

1,368,786.

Patented Feb. 15, 1921.

2 SHEETS—SHEET 1.

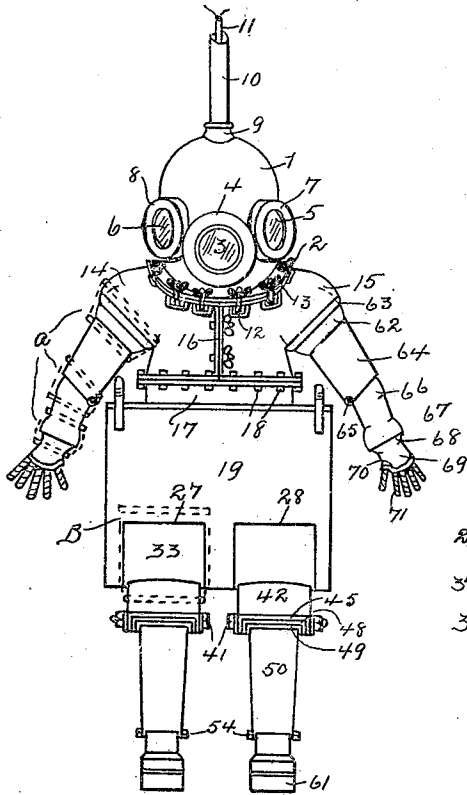


Fig 1

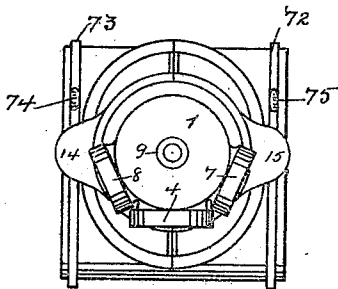


Fig 2

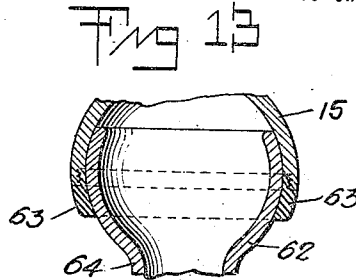


Fig 13

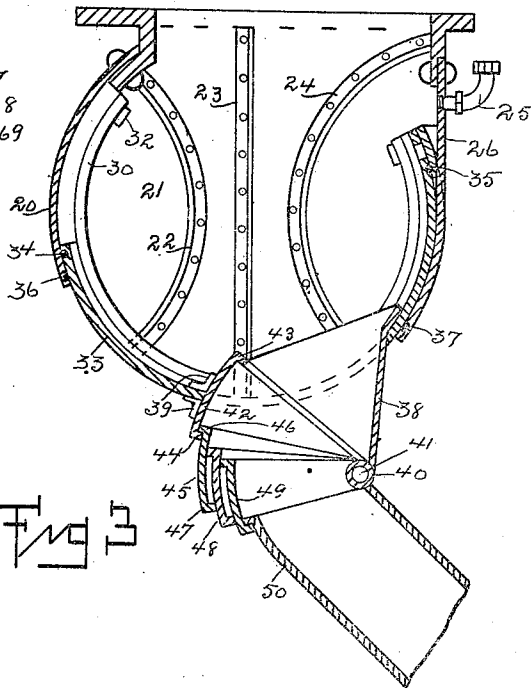


Fig 3

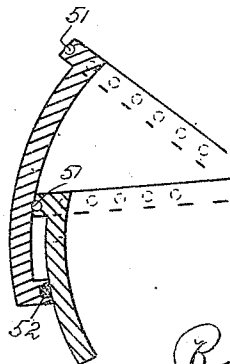


Fig 4

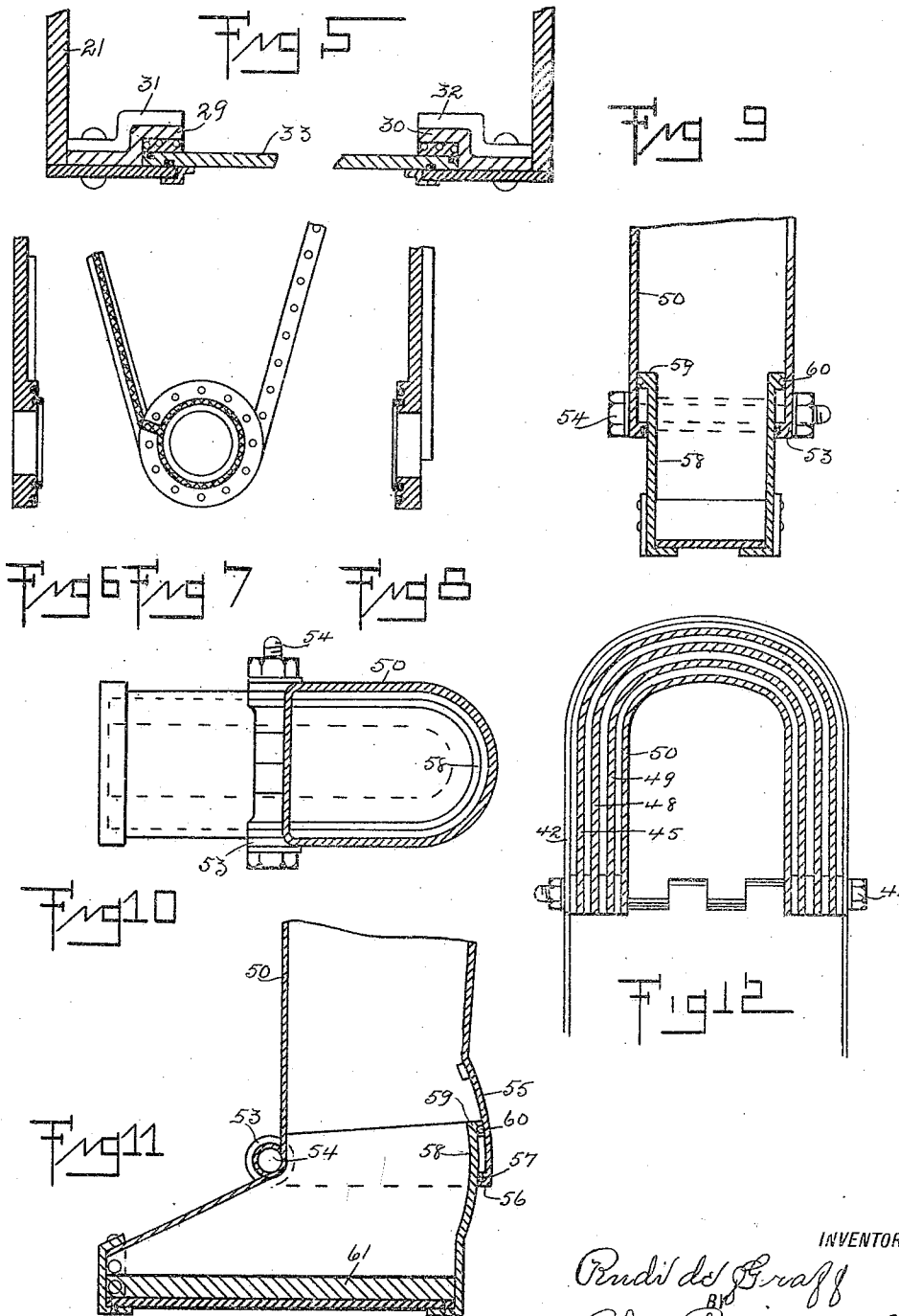
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DIVING SUIT.  
APPLICATION FILED JAN. 12, 1918.

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2 SHEETS—SHEET 2.



INVENTOR

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ATTORNEY

# UNITED STATES PATENT OFFICE.

RUDI DE GRAFF, OF NEW YORK, N. Y., ASSIGNOR TO ATALANTA ENGINEERING CORPORATION, A CORPORATION OF DELAWARE.

## DIVING-SUIT.

1,368,786.

Specification of Letters Patent. Patented Feb. 15, 1921.

Application filed January 12, 1918. Serial No. 211,482.

*To all whom it may concern:*

Be it known that I, RUDI DE GRAFF, a citizen of the Republic of Russia, and resident of the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Diving-Suits, of which the following is a specification.

The invention relates to diving suits designed for service at great depths, one hundred feet or more, and the object of the invention is to provide a metallic suit or armor capable of withstanding successfully the great pressure due to deep submersion, and also permit free movements of the body and limbs of the diver.

Another object is to provide means for supplying air at atmospheric pressure to the interior of the suit, and for removing the vitiated air therefrom through non-collapsible separate conduits.

