

Sept. 27, 1966

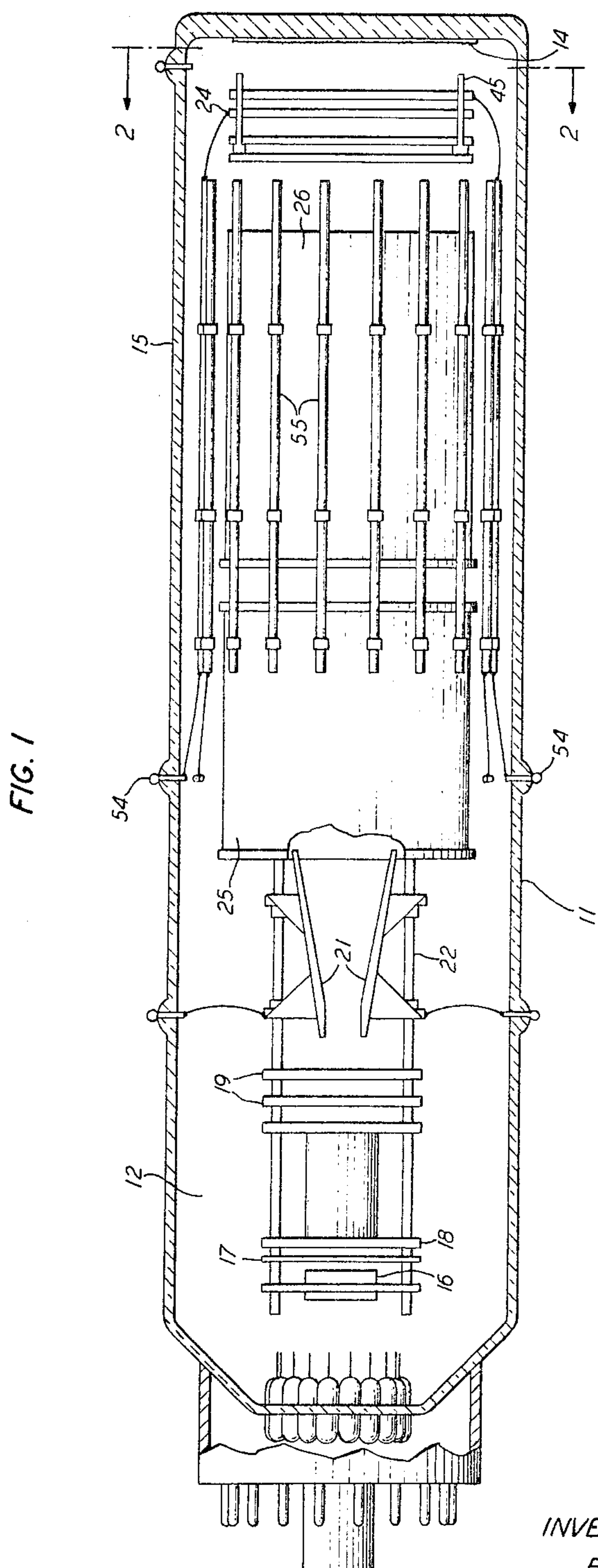
R. P. HYNES ET AL.

3,275,881

ELECTRON BEAM MODULATING DEVICE

Filed Dec. 18, 1962

5 Sheets-Sheet 1



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FIG. 2

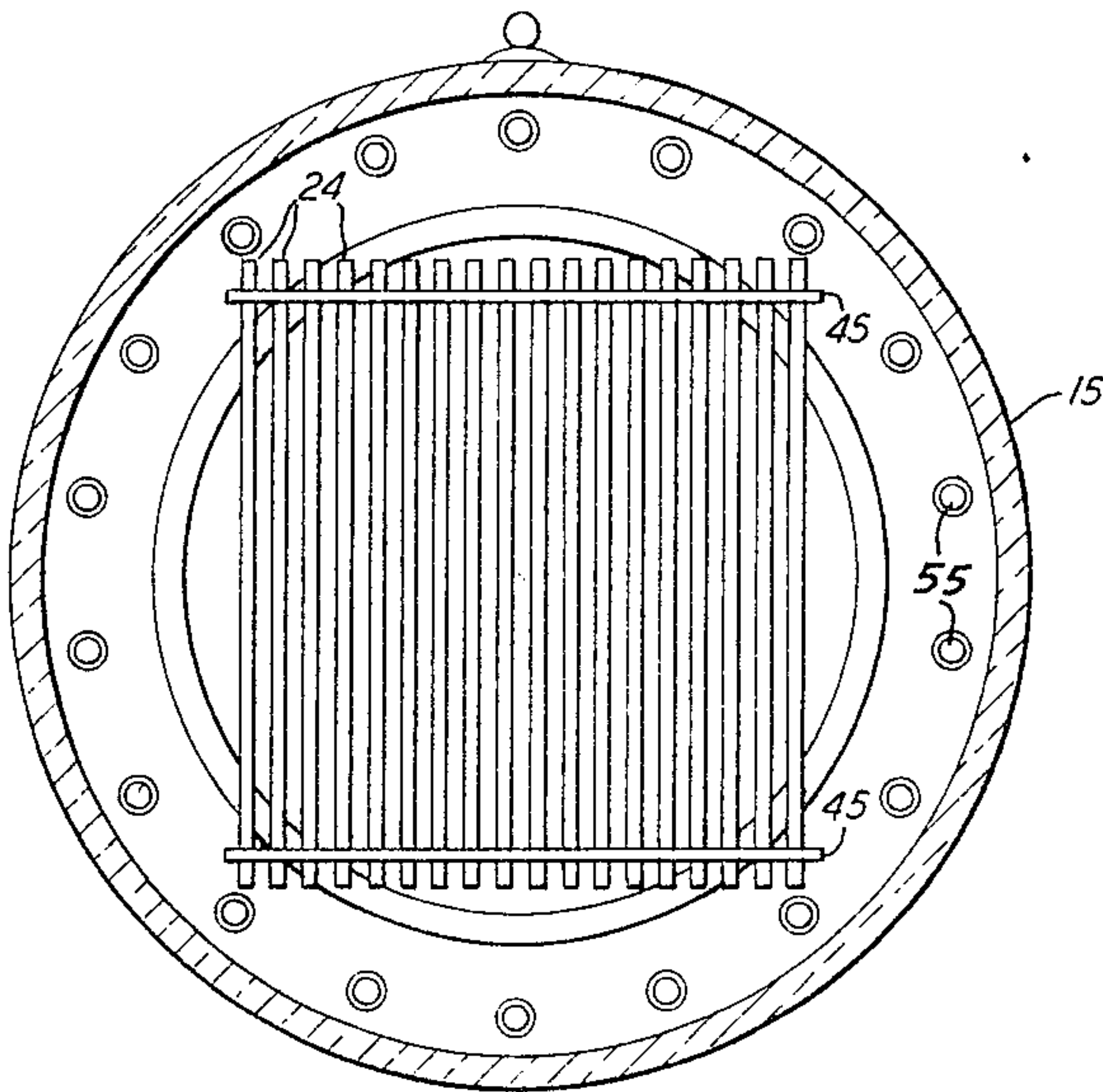
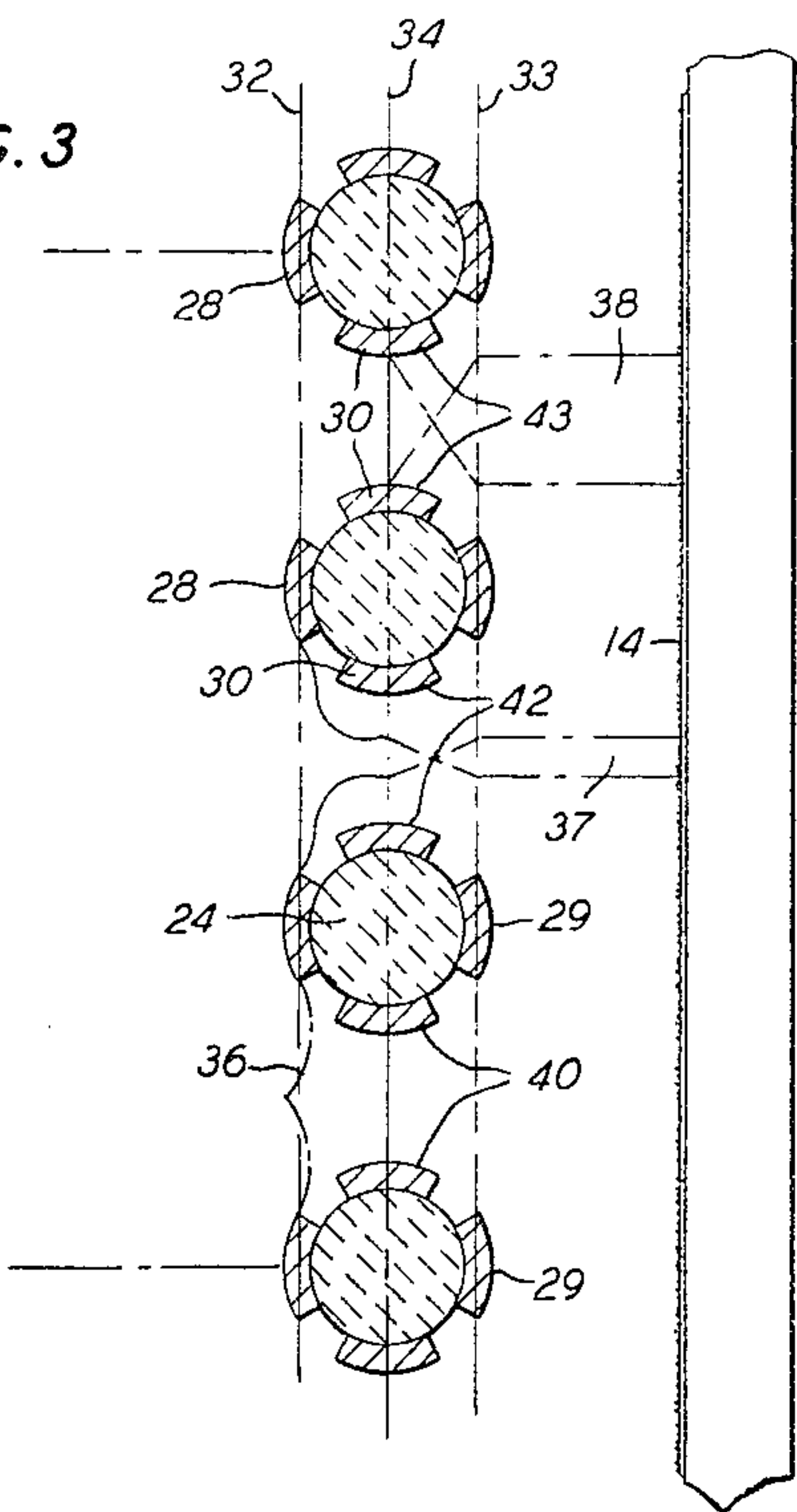


