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B8H

(54) A manipulator

(57) A manipulator 10 comprises a telescopically extensible arm 12 which may be slidably mounted through a ball joint 14 in a wall 16 of an enclosure 18. At one end of the arm 12 is a wrist mechanism 26 rotatable about an axis perpendicular to the longitudinal axis of the arm 12 and also rotatable about its own longitudinal axis. At the other end of the arm 12 is an operator's handle 22 which controls movements of the wrist mechanism 26. The telescopic action of the arm 12 may be motor-driven.

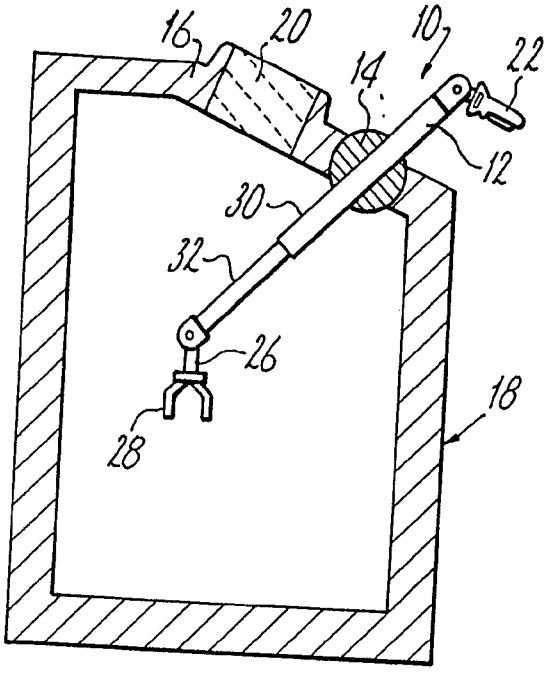

Fig.1.

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Fig.1.

