

[54] **ABRASIVE CLEANING**

[75] Inventor: Samuel K. Taylor, Cleveland, Ohio

[73] Assignee: Acme-Cleveland Corporation,
Cleveland, Ohio

[22] Filed: Aug. 5, 1971

[21] Appl. No.: 169,261

[52] U.S. Cl. 51/17, 51/317

[51] Int. Cl. B24b 31/00

[58] Field of Search..... 51/17, 7, 317, 318

[56] **References Cited**

UNITED STATES PATENTS

3,521,412	7/1970	McCarty.....	51/7 X
3,584,419	6/1971	Hulet et al.....	51/7
3,583,103	6/1971	Rystrom.....	51/7

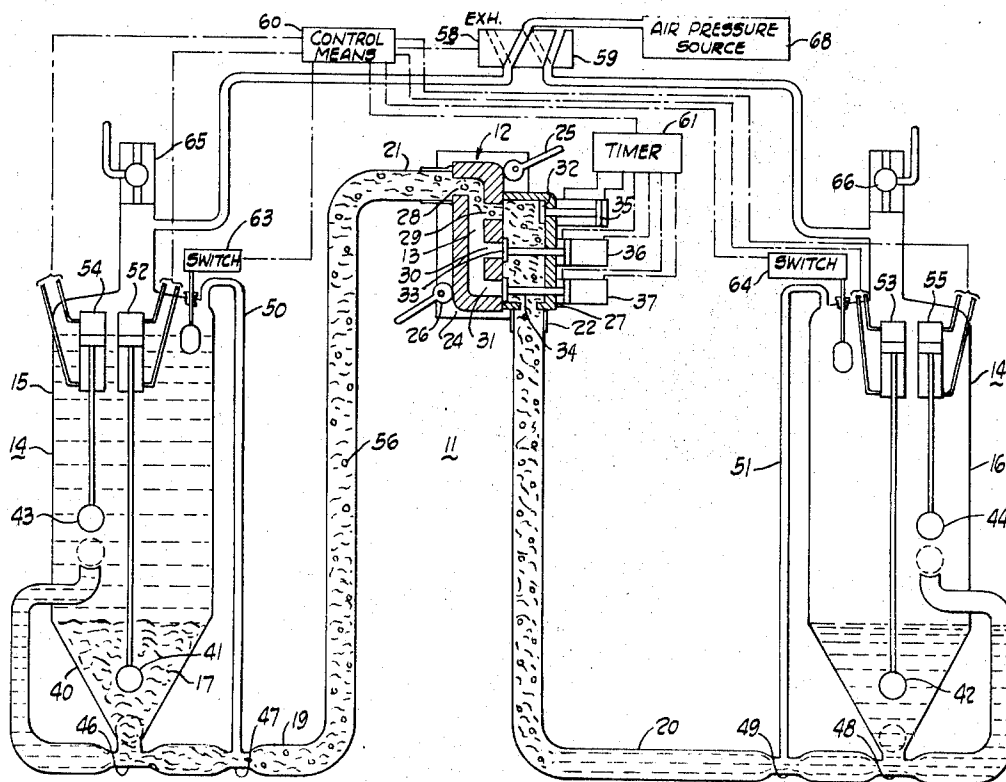
Primary Examiner—Jr. Jones

Attorney—Woodling, Krost, Granger & Rust

[57] **ABSTRACT**

Abrasive and a fluid are mixed and supplied from a container to a first part of a workpiece to be cleaned and then returned to the container means. The abrasive cleaning is accomplished by reversing the flow of the fluid and abrasive mixture to direct the mixture to a second part of the workpiece and the cleaning is also effected by utilizing the mixture of air and a liquid as the fluid carrier of the abrasive. This mixture is used to clean metal castings or to debur machined metal parts. The foregoing abstract is merely a resume of one general application, is not a complete discussion of all principles of operation or applications, and is not to be construed as a limitation on the scope of the claimed subject matter.

