

Oct. 10, 1939.

F. SCHRÖTER

2,175,573

ELECTRON BEAM CONVERTER

Filed March 20, 1939

2 Sheets-Sheet 1

Fig. 1

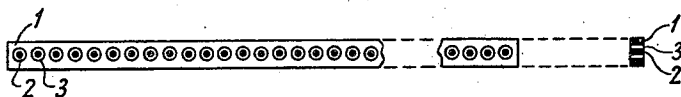


Fig. 3

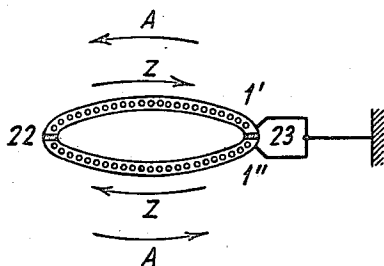
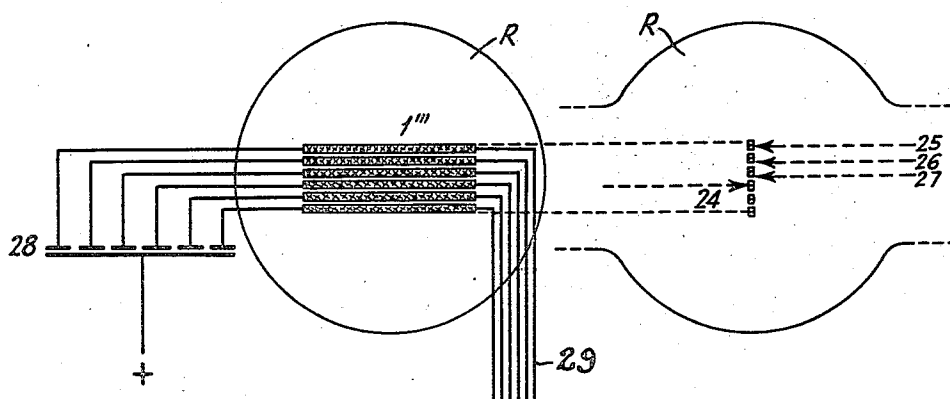


Fig. 4



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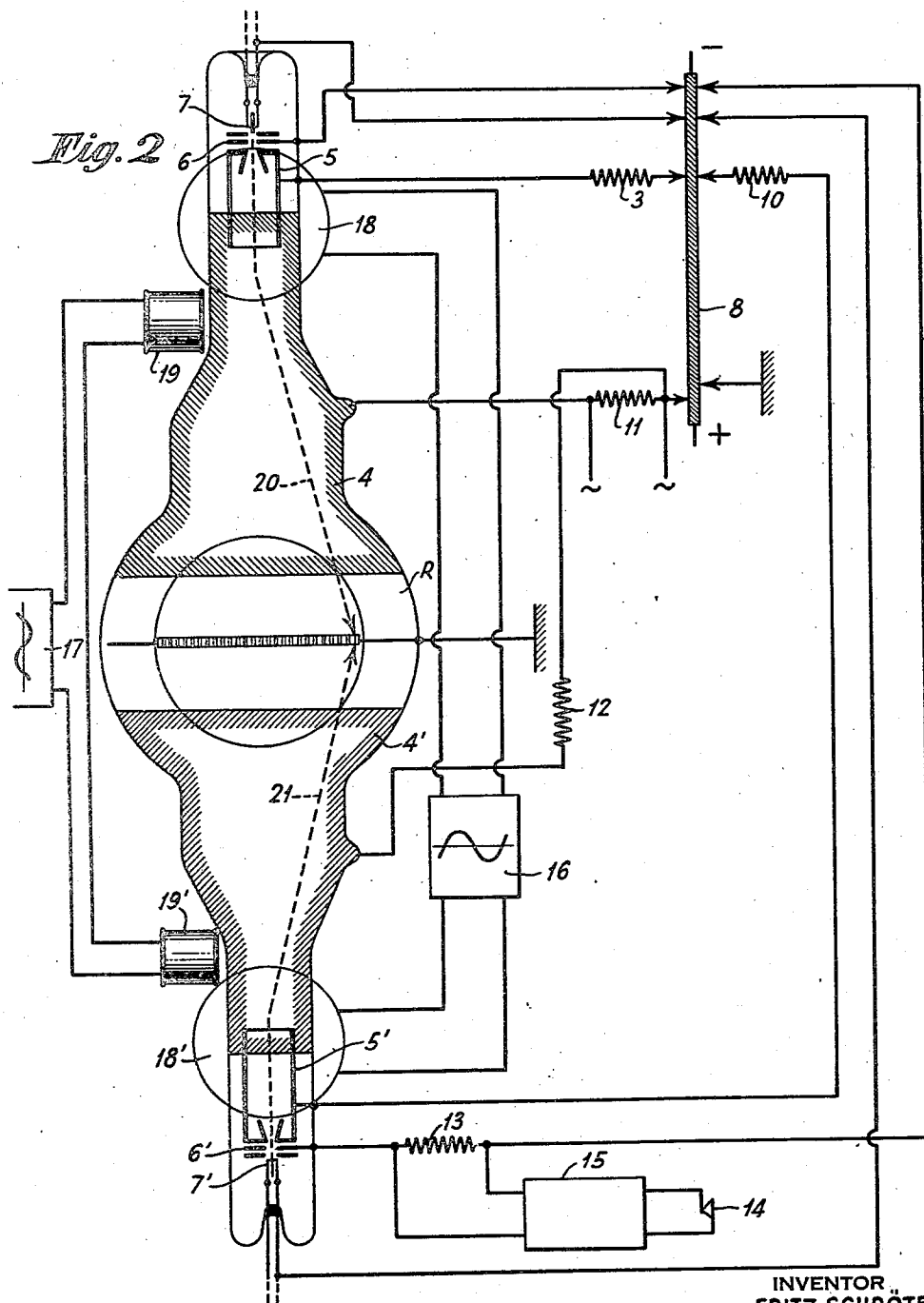
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2 Sheets-Sheet 2



