

## PATENT SPECIFICATION

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## (54) UNDER-WATER SPRAYING

(71) We, COLEBRAND LIMITED, a British Company of 15 Hampden Gurney Street, Marble Arch, London, W1M 5AL, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of applying paint or like liquid to a surface which is submerged, and the apparatus used to practise the method. The invention is primarily intended to be used in the painting of, or application of a liquid in paint-like manner to, the hull of a ship or any other submerged surface which is normally inaccessible except to a diver. Particularly in the case of modern very large ships for which docking facilities are not easily available they nevertheless require to be treated with compositions such as for corrosion or fouling protection from time to time. There are also instances when it is required to apply similar substances to the submerged part of a sea-wall or like fixed structure, or to moored buoys.

The invention is entirely concerned with spray painting, or equivalent application (which we will refer to for brevity as painting) that is to say painting by the projection of droplets of the paint with considerable velocity to impact the surface upon which the droplets then coalesce to form a uniform film. It has been proposed previously to use as an applicator a bell-like shield enclosing a spraying nozzle and to purge the interior of the bell by compressed air so that the paint can pass relatively freely through air in the bell finally reaching the surface. In such prior proposals, however, it does not seem to have been thought practicable to apply the foregoing general idea in an economic and sensible manner and, which is more important, to cover the required surface area quickly by painting in a relatively broad swath or band by just one passage of the spray. If a circular shield be used as previously proposed, the length of its margin (i.e. the linear dimension)

the enclosed volume of the shield, so that the maximum leakage of air, and therefore the maximum consumption of air, can occur. The present invention seeks to economise in air to be supplied and as a secondary advantage of such economy, to diminish the cloud of bubbles which inevitably escape and can impede the operator's view of his work. A major advantage of the present invention therefore resides in its economy and convenience of operation.

The invention also makes use of various practical expedients which may or may not be applied according to the scale of the operation. For example, if large and heavy spraying apparatus is to be used as might be the case for very large ships' sides, the invention provides for means to secure the apparatus to the surface to be treated in such a manner that it can easily be moved, and also so that in any one attached position a considerable area may be painted. Again, if the apparatus is to be hand-held means are provided by the invention whereby it can easily be moved about over the surface. Yet again, since it is required to control with considerably exactness the gap between the shield and the surface through which gap the air is to escape, the invention provides means for maintaining and controlling the gap. Since such means involve contact between the surface and parts which move over the surface, the invention provides that such contact is avoided in the area which has just been painted so that the newly applied paint is not disturbed. The means for effecting this according to the invention are reversible so that change of sense of direction of the painting operation is provided for. The invention affords other practical devices which have been found to be advantageous in some cases of submerged painting operations. The invention is in the first instance intended to be practised by a diver operator but it will not require very much elaboration to enable it to be used as a fully automatic applicator device.

Basically then, the invention resides in a method of coating a submerged surface by

11  
 5 spraying with a liquid, in which there is passed  
 over the surface the margin of an opening  
 which is of relatively short dimension in the  
 direction of such passage and of relatively  
 10 long dimension in the direction perpendicular  
 to such passage, maintaining the margin so  
 that at least its trailing edge (i.e. that of longer  
 dimension which, in relation to the sense of  
 direction of passage, is behind the other) is  
 15 spaced from the surface by a gap which leads  
 from the opening of an otherwise watertight  
 hollow shield supplying into the shield com-  
 pressed air at a sufficient pressure and rate  
 to keep the interior of the shield purged of  
 water whilst there is air escape through the  
 gap, and projecting the liquid to the surface  
 20 from a source which is inside the shield and  
 spaced from the surface as a spray of droplets  
 in a sheet-like pattern, the spray, in the plane  
 of the opening, corresponding in short and  
 long dimensions to the opening but smaller,  
 the velocity of projection of the droplets and  
 25 their mass being such that they or at least  
 a majority of them penetrate the volume of  
 intervening air maintained within the shield  
 and such film of water as there may be on  
 the surface so as to reach the surface and form  
 thereon a continuous film.

30 The invention further includes the elabora-  
 tion of the foregoing method by various  
 other features as disclosed hereinafter.

