Nov. 19, 1963 P. PESENTI 3,111,230

HEAD FOR REMOTE MANIPULATORS

Filed Aug. 1, 1960 3 Sheets-Sheet 1

Fig.1

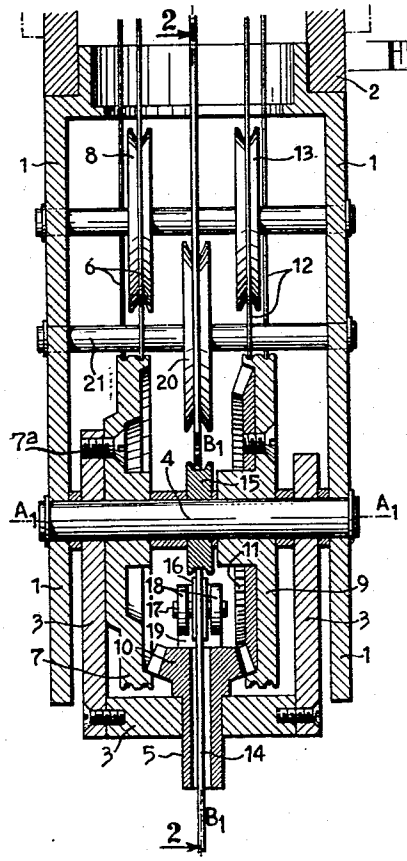

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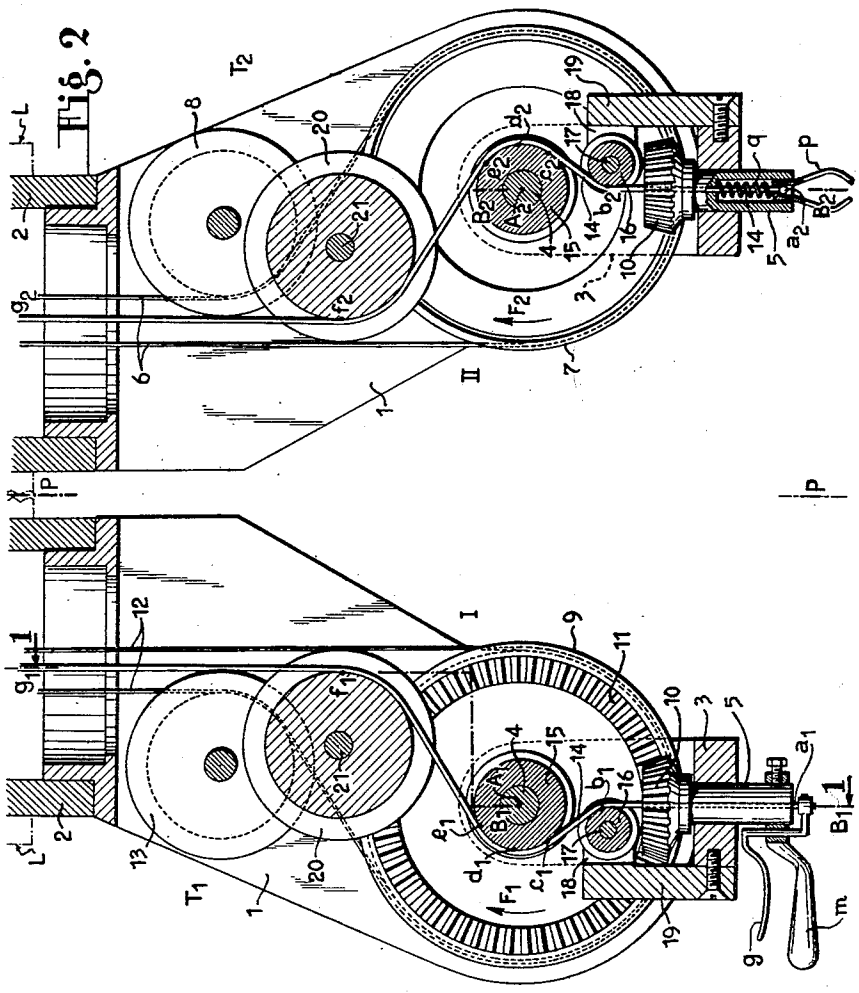
Fig. 2



