Aug. 29, 1950 A. H. DALL ET AL 2,520,129

LUBRICATING SYSTEM

Filed April 28, 1943 4 Sheets-Sheet 1

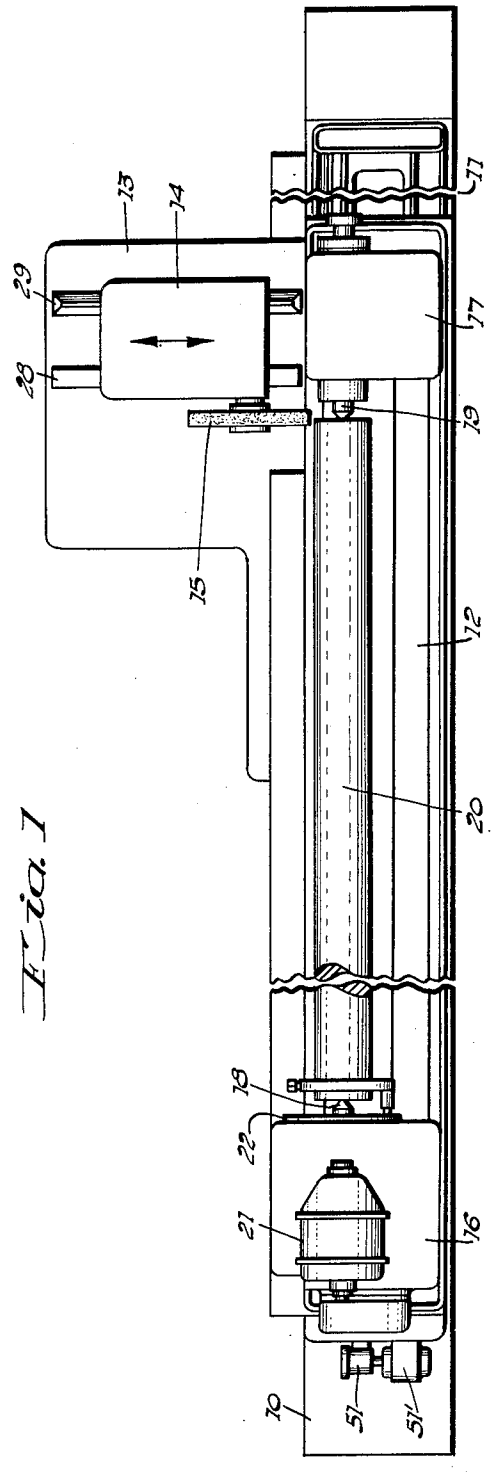


Fig. 1