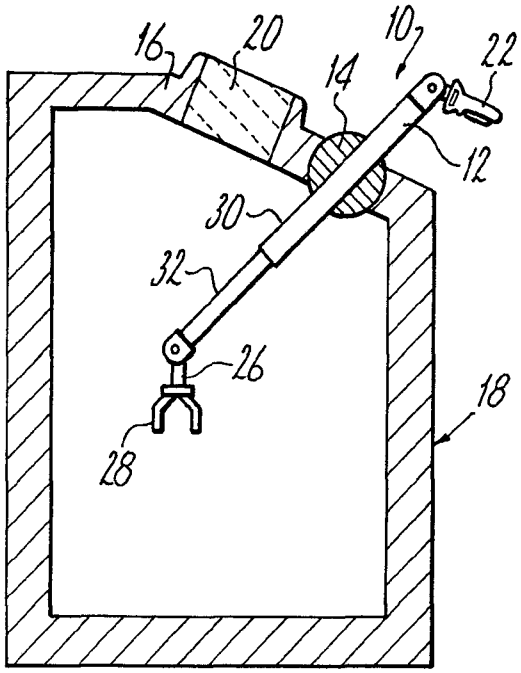
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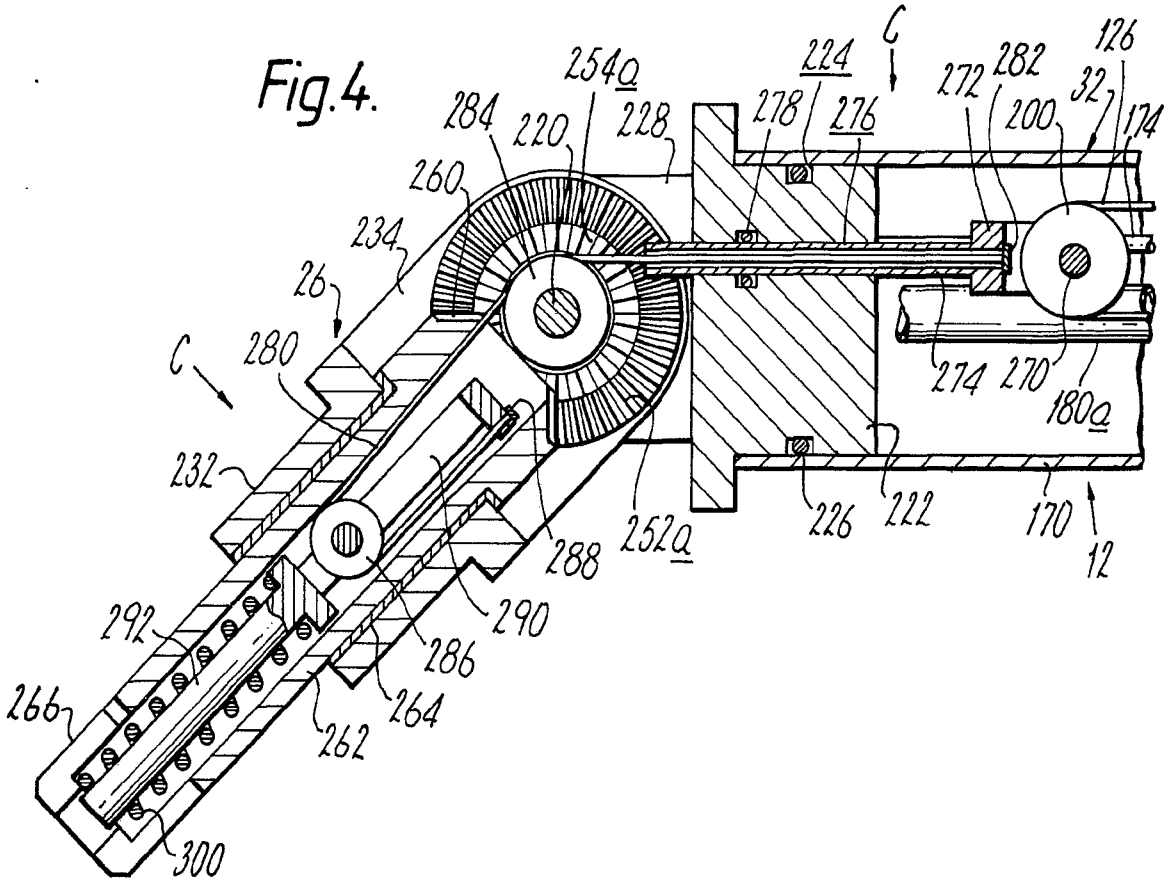
Fig.4.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32
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26
C
280
274
270
180a
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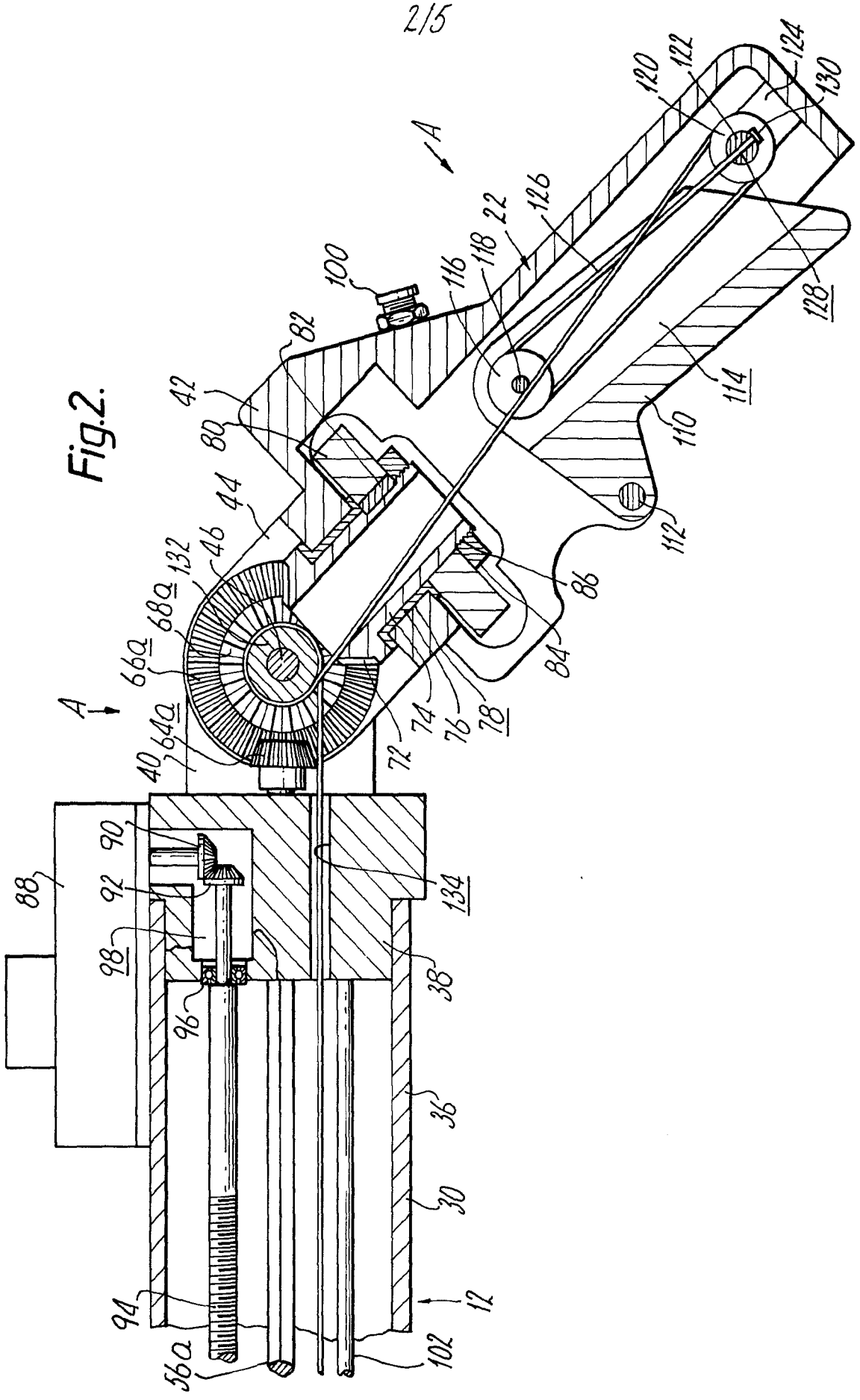
252a
226
222
170
12
288
290
292
286
264
266
262
300

Fig.2.


