Jan. 17, 1950 F. J. ARMSTRONG ET AL 2,494,534

COOLANT FILTER SYSTEM

Filed March 16, 1944 5 Sheets-Sheet 1

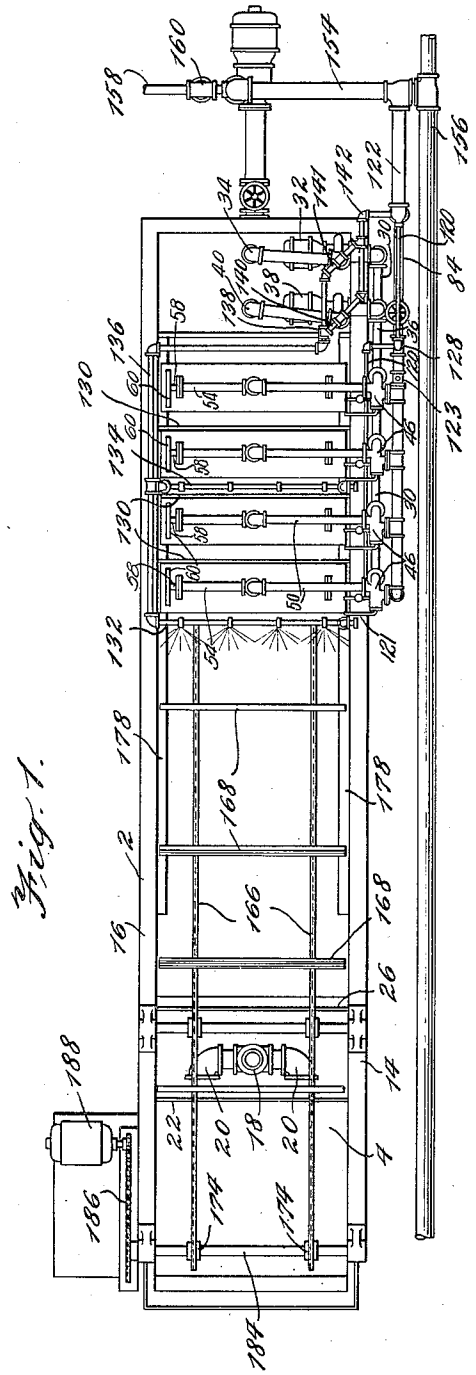


Fig. 1.

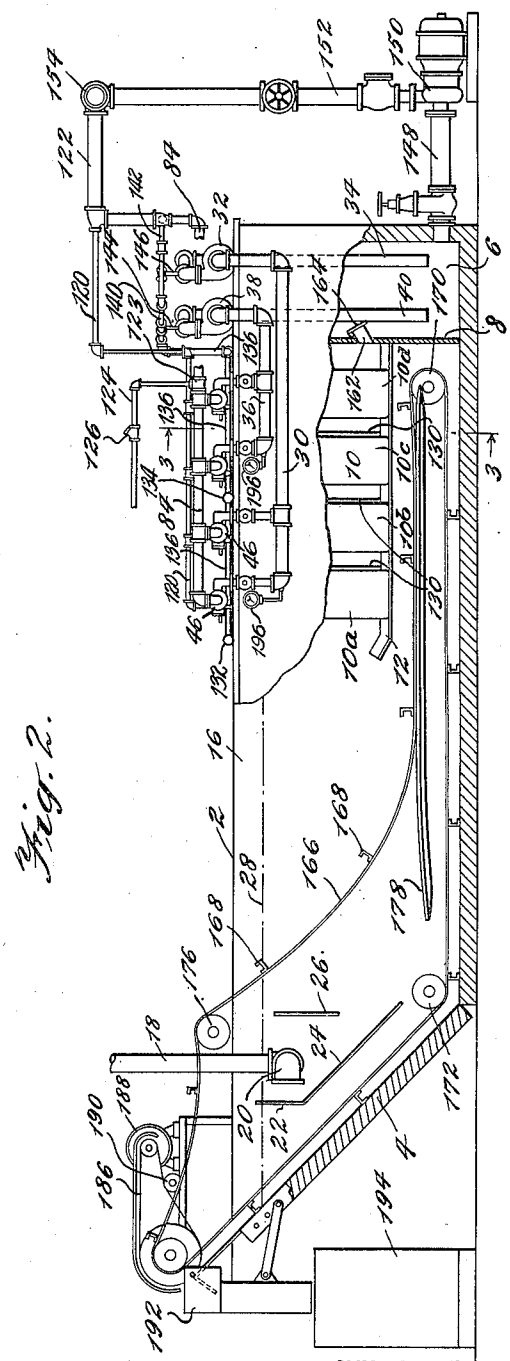


Fig. 2.

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Filed March 16, 1944 5 Sheets-Sheet 2

