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(54) Apparatus for movably mounting a work head on a structure of circular cross-section.

(57) An apparatus for movably mounting a work head (11,12) on a structure of circular cross-section. The apparatus comprises an annulus defined by two or more members (1,2,3) which are engagable co-operably and movable between an open position which allows the annulus to be fitted onto the structure and a closed position in which the annulus surrounds the structure. The apparatus is located on the structure by locating means (6) comprising three or more support legs (6) mounted on the annulus at spaced circumferential locations. At least some of its legs (6) are movable in a radial direction relative to the annulus by actuating means to locate the annulus on the structure. Each supporting leg (6) is provided with drive means (8) which are controllable independently for moving the annulus along the structure in a plane normal to the axial centre line of the structure. The work head (11,12) is mounted on the annulus for circumferential movement with respect to the structure.

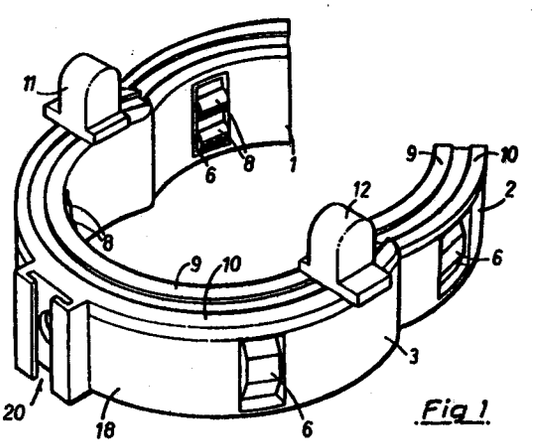

Fig 1

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Description

APPARATUS FOR MOVABLY MOUNTING A WORKHEAD ON A STRUCTURE OF CIRCULAR CROSS-SECTION

The present invention relates to apparatus for movably mounting a workhead on a structure of circular cross-section. Such apparatus are particularly useful for cleaning and descaling the exterior of cylindrical structures such as pipe lines and the jackets of off-shore oil rigs.

In our published European Patent Application No. 0 00080 8 there is described apparatus for cleaning and descaling the exterior of a cylindrical structure such as a pipe line. The apparatus comprises an annulus mounted on and surrounding the structure and means for driving the annulus along the structure in either direction. The annulus has mounted thereon an arm member which projects from the annulus parallel to the structure and which member carries a nozzle for producing high pressures which nozzle is reciprocable along the arm. The arm member is rotatable around the annulus. By the above described apparatus the exterior of the structure can be cleaned and descaled.

The arm member described above may have a reach of some six feet (2 meters) and to provide adequate support the annulus needs to be of considerable length. Furthermore, it is important that the nozzle is maintained at a predetermined stand-off distance from the cylindrical structure. The above described apparatus is particularly suitable for use on cylindrical structures which are straight. Indeed its construction with the projecting rotatable boom and reciprocating nozzle makes it unsuitable for use on cylindrical structures which incorporate bends. It is unsuitable because it cannot be manoeuvered along cylindrical structures incorporating bends, and even if it could the boom could not be rotated around the annulus to treat the concave sections of the structure.

The cylindrical structures such as pipe lines and the jackets of off-shore oil rigs frequently incorporate bends. The bends may be smooth arcuate curves or curves made up by one or more straight cylindrical sections welded together at angles. Indeed the pipe from the well head may utilise a double S-bend for expansion purposes.

Because the above described apparatus is relatively large it has to be fitted in position by divers, whilst being supported by a crane until it is located on the cylindrical structure. It would be advantageous if such apparatus could be located in position without the use of divers.

The present invention aims to provide an apparatus for movably mounting a workhead on a structure of circular cross-section be they straight or curved and an apparatus suitable for cleaning and descaling cylindrical structures be they straight or curved.

It is a further aim of the invention to provide apparatus which can be fitted in position without the use of a crane.

According to the present invention there is provided apparatus for movably mounting a work head on a structure of circular cross-section. comprising an annulus defined by two or more members which are engagable co-operably and movable between an open position which allows the annulus to be fitted onto the structure, and a closed position in which the annulus surrounds the structure, means for locating the annulus on the structure and for moving it axially along the length thereof, said means comprising three or more support legs mounted on the annulus at spaced circumferential locations with at least some of said legs being movable in a radial direction relative to the annulus by actuating means to locate the annulus on the structure, and each supporting leg being provided with drive means which are controllable independently for moving the annulus along the structure in a plane normal to the axial centre line of the structure, the work head being mounted on the annulus for circumferential movement with respect to the structure.

Preferably two work heads are provided which are mounted diametrically opposite one another on a circumferentially reciprocable mounting plate carried by the annulus. Preferably the annulus comprises a plurality of bouyancy chambers to increase the displacement of the apparatus in relation to its weight to give it a predetermined neutral bouyancy. More preferably, the annulus is defined by three arcuate members, with two of said members being pivotally secured to the third. Actuating means is provided for moving said two members pivotally with respect to the third to open and close the annulus to allow it to be fitted onto and removed from the structure of circular cross-section. Further actuating means is preferably provided to lock the free ends of the two members together in the closed position by means of an overthrow clamp or the like. The actuating means preferably comprise hydraulic rams. In one embodiment said third member is provided with a mounting lug to enable it to be held by a remotely operated vehicle (ROV).

