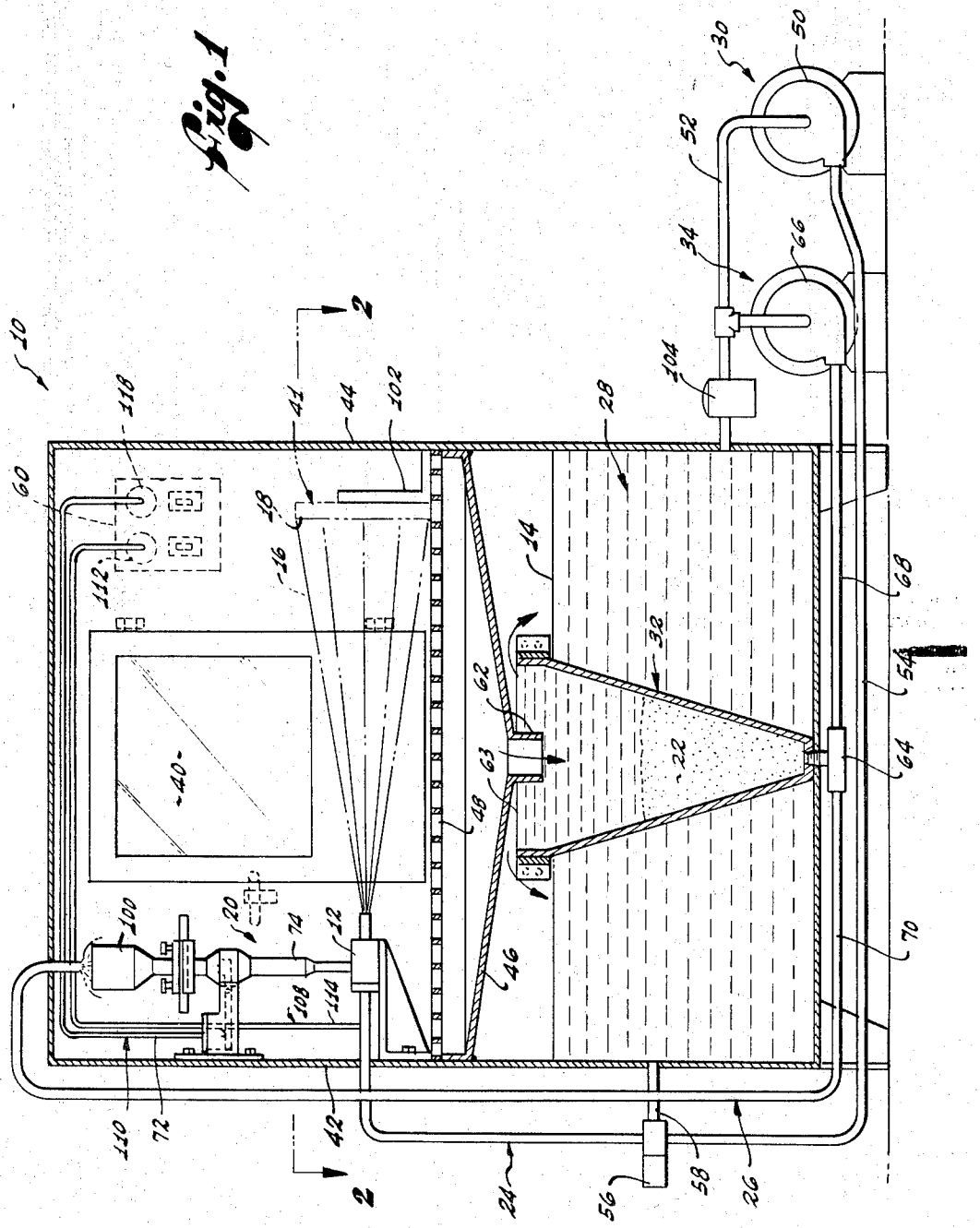
Jan. 12, 1971 B. W. POWER 3,553,895

HYDRAULIC SURFACE CONDITIONING MACHINE

Filed Nov. 20, 1967 3 Sheets-Sheet 1

Fig. 1



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HYDRAULIC SURFACE CONDITIONING MACHINE

