

July 1, 1969

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3,453,471

VACUUM TUBE RESPONSIVE TO AN ELECTRICAL IMAGE RECEIVED
THROUGH AN ENDWALL OF SAID TUBE PROVIDED WITH A
PLURALITY OF ELECTRICAL CONDUCTORS

Filed Oct. 9, 1964

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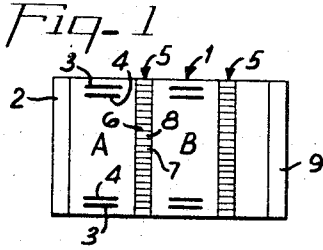
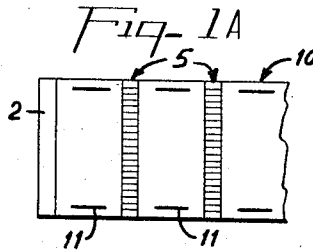
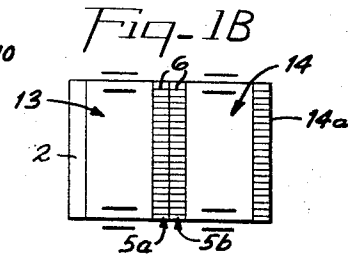
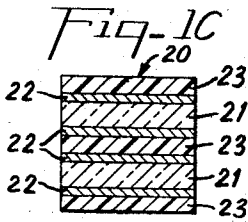
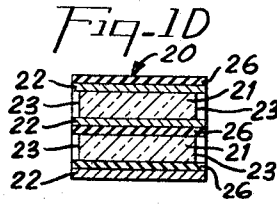
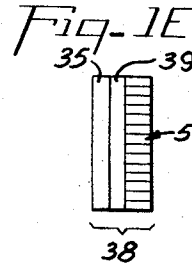
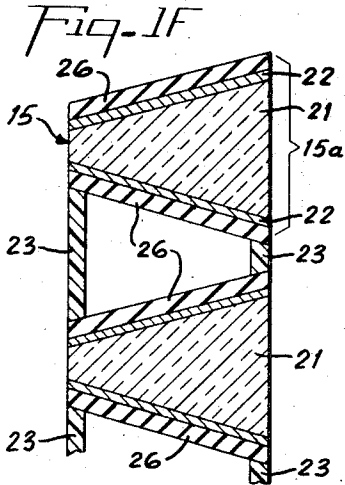
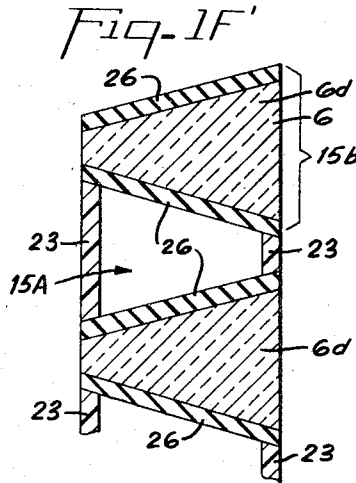
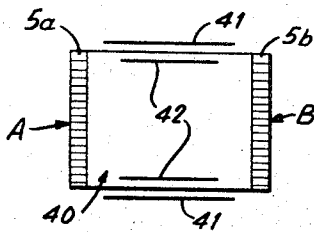


Fig. 2

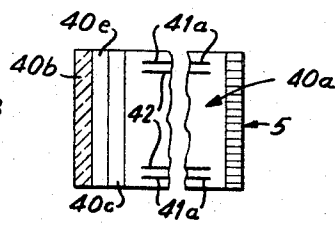


Fig. 2A

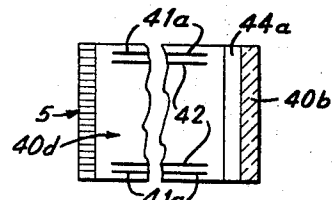


Fig. 2B

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Fig-1H

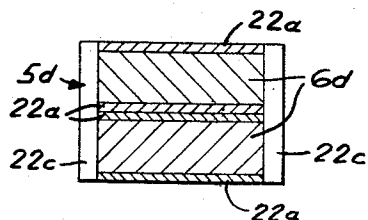


Fig-1K

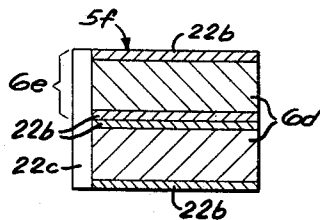


Fig-1L

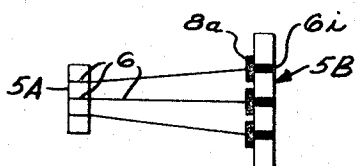


Fig-1M

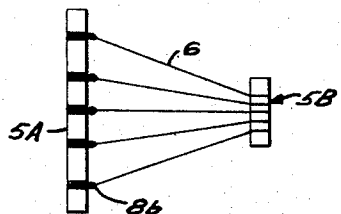


Fig-1N

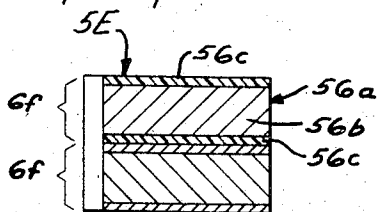
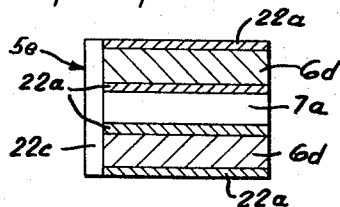


