tubes.

However, it is clear that such saving in power is at the expense of a great number of control tubes and for commercially practical reasons and initial installation expense may prove undesirable. Therefore, by a sacrifice of some power saving it is usually desirable to reduce the number of controlling tubes. The power saving is substantial where the control is arranged to function under the control either of the row scanings or of the column scanings so that single instead of double control of each image scanning tube is provided. For single control it is necessary to provide either two control tubes per row or two control tubes per column of image reproducing tubes in the complete array. With this type of arrangement the power saving may be expressed by the formula

$$P. S. (\text{power saving}) = \frac{\sqrt{n}-1}{\sqrt{n}}$$

where n again equals the number of separate image producing tubes in the complete array. For single control, therefore, it can be seen readily that $\frac{7}{8}$ ths of the total power can be saved in a 64 image reproducing tube array with the number of control tubes reduced to 16. Thus, for double control to save $\frac{63}{64}$ ths of the total power 256 control tubes are utilized but for single control $\frac{7}{8}$ ths of the total power can be saved through the use of 16 control tubes.

Not only does a system of the above type result in a substantial saving in anode power for each complete panel array but it also results in

a decrease of the average emission drain on the cathode of the image reproducing tubes associated with the discrete partial areas so that the tube life is substantially prolonged.

The operation of the above system may be described briefly by noting that tubes 511 and 511' have the control grid supplied with a negative bias, whereas tubes 513 and 513' have the control grid supplied with a positive bias. When the deflection voltage wave (see Figs. 8 and 13) applied to the deflection electrodes of the tubes 160 to deflect the developed cathode ray is considered, it will be appreciated that there is assigned to each image producing tube 160 a certain portion of the complete wave which is to be effective on the selected tube. Thus, if it is assumed that a nine tube panel array is being operated and a change in deflection voltage magnitude from 0 to 6000 volts is required to provide complete beam deflection in both horizontal and vertical directions, it can be appreciated that the tube having the column and row index 2—2 will operate in the range 2000 to 4000 volts for both horizontal and vertical deflection. If now a voltage change of 100 volts above and below these hypothetical values is assumed to be the degree of tolerance in operation then it will be appreciated that the bias voltage values 1900 volts and 4100 volts will be the battery voltage for sources 515 and 517, as well as 515' and 517', respectively. Thus, it is apparent that tubes 511 and 511' will have negative biasing voltage supplied thereon (herein assumed for explanation purposes equal to tube "cut-off" voltage) until the deflection voltage exceeds 1900 volts after which any increase in deflection voltage will cause these tubes to become positively biased and the tubes to draw plate current.

Similarly, since the tubes 513 and 513' are biased positively each tube draws plate current until this tube has applied thereon a negative voltage sufficient to equal or overcome the positive voltage of sources 517 and 517'. Since the negative deflector plate supply is connected with these tubes any voltage in excess of the assumed range will bias these tubes to "cut-off."

From the drawings, it will be seen that anode voltage is supplied to the cathode ray tube anode 501 from the source 507 through four serially connected thermionic tubes 511, 513, 511' and 513' of which tubes 511 and 511' may be termed "threshold" tubes and tubes 513 and 513' may be termed "limiter" tubes. If now, tubes 511 and 511' are biased to "cut-off" for any value of deflector voltage less than that within the operating range assumed for the cathode ray tube 160 assigned to chosen index location (2—2 assumed herein) and if tubes 513 and 513' operate for all voltages below the chosen limit value for the assumed index, it is apparent that the only time all of the tubes 511, 513, 511' and 513' draw plate current simultaneously is when the range of the deflection voltage in both horizontal and vertical directions is in the operating range 2000 volts and 4000 volts (neglecting the assumed tolerance factor) so that the only time when anode voltage from source 507 can become effective upon the anode 501 is at the time when all of the "threshold" and "limiter" tubes 511, 513, 511' and 513' are simultaneously drawing plate current. Otherwise, due to the high internal impedance of the thermionic tubes in a non-conducting state (that is, when the thermionic tubes draw zero or substantially zero plate current) the direct current from source 507 is ineffective to

form any electrons emitted from the source 503 of the cathode ray tube 160 into a beam and there is a consequent saving in cathode ray tube power.

5 The above description, it will be appreciated, considers a complete or maximum reduction in cathode ray tube power saving. However, as was above suggested, due to the large number of "threshold" and "limiter" tubes required to effect
10 this saving, it is usually desirable to save a lesser degree of cathode ray tube power. For such purpose the arrangement of Fig. 27 is preferred from a commercially practical viewpoint. By this modification, the operation is substantially
15 similar except that all cathode ray tubes in each row are maintained in an operative state for the entire time period that the deflection voltage in a vertical plane is within the range to cause the particular horizontal row of tubes to be ef-
20 fective in producing partial-image areas. The only change in the arrangement of Fig. 27 from that described in connection with Fig. 26 is that the separate partial-image area reproducing cathode ray tubes do not have the horizontal
25 sweep voltage made effective from the standpoint of controlling power saving. For such an arrangement the negative terminal of the anode voltage source 507 is connected with the cathode 503 of all cathode ray tubes in its horizontal row
30 and, similarly, the anodes 501 of all tubes 160 in each horizontal row are connected with the cathode of the limiter tube 513. The tubes 511 and 513 are "threshold" and "limiter" tubes biased and controlled as to operation by the vertical
35 synchronizing saw-tooth voltage as was described in connection with Fig. 26 and the anodes 501 of all tubes 160 in each horizontal row are all supplied with voltage from source 507 whenever tubes 511 and 513 are simultaneously operative.
40 It is also well to note that with arrangements of the type shown by Fig. 26, especially it is desirable, usually, to provide separate transformer windings to supply the A. C. heating of the filaments for cathodes of all tubes 511, 513, 511', 513' and so forth, since the voltage on each rises with
45 respect to a uniformly established potential considered as ground, for example.

In connection with the deflection and activation of each separate image reproducing tube and the manner in which each tube will reproduce
50 the partial area of the complete image area suitable deflecting control means are utilized. Various ways and means to accomplish this result may be utilized. Briefly, the manner of controlling the deflection or time when each separate tube
55 of the complete array is active may be brought within several broad classifications. As was explained in connection with the deflection control for the transmitter end of the system described by Figs. 6 and 7, a multi-bias system operating
60 at high voltage, current, or power levels may be utilized at the receiver system. Also, as a modified form of control a multi-bias control system may be utilized which may operate at low levels. Each of these systems will be classified as a mono-
65 phase system since only one phase of the deflection control signaling impulse is utilized. However, a multi-phase control may also be used. In such a form of control as many phases of the control signaling impulse, such as the saw-tooth
70 shape deflecting wave, as there are columns or rows in the panel array may be used for the purpose of controlling the several image reproducing tubes from which the several partial areas of the complete image are reconstructed. Multi-

phase systems, like the monophase systems, readily classify themselves into single bias systems which operate either at high or low levels, as will be herein explained.

For the purpose of considering these various
5 forms of systems, reference may be had to Fig. 13 in conjunction with Fig. 21a. Referring now to Fig. 13, it will be seen that the deflecting wave 190, 191, 192, 193, etc., has the portions between
10 the level 195 and 196 active to control the beam deflection of the several image reproducing tubes over the area 1-1 of Fig. 18, for example. This is true whether or not horizontal or vertical deflection is being considered with the exception,
15 of course, that the frequency of the controlling wave is lower with respect to vertical deflection than with respect to horizontal deflection. Therefore, the general wave shape of the vertical and horizontal deflecting waves, while remaining
20 substantially similar, varies insofar as the time representation is concerned. That portion of the controlling deflecting wave which lies between the levels 196 and 197 will be effective in a horizontal
25 direction of control to control the reproduction of the horizontal pattern traced in the image area 1-2 of Fig. 19 and in the vertical direction to control the image traced within the partial-image area 2-1 of Fig. 19. Similarly,
30 that portion of the deflecting wave lying between the levels 197 and 198 will be effective to control in a horizontal direction of traverse the production of the image upon the area 1-3 of Fig. 19 and in a vertical direction to control the reproduction of image traces in the area 3-1 of Fig. 19.

In connection with the foregoing, it should, of
35 course, be understood that the same wave cannot control two functions, but by reference to the similarity between the horizontal and vertical control waves, it will be understood that different levels of the horizontal and vertical wave serve
40 as this control means. Therefore, while two different waves are referred to with respect to different horizontal and different vertical partial waves, the proportionality of the wave which is effective holds for the foregoing description. So
45 considered, it can be seen by referring to the wave formation α of Fig. 21 (which assumes a composite viewed area formed from nine separate partial or component part areas) that for the
50 area 1-1, for example, the portion 191, 251 of the wave 190, 191, 192, 193 is effective in the area 1-1. The portion 251, 252 of the wave 190, 191, 192, 193 is effective in the partial area 1-2 or 2-1 depending upon whether the complete wave is a horizontal or a vertical deflection control wave.
55 Therefore, it can be seen by referring to Fig. 21 that with the wave separated as there shown into several separate parts, the different parts represented by the heavy lines indicate the portion of the wave effective in any one partial area while the dotted outline portions represent the ineffective portion of the wave.

By Fig. 21a the three curves shown represent
60 from top to bottom the deflection waves applied to three separate tubes for producing the upper partial areas or topmost row for a nine partial-
65 image system and are intended to indicate only the horizontal deflection voltage curve. The deflection voltage for the vertical columns would be similar (except for frequency) and this is not
70 shown. For example, the top curve of Fig. 21a would represent by the dark portion thereof the horizontal deflection voltage for the assumed system in the first vertical column or the vertical deflection voltage in the topmost row. Similarly,

the middle curve of Fig. 21a represents by the darkened portion the horizontal deflection voltage effective in the second column from the left or the vertical deflection voltage effective in the second row from the top. Therefore, for a complete understanding of the curves of Fig. 21a it should be appreciated that the portions of the deflection waves indicated by dotted outline represent the inactive portions of the deflecting wave, that is, during the time periods shown by dotted outline the scanning spot has not actually entered the luminescent screen field of the active image projection tube coordinated with the selected partial area or the scanning spot has moved beyond the field of the immediately active scanning tube. Therefore, the dark portion of each deflection wave of Fig. 21a represents that portion of the deflection wave actually useful in creating a partial-image area. However, under some operational conditions (see Figs. 26 and 27) the non-useful period of the scanning beam deflection wave may correspond substantially to extinction periods of the beam.