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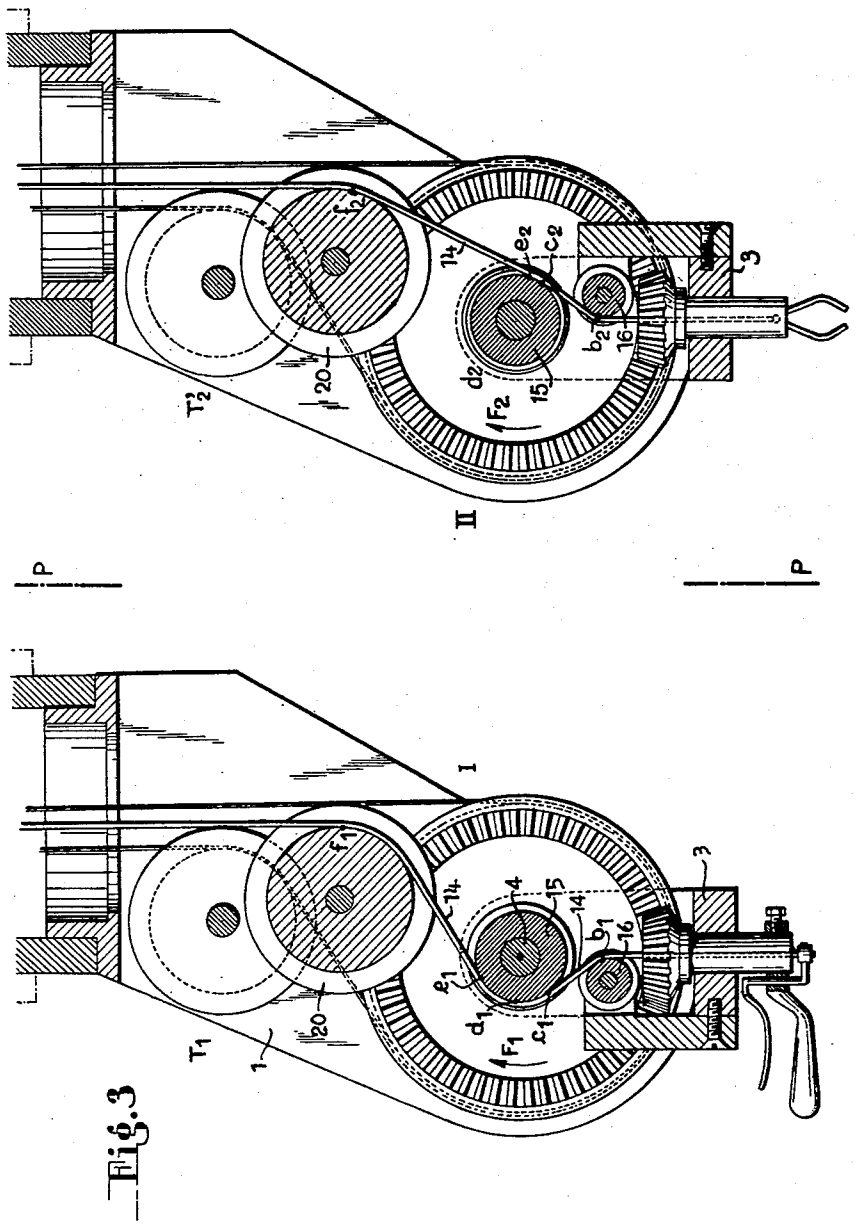

Fig.3

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HEAD FOR REMOTE MANIPULATORS

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The present invention relates to manipulators and, more particularly, to remote manipulators intended to produce, from a control station, the remote manipulation of objects disposed in a receptor station and, in particular, radioactive materials.

Known remote manipulators comprise, at the control station, a driving control head and, at the receptor station, a receptive or driven head which, by reason of appropriate connections accomplishes movements identical with those which are communicated by the operator to the control head.

The receptive head carries a holder or other equivalent device intended to grip, displace and then set down the object to be manipulated and the control head comprises an operating device permitting, on the one hand, the displacement of the holder device and, on the other hand, its opening and closing, all the movements of the holder being identical with the movements communicated by the operator to the operating device and being synchronous with the latter, homologous movable mechanisms in the two heads being connected by cables or other connecting devices.

In particular, a type of head is known which is referred to as a "knuckle-joint," in which a support is mounted to oscillate in the body of the head around a first axis and, in this support, a tubular carrying element can rotate about its own axis, which is perpendicular to the first axis, the element carrying in the driving knuckle-joint a trigger or other control member, while the homologous element in the driven knuckle-joint carries the holder, the control member and the holder being connected by a cable which passes axially within the two tubular elements.

The axis of each of these carrier elements forms, with a fixed direction passing through the axis of oscillation of the oscillating support, an angle which varies with the oscillations of the support and it is indispensable, in order that the tension of the cable should not vary as a function of the angle, for the cable to pass in each of the two heads through the fixed intersection of the axis of the carrier element and the fixed direction, this intersection being located on the axis of oscillation of the oscillating support. The cable cannot have a radius of zero curvature at this point of intersection, which conduces to the adoption in general of the following solution.