Each support leg preferably comprises two axially spaced wheels or rollers which engage the exterior surface of the structure. One or both of the wheels or rollers may be driven. The circumference of the wheels or rollers are provided with a rubber or plastics coating which exhibits high frictional qualities to provide a good grip on the structure. Preferably, each support leg is movable radially by actuating means to centralise the annulus on said structure. The radial movement is preferably actuated hydraulically by means of an equal flow system which ensures that the annulus is positioned centrally. A mechanical locking mechanism may be provided to lock in support legs in the applied position so that the annulus remains in position in the event of failure of the hydraulic system. A spring mounting system may be employed to compensate for small variations in the diameter of the structure. The use of axially spaced wheels or rollers, approximately I foot (30 cm) apart ensures stability of the annulus on the structure. An endless band may be fitted onto the axially spaced wheels or rollers to give an improved grip in certain circumstances. The

number of support legs will be determined by the diameter of the structure. Typically four legs will be provided, but the larger sizes may have six or eight.

The third arcuate member of the annulus is preferably at least 180" of arc and its axial end is defined by the mounting plate which carries the two work heads. A drive mechanism is disposed within the third member and comprises an endless chain entrained around sprockets and carrying a pin which is co-operable with a slot in a carriage to which the mounting plate is secured. The carriage runs on rails within said third member and rotation of the chain causes the carriage to be reciprocated through an arc of some 180°. A second carriage is provided diametrically opposite the first and connected thereto by means of the mounting plate. The second carriage thus moves in synchronism with the first on rails formed in the other two arcuate members of the annulus. The two work heads are secured to a respective one of the carriages. The use of two work heads enables the full 360° of the structure to be operated on. The work heads are reciprocated through an arc of slightly more than 180° to ensure complete coverage.

The apparatus of the invention is particularly suitable for cleaning and descaling structures of circular cross-section. The work heads incorporate nozzles by means of which a high pressure water jet or other abrasive material can be trained onto the surface of the structure. The jet can be a pencil jet or a fan jet. Preferably, the nozzle is mounted for rotation in a housing so as to describe a circular path. By this means, movement of the two work heads circumferentially through 180° or slightly more treats the entire circumference of the structure and over an axial length corresponding to the diameter of circle described by the jet from the nozzle. The drive means of the annulus is then used to move the annulus along the structure so that a further section can be treated.

In an alternative embodiment, the work head includes a combined camera and lighting system which is mounted to be rotatable through 180°, and a twin jet nozzle disposed between the camera and the annulus and mounted so as to be tiltable through 90°. Thus, the camera is mounted for pan and tilt.

The apparatus is particularly suitable for treating curves in such structures since the axial length of the apparatus is small. That is to say the distance between the location point (the support legs) and the work heads is short. The stand-off distance can be maintained by a follower mounted on the work head and controlling the position of the nozzle. The follower typically comprises a spherical end which contacts the surface of the cylindrical structure and which is coupled to the nozzle to determine its position from the structure. The arrangement is resiliently biased into contact with the structure. The facility of being able to drive each of the wheels independently enables the attitude of the annulus to be maintained as it moves along a curved section of the structure. That is to say the wheels on the outside of the curve have to travel further than those on the inside. Control of the apparatus is performed remotely by way of an umbilical cord. A camera is employed to monitor the position of the apparatus so that the operator can move the appropriate controls to maintain the desired attitude of the apparatus, ie. with the annulus in a plane normal to the axis of the structure.

By incorporating bouyancy chambers in the apparatus, conveniently as part of the annulus, the apparatus can have neutral bouyancy. This makes it easy to manoeuver into position by a remotely operated vehicle. By using a camera for monitoring purposes, and remote control of the actuating means for opening and closing the arcuate members of the annulus, an ROV can be used to position the apparatus on and surrounding the cylindrical structure. The locking mechanism and the actuation of the support legs are likewise operable remotely to position the apparatus on the structure before the ROV releases it. The ability to use an ROV for manoeuvering the apparatus into position avoids the need to use divers. This is particularly advantageous when the apparatus is required to work at considerable depths where saturation diving would be involved.

It is further proposed to add thrusters to the apparatus to convert it into a self-propelled remotely operated vehicle. Preferably, three thrusters are incorporated in the annulus, one in each of the arcuate members.

The apparatus according.to the invention may carry work heads having a variety of different functions, for example:- water jet nozzles; shot blast nozzles; abrasive blast; paint applicators (brush or spray); non-destructive testing equipment; abrasive; steel cutting heads; remotely controlled articulated robot arm.

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

Fig. I is a simplified perspective view illustrating one embodiment of apparatus according to the present invention;

Fig. 2 is a simplified elevational view showing the apparatus mounted on a structure of circular cross-section;

Fig. 3 is an end view looking in the direction of arrow A in Fig. 2;

Fig. 4 is an end view looking in the direction of arrow B in Fig. 2; and

Fig. 5 is an end view corresponding to that of Fig. 4 but illustrating the annulus in its open position, and

Fig. 6 is a simplified perspective view according to an alternative embodiment of the invention.

Referring to the drawings there is shown apparatus for mounting on a structure of circular cross-section such as off-shore pipelines and the like. The apparatus comprises an annulus which is made up of three arcuate members in the illustrated embodiment. Two of the arcuate members I,2 are pivotally attached to the third 3 for example by respective pivot pins 4,5 seen in Figs. 3, 4 and 5

The third arcuate member 3 extends over an arc slightly in excess of 180°, whilst the first and second arcuate members I,2 have an arc of slightly less than

90° each. The first and second arcuate members are pivotable between open and closed positions by any suitable actuator means, but conveniently the actuator means comprises a respective hydraulic ram. One ram is coupled between the first member I and the third member 3, and the other ram is secured between the second member 2 and the third member 3. The free ends of the first and second arcuate members I,2 lie adjacent one another when in the closed position and preferably abut with each other so that the three members define a continuous annulus. Figs. 3 and 4 show the annulus in the closed position, whilst Figs. I and 5 show the annulus in the open position. A locking member, not illustrated, is provided to lock the ends of the first and second members together when in the closed position. This preferably comprises an over-throw clamp which is actuated by a further hydraulic ram.