The invention also includes apparatus for  
 performing the above defined method and its  
 variations. In particular, such apparatus com-  
 35 prises a hollow shield having an opening  
 which is of relatively short dimension in a  
 first direction, being the intended direction  
 of passage for painting, and of relatively long  
 dimension in a second direction perpendicular  
 40 to the first direction, means connected to  
 the shield so as in use to bear against the sur-  
 face to be painted to maintain the margin of  
 said opening so that at least its trailing edge  
 (i.e. that of longer dimension which, in rela-  
 45 tion to the sense of direction of passage, is  
 behind the other) is spaced from the surface  
 by a gap, means for supplying into the shield  
 compressed air at a sufficient pressure and rate  
 to, in use keep the interior of the shield purged  
 50 of water whilst escaping through said gap, and  
 a spray nozzle supported within the shield  
 spaced from said opening and adapted in use  
 to project the liquid to the surface to be  
 painted as a spray of droplets in a sheet-  
 55 like pattern, the spray, in the plane of the  
 opening of the shield, corresponding in short  
 and long dimensions to the opening but  
 smaller.

60 In applying the invention it is preferred  
 to use a spray of purely hydraulic type, that  
 is to say an airless spray in which the paint  
 is delivered at a high pressure and from  
 which the paint emerges at very high velocity  
 65 and breaks up into droplets after emerging.  
 It is, however, possible to use an air type

spray but in such case the air which, as will  
 be seen below, is used to purge the shield  
 of water, will probably have to have a cer-  
 tain velocity itself, so as not to impede the  
 action of the airspray. Yet again it is possible  
 70 to make use of electrostatic spraying providing  
 that the interior surface of the shield is elec-  
 trically isolated from the paint source either  
 by virtue of an insulating coating or by an in-  
 75 sulating separator between the gun and the  
 shield thus preventing the spray being  
 attracted to the shield instead of to the sur-  
 face to be painted. For various reasons of  
 convenience however, the invention is pri-  
 80 marily concerned with simple hydraulic spray  
 means and there are many variations of  
 appropriate spray nozzles on the market which  
 produce the required spray pattern in the  
 form of a thin sheet: as will be seen, the  
 85 spray means may consist of a plurality of  
 aligned spray nozzles collectively delivering  
 a sheet of spray particles.

Apparatus according to the invention, with  
 comments on its use, will now be described  
 by reference to the accompanying drawings  
 90 in which:—

Figure 1 is a plan view of the so-called  
 spray gun constituting the effective apparatus.

Figure 2 is a part section on the line X—X  
 95 in Figure 1,

Figure 3 is an end elevation (from the same  
 aspect as Figure 2) of the spray gun shown  
 in greater detail and

Figure 4 is a plan view of the gun as  
 shown in Figure 3 illustrating a modification  
 100 intended to prevent bubbles from obscuring  
 the diver's view.

Figure 5 is a sketch illustration showing  
 a plurality of aligned spray nozzles.

Figures 6 and 6a are diagrams of another  
 105 modification of the shield, to deal with certain  
 types of surface e.g. where the surface is of  
 steel sheets with lap joints.

Figure 7 illustrates how castoring wheels  
 110 may be used.

Figure 8 is an illustration of a way of  
 moving the spray gun over the surface in  
 a mechanised manner.

Figures 9 and 9A are diagrams to show an  
 115 elaboration of the shield to economise and  
 reduce bubbling.

The gun forming the subject of this  
 example is intended for use in spray paint-  
 ing under water of substantially vertical sur-  
 120 faces (indicated at 10 in figure 2), such as the  
 sides of a ship. This gun in its simplest form,  
 is intended to be hand-held and passed up  
 and down the surface to be painted, traversed  
 transversely at the end of the up stroke, passed  
 125 through a down stroke, again traversed, and  
 so on.

