

Jan. 23, 1968

J. R. DAVY ETAL

3,364,525

MOLD ASSEMBLY FOR OPTICAL LENS

Original Filed Nov. 13, 1964

FIG. 1.

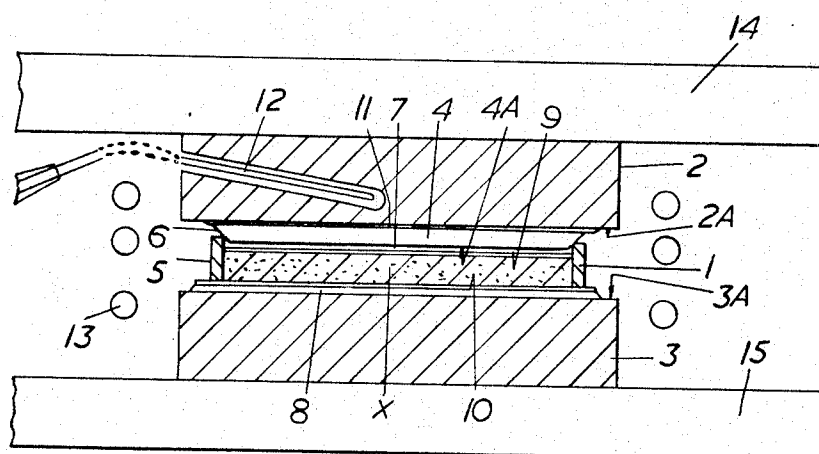
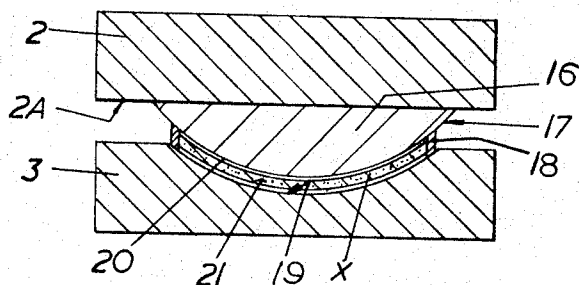


FIG. 2.



Inventors
JOHN RUPERT DAVY &
JOHN MCKILLOP BALLANTINE
By
Mason, Fenwick & Lawrence
Attorneys

1

3,364,525

MOLD ASSEMBLY FOR OPTICAL LENS

John R. Davy and John McKillop Ballantine, Glasgow, Scotland, assignors to Barr and Stroud Limited, Glasgow, Scotland, a company of Great Britain

Continuation of application Ser. No. 412,283, Nov. 13, 1964. This application May 3, 1967, Ser. No. 635,926

Claims priority, application Great Britain, Nov. 16, 1963, 45,517/63

9 Claims. (Cl. 18—42)

This application is a continuation of application Ser. No. 412,283, filed Nov. 13, 1964, now abandoned.

This invention relates to the manufacture of optical elements by subjecting a mass of powdered compound in a mould assembly simultaneously to a high pressure and a high temperature in order to convert the powder to a solid polycrystalline body. Such treatment of the powder is hereinafter and in the claims for convenience referred to as hot pressing. Powdered compounds suitable for hot pressing are inter alia magnesium fluoride, zinc sulphide and zinc selenide.

One object of the invention is to provide for substantially uniform distribution of pressure throughout the mass of powder during the hot pressing of the optical element.

Another object of the invention is to enable use of a press of relatively low operating pressure so that relatively large elements can be produced with a relatively small press.

Other objects and advantageous features will appear from the following embodiments described by way of example with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a sectional view showing hot pressing apparatus including a mould assembly suitable for use in producing relatively large optical discs, and

FIG. 2 is a sectional view of a mould assembly suitable for use in producing optical domes.