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ELECTRON BEAM CONVERTER

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12 Claims. (Cl. 179—1.5)

The object of this invention is to provide an inertialess electron-beam converter of the kind especially adapted for use in intelligence transmission. This converter utilizes the motion or sweep in vacuo of one or several independent inertialess cathode-ray pencils in such a way that the pencil electrons, in quantities controlled in a way being either constant or variable with time, are consecutively caused to strike or impinge upon a number of insulated capacitive conductors which conductors are incidentally caused to give off secondary electrons proportional to the incidence of the primary electrons. The conductors thus acquire corresponding charges, and by virtue of their uniform capacity in reference to a joint or common coat or plate are adapted also for the storing of modulator actions of the cathode-ray pencil in the form of an undistorted distribution of potential.

In the iconoscope known in the prior art and which is used for television scanning, the picture to be televised is thrown, as a whole upon a "target" plate which consists of a multiplicity of microscopic elementary condensers possessing photoelectric activity and being capable of secondary electron emission. The charges caused by light actions accumulated thereon are periodically evaluated by a scanning cathode-ray pencil by means of secondary electron emission. The so-called plate of the iconoscope thus acts as a transducer to convert light or luminous actions into current or electrical actions. Contradistinct therefrom, what is concerned in the present invention is a purely electrostatic cumulator whose elements are not acted upon by light, but which merely transmit and vary electrical actions.

The basic idea of the invention shall be illustrated and explained as follows: Upon the anterior face of a tenuous insulation layer or sheet of glass or mica are applied tiny silver areas or patches insulated from one another, while the rear face of the collective capacity is silver-coated throughout. The silver "cells" are rendered capable of secondary electron emission in known manner in the vacuum of the cathode-ray tube by deposition of vapors of barium or caesium. The cathode-ray pencil caused to sweep thereover is produced, as also known in the art, by a heated cathode opposite which are disposed a control electrode and one or several anodes forming electron-optic means. The collective or common coat of the cell condenser is at approximately anode potential. If, then, by the action of an electric or magnetic field the cathode-ray pencil is deflected and caused to