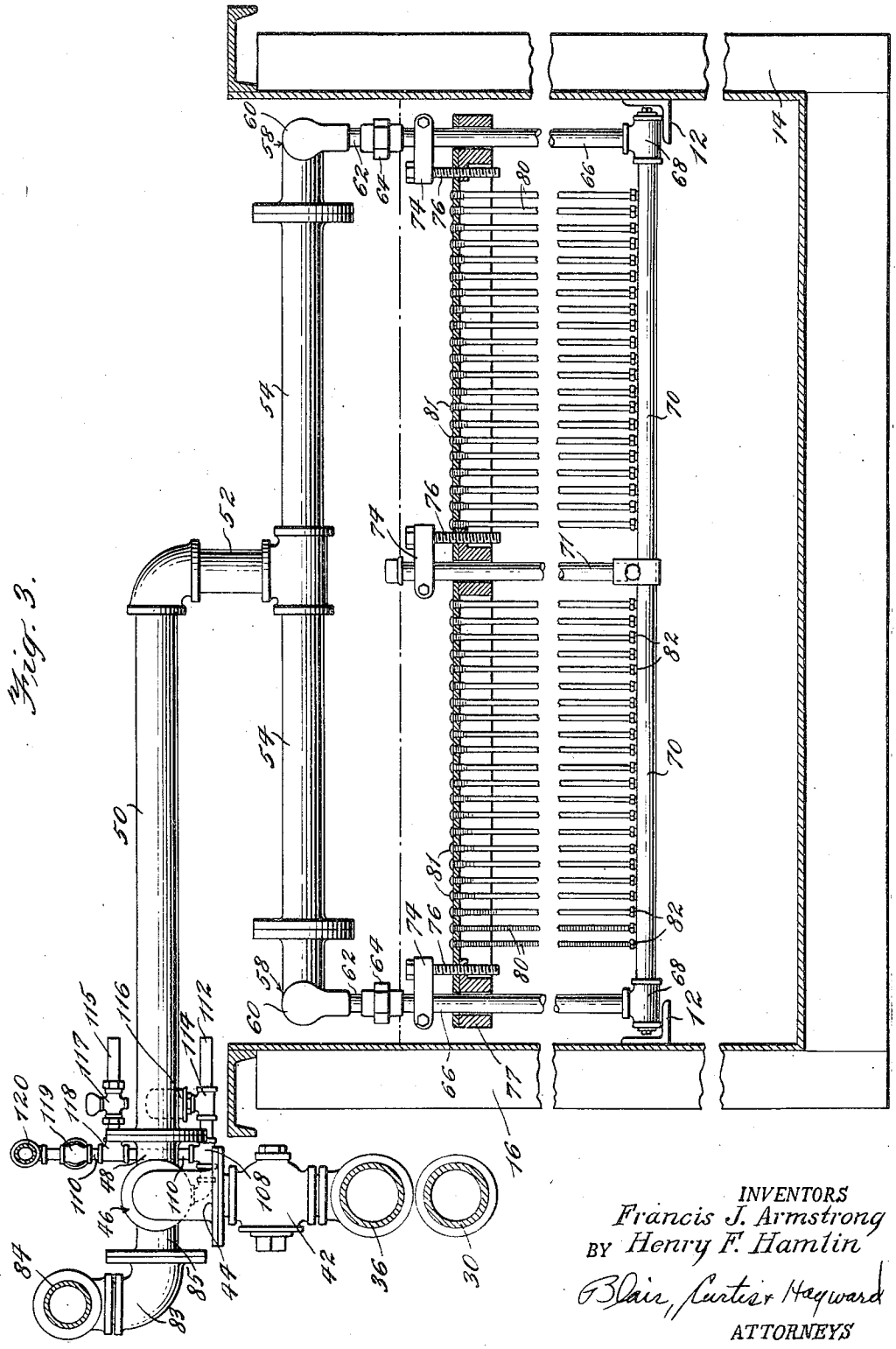


Fig. 3.

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COOLANT FILTER SYSTEM

Filed March 16, 1944 5 Sheets-Sheet 3

Fig. 4.

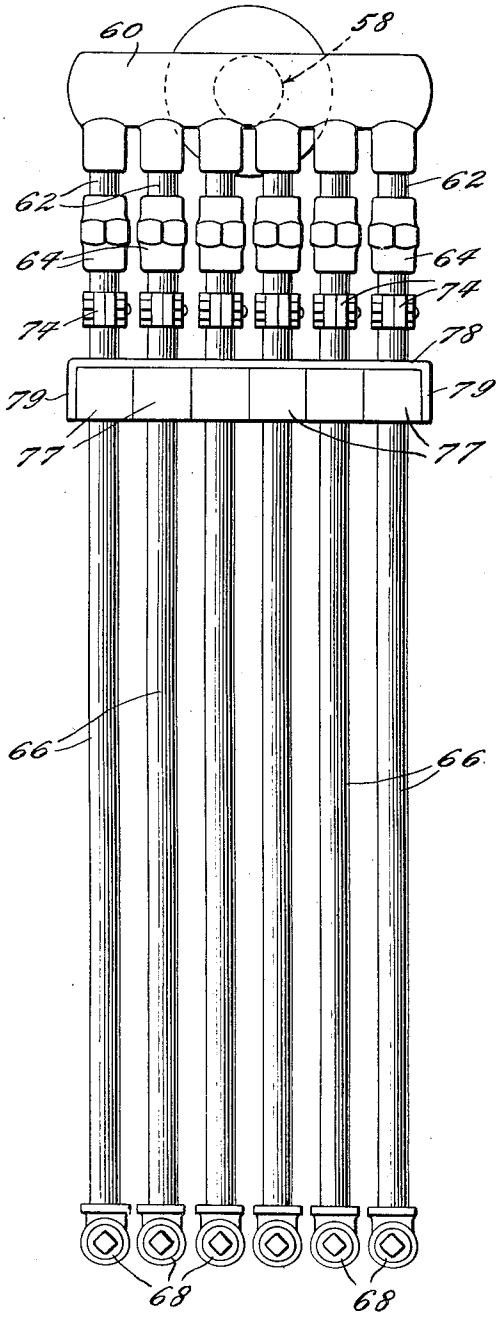


Fig. 5.

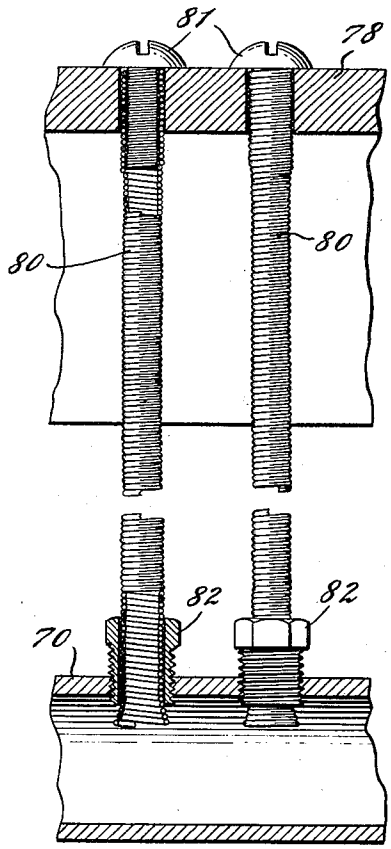
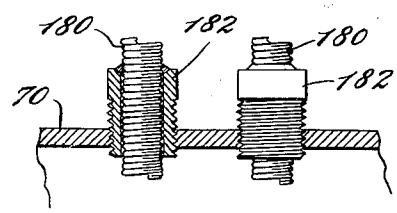


Fig. 6.



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COOLANT FILTER SYSTEM

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Fig. 7.