Referring to the drawings:

In FIG. 1, magnesium fluoride powder X is hot pressed in a mould assembly consisting of opposed end parts in the form of a pair of upper and lower steel anvil blocks 2 and 3 with opposed horizontal flat-ground faces 2A and 3A, and a powder container located for compression between the blocks and composed of an annular part in the form of a deep, relatively thin-walled rectangular-section circular ring 1 of mild steel and a closure for the top end 5 of the ring in the form of a mild steel circular disc 4 having a bevelled peripheral face 6 engaging the inner edge of the end 5 of the ring. Layers 7 and 8 of refractory powder, e.g. alumina layers, and flexible refractory sheets 9 and 10, e.g. mica sheets, are provided on the opposed faces 4A and 3A of the disc 4 and anvil block 3 respectively, and a refractory powder layer 11 is provided between the anvil block 2 and the disc 4. A thermocouple 12 is embedded in the upper anvil block 2 and is connected to a millivoltmeter (not shown) to measure temperature. An induction heater has its coil 13 surrounding the mould assembly and an 80 ton hydraulic press (not shown) receives the assembly between its platens. The alumina layers prevent adhesion during hot pressing and the mica sheets prevent the alumina powder from entering the powder X. Thick heat-insulating boards 14 and 15 are provided between the anvil blocks 2, 3 and the press platens.

The method of hot pressing is as follows:

Stage A

The magnesium fluoride powder, having mixed therewith 3% by weight of ammonium fluoride powder, is packed into the ring 1 which rests on the lower anvil block 3, the powder forming a dome shape above the top end 5 of the ring. The upper anvil block 2 is then placed

2

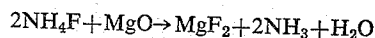
over the ring 1, and the ring-and-anvil assembly thus formed is subjected to a pressure of 12 tons/sq. in. in the press at room temperature so that the powder forms a dense, packed mass within the ring. The ring with the compacted powder therein is then removed from the press.

Stage B

The thin uniform layers 7, 8 and 11 of alumina powder are formed by sieving the powder through brass gauze, the thin mica sheets 9 and 10 are positioned, and the container composed of the ring 1 with the powder X packed therein and the disc 4 is then sandwiched between the blocks 2 and 3, as shown in FIG. 1. The temperature is raised by the heater 13 to about 750° C., and a pressure of about 12 tons per sq. inch is applied to the powder X by the press. The conditions of temperature and pressure are maintained for about 10 minutes, after which the pressure is removed, and finally the heating is switched off. This hot pressing converts the powder to a polycrystalline solid disc which transmits infra-red radiation out to the limit of transmission of the material with little absorption and scattering.

As the container is composed of mild steel which under the hot pressing conditions is capable of plastic deformation, during hot pressing the disc 4 beds sealingly against the ring end 5 which is deformed to bevelled shape, and the ring 1 beds sealingly against the adjacent block face 3A so that the packed powder is sealed within the container throughout the compression of the powder, and in the event of variations in density through the packed mass of powder the container deforms in accordance with said variations, without loss of seal, to ensure substantially uniform distribution of pressure throughout the mass of powder. The wall thickness of the ring 1 can be reduced to a small value, which means that the necessary moulding pressure for both small and large discs can be supplied by the same relatively small press. Moreover, little peripheral strain is set up in the powder X during hot pressing.

Also, during hot pressing the ammonium fluoride reacts with contaminating magnesium oxide to produce magnesium fluoride, together with ammonia and water which volatilize:



Thus the contaminant is scavenged from the powder by the reagent without the incidental addition to the product of any other harmful substance. This scavenging of contaminant from the powder is the subject of our co-pending patent application No. 38,304/63 filed Sept. 28, 1963.

The optical disc within the ring 1 attached thereto is allowed to cool to 250° C. approximately and both ring and disc are then removed from between the end parts of the mould. After the optical disc has cooled to room temperature, the ring 1 is removed therefrom by dissolving the ring in dilute nitric acid, and the optical disc is then ground and polished to the desired thickness.

