MECHANICAL MANIPULATORS FOR THE DISPLACEMENT OF OBJECTS LOCATED IN A RADIOACTIVE MEDIUM

Filed Feb. 23, 1961 6 Sheets-Sheet 1

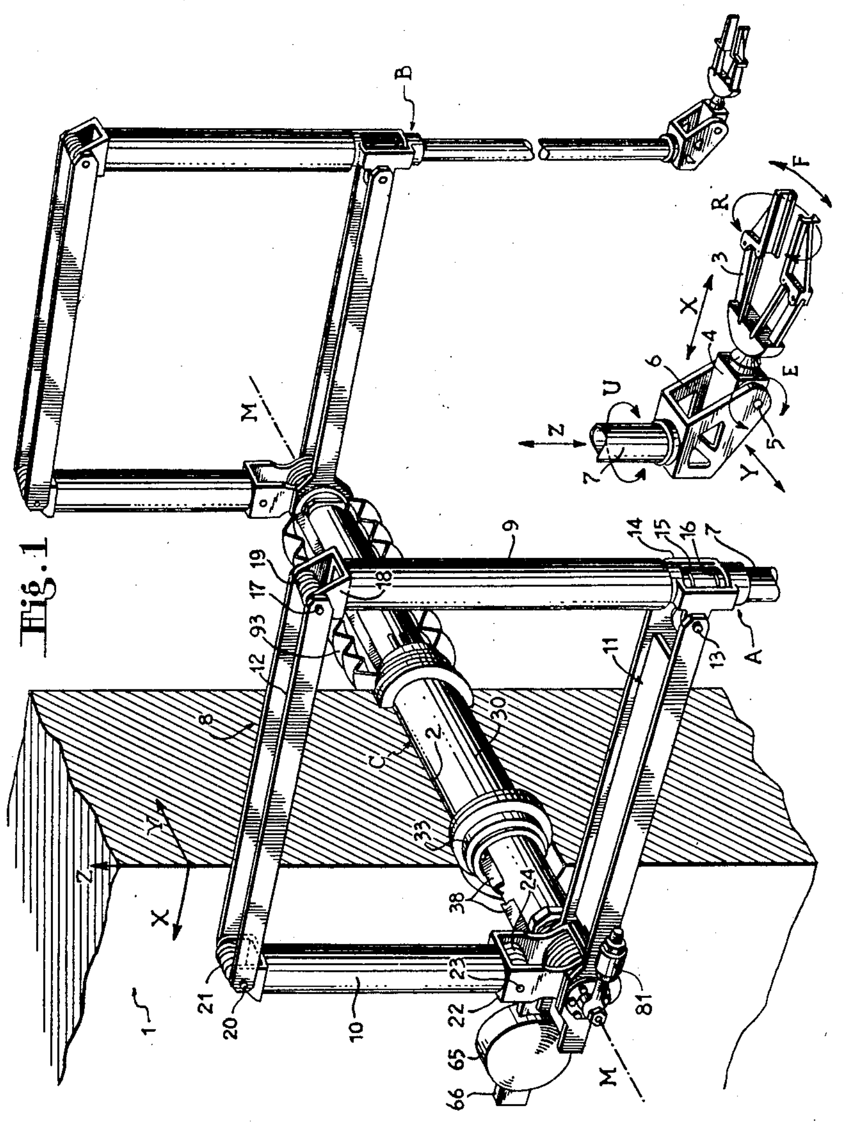

Fig.1

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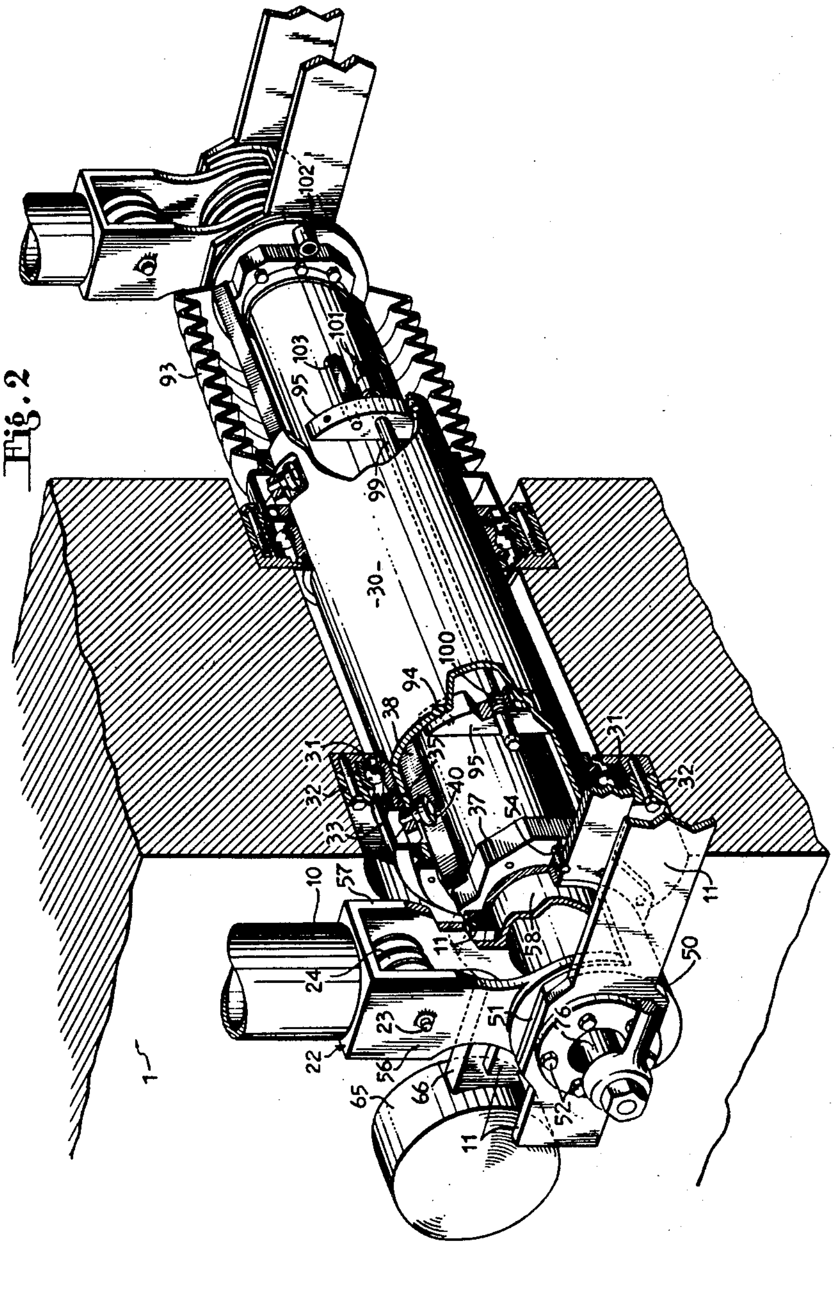
Fig. 2