The gun comprises a hollow shield 11 of  
 generally fish-tail shape and internally pro-  
 vided with a spray nozzle 12 at the closed,

5 narrow, end of the shield. This nozzle is of  
a known type such as to produce by airless  
atomisation, a divergent sheet-like spray of  
droplets conforming to the shape of the shield  
but sufficiently smaller in cross section to  
substantially avoid coating the internal sur-  
faces of the shield. These surfaces are prefer-  
ably covered with P.T.F.E. (polytetrafluoro-  
ethylene) as a further precaution against lodg-  
ing of the paint on the surfaces or to make  
easier the removal of any paint which has  
fouled the interior of the shield. Surround-  
ing the closed end of the shield is a chamber  
14 with an inlet 15 for compressed air. Per-  
forations 16 in the wall of the shield lead  
from the chamber 14 to an inner chamber 18  
defined by a baffle 19. There is an annular  
gap 20 between the baffle 19 and the housing  
for the nozzle 12 so that the air flow passes  
from the chambers 14 and 18 into the shield  
around the spray jet and out of the opening  
22 of the shield, which opening is narrow  
in the direction of intended passage and com-  
paratively wide perpendicular to such direc-  
tion. The air supply arrangement is intended  
to admit the air into the shield without dis-  
turbance the spray pattern.

30 The margin 22A of the mouth 22 lies  
in a plane making an angle of about 45°  
with the axis of the nozzle 12 and, in use,  
is spaced at a small distance from the sur-  
face 10 to be sprayed. Provision is made,  
as will be seen, to enable this distance to be  
adjusted to an optimum for the particular  
surface being sprayed. When the nozzle axis  
lies in a vertical plane and at an angle of  
about 45° to the surface 10, the greater  
dimension of the mouth 22 then lies hori-  
zontally, the lesser dimension then lying in the  
intended direction of movement of the gun.  
The rate and pressure of air supply into the  
shield is maintained at a value sufficiently  
above the pressure of the ambient water to  
purge the shield of water and keep it purged,  
so to expose the area of the surface 10 within  
the margin 22A for painting. It is an advan-  
tage of the construction described, however,  
that if for any reason water enters the shield  
(e.g. because the gun runs off the surface being  
painted) or the air is interrupted, it will only  
do so at the level *a-b* (Fig. 2) and the volume  
of water to be removed at the re-start of  
work will be small. In that sense the shield  
acts as a "diving bell".

55 The gun is mounted on a carriage 30,  
only partly shown in the drawings. This  
carriage has two wheels 31 at one side of the  
mouth 22 which runs on unpainted parts  
of the surface 10 to the side of the mouth  
22. In addition there are two wheels 32 which  
lie within the width of mouth 22 and are  
alternatively engageable as shown in Figure  
3 by means of a double acting pneumatic  
ram 36, the piston rod 37 of which is con-  
nected directly to the mounting for one wheel

32 and through a rocker 38 pivoted on the  
shield to the mounting for the other wheel.  
When the gun is moving upwardly the upper  
wheel is engaged with the unpainted part of  
surface 10 as shown and the lower wheel 32  
is held off the newly painted area of the sur-  
face. Conversely when the gun is moving  
downwardly the upper wheel is held off the  
surface and the lower wheel engages the sur-  
face. The line of the force with which the  
spray gun is applied to the surface lies with-  
in the triangle formed by the contact points  
of the three wheels, thus giving a stable  
arrangement.

The carriage may also be provided with  
a propeller (not shown) which rotates about  
an axis perpendicular to surface 10 and so  
produces a thrust tending to maintain the  
wheels 31, 32 in contact with the surface and  
hence maintain the mouth of the shield at  
its desired distance from the surface being  
sprayed.

The propeller and, for traction, the wheels  
31 (and/or 32) may be driven by electricity,  
compressed air or hydraulically, the same  
power source being used for both, if desired.  
Preferably the drive to the traction wheels,  
if provided, is reversible. The speed at which  
the wheels and/or the propeller are driven  
may be variable and means may be provided  
to maintain the speed at a predetermined  
value.

The nozzle 12 is mounted in a housing  
34 providing a feed conduit for the paint.  
This housing is mounted on the shield by  
way of a part spherical bearing 35 which  
enables the direction of the spray within the  
shield to be adjusted so that the spray may  
be caused to lie centrally in the margin of the  
shield.

Means such as an interconnection between  
a paint supply valve and the pressure of the  
ram 36 may be provided for automatically  
cutting off the supply of paint during periods  
in which the direction of movement of the  
gun is being reversed and wheels 32 changed  
over.