The arcuate members of the annulus carry support legs 6 which serve to locate the annulus on a pipe and to move it along the pipe. The legs are also mounted for radial movement with respect to the annulus and are illustrated in their withdrawn position in Fig I. Figs. 3, 4 and 5 show them in extended positions. In the illustration, each of the first and second arcuate members carries a respective support leg 6, whilst the third member 3 carries two support legs 6. Thus, in the illustration, four support legs are provided, spaced circumferentially at 90° to one another. An equal flow hydraulic system is conveniently utilised to move the support legs radially. The purpose of the support legs is two fold:- Firstly to locate the annulus centrally on the structure, and secondly to propel the annulus in either direction along the structure. To achieve these objectives, the ends of each leg carries two spaced apart rollers 8 which contact the exterior surface of the structure. The rollers are spaced apart in the axial direction of the structure so as to impart stability to the annulus and prevent twisting thereof on the structure. One or both of the rollers of each leg are rotatably driven, conveniently by a hydraulic motor. The rollers of each leg are driven independently so that the movement at each leg can be controlled independently. This is necessary to manoeuver the apparatus along curved structures, where the rollers at the larger radius have to travel further than those at the smaller inner radius if the annulus is to be maintained in the desired attitude in a plane normal to the axis of the structure. The rollers are preferably provided with a plastics or rubber tread to aid their grip on the structure.

An endless band may be placed around the rollers where it is felt this would give an improved grip. Each roller may be replaced by one or more wheels.

The above described construction enables the apparatus to be moved along the structure in either direction. The purpose of attaching such an apparatus to a structure of this nature is to be able to perform operations of numerous types on the structure. One type of operation which has to be tackled is that of cleaning and descaling the structure. This is one type of operation for which the apparatus is particularly suited. To perform such operations a work head - typically a nozzle for directing water at high pressure at the structure - has to be capable of being moved around the structure.

In the illustrated embodiment this is achieved by forming a circular track on the annulus and having two work heads disposed diametrically opposite one another which work heads are each reciprocable through an arc of some 180°. By this means the complete circumference of the structure can be operated on. More particularly, the arcuate members I, 2 and 3 incorporate concentric rails, shown diagramatically as 9 and I0 in the drawings. The third arcuate member 3 incorporates a drive mechanism which comprises an endless chain entrained around two sprockets. This is preferably accommodated within the annulus at one axial end thereof. The sprockets are disposed diametrically opposite one another and the chain is constrained to follow an arcuate path by the inner and outer radial walls of the third arcuate member. The chain carries a pin member which engages in a slot in one of two carriages. The said one carriage is constrained axially by the rails 9,I0 and circumferentially by the inner and outer walls of the arcuate member 3. Rotation of the chain causes the pin to move and its co-operation with the carriage causes the carriage to reciprocate through an arcuate path as defined by the path of the chain. As the pin passes round the sprockets, the pin moves across the slot in the carriage. This changes the speed of the carriage at the end points where the change of direction occurs.

A mounting plate is secured to the driven carriage and a second carriage is secured to the mounting plate diametrically opposite the first. The mounting plate is arcuate. By means of the mounting plate the second carriage is caused to follow the reciprocal movements of the first carriage. The second carriage runs on a track formed by the first and second arcuate members. A respective work head is mounted on each of the carriages.

Each carriage preferably comprises a plate member having four wheels or rollers journalled for rotation thereon. The wheels or rollers run on the circular track and take the axial thrust load generated by the work heads.

The described construction gives rise to a short axial length between the support legs 6 and the work heads. This enables the apparatus to move round bends in the structure whilst allowing operations, such as cleaning and descaling to be performed on the bends. The work heads may carry nozzles for high pressure water cleaning; shot blast; abrasive blast or paint applicators by brush or spray. It is further envisaged that the work heads may be provided with abrasive steel cutting heads or probes for use in non-destructive testing.

There will now be described details of apparatus for use in cleaning and descaling for which the apparatus of the invention is particularly suited. In such apparatus, each work head has a nozzle for directing a high pressure water jet with or without any additional abrasive material on to the external surface of the structure. The nozzle has to be positioned at a predetermined distance from the exterior surface of the structure. A positioning

device is provided for this purpose which conveniently comprises a spherical member 15 secured to the mounting for the nozzle and biased into contact with the exterior surface. The positioning device is movable in the radial direction to accommodate variations in the distance between the exterior of the structure and the annulus as the work head is moved circumferentially. By this simple means, the nozzle is maintained at a predetermined stand-off distance from the exterior surface of the structure. The nozzle can produce a pencil jet or a fan jet. A pencil jet is preferred for high pressure water cleaning, but to increase the area covered during the circumferential movement, the nozzle is arranged to be rotatable so as to describe a circular path. This means that an axial band on the structure is operated on during circumferential movement of the work head. This is advantageous because not only does it speed up the operation, but it also means that the movement of the apparatus in the axial direction by way of the drive means in the support legs is less critical. It will be appreciated that this "band cleaning" simplifies the procedure when bends are involved because overlap between bands ensures that all sections of the bend can be thoroughly cleaned.