31 Claims, 4 Drawing Figures



3 Sheets-Sheet 1

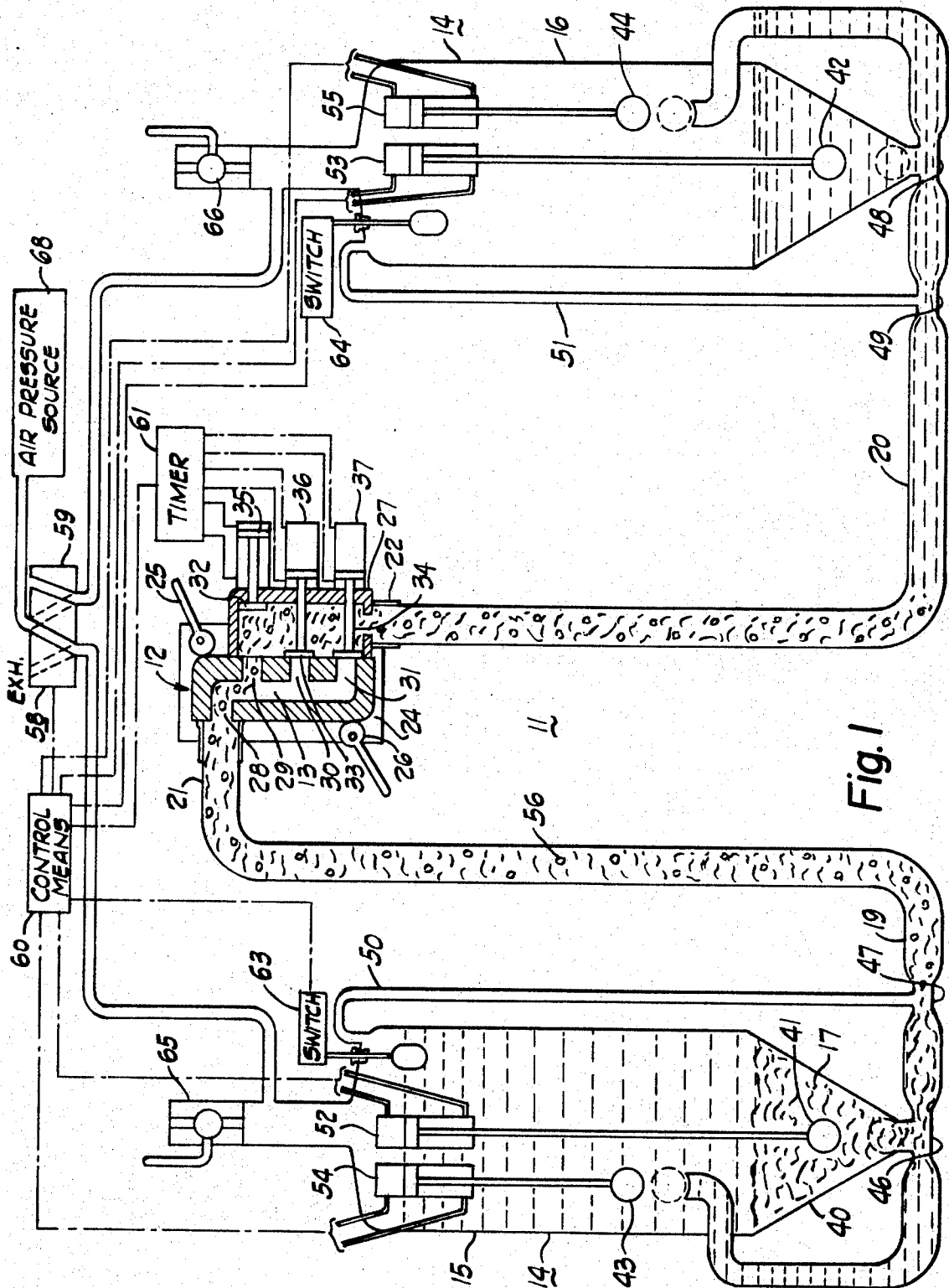


Fig. 1

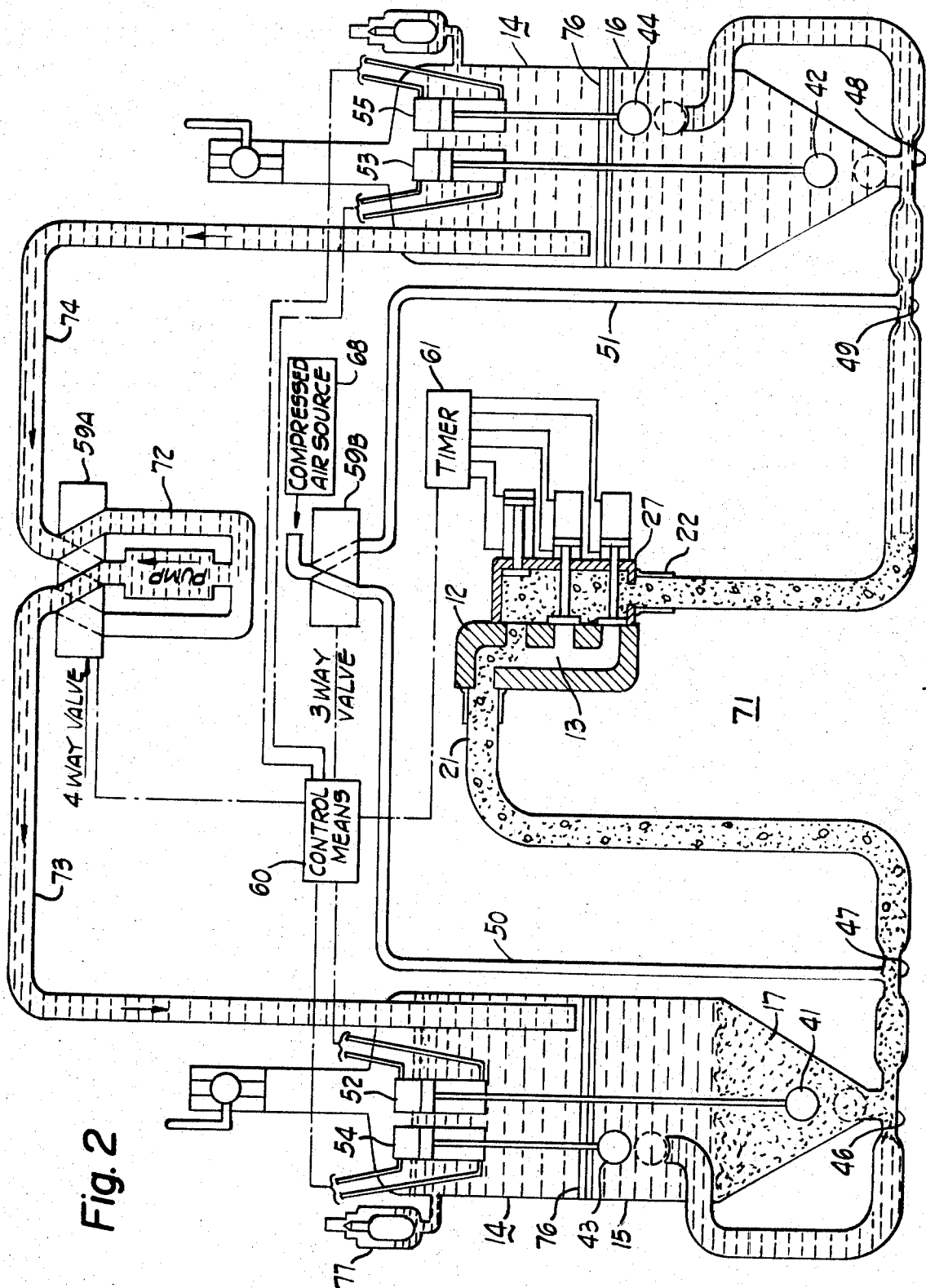


Fig. 3

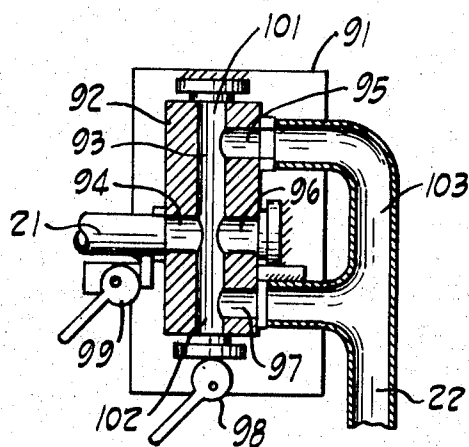
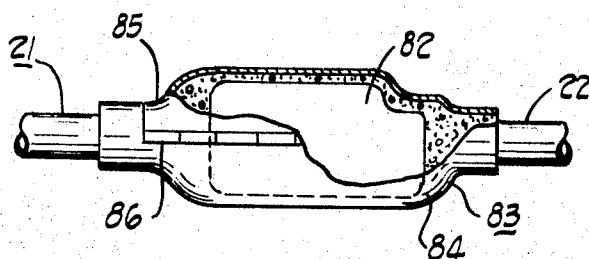


Fig. 4

ABRASIVE CLEANING

BACKGROUND OF THE INVENTION

Casting metal in a temporary mold as distinguished from a permanent mold, is an exceedingly old art. Sand as the temporary mold or form into which the molten metal is cast has been accomplished for centuries. As the art has progressed, man has learned how to make ever more increasingly complex cast metal parts. Typically a drag half and a cope half of a mold are employed with one or more cores in order to produce hollow parts; that is, parts with internal passages. The cope and drag half and the cores have typically been made from sand with some form of a binder to temporarily hold the sand in the desired shape yet the binder will burn out upon the heat of the cast metal and then the sand will be in a more or less loose form to be shaken or broken out of the metal casting.

However, as more complex shapes are cast in metal, it becomes increasingly difficult to clean the sand from the internal passageways. Where two different parts of the core come together it is customary practice to paste together these parts with some form of adhesive. However, the cores themselves are made in some form of a mold, and the mold usually has a draft or a slight taper of one or two degrees. Accordingly, it is usually difficult to have the cores pasted together perfectly without any crevice or projection at the junction. Also in mass production the laborers pasting together the core parts may tend to be careless resulting in less than perfect cores and this results in less than perfect metal castings. The result is a fin or metal flash part of the metal casting projecting into the internal passageway. This is a defect which must later be removed in order to be able to use satisfactorily the casting.

Another form of foreign matter which must be removed is the sand itself which tends to become caked, especially in narrow internal passages or at a bend in such internal passageway.

Another form of impurity which is especially troublesome is what is termed sponge, metal penetration or burn in. This is some of the cast metal which has a spongy appearance and is usually formed because the metal has crept into some imperfections or cavities in the sand core or mold. This may be caused by the hot metal burning away part of the binder and entering the crevices left by the binder. This metal sponge is a large mass of metal with many perforations in it, as distinguished from a thin flash or fin, and thus is especially hard to remove from the internal passages.

The casting of automotive engine cylinder heads with the internal water cooling passages is an example of a complex casting made by mass production in which this problem occurs. Also multiport and multidirectional valve housings are another example and these often have many small internal passageways with many turns and bends therein so that it is often not even possible to visually inspect all of the passageways.

The prior art has met this problem by employing manual labor to use small powered drills to reach down inside the internal passageways and grind or drill away the foreign matter. This hand labor is expensive due to the long time involved and can easily double the cost of the casting itself. Machined metal parts which have burrs left from the cutting tool are another example of metal parts or workpieces requiring cleaning away of foreign matter.