For simplicity of representation, the multi-bias high level monophasic system of control disclosed by Fig. 21a has been illustrated as applying only to a system wherein nine separate image reproducing tubes are utilized, that is, three tubes in each of three parallel groups of partial-images in contrast to the sixty-four tubes assumed by Figs. 14 through 19. Therefore, reference to Fig. 13 holds only insofar as two sections (assumed as sections 191, 251 and 251, 252) of the complete wave and the uppermost section 252, 192 of the complete wave is concerned. It will be understood and appreciated that for partial-image areas intermediate the area 1-2 and 1-3 the application of the operational principle would be similar.

So considered, it will be seen that the portion of the deflecting wave lying between the bracketed points 252 and 192 is, in effect, eliminated in a nine tube partial-image system. The portion of the deflecting voltage wave of Fig. 13 effective in sweeping the electron beam of the several image reproducing tubes of a nine tube array is, therefore, best understood from Fig. 21. In operation, where area 1-1 is scanned, area 1-2 is next in order so that the voltage of the deflecting wave increases in amplitude between the values represented by the points 251 and 252. The changes or increases in amplitude of the deflecting wave 190, 191, 192, 193 which occur between the points 191 and 192 are effective, for example, in moving the spot of the image reproduced in a direction from left to right looking at Fig. 19, for example, but having no effect in moving the beam of the other separate image reproducing tubes in a direction from right to left. The control of motion in the reverse direction is accomplished by the return portion of the non-reentrant wave or saw-tooth deflection wave. In other words, the slowly increasing amplitude values of each deflecting wave (between points 191 and 192, for example) cause the image point to move slowly across the luminescent screen of each separate image reproducing tube to produce the desired pattern or image when the beam is controlled in intensity by incoming signals. The rapidly decreasing amplitude values of the beam deflecting wave (for instance, those changes occurring between the points 192 and 193 of Fig. 13) cause the beam to retrace its path rapidly to a starting position, except, of course, that beam extinction during return line periods usually takes place.

This is the usual form of saw-tooth wave developed for deflecting a cathode ray beam along a saw-tooth path in any type of electrostatic deflecting system. The saw-tooth voltage wave for deflection is usually produced by charging a condenser linearly from a voltage source and when the charge has been accumulated to the desired degree suddenly releasing the charge. The charging along a linear path is usually accomplished by charging through a high resistance or through a suitable constant current tube (a diode, tetrode or pentode). Discharge of the stored charge is provided by way of a discharge tube (a high vacuum tube suddenly caused to become highly conducting or by way of a suitable form of gaseous discharge device which will discharge the stored charge when the break-down potential of the gaseous device is reached in charging). Where the high vacuum tube is used as the discharge means the tube is usually controlled in its operation by supplying to its input circuit a strong pulse of energy from an oscillator (a blocking oscillator, a "dynatron" or the like) which is, in turn controlled as to its frequency of operation by received synchronizing impulses. The electrostatic deflecting plates of the cathode ray tube are usually connected across the terminals of the condenser to be charged. The foregoing, while known in the art, is also described in the above-referred to application of A. W. Vance.

With this understanding it will be appreciated that the numerals 1, 2 and 3 of each of Figs. 21a through 21d represent either a row or a column of tubes having the identifying numerals circled. If it is desired to know the type of deflection wave for vertical column 2 and horizontal row 3, for example, it can be seen by referring to Fig. 21a, for example, that the vertical deflecting wave will be the dark outline portion of the bottom voltage wave of Fig. 21a while the horizontal deflecting wave will be that shown by the heavy outlines of the middle curve of Fig. 21a, although, naturally, each wave is upon a different and corresponding time base. Accordingly, for the assumed partial area the voltage effective upon the horizontal deflecting electrodes of the coordinated tube, and useful in producing a visible image, will be within the range between points 251 and 252 for the beam advance and between points 254 and 255 for beam return, while the vertical deflecting voltage effective will be within the range between points 252 and 192 for the beam advance and between points 192 and 254 for beam return.

If now that portion of the deflection voltage wave represented between the points 252, 192 and 254 is considered, it will be seen that the wave formation is exactly similar to the wave portion 191, 192, and 193 (Fig. 13) which was effective for the entire system although, from the above discussion, it will be apparent that the portion of the wave represented between points 252, 192 and 254 can be effective for beam deflection only for the area 1-3 or 3-1. Similarly, the two time separated portions of the complete deflection wave between the points 251 and 252, and between points 254 and 255 are also similar in slope to the portions 191, 192, and 192, 193 except for the time separation. This condition also holds true with respect to the separate portions indicated between the points 191, 251, and 255, 193.

From what has been stated above it is apparent that the portions of the deflection wave actually deflecting the developed cathode ray beams

when used either to translate light into electrical energy or electrical energy into light energy are in sequence 191, 251 and 251, 252 and 252, 192. The beams developed in the partial-image area tubes are at other times moved by the deflecting force to a position where they are not useful for scanning or as described by Figs. 26 and 27, for example, the developed beams are completely suppressed. In order to limit the effectiveness of each section of the increasing amplitude saw-tooth deflection wave to the desired partial area varying magnitude bias voltages are applied to the deflecting electrodes as explained for example, by Figs. 6, 7 and 17 with the magnitude of the bias to prevent the effect of the deflection voltage upon any tube until the desired time being applied in the opposite direction to the direction of increase of the deflection wave amplitude.

If it is assumed that the ordinate value 195, 196 (Fig. 13) of the deflection voltage (d. v.) is required to move the scanning beam from one edge to that opposite of a single tube then it can be appreciated that the tube in partial area 1-1, for example, will (with the system of Fig. 21a assumed) be acted upon by a deflection wave of an amplitude varying between 0 and 3 d. v. Similarly, since the deflection wave of amplitude 3 d. v. shall not be simultaneously effective in the partial areas 1-2 or 2-1 (depending upon vertical or horizontal deflection) the deflecting system for these areas should have applied thereto a negative bias voltage of a value—d. v. (assuming the deflecting wave is positive, so that the deflecting wave is then effective in the region starting at the point 251 continuing through point 192, although, when the point 252 is reached, the scanning spot (as with the first assumed condition) is just ready to leave the active or useful portion of the screen of this partial or component picture area. Similarly, for the tube translating the image in the partial areas 1-3 or 3-1, the deflection wave shall be inactive for two-thirds of its amplitude and, therefore, for this period the scanning spot is positioned just prior to the point of entering into the active or useful portion of the screen, and, as above assumed, with the deflection voltage increasing in the positive direction, the deflection electrodes for the last named partial or component areas will have applied thereto a negative biasing voltage of a value—2 d. v.

Since the scanning beam for the return trace across either the mosaic of a transmitter tube or the luminescent screen of a reproducing tube is suppressed, in well known manner, as above suggested, the return portion of the deflection voltage wave between points 192 and 193 (Fig. 13) is inactive to produce any useful effects. If any of the various portions of the return section of the deflection wave were active, the portion 192, 254 of the wave would produce the return trace across the partial area 1-3 or 3-1. Similarly, the portion 254, 255 of the deflecting wave would, under the same conditions, produce a return trace in the partial area 1-2 or 2-1 and, lastly, the section 255, 193 of the deflection wave would produce the return trace for the partial area 1-1.

It is seen that for a high level monophase system, such as shown by Fig. 21a, a multiplicity of different biasing voltages must be applied to the separate deflecting electrode systems controlling the tubes segregated to each partial-image area, and likewise the values of these deflecting biasing voltages are progressively increasing from tube to tube in accordance with the increase in

magnitude of the deflection voltage wave portion assigned, so to speak, to each tube. It can be seen from Fig. 21a that the change in control from different tubes for producing different partial areas is accomplished by providing multiple biasing values where the system operates at an amplitude of the deflection voltage and upon a single phase of that voltage only. The segregation of the signal effect from one tube to another is obtained by the changes in the amplitude value of the controlling wave operating different partial-image area tubes. Irrespective of the particular tube functioning at any particular time period, the changes in amplitude of the controlling deflection wave between minimum and maximum values for each separately controlled tube is always equal and the rate of increase or decrease in amplitude values of each controlling wave is always the same irrespective of the fact that the time when each portion of the wave becomes usefully effective upon each of the separate tubes depends upon the location of the several tubes with respect to the complete area and the corresponding biases.

However, it is desirable, if possible, to avoid the use of high level bias systems, and, accordingly, through the cooperative use of suitable biasing systems and current limiting devices separated from the deflection electrode systems, such as shown more particularly by Fig. 25, it is possible to confine the beam deflection control for each tube to low levels where the change in amplitude for the deflecting wave effective at any one tube of the system for producing the several partial-image areas will not exceed the value d. v., where d. v. is assumed equal in magnitude to the voltage required to move the scanning beam in any one tube from one edge of the screen to that directly opposite, and still the complete system must function effectively to segregate in time relationship the deflection voltage (d. v.) active at the desired time period upon any one tube of the system.

Consider now the second curve (Fig. 21b) wherein each portion of the beam deflecting wave is represented in identical manner to that of Fig. 21a except that the several portions of the wave effective on each of the different areas is always limited to the same amplitude value, explained by Fig. 25. In such event, the controlling portion of the complete deflection wave which will be effective upon any one of the several image reproducing tubes is in each instance a wave which changes in amplitude between its minimum and maximum value by an amount at least equal to that amplitude (d. v.) required to move the developed electron beam from one edge of the luminescent screen to the opposite edge, but the amplitude of the deflecting wave effective in any one image reproducing tube is in no instance the complete amplitude of the initially developed deflecting wave 190, 191, 192, 193 developed in the generator 706 (Fig. 25).

In considering Fig. 21b which covers the low level control system using a monophase version of the saw-tooth deflecting wave, this figure should be considered in connection with Fig. 25 in order to appreciate the manner by which the level of the controlling wave is controlled and limited to a fixed value. So considered, the saw-tooth wave generator 706 develops the saw-tooth shaped energy wave corresponding to the wave formation 190, 191, 192, 193, 194 (Fig. 13). The frequency of this developed wave is preferably controlled by means of the synchronizing sig-

nals or impulses originating at the transmitter and transmitted along with the video and audio signals. The synchronizing signals are separated from the received video and audio signals in the receiver by means of the synchronizing signal separator 705 (Fig. 20). The energy output from the saw-tooth generator 706 is fed to the threshold or bias elements 714, 715, 716 which are respectively of zero bias, a negative bias equal to $\frac{1}{2}$ the amplitude of the output from the generator 706, and a negative value equal to $\frac{2}{3}$ the amplitude of the output from the generator 706 (assuming in each case that the output deflection wave from the generator 706 is positive in sign). The wave formations appearing in the output of the threshold or bias elements 714, 715, 716 are shown by the heavy line wave formation immediately above each element. Each of these elements may, for instance, be in the form of a thermionic tube having applied to the input circuit thereof a biasing voltage which must be overcome by the amplitude of the deflecting wave in order for the tube to pass current and the magnitude of the current passed will then be proportional to changes in amplitude of the supplied input wave greater than the bias voltage. The output energy from the threshold or bias elements 714, 715, 716 is supplied, respectively, to limiting devices 717, 718, 719 which, respectively, are so arranged as to limit the amplitude of the output signals to $\frac{1}{3}$ that of the input, $\frac{2}{3}$ that of the input, and to the entire output or amplitude so that the output energy from the several limiters will, in each instance, be a wave form varying between minimum and maximum amplitude by identical amounts. However, the points of initial effectiveness of each wave output shifts in accordance with the displacement of the different sections 191, 251, and 251, 252, and 252, 192 of the controlling wave 190, 191, 192, 193 from each other in time relationship. Such limiting devices may be in the form of thermionic tubes which saturate at time periods when the input to the limiter 717 from the source reaches $\frac{1}{3}$ its amplitude value, and in the case of the limiter 718, when the input wave reaches $\frac{2}{3}$ its maximum amplitude value (this corresponds to $\frac{2}{3}$ the amplitude of the output wave from threshold or bias element 714, since the initial $\frac{1}{3}$ is suppressed in the threshold or bias element 715) and which will, as in 719, pass the entire output (the initial $\frac{2}{3}$ of the wave of the saw-tooth generator 706 having been suppressed by the threshold or bias element 716).