Fig-1J



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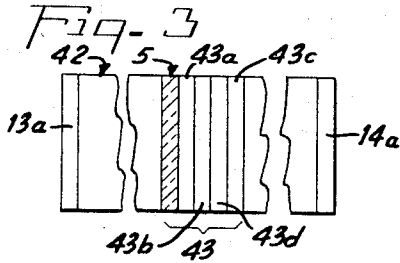
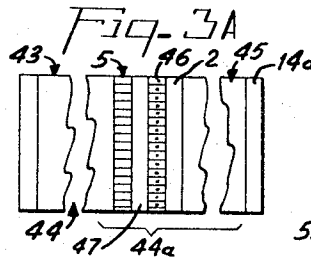
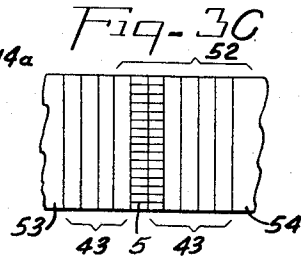
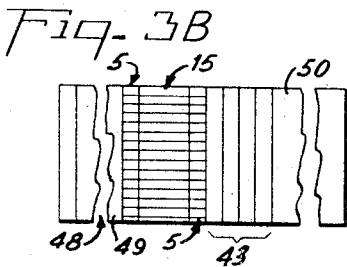
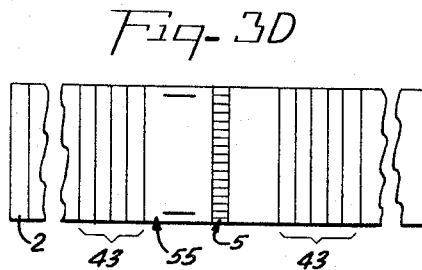
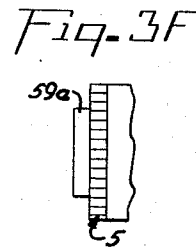
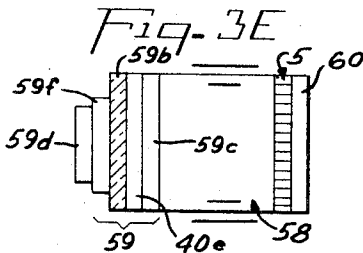
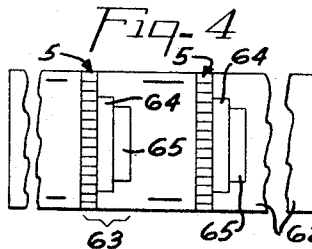
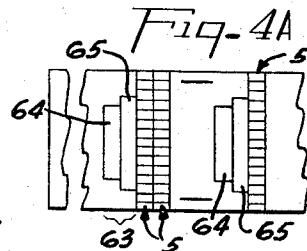
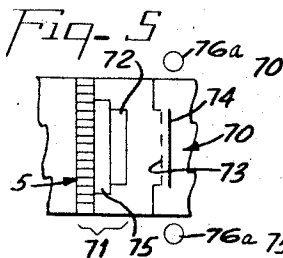
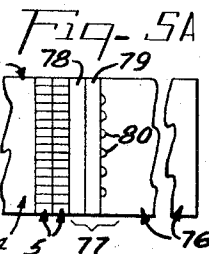
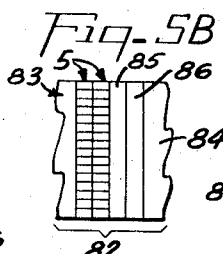
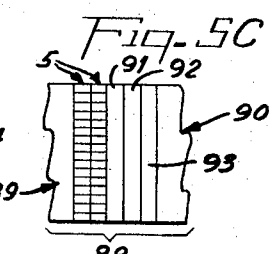
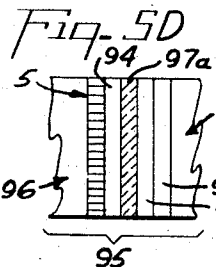
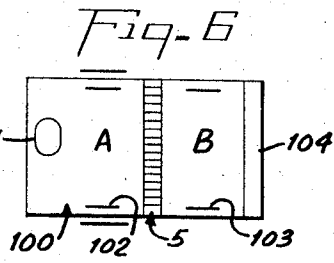
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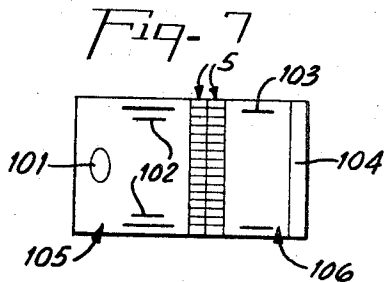
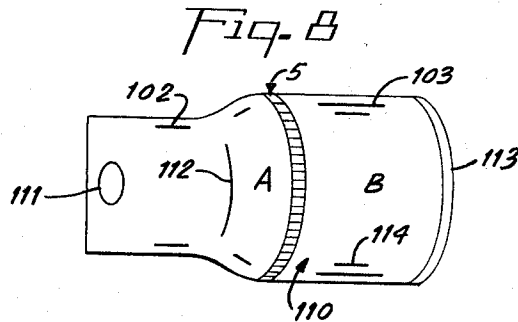
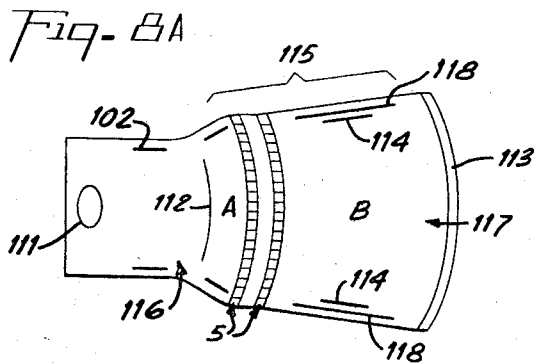
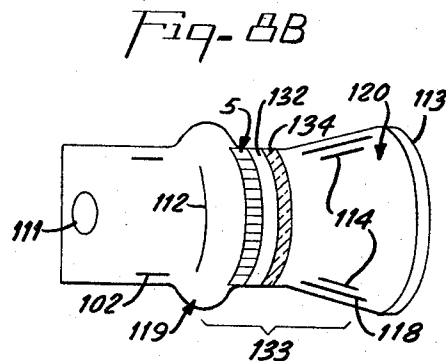
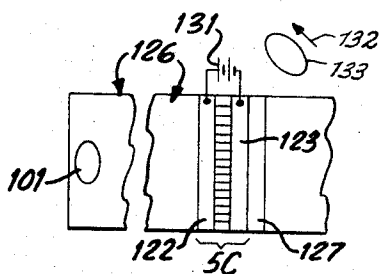
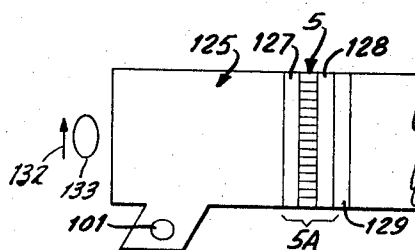
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VACUUM TUBE RESPONSIVE TO AN ELECTRICAL IMAGE RECEIVED THROUGH AN ENDWALL OF SAID TUBE PROVIDED WITH A PLURALITY OF ELECTRICAL CONDUCTORS

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U.S. Cl. 313—65

11 Claims

This invention relates to an improved method and device of intensifying and transmitting images and refers more particularly to an improved method and device for intensifying and transmitting images formed by the light, infra-red or ultra-violet radiation or by other invisible radiations such as gamma rays and the like, and also irradiation by beams of atom particles such as e.g. neutrons. This is also described in my copending divisional patent application Ser. No. 421,310, filed Dec. 28, 1964.

The novel image intensifiers described below make use of cascaded image intensification which is accomplished by the use of two or more intensifiers in one tube or in two tubes coupled together.

In the devices of the prior art the transfer of the electron image from one vacuum tube to another or from one compartment to another compartment of the vacuum tube was a complicated procedure involving conversion of the electron image into a light image before such electron transfer. This is described in my U.S. Patents 2,555,423 or 2,555,424.

In my present invention the intensification is simplified by providing means for a direct transfer of the electrons from one vacuum tube to another, or from one compartment of the same vacuum tube to another one.

The invention will be better understood when taken in combination with the accompanying drawings.

In the drawings:

FIGURE 1 represents a novel image intensifier with an electrical or electron image conductor.

FIGURE 1A, represents a modification of the novel electrical or electron image conductor.

FIGURE 1B shows two electrical or electron image conductors coupled together.

FIGURES 1C, 1D, 1E, 1F, 1F', and 1G, 1H, 1K, 1L, 1M and 1N show various embodiments of the image electron or electrical image conductor.

FIGURE 2 shows a modification of the image intensifier.

FIGURES 2A and 2B show image intensifiers provided with one endwall formed by the electron or electrical image conductor and another wall by a fiberoptic mosaic.

FIGURES 3, 3B, 3C and 3D show image intensifier provided in addition with an intensifying sandwich screen.

FIGURE 3A shows two image intensifiers in tandem.

FIGURES 3E and 3F shows an X-ray or neutron image intensifier.

FIGURES 4 and 4A show an image intensifier provided with secondary electron emissive screen.

FIGURES 5 and 5A show modifications of image intensifier provided with photoemissive means mounted on an insulating base.

FIGURE 5B shows a modification of the image intensifier provided with a layer exhibiting electron bombardment induced conductivity.

FIGURES 5C and 5D show a modification of the image intensifier provided with photoconductive means.

FIGURE 6 and FIGURE 7 show a modification of the image intensifier provided with post-deflection acceleration means.

FIGURE 8, FIGURE 8A and 8B show a novel color

television receiver provided with an electrical or electron image conductor.

FIGURES 9 and 9A show a device for intensified photo-emission by a regulated injection of electrons.

