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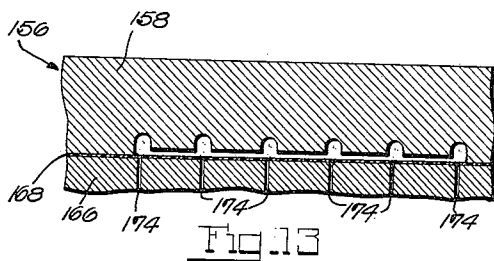
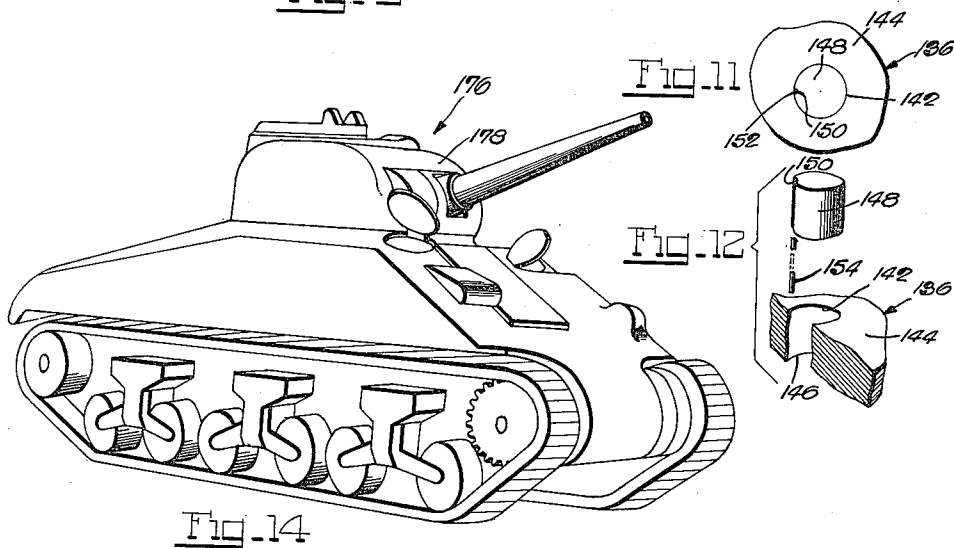
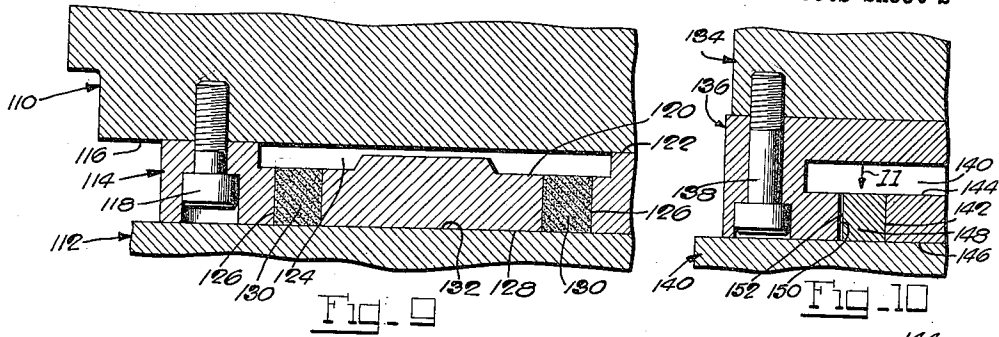
J. C. HARTLEY

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LOAD SUPPORT WITH FLUID-PRESSURE TYPE LOAD RELIEF PROVISION

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2 Sheets-Sheet 2



INVENTOR.
James C. Hartley
BY
Walter Sprungel
Attorney.

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LOAD SUPPORT WITH FLUID-PRESSURE TYPE LOAD RELIEF PROVISION

James C. Hartley, Branford, Conn., assignor to Union Manufacturing Company, New Britain, Conn., a corporation of Connecticut

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The present invention relates to highly novel and efficient load-supports with fluid pressure-type load-relief provisions, and methods of fabricating the same.