Another important object is to provide means for insuring the flexible joints of the suit independently against the entrance of water while permitting such joints to move freely.

A further object is to provide a form of universal joint for certain articulations of the suit, to permit movement in all directions while held water-tight by the pressure of the water.

A further object is to provide a form of joint having folding leaves for certain other articulations, constructed to allow free movements of the limbs without cramping.

The invention consists in certain novel features and details of construction by which the above objects are attained, to be hereinafter described and claimed.

The accompanying drawings form a part of this specification and show an approved form of the invention.

Figure 1 is a front view of the improved suit.

Fig. 2 is a corresponding plan view, from above.

Fig. 3 is a vertical section through the lower body portion of the suit and the upper leg portion at the knee-joint, on a larger scale.

Fig. 4 is a similar section showing details of the knee-joint on a still larger scale.

Fig. 5 is a horizontal section through the

lower body portion and a movable plate carrying the upper leg portion.

Fig. 6 is a section through one side of one of the movable members of the knee-joint.

Fig. 7 is a corresponding elevation of the inner face of such member.

Fig. 8 is a section similar to Fig. 6, through the other side member.

Fig. 9 is a vertical section through the lower portion of one leg and the rear portion of its attached foot, transversely of the latter and partly in elevation.

Fig. 10 is a horizontal section through the lower portion of one leg, showing the foot in plan.

Fig. 11 is a vertical section through the lower leg portion and foot, taken longitudinally of such foot.

Fig. 12 is a longitudinal section through the knee-joint shown in Fig. 3.

Fig. 13 is a section through the spherical universal joint shown as employed for the shoulder and wrist joints.

Similar reference numerals indicate the same parts in all the figures.

The helmet is of cast metal of a thickness sufficient to resist the pressures to which it may be subjected. Its upper portion is domed as at 1 to receive the head of the diver, and at the front is provided with a large flanged opening receiving a lens held to the flange by a screw threaded ring or follower 4. On both sides of this central window 3 are smaller ports having lenses 5 and 6 and holding rings 7 and 8. Either window may be opened by unscrewing its ring and removing its lens.

At the top of the helmet is a boss 9 into which the pipe 10 is screwed, connected to a non-collapsible hose, not shown, extending above the surface of the water, and also contains the insulated telephone and electric light wires 11 leading from the wrecking vessel on the surface to suitable connections, not shown, controlled by the diver.

The lower portion of the helmet is flanged outwardly and matches to a corresponding seat on the upper-body or chest portion and is held thereto by a series of swinging bolts 12 engaged in notches in the flange and secured by wing-nuts 13.

The chest portion comprises two side sec-

tions 14 and 15, each the counterpart of the other and having vertical flanges 16 matching to each other and secured together at the front and rear by bolts and wing-nuts.

5 On the lower ends of the chest pieces 14 and 15 are radial semi-circular flanges forming together a continuous flange fastened by bolts 18 to a corresponding flange on an upward extension 17 of the lower body portion 19.

10 Each body piece 14 and 15 has an overhung shoulder presenting its lower face angularly and in each such face is a spherical socket for a hollow hemispherical head 62 forming the upper extremity of the upper arm 64. The head 62 is ground into the shoulder socket to a close water-tight fit and when in place is held against retraction by a ring 63 screwed into an annular recess in the shoulder, as shown in Fig. 13. The ring is fitted to the head and extends sufficiently beyond the center line of the head to relievably hold the latter. The joint thus formed permits the upper-arm member 64 to be moved in any direction to the required extent.

The lower end of each upper arm 64 is of U-shape in cross-section and carries lugs 65 in which is a transverse pin serving as a pivot for the lower or forearm 66 also of U-section. The part 64 has an internal flange surrounding the opening and the part 66 has an external flange, the former is provided with a packing strip adapted to contact with the adjacent surface of the other part and make a tight joint, in a manner similar to that found in the knee-joint, see Fig. 4, and the flange of the part 66 is provided with a groove or channel containing a series of anti-friction balls adapted to facilitate the relative movements of these upper and lower arm portions at the elbow.

The lower end of each lower or forearm portion has a spherical socket 67 receiving a hollow ball 68, forming the wrist-joint and similar in structure to the shoulder joint above described. The ball or head 68 is part of the hollow hand 69 which latter has movable finger portions 71 formed of flexible interlocking steel or armored tubing of any suitable type, allowing the closing movement of the fingers required in grasping the handle of a tool or the like.

