Aug. 1, 1961 H. E. WAYLAND ET AL 2,994,314

STONE CUTTING APPARATUS

Filed Aug. 22, 1958 5 Sheets-Sheet 1

Fig. 1.

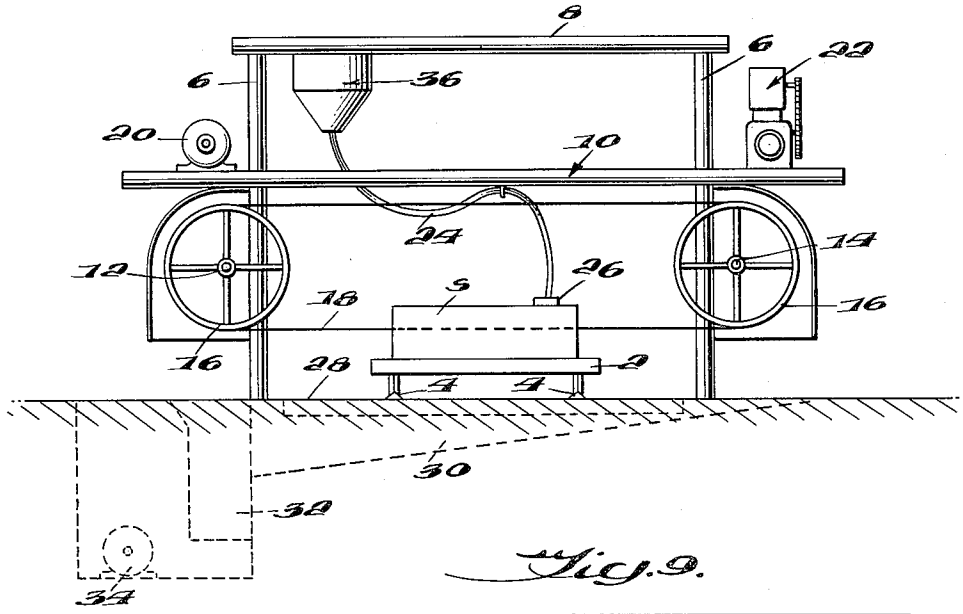
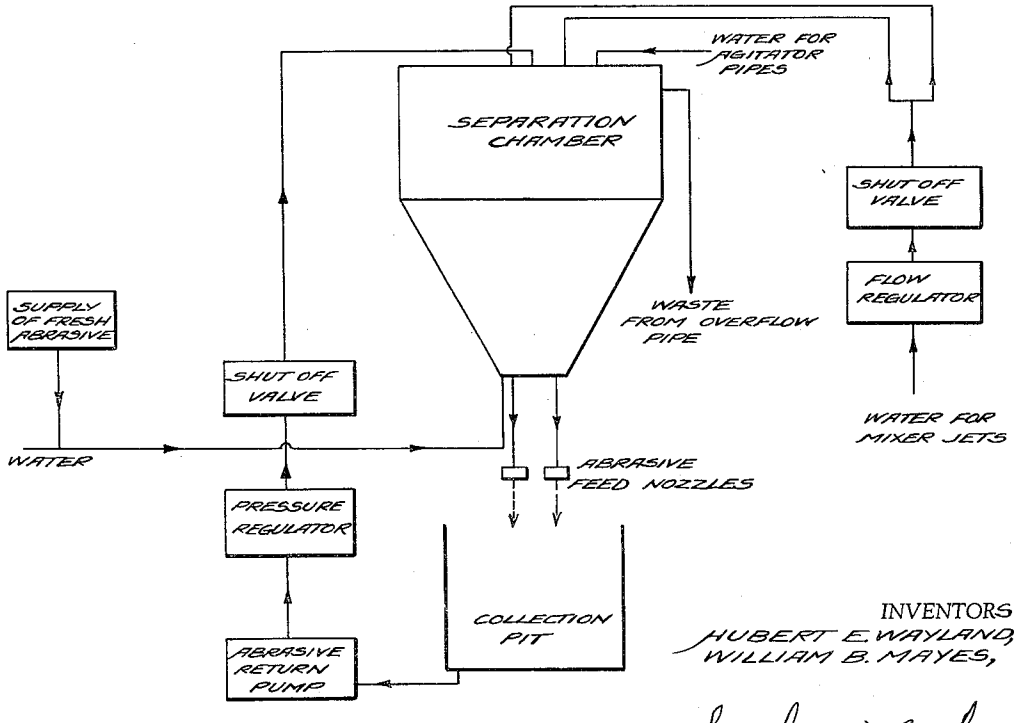


Fig. 9.



