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(54) HEAD MOUNTABLE APPARATUS

(71) We, HONEYWELL INC., a Corporation organised and existing under the laws of the State of Delaware, United States of America, of Honeywell Plaza, Minneapolis, Minnesota 55408, United States of America, do hereby declare theinvention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to head mountable apparatus for viewing operations carried out by the wearer of the apparatus, and more particularly to a remotely controlled television system for observing such manual operations as surgery.

According to the invention, there is provided head mountable apparatus for viewing operations carried out by the wearer of the apparatus, said apparatus comprising a camera for generating signals representative of a visual image received and from which signals the visual image can be reproduced at a location remote from the wearer; a remotely controlled aiming and focussing means for the camera; and an illumination means arranged so that the location of the field lighted thereby is determined solely by the attitude of the head of the wearer.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings, in which

Figure 1 is a side view of head mounted apparatus according to the invention and cut-away to show the internal workings of the apparatus;

Figure 2*a* is a partial, enlarged, side view showing the mounting of the illumination system of the apparatus;

Figure 2*b* is an enlarged front view, with parts cut-away showing the mounting of the illumination system of the apparatus;

Figure 3 is a detached, enlarged view of the camera aiming mirror depicted to show the operation thereof;

Figure 4*a* is a simplified schematic optical diagram of the illumination and imaging optics of a prior art head mounted apparatus;

Figure 4*b* is a simplified schematic optical diagram of the illumination and imaging optics of the apparatus of the present invention, and,

Figure 5 is a respective view of a remote control console for use with the apparatus of Figure 1.

In Figure 1 of the drawings, there is shown the head-mounted unit or apparatus 10 in place on the head of a wearer. The unit is typically attached to head 11 as by a headband 12 although it may also be designed to be integral with a helmet-type of head gear. The sub-systems located in the head-mounted unit include an optical sub-system which comprises lens and mirrors plus their associated mounting structures for aiming and focusing a televsion camera, a televison camera sub-system which includes video and audio systems and the independent illumination sub-system. In the head-mounted unit these systems are integrally mounted in a light weight compact coordinated package.

The basic optical system is shown in Figure 1 and in the optical schematic diagram of Figure 4. The system consists basically of mirrors 20, 21 and 22 and camera lens 23 (Figure 4). Tubular sections 24 and 25 form an enclosed optical path from the mirror 21 to the camera 13. Mirrors 21 and 22 are mounted in a stationary position such that an image reflected from mirror 20 onto the mirror 21 follows a bore-sighted path from that point into the television camera.

In the illustrative embodiment the mirror 20 is mounted so that it may be pivoted about a vertical pivot assembly, shown generally at 26, to control the horizontal deflection or yaw of the field of view of the camera. Horizontally disposed pivot mounting shown generally at 27, (Figure 3) controls the pitch or vertical attitude of the mirror and thus the field of view of the camera.

Figure 3 depicts an enlarged view of the mirror 20 of Figure 1 along with enlarged details of a method of pivotally mounting the mirror 20. Thus, the yaw control of the vertical mounted pivot 26 consists of con-

ventional top and bottom pivot joints one of which is shown at 28. A control wire 29 attached at one end to an ear 30 on the mirror 20 and at the other end to an electro mechanical servo system, like that shown at 31 (Figure 1), is utilized to position the yaw angle of the mirror 20. Return springs on the pivotal joints, one of which is shown at 32, cause the yaw adjustment to return in the opposite direction as the tension on wire 29 is decreased by reverse operation of the servo system 31.

In a like manner, adjustment of the pitch or vertical attitude of the mirror is accomplished by tension on a control wire attached to the mirror vertical pivot as at 33 (Figure 1). The mirror pivot, in turn, is attached to a mounting bracket which has two mounting arms 34 and 35 (Figure 3) which are mounted in conventional fashion to form the horizontal pivot joints of the horizontally disposed pivot 27 which allows variation in the pitch or vertical alignment of the mirror 20. Again, a return spring, depicted at 36, is utilized to return mirror 20 toward the fullest forward (uplooking) position as the tension on the corresponding control wire is decreased.

