Exhibit 3

Debra
308-0900

#4
[illegible]
6-4-97

In the United States Patent and Trademark Office

Ser. No.: 08/677,378
Filed: 07/05/96
Applicant(s): Brad A. Armstrong
Title: 6 DOF Graphic Controllers with Sheet Connected Sensors
Group Art Unit: 2609
Examiner: Examiner of Record

Disclosure Document Reference Letter

Commissioner of Patents and Trademarks
Washington, District of Columbia 20231

Sir:

A disclosure document as identified below was previously filed in the Patent and Trademark Office. As this disclosure relates to the above patent application, it is requested that this Disclosure Document be retained and referenced to the above application.

Disclosure Document Title: Multi-Axis Graphics Controllers And Components Therefor
Disclosure Document Number: 381081
Disclosure Document Filing Date: November 22, 1995

Very respectfully,

[signature] Date: 4/24/97 — Signed Name
Date: — Signed Name

Brad A. Armstrong
Printed Name, First Applicant

Printed Name Joint Applicant

848 Inyo St.
Address of First Applicant

Address of Joint Applicant

Chico CA 95928

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#4 6-4-97

MAIL ROOM APR 28 1997 PAT & TRADEMARK OFFICE

In the United States Patent and Trademark Office

Ser. No.: 08/677,378
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08/677,378
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Disclosure Document Reference Letter

RECEIVED MAY 13 97 GROUP 2600

Commissioner of Patents and Trademarks
Washington, District of Columbia 20231

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Brad A. Armstrong Date: 4/24/97 — Date:
Signed Name — Signed Name

Brad A. Armstrong
Printed Name, First Applicant — Printed Name Joint Applicant

848 Inyo St.
Address of First Applicant — Address of Joint Applicant

Chico CA 95928

#4 / [illegible] / 6-4-97

MAIL ROOM / APR [illegible] / PATENT

In the United States Patent and Trademark Office

Ser. No.: 08/677,378
Filed: 07/05/96
Applicant(s): Brad A. Armstrong
Title: 6 DOF Graphic Controllers with Sheet Connected Sensors
Group Art Unit: 2607
Examiner: Examiner of Record

Disclosure Document Reference Letter

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Commissioner of Patents and Trademarks
Washington, District of Columbia 20231

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Disclosure Document Number: 381081
Disclosure Document Filing Date: November 22, 1995

Very respectfully,

[signature] Date: 4/24/97   Date:
Signed Name   Signed Name

Brad A. Armstrong
Printed Name, First Applicant   Printed Name Joint Applicant

8463 Inyo St.
Address of First Applicant   Address of Joint Applicant

Chico CA 95928

11/07/97 FRI 15:19 FAX 7033059724 002

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6-4-97

MAIL ROOM APR 25 1997 PAT & TRADEMARK

In the United States Patent and Trademark Office

Ser. No.: 08/677,378
Filed: 07/05/96
Applicant(s): Brad A. Armstrong
Title: 6 DOF Graphic Controllers with Sheet Connected Sensors
Group Art Unit: 2609
Examiner: Examiner of Record

Disclosure Document Reference Letter

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Washington, District of Columbia 20231

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Disclosure Document Number: 381081
Disclosure Document Filing Date: November 22, 1995

Very respectfully,

Brad A. Armstrong Date: 4/24/97 Date:
Signed Name Signed Name

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11/07/97 FRI 15:18 FAX 7033059724 001

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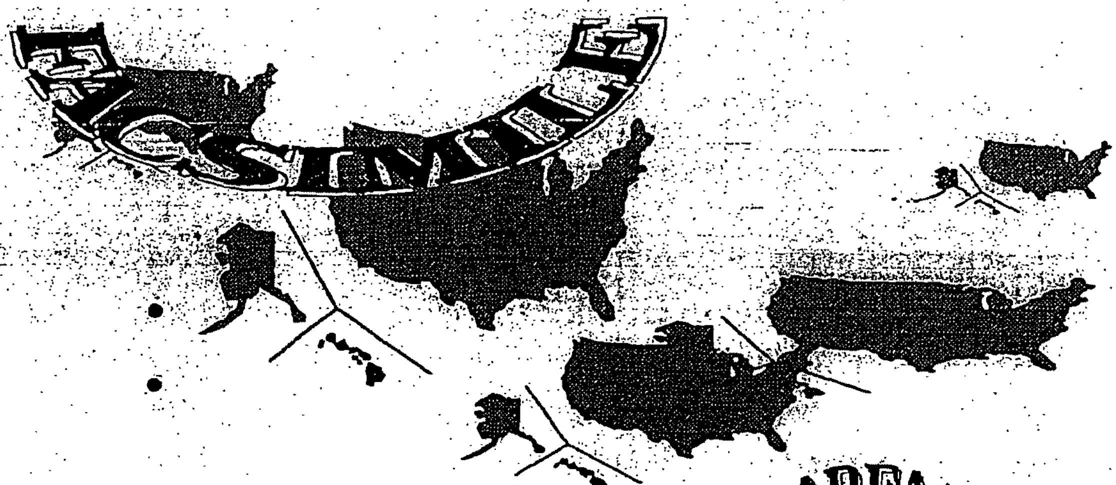

NO. OF PAGES INCLUDING THIS PAGE 2

REF (APPLICATION SER. NO.) 381,081

DATE 11/7/97

TO Crystal Hammond
NAME/ TELEPHONE NO.

COMPANY/FIRM

703 308-2840
FAX NUMBER

FROM John Suraci
NAME

703 305-4009 2415
TELEPHONE NO. / ART UNIT

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REF. (APPLICATION SER. NO.) 381,081

DATE 11/17/97

TO Crystal Hammond
NAME/ TELEPHONE NO.

COMPANY/FIRM

703 308-2840
FAX NUMBER

FROM John Soraci
NAME

703 305-4009 2415
TELEPHONE NO. / ART UNIT

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381081 Nov 21 95
08/677,378 7/5/96
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11/12/97

Brad Armstrong
848 Inyo Street
Chico,CA 95928

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Disclosure Document No.	: 381081
Patent Application No.	: 08/677,378
Group Art Unit	: 2609

Dear : Mr. Brad Armstrong

Per your request, a retention has been applied to the above Disclosure Document referenced in the above patent application. A copy of this letter will be maintained in the file of the patent application, and the Disclosure Document will be forwarded to the Group Art Unit.

Sincerely,

Crystal Hammond
Customer Service Center
Initial Patent Examination Division

10 577 Caves

Commission of Patent and Trademarks
Washington, DC 20231
BOX DD

MAIL ROOM NOV 22 1995 PAT. & TRADEMARK OFF.

DISCLOSURE DOCUMENT NO 381081

Disclosure Document

Name and address of the Inventor:
Brad A. Armstrong
848 Inyo Street
Chico, CA 95928

Dear Sir:

The undersigned, being the Inventor of the disclosed invention, respectfully requests that this Disclosure Document be accepted and retained for at least two years under the Disclosure Document Program, thank you.

The title of the Invention is:
MULTI-AXIS GRAPHICS CONTROLLERS AND COMPONENTS THEREFOR

Respectfully,

Signed *Brad Armstrong* Date: *November 22 1995*
Brad A. Armstrong, Inventor

Enclosures: Disclosure Document filing fee $10.00
Written description of the Invention
Drawings of the Invention
Photographs of the Inventions
Duplicate of this signed cover letter
Postage and addressed return envelope

17 pages written
58 figures
16 photos

CERTIFICATE OF EXPRESS MAILING

Commissioner of Patents and Trademarks
Washington, D. C. 20231
I hereby certify that this Disclosure Document is being deposited with the United States Postal Service as **EXPRESS MAIL**, article number EG313952652US with sufficient postage paid in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D. C. 20231, on this date: Nov. 22, 1995

Signature of one making deposit: *Brad Armstrong*
Brad A. Armstrong, Inventor/Applicant

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Disclosure of Inventions

by Brad Armstrong

November 22, 1995

The following discriptions, figures, and photographs show inventive material related to multiple axes controllers. It is intended to file patent applications immediately concerning the following advances in the art:

1. Mechanical-Pure resolution (sensors individually representative of axes and mechanically resolved without compromise);

2. Sheet sensor structural means;

3. Threshold Tactile (turn on/off) feedback for 3+ degrees of freedom controllers;

4. Keyboard integration for 3+ degrees of freedom controllers;

5. Remote Control integration for 3+ degrees of freedom controllers;

6. Tactile-Pressure Sensor structures;

7. Super Rugged 4+ degrees of freedom controllers for arcade environments, etc.

Please find following some written description of __17__ pages (not including many utility and process claims still to be drafted, and figures numbering __58__ drawings, and photographs of embodiments reduced to practice numbering __16__ photographs.

Thank You,

Brad Armstrong
sole inventor

1. Field of the Invention:

This invention relates to control devices having multiple degrees of freedom to be operated by the human hand. More specifically, the present invention in one form is a six degree of freedom input device for controlling or manipulating graphic images such as are displayed by a computer or television display, a head mount display or any display capable of being viewed or perceived as being viewed by a human.

2. Description of the Prior Art:

Although there are hand manipulated multi-axes and six degree of freedom controllers taught in the prior art, none are structured the same as the present invention, and none offer all of the advantages provided by the present invention due to the substantial structural differences.

In prior art related multi-axes controllers, whether 3, 4, 5 or 6 degrees of freedom, shortcomings exist which the present invention overcomes. Although all of the prior art devices do not include all of the shortcomings to be described, all of the related prior art devices do include one or more of the following substantial problems. One common and substantial problem is cost of manufacture, and this is particularly true for 6 degree of freedom controllers. It is realized that "low-cost" is a somewhat relative term, however the vast majority of consumers do not define controllers having retail sales prices ranging from $180 U.S. dollars up to several thousand U.S dollars as inexpensive or low-cost, and current manufacturing cost is, in my opinion, the single greatest force depriving society of low-cost 6 DOF controllers. To society at large, the truly useful 6 DOF controller will be, I believe, one having superb function and feel, with a very low retail cost to the end user. Another factor, and there are certainly many factors effecting cost of manufacture, is the lack of choice in useful sensors which may be utilized. Sensors of differing types vary widely in cost to the manufacturer, and many related prior art devices appear to be structured in a manner which makes them sensor-type dependant, which clearly has its disadvantages. Yet another factor dramatically effecting cost of manufacture is manual labor content of assembly, and soldering of wiring, etc. All known prior art sensor arrangements, location and orientation of the necessary plurality of sensors, appear to require the labor intensive use of individually insulated conductors (wires) which must be individually stripped, tinned, aligned, connected and then soldered to the sensors and associated circuitry. In most all cases it is highly desirable to reduce labor costs as much as possible since the single largest cost component in many manufactured items is commonly believed to be labor costs. For any controller such as a 6 DOF controller to be truly useful to society, it must be affordable for the common user to purchase.

Another common and substantial problem, and this shortcoming is particularly evident to the user in controllers providing 4 to 6 degrees of freedom, is the lack of definite and positive feedback (other than visual graphical feedback) for alerting the user as to when the controller has translated a hand input into an information output. Since a single 6 DOF controller has multiple sensors and so many axes of input interpretation, absent positive sensor actuation feedback, there exist difficulties of operation and a significant learning curve for a new user of such a device. In my opinion, even an experienced user of such a device would be appreciative of positive sensor actuation feedback.

Another common and substantial shortcoming in the related prior art is the lack of structuring for "pure- separate" interpretation, meaning straight linear hand input from a user's hand to the handle should cause the handle to move in a straight linear motion, with not even a small or significant degree of arcing or rotation of the handle. Pure-separate interpretation is also desirable for rotation inputs as will become apparent upon further reading.

Another common and substantial problem in some related prior art devices exists in structuring requiring complex and un-intuitive hand manipulations by the user. Such devices require the user to perform combined hand and finger (or thumb) manipulations to achieve a desired input. I believe ideal structuring of a controller allows manipulation of a single handle or like member in all six degrees of freedom along and about axes intersecting at a common point approximately central of the handle.

Another common and substantial problem, for a number of reasons, is the lack of mechanical resolution of all possible inputs of the handle into six individual mechanical bi-directional motions each independent of one another and respectively representing handle input along and about three mutually perpendicular axes. The lack of such structuring demands: electronic resolution, thus complex circuitry which increases the cost of manufacture; hand wiring, thus more labor increasing the cost of manufacture; and non-axial return-to-center resiliency, thus prohibiting a satisfactory degree of feedback indicating significant input has been made to control graphics along or about a given axis. Illustrating these problems, a specific prior art device described in U.S.

Patent 4,811,608 issued March 14, 1989 to J. A. Hilton for "Force and Torque Converter". The Hilton device exemplifies the lack of resolution of inputs of the handle into six individual mechanical bi-directional motions. This results in the Hilton device not being able to associate individual sensors and feedback structuring along and about each of the commonly recognized three mutually perpendicular axes.

Other closely related prior art devices of which I am aware, and which exemplify the above discussed shortcomings are described below.

U.S. Patent 4,555,960 issued Dec. 3, 1985 to M. King shows a 6 degree of freedom hand controller exemplifying the lack of "pure separate" interpretations for linear hand input. King's handle moves in a rotational arc when the user's intent is a purely linear input. See King column 4, line 13 - 18. In the King device, this is brought about by a "tilting" shaft 17 supporting the ratable handle. The shaft of King significantly tilts such that absent its tilting, there would be no ability to sense two of the three axes in regards to linear movement or force. Thus, pure-separate interpretation does not exist in the King device. King's controller also appears to be very costly to manufacture, having a large number of arms, bearings, gimbals, cams and connectors, etc., all of which apparently must be hand assembled, and sensors in an arrangement which apparently must be hand wired. Thus, again prohibiting truly low-cost manufacture.

A Great Britain patent application, published 08/07/91, application number GB 2 240 614 A, the applicants being U. A. Dzholdasbekov et al describes a control device capable of up to six axes of input. The Dzholdasbekov et al device exemplifies many problems common to the prior art, such as: lack of positive alerting as to when an input related to a particular axis has been activated; lack of resiliency for providing return-to-center function of the device and force feedback to the user; lack of suitable structuring lending itself to sensor arrangements for eliminating costly hand wiring; and lack of incorporation of all input manipulations into a single operable member (handle). On this last point, the Dzholdasbekov device is structured with two operable members: a rotatable handle and a rotatable thumb wheel, thus requiring complex and often difficult hand manipulations by the user. The user must combine separate hand and finger (or thumb) manipulations to achieve many commonly desired inputs. This may involve the user having to grasp and rotate the handle while simultaneously the handle is being moved linearly, and commonly at the same time having to operate a separate thumb wheel. Input of this type might be mastered with significant practice, but it is desirable to eliminate such complex requirements for the user. I believe, the ideal arrangement allows manipulation of a single handle or like member in all six degrees of freedom along and about axes intersecting at a common point approximately central within the handle. The Dzholdasbekov device also has structuring of sensors which appears to require hand wiring of each individual sensor, thus not allowing for low-cost manufacture.

Other problems associated with related prior art devices include: lack of low profile structuring for integration into computer keyboards and other devices, and ergonomic integration of active tactile feedback (electro-mechanical);

and lack of proper sensor arrangement and circuity for the ready low-cost integration of a multi- axes device into a computer keyboard or hand held remote control device, etc., as will become fully appreciated with further reading.

The above is not an exhaustive listing of shortcomings in the related prior art, nor is it an exhaustive listing of related prior art, but is of the most similar known prior art to the present invention. The above specifically mentioned prior art exemplifies common problems overcome by the present invention. For the sake of briefness, all prior art known to me having the same problem or problems as mentioned above have not been specifically addressed, however, some other related prior art known to me which may be of interest to the reader include U.S. patents: 3,296,882; 3,693,425; 3,771,037; 4,099,409; 4,369,663; 4,420,808; 4,935,728; 4,962,448; 5,128,671; 5,142,931, and 5,252,952.

Therefore, in review of the above mentioned problems embodied in the prior art, there clearly exists a need for further advancement and improvements in the field of multiple axes controllers, especially so regarding controllers for manipulating graphical images through a computer display device, future television screen or any display.

SUMMARY OF THE INVENTION

The following summary and detailed description is of best modes and preferred structures for carrying out the invention, and although there are clearly changes which could be made to that which is specifically herein described and shown in the included drawings, for the sake of briefness of this disclosure, all of these changes which fall within the true scope of the present invention have not herein been detailed.

In order for a user to better manipulate objects and/or navigate a viewpoint within a three-dimensional (3D) graphics environment or display, I have developed an improved hand manipulated multiple axes controller, preferably a six degree of freedom (henceforth "6 DOF") controller for use with a computer or computerized television or the like. The controller provides structuring for converting full 6 DOF operational input provided by a human hand into information states or electrical outputs useful either directly or indirectly for controlling or assisting in controlling graphic images.

The controller establishes readable moment related information states representing operation of a handle (hand manipulable member) along or about three mutually perpendicular axes preferably intersecting one another at a common point proximal to a center of the handle. The three mutually perpendicular axes are commonly referred to in the prior art as x, y and z, or yaw, pitch and roll, and because of varied different interpretations of the relative orientations of those terms, I herein refer to a generic first, second and third axes all mutually perpendicular to one another without regard to prior interpretations of orientation.

For the purpose of this specification and claims, the term "along" connotes linear movement, position or force on or parallel to an axis or combination of axes, and the term "about" connotes rotational movement, position or force (torque) orientation relative to an axis or combination of axes.

The present preferred 3D graphics controller is a hand-operated 6 DOF controller for converting human hand input manipulations into information states usefully representative of the input manipulations.

A preferred structure of the controller includes a housing, a carriage supported for allowing linear movement thereof, a non-tiltable shaft engaged with the carriage, and an exposed handle on the shaft, the handle being movable along and about all combinations of the three axes, thus providing interpretation of 6 DOF.

The controller preferably includes twelve sensors or six pairs of sensors for sensing linear and rotational inputs describing operation of the handle relative to any substantially stationary reference object such as the housing. Preferably each sensor has an associated return- to-center resiliency, and sensor-actuation passive feedback to be felt by the user's hand or heard by the user, or both. The sensor-actuation feedback is for transmitting detectable feedback to a user when the handle is operated sufficiently to actuate any of the sensors so that the user is alerted to the fact he or she has actuated a sensor. The sensor-actuation feedback includes a force feedback threshold which when the threshold is reached, the force feedback rapidly declines, which is felt by the user's hand and naturally understood by the user that a sensor has been actuated. The feedback can also be audible, as in a click-type sound. The rapid decline of the force feedback is readily detectable by the user, and to the user, appears to occur approximately simultaneously with the actuation of the sensor.

The force feedback is essentially a return force of the handle toward a center point (null) when the handle is away from the center point along or about any axis. The force feedback may be perceived by the user as a resistance to movement of the handle away from the center point. The force feedback additionally can serve as the handle return-to-center resilient structure. Additionally, the preferred structure provides a null region having a small amount of play or space along and about each axis wherein tolerance of the small inaccuracies of the human hand are accommodated absent unintended sensor actuation by the user. Preferably, the null region is in part provided by the return-to-center resilient structure and in combination with the particular sensor configuration, i.e., six pairs or twelve sensors which equates to a sensor pair or two sensors for bidirectional linear interpretation along each axis, and a sensor pair or two sensors for bi-directional rotational interpretion about each axis.

In one preferred 6 DOF embodiment the carriage supports eight sensors and the associated necessary electrical traces on a sheet surface at least in part within the housing. Rocker-style sensor activators, which are manufactured inexpensively by plastic injection molding, translate motion of the shaft relative to the carriage and motion of the carriage relative to the housing, to the eight sensors. The four remaining sensors and associated electrical traces, and possibly some desireable additional sensors such as for selection or fire buttons, may be supported upon a sheet surface at least in part within the handle. One preferred sheet surface is a generally rigid circuit board. Another preferred sheet surface is a multi-layer non-electrically conductive plastic structure having printed or otherwise supported electrically conductive sensors and associated screened or printed circuitry as is now commonly used in many computer keyboards. The electrically conductive sensors may be contacts defining on/off switches, or variable output sensors such as pressure sensitive resistors as are being developed by myself. The sheet supported sensors of the preferred embodiment allow ready low-cost integration into a modern computer keyboard, hand-held remote, stand alone controller or other like structure.

The sensors are positioned for sensing moment of the handle relative to the housing and creating moment related information usefully indicative of the handle status relative to the housing.

For the purposes of this specification and claims, the term "moment" is being utilized as meaning status, or direction, indicated in terms of either position or pressure. Moment is primarily an indication of the status of the handle: what direction it is moved, and in that direction how far positionally it is moved, or how intensely it is pressed relative to the housing. These terms defining "moment" are somewhat dependent upon type and sophistication of the sensors utilized, and a variety of sensors may be utilized with the present invention. For example, simple on-off contact sensors indicate the direction moved but only if moved a significant amount positionally sufficient to activate the sensor, and the on-off contact sensor provides information describing whether significant movement has been made or not, which in either case is valuable and useful information in part establishing the information state of the controller. More sophisticated proportional sensors such as variable resistive pressure sensors, or potentiometers and optical positional sensors, indicate direction and position or force. A pressure sensitive sensor provides information describing direction and intensity of handle movement or pressure relative to the housing, thus in part establishing the information state of the controller. Additionally, some types of proportional sensors coupled with return-to-center resilient structure may respond to a combination of position and pressure with one characteristic being dominant or more meaningful to output. The term "moment" is essentially a word indicating a significant event, status, current position, and/or pressure exerted.

For the purposes of this specification and claims, the term "sensor" or "sensors" is considered to include but not be limited to variable resistive pressure sensors, proximity sensors; capacitive sensors, piezo sensors, variable voltage/amperage limiting or amplifying sensors and switches, potentiometers, resistive and optical encoders and simple on/off switches.

For the purposes of this specification and claims, the terms "significant" or "significantly" are defined as being sufficient and necessary movement or force to actuate a sensor, excluding simple part tolerance or clearance for allowing desired movement of mechanical parts. For example, if a shaft must tilt in order to actuate a sensor, then that shaft is said to be "significantly" tiltable, and alternatively if a shaft tilts slightly due to part clearances (tolerances) and is not designed or required to tilt in order to actuate a sensor, then the shaft is "significantly" non-tiltable.

OBJECTS AND ADVANTAGES

With the present invention, there exists no requirement that the housing be moved, unlike a 6 DOF glove for example, and this aspect renders many advantages, these advantages being enhanced by the use of sheet surface supported or defined sensors in many applications. For example, the movable carriage supporting the handle may be built into or attached onto an otherwise conventional computer keyboard; built into a hand held television style wireless remote control device; built into the arm of a chair, or it may be built into a housing specific for the carriage and handle, and one which is structured to rest upon a support surface such as a table or desk when utilized to serve as a stand-alone or peripheral unit, etc.

The present invention while offering superior function and feel to the user, also allows replacement of higher cost components and labor for much lower component and labor costs, as the high cost of related devices has been a problem for sales of prior art devices to the average computer user, and the average television viewer. The preferred mounting or defining of sensors on a sheet surface allows utilizing highly automated and efficient modern manufacturing processes which eliminate or greatly reduce the requirement of hand applied individually insulated conductors (wires). For a 6 DOF controller to be truly useful to society, it must be affordable for the common user to purchase. As will become increasingly appreciated with continued reading, the present invention is structured to offer superior function and feel to the user at very low-cost.

The use of sheet surface supported or defined sensors allows the controller to have a low profile, and further particularly in regard to the handle, allows for the installation of an electro-mechanical device such as a motor or solenoid within the handle to provide non-passive feedback to the user without rendering the handle excessively large or akward.

A primary object of the invention is to provide an improved hand manipulated 6 DOF controller primarily for use in controlling or at least assisting in controlling graphic images such as those displayed by a computer, television display, head mount display or heads-up display, and the like.

check the below object for accuracy and consistency pertaining to the use of "pure" in the above prior art section.*

A further object of the invention is to provide a 6 DOF controller which includes structuring allowing pure separate interpretations for the linear related information states to represent only linear hand input, not including even a small or significant degree of arcing or rotational hand input. Likewise the structuring allowing for the rotational related information states to represent only rotational hand input, not including even a small or significant degree of linear movement hand input. Clearly, a 6 DOF controller having "pure-separate" function is preferable so as to provide a "true" 6 DOF controller absent cross-talk and cross-coupling related problems.

A further object of the invention is to provide a 6 DOF controller which allows for the application and advantage of sensor choice. This invention is an input device that has physical manifestations that can stimulate any of various types of useful sensors. The invention can be constructed with sensors as inexpensive as simple electrical contacts or more sophisticated proportional sensors such as positional or pressure reading sensors, or the like.

A further object of the invention is to provide a 6 DOF controller which preferably includes resilient structuring providing a self centering or return to a center null position of the controller structuring regarding linear movements, and further, wherein there exists a small degree of "play" between sensor activation which helps compensate or provide a degree of forgiveness for small unintentional hand movements on the controller.

A further object of the invention is to provide a 6 DOF controller which preferably includes a detectable feedback, felt by the user's hand or possibly audibly detected, which indicates that the handle has moved sufficiently from the null position to activate a given sensor.

A further object of the invention is to provide a multi-axis controller which can also be useful as an improved two or three axis controller in addition to or replacing the function of the arrow keypad on a typical computer keyboard and also possibly the page-up and page- down keys of the keyboard.

A further object of the invention is to provide a 6 DOF controller which preferably includes structuring which may be manufactured utilizing modern and efficient techniques and components so as to achieve low-cost manufacturing.

Another object of the invention in furtherance of achieving low cost manufacturing is providing sheet supported sensors in either a multiple layer membrane sensor structure or alternatively efficient use of circuit board supported sensors, thus greatly reducing or eliminating labor intensive, high cost hand wiring.

Another object of the invention in furtherance of achieving low-cost manufacturing is provided by use of sheet supported sensors which allow extremely low-cost integration of a multiple axes controller into devices already having onboard intelligent circuitry such as computer keyboards and hand held remote control devices. Many keyboards typically already use membrane supported sensor layouts which can be readily modified to accommodate the current invention, thus the invention can be incorporated into such a keyboard or device for little more than the cost of a few small injection molded parts.

These, as well as further objects and advantages of the present invention will become better understood upon consideration of the remaining specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an exploded perspective view a first preferred embodiment of the invention.

Fig. 2 is a side view in partial cross section of the first embodiment.

Fig. 3 being of the first embodiment, is a perspective view of a portion of the carriage, shaft, a shaft pin, rocker-arm actuators, sheet surface with sensors, the sensors being hidden under force feedback dome caps.

Fig. 4 illustrates a first configuration of rocker- arm actuator positioned to actuate two different types of sensors shown for illustrative purposes. Fig. 5 illustrates a second configuration of rocker- arm actuator indirectly coupled to the lower end of the shaft and positioned to be capable of actuating two sensors.

Fig. 6 illustrates a third configuration of rocker- arm actuator indirectly coupled to the lower end of the shaft and positioned to be capable of actuating two sensors.

Fig. 7 illustrates a portion of the carriage from a top viewing showing optional rocker-arm lay-out involving a forth type rocker-arm actuator.

Fig. 8 being a simplified view, shows a partial cross section of the lower portion of the carriage of Fig. 7 from a side view showing operation of the forth type rocker-arm actuator.

Fig. 9 shows an exploded view of the handle at the upper end of the shaft.

Fig. 10 shows a perspective view of a multiple-layer membrane sheet surface supporting a plurality of sensors and conductive traces, and custom shaped to integrate a 6 DOF controller into a computer keyboard or hand held remote control.

Fig. 11 shows a typical prior art computer keyboard having an arrow keypad.

Fig. 12 shows modified computer keyboard with a multiple-axes controller replacing the arrow keypad.

Fig. 13 shows in a perspective view, a stand-alone peripheral multi-axes controller generally in accordance with present invention and with an optional ergonomic design shown in broken lines.

Fig. 14 shows a hand held remote control device with an integrated multi-axes controller.

Fig. 15 shows the first, second and third axes mutually perpendicular to one another, and intersecting one another proximal to a center of the handle.

Fig. 16 shows a bifurcating metal sensor in cross section and in an open state (off).

Fig. 17 shows the sensor of Fig. 16 in an actuated or closed state (on).

Fig. 18 shows a cross sectional view of a dome cap on a circuit board having interlaced conductive traces to be closed by a conductive disk inside of the dome cap.

Fig. 19 shows in cross section, a three layer membrane defining a single momentary-on switch structure, the switch in the open state (off).

Fig. 20 shows in cross section, a three layer membrane defining a single momentary-on switch structure in the closed state (on).

Fig. 21 shows a standardized right-angle mount mechanical momentary-on switch, shown in partial cross section.

Fig. 22 shows a version of the switch of Fig. 21, only in a flat mount position, and modified to include a pressure sensitive variable resistor component.

Fig. 23 shows a circuit board in cross section, supporting interlaced conductive traces contacting a pressure sensitive variable resistor component.

Fig. 24 shows in cross section, a commonly available pressure resistive sensor in plastic sheet membrane with a resilient dome cap actuator.

Fig. 25 shows yet another sensor, being a three layer membrane including a pressure sensitive variable resistor component sandwiched between opposing electrical traces on the two outer membranes.

Fig. 26 shows the sensor of Fig. 25 in an actuated state.

Fig. 27 shows a portion of the carriage having two bi-directional slide potentiometers.

Fig. 28 shows a modified rocker-arm actuator driving a geared bi-directional rotary potentiometer.

Fig. 29 shows a modified rocker-arm actuator driving a bi-directional optical sensor. Fig. 30 shows a partial view of sensors within the handle showing one version of a geared bi-directional potentiometer on one axis, and on a second axis is a bi-directional sliding optical sensor.

Fig. 31 shows a partial cross section of a second preferred embodiment from a side view.

Fig. 32 shows a perspective view of the lower end of the shaft of the second embodiment.

Fig. 33 shows a side view of the lower end of the shaft of the second embodiment.

Fig. 34 shows a perspective bottom view of the carriage with sensors of the second embodiment.

Fig. 35 shows a graph of a common prior art force feedback.

Fig. 36 shows a graph of another prior art force feedback.

Fig. 37 shows a graph representing a force feedback having a threshold useful in the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

Although I herein very specifically describe best modes and preferred structures and use of the invention, it should be understood that many changes in the specific structures and modes described and shown in my drawings may clearly be made without departing from the true scope of my invention.

One preferred embodiment is shown in figures 1-9. Referring to Figure 1, a hand manipulatable handle 100 is shown supported on a shaft 102. Shaft 102 extends into a base assembly or housing 217. Shaft 102 passes thru a shaft guide first main hole106 within a sliding plate or platform called a first platform 352. Shaft 102 further passes thru a shaft guide second main hole 110 located in a second platform 222. Figure 2 shows Platform 222 fixedly attached to connecting structure shown as legs 112 which are fixed to first platform 352, thus platform 222, connecting structure 112 and platform 223 cooperate together forming the structure of a carriage 114.

First platform 352 is slidably retained along a first axis by a sliding plate called an anti-rotating plate 350 which is slidably retained along a second axis by at least one housing guide 108 which is fixed to housing 217. First platform 352 and plate 350 are further constrained by retaining shelf 216 and housing 217 from movement along a third axis. Thus plate 350, guide 108, housing 217, and shelf 216 cooperate to form a carriage support structure 116 in which platform 352 (and thus also carriage 114) is prohibited from significantly rotating on any axis, and also is allowed to move significantly along the first and second axes but is prohibited from significant movement along the third axis, relative to housing 217.

Within carriage 114, and platforms 352, 222, holes 106, 110 cooperate to offer sufficient fit in the passage of shaft 102 to provide advantageous structural cooperation in two substantial ways. The first is the provision of an anti-tilting structure124 which prevents shaft 102 from significant tilting (rotating about the first or second axes) relative to carriage 114. The second is provision of two-axes structure where any and all linear movement along parallel to the first and second axes by shaft 102 is coupled to equivalent movement along parallel to the first and second axes of carriage 114.