A further feature of the invention which has not yet been described is the provision of bouyancy chambers within the annulus. The members of the annulus are provided with sealed chambers 18 between the support legs which effectively increase the displacement of the apparatus disproportionately in relation to the weight so that the apparatus is given a predetermined bouyancy or even a variable bouyancy. This enables the apparatus to be manoeuvered more easily under water by remotely operated vehicles ROV's. These vehicles cannot handle heavy objects and so if the bouyancy can be set at a fixed level for a particular depth of operation the apparatus can be manoeuvered into position using such vehicles and thus avoid the use of divers.

For handling purposes the annulus is illustrated as having a T-shaped mounting slot 20 for engagement by a correspondingly shaped member of an ROV. The hole 21 serves to receive a hydraulically actuated locking pin. The shape of the mounting member may be varied to suit other designs or may simply comprise a conveniently shaped projecting lug which can be grabbed by the jaws of an articulated arm. As a further development, it is proposed that the apparatus be provided with its own thrusters, so that it can be self-propelled.

In positioning the apparatus onto the structure it will be understood that cameras will be utilised to monitor the operation. These may be mounted directly on the apparatus itself or be those of the ROV. The apparatus is controlled remotely and for this purpose an umbilical cord connects with the apparatus from the remote control station, be it a surface vessel or the oil rig - depending on the nature of the structure involved. The umbilical cord has the necessary hydraulic and electrical lines to provide the required control signals and power supply to the various motors.

The apparatus is manoeuvered up to the structure in a direction substantially normal to the axis thereof, with the first and second arcuate members in the open position as illustrated in fig. I. The support legs 6 are preferably fully withdrawn at this stage. Thus, the apparatus is manoeuvered so that the structure is positioned within the third arcuate member 3. The hydraulic rams controlling the first and second members 1,2 are then remotely operated to move these members into their closed position, whereupon the hydraulic ram controlling the overthrow lock is actuated so that the ends of the members I and 2 are held closed. Hydraulic fluid is then admitted to the rams controlling the position of the support legs 6 and this causes them to move radially inwardly. An equal flow system is employed to ensure that each of the legs moves the same distance so that the annulus is centralised on the structure. The rollers thus contact the structure to locate the annulus. The drive means to the rollers incorporates a brake mechanism which prevents rotation of the rollers when the drive motor is not operating. Thus, the loading of the legs against the structure ensures that the annulus remains in position. A mechanical locking mechanism is conveniently employed to locate the support legs in the extended position so that the annulus remains located in the event of hydraulic failure. The legs may be resiliently mounted so that small variations in the surface configuration do not result in a loss of grip by the support legs. Once the legs have been extended the ROV can be disconnected from the mounting point.

By operating the drive motors of the support legs 6 the annulus can be caused to move in either direction along the structure. By controlling the drive motors of each leg individually the annulus can be manoeuvered round bends in the structure.

In order to perform the described cleaning and descaling operation water under high pressure is fed into the nozzle at each of the two work heads, the nozzles are rotated to describe the circular path, and the work heads are reciprocated circumferentially through the arc determined by the path of the endless chain. In practice the arc covered by each nozzle is just in excess of 180° to ensure that the two nozzles together cover the full 360° of the structure. Thus, an axial band is cleaned by the described method. The apparatus is then moved axially along the structure and the reciprocal movement of the work heads repeated. Thus, the apparatus works its way along the structure, and around any bends which it encounters. It will be noted that the axial length of the appratus is short so that it can be easily manoeuvered round bends.

The embodiment of apparatus for cleaning and descaling has the advantage that it is of short axial length which enables it to be moved along structures which are curved to perform cleaning and descaling on such structures. The independent control of the support leg drive means enables the apparatus to be manoeuvered along the structure and round curves. The use of bouyancy chambers enables the apparatus to be easily manoeuvered into position by means of an ROV.

An apparatus of the above described type can also be used for performing other operations on

such structures simply be attaching the appropriate type of work head. It is also envisaged that the annulus could be provided with an articulated work arm. Such an articulated work arm could carry a non-destructive testing probe or a camera for checking welded joints on such structures. The articulated arm being remotely operated. The articulated arm could be attached to the circumferentially movable work head or secured to another part of the annulus. The annulus preferably has secured thereto a camera for monitoring movement of the annulus and operations being performed by the work heads.

Referring now to Fig. 6 there is shown another embodiment of the invention which is of the same basic construction of the apparatus described with reference to Fig. I. However, it differs in the construction and mounting of the work heads and in the provision of built-in thrusters. These features will be described further hereinafter. It will be understood that the earlier described embodiments could be provided with the thruster system or jet and/or camera system described hereafter.

The same reference numberals as used in the description of Fig. I have been used in Fig. 6 and the description of Fig. I applies to the construction of Fig. 6 in these respects.

The work heads II and I2 each comprise two jet nozzles I00,I02 which are mounted on a member I04 which is movable through approximately 90° with respect to a mounting member I06. The mounting member I06 is secured to the drive means for moving the work head on the I80° arcuate path. The member I04 is movable in a plane which is perpendicular to the plane of movement of the mounting member I06.

A combined camera I08 and light II0 is mounted in a housing II2 on the member I04. The housing II2 is mounted for movement through approximately I80° with respect to the member I04 and in a plane parallel to a plane passing though the two jet nozzles I00,I02. The fact that the member I04 is tiltable means that the camera and light are likewise tiltable. The possible movements of the camera enables the operator to view the job being cleaned (for example) and to make an appraisal of the position of the apparatus when approaching the tubular structure.

The apparatus also includes three thrusters, each of which is mounted in the annulus. A main thruster I20 is mounted in the third arcuate part 3 and comprises a rotor disposed within a tubular sleeve I22 and driven by a motor. The motor may be driven in either direction so that thrust is generated in either the direction of the arrow A or the direction of the arrow B. The sleeve passes through the annulus. Two positional thrusters I24,I26 are also provided one in each of the first and seocnd arcuate parts I and 2. These are likewise received in a tubular sleeve which passes through the member and the rotors are driven by reversible motors.