FIGURE 1 shows a novel image intensifier 1 which comprises an image reactive screen or other photocathode means 2 such as of photoelectric material comprising antimony, bismuth or arsenic with caesium, potassium or sodium. It should be understood that a mixture of afore-said elements especially K-Cs-Sb may be preferably used. In some cases best results are obtained by the use of CsOAg. The photocathode may have a planar or convex or concave shape according to the focusing fields used. The photocathode 2 may be mounted on the endwall of the tube or on a support transparent to the radiation used. The image may be formed by visible or invisible radiations such as ultra violet, X-rays or infra-red and is converted by a suitable photoelectric screen into a non-scanning photoelectron beam having the pattern of said image. It should be understood that the image producing means may be not of a photoelectric material but of any electron-emissive material such as thermo-emissive or secondary electron-emissive material. The broad non-scanning electron beam is focused by electrostatic or magnetic means 4 on the novel electrical or electron image conductor 5. The image conductor 5 comprises a plurality of electrically conducting members such as wires 6 which are embedded in an insulating matrix forming a two dimensional array. The diameter of wires may vary from a small fraction of one millimeter to a few millimeters. The insulating matrix 7 may be of a glass or a suitable plastic such as polyesters, fluorocarbons or polyethylenes. The wires 6 may be also coated with an insulating coating before embedding them in the matrix 7. The insulating coating may end before one or both ends of wires 6 or may continue up to their end leaving only the end-points uncovered. The wires 6 coated or uncoated may extend beyond the free surface 8 of the matrix 7 or may be flush with said surface 8 or may be on one or on both sides of the matrix recessed, which means that they terminate before reaching the free surface 8 of the matrix 7. In case the wires do not reach the surface 8 the remaining path to said surface may be filled with the matrix or may form an open channel according to the needs of the application. The thickness of the electrical or electron image conductor 5 may vary from a fraction of one millimeter to any size needed. The matrix 7 and wires 6 may be light transparent or opaque. The image conductor 5 may be of planar shape, may be of convex shape, or of concave shape, or of any other shape according to the application used. The electron beam from the screen 2 is accelerated by the electrical fields 3 and is focused by focusing means 4 on the image conductor 5. In some cases it is necessary to decelerate the photoelectron beam before its entry into image conductor 5. The electrons which enter the wires 6 are conducted by them across the conductor from the compartment A to the compartment B of the vacuum tube 1. As the wires have a very small diameter the resolution of the image will remain high and will be limited only by the thickness of the wires. The electron beam emerging from the image conductor 5 is again accelerated to a high potential and is focused on the next image conductor 5. In this way a marked intensification of the electron image is achieved. This construction allows the use of much higher acceleration potentials without a field emission and corona discharge, as each compartment of the vacuum tube represents an independent unit so far as the voltage is concerned. In addition this novel construction prevents effectively the spread of caesium vapors to the parts of the tube which are connected to a high potential. The final intensified electron

image is focused on the electron image reactive screen 9 which may be of luminescent or electro-luminescent material or a scotophore such as KCl. It should be understood that the final electron image may be focused also on other types of screen such as a target of a television camera tube, a storage target of the storage tube, or on any other electron-reactive means. It should be also understood that the final photoelectron beam may be conducted outside of the vacuum tube by another electron image conductor 5 or its modifications described above, mounted in the endwall of said tube and may be projected on a luminescent screen or photographic or xerographic screen mounted in contact or in close proximity to the final endwall image conductor 5. It should be understood that all modification of the image conductor may be applied to all various means of image reproduction described. This invention will be especially useful for the image tubes of proximity focusing type as shown in FIGURE 1A. In this modification of my invention the vacuum tube 10 has no focusing fields. The electrical electron image conductor 5 is mounted in a close spacing with the image producing member 2. The spacing of a fraction of one millimeter and not exceeding a few millimeters is suitable for the purposes of this invention. The use of the electrical electron image conductor 5 allows the application of much higher accelerating potential 11 and produces therefore a much higher intensification of the electron image than it was possible with devices of the prior art.

Another important modification of my invention is shown in FIGURE 1B which illustrates the coupling of two or more novel vacuum tubes 13 and 14 by means of the electrical or electron image conductor 5. The coupling of the tubes 13 and 14 allows the transfer of the electron image from the tube 13 to the tube 14 without loss of energy and of resolution of the electron image. This invention allows also flexibility in processing of each of the vacuum tubes 13 and 14 because the vacuum tube 13 has now only photoelectric or electron emissive member 2, whereas the tube 14 has only the image reproducing member 9 and therefore there can be no chemical interaction between different materials used for each of said tubes.

In addition the tubes 13 and 14 may be either in contact with each other and fixed in this position or may be spaced apart from each other. If the tubes 13 and 14 are separated an electrical contact must be provided between the wires 6 of each tube. For this purpose I constructed device 15 which is shown in FIGURES 1C and 1D. The device 15 is interposed between the tubes 13 and 14 and is in contact with their endwalls to couple them together.

The tube 13 is therefore characterized by the endwall 5a being formed partly or completely by the image conductor 5 or its modifications. The tube 14 is characterized by the endwall 5b which is formed by the identical or similar image conductor 5. As the registry of image conductors 5 in endwalls 5a and 5b it is important for resolution of the images they should be preferably formed as slices derived from one and the same large image conductor. If the size of the endwalls 5a and 5b is the same, the electrical contact between both tubes 13 and 14 will be established by bringing said tubes in contact with each other. If the sizes of the endwalls 5a and 5b are different, it was found that the transfer of the electron image from the tube 13 to the tube 14 is best accomplished by the electrical or electron image conductor device 15 which may be made in a tapered form for magnification or for demagnification of the electron image, as shown in FIGURE 1F. The electrical or electron image conductor 15 of tapered shape will be interposed between two vacuum tubes in contact with their endwalls and will provide an efficient transfer of the electron image from one tube to another. The image conductor 15

may have construction of the image conductor 5 or of conductors 20 or 20a, described below.

The electrical or electron image conductor 5 may have another construction which is advantageous in some applications. In this modification of my invention, shown in FIGURE 1C, the image conductor 20 has the conducting channels formed not by metallic wires 6 as described above but by glass or plastic fibers 21 which are coated with a metallic electrically conducting coating 22 such as of chromium, tungsten or platinum. The fibers may be of a diameter of few microns or more. The coatings may be of any thickness according to the resolution desired. The coated fibers 21 are assembled together in a two-dimensional array and are fused by a glass or plastic insulating matrix 23. This image conductor should be made vacuum tight if it is to be used as an endwall of the vacuum tube. The coated fibers 21 may be also fused only at their end-faces which will make them flexible between their end-faces. This image conductor 20a is shown in FIGURE 1D. The insulating matrix 23 of glass or a plastic is used only at the ends of the image conductor 20a. The fibers 21 are of glass or a suitable plastic and have a metallic electrically conducting coating 22 such as of aluminum or platinum or chromium and in addition an insulating coating 26 of glass or plastic mounted on said metallic coating 22. Such conductor may be completely flexible and may be made of any length and diameter according to the needs of the application. In addition the novel electrical or electron image conductor 20 or 20a may be made of any shape necessary. It may be tapered having one end surface small and another one large which is necessary in some applications, see image conductors 15 shown in FIGURES 1F and 1F'.

FIGURE 1F shows the novel electrical or electron image conductor 15 which has a tapered form. The image conductor 15 comprises a two-dimensional array of conducting members 15a. Each of said members 15a has a core of insulating material such as glass or plastic 21 coated with an electrically conducting material 22 such as of aluminum, chromium, tungsten or platinum. On the conducting coating 22 there is deposited an insulating coating 26 such as of glass, plastic CaF_2 or MgO . The coating 26 prevents the conducting layers 22 from short-circuiting each other. All said members 15a are held in position by encasing them in a suitable matrix. If a flexible image conductor is wanted, the matrix 23 is used only at the end of conducting members 15a. If a rigid image conductor is wanted, the matrix 23 will extend substantially along the entire length of the image conductor.