sweep over the row of constituent cells, while the intensity thereof is at the same time modulated by the video signal to be transmitted by means of a control electrode, this will result in charging of the cells. By properly choosing the operating potentials of the tube, the charging process occurs due to secondary emission from the cells in a positive sense. It will be apparent to those skilled in the art that optimum potential values should be chosen in operating the tube. The distribution of the charges corresponding to the modulation of the cathode ray beam will be preserved for a certain length of time on the cells, and the length of time depends on the particular cells used and, of course, the characteristic curve of these cells that charge thereon plotted against time. If, then, a cathode-ray pencil is again caused to sweep over the row of these cells, at a constant intensity, although according to the desired purpose the direction or the velocity of the pencil sweep or motion may be varied, the secondary emission effect will again be varied at the rhythm and rate of the accumulated modulation. In the said second scan or sweep, therefore, the original modulation curve will be picked up and obtained, as may be desired, in the same or in inverse sequence, and with increased, constant, or reduced velocity and incidental levelling of the potential. This, therefore, constitutes a convenient means for frequency conversion of periodic, modulated, or non-modulated currents, and for inversion of time modulation actions for use in secrecy or coding in telephony. Moreover, it affords a means adapted to insure any desired signal accumulation or storing in telegraphy work making use of repetition. Since, furthermore, converter tubes of this kind can be connected in parallel so that the incoming modulation may be impressed simultaneously upon several cumulators, which may then be scanned in sequence, this gives a chance, in picture telegraphy and television work, to vary at will any given picture sequence each second, a feature which will be found valuable with a view to reducing the band width in certain transmission channels. In other words, the sequence of scanning a picture may be varied due to the fact that the same intelligence may be recorded on several tubes, and the limitations accompanying the use of a single scanning system is avoided. The basic idea of this invention may moreover be modified in such a way that the modulation cumulated by the recording cathode-ray pencil, upon reproduction, may be scanned simultaneously by several independent cathode-ray

pencils acting in groups. For instance, a single-channel transmission may be divided between a plurality of receiver means and channels acting in parallel, or vice versa. This may be valuable, for example, with a view to obtaining large and yet bright pictures, and in this connection, because of an increased optical representation, simultaneous control and representation of several picture units may be the proper solution of the difficulties inherent in luminosity or illumination. It will be appreciated that where it is possible to divide a transmission which ordinarily takes place over a single channel between a number of parallel channels, each channel will carry a more narrow band of frequencies, and this is especially important in the transmission of video signals by wire since the use of conductors with a limited frequency band of transmission range is often both desirable and necessary.

In building cathode-ray tubes of the kind used in this invention, recourse is had to the ways and means known from high-vacuum work, electron-optics, and hot-cathode manufacture, such as found in combination in modern Braun tubes for the representation of television pictures, in the iconoscope, in the electronic microscope, etc. These tubes operate with a high vacuum, for it is only under such conditions that the secondary emission and accumulation will proceed in a satisfactory manner. To deflect or move the cathode-ray pencil or pencils there are employed periodic fields of an electrostatic or magnetic nature which are set up by potentials or currents having the desired curve-shape. Rotational movements of the cathode-ray pencils are producible by crossed fields fed with phase-displaced currents.

My invention will best be understood by reference to the figures of the drawings in which:

Fig. 1 is a screen arrangement,

Fig. 2 is one embodiment of my invention,

Fig. 3 is a combination of strip elements forming a screen, and

Fig. 4 is another embodiment of my invention.

Fig. 1 is a fundamental view of the construction of a linear electrode system adapted to accumulate charges produced by the scanning cathode-ray pencil by virtue of secondary emission. The metallic strip 1 has a series of apertures which, with the interposition of dielectric substance 3 are filled with substance 2 capable of secondary electron emission. In this manner there results a series of tiny elementary condensers whose insulated coats 2 are dielectrically separated from the joint co-operative coat 1. If, then, the cathode-ray pencil is caused to sweep either at a constant or at a variable intensity over the anterior faces of the row of cells 2 care having to be taken, however, so that 1 will be safeguarded from the impact of pencil electrons, the said pencil will occasion constant or variable potential differences between these cells and the collective or joint electrode 1. It should be appreciated that the drawings in the case are not scale drawings, and that the element 2 may be spaced closely enough together so that the electron beam which is comparatively small in cross-section will not impinge on the member 1. These charges may be evaluated by a second electron-pencil scan as described further above. The said second pencil could be brought to act also from the posterior side of the system 1. In fact, the graphic representation of Fig. 1 is merely intended to illustrate the physical features of the principles, whereas the actual arrangement as a rule

differs therefrom, that is to say, that strips of insulating material upon one face thereof are metallized throughout, while upon the opposite face metallization is in the form of tiny and separated areas or patches, whereupon the latter are rendered capable of secondary electron emission. This may be termed a double mosaic type of structure.