A second endward region 120 of shaft 102 as shown in figure 2 is shaped with a male partial spherical shape 218 which slideably contacts a complimentary female partial spherical shape 240 which is part of handle 100, and region 120 of shaft 102 also comprises a male pivot protrusion 246 having a pivot or rotational point located approximately central to handle 100 and approximately at the center of the spherical partial section shapes. Protrusion 246 provides a handle 100 pivot point and may mate to a female pivot receptacle 248. Thus handle 100 can be rotational relative to shaft 102 yet coupled for all linear movement along parallel to the first and second axes with equivalent linear movement of shaft 102 and also two-axes structure 126, therefore the above mentioned members connecting handle 100 to shaft 102 and shaft 102 to carriage

114 serve as a handle support structure 128 in which handle 100 is coupled for equivalent movement with carriage 126 along parallel to the first and second axes.

On carriage 114 are rocker-arm structures 124 shown mounted on second platform 222. Rocker-arm structures 124 convert movement of carriage 114 relative to housing 217 to a resilient thermoplastic rubber (TPR) sheet 128 formed with a plurality of resilient dome cap 128 structures. Resilient sheet 126 and second platform 222 sandwich sensors as shown in Figs. 1-3 and others, as a membrane sensor sheet structure130. Rocker-arm structures 124 have at least a mounting structure 132, a fulcrum 134, at least one sensor acutating arm 136, and an activating structure 138. Structure 138 is the distinctive part of the different two armed rocker-arm types shown in Figures 1 and 3, of which are a V-slot type 140, an H-slot type 142, and a T-bone type of which there are two rocker-arms being approximately identical but oriented perpendicular to one another and being called a first t-bone 144 and a second t-bone 146 rocker-arm actuators. Figure 7 shows the space savings in the area of second platform 222 which also may be a rigid circuit board sheet? This space savings may be valuable in tightly constricted areas such as integration of the invention into computer keyboards and hand held remote control devices. The second platform 222 layout of Figures 1-3 is shown in the larger dotted line? with the newer smaller platform 222 shown by solid line ? and first t-bone rocker-arm has been divided into two separate one-armed type ? actuators each with its own mount 132, fulcrum 134, sensor arm 136, and activating part 138 as shown in figure 8.

Understanding the action of one rocker-arm structure conveys much understanding of all rocker-arm structures to one skilled in the art, so in the interest of brevity rocker-arm structure and functionality will only focus on the unique parts of each different rocker-arm structure.

A shaft pin 122 is fixed within shaft 102 passing thru a first endward region 118 approximately perpendicular to shaft 102. A first end of shaft pin 122 passes thru a beveled slot within activating structure 132 of rocker-arm H-slot type 142 in which the slot is approximately perpendicular to the third axis and the length of shaft 102, so that when shaft 102 and shaft pin 122 move along the third axis rocker-arm 142 in moved in kind with one arm descending to compress its respective resilient dome cap 128 and upon collapse of dome cap 128 the respective underlying sensor is acutated, as shown in figure 5. Of course movement of shaft 102 in the opposite direction along the third axis likewise actuates the opposite complimentary sensor of the sensor pair. Rotation within operational limits of shaft 102 about its cylindrical center or approximately about the third axis simply causes shaft pin 122 to move within the slot and does not activate the H-type rocker-arm 142.

A second end of shaft pin 122 passes thru a slot of a rocker-arm structure of the V-slot type 140 which is activated in the converse of the above type 142 rocker arm Movement of shaft 102 along the third axis simply causes shaft pin 122 to move within the slot and not actuate V-type rocker-arm 140, but rotation about the third axis causes shaft pin 122 to activate rocker-arm 140 in the corresponding manner as shown in figure 6 with dashed lines indicating a rotational motion of shaft 102 conveyed to shaft pin 122 which activates rocker-arm 140 causing compression of a dome cap and stimulation of a sensor located on a membrane. Figure 3 shows activating part 138 of rocker-arm 140 to have a slot in structure slanting away from shaft 102. This is to accomodate the increasing moment arm as pin 122 changed distance from fulcrum 134 when shaft 102 is moved along the third axis. Thus the slope of slot compensates for varying distance of shaft pin 122 so that rotation of shaft about the third axis causes rotationally equivalent activation of rocker-arm 140 regardless of the distance shaft pin 122 is from fulcrum 134 of rocker-arm 140.

Although I have very specifically described best modes and preferred structures and use of the invention, it should be understood that many changes in the specific structures and modes described and shown in my drawings may clearly be made without departing from the true scope of the invention.

Abstract of the Disclosure

A hand-operated graphics controller having up to six degrees of freedom (6 DOF) for converting human hand input manipulations of a handle into electrical information states representative of the input manipulations. A preferred embodiment includes the handle operable relative to a housing. Handle operation is mechanically resolved to twelve sensors or six pairs of sensors for bidirectional interpretion of handle movement along and rotation about three mutually perpendicular axes, with each sensor pair being distinctly associated with a motion along or rotation about its respective axis. A null or space is provided between the sensors of each sensor pair for allowing a small amount of movement potential along and about each of the three axes before actuation of a sensor. Each sensor pair having associated return-to-center resiliency and sensor-actuation feedback to be detected by the user upon activation of a sensor. Low profile structuring and sheet supported sensors allow ready low-cost integration into a keyboard and other devices such as a hand-held remote control unit, etc. Preferred structures allow for "pure-separate" interpretation to provide a true 6 DOF controller. The invention offers superior function and feel to the user and also innovative structuring for low-cost manufacture.

10 - 77 Gaines

Commission of Patent and Trademarks
Washington, DC 20231
BOX DD

DISCLOSURE DOCUMENT
NO 381081

Disclosure Document

Name and address of the Inventor:
Brad A. Armstrong
848 Inyo Street
Chico, CA 95928

Dear Sir:

The undersigned, being the Inventor of the disclosed invention, respectfully requests that this Disclosure Document be accepted and retained for at least two years under the Disclosure Document Program, thank you.

The title of the Invention is:
MULTI-AXIS GRAPHICS CONTROLLERS AND COMPONENTS THEREFOR

Respectfully,

Signed [signature] Date: November 22 1995
Brad A. Armstrong, Inventor

Enclosures:
- Disclosure Document filing fee $10.00
- Written description of the Invention
- Drawings of the Invention
- Photographs of the Inventions
- Duplicate of this signed cover letter
- Postage and addressed return envelope

17 pages written
58 figures
16 photos

CERTIFICATE OF EXPRESS MAILING

Commissioner of Patents and Trademarks
Washington, D. C. 20231
I hereby certify that this Disclosure Document is being deposited with the United States Postal Service as **EXPRESS MAIL**, article number EG313952652US with sufficient postage paid in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D. C. 20231, on this date: Nov. 22, 1995

Signature of one making deposit: [signature]
Brad A. Armstrong, Inventor/Applicant

120 DB 01/30/96 ARMSTRONG B 3 577 10.00 CK

Disclosure of Inventions

by Brad Armstrong

November 22, 1995

The following discriptions, figures, and photographs show inventive material related to multiple axes controllers. It is intended to file patent applications immediately concerning the following advances in the art:

1. Mechanical-Pure resolution (sensors individually representative of axes and mechanically resolved without compromise);

2. Sheet sensor structural means;

3. Threshold Tactile (turn on/off) feedback for 3+ degrees of freedom controllers;

4. Keyboard integration for 3+ degrees of freedom controllers;

5. Remote Control integration for 3+ degrees of freedom controllers;

6. Tactile-Pressure Sensor structures;

7. Super Rugged 4+ degrees of freedom controllers for arcade environments, etc.

Please find following some written description of __17__ pages (not including many utility and process claims still to be drafted, and figures numbering __58__ drawings, and photographs of embodiments reduced to practice numbering __16__ photographs.

Thank You,

Brad Armstrong
sole inventor

2

1. Field of the Invention:

This invention relates to control devices having multiple degrees of freedom to be operated by the human hand. More specifically, the present invention in one form is a six degree of freedom input device for controlling or manipulating graphic images such as are displayed by a computer or television display, a head mount display or any display capable of being viewed or perceived as being viewed by a human.

2. Description of the Prior Art:

Although there are hand manipulated multi-axes and six degree of freedom controllers taught in the prior art, none are structured the same as the present invention, and none offer all of the advantages provided by the present invention due to the substantial structural differences.

In prior art related multi-axes controllers, whether 3, 4, 5 or 6 degrees of freedom, shortcomings exist which the present invention overcomes. Although all of the prior art devices do not include all of the shortcomings to be described, all of the related prior art devices do include one or more of the following substantial problems. One common and substantial problem is cost of manufacture, and this is particularly true for 6 degree of freedom controllers. It is realized that "low-cost" is a somewhat relative term, however the vast majority of consumers do not define controllers having retail sales prices ranging from $180 U.S. dollars up to several thousand U.S dollars as inexpensive or low-cost, and current manufacturing cost is, in my opinion, the single greatest force depriving society of low-cost 6 DOF controllers. To society at large, the truly useful 6 DOF controller will be, I believe, one having superb function and feel, with a very low retail cost to the end user. Another factor, and there are certainly many factors effecting cost of manufacture, is the lack of choice in useful sensors which may be utilized. Sensors of differing types vary widely in cost to the manufacturer, and many related prior art devices appear to be structured in a manner which makes them sensor-type dependant, which clearly has its disadvantages. Yet another factor dramatically effecting cost of manufacture is manual labor content of assembly, and soldering of wiring, etc. All known prior art sensor arrangements, location and orientation of the necessary plurality of sensors, appear to require the labor intensive use of individually insulated conductors (wires) which must be individually stripped, tinned, aligned, connected and then soldered to the sensors and associated circuitry. In most all cases it is highly desirable to reduce labor costs as much as possible since the single largest cost component in many manufactured items is commonly believed to be labor costs. For any controller such as a 6 DOF controller to be truly useful to society, it must be affordable for the common user to purchase.

Another common and substantial problem, and this shortcoming is particularly evident to the user in controllers providing 4 to 6 degrees of freedom, is the lack of definite and positive feedback (other than visual graphical feedback) for alerting the user as to when the controller has translated a hand input into an information output. Since a single 6 DOF controller has multiple sensors and so many axes of input interpretation, absent positive sensor actuation feedback, there exist difficulties of operation and a significant learning curve for a new user of such a device. In my opinion, even an experienced user of such a device would be appreciative of positive sensor actuation feedback.

Another common and substantial shortcoming in the related prior art is the lack of structuring for "pure- separate" interpretation, meaning straight linear hand input from a user's hand to the handle should cause the handle to move in a straight linear motion, with not even a small or significant degree of arcing or rotation of the handle. Pure-separate interpretation is also desirable for rotation inputs as will become apparent upon further reading.

Another common and substantial problem in some related prior art devices exists in structuring requiring complex and un-intuitive hand manipulations by the user. Such devices require the user to perform combined hand and finger (or thumb) manipulations to achieve a desired input. I believe ideal structuring of a controller allows manipulation of a single handle or like member in all six degrees of freedom along and about axes intersecting at a common point approximately central of the handle.

Another common and substantial problem, for a number of reasons, is the lack of mechanical resolution of all possible inputs of the handle into six individual mechanical bi-directional motions each independent of one another and respectively representing handle input along and about three mutually perpendicular axes. The lack of such structuring demands: electronic resolution, thus complex circuitry which increases the cost of manufacture; hand wiring, thus more labor increasing the cost of manufacture; and non-axial return-to-center resiliency, thus prohibiting a satisfactory degree of feedback indicating significant input has been made to control graphics along or about a given axis. Illustrating these problems, a specific prior art device described in U.S.

Patent 4,811,608 issued March 14, 1989 to J. A. Hilton for "Force and Torque Converter". The Hilton device exemplifies the lack of resolution of inputs of the handle into six individual mechanical bi-directional motions. This results in the Hilton device not being able to associate individual sensors and feedback structuring along and about each of the commonly recognized three mutually perpendicular axes.

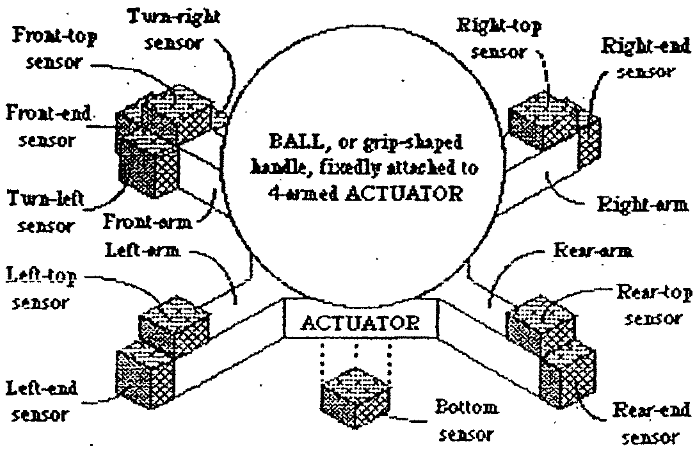
Other closely related prior art devices of which I am aware, and which exemplify the above discussed shortcomings are described below.

U.S. Patent 4,555,960 issued Dec. 3, 1985 to M. King shows a 6 degree of freedom hand controller exemplifying the lack of "pure separate" interpretations for linear hand input. King's handle moves in a rotational arc when the user's intent is a purely linear input. See King column 4, line 13 - 18. In the King device, this is brought about by a "tilting" shaft 17 supporting the ratable handle. The shaft of King significantly tilts such that absent its tilting, there would be no ability to sense two of the three axes in regards to linear movement or force. Thus, pure-separate interpretation does not exist in the King device. King's controller also appears to be very costly to manufacture, having a large number of arms, bearings, gimbals, cams and connectors, etc., all of which apparently must be hand assembled, and sensors in an arrangement which apparently must be hand wired. Thus, again prohibiting truly low-cost manufacture.

A Great Britain patent application, published 08/07/91, application number GB 2 240 614 A, the applicants being U. A. Dzholdasbekov et al describes a control device capable of up to six axes of input. The Dzholdasbekov et al device exemplifies many problems common to the prior art, such as: lack of positive alerting as to when an input related to a particular axis has been activated; lack of resiliency for providing return-to-center function of the device and force feedback to the user; lack of suitable structuring lending itself to sensor arrangements for eliminating costly hand wiring; and lack of incorporation of all input manipulations into a single operable member (handle). On this last point, the Dzholdasbekov device is structured with two operable members: a rotatable handle and a rotatable thumb wheel, thus requiring complex and often difficult hand manipulations by the user. The user must combine separate hand and finger (or thumb) manipulations to achieve many commonly desired inputs. This may involve the user having to grasp and rotate the handle while simultaneously the handle is being moved linearly, and commonly at the same time having to operate a separate thumb wheel. Input of this type might be mastered with significant practice, but it is desirable

// Sensor Arrangement and Naming

Figure 46

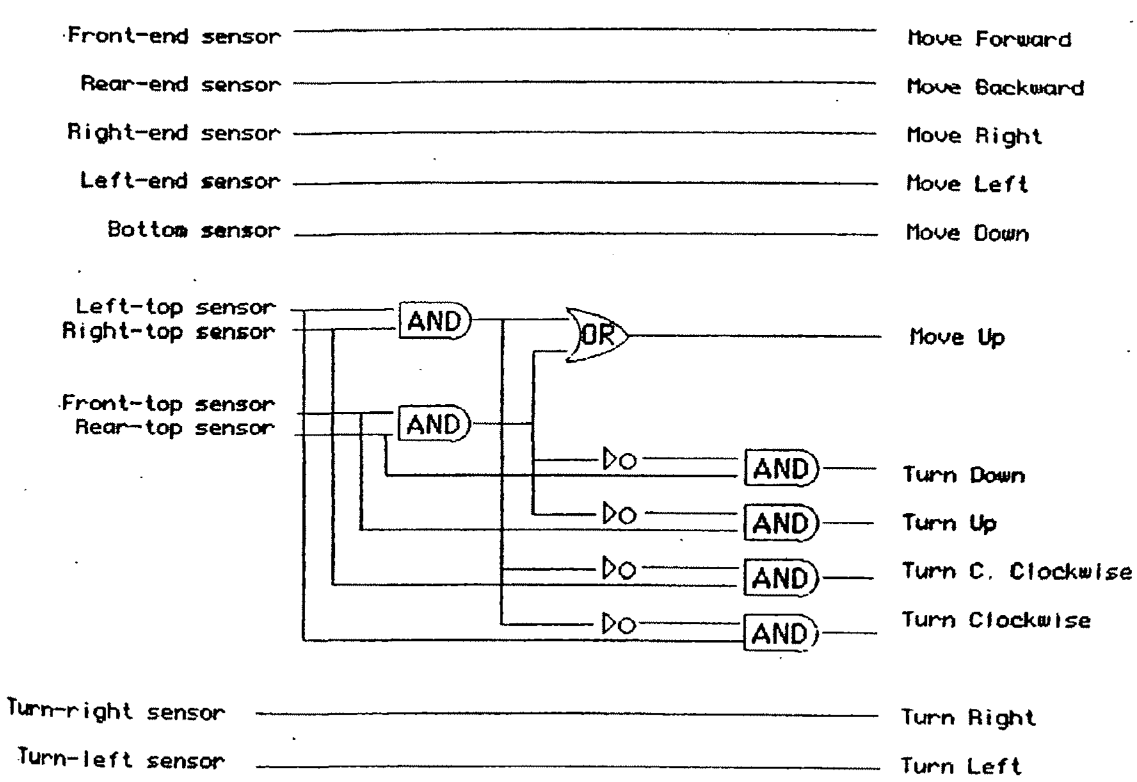


L	L	L	L	H	H	H	H	H	L	H	H	L	L	Left-top sensor
L	L	L	H	L	H	H	H	L	H	L	L	H	H	Right-top sensor
L	L	H	L	L	H	H	L	H	H	H	L	L	H	Front-top sensor
L	H	L	L	L	H	L	H	H	H	L	H	H	L	Rear-top sensor

Turn C. Clockwise & Turn Up
Turn C. Clockise & Turn Down
Turn Clockwise & Turn Down
Turn Clockwise & Turn Up
Move Up & Turn Clockwise
Move Up & Turn C. Clockkwise
Move Up & Turn Down
Move Up & Turn Up
Move Up
Turn Clockwise
Turn C. Clockwise
Turn Upwards
Turn Downwards
No Action

FIG. 47

FIG. 48


Front-end sensor
Move Forward
Rear-end sensor
Move Backward
Right-end sensor
Move Right
Left-end sensor
Move Left
Bottom sensor
Move Down
Left-top sensor
Right-top sensor
AND
OR
Move Up
Front-top sensor
Rear-top sensor
AND
AND
Turn Down
AND
Turn Up
AND
Turn C. Clockwise
AND
Turn Clockwise
Turn-right sensor
Turn Right
Turn-left sensor
Turn Left

Flat lay out of membrane sensor sheet to accommodate 3 space constellation of sensor arrangement

could be almost any shape flexible sensor membrane sufficient to adhere or fix sensors in correct position

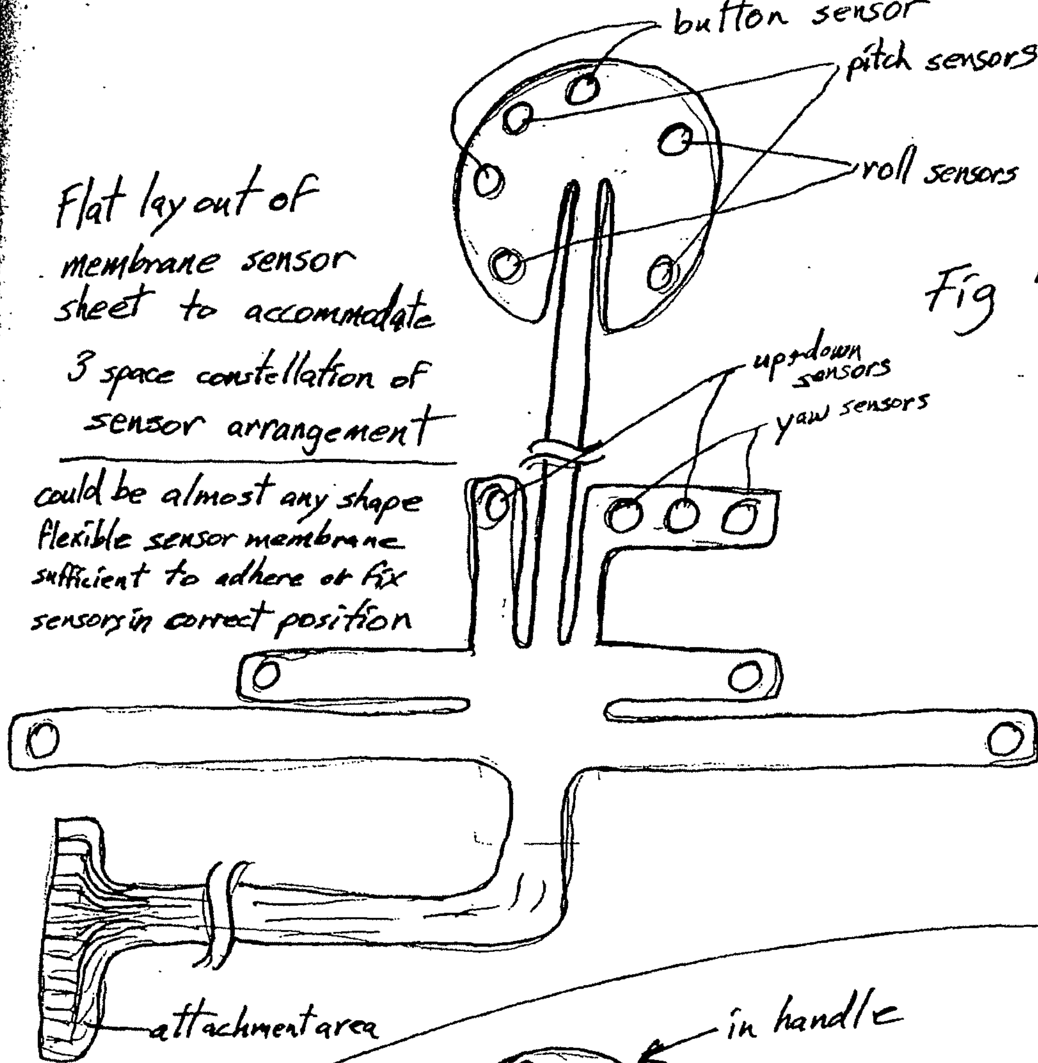
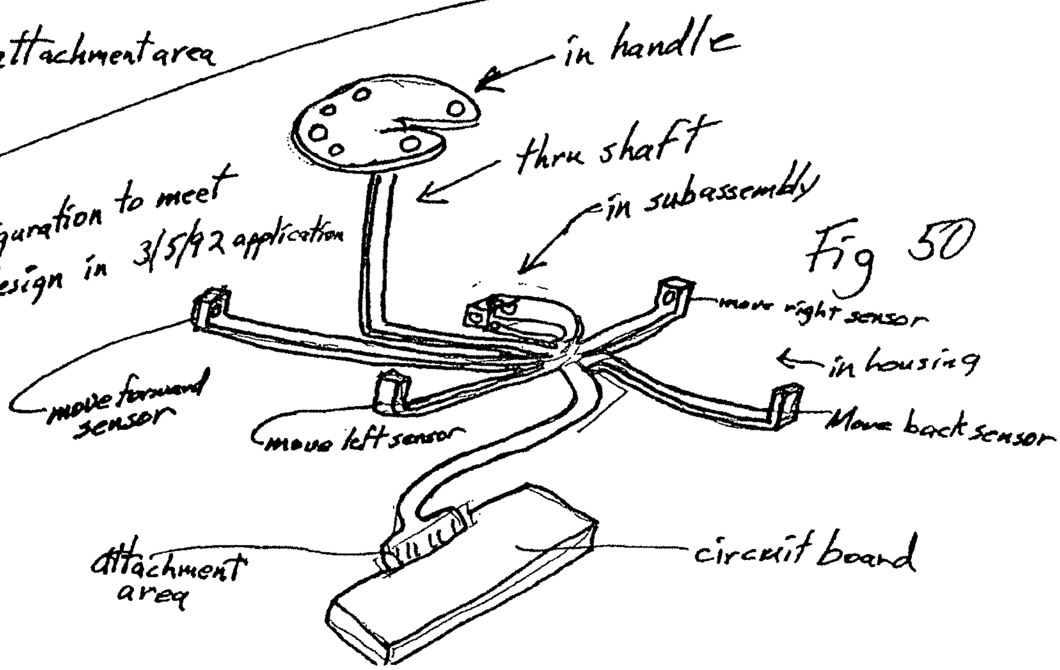


Fig 49



rough configuration to meet my structural design in 3/5/92 application

Fig 50

Some Tactile Pressure Sensor Types

Sensor mediums		Tactile Resiliency: Metallic dome (non conducting)	Metallic dome (conducting)	TPR dome (Non Conductive)	TPR dome (conductive element)
Membrane	single surface traces	X	X 1 layer	X	X 1 layer
Membrane	two surface traces	X	✓	X	✓
Membrane	single surface traces w/ 2nd surface conductive cap	X	✓	X	✓
Membrane	5 layer switched + pressure	X	X as 3 layer	X	X 3 layer
Circuit board	Interdigitated traces – cond. cap	X	X	X	X
Circuit board	Interdigitated traces – no cap	X	X	X	X
Circuit board	Bilateral outside ring trace		X		X
Package	Interdigitated traces – cond. cap	X	X	X	X
Package	Interdigitated traces – no cap	X	X	X	X
Package	Bilateral outside ring trace		X		X