Abrasive cleaning with grit, sand or flint or other particles has been tried. A liquid such as water plus an abrasive such as sand or steel shot has been proposed to clean parts and even to clean off burrs on drilled holes or to clean off flash on castings. Also the use of a venturi for aspiration of an abrasive by liquid jet has been proposed as a means to mix an abrasive and liquid. Often the abrasive strikes the workpiece only once and then is deflected away to utilize its kinetic energy only once.

These proposals have not met with success because the current state of the art is to employ manual labor using tools to grind or drill away the metal flash, metal sponge and hardened particles of sand.

Accordingly, an object of the invention is to provide apparatus for abrasive cleaning which obviates the above-mentioned disadvantages.

Another object of the invention is to provide an abrasive cleaning apparatus which circulates an abrasive and fluid mixture back and forth between two tanks to conserve the abrasive and to reduce the power required to clean a part by conserving the kinetic energy.

Another object of the invention is to provide an abrasive cleaning apparatus wherein air is entrained into a liquid and abrasive mixture in order to more thoroughly agitate the mixture and improve the cleaning performance of the mixture.

Another object of the invention is to provide an abrasive cleaning apparatus which may sequentially clean different parts of a workpiece.

Another object of the invention is to provide an abrasive cleaning apparatus which sequentially passes through a cleaning cycle, a flushing cycle and then a drying cycle.

Another object of the invention is to provide an abrasive cleaning apparatus which directs an abrasive and fluid mixture from a first part to a second part of a workpiece and then alternatively from the second part to the first part of the workpiece, utilizing several times the kinetic energy of each abrasive particle.

SUMMARY OF THE INVENTION

The invention may be incorporated in apparatus for abrasive cleaning of a workpiece, comprising in combination, container means, means for charging said container means with an abrasive, means for mixing a fluid with said abrasive, conduit means including first and second conduits each having a work end, first means connecting said work end of said first conduit to a first part of a workpiece to be cleaned, second means connecting said work end of said second conduit to a second part of any said workpiece to be cleaned, and bidirectional means to direct a fluid and abrasive mixture under pressure from said container means through said first conduit to said first part of any said workpiece to have said abrasive return to said container means via said second conduit and alternatively to direct a fluid and abrasive mixture under pressure from said container means through said second conduit to said second part of any said workpiece to have said abrasive return to said container means via said first conduit.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of the preferred embodiment of the invention;

FIG. 2 is a schematic diagram of a modification of the invention;

FIG. 3 is an elevational view partly in section of a housing to clean the external surfaces of a workpiece; and,

FIG. 4 is a partial view of a modified frame for holding a workpiece to be cleaned.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 of the drawing illustrates the preferred embodiment of the invention, however, many changes may be incorporated therein all within the scope of the hereinafter appended claims. FIG. 1 shows an apparatus 11 for abrasive cleaning of a workpiece 12. In FIG. 1 this workpiece has been shown as having internal passages 13 which need to be cleaned of internal flash, fins, sponge or mold material such as sand. Alternatively, the workpiece 12 could be a machined workpiece with burrs left from the tooling and these burrs need to be removed.

The apparatus 11 includes container means 14 which includes a first and a second tank 15 and 16, respectively. An abrasive 17 is used in the cleaning of the workpiece and this abrasive is shown in the bottom of the first tank 15, and as described below flows to the second tank 16 for a first part of a cleaning cycle and then returns to the first tank 15 for a second part of this cleaning cycle. Conduit means including a first conduit 19 and a second conduit 20 are used to interconnect the first and second tanks 15 and 16. The conduits 19 and 20 have a work end 21 and 22, respectively. Means is provided connecting the work ends of the conduits to the workpiece 12 to be cleaned. This connecting means is shown in the preferred embodiment of FIG. 1 as including a frame 24 with a quick disconnect cam clamp 25 to connect the workpiece 12 to the work end 21 of the first conduit 19. This connecting means also includes a second cam clamp 26 to clamp the workpiece 12 to plural openings of a manifold 27. The workpiece 12 is shown as having openings 28, 29, 30 and 31 with the opening 28 being connected to the work end 21 of conduit 19 and openings 29, 30 and 31 being connected to valved openings 32-34 in the manifold 27. These valved openings can be individual openings in the manifold 27 or can be, as shown in FIG. 1, simply the valves themselves adapted to close off the openings 29, 30 and 31, respectively. Means are provided to actuate these valves 32-34 and this means may be solenoids or as shown in FIG. 1 may be fluid motors 35-37 of the piston and cylinder type. Clamps 25 and 26 are illustrative of any form of connecting means connecting the workpiece to the conduit end 21 and the manifold 27 to prevent any substantial leakage at these workpiece openings.

Each of the tanks 15 and 16 is constructed in the same manner with a funnel shaped lower end 40 to direct the abrasive to an abrasive valve opening at the bottom of the tank. An abrasive valve member 41 and 42 is provided in the first and second tanks 15 and 16, respectively, to close off the flow of abrasive out of the

respective tank. The fluid used to mix with the abrasive 17 includes both a liquid and a gas. The liquid is preferably water although a water soluble oil may be used to replace part or all of the water. The gas is preferably air, for economy. First and second liquid valves 43 and 44 are provided in the first and second tanks 15 and 16. The valve seats for these valves are provided at about one-third the vertical height of each tank to be above the height of the maximum amount of abrasive 17 in each tank.

