Dec. 28, 1965 M. O. BRANDT 3,225,497

METHOD AND APPARATUS FOR FORMING A LENS SURFACE

Filed Oct. 19, 1962 2 Sheets-Sheet 1

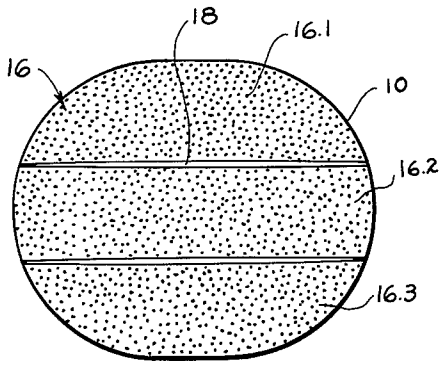

Fig. 1

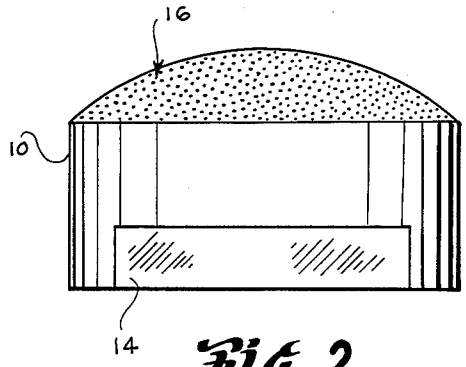

Fig. 2

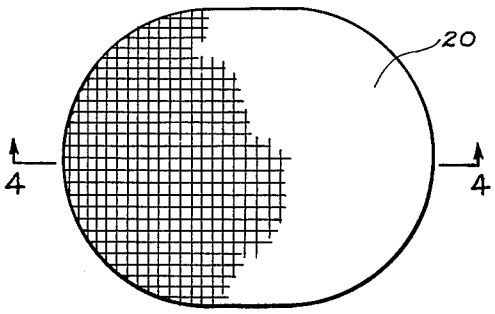

Fig. 3

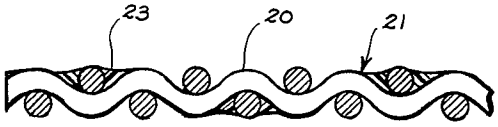

Fig. 5

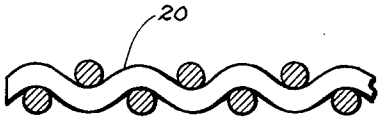

Fig. 4

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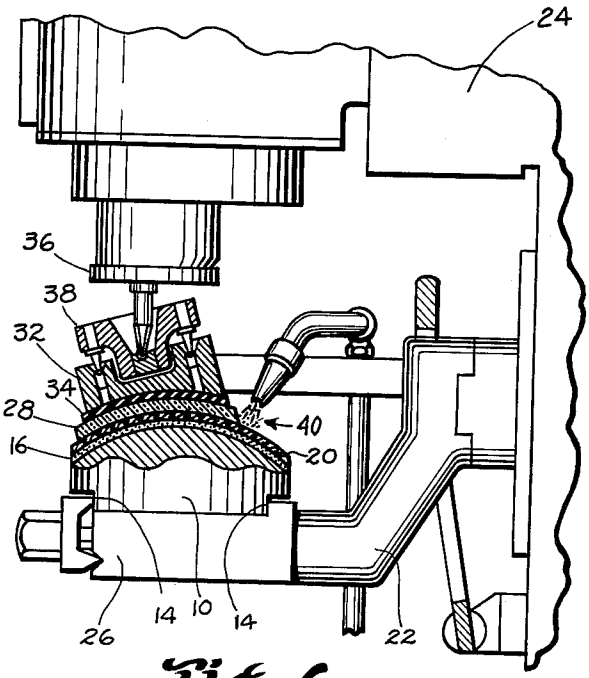