It is an object of the present invention substantially to eliminate the adverse effects of the weight and friction of a load on the movement of the latter or an underlying support, so as to reduce sliding friction between, and hence wear of, the relatively movable parts to a minimum and accordingly greatly reduce the force required to move a heavy load relative to its support, as well as eliminate costly bearing provisions heretofore customarily used for movably supporting heavier loads.

Another object of the present invention is the provision of simplified and highly effective means for floating a load, and even a heavy load, on an underlying support for readily adjusting the load relative to the support.

A further object of the present invention is the provision of a fluid-pressure operated lift mechanism in which fluid under relatively low pressure is effective to lift most any load, including very heavy loads. In this connection, it is a more specific object to provide a powerful air lift which is operated by air from a supply source under relatively low compression and has low air consumption.

Another object of the present invention is to provide the aforementioned air lift by providing the mechanism with a passage or passages of individual cross-sectional area which is as minute as practically feasible, so that air under low compression forced therethrough will create and sustain between the confronting surfaces of the load and its support an air film the integral of the pressure of which is adequate to separate these surfaces, thereby achieving not only relief of a load by air under low compression in the first place, but also load relief in this fashion with low-power, small size and low-cost equipment and exceedingly small consumption of work-performing compressed air.

A further object of the present invention is to carry the minute cross-sectional area of the aforementioned air-lift passage or passages in the mechanism to a sufficient depth to assure that the mechanism will be of adequate structural strength between the outer or discharge ends of these air passages and their inner ends which are in direct communication with an internal air supply chamber.

It is another object of the present invention to form the aforementioned mechanism or member of a relatively hard metal, or of a material having other characteristics which make it difficult or impractical to drill the aforementioned fine and relatively long passages thereinto, which member is nevertheless provided with said air passages without encountering the slightest difficulties in their formation.

In connection with the foregoing object, it is a further object to devise relatively simple methods for providing the fine air passages in a member formed of the aforementioned materials.

It is a further object to devise methods for providing the aforementioned very fine and relatively long passages in relatively hard materials, or in materials otherwise excessively resistant to a fine-drilling operation, without the necessity of drilling through said materials.

Another object is the provision of a member formed of a relatively hard material, or a material which is other-

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wise exceedingly resistant to a fine-drilling operation, and to provide this member, nevertheless, with very fine and relatively long passages by a drilling operation without encountering any difficulties whatever.

A still further object is the provision of a bearing arrangement between two relatively rotatable members, and especially a bearing arrangement subjected to thrust under considerable loads, which arrangement greatly reduces the power required to effect their relative rotation, substantially eliminates wear of said members from their relative rotation, and makes lubrication unnecessary.

Other objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a fragmentary view, in elevation and partly in section, of a machine tool having a slidable work holder and support therefor, pursuant to one form of the present invention;

FIG. 2 is a fragmentary view, in elevation and partly in section, of a machine tool provided with a rotary work holder and support therefor, also pursuant to the present invention;

FIG. 3 is a top plan view of a modified form of the support or lift device of FIG. 1;

FIG. 4 is a fragmentary section, on an enlarged scale, taken on the line 4-4 of FIG. 3;

FIG. 5 is a perspective view of a modified form of the support or lift device of FIG. 2, prior to the formation of the air passages or ducts therein;

FIG. 6 is a perspective and part-sectional view, on an enlarged scale, of a part of the support member illustrated in FIG. 5;

FIGS. 7 and 8 are enlarged fragmentary sections through the support member of FIG. 5 as taken on the lines 7-7 and 8-8 thereof, respectively, with the member shown in different stages of its fabrication, however;

FIG. 9 is a fragmentary sectional view of another slidable load carrier and support therefor embodying the present invention in another form;

FIG. 10 is a fragmentary section through still another slidable load carrier and support therefor embodying the present invention in a further modified manner;

FIG. 11 is a fragmentary view as seen in the direction of the arrow 11 in FIG. 10;

FIG. 12 is an exploded view of elements cooperating in the formation of an air duct in the embodiment of FIG. 10;

FIG. 13 is a fragmentary section through a further load support member embodying the present invention in a further modified form; and

FIG. 14 is a perspective view of a combat tank embodying the present invention.