Naturally, elements 714 and 719 since they neither bias nor limit may, in practice, be merely conductors (although shown for symmetry and ease of explanation as separate elements).

The output energy from the limiters 717, 718, 719, it will be seen, corresponds, as indicated by the heavy wave formation diagrammatically shown above each limiter, to the top, center and bottom curves of Fig. 21b. For a nine tube array to produce nine separate and distinct partial-image areas, if it is assumed that the horizontal waves, for example, as being considered, then the output from the limiter 717 may be identified as the deflection wave 1 (Fig. 21b) the output from the limiter 718 as deflection wave 2 (Fig. 21b) and the output from the limiter 719 as deflection wave 3 (Fig. 21b).

In any low level system, it will, of course, be appreciated, that it is unnecessary for the saw-tooth wave generator 706 to develop saw-tooth wave energy of sufficient amplitude to produce directly the desired beam deflection in any single

tube. The principle requisite is that the energy developed by the saw-tooth wave generator 706 (as in Fig. 25) be of a wave shape like that shown by Fig. 13 so that after this wave is passed through the threshold or biasing elements and the limiter elements the output energy shall have the wave formations shown immediately above each limiter and which bear the same proportionality to the developed wave from the generator 706 shall result. Therefore, the output energy from each limiter device is passed through an aperiodic amplifier (not shown in detail, although any suitable and known form of aperiodic amplifying device may be utilized) which amplifies the voltage wave output from each limiter to the desired amplitude required to deflect each developed scanning beam from one edge portion of the screen to the opposite edge portion. Hence, the wave formation appearing in the output of each limiter 717, 718 and 719 is proportional to the output from each aperiodic amplifier device 720, 721 and 722. Of course, if the amplitude of the energy developed in the saw-tooth wave generator 706 is (assuming the nine tube panel array) equal to 3 d. v. then the amplification factor in the aperiodic amplifier is equal to unity because the output from the limiter would then be of an amplitude corresponding to the deflection voltage (d. v.) whereas wherever the output from the limiter is of amplitude less than the deflection voltage d. v. the aperiodic amplifier amplifies this wave energy so that the output from the aperiodic amplifier is equal to the deflection voltage d. v. By separating the output energy from each limiter and directing this output energy to the deflecting electrodes of the several separate tubes of the array, the deflecting voltage applied to each of the tubes will successively vary from the same minimum to maximum values.

The point of minimum amplitude of each of the deflecting voltage curves, shown by the limiters 717, 718, 719 is proportional to (with later aperiodic amplification) or equal to (without later aperiodic amplification) that voltage value where the scanning spot is just immediately prior to entering the active or useful portion of the screen or component picture area and the point of maximum amplitude of each of the heavy line portions of the waves shown immediately above the limiters in Fig. 25 is proportional to (with later aperiodic amplification) or equal to (without later aperiodic amplification) that value of the deflecting wave which is sufficient to move the scanning spot of each tube upon its effective travel just past the point of exit from the active and useful portion of the screen or component picture area. In accordance with the arrangement for control shown by Fig. 21b and more clearly explained by Fig. 25, the amplitude of the deflecting voltage effective across the deflecting plates 165, 166 or 167 (see Fig. 11) for any partial-image area tube, is in all instances only that voltage necessary to move the developed cathode ray between the points 171 and 170 (see Fig. 11, for example) whereas with the high level control system, as was explained by Fig. 21a, the deflecting wave effective on the several tubes is several times the amplitude of the deflecting wave necessary to move the scanning beam through the active or useful portion of the screen where only through the use of suitable biasing arrangements applied directly to the deflecting electrode system, was the deflecting wave caused to be effective on the different tubes of the system in sequence.

Now, considering the foregoing, it will be seen that regardless of whether the system of control operates on multi-bias at high level or low level it requires only the development of a single non-reentrant saw-tooth formation electrical wave. However, biasing each reproducing tube to some degree is essential and required at some point in the system because the same deflecting wave controls all of the several partial-image reproducing tubes. It will also be seen that the slope of each controlling wave is similar and that while in some instances, notably in the deflection of the first and second tubes, there is a time separation between the useful deflection and the return deflection of the beam, the return path of the beam takes place at the same rate for all tubes. If, for example, that portion of the deflecting wave between the points 252, 192, 254 is considered as effective, for example, upon the areas 1-3 and 3-1 (assuming nine partial areas for the complete image) then, it will be seen that this is effectively the topmost third of the complete deflecting wave. However, each other portion of the deflecting voltage wave is a wave exactly similar except that the slowly increasing and rapidly decreasing portions of the wave are separated in time. Therefore, it can be seen that the entire system may resolve itself into one wherein only the topmost portion of the wave may be utilized, that is, the portion where the slowly increasing amplitude value of the deflecting wave is followed immediately in relationship by the rapidly decreasing portion of the wave if the wave can be separated into separate identical but time separated versions. Therefore, the system of controlling the deflection may resolve itself into a system which may be effective as a multi-phase system providing time separated versions of one controlling wave to control the image areas at which each portion of the received signal is reproduced.

Many and various ways and means to accomplish this result may be utilized, but one convenient form which will be later explained in further detail consists in utilizing a wave of the type and general formation of the wave 190, 191, 192, 193 and 194 to cause the development of separate identical waves time separated. Such a system of control briefly may comprise the utilization of the controlling wave to produce a rotary field and by split-phase methods to develop two energy components of that wave having 90° phase displacements by appropriate inductive and capacitive reactances. When such components are developed, there are then produced multi-phase voltages from the rotary field which results. The production of the multi-phase voltages of these rotary fields may then be brought about by the positioning of suitable energy pick-up coils axially in the rotary field, that is, in inductive relationship with respect to the rotary field, and with the axes of these pick-up coils separated spacially by angular distances $360^\circ/n$, where n is the number of phases desired, the desired number of the phase displaced versions of the deflecting wave may be determined. After the various desired number of phase separated signals representing $360^\circ/n$ has been produced, these separate versions of the signal then serve to control the beam deflection in the several tubes for producing the separate partial-image areas or the selected voltage waves may be fed through separate saw-tooth or non-reentrant wave amplifiers, each of which feeds a phase displaced version the same formation elec-

trical wave to the deflecting electrode system of the separate tubes (by way of suitable biasing means if necessary in accordance with the amplitude of the deflecting wave) so as to cause the desired spot deflection.

From what has gone above, it can be seen that in any of the foregoing systems operating at low level, the characterizing feature of each over the high level operation system is that there is a complete absence of any deflection bias on the deflecting electrode system of each separate image producing tube.

Turning now to a consideration of the multi-phase method of controlling the electron beam deflection as shown more particularly by curves of Figs. 21c and 21d, reference may be had also to Fig. 22 which depicts a slightly modified form of receiver from that shown by Fig. 20. In this connection, for purposes of illustration, it will be assumed that the electronic image reproducing system for producing a composite image from a series of partial-images comprises an array of nine separate image reconstructing tubes. So considered, the signals received from the transmitting point, such as those transmitted, for example, from the antenna system 87 of Fig. 5 and which comprise both the video and the synchronizing components and where desired the accompanying sound or audio signals, are received upon the antenna system 400, or its equivalent wire line, and are brought through a conventional type of receiver 401 such, for example, as that shown by patent to W. L. Carlson 1,975,056 also identified by Reissue Patent No. 20,700. The output signals from receiver 401 which represent the synchronizing signals (line synchronizing, for example) are supplied to a blocking oscillator 403 by way of the conductor 404. The blocking oscillator 403 herein shown conventionally may be of the general types known by such term and disclosed by British Patents 403,283; 402,629; and 401,990 for example, or the oscillator may be one of the types herein above mentioned throughout this description and comprise a "dynatron" or other similar type electronic device. The oscillator is for the purpose of controlling the production of a non-reentrant or saw-tooth formation electrical wave which is utilized to produce line synchronizing signals and voltages.

The saw-tooth energy is developed by the charging and discharging of a condenser which has acquired its charge in substantially a linear fashion. The discharging of the stored charges is made to take place at the frequency at which impulses are developed from the blocking oscillator 403.

This form of condenser charge and discharge arrangement is known in the art and described, for example, in the British patents last mentioned and, therefore, is shown conventionally at 412. The combination of the blocking oscillator 403 and the condenser charge and discharge system 412 is similar to the arrangement conventionally designated by the deflection voltage sources 706 and/or 707 of Fig. 20, and the saw-tooth wave generator 706 of Fig. 25.

The saw-tooth wave formation energy developed in the element 412 is then supplied to the phase shifting system 428 (shown in more detail by Fig. 23). This saw-tooth wave formation energy supplied to the phase shifting system 428 is a saw-tooth wave of a characteristic shape like that shown by the wave 190, 191, 192, 193, 194 (Fig. 13) for example. This wave formation

has been conventionally redrawn as the wave 441, 443, 445, 446, etc., in Fig. 24.

As was above described, by appropriately arranging inductive and capacitive elements it is possible to produce from the developed energy a rotary electrical field and by split phase methods two 90° phase displaced forms of this energy may be produced. The apparatus disclosed by Fig. 23 shows one suitable form of system for this purpose.

Turning now to a consideration of the manner in which the separate phase versions of the saw-tooth wave formation deflection voltages are developed, there is connected to the output of element 412, as shown by Fig. 22, for example, a phase shifting device 428, for the purpose of producing separate phase shifted versions of the deflection voltage. Turning now to Fig. 23 prior to considering the remaining portion of the horizontal-line synchronizing channel, the output from the oscillator 403 as controlling the element 412 is fed through two parallel connections by way of conductor pairs 414 and 416 to two inductive elements 418 and 420 arranged with their axes perpendicular to each other but located in the same plane. In order to provide for the phase shift of approximately 90° between the voltages energizing each of the inductive elements 418 and 420, there is provided in series with one of the coils 420 a capacitive element 422. Numerous other methods of securing 90° displaced components are known in the art.