A
A
12
22
30
36
38
40
42
44
46
56a
64a
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68a
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76
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82
84
86
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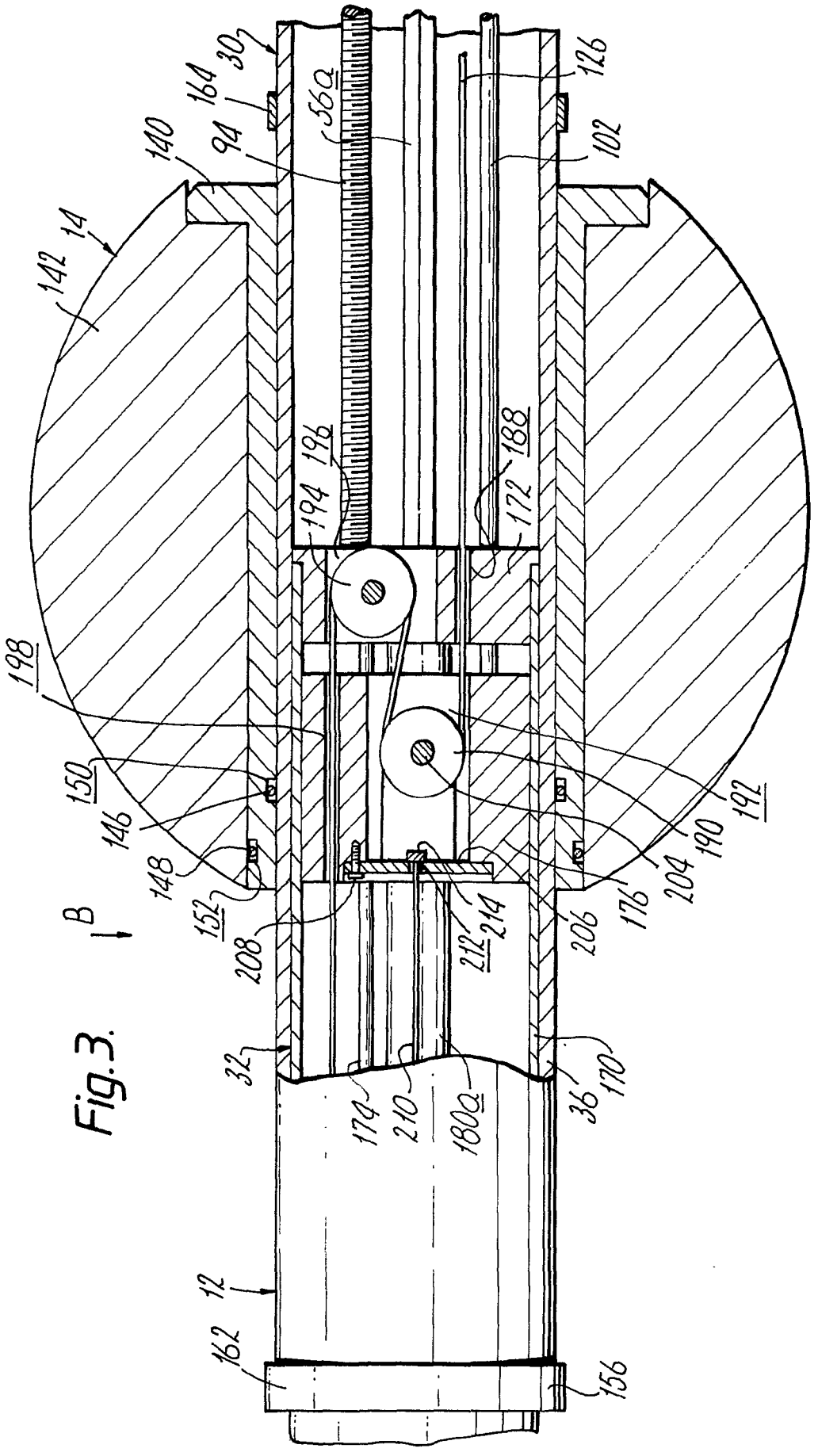
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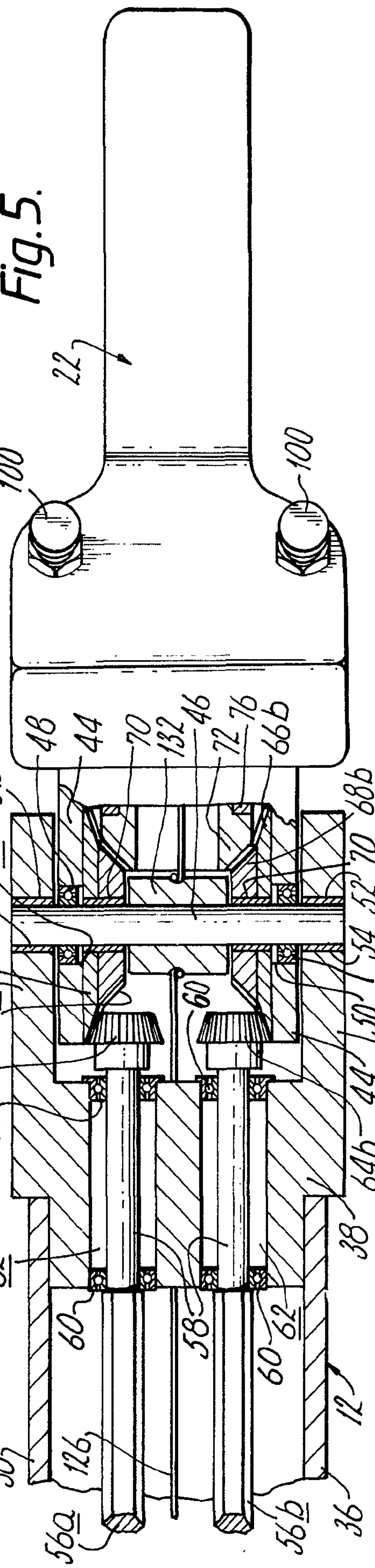
164
140
94
56a
126
102
14
142
196
194
188
172
198
150
146
148
152
208
212
214
206
176
204
190
192
B
32
174
210
180a
36
170
12
162
156