The second servo motor involved in the positioning of the mirror 20 may be idential to that illustrated at 31 (Figure 1). Thus, by remote electrical control the servo motors are used to operate bell cranks or eccentrics as at 37 which cooperate with pivotal sleeves 38 to position the mirror 20 by adjusting the tension control wires 29. A similar electro mechanical servo system, not shown, is used to remotely position the TV camera lens, shown in the optical diagrams of Figures 4*a* and 4*b*, at 23, by axially adjusting its position relative to the TV camera itself in a well known photographic focusing manner. The servo systems themselves may be, for example, CPS—12 servos available from Kraft Systems Inc., Vista, California.

The details of the improved illumination system of the present unit can best be seen in the enlarged fragmentary views of Figures 2*a* and 2*b*. It includes two separate illuminators 4 and 42 which are ridigdly attached through respective mounting brackets 43 and secured therein as by holddown collars 44. The brackets 43 are in turn secured to the tubular member 24 as by conventional screws 45.

Elevational adjustment of the illuminators 41 and 42 may be accomplished by rotating the brackets 43 about the screws 45 and tighting at the desired attitude. The illuminators 41 and 42 are interconnected by collars 46 attached to the illuminators which, in turn, are threadably attached to a common convergence adjustment screw 47. The convergence adjustment screw 47 is operated by a thumb wheel 48 through which it is nonrotatably mounted. The brackets 43 are flexible in the direction of the axis of the convergence screw 47 such that operation of the thumb wheel 48 flexes the brackets and causes the desired convergence or divergence of the beams emanating from the illuminators 31 and 42.

The mounting of the illumination system of the present unit, then, is such that the field of view illuminated follows the movement of the head of the wearer, and the wearer can by means of the above-described adjustments adjust both the relative elevation of the beam to the desired position and the convergence or divergence of the beams from the illuminators 41 and 42. The convergence adjustment allows him to eliminate shadows in the field of view and achieve better sight into the area of work.

The difference between the present head mounted unit and that of the prior art represented by U.S. Patent Specification No. 3919475 is best illustrated by means of the optical schematic diagrams of Figures 4*a* and 4*b*. In the prior art system, the illuminators 41*a* and 42*a* are mounted such that at all times the light eminating therefrom was reflected off the mirror 20*a*, which mirror also returns light from location 49 to the camera optical system through mirrors 21*a* and 22*a* and lens 23*a*. This resulted in coincidence of the camera field of view with the illuminator field of view at 49. Thus, the remote operator of the mirror 20*a* which controlled the field of view of the camera optical system was at all times simultaneously in control of the position of the illuminated spot.

Because this control was left in the hands of the remote television camera operator, the surgeon or other wearer of the head-attached television system, was constantly subjected to lighting shifts at the whim of the remote operator who many times sought to see something different from what the wearer then wanted illuminated. It has been found that wearers of the head-attached unit such as surgeons who are long accustomed to wearing conventional headband attached lights during surgery tend to steer the light field to suit their particular needs which may or may not agree with the particular filed of view sought by remote cameraman. Therefore, as the surgeon rotates or nods his head slightly to adjust the light to the particular field of view he seeks, the remote operator is simultaneously steering the light field by remotely controlling the orientation of the mirror 20a to center the activity of interest on his particular desired field of view. This of course results in constant conflicts between the wearer and the remote camera operator. The surgeon unconsciously, automatically steers the light in the direction he desires until no more motion of the mirror 20*a* is possible whereupon he can put the illumination field where he chooses; however, he will probably have to hold his head at an unusual and/or

uncomfortable angle. The remote controller then is unable to properly center the action in the camera filed or view which he desires.

Figure 4*b* illustrates the independence of the field of view of the illuminator 50 and that controlled by the remote TV camera operator 51. Once the elevation and particular desired convergence or divergence have been adjusted by the surgeon or other head-attached television system wearer the location of the illuminated field of view is then completely controlled by the wearer and will follow his head movement precisely thereby eliminating the conflict between the wearer and the remote television camera operator.

The light energy transmitted by the illuminators 41 and 42 may be provided by a source such as conventional low-voltage quartz halogen lamp shown in block form at 52 in Figure 5. The light energy from the lamp is then transmitted to the head-mounted unit as by means of conventional flexible fiber optic bundles 53 which separate to feed separate illuminators 41 and 42 (Figures 2*a* and 2*b*). The illumination brightness may be made adjustable in a conventional manner by providing an adjustment knob at the source 52. One successful illuminating system utilizes a 150 watt quartz halogen lamp, available from the General Electric Company, Schenectady, New York, and two fiber optic bundles manufactured by the American Optical Company of Sturbridge, Mass.

