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[54] **PALPATOR FOR X-RAY USE**

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[51] **Int. Cl.²** **A61B 6/00**

[58] **Field of Search** ..... 128/2 A, 2 R, 53, 61; 214/1 CM; 3/1.2; 250/439

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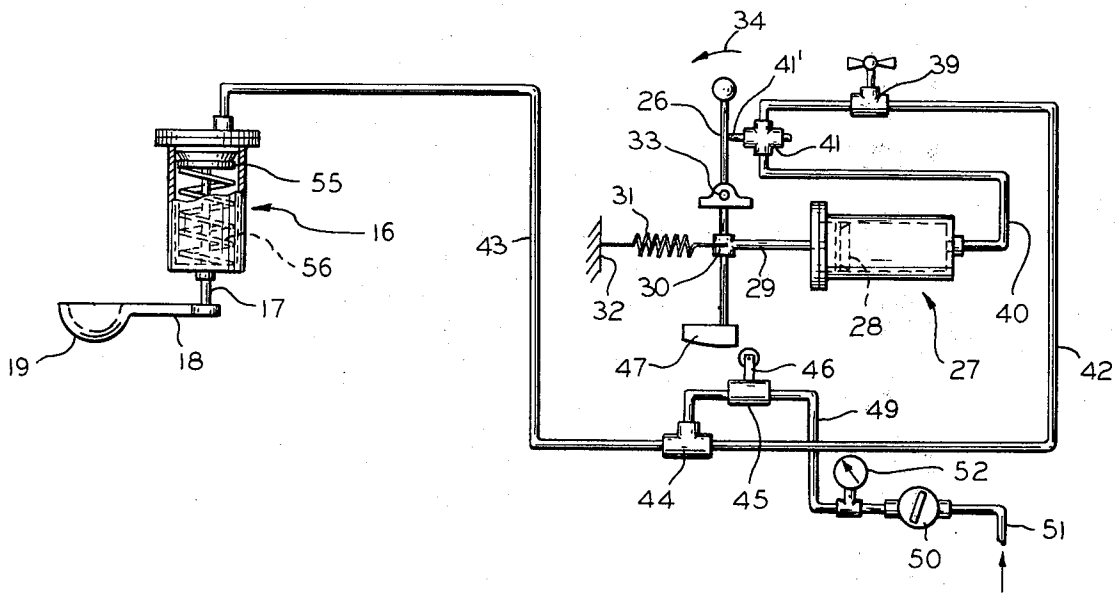
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[57] **ABSTRACT**

A palpator for manipulating the anatomy of an X-ray diagnosis subject comprises a gas operated work cylinder proximate with the subject. An X-ray transmissive palpator deforms the subject's anatomy under the influence of the work cylinder. A master cylinder coupled with the work cylinder by means of tubing is manually operated such that the operator is able to sense the amount of force being applied to a remotely situated subject. Means are provided for advancing the palpator from its parked position to contact or near contact with the subject. Further force, simulating direct manipulation of the subject, is produced by the operator applying a corresponding force to the master cylinder.

