The present invention relates to grinding and polishing machines and has particular reference to a novel form of composite diamond lap wherein the coolant liquid may more effectively be applied to the article or articles undergoing lapping and the resultant sludge more effectively discharged from the surface of the lap.

In United States Patent No. 2,607,174, granted on August 19, 1952, to Ralph Lanius and entitled "Method of Grinding Eyeglass Lenses," there is shown and described a grinding and polishing machine which is suitable for carrying out the particular grinding method of such patent. It is to this general class of machines that the present invention relates and the composite lap of the present invention is applicable to the machine which is shown in the Lanius patent, as well as to various other so-called lapping machines for performing the same function.

Insofar as the abrasive material which performs the actual cutting, grinding or polishing operation is concerned, rotary laps may be divided into two general classes. In one type of lap, the lap body is formed of close-grained cast iron and a relatively small quantity of abrasive material, such as finely divided emery, in suspension in a liquid, such as water, is continuously applied to the lap surface for the actual removal of material. From the article or articles undergoing lapping, this liquid material being distributed over the surface of the lap by a natural spreading operation. In the other type of lap, as exemplified by the machine which is illustrated in the Lanius patent, the abrasive material is in the form of finely divided crushed or fragmented diamonds which are embedded in a metallic or other matrix with the cutting points of the diamonds protruding outwardly beyond the surface of the matrix and this protruding relationship being maintained throughout the life of the matrix as the embedding material wears away. In the operation of this latter type of lap, a liquid coolant is supplied to the lap surface in relatively large quantity to produce a thin film on which the article undergoing lapping is supported or "floats," so to speak, with the diamond cutting material projecting through and protruding above the film surface to a predetermined distance as determined by the particle size. The thickness of the coolant film, as determined by the character of the coolant, and as related to the particle size, determines the nature of the cutting operation, and when these two factors are properly correlated, the rate of removal from the article or articles undergoing lapping is at its maximum consistent with effective lapping, i.e., without producing surface blemishes, such as grooves or striations, burn spots, and the like. Broadly stated, laps of the first mentioned type employ loose or free abrasive particles which may or may not have a diamond content. Laps of the last mentioned type employ diamond particles which are fixed with respect to the lap surface and rotate with the lap about the central axis of rotation. Laps of the first mentioned type are usually designed for slow speed rotation and the liquid material which is applied thereto has but little cooling function, it serving merely to distribute the abrasive particles evenly over the lap surface. Laps of the second mentioned type are usually designed for high-speed rotation and the liquid coolant that is applied thereto is both for cooling purposes and to prevent surface burns, as well as to provide the aforementioned film which properly spaces the surfaces undergoing lapping from the upper face of the diamond-carrying matrix.

The present invention specifically concerned with laps of the fixed particle type as outlined above and it is to be distinguished from laps which employ loose abrasive particles over the working surfaces thereof since to this class of lap the present invention is not applicable. It should be further understood that throughout this specification and in the following claims the terms "lap" and "lapping" relate to working planers and operations respectively by means of which material is actually removed from the surfaces undergoing treatment and is carried away by the liquid coolant.

The improved composite lap comprising the present invention has been designed for use primarily in connection with the grinding and polishing of articles having spherical or arcuate surfaces, especially lenses which are formed of glass or other transparent materials, such as synthetic plastics and the like, and are used for optical purposes. The invention is, however, capable of other uses and composite laps constructed in accordance with the principles of the present invention may, if desired and with or without modification, be employed in the grinding and polishing of articles having planar surfaces, as, for example, piezo electric or quartz oscillator crystals and small machine parts, such as the running surface of mechanical seals. Irrespective, however, of the particular use to which the present invention may be put, the essential features thereof are at all times preserved.