X = inherent usefulness
✓ = overkill

Fig 51

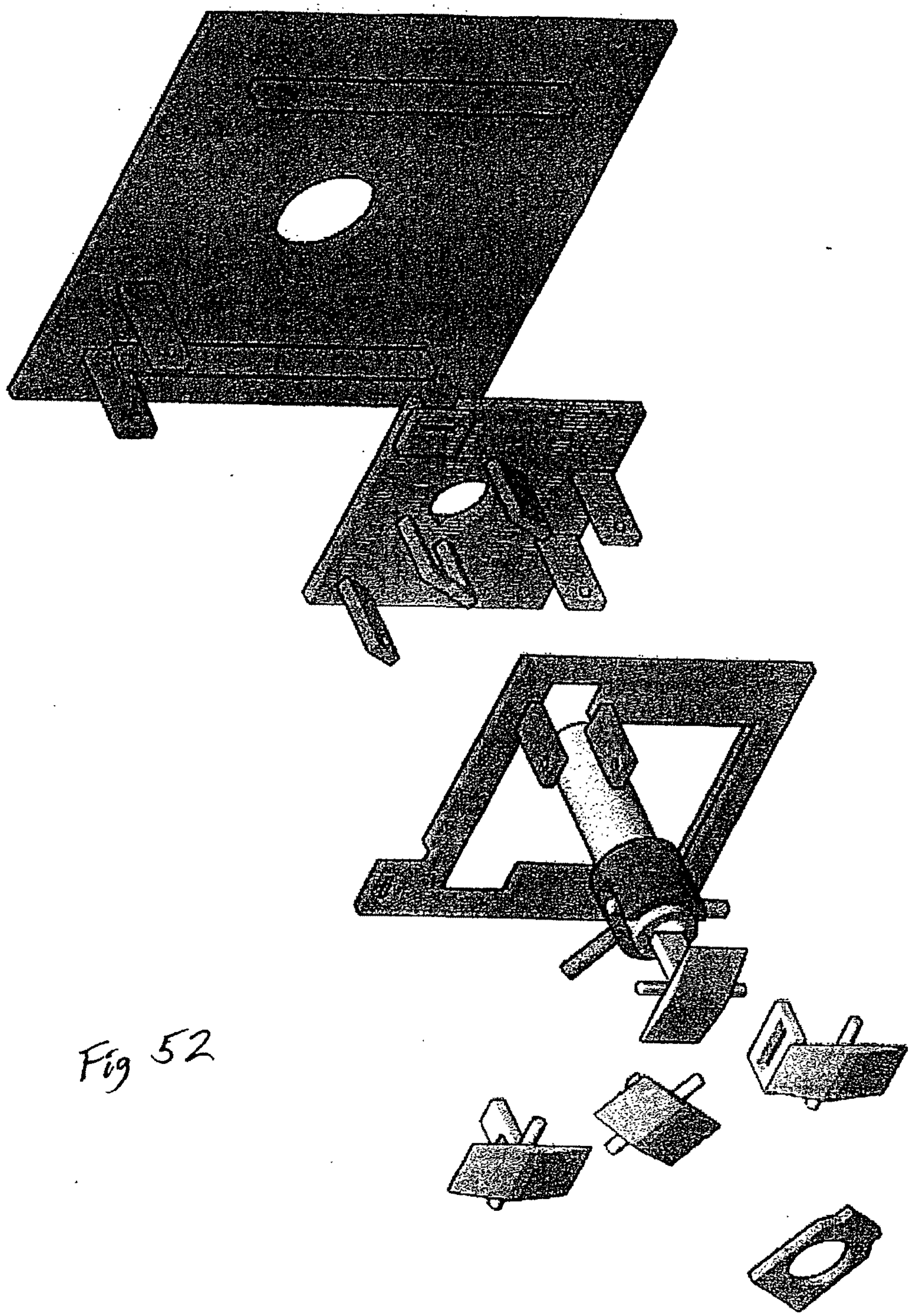


Fig 52

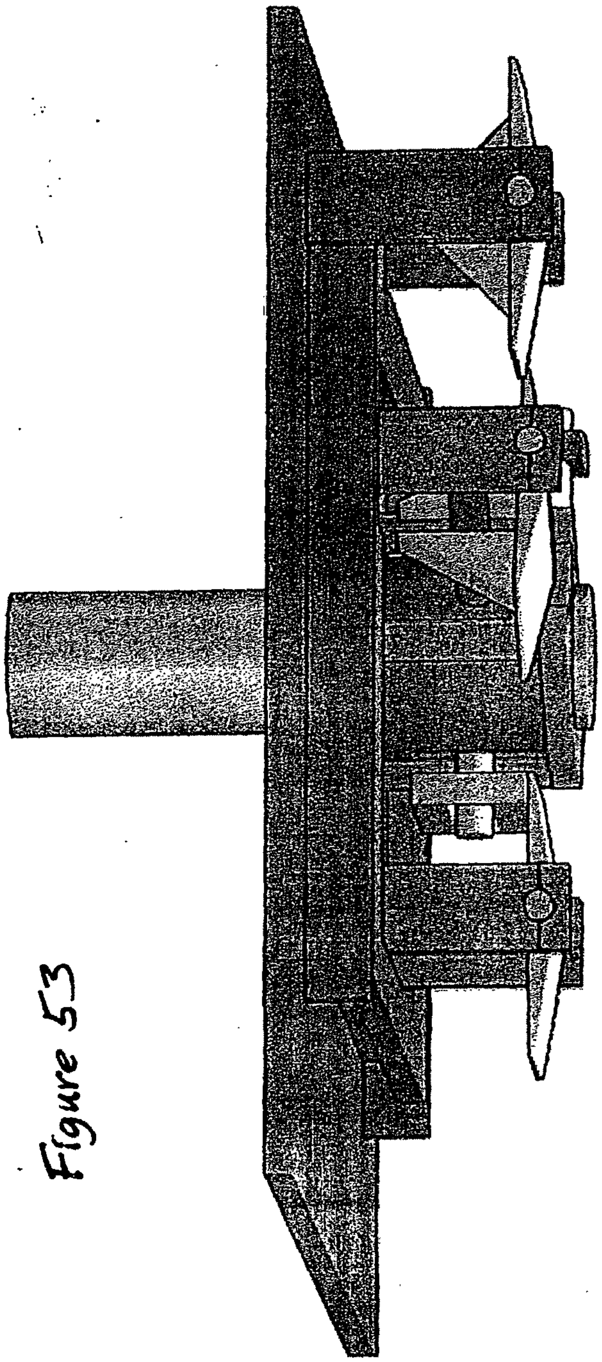


Figure 53

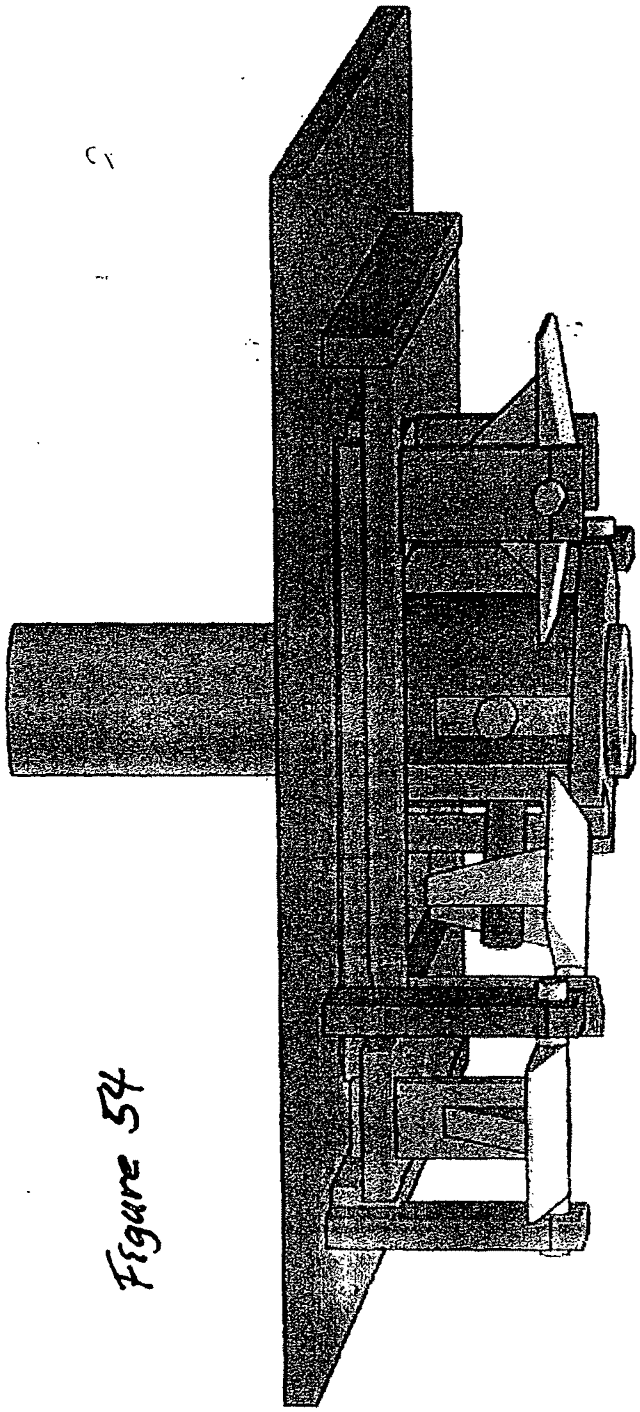


Figure 54

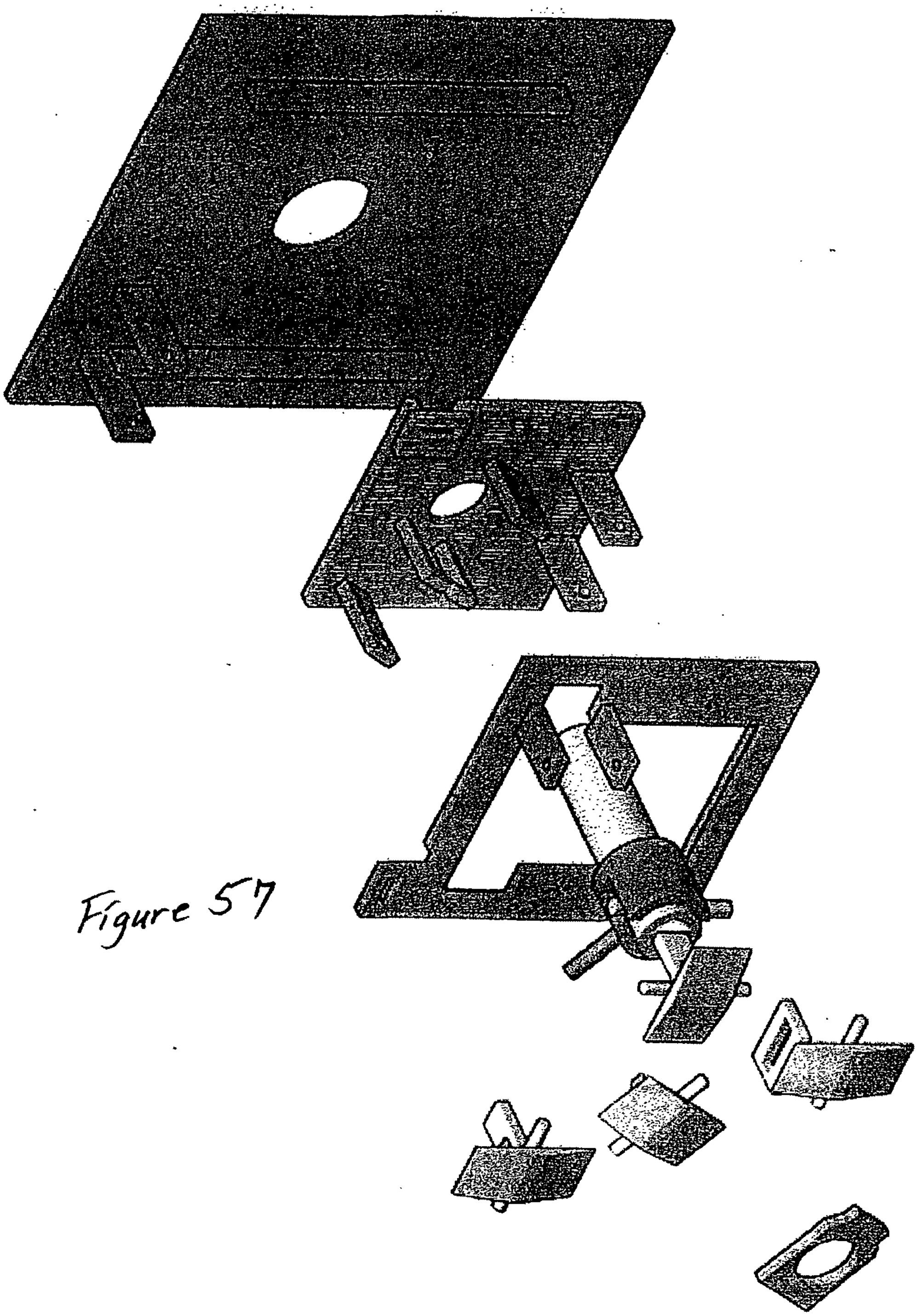


Figure 57

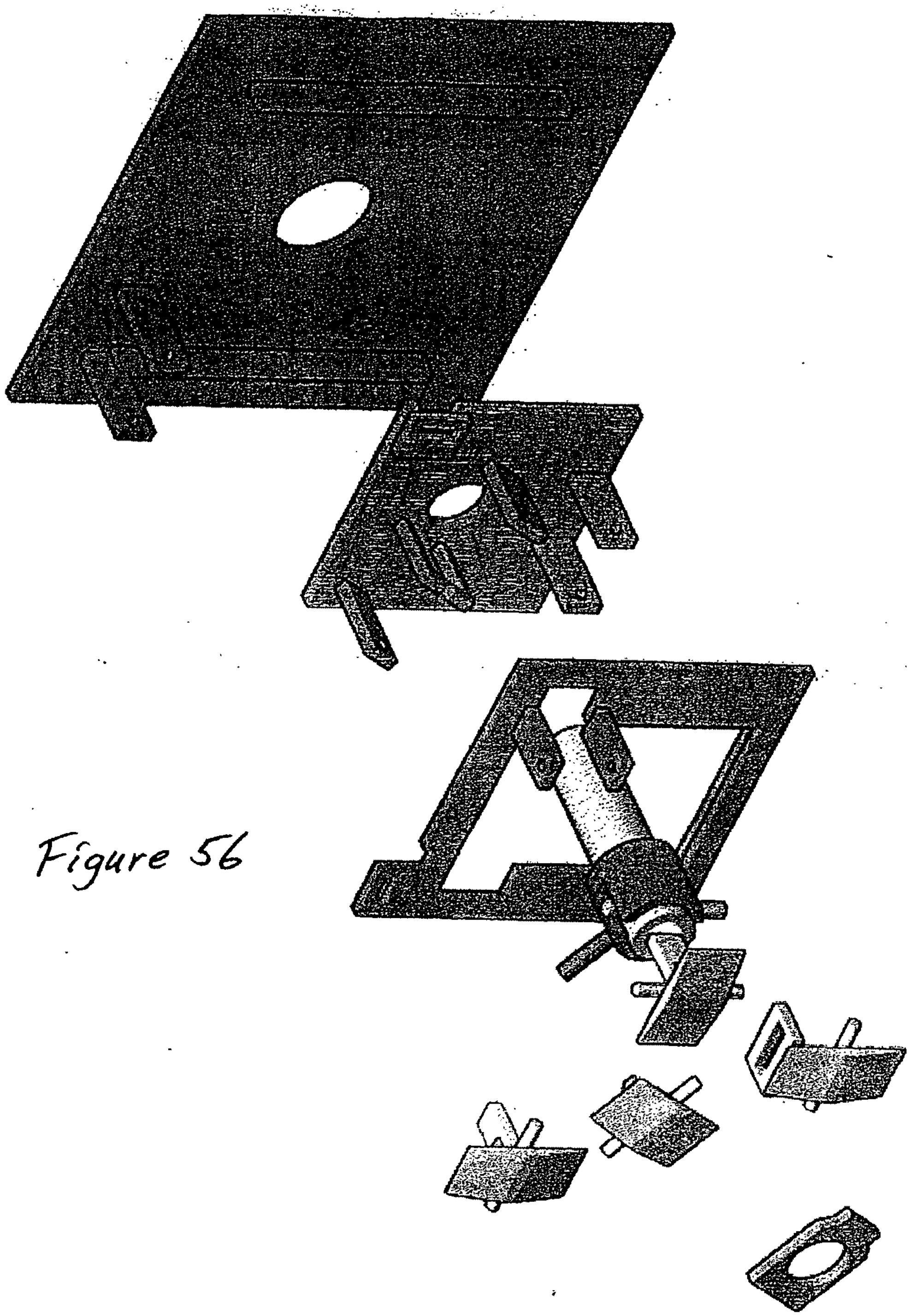


Figure 56

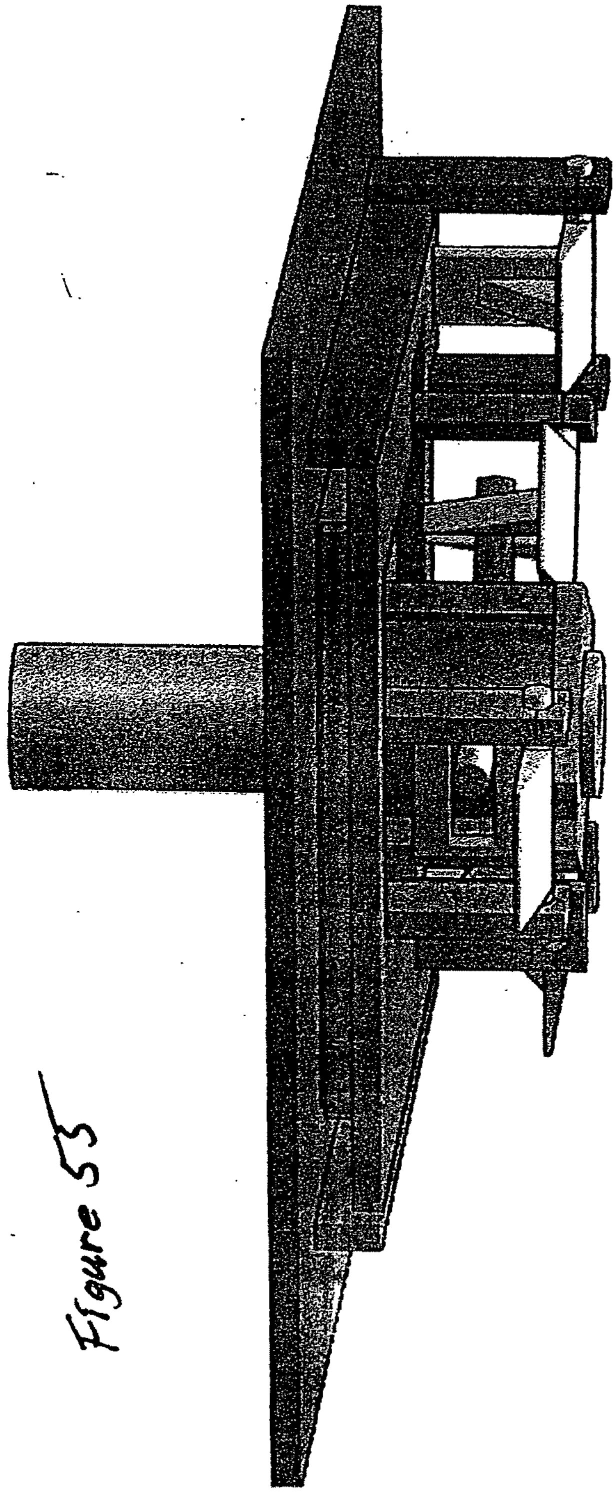


Figure 53

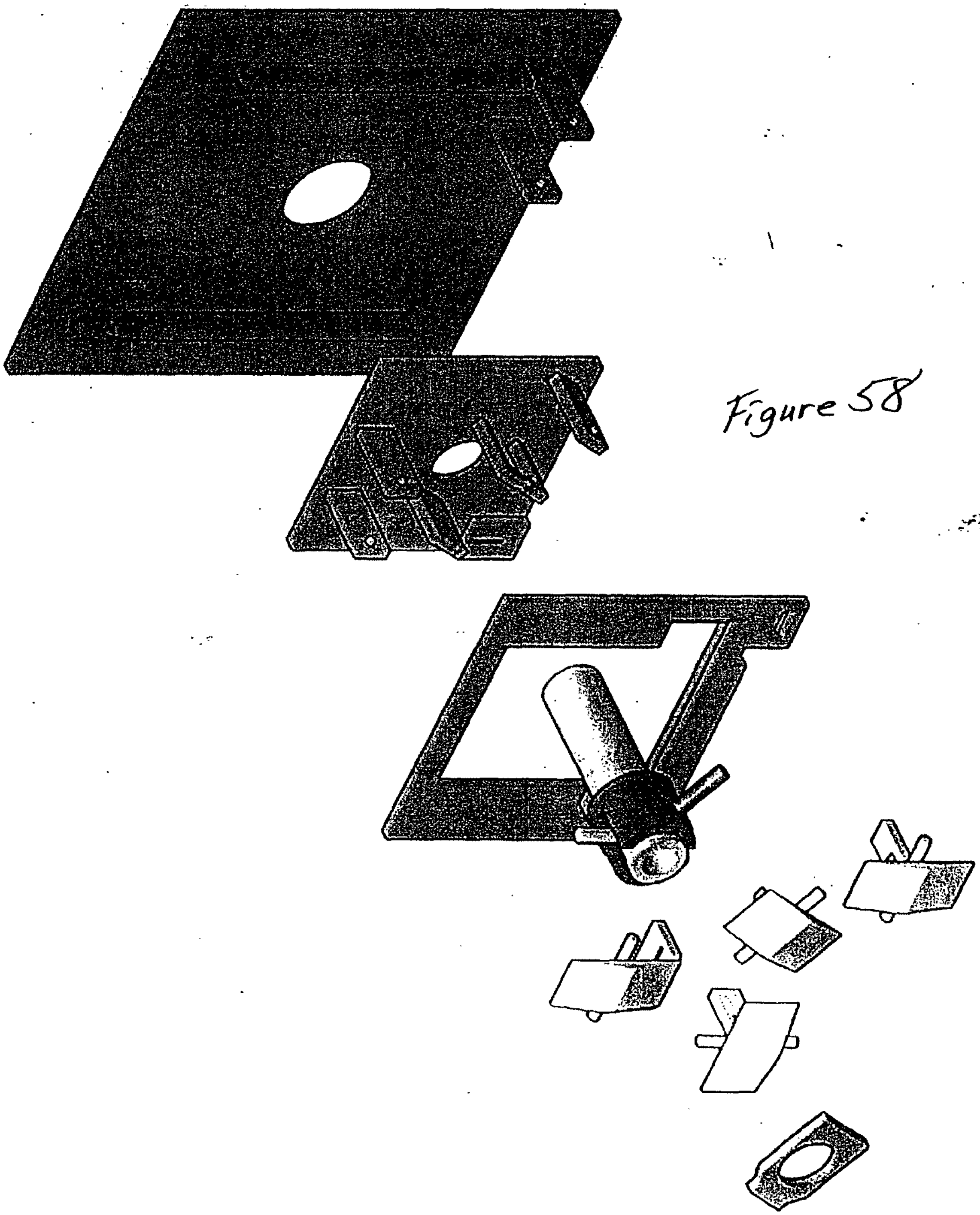
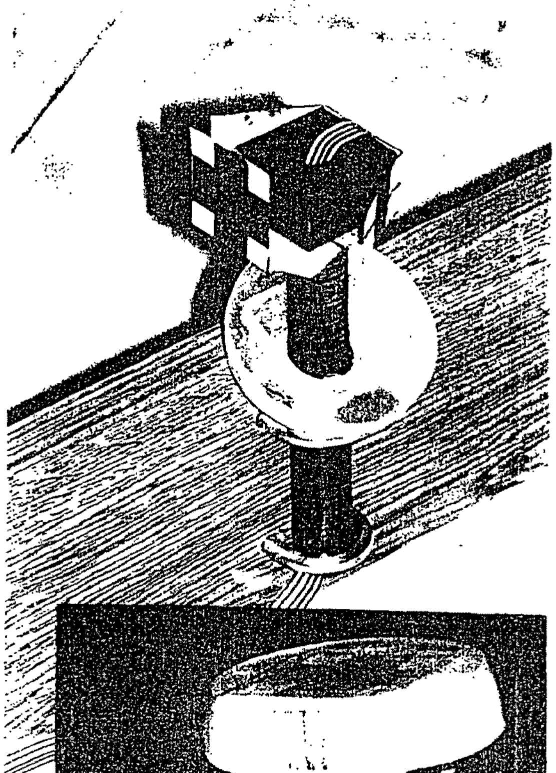
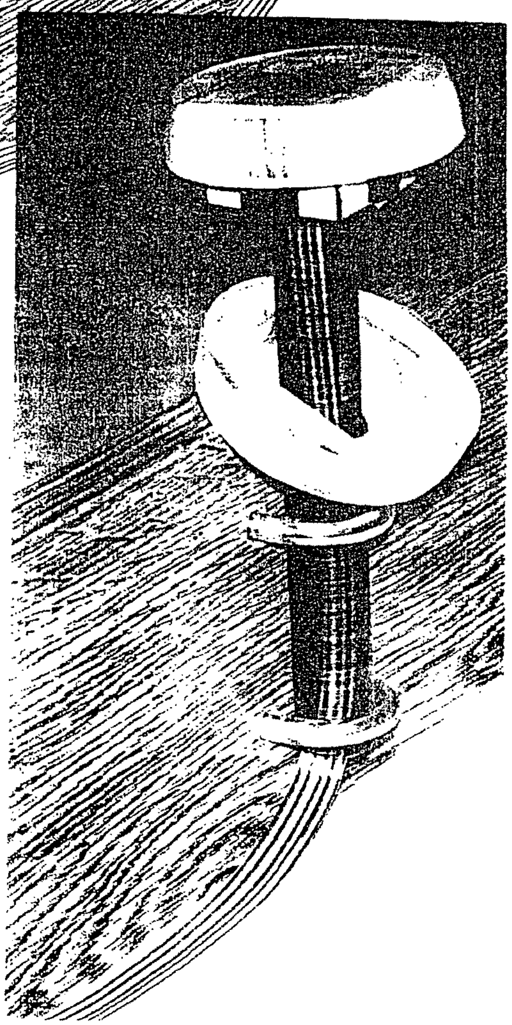


Figure 58

14





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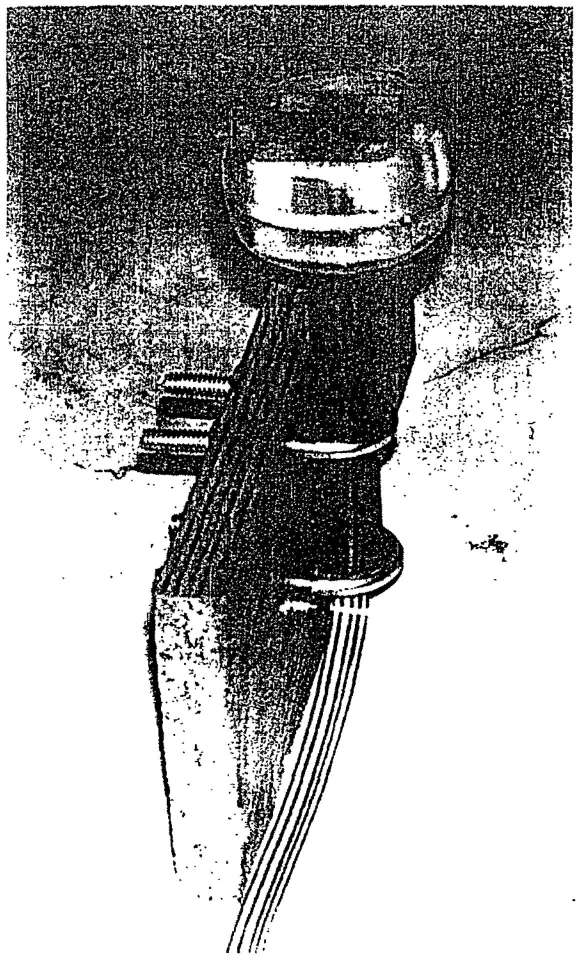
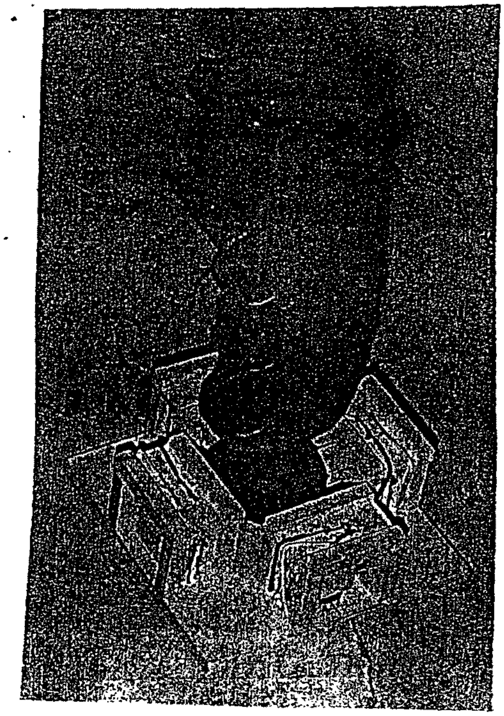


16

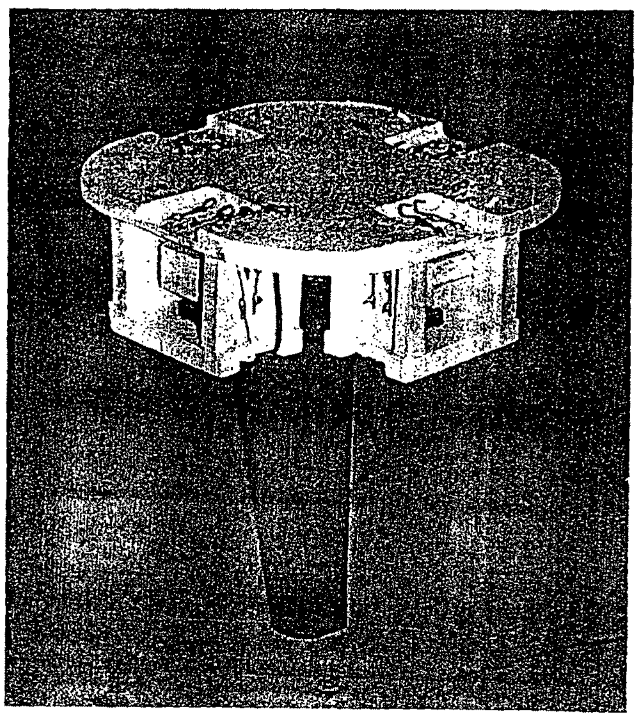
RTP
Rugged
6 DOF
controller

Photographs



#12

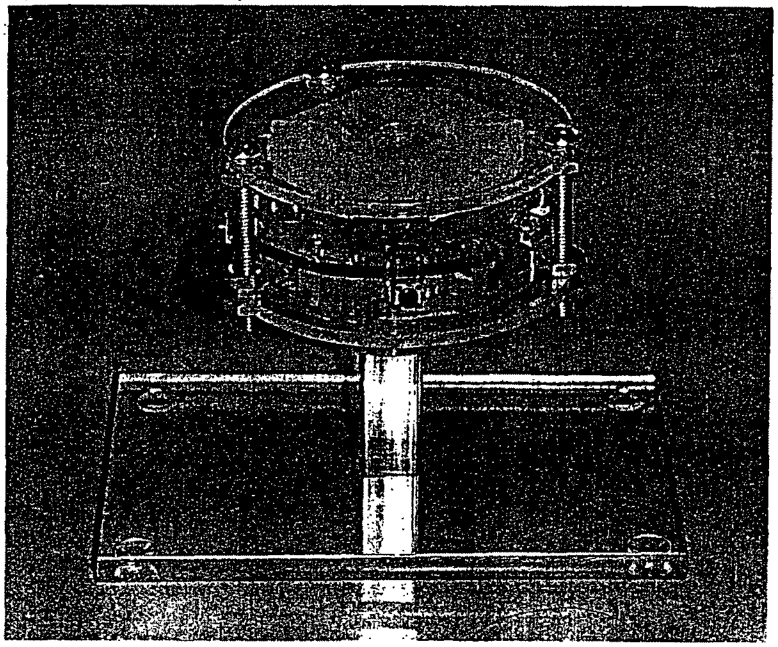
RTP
of
Fig. 42



#13

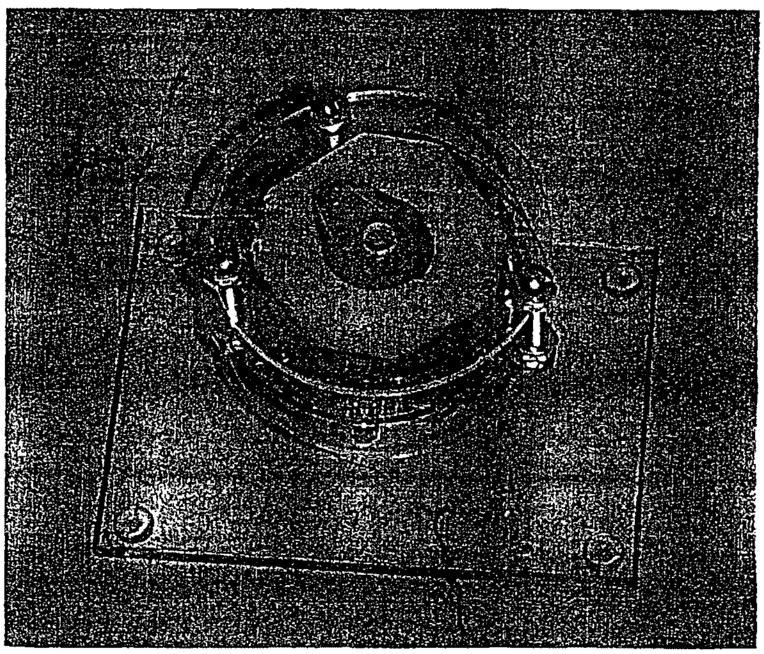
RTP
Fig 44

Photographs



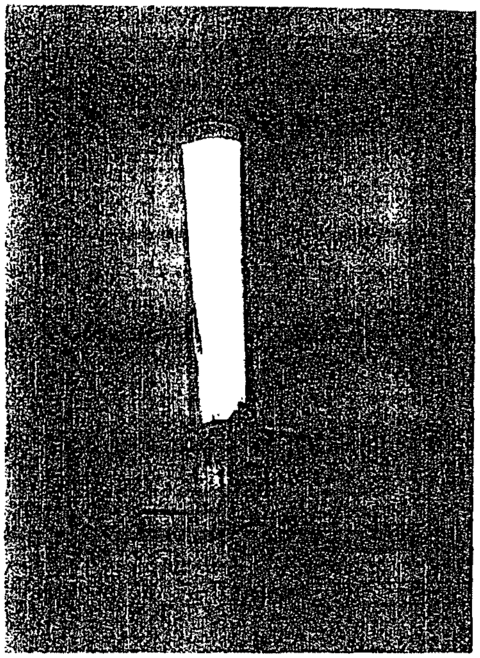
#10

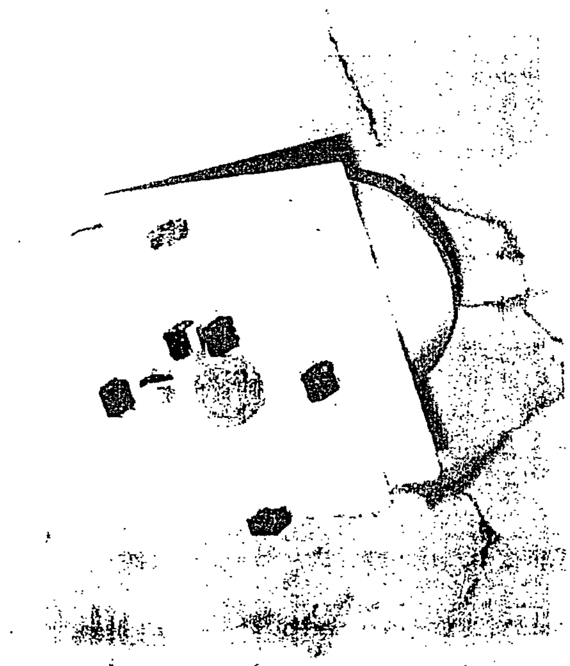
RTP
Fig
39



#
11

Photographs





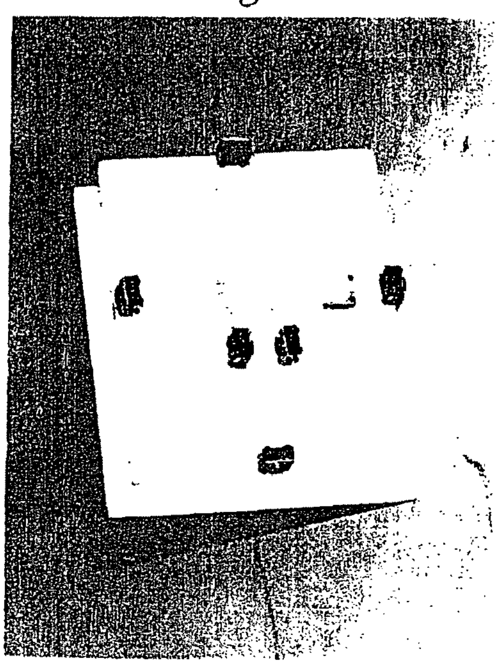
#6 RTP Fig 32

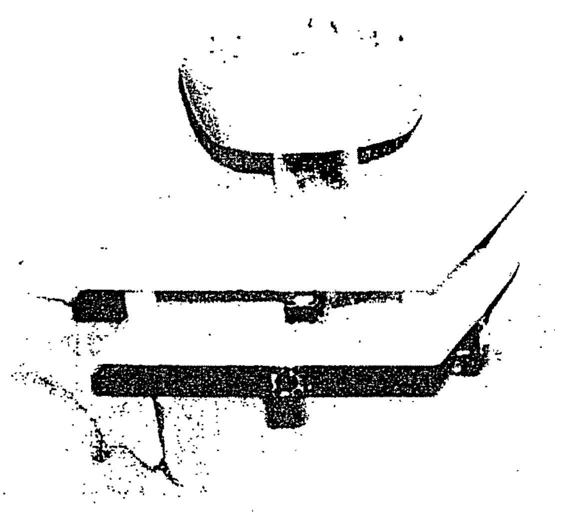
#7

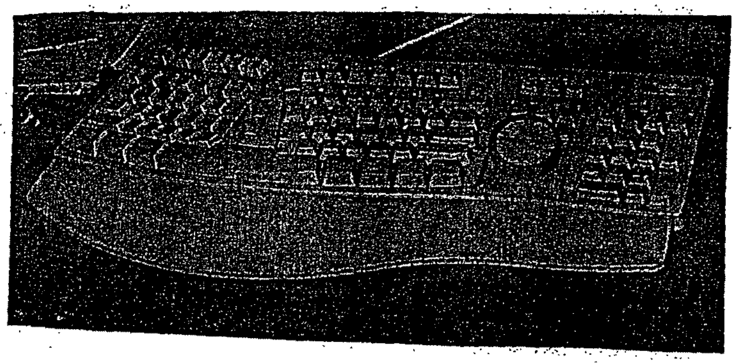
RTP Figs 31-34

#8

#9

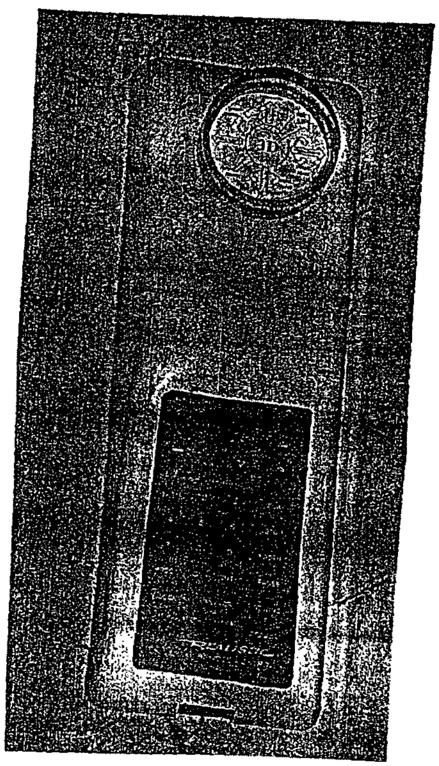






RTP fig 12

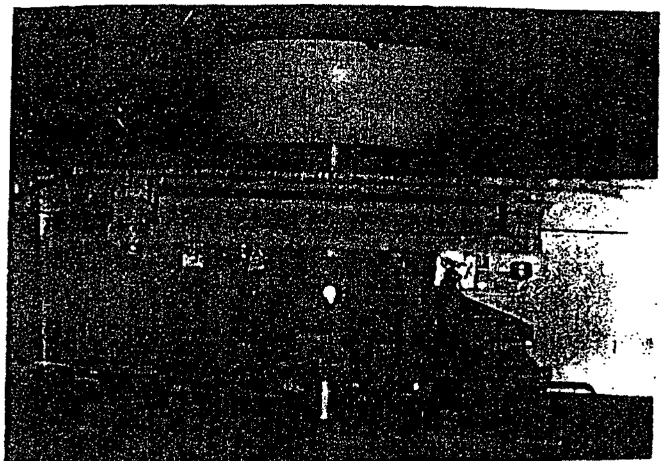
Photographs #4



#5

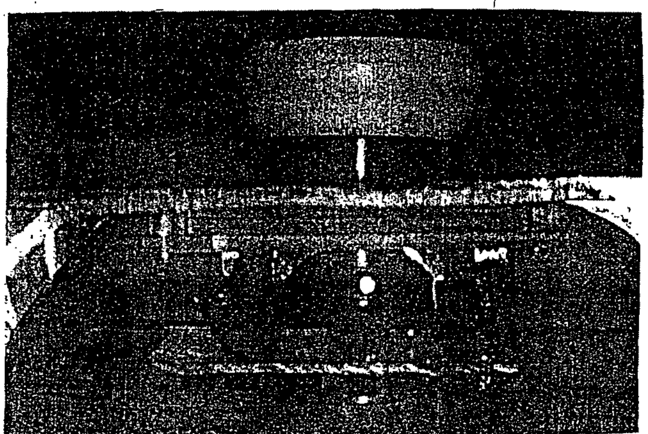
RTP fig. #14

photographs



#1

Reduction to Pratice of (hereinafter "RTP") Figs. 1, 2 & 3



#2

#3

RTP Fig #3

GP 2#75
VO
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Commissioner of Patents and Trademarks
Washington, D C 20231

Re: Patent Application of: Brad A. Armstrong
Serial No.: 08/677,378 Filed: 07/05/96
Title: 6 DOF GRAPHIC CONTROLLERS WITH SHEET CONNECTED SENSORS
Group Art Unit: 2609

Dear Sir:

In the above application, I, the Inventor of record do hereby request that the correspondence mailing address in my above specified patent application be changed.