Figs. 2 and 3 illustrate an exemplified embodiment of the invention in connection with a scheme adapted to code (or "garble") speech transmitted over telephonic channels. The twin-type cathode-ray pencil converter tube here used is indicated by R. The cumulator system 1 which corresponds to the one shown in Fig. 1 is mounted in the center of the tube R. By shielding means care is taken so that secondary electrons released by a cathode-ray pencil will be drawn only towards the anode which lies on the impact side of the primary electrons. The two anodes which consist of a conducting wall coat are designated at 4 and 4'. To produce the cathode-rays 20 and 21 indicated by the broken arrows there are further provided electrode systems of a kind well known in the art and comprising the first anodes 5, 5', the modulator electrodes 6 and 6', and the heated cathodes 7 and 7', the latter being preferably of the indirectly heated kind. To supply the working D. C. potentials for tube R, there may be provided, for instance, a potentiometer 3 on which are tapped the various potentials by way of resistors 3, 10, 11, and 12. The common coat of system 1 shall be assumed to be grounded; also a suitable point of the potentiometer.

A more detailed view of a system embodying the use of the arrangement of Fig. 1 is shown in Fig. 3. The screen or storing arrangement consists of two halves or members 1', 1'' which are elliptically or circularly curved, the said two halves being held together and assembled by short interposed pieces of insulation indicated at 22 and 23. The closed elliptical paths along 1' and 1'' are scanned by two cathode ray pencils 20 and 21 (see Fig. 2) at a definite phase in opposite sense, with a view to producing the effect hereinafter to be explained in more detail. The motion of the electron beam is provided by crossed magnetic fields which are set up by the schematically shown coils 18, 18' and 19, 19', Fig. 2. Both pairs of coils are energized from dependent generators 16 and 17 with sinuous currents of like frequency, but dissimilar amplitude, and in such phase relations that the electron pencils 20, 21, will run in opposition in the direction of the arrows shown in Fig. 3, and will meet at the neutral points 22 and 23 and cross each other.

Suppose that during this circular motion the electron ray or pencil 21 is modulated in intensity by the currents set up by microphone 14 and amplified by amplifier 15 so that across the terminals of the resistance 13 voltage variation corresponding to the voice are set up, the said voltage variations being superimposed upon the potential or the modulator electrode 6'. The elliptic motion of the voice modulated pencil is indicated in Fig. 3 by the arrows Z. In this periodic circulation, the pencil modulation will be stored up continuously in the various cells 2 (see Fig. 1) in the shape of locally varying charge potentials. At the same time, however, by the action of the oppositely sweeping electron pencil 20 from the rear there occurs a time inversed and complete pickup of the stored modulation,

in that pencil 20, as indicated in Fig. 3, is caused to sweep along I' I'' in the sense of the arrow A at the same cyclic frequency as 21. The time variations which the electron current reaching anode 4 experiences, occasion voltage variations across the terminals of the resistance 11 which correspond to the transposed, that is to say, coded or garbled voice modulation and which after proper amplification, are used for secret telephonic transmission.

The fact that in the said manner a continuous and uninterrupted translation or coding of the speech takes place will be readily understood from a reference to Fig. 3. Suppose that the two pencils 20 and 21, at a given instant, are positioned at 22; pencil 21 would sweep the upper half of the elliptic path in the sense of the arrow Z and, after a half cycle or revolution, it would cross again pencil 20 at the neutral point 23. It will be appreciated that the neutral points 22 and 23 may be used for a number of purposes such, for instance, as the development of a synchronizing signal and the like. The upper path 22—23 of the elliptical shaped member which assumes an uncharged state from the action of the beam of steady value will store up charges due to the action of the modulated beam which impinges thereon after the section has been neutralized. Pencil 20 which sweeping along the lower path has reached point 23 will then be made to scan, upon the upper half, the recorded modulation, but in inverse sequence, while at the same time the pencil 21 travels along the bottom half from 23 to 22 and thereby continues the modulation recording, seeing that the said path had just previously been rendered into the state of quiescent potential by the pencil 20 sweeping in the contrary direction. Owing to the fact that this cycle recurs again and again, there is brought about an inversion of the modulation frequencies during those periods when the cathode ray beams are continuously being deflected. The small gaps at 22 and 23 will do no harm, provided that the distance between them are relatively long. However, recourse could be had to accessory means to the end of causing the pencils 20 and 21 to jump over or skip the said neutral zones 22 and 23 so rapidly that only supersonic interruption frequencies will result (Superposed auxiliary currents).