There may be a regulator for the air pres-  
sure within or attached to the shield. This  
may comprise a diaphragm (or equivalent pis-  
ton) open on one side to the ambient water  
pressure and operable to maintain the air  
pressure within the shield at a pre-set value  
above the ambient pressure.

It is to be appreciated that by employing  
a high ratio of width to height of the open-  
ing 22 not only is a relatively wide strip  
painted at each up or down traverse of the gun  
but also the difference in water pressure at the  
upper and lower edges of the mouth is reduced  
to a minimum which assists in maintaining  
displacement of the water with a minimum of  
expenditure of air. It is also an advantage  
that the mouth of the shield may be held  
close to the surface being painted which re-

duces the consumption of air. However, a major advantage of keeping the lesser dimension of the opening as small as is practicable is that this affords the least possible length (in linear terms) of margin 22A in relation to the combined volume in the shield, thus affording the least possible leakage-path for the air.

It is within the invention to provide a deflector 39 as shown in Figure 4 above the mouth of the shield, to be held close to the surface being painted and sloped or shaped to divert to one side (or both sides) air bubbling up from the shield mouth, hence to reduce obstruction by the bubble to visual inspection of the surface which has been, or is about to be, painted.

Also, one or more scrubbers may be provided to scrub the surface prior to application of paint. The scrubbers may be separate from or embodied in the gun. These may be rotary brushes, driven by electricity, compressed air or hydraulically, and there may also be provided means for feeding at a controllable rate a wetting agent or other cleaning material through the centre of the brush.

In Figure 5 it is shown that three separate nozzles 51, 52 and 53 are used within one shield 54. In such a case the actual shape of the shield may be modified somewhat in the manner drawn so as to accommodate the three droplet sprays indicated approximately in dotted line at 55. The sprays will be so positioned and the pattern of their tips so selected that they overlap as at 56; this, if appropriately selected, will not result in any undue concentration of paint in the zone 56 because the extreme margins of the divergent spray are in any case somewhat attenuated as compared to the main part of the spray. It will be clear from this illustration that any reasonable number of nozzles may be used, the breadth to length proportion of the opening of the shield 54 of course being appropriately varied. Moreover, instead of putting several spray nozzles, within one shield the apparatus may involve the provision of several complete units of shield plus nozzle and these may be arranged in somewhat staggered relationship so that one passage of the group of shields produces a uniform swath of paint.

Figures 6 and 6a illustrate a device which copes with a particular problem encountered in painting some ships hulls or like structures. The device is one which adapts a shield to conform reasonably well with a certain type of contour of surface. The same device enables a flat surface to be painted. In Figure 6 the surface to be painted is broken up into an area 60A and a second area 60B these being supposed to be interconnected by a lap joint 61 probably by welding at 62. The shield 63 of the apparatus has at the margin of its opening two parts, 64 and 65 which are attached to the shield 63 by parallel links such as 66.

Each of these parts can be swung by virtue of the parallel links so that, for example, the part 64 being swung the shield opening has its effective margin now shaped so as substantially to match the form of the weld 62. The operator will of course move either 64 or 65 into the appropriate position for the particular circumstance encountered, in other words as is seen in figure 6a, he can select the "hand" of operation. In Figure 6a the part 65 is swung, part 64 being in the retracted position. Mechanism not shown in the drawing may be provided in any suitable form to advance a guide wheel 67 to maintain the shield parallel to the surfaces being painted. The shield is conditioned for normal use on a flat surface by retracting both parts 64 and 65 and placing the wheel 67 in the position to produce a small and uniform gap between the margin of the shield and the surface being painted. Similar provision, i.e. movable margin elements, may be used to facilitate operation over lines of rivets or similar excrescences.

Moving now to Figure 7, it is indicated diagrammatically how the carriage which is to be seen more fully in Figures 1—4 and its side running wheels can be arranged so that the operator can more readily traverse the apparatus from one completed path to a second adjacent parallel path, or to accommodate his operation to various surfaces or around obstacles. In this Figure, 30 again indicates the side part of the carriage and the two wheels (31 in previous Figures) are now indicated at 70 and they are mounted like furniture castors on pivotal axes 71 providing for 360° directional orientation of the wheels 70. The wheels 32 (earlier Figures) not shown in Figure 7, will likewise be mounted for castoring. In Figure 7 the wheels 70 are shown trailing thus indicating that the apparatus is moving in the direction of the arrow 72.