In FIG. 2 the powder container is composed of a circular, thin-walled ring 18 of mild steel and a dome-shaped male member 16 of mild steel presenting a peripheral wedge-shaped face 17 which abuts the correspondingly bevelled top end of ring 18, the base of the member 16 abutting the underface 2A of the anvil block 2. The lower end part of the mold consists of the anvil block 3 which has a dome-shaped recess 19 formed therein and engaged by the correspondingly bevelled lower end of the ring 18. The opposed faces of the male member 16 and the recess 19 are coated with refractory alumina powder at 20 and 21 to facilitate their release from the domed optical element.

On hot pressing the powder X in the mold assembly,

the container being of mild steel becomes slightly plastic and deforms to permit compression of the powder X. The member 16 beds sealingly against the ring end and the ring beds sealingly against the face of the recess 19 so that there is no leakage of powder from the dome-shaped layer packed into the container. Moreover, the container deforms to accommodate any variations in the density of the packed layer of powder so that pressure is distributed substantially uniformly throughout the layer of powder X without loss of sealing. There is a tendency for the male member 16 to move more readily into the recess 19 at the edges, causing the optical dome to be thinner at the edges. This defect can be overcome by having a male member 16 of smaller radius than the recess, thus trapping a thicker layer of the powder X at the edges of the mold.

Curved windows can be hot pressed using a mould assembly somewhat similar to that of FIG. 2.

What is claimed is:

1. A pressure mold for use in hot pressing a powdered compound to form a solid polycrystalline optical element, comprising an annular part and opposed end parts at opposite ends of said annular part having confronting moulding faces forming opposed closures for the mold cavity defined by said annular part movable toward each other under endwise moulding pressure to effect compression of a powdered compound within said annular part, the annular part being yieldable radially outwardly under endwise moulding pressure on the mould so that the powder in the mould is compressed substantially uniformly, and an end part and the annular part abutting each other and incorporating wedge means bearing axially and radially outwardly on the annular part whereby the endwise moulding pressure tends to cause radial expansion of the annular part and so tends to maintain the annular part against collapse, said end part having a wedge-shaped annular face abutting the adjacent end of the annular part so that the moulding pressure while causing yielding of the annular part tends to expand same and so maintain same against collapse, said annular part being a circular ring having a rectangular cross-section and wherein one of said end parts is a flat disc having a bevelled edge abutting the inner periphery of the adjacent end of the ring.

2. A pressure mold for use in hot pressing of powdered compound to form a solid polycrystalline optical element, comprising an annular part and opposed end parts at opposite ends of said annular part having confronting moulding faces forming opposed closures for the mold cavity defined by said annular part movable toward each other under endwise moulding pressure to effect compression of a powdered compound within said annular part, the annular part being yieldable radially outwardly under endwise moulding pressure on the mould so that the powder in the mould is compressed substantially uniformly, and an end part and the annular part abutting each other and incorporating wedge means bearing axially and radially outwardly on the annular part whereby the endwise moulding pressure tends to cause radial expansion of the annular part and so tends to maintain the annular part against collapse, said end part having a wedge-shaped annular face abutting the adjacent end of the annular part so that the moulding pressure while causing yielding of the annular part tends to expand same and so maintain same against collapse, said end parts defining opposed male and female curved parts for producing optical elements with curved surfaces, the male part presenting said wedge-shaped annular face, and said male part being of a material which is rendered slightly plastic and deformable under the hot pressing conditions so as to tend to spread laterally outwards from the centre in use and thereby ensure substantially uniform distribution of pressure throughout the curved mass of powder.