4 Claims, 4 Drawing Figures



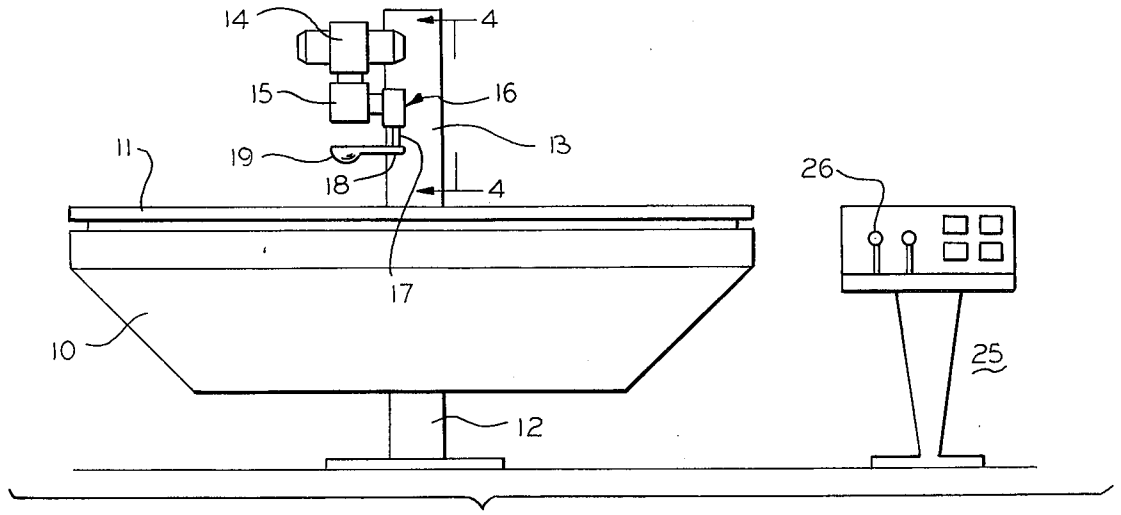


FIG.1

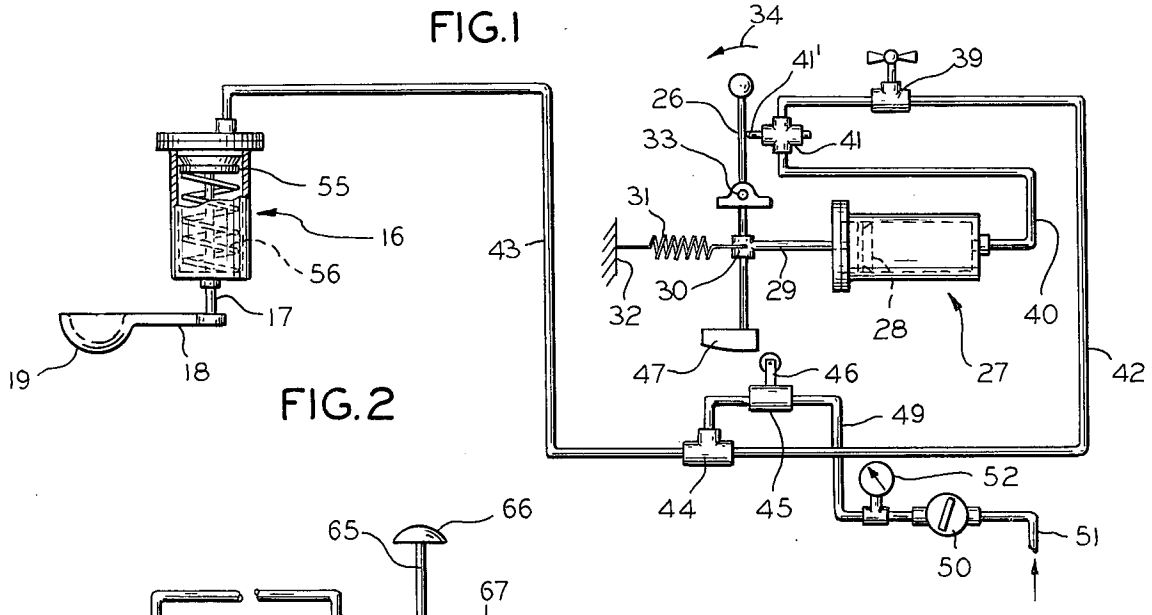


FIG.2

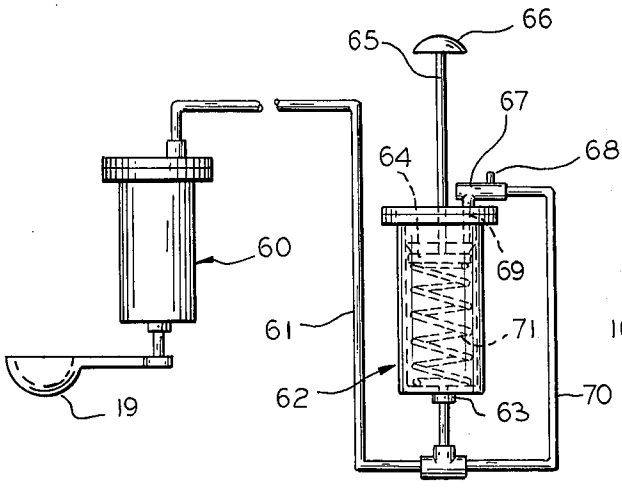


FIG.3

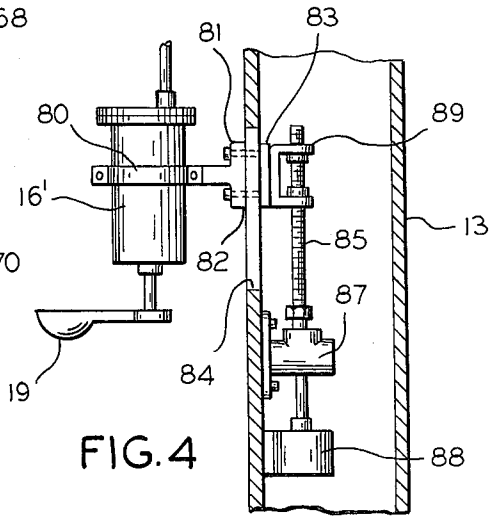


FIG.4

PALPATOR FOR X-RAY USE

BACKGROUND OF THE INVENTION

A known procedure for making an X-ray study of the gastrointestinal tract involves having the examination subject ingest an X-ray opaque substance such as barium slurry which, because of its relatively high opacity to diagnostic X-rays, inhances the radiologist's ability to visualize the anatomical condition under study. The X-ray opaque substance tends to settle in discrete pools in various parts of the tract rather than fill the tract or flow through it. Hence, it is customary for the radiologist to manipulate the subject's abdominal area to cause the slurry to flow and fill any voids in the interface between the slurry and the internal boundaries of the organ being examined. Traditionally, this has been done by pressing or palpating the patient's abdomen by hand.

Hand manipulation was satisfactory with conventional X-ray equipment where the radiologist or operator was close to the subject. In the most advanced diagnostic X-ray systems, however, the radiologist carries out substantially all of the diagnostic procedures from a control console located considerable distance from the subject. This has resulted in the need for a remote controlled manipulator or palpator.

Several different types of remotely operable palpators have been made and used in an effort to fulfill this need. One is an electromechanical palpator controlled by electric switches. It is comparable to electromechanical robots which are used for handling radioactive substances at a safe distance. This type of palpator has been considered unsatisfactory by some radiologists, primarily because it does not give them a sense of feel or force feedback such as they would get by direct manipulation of the subject's anatomy. The palpator system is also complicated and expensive.

Another type of palpator which was expected to fill the need uses a hydraulic work cylinder in proximity with the examination subject. The radiologist applies a force to a fluid filled master cylinder which is connected to the slave or work cylinder with a long tube, such that when the master cylinder is pressed, the pressurized fluid causes the slave cylinder to respond by moving toward the subject and subsequently pressing against the subject.