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April 14, 1964 R. LE GUENNEC ETAL 3,128,887

MECHANICAL MANIPULATORS FOR THE DISPLACEMENT OF OBJECTS LOCATED IN A RADIOACTIVE MEDIUM

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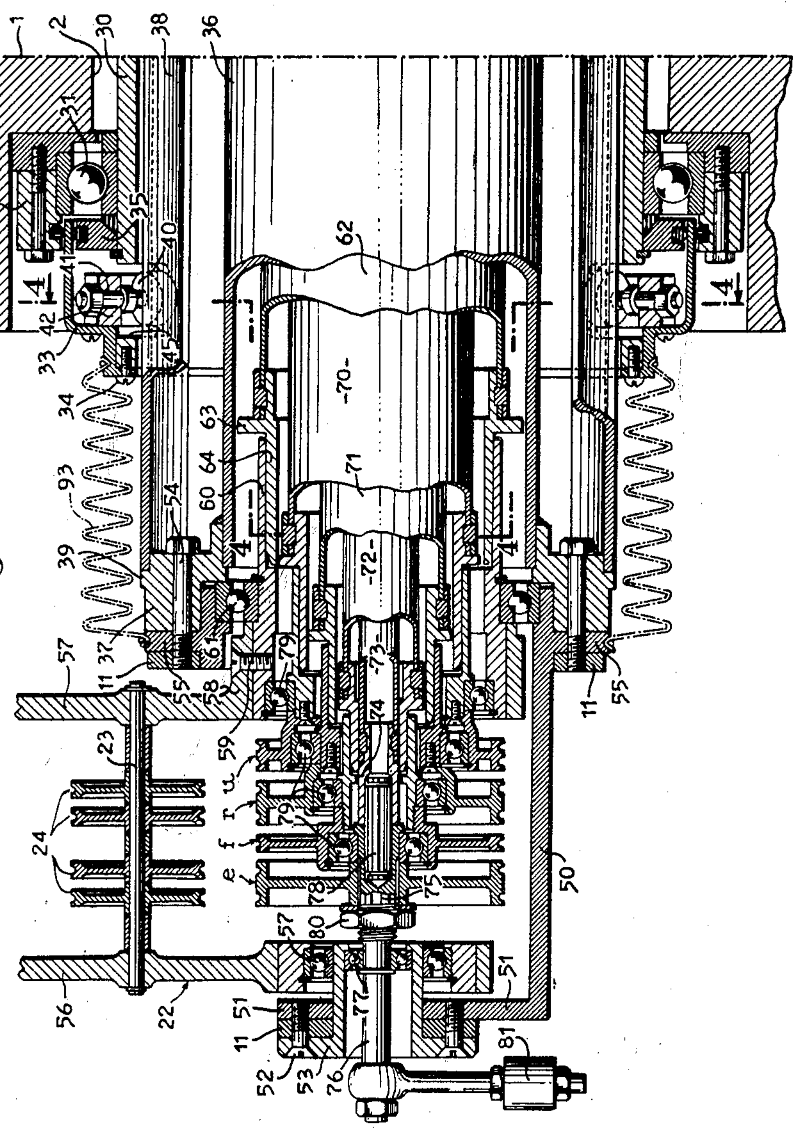
Fig. 3



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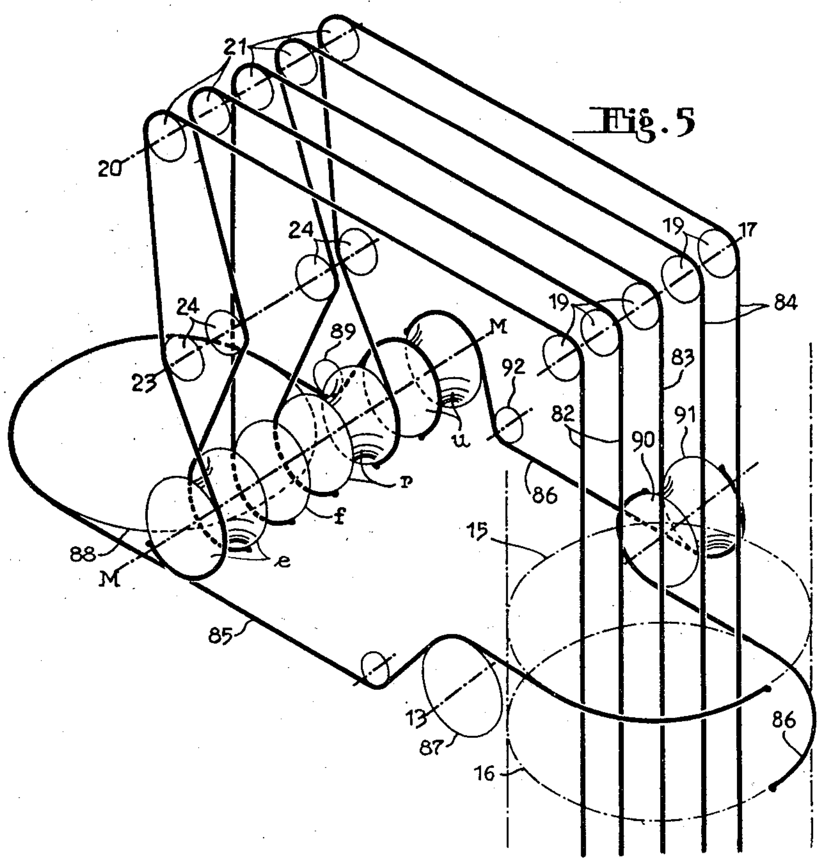