Another modification of the tapered electrical or electron image conductor 15 is shown in FIGURE 1F'. In this embodiment of my invention the conducting members 15b have the core of a conducting material such as aluminum, chromium, tungsten or platinum. The conducting core 6d is coated with an insulating layer 26 such as of glass, or plastic or CaF_2 or MgO . The advantage of this image conductor 15A resides in its ability to conduct large amounts of electrons without a damage to it.

It should be understood that electrical or electron image conductor 15 or 15A both of rigid form and of the flexible form may be constructed also without use of a matrix interposed between the conducting members 15a or 15b. In such case the said conducting members are united together in one unit by fusing their outside coatings with each other. If a flexible image conductor is wanted, the fusion will take place only at the ends of the image conductor. If a rigid image conductor is needed, the fusion will extend along substantially along the entire length of the image conductor.

Another modification of the image conductor 5 or its modifications which is useful for magnification of images is shown in FIGURE 1L. In this construction each of wires 6 or their modifications of the conductor 5A terminates in an electrically conducting member 8a bonded to the end-points of wires 6i or their modifications which

form image conductor 5B. By selecting the size of conducting members 8a larger than the diameter of wires 6 of conductor 5A we may have any desired magnification of the electron image.

If demagnification of the electron image is needed, the construction shown in FIGURE 1M will be used. In this embodiment of the invention the conducting members 8b are bonded to the end-points of the wires 6 or their modifications of the conductor 5A. By selecting the size of conducting members 8b to be smaller than the diameter of the wires 6 of the conductor 5A or their modifications we will obtain demagnification of the electron image transmitted by the conductor 5A.

Another construction to improve the capability of the image conductor to carry large currents of electrons is to use a fiber-optic mosaic described below. Such mosaic has fibers of plastic or glass which are embedded in a matrix of a suitable material. The next step is to leach out the fibers of the mosaic with an agent which dissolves glass or plastic of the fibers but leaves the matrix intact. The fibers should be for example of a boric glass which can be leached by hydrochloric acid, whereas matrix may be of a flint glass or of fluorocarbons which are resistant to hydrochloric acid. The resulting channels after the leaching are now filled with a conducting material such as silver paste or a metal such as indium in a fluid form which will solidify and provide said continuous conducting members traversing the image conductor. Another modification of the construction of the electrical or electron image conductor is shown in FIGURE 1N. The image conductor 5E comprises a plurality of electrically conducting members 6f bonded in one unit. Each of conducting members 6f is formed by a hollow tube 56a of an insulating material such as glass or plastic. Each of said tubes 56a has its lumen filled with a conducting material such as silver paste or indium or other metal in a liquid form. When the conducting metal solidifies it forms an electrically conducting member 56b which is surrounded by insulating walls 56c. The tubes 56a should be of a very fine diameter as each of them will carry one image point. Such hollow tubes can be made as thin as 10 microns in diameter. A great number of tubes 56a is stacked up together and aligned to form a two-dimensional array. There are many methods of aligning the tubes 56a in their proper spatial relationship. One of them, using vibration of the container filled with conducting members was described above. After the tubes 56a are aligned they are fixed in their position by using a suitable binder, such as was described above. In some cases it is preferable to fuse the tubes 56a together by heating them to the temperature at which their walls 56c will fuse with each other without the use of an interposed matrix. In other cases it is preferable to embed the tubes 56a in a suitable matrix such as glass or plastic of a lower melting point than the metallic conductor 56b and then heat to the temperature at which the matrix will fuse with the walls 56c of tubes.

If the electrical or electron image conductor 5E is to be used as an endwall of the vacuum tube, it must be vacuum tight. In some cases in order to improve vacuum tightness it is advisable to fuse a layer of conducting or insulating material such as glass or plastic or MgO or CaF_2 on one or both endfaces of the image conductor 5E. It should be understood that the construction of the image conductor using hollow tubes may be applied also to make the flexible image conductor 15.

A preferred method of construction of electrically conducting members 6 is to draw very fine wires of metal such as Al or Cu or tantalum. It was found that Al and Cu are the best metals for heat dissipation and that aluminum oxide is the best of insulators for heat dissipation which is a very important factor for operation of my image conductor 5 and its modifications. The thin wire is next oxidized by forming a dielectric oxide of said metal on the outer surface of the wire to produce

a dielectric coating 22a surrounding said wire. In case of aluminum, the exposure to atmosphere is sufficient to form aluminum oxide which is an excellent insulator. In some cases it is preferable to accomplish it by anodic oxidation. Next the oxidized wire is cut into pieces of the size necessary for the image conductor 5 and its modifications such as conductors 20 or 20a and others or for conductor 15. Next the sliced segments 6d of the oxidized wire are transferred into a container which is of an elongated shape and has the height greater than width. The container must be of a material which is able to withstand high temperatures such as a ceramic. The number of segments 6d placed in the container and their diameter depends on the resolution of images necessary for the device in which they will be used, as each segment will carry one image point. The shape of segments 6d may be circular or may be quadrangular or hexagonal. It should be understood that segments of all shapes come within the scope of my invention. The next step is of great importance. The wire segments 6d in the receptacle form now an irregular array. For a good resolution of images it is required that wires 6d should be disposed uniformly. Furthermore it is necessary that the end-points of the wires 6d should have the same spatial relationship to each other at each end face of the image conductor 5, 15 or their modifications. I found that this can be accomplished by subjecting the container to a vibration which causes the wires 6d to align themselves in uniform relationship to each other. After the alignment of wire segments 6d is accomplished, the next step is to fuse all said wires in this proper spatial arrangement. This is accomplished by heating the container to the temperature at which the coatings 22a of the wires 6d will fuse together without the use of interposed matrix and form a vacuum tight unit. The final construction of the electrical or electron image conductor 5d is shown in FIGURE 1H. In some cases the wires 6d may be preferably bonded by matrix 7a of a plastic such as silicone type of resins or by "Ardalit" manufactured by Ciba Company or Adhesives 4684 or 4695 manufactured by E. I. du Pont de Nemours & Co. of Wilmington, Del. The image conductor 5e of this construction is shown in FIGURE 1J. In some cases it is preferable to use as a binding matrix a material such as low-melting glass or ceramics instead of silicones.

In another modification of construction each wire 6d is coated with a glass coating 22b instead of oxidizing the same. The glass should preferably have melting temperature below the melting temperature of the wire 6d to avoid deformation of said wires during the fusion. The glass coated wires 6e are aligned together as was explained above. Next they are heated to a temperature at which the glass coatings 22b will fuse together without the use of interposed matrix and form one image conductor 5f. This construction is shown in FIGURE 1K. In some cases it is preferable to use in addition a binder or matrix to facilitate the fusing process.

The image conductor 5 and its modifications must be vacuum tight type if they are used in endwalls of vacuum tubes. The fusing of wires 6d or 6e usually forms an unit which is vacuum tight. In some cases further improvement of the vacuum tightness is necessary. This is accomplished by fusing on one or both endfaces of the image conductor 5, a thin insulating layer 22c of dielectric material such as Al_2O_3 , CaF_2 , MgO or glass. The layer 22c is fused to the surface of the endface of the image conductor 5 or its modifications as it is shown in FIGURE 1H.

All described electrical or electron image conductors may be made transparent to light or to infra-red or to ultra-violet by using materials transparent to said radiations for the insulating matrix and for wires 6 or modifications or fibers 21. In such case the conducting coatings 22 may be made of an electrically conducting tin

oxide, silver or titanium oxide which are transparent to invisible radiations.

It was found that the wires of the image conductor 5 or of all its modifications such as conductors 20, 20a or others being thin as necessary for the resolution of the image, could not transfer large amounts of electron currents without damage. It was found that one solution of this problem was the use of metals for the wires 6 which have a high melting point such as tungsten, molybdenum or platinum. It was also found that the insulating matrix of the image conductor should have heat dissipating properties. In addition it was found that the use of cooling means preferably of thermoelectric type improved markedly the performance of the image conductor 5. It should be added that heat dissipation of the image conductor 5 or its modifications may be improved by painting the image conductor with a black material. If a flexible conductor is used a small amount of silicone between the wires 6 or their modifications such as fibers 21-22 will greatly improve heat dissipation.