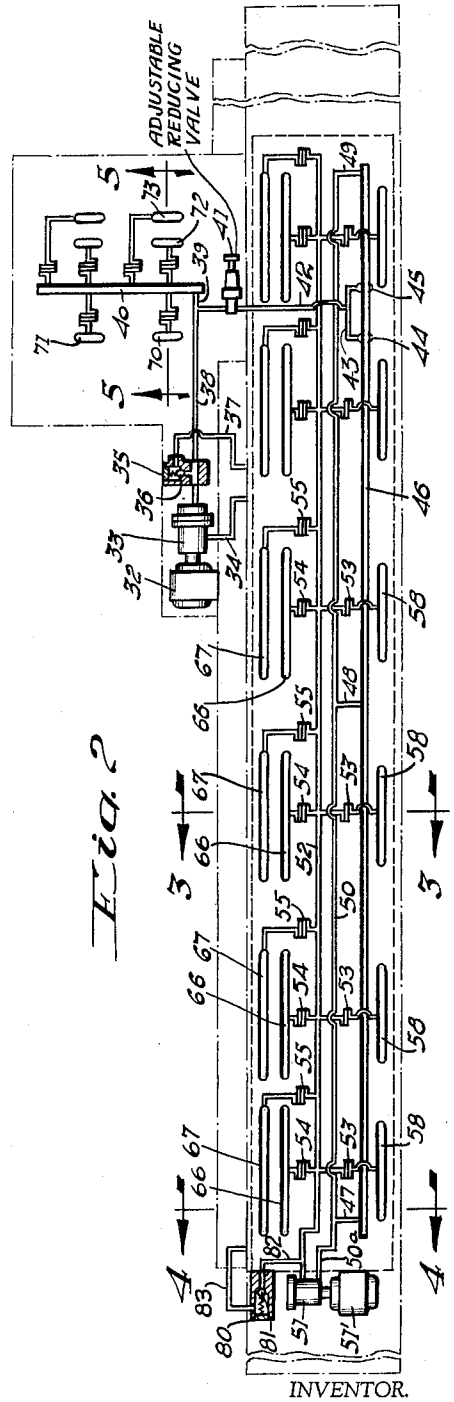


Fig. 2

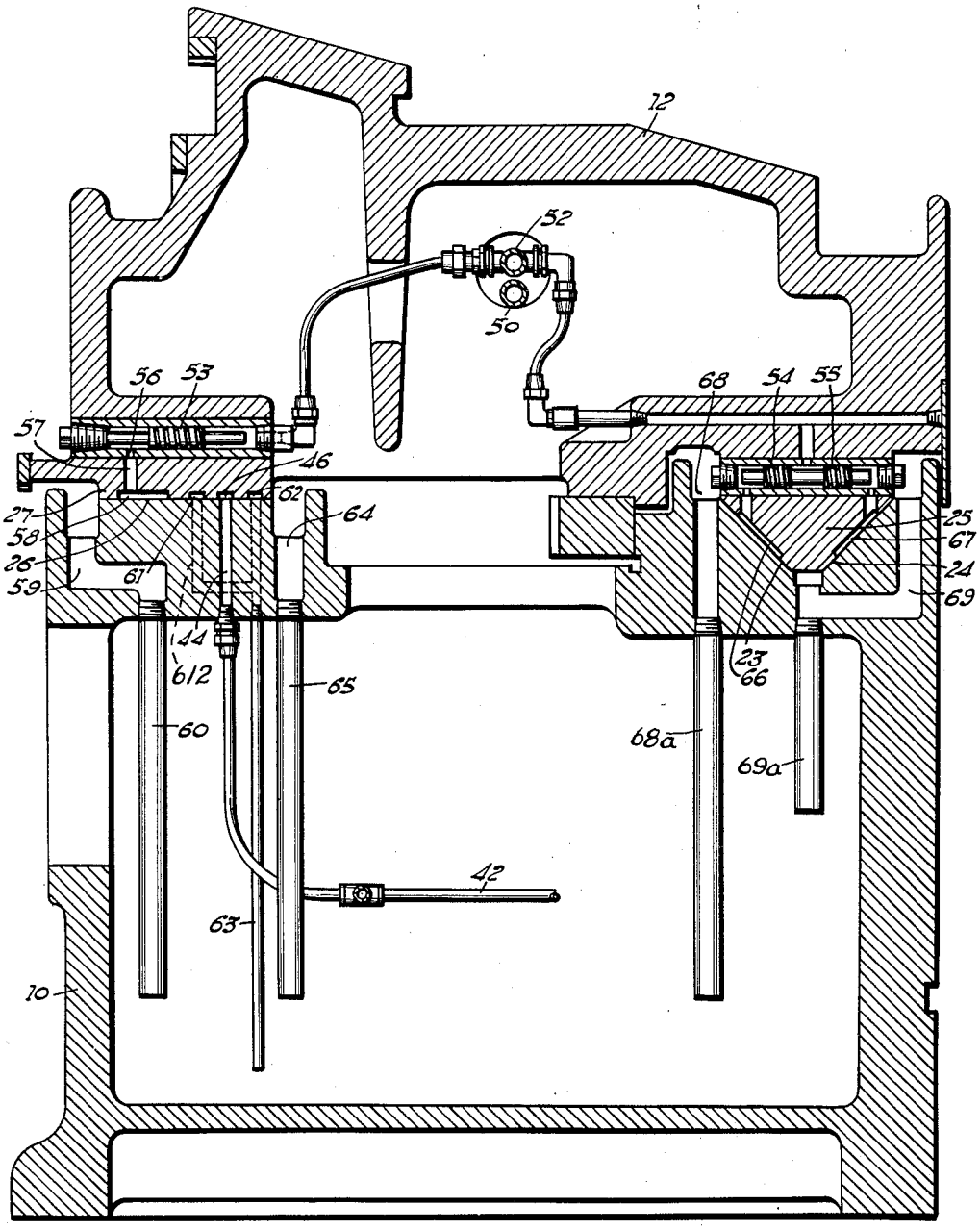
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Fig. 3