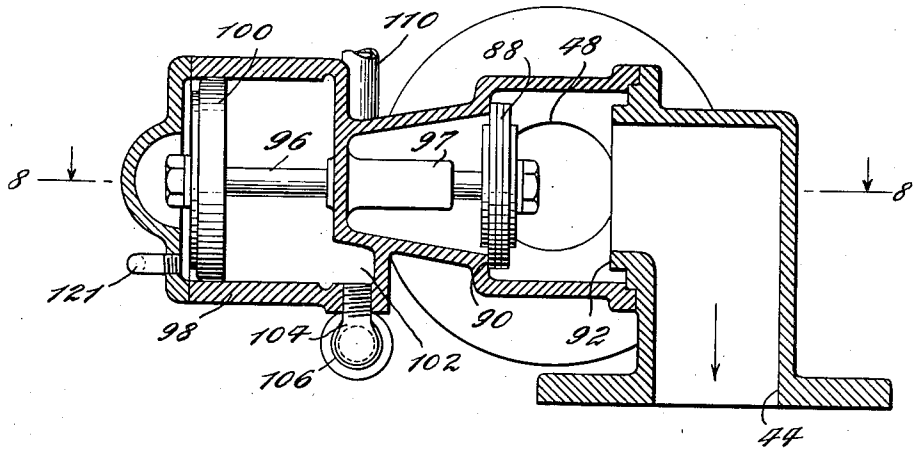
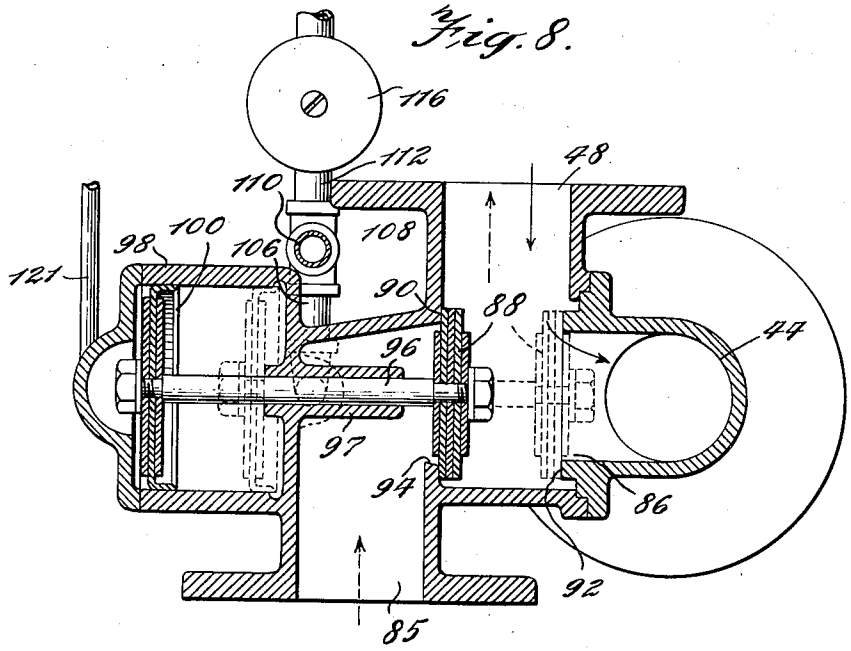


Fig. 8.



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COOLANT FILTER SYSTEM

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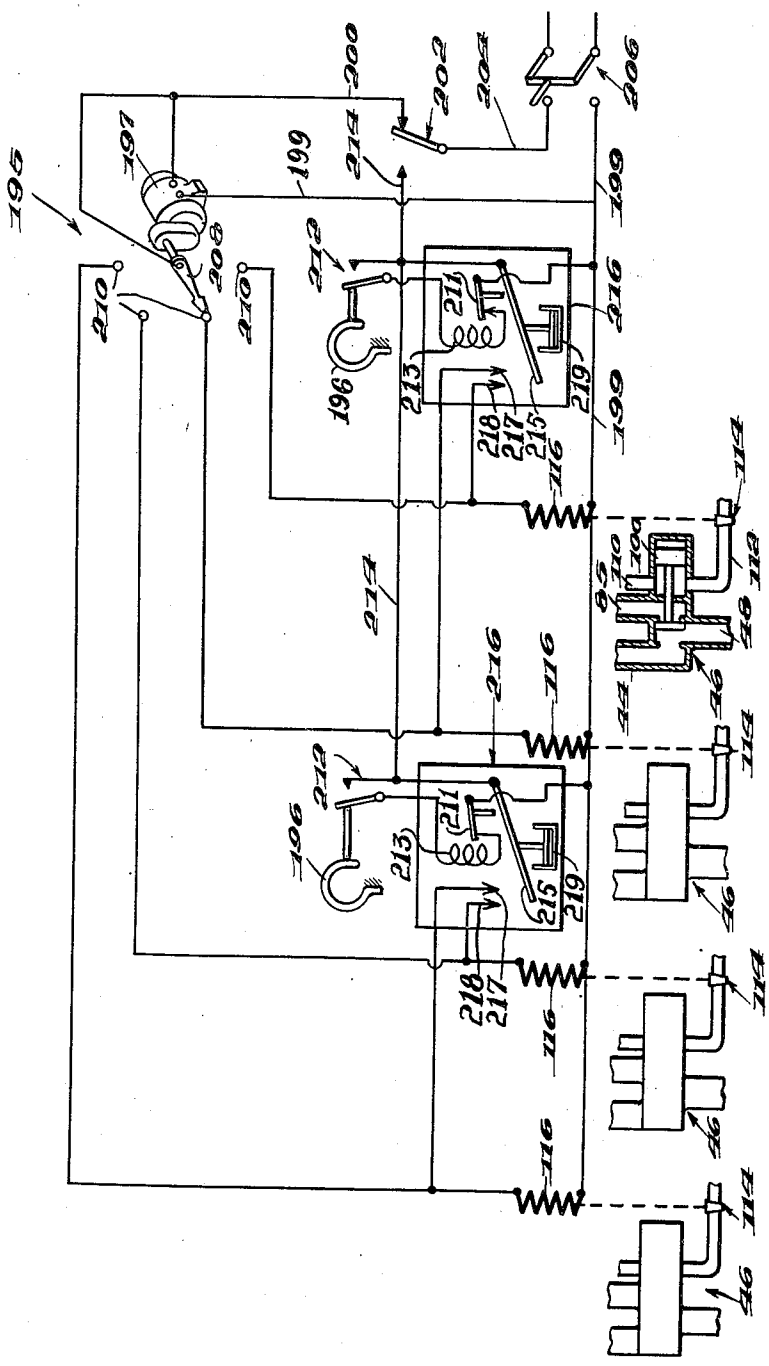


Fig. 9.

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Patented Jan. 17, 1950

2,494,534

UNITED STATES PATENT OFFICE

2,494,534

COOLANT FILTER SYSTEM

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Application March 16, 1944, Serial No. 526,735

13 Claims. (Cl. 210—150)

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This invention relates to the purification of fluids and more particularly to the removal of suspended solid materials from coolant which is used in cutting and grinding tools.

An object of this invention is to provide for a continuous and steady flow of a liquid to a machine or group of machines. A further object is to provide an automatic coolant supply system which will make available to cutting or grinding tools coolant liquid at a constant pressure. A further object is to provide a liquid supply of the above character where the supplying of liquid is insured even under emergency or abnormal conditions. A further object is to provide an efficient system of the above character which will occupy a minimum of space and which may be adapted to meet the many varying conditions which exist where such systems are needed. A still further object is to provide for supplying machine tools with an even stream of coolant which is free to the extent desirable of foreign materials, such as small particles of the metal and of the grinding wheels. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawings:

Figure 1 is a plan view of one embodiment of the invention;

Figure 2 is a side elevation of the embodiment of Figure 1 with parts broken away to show details of construction;

Figure 3 is an enlarged sectional view on the line 3—3 of Figure 2 with the central portion broken away;

Figure 4 is an enlarged elevation of one filter unit;

Figure 5 is an enlarged sectional view showing the manner of attaching the filter springs of the filter unit;

Figure 6 shows another manner of attaching the lower ends of the filter springs;

Figure 7 is a vertical section of the backwash valve;

Figure 8 is a horizontal section of the backwash valve; and

Figure 9 is a schematic wiring diagram of the backwash control system.