The conduit 19 leads from the valve seat of the liquid valve 43 through first and second venturis 46 and 47 in series to the work end 21 of this conduit. Each of the venturis 46 and 47 has a throat opening with the throat opening of the first venturi 46 connected to the discharge of the abrasive valve 41. A passageway 50 leads from the top of the tank 15 to the throat opening of this second venturi 47 to supply air under pressure thereto. The second tank 16 is constructed in a similar manner and the second conduit 20 leads from the seat of the liquid valve 44 through first and second venturis 48 and 49 in series to the work end 22 of this conduit. The first venturi 48 is for mixing abrasive into the liquid and the second venturi 49 is for entraining or mixing air 56 into the liquid by means of a passageway 51 leading from the top of tank 16 to the throat opening of the venturi 49. The venturis 46-49 may be considered a venturi means to mix the liquid and gas with the abrasive 17. Means are provided to actuate the valves 41-44 and these may be solenoids, or as shown may be fluid motors 52-55 of the piston and cylinder type.

Bidirectional means 58 is provided in the apparatus 11 to establish a bidirectional flow of fluid from the first conduit 19 to the second conduit 20 and alternatively from the second conduit 20 to the first conduit 19. This bidirectional means 58 includes generally a bidirectional or four-way valve, control means 60, a timer 61, the valve actuators 35-37, the valve actuators 52-55 for the abrasive and liquid valves 41-44, and first and second liquid level switches 63 and 64. The first liquid level switch 63 is mounted for adjustable height in the first tank 15 and the second liquid level switch 64 is mounted for adjustable height in the second tank 16. Manual valves 65 and 66 may be provided at the top of each of the tanks 15 and 16 in order to provide a means to charge the tanks with abrasive and liquid. An air pressure source 68 is provided to supply air under pressure through the bidirectional valve 59 to the top of either tank 15 or 16, under control by the control means 60.

OPERATION

The abrasive cleaning apparatus 11 is capable of performing three different cycles, namely, a cleaning cycle, a flushing cycle and a drying cycle. The cleaning cycle includes a first half cycle wherein water flows from the first tank to the second tank and includes a second half cycle wherein water flows from the second tank 16 to the first tank 15. For the first half of the cleaning cycle the control means 60 conditions the four-way valve 59 so that air under pressure is directed from the air pressure source 68 to the top of the first tank 15, and pressurizes the liquid and the abrasive therein. For this cleaning cycle both liquid valves and both abrasive valves 41-44 are open. Accordingly,

liquid flows through the liquid valve 43 to enter the first conduit 19.

It flows through the first venturi 46 whereat it gradually sucks the abrasive 17 out of the bottom of this tank 15. The abrasive and liquid mixture then passes through the second venturi 47 whereat it entrains air from the air passageway 50. This mixture of liquid, air and abrasive then passes through the conduit 19 to the first part of the workpiece 12. As shown in FIG. 1 this workpiece has internal passages 13, which preferably are rather small compared to the diameter of the conduits 19 and 20. Accordingly, the velocity of the flow of abrasive is increased as it flows through the workpiece 12. This hastens the removal of any foreign objects such as fins, flash, sponge and hardened foundry sand. The entrainment of air in the mixture has been found to create a turbulence and a tumbling of the abrasive to make the abrasive follow a random path rather than following a similar path for successive abrasive particles, and this random path has been found to better reach all of the intricate internal portions of the internal passageway 13.

During the first half of the cleaning cycle the timer 61 sequentially opens the valve openings 32-34 and preferably this sequence is with each of these valves open approximately one-third of the time. This causes the mixture to flow sequentially through each of the valved openings in the workpiece to be cleaned. During the second half of the cleaning cycle flow is in the opposite direction through the workpiece 12 and flows from a second part of the workpiece to be cleaned toward a first part of the workpiece to which the conduit 19 is connected. During the first half of the cleaning cycle, the abrasive 17 is gradually emptied from the bottom of the first tank 15 by being sucked out by means of the venturi 46. The variable height liquid level switch 63 may sense the liquid descending to a predetermined height to reverse the control means to reverse the directional valve 59. Alternatively, this preferred embodiment utilizes the liquid level switch 64 in tank 16 to sense the fact that the liquid level therein has nearly filled this tank. This applies air under pressure to the top of tank 16 thus starting the second half of the cleaning cycle. During the first half of the cleaning cycle the abrasive has entered the second tank 16 primarily through the liquid valve 44 to now fill this second tank 16 with abrasive about to the level shown in FIG. 1 for tank 15. Then upon the start of the second half of the cleaning cycle, the conditions are reversed and air pressure on the top of the water in tank 16 causes liquid flow out through the liquid valve 44, through venturi 48 where it sucks the abrasive 17 out of the bottom of tank 16 and then passes through venturi 49 wherein it entrains air under pressure from the top of tank 16. This mixture then enters the second end or second part of the workpiece 12 and exits from the first end or first part of this workpiece to return to the first tank 15. Again the timer 61 is sequentially actuated to open the valved openings 32-34 in sequence for thorough cleaning of all of the passageways 13 in the workpiece 12.