3. A pressure mould for use in hot pressing a powdered compound to form a solid polycrystalline optical element,

comprising an annular part and opposed end parts at opposite ends, annular part having confronting moulding faces forming opposed closures for the mould cavity defined by said annular part movable toward each other under endwise moulding pressure to effect compression of a powdered compound within said annular part, the annular part being yieldable radially outwardly under endwise moulding pressure on the mould so that the powder in the mould is compressed substantially uniformly, and an end part and the annular part abutting each other and incorporating wedge means bearing axially and radially outwardly on the annular part whereby the endwise moulding pressure tends to cause radial expansion of the annular part and so tends to maintain the annular part against collapse, wherein faces of the end parts have thereon layers of refractory powder to facilitate release of the faces, and have flexible refractory sheets on the refractory powder layers to prevent entry of the refractory powder to the moulded element.

4. A mould assembly for use in hot pressing a powdered compound to form a solid, polycrystalline optical element, comprising a pair of opposed anvil blocks, and a powder container of metal located for compression between the blocks and including a one-piece metal ring and a metal closure engaging one end of the ring and spaced from the anvil block at the other end of the ring so as to be bodily movable towards said anvil block, the ring and closure being composed of metal which under hot pressing conditions is capable of plastic deformation whereby during hot pressing of the mass of powder packed into the metal container the closure beds sealingly against the ring end so that the packed powder is sealed within the metal container throughout the compression of the mass of powder, and in the event of variations in density throughout the packed mass of powder the metal container deforms in accordance with said variations, without loss of seal, to ensure substantially uniform distribution of pressure throughout the mass of powder.

5. A mold assembly for use in hot pressing a powdered compound to form a solid, polycrystalline optical disc, comprising a pair of spaced anvil blocks with a pair of opposed flat-ground faces, and a powder container located for compression between the faces of the blocks and composed of a circular ring having a rectangular cross-section and a circular disc having a bevelled peripheral face engaging the inner edge of an end of the ring so that the disc closes the end of the ring, the ring and closure disc being composed of material which under hot pressing conditions is capable of plastic deformation whereby during hot pressing of the mass of powder packed into the container the closure disc beds sealingly against the ring end and the ring beds sealingly against the adjacent block face so that the packed powder is sealed within the container throughout the compression of the powder, and in the event of variations in density throughout the packed mass of powder the container deforms in accordance with said variations, without loss of seal, to ensure substantially uniform distribution of pressure throughout the mass of powder.

6. A mould assembly according to claim 5, including layers of refractory powder on the block faces and on the inner face of the closure disc to facilitate dismantling of the assembly and release of a compact constituted by the ring and the optical disc formed in the ring.

7. A mould assembly according to claim 6, including flexible refractory sheets interposed between layers of refractory powder and the powder in the container to prevent the refractory powder from contaminating the powder in the container.

8. A mould assembly for use in hot pressing a powdered compound to form a solid polycrystalline optical dome, comprising a pair of opposed anvil blocks one of which has therein a dome-shaped recess, and a powder container of metal located for compression between the blocks and composed of a circular metal ring surrounding and en-

5

6

gaging the face of the recess and a metal end closure for the ring engaging the end of the ring and including a dome projecting into the recess to trap a dome-shaped layer of packed powder, and the ring and end closure being composed of metal which under hot pressing conditions is capable of plastic deformation whereby during hot pressing of the domed layer of powder the metal end closure beds sealingly against the metal ring end and the metal ring beds sealingly against the block so that the packed powder is sealed within the metal container throughout the compression of the powder and in the event of variations in density throughout the packed layer of powder the metal container deforms in accordance with said variations without loss of seal, to ensure substantially uniform distribution of pressure throughout the layer of powder.

9. A mould assembly according to claim 8, including layers of refractory powder interposed between dome face and the powder to be pressed and between the face of the recess and the powder layer to be pressed, to facilitate disengagement of the optical dome from said faces.

References Cited

UNITED STATES PATENTS

2,292,917	11/1942	Williams.	
2,319,014	5/1943	Smith	264—1
2,913,764	11/1959	Lowey	18—16.5
3,038,210	6/1962	Hungerford et al.	
3,221,365	12/1965	Mattern et al.	

15 J. SPENCER OVERHOLSER, *Primary Examiner*.

E. MAR, *Assistant Examiner*.