Fig.3.

Fig.5.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100
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48
44
70
132
46
72
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66b
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70
52
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54
52'
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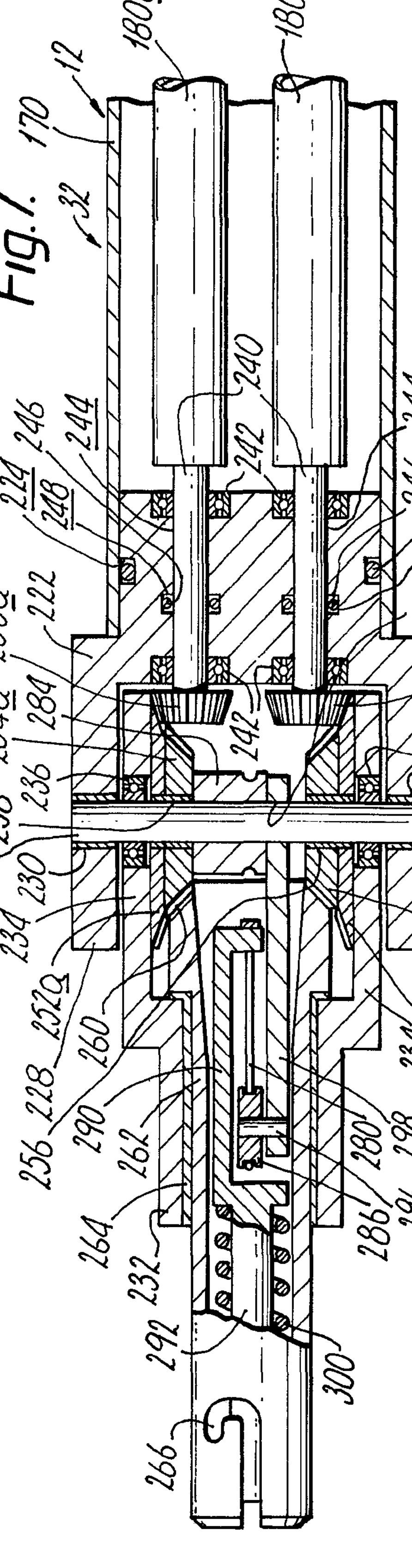
30
50
40
66a
68a
60
60
40
44
40
64a
60
64b
38
62
62
60
58
60
62
60
12
30
126
36
56a
56b