These cleaning cycles may continue for as long as necessary, for example, from one to twenty cleaning cycles, and this may be determined by trial and error and inspection of the workpiece to be cleaned. This will

depend upon the size of the part, the complexity of the part as well as the size of the tanks 15 and 16 and their capacity for water and abrasive. Alternatively, a number of cycles may be performed with only the valved opening 32 open, and then a number of additional cleaning cycles may be performed with only the valve 33 open and finally a number of cycles may be performed with only the valve 34 open.

After all passages have been cleaned with the water, abrasive and air mixture, the control means 60 causes the abrasive valve 41 and 42 to be closed in both tanks. It was at first thought that the abrasive valves had to be closed in sequence only when that particular tank was free of abrasive, but in apparatuses constructed in accordance with the invention it has been found surprisingly that the valves may be closed, or will completely close after a few cleaning cycles, even though abrasive is contained in the bottom of that particular tank. This is true even though the abrasive contains a number of sharp particles and particles of different sizes for example, sand, flint and steel shot up to $\frac{3}{8}$ inch diameter. The reason for this easy closing of the abrasive valves 41 and 42 is believed to be because the abrasive 17 is immersed in the liquid and this liquid is under a uniform pressure both from the top and the bottom because of liquid under pressure communication through the liquid valve 43 and the tank end of this conduit 19.

With the abrasive valves 41 and 42 closed and the liquid valves 43 and 44 open, only liquid such as water is now circulated back and forth through the workpiece 12 from tank to tank. The valves 32-34 sequentially open and close as controlled by the timer 61 to flush abrasive from all of the passages in the workpiece 12.

If the liquid is omitted entirely in the apparatus 11, then just a fluid such as air is circulated back and forth through the workpiece 12. In this case the passages 50, 51 and venturis 47 and 49 may be omitted, or may be retained but non-functional, with the air entraining the abrasive by means of the venturis 46 and 48. In this case the cycle times would be controlled by a timer rather than the level switches 63 and 64.

To increase the abrasive velocity in the workpiece 12, air or water may be injected or pulsed under higher pressure and at the inlet or outlet ports or at one of the blocked off ports of the part or workpiece to be cleaned.

Following the flushing cycle, a drying cycle is provided by the control means 60. This control means may be a programmer to sequentially effect the cleaning, flushing and drying cycles. During this flushing cycle air alone passes back and forth or only in one direction from tank to tank and this is accomplished by closing the liquid valves 43 and 44. Under these conditions air passes through passageway 50 into conduit 19 to enter the first end or first part of the workpiece 12 and exit from the second end or second part of the workpiece to return to the second tank 16 via the passage 51. Air is exhausted through the open port of the four-way valve 59. A second half of this drying cycle may be performed where air enters the top of tank 16 and this circulates air in the opposite direction through a workpiece 12 to dry it out to prevent any rusting. In the preferred embodiment, it usually has been found that cycling back and forth of the air is not necessary to

blow the liquid out of the workpiece 12, so only one direction of air movement is used. Again the timer 61 sequentially opens the valves 32-34 to dry each of the openings 29-31, respectively. This drying cycle also helps to remove any foreign material that might remain after the flushing cycles. Also when a part or workpiece is being dried by passing air through selected inlet and outlet ports, the ports that have been blocked off may at this time be opened to atmosphere and air blown out of these ports.

FIG. 2 shows a modification of apparatus 71 which is similar to the apparatus 11 and parts which are the same have the same reference numerals. In this apparatus 71 a liquid pump 72 pumps the liquid such as water through a bidirectional valve 59A selectively into passages 73 and 74 leading to the top of tanks 15 and 16, respectively. This provides the pressure fluid to circulate the fluid and abrasive mixture through the workpiece 12. The compressed air source 68 is used to supply air under pressure through a three-way bidirectional valve 59B into passages 50 and 51 so that air is entrained into the conduits at the venturis 47 and 49, respectively. Filters 76 are preferably provided within the tanks 15 and 16 to keep the abrasive 17 out of the pump 72. Air vent valves 77 are provided at the top of each tank in order to remove the air from the tank which is receiving the liquid. In this case the liquid level switches are not provided, and the cycles are controlled by a timer within the control means 60.

FIG. 3 shows a part or workpiece 82, the external surface of which is being cleaned by the abrasive. A multipart housing 83 shown as having two parts, houses the workpiece between the ends 21 and 22 of the conduits 19 and 20. In this case the housing 23 has a lower half 84 and an upper half 85 connected thereto by a hinge 86. This permits ready insertion and removal of the workpiece 82. Internal passages may also be cleaned in this housing 83 where the part 82 has a sufficiently straight through internal passageway.