In connection with a lap of the type briefly outlined above, it has been found, particularly where the diamond abrasive is of small mesh or micron size, that there is a tendency for the surface undergoing lapping to run dry due to the inability of the coolant liquid to enter between the article undergoing lapping and the operative lapping surface of the lap. One reason for this resides in the small entrance area leading to the space existing between the article and the operative lap surface. Furthermore, the working pressure which is maintained draws the two running surfaces together with sufficient force to exclude the entrance of the coolant liquid. For these same reasons, it is difficult to discharge the fine silt-like sludge which is created as a result of the lapping operation from beneath the article.

Another limitation that is attendant upon the construction and use of a conventional lap resides in the interference which is offered by resistance of the material undergoing lapping to actual stock removal from the surface thereof. This resistance restricts and sometimes terminates the free movement of the article undergoing lapping. This latter limitation is prevalent in connection with the use of that class of lapping machines in which the work holder is intended to allow freedom of movement of the article on the lap surface under the influence of frictional forces between the lap surface and the articles themselves, while at the same time, the work holder is prevented from revolution about the axis of rotation of the lap. In such machines, the work holder to which the article is affixed is usually mounted for limited universal movement in one sector of the lap area, while at the same time, it is permitted freedom of rotation about its own axis. It is thus held against revolting about the axis of the lap while the surface of the article undergoing lapping is free to seat squarely upon the lap. Due to the higher circumferential speed of the outer regions of the lap than the circumferential speed of the inner regions of the lap, a frictional differential is set up which produces unbalanced forces on the article tending to cause rotation of the work holder. In the case of a single article, the same is caused to rotate on the lap, while in the case of plural articles, the articles are given a localized rotary path of movement over the rotating lap surface. However, when a high degree of stock removal is taking place, this freedom of movement of the work holder is restrained, and
since the involved frictional differential is invariably small, amounting to but a few dynes of resultant torque on the work holder, the free movement of the work holder is retarded appreciably, even to the point of its cessation altogether. The net result is the production of arcuate striations on the surfaces undergoing lapping due to relativistic encounter with the same diamond or other grit particles which repeat their paths of movement across the surface being lapped.

The present invention is designed to overcome the above-noted limitations that are attendant upon the construction and use of conventional optical and similar laps and it, therefore, contemplates the provision of a composite diamond lap which physically is so constructed as to receive and evenly distribute over the operative surface thereof the liquid coolant to carry the coolant freely between the opposed running surfaces on the lap and article or articles undergoing lapping without sacrificing the necessary lapping pressure; and to establish and maintain the necessary coolant film between such running surfaces so that there will be no interference with freedom of independent rotation of the work holder, and consequently, of the article or articles that are carried thereby.

The lap of a diamond lap which, as stated above, avoids the limitations of conventional laps constitutes the principal object of the invention, and in carrying out this object, there is provided a lap body which has the desired lap curvature or configuration and in which the operative abrasive or cutting surface and lap matrix is divided into sectors or other segments by a series of intervening radial grooves, or grooves which have a large component of radial direction. The lap surface is essentially annular in that it is provided with a circular central depression therein so that it has both an inner and an outer boundary with the grooves extending between or spanning the distance between such peripherics. The depth of the grooves is preferably, but not necessarily, greater than the thickness of the diamond-embedding matrix so that this matrix is thus divided by the grooves into individual sectors or segments. The grooves which, in the preferred form of the invention, are radially disposed, serve several functions, principally among which are the creation of an entryway for the liquid coolant beneath the face of the article undergoing lapping, as well as for the positive forcing of the liquid coolant between the particle and the lap surface; the equal distribution of the liquid coolant over the operative surface of the lap so that there will be no coolant-starved lap areas; and the bleeding of the space between the article and the lap surface to the atmosphere to prevent the creation of a vacuum therein.

Still further, in carrying out the above-mentioned object, in order more effectively to feed the inner ends of the diverging grooves in the lap surface, the central depression with which the inner ends of the grooves communicate has its wall bowed outwardly or undercut to provide a generally circular peripheral pocket within which the liquid coolant may collect under the influence of centrifugal force and from thence be distributed to the ends of the grooves, while at the same time being prevented from creating a spout or fountain at the rim of the depression, such a phenomenon being prevalent when the wall or the depression is truly cylindrical.

