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REMOTE-CONTROLLED MANIPULATING APPARATUS FOR MANIPULATING OBJECTS INSIDE SEALED CHAMBERS

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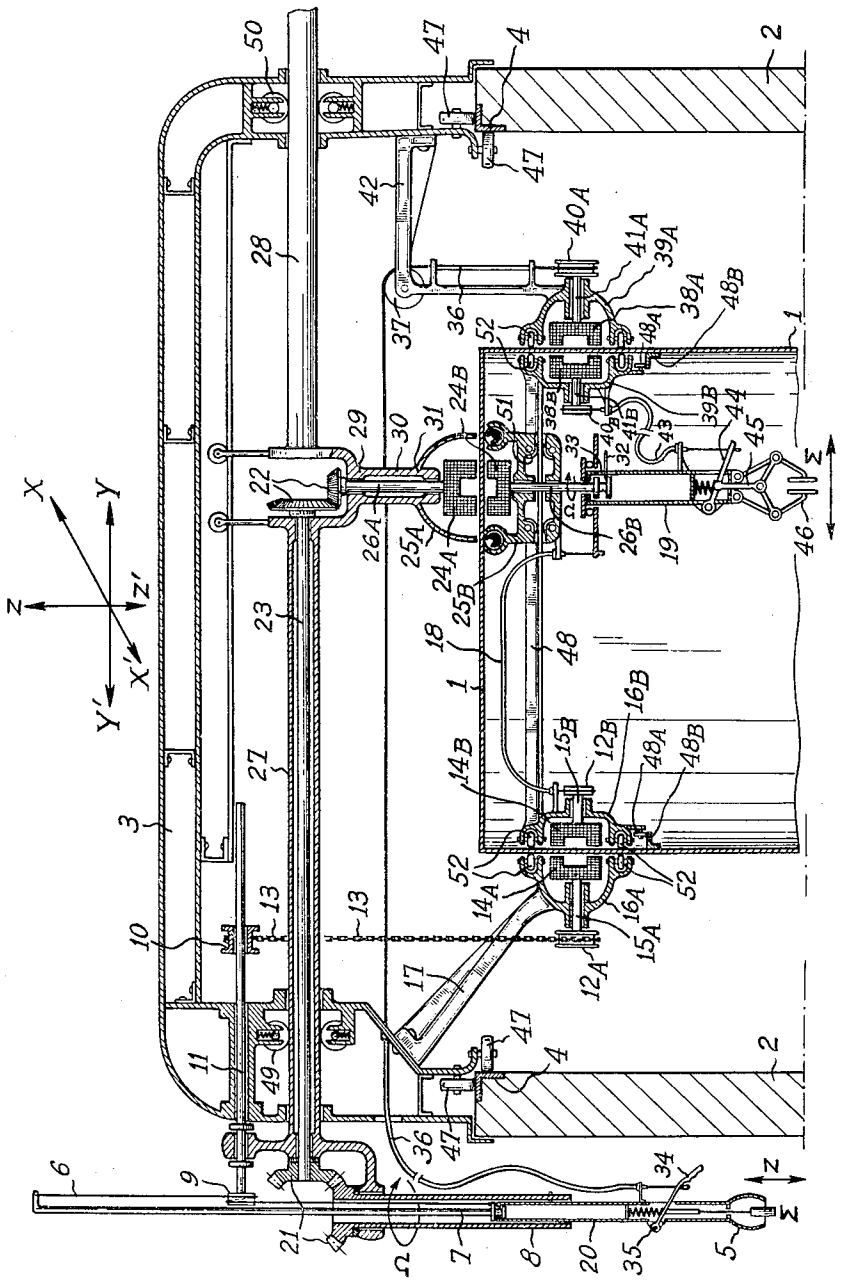

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REMOTE-CONTROLLED MANIPULATING APPARATUS FOR MANIPULATING OBJECTS INSIDE SEALED CHAMBERS

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In the atomic industry, the manipulation of radioactive products has to be done in sealed chambers in order to avoid contamination of the surrounding atmosphere and objects by dust or aerosols. Furthermore, when the level of radioactivity is high these sealed chambers have to be surrounded by a protective wall made of a material having a high atomic number.

In order to permit the control members of the "telemanipulators" or remote-controlled tongs, used for manipulating objects located inside these sealed chambers, to pass through, it is necessary to make openings in the walls of these chambers; these openings are provided with flexible sleeves or with sealing means of the stuffing-box type.