I found also that the above described devices presented a serious complication by the occurrence of a space charge in front of the image conductor 5 or its modifications. The electrons striking the image conductor are led away by the conducting wires 6 or 22. However a part of the electron beams strikes the dielectric parts of the image conductor which are present between the conducting wires. The impact of fast electrons produces secondary electron emission smaller than unity. As a result a negative charge builds up on these dielectric parts. A negative charge has a detrimental effect on the incoming electron beam, and impairs resolution of the image. Additional complications arise from the presence of secondary electrons emitted from the dielectric parts of the image conductor. I found that all these complications could be eliminated by depositing electrically conducting means 35 which may be in the form of a continuous or perforated layer or of a conducting mesh screen on the surface of the image conductor which receives the electron beam. This construction was found to perform well only if the electrically conducting wires 6 or 22 were built to be recessed from the surface of the image conductor. In this way the conducting means 35 are prevented from making a contact with electron image conducting wires 6 or 22 and cannot shortcircuit them. The member 35 is connected to a source of a suitable electrical potential and neutralizes the negative space charge and the secondary electrons. The thickness of the electrically conducting means 35 if they are in the form of a continuous layer has to be controlled critically. It was found that the layer of 0.1 micron thickness will reduce the velocity of the electron beam by 3-4 kv. It is preferable therefore to make the layer 35 thinner than 0.1 micron and one of metals such as tungsten, gold, platinum or aluminum. In case a light transparent layer 35 is needed, we may use tin oxide for visible light, silicon or germanium for infra-red light, and silver for ultra-violet light. The recessed form of the electrically conducting wires 6 or 22 may be obtained by depositing an additional very thin insulating layer 39 on the free surface 8 of the image conductors described above, as shown in FIGURE 1E. The image conductor 38 may be of any construction described herein but in addition it is provided with an insulating layer 39. The thickness of the insulating layer 39 must be critically controlled as it has to be thin enough to permit the exit of electrons without any large loss of energy. Layer 39 may also serve to improve vacuum tightness of the tube.

Another modification of the electrical or electron image conductor of recessed form may be obtained by etching the endfaces of the conducting wires 6 or 22 with a suitable leaching agent which dissolves the wires but leaves the insulating matrix intact. By leaching for a predetermined time we may obtain open channels of a necessary depth extending between the endpoints of wires and

the surface of matrix. In this construction the insulating layer 39 may be eliminated, which improves sensitivity of my device.

Another construction for the prevention of the space charge is the use of means to be deceleration of the electron beam in front of the image conductor 5 or its modifications. In such case however a stronger acceleration potential is preferably applied to the electrically conducting layer or mesh screen 35 mounted on the side of image conductor where the electrons emerge. In this construction the electrically conducting wires 6 or 22 must also be recessed from the surface of the image conductor coated with the conducting layer 35. The deceleration of electron beam in front of the image conductor 5 may be obtained by the use of a ring electrode or by a mesh screen connected to a suitable source of potential.

It should be understood that the construction using recessed electrically conducting means 6 or 22 and space charge preventing means 35 may be applied to all modifications of my invention.

Another construction for elimination of the space charge and secondary electrons is to make the electrical or electron image conductor 5 or all its modifications only a part of the end-wall of the vacuum tube. The parts of the end-wall adjacent to the image conductor are made of an electrically conducting material such as a metal or of a glass coated with electrically conducting layer such as tin oxide. The electrically conducting parts of the tube envelope are connected to a suitable source of electrical potential or to the ground and lead away the accumulated charges or electrons. This construction is similar, but less efficient than the systems described above.

Another important modification on my invention is shown in FIGURE 2. The vacuum tube 40 is provided with the electron image conductors 5 on the input side A and on the output side B. The image conductors may be of any type described in this specification. The tube 40 can receive an electron image from any image producing source connected to the conductor in A and transfer it without the loss of resolution to another vacuum tube or to any other non-vacuum image reproducing member such as photographic, xerographic, or luminescent means mounted in contact or in close spacing to the vacuum tube 40. The electron image on its travel through the tube 40 is focused by electrostatic or magnetic fields 41.

In addition it may be intensified by accelerating fields 42. It should be understood that the tube 40 may also operate by proximity focusing in which case the image conductors 5a and 5b have to be brought into a close spacing to each other.

It should be also understood that vacuum tubes may have the image conductor 5 or its modifications only on their input side or only on their output side. This is shown in FIGURE 1B, see vacuum tubes 13 and 14. They are shown in a coupled combination but each of them can be used separately in many applications. As was explained above, the image forming member 13a in the tube 13 may be a photoelectric photocathode or an electron gun with a specimen stage, such as used in electron microscopes. The image receiving member 14a may be as was explained above mounted in the vacuum tube 14 inside or outside of it and may be in the form of a luminescent member, an image storage target, or a cathode of a television camera tube.

In some cases it is advantageous to use a vacuum tube 40a which is shown in FIGURE 2A. The tube 40a has one end-wall provided with the image conductor 5 or its modifications and another end-wall of fiber-optic mosaic 40b which is constructed of an array of fibers transparent to light of a glass or a plastic of a high index of refraction which are embedded in a matrix of a light transparent material such as glass of a lower index of refraction than the fibers. The fiber-optic mosaic 40b may

consist of multiple fibers of material having a high refractive index such as quartz, rutile or special plastics. Especially Lucite is suitable for this purpose because it causes smaller losses of conducted light than other materials. Lucite and other above-mentioned materials characterized by a high refractive index have the property of internal reflection of the light conducted by them. Such material cannot conduct a whole image as such but they can conduct well a light signal, which means an image point. The size of the image point I found is determined by the diameter of a single conducting fiber. I assembled a bundle of such fibers which form a mosaic-like end-faces and which, therefore, can conduct plurality of image points. All these image points will reproduce at the other end-face of the electrical or electron image conductor the original image, provided that the ends of image conducting fibers remain in their original spatial relationship. Each fiber should have, as was described above, a diameter corresponding to the size of one image point. The light conducting fibers should be polished on their external surface very exactly. Each of them must also be coated with a very thin light opaque layer to prevent spreading of light from one fiber to another. I found that without said light impervious coating, the image will be destroyed by leakage of light from one tube to another. The light opaqued layer should have a lower index of refraction than the light conducting fiber itself. Such a coating may have a thickness of only a few microns. It may be added that smaller loss of light may be obtained if the fibers are hollow inside instead of being solid. Such mosaics can transmit the image with a good resolution. A photoemissive or photoconductive screen 40c, which may be the same as described in screen 2 is mounted on the inside surface of the fiber-optic mosaic 40b. The emitted photoelectron beam from the screen 40c is focused by the focusing means 41a and is accelerated by accelerating means 42.

In some cases a light transparent protecting layer 40e such as of MgO or CaF₂ is interposed between the fiber-optic wall 40b and photoemissive or photoconductive layer 40c.

Another modification of this invention is shown in FIGURE 2B. In this embodiment the vacuum tube 40d has endwall formed by a fiber-optic mosaic 40b which is coated on its inside or outside surface with luminescent means 44a. The other endwall of the tube 40d is formed by the image conductor 5 or its modifications.