FIG. 3



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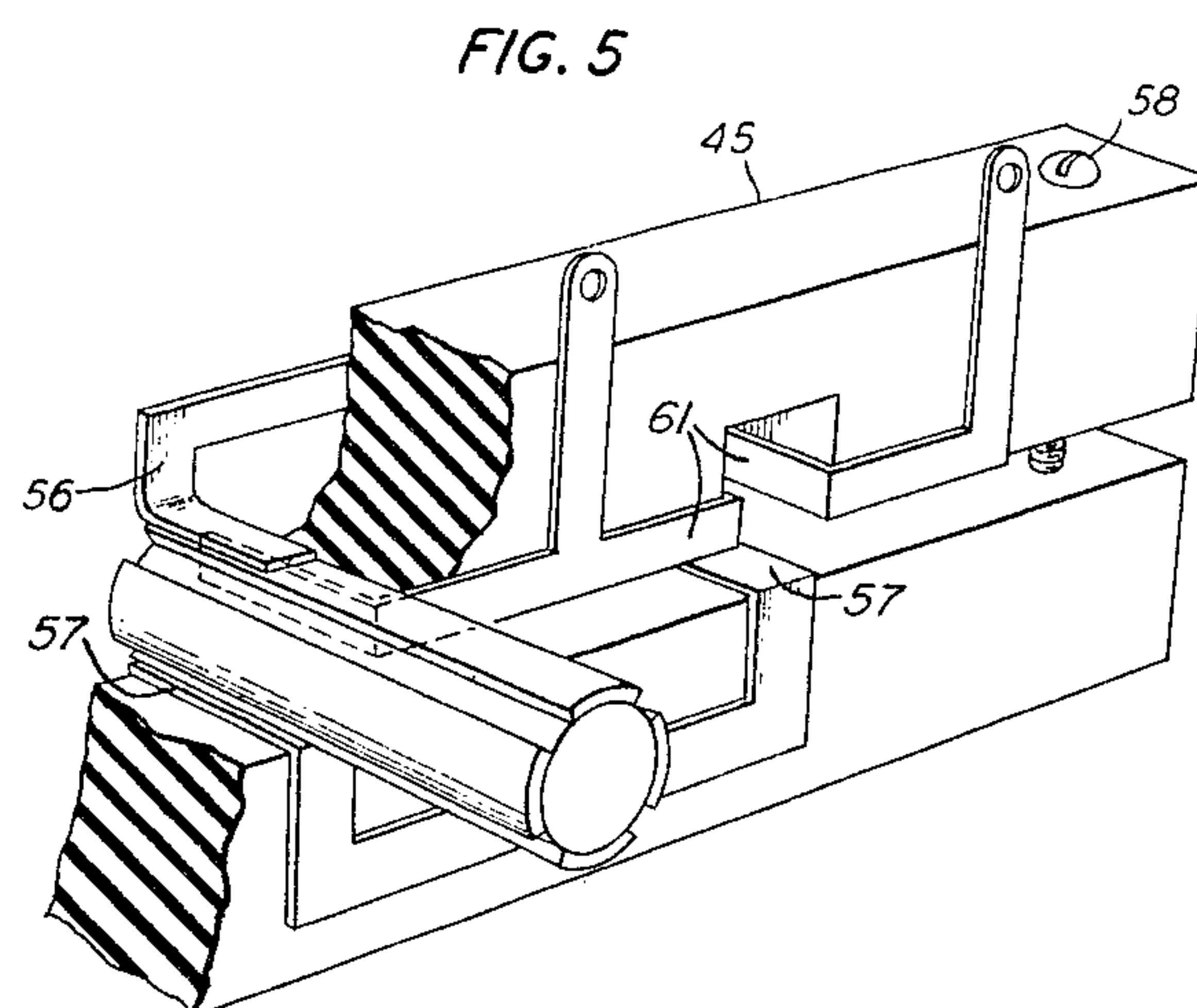
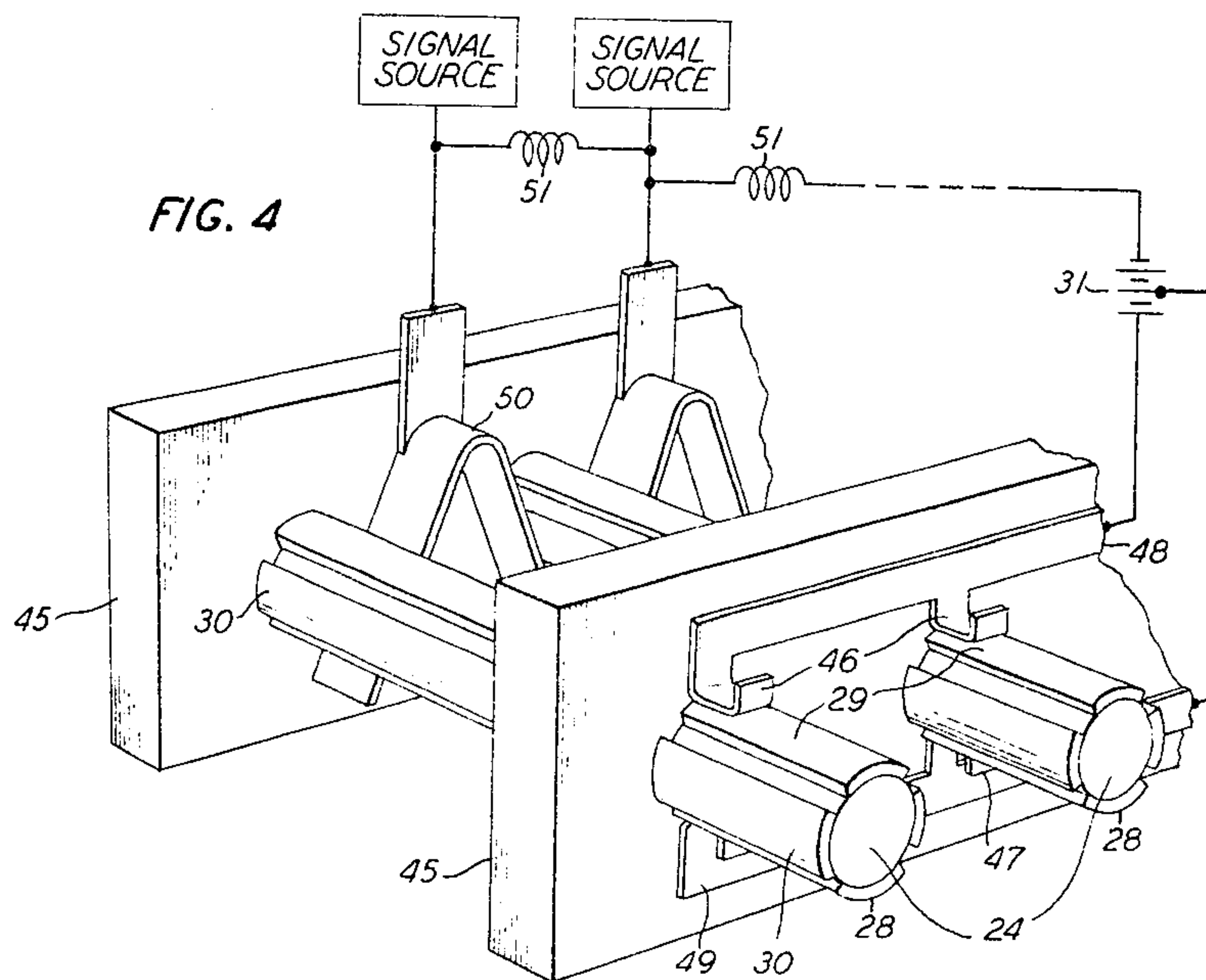
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FIG. 6