From a general understanding of electrical engineering principles, it will be understood that a rotary field may be produced from a single phase power supply, such as that feeding the two coils 418 and 420, by splitting the single phase into two components 90° to each other through the use of an appropriate inductive and capacitive reactances. In such event, the fields produced in each coil are of equal amplitude and 90° apart in space and also in phase. Since, now, it is desired to produce from the single phase deflection voltage wave three separate phase displaced signals or controlling voltages of like wave formation, three separate energy pick-up coils 424, 426 and 428 are axially positioned in the field of the coils 418 and 420 that is, in inductive relation to the field. The axes of the separate coils 424, 426, and 428 are separated spatially by an angular separation represented by $360^\circ/n$, where n is the desired number of phases to be selected. In such event, of course, it will be appreciated that n will be equal to three for the nine partial-image system.

If now it is assumed, for example, that the deflection voltage output from the element 412 is of appropriate wave form in 418 and 420 to produce inductively in 424, for example, a saw-tooth wave corresponding to the wave 441, 442, 443, 444 and 445 (Fig. 24) then for example, the same voltage wave may appear in the coil 424 undisplaced in phase but two identical formation deflection voltage waves phase displaced with respect to the wave in the coil 424 by 120 electrical degrees, will appear in the coils 425 and 426 respectively. These waves are conventionally represented in Fig. 24 by the waves 441', 442', 443', 444', 445' and 441'', 442'', 443'', 444'', 445'' as indicated by Fig. 24. The voltage wave which is undisplaced in phase is indicated by the solid line, while when the voltage wave is displaced 120° (electrically) it is indicated by the dash line, while the voltage wave which is displaced 240° (electrically) with respect to the

undisplaced voltage wave is indicated by the dotted line. The portion of each of these waves which is a greater amplitude than that represented by the ordinate values O—A is shown in heavier outline than the remaining portion of the wave and it is this part of the wave picked up in each of the coils 424, 425 and 426 which will be applied to the deflecting electrode system of the several partial-image reproducing tubes.

The three separate phase displaced versions of the saw-tooth deflection wave which are fed to the amplifiers 430, 432 and 434 respectively, are then supplied to the deflecting electrode plates 456, 458 and 460 of the tubes 462, 464 and 466 respectively by way of conductors 450, 452 and 454 respectively. Since only that portion of the saw-tooth deflecting voltage wave 441, 443 and 445, or its phase displaced counterparts, which is of an amplitude greater than that represented by the ordinate value O—A is to control the deflection in each of the separate tubes 462, 464 and 466, the biasing sources 436, 438 and 440 (each of different magnitude as above explained) are connected serially between the amplifiers and the deflecting electrodes of the several tubes in such manner as to oppose the deflecting wave and accordingly each biasing source is of a value equal to that voltage value represented by the ordinate O—A. Actually, source 436 is preferably of zero value as apparent from the above considerations and also Fig. 25.

Thus, there takes place in each tube 462, 464, 466 and the like of the system a sequential deflection of the electron beam so that if the tube 462 is assumed to be coordinated with the partial-image area 1—1, and the tube 464 coordinated with the partial-image area 1—2 (for horizontal deflection) or 2—1 (for vertical deflection) and the tube 466 is coordinated with the partial-image area 1—3 (for horizontal deflection) or 3—1 (for vertical deflection) then it will be appreciated that the deflection of the electron beam developed within the tube 462 will take place at a relatively slow rate during the portion of the deflection voltage wave represented between the points 442 and 443 (Fig. 24) and that during this time period no deflection will be produced within the tubes 464 and 466. Similarly, after the electron beam developed within the tube 462 has been deflected and the next phase of the deflecting voltage represented by the voltage change between the points 442' and 443' becomes effective on the tube 464, the beam developed within that tube will be deflected while no deflection will take place in tubes 462 and 466. The same holds for the phase displaced version represented between the points 442'' and 443''.

As was explained in connection with Figs. 21a and 21b for monophase systems any system of multiphase control of the electron beam deflection may also resolve itself into one operating at a high level or one operating at low level. The illustration immediately above represents the high level operation, as disclosed by Fig. 21c, and as more particularly explained by Fig. 24. Where low level operation, however, is desired, in multi-phase systems, the three separate phase displaced versions of the deflection voltage wave may be supplied through the threshold or biasing elements shown by Fig. 25 and thence applied through suitable limiters as is also shown by Fig. 25 whereupon the operation of the system will coincide substantially with that explained for low level operation by Fig. 21b. The

low level operational arrangement is shown in more particular detail by curves in Fig. 21d. Therefore, any further explanation is believed to be unnecessary in view of the detailed explanation made as to the differences and distinctions between low and high level operation for the monophasic systems of Figs. 21a and 21b, since it is clearly apparent that the same principles of operation may be carried over into the multi-phase control system described by Figs. 21c and 21d and also in connection with the description of Figs. 22, 23 and 24.

Having produced the three separate phase displace versions of the controlling signal or deflection wave, there is connected to the output of the coil 424, for example, the input circuit of a separate amplifier 430 although where the portion 442, 443, 444 of the wave is of sufficient amplitude to produce the requisite degree of beam deflection the amplifier may be omitted. Similarly, the coil 425 is connected to the input circuit of an amplifier 432 and to the coil 428 the input of an amplifier 434 is connected. The voltages fed to each of the amplifiers 430, 432 and 434 are similar to the original voltage except as to the matter of phase where there is a 120° phase separation for the three phase system (a system using nine separate partial-image tubes). However, for a sixteen tube array four separate 90° phase displaced waves may be produced, and for a twenty-five tube array five separate 72° phase displaced waves may be produced.

Similarly, the receiver 401 energizes the vertical deflection voltage circuit 405 by way of the conductor 406. The vertical deflection system is of a general character similar to the horizontal system 403 and 412 in that it produces the vertical synchronizing or frame deflecting waves of the same general wave formation but at a different frequency. The video signals representing the image to be reproduced on the observation screen of the several image reproducing tubes are directed to the video signal amplifier 407 by way of the conductor 408. This is also described in the above mentioned Carlson patent. The video frequency amplifier is preferably of the superheterodyne type and has its output connected with the control electrode of each of the separate image reproducing tubes which depict the several partial-image areas. Background control signals may be developed directly in the video frequency amplifier 407 as has been disclosed by British Patent No. 434,496 or French Patent No. 781,668 as well as by R. S. Holmes copending U. S. applications Serial Nos. 658,894 and 700,478, for example, or these may be supplied through a separate amplifier of the same general type and description.

The audio signals which are to produce the sound to accompany the visual action are preferably directed through a separate audio amplifier 409 by way of the conductor 410. The audio frequency amplifier 409 may follow the same general form as was described in the above mentioned Carlson patent. For the purpose of illustration, the connections from the output of the electrical synchronizing signal generator are not shown since they are similar in nature to those shown for the horizontal synchronizing signals and likewise, the output connections from the video frequency amplifier 407 are not shown although it will be understood that there is a connection herefrom as above pointed out to each of the separate image producing tubes; and the output of the audio frequency amplifier 409 while

not shown will be understood to be connected with a suitable type of sound reproducing device, such as 712 of Fig. 20.

It is desirable that the complete system be so arranged that it will so operate that the beam deflecting voltages or currents supplied upon the various tubes shall be substantially free from fluctuation arising because of voltage fluctuations in the power supply energy feeding the corresponding electron beam deflection wave generators. If this condition is fulfilled, there will be no effective alterations in the deflection voltage (assumed, for illustration, electrostatic beam deflection) applied between the deflecting electrodes of the several tubes with changes in the power supply, and any increases or decreases of the power supply energy will be entirely compensated. It can easily be appreciated that if substantial fluctuations in the power supply energy take place under normal operational conditions of the system already described accurate juxtapositioning of the several component or partial-image areas either at the transmitter or at the receiver may be difficult or at times substantially impossible, but by compensating for such changes, it can be appreciated equally well that the several component or partial-image areas can be made to be entirely unaffected by any variations in power supply voltages so that proper juxtapositioning of the several component or partial-image areas is always maintained.

The deflection voltages of currents supplied to the deflecting electrode systems for deflecting the cathode ray beam developed within any of the image screens or image reproducing tubes are naturally dependent at least to some extent upon the power supply voltage. Either manually operable or automatically operable means for obtaining an adjustment of all deflection voltages or currents in both horizontal and vertical directions in the array with power supply fluctuations may be provided in order to compensate for such fluctuations.

Manual adjustments of this nature will counteract the formation of gaps between the component or partial-image areas when the deflection voltage drops or will compensate the existence of overlapping between the component or partial-image areas when the deflection rises. If reference is made, for example, to Fig. 1 showing the several partial-image areas 1, 2, 3 and 4, it will be appreciated, that if the deflection voltage decreases the size of each of the partial or component areas 1, 2, 3 and 4 will shrink uniformly so that the areas 1 and 2 and 3 and 4 will no longer be contiguous along the line 6, 11 nor will the areas 1 and 3 and 3 and 4 remain contiguous along the line 8, 10 since the voltage change in the power supply will tend to shrink the size of each partial-image areas. With suitable compensation for changes in the deflection voltage arising, for example, due to power supply fluctuations, the several partial or component image areas 1, 2, 3 and 4 (as shown by Fig. 33) may be caused, with decreases in the power supply energy, to shrink so as to assume the dotted line outline shown by Fig. 33 rather than to shrink along all border lines. With compensation for partial-image locational changes power supply energy decreases will cause the partial-image area 1 to assume a shrunken size and be limited by boundaries 5', 6', 7, 8'. Similarly, the component or partial-image area 2 will be restricted to a size designated by the area 6', 9', 10', 7. It will, however, be noted that the adjacent

borders of the partial-image areas 1 and 2 are still coincident along the inner border line 6, 7.

A suitable system by which compensation of the above form is provided is disclosed by Fig.

32. This system is particularly adapted to a four tube array but by slight changes may be made to operate for additional tubes. For compensation a biasing source 754 having a value equal to one-half the deflecting voltage applied to the deflecting electrodes is connected with one of the tubes of each row or column but, in contrast to the systems previously described, it will be noted that with compensation provided the deflecting voltages for a four tube array is introduced between terminal point 750 and ground 756, and also terminal 752 and ground 756. With this form of arrangement and the application of the deflection voltage between ground and the deflector plates, as shown, any changes in the amplitude of the deflecting voltage will tend to cause the partial-image areas to shrink to the dotted line border areas indicated by Fig. 33, it being understood, however, that vertical deflection voltages are applied in a manner similar to those shown for horizontal deflection. In the case of Fig. 32, for simplicity, the value of the deflecting voltage required to move the developed electron beam within any tube from one extreme edge portion of the screen to the opposite extreme edge portion has been represented as being equal to d.v. and consequently the value for the biasing source 754, applied to oppose the deflection voltage, also will be substantially equal to the amplitude of d.v.