Leakage is a significant problem in hydraulic palpator systems. When a small amount of hydraulic fluid leaks out, air leaks in and this changes the feeling sensed by the operator from a solid feeling to which he has become accustomed to a spongy feeling due to compressibility of the entrapped air. This compressibility compels additional movement of the master cylinder for a given slave cylinder travel which is disadvantageous because the hydraulic system has little overtravel capability. It is difficult to purge or bleed entrapped air from a hydraulic system as is well known. Leakage of fluid creates a mess in the X-ray room and is potentially dangerous since some hydraulic fluids are combustible and slippery. Most hydraulic fluids are malodorous and some are nauseating. These are highly undesirable characteristics in a hospital.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide a palpator system which permits a radiologist or other operator to apply a force remote from the examination subject and to derive a sense of reactive force comparable to that which is experienced when directly manipulating the subject.

A further object is to provide a palpator system which uses air or other gas as a force transmissive medium between a palpator driving slave or work cylinder that is near the subject and a manually operable master cylinder to which the radiologist may apply a direct force and that affords a feeling of resilience and force feedback comparable to that which would be obtained by directly contacting the subject.

Still another object is to provide a gas pressure operated palpator system which is substantially immune from the effects of minor gas leaks.

Yet another object of the invention is to provide a system wherein substantially one-to-one or any desired correspondence is obtainable between force generated by the radiologist at a remote station and the force applied to the examination subject.

How the foregoing and other more specific objects of the invention are achieved will be evident in the more detailed description of illustrative embodiments of the invention which will be set forth hereinafter.

In general terms, in accordance with the invention, a slave cylinder-piston assembly is located near the position occupied by a subject's body on a diagnostic X-ray table. The work cylinder is coupled with tubing to a master cylinder-piston assembly located at a control console remote from the X-ray table. In one embodiment, when the piston of the master cylinder is depressed, a flow of gas is initiated which advances the piston of the slave cylinder from its parked position to a point where it places the palpator near or in contact with the examination subject. Continued application of force by the operator on the master cylinder then causes the subject's anatomy to be depressed with an attendant force feedback that is felt by the operator. When the radiologist removes his hand from the level or other means for operating the master piston, the elastic properties of the subject's body will push the slave piston up to the no force position. Upon this event, a microvalve opens to equalize the system with atmospheric pressure which assures that the system will always start from the same initial gas volume and pressure states despite any small leak in the system.