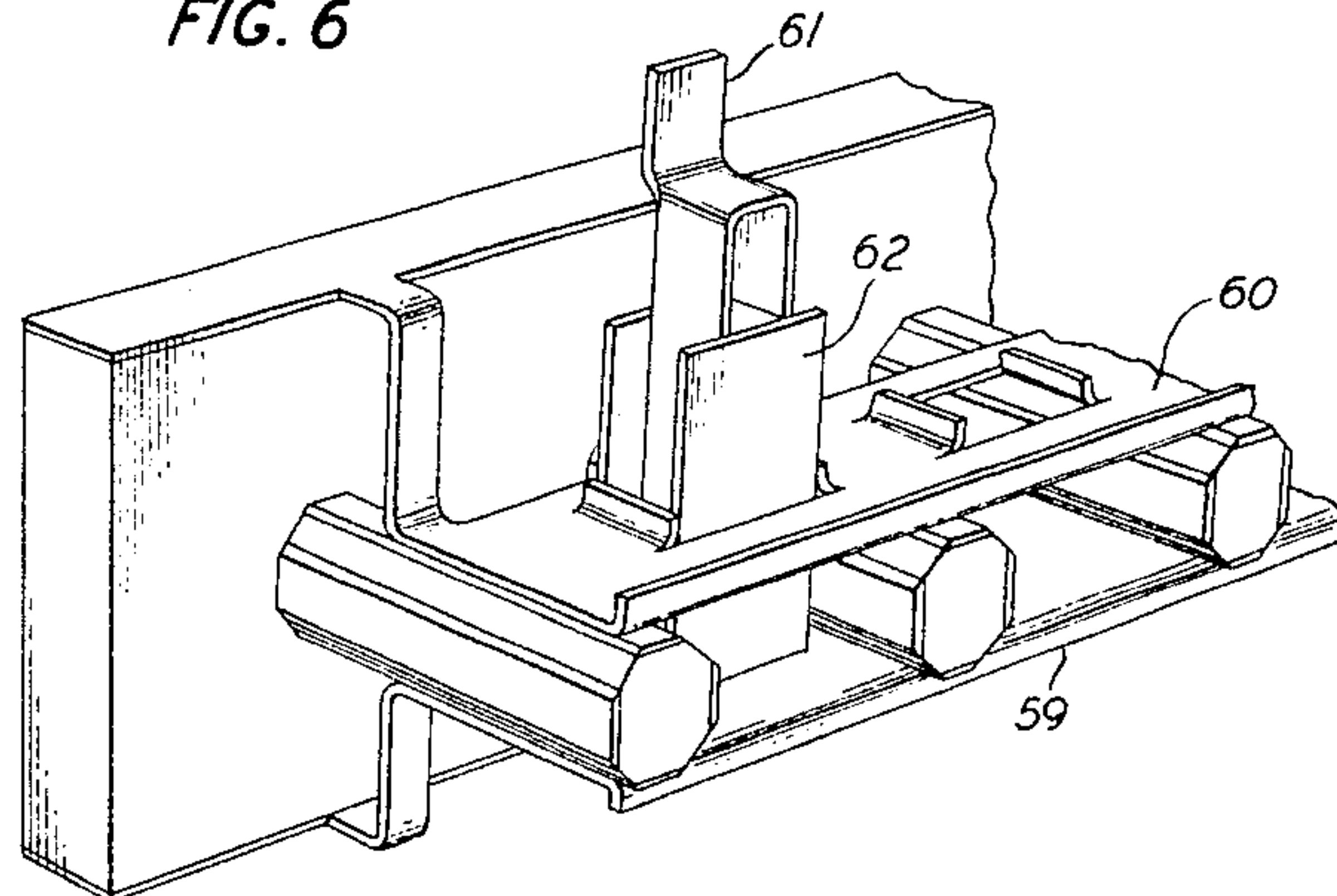


FIG. 7

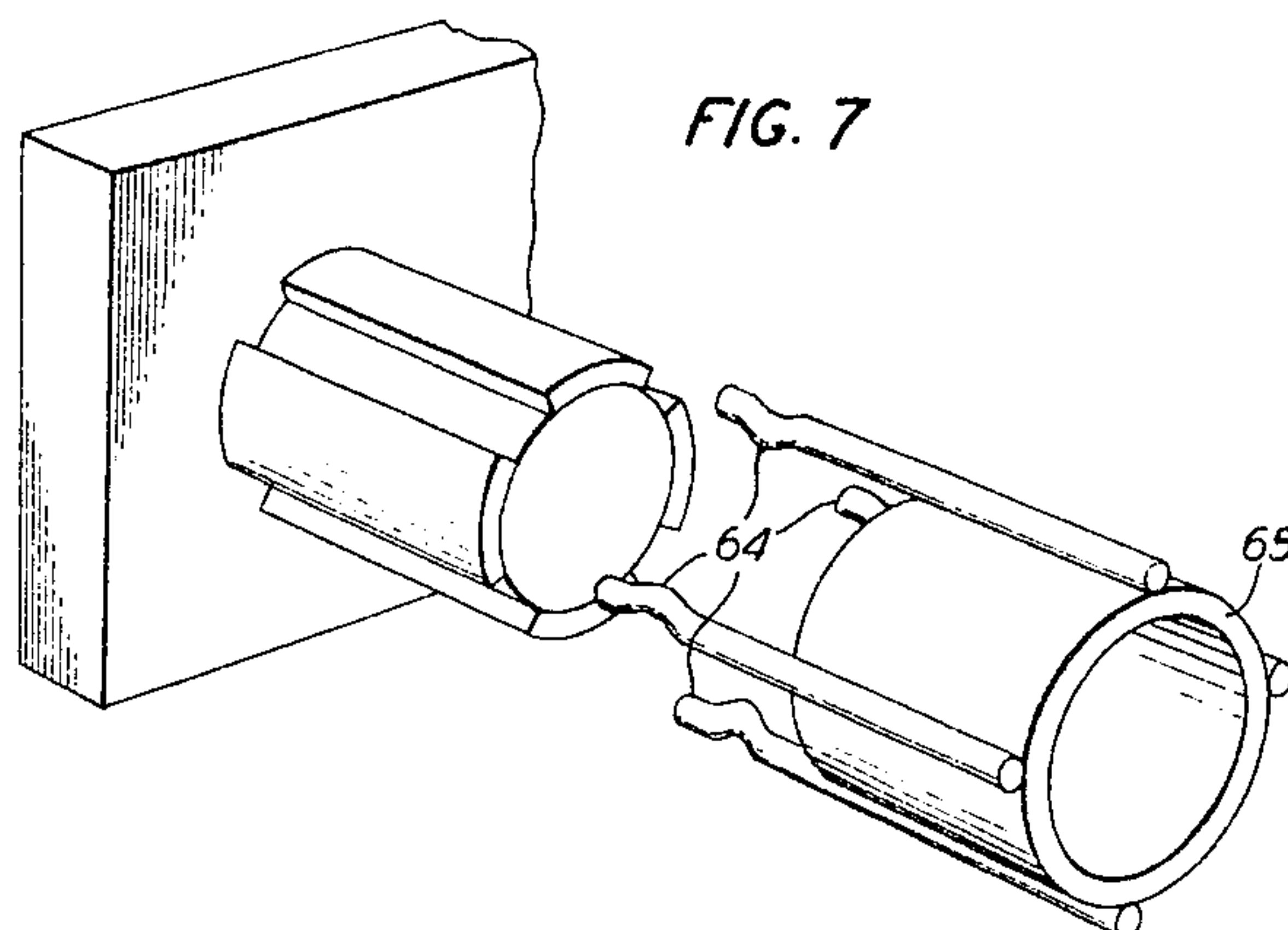
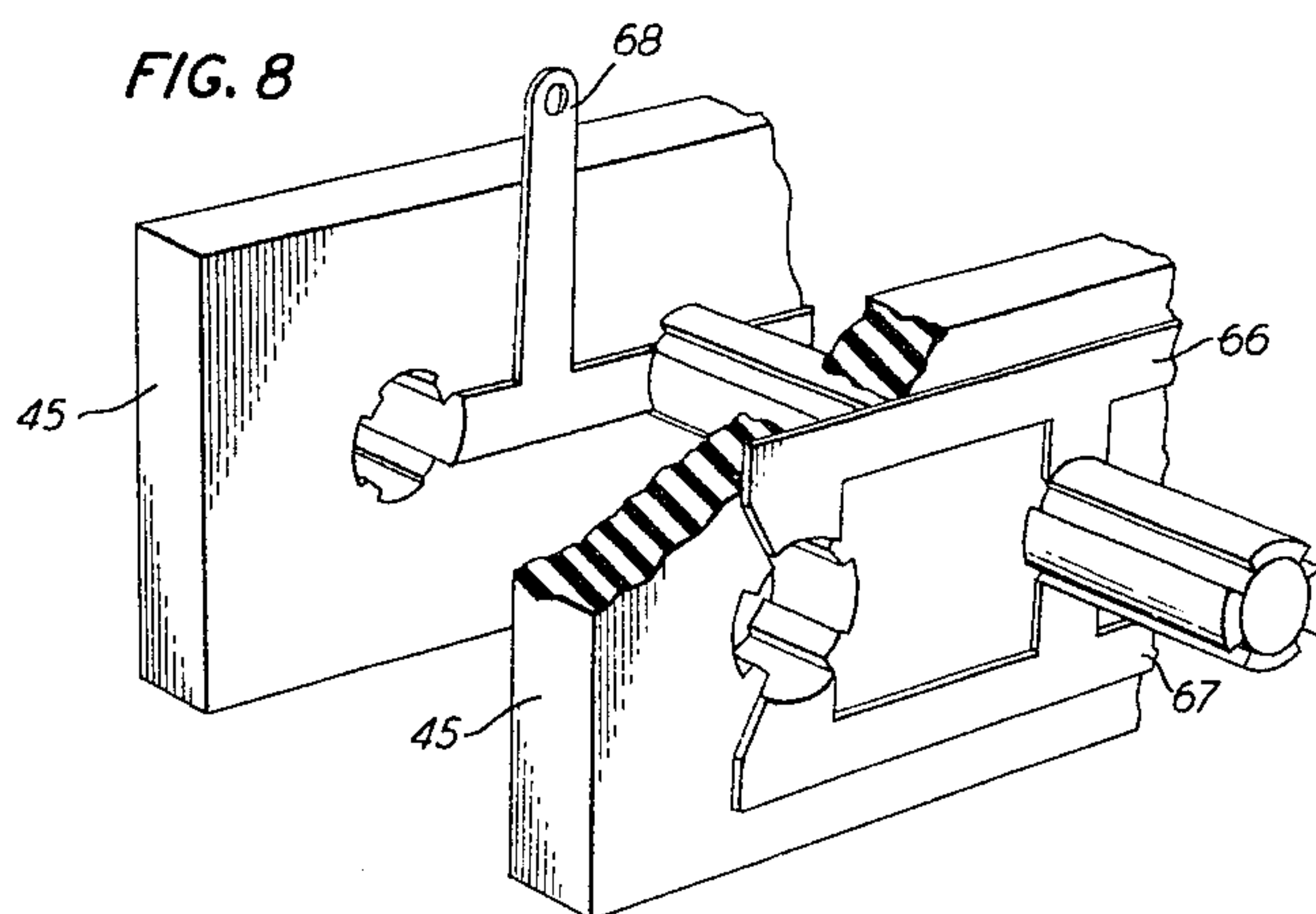