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As conducive to a clearer understanding of the invention, we will set forth certain of the problems which are met with in connection with an installation where the illustrative embodiment of the invention is used. With cutting and grinding tools it is common practice to supply a coolant in the form of a stream of liquid such as an oil-water emulsion which flows onto the tool and the work during the working operation. This coolant carries away from the work small particles of metal and, during a grinding operation, small particles of the grinding wheel (referred to as emery). Particularly when the liquid is agitated, these small particles tend to remain suspended and even large particles often settle out very slowly. This is especially true with emulsions where some of the small particles become coated with films of oil. These oil-coated particles tend to float on the top of the liquid and combine with surface oil to form foam; the foam does not disappear rapidly but releases the particles slowly so that the coolant remains dirty for a long period of time.

In considering the question of cleaning coolant it is important to understand the varying demands which are placed upon any particular system, and the varying requirements for different systems. When fine grinding and other finishing operations are being carried on in a shop, the presence of emery or metal particles in the coolant may result in scratching the finished surfaces; thus, it is important to remove even fine particles from the coolant. Under other circumstances, such as when all of the machines in a shop are performing rough cutting operations, it is important that large quantities of coolant be available but it is immaterial whether or not the coolant contains some suspended particles because these will not interfere with the cutting operations and will not damage the work. In this last situation the larger particles of metal must be removed from the coolant but the coolant need not be filtered to the extent necessary to remove the smaller particles. In order to meet these and other situations the commercial system for treating coolant must be adaptable to the particular job at hand so that only the necessary filtering is carried on. In considering this problem, it should also be understood that under emergency conditions partly cleaned coolant is preferable to no coolant because the tools will be severely damaged if the coolant supply is completely cut off. For this reason, the system should insure a supply of coolant even if the coolant is not cleaned to the desired standard.

It is desirable that the system be capable of handling the maximum demand for long periods of time and there should be a reserve supply of coolant. Furthermore, the starting up or shutting down of one machine should not cause a change in the stream of coolant being supplied to the other machines. The stream should be constant and thus should be free of air as this causes spurting and uneven flow at the tool. The illustrative embodiment of the invention meets the requirements above set forth and satisfies the objects discussed.

In the illustrative embodiment of the invention the supply of coolant is held in a horizontal tank which has a partition adjacent one end which forms a chamber for the clean coolant separate from the main body of dirty coolant. At the end of the tank opposite the chamber for the clean coolant the end wall of the tank is inclined, and a slow-moving endless-chain drag arrangement continuously removes sludge from the bottom of the tank and discharges the sludge over the top of the inclined end wall. In the central portion of the tank, adjacent the space for clean coolant, is a bank of filter units through which clean coolant is drawn from the tank and pumped to the chamber for clean coolant at the end of the tank.

Each of these filter units is formed by a large number of vertical, tight-wound coil springs which are under uniform tension to provide even spaces between the adjacent turns of the springs; the coolant flows through these spaces but the dirt or solid particles form a deposit on the outside of the springs. The upper end of each spring is closed by a supporting screw, and the bottom end is open to a header assembly to which the springs are attached. The clean coolant is pumped from the bottom ends of the springs through the header assembly. The deposit which collects upon the springs is removed periodically by reversing the flow, i. e., by pumping clean coolant back through the header assembly and out through the springs. Air is added to the clean coolant as the coolant flows to the filter units to aid the backwash operation. This reversal of flow of the coolant is initiated in the various filter units successively by a timing arrangement. The frequency of the cleaning operation is increased in the event that the flow of coolant from the various units falls below a predetermined minimum.

In the illustrative embodiment, a coolant filter system includes centrifugal pumps and piping to deliver the clean liquid at a constant pressure to the machines where the cutting and grinding operations are carried on. The dirty coolant from the machines is pumped to the main body of dirty coolant in the filter tank and the system is operated continuously to maintain a reserve supply of clean coolant.

Referring particularly to Figures 1 and 2 of the drawings, an open-topped horizontal tank 2, rectangular in horizontal cross-section, has at the left (Figure 2) an inclined end wall 4. At the right hand end of the tank is a chamber 6 for clean coolant which is separated from the remainder of the tank by a partition 8. Submerged in the dirty coolant at the left of partition 8 are four identical filter units designated 10*a*, 10*b*, 10*c*, and 10*d*, but referred to collectively as units 10. Filter units 10 rest on angle bars 12 (see also Figure 3) which are welded to the respective tank side walls 14 and 16 (Figures 1 and 2). The dirty coolant is pumped

to tank 2 in the zone over the inclined end wall 4 through a vertical pipe 18 and two outlets 20. Outlets 20 direct the coolant toward the left against a vertical baffle 22 the upper edge of which is above the normal liquid line 28, and the lower edge of which is attached to an inclined baffle 24, parallel to end wall 4. To the right of outlets 20 is a second vertical baffle 26 the upper edge of which is below the liquid line 28. Baffles 22, 24, and 26 extend between the tank side walls 14 and 16 with the ends of the baffles welded to the side walls. The incoming dirty coolant from outlets 20 is deflected by baffles 22 and 24 toward baffle 26 and the center of the tank. Foam and light particles, such as oil-coated emery, float to the right along the surface while the heavier particles and the main body of the liquid is deflected downwardly. However, the liquid movement caused by the incoming coolant is largely dissipated without causing agitation of the body of the coolant such as would interfere with the removal of suspended solids from the coolant.

The filter units 10 are operated continuously except that they are shut down intermittently for backwashing; that is, to remove the deposit of solid particles collected on the individual filters, all in a manner to be explained below. The filter units 10*a* and 10*b* at the left are operated as a pair with the clean coolant being pumped from them through a pipe 30 by a centrifugal pump 32, the discharge of which is connected to a pipe 34 extending to the lower part of chamber 6; the pair of filter units 10*c* and 10*d* at the right has clean coolant pumped from it through a pipe 36 by a centrifugal pump 38 which discharges into chamber 6 through a pipe 40. Referring to Figure 3 which shows the filter unit 10*d*, pipe 36 is connected through a normally open shut-off valve 42 to the vertical outlet 44 of a backwash valve 46.

Backwash valve 46 is connected through pipes 50 and 52 to two pipes 54 which form the connections to the opposite ends of the filter unit 10. The details of construction of this filter unit are covered in a copending application, Serial No. 526,736, filed March 16, 1944, of Francis J. Armstrong, one of the inventors in the present application, and only those details which are pertinent to the present invention will be discussed here. At the end of each of pipes 54 is a transverse header 58 (see also Figure 4) having a horizontal portion 60 and six downwardly extending connecting nipples 62. Each nipple 62 cooperates with the corresponding nipple of the other header to provide the connection to one of the six individual filter assemblies, one of which is shown in Figure 3 and is formed by a U-shaped pipe assembly and a row of vertical springs 80. Accordingly, each nipple 62 is connected through a coupling 64 to a vertical pipe 66, the lower end of which is connected through a coupling 68 to the end of a horizontal pipe 70.