These sealing means or sleeves present awkward maintenance problems; they are hard to set in place and to withdraw, more particularly when they are torn and consequently contaminated. Furthermore, in most cases they restrict the zone of action of the apparatus.

The present invention, based on a system devised by Guy Cherel, aims at providing a "telemanipulator" or remote-controlled manipulating apparatus for sealed chambers, which does not call for the creation of openings in the walls of these chambers, and which therefore does not have the abovementioned disadvantages.

With this object in view, a "telemanipulator" of this kind comprises a first group of control units which are outside a sealed chamber and which actuate at least one second group of corresponding operating units inside the chamber, and, according to the invention, is essentially characterized in this, that the connection between the abovementioned two groups of units is effected by means of at least one transmission system known per se and comprising on the one hand a first movable magnet disposed outside and against the wall of the chamber, which wall is made of non-magnetic material, and on the other hand a second magnet disposed inside and against the wall of the chamber.

A "telemanipulator" of this kind calls for a chamber of which the walls are made of a material that is not magnetic; this is generally true of the unoxidizable metals and plastic materials ordinarily used.

This "telemanipulator" with magnetic transmission makes it possible to construct chambers that are perfectly sealed with respect to their surroundings, without in any way affecting the movements to be performed; moreover, these movements may be very varied; for instance, they may be such movements as are performed by a human hand.

The fact that the operating unit (inside the chamber) and the control unit (outside the chamber) are separate makes it possible to work a plurality of chambers, each provided with its own operating units, by means of a single group of control units.

I describe hereinafter one embodiment, chosen by way of example and not of limitation, of a telemanipulator with magnetic transmission, for manipulating objects inside sealed chambers in accordance wiht the present invention.

The accompanying drawing diagrammatically is an elevation section of a telemanipulator of this kind.

This telemanipulator essentially comprises two groups of units:

(1) A first group outside a sealed chamber 1. This group is made up of movement control units. The movements may be horizontal translations parallel to the directions XX' and YY', vertical translation movements ZZ', gripping movements ϵ and rotary movements Ω about a vertical axis of a forceps or tongs. All of these control units end in magnets (electromagnets or permanent magnets) disposed outside and against the wall of the chamber 1 which wall is made of non-magnetic material.

(2) A second group inside the sealed chamber 1. This group is made up of units performing the different movements hereinabove referred to as XX', YY', ZZ', ϵ and Ω. These movement-performing units are controlled from magnets (electromagnets or permanent magnets) disposed inside and against the wall of the chamber 1, opposite the corresponding magnets of the outer group when operating.

The outer group receives the commands of the operator through the intermediary of mechanical means when the activity inside the sealed chamber 1 is at a low level, or of electrical means (such as direct-current motors) when this activity is at a high level; in this latter case, the creation of openings in additional protective barriers constituted by walls 2 and a movable caisson 3 forming a roof, is avoided. These walls 2 and this caisson 3 are so made as to ensure protection against radiation, in any of the ways known in this art.

The outer group is connected to the caisson 3 which moves in the direction XX' on rails 4 fixed for instance to the protective walls 2.

Any vertical movement ZZ' which has to be imparted to a tongs or forceps is performed by raising or lowering a handle 5. A cable 6, which is connected to this handle 5 by a rod 7 provided with a slide 8, drives in succession a pulley 9, a pulley 10 (connected to the pulley 9 by a shaft 11), and a pulley 12A connected to the pulley 10 by a chain 13. The pulley 12A is connected rigidly to a magnet 14A by a shaft 15A passing through a casing 16A which is fixed to the caisson 3 by a support 17.

On the other side of the wall there is another magnet 14B which corresponds to the magnet 14A and which is connected by a shaft 15B passing through a casing 16B, to a pulley 12B which controls the direction Z of a tongs 19 by means of a cable in a flexible tube 18.

The rotation Ω of the tongs 19 about a vertical axis is effected by rotating the handle 5 about its axis; this causes rotation of a tube 20, which is rigid with this handle, and of pairs of bevel pinions 21 and 22 operatively interconnected by a shaft 23 passing through the casing 3. This results in rotation of a magnet 24A (contained in a casing 25A) through the intermediary of a shaft 26A which is rigid with one of the pinions 22. The pinions 21 and 22, and also the shafts 23 and 26A, are kept in place by hollow tubes 27 and 28 fixed at 29 to a tube 30 which is fixed at 31 to the casing 25A which is thus made rigid with the group.