However, since the four tube array was assumed for Fig. 32, and since each tube of the array functions sequentially to reconstruct or to scan partial-image areas of Fig. 33, the actual amplitude of deflection voltage applied across each tube is the total deflection voltage required to move the scanning beam from the edge 5, 8, for example, of partial-image area 1 to the edge 9, 10 of partial-image area 2 and thus is equal to twice the deflection voltage to move a scanning spot from the edge 5, 8 of partial-image area 1 to the edge 6, 7, for example. Consequently, between each of terminals 750 and 752 and ground there is applied a deflection voltage equal to 2 d.v.

In connection with the foregoing description, it should be borne in mind that the purpose of the arrangement above described is to maintain adjacent the edges of the several partial or component areas and always abutting throughout the maximum distance possible under conditions of voltage supply variations, therefore, the fixed edges of each partial-image area cannot shift in location but the outer edges of each partial-image area are flexible and can move in and out with voltage variations, always forming, however, a partial-image area of similar configuration to the first assumed partial-image areas of Fig. 1 and having substantially the same aspect ratio. Therefore, the outer boundaries indicated in the combined partial-image areas 1, 2, 3 and 4 in Fig. 33 as being the boundary limits, 5, 9; 9, 13; 13, 12; and 12, 5 may be assumed either as the maximum size boundary or the minimum boundary or any intermediate value.

As Fig. 33 has been drawn, for example, it may be regarded that the heavy outline border areas represent a maximum condition for voltage supply, in which event, with a decrease in voltage, the outer boundaries of the partial-image areas will shrink to the dotted line configuration. The

partial-image areas nevertheless will remain in juxtaposition and the only variation which can or will take place will be that within the border area represented 5, 6'; 8, 8', etc., a dark area will appear. Such a darkened portion can be regarded as a masking area, if desired.

If the heavy outline border areas 5, 9; 9, 13, etc., are assumed as minimum values of any deflection voltage supplied, it will be appreciated that increases in deflection voltages may tend to mask the outer borders of each partial-image area but even in this instance no detrimental effects will result because the center of interest portion of the produced or scanned image or picture is included within the scanned partial area and such partial-image areas remain in juxtaposition. Only those portions of the image which are of relatively minor interest or detail are lost at the edges.

The arrangement of Fig. 32, furthermore, is of particular advantage from another standpoint and that is in some instances where a receiver, for example, is installed in a location where the larger size of a component image area, for instance, that designated by the boundary limits 5, 9, 13, 12 of Fig. 33, makes too large an image to be viewed conveniently, the component area size may be reduced. This is made possible by decreasing the amplitude of the saw-tooth wave produced and applied between the terminal 750 and ground 756 and also between the terminal 752 and ground 756 to decrease the size of the composite image to a size such as that shown by the rectangle 5', 9', 13' and 12' of Fig. 33. The amplitude of the deflecting wave can be varied, for instance decreased, by the use of a suitable damping resistance in well known manner. Even though the size of the partial areas is reduced it will be noted, that the several partial-image areas are still juxtaposed and the abutting portions remain contiguous.

An automatic form of arrangement to control and maintain the size of the several partial-image areas substantially constant irrespective of changes in the power supply source energy amplitude, or at any other place in the system, is usually to be desired over the form of arrangement shown more specifically by Fig. 32. Any automatic control to be completely satisfactory should function so that if the deflection voltages naturally produced tend to fall below a certain predetermined level (hereinafter assumed to be the normal deflection voltage d.v.), the automatic control will function to raise the deflection voltage to the desired value or if the deflection voltages tend to exceed the desired value d.v. the automatic deflection control will function to prevent such an increase. Such an arrangement broadly may be characterized as an automatic volume control system to control the deflection voltages applied to all image scanning tubes or image reproducing tubes of the system. The automatic deflection control is preferably set initially for a given value of deflection voltage equal to the assumed value d.v. for each tube.

Automatic volume control circuits per se are well known in the art and, for example, a suitable type of automatic volume control which is suitable for use in a system of the nature herein disclosed may be patterned according to the teachings in Travis Patent No. 2,034,497 of March 17, 1936. It is an arrangement of this general nature which has been disclosed by Fig. 31, this being somewhat closely related to the general

form of control disclosed, for example, by Fig. 5 of the aforesaid Travis patent, although herein the application concerns video signal.

Considering now the system for supplying deflection voltages disclosed by Fig. 31, the alternating current supply voltage which is to provide operating potentials for the deflection wave generators and, in fact, all portions of the system (although where desired separate power supply may be used for different sections of the complete system) are connected at each terminal points 735 to the power supply source rectifier 736 which is of any well known and suitable type. The output taken from the terminal 737 of the power supply source and rectifier 736 connect with the input terminal 738 of the deflection wave generator 739. This generator includes the arrangement for charging and discharging the condenser, as well as the blocking oscillator, and also where desired the arrangements for controlling the deflection of any one tube at high or low levels or either for multi-phase or monophasic as described by the curves of Fig. 21 and figures related thereto. Suitable synchronizing signals are also supplied to the deflection wave generator, as was above explained.

The output energy from the deflection wave generator terminal 740 is supplied to the input terminal 741 of an amplifier 742 for amplifying the beam deflection voltage to the desired value and from output terminals 743 of this amplifier the developed deflection voltage wave is supplied to the deflecting electrode members 167 contained within the neck of the tube 161 (such as the tube shown in Fig. 11). As was explained in the Travis patent, above referred to, a part of the energy from the amplifier 742 is fed back through the conductor 744 to a suitable point on a potentiometer 745 connected across the terminal 746 of a rectifier 747. The output energy from the rectifier 747 connects to the power supply source 736 by way of a conductor 748 in order to provide regulation in accordance with the current flowing between rectifier 747 and the power supply source 736. By suitably adjusting the position at which the conductor 744 makes contact with the potentiometer 745, the normal operating condition may be established. If now the energy level output from the power supply source 736 changes, it will cause a change in the amplification level and consequently by way of the feed back connection from the amplifier 742 to the rectifier 747 which serves to bias the power supply source 736 regulation may be established so that the resulting amplitude of the output energy appearing at terminals 743 of the amplifier 742 is maintained constant.

While one preferred connection for providing the automatic volume control effect or, in other words, the constancy of amplitude of the developed saw-tooth formation electrical energy is shown, it is, of course, obvious that other alternative connections may be established. For instance, one alternative may be to connect the potentiometer 745 by way of conductor 744 directly to the input of the power supply source 736 instead of to the amplifier 742 while maintaining the connection 748 as shown. Alternatively, also, a further modification may comprise connecting the conductor 748 to the output of the deflection wave generator 739 instead of to the power supply source 736, while maintaining the connection 744 from the amplifier 742 to the potentiometer 745 as shown, and a still further modification may comprise the connection of the conductor 744 to

the input of the deflection wave generator 739 instead to amplifier 742 while maintaining the connection provided by the conductor 748 as shown by Fig. 31. In any event, the arrangement provided is for the purpose of regulating in accordance with the change in output level of any point in the system the amplitude of the actual deflection voltage applied across the deflecting electrode pairs of each separate tube.

An alternative method for applying deflection bias to the deflecting electrode pairs from that method shown by Figs. 6, 7 and 17, for example, is shown more particularly by Figs. 34, 35 and 36. In accordance with the showing in Fig. 34, for example, the negative bias from source 110 is applied in parallel to the deflection wave supplied from the deflection wave generator 108 and, as shown, both the bias source and the saw-tooth deflection wave generator are connected directly to the deflector plates 96, 97 of the tube 42. It will be seen that the bias is connected in reverse relative to the deflection wave. The foregoing system is applicable either at the transmitter or at the receiver and, accordingly, for simplicity of understanding reference numerals like those applied for the transmitter illustration have been used where possible.

Fig. 35 shows a system for applying bias which is essentially like that of Fig. 34 except that a blocking choke 760 is inserted in series with a negative bias source 110 to prevent the passage of the deflection wave current therethrough. Also, in order to prevent the passage of direct current originating from the negative bias source through the deflection wave circuit a suitable blocking capacity 762 is placed in series with the deflection wave generator 110. In this connection it should be noted that the blocking capacity may tend to change slightly the form of the deflection wave developed by the deflection wave generator and, therefore, it is preferred to select such parameters for the deflection wave generator 110 that the wave output after passing through the blocking capacity element 762 shall be a linear saw-tooth wave. Where desired, for example, a large size electrolytic condenser may be used as the blocking capacity which prevents the negative bias from entering into the deflection wave generator and in such event very little change, if any, will result in the wave formation developed by the deflection wave generator 110. In place of the blocking capacity above suggested to prevent the negative bias voltage from entering the circuit of the deflection wave generator, it is possible to insert a bandpass filter which will permit the passage of the deflection wave substantially unaltered and yet prevent any flow of direct current. Such forms of bandpass filters are generally known and, therefore, need not be explained in detail.

Where it is desired to provide a multiplicity of image scanning or image reproducing tubes in the system and to provide a parallel connection of the deflection wave voltages and biases in accordance with the forms disclosed by Figs. 34 and 35, certain modifications of the arrangement are necessary because of the inclusion of the multiplicity of tubes. If it be assumed that a nine tube array is to be utilized and each of the separate tubes is to be coordinated with the partial-image area indicated by the numbers showing row and column immediately beneath each tube. The generator delivering saw-tooth wave energy on the deflection plates as with this type system disclosed by Fig. 36, was explained in connection with

Fig. 35, must be of such a character as to deliver a symmetrical saw-tooth wave of energy as the amplitude is linearly increasing and decreasing after passage through the blocking condenser 762, as was explained in Fig. 35. With the multi-tube system of Fig. 36, the biasing potentials applied to the several tubes of the complete array are provided from a source 764 which is shunted by a resistor element 766 which may be tapped at suitable points 767 and 768 to obtain the necessary biasing voltage. This biasing voltage is equal (assuming, for instance, the horizontal deflection of the beam is to be considered) for the first column of tubes to a bias of zero value, for the second column of tubes to a value equal to the deflection voltage required to move the electron beam from one edge to the opposite edge of one tube (d. v.) and for the third column the biasing voltage required is equal to twice the voltage required to move the scanning beam from one edge to the opposite edge of each, it, of course, being appreciated that the total deflection voltage applied between the first and the last tube of the column will be equal to three times the deflection voltage for one tube.