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STONE CUTTING APPARATUS

Filed Aug. 22, 1958 5 Sheets-Sheet 2

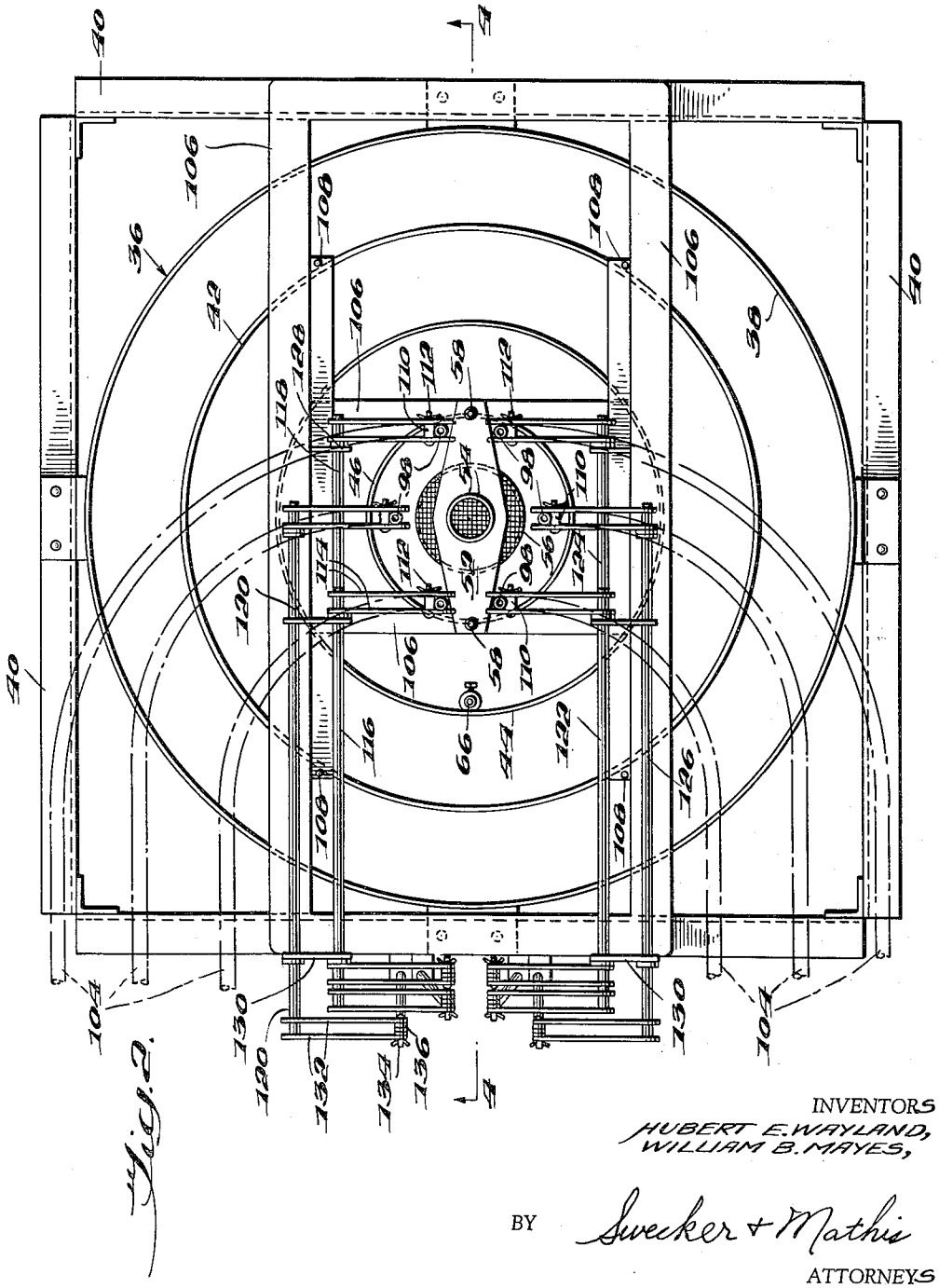

Fig. 2.

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STONE CUTTING APPARATUS

Filed Aug. 22, 1958 5 Sheets-Sheet 3

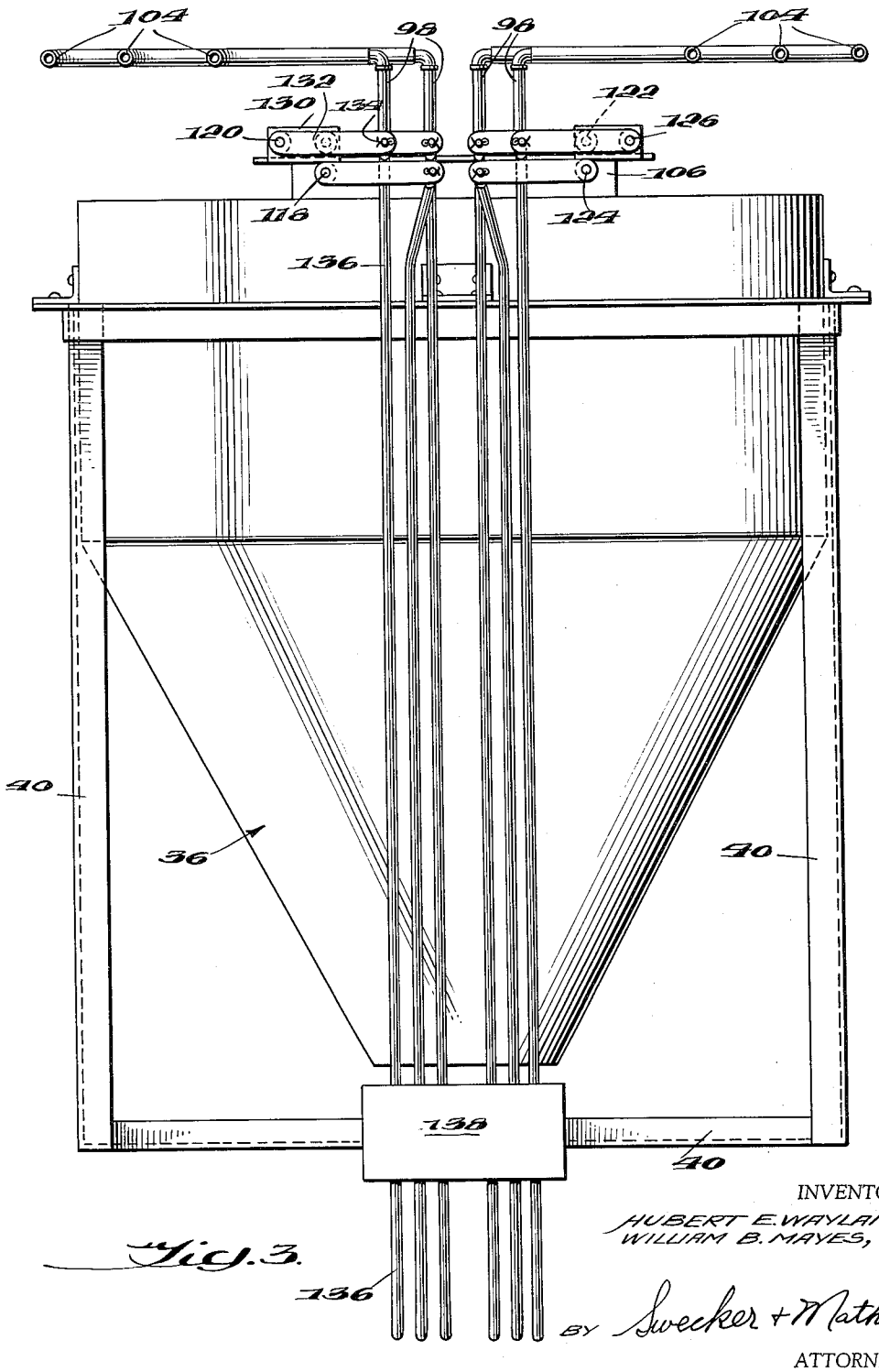

Fig. 3.