Please have all further mailed correspondences pertaining to the above application sent to:

Brad A. Armstrong
P.O. Box 1419
Paradise, CA 95967

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Thank you.

Sincerely yours;

Signature: Brad A. Armstrong
Brad A. Armstrong, Inventor

Date: April 24, 1997

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, with sufficient postage paid in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D. C. 20231, on this date: April 24, 1997.

Signature: Brad A. Armstrong
Brad A. Armstrong, Inventor

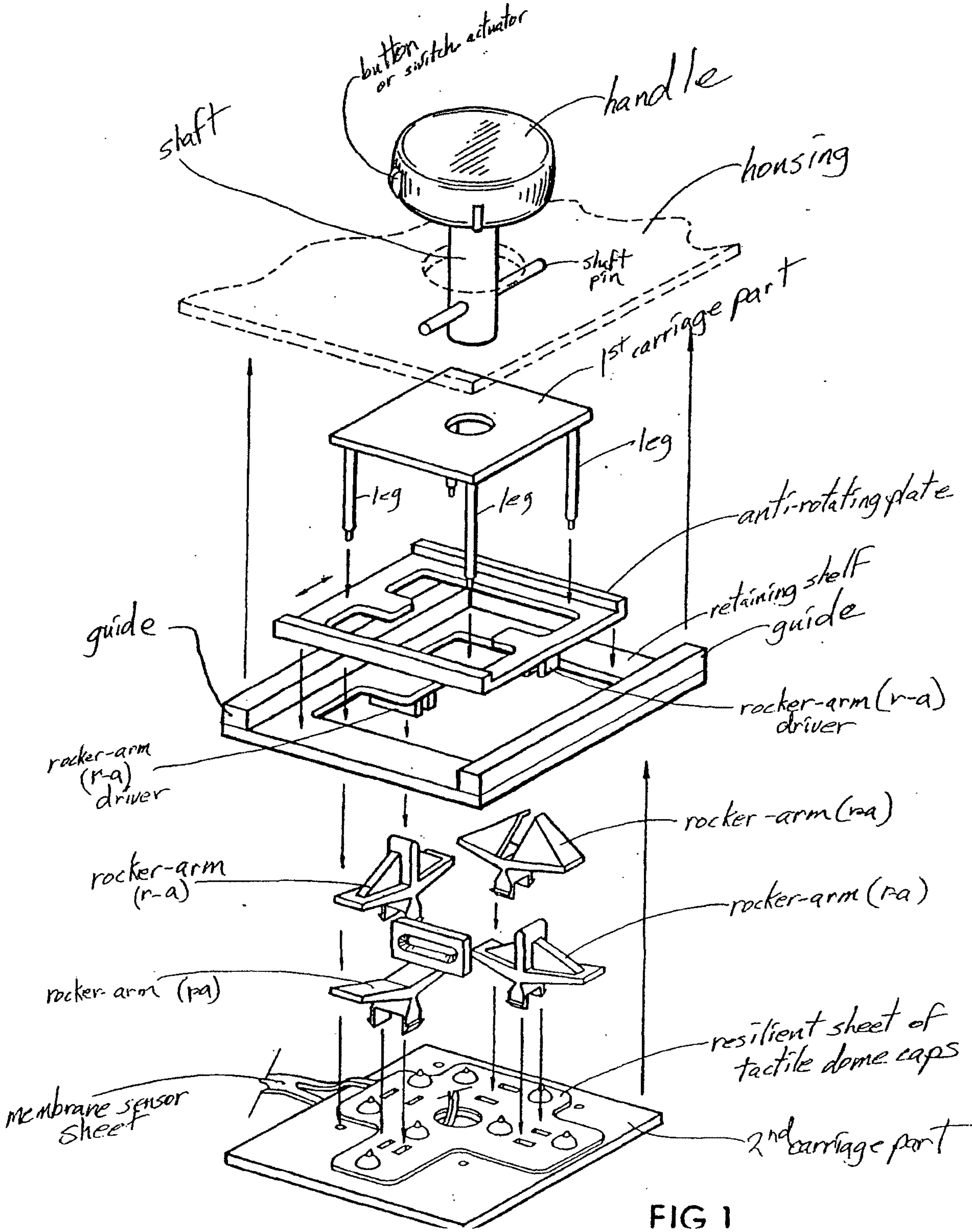

button or switch actuator
handle
shaft
housing
shaft pin
1st carriage part
leg
leg
leg
anti-rotating plate
retaining shelf
guide
guide
rocker-arm (r-a) driver
rocker-arm (r-a) driver
rocker-arm (ra)
rocker-arm (r-a)
rocker-arm (ra)
rocker-arm (ra)
resilient sheet of tactile dome caps
membrane sensor sheet
2nd carriage part

FIG 1

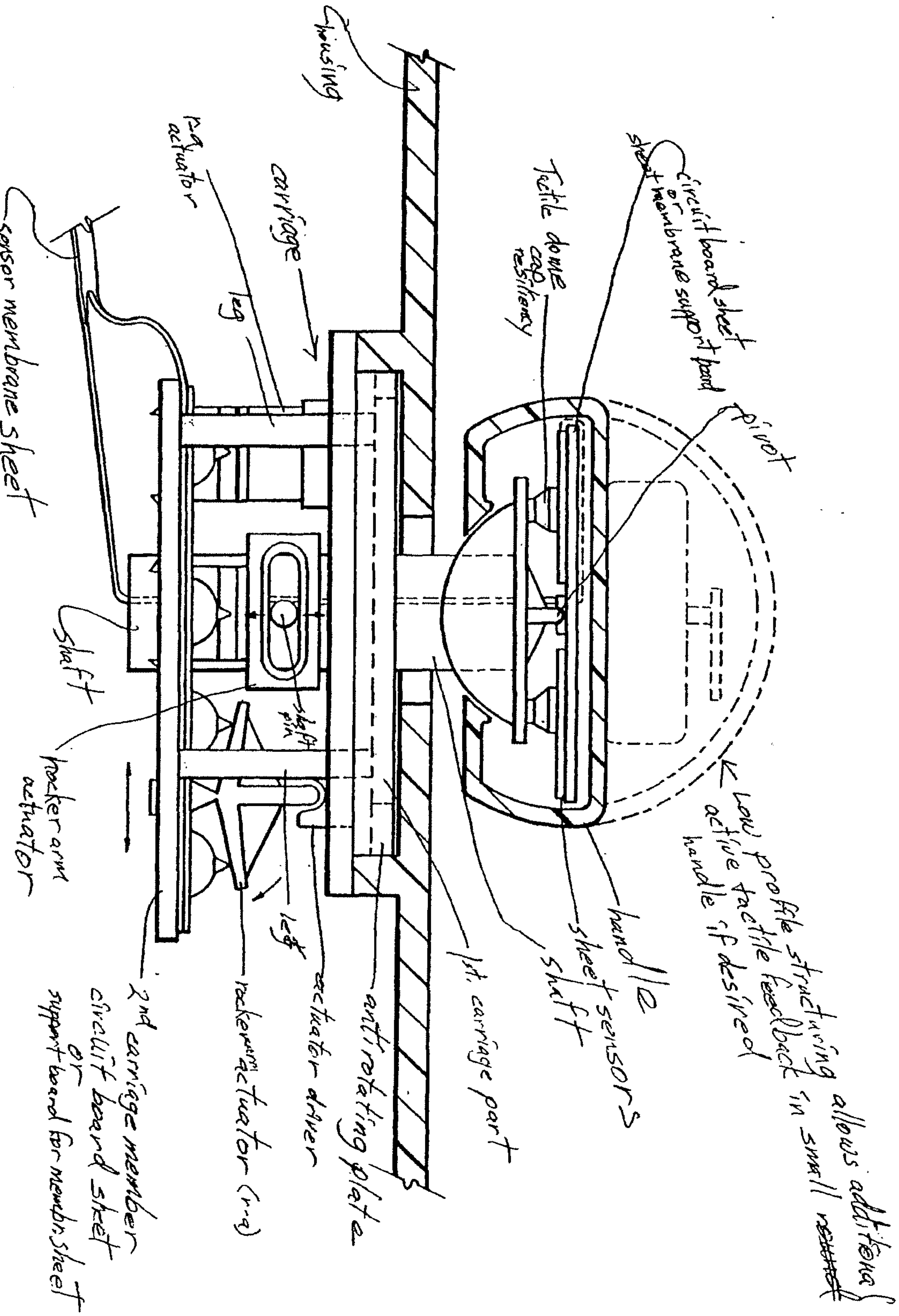

housing
r-a actuator
carriage
leg
sensor membrane sheet
Tactile dome cap resiliency
circuit board sheet or sheet membrane support pad
pivot
Low profile structuring allows additional active tactile feedback in small handle if desired
handle
sheet sensors
shaft
1st. carriage part
anti rotating plate
actuator driver
rocker arm actuator (r-a)
leg
shaft pin
2nd carriage member circuit board sheet or support board for membr. sheet
rocker arm actuator
shaft

FIG. 2

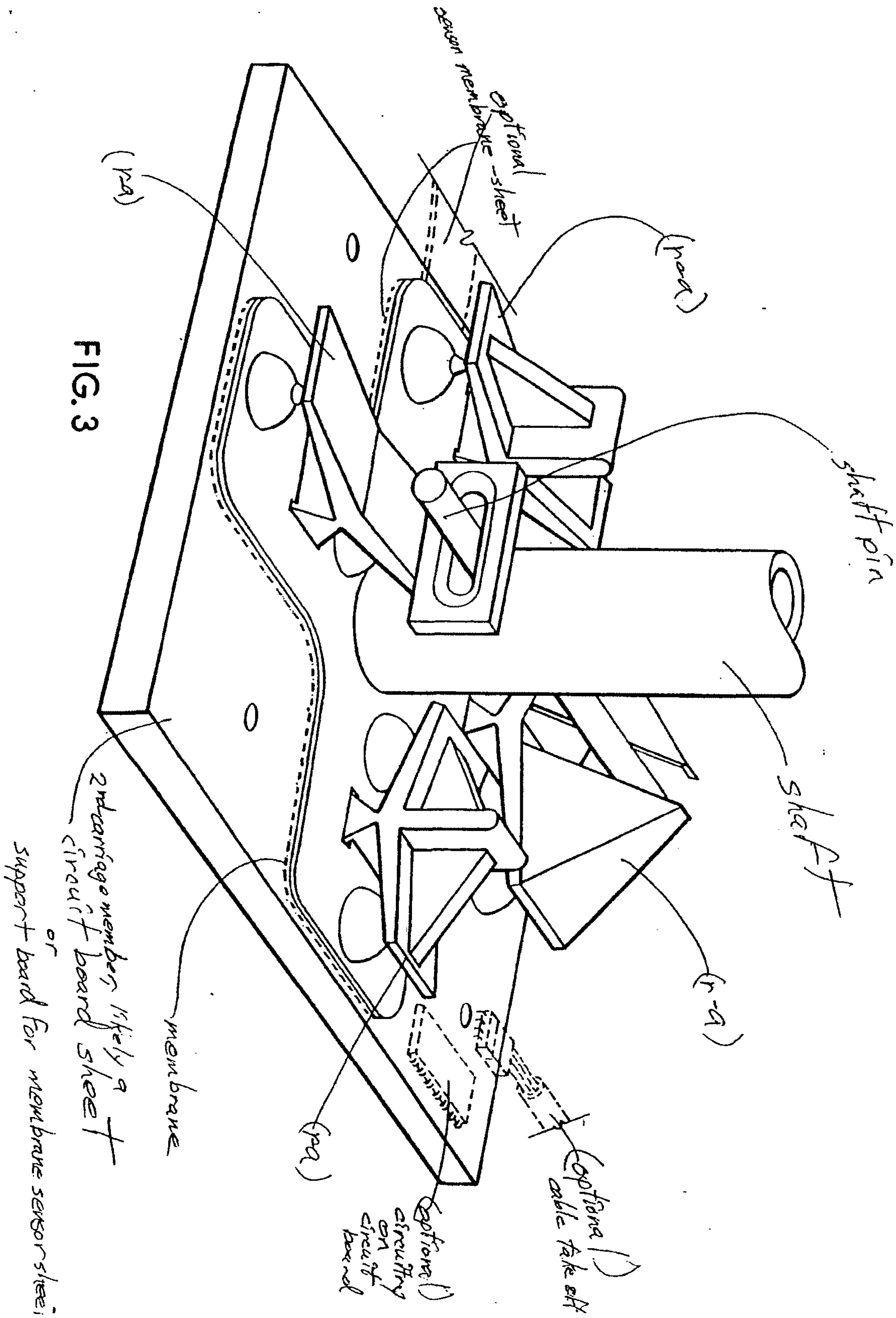

optional
sensor membrane sheet
(pad)
(ra)
shaft pin
shaft
(r-a)
membrane
2nd carriage member likely a
circuit board sheet
or
support board for membrane sensor sheet
(ra)
optional
circuitry
on
circuit
board
optional
cable take off

FIG. 3

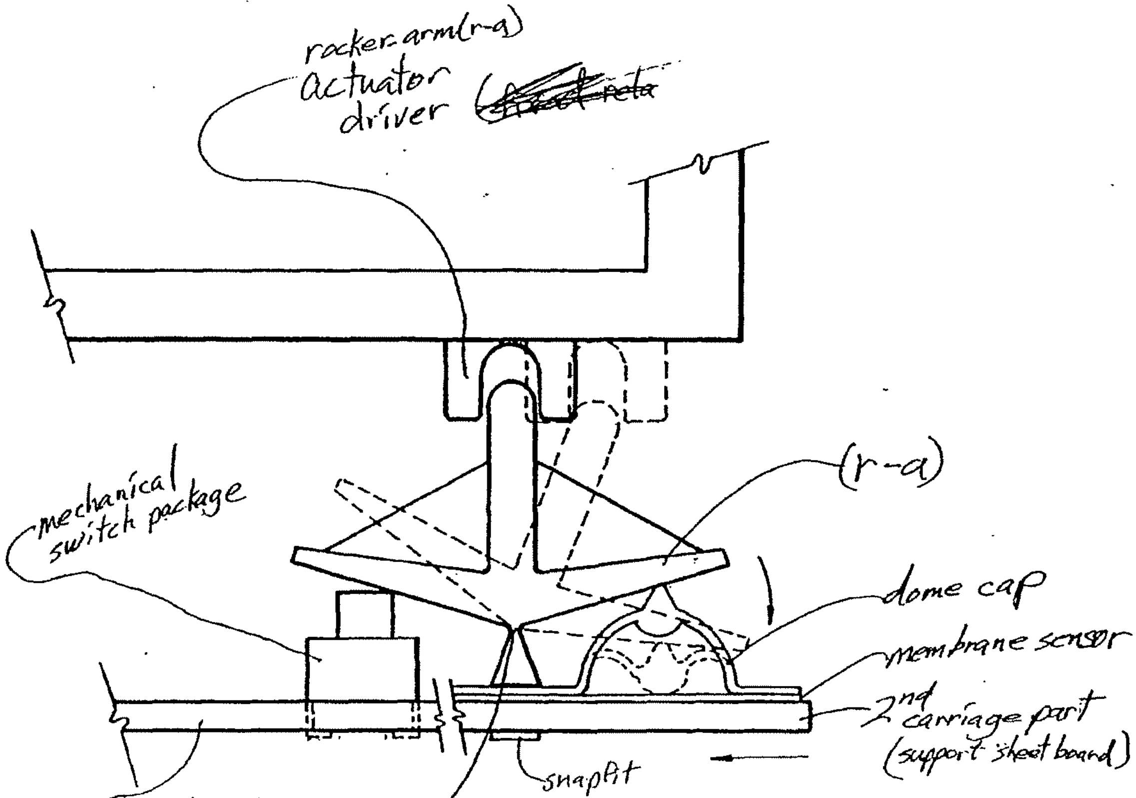

rocker arm(r-a)
actuator
driver
(r-a)
mechanical
switch package
dome cap
membrane sensor
2nd carriage part
(support sheet board)
snapfit
circuit board

FIG. 4

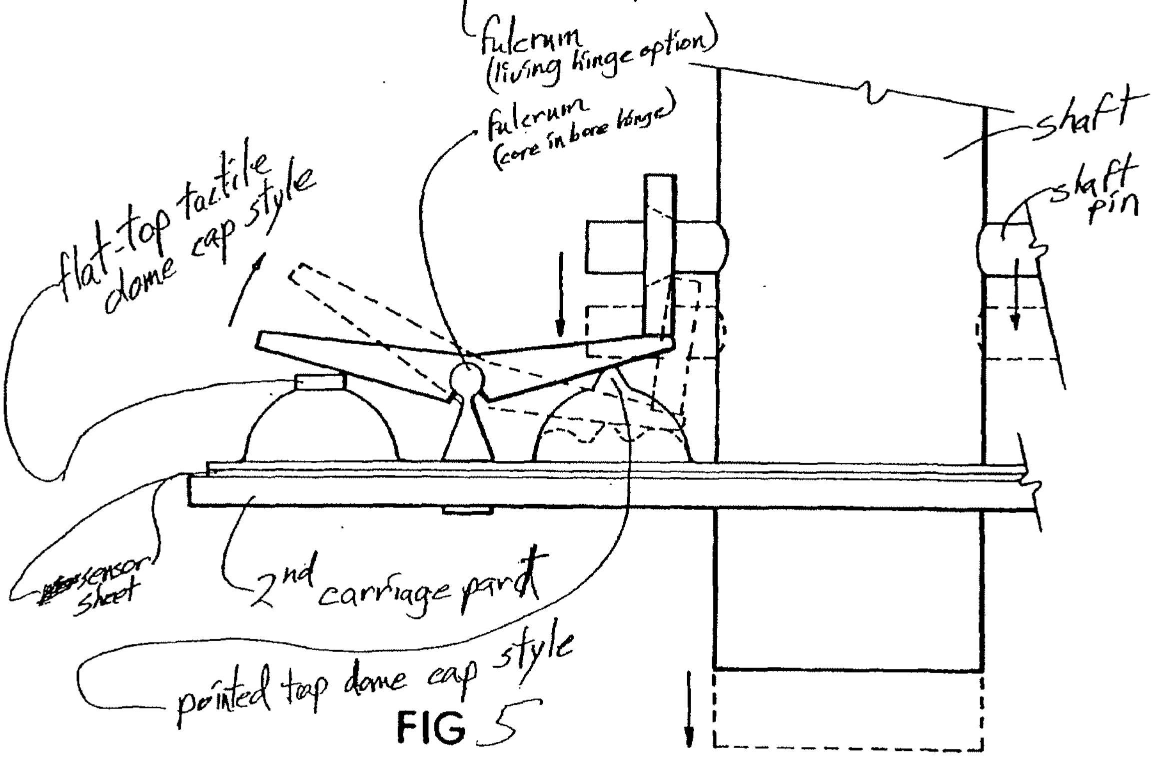

fulcrum
(living hinge option)
fulcrum
(core in bore hinge)
shaft
shaft
pin
flat-top tactile
dome cap style
sensor
sheet
2nd carriage part
pointed top dome cap style

FIG 5

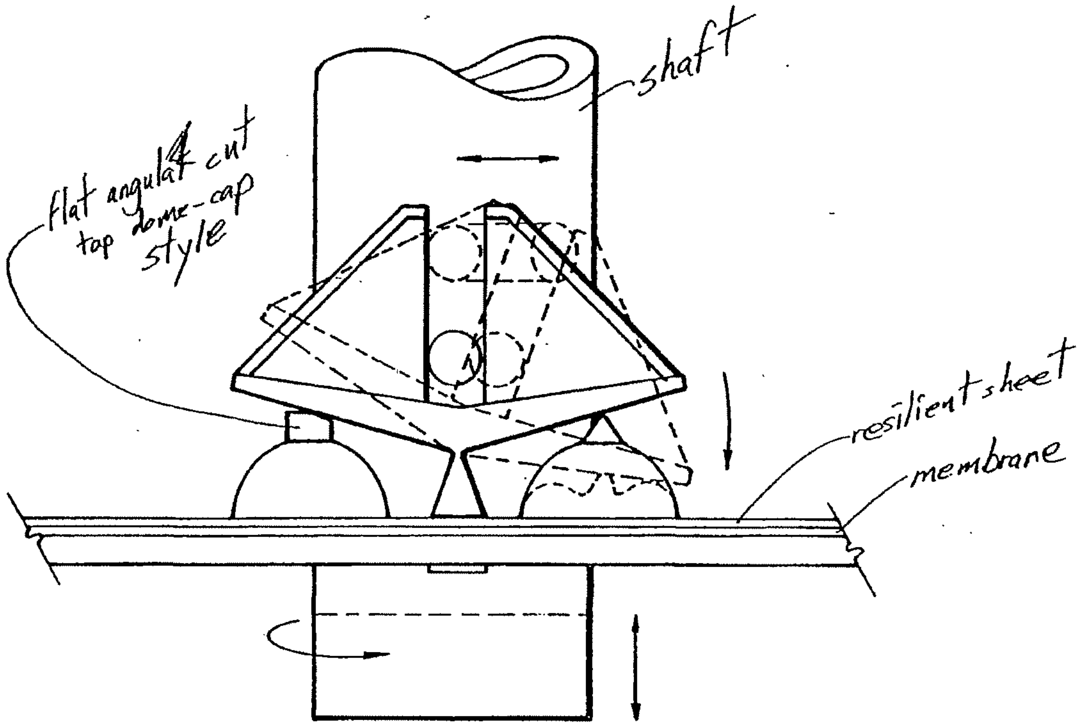


FIG. 6

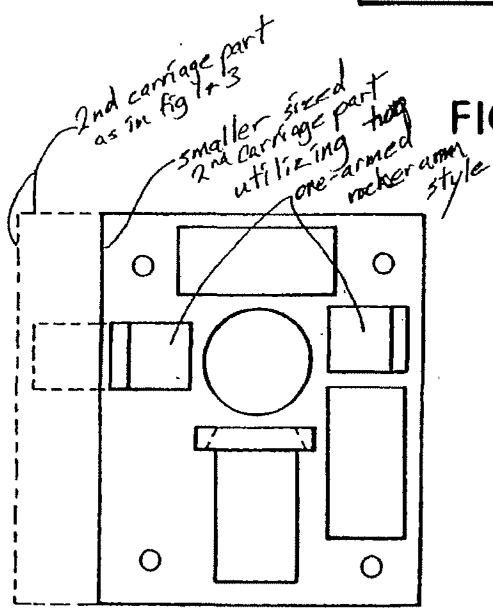


FIG. 7

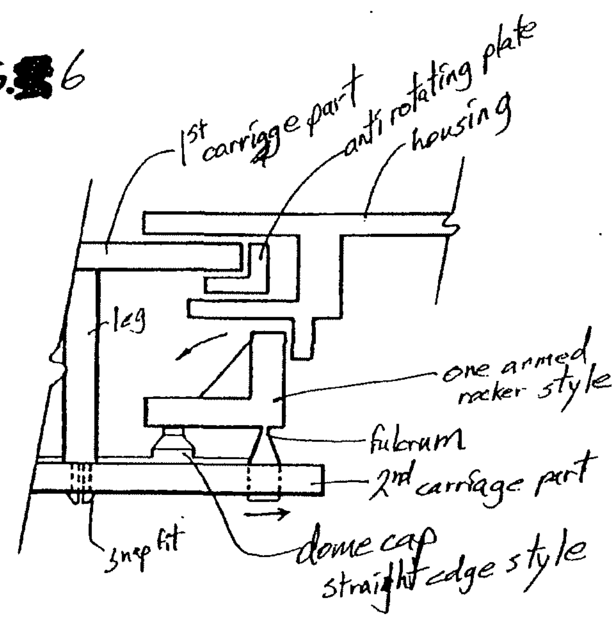


FIG. 8

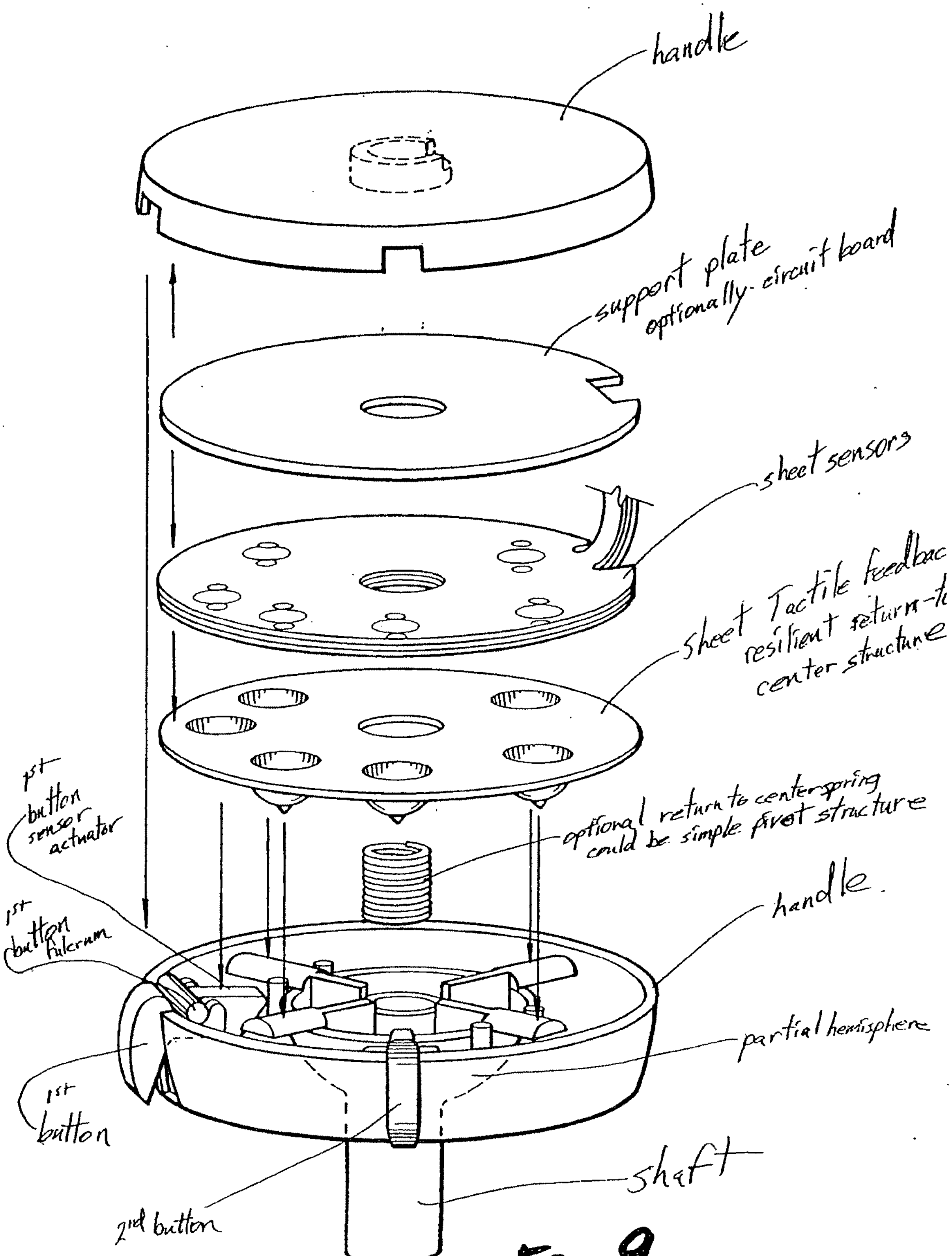

handle
support plate
optionally circuit board
sheet sensors
Sheet Tactile feedbac
resilient return-to
center structure
1st button sensor actuator
optional return to center spring
could be simple pivot structure
handle
1st button fulcrum
partial hemisphere
1st button
shaft
2nd button