Filed Nov. 20, 1967 3 Sheets-Sheet 2

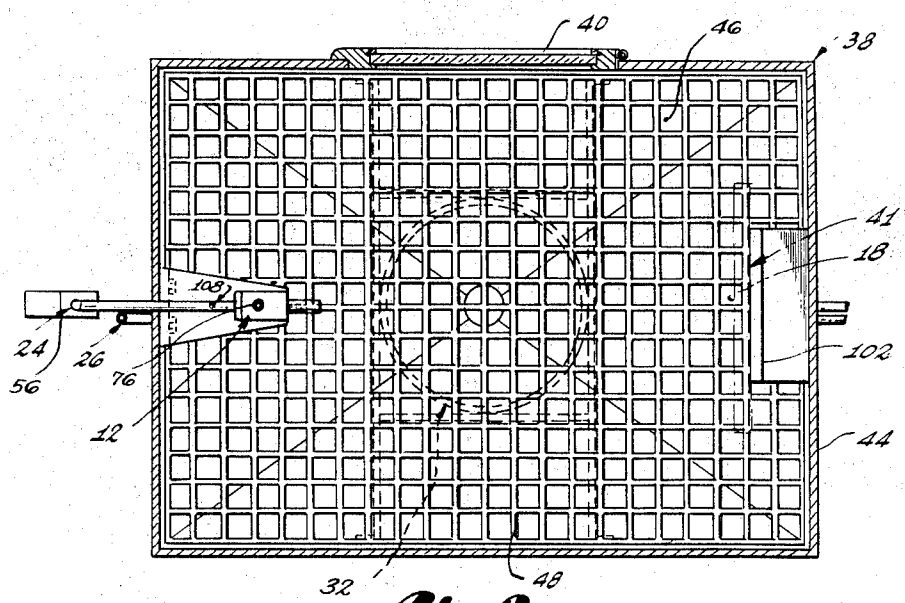


Fig. 2

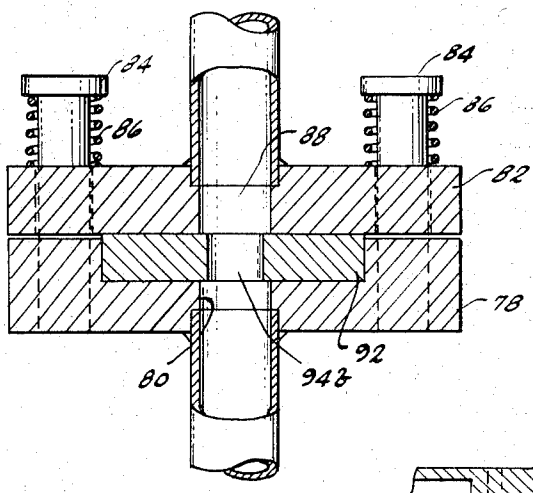


Fig. 4

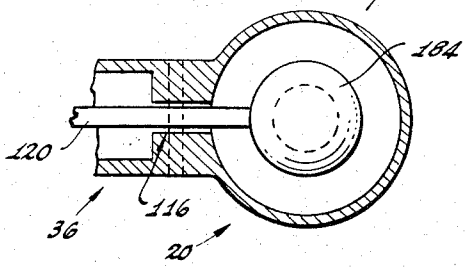


Fig. 5

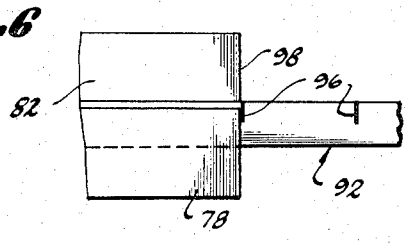


Fig. 6

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Jan. 12, 1971 B. W. POWER 3,553,895