Fig. 5

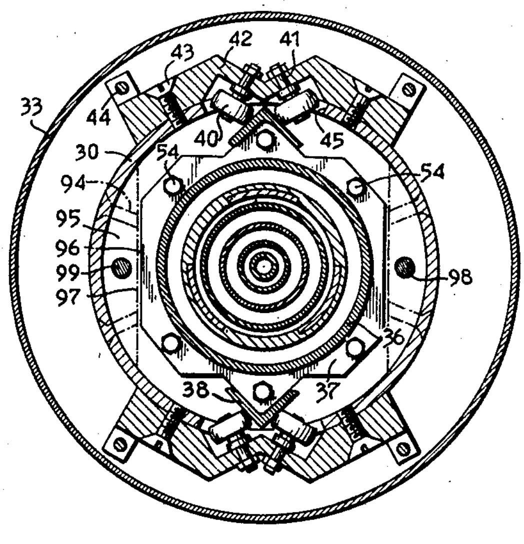

Fig. 4

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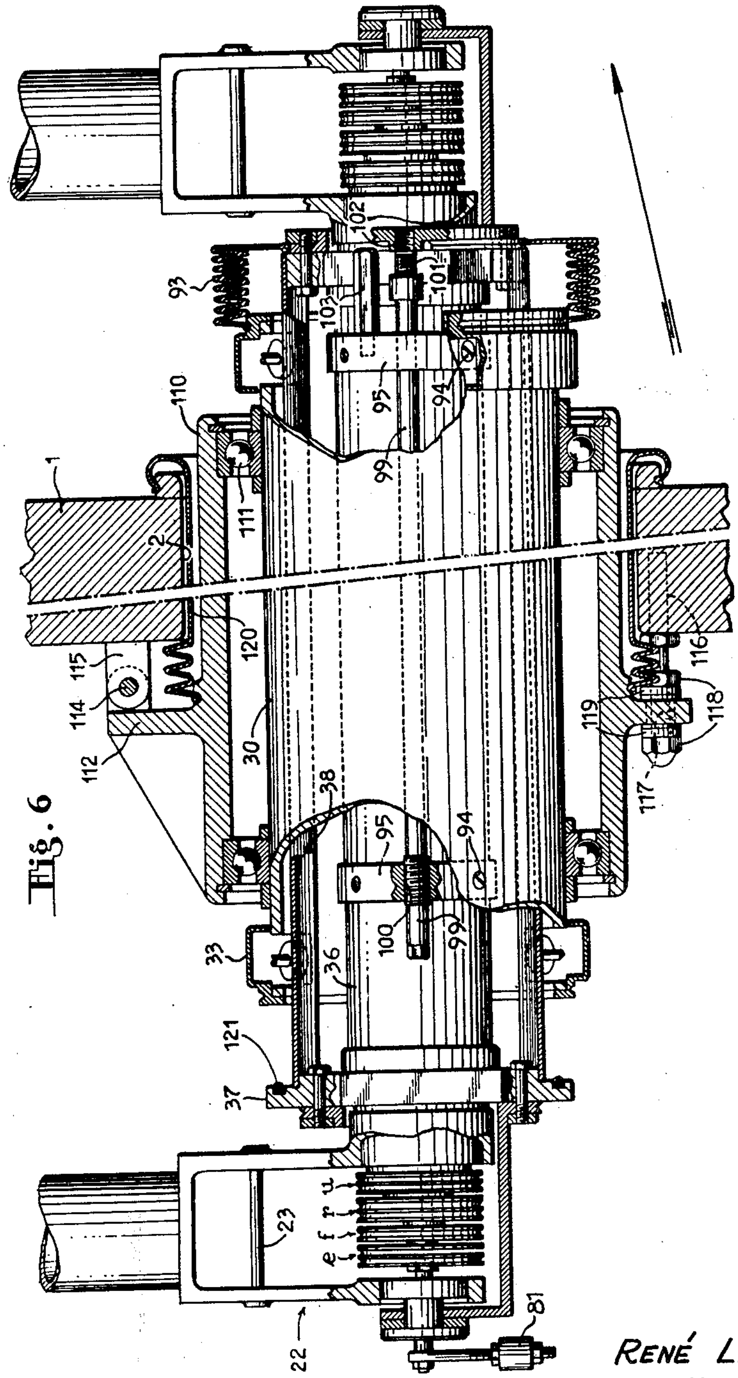

Fig. 6

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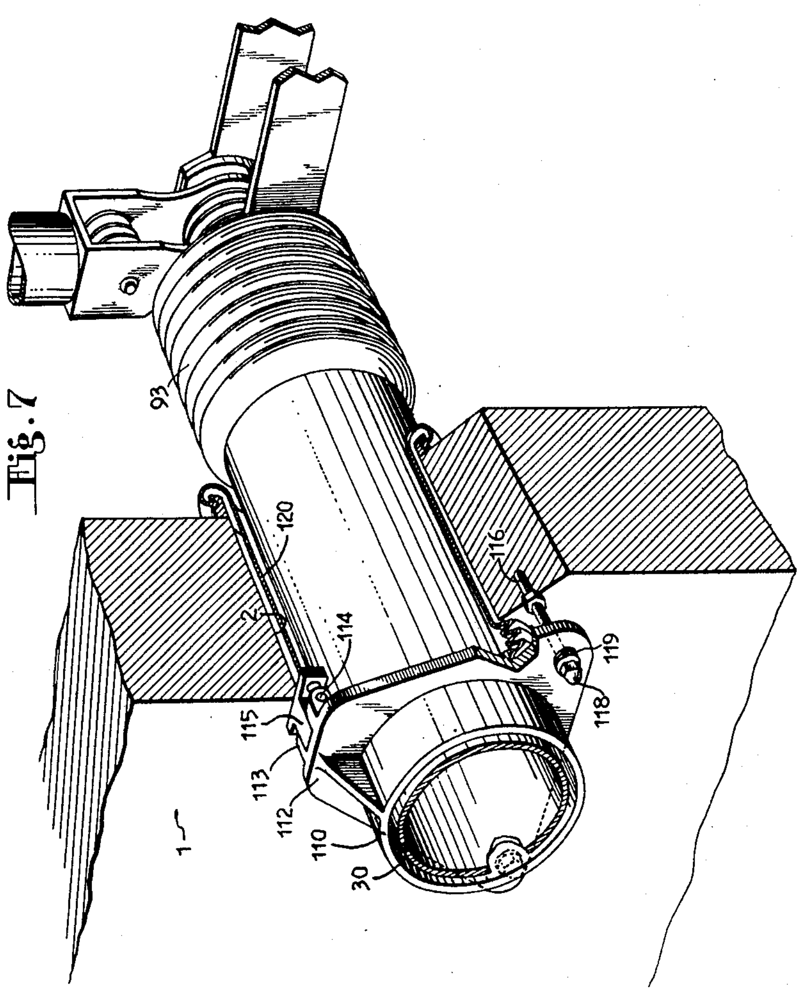

Fig. 7

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3,128,887

MECHANICAL MANIPULATORS FOR THE DISPLACEMENT OF OBJECTS LOCATED IN A RADIOACTIVE MEDIUM

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Claims priority, application France Feb. 25, 1960
12 Claims. (Cl. 214—1)

It is already known to displace objects located in a radioactive medium with the aid of mechanical manipulators.