With the multi-tube array of Fig. 36 all of the lefthand deflection plates of the several tubes, as shown, are connected together and the righthand deflection plates of the tubes of each column are likewise connected together. The righthand deflection plates for the tubes in the first column have no bias voltage applied, while the tubes in the second column have a biasing voltage equal to d. v. applied by way of conductor 780 from the point 767. The righthand deflection plate of the tubes of the third column have a biasing voltage equal to 2 d. v. applied by way of conductor 781 from the point 768. The condenser element 762 serves to block the direct current from the biasing source from the saw-tooth wave generator. From the upper terminal of this condenser (marked +) there must be developed relative to the terminal of the choke coil 760 connected to the opposite terminal of the saw-tooth wave generator 706 a deflection voltage equal to 3 d. v. if satisfactory beam deflection is to be obtained and the system is assumed to operate at high level as indicated. This value of the deflection voltage is indicated on Fig. 36.

Additional condensers 772 and 773 are required with a multiple tube panel embodying as many as nine tubes in order to give identity of the deflection wave form between the first and second columns on the one hand and the third column on the other hand because it can be seen that if the generator 706 delivering the saw-tooth wave energy at the deflection plates 167 and 167' after this energy has passed through the blocking condenser 762 is to have such a characteristic that the change in amplitude uniformly increases and decreases, and these is a change taking place due to the fact that the energy must be passed through a condenser, the additional condensers 772 and 773, while not required to prevent short-circuiting between the terminal points on the resistor 766, where the biasing voltages d. v. and 2 d. v. are developed, are desirable for unity of operation.

While the invention hereinabove described has been explained in several of its preferred forms, it, of course, will be appreciated that many and various modifications may be resorted to without departing from the spirit and scope of the disclosure as hereinabove set forth. Further, it will be appreciated, that while in many instances certain suitable values, various parameters and vari-

ous suggested operational methods are set forth, these also may be varied within wide limits. Accordingly, it is believed that all changes in parameters, forms of the invention, and operational practices may be made and utilized insofar as these changes fall fairly within the spirit and scope of the hereinafter appended claims.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. A method of television which comprises the steps of scanning a selected bi-dimensional image area, concurrently dividing the selected bi-dimensional image area into a multiplicity of columns and rows of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas, and systematically selecting through this multiplicity of partial image areas for preserving the capability of reconstituting the selected bi-dimensional image.

2. A method of television which comprises the steps of scanning a selected bi-dimensional image area along a series of substantially parallel scanning paths, concurrently dividing the selected bi-dimensional image area into a multiplicity of columns and rows of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas, and systematically selecting through this multiplicity of partial image areas for preserving the capability of reconstituting the selected bi-dimensional image.

3. A method of television which comprises the steps of dividing a bi-dimensional image area into a plurality of columns and rows of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas individually and in a predetermined sequence, scanning the several produced partial image areas, and commutating through the plurality of partial image areas scanned for reconstituting a complete bi-dimensional image.

4. The method of television which comprises the steps of independently producing a plurality of electronic scanning beams, deflecting each electronic scanning beam according to a predetermined deflection pattern for scanning a predetermined image area along a series of substantially parallel paths, each of said predetermined areas constituting a partial image area of a complete image area with each of the plurality of partial image areas being boundarywise-spatially-separated and juxtaposable, applying at least one of a bi-directional progression of electrical biases upon each electronic scanning beam concurrently with the deflection for commutating in sequence through each of the series of scanned partial areas and reconstituting a complete image area from the plurality of partial image areas.

5. In a television system wherein an electro-optical bi-dimensional image is produced from a multiplicity of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas spatially separated and arranged in a plurality of rows and columns, the method of scanning which comprises the steps of sequentially scanning the multiplicity of the partial images in rows, and progressively scanning the multiplicity of partial images in a column, and producing from the scanning a conversion between radiant and electrical energy in either direction.

6. In a television system wherein an electro-optical bi-dimensional image is produced from a

multiplicity of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas spatially separated and arranged in a plurality of rows and columns, the method of scanning which comprises the steps of sequentially scanning the bi-directional partial image areas in one direction by rows and progressively scanning the bi-directional partial image areas in a second direction in a column which is the summation in the second selected direction of the plurality of rows.

7. In a television system wherein a bi-dimensional electro-optical image is produced from a plurality of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas normally arranged to form a plurality of rows and columns, the method of scanning which comprises reproducing an electro-optical image of each partial image area in each row in a sequential manner, simultaneously progressively advancing the image projection of the partial image areas in a columnar direction, and combining the several produced electro-optical bi-dimensional partial image areas of the rows and columns into a unitary bi-dimensional image area formed from the juxtapositioning of the individually produced partial image areas.

8. The method of television which comprises the steps of dividing a selected bi-dimensional image area into a plurality of boundarywise-individually-spaced juxtaposable and interlockable internally continuous bi-dimensional partial image areas arranged in series of rows and columns, sequentially scanning the several partial image areas of each row progressively, scanning the several partial image areas of each column, interlacing each complete series of sequential scanings with each preceding and succeeding complete series of sequential scanings, and producing during substantially the entire period of each scanning image signals for transmission to be effective at receiving points for reconstituting the complete original bi-dimensional image.

9. A television system wherein an electro-optical image is reproduced from a series of juxtaposed partial-image areas to form a combined image unit comprising a plurality of spatially separated cathode ray tubes arranged in a series of rows and columns, means to develop within each tube an electron scanning beam, a target area for each tube positioned in the path of the developed scanning beam, means for deflecting each developed scanning beam to cause it to traverse its associated target and thereby to produce luminous energy, means for developing a single controlling electrical energy wave to deflect each of the several scanning beams so as to scan the plurality of screen areas of each row of tubes in a sequential manner simultaneously progressing in a columnar manner and means to reconstitute the several separate luminous effects into a unitary luminous image area formed from the partial images in juxtaposed relationship.

10. A television scanning system comprising a plurality of electronic scanning tubes arranged in a series of rows and columns means to produce from an optical image an aerial image thereof, means to segregate and divide the produced aerial image into a plurality of partial images, means to segregate the produced partial image areas of the complete optical image upon individual and separate tubes, and means for producing controlling energy to cause each tube to

become sequentially operative to produce signal energy output representative of a portion of a complete optical image.

11. In a television system, a plurality of cathode ray tubes arranged in a series of rows and columns, means for developing within each tube an electron beam for projection axially of the tube, a target area positioned within each tube in the path of the projected electron beam, a source of energy for deflecting each electron beam; means for deflecting under the control of the deflection energy the developed electron beams according to similar patterns of deflection to trace the associated target, and means for controlling in a sequential manner the tube instantaneously subjected to the beam deflection energy.

12. The system claimed in the preceding claim comprising, in addition, means to develop image signals from each electron beam by the scanings and means to piece together the several image signals developed to form from the composite scanings a single train of signal energy representative of a complete optical area.

13. A television system comprising a plurality of cathode ray image translating tubes which each have a target area, means for producing upon the target area of each of the tubes an internally continuous bi-dimensional partial image area of a complete bi-dimensional image, an image utilization screen, and means for juxtaposing the several produced partial images upon the image utilization screen to form a single and unitary composite bi-dimensional image of all of the several bi-dimensional partial image areas.

14. A television system for transmitting a plurality of component image areas collectively representative of a subject of which the image is to be produced at reception points comprising a plurality of independent boundarywise-spatially-separated image transmitting tubes each having a target area, means for forming an aerial image of a selected bi-dimensional image area, means for allocating and directing different bi-dimensional internally continuous sections of the produced aerial image to the target electrode of each of the distinct and separate image transmitting tubes, means to produce upon the target area within each of the separate image transmitting tubes an electrical representation of the light values represented by the internally continuous bi-dimensional section of the complete aerial image directed upon the tube, means for scanning in a sequential manner the electrical representation of the light values of the aerial image section directed upon each of the separate image transmitting tubes, and means for producing from the sequence of scanings a train of electrical image signals representing the complete subject from which the aerial image was developed.

15. A television system comprising a plurality of electronic image transmitting tubes each having a light-responsive target area adapted to develop an electrical representation of the light of an optical image cast thereupon, means to allocate equal sections of an optical image of a subject which is to be reproduced at receiver points upon the target areas of a plurality of boundarywise-spatially-separated and independent image transmitting tubes to produce an electrical representation of the optical image, means to scan the electrical representation produced upon the target area of each of the image transmitting tubes according to a pre-established pattern of scanning whereby instantaneously the image on

a single tube only is being scanned and the image on all of the separate image transmitting tubes is scanned at a rate at which persistence of vision substantially causes flicker disappearance, and means to produce from the separate scan-

5 nings a single series of image signals representative of the composite image on all of the separate image transmitting tubes.

16. In a television system, means for forming an aerial image of an optical image, a plurality of spacially separated electronic image scanning tubes arranged in a series of rows and columns, means for dividing the aerial image into a series of partial-images and means for projecting the several spacially separated partial-images upon individual image scanning tubes, means for scanning the images upon each of the tubes sequentially for each row of tubes and progressively for each column of tubes, and means for producing from the scan-

17. A television transmission system comprising a plurality of image scanning tubes arranged in an orderly series of rows and columns, means for producing an aerial image of a subject of which the image is to be produced at a distant point, means for dividing the aerial image into a series of spacially separated partial-image areas, means for projecting a single partial-image only upon a single one of said image transmitting tubes and simultaneously projecting the remaining different partial-images upon individual other scanning tubes, means for scanning the images projected upon all of the tubes comprising means for sequentially scanning the partial images upon all tubes of each row and then scanning the partial images upon the tubes of each column in a progressive direction, and means for producing from the scan-

18. In a television system, a plurality of cathode ray tubes equal to n , where n is a whole number, means for producing within each tube a cathode ray scanning beam, means for deflecting the cathode ray beam developed within each separate tube according to a similar beam deflection pattern, means for controlling the intensity of each developed cathode ray beam in accordance with received signal energy, and means to control the sequence of beam deflection in each of the several tubes to segregate the control signals to different cathode ray tubes in sequence to produce upon each tube a partial-image record covering a plurality of two-dimensional contiguous picture elements whose combined areas occupy substantially a $1/n$ th portion of the complete image area of any received complete train of signal energy.