Fig.7.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170
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240
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246
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284
254a
242
236
236
256
230
220
230
228
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300
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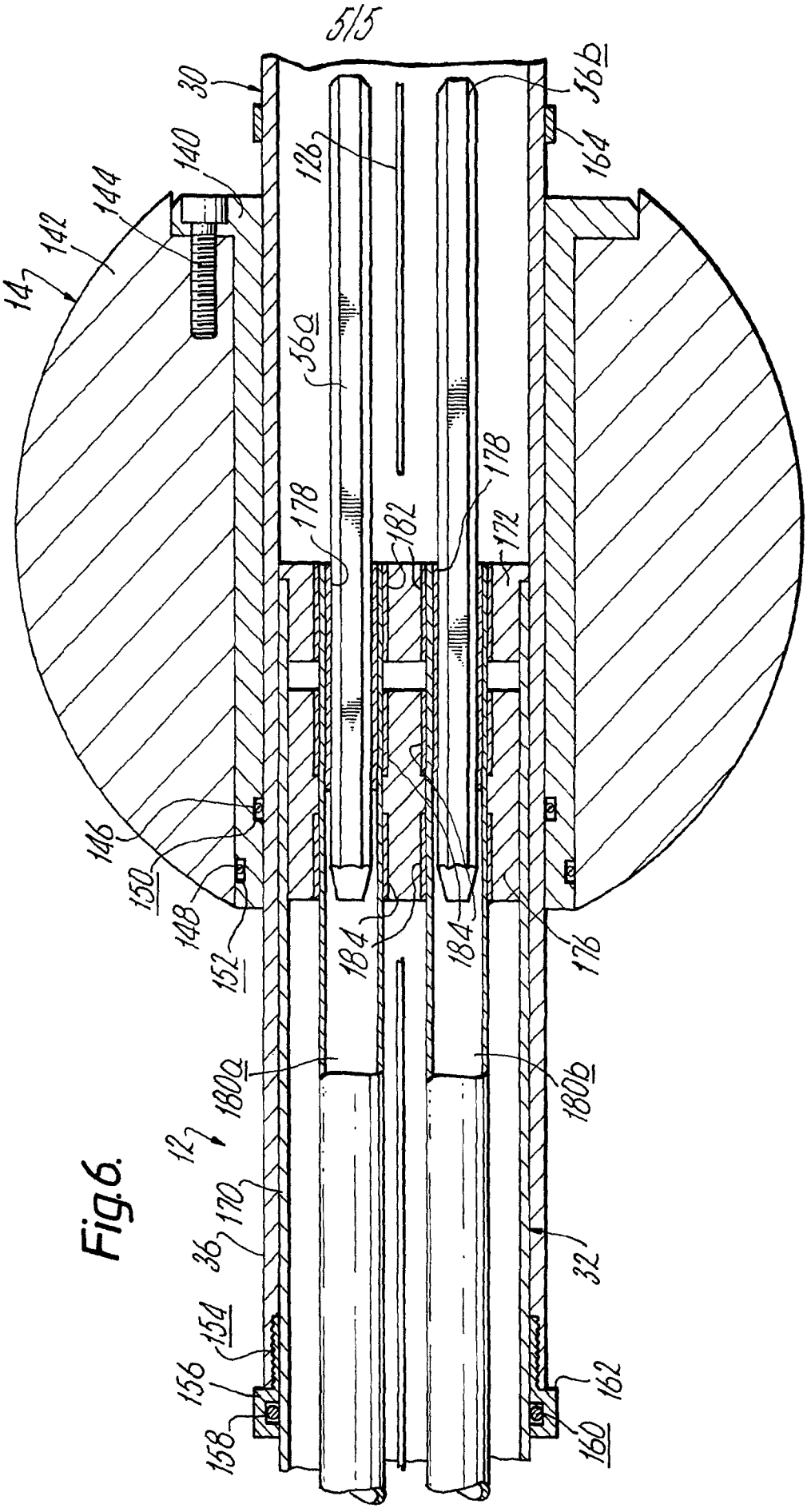
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126
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166
166
178
178
182
172
146
150
148
152
184
184
176
180a
180b
12
170
36
154
156
158
32
162
160

Fig.6.

SPECIFICATION

A manipulator

This invention relates to manipulators for remote handling of objects within an enclosure, by an operator outside the enclosure.

According to the present invention there is provided a manipulator comprising, a telescopically extensible arm member to be mounted at an intermediate position along its length through a pivot in a wall, a wrist mechanism rotatably connected to one end of the arm member so as to be rotatable about the longitudinal axis of the wrist mechanism and rotatable about an axis at an angle to the longitudinal axis of the arm member, an operating handle rotatably connected to the other end of the arm member, and drive means to connect the handle to the wrist mechanism.

The said angle is preferably a right angle, and the drive means are preferably telescopic rotary drive shafts extending along the arm member. Desirably, the telescopic action of the arm member is controlled by a motor-driven lead screw. The arm member may also be slidably mounted in the pivot so that it can undergo limited longitudinal motion relative to the pivot.

A grip mechanism having two opposed jaws may be attached to the wrist mechanism, and may be controlled by means of a cable extending along the arm member with means to compensate for extension of the arm member.

It will be understood that the invention also includes an assembly comprising the manipulator of the invention, and said pivot adapted for incorporation in the wall.

The manipulator will now be further described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a diagrammatic view of a manipulator installed in a shielded enclosure;

Figures 2, 3 and *4* show longitudinal medial sectional views of parts of the manipulator of Figure 1, to an enlarged scale; and

Figures 5, 6 and *7* show longitudinal sectional views in the directions of arrows A, B and C of Figures 2, 3 and 4 respectively.

Referring to Figure 1, a manipulator 10 comprising an arm member 12 is mounted in a ball joint 14 in a wall 16 of a shielded container 18. A thick lead glass window 20 in the wall 16 enables an operator to observe the inside of the container 18. At one end of the arm member 12 is a operating handle 22, and at the other end is a wrist mechanism 26 to which a grip mechanism 28 is attached. The arm member 12 consists of an upper arm portion 30, mounted in the ball joint 14, and a lower arm portion 32 telescopically slidable therein.

Referring now to Figures 2 and 5 which show the handle 22 and the adjacent parts of the arm member 12, the upper arm portion 30 comprises a tubular member 36 and an end cap 38 from which extend two yoke plates 40. The handle 22 comprises a frame 42 from which extend two handle yoke plates 44, and the handle 22 is pivotally supported by a gear shaft 46 passing through bearings 48 located in opposed cylindrical holes 50 in the handle yoke plates 44 and through bearings 52 located in opposed cylindrical holes 54 in the yoke plates 40.

Two parallel steel drive shafts 56*a*, 56*b*, hexagonal in section, extend along the upper arm portion 30 and have cylindrical end portions 58 supported by spaced-apart bearings 60 through longitudinal cylindrical holes 62 in the end cap 38. At the free end of each end portion 58 is a small bevel gear 64*a*, 64*b* engaging a respective bevel gear 66*a*, 66*b* rotatably supported by an elongate bearing 70 on the gear shaft 46. Each bevel gear 66*a*, 66*b* is secured to a bevel gear 68*a*, 68*b* of smaller diameter, rotatably supported on the gear shaft 46 by the respective bearing 70. A bevel gear 72 defined at one end of tubular stub shaft 74 engages both the bevel gears 68*a* and 68*b*. The stub shaft 74 is rotatably located by a bearing 76 in an axial hole 78 in the frame 42, and a knurled knob 80 is keyed to the stub shaft 74 by a key 82 and secured thereto by a nut 84 engaging a threaded end 86 of the stub shaft 74.