FIG. 4 shows an alternative frame 91 for holding a workpiece 92. This workpiece 92 has an internal passageway 93 and a plurality of openings 94-97. In this case of FIG. 4 a manifold with sequentially valved openings is not provided, instead, the work end 21 of conduit 19 is supplied to one opening 94 and two of the openings 95 and 96 are connected to a T-connection 103 directly to the work end 22 of the conduit 20. The frame 91 may include a clamp 98 to clamp the workpiece 92 in the frame 91 and also to block off openings 101 and 102. A clamp 99 may be provided to clamp the workpiece 92 in the frame 91 to clamp the conduit work end 21 to the workpiece opening 94, to clamp the workpiece opening 95 and 97 to the conduit work end 22 and to block off the workpiece opening 96. Experience in apparatus constructed according to the invention has shown in many instances a complicated workpiece with a plurality of openings may be cleaned successfully by directing the fluid and abrasive mixture through selected two, three or four of the openings. If the openings selected are those which are most likely to be partially obstructed by foreign matter, then the cleaning is most apt to be successful. Also if the fluid is directed to those of the plural openings through which the mixture must flow through all or most of the bends, twists or turns of the internal passage 93, then the workpiece will be successfully cleaned.

It will be noted that the venturis 46-49 aspirate the abrasive 17 and also aspirate or entrain air or other gas into the mixture. This is possible even though all parts within a particular tank are supposedly at the same pressure. The reason for this is that the venturi establishes a slightly lower pressure at its throat than at the main inlet to the venturi. This slightly lower pressure helps to suck the abrasive or air into the flow of fluid through the venturi.

The flow of abrasive from a first part to a second part of the workpiece, as directed by the internal passageway 13 or 93 or by the housing 83 saves power and abrasive. The abrasive is directed to the opposite tank for reuse. The power saving is because each abrasive particle is used more than once during each half of the cleaning cycle. Each particle is not used just once and then dissipated into the ambient. Its kinetic energy is used many times as it moves along the workpiece, scouring away the foreign matter and smoothing the casting. This multiple use of each abrasive particle better utilizes the kinetic energy thereof, and hence is a saving of power in the proper cleaning of a workpiece.

The present disclosure includes that contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

What is claimed is:

1. Apparatus for abrasive cleaning of a workpiece, comprising in combination,
 - container means,
 - means for charging said container means with an abrasive,
 - means for mixing a fluid with said abrasive,
 - conduit means including first and second conduits each having a work end,
 - first means connecting said work end of said first conduit to a first part of a workpiece to be cleaned,
 - second means connecting said work end of said second conduit to a second part of any said workpiece to be cleaned,
 - and bidirectional means to direct a fluid and abrasive mixture under pressure from said container means through said first conduit to said first part of any said workpiece to have said abrasive return to said container means via said second conduit and alternatively to direct a fluid and abrasive mixture under pressure from said container means through said second conduit to said second part of any said workpiece to have said abrasive return to said container means via said first conduit.
2. Apparatus as set forth in claim 1, wherein said fluid is a liquid.
3. Apparatus as set forth in claim 1, wherein said fluid is a mixture containing air and water.
4. Apparatus as set forth in claim 1, wherein said mixing means includes a venturi.
5. Apparatus as set forth in claim 1, wherein said charging means includes manual valve means to permit entrance of abrasive and fluid to said container means.
6. Apparatus as set forth in claim 1, wherein said container means includes first and second tanks,

and said bidirectional means directs a fluid and abrasive mixture from said first tank to said second tank and alternatively from said second tank to said first tank.

7. Apparatus as set forth in claim 1, including an air pressure source,
and said mixing means including means to entrain air into abrasive in said first conduit.

8. Apparatus as set forth in claim 7, wherein said mixing means includes means to entrain air into abrasive in said second conduit.

9. Apparatus as set forth in claim 1, including an air pressure source,
and said mixing means including means to mix abrasive and a liquid and means to entrain air into said first conduit to mix with said liquid and abrasive mixture therein.

10. Apparatus as set forth in claim 9, wherein said mixing means includes means to mix abrasive and a liquid and means to entrain air into said liquid and abrasive mixture in said second conduit.

11. Apparatus as set forth in claim 1, wherein said mixing means includes a venturi having a throat opening,
and means connecting said throat opening to said container means to aspirate abrasive from said container means into said conduit means.

12. Apparatus as set forth in claim 1, including an air pressure source,
and wherein said mixing means includes a venturi connected in said conduit means with the throat opening of said venturi connected to said air pressure source to aspirate air into said conduit means.

13. Apparatus as set forth in claim 1, wherein said fluid includes a liquid,
said mixing means includes an abrasive valve in said container means,
a liquid valve in said container means positioned therein above the highest level of abrasive in said container means,
first and second venturis for said container means and each having a throat opening,
means connecting the throat opening of said first venturi to the outlet of said abrasive valve,
an air pressure source,
and means connecting the throat opening of said second venturi to said air pressure source to obtain a mixture of liquid, abrasive and air in said conduit means.

14. Apparatus as set forth in claim 1, wherein said fluid includes a liquid,
said container means includes first and second tanks,
said bidirectional means including first and second liquid level switches in said first and second tanks, respectively,
and control means connected with said switches to control the direction of the liquid and abrasive mixture flow in said bidirectional means.

15. Apparatus as set forth in claim 1, wherein said workpiece has at least two openings to internal passages,
said first connecting means including means connecting said work end of said first conduit to a first opening in a workpiece,
and said second connecting means including means connecting said work end of said second conduit to a second opening in any said workpiece.