HYDRAULIC SURFACE CONDITIONING MACHINE

Filed Nov. 20, 1967 3 Sheets-Sheet 3

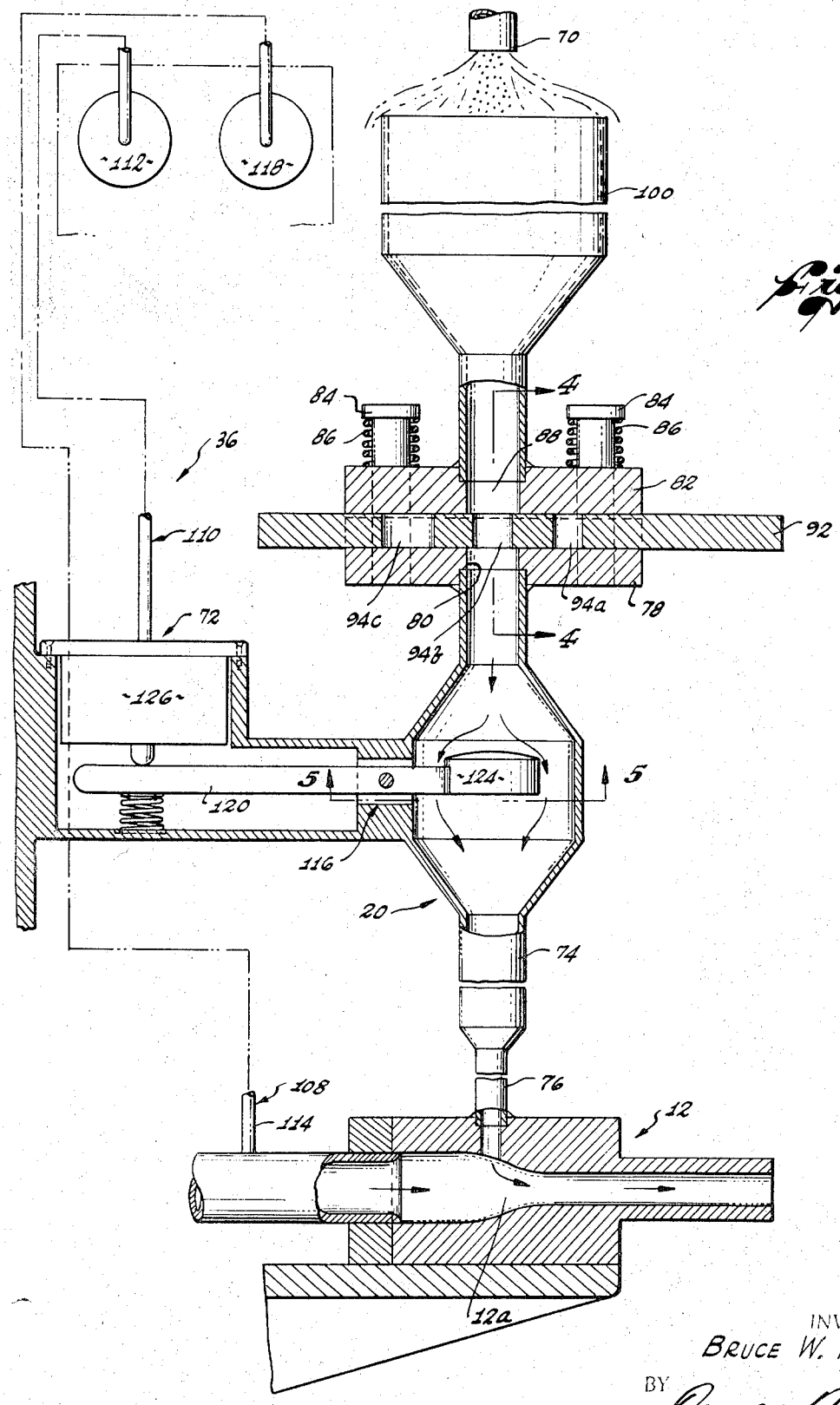


Fig. 3

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3,553,895

HYDRAULIC SURFACE CONDITIONING MACHINE

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Filed Nov. 20, 1967, Ser. No. 684,273
Int. Cl. B24c 3/00
U.S. Cl. 51—8 13 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic method of and a hydraulic machine for conditioning the surface of a work piece wherein a high velocity jet stream of working liquid, such as water, containing entrained surface conditioning media, such as metal pellets, is projected against the surface to work harden, abrade, or otherwise condition the surface, and the spent liquid and media of the jet stream are collected after impingement against the work surface and recirculated to provide a closed cycle surface conditioning action.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to the work surface conditioning art and more particularly to a hydraulic method of and machine for conditioning a work surface by projection against the surface of a high velocity liquid jet stream containing entrained surface conditioning media.

As will appear from the ensuing description, the present surface conditioning method and machine are susceptible of various applications. The invention will be disclosed in connection with two of its principal applications which are shot peening and abrasive finishing.

Prior art

Surface conditioning techniques of the general class described are known in the art. Generally speaking, such techniques involve projection of a high velocity jet stream against the work surface to be conditioned. This jet stream is composed of a working fluid containing surface conditioning media, such as metal pellets or shot. The working fluid serves, in effect, as a vehicle for propelling the media into high velocity impact with the work surface. The surface conditioning media employed in shot peening applications comprise metal pellets which effect work hardening of the work surface by high velocity impact with the surface. The effectiveness of such shot peening techniques is commonly determined with the aid of precision-made flat steel strips of predetermined thickness which are supported in a holder and exposed for a predetermined period of time to a jet stream containing entrained shot peening media. High velocity impact of the media against the exposed surface of such a strip work hardens the surface in such a way that the strip assumes a curvature related to the surface hardness. Accordingly, the surface hardness can be determined by measuring the curvature of the strip. In abrasive finishing applications, the surface conditioning media comprise abrasive pellets which are effective to abraid material from the work surface.

The existing surface conditioning techniques and machines of the kind under discussion are subject to various disadvantages which the present invention seeks to overcome. One of the major disadvantages of the existing surface conditioning techniques and machines, for example, results from the fact that they employ a gas, namely, air, as the working fluid for the jet stream. As a consequence, large and costly compressors are required

to supply the air to the jet stream nozzle at the high volume and pressure necessary to achieve an effective surface conditioning action. Moreover, the use of air as a working fluid creates a serious dust problem and an attendant need for a highly efficient and costly dust recovery system. Another disadvantage of using air as a working fluid resides in the fact that the efficiency of the surface conditioning action is relatively low. This is due to the fact that the air in the jet stream, because of its relatively low density and viscosity, is incapable of accelerating the surface conditioning media to an optimum surface conditioning velocity. The latter disadvantage is particularly undesirable in shot peening applications and substantially prolongs the time required to shot peen a work surface to a given hardness.

Efficient, economical operation of a surface conditioning machine of the kind under discussion requires continuous collection and recirculation of the spent surface conditioning media after impingement against the work surface. This particular requirement presents a problem in the existing surface conditioning machines for the reason that collection of the media and separation of the latter from other foreign matter, such as surface material removed from the work piece, is difficult to accomplish. As a consequence, the media recovery and recirculation means of the existing machines tend to be complex and costly. Moreover, high operating precision, that is, successive reproduction of a given surface condition with a high degree of accuracy, is also extremely difficult, if not impossible, to achieve with the existing surface conditioning machines.

It is evident at this point, therefore, that the existing surface conditioning techniques and machines of the class described are characterized by large size, low operating efficiency, high manufacturing and operating costs, low precision, and high dust emission.