Fig. 6

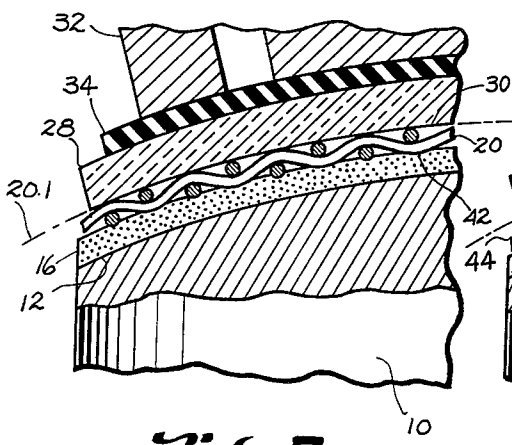

Fig. 7

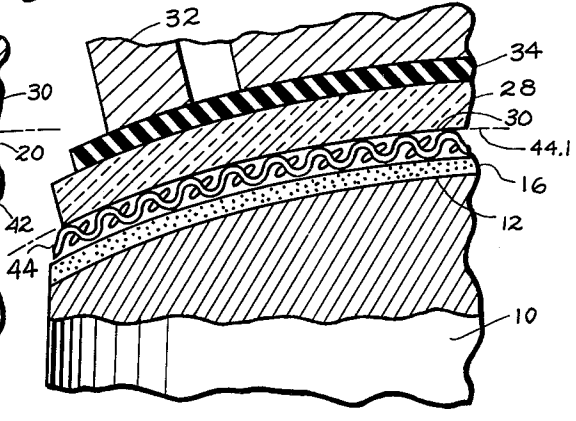

Fig. 8

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METHOD AND APPARATUS FOR FORMING A LENS SURFACE

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5 Claims. (Cl. 51—358)

The field of this invention is that of lens manufacture, and the invention relates, more particularly, to novel and improved methods and apparatus for providing a lens blank with a surface of selected curvature.

In a conventional process for providing a lens blank with an optically finished surface of selected curvature, a surface of the blank is rough ground to substantially the curvature desired. Then this rough ground surface is finely ground to more precise curvature and this fined surface is polished to a high degree of perfection. A lens blank surface is usually fine ground to precise curvature by use of a tool made of cast iron or the like which is provided with a lapping surface having a curvature precisely corresponding to the curvature desired to be formed upon the lens blank surface. Relative rotary or oscillatory motion is then provided between the tool lapping surface and the lens blank surface as a slurry containing abrasive particles of carefully selected size is directed between said surfaces, thereby to abrade the lens surface until it acquires the precise curvature of the lapping surface. This fined lens blank surface is then customarily polished by use of another tool having a member of plastic material or the like secured thereto, the plastic member also having a lapping surface of a curvature corresponding to that of the lens blank surface to be polished. As will be understood, relative movement is provided between the fined lens blank surface and the lapping surface of the polishing tool as a slurry of rouge or other polishing medium is directed between said surfaces, thereby to polish the lens blank surface. In this process, the lapping surface of the fining tool will wear fairly rapidly and must frequently be remachined or trued for returning the lapping surface to the desired curvature. Similarly, the lapping surface of the polishing tool will tend to wear out of its desired curvature and will require truing or replacement of the tool.

It is an object of this invention to provide novel and improved methods and apparatus for carrying out the final steps in formation of lens surfaces of selected curvature and to provide such methods and apparatus which avoid the above-mentioned difficulties experienced in prior art lens surfacing processes.

It is also an object of this invention to provide such methods and apparatus in which inexpensive and replaceable facing means are disposed between a lens blank surface and the lapping surface of grinding and polishing tools during fining and polishing of the lens blank surface, thereby to function as the effective abrading surfaces of the tools and to experience the wear which would otherwise be experienced by said tools.

It is an additional object of this invention to provide such methods and apparatus in which said facing means can be conveniently conformed to the curvature of said lapping surfaces; in which said facing means can be conveniently held between said lapping surfaces and said lens blank surface during abrading of said lens blank surface; and in which said facing means can be conveniently replaced whenever desired.