Clamped to the center of each pipe 70 is a vertical brace pipe 71 which is parallel to pipes 66. Near the top of pipes 66 and 71 is a horizontal channel plate 78 which has downwardly extending sides (Figure 4) 79. The pipes extend through holes in this plate and the plate is adjustably supported from the pipes by brackets 72 clamped to the pipes. Each bracket 72 is clamped to its pipe by a clamping bolt 74 and (Figure 3) in turn supports an adjusting stud 76 which is received in a vertical hole in the bracket; each of studs 76 is threaded in an adjusting block 77 which

is welded to the channel plate 78 and through which the pipe passes. Adjusting blocks 77 are in three groups positioned respectively at the two ends and center of the channel plate with the blocks in each group fitting together in side-by-side relationship as shown in Figure 4; this strengthens the channel plate and provides rigid bracing for the pipes. A rigid frame is formed by pipes 54, the two headers 58, channel plate 78, and the six U-shaped pipe assemblies each formed by a pair of vertical pipes 66 and a horizontal pipe 70; this rigid frame is braced by pipes 71 and is supported by the couplings 68 which rest upon the angle bars 12 at the two sides of the tank.

Channel plate 78 supports the upper ends of six rows of the filter springs 80, the lower ends of the springs of each row being attached to one of pipes 70. The springs attached to each pipe are equally spaced along the pipe except at the center at pipe 71. Springs 80 are connected to plate 78 and pipes 70 in the manner shown in Figure 5, there being threaded into the top end of each spring a stud 81 the thread of which has a pitch slightly greater than the natural pitch of the coil spring; thus, the stud is automatically locked into the end of the spring. The head of the stud rests upon the upper surface of plate 78 with the result that a firm support is provided for the upper end of the spring.

The lower end of each spring 80 extends through a nipple 82 and is flared outwardly as shown at the bottom of Figure 5. Nipple 82 is threaded into a hole in pipe 70 with its lower end providing a seat for the flared end of the spring. Springs 80 are close-wound springs of uniform size and other characteristics and during use the springs are all held under slight tension so that there is a small gap of predetermined thickness between each turn of the spring and the next adjacent turn. Thus, the spring forms a helical slit or gap extending between stud 81 and nipple 82, the length of the gap being approximately equal to the length of the wire in the spring. The uniform length of the springs permits ready assembly and easy replacement, the assembly being merely the sticking of the upper end of the spring through the hole in plate 78, the turning of stud 81 into the end of the spring, and the turning of nipple 82 into the threaded hole in pipe 10. When the filter unit is initially assembled, nipples 82 are turned into their holes a predetermined amount so that with the springs of equal length the gaps are equal in all of the springs. Thereafter the gaps in all of the springs are changed simultaneously by turning studs 76 and thus moving plate 78 vertically.

The embodiment of Figure 6 differs from that of Figure 5 in that each of springs 180 is attached to its pipe 70 by soldering it to a nipple 182 threaded in the pipe. During assembly, the spring is suspended freely from its supporting stud 81 and its lower end extends freely into nipple 182; the spring is then soldered to the nipple. Thereafter the channel plate 78 is adjusted to obtain the desired filter gap in all of the springs in the same manner that the gap is adjusted in the other illustrative embodiment.

During use, suction is maintained in pipe 70 so that the coolant flows through this gap into the center of the spring and thence downwardly to pipe 70. The diameter of the spring is relatively small but is large enough to permit the coolant to flow freely. The wire from which the

spring is made is of sufficient strength to hold the weight of the spring without appreciably extending the spring; thus the gap is uniform throughout the length of the spring. The tension on the springs is such that the gaps prevent the passing of undesirable substances with the coolant and these substances form a deposit upon the outside of the spring. As indicated above, each filter unit is backwashed intermittently to remove this deposit. The backwash operation is carried on at such a time and at a frequency as to suit the demands of the particular installation. Generally, it may be said that the filter unit is backwashed at the time that the flow of clean coolant from the unit is reduced below a practical minimum. For any particular conditions of operation, all of the springs in a filter unit tend to become clogged at the same time. However, the premature clogging of one or several springs of a unit or the clogging of a part of one spring does not interfere with the operation of the remainder of the filter unit.

The backwash operation is performed by supplying clean coolant and slugs of air under pressure to the inside of springs 80 and thus causing an agitated reverse flow through the filter gaps. Under some circumstances, clean coolant alone may be used for backwashing but it has been found that the combined action of the clean coolant and slugs of air removes the deposited substances effectively in a minimum of time. Referring again to Figure 3, the clean coolant and air is supplied to pipes 70 through pipes 66, holders 58, pipes 54, and pipes 52 and 50. Pipe 50 receives the clean coolant and air through the backwash valve 46 from coupling 83 and pipe 84, which is connected to a pipe 122 (Figure 2) which is connected to the pipe 154 supplying coolant to the machine tools as will be explained below.

The details of the backwash valve 46 are best shown in Figures 7 and 8, there being, as shown in Figure 8, the following connections: at the right of the figure the downward connection 44 to the clean coolant suction, at the upper portion of the figure the connection 48 to the filter unit, and at the bottom of the figure a connection 85 to the supply of coolant and air for backwashing. Connection 48 is open to the central valve chamber in which is positioned a double-faced valve 88. The valve chamber is connected at the right through an opening 86 to connection 44 and at the left through an opening 90 to connection 85. The double-faced valve 88 is normally held in the full line position against seat 90 where it closes opening 94; thus, the filter unit is connected through connection 48, opening 86, connection 44, valve 42 (see Figure 3) to pipe 36 and thus to the clean coolant suction. However, when backwashing is taking place, valve 88 (Figures 7 and 8) is in the broken line position against seat 92 where it covers opening 86 so that the supply of air and clean coolant from connection 85 flows through opening 94 and connection 48 to the filter unit.

Valve 88 is supported by a valve rod 96 which is snugly received in a sleeve 97. The pressure on the left-hand face of valve 88 which results from the high pressure from connection 85 and the suction from connection 44 tends to move valve 88 from the full line position to the broken line position. However, the valve is normally held in the full line position by a piston 100 connected to the left-hand end of rod 96 and positioned in a cylinder 98. Accordingly, the

left end wall of the cylinder is open to atmospheric pressure through a pipe 121, and high pressure coolant is supplied (see Figure 7) to the right-hand end of the cylinder through a well 102 at the bottom of the cylinder. Well 102 is connected through a threaded nipple 104 to a pipe 106 (see also Figures 3 and 8) through which the coolant is supplied and discharged.

Referring to Figure 3, pipe 106 is connected through a T-coupling 108 to a drain pipe 112 at the right, and to a fluid supply pipe 110 which extends upwardly. Drain pipe 112 has a normally closed solenoid valve 114 which is opened by the energization of a solenoid 116. Pipe 110 is connected through a T-coupling 118 to an auxiliary drain pipe 115 having a normally closed valve 117. The upper end of pipe 110 is connected through a needle valve 119 to a pipe 120 which is connected to a pipe 122 (Figure 2) which in turn is connected to pipe 154 which is the supply of high pressure clean coolant, and the needle valve is partially open to permit the flow of a small stream of coolant into pipe 110 (Figure 3). Under normal circumstances, valves 114 and 117 are closed and the small stream of coolant from needle valve 119 flows through pipe 106 where it builds up pressure in cylinder 98 and moves piston 100 (see Figures 7 and 8) to the left. After piston 100 and valve 88 reach the full-line position the pressure in cylinder 98 builds up and reaches substantially the pressure in the supply pipe 120; and valve 88 is held tightly against seat 90.