SUMMARY OF THE INVENTION

This invention provides a novel hydraulic surface conditioning machine of the class described which avoid the above noted and other deficiencies of the existing surface conditioning techniques and machines. A major improvement feature of the present invention, for example, resides in the use of a liquid, such as water, as the working fluid for projecting the surface conditioning media at high velocity against the work surface to be conditioned. The use of a liquid working fluid achieves several highly important and beneficial advantages. Among the foremost of these advantages are reduced over-all machine size and cost owing primarily to the reduced size and cost of the pressurizing means, or pumps, required to supply the liquid working fluid to the jet stream nozzle in an optimum flow rate and pressure; high operating efficiency resulting from the relatively high density and viscosity of the liquid working fluid which render the fluid capable of accelerating the surface conditioning media to an optimum surface conditioning velocity; automatic dust control by the liquid in the jet spray without the need for costly dust recovery means; ease of separation of the surface conditioning media from foreign matter; and high operating efficiency.

Another unique feature of the invention is concerned with novel media recovery and recirculation means for recovering the spent surface conditioning media from the liquid jet stream after impingement against the work surface and returning the media to the jet stream. According to this feature, the spent media are collected in a receiver, or hopper, in which the media gravitate after impact with the work piece and from which the media are conveyed to an elevated position above the jet stream nozzle by entrainment in a stream of the working liquid. The media are then separated from the

liquid by a novel decanting action, after which the media gravitate back into the path of the jet stream. As will appear presently, this method of returning the media to the jet stream minimizes energy loss in the stream and interference with the jet stream concentration.

According to yet another of its features, the invention provides shot intensity metering means for continuously metering and monitoring or recording the mass flow infeed rate of the surface conditioning media to the jet stream, as well as the inlet pressure to the jet stream nozzle. This shot intensity metering action provides a permanent record of each surface conditioning run and permits accurate reproduction of any given surface condition. It will be recognized, therefore, that this feature of the invention is particularly beneficial in shot peening and other similar applications in which reproduction, with a high degree of accuracy, of a given surface hardness or other surface condition on a number of successive work pieces is desirable or mandatory.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section through a hydraulic surfacing conditioning machine according to the invention;

FIG. 2 is a horizontal section through the machine taken on line **2—2** in FIG. 1;

FIG. 3 is a vertical section through a media infeed regulating and monitoring means embodied in the machine;

FIG. 4 is an enlarged section taken on line **4—4** in FIG. 3;

FIG. 5 is a section taken on line **5—5** in FIG. 3; and

FIG. 6 is an enlarged fragmentary detail of the media monitoring means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general terms, the invention provides, according to one of its aspects, a hydraulic surface conditioning machine, represented in the drawings by the machine **10**. having a nozzle **12** for connection to a source of working liquid **14** under pressure. In this disclosure, it will be assumed that the working liquid is water. It will become evident as the description proceeds, however, that other working liquids may conceivably be employed in the machine. Nozzle **12** receives water under pressure from the source and projects the water as a high velocity jet stream **16** against the work surface **18** to be conditioned. Media infeed means **20** are provided for feeding a stream of surface conditioning media **22**, such as metal pellets, into the path of the jet stream adjacent its origin, i.e., adjacent the nozzle **12**, in such a way that the pellets are entrained in the jet stream and projected by the latter into high velocity impact with the work surface. As noted earlier, two principal applications of the hydraulic surface conditioning machine are shot peening and abrasive finishing. The surface conditioning media employed for shot peening commonly comprise steel balls having a diameter in the range of 0.0049 to .2500 inch, depending upon the work material to be conditioned and the surface hardness desired. The surface conditioning media employed for abrasive finishing commonly comprise abrasive balls or shot on the order of 0.0017 to 0.1110 inch in diameter.

The particular hydraulic surface conditioning machine illustrated is equipped with water and media recirculation systems **24, 26**. The water recirculation system **24** includes receiving means **28** for collecting the spent water in the jet stream **16** after impingement of the latter against the work surface **18**, and return means **30** for returning the water under pressure to the jet stream nozzle **12**. The media recirculation system **26** includes receiving means **32** for collecting the spent surface conditioning media **22** in the jet stream after impact against the work surface, and return means **34** for returning the media to the media infeed means **20**.

Briefly, during operation of the present hydraulic surface conditioning machine, the water **14** is recirculated in an essentially closed flow path in such a way that the water is projected under pressure from the nozzle **12** to produce the high velocity jet stream **16**. The work surface **18** to be conditioned is located in the path of this jet stream so as to be impinged by the latter. The surface conditioning media **22** are fed, by the media infeed means **20**, into the path of the jet stream **16** adjacent its origin, that is, the nozzle **12**, in such manner that the media are entrained in the stream and projected at high velocity against the work surface by the stream. The media are then collected and returned to the jet stream to repeat the process.

As noted earlier, and hereinafter described in greater detail, a unique feature of the media infeed means resides in a decanting action for separating the media returning to the jet stream from the water stream which returns the media to the jet stream, thus to minimize energy lost in the jet stream and interference with the jet stream concentration. Another feature of the media infeed means resides in a shot intensity meter **36** which is effective to continuously meter and monitor or record the mass flow rate of the media into the jet stream, as well as the inlet pressure to the jet stream nozzle **12**. This feature is particularly useful in shot peening applications of the machine to provide a record of each run of the machine and to permit reproduction, with a high degree of accuracy, of a given surface hardness on a number of successive work pieces.