Another object of this invention is to provide improved methods and apparatus for surfacing lenses which are so inexpensive, accurate and efficient and so convenient to use that there will be no requirement for the exercise of human judgement in using said apparatus or in performing said methods, whereby said methods and apparatus can be emloyed for forming lens surfaces with consistently high accuracy.

Briefly described, the apparatus provided by this invention includes a tool or lapping member having a carefully formed surface of a curvature corresponding to the curvature to be formed on a lens blank surface. This tool or lapping member surface is furnished with a coating which provides the surface with a selected, preferably relatively high, coefficient of friction. Most desirably this coating can be simply and inexpensively formed on the tool surface by adhering a plurality of strips of an adherent tape in side-by-side relation upon the tool surface.

The apparatus provided by this invention further includes a facing means which may comprise a thin disc-shaped sheeting of interwoven metallic wire strands or a thin disc-shaped pad of fibrous material. The facing means is adapted to be readily conformed to and frictionally engaged with the coated lapping member surface above-described.

In the methods contemplated by this invention, a lapping member having a surface of selected curvature can be coated with strips of an adherent tape, or the like, and can be placed in juxtaposition to a surface of a lens blank which has been rough ground to a curvature corresponding to that of the lapping member. A facing means such as a thin disc of interwoven wire strands can be disposed between the lapping member surface and the rough ground lens blank surface and the lapping member and lens blank can be pressed together for conforming the facing means to the curvature of said surfaces. A stream of slurry containing abrasive particles of carefully selected size can then be directed between the lapping member surface and the lens blank surface and relative rotary or oscillatory motion can be provided between the member and blank. During this relative movement, the facing means is frictionally engaged with the coated lapping member surface so that the facing means is held immobile with reference to the coated surface and accordingly, the rough ground lens blank surface will be abraded or fine ground to the precise curvature desired by action of the abrasive particles in the slurry. Thereafter, the lapping member and lens blank can be moved apart for releasing the facing means and the facing means can be discarded. Alternatively or subsequently, a facing means comprising a fibrous polishing pad or the like can be substituted for the interwoven wire facing above-described and, using a slurry containing finer abrasive particles such as a rouge or the like during relative movement between the lapping member and lens blank, a fine ground lens blank surface can be polished to a high degree of optical perfection.

Other objects, advantages and details of the methods and apparatus provided by this invention appear in the following detailed description of preferred embodiments of the invention, the detailed description referring to the drawings in which:

FIG. 1 is a plan view of a lapping member having its lapping surface coated according to this invention;

FIG. 2 is a side elevation view of the lapping member of FIG. 1;

FIG. 3 is a plan view of a wire facing means as contemplated by this invention;

FIG. 4 is a section view along line 4—4 of FIG. 3;

FIG. 5 is a section view similar to that of FIG. 4 showing an alternative facing means provided by this invention;

FIG. 6 is a fragmentary side elevation view of a lens surfacing apparatus shown partially in section illustrating the method and apparatus of this invention;

FIG. 7 is a fragmentary side elevation view similar to FIG. 6, but is drawn to enlarged scale; and

FIG. 8 is a fragmentary side elevation view similar to FIG. 7 illustrating the method and apparatus of this invention using an alternative facing means to that shown in FIG. 7.

Referring to the drawings, **10** in FIGS. 1 and 2 and in FIGS. 6–8 indicates a lens-forming tool which can be made of cast iron or other suitably rigid material and which has a carefully shaped surface **12** of a curvature corresponding to that desired to be formed on a lens blank surface. The tool can have flattened portions **14** on opposite sides of the tool or can incorporate other conventional means by which the tool can be securely held in a lens surfacing machine.