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STONE CUTTING APPARATUS

Filed Aug. 22, 1958 5 Sheets-Sheet 4

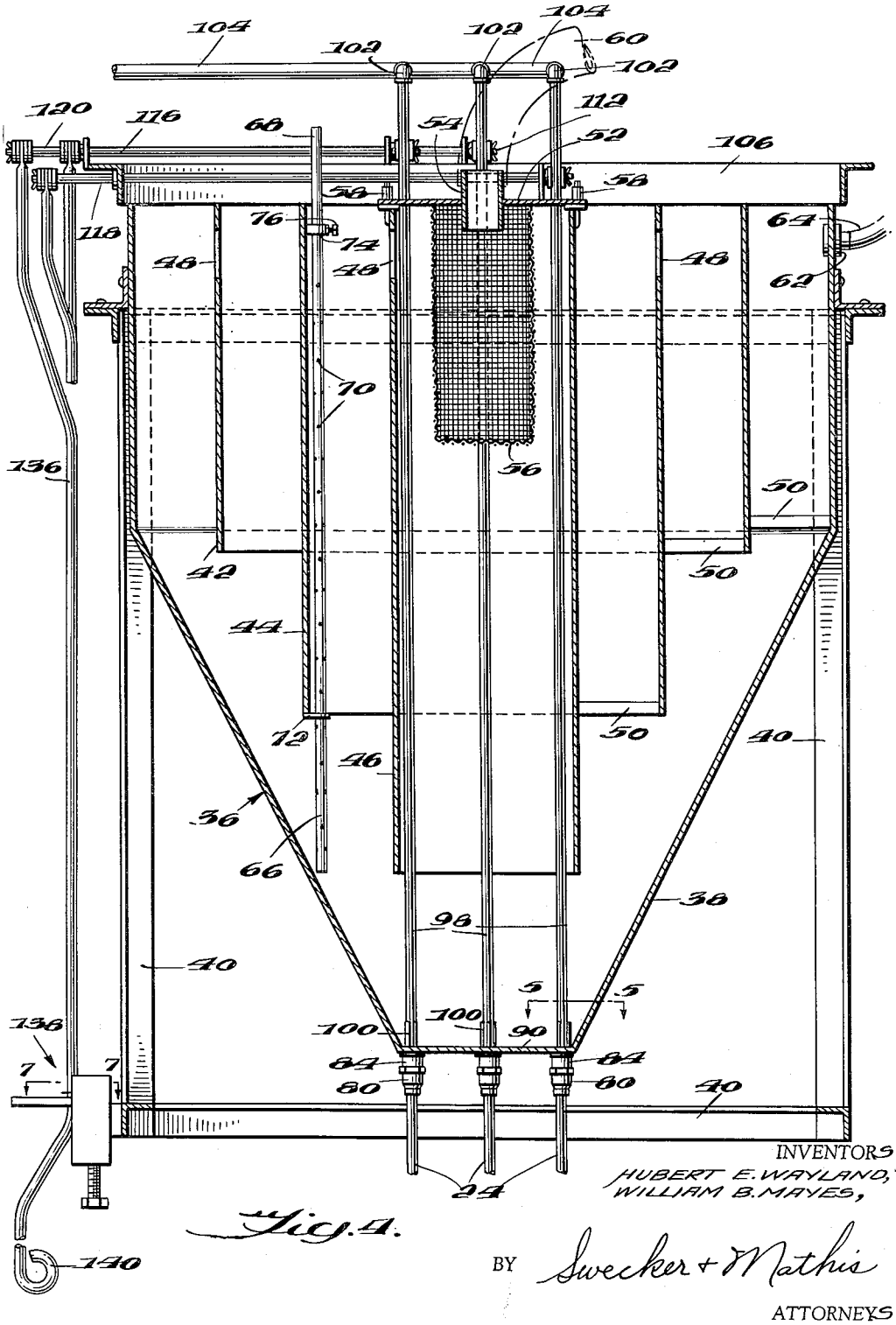

Fig. 4.

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STONE CUTTING APPARATUS

Filed Aug. 22, 1958 5 Sheets-Sheet 5

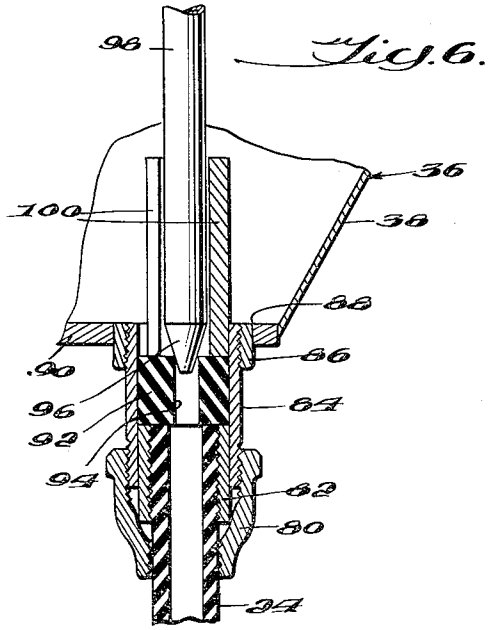

Fig. 6.

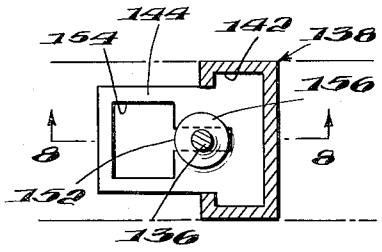

Fig. 7.

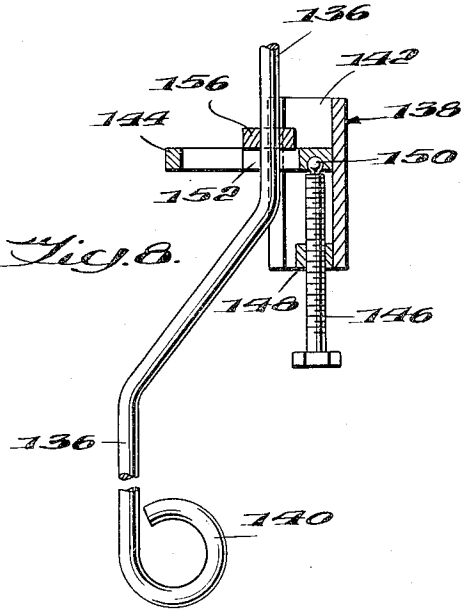

Fig. 8.

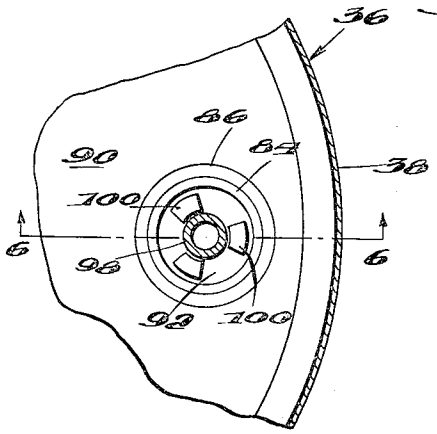

Fig. 5.

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United States Patent Office 2,994,314 Patented Aug. 1, 1961

2,994,314

STONE CUTTING APPARATUS

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Filed Aug. 22, 1958, Ser. No. 756,689
16 Claims. (Cl. 125—21)

This invention relates to stone cutting apparatus, and more particularly to an abrasive feed system for a wire saw.

Various types of wire saws are employed in the production of stone. One type is used in quarries for the severing of stone blocks from the quarry walls. Another type is used at a subsequent point in the stone-processing operation to subdivide blocks of stone into slabs of such size that they may be employed in the building industry. All of these saws include one or more wires moved along paths which cross and contact the stone to be cut. Although the wires themselves tend to abrade the stone to some extent, the major cutting action is achieved by small particles of hard abrasive material which are rolled in contact with the stone by the wires.

The abrasive supply systems in use prior to the present invention were not entirely satisfactory in several respects. One of the difficulties encountered in using such systems arises from the necessity for regulating the consistency of the abrasive mix fed to the cutting zone. The abrasive particles are carried to the cutting zone by a stream of water, and, of course, the volume of flow as well as the proportion of abrasive to water in the stream must be regulated in order to provide the most effective concentration of abrasive particles at the cutting zone. However, the structures employed in prior systems for making the necessary adjustments have not been satisfactory, and much production time has been lost in attempts to obtain the proper abrasive mix for the cutting operations to be performed.

Moreover, the nature of the usual production operations is such that it should not be necessary to readjust the abrasive mix for each cutting cycle. When a series of stones are being cut by a machine, they normally will be of comparable consistencies, so that the abrasive mix fed to one probably will be appropriate for the next, etc. Yet, the prior systems have not taken advantage of this fact, and it has been necessary to disturb the machine adjustments when the feeding of abrasive was stopped between cutting cycles.

Another factor to be considered in connection with the abrasive feed system for a wire saw is that the used abrasive material passing from the stone being cut normally contains many abrasive particles which can be reused effectively. Since the abrasive material is fairly expensive, it is most desirable that the abrasive feed system be capable of separating the re-usable particles from the stone cuttings and spent abrasive, so that the material will not be wasted. However, the recirculation systems employed heretofore were not entirely effective with respect to the separation of spent abrasive particles from re-usable abrasive particles. Unless such systems are effective, they are of little value, because considerable additional equipment is required for them.