Consequently, rotation of the handle 22 about the gear shaft 46 causes the bevel gears 66*a*, 66*b*, 68*a*, 68*b* to rotate in the same direction as the handle 22, so rotating the small bevel gears 64*a*, 64*b* and the drive shafts 56*a*, 56*b* in opposite directions. Rotation of the knob 80 in its bearing 76 on the other hand causes the bevel gears 66*a*, 68*a* and the bevel gears 66*b*, 68*b* to rotate in opposite directions on the gear shaft 46, so rotating the small bevel gears 64*a*, 64*b* and the drive shafts 56*a*, 56*b* in the same direction.

As shown in Figure 2 an electric motor 88 is attached to the end of the upper arm portion 30, and is drivably connected by bevel gears 90 and 92 to a lead screw 94 extending along the upper arm portion 30 (below the plane of Figure 2), supported by a bearing 96 in a hole 98 in the end cap 38. The electric motor 88 can be energised to rotate the lead screw 94 in either direction, and is controlled by two press-type switches 100 on the handle 22. Also extending along the upper arm portion 30 are two tie rods 102 (only one is shown) attached to the end cap 38.

A trigger 110 is pivotally attached to the frame 42 of the handle 22 by a pivot pin 112, and has a rectangular slot 114 in which a pulley 116 is located by a pivot pin 118. A second pulley 120 is attached to the end of the frame 42 remote from the arm member 12 by a pivot pin 122 locating in a bracket 124 which is narrower than the width of the slot 114. One end of a steel cable 126 passes through a hole 128 in the pivot pin 122 and is secured to a nipple 130. The cable 126 passes firstly around the pulley 116 and then the second pulley 120, and passes through the stub shaft 74, completely around a grooved wheel 132 mounted on the gear shaft 46, through a hole 134 in the end cap 38 and along the upper arm portion 30. In Figure 2 the trigger 110 is shown in its released position, protruding from the frame 42 of the handle 22. When the trigger 110 is squeezed into the handle 22, the pulley 116 moves away from the second pulley 120, so pulling on the cable 126.

Referring now to Figures 3 and 6, which show the

parts of the arm member 12 adjacent to the ball joint 14, the upper arm portion 30 is slidably mounted in a flanged bush 140 extending diametrically through a truncated sphere 142 of the ball joint 14. The bush 140 is attached by screws 144 (only one is shown in Figure 6) to the sphere 142, and O-ring seals 146 and 148 are located in internal and external circumferential grooves 150, and 152 respectively in the bush 140. The tubular member 36 of the upper arm portion 30 has, at one side of the ball joint 14, an internally threaded end portion 154 to which a ring member 156 is attached, the ring member 156 locating an O-ring seal 158 in an annular groove 160 and defining a circumferential flange 162. A flange 164 is attached to the outside of the tubular member 36 on the other side of the ball joint 14, the flanges 162 and 164 thus limiting axial movement of the upper arm portion 30 through the bush 140.

The lower arm portion 32 comprises a lower tubular member 170 at one end of which is an end plug 172, held in position by two tie rods 174 (only one is shown in Figure 3) extending the length of the lower arm portion 32. A shielding block 176 is slidably located within the lower tubular member 170 and is attached by the tie rods 102 (only one is shown in Figure 3) to the end cap 38 (see Figure 2) of the upper arm portion 30, the tie rods 102 passing through clearance holes (not shown) in the end plug 172, and the tie rods 174 passing through clearance holes (not shown) in the shielding block 176.

As shown more clearly in Figure 6, the hexagonal section drive shafts 56*a*, 56*b* are slidably located in hexagonal guides 178 at the ends of tubular drive shafts 180*a*, 180*b* so that rotation of the drive shafts 56*a*, 56*b* causes rotation of the corresponding tubular drive shafts 180*a*, 180*b*. The tubular drive shafts 180*a*, 180*b* are rotatably supported in bearings 182 in the end plug 172 and rotatably and slidably supported in bearings 184 in the shielding block 176, and extend the length of the lower arm portion 32.

As shown in Figure 3 the lead screw 94 (below the plane of the Figure) engages in a threaded hole (not shown) through the end plug 172 of the lower arm portion 32, rotation of the lead screw 94 thus causing the lower arm portion 32 to slide telescopically relative to the upper arm portion 30.

The steel cable 126 from the handle 22 (see Figure 2) passes through a hole 188 through the end plug 172, round a pulley 190 mounted in a slot 192 in the shielding block 176, then round a pulley 194 mounted in a slot 196 in the end plug 172, through a hole 198 through the shielding block 176, along the length of the lower arm portion 32, around a pulley 200 (see Figure 4) at the other end of the lower arm portion 32 and back to terminate at the shield block 176. The pulley 190 is mounted on a pivot pin 204 supported by a bracket 206 attached to the shielding block 176 by screws 208 (only one is shown), and the end 210 of the cable 126 passes through a hole 212 in the bracket 206 and is secured to a nipple 214.