The thrusters I20.I24,I26 are employed to manoeuver the appartus into position about a tubular structure. The neutral bouyancy enables this to be done with only low powered thruster and being self-propelled. a diver is not reqired. Accordingly, the device can be easily manoeuvered into position. The first and second members will usually be in the position illustrated in Fig. 6 when manoeuvering is taking place.

Claims

I. An apparatus for movably mounting a work head (II,I2) on a structure of circular cross-section, comprising an annulus defined by two or more members (I,2,3) which are engagable co-operably and movable between an open position which allows the annulus to be fitted onto the structure, and a closed position in which the annulus surrounds the structure, means (6) for locating the annulus on the structure and for moving it axially along the length thereof, said means (6) comprising three or more support legs (6) mounted on the annulus at spaced circumferential locations with at least some of said legs (6) being movable in a radial direction relative to the annulus by actuating means to locate the annulus on the structure, characterised in that each supporting leg (6) is provided with drive means (8) which are controllable independently for moving the annulus along the structure in a plane normal to the axial centre line of the structure, the work head (II,I2) being mounted on the annulus for circumferential movement with respect to the structure.

2. Apparatus according to claim I, characterised in that the annulus is defined by three arcuate members (I,2,3) with two of said members (I,2) being pivotally secured to the third (3).

3. Apparatus according to claim I, characterised in that actuating means is provided for moving said two members (I,2) pivotally with respect to the third (3) to open and close the annulus to allow it to be fitted onto and removed from the structure of circular cross-section.

4. Apparatus according to claim 2 or 3, characterised in that actuating means is provided to lock the free ends of the two members (I,2) together in the closed position by means of an overthrow clamp or the like.

5. Apparatus according to claim 4 and 5, characterised in that said actuating means and the lock actuating means each comprise hydraulic rams

6. Apparatus according to any preceding claim, characterised in that each support leg (6) comprises two axially spaced wheels or rollers (8) which engage the exterior surface of the structure and one or both of the wheels or rollers (8) may be driven.

7. Apparatus according to any preceding claim, characterised in that each support leg (6) is movable radially by actuating means to centralise the annulus on said structure and the radial movement is actuated hydraulically by means of an equal flow system which ensures that the annulus is positioned centrally.

8. Apparatus according to claim 7, character-

ised in that a mechanical locking mechanism is provided to lock the support legs (6) in position on said structure.

9. Apparatus according to claim 6, 7 or 8, characterised in the a spring mounting system is employed on each support leg (6) to compensate for small variations in the diameter of the structure.

10. Apparatus according to any preceding claim, characterised in that two work heads are provided which are mounted diametrically opposite one another on a circumferentially reciprocable mounting plate carried by the annulus.

11. Apparatus according to claim 10, characterised in that the third arcuate member (3) of the annulus is at least 180° of arc and its axial end is defined by the mounting plate which carries the two work heads (11,12).

12. Apparatus according to claim 11, characterised in that a drive mechanism is disposed within the third member (3) and comprises an endless chain entrained around sprockets and carrying a pin which is co-operable with a slot in a carriage on which is mounted one of the two work heads (11,12) and to which the mounting plate is secured.

13. Apparatus according to claim 12, characterised in that the carriage runs on rails (9,10) within said third member (3) and rotation of the chain causes the carriage to be reciprocated through an arc of some 180°.

14. Apparatus according to claim 13, characterised in that a second carriage on which is mounted the other work head (11,12) is provided diametrically opposite the first and is connected thereto by means of the mounting plate such that the second carriage thus moves in synchronism with the first on rails (9,10) formed in the other two arcuate members (1,2) of the annulus.

15. Apparatus according to any preceding claim, charactetised in that the work heads (11,12) incorporate nozzles by means of which a high pressure water jet or other abrasive material can be trained onto the surface of the structure.

16. Apparatus according to claim 15, characterised in that each nozzle (11,12) is mounted for rotation in a housing so as to describe a circular path.

17. Apparatus according to any preceding claim, characterised in that each work head (11,12) comprises a combined camera and lighting system which is mounted so as to be able to view the work done and the work ahead of the apparatus.

18. Apparatus according to any preceding claim, characterised in that the annulus comprises a plurality of bouyancy chambers (18) to increase the displacement of the apparatus in relation to its weight to give it a predetermined neutral bouyancy.

19. Apparatus according to any preceding claim, characterised in that thrusters (120,124,126) are connected to the apparatus to allow it to operate as a self-propelled remotely operated vehicle.

20. Apparatus according to claim 19, characterised in that the thrusters (120,124,126) are incorporated in the annulus, one in each of the members (1,2,3).