It has been found that in certain instances it may be desirable to restrict the flow of liquid coolant radially outwardly along the grooves by damming up the ends of the latter, so to speak, thereby causing such liquid coolant as may flow outwardly in the grooves to be retained under the article or articles undergoing polishing on the lap surface. Toward this end, in one modified form of the invention, means are provided at the outer ends of the grooves for effectively damming them so that the quantity of liquid coolant flung from the lap by centrifugal force will be restricted. In another modified form of the invention, means are provided at the inner ends of the grooves for effectively restricting the quantity of coolant which may enter these grooves and for thus diverting some of the liquid coolant issuing from the central depression to the inter-groove areas of the lap. By such an expedient, the tendency for too high a concentration of coolant in the grooves with a consequent desirous of coolant on the surface of the lap is eliminated. It is a further object of the invention to provide novel means for thus restricting the outward flow of coolant and effecting a more even distribution of the coolant over all areas of the lap than has hitherto been possible.

It is an ancillary object of the invention to provide a complicated diamond matrix, by reason of the greater groove depth as outlined above, will permit the diamond-carrying matrix which establishes the lap surface proper to be used to completion, while at the same time maintaining throughout its entire useful life the benefits afforded by the radial grooves.

With these and other objects and advantages in view, which will more readily become apparent as the following description ensues, the invention consists in the novel construction, combination and arrangement of parts shown in the accompanying five sheets of drawings forming a part of this specification.

In these drawings:

FIG. 1 is a side elevation view, partly in vertical longitudinal section, of a polishing and grinding machine employing a composite diamond lap constructed in accordance with the principles of the present invention and designated as producing spherical concave surfaces on an optical lens or the like.

FIG. 2 is an enlarged vertical section of the lap of FIG. 1;

FIG. 3 is a section similar to FIG. 2, but showing the lap being employed for multiple lens lapping purposes;

FIG. 4 is a top plan view of the lap of FIG. 2;

FIG. 5 is a sectional view similar to FIG. 2 but showing a slightly modified form of the invention;

FIG. 6 is a sectional view similar to FIG. 2 but showing a diamond lap designed for use in producing spherical convex surfaces on an optical lens or the like;

FIG. 7 is a sectional view similar to FIG. 6 but showing another form of diamond lap;

FIG. 8 is a top plan view similar to FIG. 4 but showing a further modified form of the invention;

FIG. 9 is a top plan view similar to FIGS. 4 and 8, but showing another modified form of the invention;

FIG. 10 is a sectional view similar to FIG. 5 but showing a further modified form of lap for producing concave surfaces on an optical lens;

FIG. 11 is a plan view of the lap of FIG. 10; and

FIG. 12 is a sectional view similar to FIG. 10 but showing a modified form of lap for producing convex surfaces on an optical lens.

Referring now to the drawings in detail, and in particular to FIG. 1, a more or less conventional grinding and polishing machine employing a composite diamond lap constructed according to the present invention has been designated in its entirety by the reference numeral 19 and involves in its general organization a base casting 12 of hollow, generally cylindrical design and including a central hub portion 14, an upper horizontal table portion 16, and an outer cylindrical apron portion 18. The hub portion 14 serves rotatably to support a composite diamond lap 29 having an upwardly facing convex lap surface 22. The lap 20 is of novel design and constitutes the subject matter of the present invention. It will be described in detail presently after its environment in the machine 10 has been set forth.