Referring now to Figures 4 and 7, which show the wrist mechanism 26 and the adjacent parts of the arm member 12, the lower arm portion 32 is rotatably connected to the wrist mechanism 26 by a gear shaft 220. As the grip mechanism 28 of Figure 1 is of a conventional form, further details will not be given. The lower tubular member 170 terminates in an end cap 222 defining a peripheral groove 224 for an O-ring seal 226, and is held in position by the two tie rods 174 (only one is shown in Figure 4). Two yoke plates 228 extend from the end cap 222 and rotatably support the ends of the gear shaft 220 in bearings 230. The wrist mechanism 26 comprises a tubular wrist member 232 from which two yoke plates 234 extend and are rotatably supported on the gear shaft 220 by bearings 236.

Each of the tubular drive shafts 180*a*, 180*b* terminates in a respective cylindrical shaft 240 which is rotatably supported in spaced-apart bearings 242 through respective holes 244 through the end cap 222, and is sealed by O-ring seals 246 in annular grooves 248 in the end cap 222. At the end of each cylindrical shaft 240 is a small bevel gear 250*a*, 250*b* engaging a respective bevel gear 252*a*, 252*b* rotatably supported by an elongate bearing 256 on the gear shaft 220. Each bevel gear 252*a*, 252*b* is fixed to a bevel gear 254*a*, 254*b* of smaller diameter mounted on the respective bearing 256. The two bevel gears 254*a*, 254*b* both engage a bevel gear 260 defined at one end of a tubular shaft 262 rotatably mounted in the tubular wrist member 232 by a bearing 264. The other end of the tubular shaft 262 defines a conventional bayonet slot 266 to which the grip mechanism 28 of Figure 1 or another tool may be connected.

As shown in particular in Figure 4, the pulley 200 is supported by a pivot pin 270 in a bracket 272. The bracket 272 is defined at one end of a tube 274 slidably extending through a hole 276 through the end cap 222 and sealed therein by an O-ring seal 278 in a groove 279. A wrist cable 280 with at one end a nipple 282 is attached thereby to the bracket 272 and extends through the tube 274. The wrist cable 280 then passes over a grooved wheel 284 rotatable about the gear shaft 220, passes round a pulley 286 at an intermediate position along the tubular shaft 262, and is connected at its other end by means of a nipple 288 to an arm 290 extending from one side of a spring-loaded plunger 292. The pulley 286 is supported on a pivot pin 296 at one end of a stay rod 298, the other end of the stay rod 298 having a hole 294 through which the gear shaft 220 extends. Thus the pulley 286 is at a fixed distance from the gear shaft 220, while the plunger 292 is movable axially within the tubular shaft 262 and is resiliently urged towards the gear shaft 220 by a compression spring 300.

In operation of the manipulator 10, the manipulator 10 itself can be rotated in the flanged bush 140 about the longitudinal axis of the arm member 12, and the arm member 12 can be moved axially with respect to the ball joint 14 through a distance limited by the flanges 162 and 164 on the upper arm portion 30 (see Figure 3). The electric motor 88 may be controlled by the switches 100 on the handle 22 to rotate the bevel gears 90 and 92 and hence the lead screw 94 in either direction (see Figure 2) and consequently to cause the lower arm portion 32 to move slidably and telescopically in the tubular member 36 of the upper arm portion 30 (see Figure

3). The manipulator 10 can also be pivoted in the ball joint 14.

Rotation of the handle 22 about the gear shaft 46 causes the bevel gears 66*a*, 66*b*, 68*a*, 68*b* to turn with the handle 22, so rotating the small bevel gears 64*a*, and 64*b* in opposite senses (see Figure 5). Consequently the drive shafts 56*a*, 56*b* rotate in opposite directions, as do the tubular drive shafts 180*a*, 180*b* (see Figure 6), and the small bevel gears 250*a*, 250*b* (see Figure 7). Hence the bevel gears 252*a*, 252*b*, 254*a*, 254*b* turn with the tubular wrist member 232 of the wrist mechanism 26 about the gear shaft 220.

Rotation of the knob 80 in the handle 22 causes the bevel gears 66*a*, 68*a* and the bevel gears 66*a*, 68*b* to rotate in opposite directions on the gear shaft 46, so rotating the small bevel gears 64*a* and 64*b* in the same directions (see Figure 5). This causes rotation of the drive shafts 56*a*, 56*b*, and the tubular drive shafts 180*a*, 180*b* (see Figure 6), and hence of the small bevel gears 250*a*, 250*b* in the same directions (see Figure 7). Consequently the bevel gears 252*a*, 254*a* and 252*b*, 254*b* rotate in opposite directions on the gear shaft 220, so rotating the tubular shaft 262 of the wrist mechanism 26 in its bearing 264. Rotation of the knob 80 thus rotates the grip mechanism 28 (see Figure 1) about the longitudinal axis of the wrist mechanism 26. Since the drive shafts 56*a*, 56*b* are slidable in the hexagonal guides 178 in the tubular drive shafts 180*a*, 180*b*, telescopic movement of the lower arm portion 32 relative to the upper arm portion 30 does not affect operation of the drive shafts 56*a*, 56*b*, 180*a*, 180*b*.