Figure 8 shows one way in which the apparatus of any previous Figure can be mounted so that it is held against the surface to be painted and so that the gun as a whole may be manipulated with considerable facility over a wide area, both as to vertical and horizontal passage over the surface. The gun is attached to the structure of Figure 8 by means of a bush 80 which slides on a rod 81. The gun is caused to traverse the rod 81 by an air motor, omitted from the drawing for simplicity, spraying a swath of paint as it does so. The rod 81 is attached to two radius arms 82 (only one of which is shown) which are connected by journals to the frame 83 which also carries, in bearings, the two shafts 84. Attached to the ends of the shafts 84 are vacuum cups 85 (only two of which are shown). A turning movement is imparted via a shaft 88 to the radius arms 82 by means of a pneumatic motor 89, the torque reaction

being transmitted from the motor casing to the frame 83.

In operation the device is placed on the surface to be painted and all four vacuum cups 85 evacuated causing them to adhere strongly to the surface. A torque is produced by the motor 89 in the arrowed direction and in consequence the spray gun is pressed against the surface. The gun is caused to traverse the length of the rod 81 and come to rest at one end. If the vacuum is released from vacuum cups 85C and 85D whilst torque is maintained by the motor, the frame 83 will, because of torque reaction, rotate about the shaft 88 and will so to speak, take one "step" to the left (of the Figure). Re-evacuating cups 85C and 85D will once more cause the device to be held rigidly to the surface and the movement of the spray gun restarted. The sprockets 86 and chain 87 cause the two vacuum cups which are taking the "step" to present their openings squarely to the surface. By repetitive functioning of the vacuum system the device may be made to "walk" along the surface to be painted.

The radius arms 82 may be in the form of a toggle linkage and may thus permit the rod 81 to be angled in respect to the frame 83 and in consequence may give improved mobility to the gun.

The whole of this device may be controlled both as to suction and "stepping" by any suitable type of pilot or electrically operated valves.

Although this method of temporary attachment of the gun apparatus to the surface to be painted is given by way of example, it is to be understood that various other expedients may be used. We have previously mentioned the possibility of using a propeller-like device. Permanent or electromagnets may be used where the surface to be painted is for example of mild steel.

Turning now to Figures 9 and 9a, a variant is illustrated which is in its turn capable of being very considerably changed. In essence its purpose is first to economise in the required airflow and secondarily to reduce the amount of bubbling which may inconvenience the operator; further the device may have some use in removing loose particles from the surface about to be painted. There is indicated a shield 90 with the margin of its opening at 91. On a sliding bar such as at 92 which is mounted parallel with the long dimension of the margin 91, there is mounted a flexible strip 93 which may be formed of bristles or of a resilient material. Along the other dimension of the margin 91 is a similar bar and strip, 95 and 96. The bars 92 and 95, can be moved on their guides and thus bring the strips 93 and 96 into contact with the surface 97 to be painted. When the spray is being moved upwards as indicated by the arrow in Figure 9 the strip 93 is moved into

a position where it acts, somewhat like a skirt of cushioncraft vehicle but actually in contact with the surface 97 and therefore sealing the leading edge of the margin 91 against outward leakage of air from the shield 90. Alternatively in Figure 9a when the spray is being moved downwards the strip 96 is put in contact with the surface 97. The movements of the strips 93 and 96 are controlled in harmony with movement of a guidewheel 98 or 99 which is moved down to roll on the surface 97 according to the sense of direction of the passage of the apparatus. The wheels 98 and 99 are the equivalent of the wheels 32 in the previous Figures. It is unimportant what interconnection there is between the guidewheels and the sealing strips. By this device it will be seen that where the apparatus is being passed in one sense or the other of direction the leading edge is in effect sealed against the surface 97 whilst the trailing edge is clear. It is of course behind the leading edge that wet paint is deposited. The end portions of the shield 90 can either be left unsealed or may have extensions of the seal 93 or 96 extending partially around such ends.

The invention will have been seen to include not only a method for painting or performing like functions under-water, but also apparatus for carrying out such a method and various modifications thereof.