The lap 20 is removably carried on the upper end of a vertically extending rotatable shaft 24 which is telescopically and slidably mounted within a sleeve 26 and is keyed to the sleeve as at 28 for rotation in unison therewith. The sleeve 26 is rotatable in bearings 29 which are supported in the hub 14. The shaft 24 is formed
with a depending shank 30 of reduced diameter. The lower end of the shank 30 receives thereover an adjusting collar 32 and has its upper end bearing against a downwardly facing shoulder 36 on the shaft 24 and serves to urge the latter, and consequently, the lap, upwardly so that the desired working pressure between the lap surface 22 and the work may be maintained. A set screw 38 permits the necessary vertical adjustment of the collar 32. A pulley 40 is mounted on the lower end region of the sleeve 26 and is adapted to be driven by a belt 42 leading from a suitable source of power which may be the drive shaft of an electric motor (not shown).

The article which is to be applied to the upwardly facing convex face lap surface 22 is adapted to be positioned in a suitable work holder, such as the holder shown at 50 in FIG. 1. The work holder 50 illustrated herein is purely exemplary as various other types of work holders may be employed. The work holder 50 is designed to accommodate the positioning of a single concavo-convex lens blank 52 with its concave face against the lap surface 22 and, accordingly, the underlapping face of the holder is provided with a surface 54 (FIG. 3) to which the complementary concavo convex face 56 of the blank 52 is suitably cemented or otherwise adhered.

The work holder 50 is positioned over the rotating face lap 20 and is possessed of a limited degree of universal motion so that it will follow the lap contour. As shown in FIGS. 1 and 2, the work holder is adapted to be positively rotated independently of the rotational movements of the lap while preserving such universal motion. Accordingly, the work holder has a ball and socket connection 60 with the lower end of a spindle 62 and a driving connection in the form of engageable driving pins 64 and 66 on the work holder and spindle, respectively, establishing this driving connection.

The spindle 62 is rotatably mounted in upper and lower bearings 68 and 70 and they are carried in a sleeve 72 which is slidable in a yoke 73. The yoke is longitudinally adjustable in a bracket 74 which is pivoted as at 76 to a foot piece 78. The latter is adjustable mounted as at 80 on the table portion 16 for motion toward and away from the axis of rotation of the lap 20. The upper end of the spindle 62 carries a pulley 82 which is adapted to be operatively connected to a belt 84 by means of which the spindle is rotated. The yoke 74 is provided with a threaded bore 86 through which there extends a feed screw 88, the ends of which are rotatable in the brackets 75. An operating hand wheel 90 engages the feed screw 88 to be manually rotated to adjust the position of the yoke 74, and consequently, of the work holder 50 toward and away from the lap surface. The proper working pressure of the work holder 50 against the lap may be regulated by means of an adjusting collar 92 and a cooperating spring 94.

The arrangement of lapping machine parts thus far described is purely conventional and no claim is made herein to any novelty associated with the same. The work holder 50 may be positioned against the lap 20 by mechanism other than that illustrated in FIG. 1. The illustrated mechanism maintains the work holder against the lap at a fixed radial distance from the center of the lap, but it is contemplated that gyratory or other movements having a radial component of motion may be applied to the work holder if desired. Under certain circumstances, it may be found desirable manually to move the work holder 50 over the surface of the lap in the manner shown in the above brief narratives to assist in lapping. The present invention is independent of any particular lapping machine or any particular form of work holder or work holder operating mechanism and consists rather in the novel form of lap and in the means whereby the lap surface thereof is fed with a liquid coolant, as will now be described in detail.

Referring now additionally to FIG. 2, the composite lap 20 is in the form of a generally cylindrical body 100 which is formed of a suitable metal, such as brass, bronze, or the like. The flat face of the body 102 of the body is provided with a bolt-receiving hole 104 for the reception therein of a fastening bolt 106 by means of which the lap may be secured to a suitable adapter 108 having a shank 110 receivable in a socket 112 in the upper end of the rotary drive shaft 24 (see FIG. 1). The lap body 100 is provided with a peripheral surface 113 which is contoured to meniscate in shape to the configuration of the surface on the lens 52 or other article undergoing lapping. As shown additionally in FIG. 4, the upper surface of the lap body 100 is substantially covered with a matrix 114 having diamond particles distributed throughout the same. The matrix may be formed of any suitable material and the particles are substantially evenly distributed therein, the matrix serving to fix the individual diamond particles on the lap surface for movement with the lap as the latter rotates. The hardness and other physical characteristics of the matrix are such that as the matrix wears, the diamond particles are exposed for approximately one-third of their over-all height, such being the nature of a lap which will produce optimum results and effect maximum removal of material from the lens with a minimum of wear on the lap surface. The upper surface 72 of the matrix constitutes the actual operative lap surface.