FIG. 8



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FIG. 9

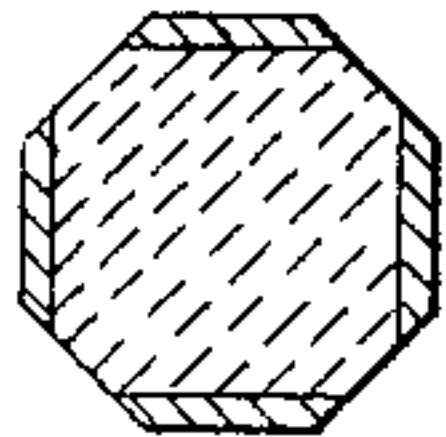


FIG. 11

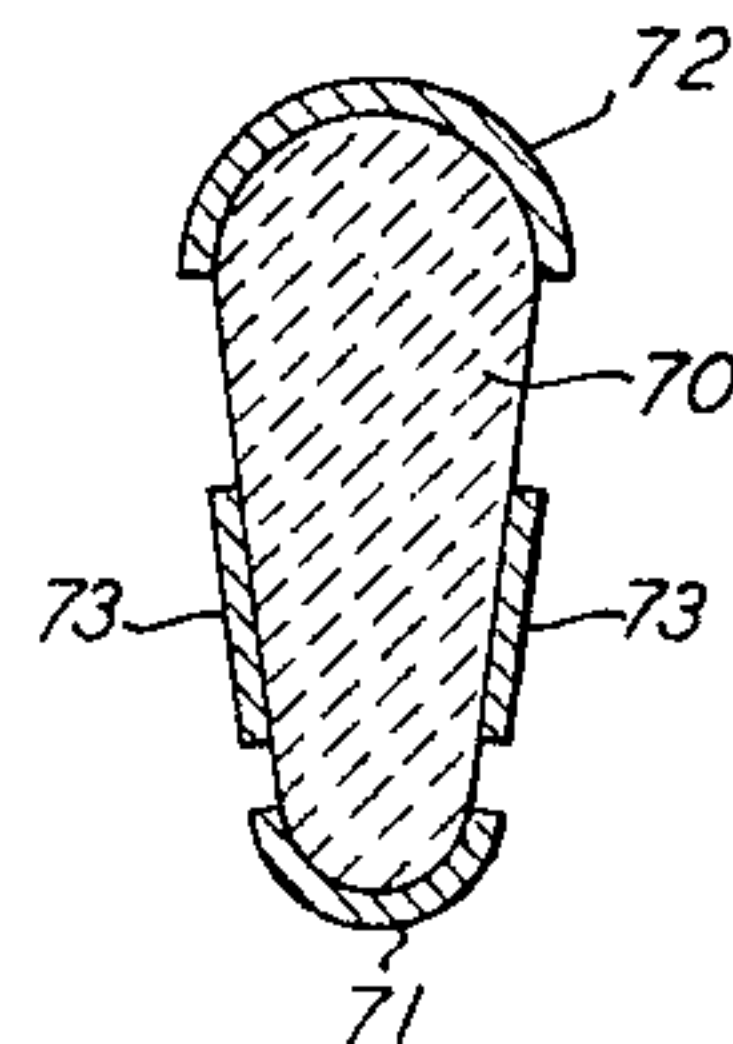


FIG. 10

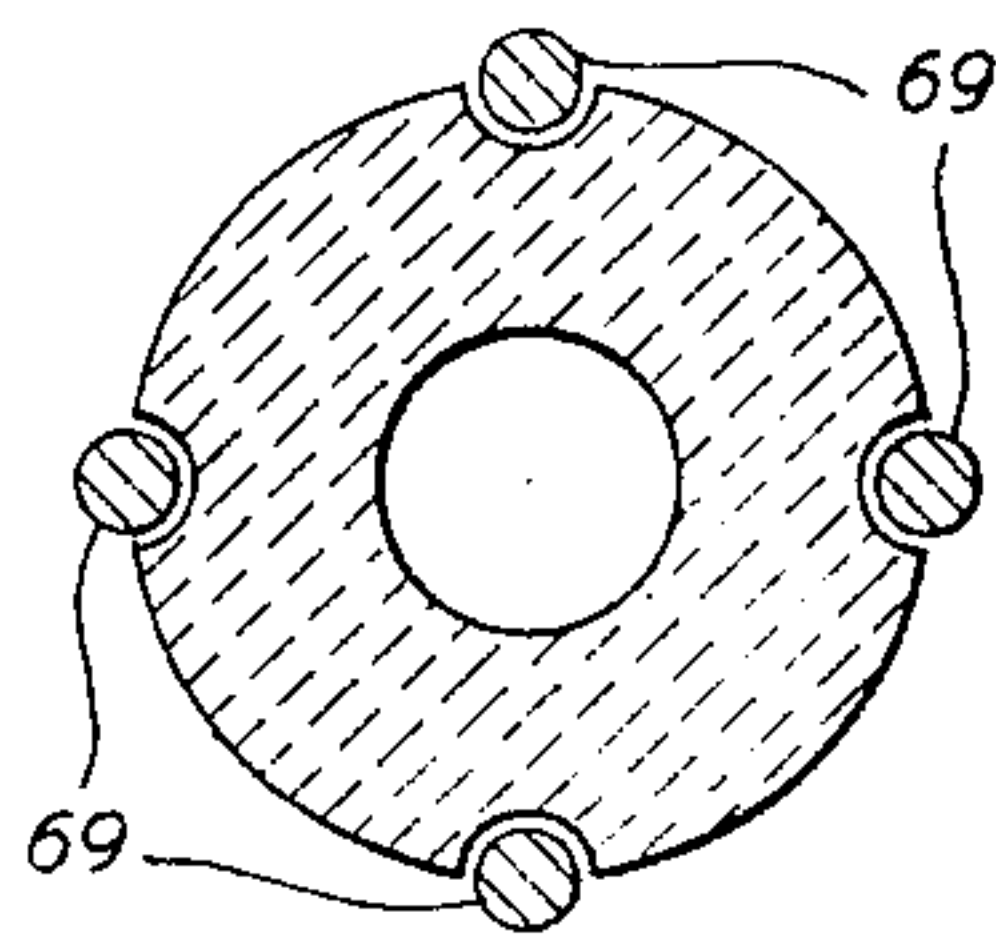


FIG. 12

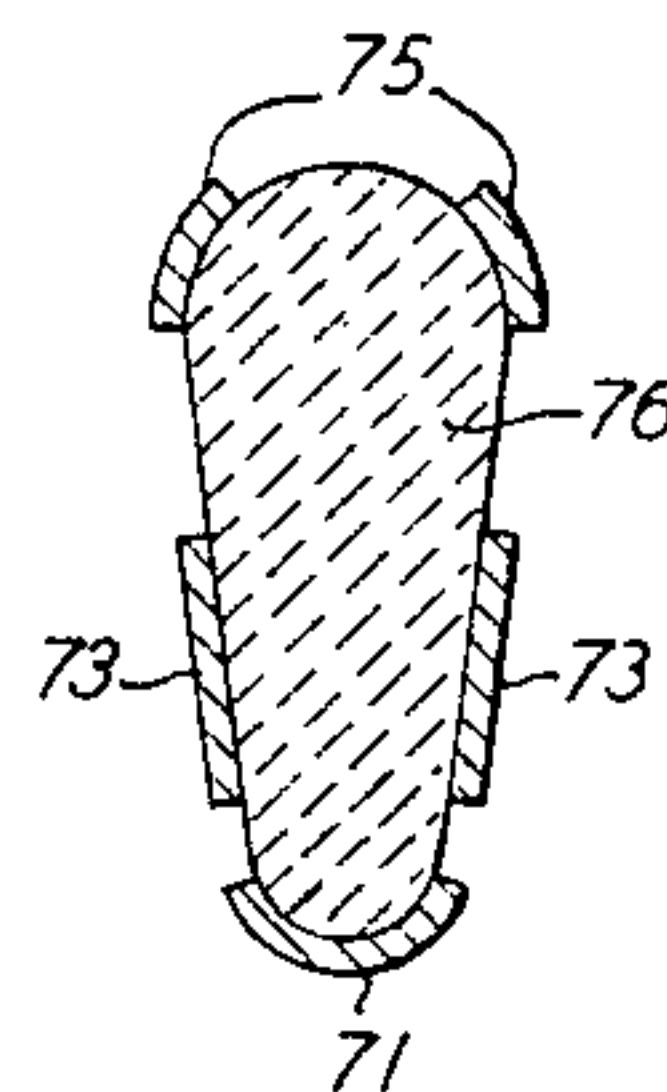
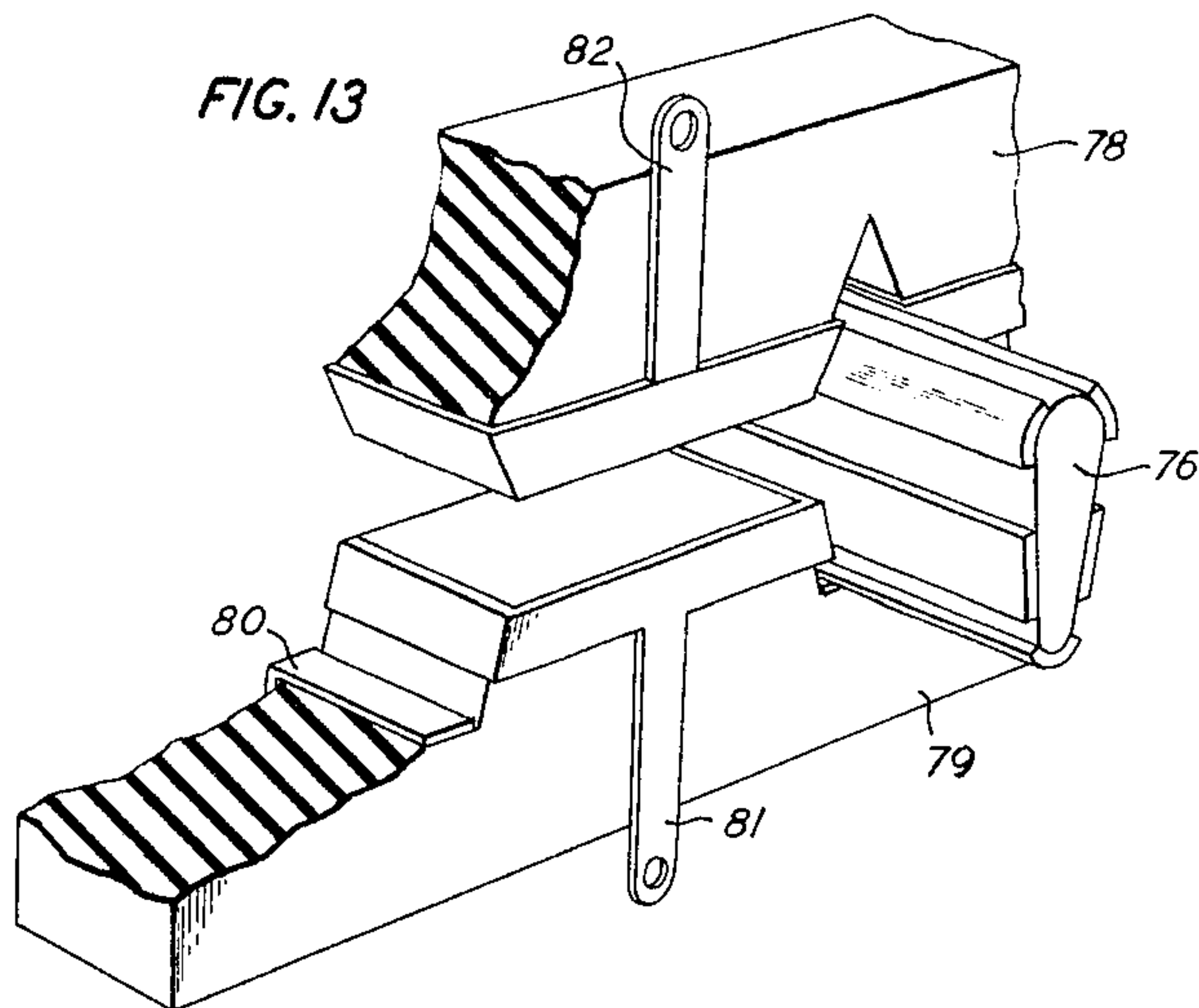


FIG. 13



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ELECTRON BEAM MODULATING DEVICE

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Filed Dec. 18, 1962, Ser. No. 247,442

12 Claims. (Cl. 315-13)

This invention relates to cathode-ray tubes and, more particularly, to apparatus for modulating the electron beams of cathode-ray display devices.