The oscillating support oscillates on two pins which are co-axial but are spaced one from the other. In the free space between the two pivot pins, two small grooved wheels are disposed, which are tangential to the common axis of the two pins, are connected to the oscillating support and are arranged to guide the cable while maintaining it as close as possible to its theoretical course.

This solution is a relatively complicated construction, because of the formation of the oscillation axis of the oscillating support as two separated pins and, also, experience shows that the tension of the cable is not maintained strictly constant.

The invention has the object of providing an improved head of the knuckle-joint type mentioned above, having a tubular element carried by an oscillating support and traversed axially by a cable arranged to connect a control member to a holder or other receptor device, this improved head alleviating in a simple manner the disadvantages mentioned above and permitting, in particular, the tension of the cable to be maintained strictly constant.

These results are obtained due to the fact that, on the one hand, the axis of oscillation of the oscillating support is constituted by a single pivot pin which extends from one part to the other of the head and that, on the other hand, guiding of the cable is ensured by the combination of a pulley freely mounted on the pin, a roller or other return device freely mounted on a pivot pin carried by the oscillating support and arranged to return the cable into the axis of the tubular carrying element which rotates within the support, after a certain amount of winding of the cable on to the pulley and, at the opposite side of the roller with respect to the pulley, a second pulley or equivalent means carried by the head to give to the portion of the cable located between the two pulleys an invariable direction.

The invention also has the object of providing a remote manipulator which is remarkable in that it comprises two heads of the improved type mentioned, one being the driving head and one the driven head.

In the accompanying drawings, embodiments of the invention are given by way of illustration:

FIG. 1 shows a transverse sectional view generally along the line 1—1 of FIG. 2 of one head of an improved remote manipulator according to the invention;

FIG. 2 shows a transverse section along the line 2—2 of FIG. 1 of a possible arrangement of two homologous, control and receptive or driving and driven heads of a remote manipulator;

FIG. 3 is an analogous view of another possible arrangement of the two heads of a remote manipulator.

According to the embodiment shown in FIGS. 1 and 2, the invention is assumed to be applied to the remote control, from a control station I, of a pair of toothed jaws *p* or the equivalent, disposed in a receptor station II separated from the station I by a distance which can be relatively large and, also, by any wall or other means, such as a physiological screen in the case of application of the invention to the manipulation of radioactive materials, the separation between the two stations I and II being shown diagrammatically in FIG. 2 by the plane P—P.

The operator is at the station I and, in order to operate the holder *p*, so that he can displace in the space and open and close it, controls the two operating members represented by a handle *m* and a trigger or other device *g*. The handle *m* is intended to provide for displacement of the holder *p*, either open or closed, while the trigger *g* permits the movements of opening and closing of this holder.

Thus, at the station I, the operating members *m* and *g* are part of a head control or driving "knuckle-joint" head T_1, while, at the receptor station II, the holder *p* is part of a receptor or driven "knuckle-joint" head T_2.

In the embodiment of FIGS. 1 and 2, the two heads T_1 and T_2 are in accordance with the invention and, apart from details of the parts *g*, *m* and *p*, are strictly symmetrical with respect to the plane P—P.

Each of them comprises, as is known, a support carrying a mechanism and formed, for example, by a housing 1, formed by two parallel plates, fixed to an arm 2.

The two arms relating to one or other of the two heads are carried by a support device (not shown) and, through the intermediary of this device, the connections between the two heads mentioned below are established. This device and these connections are indicated diagrammatically in FIG. 2 by the chain-dotted lines L.

In the housing 1 of each head is mounted, in known manner and about a transverse axis A_1—A_1 or A_2—A_2, an oscillating support 3, itself in the form of a housing, but, while in known heads the support 3 is connected by each of its side limbs to a pivot pin for such side limb, the two co-axial pins being separated by a free space, in

accordance with the present invention, the support **3** oscillates about a shaft **4** which extends from one limb to the other of the support **1**.

A tubular element **5** rotates about an axis B_1—B_1 or B_2—B_2 perpendicular to the axis A_1—A_1 or A_2—A_2, likewise in known manner, in the base of the support **3**.

For the head T_1, the element **5** carries the handle *m* and the trigger *g*, while, for the head T_2, the homologous element serves to guide the holder *p*, which tends to leave this guide under the action of a spring *q*, the holder opening when and to the extent that it emerges from the element **5**, while, through its penetration into this element, closing of the holder is effected.