Fig. 9

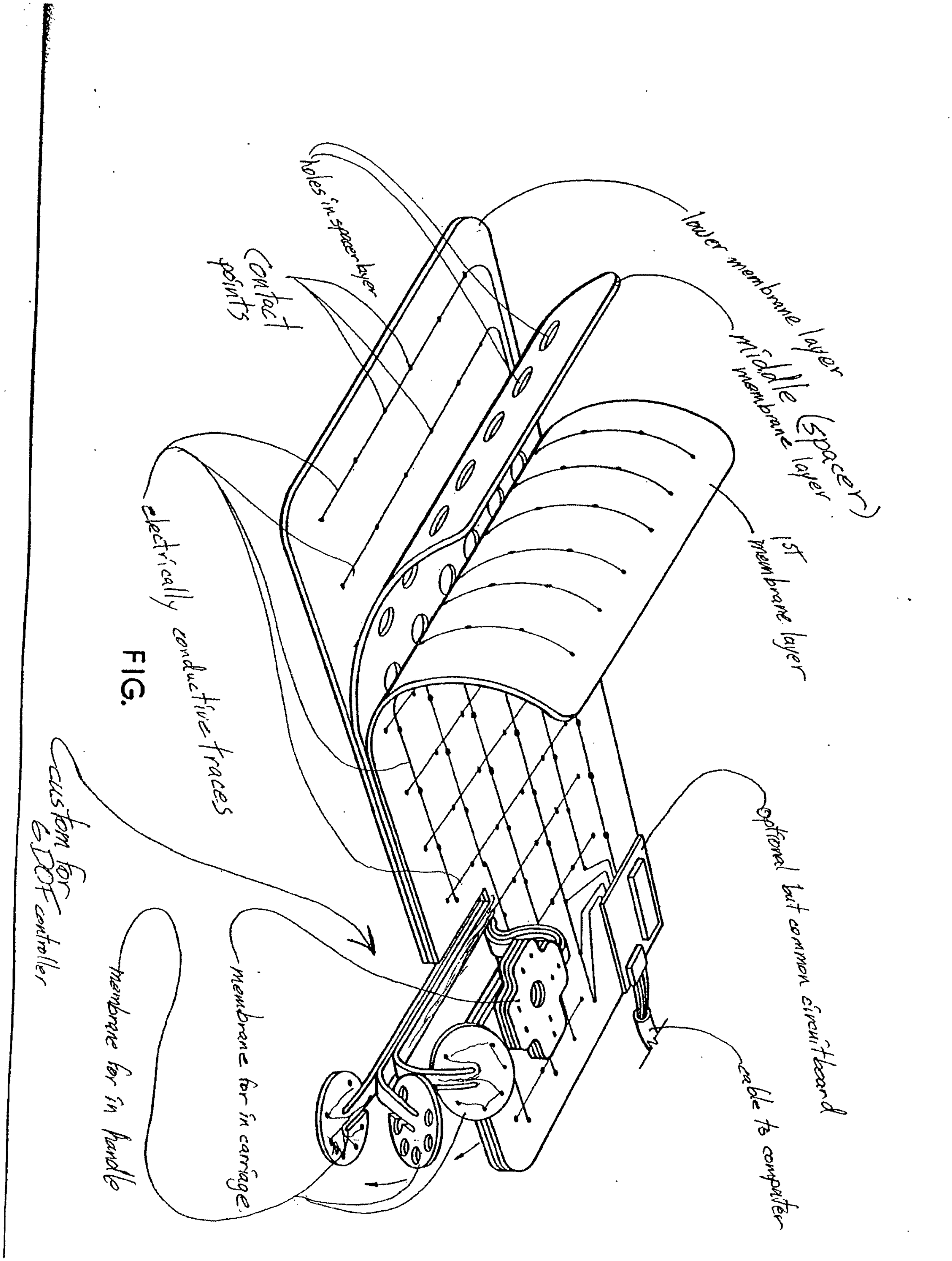

lower membrane layer
middle (spacer) membrane layer
holes in spacer layer
contact points
1st membrane layer
electrically conductive traces
optional but common circuit board
cable to computer
custom for 6 DOF controller
membrane for in carriage
membrane for in handle

FIG.

typical prior art keyboard

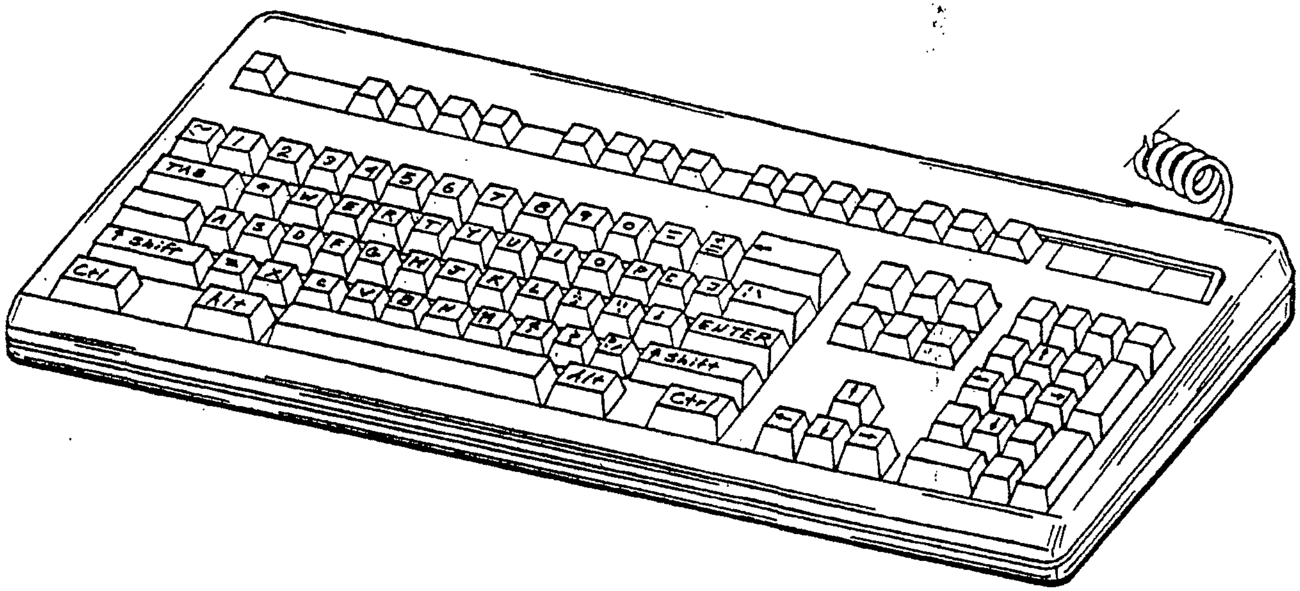


FIG. 11

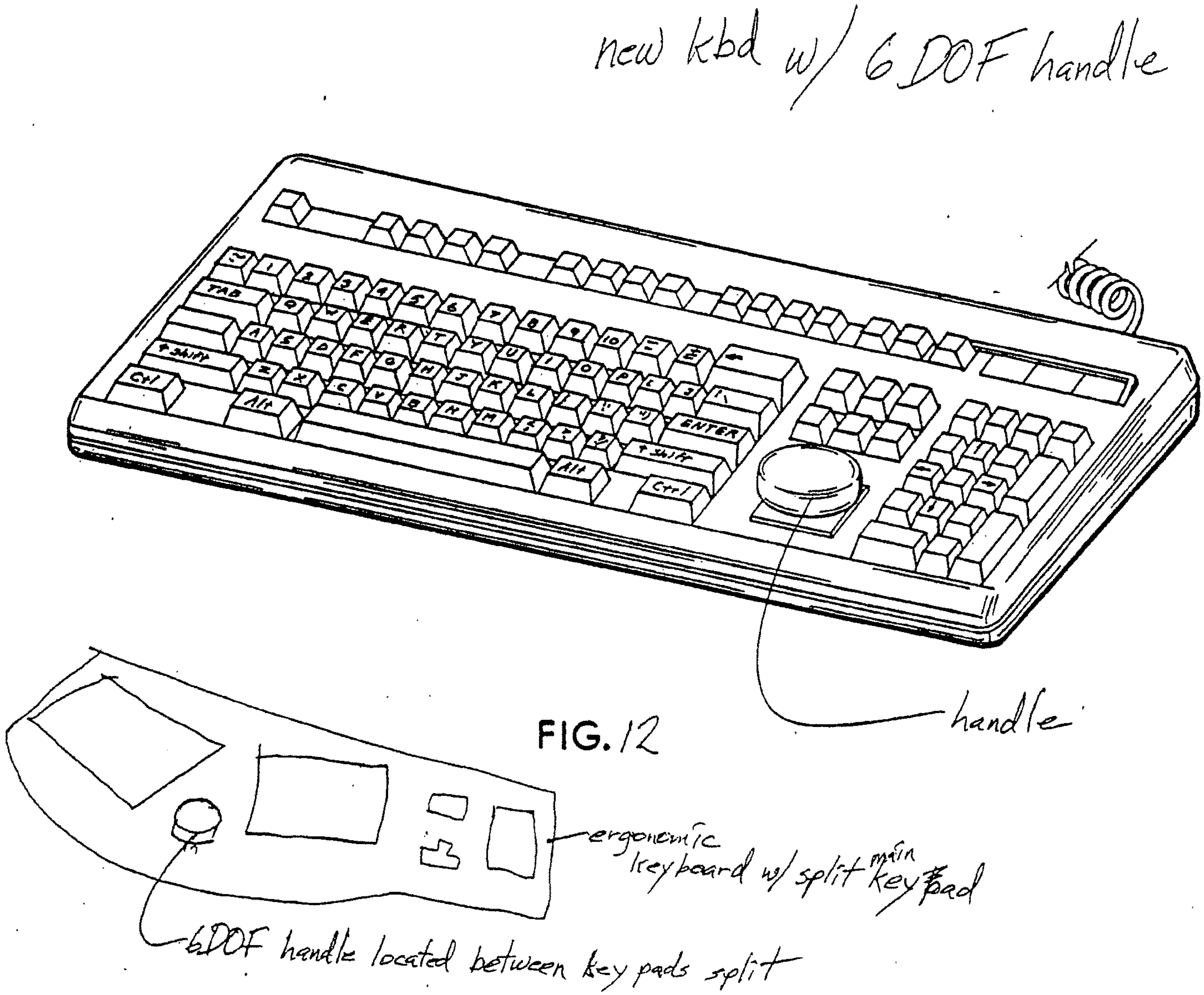

new kbd w/ 6DOF handle
handle
ergonomic keyboard w/ split main keypad
6DOF handle located between key pads split

FIG. 12

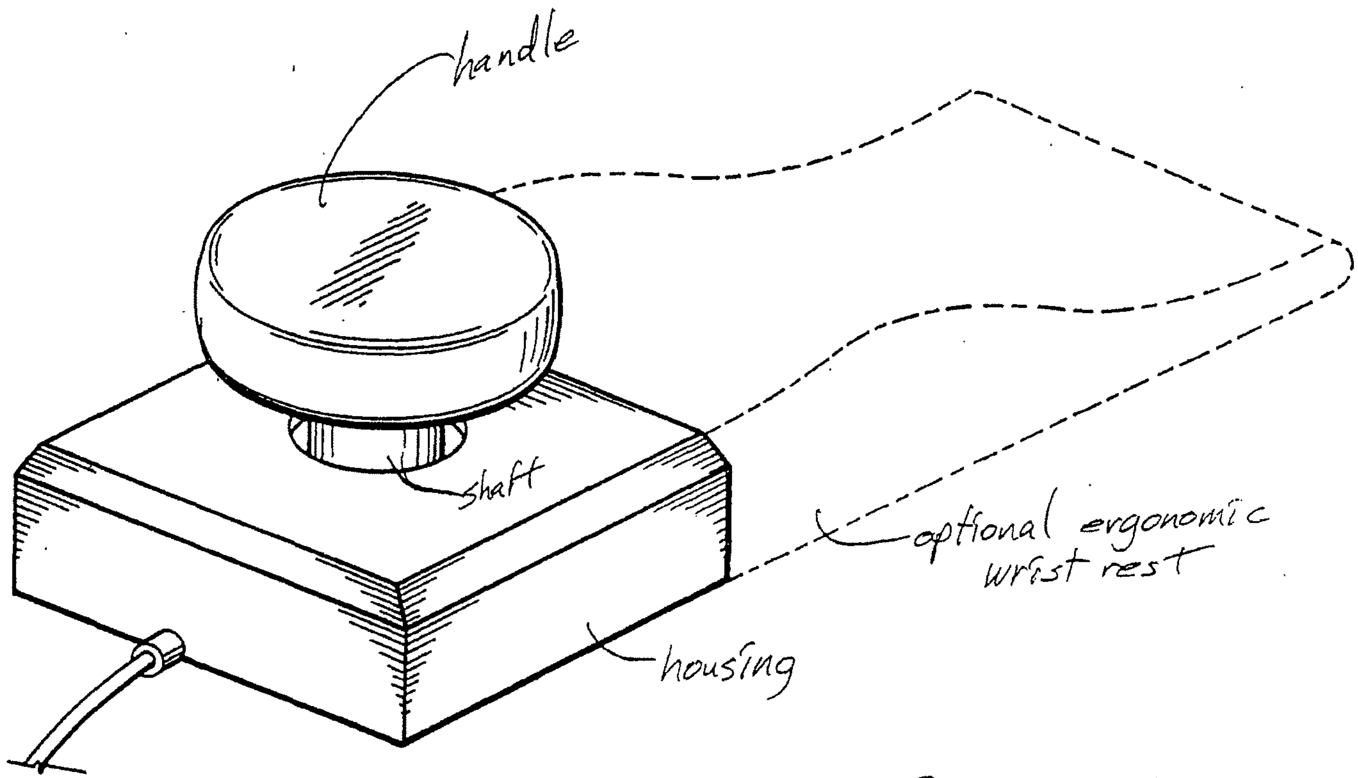


FIG. 13

self standing controller
desktop, table top or handheld

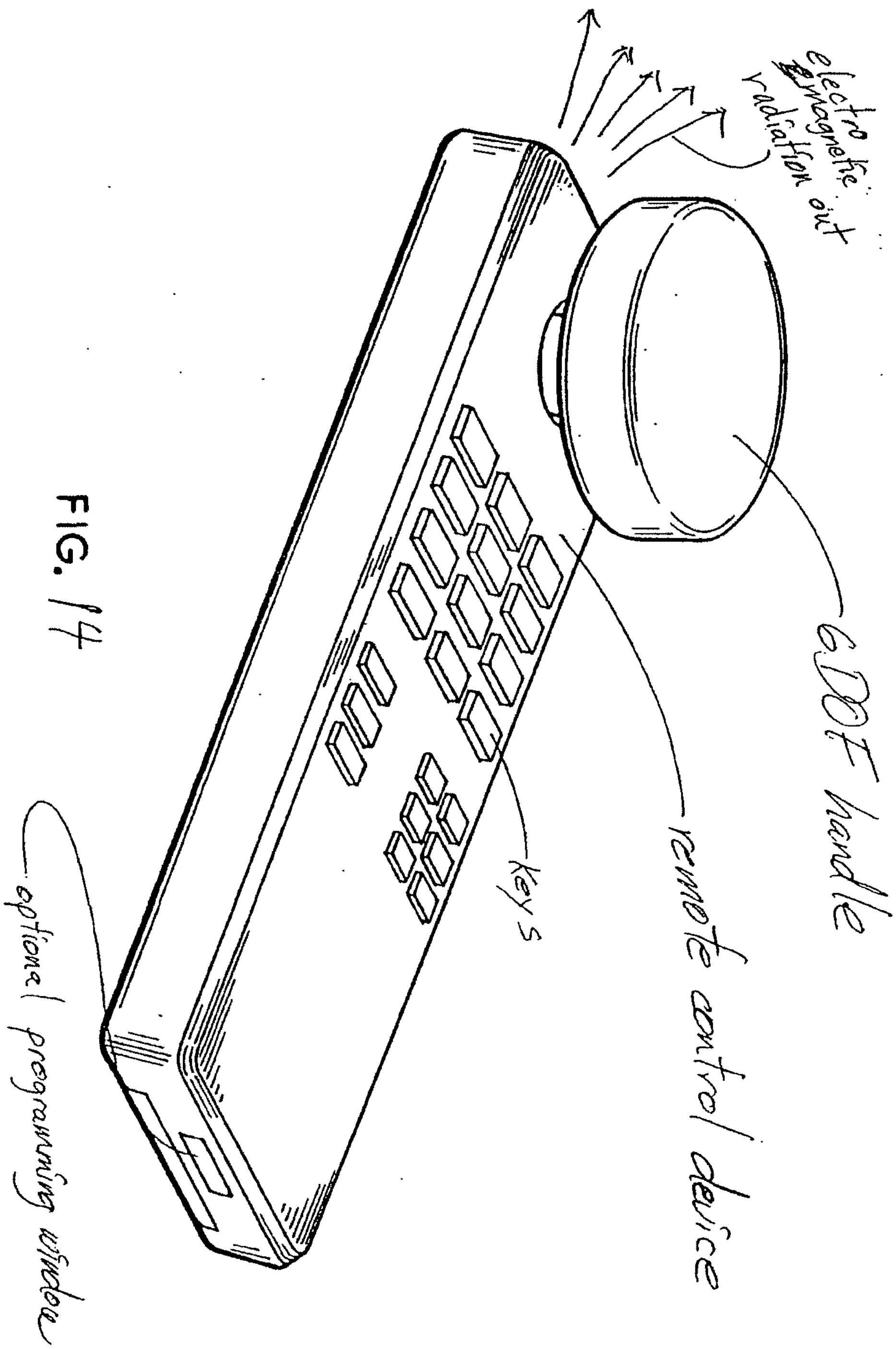

electro magnetic radiation out
6DOF handle
remote control device
keys
optional programming window

FIG. 14

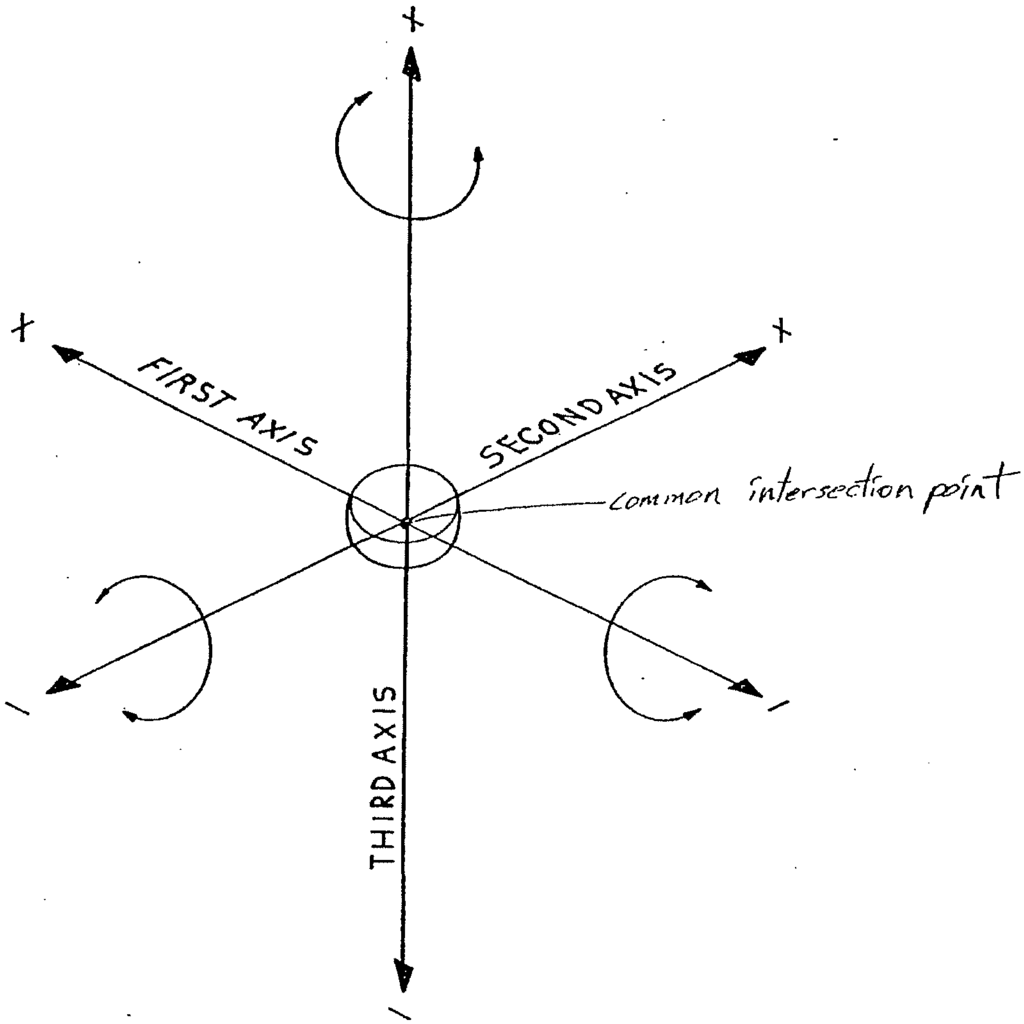

+
+
+
FIRST AXIS
SECOND AXIS
common intersection point
THIRD AXIS
-
-
-

FIG. 15

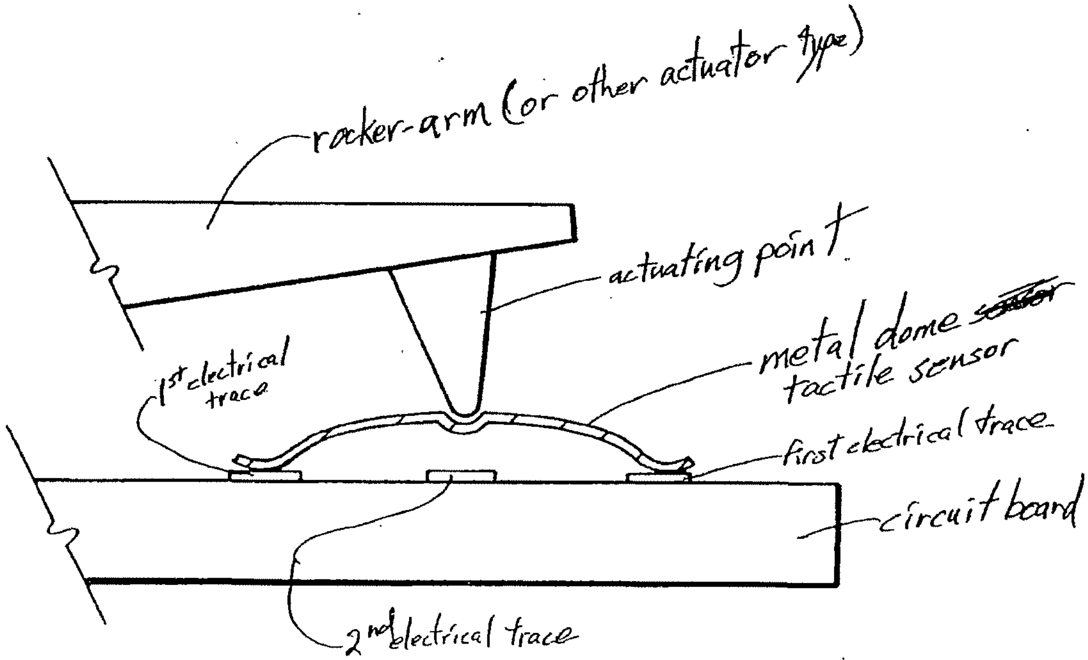

rocker-arm (or other actuator type)
actuating point
metal dome ~~sensor~~
tactile sensor
1st electrical trace
first electrical trace
circuit board
2nd electrical trace

FIG. 16

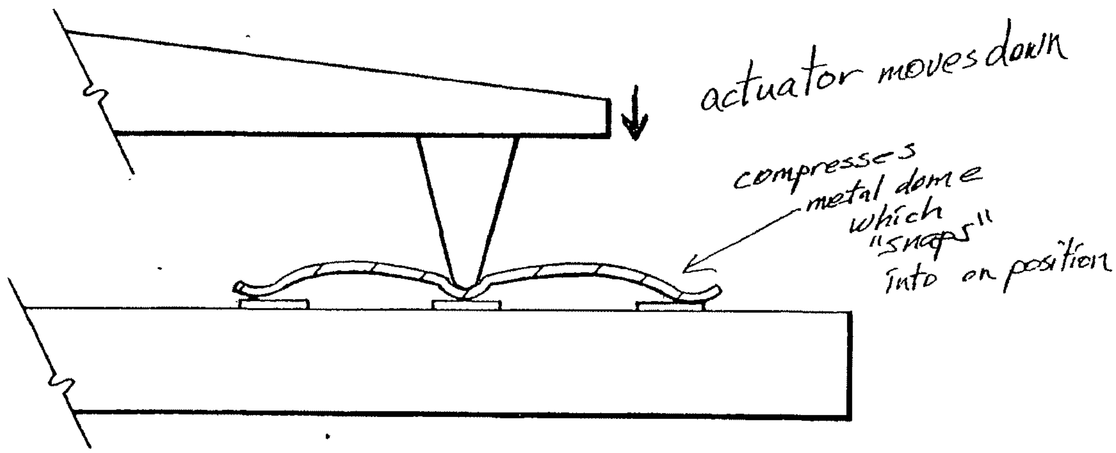

actuator moves down
compresses metal dome which "snaps" into on position

FIG. 17

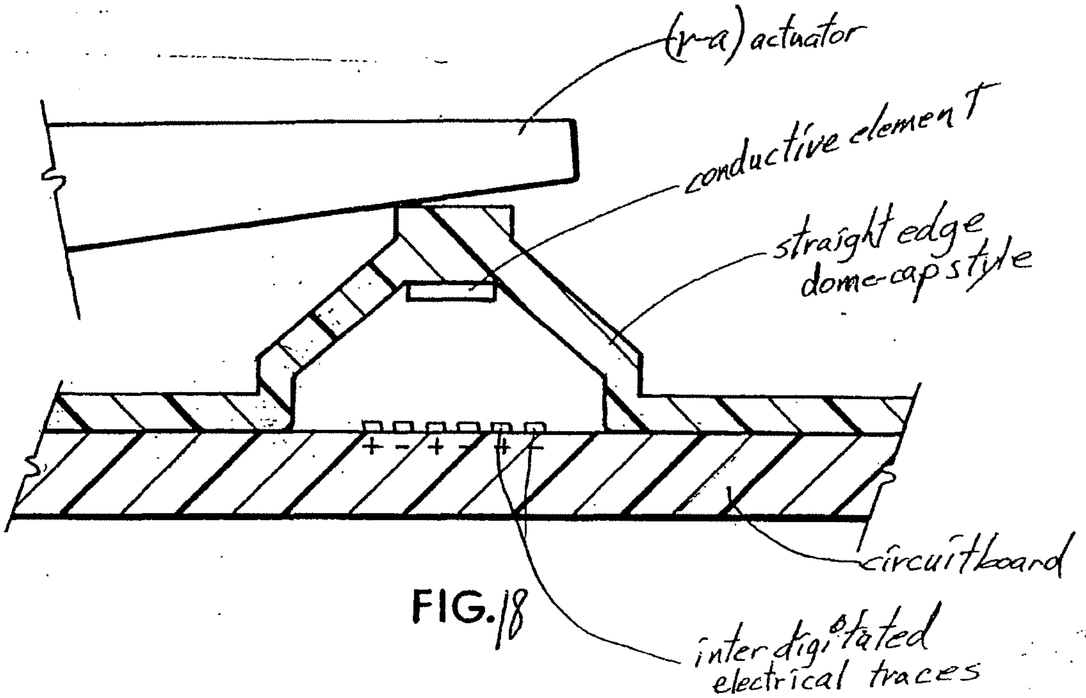


FIG. 18

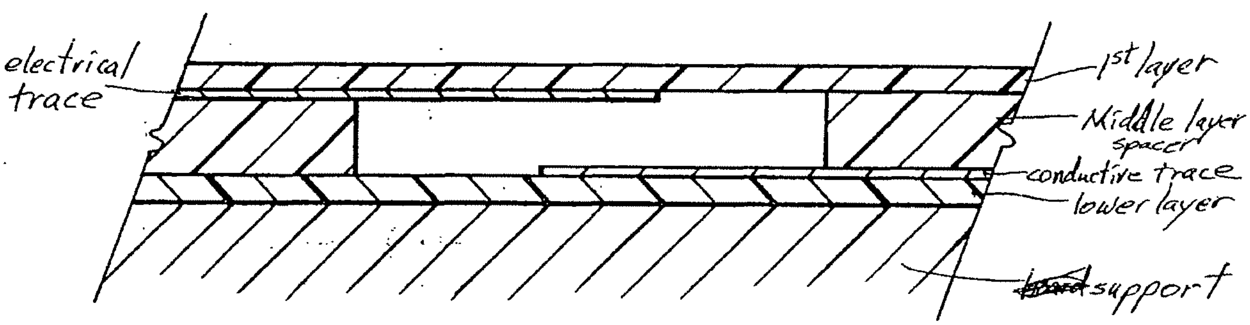


FIG. 19

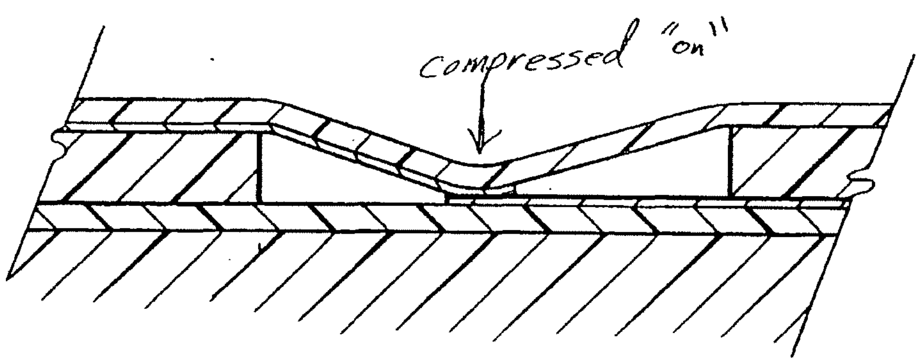


FIG. 20

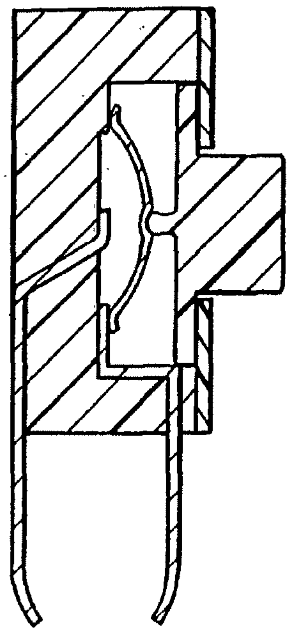


FIG. 21

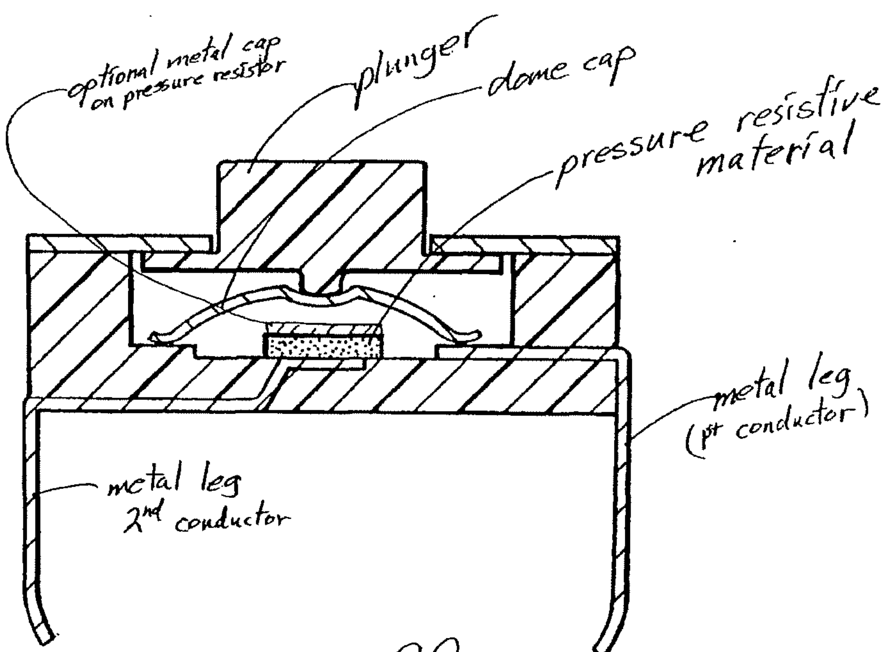

optional metal cap on pressure resistor
plunger
dome cap
pressure resistive material
metal leg (1st conductor)
metal leg 2nd conductor