Known mechanical manipulators generally comprise, to this end, two symmetrical members disposed on either side of one of the protective walls of an enclosure surrounding the radioactive medium, the movements of one of these members, known as the pilot member, being communicated to the other member, known as the controlled member, by transmission means passing through the wall.

In the known devices, the transmission means consists essentially of a plurality of cables interconnecting the pilot member and the controlled member, which on the one hand makes the assembly and disassembly of the transmission means very complex and on the other hand prevents the adequate hermetic sealing of the enclosure surrounding the radioactive medium. In fact, because the displacements of the transmission cables must not be obstructed, it is a very difficult and delicate matter to locate efficient sealing devices around these cables.

An object of the present invention is to remedy these drawbacks, and according thereto, a mechanical manipulator for the displacement of objects in a radio-active medium, and comprising a pilot member and a controlled member disposed on either side of one of the walls of an enclosure surrounding the radioactive medium consists in two articulated parallelograms which are deformable in two parallel planes and connected by one of their corners by two concentric tubes, which are perpendicular to said planes and relatively rotatable, the outer tube, which is slidably and rotatably mounted within the wall of the enclosure, being, in each parallelogram, integral with a first arm to which the arm respectively carrying the pilot member or the controlled member is adjacent, the inner tube, being itself integral with an arm parallel to the said arm adjacent to each parallelogram, the said tubes allowing the transmission to the controlled member, by the sliding of the assembly, of the vertical movement of the pilot member and, by their relative rotation, function of the deformations of the parallelograms, of the lateral and vertical movements of the said pilot member.

According to a feature of the invention, as many concentric tubes are disposed in the inner tubes, as there are supplementary movements to be transmitted from the pilot member to the controlled member, each tube being rotatably mounted with respect to the others and integral in rotation at each of its end with a pulley connected by a cable system to one of the axes about which the supplementary movements are effected.

The sealing of the enclosure is thus greatly facilitated. On the one hand, in fact, the sealing of the transferred movement can easily be ensured by a flexible bellows sleeve fixed by one end to the outer tube on the controlled side and by the other end to a concentric tube surrounding the first, with which it is integral in rotation and which is located in the wall of the enclosure. On the other hand, the other movements, corresponding to the remaining six degrees of free movement, are transformed into rotary movements: the sealing is, for these movements, effected by rotary joints appropriate to the tightness of the seal required and to the sensitivity required for the said movements.

Other characteristics and advantages of the invention will result from the detailed description which follows. Reference will now be made for this purpose to the accompanying drawings which are given only by way of example and in which:

FIGURE 1 is a perspective view of an embodiment of the assembly of the manipulator,

FIGURE 2 is a perspective view with some parts cut away, on a larger scale, of a detail of FIGURE 1,

FIGURE 3 is an axial section on a larger scale of a detail of FIGURE 1,

FIGURE 4 is a view in section along the line 4—4 of FIGURE 3,

FIGURE 5 is a diagrammatic view of the cable system of one of the ends of the manipulator illustrated in the preceding views,

FIGURE 6 is a lateral elevation with some parts cut away, of a modification of the manipulator according to the invention, and

FIGURE 7 is a perspective view of a detail of this modification.

As previously indicated, the manipulator according to the invention is intended for the displacement of objects located in a radioactive medium surrounded by an enclosure referred to, therefore, as "hot," said manipulator passing through a vertical wall **1** of said enclosure through a horizontal opening **2** and having an axis MM. In the following description with respect to the drawings, it should be noted that that portion to the left of the wall **1** represents that side of the apparatus which is outside the enclosure, i.e. that side where the operator is situated, and the portion on the right of this wall indicates the inside of the enclosure.

According to the embodiment shown in FIGURES 1 to 5, the manipulator according to the invention comprises three essential parts: a pilot part A and a controlled part B, which are symmetrical with one another with regard to the wall **1**, and a transmission part C, transmitting the movements of part A to part B, through the wall **1**.

In the first place the pilot part A will be described, this description being also appropriate for the reason which has already been mentioned, for the controlled part B. Therefore the same numerical references will be used for the homologous members of parts A and B and these references will be followed, solely in the description, by the indices *a* and *b* respectively when it is necessary to distinguish the members of part A from those of part B.

The basic member of the pilot part A is a pincer **3** of conventional design which the operator manipulates, the pincer in part B reproducing the movements of the pincer **3***a* and grasping the radioactive object inside the enclosure. The two jaws of the pincer **3** are normally held apart by a spring (not shown) and the first stage of freedom of movement of the manipulator corresponds to the movement of closing the pincer, a movement which is diagrammatically shown by the arrow F. The radioactive object can be grasped by the closure of the equivalent pincer **3***b*.

The pincer **3** is connected to the rest of the apparatus by a universal mechanism which ensures that it has the other necessary degrees of freedom of movement. This mechanism is shown diagrammatically and operates as follows. The pincer **3** is rotatably mounted about a horizontal axis in a block **4**, the rotary movement of the pincer about this axis symbolized by the arrow R constituting a second degree of freedom of movement of the apparatus. The block **4** is articulated about a horizontal axis 5 perpendicular to the axis of rotation of the pincer in a vertical fork 6. The rotation of the block 4 about the axis 5 according to the arrow E constitutes a third degree of freedom of movement of the apparatus and corresponds to the raising movement. The fork 6 is fixed to the end of the tube 7, the axis of which is disposed in a vertical plane parallel to the wall 1; the tube 7 can turn about its axis according to the arrow U and this constitutes a fourth degree of freedom of movement, the corresponding movement being called "azimuth."