The upper surface 113 of the lap 20 is formed with a generally cylindrical coolant-receiving depression or well 116, the side wall of which is undercut as at 118 so as to provide an inwardly extending lip 120 which constitutes, in effect, a weir over which the liquid coolant that is supplied to the well is adapted to flow in a manner and for a purpose that will be hereinafter more particularly described. The lip region of the well 116 communicates with a series of radially disposed linear grooves 122 (see particularly FIG. 4) which substantially span the distance between the inner periphery 124 of the annular lap surface 113 and the outer periphery 125 thereof. The linear grooves as shown in FIG. 2 is preferably, but not necessarily, slightly greater than the thickness of the matrix so that these grooves cut completely through the matrix and into the metal of the lap body 100, thus completely dividing the matrix into a series of independent sectors which are separated from one another by the various grooves 122. The bottoms of the grooves 122 have their external outer regions 123 turned upwardly so as to provide, in effect, dams or restrictions which inhibit the passage of liquid coolant along the grooves. Such an arrangement prevents inordinate centrifugal flinging of the coolant from the outer edges of the grooves and thus conserves the coolant while at the same time serving to hold an adequate supply of coolant on the upper surface 113 of the lap.

In order to supply the liquid coolant to the lap surface 113, a supply pipe 130 is arranged to discharge such coolant into the well 116 from above the lap. Various types of coolant are suitable for use in connection with the present lap and any coolant which is non-oily, non-slippery, non-toxic and non-rusting does not necessitate cleaning of the lens blank 52 after a grinding operation. The coolant will not permit filling of the spaces between the exposed portions of the diamond particles at the lap surface 113 and is chemically stable, may be used. Extremely desirable results have been obtained by either of the liquid coolant materials which are now being marketed by Super-Cut, Inc. of Chicago, Illinois, under the trade designations S5 and S25. A cylindrical guard or shield 131 is secured by screws 133 to the marginal regions of the table portion 16 to collect the liquid coolant which is flung from the periphery of the lap 20. This coolant flows through a series of small holes 135 in the table portion 16 and is collected in a drip pan 137 for re-use if desired.

During the grinding of the lens blank 52, the blank is mounted on the underneath surface 54 of the work holder...
The feed screw 88 is manipulated to bring the lens into operative grinding relation with respect to the lap 20, after which the driving belts 42 and 44 are set into motion to drive both the lap and the work holder in the manner previously described. At the same time, the liquid coolant is fed from the pipe 130 to the interior of the well 116.

The feed screw 88 is manipulated to bring the lens into operative grinding relation with respect to the lap 20, after which the driving belts 42 and 44 are set into motion to drive both the lap and the work holder in the manner previously described. At the same time, the liquid coolant is fed from the pipe 130 to the interior of the well 116.

It is to be noted that the working pressure which is maintained by reason of the springs 34 and 94 maintains the surface 54 of the lens 52 undergoing grinding in close proximity to the lap surface 113, except that the surface of the lens is maintained slightly spaced from the body of the matrix by a thin film of the coolant. Only extremely limited portions of the upper ends of the diamond particles project through this film and operate upon the lens for cutting purposes. If the surface tension of the film is insufficient to maintain the lens properly supported, the diamond particles will cut too deeply into the lens and provide scratches on the latter. If the surface tension is too great, insufficient cutting action will take place. The character of the liquid coolant is thus important. With diamond exposure of the magnitude set forth above and with the proper liquid coolant, a long wearing and effective lap will be obtained.