FIG. 22

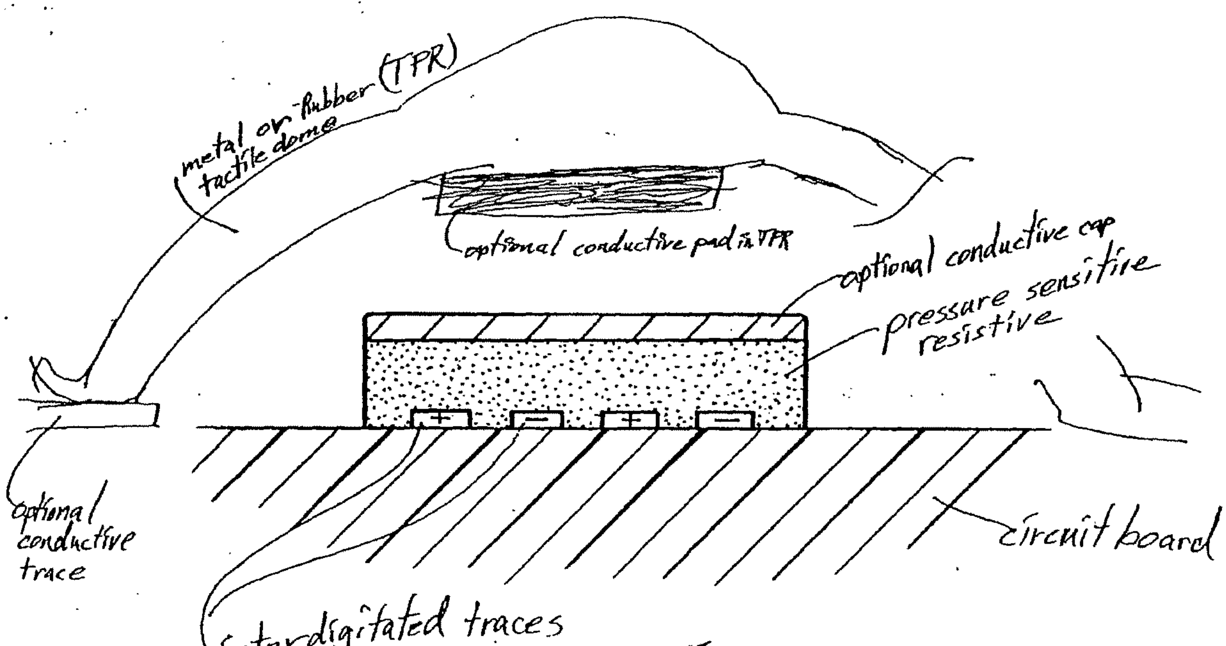

metal or Rubber (TPR) tactile dome
optional conductive pad in TPR
optional conductive cap
pressure sensitive resistive
optional conductive trace
circuit board
interdigitated traces

FIG. 23

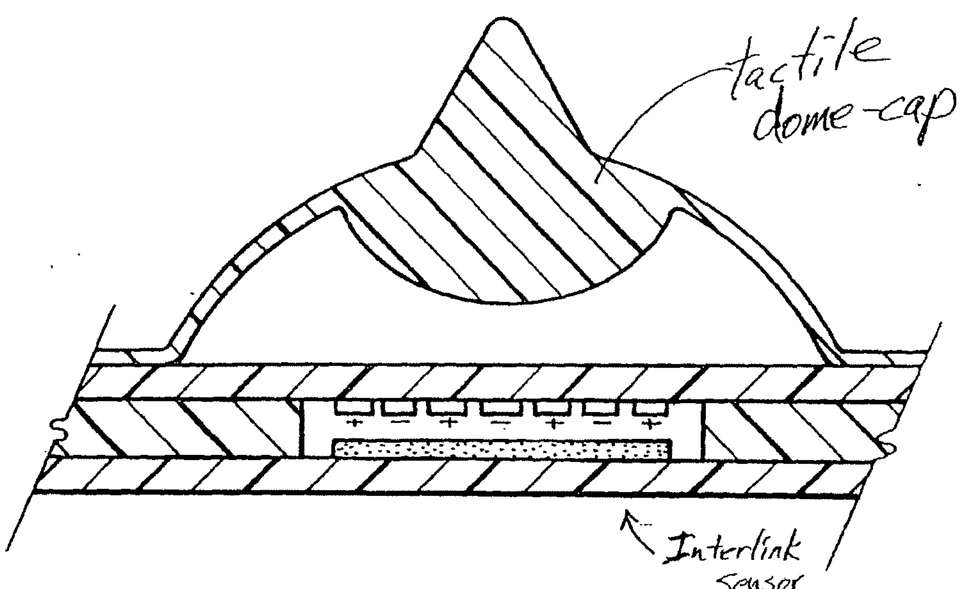

tactile dome-cap
Interlink sensor

FIG. 24

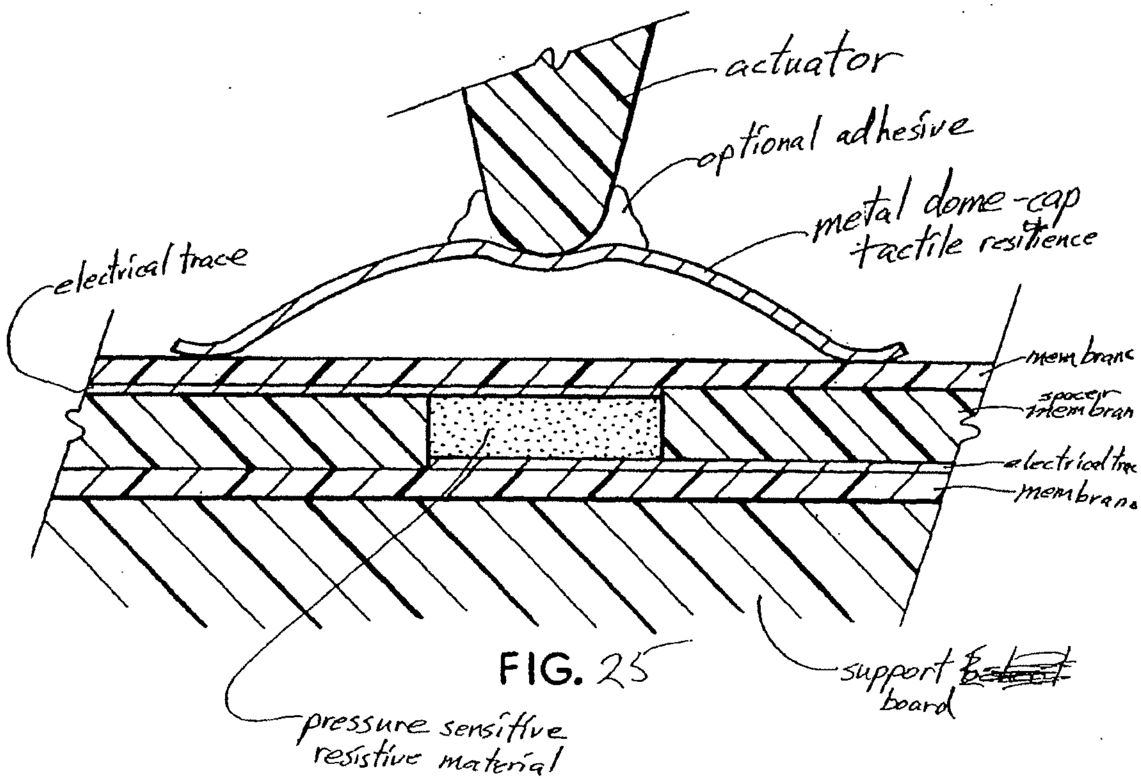


FIG. 25

showing three layer membrane.

5 layer membrane could have pressure sensors as in figs. 25 & 26 and on/off switches as in Figures 19 & 20 so that for example a keyboard could have both a simple switched and a proportional controller at the same time

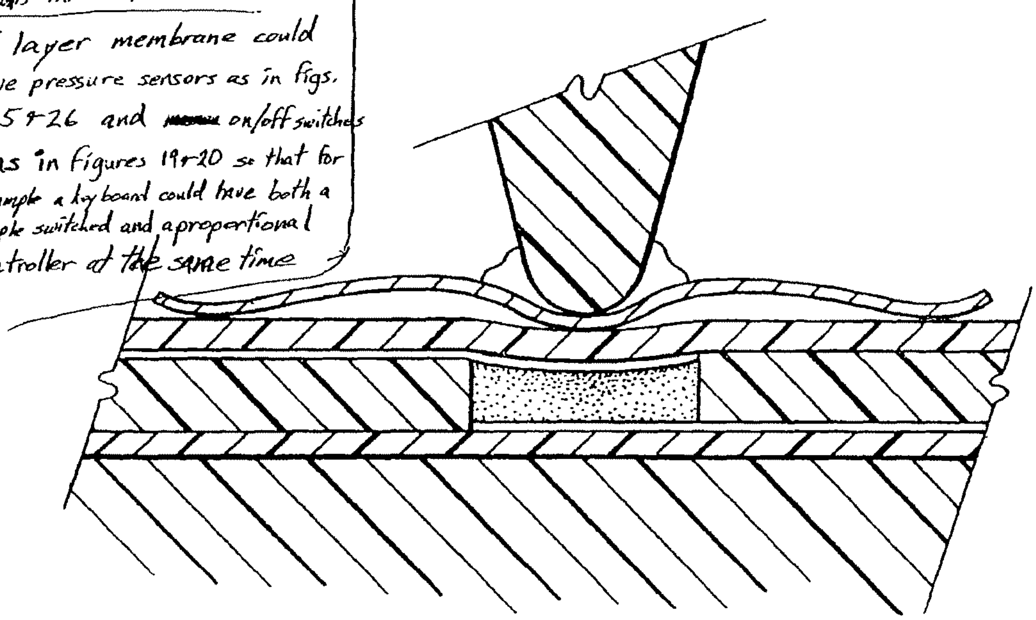


FIG. 26

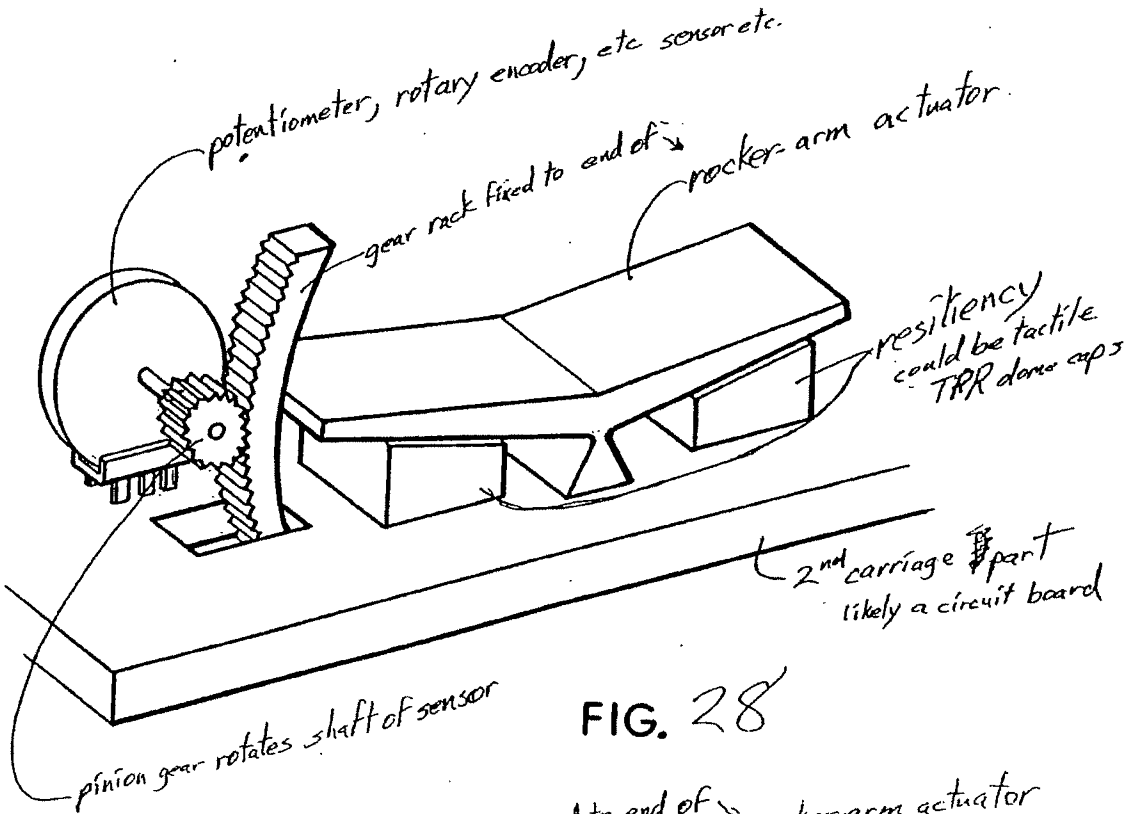

potentiometer, rotary encoder, etc sensor etc.
gear rack fixed to end of
rocker-arm actuator
resiliency
could be tactile
TPR dome caps
2nd carriage part
likely a circuit board
pinion gear rotates shaft of sensor

FIG. 28

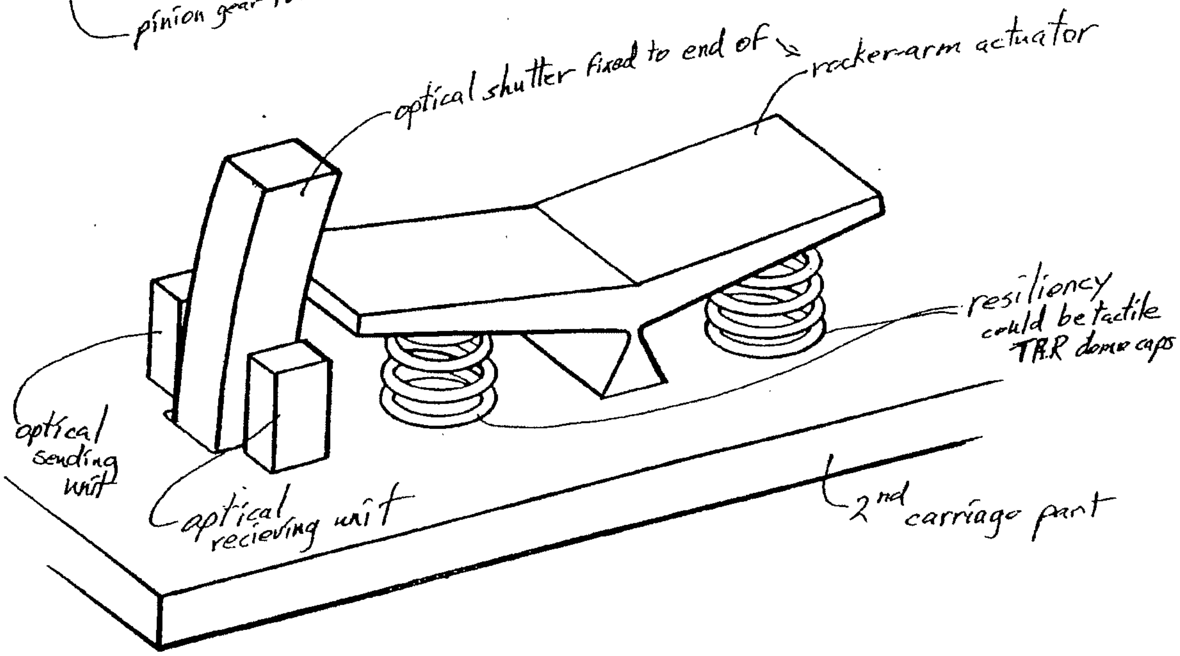

optical shutter fixed to end of
rocker-arm actuator
resiliency
could be tactile
TPR dome caps
optical
sending
unit
optical
recieving unit
2nd carriage part

FIG. 29

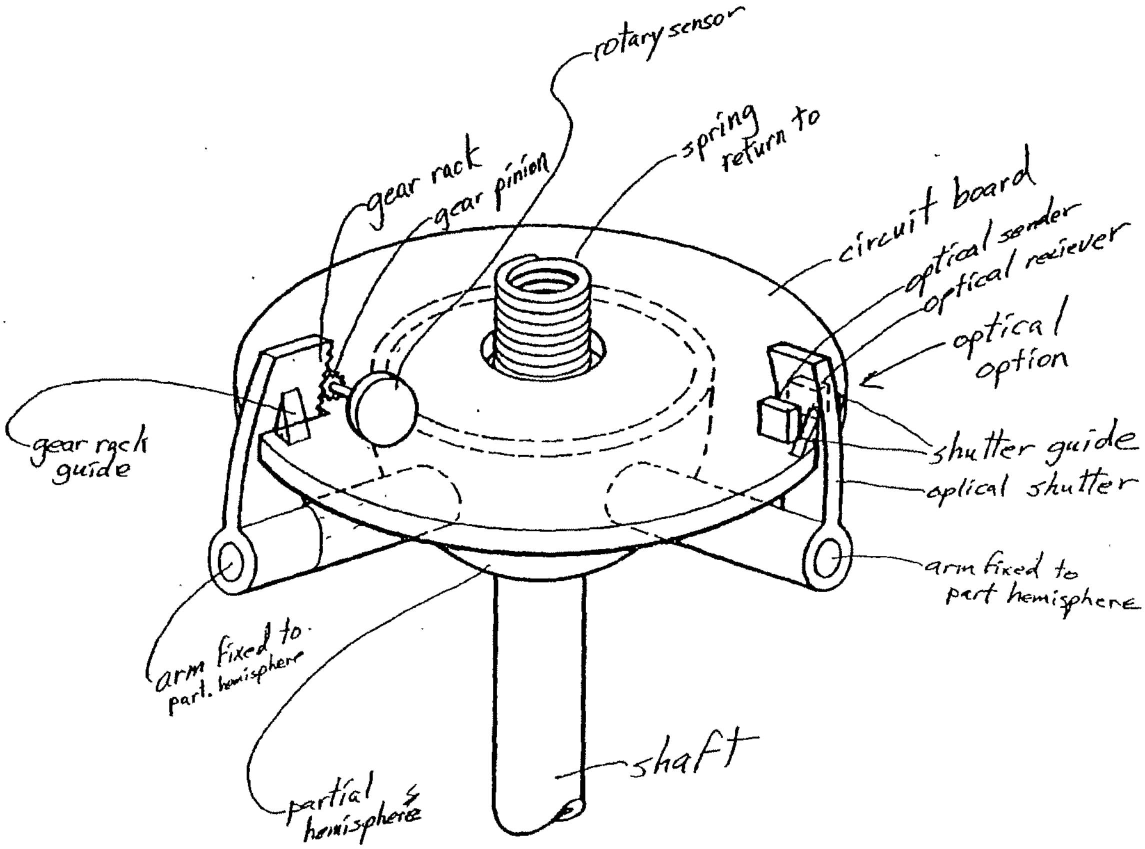
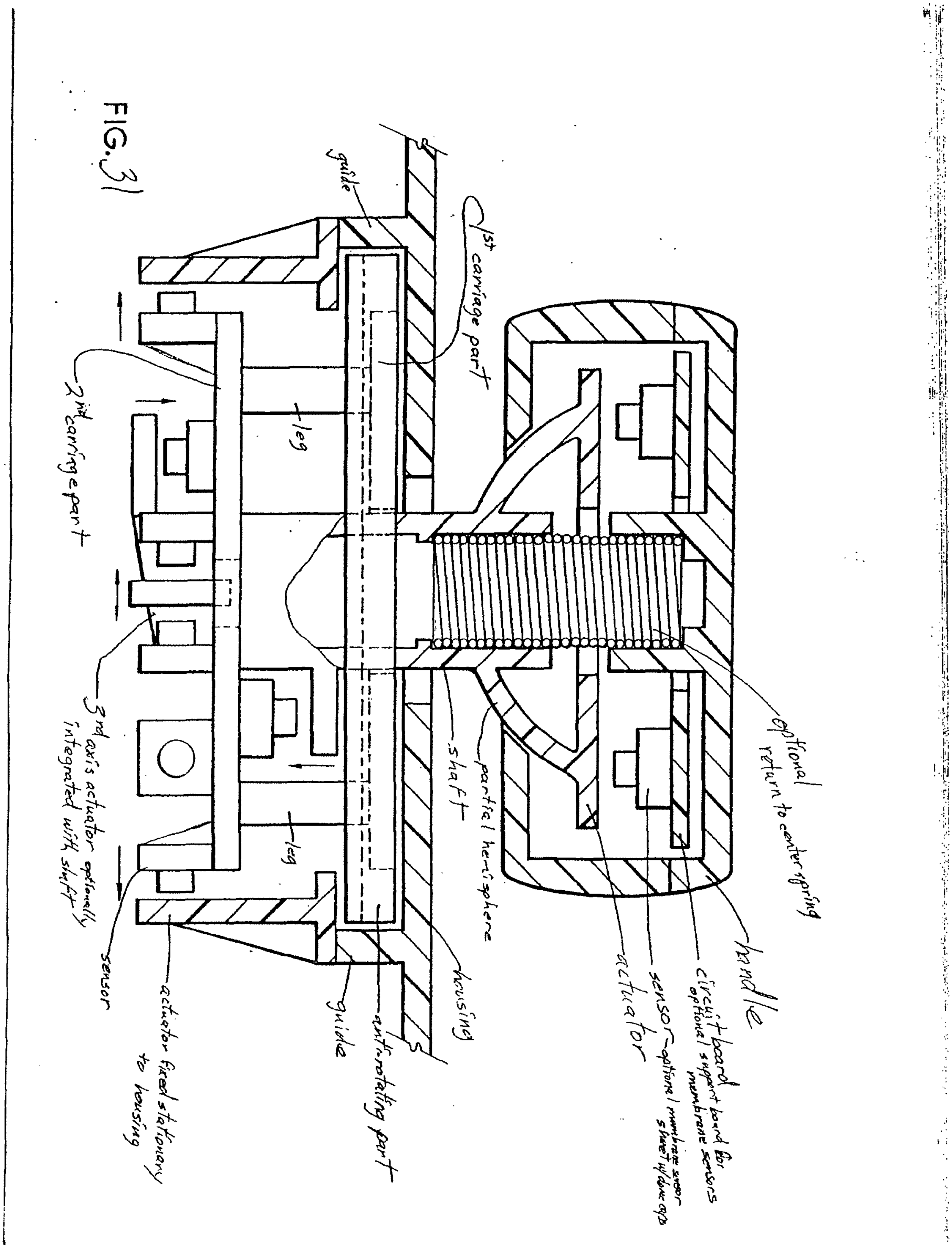

rotary sensor
spring return to
gear rack
gear pinion
circuit board
optical sender
optical reciever
optical option
gear rack guide
shutter guide
optical shutter
arm fixed to part hemisphere
arm fixed to part. hemisphere
shaft
partial hemispheres

FIG. 30



guide
1st carriage part
leg
2nd carriage part
3rd axis actuator optionally integrated with shaft
sensor
actuator fixed stationary to housing
guide
anti-rotating part
housing
shaft
partial hemisphere
leg
optional return to center spring
handle
circuit board
optional support board for membrane sensors
sensor—optional membrane sensor sheet w/ dome caps
actuator

FIG. 31

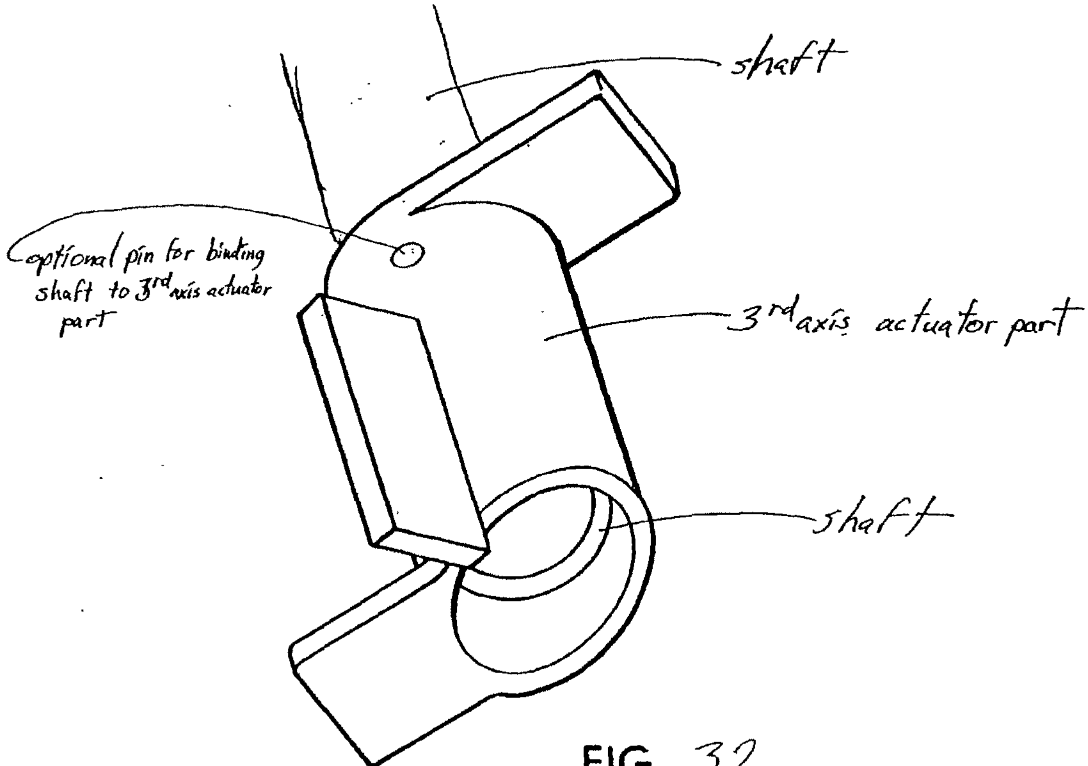

shaft
(optional pin for binding shaft to 3rd axis actuator part
3rd axis actuator part
shaft

FIG. 32

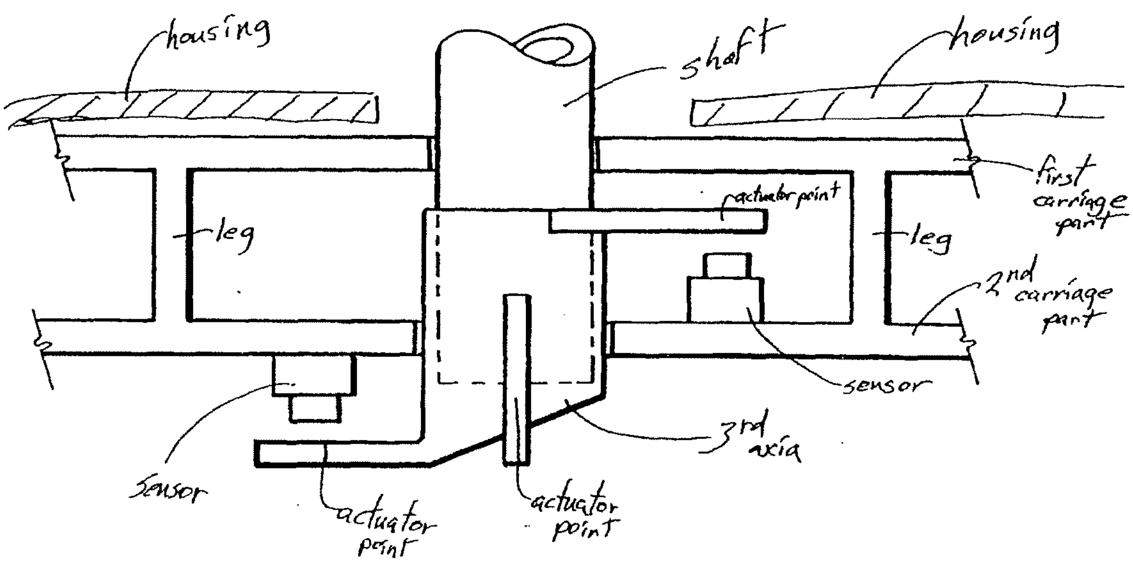

housing
shaft
housing
first carriage part
actuator point
leg
leg
2nd carriage part
sensor
3rd axis
Sensor
actuator point
actuator point

FIG. 33

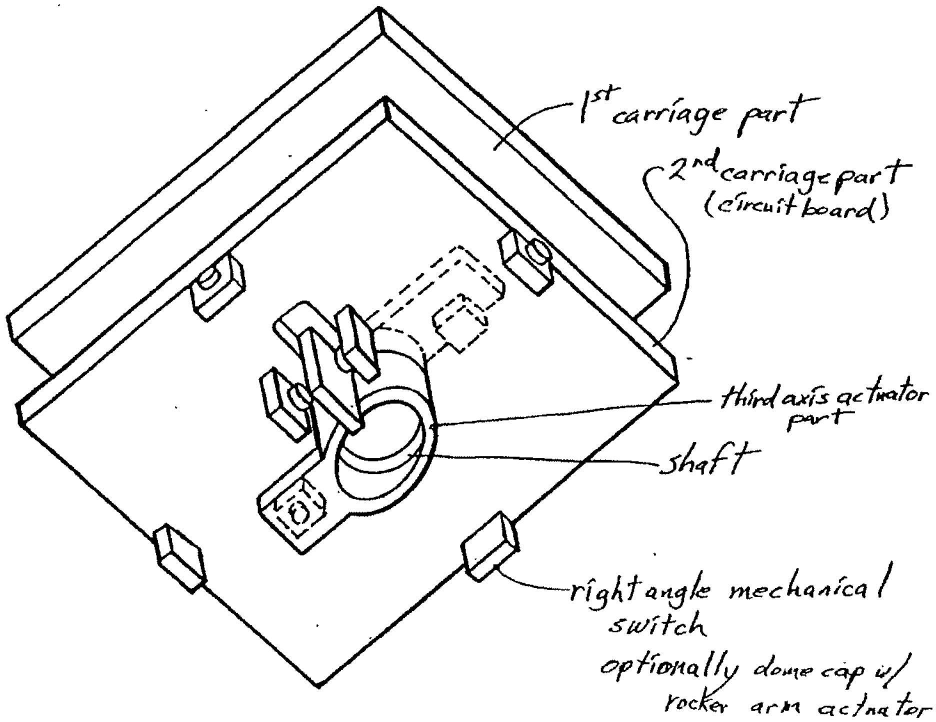

1st carriage part
2nd carriage part (circuit board)
third axis actuator part
shaft
right angle mechanical switch
optionally dome cap w/ rocker arm actuator

FIG. 34

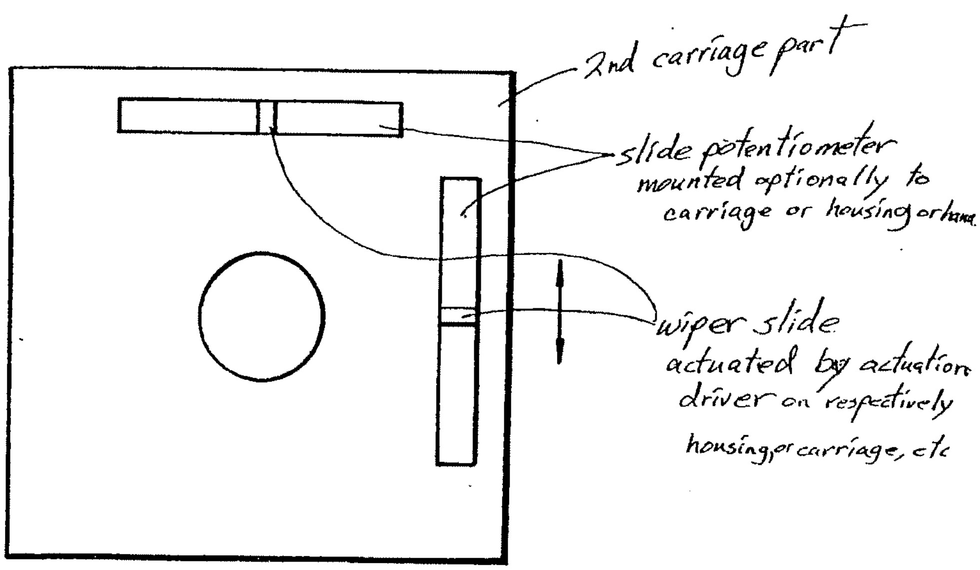

2nd carriage part
slide potentiometer mounted optionally to carriage or housing or hand
wiper slide actuated by actuation driver on respectively housing, or carriage, etc