Referring now to FIG. 1 of the drawings in detail, there is shown a machine tool 20 provided with a work holding fixture or jig 22 in which a workpiece 24 is rigidly held or clamped. For illustrative purposes only, the machine tool 20 is here shown as a conventional multiple drill press, in which the workpiece 24 is subjected to the action of the drills 26 provided in the spindles 28. The fixture or carrier 22 is mounted for linear movement on a stationary support or track member 30 so that the workpiece 24 may be accurately positioned relative to the drills 26 for the machining operation.

The workpiece 24 and the fixture 22 may constitute a comparatively heavy load on the fixed support or table 30 so that a considerable amount of force is required to overcome the effects of the weight and friction engagement of the loaded fixture on the table 30. However, this force is presently derived from compressed air

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under relatively low compression. As here shown, provision is made for a fluid distributing chamber or manifold 32, in this instance an air distributing manifold, which is defined within the table 30. A plurality of air ducts or passages 34 of very small cross-sectional dimensions extend upwardly from chamber 32 to the upper surface 36 of the support 30 on which the slide or fixture 22 is slidably supported. A conduit or air pipe 38, provided with a shut-off valve 40, extends from the chamber 32 to a compressed air supply which is not illustrated.

When it is desired to move the loaded fixture relative to the stationary support, the valve 40 is opened to admit air, under pressure, into the chamber 32. From the chamber, the air flows through the highly constricted passageways defined by the ducts 34 to issue therefrom as air jets which create and sustain an air film between the confronting support and fixture surfaces 36 and 42, respectively. The integral of pressure of this air film is adequate to lift the fixture 22 sufficiently from the support surface 36 actually to float thereon as long as air under pressure is being supplied to the distribution chamber 32. With the loaded fixture 22 thus floating on the support or table 30, the effects of the weight of the loaded fixture and its friction on the support are eliminated to all practical intents and purposes, and an operator may thus move even a very heavy loaded fixture on the support 30 with very little effort. After the workpiece is properly positioned, the air valve 40 is closed and the fixture comes to rest on the underlying table.

As previously indicated, the air supply for the manifold 32 need be only under comparatively small compression, for example, the compressed air pressure normally used in industrial plants. Nevertheless, due to the resistance to flow encountered by the air in the air film between the plane machined support and fixture surfaces 36 and 42, and despite some drop in pressure of the air jets supplying the air film from the pressure of the air supply in the distribution chamber 32, the integral of the pressure of the air film is sufficient to air-float the loaded fixture 22. Consequently, the number of jets applied at spaced points on the table 30, each to supply an appropriate portion of the air film over the overall area of the surface 42 of the loaded fixture 22, combine to sustain the air film for the necessary lift of the loaded fixture from its support 30, air from the film constantly escaping therebetween.

The efficiency of the load lifting performance of the present equipment under a given pressure increases, within limits, with the reduction in the cross-sectional area of the individual air ducts 34. Hence, it is important from this standpoint, and especially from the standpoint of obtaining a constant adequate compressed air supply with the lowest-power, smallest size and lowest cost equipment and achieving the load lift with the least consumption of work-performing compressed air, to make the cross-sectional area of these individual ducts as small as practicable, keeping in mind that the cross-sectional area of these ducts must not be so exceedingly small that the friction of the air jets on the duct walls causes an undue drop of pressure of the former. The objective of making these air ducts of the smallest permissible cross-sectional area prevails even if the load to be lifted from its support sufficiently to air-float thereon is an exceptionally great one, for it is the minute cross-sectional dimension of these ducts which is largely responsible in achieving the above-described economic performance of the equipment, whereas the magnitude of the load to be lifted may conveniently be accommodated by proper selection of the number of air ducts and their spacing from each other. In order that the table 30 may have great structural strength despite the provision of the air chamber 32 therein, it is also important that the minute

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cross-sectional areas of these ducts are maintained at least to a substantial depth.