The copending application of R. J. Beck, Serial No. 219,343, filed August 24, 1962, and assigned to the Bell Telephone Laboratories, Incorporated, discloses a unique system for simultaneously displaying information from a plurality of sources on a single cathode-ray tube screen. This is done by periodically sweeping a ribbon electron beam across a slotted shield plate which masks the phosphor screen. A modulating wire in front of each of the slots controls electron flow through the slot thereby intensity modulating the visible trace that is left on the phosphor screen. With each modulating wire connected to a separate source, a visual indication of signals from all the sources can be made simultaneously.

It is convenient to use this system for the simultaneous display of the outputs of a plurality of radar antennas, each of which is directed to a different elevation angle. With the horizontal deflection of the electron beam synchronized with the radiation of radar pulses from the antennas the horizontal position of the beam at the time of reception of any reflected pulse is a function of the range of the target. Each antenna is connected to a different modulating wire in order according to elevation angle so that the vertical position of any spot on the phosphor screen indicates elevation angle while its horizontal position indicates target range.

The use of higher microwave frequencies and other refinements have made radar antennas so highly directional that it is feasible to use more than 100 antennas in one system of the type described above. The Beck cathode-ray tube, however, is not sensitive enough to divide the ribbon beam into that many segments for individual intensity modulation. First, when adjacent beam segments are very close together they tend to overlap. Secondly, the various modulation voltages produce differential divergence of the various beam segments thereby affecting their intensity and impairing the accuracy of the modulation.

An improved cathode-ray display tube which prevents divergence and overlapping of the beam segments is described in the patent of M. H. Crowell, No. 3,151,272, granted Sept. 29, 1964, and assigned to the Bell Telephone Laboratories, Incorporated. The modulation apparatus of the Crowell device includes the following elements between the deflection plates and the phosphor screen: a slotted beam forming structure for segmenting the beam; a pair of rod-shaped modulating electrodes on opposite sides of each beam segment for intensity modulating the segment; a pair of rod-shaped lens electrodes on opposite sides of each segment for focusing it and preventing it from diverging. The array of modulating electrodes defines a modulating plane while the array of lens electrodes defines a lens plane. As taught in the Crowell case, the electrons of each segment will leave the lens plane in parallel lines if the focal length of the lens electrodes plus the focal length of modulating electrodes equals the distance between the modulating plane and the lens plane.

Theoretically, the Crowell device can accurately intensity modulate more than 100 segments of a 10-inch wide ribbon electron beam. As a practical matter, it would be very difficult to build such a device because 100

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separate channels require 200 closely spaced modulating electrodes and 200 corresponding lens electrodes which must be suspended over a relatively long length. In such a case, the electrodes would have to be thin wires with very little inherent mechanical strength. The physical tolerances are, of course, very demanding and any perceptible sagging or other misalignment of the electrodes would cause serious malfunctioning.

Accordingly, it is an object of this invention to provide a sturdy and accurate ribbon electron beam modulating apparatus of simple construction.

This and other objects are attained in an illustrative embodiment thereof comprising an electron gun for forming and projecting a ribbon electron beam toward a phosphor screen. A pair of deflection plates periodically deflects the ribbon beam in a direction transverse to its plane. Before striking the screen the beam passes through a beam forming plane, a modulating plane, and a lens plane. The modulating plane and the lens plane are defined by a plurality of elongated electrodes which act as electron lenses. The sum of the focal lengths of the modulating plane and the lens plane is approximately equal to the distance between the modulating plane and the lens plane.

It is a feature of this invention that all of the electrodes defining the beam forming, modulating, and lens planes be supported by a single array of parallel rigid support rods. The rods are made of a rigid insulator material such as ceramic. The electrodes on the side of each rod facing the electron gun define the beam forming plane, while electrodes on the side of each rod facing the screen define the lens plane. Modulating electrodes are located on opposite sides of each support rod between the beam forming plane and the lens plane. All of the electrodes comprise conductive strips which extend lengthwise along the rods. Adjacent modulating electrodes on adjacent support rods act together as a pair to modulate the intensity of electrons that flow between them. Likewise, the lens electrodes of adjacent rods focus the beam segment that flows between them to prevent undue divergence. The beam forming electrodes which face the electron gun effectively act as masks or shields to divide the beam into the proper plurality of segments.

The position and alignment of the support rods are maintained by parallel insulator slabs on opposite ends of the rods. The ends of the rods extend through preformed apertures in the slabs. According to one embodiment the rods are held firmly in position by a pair of spring contacts on opposite sides of each rod. One spring contact energizes the beam forming electrode while the other one energizes the lens electrode. A V-shaped spring contact bears against the modulating electrodes of adjacent rods so that they can be energized simultaneously. Each of the signal sources is therefore connected to one of the V-shaped contacts.

In another embodiment the spring contacts extend into the aperture and bear equally on each rod in four directions. The contacts therefore perform the dual function of energizing the electrodes and maintaining them in proper alignment. The insulator slab is split along the apertures so that the rods can be removed by separating the two portions.

Other structures may alternatively be employed for energizing the electrodes. For example, spring contacts may be mounted in quadrature around an insulator ring so that the contacts bear tightly on the electrodes when fitted thereto. Two parallel bus bars can be used one of which contacts the beam forming electrodes with the other one contacting the lens electrodes. Apertures in one of the bus bars permits access of modulating electrode contacts.

In one embodiment the ceramic rods are round and

are first coated entirely with conductive metal. Four electrode strips are defined by scribing four lines in quadrature along the length of the rod. Alternatively, a square rod can be used which is coated with metal. The four electrodes can then be defined by grinding off the corners of the rod.

If the focal length of the modulating electrodes is longer than that of the lens electrodes, the beam segment will have a wider cross-section as it approaches the rods than when it leaves the rods. It may then be advantageous to use ceramic rods of tapered cross-section so that the distance between lens electrodes of adjacent rods is smaller than the distance between the beam forming electrodes. In this case the cross-section of the rods will be somewhat egg-shaped with the modulating electrodes being tapered at an angle.

The foregoing embodiments have presupposed a constant voltage on the lens electrodes with varying voltages being applied only to the modulating electrodes. If it is desired to vary the voltage on the lens electrodes to follow the voltage on the modulating electrodes, two lens electrodes can be bonded on the wide side of a tapered rod. Adjacent lens electrodes of adjacent rods are then energized in the same manner as the modulating electrodes. This is conveniently accomplished by using a pentagon-shaped slot in the insulator slab in which the rods are fitted. T-shaped printed circuit contacts can then be used for energizing each pair of lens electrodes and each pair of modulating electrodes.

These and other objects and features of our invention will be more fully appreciated from a consideration of the following detailed description taken in conjunction with the accompanying drawing in which:

FIG. 1 is a cross-sectional view of a cathode-ray tube employing the present invention;

FIG. 2 is a view taken along lines 2—2 of FIG. 1;

FIG. 3 is a schematic view illustrating the operation of the modulating apparatus of the device of FIG. 1;

FIGS. 4 through 8 illustrate different electrode-contacting structures that can alternatively be used in the device of FIG. 1;

FIGS. 9, 10, and 11 illustrate different cross-sectional forms that can be taken by the electrode support rods of the device of FIG. 1;

FIG. 12 illustrates another embodiment of the invention; and

FIG. 13 illustrates an electrode-contacting structure than can be used in conjunction with the embodiment of FIG. 12.

Referring now to FIG. 1 there is shown a cathode-ray tube 11 having an electron gun 12 for forming and projecting a ribbon electron beam toward a phosphor screen 14. The beam is maintained within a vacuum by an envelope 15 which is typically made of glass. The electron gun comprises, by way of example, a cathode 16, a control electrode 17, an accelerating electrode 18, and a focusing lens 19 of the type known in the art as an Einzel lens. A pair of deflection plates 21 deflects the beam in a direction transverse to the plane of the beam; as shown in FIGS. 1 and 2 the beam is deflected vertically. Support rods 22 support the electron gun elements and also support appropriate electrical conductors. The various electrodes are connected in a known manner to voltage sources which, for purposes of simplicity and clarity have not been shown.

The deflecting plates sweep the beam across modulation apparatus comprising an array of parallel electrode support rods 24, as best seen in FIGS. 2 and 3. To compensate for differences in velocity direction due to deflection, a beam collimation lens is included between the deflection plates and the modulation apparatus, which comprises shield cans 25 and 26. By maintaining an appropriate voltage difference between these two shield cans as explained in the Crowell patent, the electrons are forced to travel in a direction substantially parallel

with the tube axis as they approach the modulation apparatus regardless of the extremes of their deflection.