The tube 7 can be displaced in its vertical plane along two perpendicular directions, represented by arrows X and Z, the two degrees of liberty of movement thus defined corresponding to the lateral (X) and the raising (Z) movements. Furthermore the vertical plane of the tube 7 can be displaced along a direction Y which perpendicular to the direction X and Z; the corresponding degree of freedom of movement constituting the downward movement of the apparatus.

The three directions X, Y and Z have been related to the level of the wall 1, and they form a system of three-dimensional coordinates, the direction Y being the direction parallel to the axis MM and the directions X and Z defining a parallel plane to the wall 1.

With this explained, it will be examined how the tube 7 is connected to the other members of part A.

The tube 7 is enclosed in an articulated parallelogram indicated in a general way by the reference 8. The parallelogram comprises two parallel opposite tubes 9 and 10, or "little arms," connected by the parallel arms 11 and 12. The arms 11 and 12 are double and constituted by two vertical side-pieces connected by a horizontal bar, the wall having a section in the shape of an I lying on its side.

The tube 7 is concentrically and rotatably mounted in the little arm 9, so as to allow the azimuth movement following the arrow U. The arm 9 is articulated at its lower end on the arm 11 about an axis 13 by a fork 14, between the arms of which and on the tube 7 may be seen two grooves 15 and 16, the purpose of which will be explained later.

On its upper end the arm 9 is articulated on the arm 12 about an axis 17 by means of a fork 18, and a series of idler pulleys 19, which are mounted loose on this axis. In the same way the arms 12 and 10 are articulated about an axis 20 on which the idler pulleys 21 revolve. Finally the arm 10 is articulated on the arm 11 about the axis MM by a fork 22, having an axis 23 parallel to the axis MM and on which revolves a third series of idler pulleys 24.

The articulation of the arms 10 and 11 about the axis MM will be examined fully below in relation to FIGURES 2 and 3, this necessitating the preliminary description of the essential members of part C to which part A is connected about the axis MM.

The part C comprises an outer tube 30 in the wall 1, which tube is located in the opening 2, along the axis MM. The tube 30 is rotatably mounted in the opening 2 by means of roller bearings 31, held in position by retaining members 32. Caps 33 are fixed to the tube 30 by screws 34 screwed longitudinally into the ends of the tube 30: at their other end these caps are provided with rotary joints 35. Inside the tube 30 is concentrically located a principal or outer tube 36 integral in rotation with the tube 30, but able to slide inside the latter. To this end, the 36 has, at each of its ends, a cheek 37, the two cheeks 37 being braced by two angle irons 38, parallel to each other and to the axis MM and located in a plane YZ as previously defined.

The angle irons 38 simply abut against shoulders formed by the triangular points 39 and the cheeks 37. Rollers 40 (FIGURE 4) are carried by inclined axes 41 located in the iron members 42 fixed at 43 in the wall of the tube 30 and at 44 in the wall of the caps 33. The tube 30 is notched at 45 at each of its ends in order to allow the rollers 40, which are supported upon the two sides of each of the angle irons 38, to pass.

The principal tube 36 ensures the liaison between the parallelograms 8 of the two parts A and B in the following manner.

The two side pieces of each arm 11 are integrated with the tube 36, by means of a cradle 50 of a general semi-cylindrical shape. This cradle has a forward cheek 51 on to which is screwed the rearward sidepieces of the arm 11 by means of the screw 52, this screw at the same time holding the flange of a tubular union 53 mounted along the axis MM.

The rearward side piece of the arm 11 is fixed on to the cheek 37 by means of screws 54 which at the same time hold a flange 55 of the cradle 50 parallel to the cheek 51.

The joint between the arm 10 on the arm 11 is effected by means of a fork 22 located within the cradle 50. The forward arm 56 of this fork is for this purpose rotatably mounted by the roller bearings 57 on the tubular union 53 integral with the arm 11. The rearward arm 57′ of the fork 22 has a cylindrical bush 58 which is fastened by screws 59 to a tubular union 60 rotatably mounted inside the principal tube 36 along the axis MM by roller bearings 61.

The union 60 is connected to a tube 62 concentric with the tube 36, by means of a member 63 welded to the end of the tube 62 and dogged or splined at 64 on to the union 60. The union 60 and tube 62 are thus integral in rotation but can slide relatively to each other for a purpose which will be explained later.

In order to balance the weight of the two parallelograms 8 and the members which they support, a counterweight 65 is provided and is mounted by means of an arm 66 on the forward cheek 37. The arm 66 forms an extension of the arm 11 in such a way that the tube 36 is in complete equilibrium about the axis MM.

The device which has been described above, ensures the transmission of three of the movements which have been defined above i.e. the downward movement along the axis Y and the lateral and upward movements, along the axes X and Z.

In fact the movement Y corresponds to the displacement of the assembly of the parts A and B along the axis MM allowed by the sliding of the tube 36 in the tube 30 due to the rails 38.

Otherwise the movements X and Z correspond to the deformations of the parallelograms 8, which are transferred by the relative rotations of the arms 11 and 10. The rotations of the arm 11 are transmitted by the tube 36 while the rotations of the arm 10 are transmitted by the tube 62.

The four remaining degrees of freedom of movement corresponding to the four other possible movements are, according to an embodiment of the invention, also transmitted through the wall 1 by tubes concentrically located inside the tube 62, in the same way as this latter is located with regard to the tube 36.

These four tubes, from the inside to the outside, are the tubes 70, 71, 72 and 73.

The tubes 70, 71 and 72 are in two parts, joined by dogs as the parts 60 and 62 are joined for the tube 62. This structural detail, however important it is for the assembly and disassembly of the apparatus, has no influence upon its action and in what follows these tubes will be considered as a single member for convenience of explanation.

As a preliminary, the assembly of the internal tube 73 will be explained in any case, as it is a little peculiar by the very fact of its location. The tube 73 is fixed at each of its ends to a tubular union 74 which abuts against the tubular enlargement 75 of a shaft 76, which is mounted rotatably in the union 53 due to a roller bearing 77. A splined shaft 78 joins the union 74 and the enlargement 75, in which it is located, in their rotation.