The lower body portion consists of a substantially cylindrical drum 19 horizontally disposed with its axis lying transversely; its upper face carries the vertical extension 17 having a radial flange to which are secured the flanges of the upper-body pieces 14 and 15, by bolts 18, as above described.

The ends of the drum are closed by plates 21 reinforced on their inner faces by angle-iron braces 22, 23 and 24, see Fig. 3, to resist external pressure or crushing strains. The lower part of the drum 19 is provided

with two circumferential openings or wide slots 27 and 28 having at their sides correspondingly curved guides 29 and 30 held by clamps 31 and 32 and forming curved grooves or channels in which the side margins of a curved plate 33 are received, as in Fig. 5. The curves of the guide-grooves and plates are concentric to the axis of the drum, and the guides extend beyond the ends of the slots 27, 28 so that the plates 33 may move relatively to the drum to the required extent without uncovering the slots. The guides are provided with strips of packing on their inner faces to prevent leakage inwardly to the drum, and the plates are provided with grooves which may contain packing or a series of anti-friction balls, not shown, to facilitate the sliding movement, and grooves on their outer edges adapted to contain strips of packing. These parts are also shown as having transversely extending packing strips in the drum at 36 and 37, and balls 34 and 35 in transverse grooves in the plates 33. The latter permit the forward and backward swing of the thighs or upper portions of the legs of the diver, and each is provided with an aperture in which the hollow upper leg member 38 is rigidly secured.

The lower end of the member 38 is U-shaped in horizontal section and at the rear, behind the knee, are lugs 40 inclosing a transverse pin 41 to which is hinged the lower leg member 50 and a series of U-shaped segments or leaves 42, 45, 48 and 49, forming the knee joint. The first or upper segment 42 may be a stationary portion of the upper leg 38. It has its upper and lower edges inturned or provided with the lips 43 and 44, the former serving as a stop to limit the upward movement of the next segment 45 which has an external lip 46 adapted to strike the lower lip 44 on the fixed segment 42. The succeeding segments are provided with similar lips and the lower leg member 50 has an external lip so that all may fold telescopically one within the other as will be understood, see Fig. 12, and permit the diver to bend the knees in the act of walking or other movements, the axis of flexure being in rear of his knee joints allowing a freedom of movement not otherwise attainable.

Each lower leg member 50 carries lugs 53 at the front and a horizontal pivot pin 54 on which swings the foot or shoe, shown as having a weighted sole 61. The opening in the lower end of the member 50 is U-shaped and the mouth of the shoe is shaped to match therein, and both are curved vertically at the back on a radius of which the pin 54 is the center, as at 55 and 58 in Figs. 10 and 11.

An outward lip 59 on the top of the shoe carries a series of anti-friction balls 60

rolling in contact with the curved inner face of the lower leg member at 55 and the leg member has an interior lip 56 carrying packing 57 in contact with the curved outer face of the shoe-top as at 58.

Secured at the ends of the drum 19 are circumferential bands 72 and 73 having loops or eyes 74, 75, adapted to receive a sling, not shown, or other cable connection by which the diver with the suit may be raised or lowered. At the back of the drum is a connection 25 to which the air-supply pipe or hose, not shown, is coupled and fresh air delivered to the interior of the suit preferably at atmospheric pressure; the vitiated air escapes through the pipe 10 at the top of the helmet, and its connected pipe, at a point above the surface of the water.

When the suit is to be used, the helmet is removed by loosening the wing-nuts 13 and folding down the bolts 12. The bolts holding the chest piece 14 to its companion chest-piece 15 are loosened and removed and one of these pieces separated from the extension 17 and is removed together with its arm. The removal of the helmet and the one chest piece 14 or 15 allows the diver to enter, the chest piece is then replaced, joined to its mate, and to the extension 17 and the helmet replaced and secured. Air is forced through the connection 25 into the drum, and drawn out or permitted to escape through the pipe 10. By means of suitable cables or hawsers secured to the eyes 74 and 75, the diver and suit are lowered.

The articulations of the suit permit the diver to work with practically the same freedom as in the usual diving suit used for relatively shallow depths. The universal ball-and-socket joints of the shoulders permit movements of the arms in all directions; the pins 65 allow the elbow movements, and the ball joints 69 at the wrists give the hands freedom of motion in every direction. The fingers can be closed sufficiently to allow the diver to grasp a rope or other object, or to hold a tool reliably.