The quantity of electrons that finally reach phosphor screen 14 is controlled by an array of electrodes that are bonded onto the support rods 24. As best seen in FIGS. 3 and 4, four electrode strips are bonded in quadrature on each rod. Beam forming electrodes 28 are bonded on each rod on the side facing the electron gun. Lens electrodes 29 are bonded on each rod on the side facing the phosphor screen. Modulating electrodes 30 are included on each rod between the beam forming electrodes and the lens electrodes. In accordance with the invention, the support rods 24 insulate the various electrodes and maintain them in accurate predetermined alignment. The support rods are preferably made of ceramic but may alternatively be made of any rigid nonconductive material. While they are shown as solid rods, they may also be constructed of tubing to reduce weight while maintaining rigidity.

The beam forming electrodes 28 of all of the rods are conductively interconnected to form an electrical beam forming plane 32. Likewise, the lens electrodes are conductively interconnected and form an electrical lens plane 33. The modulating electrodes are interconnected by a series of radio-frequency chokes and are maintained at a constant quiescent direct-current voltage and therefore cooperate to form a modulating plane 34. The appropriate direct-current voltages are maintained on the various electrodes by voltage sources 31 shown schematically in FIG. 4.

FIG. 3 illustrates intensity modulation by the modulating electrodes of three typical beam segments 36, 37, and 38. The adjacent modulating electrodes of each adjacent pair of ceramic support rods are connected together and cooperate to control the intensity of the beam segment flowing between such pair. They are maintained at a quiescent negative direct-current voltage which is sufficient to repel approaching electrons in the absence of any signal. However, each pair is also connected to a signal source which drives such pair to a positive voltage in accordance with the strength of the signal. For example, no signal voltage has been transmitted to modulating electrode pair 40 and so electron beam segment 36 is completely repelled. A small signal voltage has been transmitted to electrode pair 42 so that part of beam signal 37 is transmitted to the phosphor screen 14. A large positive signal has been transmitted to electrode pair 43 so that all of beam segment 38 impinges on the screen. Hence, it can be appreciated that each pair of modulating electrodes acts as an electron lens for intensity modulating one individual electron beam segment.

The purpose of the beam forming electrodes 28 is to divide the ribbon beam into segments. The purpose of the lens electrodes 29 is to focus each segment to prevent adjacent segments from overlapping. In accordance with the principles of the Crowell case, the electrons will leave lens plane 3 in parallel lines as shown in FIG. 3, if the following condition is met:

$$\frac{2V_M}{V_L' - V_{BF}'} + \frac{2V_L}{V_P' - V_M'} = d_2 \quad (1)$$

where V_M is the voltage on the modulating electrodes, V_L is the voltage on the lens electrodes, V_L' is the potential gradient at lens plane 33, V_{BF}' is the potential gradient at beam forming plane 32, V_P' is the potential gradient at the phosphor screen, V_M' is the potential gradient at modulating plane 34, and d_2 is the distance between the modulating plane and the lens plane.

Equation 1 mathematically requires that the distance between the modulating plane 34 and the lens plane 33 equal the sum of the focal lengths of the electron lenses which define the modulating plane and the lens plane. In order to fulfill this equation strictly, the voltage on the lens electrodes would have to vary to follow the voltage variations on the corresponding modulating elec-

trodes. As a practical matter, the lens electrodes can usually be maintained at a constant voltage to fulfill the equation when an average modulation voltage is applied. For example, it may be convenient to maintain modulating electrodes 30 at a quiescent direct-current voltage of -3 volts, the lens electrodes at +550 volts, and the phosphor screen at +10,000 volts each in respect to a cathode voltage of zero volts. With such a large lens electrode voltage, comparatively small modulation voltages can intensively modulate the beam segments without unduly upsetting the condition of Equation 1. The lens electrodes still sufficiently compensate for the diverging effect of the modulating electrodes to permit a 10-inch wide electron beam to divide into more than 100 segments without overlapping. In this situation the phosphor screen 14 should be aluminized as is known in the art to permit maintenance of such a high voltage.

FIG. 4 illustrates one structure for supporting the ceramic support rods 24 and for electrically connecting the various electrodes. The rods are supported between parallel insulator slabs 45; see also FIGS. 1 and 2. The lens electrodes 29 are electrically connected by spring contacts 46 while the beam forming electrodes 28 are connected by spring contacts 47. Contacts 46 and 47 bear against the ceramic rods 24 to hold them in alignment and to maintain a firm electrical connection. The spring contacts 46 and 47 are connected respectively to conductors 48 and 49 which can be bonded, riveted, or printed on the insulator slab 45. Each pair of modulating electrodes must, of course, be individually energized; this is conveniently accomplished by V-shaped spring contacts 50, each of which are connected to a separate signal source. Radio-frequency chokes 51 permit all of the modulating electrodes to be maintained at a quiescent direct-current voltage when they are not energized.

Consider next the fabrication of the electrode strips. Each support rod is first preferably metallized using one of the well-known techniques, and is then coated with another metal or metals. The various electrodes are next defined by scribing longitudinal notches which cut through the metal coating to expose the insulative support rod. The rods are then inserted in preformed apertures in the insulator slabs 45. The apertures are shown as being keyed to restrict rotation; they could alternatively be round with each rod being bonded to the insulated slab or the contacts.

Referring again to FIG. 1, the various electrodes are connected to an array of terminals 54 by way of a circumferential array of rods or tubing 55. The device of FIG. 1 has eighteen terminals 54, only four of which are shown. Two of the terminals are connected to the lens electrodes and the beam forming electrodes with the other sixteen being connected to sixteen pairs of modulating electrodes. It should be understood, however, that the present invention is designed to accommodate a large plurality of modulation channels and typically, more than 100 separate channels. The total array of ceramic electrode support rods 24 shown in FIG. 2 extend only one and one-half inches. This demonstrates that 100 rods could be used with a phosphor screen that is only 10 inches wide. It is quite apparent that with 100 ceramic support rods and with the contact structure of FIG. 4, the electrodes are much more dependably aligned and energized than with the separate beam forming structure, 200 modulating electrodes and 200 lens electrodes of the Crowell disclosure. Further, the use of the ceramic rods, the coating method, and the contacting structure greatly simplifies the assembly of the cathode-ray tube.

Alternative devices for contacting the various electrodes of the modulation apparatus are shown in FIGS. 5 through 8. In FIG. 5, spring contacts 56 which energize the lens electrodes and contacts 57 which energize the beam forming electrodes extend into apertures of the insulator slab 45. U-shaped spring contacts 61 also extend into the apertures to energize the modulating electrodes. The

insulator slab can be clamped tightly over the rods by tightening bolt 58. The advantage of this embodiment is that equal pressures by the spring contacts can be exerted on all four sides of each rod to secure it in firm alignment.

In the embodiment of FIG. 6 the ceramic rods have flat sides for receiving flat electrode strips. A bus bar 59 is bonded to all of the beam forming electrodes and a bus bar 60 is bonded to all of the lens electrodes. Contact with the modulating electrodes is made by input conductors 61 which extend through apertures in bus bar 60 and which are insulated and supported by H-shaped insulators 62. Although this embodiment may prove to be more complicated to assemble, it is obviously a very solid structure.

In the embodiment of FIG. 7 the electrodes of each ceramic support rod are individually energized by clamping on spring contacts 64 which are attached to an insulator tube 65. Firm mechanical contact is made by bonding the insulator tube 65 over the ceramic support rod with an insulating cement or glaze. Firm electrical contact is maintained by the pressure of the spring contacts. Alternatively, a solid rod could be substituted for tube 65, in which case only the spring contacts would overlap onto the ceramic rod. This embodiment is obviously quite easy to assemble.

In the embodiment of FIG. 8 all of the contacts are of the printed circuit type. Lead 66 contacts the lens electrodes, lead 67 contacts the beam forming electrodes, and signal input leads 68 contact the modulating electrodes. All of the leads extend into the preformed apertures of the insulator slabs 45. The rods may be held in place by friction and make electrical contact with the electrodes printed on the sides of the aperture or may additionally be bonded in place. This embodiment is also quite easy to assemble.

Another method of assembly of the ceramic electrode support rods is illustrated in FIG. 9. In this case a square rod is used which is completely coated with electrode material. The corners of the rod are then ground off its entire length thereby defining the four electrode strips in quadrature around the rod.

In an alternative form shown in FIG. 10, four longitudinal grooves are formed in the support rod for receiving four wires 69 which constitute the electrodes. The wire electrodes 69 are bonded in place for example by cementing or glazing.