The paint selected to be used for underwater application by the spray apparatus should be such as to set cure, or dry by chemical reaction (e.g. as in the epoxy system); solvent loss, or absorption of oxygen from the water to polymerise the film, perhaps aided by the air supplied to purge the shield. The nature of the paint itself is believed to aid penetration of the thin water film left on the surface; probably this has to do with water solubility of one or more ingredients, and flushing-off of solvents may play a part. Such features may be of account in making the selection.

#### WHAT WE CLAIM IS:—

1. Method of coating a submerged surface by spraying with a liquid, which resides in passing over the surface the margin of an opening which is of relatively short dimension in the direction of such passage and of relatively long dimension in the direction perpendicular to such passage, maintaining the margin so that at least its trailing edge (i.e. that of longer dimension which, in relation to the sense of direction of passage, is behind the other) is spaced from the surface by a gap which leads from the opening of an otherwise water-tight hollow shield, supplying into the shield compressed air at a sufficient pressure and rate to keep the interior of the shield purged of water whilst escaping through the gap, and projecting the liquid to



being transmitted from the motor casing to the frame 83.

In operation the device is placed on the surface to be painted and all four vacuum cups 85 evacuated causing them to adhere strongly to the surface. A torque is produced by the motor 89 in the arrowed direction and in consequence the spray gun is pressed against the surface. The gun is caused to traverse the length of the rod 81 and come to rest at one end. If the vacuum is released from vacuum cups 85C and 85D whilst torque is maintained by the motor, the frame 83 will, because of torque reaction, rotate about the shaft 88 and will so to speak, take one "step" to the left (of the Figure). Re-evacuating cups 85C and 85D will once more cause the device to be held rigidly to the surface and the movement of the spray gun restarted. The sprockets 86 and chain 87 cause the two vacuum cups which are taking the "step" to present their openings squarely to the surface. By repetitive functioning of the vacuum system the device may be made to "walk" along the surface to be painted.

The radius arms 82 may be in the form of a toggle linkage and may thus permit the rod 81 to be angled in respect to the frame 83 and in consequence may give improved mobility to the gun.

The whole of this device may be controlled both as to suction and "stepping" by any suitable type of pilot or electrically operated valves.

Although this method of temporary attachment of the gun apparatus to the surface to be painted is given by way of example, it is to be understood that various other expedients may be used. We have previously mentioned the possibility of using a propeller-like device. Permanent or electromagnets may be used where the surface to be painted is for example of mild steel.

Turning now to Figures 9 and 9a, a variant is illustrated which is in its turn capable of being very considerably changed. In essence its purpose is first to economise in the required airflow and secondarily to reduce the amount of bubbling which may inconvenience the operator; further the device may have some use in removing loose particles from the surface about to be painted. There is indicated a shield 90 with the margin of its opening at 91. On a sliding bar such as at 92 which is mounted parallel with the long dimension of the margin 91, there is mounted a flexible strip 93 which may be formed of bristles or of a resilient material. Along the other dimension of the margin 91 is a similar bar and strip, 95 and 96. The bars 92 and 95, can be moved on their guides and thus bring the strips 93 and 96 into contact with the surface 97 to be painted. When the spray is being moved upwards as indicated by the arrow in Figure 9 the strip 93 is moved into

a position where it acts, somewhat like a skirt of cushioncraft vehicle but actually in contact with the surface 97 and therefore sealing the leading edge of the margin 91 against outward leakage of air from the shield 90. Alternatively in Figure 9a when the spray is being moved downwards the strip 96 is put in contact with the surface 97. The movements of the strips 93 and 96 are controlled in harmony with movement of a guidewheel 98 or 99 which is moved down to roll on the surface 97 according to the sense of direction of the passage of the apparatus. The wheels 98 and 99 are the equivalent of the wheels 32 in the previous Figures. It is unimportant what interconnection there is between the guidewheels and the sealing strips. By this device it will be seen that where the apparatus is being passed in one sense or the other of direction the leading edge is in effect sealed against the surface 97 whilst the trailing edge is clear. It is of course behind the leading edge that wet paint is deposited. The end portions of the shield 90 can either be left unsealed or may have extensions of the seal 93 or 96 extending partially around such ends.