If at the receiving place a similar equipment is provided as in Figs. 1 and 3, the modulation coming in in inverted form can be restored to the original shape. The operation of such a decoding or re-converting arrangement will be perfectly clear from what has been explained above.

The cumulator arrangement shown in Fig. 3 is merely to be considered as a simplified embodiment given by way of example. Under practical conditions, short storing paths as here shown will ordinarily not be used, indeed, by the provision of longer cumulator paths or surfaces designed to accommodate more modulation, care will be taken so that the interrupting frequencies caused by the inter-crossings at the points 22 and 23, Fig. 3, will be rendered as low as possible. A limitation, of course, is imposed in this respect by the permissible lag in the garbled modulation in reference to the original modulation.

As has been pointed out, arrangements of the said sort and comprising suitably designed cumulator system could be used also in connection with telegraphic work using methods in which the same letter signal or impulse, with a view to

neutralizing interference or fading or losses of signals, is repeated several times at certain time intervals, such repeated signals being stored up in the receiver, as known from the Verdan and the Siemens-Verdan method, etc., as for instance as explained in U. S. 1,677,062.

However, for the practical utilization of this principle large-sized mechanical or electrostatic storing means have heretofore been required. The present invention discloses ways and means to solve the same problem in a simplified manner by the aid of microscopic charge accumulators capable of accommodating a large number of signals so that a greater variation in regard to "amount of signals of repeating period" and the speed of transmission is permissible.

The principles hereinbefore disclosed will be found of great value in connection with the conversion of television or video signals, for purposes hereinbefore explained in detail. The basic idea of such conversion is schematically illustrated in Fig. 4. Suppose the problem consists in dividing a normal single-channel television transmission into three simultaneously operating channels, say, for controlling three independent picture units in the receiving or re-created picture. The incoming modulation therefore corresponds to the usual scanning in which always only one elementary area of the picture is transmitted. Confined inside the tube R are two groups each comprising three or a total of six strip-shaped cumulators indicated at I'''. Along each strip is disposed an adequate number of microscopic condenser cells in order that a full line of the incoming single-channel modulation may be faithfully recorded. The six collective or joint coats (corresponding to coat I in Fig. 1) are united with one another for RF energy by the capacities 28 so that they represent for RF modulation of the single-channel transmission a common coat. For the resultant modulation of reduced frequency are provided $2 \times 3 = 6$ individual lines 29 or, in other words, three pairs of transmission lines. The single-channel modulation is recorded by the electron pencil 24 which is subjected to intensity modulation by the incoming video signal, while the division into the three reproducer channels is effected by three independent and constant cathode-ray pencils 25, 26, 27 upon the rear of the system I'''. By the ways and means known in modern art it will be readily possible to provide such multiple pencils in a way so that they will not mutually interfere. By synchronized deflector systems working with ratchet or relaxation circuit organization, and by means of electrical equalizing means care is taken so that the pencil 24 will sweep consecutively over the six line cumulators of system I''' in normal line motion, while inside a length of time which must be short in contrast to the synchronizing pause at the end of each line, it will be made to fly back to the beginning of the first line. In the meanwhile, the three pick-up pencils 25, 26, and 27, at a velocity which is only one-third of the other, and with the proper phase displacement, cover parallel to one another and in cyclic alternation the upper and the lower group of strips. The time shift in reference to pencil 24 is so chosen that the scanning sweep will start at the edge of the picture only after the whole area to be covered inside the period of one line has been finished by the pencil 24. The proper control of the three pencils 25, 26, 27, is insured by the aid of relaxation oscillations which bear a rational