While no particular spot size is necessary for the two illuminators 41 and 42, it has been found that when they are operated in a slightly defocused manner the best shadowless illumination is achieved. Although the fixed illuminators of the prior art did provide adequate illumination for operation of the color TV camera and provided a spot of light for aiming the TV camera, it has been found that they did not always meet the needs of the wearer. In some cases such as abdominal surgey, external high intensity illumination was externally provided but in many cases involving oral, neuro and opthalmic procedures, the operator wanted to use head mounted illumination but needed a capability to adjust the spot size as well as the convergence distance of the two illumination beams. The nominal design of the illuminators is such that they produce spots of light about four inches in diameter at a working distance of approximately 18 inches. It may be appreciated that this can also be readily rendered mechanically adjustable so that the spot size can be increased or decreased at a given working distance.

The color television camera sub-system normally includes video and audio inputs. One-inch, single tube vidicon models available as from Magnavox Corporation (Model CV—400), Cohu Corporation (Model 12120) and others may be used. These are normally modified in form as described below. The above-type camera provides components for a lightweight small head-mounted unit consisting of the single vidicon and yoke, video per-amplifiers and an audio transducer (capacitor microphone) to provide the initial televsion and audio input in a well-known manner. A miniatue speaker or speakers may be added to provide two-way audio communication between the wearer and remote operator or viewer(s). Because sweep amplifier and some other vidicon control circuits must be located close to the camera tube in order to function properly, a convential support unit which is shown in block form at 54 (Figure 5) is connected at fairly close range to the head-mounted camera as by a flexible conduit 55.

The bulk of the color television camera electronics and controls are located in the control console 56 as illustrated in Figure 5. That unit may be located remotely from the remainder of the system and contains all the controls for operating the remote focusing and aiming and also the controls for a remote video monitor 57 with its associated controls and a conventional audio monitor (not shown). Such other things as tape recorder control, etc. which are conventional additions to any such systems may also be used in conjunction with the monitor 57. The monitor 57 is connected remotely as through cables 58 and 59 with the illumination source 52 and camera-associated electronics 54, respectively. Both the console 56 and the support units 52 and 54 are shown as wheel mounted for convenience in moving same. In a preferred finished version the units 49 and 51 are physically united to form a single unit which may be mounted on a standard hospital "IV" stand for convenience and minimum space utilization in a surgical operating room.

A single operator sitting at the console 56 then may manipulate a control such as joy stick 60 while viewing a real-time image of the field of view of the camera on the monitor 57 to aim the field of view of the camer to coincide with the field of view which he desires to capture. Some preliminary adjustments must also be made to align the camera axis to the wearers normal working field by a manual manipulations of the head-mounted unit on his head. A separate control as at 61 may be utilized to remotely adjust the focus of the camera also in response to the focus of the real-time image as seen by the operator on the monitor 72.

It can readily been seen that the present unit contemplates an improved illumination system for an apparatus for viewing intricate manual manipulations such as those performed by a surgeon utilizing a system which, unlike the previous systems allows the flexibility of the wearer's control of the filed

of view which is to be illuminated by the illuminators 41 and 42.

In addition to the system described above, of course, one or more stationary camera systems may be added to show, in a conventional manner, other views and depict certain other operations of the wearer or, if such additional camera work is required for any other reason. In such cases, additional monitors may be added to the console 56 corresponding to the additional cameras. Aslo, while the preferred embodiment utilizes a remote console unit certain applications where a less complex setup is required, a smaller portable unit may be employed.

It can be appreciated that advances in the rapidly changing electronics art can modify details of the color TV camera embodiment. In particular, use of new integrated circuits or solid state camera sensors may eliminate the need for any electronic unit such as 54. Also, use of the newest miniature quartz halogen lamps would permit their incorporation into the head-mounted unit thus eliminating the need for a separate illumination source, 52.

WHAT WE CLAIM IS:—

1. Head mountable apparatus for viewing operations carried out by the wearer of the apparatus, said apparatus comprising a television camera for generating signals representative of a visual image received and from which signals the visual image can be reproduced at a location remote from the wearer; a remotely controlled aiming and focusing means for the camera; and an illumination means arranged so that in use the location of the field lighted thereby is determined solely by the attitude of the head of the wearer.