Still other difficulties have arisen in connection with clogged abrasive feed lines in the prior systems. Since the abrasive mix is not fed continuously through these lines, there is a likelihood that the abrasive particles will pack in the lines from time to time, and when this occurs, it is necessary to flush the lines in order to resume production operations. However, prior systems have made no special provisions for the flushing of clogged lines without shutting down the machines,

Accordingly, it is a primary object of the present invention to provide an improved abrasive feed system for a wire saw which will overcome the objections and disadvantages noted above and which will operate effectively to deliver abrasive mixes of the proper consistency to the cutting zone of the saw.

Another object of the invention is to provide an improved abrasive feed system in which the abrasive particles are entrained in a fluid stream by a jet action and in which the volume of fluid and the volume of abrasive particles can be controlled independently of each other.

Another object of the invention is to provide an abrasive feed system in which the required adjustments for establishing the proper abrasive mix need not be repeated each time the system is set in operation. This will enable the operator of the machine to stop the feed of abrasive mix between cutting operations without disturbing the settings of the regulatable elements of the system, and cut after cut may be made without the necessity for additional time-consuming adjustments.

Yet another object of the invention is to provide an abrasive feed system with an effective settling tank for separating re-usable abrasive particles from spent abrasive particles, stone cuttings, and the like.

The foregoing objects are accomplished, according to a preferred embodiment of the invention, by providing a wire saw with a settling chamber into which the used abrasive material may be directed and from the bottom of which the re-usable abrasive particles are withdrawn by a water jet for delivery to the cutting zone of a wire saw. Separation of the spent abrasive particles from the re-usable abrasive particles is accomplished by circulating these materials in a liquid carrier along a tortuous path in the upper end of the settling chamber, and allowing the heavy, re-usable abrasive particles to settle out by gravity. A group of baffles is provided for defining the path of travel of the material entering the chamber so that it is not possible for any of the abrasive particles to pass directly from the inlet to the waste discharge outlet of the chamber. Agitator means also are provided in the settling chamber to prevent packing of the material and to promote circulation in the desired manner.

The bottom wall of the separation chamber has one or more openings therein, each provided with a valve seat. A valve member cooperates with each of these valve seats to control the size of the opening through which abrasive particles may pass. The valve members also are connected to a supply a fresh water and serve to deliver a jet stream of water through the valve seats, so that the abrasive particles passing through the space between the valve member and the valve seat are immediately entrained in the liquid stream.

Regulation of the proportions of the abrasive mix may be accomplished by independent adjustments of the water flow through the valve member and the spacing of the valve member from the valve seat. Moreover, the means employed for effecting these adjustments can be inactivated independently when it is desired to stop the flow of abrasive mix to the cutting zone or when it is desired to flush the discharge lines.

A better understanding of the construction and the advantages of the invention will be gained from a consideration of the following detailed description of the embodiment thereof illustrated in the accompanying drawings, in which:

FIG. 1 is a diagrammatic view illustrating a wire saw embodying the present invention;

FIG. 2 is a plan view of the main separation tank of the abrasive system used in the wire saw of FIG. 1;

FIG. 3 is an elevational view of the separation tank;

FIG. 4 is a vertical cross sectional view taken along the line 4—4 in FIG. 2;

FIG. 5 is a partial horizontal cross sectional view taken along the line 5—5 in FIG. 4;

FIG. 6 is a vertical cross sectional view taken along the line 6—6 in FIG. 5;

FIG. 7 is a partial horizontal cross sectional view taken along the line 7—7 in FIG. 4;

FIG. 8 is a vertical cross sectional view taken along the line 8—8 in FIG. 7; and

FIG. 9 is a flow diagram for the abrasive system.

The wire saw illustrated diagrammatically in FIG. 1 is of a type which is used extensively in subdividing stone blocks. As removed from the quarries, these stone blocks usually are too large for use in the building industry, and they must be subdivided into a number of smaller slabs. In this description, it will be assumed that the wire saw is capable of making six parallel cuts through the stone simultaneously. However, it is to be understood that the number of cuts may be varied as desired.

It will be understood also that the invention is in no way restricted to the cutting of any particular material. Wire saws of the type shown in FIG. 1 may be used for the cutting of granite, marble, limestone, and many other materials. In general, it may be said that such saws are applicable to any material which may be cut by contact with rolling abrasive particles.

The wire saw includes a platform **2** for supporting a stone S to be cut. This platform **2** is mounted for movement along tracks or guides **4** so that the stone S may be brought into proper positional relationship with respect to the other portions of the apparatus and so that the severed stone may be removed conveniently. Ordinarily, the platform **2** remains stationary during cutting operations and is moved only when it is desired to bring a new stone into position or to remove a severed stone from the cutting zone.

On opposite sides of the platform **2** there are a pair of stationary uprights **6** which form the major structural components of the main frame of the machine. These uprights **6** are fixed at their lower ends with respect to the ground or other support surface, and they are connected together at their upper ends by a cross beam **8**.

A movable frame, designated generally by the numeral **10**, is mounted for vertical movement relative to the uprights **6** of the main frame. This movable frame **10** carries a pair of shafts **12** and **14** for supporting wire guiding wheels **16** located on opposite sides of the stone S. One or more endless saw wires **18** are looped about the wheels **16** so that their lower runs extend across the stone S positioned upon the platform **2** of the machine. Only one saw wire **18** is visible in FIG. 1, but it will be understood that the machine may include several of these wires. The additional wires would be disposed behind the illustrated wire **18**, as viewed in FIG. 1.

The illustrated wire saw is of a type commonly referred to in the trade as a "short wire" machine, because the saw wires **18** are looped directly about the guide wheels **16**. There is also in extensive use a similar type known as a "long wire" machine, in which the wire paths may extend one hundred feet or more to one side of the main body of the machine. The present invention is equally applicable to both types.

During cutting operations, the saw wires **18** are driven along the endless paths defined by the guide wheels **16** by a suitable electric motor **20** which may be connected to the shaft **12** by a V-belt or the like. The wires **18** also must move vertically with respect to the stone S. Such vertical movements are controlled by a feed mechanism **22** which serves to raise or lower the movable frame **10** along the uprights **6** of the main frame. As the depths of the cuts in the stone S increase, the mechanism **22** is actuated to lower the cutting runs of the saw wires **18** at a controlled rate so that the wires **18** bear against the bottoms of the cuts in the manner required for efficient cutting.

The actual cutting of the stone S is brought about by an abrading action. A mixture of water and a particulate abrasive, such as silicon carbide particles for example, is fed to the stone S and rubbed against the stone by the wires **18**. These saw wires **18** are twisted structures which present many inclined surfaces for contacting the abrasive particles and moving them along the stone S.

FIG. 1 illustrates generally the relationship of the major components of the abrasive supply system to the other elements of the wire saw. The mixture of water and abrasive particles is delivered to the stone S through a plurality of flexible hoses or conduits **24**, only one of which is visible in FIG. 1. These conduits **24** terminate at distribution blocks or abrasive feed nozzles **26** fixed to the stone S immediately adjacent the planes of movement of the saw wires **18** so that the abrasive mixture is delivered directly into the cuts produced in the stone S.