Referring now in greater detail to the drawings, the hydraulic surface conditioning machine **10** of the invention which has been selected for illustration comprises a cabinet **38** having an access door **40** which may be opened to permit placement of a work piece **41** in and removal of the work piece from the cabinet. The jet stream nozzle **12** is rigidly mounted within the cabinet adjacent one of its side walls **42** and at an intermediate level between the top and bottom of the cabinet. The axis of the nozzle is horizontal and extends generally normal to the opposite cabinet side wall **44**. The nozzle is located approximately midway between the two remaining cabinet side walls, one of which contains the cabinet access door **40**.

The water and media recirculation systems **24, 26** comprise a common, generally funnel-shaped sub-hopper **46**. This sub-hopper is mounted within the cabinet **38**, a small distance below the level of the jet stream nozzle **12**. The top of the sub-hopper has the same rectangular shape in horizontal section as the interior of the cabinet and is joined about its perimeter to the cabinet side walls. Extending across the open top of and supported on the sub-hopper is a grating **48**. The interior space of the cabinet **38** below the sub-hopper defines a water tank which constitutes the receiver **28** of the water recirculation system **24**. In this regard, it will be understood that the cabinet has a water-tight construction, such that the cabinet is capable of containing water in the tank **28** to the normal level indicated without leaking.

The water return means **30** of the water recirculation system **24** comprises a high pressure water return pump **50**. The suction side of this pump is connected to the water tank **28**, below the normal water level in the tank, by a suction line **52**. Connected between the pump discharge and the inlet of the jet stream nozzle **12** is a high pressure water return line **54**. Return line **54** contains a by-pass valve **56** having a discharge line **58** which opens to the water tank **28** below the normal water level. Valve **56** may be a pneumatic valve operated from a control panel **60** on the machine. It is evident at this point that when the by-pass valve **56** is open to the jet stream nozzle **12**, water is pumped under high pressure from the water tank **28** to the nozzle and emerges from the nozzle as the high velocity jet stream **16**. When the by-pass valve is open to the water tank, the high pressure efflux from the pump is returned directly to the tank with-

out passing through the nozzle. Thus, the valve permits selected projection of the jet stream **16** while the pump **50** operates continuously.

The media receiver **32** of the illustrated media recirculation system **26** comprises a generally funnel-shaped hopper. This media hopper is mounted within the water tank **28**, directly below the lower spout **62** on the sub-hopper **46**. The upper edge **63** of this media hopper is located a distance above the normal water level in the tank, as shown. As will appear presently, this upper hopper edge functions as a weir. Mounted at the lower end of the media hopper **32** is a Venturi **64** which forms part of the media return means **30**. The throat of this Venturi opens upwardly to the lower end of the media hopper. Also forming part of the media return means is a low pressure pump **66**, the suction side of which is connected to the suction line **52**. Extending between the discharge of the pump **66** and the inlet of the Venturi **64** is a water line **68**. A media return line **70** extends from the Venturi outlet to the media infeed means **20**. It is evident at this point that the low pressure water stream which flows through the media Venturi **64** during operation of the pump **66** aspirates media **22** from the hopper **32**. The media are thereby entrained in the low pressure water stream and are carried by the latter through the media return line **70** to the media infeed means **20**.

Mounted within the machine cabinet **38**, above the jet stream nozzle **12**, is a housing **72** which forms part of both the media infeed means **20** and the shot intensity meter **36**. Housing **72** includes a vertical media metering tube **74**. Secured at one end to the lower end of this tube is a media infeed conduit **76**. The other end of the conduit is secured to the top of the jet stream nozzle **12** in line with the nozzle throat **12***a*. The interior passage in the conduit opens at its upper end through the lower end of the metering tube **74** and at its lower end to the nozzle throat. Rigid on the upper end of the tube is a lower aperture plate **78** having a central aperture **80** which opens through the upper end of the tube. An upper aperture plate **82** is located over the lower plate and is secured to the lower plate by bolts **84**. The upper plate is slideably mounted on these bolts for movement toward and away from the lower plate. Surrounding the bolts **84** above the upper plate are compression springs **86** which yieldably urge the upper plate toward the lower plate. An aperture **88** extends centrally through the upper plate. This aperture has approximately the same diameter as and is coaxially aligned with the aperture **80** in the lower plate. Formed in the upper side of the lower aperture plate **78** is an upwardly opening channel or guideway which opens endwise through opposite edges of the plate and slidably receives an orifice plate **92**. The thickness of this orifice plate is slightly greater than the depth of its receiving guideway. Accordingly, the springs **86** yieldably retain the aperture plates **78**, **80** in seating contact with opposite sides of the orifice plate but permit endwise adjustments of the orifice plate relative to the aperture plates. Extending through the orifice plate **92**, in spaced relation along its longitudinal center line, are a number of media metering orifices **94***a*, **94***b*, **94***c* of different diameters. The orifice plate is longitudinally adjustable relative to the aperture plates **78**, **82** to locate any selected orifice **94***a*, **94***b*, or **94***c* in metering position, wherein the respective orifice registers with the apertures **80**, **88** in the aperture plates. Any suitable index means may be provided for indicating when the different orifices are in metering position. In this instance, the indexing means comprise index marks **96** on the orifice plate corresponding to the three orifices, respectively, in the plate and a reference **98** on the upper aperture plate **82** with which each index mark is aligned when its corresponding orifice is located in metering position.