2. The apparatus of claim 1, wherein the illumination means includes a pair of illuminators which can be adjusted to produce a combined single field of illumination.

3. The apparatus of claim 2, including means for adjusting the convergence angle described by the illuminators.

4. The apparatus of claim 1, 2 or 3, including means for adjusting the elevation of the illuminating means relative to the wearers' head.

5. Head mountable apparatus substantially as herein described with reference to Figures 1, 2a, 2b, 3, 4b and 5 of the accompanying drawings.

JOHN RIDDLE.

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1589448 COMPLETE SPECIFICATION

5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

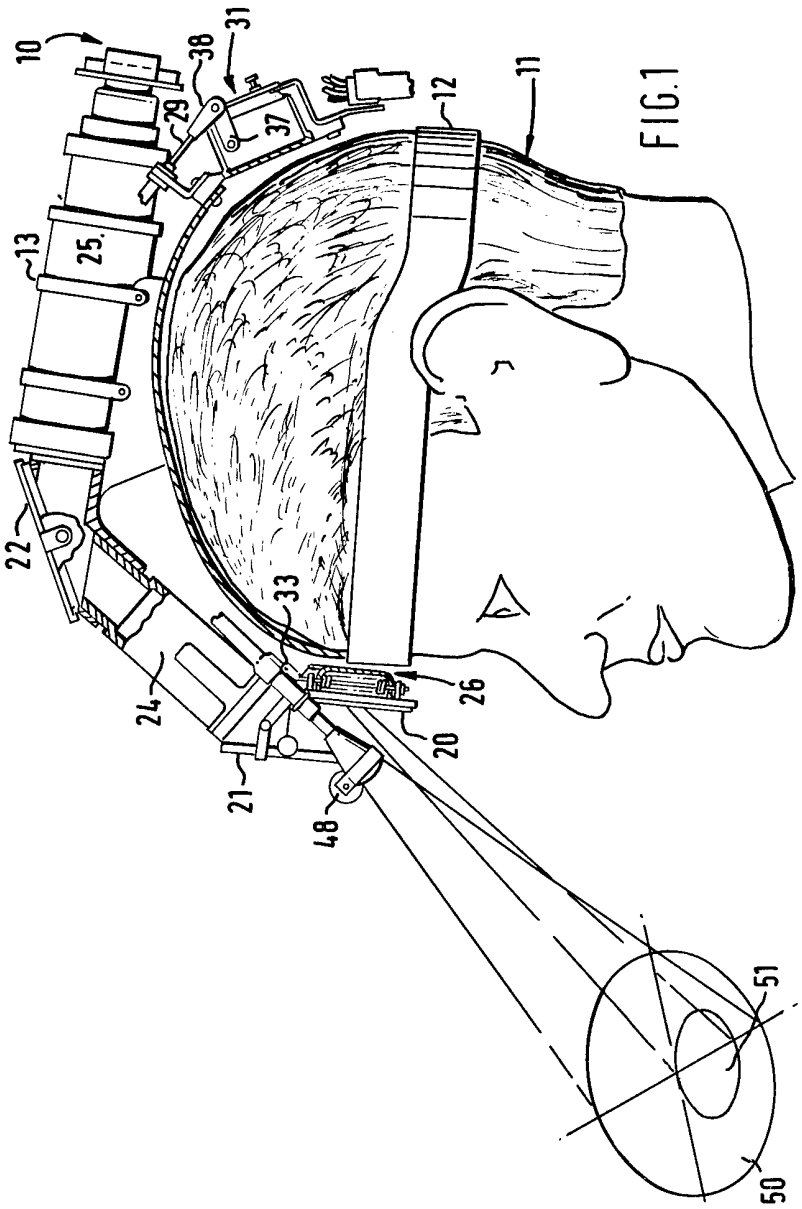

FIG.1

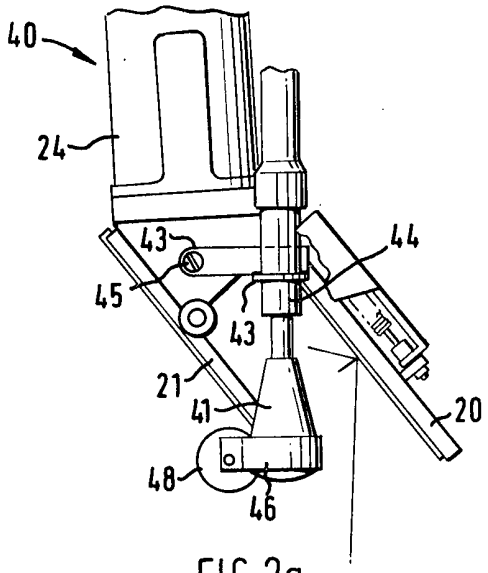

FIG. 2a

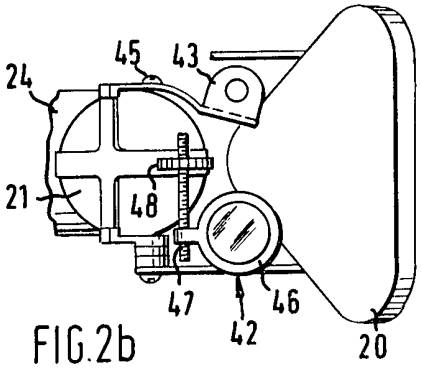

FIG. 2b

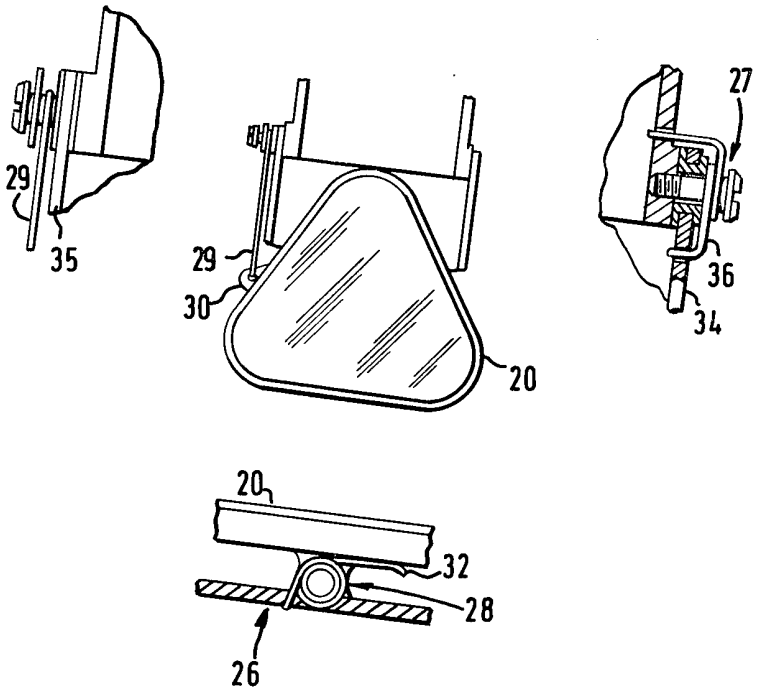

FIG. 3

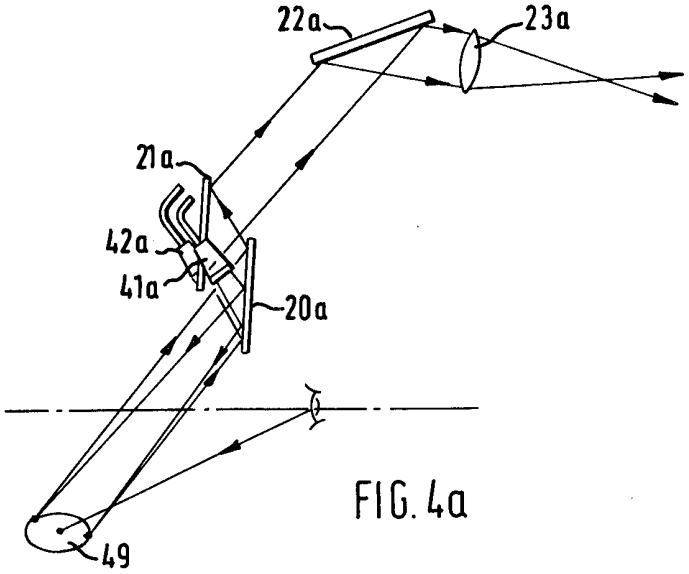

FIG. 4a

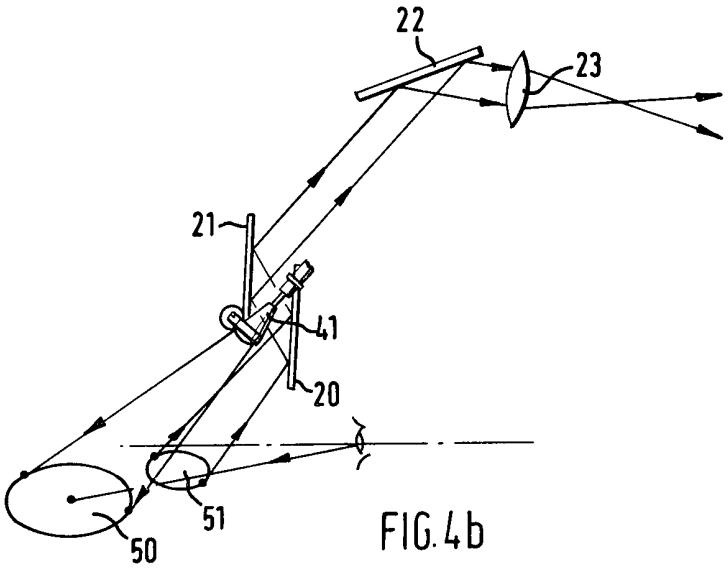

FIG. 4b

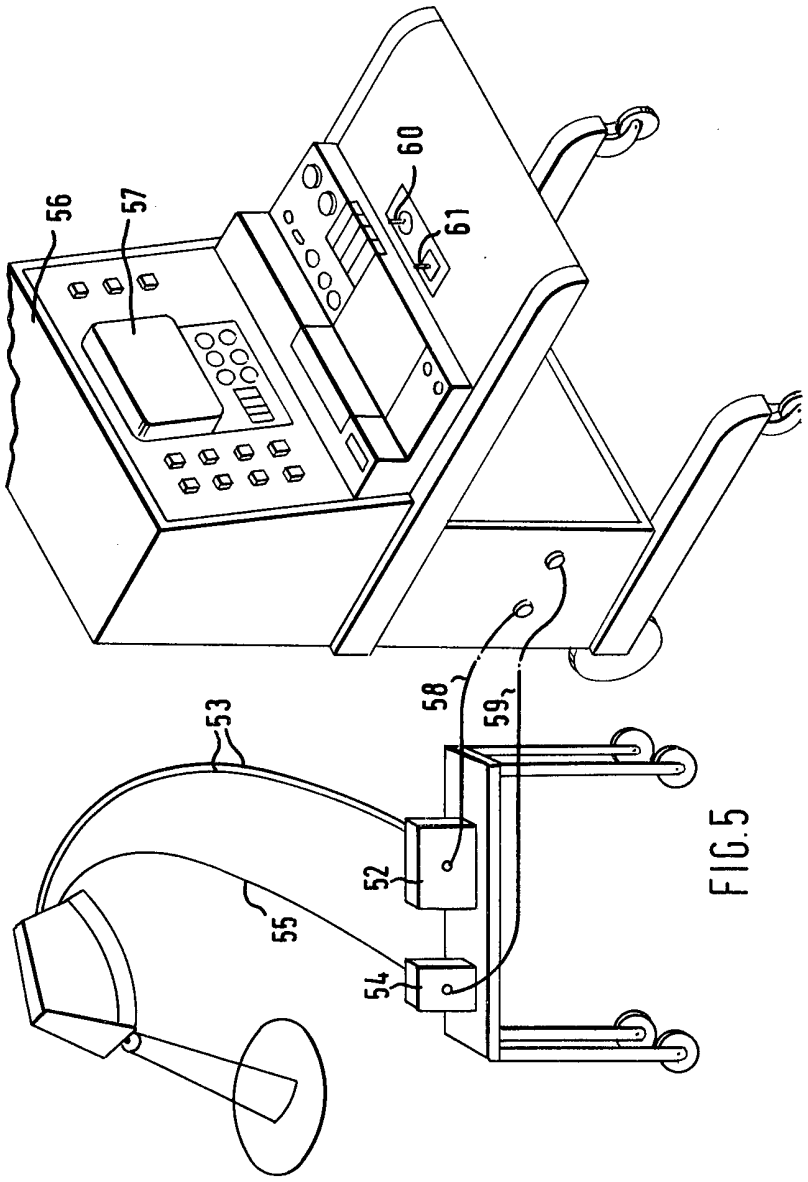

FIG.5