Referring now to FIG. 2 in detail, there is shown a machine tool 44 provided with a fixture or work holding jig 46 which is constituted by a turret mounted for rotary indexing movement on a stud 43 on a fixed base 50. The turret 46 has conventional means to secure or clamp the workpiece 52 in position thereon for the subjection of the workpiece to a machining operation, in this instance to drilling by horizontally reciprocable multiple drills 54.

The turret 46 is mounted for rotary movement on a stationary table or support 56 provided on the base 50. Pursuant to the present invention, the loaded turret 46 may, despite its comparatively heavy weight, be readily indexed on the table 56 by being air-floated thereon. In this connection, the table or air lift means 56 has a circular distributing chamber or manifold 53 provided therein, a conduit or air pipe 60 with a shut-off valve 62 connecting the manifold to an air supply under comparatively low compression. The relatively long air passages or ducts 64, of minute cross-sectional areas extend upwardly from the manifold 53 to the upper surface 66 of the table 56.

As in the previously described embodiment, the valve 62 is opened to produce a plurality of air jets which create and sustain between the upper surface 66 of the table 56 and the bottom surface 68 of the turret 46 an air film which will lift the latter above the support 56. With the turret floating slightly above the underlying support, the turret may readily be indexed, without any real effort or force, the air from the air film constantly escaping between the confronting turret and support surfaces, as in the previously described example. After the turret is indexed to properly align the workpiece 52 with the tools 54, the valve 62 is closed and the turret reseats on the support.

As previously indicated, economic performance of the load-lifting or floating equipment requires very fine air ducts or passages. For many applications, it is necessary to provide these ducts or air passages in rigid members formed of hard metal or of a material which is exceedingly resistant to penetration by very small diameter drills which normally would be required to drill these fine ducts. In any event and regardless of the resistance to drilling of the material of the rigid member, the further requirement that the minute cross-sectional areas of these air ducts be maintained to a considerable depth for adequate structural strength of this member makes it all the more difficult to drill these ducts because of the well known and uncontrollable tendency of very fine drills to wander off-center in the process of drilling. Pursuant to the present invention, provision is made to provide these ducts in members made of such hard or otherwise drill-resistant materials, without encountering any difficulties whatsoever.

Referring now to FIGS. 3 and 4 in detail, there is illustrated a support table or track 70 pursuant to the present invention. As here shown, the support 70 is in this instance of rectangular configuration for use, for example, as the support table or track in the previously described machine tool 20. The table 70 comprises a plate 72 formed of relatively hard steel, cast iron, or other material suitable for its intended use, which materials are too hard, or the table formed thereof is too thick, to be drilled with very small drills which would be required to form the cross-sectional minute and relatively long air ducts therein, as previously described.

The plate 72 is provided at its upper or load-support surface 74 with a continuous groove 76 which, as here shown, is of serpentine outline. The groove 76 is open at one end thereof, as at 78, at one side of the plate 72, and is closed at the other end thereof, as at 80. A conduit or air pipe 82, which has relatively small wall thickness and may, if desired or feasible, be formed of relatively soft material, such as, for example, and not by

way of limitation, copper or other easily drillable material, is press-fitted, or otherwise disposed within the groove 76, with one end of the conduit projecting from the plate 72, as at 84. It will be noted that the diameter of the conduit is substantially less than the depth of the groove 76, the groove being filled above the conduit with a suitable molten metal filling 86, having a relatively low melting point, which is cast over the conduit to secure the latter in position within the groove. For a suitable filling material 86, I may use an alloy of zinc, aluminum, copper and magnesium, known as "Kirkite," although other suitable metal alloys having low melting points may be used.

After the metallic filling hardens, the top surface 74 of the plate 72 is planned by a suitable machining operation, such as milling or grinding. The metallic insert 86 is then drilled at spaced intervals, longitudinally thereof to provide the air ducts or passages 88 which extend through the upper surface of the conduit 82. Since at least the metallic insert 86 is formed of relatively soft material and the conduit 82 has in any event relatively small wall thickness, they may be readily drilled with very small drills of the required lengths, without encountering such resistance as would break the drills even on their fast advance into the material or cause them to wander off-center. The projecting end 84 of the conduit 82 may be readily connected to the usual industrial compressed air supply, as previously described, to provide air jets which pass through the ducts 88. The table or air-lift support 70 may be used to lift a loaded fixture in the same manner as the previously described air-lift table 30.