Illustrative embodiments of the new palpator system will now be described in detail in reference to the drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevation view of an X-ray table which employs the new palpator, said table being associated with a control console;

FIG. 2 is a schematic diagram of the palpator system isolated from the X-ray table and control console;

FIG. 3 is a schematic diagram of an alternative form of the palpator; and

FIG. 4 is a fragmentary side view, partly in section, of the mechanism inside the X-ray table column, for moving the slave cylinder of the palpator, said section being taken on a line corresponding with 4—4 in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

The new palpator system is an accessory for a diagnostic X-ray table which is typified by the bidirectionally tiltable X-ray table illustrated schematically in FIG.

1. The X-ray table comprises a body **10** having an X-ray permeable top **11** for supporting a human examination subject for diagnosis. The table body **10** is tiltable on a floor mounted stand **12** by mechanism interior of the table body which is well known to those skilled in the art and is not shown.

Mounted on body **10** or joined with the mechanism therein is an X-ray tube support column **13.** An X-ray tube casing **14** is carried by an arm, not visible, extending from the column **13.** The tube casing **14** is supported in a conventional manner for being moved vertically and/or being angulated relative to a patient or examination subject supported on table top **11.** Attached to tube casing **14** is an X-ray beam collimator **15.**

Mounted on column **13** is a gas pressure operated work cylinder **16,** hereinafter called a slave cylinder, which comprises part of the new palpator system. Slave cylinder **16** includes a piston, not visible in FIG. **1,** from which a piston rod **17** extends. Fastened to the lower end of rod **17** is an arm **18** which may be integrally molded with a cup-shaped element **19.** Cup **19** and integral palpator arm **18** are preferably made of a material such as thermoplastic resin which has low X-ray absorption. The palpator may remain in the X-ray beam during fluroscopy and radiography.

As mentioned earlier, when the radiologist desires to palpate or compress the anatomy of a subject lying on table top **11,** arm **18** together with cup **19** are advanced from an uppermost parked position to a position in near proximity with the subject. Then, by means which will be described, the palpator cup **19** is advanced at a rate and with a force determined by the radiologist at console **25.** Console **25** is provided with such switches and indicators as the radiologist needs to control the various functions of the X-ray table such as tilting it, moving the top **11** and subject thereon longitudinally, raising and lowering and angulating the X-ray tube casing and operating the palpator slave cylinder **16.** By way of example, palpation or compression of a subject by means of slave cylinder **16** may be controlled with a lever **26** on control console **25.**

A schematic diagram of an embodiment of the new palpator system, isolated from the X-ray table, is shown in FIG. **2** in reference to which features of the system will now be explained.

In FIG. **2** the control level **26** which the radiologist actuates to palpate or compress a patient is operatively connected to a pneumatic master cylinder **27.** The master cylinder has a longitudinally movable internal piston assembly **28** from which a connecting rod **29** extends. Connecting rod **29** is pivotally connected at **30** to operating lever **26.** A light tension spring **31** having one end anchored at **32** and its other end connected to operating lever **26** at near pivot point **30** may be used to retract piston **28** to the initial or parked position in which it is shown. However, spring **31** may be omitted when master cylinder **27** is positioned horizontally as shown because gravity does not tend to shift piston **28** anyway and pressure in the system plus a small force by the operator to overcome friction are usually sufficient to restore the piston to parked position. Spring **31** or some other return spring should be used when the cylinder **27** and piston **28** are vertical so as to counterpoise the piston against the force of gravity.

Lever **26** is mounted for pivoting about an axis **33.** It will be evident that when operating lever **26** is manually pushed in the direction of the arrow **34** or counterclockwise with reference to pivot **33,** piston **28** will move in cylinder **27** to thereby compress air or other gas which is in the cylinder. This pressure is transmitted to slave cylinder **16** by way of tubing comprised of sections **40, 42** and **43.** Thus, application of a force to operating lever **26** will result in operation of slave cylinder **16** on the X-ray table such that the palpator cup **19** will be advanced toward the patient. At this stage gas pressure is minimal and only needs to be enough to overcome friction and counterpoising spring force of the slave cylinder piston.

The master cylinder piston **28** may, if desired, be pushed directly by the operator to develop pressure for palpation or compression in which case lever **26** may be omitted if substitute means for operating certain valves are provided as will be evident from the ensuing discussion.