The construction of the leg members and their relation to the lower body portion allow the diver to walk and move about without difficulty. It will be noted that the drum 19 is of such diameter as to extend well down upon the legs of the diver and that the knee joints of the leg members are close to the lower side of the drum. By this arrangement the plates 33 engage the legs of the diver just above his knees so that when the leg of the diver is swung forward to slide the plate 33 the resistance of the latter is readily overcome by reason of the effective thrust he can exert at this low point on his upper leg. This movement in walking may or may not be accompanied by a flexure of the knee joint on the pin 41, but

in raising the foot and leg such flexure is necessary and is provided for by the segments 42, 45, 48 and 49.

The movement of the foot at the ankle is permitted by the pivot pin 54. The frictional engagement of the parts in all the movable joints is sufficient to prevent any movement other than that induced by the diver, so that any position assumed will be retained by friction until intentionally changed by the diver.

It will be noted that anti-friction balls are introduced between all relatively moving parts or surfaces and that in all such situations the anti-friction joint is protected by a packing interposed between such ball-bearing and the exterior of the suit exposed to the water-pressure.

The joints thus constructed are practically water tight but as an additional safeguard against the entrance of water a sleeve or covering of flexible soft vulcanized rubber may be applied to inclose such joints. It will be observed that the exterior surfaces of all the joints are sufficiently smooth to permit the use of such sleeves without danger of becoming caught between the parts of the joint and thereby jamming the joint or cutting the sleeve. The application of the sleeve is indicated by dotted lines at *a* in Fig. 1.

A feature of especial importance in all the flexible joints is the avoidance of pivots or shafts extending across the openings or so located as to reduce the effective areas of the openings when the joints are flexed; all the joints in the improved suit offer unobstructed passages therethrough for the limbs of the diver and permit the joints to be flexed at will without cramping the limbs or requiring unusual movements thereof. This will be noted in the ball-and socket joints at the shoulders and wrists of the suit, in the circular sliding junction of the upper leg portion with the lower body portion, and in the knee, elbow and foot joints in which the pivot or center of motion is located outside the joint at a point farthest removed from the contacting surfaces of the leaves comprising the joint.

Ball-and-socket joints similar to that shown in Fig. 13 may be employed to provide the articulations for the elbow, knee and foot.

I claim:—

1. In a metallic diving suit, a body member provided with a slot and a guide adjacent thereto and within said body member, an arc-shaped plate operable in said guide and engageable with the leg of the wearer at a point just above his knee, said plate having an aperture, and a leg member extended through said aperture.

2. In a metallic diving suit, a body member provided with a slot, and a guide adja-

cent thereto and within said body member, an arc-shaped plate operable in said guide, said plate having an opening, and a leg member extended through said opening and engageable with the leg of the wearer at a point just above his knee, said leg member having lugs for the reception of a pivot for the leaves of a telescoping joint.

3. In a metallic diving suit, a body member provided with a slot, and a guide adjacent thereto and within said body portion, an arc-shaped plate operable in said guide, said plate having an opening and engageable with the leg of the wearer at a point just above his knee, and a leg member extended through said opening, combined with a plurality of leaves mounted on a pivot at the angle of said members, one of said leaves extended through said slot.

4. In a metallic diving suit, a body member provided with a slot, and a guide adjacent thereto and within said body member, an arc-shaped plate operable in said guide, said plate having an opening and engageable with the leg of the wearer just above his knee, and a leg member extended through

said opening, said leg member having lugs for the reception of a pivot for the leaves of a telescoping joint, said pivot being arranged in close proximity to said body member.

5. In a metallic diving suit, a chest portion comprising side sections each a counterpart of the other and having radial semi-circular flanges at their lower ends, a lower body portion having an upward extension secured to said flanges, said lower body portion comprising a cylindrical drum horizontally disposed with its axis lying transversely and having circumferential openings, a hollow upper leg portion U-shaped in horizontal section, a pin inclosed within the same at the rear, and a lower leg member mounted on said pin, and intermediate series of U-shaped segments mounted on said pin and telescopically movable within each other and the said upper leg portion.

Signed at New York city, in the city, county and State of New York this 28th day of Dec. 1917.

RUDI DE GRAFF.