Referring now to FIGS. 5 through 8, in detail, there is illustrated a modification of the embodiment of FIG. 3, which is shown in connection with an air-lift table of a rotary indexing device, as described in connection with FIG. 2. As here shown, provision is made for a circular air-lift table or support 90 comprising a circular plate 92 of a suitable metal or other material of the required hardness. The plate 92 is formed, in its upper surface 94, with a spiral groove 96. One end of the groove 96 is open at the periphery of the plate 92, as at 98, and the other end is closed as at 100. The plate 92 is, in the present instance, formed with integral projections or lugs 102 which extend into the groove 96, as best illustrated in FIGS. 6 and 7. A conduit or air pipe 104, similar to the previously described conduit 82 in FIGS. 3 and 4, is inserted into the groove 96, being forced under the lugs 102 (FIG. 7) which serve permanently to retain the conduit in position within the groove. It will be noted in FIG. 7 that the conduit 104 is, in consequence of its being forced past the lugs 102, partially deformed or constricted where it underlies the latter, but the conduit is there sufficiently open to permit air flow therethrough. It will be understood that the inner end of the conduit is preferably closed and abuts the closed groove end 100, while the other open end of the conduit projects outwardly of the open groove end 98.

As in the embodiment of FIG. 3, a suitable filler of low melting metal alloy is cast in the groove 96 over the conduit 104, as at 106 (FIG. 8). After the metal filler 106 is hardened and the upper surface 94 suitably planed, fine drills are used to drill through the filler into the underlying conduit to form the air ducts 108 at spaced intervals along the spiral filler 106. With the projecting end (not illustrated) of the conduit 104 connected to a compressed air supply, the circular air-lift table 90 may be used in the rotary indexing apparatus 44 in lieu of the table 56 thereof, to raise the loaded fixture or turret 46 sufficiently for rotary indexing movements thereof.

It will be noted that the conduits 82 and 104 of FIGS. 4 and 8 constitute air distribution chambers or manifolds for their respective air ducts and function in the same manner as the previously described chambers or manifolds 32 and 58.

Referring now to FIG. 9, in detail, there is illustrated

another embodiment of the present invention, pursuant to which the necessity for drilling the air passages is obviated. Pursuant to the present embodiment, a work-holding fixture or jig 110 is mounted for relative movement on a stationary support or track member 112. A separate air-lift base member or plate 114 is in this instance bolted at 118 to the bottom surface 116 of the fixture 110. The member 114 is recessed, as at 120, in its upper surface 122 to define an air distribution chamber or manifold 124 between the recessed portion 120 and the overlying jig surface 116. It will be understood that the chamber 124 is connected to a compressed air supply in a suitable manner, for example as illustrated in FIG. 2.

In addition to having the recess 120 formed therein, the member 114 is provided also with bores 126 which extend from the recess 120 through the opposite or lower surface 128 of plate 114. Air permeable or porous plugs 130 are press-fitted into or otherwise secured in the bores 126. These plugs may suitably be formed of metal powders, such as for example and not by way of limitation, stainless steel powder, copper powder, bronze powder, or other suitable metallic powders. In forming the plugs, the metal powder may be compacted and sintered at pressures below that which will produce air-impermeable compacts. The compacting pressure may be adjusted or pre-set to provide a predetermined air permeability to obtain desired air-flow characteristics for the plugs.

Compressed air admitted into the chamber 124 will flow through the numerous air passages formed in the air-permeable plugs 130 to provide numerous extremely fine air jets issuing from the bottom surfaces of the plugs. These air jets will be much finer than air jets produced by drilled air ducts, even using the extremely small diameter drills utilized in the embodiments of FIGS. 4 and 8. The numerous fine air jets will create and sustain between the plate surface 128 and the surface 132 of the support table 112 an air film which will lift the loaded jig 110 with its air-lift plate 114 from the support 112 sufficiently to permit their sliding on the latter without any appreciable exertion of force. After the jig is properly adjusted, the air supply to the chamber 124 is interrupted and the loaded jig becomes resealed on the support.