In order rotatably to drive the tubes **70**, **71**, **72** and **73** with relation to the four movements which they are intended to transmit, the axes about which these movements are effected are connected by cables to their respective tubes. These cables are fixed on these tubes by pulleys fixed on the latter. Thus at each end of the part C there are provided four pulleys which are referred to on the drawing by the same letters in lower case as that which symbolizes the movement which they are intended to transmit. Thus from the outside to the inside we have the pulleys *e*, *f*, *r* and *u*. All these pulleys, with the exception of pulley *f*, have two grooves, for they must transmit movements in both directions. The single groove pulley *f* has to transmit its movement only in one direction, the direction of closure of the pincer **3**. The opening movement of the pincer **3** is in fact effected by the pincer return spring. These pulleys are fixed on their respective tubes either by passing through the pulley hub and screwed into the wall of the tubes (in the case of pulleys *r* and *u*), or by the direct screwing of their threaded hub on to the tubes (in the case of the pulleys *e* and *f*).

Roller bearings **79** are fixed in the hub of the pulleys and in the tubular union **58** in order to ensure the rotary mounting of the different tubes with regard to each other. The longitudinal fixing of the pulleys *e*, *f*, *r* and *u* is effected by a nut **80** screwed on to a threaded portion of the shaft **76** and abutting against the pulley *e*; the nut **80** thus forms a lock-nut for the nut constituted by the threaded hub of the pulley *e*. It will be noted that by the fact of its mounting the shaft **76** is integral in rotation only with the pulley *e*, which is connected by a cable system to the horizontal shaft **5**, about which the pincer **3** pivots. In order to counterbalance the weight of the pincer **3** and thus to keep it in complete equilibrium about its shaft **5**, a counterweight **81** is fixed to the shaft **76**.

We will now examine the way in which the cables join the shafts about which the different movements of the pilot member with pulleys *e*, *f*, *r* and *u* are carried out, which pulleys have to transmit these movements to the tubes on which they are fixed and therefore to the controlled member.

FIGURE 5 diagrammatically shows the cabling system on the operators' side, the cabling system on the side of the enclosure being identical but connected in such a way as to reproduce the movements transmitted in the same direction as the original movements.

In order to transmit the raising movement E, two cables **82** are fixed on to the pulley fixed on the shaft **5** with opposite winding directions. These cables cross the tube **7**, and the little arm **9** and follow the outlines of the parallelograms **8** by passing over loose pulleys **19**, **21** and **24**. They are each fixed at their other end on to one of the grooves of the pulley *e*, in such a way as to be wound on to the latter in the opposite direction. The movement of the pincer **3** in one direction or the other about the shaft **5** is thus converted by a rotation in one direction or the other of the pulley *e*.

The closure movement F of the pincer **3**, having regard to what has gone before, needs only a single cable **83**; this latter is fixed in a conventional way, at one end to the jaws of the pincer **3** and at the other end to the single groove of the pulley *f*, after running through the tube **7** and the parallelogram **8** similarly to the cables **82**.

The two cables **84** which have to transmit the rotary movement R of the pincer **3** are mounted in exactly the same way as the cables **82**. They are in any case fixed at one end on to pulleys fixed on to the axis of rotation of the pincer **3** and at their other end abut at the two grooves of the pulley *r*.

The azimuth movement is transmitted by two cables **85** and **86**. These cables are fixed at one end respectively to the grooves **15** and **16** of the tube **7** on which they wind in opposite directions. The cable **85** then passes over a loose pulley **87** on the axis **13**, over a second loose pulley **88** on a shaft parallel to the tube **7** mounted at the end of the arm **11** and is then fixed on to a groove of the pulley *u* after being guided over a pulley **89**. The cable **86** for the purposes of convenience of the enabling system is made up of two strands. The first of these, starting from the groove **16**, is fixed on a pulley **90** freely mounted on the shaft **13**. The second fixed on a pulley **91**, which is freely mounted on the shaft **13** but integral in rotation with the pulley **90**, abuts in the second groove of the pulley *u* after being guided over a pulley **92**. The cables **85** and **86** are wound in inverse directions on to the pulley *u*.

The manipulator is completed by sealing devices and devices coming into use during disassembly and these will be examined later.

It will be noted in the first place that the protection of the operator from the radiation within the enclosure is greatly facilitated by the actual disposition of the apparatus. The radioactive source is in fact located in the enclosure, at a considerably lower level than that of the opening **2**. As a result, even if the operator were to place himself exactly in front of the opening **2**, he could only receive diffused radiations which represent only a very small percentage, of the order of 1%, of the direct radiations. It would not be the same if the opening **2** were situated not in the vertical wall **1** but in the roof of the enclosure parallel to the working floor as is the case in certain known manipulators.

Otherwise sealing against diffused radiations can be brought about in a simple way, due to the transmission of the movements by concentric tubes, through the wall **1**. Thus, apart from revolving joints such as **35**, a first bellows sleeve **93**, as shown in FIGS. 1, 2, 6 and 7, formed of flexible material is used. This sleeve is disposed on the part C, inside the enclosure and is fixed at one end to the corresponding cap **33** and at the other on the flange **55** of the cradle **50**, inside the enclosure. A second bellows sleeve **93**, shown in broken and dotted lines on FIGURE 3, can in a similar way be mounted complementarily on part C on the operator's side. The sleeves **93** integral in rotation by their mounting with the part C do not undergo any torsion during the operation of the manipulator. Also their accordion pleats allow them to undergo the sliding movements of the apparatus along the axis MM, without any damage. This simplicity of the sealing device can easily be seen.

The disassembly of the apparatus where necessary, for example by a mechanical breakdown, is also facilitated by the actual design of the manipulator. It would be as well, with regard to this, to emphasize that access to the enclosure is not immediately possible by reason of the radioactivity present therein. It is thus important to be able to extract the maximum number of members of the apparatus from the operator's side, in such a way as only to leave inside the enclosure a few members which can be retrieved later.

It is for this purpose that the dog connections or spline mountings such as **64** and **78** between the parts of the tubes **62**, **70**, **71**, **72** and **73** are provided.

In order to disassemble the apparatus it is sufficient to introduce box spanners from the operator's side between the tube **36** and the passage in the wall **30** or between the tube **36** and the rails **38**, in such a way as to engage the heads of the screws **54*b*** which are for this purpose facing the operator's side. In the process of unscrewing the screws **54*b***, part B is detached from part C. It is thus possible to extract all of part C with the exception of the passage **30** in the wall, since the tubes **62**, **70**, **71**, **72** and **73** are detached from the pulleys *e*, *f*, *r* and *u*, which are inside the enclosure and enclosed in the parallelogram **8*b*** by reason of their dog or spline mounting. In the course of this extraction, the parallelogram **8*a*** can be kept fixed on the cheek **37** or for reasons of convenience dismounted by unscrewing the screws **54*a***.