Squeezing of the trigger 110 moves the pulley 116 away from the second pulley 120 (see Figure 2) and so pulls on the cable 126. This tension is transmitted around the pulleys 190 and 194 in the shielding block 176 and the end plug 172 (see Figure 3) to the pulley 200 (see Figure 4). This causes the tube 274 to move relative to the end cap 222, so pulling on the wrist cable 280 and so pulling the plunger 292 axially along the tubular shaft 262 and compressing the spring 300. This movement of the plunger 292 may be utilized to operate the grip mechanism 28 (see Figure 1) or another tool attached to the wrist mechanism 26. When the trigger 110 is released the spring 300 provides a tension in the wrist cable 280 as it urges the plunger 292 towards its original position. This tension is transmitted by the bracket 272 to the pulley 200 and so to the cable 126, returning the trigger 110 to its relaxed position as shown.

The pulleys 190 and 194 provide compensation for telescopic movement of the arm member 12, to maintain constant tension in the cable 126. For example, referring to Figure 3, if the lower arm portion 32 slides telescopically into the upper arm portion 30, the pulley 190 remains stationary as it is mounted on the shielding block 176 which is held at a fixed distance from the end cap 38 of the upper arm portion 30 by the tie rods 102. The pulley 194 is mounted on the end plug 172 of the lower arm portion 32 and so moves the same distance as the lower arm portion 32. Consequently the increase in the two lengths of the cable 126 between the pulley 194 and the shielding block 176 is exactly balanced by the decrease in the two lengths of the cable 126 between the shielding block 176 and the pulley 200 (see Figure 4), and so the tension in the cable 126 is unaffected.

It will be appreciated that the arm member 12 is sealed against contamination from within the container 18 by the O-ring seals 146 and 148 (see Figure 6) between the upper arm portion 30 and the ball joint 14, by the O-ring seal 158 between the upper arm portion 30 and the lower arm portion 32, and by the O-ring seals 226, 246, and 278 (see Figures 4 and 7) at the end of the arm member 12 adjacent to the wrist mechanism 26. The manipulator 10 is also shielded against the passage of radiation through the ball joint 14 by the shielding block 176 (see Figure 3) which is constrained to remain with the sphere 142 by the tie rods 102, and by the flanges 162 and 164 which limit axial movement of the upper arm portion 30 and consequently of the shielding block 176. If desired, the manipulator 10 may be removed from the ball joint 14 by removing the screws 144 (see Figure 6), the manipulator 10 and the bush 140 then being removable through the sphere 142. Sealing may be maintained by the use of a conventional gaiter (not shown) extending from the ball joint 14 to the tubular shaft 262 (see Figure 4) of the wrist mechanism 26.

Although the manipulator 10 has been described as being supported by a ball joint 14 in a wall 16 of a shielded container 18, it will be understood that the ball joint 14 may alternatively be mounted in a support frame (not shown) adjacent to a glove box (not shown), the manipulator 10 extending through a port in the wall of the glove box.

The grip mechanism 28 has been described as being operated by means of the cable 126 from the trigger 110, but alternatively it may be operated by means of a rotary telescopic drive shaft (not shown).

CLAIMS

1. A manipulator comprising, a telescopically extensible arm member to be mounted at an intermediate position along its length through a pivot in a wall, a wrist mechanism rotatably connected to one end of the arm member so as to be rotatable about the longitudinal axis of the wrist mechanism and rotatable about an axis at an angle to the longitudinal axis of the arm member, an operating handle rotatably connected to the other end of the arm member, and drive means to connect the handle to the wrist mechanism.

2. A manipulator as claimed in Claim 1 wherein the said angle is a right angle.

3. A manipulator as claimed in Claim 1 or Claim 2 wherein the drive means comprises at least one telescopic rotary drive shaft extending along the arm member.

4. A manipulator as claimed in any one of the preceding Claims wherein the arm member is slidably mounted in the pivot so that it can undergo limited longitudinal motion relative to the pivot.

5. A manipulator as claimed in any one of the preceding Claims wherein the telescopic action of the arm member is controlled by a motor-driven lead

screw.

6. A manipulator as claimed in any one of the preceding Claims further comprising a radiation shielding member within the arm member.

7. A manipulator as claimed in any one of the preceding Claims wherein the operating handle is rotatable, relative to the arm member, only about an axis at right angles to the longitudinal axis of the arm member, and the operating handle includes a rotatable member drivably connected to the wrist mechanism for causing the rotation of the wrist member about the longitudinal axis thereof.

8. A manipulator as claimed in any one of the preceding Claims further comprising a grip mechanism having two opposed jaws, and attached to the wrist mechanism.

9. A manipulator as claimed in any one of the preceding Claims further comprising a cable extending along the arm member for operating a grip mechanism attached to the wrist mechanism, and compensating means for ensuring the tension in the cable is unaffected by extension of the arm member.

10. An assembly comprising a manipulator as claimed in any one of the preceding Claims, and the pivot adapted for incorporation in the wall.

11. A manipulator substantially as hereinbefore described and with reference to Figures 1 to 7 of the accompanying drawings.

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