Subsequently, when it is desirable to initiate the backwash operation, solenoid 116 (Figure 3) is energized with the result that valve 114 is opened and coolant is drained from pipes 106 and 110 faster than the coolant is supplied through needle valve 119. This results in the draining of coolant from cylinder 98 and (Figures 7 and 8) piston 100 and valve 88 are moved to their broken line positions by the difference in pressures on the opposite sides of the valve. As a result, the backwash operation is started and it continues until solenoid 116 is deenergized thereby closing valve 114. Coolant which seeps past piston 100 in cylinder 98 is discharged through pipe 121 into tank 2. Any sediment which tends to collect in cylinder 98 is discharged through well 102 along with the coolant.

When the backwash operation is started the high pressure clean coolant flows from pipe 70 (Figure 5) into the lower ends of the springs 80. The pressure on the inside of each spring tends to extend the spring upwardly and thus raise the head of stud 81 away from the upper surface of plate 78. This increases the width of the gap in the spring so that the spring is flexed; the movement assists the coolant and air in dislodging the deposit on the spring. The air causes the coolant to surge and this gives an added action. The effect is very pronounced when the springs are badly clogged by the deposit so that a high pressure is built up within the springs.

The pipe connections for the system are shown best in Figures 1 and 2. The supply of clean coolant for backwashing is carried by pipe 84 which is connected at the right to a pipe 122. Near the top of the right-hand filter unit 10*d* (see Figure 2) is an air connection 123 through which air is supplied to pipe 84 through a pipe 124; a check valve 126 permits flow to the right only. Referring to Figure 1, at the right of air connection 123 is a check valve 128 which permits liquid to flow to the left but which prevents the liquid with air added to it from flowing to the right. Check valve 126 in pipe 124 performs a similar function by permitting air to flow into pipe 84 and preventing the reverse flow. Liquid and air are supplied at substantially the same pressure and it has been found that a substantial amount of air is carried with the liquid to the filter units. As indicated above, the deposit which is released from the springs falls to the bottom of tank 2. In this embodiment the filter units are backwashed individually under the control of an electric timer all in a manner to be more fully explained below. The deposit which is dislodged from one filter unit during backwashing should not be drawn onto the springs of another filter unit. Accordingly, mounted between each filter unit and the next filter unit is a baffle 130 which causes the dislodged deposit to settle to the bottom of the tank. At the end of the backwash operation the filter unit remains idle for a short period of time thus permitting the dislodged deposit to settle.

As shown best in Figure 1, at the left of the group of filter units is a spray unit 132 which has four spray heads each directing a fan-shaped spray of clean fluid to the left against the surface of the coolant. Between filter units 10*b* and 10*c* is a similar spray unit 134 which also directs fan-shaped sprays to the left along the surface of the coolant. These sprays of coolant tend to stop surface movement toward the filter units so that floating substances are kept away from the top of the filter units. Furthermore, these sprays tend to destroy foam and to submerge floating solids.

The coolant supply for the spray units 132 and 134 is received through a pipe 136 which is connected by a coupling 138 to two branch pipes 140 and 141, the other ends of which are connected through a supply pipe 142 to pipe 122. Pipe 140 extends over the top of centrifugal pump 38 and, as shown in Figure 2, is connected to the top of the outlet of the pump through a vertical pipe 144. Similarly, pipe 141 extends over the top of pump 32 and is connected to the pump through a vertical pipe 146. The flow of coolant through pipes 140 and 141 to the sprays is sufficient to carry away constantly any air which tends to collect in the centrifugal pumps and the centrifugal pumps are constantly primed by the high pressure coolant in these pipes; thus, the centrifugal pumps provide a steady and unfailing suction upon their respective filter units.

As indicated above, the clean coolant is delivered to chamber 6 and this chamber holds the reserve supply of clean coolant. Excess coolant flows over the top of partition 8 into the main body of coolant so that the top of partition 8 acts as a wier to maintain a constant liquid head in chamber 6 so that the pressure is constant at the bottom of the chamber. Air in the coolant tends to come out in chamber 6 so that there is always air-free clean coolant at the bottom of the chamber. As shown best in Figure 2, this coolant is drawn from chamber 6 through a pipe 148 by a centrifugal pump 150 and delivered under pressure to a vertical pipe 152. The constant pressure at the bottom of chamber 6 insures a constant outlet pressure from pump 150. Centrifugal pumps 32, 38, and 150 will handle any coolant which is passed by the filter units 10, and even when small particles remain in the coolant the pumps are not damaged and do not suffer from excessive wear.

Pipe 152 is connected at its top to a horizontal pipe 154 which, as shown in Figure 1, passes to the side of the tank where it connects to pipe 122, referred to above, and also to pipe 156 which extends to the machine tools. At the side of pump 150 (see Figure 1) is a drain pipe 158 having a normally closed valve 160 which is opened to drain coolant from the system.

Under some circumstances, it may be necessary to close down all of the filter units at once or the filter units might become inoperative due, for example, to clogging without the operator becoming aware of the situation. However, it is important to maintain a supply of coolant to certain machine tools as they would be severely damaged if they were operated without coolant. Accordingly, partition 8 has a normally-closed one-way valve 162 midway between the top and bottom of the partition which opens automatically when desirable to permit coolant to flow into chamber 6 from the main body of coolant. This valve extends at an angle upwardly to the right from partition 8 into chamber 6 and it has a valve flap 164 hinged at its upper edge and weighted to hold the flap down. The valve is open at the left to the main supply of coolant and the bottom wall of the valve slants at such an angle that any particles which fall upon the bottom wall are deflected to the left and thence fall to the bottom of tank 2.

During normal conditions, with the liquid level in chamber 6 above or equal to the liquid level in the main tank, the weighted flap is held down by the action of gravity and the added action of any favorable pressure difference. However, if the liquid level in chamber 6 falls to the level of valve 162, the liquid pressure at the left of the valve overcomes the force of gravity holding flap 164 down and the flap is raised permitting liquid from the main body to flow through the valve into chamber 6; thus, chamber 6 will be supplied with coolant even though the filter system is not operating. It should be noted that the position of valve 162 is such that partially clean coolant flows into chamber 6 through the valve; that is, valve 162 is above the bottom of the tank where the sludge formed by large particles and the deposit from the filter units tend to settle. Furthermore, the valve is below the top of the liquid where the lighter particles tend to float and the valve is at the opposite end of the tank from the supply of dirty coolant.