After being rubbed against the stone S by the wires **18**, the mixture falls down through a suitable grating **28** into an inclined trough **30** which delivers it to a collection pit **32**. The material in the collection pit **32** includes stone cuttings, spent abrasive particles, and some abrasive particles which can be re-used effectively. In order to preserve this re-usable material, the entire mixture in the pit **32** is removed therefrom by a self-priming, centrifugal, rubber-lined pump **34** and delivered thereby to a separation chamber **36** carried by the cross beam **8** of the main frame of the machine. In the separation chamber **36**, the stone cuttings and the spent abrasive particles are removed, and then the re-usable abrasive material is fed again to the stone S through the flexible conduits **24**. Suitable mechanisms are associated with the separation chamber **36** for assuring that the abrasive particles will be delivered to the conduits **24** under a proper pressure and along with sufficient water to provide the desired abrasive mixture for the cutting operation.

The construction of the separation chamber **36** and the mechanisms associated therewith can best be explained by references to FIGS. 2 through 8 of the drawings. The chamber **36** includes an outer shell **38**, the upper portion of which is substantially cylindrical and the lower portion of which is conical. This shell **38** is carried by a rigid, openwork frame **40** connected by suitable means (not illustrated) to the cross beam **8** of the wire saw.

Referring particularly to FIG. 4 of the drawings, it will be seen that the interior of the chamber **36** is occupied by a plurality of concentric, cylindrical baffles **42**, **44**, and **46**. Each of these baffles terminates at a level above the bottom of the shell **36** and is provided with an opening **48** near its upper end through which liquid may pass radially. These baffles are held in the proper spaced relationship with respect to each other and the main shell **38** by struts **50** which may have various configurations. It is desirable, however, that the struts **50** be so shaped that they do not interfere materially with the circulation of the materials in the chamber **36**.

The upper end of the shell **38** is open to the atmosphere throughout a major portion thereof so that the upper ends of the baffles **42**, **44**, and **46**, may serve to support other components of the structure. Mounted upon the upper end of the innermost baffle **46** is a plate **52** which carries an intake coupling element **54** and a filter chamber **56** for the incoming fluid. The filter chamber **56** is a wire screen of generally cylindrical configuration which is closed at its lower end and open at its upper end. The plate **52** may simply rest upon the upper end of the baffle **46**, or it may be connected to the baffle by bolts, or the like, **58**. In any event, it is preferred that the arrangement be such that the plate **52** may be removed easily from the upper end of the chamber **36** for maintenance purposes.

The mixture of water, stone cuttings, spent abrasive particles, and re-usable abrasive particles contained in the collection pin **32** of the wire saw is delivered to the chamber **36** through a hose **60** detachably connected to the coupling element **54** on the plate **52**. As it passes into the filter chamber **56**, this mixture is subjected to a preliminary screening action for removing any foreign mat-

ter, such as leaves or the like, which may have found its way into the pit 32.

Within the separation chamber itself, the material is subjected to the action of gravity so that separation occurs as between components of different weights. The heavier particles fall to the bottom of the chamber 36, while the lighter particles remain suspended in the carrier liquid. This is the very pattern required for effective separation of the re-usable abrasive particles, because such particles are by far the heaviest components of the mixture delivered to the chamber 36 from the collection pin 32. The spent abrasive particles and the stone cuttings are very small, being of a fineness comparable to dust, so that they are effectively suspended in the liquid.

During normal operations, the shell 38 will remain substantially full of the material delivered to it through the hose 60. Hence, the material passing out of the filter chamber 56 is free to circulate both vertically and laterally. The very heavy particles of the mixture will tend to settle immediately to the bottom of the shell 38 without moving laterally out of the cylindrical zone defined by the innermost baffle 46. However, the lighter particles will move about with the circulating liquid to a considerable extent. Some of these will move from the innermost zone bounded by the baffle 46, outwardly through the hole 48 in the upper end of the baffle 46 to the annular zone defined by the baffles 44 and 46. Again, some settling will take place, and again some of the mixture will move radially through the hole 48 in the baffle 44 into the next annular zone, etc. It will be noted in this connection that the holes 48 in the several baffles 42, 44, and 46, are staggered so that a tortuous course must be followed by any material which moves radially through the several zones defined by the baffles 42, 44 and 46. Particles which settle out of the mixture in zones other than the innermost zone defined by the baffle 46, fall down onto the sloping wall of the conical portion of the shell 38 and are guided thereby toward the center of the shell 38.

The liquid and the lighter solid particles which do not settle out of the mixture must be discarded. To this end, the upper end portion of the shell 38 is provided with a suitable outlet coupling element 62 communicating with a hose or other conduit means 64. The hose 64 preferably discharges the waste material passing therethrough at some location remote from the wire saw.

Circulation within the chamber 36 may be promoted by the use of one or more agitating devices. In FIG. 4 one such device is illustrated in cooperative relationship with the baffle 44. This device is a pipe 66, closed at its lower end and communicating at its upper end with a supply conduit 68 for water under pressure. The pipe 66 has a plurality of small holes 70 therein through which water may be directed into the mixture within the settling chamber 38 in the form of a plurality of jets. The pipe 66 may be attached to the baffle 44 by guides 72 and 74, and it may be held in position by a set screw 76 or other means which will permit adjustment of the pipe 66.

The jets of water issuing from the small holes 70 in the pipe 66 perform several important functions. The jet streams in the upper portion of the chamber 36 keep the mixture of liquid and particulate matter in a state of agitation which prevents gravity separation of the finer particles. These jets also prevent accumulations of material on the baffles adjacent thereto. At the lower end of the chamber 36, the jets serve to prevent packing of the reusable abrasive particles and keep these particles in a fluid state which facilitates their removal.

Fresh abrasive material may be supplied to the system by putting it into the shallow end portion of the inclined trough 30, and washing it down as needed into the collection pit 32. This procedure assures thorough mixing of the fresh abrasive material with the abrasive material already in the system.

The structure for feeding the abrasive particles from the bottom of the settling chamber 36 to the flexible hoses 24 is best illustrated in FIGS. 5 and 6. These views relate to the supply mechanism for a single hose 24, and it will be understood that the apparatus includes one such mechanism for each of the six hoses 24. Fixed to the end of the hose 24 is a reducing sleeve 80 and a sleeve coupling 82. These are detachably connected to a nipple 84 secured to a short sleeve 86 positioned in an opening 88 in the bottom wall 90 of the shell 38. The sleeve 86 may be welded or otherwise permanently secured to the bottom wall 90.

An annular rubber valve seat element 92 is disposed within and fixed to the nipple 84, with its central opening or hole 94 in communication with the interior of the hose 24. As illustrated in FIG. 6, the upper end of the central opening 94 in the valve seat element 92 may be closed by a hollow conical valve member 96 integral with or fixed to the lower end of a water pipe 98. The central opening in the valve member 96 forms a continuation of the interior of the pipe 98 and is directed toward the hole 94 in the valve seat element 92. When the valve member 96 is in the position shown in FIG. 6, no abrasive can enter the hose 24. However, when the pipe 98 is elevated slightly, the valve member 96 moves away from the valve seat 92 sufficiently to provide an annular space between its external surface and the entrance portion of the central opening 94 in the valve seat 92 through which the abrasive may enter the hose 24. Water under pressure is supplied to the interior of the pipe 98, and the flow of water downwardly through the valve member 96 into the central opening 94 in the valve seat element 92 produces a jet action which tends to entrain the abrasive particles in the bottom of the settling chamber 36. The effectiveness of this entraining action will depend, of course, upon the size of the opening between the valve member 96 and the valve seat element 92. Accordingly, the pipe 98 carrying the valve member 96 is mounted for vertical movement in such a way that the opening of the valve member 96 may be regulated as desired.