According to this invention a coating **16** can be formed upon and secured to the tool surface **12** for providing the tool surface with a selected, preferably high, coefficient of friction. Most conveniently, the coating **16** can be formed by applying several strips of a conventional pressure-sensitive masking tape, or the like, to the tool surface **12**. For example, several strips **16.1**, **16.2** and **16.3** of a masking tape such as that which is commercially available under the trade name Permacel can be adhered to the tool surface **12** in side-by-side relation. Where the strips of tape are relatively narrow and somewhat pliable and textured as is preferred, the strips can be easily conformed to the entire curved tool surface **12** without wrinkling or overlapping but, if necessary or preferred for convenience in applying the tape, small spaces **18** can be permitted between the tape strips without undesirable results. Such strips of tape can provide the tool surface **12** with a coating **16** of satisfactorily uniform thickness and of suitably high coefficient of friction for carrying out the purposes of this invention. If preferred, however, other means such as lacquers, plastic or latex coatings or the like, can be applied to the tool surface **12** for providing the surface with a selected coefficient of friction.

A thin replaceable facing **20** can then be provided for use with the coated tool **10** in forming a lens blank surface according to this invention. For example, as shown in FIGS. 3 and 4, the facing can comprise a flat sheet of finely woven wire mesh of the approximate size of the tool surface **12**, the facing being such as can be simply cut from a sheet of flat wire-mesh stock. Alternatively, a facing **21** can comprise a sheet of wire mesh **20** having a lacquer or shellac **23** applied thereto for adhering intersecting strands of the mesh together, at least at selected locations, without significantly altering the foraminous nature of the mesh as illustrated in FIG. 5. Of course, other simliar conformable and foraminous facing materials could also be employed within the scope of this invention.

As shown in FIGS. 6 and 7, the tool **10** can be mounted upon an oscillating arm **22** of a conventional lens surfacing machine **24** and can be securely fixed thereon in a conventional vise-like clamp **26** which can grippingly engage the flattened portions **14** of the tool. Similarly, a lens blank **28** having a surface **30** which has previously been rough ground or otherwise conventionally shaped to substantially the curvature desired upon said surface can be secured to a lens holder **32** with an adhesive layer of pitch **34**, or by other suitable means. The lens holder can be suspended from a rotatable crank arm **36** and can be properly positioned thereon by the conventional aligning means **38**. The crank arm **36** can support the lens blank surface **30** in juxtaposition to the tool surface **12** as shown in FIGS. 6 and 7 and can urge the blank toward the tool with a selected pressure, but can also be elevated when desired for withdrawing the lens blank from the tool. The tool-supporting arm **22** can oscillate the tool **10** as the crank arm **36** imparts a rotary motion to the lens blank **28** and urges the lens blank toward the tool, thereby to provide relative movement between the lens blank and tool. As the lens surfacing machine **24** including the oscillating arm **22**, the crank arm **36**, the tool holder **32** and the aligning means **38** can be of any conventional design, it will not be further described herein, it being understood that any conventional lens surfacing means can be employed for urging the lens blank surface **30** toward the tool surface **12** and for providing relative movement between said surfaces.

According to this invention, the flat facing **20** shown in FIGS. 3 and 4 can be inserted between the lens blank surface **30** and the tool surface **12**, preferably when the crank arm **36** is in an elevated position as will be understood, and the lens blank can be urged toward the tool **10** so that the facing **20** is conformed to the curvature of the tool surface **12** by the blank surface **30**. As the facing is formed of wire mesh or other conformable material and is not cemented or otherwise permanently affixed to the tool surface **12** or to the coating **16**, the facing will be readily conformed to fit snugly against and to stay snugly against the coating **16** without tending to bunch-up or wrinkle. A stream of slurry **40** containing abrasive particles of selected size can then be directed between the lens blank surface **30** and the tool surface **12** in conventional manner and the lens surfacing machine can impart relative movement between the blank and tool as above-described. As shown particularly in FIG. 7, the facing **20** can be frictionally engaged with the coating **16** formed on the tool surface **12** to be securely held between the tool and blank and can move with the tool surface during relative movement between the tool and the lens blank. In fact, the strands of wire in the facing **20** can be slightly embedded in the coating **16** as indicated at **42** in FIG. 7 to assure that the facing is held immobile with reference to the tool. As will be understood, this arrangement permits a scrubbing or abrading action to occur between the rough ground lens blank surface **30** and the facing **20** as the slurry **40** is directed therebetween and as relative movement is provided between the lens blank and tool, thereby to fine grind the lens blank surface **30** to the precise curvature of the outer surface **20.1** of the facing. It has previously been stated that the tool surface **12** can have a curvature corresponding to that desired to be formed upon the blank surface **30**. It can be seen by reference to FIG. 7 that the curvature of the tool surface **12** should be either convex or concave such that, when the coating **16** and the facing **20** have been positioned over the tool surface **12**, the abrading surface of the facing indicated by the broken line **20.1** can be of a curvature which is precisely complementary to that to be formed on the lens blank surface **30**.