Thus only part B remains inside the enclosure, which part would normally fall down inside the enclosure, for lack of support. In order to prevent this, which would risk damaging this part B, a holding device is provided for part B in the passage in the wall 30 and this part can be made operable during the disassembling process.

This device (FIGURES 2 and 4) is carried out as follows: to the internal wall of the tube 30 and perpendicularly to the latter are fixed by screws 94, segments 95, four in number, symmetrically distributed two by two on either side of the plane YZ, passing through the axis MM. These segments have a radial extent such that they allow the cheeks 37 to pass during the sliding of the tube 36 in the passage of the wall 30. To this end, these cheeks are cut away along a polygonal outline, having in particular edges 96 parallel to the internal edges 97 of the segments 95. This arrangement thus allows a complementary guiding of the tube 36 in the tube 30 when it is being extracted.

The segments 95 each have an opening 98, the openings 98 of two segments located on the same side being in alignment. A rod 99 provided with a square at its end towards the operator, passes through each pair of aligned openings 98: it has two threaded portions 100 and 101, the first of which is screwed normally into the opening 98 located on the side of the operator, and threaded for this purpose. The portion 101 is provided at the end of the rod 99, which is nearest the enclosure. It can be screwed into a threaded pipe 102 carried by the internal surface of the flange 55 of the cradle *50b*. Apart from this, the two segments 95 located on the side of the enclosure, each have a pin 103 directed towards the inside of the enclosure perpendicularly to their plane.

The device which has just been described is used in the following manner, just before disassembly. The tube 36 and its internal members are displaced towards the outside of the enclosure relatively to the tube 30 along the axis MM until the positioning pins 103 come up against the flange 55 of the cradle *50b*. Each of the rods 99 is then engaged in rotation by its square while being unscrewed from the external segment 95 and while being screwed into the pipe 102. The part B is thus integrated with the tube 30 and is firmly held by the latter when the internal tubes 36, 62, 70 and 73 are extracted without the risk of anything falling into the enclosure.

The actual functioning of the manipulator is sufficiently different from that which precedes for it to be necessary to explain it in detail. It should be recalled that the tube 36 by its sliding in the tube 30 which it communicates to all the internal tubes, transmits the downward movement Y of part A to part D. The same tube 36 by its rotation about the axis MM in which it is integral with the large arms 11 and the parallelograms 8, transmits the rotation of the arm 11 of part A to the arm 11 of part B. The same function is fulfilled for the little arms 10 by the tubes 62. Therefore all the deformations of the parallelogram 8 of part A which transfers the lateral movement X and the upward movement Z are reproduced by the parallelogram 8 of part B and this ensures the transmission of these two movements. Finally the four other movements transmitted by the cables to pulleys *e*, *f*, *r* and *u* of part A ensure the rotation of the tubes 70 to 73 and as a result that of the pulleys *e*, *f*, *r* and *u* of part D. These latter by means of their cables transmit their rotations to the axis about which the pincer 3 of part B is movable and thus this pincer receives the movements communicated by the operator to the pincer 3 of part A.

FIGURES 6 and 7, illustrate a modification of the manipulator which differs from the preceding one only by the mounting of the tube 30 in the opening 2 of the wall 1. This tube 30 instead of being directly engaged in the opening 2 is surrounded by another tube 110, in which it is rotatably mounted by means of roller bearings 111, which which fulfil the function of the roller bearings 31. The tube 110 is mounted with a certain play in the opening 2, where it is held in the following manner. On its outer end the tube 110 is provided with a triangular flange 112, the upper angle of which carries a fork 113, articulated about a shaft 114, carried by a stanchion 115, fixed in the wall 1. This shaft 114 is parallel to the direction X defined with regard to FIGURE 1, in such a way that the axis of tube 110 and therefore the axis MM of the apparatus can be displaced about the shaft 114 in a plane YZ.

At its two other angles, the flange 112 is held at an adjustable distance from the wall 1 by the fixing screws 116, engaged at one end in the wall 1. These screws pass through the openings 117 of the flange with a certain play and the flange is fixed on these screws by nuts 118 with interposed flexible washers 119.

The fixing by means of the screws 116 is carried out in such a way that the axis MM of the apparatus is horizontal when there is no reduction in pressure with regard to the external atmosphere prevailing in the working enclosure. At all times during normal working, the enclosure is at less than atmospheric pressure. The fixing by the screws 116 then allows an inclination to be given to axis MM which is directed from below, upwards from the outside towards the inside so that the pressure exerted on part C and proportionally on the passage section of the movable portion (tube 30 in FIG. 3) is exactly compensated by the component along the axis of total weight of the said movable portion.

It is, of course, therefore necessary that the sealing of the enclosure be ensured and this in the present case requires a supplementary sealing barrier about the opening 2.

This supplementary barrier, which is provided in addition to the sleeve 93, is made up by a flexible sleeve 120 fixed at one end on the wall 1 in the inside of the enclosure and at the other end on the tube 110 outside the enclosure.

When the pressure inside the chamber is below that of the surrounding atomsphere, the pressure on the entire outer surface of the movable part C (tube 30) pivots the part C about the axis MM so that the tube is inclined with the end of tube 30 disposed inside the chamber slightly higher than the end of the tube disposed outside of the chamber and the nose of part C, that is, the entire end disposed outside of the chamber, is moved inwardly toward the chamber. When the pressure inside the chamber returns to that of the surrounding atmosphere, tube 30 returns to a horizontal position and in so doing the nose of part C moves outwardly or "points its nose" outwardly. Due to this device, any failure in sealing of the enclosure is immediately felt by the operator, the apparatus "pointing its nose" outwards. In any case if this escape is due to a deterioration of the sleeve 93 it can be temporarily blocked.

The forward check 37 is in fact provided on its inner face with an annular ring 121 which can be applied by relative displacement of the tubes 36 and 30 on the forward cap 33.

The invention is not, of course, limited to the embodiments shown and described which have only been given by way of example.