Inside the chamber there is a magnet 24B (contained in a casing 25B) which corresponds to the magnet 24A, the tongs 19 is made to pivot about its vertical axis by this magnet 24B by means of a shaft 26B and a lug 32 passing through a longitudinal slot 33 made in the body of the tongs 19. The system comprising the lug 32 and the slot 33 allows the tongs 19 to be raised or lowered without being rotated.

The closing of the tongs 19, diagrammatically indicated by the arrow ϵ, is controlled by pulling a handle 34

which is pivoted at 35 to the side of the handle 5 and controls a cable in a flexible tube 36. This cable, after passing over a direction-changing pulley 37, rotates a magnet 38A (contained in a casing 39A) through the intermediary of a pulley 40A and a shaft 41A passing through this casing. The pulley 37 and the casing 39A are fixed to the caisson 3 through the intermediary of a support 42.

Inside the chamber there is a magnet 38B (contained in a casing 39B) which corresponds to the magnet 38A by means of a pulley 40B connected to the magnet by a shaft 41B. This magnet 38B actuates a cable in a flexible tube 43. The pull on this cable displaces a lever 44 which closes the jaws 46 of the tongs 19 through the intermediary of a linkage 45.

As mentioned above, displacement along the axis XX', i.e. perpendicularly to the plane of the drawing, is effected by pushing the handle 5 in a direction parallel to this axis XX'. The caisson 3 is then displaced on the rails 4 and is guided by rollers 47.

The magnets 14A, 24A and 38A displaces the part of the telemanipulator situated inside the sealed chamber, by imparting their own movements to the corresponding magnets 14B, 24B and 38B which are inside.

The three magnets 14B, 24B and 38B are interconnected for movement along the axis XX', by means of a beam 48 to which the casings 16B and 38B are fixed and along which the casing 25B is displaced. The beam 48 can roll, through the intermediary of rollers 48A, on rolling tracks 48B which are parallel to the direction XX' and are fixed to the inside of the wall of the chamber 1.

Displacement along the axis YY', i.e., parallel to the plane of the drawing, is controlled in a similar manner by pushing the handle 5 to the right or to the left. This actuates the tubes 27 and 28 which slide across the caisson 3 by means of ball bearings 49 and 50 respectively. The magnet 24A which is connected to these two tubes is thereby displaced in the direction YY'.

The casing 25B is provided with rollers 51 which permit this casing to run along the beam 48, which forms a rolling track, when the casing is driven by the magnet 24B. It will be understood that the magnet 24B follows the displacements of the magnet 24A along the axis YY', and the tongs 19, which is connected to the magnet 24B, therefore follows the displacements of the handle 5 along the axis YY'.

The casings of the magnets 14A, 14B, 38A and 38B are mounted on bearings 52 supported on the walls of the chamber 1, in order to facilitate their movements and to keep the interferric spaces between each driving magnet and receiving magnet constant. This arrangement keeps the mutual characteristics of each pair of magnets constant, independently of the force that has to be transmitted.

In a practical embodiment of the abovedescribed telemanipulator, using the form of magnetic connection with which the present invention is concerned, the rotation about a vertical axis is through 120°, the closing movement of the tongs has an amplitude ranging from 10 to 150 millimetres, and the lifting force of the tongs is of the order of several kilogrammes, which is generally sufficient for manipulation of objects in sealed chambers in technical laboratories; however, with magnets having stronger fields it is possible to improve the performance of the tongs. The magnets are horseshoe magnets made of the usual alloys such as aluminium-nickel-cobalt or titanium-cobalt-aluminium, with oriented grains.

The selected arrangement of the magnets is important: it is necessary to avoid interaction between them, and to form a rigid unit. Thus, grouping all the magnets on one and the same plate would make it difficult to avoid interaction; on the other hand, disposing the magnets on each vertical wall of the chamber would seriously increase the external dimensions, but would make it easy to obtain rigidity of the inner group. The arrangement chosen and described above is a compromise between these two solutions.

What I claim is:

1. A telemanipulator for manipulating objects inside a sealed chamber having walls of non-magnetic material, comprising manipulative means for manipulating objects; means for movably mounting said manipulative means inside said chamber; operating means operatively connected to said manipulative means located inside said chamber; control means located outside said chamber; control magnet means connected to said control means; operating magnet means connected to said operating means for cooperation with said control magnet means, whereby control movements applied to said control means are imparted to said manipulative means; said manipulative means being mounted for sliding movement on a beam movable in a plane parallel to and below a top wall of the chamber; other operating magnet means for opening, closing, and vertically moving said manipulative means mounted on the ends of said beam; and other control magnet means, cooperating with said other operating magnet means, connected to said control means.