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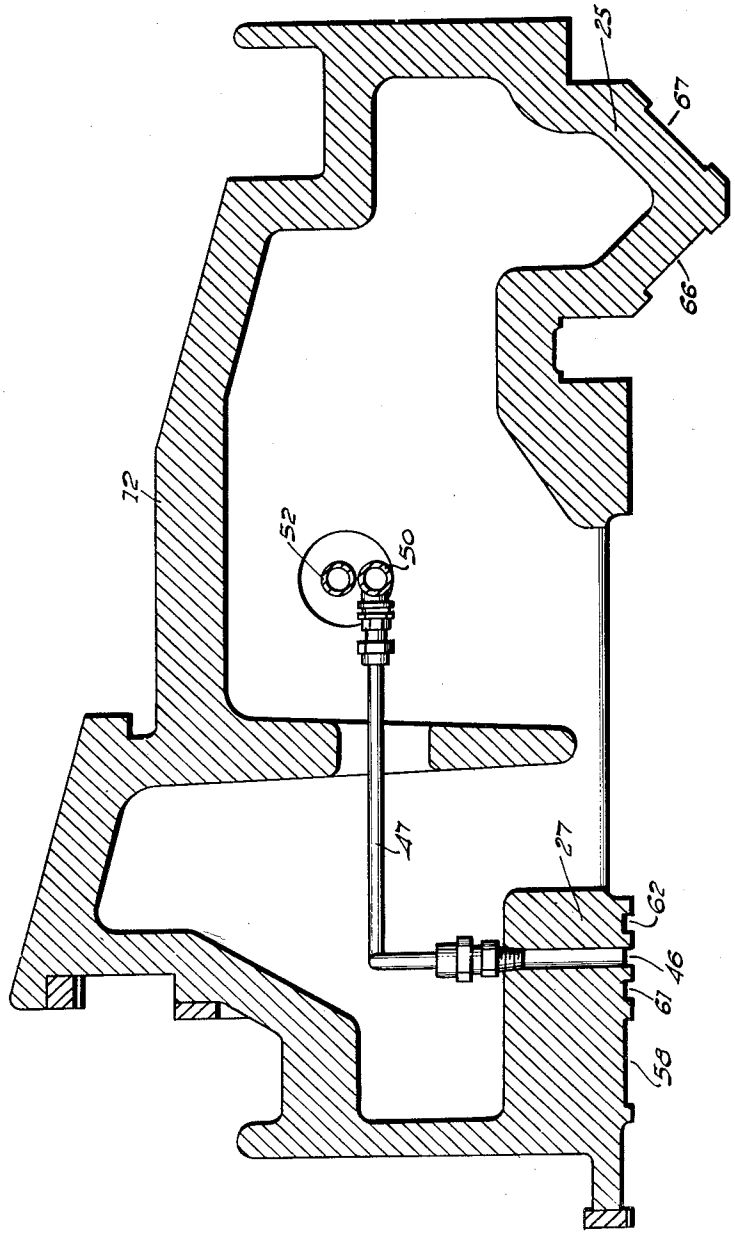
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Fig. 4



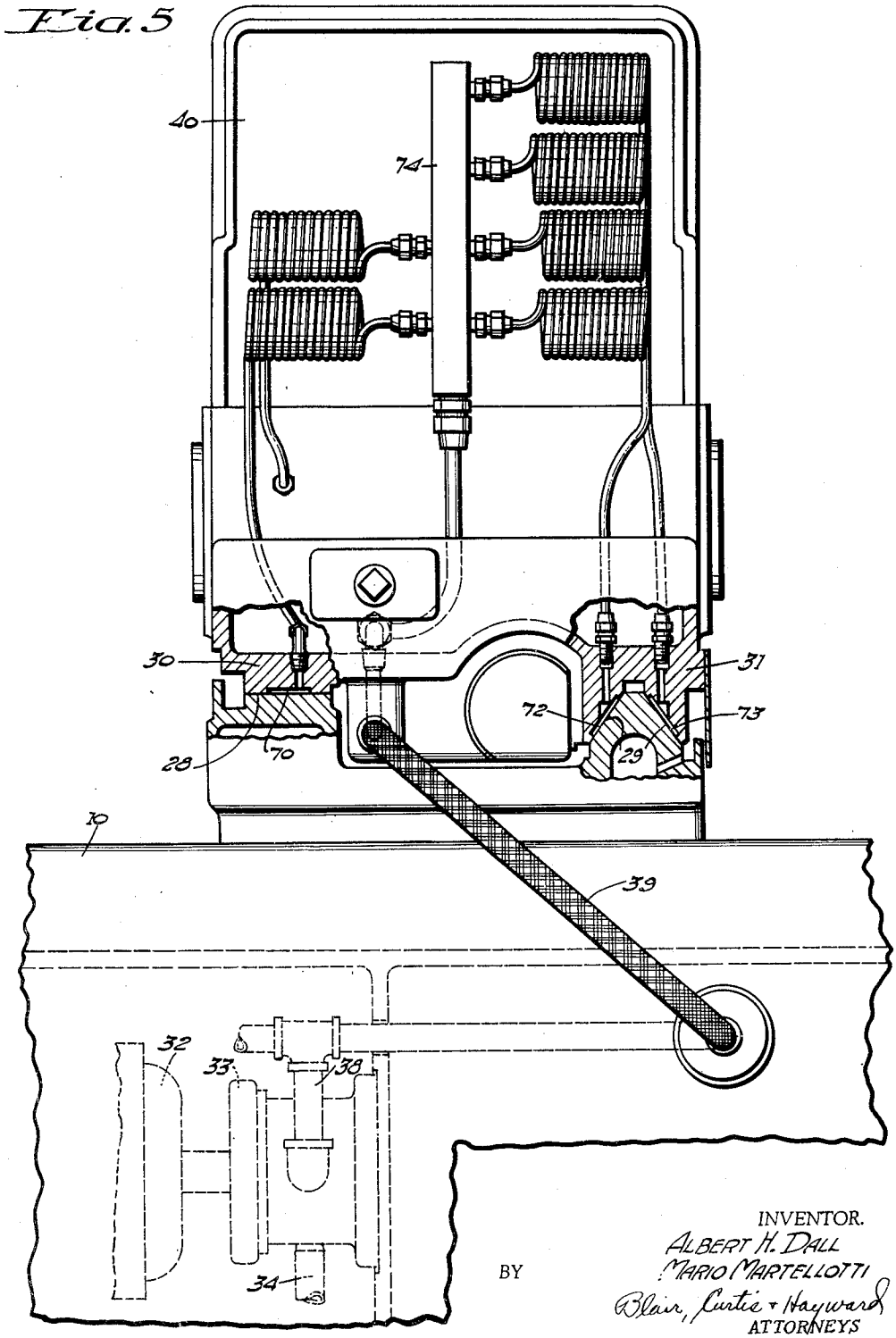
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Fig. 5