The various grooves serve several functions when employed in connection with diamond laps of the general character herein described. Principal among these functions is the carrying of the liquid coolant beneath the surface of the lens undergoing grinding. Due to the pressure which is exerted by the springs 34 and 94 as described above, especially where diamonds of small particle size are concerned, for example, particles of 270 mesh size, or smaller, the surface 54 undergoing lapping and the lap surface 113 are relatively close together so that the liquid coolant cannot be sufficient to carry it into the space between the lap and the lens in the absence of the grooves 122. These grooves serve to carry the coolant beneath the lens surface 54 and thus establish the necessary supporting film for effective grinding operations, and for prevention of scratches on the lens surface and prevention of surface burns.

The radial grooves also constitute conduits for liquid coolant distribution of the liquid coolant over the entire lap surface 113. Since the inner ends of the grooves communicate through the lip 120 with the well 116, an equal supply of liquid coolant will be distributed in the direction of each groove. The undercut portion 118 of the well 116 provides an annular retaining pocket for the coolant which is forced therein by the centrifugal force initiated by the high speed of the lap rotation, and as more liquid is supplied to the well 116, the coolant passes directly from the well around the lip 120 and into the inner ends of the various grooves 122 from whence it is carried outwardly radially of the lap and distributed evenly over the lap surface as previously described.

Although in FIG. 4 eight of the grooves 122 have been shown with the grooves extending truly radially of the lap, it will be understood that a greater or lesser number of such grooves may be employed if desired. Furthermore, it is not essential, but only preferable, that the grooves extend truly radially since good results may be obtained where the grooves extend between the inner and outer peripheries of the lap surface 113 in secant fashion. The grooves 122 may be formed by cutting completely through a continuous matrix and then applying them to the surface of the lap body 100, or they may be formed by making the matrix in individual segments and then applying them to the surface of the lap body in slightly spaced relationship, in which case the grooves will be of a depth only equal to that of the matrix. In either event, the grooves will remain in evidence and be effective until such time as the matrix has been completely used up.

In FIG. 3 the composite lap 20 of FIG. 1 is shown as being operatively associated with the lapping of surfaces on plural lens blanks 152. The lens holder 150 is similar in its construction to the lens holder 50 of FIGS. 1 and 2 and to avoid needless repetition of description, reference numerals of a higher order, but similar in character, have been applied to the corresponding parts as between the two lens holders. The holder 150 is larger in size than the holder 50 and its underneath surface 154 is designed to have adhered thereto a plurality of the lens blanks 152 which may be spaced about the longitudinal axis of the holder. The surface 154 overlies both the inner and outer peripheries of the lap surface 113 of such an extent that the lens blanks 152, during the gyratory motion that is imparted thereto under the influence of the driving pins 164 and 166, are caused to sweep over these peripheries during the course of their movements. If the driving pins 164 and 166 are omitted, a similar gyratory motion will be applied to the lens blanks 120 under the influence of the frictional differential which exists between the faster moving outer peripheral regions of the lap and the slower moving inner peripheral regions thereof.

It is to be noted in connection with FIG. 3 that although the holder 150 overlaps the inner periphery of the lap surface 113 and overlies the well 116, there still is adequate space for introduction of the liquid coolant into the well from the pipe 130.

In FIG. 5, the composite diamond lap is similar in many respects to the lap 20 of FIGS. 1 to 5, inclusive. Thus, again to avoid needless repetition of description, reference numerals of a still higher order have been employed as between the corresponding parts. In this latter form of the invention, the bottoms of the radial grooves 222 terminate short of the outer periphery of the lap body so that the matrix is not completely divided into individual sectors. The sectors which are created by reason of the grooves 222 are joined together at the outer periphery of the lap body by narrow circumferentially extending webs 223, these webs constituting restrictions against the free flow of liquid coolant in a manner similar to the restrictions 123 at the outer ends of the grooves 122 of the lap 20.