It will be understood that the facing **20** will protect the tool surface **12** from wear so that the life of the tool **10** can be extended almost indefinitely. Further, the foraminous facing will readily transmit the slurry **40** to all parts of the lens surface **30** to assure that abrading of the blank surface can be rapid and uniform. In addition, in the system provided by this invention, the facing **20** is securely held between the lens blank **28** and the tool **10** during fining of the blank surface **30** only by the pressure exerted between the blank and tool and by frictional engagement of the facing with the tool surface coating **16**. Accordingly, the facing can be very easily positioned on or removed from the coating **16** in a few seconds. Thus, although the facing may be used in fining more than one lens surface without experiencing excessive wear it is preferable, particularly in view of the inexpensive nature of the facing, to discard the facing after it has been used in fining a single lens blank surface. This means that no exercise of human judgment is required in determining when a facing has been excessively worn and assures that each lens surfaced can be formed to the precise curvature desired. The coating **16** may also be easily applied to and removed from the tool surface **12** but is not likely to be damaged in a single fining operation and therefore can be safely used in several surfacing operations before replacement.

The wire mesh facing **21** shown in FIG. 5 as having its separate strands adhered together with a lacquer can be referred to as tie-coated mesh and can be employed in

place of the facing **20** in the lens surfacing process above-described. The use of a tie-coated wire mesh facing reduces the quantity of wire fragments which will be lost from the mesh during the lens surfacing operation and which would tend to contaminate the slurry **40** used in the surfacing operation, whereby the abrasive particles in the slurry can be easily reclaimed from used slurry in conventional manner.

According to this invention, the facing **20** can be disposed between a lens blank surface **30** and a coating **16** formed on a tool surface for fining the lens surface as above-described. The facing **20** can then be discarded and replaced with a polishing pad **44** as shown in FIG. 8. This polishing pad may comprise a flat sheet of felt or the like which is similar in shape to the facing shown in FIG. 3 and which can be readily conformed to the curvature of the coated surface of the tool **10** in the same manner as the facing **20**. For example, the polishing can comprise a pad of non-woven fibrous material such as is commercially available under the trademark Pellon. Such a polishing pad can be securely held between the fine ground lens blank surface and the tool surface coating **16** and can be frictionally engaged with the coating **16** in the same manner as the facing **20**. Then relative movement can again be provided between the lens blank **28** and the tool **10** as a slurry **40** is directed between the blank and the tool, this slurry containing very fine abrasive particles such as a polishing rouge or the like. In this arrangement the polishing pad **44** can be held immobile with reference to the tool surface coating **16** by reason of the frictional engagement of the pad with the coating, thereby to polish the lens blank surface **30** to a high degree of optical perfection. After completion of this polishing operation, the polishing pad **44** can be discarded. It will be understood that the pad **44** can have a thickness which is substantially identical to that of the facing **20**, whereby the pad can be substituted for the facing without changing the curvature of the surface indicated by the broken line **44.1** which is brought into abrading or polishing engagement with the lens blank surface **30**. In this way the tool **10** can be used indefinitely for both fining and polishing lens surfaces and can consistently provide said lens surfaces with precise curvatures in a rapid and convenient manner without requiring the exercise of skilled judgment by the workmen performing the lens surfacing operations.

Although particular embodiments of the methods and apparatus provided by this invention have been described for the purpose of illustrating the invention, it should be understood that this invention includes all modifications and equivalents of the described embodiments which fall within the scope of the appended claims.