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LUBRICATING SYSTEM

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Application April 28, 1943, Serial No. 484,806

12 Claims. (Cl. 184—6)

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This invention relates to lubrication, and, with regard to certain features thereof, to lubrication in which the film of lubricant is automatically maintained.

One of the objects of this invention is to provide practical apparatus for the above purpose of simple construction and efficient and dependable action. Another object is to provide lubricating apparatus adapted to maintain effective action under varying conditions of use. Another object is to provide apparatus of the above nature adapted to maintain a lubricant film on various forms and types of bearing surfaces. Other objects will be in part obvious and in part pointed out hereinafter.

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 accompanying drawings in which is shown one of the various possible embodiments of the mechanical features of this invention:

Figure 1 is a top plan of a grinding machine;

Figure 2 is a diagrammatic plan showing the relation of various parts for handling the lubricant;

Figure 3 is a sectional elevation taken along the line 3—3 of Figure 2 showing the parts structurally rather than in diagrammatic form;

Figure 4 is a similar section taken along the line 4—4 of Figure 2; and,

Figure 5 is a similar section taken along the line 5—5 of Figure 2.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring now to Figure 1 of the drawings, the invention is shown embodied in a grinding machine in which the main bed is indicated at 10, this bed being broken away as indicated at 11 and being of such total length as to permit any desired travel of the table 12 mounted thereon.

The bed or support for the grinding head is indicated at 13, extending, as usual, at right angles to the main table and having the head 14 mounted to reciprocate, as indicated by the double arrow, traveling in this direction under either manual or automatic control in the usual manner. This head supports the grinding wheel 15 driven in the usual manner by a suitable electric motor on the grinding head.

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Referring to the table 12, it is provided with the headstock 16 mounted on one end thereof and at the opposite end with the tailstock or footstock 17 which is adjustable lengthwise of the table by the usual mechanism. Headstock and footstock are respectively provided with the centers 18 and 19, and the work, indicated at 20, is rotated by the motor 21 geared to drive any suitable form of connection from its face plate 22.

The main table 12 travels or reciprocates along the bed under either automatic or manual drive connected by mechanism of any of the well known suitable types.

The table 12 rests, as shown in Figure 3 of the drawings, on the V-shaped way having the surfaces 23 and 24 between which the downwardly projecting portion 25 of the table fits. These parts extend lengthwise of the machine throughout the length of the table and throughout such portion of the length of the bed as will afford to the table the maximum desired travel. On the other side of the machine, commonly called the front side, the bed is provided with a flat horizontal surface 26 on which the bearing portion 27 of the table rests. These coacting surfaces also extend throughout the length of the table and substantially throughout the length of the bed.

The supporting bed for the grinding head 14 is provided with ways forming the flat bearing surface 28 and the surfaces 29 disposed to form an inverted V. Respectively coacting with these bearing surfaces are those at the bottom of the parts 30 and 31 through which the grinding head is carried, all as shown in Figure 5 of the drawings.