The first portion of tubular output line **40** from master cylinder **27** extends to a microvalve **41.** Valve **41** has a passage for maintaining gas flow continuity from the master cylinder **27** to the tubing lines **40–43** at all times. However, when a roller tipped plunger **41'** is depressed, the microvalve connects the system to the atmosphere to enable air intake or exhaust, depending on the pressure differential. When level **26** is moved from parked position, plunger **41'** moves out and closes the port to the atmosphere.

As mentioned earlier, when the palpator arm **18** and its associated X-ray transparent cup **19** are in parked or inactive position, they are remote from the subject on the X-ray table top. This allows the subject to be positioned on the table top without interference by the slave cylinder assembly. When the palpator arm is to be used, however, it is desirable to advance it to proximity with the subject rapidly after which force may be applied to the subject more gradually as determined by the radiologist. For this reason means are provided in the FIG. **2** embodiment to prepressurize slave cylinder **16** at the outset of palpator operation. The amount of palpator arm movement needed for depressing the subject's anatomy is about three inches but the arm will generally be moved some preliminary distance of about twelve inches to locate it near the subject before any force is applied.

Prepressurization is obtained by the use of a known type of roller valve **45** which is triggered open by moving operating lever **26** slightly away from its parked position. Valve **45** has a plunger **46** which opens the valve when it is depressed by a cam **47** fixed on the lower end of manual operating lever **26.** Thus, when the cam **47** swings counterclockwise as shown, it strikes valve operating plunger **46** and depresses it, thus causing the valve to admit air or other gas under pressure to the tubing system by way of a T-fitting **44.** When the operating lever **26** and cam **47** are restored to parked position as shown, valve **45** recloses so the system can be connected to the atmosphere by means of microvalve **41** as explained above. When pressure that is produced by further manual actuation of master cylinder piston **28** exceeds the set output pressure of a regulator **50,** gas stops flowing through the regulator.

The input pipe **49** to valve **45** is connected to a gas pressure regulator **50** that is supplied through a pipe **51** which may be connected to an inert gas supply or in-house air supply line which is usually available in an X-ray room. Regulator **50** can also be supplied from an independent gas pressure tank or metal bottle, not

shown. The output side of regulator **50** may also have a pressure gauge **52** for setting its output pressure.

It will be evident that when movement of manual operating lever **26** is initiated, valve **46** will be triggered open to provide pressurized air to slave cylinder **16** which will extend piston rod **17** through a major portion of its stroke and cause palpator cup **19** to nearly contact the subject on the X-ray table. For example, the preliminary non-working part of the stroke may be on the order of twelve inches of slave piston movement.

After the piston **55** of slave cylinder **16** has been actuated to preliminarily advance palpator **19,** further counterclockwise movement of manual operating lever **26** results in master cylinder piston **28** advancing to further pressurize lines **40, 42, 43** and slave cylinder **16** above the pressure which is caused by operation of valve **46.** This further pressure advances palpator **19** into the subject's anatomy to compress and deform it as required by the radiologist. As will be explained, the system may have approximately a one-to-one ratio between the force applied on manual operating lever **26** and the force exerted by palpator **19.** This is a factor in giving the radiologist a true sensation of the amount of force he is applying to the subject.

When the palpation procedure is completed, manual operating lever **26** may be released in which case master piston **28** is returned to its inactive or parked position under influence of pressure in the system primarily. At this time, the regulated preliminary pressure supplied through valve **45** still exists in the system and it is relieved by manual operating lever **26** striking the operating plunger **41'** on microvalve **41.** When plunger **41'** is depressed, microvalve **41** bleeds pressure from slave cylinder **16** and the other parts of the system to the atmosphere. This allows the slave piston **55** and palpator arm **18** to retract fully to its parked position.

A valve **39** may be provided in tubing section **42.** Valve **39** may be closed after the desired pressure is generated in the system to prevent pressure relief even though master piston is restored to parked position. This temporary maintenance of constant pressure on the slave piston effectively locks the palpator so that compression of the subject can be maintained for any interval desired by the operator.

The slave cylinder **16** shown in FIG. **2** has a piston assembly **55** which reacts against a return spring **56** that appears in dashed or hidden line in FIG. **2.** This spring is sufficiently strong to counteract the gravitational force of the palpator and helps to hold the palpator in upper most parked position when slave cylinder **16** is depressurized.