Secured to and rising above the upper aperture plate **82** is a funnel-shaped media receiver **100**. As will appear presently, this receiver functions as and will be hereinafter referred to as a water decanter, or simply, a decanter. The lower end of the decanter opens to the aperture **88** in the upper aperture plate **82**. The upper end of the decanter opens to the interior of the cabinet **38**. The media return conduit **70** extends from the media Venturi **64** upwardly to a position above the decanter **100**. The upper end of this conduit is firmly attached to the cabinet **38** and opens downwardly toward the open top of the decanter.

The operation of the hydraulic surfacing machine **10** to this point is believed to be obvious from the preceding description. Thus, the work piece **41** to be conditioned is mounted in a fixed position in front of the jet stream nozzle **12**, as shown. A suitable work support **102** may be provided for this purpose. In this instance, the work support is rigidly secured to the upper side of the sub-hopper grating **48**. It is significant to recall here that access to the interior of the cabinet **38** for installation and removal of the work piece is provided by the cabinet access door **40**.

The machine is activated by energizing the pumps **50**, **66**. The high pressure pump **50** delivers water under high pressure (i.e., on the order of 0–1500 p.s.i.) from the water tank **28** to the jet stream nozzle **12** to produce the high velocity jet stream **16**. This jet stream impinges the work piece **41** which is currently mounted in front of the nozzle. The low pressure pump **66** delivers water under low pressure (i.e., on the order of 0–100 p.s.i.) from the water tank **28** to the media Venturi **64**. As the low pressure water stream passes through the Venturi, it aspirates media **22** from the media hopper **32** and carries the entrained media upwardly through the media return conduit **70** to the media infeed means **20**. The low pressure water stream and its entrained media emerge from the open upper end of the media return conduit and drop into the open upper end of the decanter **100**. The media then gravitate downwardly through the decanter, the metering orifice **94***a*, **94***b*, **94***c* currently in metering position, the metering tube **74**, and the infeed conduit **76** to the jet stream nozzle **12**. At this point, the media are aspirated into the nozzle throat **12***a* by the high velocity water stream flowing through the nozzle and are thereby entrained in the stream and projected with the jet stream **16** against the work piece **41**.

After impingement against the work piece **41**, the spent water and media **22** in the jet stream drop through the grating **48** into the sub-hopper **46** and then gravitate downwardly through the sub-hopper into the underlying media hopper **32**. The media collect in the bottom of this hopper, as shown. During initial operation of the machine, the water level in the hopper rises until a steady state condition is attained, wherein the water overflows the upper weir edge **63** of the hopper and returns to the main water tank **28**.

This tank serves the dual function of a storage tank and a settling tank. In this regard, it will be understood that the surface material removed from the work piece **41** by the action of the jet stream **16** and its entrained surface conditioning media **22** is carried by the water into the tank **28** and then settles to the bottom of the tank. The above described weir action of the upper hopper edge **63** permits the water to flow from the hopper into the tank without agitation of the water in the tank and hence without causing re-entrainment of the debris collected at the bottom of the tank in the water flowing from the tank to the pumps **50**, **66**. Also, a magnetic separator and mechanical filter **104** may be installed in the pump suction line **52** to remove any metallic particles and other debris in the efflux from the tank.

It is now evident that the invention provides a hydraulic surface conditioning machine having a closed cycle surface conditioning action wherein the water **14** and surface conditioning media **22** are continuously recirculated to the jet stream **16** into impingement with the work piece **41** being conditioned.

At this point, it is significant to recall that the media infeed means **20** embodies an adjustable orifice plate

92 containing media metering orifices 94*a*, 94*b*, 94*c* which may be selectively located in metering position, wherein the surface conditioning media 22 return to the infeed means and gravitate downwardly through the orifice to the jet stream nozzle 12. The orifice in metering position thus meters the media to the nozzle at a rate determined by the orifice diameter. Because of the differing diameters of the several orifices in the plate, shifting of the orifice plate from one metering position to another effectively regulates the infeed rate of the media to the nozzle and, thereby, the rate at which the work surface is conditioned by the media. Moreover, the different applications, referred to earlier, of the present hydraulic surface conditioning machine, i.e., shot peening, abrasive finishing, etc., require pellets of different size. In this case, the orifices in the orifice plate may be sized to yield the optimum media infeed rate to the nozzle for each particular application.