As casting light on the features about to be described, it is to be noted that the load distribution along a member such as table 12 is inherently irregular; that is, the weight imposed on the bearings at one part, as, for example, the headstock, is quite different from that imposed at another longitudinally spaced location as under the unsupported center of the work. This lack of uniformity, moreover, varies widely under different conditions and the resultant load, furthermore, varies in direction, these variables depending, for example, on the connection and distribution of the work, the position of the footstock, and the side thrust of the grinding wheel or other tool. If it were attempted merely to use a lubricating system of high pressure in order to reduce friction, such pressure, if adequate at, for example, the headstock, would tend to

be excessive at certain other parts and even tend to bend the table. This bending action gives rise, among other objectionable features, to a tendency of the ends of the table to settle, and, by offering heavy pressure on extremely small surfaces, break through the lubricant film and scrape metal-to-metal along the surface of the bed.

It is also to be noted that in many lubricating arrangements of the ordinary type the effort to meet the problems presented places restrictions on the materials to be used in order to avoid scoring the galling of the surfaces. Furthermore, the power requirements in such arrangements, both for working and idle movements, are considerable and often special auxiliary devices are required in connection with the manual actuation of heavily loaded slides.

One other point to be noted is that, with a reciprocating part such as the table 12, it must, of course, come to a standstill at each end of its travel or stroke and to start its return trip must overcome static friction as well as inertia, the static friction being normally substantially in excess of the kinetic friction encountered during movement. There is, accordingly, a tendency to deviation from a smooth reversal due to this action and a problem introduced which is not found in a bearing in which the parts are in continuous relative movement.

Turning to the means whereby the problems thus introduced are solved herein, reference is made to Figure 2 which might be termed a hydraulic diagram. It will be understood that the term "hydraulic" is broadly used, and it may also be noted that the term "reciprocating" is used throughout in a broad sense to denote any non-rotary travel and to include movement which might technically be called oscillating. There is indicated at 32 an electric motor driving a lubricant pump 33 which draws lubricant as by the pipe 34 from a sump which extends throughout the lower portion of the bed 10. The discharge from this pump is of relatively high pressure and of a volume ample for the purposes hereinafter described.

At 35 is indicated a form of pressure regulator which is an adjustable relief valve having a spring-pressed part 36 controlling a by-pass 37 which returns to the sump. This relief valve having been set at a suitable pressure, as, for example, 100 lbs. to the square inch, will maintain that as a maximum pressure of its output, and its volume is such that there is normally a continuous overflow through the by-pass 37. At the discharge end of this pressure regulator a conduit 38 is provided with a branch 39 which supplies a lubricating unit 40 hereinafter described in detail.

The main flow from the pump, after passing the branch 39, travels through an adjustable reducing valve 41 by which the pressure is substantially reduced. From this valve conduit 42 is branched at 43 to lead to two discharge openings 44 and 45 in the bed. These discharge ports are both arranged opposite a groove 46 formed in the under surface of the table as shown in Figure 3. This groove extends substantially throughout the length of the table, as indicated in Figure 2, and is connected, preferably at a plurality of longitudinally spaced points, by the short pipes 47, 48, and 49 with a conduit 50 connected to a conduit 50*a* leading to a high pressure pump 51 driven by a motor 51' preferably mounted on the end of the table. The high pressure lubricant from the pump 51 is carried by a conduit 52 throughout the length of the table substantially parallel with the conduit 50, as shown in Figure 2 of the drawings. A relief valve 80 having a spring pressed part 81 is connected to the high pressure conduit 52 by a conduit 82; the discharge from the relief valve is carried to the sump by way of line 83.

Spaced along the table are a number of lubricating units, here shown as six, on the main table. As these are substantially identical in construction and action, one only will be described. From pipe 52 three branches lead through pressure reducing devices 53, 54, and 55. These devices may be considered as coils of any desired length and each having a passage therethrough of very small cross section. Preferably the physical construction of these pressure reducing devices, as shown in Figure 3, take the form of a plug having a spiral thread throughout the entire outer surface through which the lubricant flows.

The discharge from pipe 52 travels through one of these devices and its pressure with a normal rate of flow is thereby reduced. The lubricant of reduced pressure flows through an outlet 56 and a passage 57 into a pocket or recess 58 formed in the under surface of the bearing portion 27. This recess or pocket is preferably elongated in the direction of the length of the table, as indicated in Figure 2, and the sole discharge of lubricant therefrom escapes through the films formed between the bearing surfaces of the adjacent portion of the bearing, as will be later explained.