frequency relation to the oscillations causing deflection of the pencil 24. In this manner a perfectly continuous and complete change of the single-channel modulation into the three-channel modulation here chosen for the sake of argument is feasible, in fact, division into a greater number of channels is possible by simple means. In order that the simultaneously acting spots which, in the case here concerned, cause recreation of the incoming picture, may be modulated independently of one another, it will be necessary to include in the leads 23 many common coats of the system ("" separate resistances which act as input impedances of the three picture signal amplifiers. Pairs of these corresponding to similar strips of the upper and the lower group of three are co-ordinated to the same amplifier. The drops of potential of these three pairs of conjugate resistances may be brought to act alternately in balanced measure upon distinct control grids of the same input tube (hexode), or else they may be brought to act, by way of push-pull input tubes, alternately upon a single input impedance for each of the three picture-signal amplifiers.

Alternate transmission from a single amplifier of differing impressed signals is known in the prior art.

What I claim is:

1. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for accelerating each of said beams, means for modulating at least one of said beams in accordance with said intelligence to be transmitted, means for storing an electrostatic image of a portion of said intelligence, and means for translating said stored electrostatic image.

2. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with said intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, means comprising a plurality of discrete condensers for storing an electrostatic image of a portion of said intelligence, and means for translating said stored electrostatic image.

3. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with said intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of discrete elements having a high secondary emission characteristic, said elements being arranged in the path of said beams, a conductor common to all of said discrete elements and in capacitive relationship thereto, and means for translating the charge on each of said discrete elements sequentially.

4. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with said intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements, said screens being arranged adjacent to and insulated from each other, and means for energizing said beam deflecting means in such fashion that unmodulated beams impinge on said screens

sequentially and in timed relationship to the modulated beams.

5. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with said intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, means comprising a plurality of discrete condensers for storing an electrostatic image of a portion of said intelligence, and means for translating said stored electrostatic image in a fashion reversed with respect to the direction of storing of said image.

6. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements, a conductor adjacent each screen and common to the capacitor elements thereof, said capacitive elements each being capable of secondarily emitting electrons, and means for simultaneously deflecting said independent beams so as to maintain a definite relationship between said image recording and said image translation.

7. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements, a conductor adjacent each screen and common to the capacitor elements thereof, said capacitive elements each being capable of secondarily emitting electrons, and means for simultaneously scanning all of individual screens so as to divide the complete intelligence pattern into groups of signals.

8. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements coated with a material having a high secondary emission characteristic, a conductor adjacent each screen and common to the capacitor elements thereof, and means for simultaneously deflecting said independent beams so as to maintain a definite relationship between said image recording and said image translation.

9. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements, a conductor adjacent each screen and common to the capacitor elements thereof, said conductor being adapted to be maintained substantially at anode potential, said capacitive elements each being capable of secondarily emitting electrons, and means for simultaneously deflecting said independent beams so as to maintain a definite relationship between said image recording and said image translation.

10. An intelligence transmitter comprising

means for developing a plurality of independent cathode ray beams, means for modulating one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements, a conductor adjacent each screen and common to the capacitor elements thereof, said conductor being adapted to be maintained substantially at anode potential, said capacitive elements each being capable of secondarily emitting electrons, and means for simultaneously scanning all of individual screens so as to divide the complete intelligence pattern into groups of signals.

11. An intelligence transmitter comprising means for developing a plurality of independent cathode ray beams, means for modulating at least one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a plurality of individual screens containing discrete capacitive elements coated with a material having a high secondary emission characteristic, a conductor adjacent each screen and common to the capacitor elements thereof, said

conductor being adapted to be maintained substantially at anode potential, and means for simultaneously deflecting said independent beams so as to maintain a definite relationship between said image recording and said image translation.

12. An intelligence transmitter comprising means for developing a pair of independent cathode ray beams, means for modulating at least one of said beams in accordance with intelligence to be transmitted, means for accelerating each of said beams, means for deflecting each of said beams, a pair of individual screens each containing a plurality of discrete conducting elements insulated each from the other, said screens being arranged together so as to form an elliptically shaped member, a conductor adjacent each of said screens and common to the discrete elements thereon so as to form a capacity therewith, said capacitive elements being capable of secondarily emitting electrons, and means for deflecting said independent beams so as to follow the elliptical shape of the screens and to maintain a definite phase relationship between said independent beams.

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