In order to obtain an approximate one-to-one ratio between the force applied to master cylinder **27** and that developed by slave cylinder **16** on the subject, it is necessary to account for the slight resistive force of restoring spring **56** in the slave cylinder. If spring **31** is used, its force must also be accounted for. In other words, this restoring force must be overcome by the operator and by the preliminary gas pressure before any force is applied to the subject. It must also be overcome as force is applied to the subject. There is also some friction in the system which cannot be compensated since it reverses and is always working in a direction opposite to that of the motion. A one-to-one force ratio may be obtained by appropriately sizing the pistons **55** in the slave cylinder and **28** in the master cylinder. To account for the unbalanced force due to the return spring **56,** it is only necessary to make the slave cylinder piston slightly larger than the master cylinder piston.

In one system design, the slave cylinder piston **55** had a diameter of about **3** inches, providing an area of about **7** square inches. The return spring **56** force for equipoising the palpator and piston was about three pounds. Thus, about **0.4** additional pounds per square inch of manually supplied pressure was necessary to overcome the spring force. The additional unit pressure necessary to create a one-to-one total force relationship was achieved by reducing the master cylinder piston diameter to about **2.9** inches. Thus, the ratio of the areas of the two pistons was about **1.06** to **1.** These areas applied to a design wherein it was contemplated that the maximum force which a radiologist might want to apply to a subject would be about **50** pounds. The areas would be somewhat different for another desired total force. Experience has shown that a total force of **20** pounds is generally not exceeded and that **30** pounds might be enough for any conceivable procedure.

To recapitulate the operating mode of the FIG. **2** system, when the subject is to be palpated, the operator pushes operating lever **26** in the direction of arrow **34.** This terminates atmospheric exhaust and conditions microvalve **41** for allowing tubing system to be pressurized. An instant later, valve **45** opens to advance slave cylinder **16** and palpator **19** through the prepressurized portion of the stroke of the latter to bring the palpator into contact with subject. Further manual force on operating lever **26** causes the body to deform and a reaction force is developed at the piston of the slave unit. This reaction force will be balanced by an increase in pressure in the closed system. The increase in pressure is caused by the additional force supplied by the radiologist's hand so that he has the feel for the force applied to the subject's body. When the operator's hand is removed from lever **26,** the pressure built up in the system will restore lever **26** to its parked position. Some restoration force is recovered from spring **56** in the slave cylinder. When operating lever **26** reaches its initial or parked position, it strikes plunger **41'** of microvalve **41** which then acts to relieve the pressure of the system to the atmosphere. When microvalve **41** is operated for atmospheric discharge, piston **55** in slave cylinder **16** is substantially unopposed in which case spring **56** maintains the piston in its upper most or parked position. During radiography X-radiation is projected through X-ray transparent palpator arm **19.**

An alternative to using gas pressure from regulator **50** for moving slave piston **55** through the preliminary portion of its stroke or until the palpator arm just contacts the subject is to move the whole slave cylinder through this preliminary portion and then begin to apply gas pressure for palpating or compressing. An advantage of this alternative is that the slave cylinder on the X-ray table can be made shorter since its piston actually only needs to travel about three inches for palpating.

FIG. **4** illustrates an arrangement for moving the whole slave cylinder and palpator arm preliminarily. In this case, the slave cylinder **16'** is axially shorter than cylinder **16** in FIG. **2** since it is adapted for about a 3-inch piston stroke. The piston rod has the same type of palpator arm **19** and the cylinder has an internal piston

and counterpoising spring as in the previously discussed design.

In FIG. 4 the slave cylinder 16' is carried on a bracket 80. The bracket is connected to a sliding bearing block 81 which, by means of screws 82, is joined in fixed spacing with another bearing block 83. The blocks bridge a vertical slot 84 in X-ray table column 13 which is shown fragmentarily and in section as viewed in the direction of the arrows 4–4 in FIG. 1. The blocks serve as a bearing for vertical movement of slave cylinder 16'.

A lead screw 85 is used in this case for moving the bearing assembly and, hence, the slave cylinder 16' vertically. The lead screw 85 is coupled to a speed reducer 87 that is driven by a reversible motor 88. The lead screw is threaded into a follower 89 which is fastened to bearing 83. It is evident that when motor 88 rotates in one direction, the slave cylinder 16' will be lowered toward the subject and when it rotates in the other direction the cylinder will be raised to its parked position in which it is shown in FIG. 4. When sufficiently lowered, gas pressure can be developed by operating the master cylinder piston for any additional desired travel of the slave cylinder piston. The control circuitry for motor 88 is not shown but can be easily devised. A switch, not shown, for energizing the motor is provided on control console 25.