The sludge which collects on the bottom of the tank is removed by an endless chain assembly formed by two endless chains (Figure 1) 166 and a number of spaced scrapers or flights 168 which are in the form of channel members each attached at its edge to the endless chains. Each chain extends (Figure 2) around a sprocket wheel 170 at the right-hand end of tank 2, along the bottom of the tank to a sprocket wheel 172, up the slanting end wall of the tank to a sprocket wheel 174, and thence to the right over a sprocket wheel 176 and down into the tank to sprocket wheel 170. Welded to each side wall of the tank is an angle bar 178 upon which the ends of flights 168 slide as they move beneath the filter units; the angle bars guide and support the flights and the adjacent portions of chains 166 and the flights and chains moving toward sprocket wheels 170 do not disturb the sludge on the bottom of the tank. Each pair of the sprocket wheels is mounted on a shaft (see Figure 1) which is supported at the two sides of the tank. Sprocket wheels 174 have a shaft 184 which is driven at one end through

a belt 186 by a motor 188; as shown in Figure 2, the tension of belt 186 is adjusted by an idler pulley 190. The flights 186 are moved slowly across the bottom of tank 2 and up end wall 4. At the top of the end wall the sludge carried by each flight is discharged over the top of the end wall and into an adjustable chute 192 from which it falls to a refuse can 194.

As indicated above, the backwash operation is started and stopped automatically by an electric timer 195, the functioning of which will be explained in connection with Figure 9. Timer 195 has its motor 197 connected at one side to a line 199 and at the other side to a line 200. Line 200 is connected to a line 204 through a manual switch 202 which is normally in the right-hand position as shown and lines 199 and 204 are connected through a normally closed switch 206 to a source of power. Timer 195 has an armature 208 which is also connected to line 200 and which engages four contacts 210 in series so as to energize each of these contacts for a predetermined period at stated intervals. Each of the contacts 210 is connected to one side of one of the solenoids 116 of valves 114 and the other side of each of these solenoids is connected to line 199. Thus the solenoids are energized at spaced intervals each for a predetermined time and as pointed out above the backwash operation for each of the filter units is carried on during the time that its solenoid 116 is energized. It is thus seen that for example at stated periods, the timer backwashes the filter unit 10*a*, and when this operation is completed filter units 10*b*, 10*c* and 10*d* are backwashed in succession. The timer may be adjusted with respect to the time, frequency and duration of the backwash operations.

Under some circumstances, it is desirable to backwash a filter unit only when the flow rate of the coolant through the unit is substantially reduced. To obtain this result switch 202 is turned manually from the normal position where the timer controls the backwash operation to a secondary position at the left where the backwashing is under the control of the flow rate of the coolant. As indicated above, pumps 32 and 38 are of the centrifugal type, and the suction maintained by them is increased when the flow is restricted by an excessive deposit. This characteristic of the centrifugal pump is utilized to initiate the backwash operation on the units in accordance with the reduction in the flow rate of the coolant. This is accomplished by providing at the left-hand end of each of pipes 30 and 36, a pressure gauge 196 (see Figure 2) which is provided with a gauge switch 212 which closes when the gauge indicates a predetermined pressure in the pipe. The closing of each gauge switch initiates a backwash cycle for the two filter units connected to that particular gauge so that each backwash cycle is initiated by one of the gauges 196. However, the backwashing is carried on for a predetermined time in the same manner as when the timer is controlling the entire operation.

The initiation of the backwash cycles upon the closure of gauge switches 212 is accomplished by means of relays 216 (Figure 9). There are two of these relay switches 216 which are identical, the right-hand one of which controls the backwashing of filter units 10*c* and 10*d*, and the left-hand one of which controls the backwashing of filter units 10*a* and 10*b*. The operation of the right-hand relay 216 will be described in detail, with the understanding that the left-hand relay is constructed and operates in an identical man-

ner. This relay has an armature 215 connected to line 214 and it has a winding 213 connected at one side to switch 212 and at the other side through a normally-closed switch 211 to line 199. Armature 215 is raised by the energization of winding 213, and when raised it engages a pair of contacts 217 and 218 connected respectively to the solenoids 116 of filter units 10c and 10d.

When winding 213 is energized, armature 215 is raised immediately so that contacts 217 and 218 are connected to line 214, and this energizes solenoids 116 and initiates the backwash operation, as described above, and the backwash operation continues as long as armature 215 is raised. The lifting of armature 215 opens switch 211 so that winding 213 is deenergized. However, the relay has a dash pot 219 mechanically connected to armature 215 which holds the armature up for a predetermined time after winding 213 is deenergized. This dash pot gives the relay a delayed opening characteristic whereby solenoids 116 are held energized for a predetermined time after the relay is deenergized. This period of time is the time required for completion of the backwash operation, and at the end of this time the armature drops slowly and the filter units are returned to their normal filtering operation. During the backwash operations, the centrifugal pumps 32, 38, and 150 continue to operate.

In practice, it is desirable to maintain a reserve supply of clean coolant at all times; thus, the system is able to handle unpredicted emergency demands. The continued operation of the filtering process during periods when there is very little or no demand for clean coolant raises the standard of purity of the main body of coolant to a point that the main body of coolant is substantially free of foreign particles. In this way, when an excessive load is placed on the system, the filter units continue to operate efficiently because they do not become clogged and the excessive load is carried without bringing the standards of purity of the coolant below the desired value.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In a system for removing substances from liquid, the combination of, an elongated horizontal tank containing the liquid and having an outwardly slanting end wall at one end thereof, means forming an end chamber for clean liquid at the end of the tank opposite said slanting end wall, an endless chain assembly mounted to move longitudinally of said tank and having spaced means which are moved successively from the end of the tank opposite said slanting end wall along the bottom of the tank and up along said slanting end wall thereby to discharge sludge from the tank, a plurality of filter units positioned within said tank below the normal liquid level in the tank whereby the filter units are immersed in liquid, said filter units being adapted to have liquid withdrawn therethrough, pump means connected to draw liquid from said filter units and to discharge the liquid in said end chamber, and means to deliver liquid to the end of the tank opposite said end chamber beneath the normal liquid level and substantially in the direction of said slanting end wall.

2. Apparatus as described in claim 1 wherein said means forming said end chamber has a weighted valve substantially above the bottom of said tank and below the normal liquid levels in the end chamber and tank which valve is adapted to be opened by the differential of liquid pressure on the two sides of the valve when the liquid level in said end chamber falls a predetermined amount below the level in the tank.

3. In a system as described in claim 1 wherein the liquid being filtered is coolant and which includes, pump means to pump clean coolant from said end chamber and valve means connected between the pump means and the filter units whereby the filtered coolant normally flows from said filter units and which valve means is operated to stop the normal flow and to direct the clean coolant from said pump means to said filter unit.