The escaping lubricant travels at one side over the edge of the bearing surface of the bed into a trough 59 (see Figure 3) from which it is discharged as through the pipe 60 down into the sump formed by the bottom of the bed or frame of the machine. The lubricant escaping toward the opposite side is picked up by a groove 61 formed in the table and extending parallel to and substantially coextensive in length with the groove 46. This drainage groove 61 is connected by any suitable passage or conduit (diagrammatically indicated at 612) with the groove 62 on the opposite side of the inlet groove 46, and these drainage grooves serve to collect lubricant flowing in their direction from the adjacent films and discharge it into the sump as through the pipe 63. Any excess lubricant flowing toward the inner or right-hand edge of the bearing as viewed in Figure 3 is gathered by the trough 64 and discharged into the sump by the drain pipe 65.

Considering the action of the lubricating parts thus far described, assuming that the lubricating system is first started up with the bearing surfaces in metal-to-metal contact, the lubricant flows into the various recesses, such as pocket 58. The escape from the pocket being at this stage cut off, the pressure therein naturally rises until it reaches a point sufficient to raise the table and cause a slight separation of the adjacent bearing surfaces on the table and bed. This separation affords an escape of the lubricant from the pocket, and, due to its restricted cross section, this crevice forms what may be considered a hydraulic resistance, just as is the constricted passage through the device 53. This crevice between the bearing surfaces increases in width due to the lift of the lubricant on the upper surface of the pocket and, acting through the film, on the under surface of the table. When the hydraulic resistance of the outflowing lubricant through the films equals that of the corresponding device 53 at the inlet to the pocket, then the

outflow through the film is equal to the inflow to the pocket.

If, now, there is an increase of load on the table at the point under construction, there is a tendency to constriction of the film through an extremely minute downward movement of the table toward the bed. This tends to choke off the escape of lubricant and the pressure builds up in the pocket. Of course, if the escape were completely closed, as is not the case, then the pressure in the pocket would increase until it equaled the pressure of the supply line. However, even a slight constriction of the outflowing film results in a substantial excess of pressure, which increase continues until the additional load is balanced. A decrease of load tends to a minute lifting of the table and opening of the crevice so as to increase the discharge from the pocket and lessen the pressure by an action the reverse of that above described.

The pressures are adjusted by proper selection of resistance sizes so that they will balance the computed load imposed on the portion of the bearing at which the particular pocket is located. With such balance there is a continuous flow of lubricant into and out of the pockets, the flow out of the pocket being in the form of a pressure film of thickness sufficient to guard against any chance of a metal-to-metal contact.

All of the foregoing actions occur instantaneously on a tendency to variation in the film thickness, and the remedy is applied simultaneously with the occurrence of variation in effective load. In this manner the film thickness is maintained approximately constant, and any chance of rupture of the film is precluded. The moving part, the table, thus travels on a lubricant surface and its friction is reduced to a minimum.

At the opposite side of the bed the bearing comprises two pockets 66 and 67, and, although in the diagrammatic view Figure 2 the supply of these pockets is shown for clarity as having separate connections with the high pressure line 52, they are in physical structure preferably joined, as indicated in Figure 3. The devices 54 and 55 lead through suitable passages to the recesses or pockets 66 and 67, as shown, and have the same automatic action as described with reference to the similar pocket 58 on the forward side of the machine. The discharge from the films is taken in the troughs 68 and 69 connected, as by the piping 68*a* and 69*a* shown, with the sump. This piping also takes drainage from the groove at the bottom of the V.

With respect to the pocket 66, it is to be noted that it extends transversely not only to the line of downward pressure from the table of the main machine but also to the resultant of the lateral forces brought about by the operation of the grinding wheel. Thus any variation in direction of the resultant of the lateral forces due to the grinding wheel or other device is automatically resisted and compensated for just as is the downward pressure on the bearing which extends along the front of the machine.

Referring to the unit 40 shown in Figure 5 of the drawings, it is believed that detailed description will be unnecessary. The pressure reducing devices are diagrammatically indicated as coils rather than in the preferred physical form of helically grooved plugs, as shown in Figure 3. The two devices on the left-hand side lead respectively to pockets 70 and 71 diagrammatically indicated in Figure 2, the pocket 70 in its relation to the bearing being shown in Figure 5. At the other side of the unit the four devices lead respectively to the pair of pockets 72 and 73 and the similar pockets spaced therefrom in the direction of travel of the grinder head. The supply conduit 39 is preferably of flexible form, as indicated in Figure 5, to permit full travel of the grinder head, and this conduit leads to the receptable 74 from which the various reducing units are supplied.