The slave cylinder 16' can also be advanced and retracted in other ways, such as by using a second work cylinder, not shown, which acts on the bearing assembly 81–83. The second work cylinder will, of course, have a longer stroke than the other work or slave cylinder 16'. The second work cylinder can be supplied through a valve such as 45 in FIG. 2 from a similar regulated gas pressure source.

An alternative and more simplified embodiment of the invention is depicted schematically in FIG. 3. In this embodiment, a slave cylinder 60 may be constructed similarly to slave cylinders 16 in FIGS. 2 and 4 except that in the FIG. 3 embodiment the stroke of the master cylinder piston is longer than that of the FIG. 4 embodiment. Slave cylinder 60 is connected by means of flexible tubing 61 to the outlet 63 of a master cylinder 62. The master cylinder has a piston 64 from which a piston rod 65 extends. The upper end of piston rod 65 has a knob 66 on which the radiologist may exert a downward manual force to generate pressure in master cylinder 62 for actuating slave cylinder 60.

Mounted on top of master cylinder 62 is a microvalve 67 which has an atmosphere communicative inlet-outlet port 68 that is either open or closed depending on the position of its operating stem or plunger 69. When master piston 64 is up or parked as shown, it strikes stem 69 and causes the microvalve to open to the atmosphere. Because the microvalve 67 also has a tube 70 connecting to the interior of master cylinder 62 and to the interior of slave cylinder 60 by way of tubing 61, the entire system is exhausted of pressurized air when plunger 69 is depressed by virtue of master cylinder piston 64 being in its uppermost position.

When the radiologist desires to compress or palpate a subject, he applies a manual force to knob 66, thus depressing master cylinder piston 64. As soon as movement of piston 64 is initiated, plunger 69 of the microvalve 67 operates to prevent communication with the atmosphere so the system may be pressurized to the extent desired by further downward depression of piston 64. In this case, part of the master cylinder piston stroke is used for advancing the slave cylinder and the palpator 19 driven thereby toward the patient. When the subject is contacted, further pressure on master cylinder piston 64 results in a substantially corresponding force being applied to the subject. Again, reaction from the subject is felt by the radiologist who has his hand on operating knob 66 and pushes on it as if he were pushing directly against the subject. A valve such as 39 in FIG. 2 may also be inserted in tube 61 of FIG. 3 so that the system may be sealed to hold a subject in compression.

The master cylinder 62 is provided with an internal spring 71 which holds piston 64 in its uppermost or inactive position in opposition to gravity when manual force is relieved from knob 66 and the atmosphere port is open. As indicated, slave cylinder 60 also has a spring corresponding with spring 56 in FIG. 2 so that the palpator is held in its parked position when the operating force on knob 66 and system pressure are relieved.

When a palpation procedure is terminated, the operator removes his hand from knob 66 and piston 64 of the master cylinder 62 and the slave cylinder piston are restored to their uppermost positions by expansion of the compressed gas in the system primarily. When master piston 64 returns to initial or parked position, it causes microvalve 67 to open to the atmosphere so that air can enter the system to make up for any leakage of air that may have occurred during compression. This assures that compression is always restarted with the same initial system pressure.

As in the previously discussed embodiment, the pistons in the master cylinder 62 and slave cylinder 60 are appropriately sized for bringing about a one-to-one force relationship between the force applied to knob 66 and the reactive force exerted by the subject's body. In other words, the slave cylinder piston will be slightly larger than the master cylinder piston 64 to compensate for the resistance offered by return spring 71 in the master cylinder and the restoring spring in the slave cylinder.

In all embodiments, it is contemplated that the slave cylinder piston and palpator be capable of about 3 more inches of travel after the palpator 19 has established contact with the patient.

In the FIG. 3 embodiment, the travel of the slave piston corresponds closely to the travel of the master piston for the entire range of the slave piston from its parked position to the limit of its travel. In other words, there is no rapid traverse of the slave piston when the master piston is moved just slightly as is the case in the FIG. 2 embodiment. In both cases, however, after the patient is contacted by the palpator, there is substantially one-to-one correspondence between applied force and active force, thus giving the radiologist the feeling of being in intimate and direct contact with the patient.

Although having a substantially one-to-one force relationship between the master and slave cylinder has been indicated to be desirable, other relationships may be desired by some operators. This results from the fact that, in practice, a force of perhaps 10 pounds is the maximum that will be applied in the particular operator's procedures. Forces of 10 pounds or less may not be sensed or felt to the satisfaction of the operator who may, for example, want the feeling of twice the resistance for every pound of force actually applied to the

subject. In such case, the master cylinder may be made with up to twice the area of the slave cylinder. Of course, any desired total reactive force and total manually applied force may be established by selecting the corresponding piston area ratio.