We claim:

1. A mechanical manipulator for the displacement of objects in a radioactive medium comprising: a pilot member and a controlled member disposed symmetrically in parallel relation on opposite sides of one wall of an enclosure surrounding the radioactive medium; and articulated parallelogram connected to each of said members deformable in parallel planes; a pair of concentric tubes disposed perpendicular to said parallelograms and extending through an opening formed in said one wall, said tubes being connected at the opposite ends thereof to one corner of said parallelograms for transmitting movement from said pilot member to said controlled member by way of said parallelograms, said one corner of each of said parallelograms including a pivotal connection between

one end of a first arm and the adjacent one end of a second arm, the outer of said tubes being axially slidable and rotatably mounted within said opening and being fixedly secured at the opposite ends thereof to said one end of said first arms, the inner of said tubes being mounted within said outer tube for axial movement therewith and for independent rotary movement relative thereto; said inner tube being nonrotatably secured at the opposite ends thereof to said adjacent one end of said second arms, each of said parallelograms including third and fourth arms pivotally joined together at one end thereof, the other end of said third and fourth arms being pivotally joined to the other end of said first and second arms respectively, said pilot member and said controlled member being mounted on and forming extensions of corresponding arms of respective parallelograms other than said first and second arms thereof, movement of said pilot member toward and away form said wall producing a simultaneous, parallel movement of said controlled member, and lateral and vertical movement of said pivot member producing simultaneous, parallel movement of said controlled member.

2. A mechanical manipulator as defined in claim 1 wherein: said pilot member and said controlled member are mounted for rotary motion, a third tube rotatably mounted in said inner tube with the opposite ends thereof extending beyond the ends of said inner tube; a pulley mounted on each end of said third tube, and cable means connected at one end to said pulleys and at the other end to said respective pilot and control members for transmitting rotary movement of said pivot member to said controlled member through said cable means and said third tube.

3. A mechanical manipulator as defined in claim 1 wherein: pincer means is mounted on the outer end of said pilot member and said controlled member for rotary, opening and closing, and raising and lowering movement with respect thereto; four concentric tubes mounted for independent rotation disposed within said inner tube for transmitting the movements of said pivot pincer means to said controlled pincer means, means connecting the ends of one of said four tubes to said respective pincers for transmitting rotary movement of said pilot pincer to said controlled pincer, means connecting the ends of a second one of said four tubes to said respective pincers for transmitting closing movement of said pilot pincer to said controlled pincer, means connecting the ends of a third one of said four tubes to said respective pincers for transmitting raising and lowering movement of said pilot pincer to said controlled pincer, and means connecting the ends of a fourth one of said four tubes to said respective pilot and controlled member for transmitting azimuth movement of said pilot pincer to said controlled pincer.

4. A mechanical manipulator as defined in claim 3 wherein: said pilot member and said controlled member are mounted on said arms for rotation on an axis co-axial with the axis of the respective arm.

5. A mechanical manipulator as defined in claim 1, wherein: said outer tube is mounted concentrically within a passage tube; said passage tube being rotatably mounted in said opening and fixed against axial movement, said outer tube being mounted to slide axially within said passage tube, said passage tube and said outer tube being mounted for simultaneous rotation; and a flexible, concertina bellows sleeve fixedly secured at one end to the end of said passage tube in the enclosure and being fixedly secured at the other end thereof to said wall in the enclosure surrounding said passage tube.

6. A mechanical manipulator as defined in claim 1, wherein: said outer tube is connected at each end thereof to a cheek, angle irons supported on said cheeks extending axially on the outer surface of said outer tube, a passage tube secured in said opening and mounting concentrically therein said outer tube, and rollers carried by said passage tube engaging said angle irons mounting said outer tube for sliding movement within said passage tube.

7. A mechanical manipulator as defined in claim 6, wherein: said outer tube is fixedly secured at the opposite ends thereof to said one end of said first arm by means of said cheeks interposed therebetween, a cradle fixedly mounted on each of said cheeks, said inner tube being rotatably mounted adjacent the ends thereof on said cradles.

8. A mechanical manipulator as defined in claim 7, wherein: a counterweight balance is attached to said cheek located outside the enclosure for balancing the weight of the manipulator about the axis of said outer tube.

9. A mechanical manipulator as defined in claim 7, wherein: a third tube is concentrically mounted for rotation within said inner tube with the opposite ends thereof extending beyond the ends of said inner tube; a pulley non-rotatably mounted on each end of said third tube; cable means connected at one end to said pulleys and at the other end to said respective pilot and controlled members for transmitting movement of said pilot member to said controlled member through said cable means and said third tube, said inner tube being secured to said one end of said second arms by means of axially extending splines, said pulleys being mounted on said third tube by means of splines, said cheeks being removably connected to said first arms, whereby disconnecting said cheek disposed in said enclosure from said one end of said respective first arm permits withdrawal of said outer and inner tubes and said third tube from said opening.

10. A mechanical manipulator as defined in claim 1, wherein: said outer tube is mounted concentrically within a passage tube; said passage tube being rotatably mounted in said opening and fixed against axial movement, said outer tube being mounted to slide axially within said passage tube, said passage tube and said outer tube being mounted for simultaneous rotation only, said outer tube being fixedly secured at the opposite ends thereof to said one end of said first arms by means of cheeks interposed therebetween, a cradle fixedly mounted on each of said cheeks, said inner tube being rotatably mounted adjacent the ends thereof on said cradles; threaded rods supported for axial sliding movement disposed in the space between said passage tube and said outer tube, the surface of the cradle and of the parallelogram within the enclosure facing said opening being provided with threaded openings adapted to cooperate with said threaded rods, screw threaded engagement of the ends of said rods in said threaded openings holding said parallelogram and controlled member in said enclosure in place upon withdrawal of said concentric inner and outer tubes.

11. A mechanical manipulator as defined in claim 5, wherein: said passage tube is rotatably mounted within a support tube loosely mounted in said opening, means pivotally supporting said support tube at the end outside said enclosure about a horizontal axis, means for adjusting the inclination of said support tube in a vertical plane for balancing said manipulator upon reducing the pressure in the enclosure.

12. A mechanical manipulator as defined in claim 1, wherein: said outer tube is mounted within a passage tube, said passage tube being mounted within a support tube, said support tube being loosely mounted in said opening, and a hermetic sleeve surrounding said support tube at the end disposed in said enclosure, one end of said sleeve being secured to said support tube, and the other end of said sleeve being secured to the inner wall of said enclosure around said support tube.

References Cited in the file of this patent

Supplement to the Proceedings of the Seventh Hot Laboratories and Equipment Conference, June 10, 1959, pp. 1 and 2 and FIG. 5 of the paper "French Master Slaves" (Pesenti and Cherel).