Considering broadly the action by which the various problems encountered are solved, it may first be noted that the lubricant is injected at various portions of the bearings in a manner to create pressures suited to the particular load on that area by proper selection of resistance values. Furthermore, the lifting pressure for any area is automatically varied to meet any variations of load at that area independently of what is occurring at any other portion of the bearings. These pressures are not only varied but are brought into effect in such directions as to meet variations in direction as well as amount of the resultant load in the adjacent neighborhood. It is also to be noted that the pressure in the system as a whole is controlled to meet the particular conditions as the lubricant travels from the sump throughout its entire trip back to the sump. In this particular machine the pressure is first raised and then supplied with ample volume but at a chosen maximum limit. In this condition it supplies the grinder head. The pressure is then reduced to be suitable for transmission through the pick-up arrangement comprising ports 44 and 45 to the groove 46 in the relatively movable main table, and it is transferred at a number of points to the main supply conduit 59 so as to assure ample feed to that conduit and avoid any chance in fall of pressure by protracted travel through the groove or slot 46. The pressure is then raised on the table and is supplied to the various units as herein described.

It will accordingly be seen that there is provided apparatus whereby the objects of this invention are attained in an essentially practical manner well adapted to meet the hardest and most varying conditions of use.

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 lubricating system, in combination, a machine tool comprising a bed and a table movable along the same, means adapted to supply liquid at relatively low pressure, said table and bed having a connection comprising a groove in one of the same in the direction of movement of the table and a passage in the other communicating with said groove in all positions of the table, a lubricant pump mounted on said table, means leading said low pressure liquid through said connection to said pump, and means leading liquid from said pump to the bearing surfaces between said table and bed.

2. In a lubricating system, in combination, a machine tool comprising a bed and a table adapted to travel along the same, said table having a longitudinal groove in its under surface connecting with a conduit on said bed adapted to lead lubricant to said groove in all positions of

the table, and said table having lubricant-receiving recesses in its bearing surface on the bed, means adapted to supply lubricant to said recesses from said groove through conduits of restricted cross section, the sole escape from said recesses being through lubricant films between the adjacent bearing surfaces, and means comprising grooves extending longitudinally along the bed spaced from said recesses and adapted to collect lubricant as it is discharged from the bearing through said films.

3. In a lubricating system, in combination, a machine tool including a bed and a table, said table being movable along said bed on way bearing surfaces, means to supply liquid at relatively low pressure, said table and bed having a connection comprising a groove in one of the same in the direction of movement of the table and a passage in the other communicating with said groove in all positions of the table, a liquid pump mounted on said table, means leading said low pressure liquid through said connection to said pump, means forming a plurality of recesses in said way bearing surfaces, and means connecting said pump to said recesses, said pump constantly supplying liquid to each of said recesses under sufficient pressure to lift the portion of the table positioned above each recess.

4. In a lubricating system, in combination, a supporting member, an elongated slide member, said members having opposed load-supporting bearing surfaces and said slide member being mounted for movement with respect to said supporting member on said bearing surfaces, at least one of said bearing surfaces having a plurality of recesses formed therein and spaced from the edges of said surface, said recesses being longitudinally spaced from each other in the direction of said movement, and a separate conduit for each recess containing a flow restriction through which fluid is pumped continuously to each recess under table lifting pressure controlled by the separation of said surfaces to create and maintain a table supporting film between said surfaces under sufficient pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

5. In a lubricating system, in combination, a supporting member having a flat load-supporting bearing surface, a work supporting member having a flat load-supporting bearing surface, said work supporting member being mounted for movement with respect to said first-mentioned member on said bearing surfaces, said work supporting member having a plurality of recesses formed in its bearing surface and spaced from the edges of said surface, said recesses being longitudinally spaced from each other in the direction of said movement, and separate conduits for each recess, each conduit containing a flow restriction and being connected at one end to a recess and to a source of fluid under pressure at the other end, said source of fluid under pressure being operable to continuously supply fluid to each recess through said conduits under work supporting pressure controlled by the separation of said surfaces to create and maintain a work supporting film under pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

6. In a lubricating system, in combination, a supporting member having a flat load-supporting bearing surface, a work supporting member having a flat load-supporting bearing surface, said work supporting member being mounted for movement with respect to said first-mentioned member on said bearing surfaces, said work supporting member having a plurality of recesses formed in its bearing surface and spaced from the edges of said surface, said recesses being spaced from each other in the direction of said movement, a pump, and a separate conduit for each recess containing a flow resistance and connecting the pressure side of said pump to each recess, said pump being operable to continuously supply fluid through said conduits to each recess under work supporting pressure controlled by the separation of said surfaces to create and maintain a work supporting film under pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