Means, not shown, may also be provided for swinging the slave cylinder assembly and its attached palpator arm horizontally from a parked position to a position over the subject where it is desired to have the palpator completely out of the way when its use is not contemplated. Another matter not previously mentioned is that the palpator arm support rod extending from the slave piston may be splined or otherwise key to prevent rotation when the palpator is pressed against the subject.

Any of the described systems may also apply compressive force constantly to a subject, as compared with palpating and relieving the force on a subject sequentially. In such case, it is only necessary to lock the master cylinder piston in a fixed position after the subject has been depressed to the satisfaction of the radiologist. Valve **39** provides one way of locking the slave cylinder as mentioned earlier but mechanical locking of the master piston would also serve the purpose.

The described systems may be simplified and cost reduced by designing them as closed systems. For example, in the FIG. **3** embodiment, the microvalve **67** could be eliminated and the branch of the T-fitting to which tube **70** connects would then be plugged so that no air would get into the system except by leakage. However, it has been found in practice that the system can be made leak free and that the slave and master pistons can be easily made free enough from leakage that pressure can be maintained for a satisfactorily long period without repumping the master cylinder.

In summary, embodiments of a new palpator system has been described. The systems are distinguished by providing force feedback for better operator feeling and control. The systems use room air at atmospheric pressure so as to obviate the need for compressors. The tubes such as **43** and **61** which connect the master cylinder to the slave cylinder may be flexible and elastic to serve as a filter for preventing accidental high impulse forces being applied to the subject. The system fails safe in that the only significant mode of failure is leakage from the system in which case no force can be applied to the subject. Any leakage from the system is made up after each use by allowing atmospheric air to enter the system.

Although embodiments of the invention have been described in considerable detail, such description is to be considered illustrative rather than limiting for the invention may be variously embodied and is to be limited only by interpretation of the claims which follow.

I claim:

1. A palpator system for use in conducting diagnostic X-ray examinations comprising:

a. gas pressure operated slave cylinder means mounted adjacent a space for accommodating an examination subject, said slave cylinder means including a first cylinder and a first piston therein, said cylinder having a gas inlet and said piston having an initial position,

b. palpator means operatively connected with said first piston to move relative to a subject in correspondence with movement of said first piston,

c. master cylinder means located remotely from said slave cylinder means and including a second cylinder and a second piston therein, said second cylinder having a gas outlet and said second piston having an initial position and being movable to pressurize gas in said cylinder means,

d. tubular means for connecting said outlet of said second cylinder to said inlet of said first cylinder,

e. first valve means having an inlet in communication with the interiors of said cylinder means and an outlet in communication with the atmosphere, and having means operable to selectively close and open a gas flow path between said cylinder means and the atmosphere,

f. manually operable means operatively connected to said second piston for applying force thereto, to move said piston and produce pressure in said cylinder means

g. said manually operable means when in its initial position controlling said operable means of said first valve means to open said gas flow path to the atmosphere to thereby establish the interiors of said master cylinder, said slave cylinder and said tubular means initially at atmospheric pressure and said manually operable means when moved from its initial position controlling said operable means of said first valve means to close said gas flow path whereupon further movement of said second piston by means of said manually operable means will pressurize said first cylinder and move said palpator in said examination subject accommodating space.

2. The system set forth in claim **1** wherein:

a. said first piston has an area at least sufficiently larger than said second piston so that the manually applied force on said second piston means has a substantially one-to-one relationship to the total reactive force developed by said first piston.

3. The apparatus set forth in claim **1** including:

a. second valve means having an inlet for being connected to a gas pressure source and an outlet connected for admitting gas from said source to the interiors of said tubular means, said master cylinder means and said slave cylinder means, and

b. means operable by said manually operable means for operating said second valve means selectively to admit said gas from said source substantially simultaneoulsy with initiating said manual force on said manually operable means whereby said admitted gas will force said first piston from initial position and advance said palpator device freely through said subject accommodating space to subject contacting position after which further application of manual force to said second piston will cause said first piston and palpator to move further to subject pressure applying positions.

4. The apparatus set forth in claim **1** including:

a. manually operable valve means interposed in said tubular means between said first cylinder and said second cylinder, said valve means being selectively openable to permit transmission of gas pressure produced by movement of said second piston means from said second cylinder to said first cylinder and closeable to maintain pressure in said first cylinder, whereby to maintain compressive force by said palpator when said second piston is restored to its initial position.

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