It was pointed out in the above-mentioned Crowell patent that the width of the beam segments remains unchanged only if the focal length of the lens electrodes equals the focal length of the modulating electrodes. This condition is illustrated in FIG. 3 wherein electron segment 38 is the same width after cross-over as before. In many practical cases, however, it is advantageous to use modulating and lens electrodes with different focal lengths, in which case the electron beam segment width will change. Referring to FIG. 11 there is shown a ceramic rod 70 having a tapered cross-section which corresponds to the change in width of the electron beam segment. The beam forming electrode 71 is on the narrow end of the rod, the lens electrode 72 is on the wide end, with the modulating electrodes 73 being located on the tapered surfaces. Lens electrodes 72 of adjacent rods are relatively close together to accommodate the smaller width of the beam segment and thereby give more accurate and efficient beam focusing.

As was indicated above, strict fulfillment of Equation 1 requires that the voltage on adjacent pairs of lens electrodes must change with variations of voltage on corresponding pairs of modulating electrodes. This requires that each pair of lens electrodes be separately energized just as the modulating electrodes. As a result, five conductor strips, instead of four, must be laid on each ceramic rod. This is conveniently accomplished by using a tapered ceramic rod as shown in FIG. 12 wherein distinct lens

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electrodes 75 are bonded to the wide end of tapered ceramic rod 76. Beam forming electrode 71 divides the beam into segments while modulating electrodes 73 modulate the beam segment as in the embodiment of FIG. 11.

One convenient device for supporting and contacting the embodiment of FIG. 12 is shown in FIG. 13 wherein the insulator slab comprises an upper segment 78 and a lower segment 79. A V-shaped slot in the upper slab 78 and a modified U-shaped slot is made in the lower slab 79 which together constitute a pentagon-shaped aperture for individually energizing the five electrode strips of each rod. As in the embodiment of FIG. 8 the input conductors are printed on the sides of the aperture and make friction contact with the various electrodes. Hence contact 80 energizes the beam forming electrode, contact 81 energizes adjacent pairs of modulating electrodes, and contact 82 energizes adjacent pairs of lens electrodes. Proper axial rod positions can be maintained by bonding the rods to the insulator slab, if this proves desirable. Various methods of attaching the contacts to the insulator slab can alternatively be used.

The above embodiments illustrate different modes of implementation of the inventive concept. In all of the embodiments three distinct electrical planes are formed by a single mechanical structure comprising a single array of ceramic rods having elongated electrodes bonded on them. Numerous other modifications may be made by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A cathode-ray tube comprising:

means for forming and projecting a ribbon electron beam;

a pair of deflecting plates for deflecting the beam;

an indicating screen;

a plurality of parallel dielectric rods between the plates and the screen and extending parallel with the direction of the beam deflection; and

four electrodes bonded lengthwise and in quadrature on each rod including a first electrode on each rod facing the deflecting plates, a second electrode on each rod facing the screen with the remaining electrodes being intermediate the first and second electrodes.

2. A cathode-ray tube comprising:

means for forming and projecting a ribbon electron beam;

means for deflecting the beam in a direction transverse to the plane of the beam;

an indicating screen;

means for dividing the beam into a plurality of segments and for individually intensity modulating each segment comprising a plurality of parallel ceramic rods located between the deflecting means and the indicating screen and extending in the direction of beam deflection;

first electrode means located on one side of all of the rods for defining a beam forming plane;

second electrode means located on the opposite side of all of the rods for defining a lens plane; and

third electrode means located on all of the rods intermediate the beam forming plane and lens plane for defining a modulating plane.

3. The cathode-ray tube of claim 2 wherein:

the first and second electrode means comprise first and second conductive strips extending along the length of the ceramic rods; and

the third electrode means comprises third and fourth conductive strips located on opposite sides of the ceramic rod between the first and second strips.

4. The cathode-ray tube of claim 3 wherein:

each ceramic rod is supported at each end by an insulator slab having an aperture through which the rod extends and by four spring contacts each of

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which is biased against one of the conductive strips.

5. The cathode-ray tube of claim 4 wherein:

the spring contact which contacts the third conductive strip of one rod and that which contacts the fourth conductive strip of an adjacent rod constitute legs of a U-shaped spring; and

means for transmitting a modulation signal to each of the U-shaped springs.

6. The cathode-ray tube of claim 4 wherein:

the cross-section of the ceramic rods is circular; and the spring contacts are mounted in quadrature around an insulator ring of approximately the same circumference as that of the ceramic rods whereby the contacts bear tightly on the conductive strips when fitted thereto.

7. The cathode-ray tube of claim 2 wherein:

the ceramic rods having a tapered cross-section;

the first selectrode means are located on the narrow side of each ceramic rod and face the beam forming means;

the second electrode means are located on the wide side of each ceramic rod and face the indicating screen; and

the third electrode means are located on both tapered surfaces of each rod.

8. In a cathode-ray tube of the type having an electron gun for forming and projecting an electron beam toward an indicating screen on which indications are made in response to the impingement of electrons, a modulating device for controlling electron impingement on the indicating screen in response to input signal energy comprising:

a plurality of parallel ceramic rods between the electron gun and the indicating screen;

a first conductive strip on each rod on the side facing the electron gun;

a second conductive strip on each rod on the side facing the indicating screen;

a third and fourth strip on the intervening sides of the rods;

the first strip of all the rods being conductively connected and defining an electrical beam forming plane;

the second strip of all the rods being conductively connected and forming an electrical lens plane;

the third strip of one rod being conductively connected to the fourth strip of an adjacent rod and forming therebetween an electrical modulating plane.

9. In a cathode-ray tube of the type having an electron gun for forming and projecting a ribbon electron beam toward an indicating screen on which indications are made in response to the impingement of electrons, a modulating device for controlling an electron impingement on the indicating screen in response to input signal energy comprising:

a plurality of insulative support rods between the electron gun and the indicating screen;

a first conductive strip on each rod on the side facing the electron gun;

a second conductive strip on each rod on the side facing the indicating screen;

a third and fourth strip on the intervening sides of the rods between the first and second strips;

the first strips comprising means for dividing the beam into a plurality of segments;

the second strips forming a first array of electron lenses having a first focal length;

the third and fourth strips on the rods forming a second array of electron lenses having a second focal length;

the distance between the first and second arrays being approximately equal to the sum of the first and second focal lengths.

10. A cathode-ray tube comprising means for forming and projecting a ribbon electron beam;

means for deflecting the beam;

an indicating screen;

a plurality of parallel insulative rods extending in the direction of beam deflection and located between the beam forming means and the indicating screen;
a plurality of parallel conductive strips extending lengthwise along the rods;

adjacent strips on adjacent rods comprising a first electron lens for controlling electron flow therebetween;
other adjacent strips on adjacent rods comprising a second electron lens for focusing the electrons that flow therebetween;

the distance between the first and second electron lenses being approximately equal to the sum of the focal lengths of the first and second electron lenses.

11. In a cathode-ray tube of the type having an electron gun for forming and projecting an electron beam toward an indicating screen on which indications are made in response to the impingement of electrons, a modulating device for controlling an electron impingement on the indicating screen in response to input signal energy comprising:

a plurality of insulative support rods between the electron gun and the indicating screen;

each of the rods having a tapered cross-section;

a first conductive strip extending lengthwise along the narrow side of each rod facing the electron gun;

a second and third conductive strip extending lengthwise along the wide side of each rod facing the indicating screen;

a fourth and fifth strip extending lengthwise along the tapered sides of each of the sides;

each rod being supported at each end by an insulator slab having a pentagon-shaped aperture through which the rod extends;

first electrode means bonded to one of the insulator

slabs for interconnecting the first strips of each of the rods;

second electrode means bonded to one of the slabs for interconnecting the second strip of each of the rods and the third strip of an adjacent rod; and

third electrode means bonded to one of the slabs for interconnecting the fourth strip of each of the rods and the third strip of an adjacent rod; and

12. A cathode-ray tube comprising:

means for forming and projecting a ribbon electron beam;

means for deflecting the beam in a direction transverse to the plane of the beam;

an indicating screen;

a plurality of parallel insulative support rods between the deflecting means and the screen and extending parallel with the direction of beam deflection;

four electrodes bonded lengthwise and in quadrature on each rod including a first electrode on each rod facing the screen, a second electrode on each rod facing the deflecting means, with the remaining electrodes being intermediate the first and second electrodes;

and means for applying a first direct-current potential to all of the first electrodes, a second direct-current potential to all of the second electrodes, and a third direct-current potential to all of the intermediate electrodes, where the first and second and the third potentials are mutually different.

No references cited.

JAMES W. LAWRENCE, *Primary Examiner*.

P. C. DEMEO, *Assistant Examiner*.