It is worthy of note here that the media return conduit 70 could conceivably connect directly to the throat of the jet stream nozzle 12. This direct connection of the conduit to the nozzle, however, has a two-fold disadvantage. First, the water efflux from the return conduit would then enter the nozzle throat 12*a* under slightly super-atmospheric pressure. This condition would cause undesirable expansion of the jet stream 16 emerging from the nozzle which, in turn, would reduce the effective concentration of the stream at the work surface being conditioned. This disadvantage is avoided with the illustrated media infeed means 20 for the reason that the upper end of the infeed means, i.e., the upper end of the decanter 100, opens to atmosphere. Secondly, direct connection of the media return conduit 70 to the nozzle 12 would require acceleration by the jet stream of the water entering the nozzle from the return conduit. This acceleration of the entering water by the jet stream would obviously consume a substantial portion of the jet stream energy and, thereby, render less jet stream energy available for accelerating the surface conditioning media 22. As noted earlier, the illustrated media infeed means 20 provides a unique water decanting action which avoids the latter disadvantage.

Thus, according to the present invention, the media return system 34 is operated in such a way as to return the surface conditioning media 22 to the upper end of the media infeed means 20, that is, the upper end of the decanter 100, at a rate which is slightly greater than the media infeed rate determined by the metering orifice 94*a*, 94*b*, 94*c*, currently in metering position. This may be accomplished in various ways, as by adjusting the flow rate of the low pressure water stream passing through the media Venturi 64. It is evident, therefore, that when the surface conditioning machine 10 is initially activated, the media level in the decanter 100 will immediately rise until the decanter is completely filled with the surface contioning media 22. Thereafter, the decanter will remain completely filled with the media, and the excess media returned to the decanter will simply run off into the sub-hopper 46 and then gravitate back into the media hopper 32. The media, being denser than water, will displace from the decanter any water which initially enters the decanter from the media return conduit 70 and will thereafter effectively prevent the passage of water from the conduit through the decanter to the nozzle 12. The water efflux from the media return conduit will thus simply run off into the sub-hopper 46 and then gravitate downwardly into the water tank 28. The decanter 100 thus acts to decant or separate the water media returning to the media infeed means 20, whereby little if any of the water enters the nozzle 12 through the media infeed conduit 76. As a result, little if any of the energy of the jet stream 16 is consumed in accelerating the water which returns the surface conditioning media 22 to the media infeed means 20, and virtually the entire jet stream energy is available to project the media against the work surface. It is now evident, therefore, that the present hydraulic surface conditioning machine 10 is characterized by relatively high operating efficiency.

In some if not all applications of the present machine, it is desirable to monitor or record the operating parameters which govern the surface conditioning action produced by the machine in order to provide a record of each run of the machine and/or to permit reproduction of a given work surface condition with a high degree of accuracy. Such reproduction capability is particularly desirable, if not essential, in shot peening applications, wherein it is necessary to successively shot peen a number of work pieces to the same surface hardness. The parameters referred to above are the media infeed rate and the inlet pressure to the jet stream nozzle 12. In the illustrated machine, these parameters are monitored and recorded by the shot intensity meter 36.

The illustrated shot intensity meter 36 comprises a nozzle inlet pressure recorder 108 and a media infeed rate recorder 110. The inlet pressure recorder 108 has a conventional recording mechanism 112 which is connected by a water line 114 to the inlet of the jet stream nozzle 12 so as to be responsive to the nozzle inlet pressure. This recording mechanism produces a continuous recording or trace of the inlet pressure during each run of the machine.

The media infeed rate recorder 110 includes a media infeed rate transducer 116 for continuously sensing the media infeed rate to the jet stream nozzle 12 and a recording mechanism 118 for producing a recording or trace of the infeed rate. The illustrated infeed rate transducer 116 has a balance beam 120 which extends through a slot in the wall of the metering tube 74 and is pivoted intermediate its ends on the tube wall. Fixed to the inner end of this beam, that is, the end of the beam within the tube, is an enlarged metering head 124 having a spherically rounded surface facing upstream relative to the direction of media flow through the tube. The diameter of the metering head 124 in a plane transverse to the axis of the metering tube is substantially equal to or slightly greater than the internal tube diameter above the head. The tube flares outwardly to a larger diameter in the region of the head, as shown, to provide an annular media flow space about the head. It is evident at this point that the surface conditioning media 22 which are returned to the media infeed means 20 and gravitate downwardly through the metering tube 74 impinge the scale beam metering head 124 and thereby exert on the scale beam 120 a moment related to the mass flow of the media through the tube. This moment tends to rock the beam in the clockwise direction in the drawings. Mounted opposite the outer end of the beam 120 is a transducer 126 which produces an opposing moment on the beam for maintaining the latter balanced in its illustrated neutral position and feeds an output to the recording mechanism 118 related to this opposing moment and hence to the mass flow of media to the jet stream nozzle 16. This output is continuously recorded by the recording mechanism 118. It will be evident to those versed in the art that a variety of transducer devices may be employed as the scale beam transducer 126. One such device is a pneumatic transducer which is currently available on the market under the trade name of Moore Nullmatic Force Transmitter.

It is now obvious, therefore, that the shot intensity meter 36 produces continuous recordings of the inlet pressure and the media infeed rate to the jet stream nozzle 12. These recordings may be utilized for the purposes explained earlier.

While the invention has been disclosed in connection with one of its physical embodiments, it will be recognized by those versed in the art that various modifications of the invention are possible within the spirit and scope of the following claims.