19. A television system for producing composite television images composed of a juxtaposed series of partial-image areas comprising a plurality of cathode ray tubes each adapted to produce over the luminescent screen thereof an optical record of the intensity of the cathode ray beam developed within each tube, said tubes being arranged in a series of rows and columns of at least two tubes each, means to deflect the cathode ray beam developed within each of the cathode ray tubes, means to control the sequence of the beam deflection in two mutually perpendicular directions in each of the cathode ray tubes in accordance with a pair of beam deflection wave energies only, an observation screen positioned to receive the luminescent image from

all of said tubes, an optical system for focussing and juxtapositioning at least two boundaries of each of the produced luminescent images upon the observation screen, and means for maintaining juxtapositioning of each optical image upon the screen irrespective of the amplitude of the deflection of the cathode ray beam within each of the several tubes.

20. In a television system wherein a composite image is formed from a series of juxtaposed initially marginally and spatially separated partial-image areas each produced upon the viewing screen of a cathode ray tube and wherein the cathode ray tubes are arranged in series of rows and columns, the method which comprises the steps of scanning the tubes of each row in sequence and progressively scanning the tubes of each column in a columnar direction, and projecting the resultant partial-image areas upon the viewing screen in juxtaposed manner for observation.

21. The method of television transmission by a series of electronic scanning tubes arranged in an orderly series of rows and columns which comprises the steps of developing an aerial image of a subject of which the image is to be produced at remote points, dividing the aerial image into a series of partial-images, projecting the several produced partial images upon independent and individual scanning tubes each marginally and spatially separated, scanning the separate partial-images projected upon the tubes of each row sequentially and in a progressive columnar direction and producing from the scanning of all partial-images a single series of image signals representative of the complete aerial image for transmission.

22. A television system comprising a plurality of cathode ray image producing tubes, means for producing upon the observation screen of each of the tubes a partial-image area of a complete image, an image observation screen, means for juxtaposing the several produced partial-image areas upon the observation screen to form a single composite image of all of the several partial-images produced, and means to alter the size of each partial-image area without affecting the juxtapositioning of the partial-images forming the composite image upon the observation screen.

23. A television system comprising a plurality of cathode ray image producing tubes positioned in a bi-directional array, means for producing upon the observation screen of each of the tubes a partial-image area of a complete image, an image observation screen, means for projecting the produced partial-image areas upon the image observation screen in juxtaposed relationship, and means for maintaining the border portions of each abutting partial-image area contiguous irrespective of the height and width dimensions of each produced partial-image area.

24. A television system comprising a plurality of cathode ray image producing tubes positioned in a bi-directional array, means for producing upon the observation screen of each of the tubes a partial-image area of a complete image, an image observation screen, means for projecting the produced partial-image areas upon the image observation screen in juxtaposed relationship, and means to maintain a single composite image area formed from the series of contiguous partial areas independently of the size variations of the partial-image areas.

25. A television system wherein a plurality of spatially separated juxtaposable partial-image

areas are combined to form a single composite image area comprising means for producing images of each partial area of the complete image as a series of sequentially produced rows of partial-images progressively forming a column of partial-images and means for projecting the partial-images upon a viewing plane, and means for matching the border of each partial-image area to form a complete image area from contiguously positioned partial image areas.

26. A television system comprising a plurality of cathode ray tubes arranged in a series of rows and columns and each adapted to produce an electro-optical image of a partial area only of a complete image area, a source of voltage connected between the cathode and anode of each of the cathode ray tubes for causing the development of a cathode ray beam within the tube, means for controlling the intensity of the electro-optical image developed by the cathode ray beam in accordance with control signal energy, means operating under the control of developed deflection energy for deflecting the cathode ray beam developed within each tube to cause the cathode ray beam to trace across the luminescent tube screen an electro-optical representation of the signal energy, and a plurality of normally inoperative thermionic tubes serially connected with the voltage source for normally preventing the development of a cathode ray beam within each cathode ray tube, and means for supplying a portion of the cathode ray beam deflecting energy to said thermionic tubes to render said tubes operative for a portion only of the time of beam deflection.

27. In a television system, a plurality of cathode ray tubes arranged in a series of rows and columns, means for developing within each tube an electronic scanning beam, a target area positioned within each tube in the path of the electronic scanning beam to become activated upon impact thereby, means associated with each tube to deflect, when energized, the scanning beam across the screen structure, means for producing an electrical energy wave of non-reentrant form, means for converting the produced non-reentrant wave into a series of separate electrical waves each having variable and constant portions which, when combined, form the original non-reentrant wave, and means for supplying individual converted wave formations to individual cathode ray tube deflecting means whereby the scanning beams of each tube are sequentially deflected and only the variable portions of each converted electrical wave are effective to deflect the developed electronic scanning beams so that the scanings of the several tubes occur in sequence for each row of tubes while simultaneously progressing in columnar direction.

28. The system claimed in claim 27 comprising, in addition, means to bias the deflecting means of each tube to a fraction

$$\frac{n-1}{n}$$

of the complete amplitude of the non-re-entrant deflecting wave, where n represents the number of tubes in each row or column, whereby the scanning of the screen structure by the cathode ray beams of each of the several tubes occurs sequentially for the tubes of each row and simultaneously progresses for all tubes of the system in a columnar fashion.

29. The system claimed in claim 27 comprising, in addition, means to suppress those portions of

each of the produced phase displaced waves having amplitude values less than

$$\frac{n-1}{n}$$

of the complete amplitude of the deflecting wave, where n represents the number of tubes in each column or row, and means for energizing the beam deflecting electrode system by the unsuppressed portions of the phase displaced electrical saw-tooth formation electrical waves.

30. The system claimed in claim 27 comprising, in addition, means to suppress those portions of each of the produced phase displaced electrical waves of non-re-entrant formation having amplitude values less than

$$\frac{n-1}{n}$$

of the complete amplitude of the saw-tooth deflecting wave, where n represents the number of tubes in each row or column, and an aperiodic amplifier connected with the deflecting electrode system of each tube and having its input circuit connected to be energized by the unsuppressed portion of each produced non-re-entrant phase displaced electrical wave.

31. The system claimed in claim 27 comprising, in addition, means to energize the deflecting means of each tube from a

$$\frac{1}{n}$$

portion of the developed deflecting wave energy, where n represents the number of tubes in each row or column.

32. The system claimed in claim 27 comprising, in addition, a biasing and a limiting means serially connected with each other and with the electron beam deflecting means for each of the individual tubes, means for supplying to each of the biasing and limiting means the produced non-re-entrant electrical wave energy, and means for producing within the several biasing and limiting means a plurality of electrical waves each of like amplitude and each including variable and constant portions so that, in time relationship, the variable portions of each wave produced occur sequentially, whereby the deflecting means associated with each of the tubes become sequentially operative to deflect the electron beam developed therein.

33. In a television system wherein an electro-optical image is produced from a series of juxtaposed partial-image areas, a plurality of partial-image producing cathode ray tubes each having screen structure upon which an electro-optical image is to be developed, said tubes being arranged in two adjacent rows of two tubes each, means for developing within each tube an electronic scanning beam, a pair of deflecting electrodes associated with each tube for deflecting the developed cathode ray beam when voltages are applied thereto, means for developing saw-tooth wave formation electrical energy having an amplitude equal to at least twice that required to move one cathode ray beam from one edge portion of the screen thereof to that edge portion diametrically opposite, means for applying to a portion of the deflecting electrode members biasing voltages to oppose the deflection voltages developed, and means for applying the developed saw-tooth wave formation electrical energy between the deflecting electrode members of each of the tubes, whereby fluctuations in amplitude of

the voltage are ineffective to alter juxtapositioning of the several partial-image areas.

34. A television system comprising a plurality of electronic scanning tubes arranged in a series of rows and columns, means for developing within each tube an electronic scanning beam, a target element positioned within each tube and adapted to be activated by the action of the scanning beam developed within each tube, deflecting electrode means associated with each tube and adapted, when energized, to deflect the developed scanning beams in two mutually perpendicular directions, means for developing two saw-tooth wave formations of different frequency for deflecting the electronic beams in the said two perpendicular directions, means for converting each of the developed saw-tooth waves into a plurality of similar wave formation electrical waves each phase displaced from the original wave and from each other by

$$\frac{360^\circ}{n}$$

- where n represents the number of tubes in each row or column, and means for energizing the deflecting electrodes of each tube by individual saw-tooth electrical waves.

35. The system claimed in the preceding claim comprising, in addition, means for biasing the deflecting electrode systems of each of the tubes in the direction to oppose the saw-tooth wave formation electrical energy to like bias values, whereby each saw-tooth phase displaced electrical wave is effective to produce deflection of the developed scanning beam for a portion only of its complete cycle.

36. In a system for producing composite television images from a series of boundary-wise-individually-spaced juxtaposable and interlockable internally continuous partial-images, a viewing screen, a plurality of cathode ray tubes arranged in rows and columns and each having a target area, means to create upon the target area of each tube an electro-optical representation of a partial area of a complete image area, and an optical system associated with each of the cathode ray tubes for focussing the produced partial area electro-optical images upon the viewing screen in juxtaposed manner with the boundary portions contiguous.

37. The system claimed in claim 36 where the optical system comprises a plurality of bi-directionally movable lens elements.

38. The system claimed in claim 36 where the optical system comprises a plurality of reflecting surfaces.

39. In a television receiving system, a plurality of cathode ray tubes arranged in a series of rows and columns, means for developing within each tube an electron beam, means for receiving image signals and controlling the intensity of each developed electron beam in accordance therewith, a luminescent viewing screen for each tube upon which electro-optical images are developed by impact of the intensity controlled electron beam, means for deflecting the electron beam developed within each tube in two mutually perpendicular directions, said deflecting means comprising means for developing an electric wave formation of saw-tooth pattern and of amplitude equal to that required to deflect the electron beam from a minimum to a maximum position in one tube multiplied by the number of tubes in each row or column, and means for biasing the deflecting systems of each tube whereby the single developed deflecting energy wave is adapted to deflect the

cathode ray beam of each of the tubes in individual rows or columns in sequence whereby there is produced on each tube a partial-image record only of the controlling signals.

40. In a television receiving system, a plurality of cathode ray tubes arranged in a series of rows and columns, means for developing within each tube an electron beam, means for receiving image signals and controlling the intensity of each developed electron beam in accordance therewith, a luminescent viewing screen for each tube upon which electro-optical images are produced by impact thereon of the signal controlled electron beam, means for deflecting the electron beam developed within each tube in two mutually perpendicular directions said deflecting directions, said deflecting means including means for generating electrical energy of saw-tooth wave formation for deflecting the produced electron beam, means for producing from the developed saw-tooth wave formation electrical energy a plurality of similar wave energies each phase displaced from the other by an electrical separation of

$$\frac{360^\circ}{n}$$

- where n is the number of tubes in each column or row, and means for controlling the deflection of the electron beam developed in each tube by one phase version only of the deflecting wave energy, whereby the tubes become sequentially operative to produce on the luminescent viewing screens thereof partial-images only of the complete image represented by the controlling signals.