FIG. 27

Fig 35

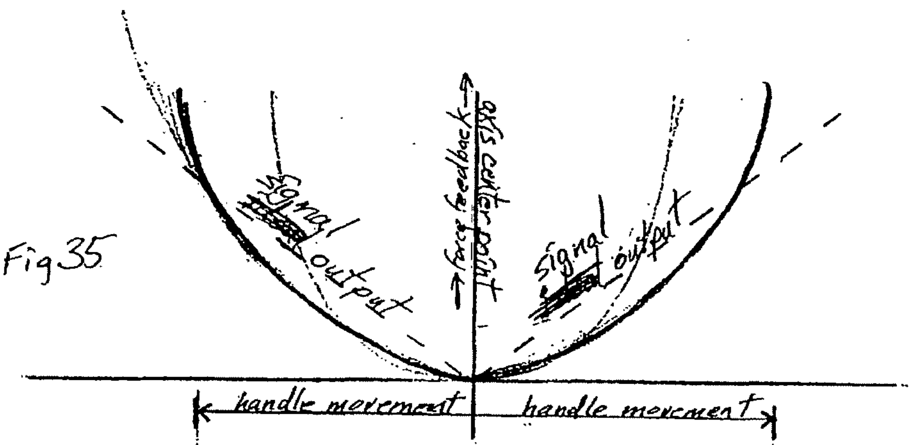


Fig 36

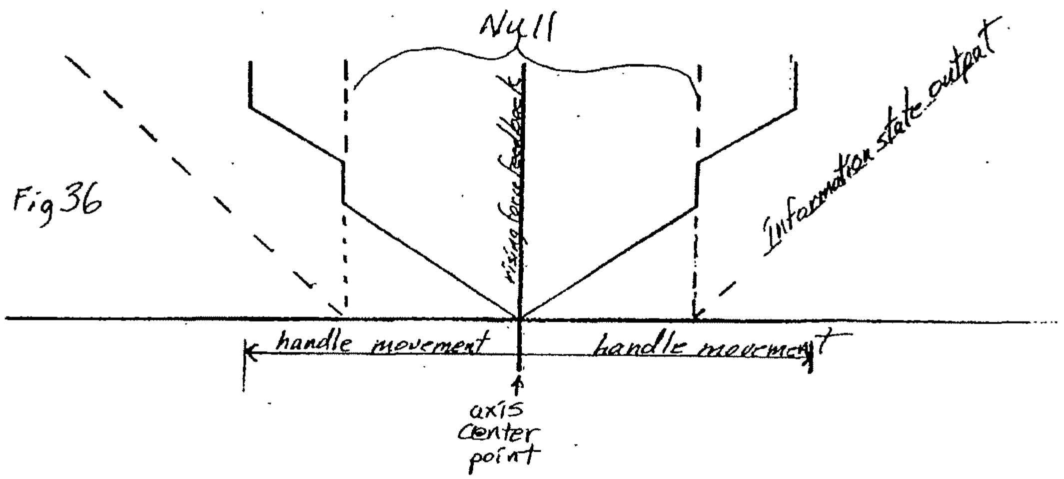
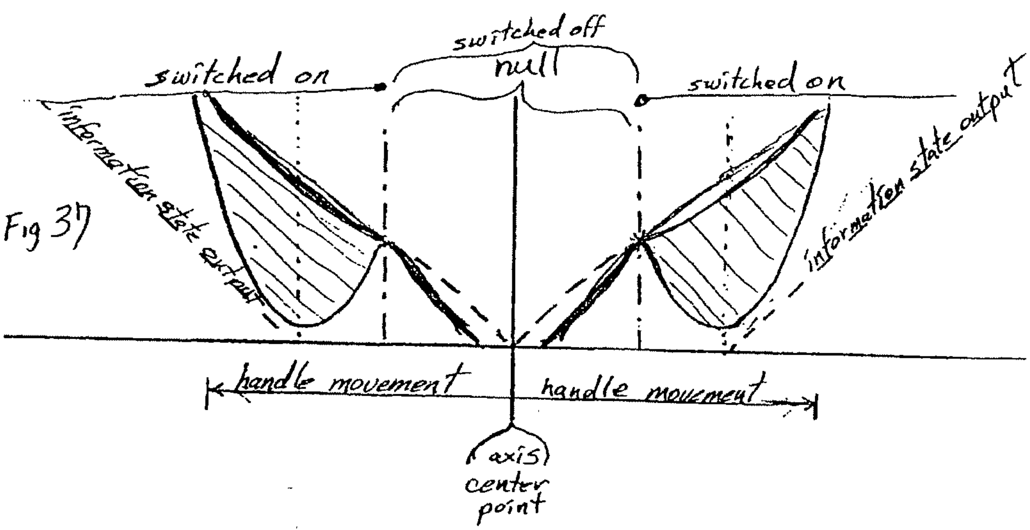


Fig 37



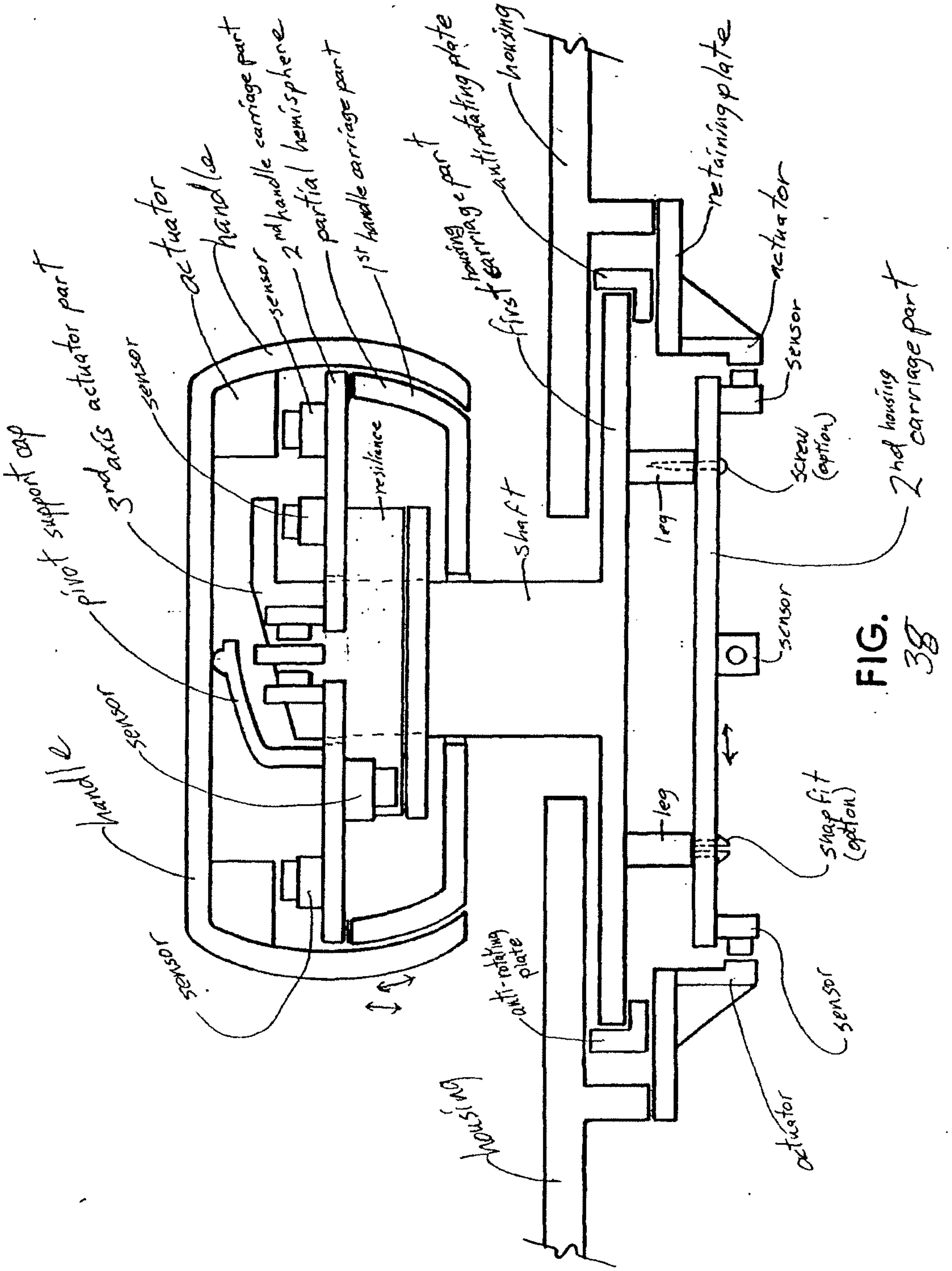

pivot support cap
3rd axis actuator part
sensor
actuator
handle
sensor
2nd handle carriage part
partial hemisphere
1st handle carriage part
first housing carriage part
anti-rotating plate
housing
retaining plate
actuator
sensor
screw (option)
2nd housing carriage part
resilience
shaft
leg
sensor
leg
snap fit (option)
sensor
actuator
anti-rotating plate
housing
sensor
sensor
handle

FIG. 3B

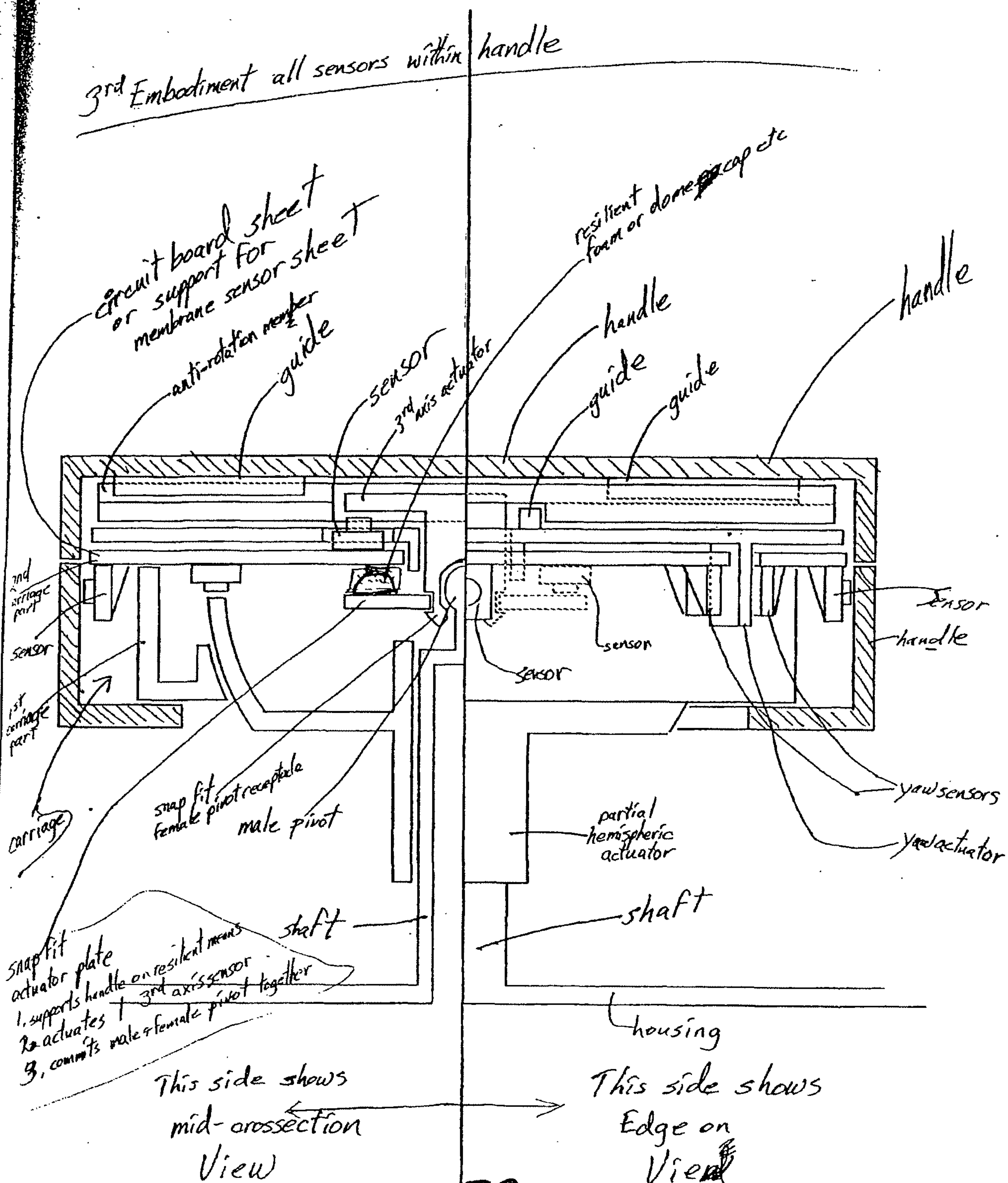


Fig 39

(handle in crossection)

4th Embodiment

This design incorporates all sensors for both movement and rotation into the ball handle.

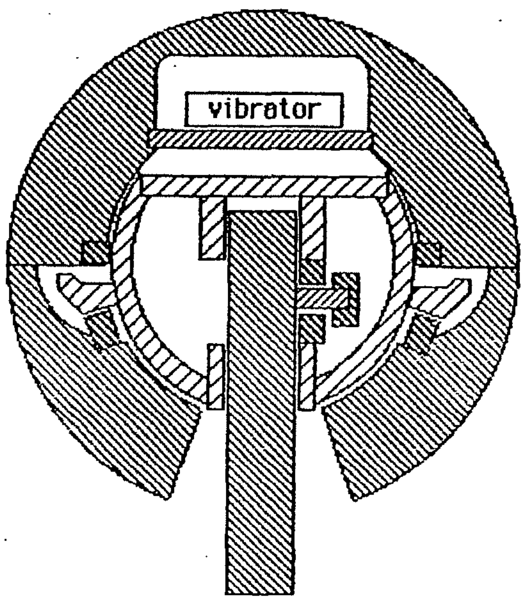


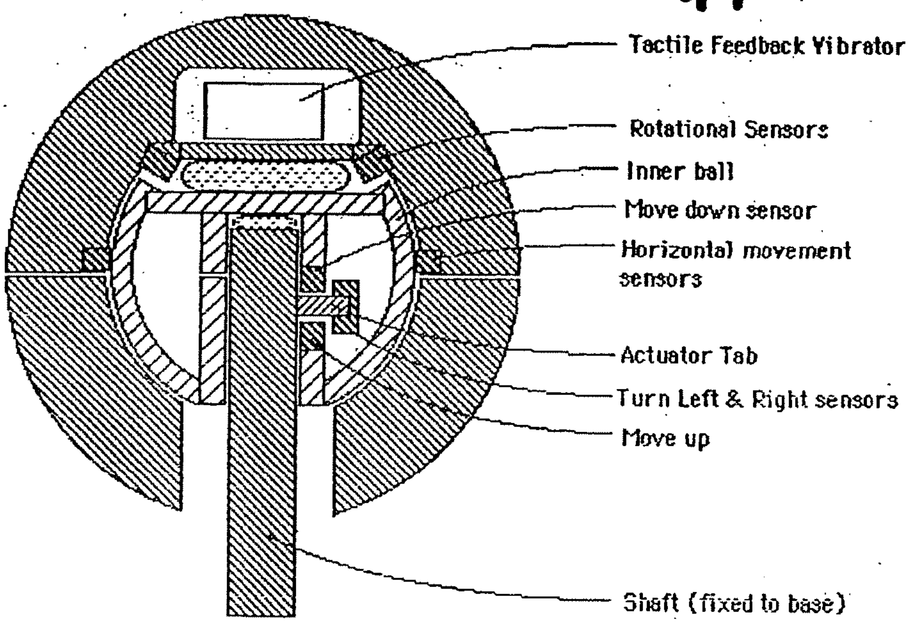
Fig. ~~40~~ 40

Sectional view from median

Variation on 4th Embodiment

This design incorporates all sensors for both movement and rotation into the ball handle.

Fig. 41



Sectional view from median

Scott Flowers

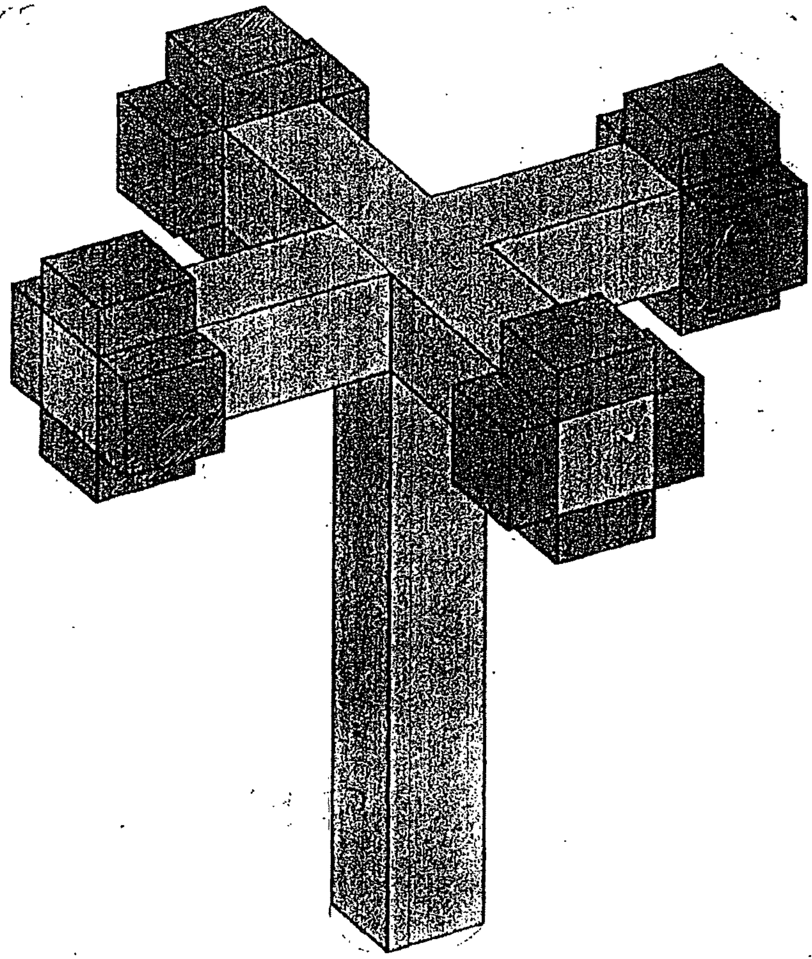


Fig 44

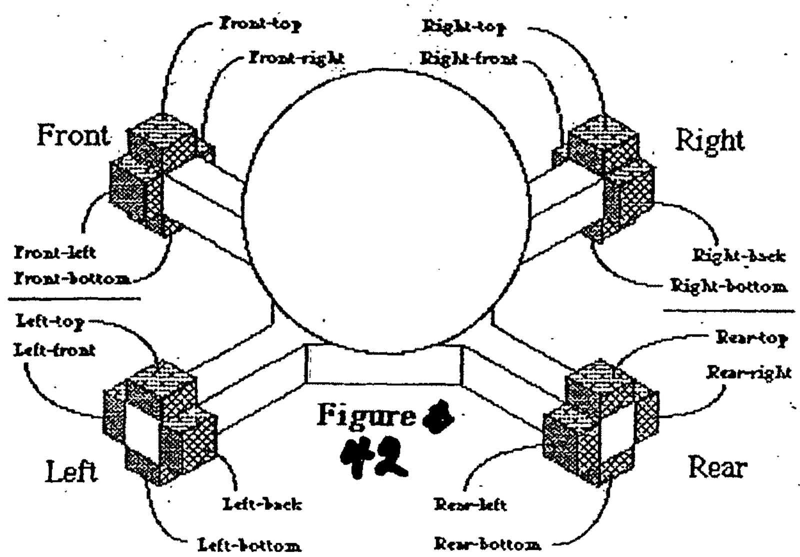


Figure 42

WIRING LOGIC Figure 43

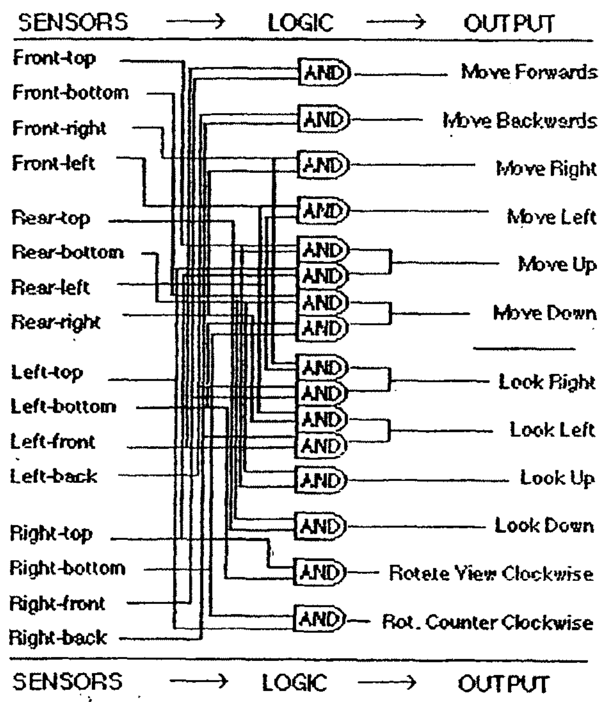
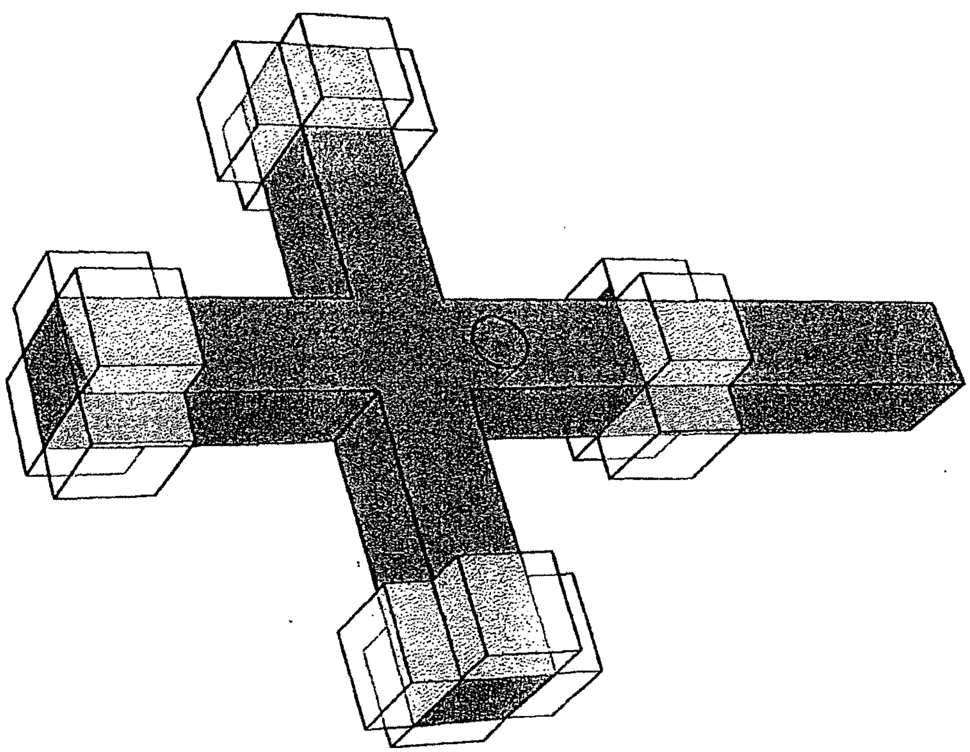
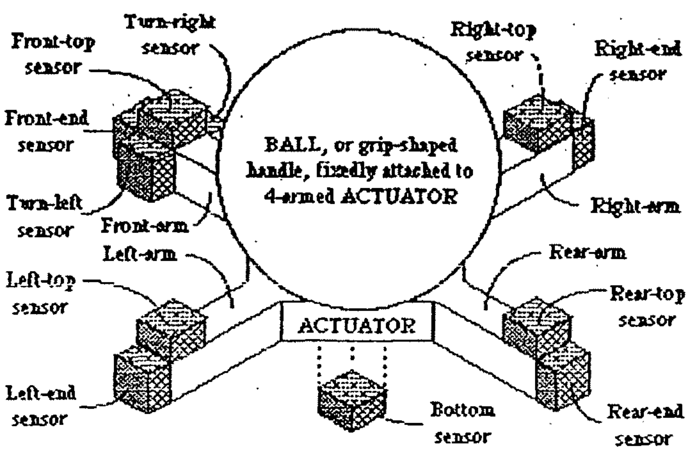


Fig 45



// Sensor Arrangement and Naming

Figure 46



L	L	L	L	H	H	H	H	H	L	H	H	L	L	Left-top sensor
L	L	L	H	L	H	H	H	L	H	L	L	H	H	Right-top sensor
L	L	H	L	L	H	H	L	H	H	H	L	L	H	Front-top sensor
L	H	L	L	L	H	L	H	H	H	L	H	H	L	Rear-top sensor

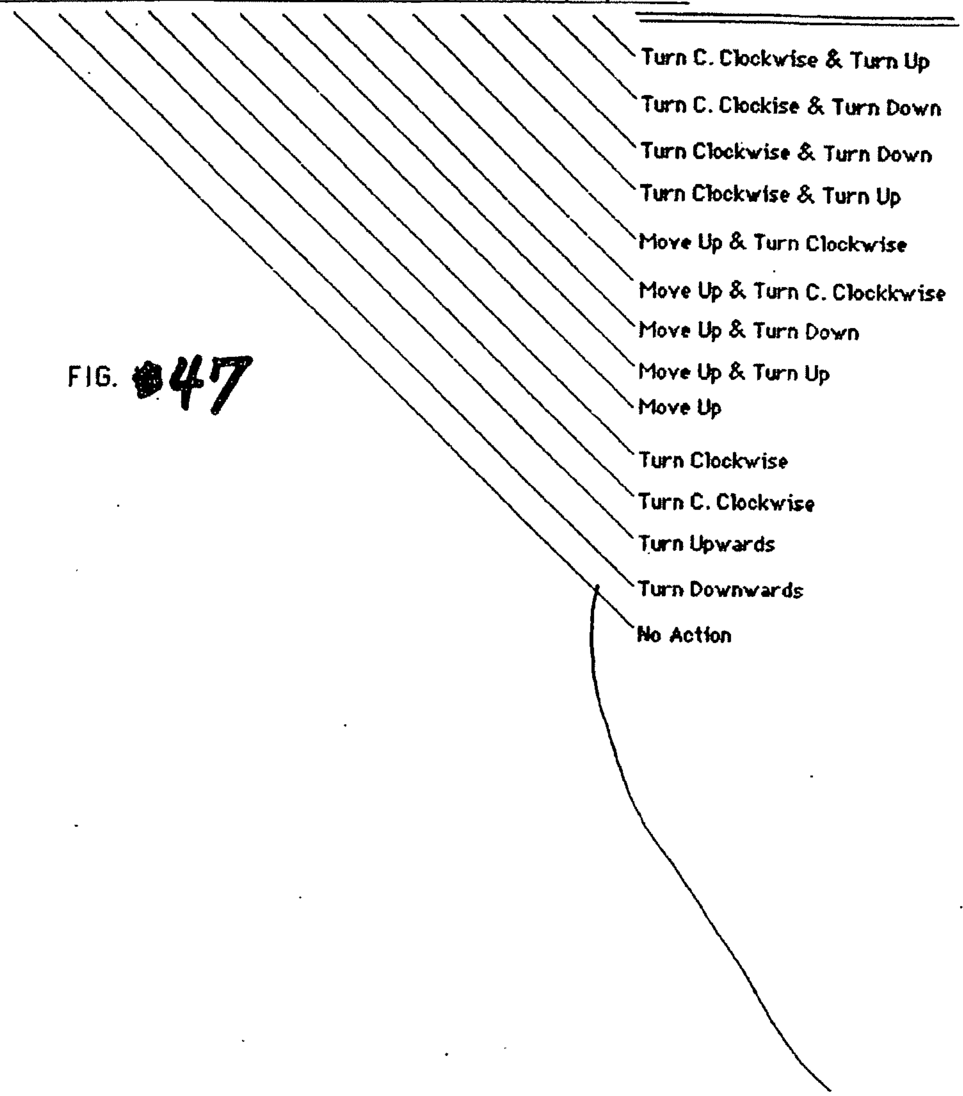
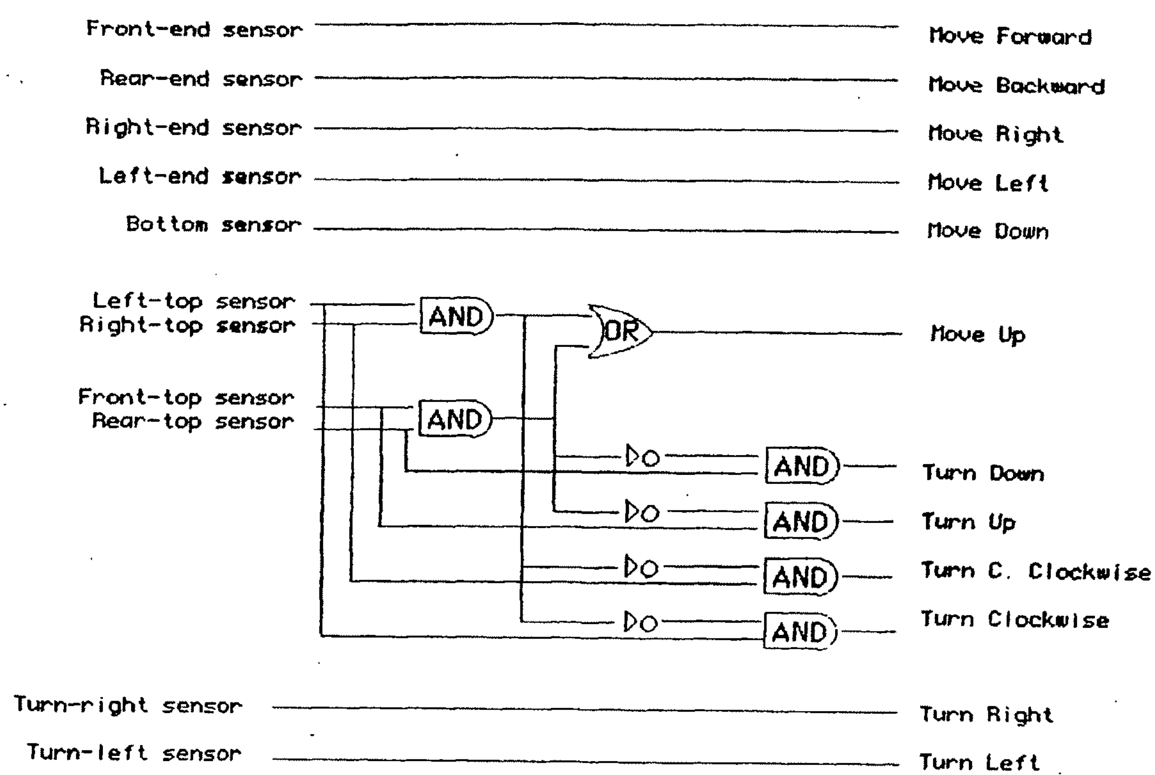