In FIG. 6, the principles involved by the provisions of the radial grooves 122 in connection with the lap 20 are applied to a composite diamond lap 320 in which the upper surface 313 thereof is of concave configuration and is provided with grooves 322. The bottoms of these grooves 322 have their extreme inner end regions turned upwardly at 323 to distribute the coolant over the restrictions at the inner ends of the grooves 322, the restrictions inhibiting but not completely preventing the entry of liquid coolant into the groove from the well 316. Such turning of the inner ends of the grooves prevents overflow of the liquid coolant and, in effect, serves a function similar to the restrictions 123. In this form of the invention, the matrix 314 is divided into individual and separate sectors. The lap 320 is designed for use in the lapping of convex surfaces on concavo-convex, plano-convex or double convex lenses.

The composite diamond lap 420 of FIG. 7 is substantially the same as the diamond lap of FIG. 6 with the single exception that the radial grooves 422 have the bottoms of their outer ends turned upwardly at 423 to provide fluid restrictions to inhibit coolant discharge as described in connection with the diamond lap of FIG. 5. In this form of the invention, the grooves 422 divide the matrix 414 into individual sectors.

In FIG. 8, a further modified form of the invention is illustrated wherein the radially diverging grooves 522 are of arcuate extent, while in FIG. 9, another modified form of the invention reveals that the grooves 622, instead of extending truly radially as in the case of the laps of FIGS. 1 to 7, inclusive, extend in secant fashion between the inner and outer peripheries of the lap. In each of these two views, reference numerals of a progressively higher order are employed to designate corresponding parts as between the laps of the preceding views and those of FIGS.
Having thus described the invention what I claim as new and desire to secure by Letters Patent is:

1. In a lapping machine for producing a spherical surface in a lens or the like, in combination, a rotary diamond lap body having an upwardly presented annular surface of frusto-spherical contour and shaped conformably to the spherical surface to be produced on the lens, a thin sheet-like matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an annular upper lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap surface becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central well having a circular rim which defines the inner periphery of the lap surface, said lap surface being formed with a series of equally spaced diverging grooves which are of substantially equal depth throughout and extend from the inner peripheral region of the lap surface to the outer peripheral region thereof so that they substantially divide the matrix into a series of circumferentially spaced segments, the extreme ends of the bottoms of said grooves may be provided with fluid restrictions therein, and means for supplying a liquid coolant to said central well.

2. In a lapping machine, the combination set forth in claim 1 and wherein the fluid restrictions are provided at the ends of the grooves which are adjacent to the inner periphery of the lap.

3. In a lapping machine, the combination set forth in claim 1 and wherein the grooves are of a depth greater than the thickness of the matrix.

4. In a lapping machine for producing a spherical surface in a lens or the like, in combination, a rotary diamond lap body having an upwardly presented annular surface of frusto-spherical contour and shaped conformably to the spherical surface to be produced on the lens, a thin sheet-like matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an annular upper lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap surface becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central well having a circular rim which defines the inner periphery of the lap surface, said well providing with a cylindrical wall surface, the bottom region of which is under-cut to provide an annular pocket and an overlying inwardly extending circular lip which terminates in said circular rim, said lap surface being formed with a series of equally spaced diverging grooves which are of substantially equal depth throughout and extend from the inner peripheral region of the lap surface to the outer peripheral region thereof so that they substantially divide the matrix into a series of circumferentially spaced segments, the extreme ends of the bottoms of said grooves adjacent to one of the lap peripheries being provided with fluid restrictions therein, and means for supplying a liquid coolant to said central well.

5. In a lapping machine for producing a spherical surface in a lens or the like, in combination, a rotary diamond lap body having an upwardly presented annular surface of frusto-spherical contour and shaped conformably to the spherical surface to be produced on the lens, a thin sheet-like matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an annular upper lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap surface becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central well having a circular rim which defines the inner periphery of the lap surface, said well providing with a cylindrical wall surface, the bottom region of which is under-cut to provide an annular pocket and an overlying inwardly extending circular lip which terminates in said circular rim, said lap surface being formed with a series of equally spaced diverging grooves which are of substantially equal depth throughout and extend from the inner peripheral region of the lap surface to the outer peripheral region thereof so that they substantially divide the matrix into a series of circumferentially spaced segments, the extreme ends of the bottoms of said grooves adjacent to one of the lap peripheries being provided with fluid restrictions therein, and means for supplying a liquid coolant to said central well.