FIGURE 3 shows another modification of my invention. The vacuum tube 42 contains an input member 13a for producing a broad electron image and a composite sandwich screen 43. The composite sandwich comprises in combination a novel image conductor 5 or any of its modifications and an electron transparent light reflecting layer 43a such as of aluminum, luminescent means 43b, light transparent separating means 43d such as of glass, a suitable plastic such as silicone or polyester or of a fiber-optic mosaic and photoemissive means 43c of one of materials described for the screen 2. The construction of the composite screen 43 is better than of similar screens in the prior art because the composite screen 43 does not require any more supporting member having the image conductor 5 for its support. The light transparent separating means 43d may therefore be made very thin as they are not needed any more for the support of the screen 43 and serve only to prevent chemical interaction between layers 43b and 43c. As a result the resolution of the image produced by the screen 43 is greatly improved over the prior art. The image produced by the member 13a is intensified by the sandwich screen 43 and the intensified photoelectron beam emitted by the screen 43 and is focused on the electron image reactive member 14a mounted inside of the vacuum tube 42 or outside of the vacuum tube 42.

FIGURE 3A shows a modification of the image intensifier illustrated in FIGURE 3. The intensifier 44a com-

prises two or more vacuum tubes 44 and 45. The vacuum tube 44 has an endwall comprising the image conductor 5 or any of its modifications. A luminescent screen 47 is mounted on the outside surface of the image conductor. A vacuum tube 45 is brought into contact with the luminescent screen 47. The vacuum tube 45 has a fiber-optic mosaic endwall 46 which transmits the image from the luminescent screen 47 to the photoemissive screen 2 mounted on the inside surface of the endwall of the tube 45. The rest of the construction of the tube 45 may be the same as was described for the tube 14 and for all its modifications. In some cases the luminescent screen 47 may be mounted on the outside surface of the endwall 46 of the tube 45 instead of being mounted on the tube 44.

Another modification of the image intensifier is shown in FIGURE 3B. In this modification of my invention the image intensifier 48 comprises two or more vacuum tubes 49 and 50. The tube 49 has the construction of the tube 13 or its modifications. The tube 50 has the construction of the vacuum tube 14 or its modifications and is provided with the endwall comprising a sandwich screen 43. The tubes 49 and 50 may be mounted in apposition to each other or may be coupled by means of the image conductor 15. The composite screen 43 may be also mounted in a spaced relationship to the endwall of the tube 50 and to image conductor 5. In such case the endwall of the tube 50 comprises the image conductor 5 and the electron image is transmitted by the image conductor 5 to the composite screen 43, being focused by electrostatic or magnetic fields or by a proximity focusing.

Another modification of the image intensifier is shown in FIGURE 3C. In this embodiment of the invention the image intensifier 52 comprises two or more vacuum tubes 53 and 54. The tube 53 has the same construction as the tube 13 or its modification and is provided in addition with a composite screen 43.

The tube 54 has the same construction as the tube 14 or its modifications and is also provided with the intensifying screen 43. Both tubes 53 and 54 are coupled together by a contact or by means of the image conductor 15. This combination produces a marked intensification of the electron image. It should be understood that instead of two tubes 53 and 54 it is possible to use one tube 55 as shown in FIGURE 3D.

All image intensifiers described may be used for X-ray or neutron images as well by using in them an X-ray or neutron reactive screen as shown in FIGURE 3E. The X-ray or neutron image intensifier 58 has one or more composite screens 59. The composite screen 59 comprises an X-ray or neutron transparent, light reflecting layer 59d, a luminescent layer 59f, a light transparent separating means 59e which form endwall of tube and may have the same construction as the fiber-optic transparent means 40b or 46 described above and a photoemissive layer 59c which may be of one of materials used for the screen 2. The X-ray or neutron image is converted by the composite screen 59 into a photoelectron image. It should be understood that instead of the composite screen 59 other X-ray reactive screens 59a such as of electron emitting material like gold or lead may be used according to the needs and are mounted in contact with electron image conductor 5 or its modifications, as shown in FIGURE 3F.

For neutron images we may use the composite screen 59 in which the luminescent means are enriched with neutron reactive elements such as boron or we may use instead of screen 59 or in combination with screen 59 a screen of gadolinium, cadmium or copper.

The photoelectron image corresponding to the original X-ray or neutron image is conducted by the image conductor 5 or its modification to the luminescent or xerographic or photographic means mounted outside of the vacuum tube 58. The great advantage of this construction resides in the ability of my device to form a photographic or cinematographic image without the use of the optical

system by bringing it into a contact with the luminescent means or by substituting the luminescent means with photographic means. In the devices of the prior art the luminescent image had to be focused on the photographic film by means of an optical system which causes a great loss of sensitivity and necessitates the use of a large amount of X-ray energy which is not beneficial to the patients.

Another embodiment of the X-ray or neutron image intensifier comprises a vacuum tube 58 in combination with a vacuum tube 40a which was shown in FIGURE 2A. These two tubes are coupled together as was described above by mechanical means or by the image conductor 15. In this way the fluorescent image produced in screen 60 is transferred to the next intensifier tube for further intensification.

In another modification of the X-ray or neutron image intensifier the vacuum tube 58 is used without the luminescent screen 60. The electron image produced by the tube 58 and having the pattern of the original X-ray or neutron image is transmitted by the image conductor 5 from the tube 58 to the vacuum tube 40c which was shown in FIGURE 2B, or to the tube 40 for further intensification.

Another modification of my invention is shown in FIGURE 4. In this embodiment the vacuum tube 62 comprises novel intensifying screens 63 which operate by secondary electron emission. The screen 63 comprises the image conductor 5 or its modifications, an electrically conducting layer 64 which is transmitting for the electrons used and which may be of continuous type, of perforated type, or of mesh screen type. In addition the screen 63 comprises a secondary electron emissive layer 65 such as of MgO or of KCl. The electron image striking the screen 63 is transmitted by the conductor 5 to the layer 65 and causes secondary electron emission therefrom resulting in the intensification of the electron beam. This construction permits a rugged and efficient structure which was not possible in the prior art.

It should be understood that instead of secondary electron emissive layer 65 of a dielectric type, a layer of conducting electron emitting materials such as Ni, Be or Cu may be used as well. In such case the layer 64 may be eliminated. This construction will permit the use of low voltages instead of high voltages necessary for the operation of the screen 63 described above.

It should be also understood that the screen 63 or the secondary electron emission layer 65 may be mounted in a separate vacuum tube and may receive the electron beam by means of the image conductor 5 or its modifications forming the endwall of the tube 62.

In another modification of my invention shown in FIGURE 4A the intensifying screen 63 comprises a conducting layer 64 and a secondary electron emissive layer 65 both mounted on the inside surface of the image conductor 5 or its modifications. Another intensifying screen 63 comprising conducting layer 64 and secondary electron emissive layer 65 is mounted in the same intensifier tube or in the second vacuum tube coupled with the first one, for a cascade intensification of the image.

Another modification of the image intensifier is shown in FIGURE 5. The intensifier 70 comprises a novel intensifying screen 71 having an insulating layer 72 mounted on the image conductor 5 or its modifications. In a close proximity to the insulating layer 72 is mounted a conducting mesh screen 73 on which is deposited a continuous or perforated or mosaic photoemissive layer 74. In some cases an electrically conducting layer 75 of continuous type or perforated type or in the form of a mesh screen and which is transmitting for the electrons conducted by the image conductor 5 or its modifications is mounted between the insulating layer 72 and the image conductor 5. The electron image transmitted by the conductor 5 produces a charge image in the insulating layer 72 by secondary electron emission. The charge image modulates the emission of photoelectrons from the layer

74 which is irradiated by a uniform source of light 76a preferably of infra-red type. The modulated emission of photoelectrons produces an intensified photoelectron beam having the pattern of the original electron image transmitted by the image conductor 5.

In another modification of my invention shown in FIGURE 5A the image intensifier 70a comprises two vacuum tubes 75a and 76. The tube 75a serves to produce an electron beam carrying the image and to transfer this image to the tube 76 by means of the image conductor 5 or its modifications. The tube 76 comprises a composite screen 77 mounted on its electrical or electron image conductor 5 or its modifications. The composite screen 77 comprises luminescent means 78, light transparent insulating means 79, and a photoemissive mosaic layer 80. The electron image from the tube 75a produces a luminescent image in the tube 76 which is converted in the mosaic layer 80 into a charge image having the pattern of the original electron image. The charge image may be converted into video signals by means of a scanning electron beam of a slow or of a fast type. The charge image on the layer 80 may also serve to modulate a broad electron beam of decelerated type.