Having described my invention, I claim:

1. Lens fining means comprising a lap member having a surface of selected curvature, a coating covering substantially all of said surface for providing said surface with a relatively high coefficient of friction, said coating embodying a plurality of strips of tape detachably adhered to said member surface in side-by-side relation, and a separate replaceable sheeting of interwoven metallic wire strands adapted to be conformed to and frictionally engaged with said coated surface for forming a protective facing for said surface, whereby the sheeting can be conformed to and held relatively immobile with reference to said lap member surface between said coated lap member surface and a rough ground lens blank surface of substantially complementary curvature during relative movement of said lap member surface and said lens blank surface for fining said lens blank surface.

2. Lens polishing means comprising a lap member having a surface of selected curvature, a coating covering substantially all of said lap member surface for providing said surface with a relatively high coefficient of friction, said coating embodying a plurality of strips of tape detachably adhered to said member surface in side-by-side relation, and a separate, replaceable, fibrous, polishing pad adapted to be conformed to and frictionally engaged with said coated surface for forming a facing for a said surface, whereby the pad can be conformed to and held relatively immobile with reference to said lap member surface between said coated lap member surface and a fined lens blank surface of substantially complementary curvature during relative movement of said lap member surface and said lens blank surface for polishing said lens blank surface.

3. A method for fining a surface of a selected curvature on a rough ground lens blank, said method comprising the steps of providing a lap member having a rigid surface of a curvature corresponding to that desired to be fined upon said lens blank surface, detachably adhering a plurality of strips of tape to said lap member surface in side-by-side relation for substantially covering said surface and for providing said surface with a relatively high coefficient of friction, pressing a separate, replaceable sheeting of interwoven metallic wire strands between said coated lap member surface and said lens blank surface so that said sheeting is conformed to and frictionally engaged with said covered member surface to form a protective facing for said surface and so that said sheeting can be held relatively immobile with reference to said covered member surface during subsequent relative movement between said member surface and said lens blank surface, directing an abrasive medium between said facing and said lens blank surface, and causing relative movement between said lap member surface and said lens blank surface for fining said lens blank surface.

4. A method for polishing a fined lens surface of a selected curvature on a lens blank, said method comprising the steps of providing a lap member having a rigid surface of a curvature corresponding to that desired to be polished upon said lens blank surface, detachably adhering a plurality of strips of tape to said lap member surface in side-by-side relation for substantially covering said surface and for providing said surface with a relatively high coefficient of friction, pressing a separate, replaceable, polishing pad between said covered lap member surface and said lens blank surface so that said pad is conformed to and frictionally engaged with said covered member surface and so that said pad can be held relatively immobile with reference to said covered member surface during subsequently relative movement between said member surface and said lens blank surface, directing a polishing medium between said pad and said lens blank surface, and causing relative movement between said lap member surface and said lens blank surface for polishing said lens blank surface.

5. A method for optically finishing a surface of a selected curvature on a rough ground lens blank, said method comprising the steps of providing a lap member having a surface of a curvature corresponding to that desired to be finished upon said lens blank surface, detachably adhering a plurality of strips of tape to said lap member surface in side-by-side relation for substantially covering said surface and for providing said surface with a relatively high coefficient of friction, pressing a separate, replaceable sheeting of interwoven metallic wire strands between said covered lap member surface and said lens blank surface so that said sheeting is conformed to and frictionally engaged with said covered member surface to form a protective facing for said surface and so that said sheeting can be held relatively immobile with reference to said covered member surface during subsequent relative movement between said member surface and said lens blank surface, directing an abrasive medium between said facing and said lens blank surface, causing relative movement between said lap member surface and said lens blank surface for fining said lens blank surface, removing said facing, pressing a separate, replaceable, polishing pad between said covered

lap member surface and said lens blank surface so that said pad is conformed to and frictionally engaged with said covered member surface and so that said pad can be held relatively immobile with reference to said covered member surface during subsequent relative movement between said member surface and said lens blank surface, directing a polishing medium between said pad and said lens blank surface, and causing relative movement between said lap member surface and said lens blank surface for polishing said lens blank surface.

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