7. In a lubricating system for a machine tool, in combination, a bed, a table, said bed and table having opposed load-supporting way bearing surfaces, said table being mounted for longitudinal movement with respect to said bed on said way bearing surfaces, at least one of said bearing surfaces having a plurality of recesses formed therein, said recesses being spaced from the edges of the bearing surfaces in which they are formed and being longitudinally spaced with respect to each other in the direction of said movement, the principal path for escape of fluid from each recess being between said bearing surfaces, and a separate conduit for each recess containing a flow restriction through which fluid is pumped continuously to each recess under table lifting pressure controlled by the separation of said surfaces to create and maintain a table supporting film between said surfaces under sufficient pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

8. In a lubricating system, in combination, a supporting member, an elongated slide member, said members having opposed load-supporting bearing surfaces and said slide member being mounted for movement with respect to said supporting member on said bearing surfaces, at least one of said bearing surfaces having a plurality of recesses formed therein and spaced from the edges of said bearing surface, said recesses being longitudinally spaced from each other in the direction of said movement, and a separate conduit for each recess containing a hydraulic resistance and each connecting a recess to a source of liquid under pressure, the sole path of escape of said liquid from each recess being between said bearing surfaces thereby forming a hydraulic resistance to flow out of each recess, said source of liquid under pressure being operable to continuously supply liquid through said conduits to each recess under slide lifting pressure controlled by said second-mentioned hydraulic resistances to create and maintain a slide supporting film under pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

9. In a lubricating system for a machine tool, in combination, a bed, a table, said bed and table having opposed load-supporting way bearing surfaces, said table being mounted for longitudinal movement with respect to said bed on said way bearing surfaces, at least one of said bearing surfaces having a plurality of recesses formed therein and spaced from the edges of

said surface, said recesses being longitudinally spaced from each other in the direction of said movement, and a separate conduit for each recess containing a hydraulic resistance and each connecting a recess to a source of liquid under pressure, the sole path for escape of said liquid from each recess being between said bearing surfaces and forming a hydraulic resistance to flow out of each recess, said source of liquid under pressure being operable to continuously supply liquid through said conduits to each recess under table lifting pressure controlled by the separation of said surfaces to create and maintain a table supporting film under pressure to separate said way bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

10. In a lubricating system for a machine tool, in combination, a bed, a table, said bed and table having opposed pairs of load-supporting way bearing surfaces, said table being mounted for longitudinal movement with respect to said bed on said way bearing surfaces, said table being of uneven weight throughout its length and being long in comparison with its thickness with a tendency to bend vertically, said table way bearing surfaces each having a plurality of recesses formed therein, said recesses being spaced from the edges of said table way bearing surfaces and being longitudinally spaced with respect to each other in the direction of said movement of said table, the sole path for escape of fluid from each recess being between said bearing surfaces, and a separate conduit for each recess containing a flow restriction and connecting the pressure side of a pump to each recess, said pump being operable to continuously supply fluid through said conduits to each recess under table lifting pressure controlled by the separation of said surfaces to create and maintain a table supporting film under pressure to separate said bearing surfaces at all points, said pressure lifting the weight of any portion of the table plus any additional load that might be placed thereon when the machine is in use, whereby there is a continuous flow of fluid between said bearing surfaces.

11. In a lubricating system for a machine tool, in combination, a bed, a table, said bed and table having opposed load-supporting flat way and V way bearing surfaces, said table being mounted for longitudinal movement with respect to said bed on said way bearing surfaces, the flat way bearing surface and both V way bearing surfaces on said table having a plurality of recesses formed therein, said recesses being spaced from the edges of the bearing surfaces in which they are positioned and being longitudinally spaced with respect to each other in the direction of movement of said table, the sole path for escape of liquid from each recess being between said bearing surfaces and forming a hydraulic resistance to flow of liquid from each recess, and a separate conduit for each recess containing a hydraulic resistance through which fluid is pumped continuously to each recess under table lifting pressure controlled by the separation of said surfaces to create and maintain a table supporting film between said bearing surfaces under pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

12. In a lubricating system, in combination, a supporting member, an elongated slide member, said members having opposed load-supporting bearing surfaces and said slide member being mounted for movement with respect to said supporting member on said bearing surfaces, at least one of said bearing surfaces having a plurality of recesses formed therein and spaced from the edges of said surface, said recesses being longitudinally spaced from each other in the direction of said movement, a pump, a relief valve connected to the pressure side of said pump, and a separate conduit connecting each recess to the pressure side of said pump, a hydraulic resistance positioned in each conduit, said pump being operable to continuously supply liquid through said conduits to each recess under slide lifting pressure controlled by the separation of said surfaces to create and maintain a slide supporting film under pressure to separate said bearing surfaces, whereby there is a continuous flow of fluid between said bearing surfaces.

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