Another modification of my invention is shown in FIGURE 5B. The image intensifier 82 comprises a vacuum tube 83 which is provided with means to produce an electron beam carrying the image and to transfer said electron image by means of the image conductor 5 or its modifications to the tube 84. The tube 84 has a wall formed by the image conductor 5 or its modifications. On the image conductor 5 is mounted a thin conducting layer 85 transmitting to electrons transferred by the conductors 5 and a layer of material exhibiting electron bombardment induced conductivity such as of ZnS, Sb₂S₃, or MgO. The electrons striking layer 86 produce a pattern of conductivity changes therein. This pattern may be converted into video signals by a scanning electron beam irradiating the opposite surface of the layer 86.

Another modification of my invention is shown in FIGURE 5C. The image intensifier 88 comprises two vacuum tubes 89 and 90. The vacuum tube 89 has the same construction as the tube 83 described above. The vacuum tube 90 has the wall formed by the image conductor 5 or its modifications. On the image conductor 5 there are mounted luminescent means 91, electrically conducting and light transparent means 92, and photoconductive means 93 such as of CdS, ZnSe, Sb₂S₃ or PbO or a mixture thereof. The electron image transmitted from the tube 89 by image conductor 5 strikes the luminescent means 91 and produces a luminescent image. The luminescent image is converted by photoconductive means 93 into a pattern of conductivity changes corresponding to the original electron image. This pattern of conductivity changes may serve to produce video signals by irradiation with a scanning electron beam of a slow or of a fast type. It may also serve to modulate a broad non-scanning electron beam preferably of a decelerated type.

Another modification of my invention is shown in FIGURE 5D. The image intensifier 95 comprises two or more vacuum tubes 96 and 97. The vacuum tube 96 is provided with means for producing an electron beam carrying the original image. The electron image is transmitted by the image conductor 5 or its modifications to the luminescent means 94 mounted outside of the tube 96 either on the external surface of the endwall of the tube 96 or on the external surface of the endwall of the tube 97. The vacuum tube 97 has endwall formed by a fiber-optic mosaic 97a. On the inside surface of the fiber-optic endwall there is mounted a light transparent conducting layer 98 and a photoconductive layer 99. Both tubes 96 and 97 are brought into a contact and registry with each other. In some cases the image conductor 15 may be interposed between the tubes 96 and 97 to make possible their separation.

It should be understood that the devices shown in FIGURES 5A, 5B, 5C and 5D may be constructed in one

vacuum tube envelope instead of using two vacuum tubes coupled together. It should be also understood that the devices shown in FIGURES 5, 5A, 5B, 5C and 5D may be constructed as television pick-up tubes by providing them with means for producing a scanning electron beam of a fast or a slow type to read off the charges produced by the electrons transmitted by the image conductors. The construction of television pick-up tubes is well known in the art. It is believed therefore that their description may be omitted.

The devices shown in FIGURES 5, 5A, 5B, 5C and 5D may be also constructed as image tubes by providing them with an electron reactive image reproducing means mounted inside or outside of the end wall of the vacuum tube. In some cases a broad non-scanning electron beam may be used to read off the charges produced by the electrons transmitted by image conductors and to reproduce a visible image on an electron reactive screen.

It should be also understood that the devices shown in FIGURES 5, 5A, 5B, 5C and 5D may be also constructed as storage tubes by providing them with means for a non-destructive read-out using an electron beam or by incorporating in said tubes a storage target or perforated type or using as a storage target an imperforated photoconductive layer or an insulating layer.

It should be also understood that in all embodiments of my invention the source of electrons may be a photoelectric screen, or a source of thermoelectrons such as an electron gun or a cold emission emitter of electrons.

Another modification of my invention is shown in FIGURE 6. The vacuum tube 100 comprises a source of electrons to produce a beam of electrons such as an electron gun or a photoemissive member or a cold source of electron emission 101. In addition tube 100 comprises deflecting means 102 which may be in the form of plates or of coatings on the wall of the tube to produce a scanning motion of the electron beam from the source 101. These elements are well known in the art. It is believed therefore that their detailed description is not necessary. The image conductor 5 or any of its modifications divides the tube 100 into two separate compartments A and B. The scanning electron beam is transmitted by the image conductor 5 or any of its modifications from compartment A to compartment B. After the electron beam enters the compartment B it is accelerated by the fields 103 which may be in the form of cylinders, rings, or coatings on the inside walls and which focus said electron beam on the electron receiving means which may be in the form of luminescent screen 104 or may be a target of the storage tube or of a television pick-up tube. The advantage of my invention resides in the fact that simple and efficient means are provided to accomplish a post-deflection acceleration for the scanning electron beam which is very important in some applications.

A modification of this device is shown in FIGURE 7. The same purposes of the invention are obtained by using two vacuum tubes 105 and 106 coupled together by image conductor 5 or its modifications. The tube 105 is provided with a source of electrons 101 to produce an electron beam. The electron beam is deflected by deflecting means 102 and is focused on the image conductor 5 which forms the endwall of the tube 105. The scanning electron beam after the passage through the image conductor 5 enters the tube 106. The tube 106 is provided with strong electron accelerating means 103 such as cylinders, rings, or coatings on the inside walls of the tube. The accelerated electron beam is next focused on electron receiving means 104 such as luminescent means mounted inside or outside of the tube 106. It should be understood that this invention is not limited to any specific electron receiving means, as the electron beam may be focused on the storage target or on a photoelectric screen or on any other electron reactive member. It should be also understood that the electron beam may be further transmitted

outside of the vacuum tube 106 by providing its other end-wall with image conductor 5 or its modifications.

This invention will be especially valuable for the color television receivers, as shown in FIGURE 8. In this embodiment of my invention the vacuum tube 110 comprises a source of electron beams 111 which may be in the form of a single electron gun or three guns combination which is well known in the television art. The electron beam is deflected by the deflecting means 102 and is focused on the apertured shadow mask 112 which is well known in the color television art. The electron beams transmitted by the mask 112 are focused on the image conductor 5 or its modifications. The image conductor 5 divides the tube 110 into two compartments A and B. The electron beam is transmitted by the image conductor 5 from the compartment A to compartment B. In the compartment B it is accelerated by accelerating means 103 and is focused by focusing means 114 on the color image reproducing screen 113. In this way an efficient post-deflection acceleration is achieved which was the purpose of this invention. It should be understood that the compartment B may be many times larger in diameter than the compartment A whereby a larger image may be produced. In such case the focusing means 114 are of magnifying type. It should be also understood that the accelerated electron beam may be transmitted outside of the compartment B. In such case the image reproducing screen 113 is replaced by the image conductor 5 or its modifications which will form the endwall of the compartment B.

Another modification of this invention is shown in FIGURE 8A. The color television receiver 115 comprises two vacuum tubes 116 and 117. The vacuum tube 116 has a source of electrons 101 or 111, deflecting means 102 and an aperture shadow mask 112, as they were described in FIGURE 8. The electron beam after the passage through the mask 112 is transmitted by the image conductor 5 or its modifications which forms the endwall of the tube 116 to the vacuum tube 117. The vacuum tube 117 is provided with the endwall formed by the image conductor 5 or its modifications. The electron beam enters the vacuum tube 117 through the conductor 5 or its modifications and is accelerated by the fields 114. The accelerated electron beam is focused by the focusing means 118 which are of magnifying type on the large image reproducing screen 113. In this way the color television image may be obtained in an enlarged and intensified form which was the purpose of this invention.