FIG. 47

Fig. 48


Front-end sensor
Move Forward
Rear-end sensor
Move Backward
Right-end sensor
Move Right
Left-end sensor
Move Left
Bottom sensor
Move Down
Left-top sensor
Right-top sensor
Move Up
Front-top sensor
Rear-top sensor
Turn Down
Turn Up
Turn C. Clockwise
Turn Clockwise
Turn-right sensor
Turn Right
Turn-left sensor
Turn Left

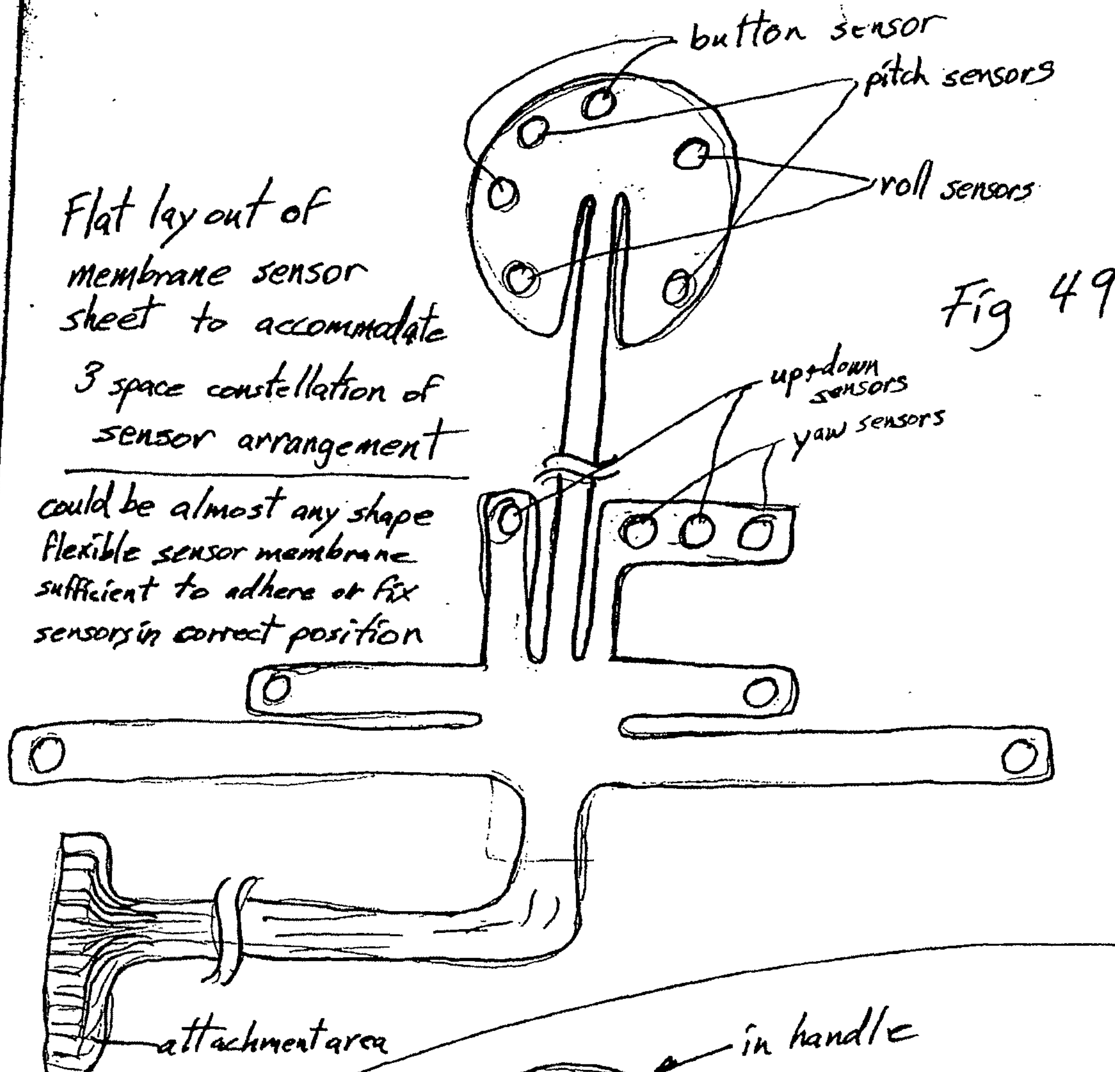

button sensor
pitch sensors
roll sensors
Flat layout of membrane sensor sheet to accommadate 3 space constellation of sensor arrangement
could be almost any shape flexible sensor membrane sufficient to adhere or fix sensors in correct position
up+down sensors
yaw sensors
attachment area

Fig 49

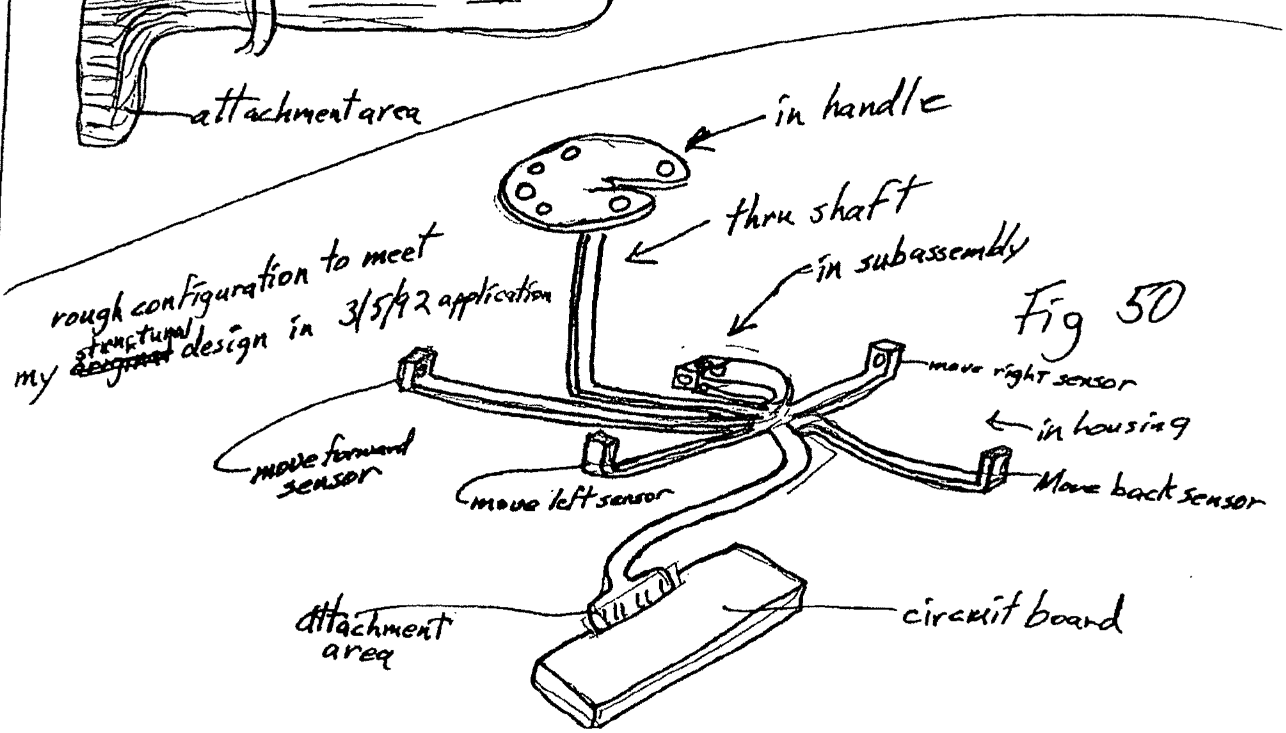

in handle
thru shaft
in subassembly
rough configuration to meet my structural design in 3/5/92 application
move right sensor
in housing
move forward sensor
move left sensor
Move back sensor
attachment area
circuit board

Fig 50

some Tactile Pressure Sensor Types

Tactile Resiliency

Sensor mediums			Metallic dome (non conducting)	Metallic dome (conducting)	TPR dome (Non Conductive)	TPR dome (conductive element)
Membrane	single surface traces		X	X 1 layer	X	X 1 layer
Membrane	two surface traces		X	✓	X	✓
Membrane	single surface traces w/ 2nd surface conductive cap		X	✓	X	✓
Membrane	5 layer switched + pressure		X	X as 3 layer	X	X 3 layer
Circuit board	Interdigitated traces	cond. cap	X	X	X	X
Circuit board	Interdigitated traces	no cap	X	X	X	X
Circuit board	Bilateral outside ring trace			X		X
Package	Interdigitated traces	cond. cap	X	X	X	X
Package	Interdigitated traces	no cap	X	X	X	X
Package	Bilateral outside ring trace			X		X

X = inherent usefulness
✓ = overkill

Fig 51

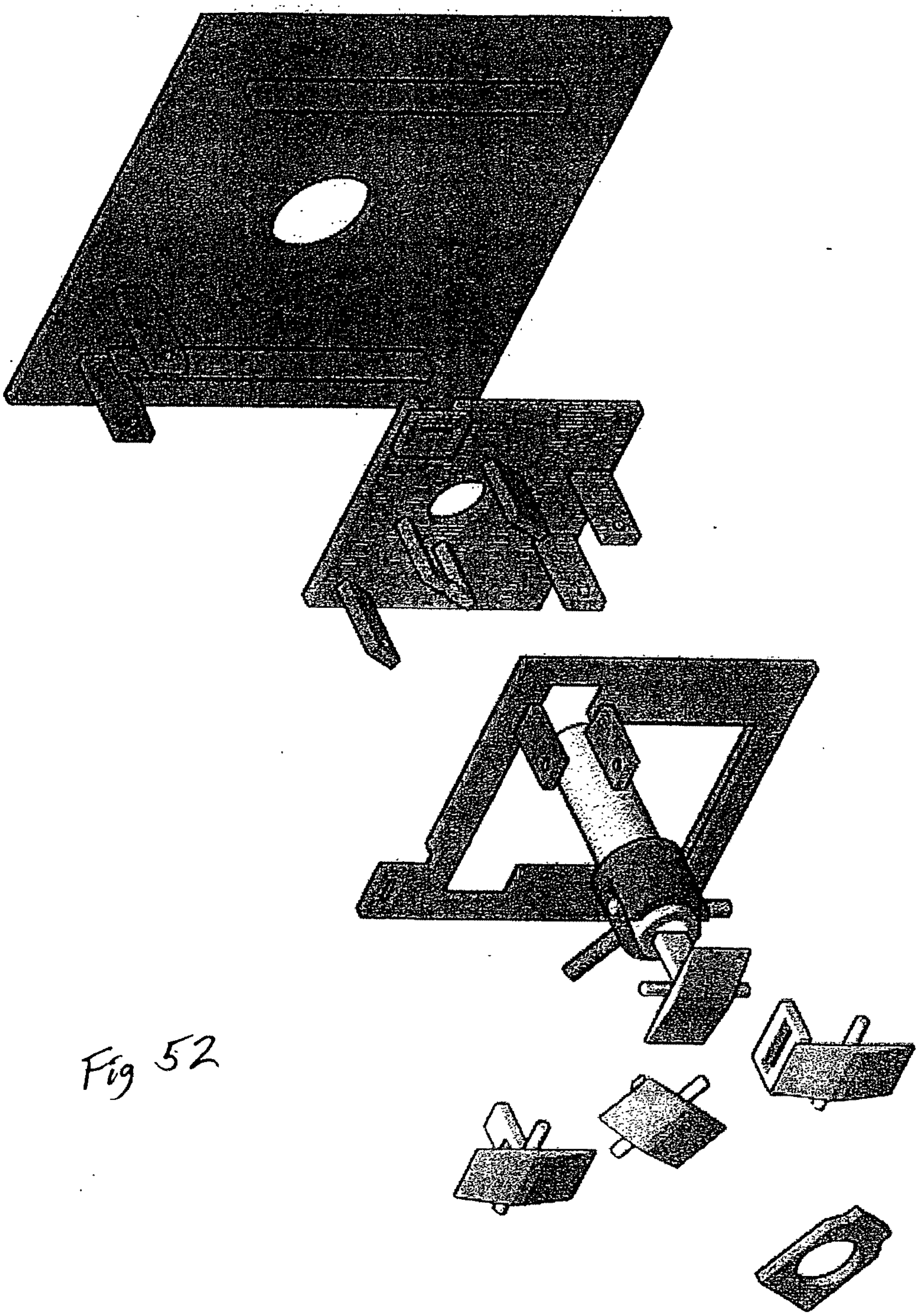


Fig 52

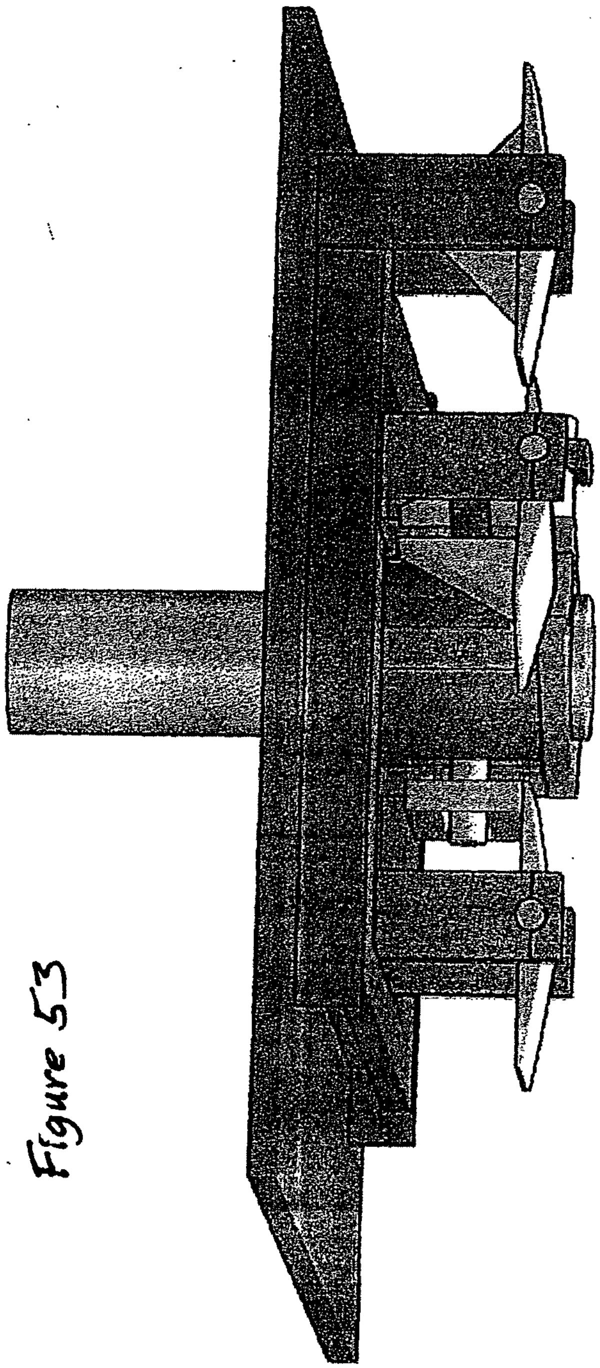


Figure 53

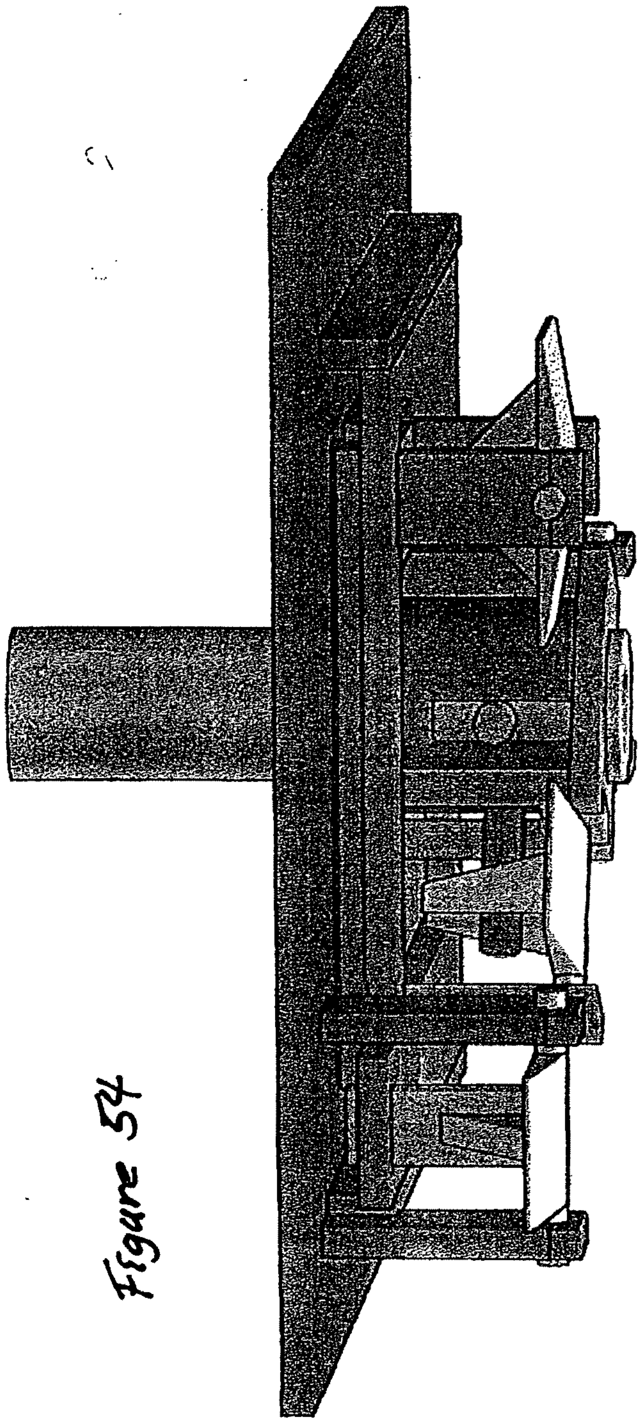


Figure 54

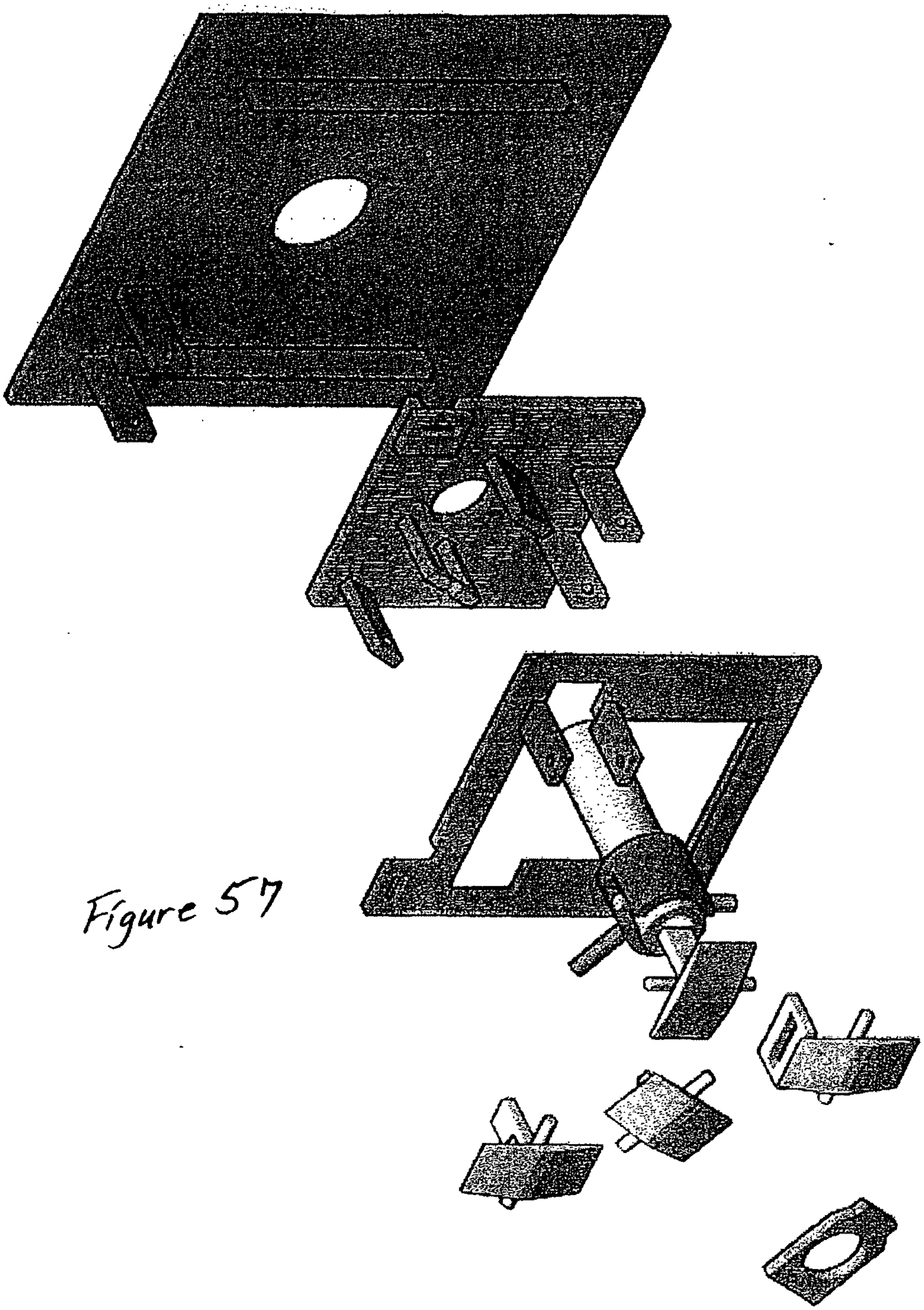


Figure 57

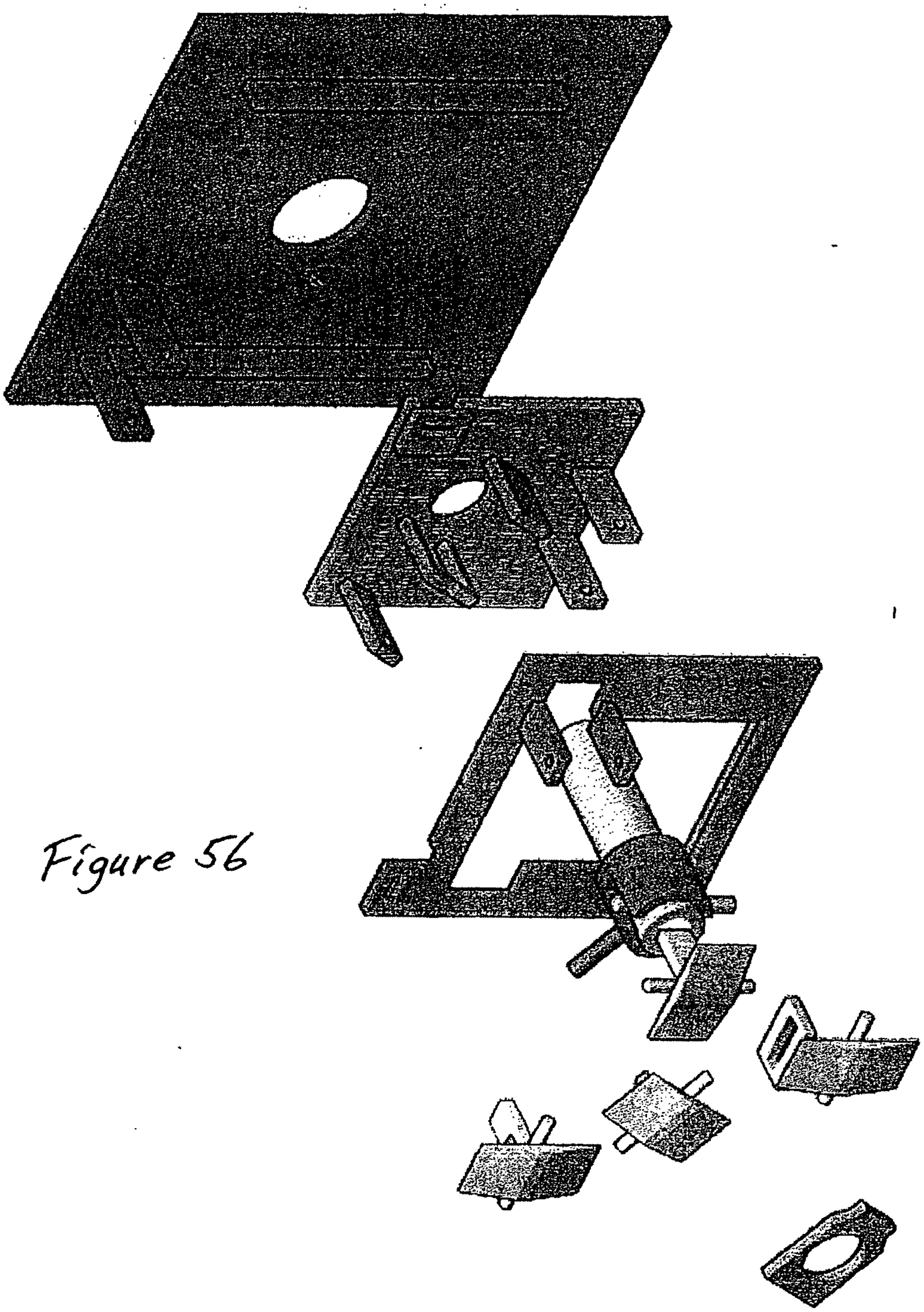


Figure 56

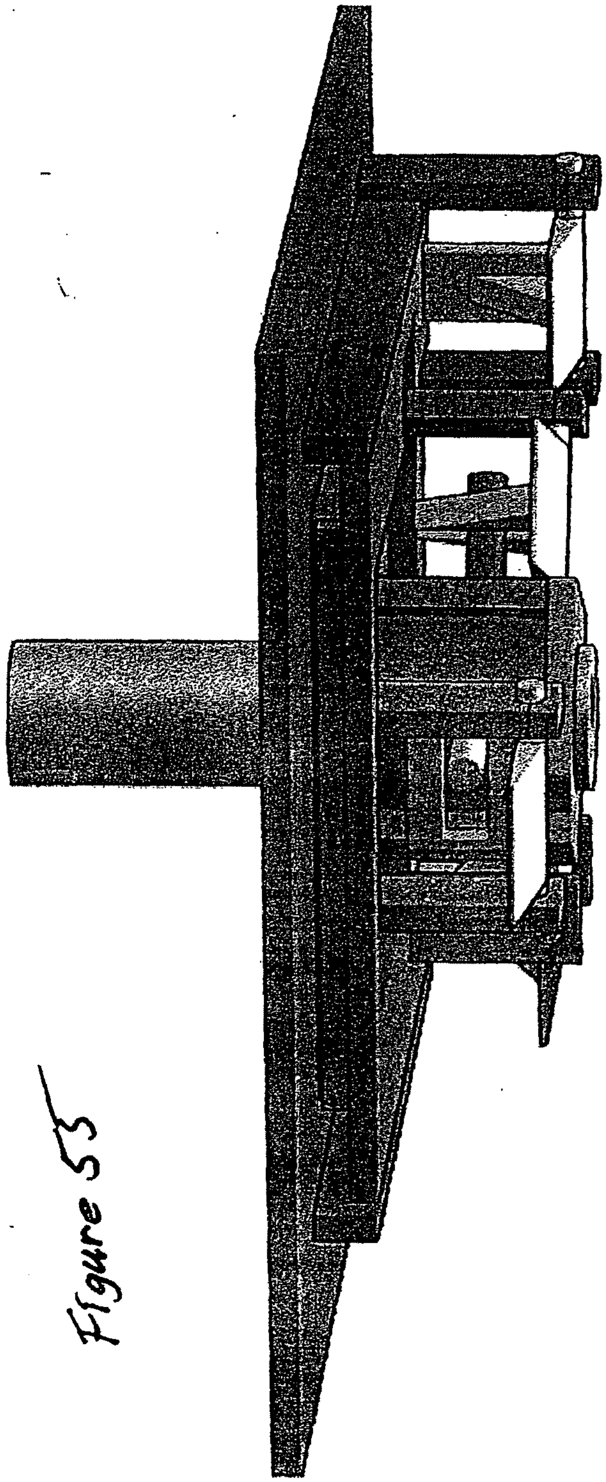


Figure 53

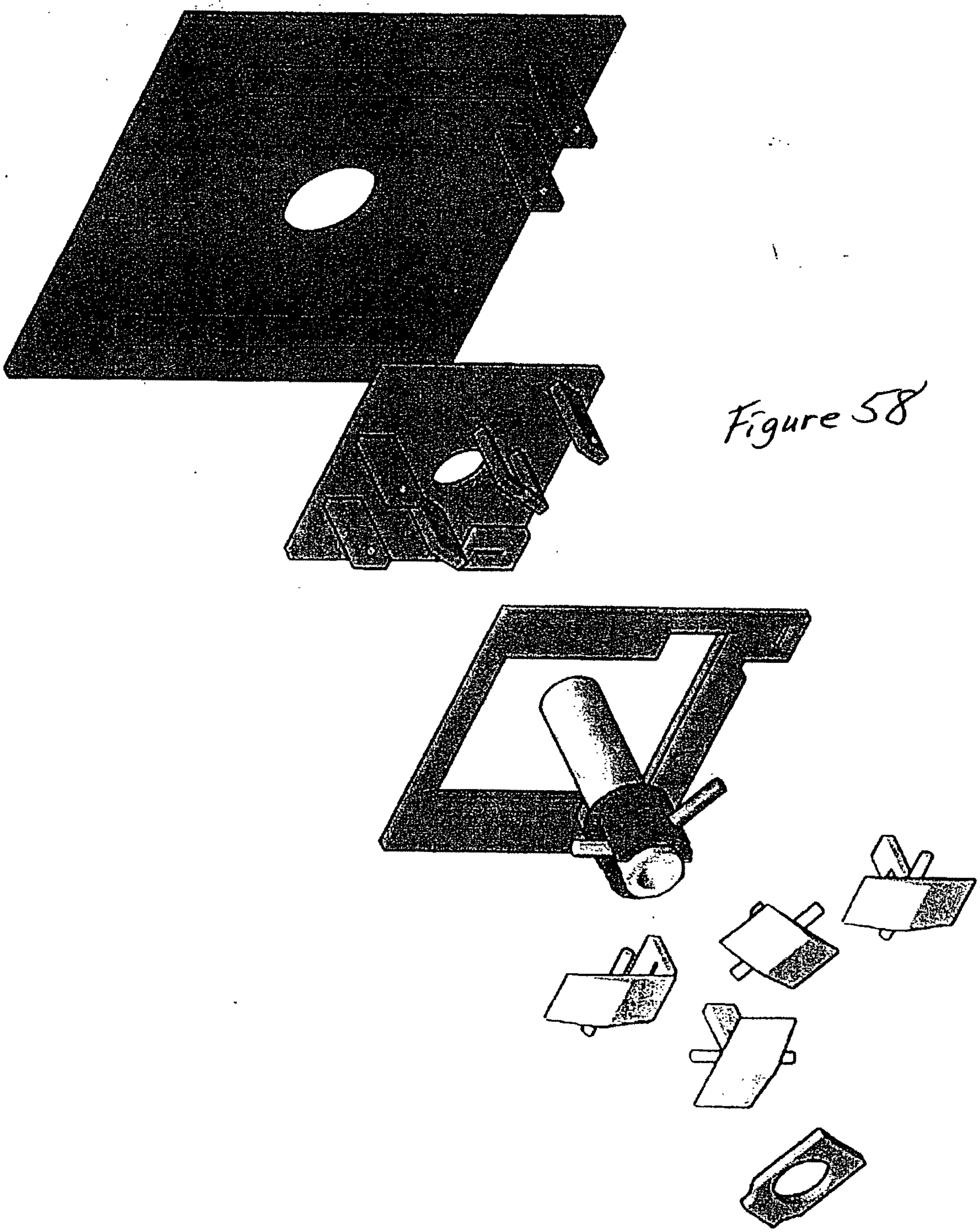


Figure 58