Again as known, connection means, on the one hand, between the oscillating supports **3** of the two heads and, on the other hand, between the two elements **5**, are provided so that any oscillation of the support **3** of the head T_1 about the axis A_1—A_1 is translated into an oscillation in the same sense of the homologous support in the head T_2 about the axis A_2—A_2 and that, on the other hand, any oscillation of the element **5** carrying the parts *m* and *g* about the axis B_1—B_1 is translated into a synchronous oscillation in the same sense and of the same amplitude of the holder member in the head T_2 about the axis B_2—B_2.

The oscillations of the support **3** in the head T_1 about the axis A_1—A_1 are communicated to the homologous support of the head T_2 by means of a cable **6** passing within each head upon a return pulley **7** fixed to the corresponding support **3**, for example by a screw **7***a*.

As with the oscillations of the element **5** of head T_1 about the axis B_1—B_1, they are communicated to the homologous element of the head T_2 in the following manner.

Each element **5** is connected to a pulley **9**, mounted freely on the corresponding pin **4**, through the intermediary of a transmission constituted, for example, by a bevel pinion **10** connected or mounted at the end of the element **5** and a bevel gear **11** connected to the pulley **9**; the two homologous pulleys of the two heads are connected by an endless cable **12** passing in each head around a return pulley such as **13**.

Also, as known, the trigger *g* of the head T_1 is connected to the holder *p* of the head T_2 by a cable **14**, the end portions of which are disposed along the axis B_1—B_1 and B_2—B_2 at the interior of the two homologous elements **5**.

As will be understood, the cable **14** should transmit to the holder *p* synchronous movements which are in the same sense and are equal to those of the trigger *g*, the holder *p* penetrating into the element **5** of the head T_2 for closure, when the operator moves the trigger *g* towards the handle *m*.

Naturally, the holder *p* must not move with respect to the element **5** which carries it, when the operator does not operate the trigger *g* and, whatever may be the movements communicated to the element **5** of the head T_2, in order to displace the holder *p* in its assembly, the operator correspondingly controls the element **5** of the head T_1.

It is evident that the movements of oscillation of the elements **5** about their respective axes B_1—B_1 and B_2—B_2 have no influence on the cable **14**, because the latter passes axially through the elements but, in return, means are necessary for avoiding oscillations of the elements **5** with their supports **3** about the axes A_1—A_1 and A_2—A_2 which could be translated into a longitudinal displacement of the cable **14**.

It is these measures, provided for this purpose, which, together with the symmetry of the heads T_1 and T_2 of the present embodiment of FIGS. 1 and 2 and the provision of a single axle journal or pivot pin **4**, constitute the novel characteristics of the present invention.

For each head, on the shaft **4**, a pulley **15** with a single groove is freely mounted, between the two pulleys

7 and **9** of the connection, on which the cable **14** becomes wound or wrapped along a certain arc c_1—d_1—e_1 or c_2—d_2—e_2 of an angle of variable centre.

On one side and the other of this pulley **15**, two cable guiding devices are provided.

One of these devices consists of a grooved roller **16**, freely mounted about a spindle **17** in a mounting **18** which a support member **19** rigidly connects to the corresponding oscillating support **3**. This roller **16** is disposed so that the end a_1—b_1 or a_2—b_2 of the cable **14**, disposed axially within the corresponding element **5**, is tangential to the roller **16** at the base of its groove.

The other guiding device is constituted by a grooved pulley **20** freely mounted on a spindle **21** carried by the housing **1**. It is disposed in such a manner that the portion of the cable f_1—g_1 or f_2—g_2 located between this pulley and the support arm **2** is disposed along the axis of the arm.

Owing to this device, it will be seen that the sections e_1—f_1 and e_2—f_2 of the cable located between the central pulley **15** and the auxiliary pulley **20** of the heads T_1 and T_2 do not change during oscillations of the supports **3** about the axes A_1—A_1 and A_2—A_2.

The same holds for the sections b_1—c_1 and b_2—c_2 located between the rollers **16** and the pulley **15**. On the other hand, the wrapped arcs c_1—d_1—e_1 and c_2—d_2—e_2 vary in inverse senses and equal amounts, the cable unwinding at c_1 in the head T_1 to wind up at c_2 by an equal amount in the head T_2, if the heads rotate in the senses of the arrows F_1 and F_2 or vice versa, such that there is, in all cases, a strict compensation and the ends a_1—b_1 and a_2—b_2 connected to the trigger *g* and to the holder *p* do not undergo any displacement.