The plugs 130 may be provided in a single plate 114 secured to the jig 110, or a plurality of plugged plates 114 may be provided on a single overlying plate or jig 110, depending upon the area to be covered. It will be readily apparent that the present embodiment may be employed where a linear adjustment or movement is to be obtained, as in FIG. 1, or where a rotary movement or adjustment is to be obtained, as in FIG. 2.

Referring now to FIGS. 10 through 12, in detail, there is illustrated another embodiment which also obviates the need to drill the air ducts. The present embodiment is similar to that of FIG. 9 in the provision of a jig or fixture 134 having an air-lift plate or member 136 secured to the bottom thereof as by bolts 138, which member is disposed on a stationary support or track 140. The member 136 has an air distribution chamber or manifold 140 defined therein, which is connected to a compressed air supply through a shut-off valve, as previously described.

Member 136 is provided with a plurality of bores 142 which extend from the chamber surface 144 through the lower surface 146 of said member, as best illustrated in FIG. 12. An air-impermeable plug 148 is press-fitted into each bore 142. Each plug 148 is suitably provided, at its periphery, with a longitudinally extending notch or recess 150 which defines, with the adjacent surface of the bore 142, an air duct or passageway 152 between chambers 140 and surface 146 when the plug is disposed within the bore.

It will be understood that the cross-sectional areas of the notches 150 are quite small so as to define the

required cross-sectionally minute air passages. In order to prevent these ducts or air passages from being blocked due to possible deformation of the notches 150 when the plugs are inserted in the respective bores 142, a wire element 154 of a size substantially to fit the notch in each plug 148 is placed therein before the plug 148 is forced into its associated bore (FIG. 12). The wire element 154, which may be formed of any suitable material characterized by low elastic limit and relatively high tensile strength, remains within the notch in a plug until the latter is fully inserted in its receiving bore. Thereafter the wire element is retracted from the notch to leave the latter as a clear air duct 152 (FIGS. 10 and 11). The fixture 134 provided with the air-lift plate or member 136 will operate in the same manner as the fixture 110 when compressed air is admitted into the chamber 140 and flows through the air ducts 152.

Under certain conditions, characteristics other than the great strength of metal, may be required of an air-lift table or support. For example, it may be desirable to have an air-lift table which is relatively light in weight, or highly resistant to abrasion, or non-magnetizable, or resistant to electrical current flow, or a good thermal insulator. Under such circumstances, an air-lift table 156 (FIG. 13) may be provided which comprises complementary plates 158 and 166 of which at least the thinner plate 166 through which the air ducts 174 are to extend is made of a material having any one or more of the above-mentioned desired characteristics. Thus, if the air-lift table 156 should have very low weight and the plate 166 should be highly resistant to abrasion, or non-magnetic, or a poor thermal conductor, the plate 166 may, for example, be made from laminated glass fiber cloth into which the air ducts 174 of minute cross-sectional areas may readily be drilled. The fiber glass layers of the plate 166 may readily be bonded together, and the plate 166 bonded to the plate 158 as at 163, with either thermoplastic or thermo-setting resins, as is well known to those skilled in the art.

While the present invention has, by way of example, been illustrated and described in connection with the shifting of a work load on a support of a machine tool, its utility and application is by no means limited thereto. In this connection, an important application of the present invention may reside in its utility for readily and quickly rotating a gun turret on a battleship or on a combat tank.