What is claimed as new in support of Letters Patent is:

1. A hydraulic machine for conditioning a work surface with the aid of a working liquid and solid surface conditioning media such as pellets, comprising:
a nozzle,
a liquid receiver for containing a body of said liquid,
liquid return means for delivering liquid under pressure from said receiver to said nozzle, whereby said liquid is projected from said nozzle as a high velocity jet stream for impingement against said work surface,
a media receiver for containing a body of said surface conditioning media,
media infeed means for feeding said media into the path of said jet stream adjacent said nozzle in such manner that said media are entrained in and projected at high velocity by said jet stream,
recovery means for collecting the spent liquid and media in said jet stream and returning said spent liquid to said liquid receiver and said spent media to said media receiver,
media return means for transporting said media in a stream of said liquid from said media receiver to said infeed means, and
said media infeed means including liquid separation means for separating said media from said liquid prior to introduction of said media into said jet stream.

2. A hydraulic surface conditioning machine according to claim 1 wherein:
said machine has an enclosed conditioning area in front of said nozzle for receiving a workpiece having the work surface to be conditioned, and
said recovery means comprise a liquid and media collecting hopper below said area for receiving the spent liquid and media in said jet stream, and means for effecting passage of the spent liquid and media from said hopper to said liquid receiver and media receiver respectively.

3. A hydraulic surface conditioning machine according to claim 1 wherein:
said machine has an enclosed conditioning area in front of said nozzle for receiving a workpiece having the work surface to be conditioned,
said media receiver is located a distance below the level of said conditioning area and communicates to said liquid receiver, and
said recovery means comprise a hopper located directly below said conditioning area and projecting above the level of liquid in said liquid receiver for receiving spent liquid and media from said jet stream and having a lower outlet communicating with said media receiver, whereby said spent liquid and media gravitate from said hopper into said media receiver and said spent liquid then flows from said media receiver to said liquid receiver.

4. A hydraulic surface conditioning machine according to claim 3 wherein:
said liquid receiver comprises a tank, and
said media receiver comprises a container located within said tank.

5. A hydraulic surface conditioning machine according to claim 4 wherein:
said tank serves the dual function of a liquid storage tank and a settling tank,
said liquid return means comprises a pump connected between said tank and nozzle, and
said container has a top opening to said tank bounded by an inner weir edge over which liquid flows from said container to said tank to minimize agitation of the liquid in said tank.

6. A hydraulic surface conditioning machine according to claim 1 wherein:
said media infeed means comprises an infeed conduit secured to and rising from said nozzle and containing a media passage opening at its lower end to the nozzle throat and at its upper end to atmosphere, and
said media return means comprise a media return conduit opening to the upper end of said infeed conduit for conveying media from said media receiver to said infeed conduit.

7. A hydraulic surface conditioning machine according to claim 6 wherein:
said media reutrn means further comprise a Venturi having an outlet connected to said media return conduit, means for pumping liquid from said liquid receiver to said Venturi, and means communicating the throat of said Venturi to the lower end of said media receiver in such manner that media are aspirated from said media receiver into the liquid stream passing through said Venturi.

8. A hydraulic surface conditioning machine according to claim 1 wherein:
said media infeed means comprise an infeed conduit secured to and rising from said nozzle and containing a media infeed passage opening at its lower end to said nozzle throat, and
said liquid separation means comprise a decanter secured to the upper end of said infeed conduit for receiving liquid and media from said media return conduit and opening downwardly to said infeed passage in said infeed conduit, and means for metering media flow from said decanter to said nozzle in such manner that the infeed rate of media from said decanter to said nozzle is less than the infeed rate of media to said decanter from said media return conduit, whereby said decanter fills with media and the liquid efflux from said media return conduit runs off from the top of said decanter.

9. In a hydraulic machine for conditioning a work surface with the aid of a working liquid and solid surface conditioning media such as pellets, the combination comprising:
a nozzle for connection to a source of said liquid under pressure,
a media infeed conduit secured to and rising from said nozzle and containing an infeed passage opening to the nozzle throat,
an upwardly opening decanter secured to the upper end of said conduit and opening downwardly to said infeed passage for receiving a liquid stream containing said media, whereby said liquid overflows said decanter to separate said liquid from said media and said media gravitate downwardly through said decanter and infeed passage into said nozzle throat, and
means for metering the rate of flow of said media from said decanter to said nozzle throat.

10. The combination according to claim 9 wherein:
said metering means comprises an adjustable orifice plate containing a number of different sized orifices, and
said plate is adjustable to locate any selected orifice in metering position in said infeed passage.

11. In a hydraulic machine for conditioning a work surface with the aid of a surface conditioning medium consisting of a working liquid and solid surface conditioning media such as pellets, comprising:
a nozzle for connection to a source of said liquid under pressure,
media infeed means for feeding said media to the nozzle throat, and
means for monitoring the infeed rate of said media to said nozzle throat.

12. The combination according to claim 11 including:
means for monitoring the inlet presure to said nozzle.

13. The combination according to claim 11 wherein:
said monitoring means comprise a pivoted scale beam having one end disposed in the path of flow of said

media through said infeed means, whereby said media produce a moment in one direction on said beam, and

means for producing an opposing moment on said beam for balancing said beam in a neutral position and generating an output related to said opposing moment.

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