In order that the lower end portion of the pipe 98 may be guided positively for vertical movements with respect to the valve seat element 92, the upper end portion of the nipple 84 is provided with a guide cage made up with a plurality of vertical pins or bars 100 extending upwardly from the bottom wall 90 of the settling chamber 36. The cage shown in FIG. 5 is made up of three of these pins 100, but it will be understood that the number may be varied if desired. Since the pins 100 are spaced from each other, they do not obstruct the passage of the abrasive particles into the valve to a material degree. However, their substantial vertical extent make them very effective as guide elements for controlling the movements of the pipe 98.

If the wire saw is to operate efficiently, the mixture of water and abrasive particles delivered to the hoses 24 must have a consistency which is related to the particular cutting operation being performed. That is to say, it is essential that the proportion of abrasive to water in the mixture must be regulated in accordance with the nature of the material being cut, the consistency of the abrasive itself, and other variables. According to the present invention, this regulation is achieved in a very simple manner by controlling independently the flow of water through the pipes 98 and the openings between the valve members 96 and the valve seat elements 92.

As shown in FIG. 4, the pipes 98 extend vertically through the open top of the separation chamber 36. At their upper ends, they are provided with suitable couplings 102 by which they may be connected with flexible water hoses 104 which supply water under pressure to them. Below the couplings 102, and above the level of the upper end of the shell 38 of the settling chamber 36, the pipes are connected to linkages for controlling their vertical positions with respect to the stationary valve seat elements 92 at the bottom of the chamber.

A frame unit 106 for such linkages is positioned upon the upper end of the shell 38 and the upper ends of the baffles 42, 44, and 46, in the manner shown in FIGS. 2 and 4. It is desirable that this frame unit 106 be detachable from the shell 38 for maintenance purposes, and to this end, it may simply rest upon the upper ends of the shell and the baffles. The orientation of the frame unit may be established by a group of dependent pin elements 108 (FIG. 2) which bear against the external surface of the baffle 42 when the frame unit 106 is positioned properly with respect to the settling chamber 36. It is preferred that the mounting plate 52 for the intake coupling 54 and the filter element 56 be disposed above the central cross members of the frame unit 106 so that this plate may be removed for cleaning without removing the entire frame unit 106.

The upper end portion of each of the water pipes 98 has a lug or bushing element 110 (FIG. 2) welded or otherwise secured to its external surface. This bushing 110 receives a pivot pin 112 which passes through a pair of parallel link elements 114 secured at their opposite ends to a horizontal shaft. Each pair of link elements 114 is fixed to a separate horizontal shaft. There are six of these horizontal shafts 116, 118, 120, 122, 124, and 126, in the illustrated embodiment of the invention, and each of them is mounted for rotation in one or more suitable bearing brackets such as the bracket 128, carried by the central portion of the frame unit 106, and also in a bearing plate 130 at an end of the frame 106. Since the linkage elements 114 are fixed to their respective shafts and pivotally connected to the bushings 110 on the water pipes 98, it will be evident that rotation of the shafts will result in vertical movements of the water pipes 98. Controlled rotation of the individual shafts 116, 118, 120, 122, 124 and 126, is brought about by means best illustrated in FIGS. 2, 3, 7 and 8. Since the several shafts are controlled in similar manners, a description of the controls for the shaft 120 will suffice for all.

The end portion of the shaft 120 disposed beyond the end plate 130 is fixed rigidly to a pair of parallel links 132 which extend laterally therefrom and are pivotally connected by a pin 134 to the upper end of a long rod member 136. This rod member extends downwardly through a control box 138 carried by the lower end portion of the openwork frame 40 for the settling chamber 36. The lower end of the rod 136 below the control box 138 has a handle 140 which may be gripped by the operator of the machine when it is desired to move the rod 136. The box 138 may have a cover plate, as suggested in FIG. 3, but this is not essential, and the cover plate has been omitted in FIGS. 4, 7, and 8, in the interest of clarity.

The control box 138 includes a vertical channel 142 for each of the control rods, such as the rod 136, in the apparatus. An adjustable block 144 is slidably mounted within each of the vertical channels 142, and is supported by a screw member 146 threadedly connected to a nut 148 fixed rigidly to the lower end portion of the box 138. Rotation of the screw 146 with respect to the block 144 is facilitated by a ball and socket connection 150 between the upper end of the screw and the block 144, although it will be apparent that other suitable means for connecting the screw 146 to the block 144 may be employed if desired. When the screw 146 is rotated, it moves axially with respect to the stationary nut 148 and serves to alter the vertical position of the block 144.

The block 144 is provided with an opening which includes a narrow slot portion 152 of a width slightly greater than the diameter of the control rod 136, and an enlarged portion 154 communicating with the slot portion 152. The control rod 136 has a large washer 156 fixed permanently to its external surface in position to cooperate with the block 144. In FIGS. 7 and 8, the washer 156 rests upon the upper surface of the block 144 so that its vertical position is established by the vertical position of the block itself. However, the control rod may be freed from the influence of the block 144 by shifting the rod outwardly so as to bring the washer 146 into alignment with the enlarged portion 154 of the hole in the block 144, and then pulling the rod 146 downwardly. Thus, the washer 156 may be brought to a position below the block 144.

A comparison of FIGS. 2, 3 and 4, will reveal that the lowermost position of the control rod 136 corresponds to the lowermost position of the water pipe 98 controlled thereby. When the control rod 136 is elevated, its water pipe 98 also is elevated, and the valve member 96 (FIG. 6) is moved away from the valve seat element 92 to permit the flow of abrasive into the hose 24. Thus, the vertical position of the control rod 136 is directly related to the opening of the abrasive valve in the settling chamber 36.

During a cutting operation, the control rod 136 will be positioned in the manner indicated in FIGS. 7 and 8 of the drawings, i.e., its washer 156 will bear against the upper surface of the movable block 144 in the control unit. Any adjustments that need be made in the opening of the abrasive valve can be effected by rotating the screw 146 in one direction or the other. When the screw 146 is rotated in a direction such that it moves upwardly, the opening in the abrasive valve will be enlarged. When the screw 146 is moved downwardly, the opening in the abrasive valve will be restricted. Hence, the operator of the machine can obtain a precise setting of the abrasive valve so that the desired mixture of water and abrasive particles will be fed into the hose 24.

When the cutting operation has been completed, the abrasive valve must be closed to prevent waste of the abrasive material during the period of time required for the removal of the cut stone from the platform 2 of the saw and the positioning of a new stone S. This closing of the abrasive valve may be accomplished easily and quickly by grasping the handle 140 at the lower end of the control rod 136, moving the control rod 136 to the left as viewed in FIGS. 7 and 8, and then pulling the rod 136 downwardly. If any abrasive particles should stick in the space between the cooperating surfaces of the valve member 96 and the valve seat element 92, they may be dislodged by a jiggling movement imparted to the valve element 96 by manipulation of the handle 140 on the control rod 136.

It should be noted particularly that in closing the valve, it is not necessary to disturb the setting of the block 144 in any way. When the next cutting operation is to be commenced, the already established valve setting may be restored by simply lifting the control rod 136 and moving it laterally to bring its washer 156 onto the upper surface of the block 144.