Referring now to FIG. 14, in detail, there is illustrated a tank 176 provided with a conventional rotary gun turret 178. The turret 178 may have a conventional rotary mount rotatable relative to an underlying stationary support. An air-lift assembly, as in FIGS. 2 and 8, for instance, may be mounted on the stationary support, or the air-lift assembly may be provided on the bottom of the rotatable mount, as in FIGS. 9, 10 and 13. In either case, air would be admitted to float the rotary mount above its stationary support, as previously described. This arrangement will provide a gun turret which is practically noiseless when rotated, requires much less power to effect its rotation, and would eliminate such wear on the parts as would normally occur in the case of a mechanical bearing used to effect the rotation of the turret.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

What is claimed is:

1. In combination, a support member, a load carrier member disposed in normally surface-to-surface contact on said support member and mounted for movement

thereon, one of said members having defined therein an air chamber and at least one opening which extends from said air chamber to the contacting surface thereof, an air-impermeable plug filling said opening and being peripherally notched to define an air duct with the bonding surface of said opening, said air duct being in communication with said air chamber and extending to the contacting surface of said one member, and said one member having provision to connect said air chamber to a compressed air supply whereby to provide a fine air jet issuing from said duct and creating and sustaining between the contact surfaces of said members an air film to float the load carrier member above the support member when compressed air is admitted to said chamber.

2. The combination defined in claim 1, further characterized in that said one member is the load carrier member and the latter has a plate secured to the bottom thereof, the bottom surface of said plate constituting the contacting surface of the load carrier member, and said plugged opening is provided in said plate to direct the air jet against the contacting surface of the support member.

3. An air lift device comprising a member having an air distribution chamber defined therein between opposite surfaces thereof and adapted for connection to a compressed air supply, said member having bores defined therein which extend from said chamber to one of said surfaces, and plugs of air impermeable material filling said bores, said plugs being peripherally notched longitudinally thereof to define air ducts, each of minute cross-sectional area, between said chamber and said one surface.

4. An air lift device as defined in claim 3, further characterized in that said member is formed by two plates which are secured together and define the air chamber therebetween, said bores and said air impermeable plugs being provided in one of said plates.

5. The method of manufacturing an air lift device formed of relatively hard or drill-resistant material and provided with relatively fine air passages, said method comprising providing a member formed of relatively hard material having an air chamber and bores extending from a surface thereof to said chamber, providing plugs which are peripherally notched longitudinally thereof, and tightly inserting the plugs into the bores, with a removable wire element positioned in each notch, and withdrawing the wire elements from the inserted plugs.

6. An air lift device comprising a pair of rigid members bonded together in surface-to-surface contact, one of said members having air distribution means defined in the contacting surface thereof and adapted for connection to a compressed air supply, and the other of said members having bores of minute cross-sectional areas defined therein which communicate with said air-distribution means and extend to the opposite surface of said other member, and at least the latter is formed of bonded layers of glass fibers.

7. In combination, a support member, a load carrier member above and mounted for movement with its lower surface on the upper surface of said support member, said support member being formed of relatively hard metal and having a groove in said upper surface, conduit means positioned in the bottom of said groove, said conduit means having a diameter less than the depth of said groove, a plurality of lugs provided on said support member and extending into said groove above said conduit means to retain said conduit means in said groove, and a metallic insert of relatively low melting point filling said groove above said conduit means for securing the latter in said groove, said insert having a plurality of fine bores extending therethrough and being in communication with the interior of said conduit means, said conduit means being adapted for connection to a compressed air supply, to thereby provide relatively fine air jets issuing from said support member for creating and sustaining between the upper surface of said support member and the lower surface of said load carrier member an air film to float said

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carrier member above said support member when compressed air is admitted to said conduit means.

8. An air lift device comprising a member having a groove in one surface thereof, a conduit disposed in the bottom of said groove and adapted for connection to a compressed air supply, the diameter of said conduit being less than the depth of said groove, lug means provided in said groove above said conduit to retain said conduit in said groove, conduit securing insert means filling said groove between said conduit and said surface, and a plurality of air ducts, each of minute cross-sectional area, extending through said insert means to said surface and being in communication with the interior of said conduit.

9. The method of manufacturing an air lift device formed of relatively hard drill-resistant material and provided with relatively fine air passages, said method comprising forming a surface groove in a member of relatively hard material, providing retaining lugs on said member which extend into said groove, locating a conduit in said

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groove by forcing said conduit past said lugs to thereby partially deform said conduit in the regions of contact with said lugs, positioning said conduit away from said surface, filling said groove between said conduit and said surface with a readily drillable material, and drilling with a fine drill through the filling material into said conduit.

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