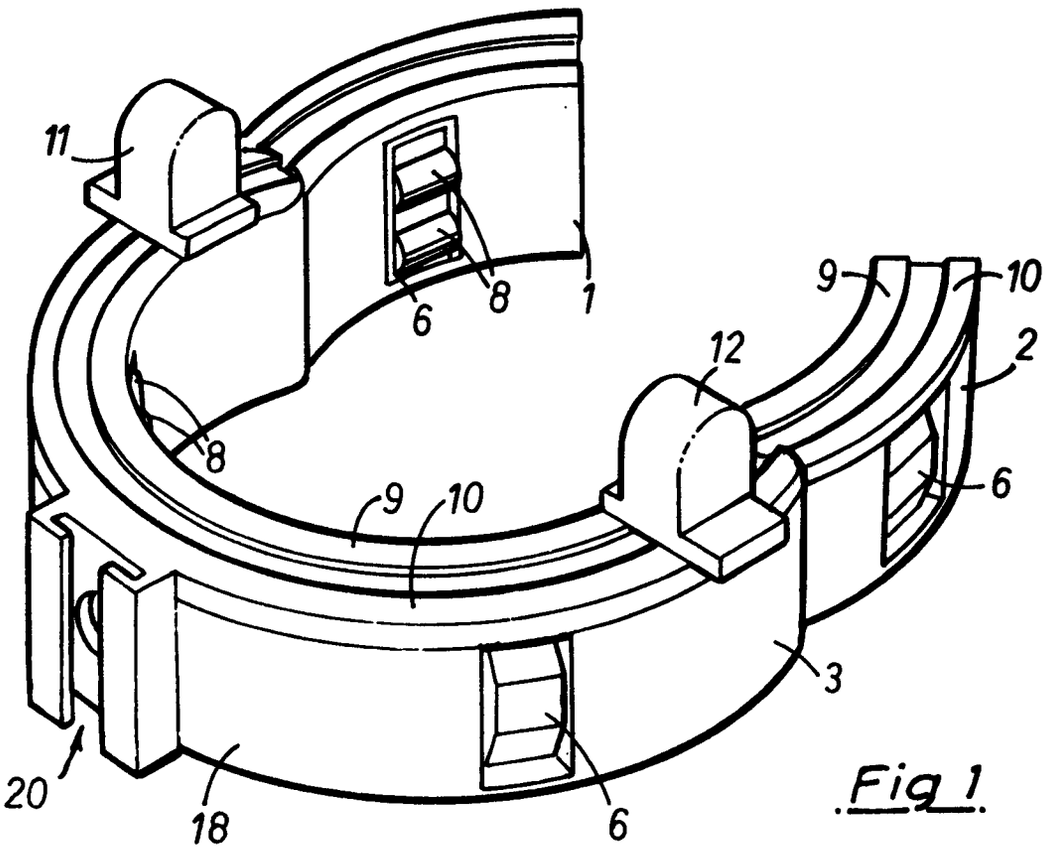

Fig 1

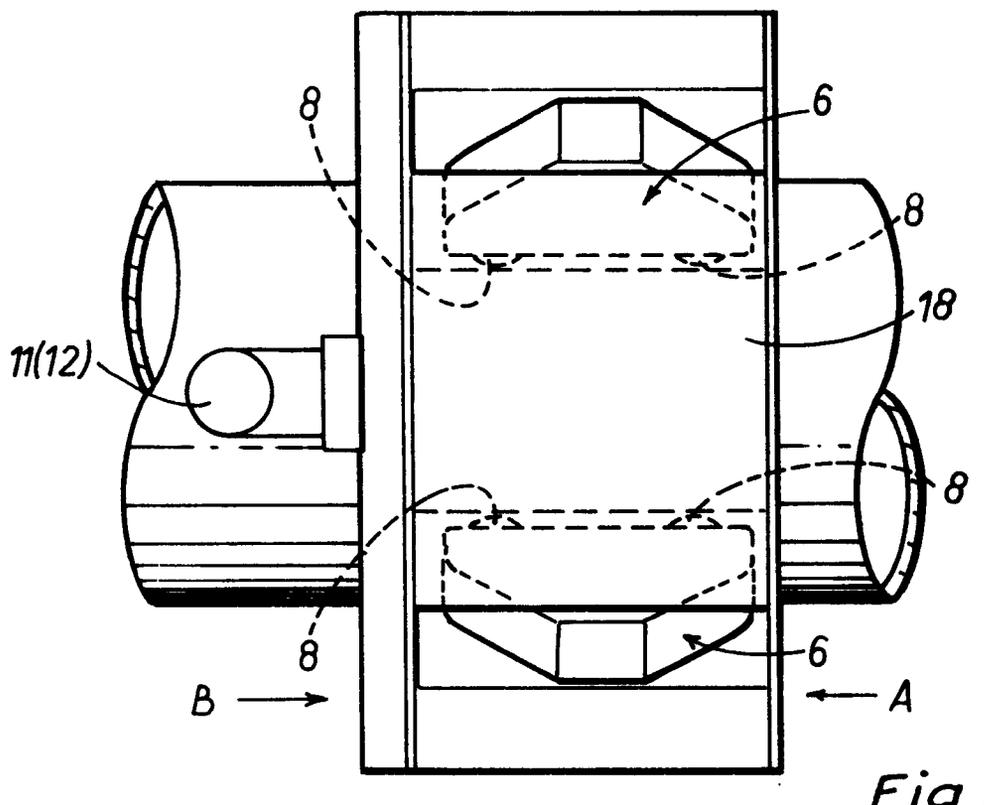

Fig 2

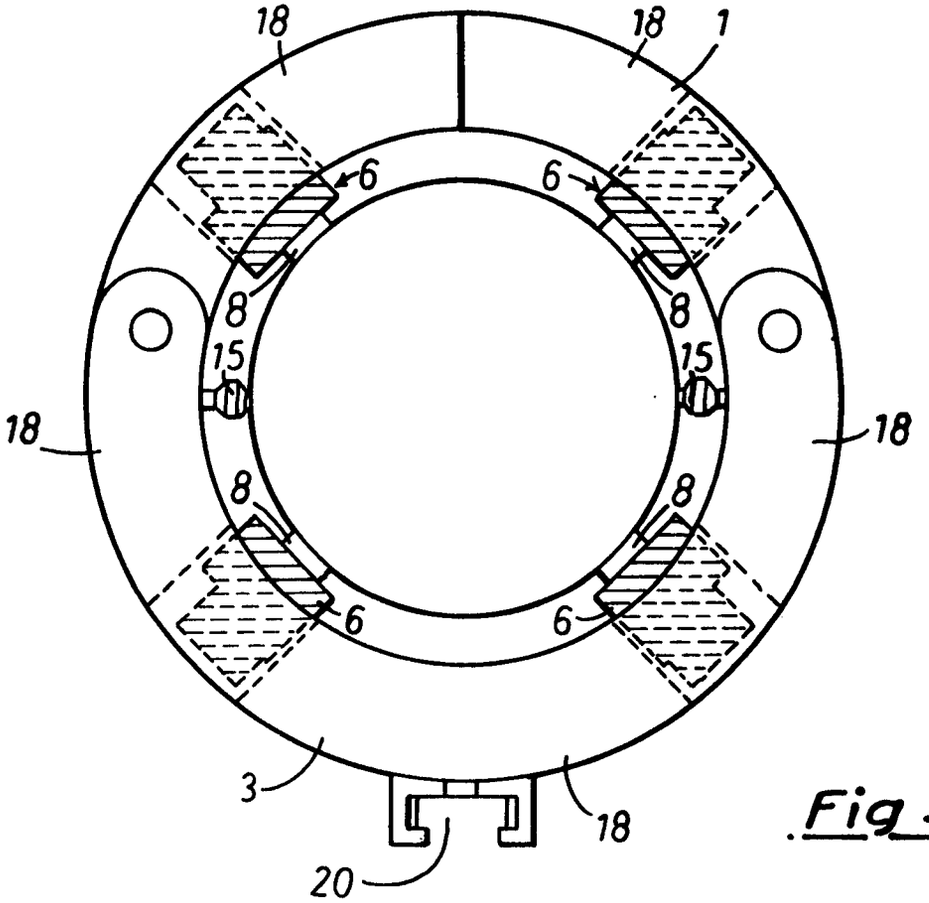
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Fig 3