2. A telemanipulator for manipulating objects inside a sealed chamber having walls of non-magnetic material, comprising: means for manipulating objects; means for mounting said manipulating means for movement along X—X' and Y—Y' axes, in a vertical direction, in a rotary direction, and for opening and closing movement, said means including a beam within said chamber, means for movably mounting said manipulating means for movement along a Y—Y' axis on said beam, means for mounting said beam for movement along an X—X' axis; first operating magnet means carried by the ends of said beam and connected to said manipulating means to move said beam along an X—X' axis, to move said manipulating means vertically and for opening and closing movement; other operating magnet means carried by said means for mounting the manipulating means for movement along a Y—Y' axis and connected to said manipulating means for rotary movement and vertical movement; control magnet means mounted outside said chamber in cooperating relation with said first operating magnet means and said other operating magnet means; and control means, connected to said control magnet means, to remotely actuate said manipulating means.

3. A telemanipulator as recited in claim 2, in which said magnet means are rotatably mounted.

4. A telemanipulator as recited in claim 3, in which the first operating magnet means are connected to the manipulating means to cause movement along the X—X' axis as said operating magnet means are moved longitudinally and to cause vertical movement and opening and closing movement as said operating magnet means are rotated, and the other operating magnet means are connected to the manipulating means to cause movement along the Y—Y' axis as said other operating magnet means are moved longitudinally and to cause rotary movement as said other operating magnet means are rotated.

5. A telemanipulator as recited in claim 4, including means to support said control magnet means outside said chamber for longitudinal movements in transverse planes.

6. A telemanipulator for manipulating objects inside a sealed chamber having walls of non-magnetic material, comprising: means for manipulating objects comprising a pair of opposed jaws; means for pivotally mounting said jaws for movement toward and away from one another; means for supporting said manipulating means including a beam within said chamber; means for mounting said manipulating means on said beam for movement in a Y—Y' direction, said mounting means including a connection for vertical and rotational movement of the manipulating means; means for mounting said beam for movement in an X—X' direction; a first rotatable operating magnet means on one end of the beam

adjacent a wall of the chamber; connecting means between said magnet means and the manipulating means for raising and lowering the manipulating means; a second rotatable operating magnet means on the other end of the beam adjacent a wall of the chamber; connecting means between said second operating magnet means and manipulating means to operate the jaws thereof; a third rotatable operating magnet means on the manipulating means mounting means adjacent a wall of the chamber; connecting means between said third operating magnet means and the manipulating means to cause rotation of the latter; and a control means outside the sealed chamber, including first, second and third rotatable controlling magnet means adjacent the exterior walls of the chamber and operatively associated with said first, second and third rotatable operating magnet means within the chamber, to produce a linear traverse and rotational movement of the latter magnet means.

7. A telemanipulator as recited in claim 6, in which the control means comprises a manually operated member mounted for axial movement, and rotational movement about a longitudinal axis, and connecting means between said manually operated member and said first and third controlling rotatable magnet means whereby axial movement of the member produces rotation of said first controlling magnet means, and rotational movement about a longitudinal axis produces a rotation of the third controlling magnet means.

8. A telemanipulator as recited in claim 7, in which the manually operated member includes an additional operating element, and connecting means between said element and said second controlling rotatable magnet means to produce rotation of the latter.

9. A telemanipulator as recited in claim 8, including a movable support for said control means, and means adjacent said chamber for mounting said support for movement along an X—X′ axis.

10. A telemanipulator as recited in claim 9, in which said movable support includes means to support said connecting means between the control member and the first and third controlling magnet means for movement along a Y—Y′ axis, whereby movement of the control member along a Y—Y′ axis causes concurrent movement of the first and third control magnet means.

11. A telemanipulator as recited in claim 10, including a housing for each magnet means, and bearing means, carried by each housing, in rolling contact with the walls of the chamber.

12. In or for a sealed chamber having walls made of a non-magnetic material, a telemanipulator, comprising: control means located outside said chamber; operating means located inside said chamber; control and operating magnet means cooperating with said control means and said operating means, respectively, whereby a magnetic coupling is established through the wall of the chamber between said control means and said operating means; rotatably mounted shafts carrying said magnetic means; housings having means rotatably supporting said shafts; rolling means, carried by said housings, having rolling contact with the outside walls and inside walls of said chamber; rotating means, responsive to said control means, rotating said control magnet around an axis perpendicular to said walls; and means, responsive to said control means, translating said control magnet means along said walls.

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