The invention will have been seen to include not only a method for painting or performing like functions under-water, but also apparatus for carrying out such a method and various modifications thereof.

The paint selected to be used for underwater application by the spray apparatus should be such as to set cure, or dry by chemical reaction (e.g. as in the epoxy system); solvent loss, or absorption of oxygen from the water to polymerise the film, perhaps aided by the air supplied to purge the shield. The nature of the paint itself is believed to aid penetration of the thin water film left on the surface; probably this has to do with water solubility of one or more ingredients, and flushing-off of solvents may play a part. Such features may be of account in making the selection.

#### WHAT WE CLAIM IS:—

1. Method of coating a submerged surface by spraying with a liquid, which resides in passing over the surface the margin of an opening which is of relatively short dimension in the direction of such passage and of relatively long dimension in the direction perpendicular to such passage, maintaining the margin so that at least its trailing edge (i.e. that of longer dimension which, in relation to the sense of direction of passage, is behind the other) is spaced from the surface by a gap which leads from the opening of an otherwise water-tight hollow shield, supplying into the shield compressed air at a sufficient pressure and rate to keep the interior of the shield purged of water whilst escaping through the gap, and projecting the liquid to



the surface from a source which is inside the shield and spaced from the surface as a spray of droplets in a sheet-like pattern, the spray, in the plane of the opening, corresponding in short and long dimensions to the opening but smaller, the velocity of projection of the droplets and their mass being such that they or at least a majority of them penetrates the volume of intervening air maintained within the shield and such film of water as there may be on the surface so as to reach the surface and form thereon a continuous film.

2. Method according to Claim 1 in which the compressed air is supplied to the interior of the shield through a passage which surrounds the source of liquid so that the general direction of air movement in the shield corresponds with that of the spray over substantially the same distance.

3. Method according to Claim 1 in which the said gap is maintained by urging the shield towards the surface and lifting its position by means bearing against unsprayed area of the surface.

4. Method according to Claim 3 in which the said means is adjustable so as to adjust the gap.

5. Method according to Claim 3 in which the gap is maintained between the trailing edge of the shield margin and the surface at least the leading edge of the margin being of yieldable material such as to slide in relatively airtight contact on the unsprayed surface.

6. Method according to Claim 1 in which the shield is urged towards the surface by thrust caused by displacement of the ambient water.

7. Method according to Claim 6 in which the thrust is caused by propeller-like means.

8. Method according to Claim 1 in which the shield is urged towards the surface by magnetism.

9. Method according to Claim 1 in which the shield is held towards the surface by the ambient pressure acting on pliable cups within which a sub-ambient pressure is created.

10. Method according to Claim 3 in which the position-limiting means is changed according to the sense of direction of passage over the surface.

11. Method according to Claim 3 in which the position-limited means comprise a surface-bearing device arranged to one side of the shield (as related to its passage direction) and at least two other secondary bearing devices spaced from the opening of the shield in the path of the opening, in which method one or other of the secondary bearing devices is controllably put into operation according to the sense of direction of passage whereby the alternative of such secondary devices is out of contact with newly-sprayed surface.

12. Method according to Claim 3 in which the position-limiting means include wheels

which are mounted for directional orientation and in which method the wheels are oriented so as to traverse the shield from one passage track to a further parallel track.

13. Method according to Claim 1 in which the shield is arranged and held positioned relatively to the surface so that its opening is lower than its main interior volume, so that it acts as a "diving-bell" to retain a pocket of air even if the air supply thereinto is interrupted.

14. Method according to Claim 1 in which the spray of droplets is produced by forcing the liquid under high pressure through one or more atomising orifices of the kind known to produce a substantially flat divergent spray pattern with substantially uniform droplet distribution.

15. Method according to Claim 1 in which the pressure of the air supply is controlled so as to be compatible with the depth at which the method is performed.

16. Method according to Claim 1 in which the source inside the shield comprises a plurality of droplet-spraying nozzles spaced across the direction of passage, the liquid being supplied to such nozzles in parallel during the passage.