4. In a system for supplying clean coolant of the emulsion type to a bank of machine tools, the combination of, an elongated settling tank for the dirty coolant positioned horizontally and having a slanting end wall, partition means at the end of said tank opposite said slanting end wall and dividing off the end of said tank as an end chamber for clean coolant, said partition means having a wier at its top edge above the normal level of dirty coolant in said tank whereby excess clean coolant flows from said end chamber over said wier to the dirty coolant, a plurality of filter units positioned between said partition means and the central portion of said tank below the normal liquid level in the tank and with a free space beneath the filter units into which dirt may settle from the coolant, said filter units each being formed by a plurality of vertical coil springs having predetermined gaps between the adjacent turns and means to direct a flow of coolant from the bottom of each spring whereby clean coolant flows through the gaps in the springs and the dirt is collected about the springs, means to pump the clean coolant from the filter units to said end chamber, means to reverse the flow of coolant in the various filter units whereby the dirt collected about the springs is released and falls to the bottom of the tank, a dirt-removing mechanism formed by a pair of endless chains mounted longitudinally of the tank and having spaced scraping means mounted as flights upon the chains so that as the chains are moved the flights are successively moved along the bottom of the tank from the end adjacent said partition means to said slanting end wall and thence up along said slanting end wall to discharge the dirt collected, and means to withdraw clean coolant from said end chamber.

5. Apparatus as described in claim 4 which includes, means to supply clean coolant to perform the reverse flow operation, and means to add air to the clean coolant at substantially the same pressure as the clean coolant, whereby slugs of air and coolant are delivered to the springs.

6. In a system for supplying clean coolant to machine tools, the combination of, a horizontally elongated tank for the dirty coolant with the body of dirty coolant occupying a relatively large and horizontally disposed space, partition means adjacent one wall of said tank and forming a chamber for clean coolant which has at the top a wier discharging excess clean coolant from said chamber into the body of dirty coolant, a plurality of filter units mounted adjacent said parti-

tion means below the normal liquid level in the tank and with each filter unit formed by a plurality of coiled springs, means to add dirty coolant to the tank in a zone remote from said filter units, baffle means to direct the incoming dirty coolant in a downward direction toward the central portion of the tank and to direct the floating matter along the surface of the dirty coolant toward the central portion of the tank, pump means to pump the clean coolant under pressure, spray means connected to the last-named means and directing a spray of the clean coolant against the surface of the dirty coolant in a surface zone separating the surface of the dirty coolant above said filter units from the remaining surface of the dirty coolant with the spray being directed so as to cause a surface movement away from the area above the filter units, said spray being effective to destroy foam and to sink other floating substances, rake means to remove dirt collected on the bottom of said tank without materially interfering with the filtering and settling operations, and means to reverse the flow of coolant in each of said filter units whereby the dirt collected is released so that it may settle to the bottom of the tank.

7. Apparatus as described in claim 6 which includes, centrifugal pump means positioned above said chamber and connected to withdraw clean coolant from the filter units, pipe means connected to said spray means to supply the clean coolant thereto, said pipe means extending across the top of said centrifugal pump means and being connected thereto whereby air which tends to collect in said centrifugal pump means is carried away to said spray means.

8. Apparatus as described in claim 6 wherein the clean coolant is delivered to said end chamber below the normal liquid level in the end chamber and which apparatus includes, a centrifugal pump connected to the bottom of said end chamber to withdraw clean coolant therefrom, whereby air in the clean coolant escapes and air-free coolant is withdrawn by said centrifugal pump.

9. In a filter system wherein fluid is filtered by drawing it through a filter unit which is immersed in a body of the unfiltered fluid with the result that the substances being filtered from the fluid form a deposit on the filter unit and wherein a supply of clean fluid is pumped into the filter unit to discharge said deposit, fluid control means connected to the filter unit to control the drawing of fluid from the filter unit and the reverse flow of the fluid comprising: a double-acting valve having a valve element and a central valve chamber which has an opening connected to the filter unit and in which chamber the valve element is positioned, and wherein said valve chamber has at one side a supply opening through which it is connected to a supply of clean fluid under pressure and has on the side opposite a fluid discharge opening through which the clean fluid from the filter unit is pumped, said supply and discharge openings each having a valve seat against which said valve element may be positioned to close the opening; and motive means to move said valve element between the two positions against said seats of said supply and discharge openings, said motive means comprising, a piston rod, a piston-cylinder unit having a cylinder and a piston positioned therein, said piston being rigidly connected by said piston rod to said valve element, and a fluid supply means through which fluid is supplied to said cylinder at one side of said piston with sufficient pressure to move said piston to one extreme position with the valve element closing the opening to the supply of clean coolant.

10. Apparatus as described in claim 9 which includes a needle valve connected in the inlet from said fluid supply means to said cylinder whereby the fluid is supplied to said cylinder at a slow rate, and fluid discharge means to release the fluid from said cylinder at a more rapid rate than the fluid is supplied through said needle valve whereby the fluid pressure within said cylinder is released and the fluid pressure of the coolant at said openings and within said chamber moves said valve element against the valve seat of the opening through which the coolant is pumped.

11. In a filter system, the combination of, an elongated horizontal tank having a vertical side wall, a plurality of filter units adjacent one end of said tank and positioned in parallel relationship transversely of said tank below the normal liquid level in the tank, a connecting pipe assembly connected to said filter units including parallel pipes extending over the top of said side wall, means to deliver the liquid to be filtered beneath the surface of the liquid at the end of the tank opposite said filter units, means to withdraw the filtered liquid from said filter units thereby to form a deposit on each of said filter units, means constituting a supply of fluid to be delivered to said filter units whereby the flow through the filter units is reversed and the deposit is released, and means to control the flow to and from said filter units comprising a valve assembly associated with each of said filter units including a fluid control system and solenoid means to regulate said fluid control system.

12. In a filter system, the combination of, an elongated horizontal tank, means to deliver the liquid to be filtered to said tank at one end thereof, a plurality of filter units at the opposite end of said tank below the liquid level in the tank, means forming a chamber for filtered liquid adjacent said filter units and having a wier at its top through which excess filtered liquid flows from said chamber into the body of unfiltered liquid, means to withdraw filtered liquid from said filter units and to deliver said filtered liquid to said chamber, a weighted valve connecting the body of filtered liquid in said tank to said chamber at a point above the bottom of said tank and below the normal liquid level in the tank, pump means to pump clean coolant from said chamber and thence in a reverse direction through said filter units whereby materials filtered from the liquid are released from the filter units, and baffle means between two adjacent filter units to deflect the released materials from one filter unit away from the other filter unit.

13. In a filter system, the combination of, an elongated horizontal tank constituting a container for a body of unfiltered liquid, means to deliver the unfiltered liquid to said tank at one end thereof whereby the large suspended particles may settle by gravity, means to project an intense spray of liquid against the surface of the body of the unfiltered liquid whereby foam is destroyed and floating substances are immersed and caused to sink, a plurality of filter units positioned in the body of unfiltered liquid at the end thereof opposite the zone where the unfiltered liquid is delivered to the tank, means to withdraw filtered liquid from said filter units to store a substantial quantity of the filtered liquid, means to backwash the filter units individually by reversing the flow of liquid therethrough, and means to scrape

the particles collected at the bottom of the body of liquid from the end of the tank opposite the end at which the filter units are positioned.

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Certificate of Correction

Patent No. 2,494,534 January 17, 1950

FRANCIS J. ARMSTRONG ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 51, for "pipe 10" read *pipe 70*; column 6, line 34, for "holders 58" read *headers 58*; column 14, line 49, for the word "filtered" read *unfiltered*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of June, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.