41. The system claimed in the preceding claim comprising, in addition, means for limiting the control period of each produced energy wave of saw-tooth form on the associated cathode ray tube to a fraction of the order

$$\frac{1}{n}\text{-th}$$

of the saw-tooth wave amplitude.

42. In a television system comprising a plurality of cathode ray tubes arranged in a series of rows and columns and each adapted to produce an electro-optical image of a partial area only of a complete image area, means for developing within each cathode ray tube an electron beam, means for controlling the intensity of the developed electron beam under the control of received signal energy, means for deflecting the developed electron beam in each tube to cause the developed beam of each tube effectively to trace from one edge portion of one tube through to the opposite edge portion of the tube most removed in the same row or column, and thermionic means for limiting the time periods of development of the cathode ray beam in each tube to a minor fraction only of the total scanning time required for beam traversal of all tubes in the rows and columns.

43. The system claimed in the preceding claim wherein the thermionic means comprise a plurality of series connected thermionic tubes.

44. In a television system, a plurality of electronic image producing tubes, means for developing in each tube an electronic scanning beam, means for deflecting the scanning beam developed within each tube in accordance with a pre-established scanning deflection electric wave pattern, means to receive signals representative of an image of which the electro-optical counterpart is to be produced, means to energize each

tube simultaneously by the received signals to control thereby the effective intensity of the developed scanning beam, and means to control the deflection wave pattern effective upon each separate tube to limit the time period of effectiveness of the received signals upon each separate tube and thereby to produce from the signals received an electro-optical representation wherein separate partial areas are segregated to separate image reproducing tubes and the remaining tubes are inoperative to produce image representations of elemental partial areas confined to another tube.

45. The system claimed in the preceding claim comprising, in addition, means to render the tubes of the system other than actively useful in instantaneously producing electro-optical effects inoperative to a number at least as great as the next whole number larger than the ratio of one less than the square root of the complete number of image producing tubes to the square root of the complete number of image producing tubes.

46. A system of television comprising, a plurality of image producing tubes arranged in a plurality of rows and columns, means for developing within each separate tube an electronic scanning beam for scanning an image area, means for deflecting the developed electronic scanning beams according to a pre-established deflection pattern, means for energizing the beam deflecting means from a single source of energy having a signal strength represented by the magnitude of energy required for deflecting one of the scanning beams multiplied by the number of adjacent tubes, means for biasing the tubes by successively increasing amounts determined in accordance with the position of the tubes within the plurality of rows and columns.

47. In a television system, a viewing screen, means for forming a plurality of partial-image areas upon the viewing screen, means for matching together a portion of the total number of partial-image areas to form a section of a complete composite image area having contiguous boundaries, and means for moving the matching means to match together additional partial-image areas and match the boundaries thereof as contiguous areas, and means for matching together the several sectional partial areas to form a complete composite image area of juxtaposed partial-image areas.

48. In a television system wherein a composite image area is formed from a series of juxtaposed partial-image areas formed in a plurality of rows and columns, cathode ray tubes for individually producing each of the partial-image areas, a masking screen positioned adjacent the end viewing wall of each of the cathode ray tubes, said masking areas having viewing apertures of a pattern corresponding to the aspect ratio of the composite picture to be produced from the partial areas additively arranged in rows and columns, a viewing screen, orthogonally tri-directionally movable optical means positioned adjacent each of the viewing apertures of the cathode ray tubes for projecting the corresponding partial-image projected from the related tube upon the viewing screen.

49. In a television system, a plurality of image producing cathode ray tubes positioned in a bi-directional array formed from a series of rows and columns, means for producing within each of the cathode ray tubes a partial-image of a complete composite image, and a viewing screen positioned to receive the plurality of partial-

image areas produced, and means to position the several partial-image areas in juxtaposed relationship upon the viewing screen.

50. In a television system, a plurality of cathode ray tubes positioned in a bi-directional array comprising a series of rows and columns, means to produce upon the viewing screen of each tube a partial-image area of a complete image area, a viewing screen, optical means for projecting the several produced partial-images in juxtaposed relationship upon the viewing screen, and optical shielding means for optically shielding each of the several partial-image producing tubes and the produced partial-images from each other and from stray light.

51. In a television system wherein a plurality of related partial-image portions of a complete composite image are scanned independently, a plurality of cathode ray tubes each having screen structure adapted to be scanned by the cathode ray beam developed within each tube, electro-magnetic means for deflecting the scanning beam developed within each tube according to desired deflection patterns by the application of deflecting currents to the electro-magnetic means, means for applying biasing currents upon the electro-magnetic beam deflecting means to control the time periods of deflection of the cathode ray developed within each cathode ray tube to time periods when the amplitude of the deflecting currents exceeds the magnitude of the biasing currents, and means for preventing interaction of the biasing and deflecting currents upon each other.

52. The system claimed in the preceding claim wherein the means for preventing interaction of the biasing and deflecting currents upon each other comprises a capacity element connected in series with the deflecting currents and in parallel with the biasing currents for shunting the biasing source with the deflecting currents, and an inductive element connected in series with the biasing currents and in parallel with the deflecting current source for bypassing the deflecting current source with the biasing currents.

53. A television system comprising a plurality of cathode ray tubes arranged in a series of rows and columns and each adapted to produce an electro-optical partial-image of a complete electro-optical image, means for applying deflecting voltages to the several tubes of each row or column of the array to deflect the electron beam developed with each tube of the array, means for supplying biasing voltages upon the tubes of the array in parallel with the deflecting voltages, inductive and capacitive means for preventing inter-action of the biasing and deflecting energy sources upon each other, and additional capacitive means connected with at least a portion of the partial-image producing tubes for compensating for distortion introduced into the deflecting wave energy source by the capacitive means for separating the biasing and deflecting energy sources.

54. In a television system wherein a plurality of cathode ray tubes are positioned in a bi-directional array comprising a series of rows and columns and wherein a cathode ray scanning beam is developed within each tube to scan a partial-image area of a composite image area and wherein each scanning beam is subject to deflection across the screen structure of each tube by the application of an electrical voltage wave having an amplitude value a to

produce an electrostatic field to scan a partial-image area in one direction, the method of operation which comprises the steps of developing an electrical voltage wave of scanning beam deflecting energy having an amplitude of $n \cdot a$, where n represents the number of tubes in either direction of the bi-directional tube array and a represents the amplitude of the wave of electrical energy required to move the scanning beam across the screen structure of each tube of the array to scan a partial-image in one direction, applying biasing voltages upon the scanning beam deflecting system of each tube of the array in each row or column thereof, and increasing the biasing voltages upon each tube of a row or column successively and by equal amounts in arithmetrical progression between two limiting values of zero and a value of $(n-1) \cdot a$, where n represents the number of tubes in each row or column of the array and a represents the amplitude of the deflection voltage wave to move the scanning beam across the screen structure of a single tube of the array.

55. The method claimed in the preceding claim comprising, in addition, the step of limiting the effect of the deflecting voltage upon each tube of each row or column during increasing amplitudes of the deflecting voltage to periods of voltage increase having values equal only to the value of the initial bias increased by a value equal substantially to that voltage required to move the scanning beam across the partial-image area represented by a single tube only of the array of rows and columns.

56. In a television system wherein a plurality of cathode ray tubes are positioned in a bi-directional array comprising a series of rows and columns and wherein a cathode ray scanning beam is developed within each tube to scan a partial-image of a complete composite image area and wherein each scanning beam is subject to deflection across the screen structure of each tube by the application of an electrical voltage wave having an amplitude value a to produce an electrostatic field to scan a partial-image area in one direction, the method of operation which comprises the steps of developing an electrical voltage wave of scanning beam deflecting energy having an amplitude $n \cdot a$, where n represents the number of tubes in either direction of the bi-directional array and a represents the amplitude of the wave energy required to move the scanning beam across the screen structure of each tube of the array to scan a partial-image in one direction, shifting the deflecting wave energy wave form as to origin and limiting amplitude to produce a series of deflecting energy waves equal in number to n , where n represents the number of tubes in each row or column and wherein each developed wave has a minimum amplitude of zero and a maximum amplitude of a , where a represents the amplitude of the deflecting wave required to deflect the scanning beam across the screen structure of a single tube of the array, and applying the n waves developed to the tubes of each row or column in sequence in accordance with the time period of change in amplitude value of each of the n waves between zero and a limiting value a .

57. In a television system wherein a plurality of cathode ray tubes are positioned in a bi-directional array comprising a series of rows and

columns and wherein a cathode ray scanning beam is developed within each tube to scan a partial-image of a complete composite image area and wherein each scanning beam is subject to deflection across the screen structure of each tube by the application of an electrical voltage wave having an amplitude value a to produce an electrostatic field to scan a partial-image area in one direction, the method of operation which comprises the steps of developing an electrical voltage wave of scanning beam deflecting wave energy having an amplitude of $n \cdot a$, where n represents the number of tubes in either direction of the bi-directional tube array and a represents the amplitude of the wave of electrical energy required to move the scanning beam across the screen structure of each tube of the array to scan a partial-image in one direction, converting the developed electrical wave into a plurality of substantially identical electrical waves each phase displaced from the original wave and from each other by $360^\circ/n$, where n represents the number of tubes in either direction of the bi-directional array, applying one phase version of the electrical wave to the tubes of each row or column sequentially, and applying to each of the tubes of each row or column a biasing voltage of a value $(n-1) \cdot a$, where n represents the number of tubes in each row or column and a represents the amplitude of the electrical wave energy required to move the scanning beam across the screen structure of each tube of the array.

58. In a television system wherein a plurality of cathode ray tubes are positioned in a bi-directional array comprising a series of rows and columns and wherein a cathode ray scanning beam is developed within each tube to scan a partial-image of a composite image area and wherein each scanning beam is subject to deflection across the screen structure of each tube by the application of an electrical voltage wave having an amplitude value a to produce an electrical field to scan the partial-image area represented by each tube in one direction, the method of operation which comprises the steps of developing a wave of electrical energy of saw-tooth formation, producing from the developed electrical wave a plurality of phase displaced electrical waves each separated from the other by an electrical separation of $360^\circ/n$, where n represents the number of tubes in each row or column, amplifying the produced phase displaced electrical waves each to an amplitude value of a , where a represents the amplitude of the voltage required to produce complete deflection of the scanning beam in each tube of the array, and applying in sequence to the several tubes of each row or column one of the produced phase displaced versions of the produced electrical wave to cause the scanning in one direction of the partial-image area represented by each individual tube of the array.

59. The system claimed in claim 44 comprising in addition means to render the tubes of the system other than that one which is to be useful in instantaneously producing electro-optical effects inoperative to a fraction of the whole as great as represented by the fraction

$$\frac{n-1}{n}$$

where n represents the complete number of image producing tubes.

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