17. Apparatus for coating a submerged surface by spraying with a liquid in accordance with the method of claim 1, comprising a hollow shield having an opening which is of relatively short dimension in a first direction, being the intended direction of passage for painting, and of relatively long dimension in a second direction perpendicular to the first direction, means connected to the shield so as in use to bear against the surface to be painted to maintain the margin of said opening so that at least its trailing edge (i.e. that of longer dimension which, in relation to the sense of direction of passage, is behind the other) is spaced from the surface by a gap, means for supplying into the shield compressed air at a sufficient pressure and rate to, in use, keep the interior of the shield purged of water whilst escaping through said gap, and a spray nozzle supported within the shield spaced from said opening and adapted in use to project the liquid to the surface to be painted as a spray of droplets in a sheet-like pattern, the spray, in the plane of the opening of the shield, corresponding in short and long dimensions to the opening but smaller.

18. Apparatus according to Claim 17 in which such means connected to the shield so as in use to bear against the surface to be painted include at least four rollers supporting the shield through a carriage structure, at least two of the rollers being singly retractable from bearing on the painted surface behind (i.e. behind in the sense of direction of passage) the opening.

19. Apparatus according to Claim 17 in



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which said means connected to the shield so as in use to bear against the surface to be painted include rollers and the rollers are mounted so as to be orientable in direction to enable the apparatus to move in traverse across the direction of painting.

20. Apparatus according to Claim 17 in which the opening of the shield is furnished at least along its longer marginal part with pliable sealing strips so mounted that one of them can be retracted so as to clear the newly-painted surface.

21. Apparatus according to Claim 20 in which means are provided whereby the retraction of a sealing strip is accompanied by retraction of a gap-limiting means from bearing on the newly-painted surface.

22. Apparatus as claimed in Claim 17 further provided with means to urge the margin of the shield towards the surface.

23. Apparatus as claimed in Claim 22 in which the urging means includes a magnet.

24. Apparatus as claimed in Claim 22 in which the urging means includes a producer of hydrodynamic thrust.

25. Apparatus according to Claim 17 further provided with means adapted to adhere detachably to the surface and structure whereby such adherent means supports the shield.

26. Apparatus according to Claim 25 in which the adherent means comprises suction cups.

27. Apparatus according to Claim 25 in which the adherent means comprises electromagnetic means.

28. Apparatus according to Claim 25 in which the supporting structure comprises articulated linkage allowing the shield to be moved over a substantial area of the surface.

29. Apparatus according to Claim 17 in which the margin of the shield is provided with movable elements whereby the effective profile of the margin may be selectively altered to adapt the shield for use over surfaces which are substantially plane or are non-planar.

30. Apparatus according to Claim 17 in which the shield is so shaped and supported that its opening can be arranged to be always below the spray nozzle, so that the shield acts in effect as a "diving bell" to retain air within itself even when not continuously supplied with air.

31. Apparatus according to Claim 17 in

which a plurality of spray nozzles is provided, all projecting their sprays in a pattern aligned transversely to the direction of operative movement of the apparatus.

32. Apparatus according to Claim 31 in which a plurality of shields each with spray nozzle and air supply means, is provided in such relationship as to result in a substantially uniform pattern of spray on the surface.

33. Apparatus according to Claim 17, further provided with means to deflect bubbles of air escaping from the shield so as to avoid obscuring the view of the operator.

34. Apparatus according to Claim 17 in which the shield is internally coated with a substance suitable to minimise the adhesion of the spray to the shield.

35. Apparatus according to Claim 34 in which the substance is P.T.F.E.

36. Apparatus for painting a submerged surface substantially as described in relation to Figure 1 and 2 of the accompanying drawings.

37. Apparatus as claimed in Claim 36 modified substantially as described with reference to Figures 3 and 4 of the accompanying drawings.

38. Apparatus according to Claim 17 modified substantially as described with reference to Figure 5 of the accompanying drawings.

39. Apparatus according to Claim 17 modified substantially as described with reference to Figure 6 and 6A of the accompanying drawings.

40. Apparatus according to Claim 17 having castoring wheels substantially in the manner with reference to Figure 7 of the accompanying drawings.

41. Apparatus according to Claim 17 provided with supporting and travelling means substantially as described with reference to Figure 8 of the accompanying drawings.

42. Apparatus according to Claim 17 modified substantially as described with reference to Figures 9 and 9A of the accompanying drawings.

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