6. In a lapping machine for producing a spherical surface on a lens or the like, in combination, a rotary diamond lap body having an upwardly presented annular surface of frusto-spherical contour and shaped conformably to the spherical surface to be produced on the lens, a thin sheet-like matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an annular lap surface from which fixed diamond particles project in part out-
wardly for cutting purposes as the lap surface becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central well having a circular rim which defines the inner periphery of the lap surface, said well being provided with a cylindrical wall surface, the bottom region of which is undercut to provide an annular pocket and an overlying inwardly extending circular lip which terminates in said circular rim, said lap surface being formed with a series of equally spaced diverging grooves which are of substantially equal depth throughout and extend from the inner peripheral region thereof and thus substantially divide the matrix into a series of circumferentially spaced segments, the extreme ends of the bottoms of said grooves adjacent to both of the lap peripheries being provided with fluid restrictions therein, and means for supplying a liquid coolant to said central well.

7. In a lapping machine, a rotary diamond lap comprising a lap body having an upwardly presented annular surface shaped conformably to the contour of a surface on an article to be lapped, a matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an upper annular lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central coolant-receiving well having a circular rim which defines the inner periphery of the lap surface, said lap surface having formed therein a series of outwardly diverging grooves which extend from respective points spaced a slight distance radially outwards of the outer periphery of the lap surface and terminating adjacent to the outer periphery of the lap surface, said grooves serving to divide the lap surface into a series of substantially equal and circumferentially spaced matrix sectors, adjacent sectors being connected together at the inner periphery of the lap by narrow webs which constitute restrictions to the radial flow of coolant entering said grooves, and means for supplying a liquid coolant to said central well.

8. In a lapping machine, a rotary diamond lap comprising a lap body having an upwardly presented annular surface shaped conformably to the contour of a surface on an article to be lapped, a matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an upper annular lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central coolant-receiving well having a circular rim which defines the inner periphery of the lap surface, said lap surface having formed therein a series of outwardly diverging grooves which extend from points adjacent to the inner periphery of the lap surface to respective points spaced a slight distance radially outwards of the outer periphery of the lap surface, said grooves serving to divide the lap surface into a series of substantially equal and circumferentially spaced matrix sectors, adjacent sectors being connected together at the outer periphery of the lap surface by narrow webs which constitute restrictions to the radial flow of coolant leaving said grooves, and means for supplying a liquid coolant to said central well.

9. In a lapping machine, a rotary diamond lap comprising a lap body having an upwardly presented annular surface shaped conformably to the contour of a surface on an article to be lapped, a matrix of uniform thickness throughout bonded to said surface and coextensive therewith, said matrix having diamond particles distributed throughout the same, said matrix presenting an upper annular lap surface from which fixed diamond particles project in part outwardly for cutting purposes as the lap becomes progressively worn, said lap body and matrix, considered as a whole, being formed with a central coolant-receiving well having a circular rim which defines the inner periphery of the lap surface, said lap surface having formed therein a series of outwardly diverging grooves which extend from respective points spaced a slight distance radially outwards of the inner periphery of the lap surface, said grooves serving to divide the lap surface into a series of substantially equal and circumferentially spaced matrix sectors, adjacent sectors being connected together at the inner and outer peripheries of the lap by narrow webs which constitute restrictions to the radial flow of coolant entering and leaving said grooves, and means for supplying a liquid coolant to said central well.

10. In a lapping machine, the combination set forth in claim 9 wherein the grooves are of a depth greater than the thickness of the matrix.

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