The cable is thus not submitted to any variation of tension and the holder *p* remains exactly in an invariable position with respect to the tubular element **5** which carries it when, during displacements of the holder assembly, the trigger *g* is not displaced with respect to the handle *m*.

In FIG. 3, there is shown another arrangement of heads T_1 and T_2'. The driving head T_1 is disposed exactly as in the embodiment of FIG. 2; in contrast, the head T_2' is not symmetrical to the head T_1 with respect to the plane P—P.

It has in fact the same orientation as the head T_1; only the oscillating supports **3** with their rollers **16** are symmetrical with respect to the plane P—P.

The winding c_1—d_1—e_1 of the cable **14** is not changed but, in contrast, the winding c_2—d_2—e_2 is such that it forms around the pulley **15** a substantially complete turn if the runs b_1—c_2 and e_2—f_2 are co-axial one with the other or about 360° if, as shown, these two runs form between them a slight angle.

Naturally, the invention is in no way limited to the embodiments shown and described, which have been selected merely by way of example.

It is evident that the return members **16** and **20** can be provided otherwise than in the form of free pulleys, for example, in the form of simple spindles, but in this case there will be friction of the cable **14** during operation of the holder *p* in the opening sense or closing sense, whereas the rotating elements **16** and **20**, as also does the pulley **15**, eliminate all friction and, consequently, all risk of wear of the cable **14**.

Naturally, the invention applies itself to other operating means and control devices connected to the two ends of the cable **14**.

I claim:

1. In a remote-control manipulator and the like, a terminal head comprising a housing, a pivot pin received in said housing, a support supported by said pivot pin, a tubular element rotatably received in said support, a drive member carried by said tubular member, and cable means extending through said head and tubular member to said drive member, roller means rotatably mounted on said support guiding said cable means, a first pulley journalled

on said pivot pin guiding said cable means, and a second pulley rotatably mounted on said housing guiding said cable means, said roller means and said pulleys being so constructed and arranged that said cable means between said roller means and said first pulley has an invariable angular position with respect to said housing in the whole range of angular movement of said support.

2. In a remote-control manipulator and the like, a terminal head comprising a housing, a pivot pin received in said housing, a support supported by said pivot pin, a tubular element rotatably received in said support, a drive member carried by said tubular member, and cable means extending through said head and said tubular member to said drive member, roller means rotatably mounted on said support guiding said cable means, a first pulley journalled on said pivot pin guiding said cable means, and a second pulley rotatably mounted with respect to said housing guiding said cable means, said roller means and said pulleys being so constructed and arranged that said cable means contacts said roller means and said first pulley throughout the complete range of angular movement of said support.

3. In a remote-control manipulator as described in claim 2, said drive member being a manually actuatable control member.

4. In a remote-control manipulator as described in claim 2, a driven head, a driven mechanism in said head energized by said cable means upon transmission of a tractive force through said cable means.

5. A remote-control manipulator of the "knuckle joint" type having support means, a pair of pivot pins received in said support means in substantially symmetric relation with respect to the midplane of said support means, a control head and a driven head each pivotally carried by one of said pins and substantially symmetric with respect to the midplane of said support means, a control mechanism carried by said control head, a driven mechanism carried by said driven head, means operatively interconnecting said heads for identical angular movements of said heads with respect to said support means including cable means operatively interconnecting said control and driven mechanisms, means for supporting said cable means in each head comprising a roller rotatably connected to the associated mechanism, a first pulley providing relative pivotal movement between the head and support, and a second pulley rotatably mounted on said support means, said roller and said pulleys being engaged by said cable means at all times whereby tension of said cable between said control and said driven mechanisms is maintained at a constant value.

6. A remote-control manipulator of the "knuckle joint" type having support means, a pair of pivot pins received in said support means in substantially symmetric relation with respect to the midplane of said support means, a control head and a driven head each pivotally carried by one of said pins and in substantially identical angular positions with respect to said support means, a control mechanism carried by said control head, a driven mechanism carried by said driven head, means operatively interconnecting said heads for identical angular movements of said heads with respect to said support means including cable means operatively interconnecting said control and driven mechanisms, means including a roller rotatably connected to the associated mechanism for supporting said cable means in each of said heads, a first pulley rotatably supported about said pivot pin providing pivotal movement between said head and said support, and a second pulley rotatably mounted on said support, said cable means engaging a small angular portion of said first pulley and engaging a greater portion of said second pulley for an angular position of said head corresponding to one of the limits of the range of angular movement thereof and said cable means in one of said heads crossing the line of centers of the associated first and second pulleys between its points of contact with said pulleys, and in the other of said heads being located on one side of the line of centers of the associated first and second pulleys between its points of contact with said pulleys.

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