Another advantage of my invention is that the vacuum tube 116 may be provided with the image reproducing screen 113 mounted on the outside surface of the image conductor 5. In this way the tube 116 may serve as an independent color television receiver without the intensifier tube 117. When intensification or enlargement of the color television image is wanted, the intensifier tube 117 is coupled to the tube 116 either by a mechanical contact of both tubes or by connecting them by means of the image conductor 5 interposed between them. It should be understood that the devices described above for color television images may be used as well for black and white television images or for radar images.

It should be understood that the novel color television receiver does not have to be of "shadow mask" type. My invention applies as well to the color kinescopes which do not use any apertured mesh screens. My invention applies to all color television receivers regardless of whether they have color screens formed by a pattern of three phosphor dots or of three strips of phosphors or of three superimposed phosphor layers of three superimposed phosphor screens.

It should be also understood that the definition "luminescent means" used throughout this specification embraces electroluminescent means as well.

Another modification of my black and white or color television receiver is shown in FIGURE 8B. The receiver 133 comprises vacuum tubes 119 and 120. The vacuum

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tube 119 has the construction of the tube 116 described above. In addition it is provided with a color image reproducing screen 132 which may be of luminescent materials and which is mounted on the external surface of the image conductor 5 or its modifications. The electron image is transmitted by the electron conductor 5 to the luminescent screen 132. The luminescent image from the screen 132 is transmitted into vacuum tube 120 by means of the fiberoptic mosaic 134 which was described above and which forms the endwall of said tube. The rest of the construction of the tube 120 is the same as was described above and illustrated in FIGURE 8A. In this way an enlarged and intensified image may be reproduced on the final viewing screen 113. It should be understood that the luminescent screen 132 may be of one color type or may be of a multicolor type. The luminescent means 132 may be also mounted on the external surface of the fiberoptic mosaic endwall 134 instead of on image conductor 5. The tubes 119 and 120 may be in a close contact to each other or may be separated by means of the image conductor 15 or its modifications.

It was found that the wires of the image conductor 5 or of its modifications being thin, as it is necessary for the resolution of the images, could not transfer large electron currents without a damage. It was found that the solution of this problem was the use of metals for the wires 6 which have a high melting point such as tungsten, molybdenum or platinum. It was also found that the insulating matrix of the image conductor should have heat dissipating properties.

In addition it was found that the use of cooling means applied to the image conductor 5, preferably of thermoelectric type, improved markedly the performance of the image conductor 5.

I found that the above described television receiver devices presented a serious complication by the occurrence of a space charge in front of the image conductor 5 or its modifications as was described above. The construction of electrical image conductors and of endwall for prevention of space charge effects was described in detail above and it should be understood that this description applies also to the television receiver devices.

Another way to remove the space charge and secondary electrons is to make the endwall of the vacuum tube in which the image conductor 5 or its modifications is mounted, of a conducting material such as tin oxide or a metal. The metallic endwall may be held at the potential which will draw the secondary electrons and will eliminate them.

Another embodiment of my invention is shown in FIGURE 9. I have found that the efficiency of the photoemissive layer such as described for screen 2 can be improved by injection into said layer of electrons of a predetermined velocity. The problems is that the injected electrons have to penetrate into photoemissive layer which is extremely thin but should not emerge out of said layer. The solution of this problem is shown in vacuum tube 126. The vacuum tube 126 has a source of electrons 101. The electron beam emitted from source 101 irradiates the photoemissive member 127 which may be in the form of a continuous layer or a mosaic layer through the image conductor 5A. The image conductor 5A may be of the same construction described for the conductor 5 and its modifications but in addition it is provided with very thin conducting layers 122 and 123 mounted on its both sides. The layer 122 and layer 123 are connected to a suitable source of DC potential 131. The layers 122 and 123 serve to provide a suitable electrical potential to the image conductor 5C in order to decelerate injected electrons to the velocity at which their effect on the photoemissive layer 127 is the best. The voltages used depend on the thickness of the layers 122 and 123 as well as on the thickness of the image conductor 5A and on the original velocity of the electrons used. In case the light image will be projected on the photoemissive member

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127 in the normal direction, the image conductor 5A and its conducting members must be transparent to radiation use. In some cases it is sufficient to use only layer 122 and to omit layer 123. The image may be also projected obliquely, as it is shown in FIGURE 9, in which the arrow 132 represents an image and the circle 133 represents an optical system.

I also found that regulated injection of the electrons improves the function of the photoconductive layer both as to its sensitivity and its lag. This embodiment of the invention is shown in FIGURE 9A. The vacuum tube 125 is provided with a source of electrons 101 and with image conductor 5A which was described above. The electrical or electron image conductor 5A has light transparent conducting layers 127 and 128 one or both of which are connected to the source of DC potential 131. The photoconductive layer 129 is mounted on the layer 128. The velocity of injected electrons is regulated empirically until the best results are obtained. The light image projected on the tube and optical system are again identified by an arrow 132 and a circle 133.

It should be understood that all vacuum tubes described may be of electrostatic or magnetic type or of combination thereof.

It is also understood that the shape of all image conductors may be planar, convex or concave, according to the application in which they are used.

All the particular embodiments and forms of this invention have been illustrated and it is understood that modifications may be made by those skilled in the art, without departing from the full scope and spirit of the foregoing disclosure.

I claim:

1. A device comprising in combination separate means for producing an electrical image formed by a plurality of different from each other electrical currents, and a separate vacuum tube having an endwall for receiving said electrical currents image, said endwall comprising an array of electrically conducting means extending substantially through the thickness of said endwall, said conducting means comprising a plurality of hollow electrical conductors filled with an electrically conducting material and having one end thereof outside of said tube and another end thereof within said tube, said conductors being mounted at each of said ends in a fixed spatial relationship to each other, said conducting means furthermore receiving and transporting said electrical currents from the outside of said tube, and electrical currents exiting from said conductors as free electrons into the vacuum space of said tube, means for accelerating said exited electrons, and introducing said currents within said tube, said vacuum tube comprising in addition means for utilizing said exited electrons in said device furthermore said electrical image producing means being mounted outside of said vacuum tube.

2. A device as defined in claim 1, in which each of said electrical conductors within said endwall is provided with its own coating of an electrically insulating material.

3. A device comprising in combination separate means for producing an electrical image formed by a plurality of different from each other electrical currents, and a separate vacuum tube having an endwall for receiving said electrical currents image, said endwall comprising an array of electrically conducting means extending substantially through the thickness of said endwall, said conducting means comprising a plurality of electrical conductors having one end thereof outside of said tube and another end thereof within said tube, said conductors being mounted at each of said ends in a fixed spatial relationship to each other, said conducting means furthermore receiving and transporting said electrical currents from the outside of said tube and introducing said currents within said tube, said electrical currents exiting from said conductors as free electrons into the vacuum space of said tube, means for accelerating said exited electrons and means

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for receiving said exited electrons, in said device furthermore said electrical currents image producing means being mounted outside of said vacuum tube.

4. A device as defined in claim 3 in which said electrical conductors in said endwall are provided with own individual coating means of an electrically insulating material.

5. A device as defined in claim 3, in which said electrical conductors have their ends within said tube uncovered.

6. A device as defined in claim 3, in which the diameters of ends of said conductors within said tube have different size than the diameter of said conductors outside of said tube.

7. A device as defined in claim 3 in which said means producing said electrical currents image are spaced apart from said tube.

8. A device as defined in claim 3 in which said means producing said electrical currents image are mounted in a separate vacuum tube.

9. A device as defined in claim 3 in which said means producing said electrical currents image comprise photoelectric means.

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10. A device as defined in claim 3 in which said means producing said electrical currents image comprises means responsive to X-rays.

11. A device as defined in claim 3 which comprises means converting said exited electrons into an image in said vacuum tube.

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