16. Apparatus as set forth in claim 1, wherein said fluid is air.

17. Apparatus as set forth in claim 1, wherein said workpiece has a plurality of openings to internal passages,

said second connecting means includes a manifold having a master opening and a plurality of valved openings connected to a plurality of openings in any said workpiece to be cleaned,
means to actuate said valved openings,
said work end of said second conduit being connected to said master opening,
and control means in said bidirectional means to alternatively actuate said valve openings to alternatively direct fluid and abrasive mixture through different openings in any said workpiece.

18. Apparatus as set forth in claim 17, wherein said control means in said bidirectional means includes timer means to sequentially actuate said solenoid valves during each portion of the cycle to sequentially clean each of the openings in the workpiece.

19. Apparatus as set forth in claim 1, including an air pressure source,
said fluid including a liquid,
first and second tanks in said container means,
said bidirectional means including first and second liquid level switches in said first and second tanks, respectively,

bidirectional valve means in said bidirectional means,
and control means connecting said switches to control actuation of said valve means to direct air under pressure into said first tank to circulate liquid and abrasive mixture from said first conduit to a first part of a workpiece to be cleaned and to said second tank via said second conduit,
and said second switch controlling said control means and reversing said valve means upon the liquid level in said second tank ascending to the level of said second switch to thus circulate liquid and abrasive from said second conduit to said second part of said workpiece and return to said first tank via said first conduit.

20. Apparatus as set forth in claim 19, including an air passageway from the top of said first and second tanks to said first and second conduits, respectively, to entrain air in said liquid and abrasive mixture.

21. Apparatus as set forth in claim 1, including an air pressure source,
said fluid including a liquid,
first and second tanks in said container means,
said bidirectional means including an abrasive valve and a liquid valve for each of said first and second tanks,
bidirectional valve means in said bidirectional means,

control means in said bidirectional means opening both of said abrasive valves and both of said liquid valves and directing air pressure by said bidirectional valve means into said first tank to circulate liquid and abrasive from said first tank to a first part of a workpiece to be cleaned and to said second tank via said second conduit,
said control means reversing said valve means to direct air pressure into said second tank to thus circulate liquid and abrasive mixture from said

second conduit to said second part of said workpiece and return to said first tank via said first conduit,

means in said control means to close both said abrasive valves to perform a flushing cycle of liquid only from said first tank to said second tank and then reversing for liquid flow from said second tank to said first tank,

and means in said control means to close both of said liquid valves to perform a drying cycle to have air only pass from said first tank through said conduit means to said second tank.

22. Apparatus as set forth in claim 1, wherein said fluid includes a liquid,

a liquid pump,

bidirectional valve means in said bidirectional means,

first and second tanks in said container means,

said bidirectional means including control means to control actuation of said valve means to direct liquid from said second tank under pressure into said first tank to circulate liquid and abrasive mixture from said first conduit to a first part of a workpiece to be cleaned and to said second tank via said second conduit,

and said control means reversing said valve means to thus circulate liquid and abrasive from said second conduit to said second part of said workpiece and return to said first tank via said first conduit.

23. Apparatus as set forth in claim 1, including an openable housing within said conduit means, and means in said housing to hold a part to be cleaned by said abrasive on the external surfaces thereof.

24. Apparatus as set forth in claim 1, wherein said workpiece has at least three openings to internal passages,

said first connecting means including means connecting said work end of said first conduit to a first opening in a workpiece,

and said second connecting means including means connecting said work end of said second conduit directly to a second and a third opening in any said workpiece.

25. Apparatus for abrasive cleaning of a workpiece,

comprising in combination,

container means,

means for charging said container means with an abrasive,

conduit means having a work end,

means connecting said work end of said conduit means to a first part of a workpiece to be cleaned,

a source of liquid,

an air pressure source,

means to mix abrasive from said container means with a liquid from said liquid source and direct it to said conduit means,

and means in said mixing means to entrain air from said air pressure source into said conduit means to direct a mixture of liquid, air and abrasive through said conduit means to said first part of any said workpiece.

26. Apparatus as set forth in claim 25, wherein said mixing means includes venturi means.

27. Apparatus as set forth in claim 25, wherein said mixing means includes first and second venturis each having a throat opening,

means to direct abrasives to the throat opening of said first venturi,

and means to direct air to the throat opening of said second venturi.

28. Apparatus as set forth in claim 27, wherein said venturis are connected in series.

29. Apparatus as set forth in claim 25, including bidirectional means to direct said mixture of liquid, air and abrasive to said first part of a workpiece to be cleaned and alternatively to a second part of a workpiece.

30. Apparatus as set forth in claim 25, wherein said source of liquid is under pressure from said air pressure source to establish a substantially equal air and liquid pressure on the abrasive mixture at a given time,

and said mixing means including venturi means to establish a lower pressure at the throat of the venturi means to enable entrainment of the abrasive and the air into the liquid.

31. Apparatus as set forth in claim 30, including an air passage from said container means to the throat opening of said venturi means to entrain air into said conduit means.

* * * * *

50

55

60

65