Control over the water flow may be achieved by conventional valves and flow regulators. Since the construction of these elements forms no part of the present invention, they have not been illustrated in detail. However, the flow diagram shown in FIG. 9 should be referred to for a complete understanding of the system.

In FIG. 9, the legend "water for mixer jets" refers to the main water supply for the system. This may be established by merely coupling into a municipal water supply, or a separate pump may be employed. It is essential only that the water be delivered to the machine under substantial pressure.

A flow regulator should be inserted in the line, and this regulator should be adjustable so that the flow of water through the pipes 98 may be varied when necessary. Once the flow regulator has been adjusted to produce a desirable proportioning of the water and abrasive being fed to the hoses 24 of the machine, it is important that this setting be left undisturbed during temporary shutdowns of the abrasive feed system. This result may be

brought about conveniently by inserting a shutoff valve in the line.

Two other water supplies are suggested in FIG. 9. These are necessary for the feeding of fresh abrasive into the system and for supplying the agitator pipes **66** in the separation chamber **36**. The degree of control over these water supplies is largely a matter of choice, and for this reason no control elements have been indicated in FIG. 9. Of course, it will be evident that proper shutoff valves would normally be used for these supplies in order to prevent waste.

It is preferred that the recirculation circuit for delivering material from the collection pit **32** to the upper end of the settling chamber **36** include a pressure regulator and a shutoff valve downstream of the pump **34**. The flow to the settling chamber need not be regulated with great precision, but these control elements have several advantages. The pump **34** must operate upon a fluid which is not uniform and which is inherently difficult to handle. Therefore, periodic surges in the pump output may be anticipated. The pressure regulator serves to iron out these surges, and to keep the pump **34** loaded properly for efficient operation. Similarly, the shutoff valve may be required at times in order to prevent flooding of the settling chamber, etc.

By way of summary, a brief description of the operation of the abrasive feed system of this invention may be helpful. Assuming that all of the various hoses have been coupled properly to the supply lines so as to place the apparatus in operating condition, and assuming further that a supply of abrasive particles has been placed in the bottom of the separation chamber **36**, the first step would be to turn on the water supply for the agitator pipes **66**. The jets of water issuing from the holes **70** in these pipes would keep the abrasive in the bottom of the chamber **36** in a fluid state ready for delivery to the flexible hoses **24** leading to the cutting zone of the wire saw.

The first cutting cycle of the machine probably would be preceded by a test run of the abrasive system. The operator would select approximate settings for the flow regulator in the main water supply line and for the adjustment screws **146** controlling the jet valves in the bottom of the separation chamber **36**. Then, the material issuing from the flexible hoses **24** would be tested to ascertain whether or not the abrasive mix was appropriate for the particular cutting operation to be performed. If it were not of the proper consistency, additional adjustments of the flow regulator valve and the screws **146** might then be made.

Still further adjustments can be made during the first cutting cycle, if necessary. Should the operator of the saw observe that the cutting operation is not proceeding as well as he had anticipated, he may make further corrections in the abrasive mix. Such corrections as are required can be made without interruptions in the cutting cycle.

Upon completion of the first cutting cycle, the abrasive feed may be interrupted by manipulation of the shutoff valve in the main water supply line and by pulling the control rods **136** downwardly to move the valve members **96** connected thereto into engagement with the valve seat elements **92** in the bottom of the separation chamber **36**. Then the cut stone may be removed from the machine, and a new stone S brought into position below the saw wires **18**.

In order to condition the abrasive feed system for the next cutting cycle, all that need be done by the operator is to turn on the valve in the water supply line and to restore the several control rods **136** to the positions in which they cooperate with the blocks **144** adjusted by the screws **146**. The settings of the screws **146** and the flow regulator in the water supply line need not be re-established, because these are not disturbed during the temporary interruption in the feeding of the abrasive.

After a period of time, a substantial quantity of liquid, stone cuttings, and abrasive particles will collect in the pit **32** beneath the wire saw. Then, the recirculation system may be operated by activating the pump **34** to deliver material from the pit **32** to the upper end of the separation chamber **36**. As the recirculated material moves through the separation chamber **36** to the waste outlet hose **64**, the re-usable abrasive particles will settle to the bottom of the chamber and will be available again for delivery to the hoses **24**.

If, at any time, one of the hoses **24** should become clogged, it may be blown out very easily. All that need be done is to close off the abrasive feed valve connected to that particular hose, by manipulation of the control rod **136** connected thereto, and to adjust the flow regulator in the main water line so as to bring a substantial water pressure to bear against the obstruction in the hose **24**. After the line has been cleared, the system may be restored to normal operating conditions by simply returning the flow regulator and the abrasive valve to their original positions.

Although a single embodiment of the invention has been illustrated and described in detail, various modifications and alterations will be apparent to persons skilled in the art. It will be evident also that the utility of certain features of the invention is not restricted to the particular combination of elements disclosed above. It is intended therefore that the foregoing description be considered as exemplary only, and that the scope of the invention be ascertained from the following claims.

We claim:

1. An abrasive supply system for apparatus of the type in which the work operated upon is abraded by contact with particles of abrasive material comprising a chamber for a quantity of particulate abrasive material, a valve seat fixed with respect to a wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber mounted for movement toward and away from said valve seat for closing and opening said hole, a manually operable control member operatively connected to said valve member so that movement of said control member results in movement of said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, manually adjustable means releasably connected to said control member so that a setting of said valve member may be established by manipulation of said manually adjustable means and so that said control member may be moved independently of said manually adjustable means to bring the valve member into contact with said valve seat without disturbing the adjustment of said manually adjustable means, said valve member having an opening therethrough communicating at one end with said hole, a fluid conduit extending into said chamber and communicating with the said opening in said valve member opposite said valve seat for delivering fluid under pressure through said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the fluid stream when said valve member is spaced from said valve seat, and a conduit communicating with said hole in said valve seat for transmitting the material discharged therefrom to the work.

2. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber for a quantity of particulate abrasive material, a valve seat fixed with respect to a wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, conduit means connecting said source to said

valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, an adjustable flow regulator in said conduit means operable independently of said means for moving said valve member so that the liquid flow through said opening in said valve member may be varied, a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone, and a cut-off valve in said conduit means operable independently of both said flow regulator and said means for moving said valve member.

3. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber for a quantity of particulate abrasive material, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a liquid pipe in said chamber having a plurality of outlets near the lower end thereof for discharging liquid in a plurality of jets to keep the abrasive in a fluid state, a source of liquid under pressure, conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone.

4. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber for a quantity of particulate abrasive material, a valve seat fixed with respect to a wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, a control rod operatively connected to said valve member so that movement of said rod results in movement of said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, an adjustment screw releasably connected to said control rod so that a setting of said valve member may be established by manipulation of said screw and so that said rod may be moved independently of said screw to bring the valve member into contact with said valve seat without disturbing the adjustment of said screw, a source of liquid under pressure, conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone.

5. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber for a quantity of particulate abrasive material, an annular valve seat of resilient material fixed with respect to the bottom wall of said chamber for discharging abrasive particles through its central hole, a vertically movable pipe in alignment with said hole, a valve member fixed with respect to the lower end of said pipe and having a central opening coaxial with said hole and communicating with the interior of said pipe, the external surface of said valve member being shaped to provide a downwardly converging portion the lower end of which is smaller than said hole and the upper end of which is larger than said hole, means connected to said pipe for moving said pipe up and down to adjust the position of said converging portion of said valve member relative to said valve seat so as to alter the resistance offered by said member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, conduit means connecting said source and the upper end of said pipe for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone.

6. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber above said wire for a quantity of particulate abrasive material, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber cooperating with said valve seat and having a vertical opening therethrough in alignment with said hole, a pipe fixed with respect to said valve member and extending upwardly through said chamber, linkage means connected to the upper end portion of said pipe for moving said pipe vertically, a control rod extending downwardly along one side of said chamber and being connected to said linkage means so that movement of said rod results in movement of said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a block having an opening for receiving said rod, a projection on said rod adapted to rest upon said block when said rod is in one position relative to said opening in said block and adapted to pass through such opening when said rod is in another position, a vertical adjustment screw connected to said block for controlling the elevation thereof so that a setting of said valve member may be established by manipulation of said screw and so that said rod may be moved independently of said screw to bring the valve member into contact with said valve seat without disturbing the adjustment of said screw, a source of liquid under pressure, conduit means connecting said source to the upper end of said pipe for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone.

7. Apparatus for cutting stone comprising means for supporting a stone to be cut, a wire, means for moving said wire along a path such that it contacts the stone, a conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a collection pit for receiving the liquid and particulate matter falling from the stone during cutting, a separation chamber, means for delivering the material in said pit to the upper end of said chamber, means communicating with the upper end portion of said chamber for discharging liquid and light solid particles therefrom, adjustable means communicating with said conduit for discharging heavy solid particles from the bottom of said chamber into said conduit in predetermined

amounts, and means for supplying liquid under pressure to said conduit to feed such particles to the stone.

8. Apparatus for cutting stone comprising means for supporting a stone to be cut, a wire, means for moving said wire along a path such that it contacts the stone, a conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a collection pit for receiving the liquid and particulate matter falling from the stone during cutting, a settling chamber having an inlet near its upper end and a waste outlet near its upper end spaced horizontally from said inlet, means for delivering the material in said pit to said inlet, baffle means in said chamber for preventing flow of the material directly from said inlet to said outlet so as to allow the heavy abrasive particles to settle to the bottom of the chamber under the influence of gravity, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom of said chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive into said hole, and means for feeding liquid under pressure through said opening and said hole into said conduit.

9. Apparatus for cutting stone comprising means for supporting a stone to be cut, a wire, means for moving said wire along a path such that it contacts the stone, a conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a collection pit for receiving the liquid and particulate matter falling from the stone during cutting, a settling chamber having an inlet near its upper end and a waste outlet near its upper end spaced horizontally from said inlet, means for delivering the material in said pit to said inlet, a screen removably mounted on said chamber in surrounding relationship to said inlet for preventing passage of large solid bodies into the interior of said chamber, baffle means in said chamber for preventing flow of the material directly from said inlet to said outlet so as to allow the heavy abrasive particles to settle to the bottom of the chamber under the influence of gravity, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom of said chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive into said hole, and means for feeding liquid under pressure through said opening and said hole into said conduit.

10. Apparatus for cutting stone comprising means for supporting a stone to be cut, a wire, means for moving said wire along a path such that it contacts the stone, a conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a collection pit for receiving the liquid and particulate matter falling from the stone during cutting, a settling chamber having an inlet near its upper end and a waste outlet near its upper end spaced horizontally from said inlet, means for delivering the material in said pit to said inlet, baffle means in said chamber for preventing flow of the material directly from said inlet to said outlet so as to allow the heavy abrasive particles to settle to the bottom of the chamber under the influence of gravity, agitator means in said chamber to keep the material therein in motion, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom of said chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive into said hole, and means for feeding liquid under pressure through said opening and said hole into said conduit.

11. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a chamber for a quantity of particulate abrasive material, a valve seat fixed with respect to the bottom wall of said chamber and having a hole therein for the discharge of abrasive, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, a plurality of spaced apart guide pins embracing said valve member and extending upwardly from said valve seat in concentric relation to said hole for guiding said valve member, means for moving said valve member up and down with respect to said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a discharge conduit communicating with said hole in said valve seat for delivering the mixture of liquid and abrasive particles discharged therefrom to the zone of contact between said wire and said stone.

12. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a discharge conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a separation chamber having an inlet and having a waste outlet near its upper end, means for collecting the liquid and particulate matter falling from the stone during cutting and for delivering such material to the inlet of said separation chamber, a valve seat in the bottom portion of said chamber fixed with respect to a wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom portion of the chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, a manually operable control member operatively connected to said valve member so that movement of said control member results in movement of said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, manually adjustable means releasably connected to said control member so that a setting of said valve member may be established by manipulation of said manually adjustable means and so that said control member may be moved independently of said manually adjustable means to bring the valve member into contact with said valve seat without disturbing the adjustment of said manually adjustable means, a source of liquid under pressure, and conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat.

13. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a discharge conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a separation chamber having an inlet and having a waste outlet near its upper end, means for collecting the liquid

and particulate matter falling from the stone during cutting and for delivering such material to the inlet of said separation chamber, a valve seat in the bottom portion of said chamber fixed with respect to a wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom portion of the chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, and conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat.

14. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a discharge conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a separation chamber having an inlet and having a waste outlet near its upper end, means for collecting the liquid and particulate matter falling from the stone during cutting and for delivering such material to the inlet of said separation chamber, a valve seat in the bottom portion of said chamber fixed with respect to a wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom portion of the chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and a cut-off valve in said conduit means operable independently of said means for moving said valve member so that said discharge conduit may be cleared of obstructions by delivering liquid under pressure to said discharge conduit when said hole in said valve seat is closed by said valve member.

15. Apparatus for cutting stone comprising a wire, means for moving said wire along a path such that it contacts the stone to be cut, a discharge conduit for delivering a mixture of liquid and abrasive particles to the zone of contact between said wire and the stone, a

separation chamber having an inlet and having a waste outlet near its upper end, means for collecting the liquid and particulate matter falling from the stone during cutting and for delivering such material to the inlet of said separation chamber, a valve seat in the bottom portion of said chamber fixed with respect to a wall of said chamber and having a hole therein communicating with said conduit for discharging abrasive particles from the bottom portion of the chamber into said conduit, a valve member in said chamber cooperating with said valve seat and having an opening therethrough in alignment with said hole, means for moving said valve member toward and away from said valve seat to vary the resistance offered by said valve member to passage of abrasive particles into said hole in said valve seat, a source of liquid under pressure, conduit means connecting said source to said valve member for delivering liquid through said opening in said valve member into said hole in said valve seat to cause entrainment of abrasive particles in the liquid stream when said valve member is spaced from said valve seat, and an adjustable flow regulator in said conduit means operable independently of said means for moving said valve member so that the liquid flow through said opening in said valve member may be varied.

16. In combination with a stone cutting apparatus using a mixture of liquid abrasive particles in a cutting operation and a re-circulating system for said mixture, the improvement comprising a separation chamber for removing spent abrasive and stone dust from the mixture, a discharge conduit connected to the bottom of said separating chamber, adjustable means within said chamber and cooperating with said discharge conduit for regulating the amount of mixture released into said discharge conduit, conduit means connecting said adjustable means to a source of liquid under pressure, valve means in said conduit, means for moving said adjustable means and means for positioning said moving means at predetermined positions to enable the operator to return the adjustable means to the same setting after a complete shut down of the flow of said mixture into said discharge conduit.

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