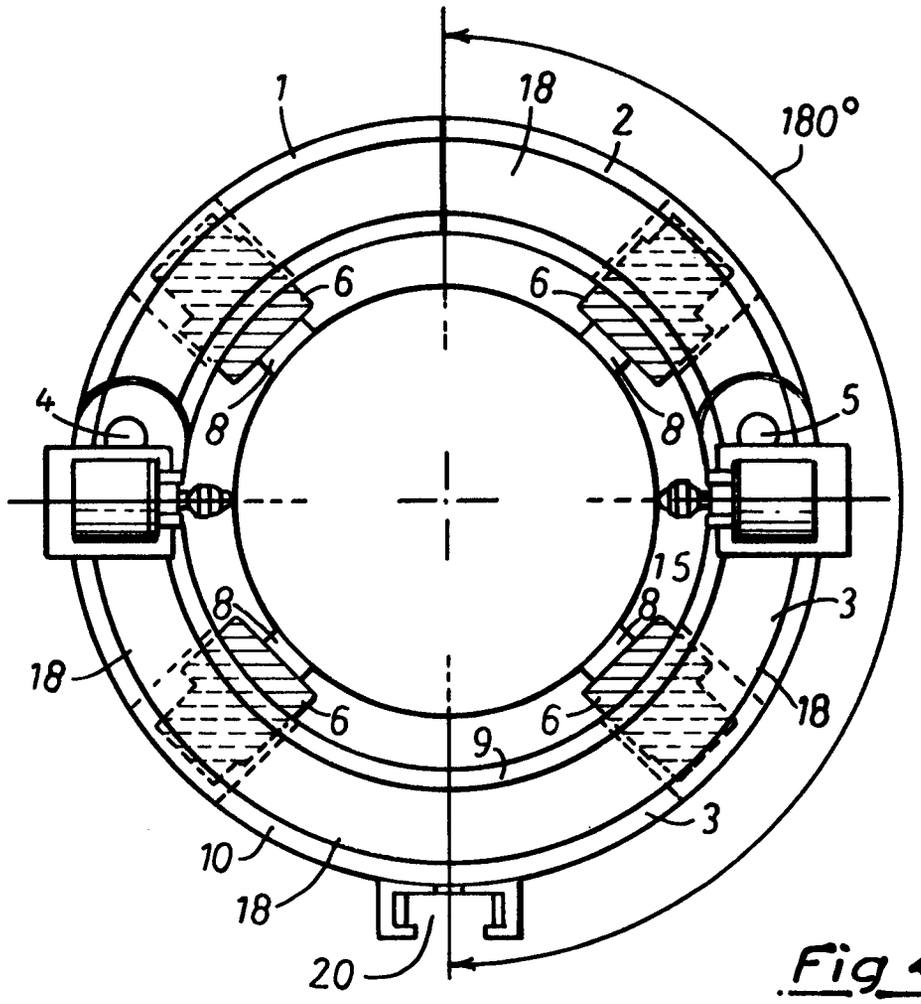
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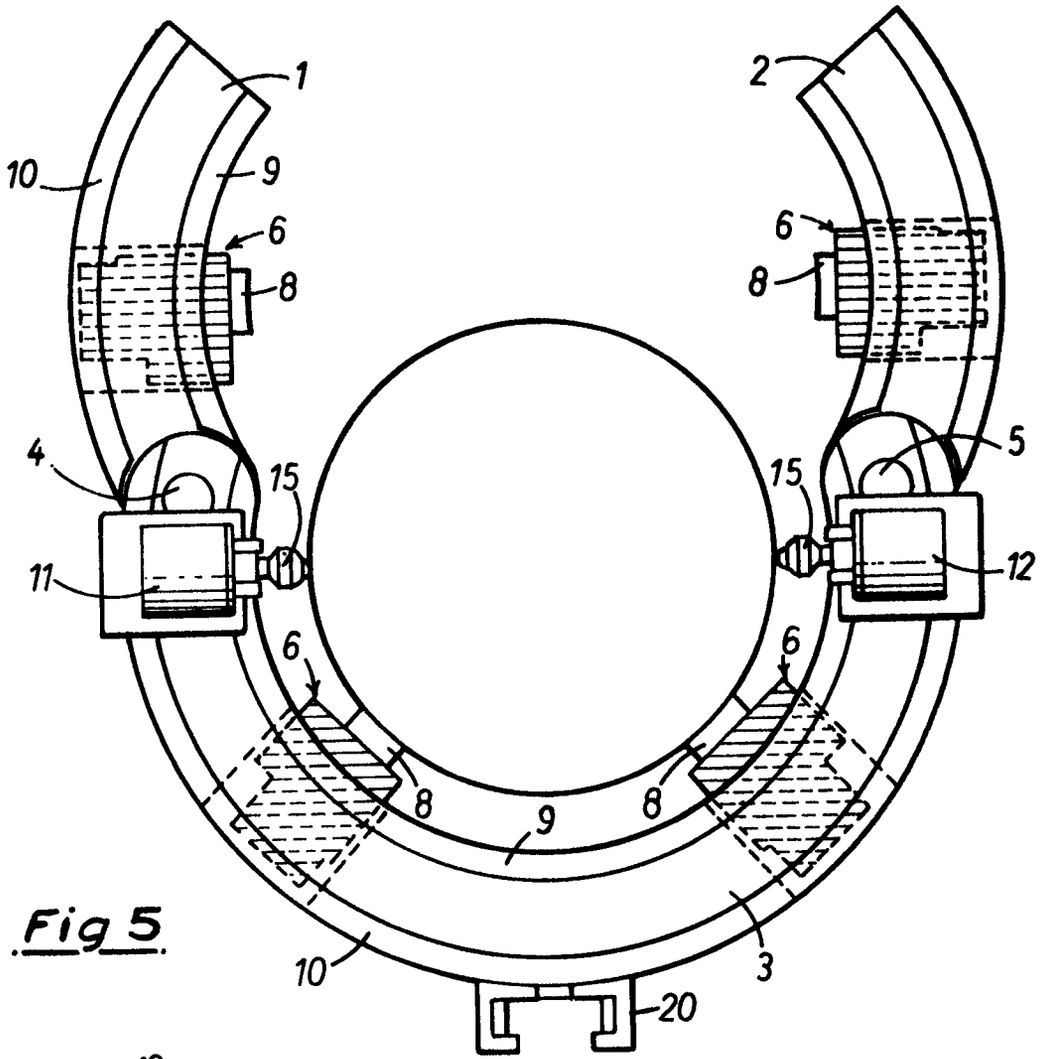
Fig 4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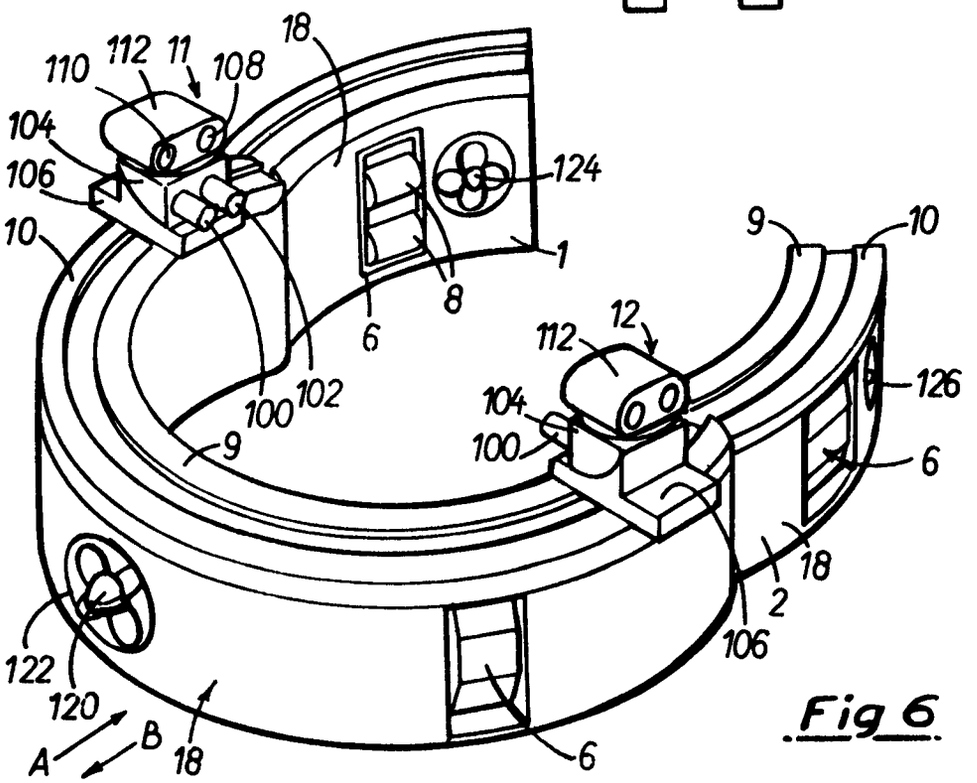
9
6
8
4
15
5
11
12
3
20

Fig 5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11
108
104
106
124
10
1
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6
9
10
12
112
126
100
102
104
100
9
6
18
2
106
122
120
A
B
18
6

Fig 6