March 7, 1961 J. N. CARMAN ET AL 2,973,605

LAPPING MACHINE

Filed Nov. 9, 1959 2 Sheets-Sheet 1

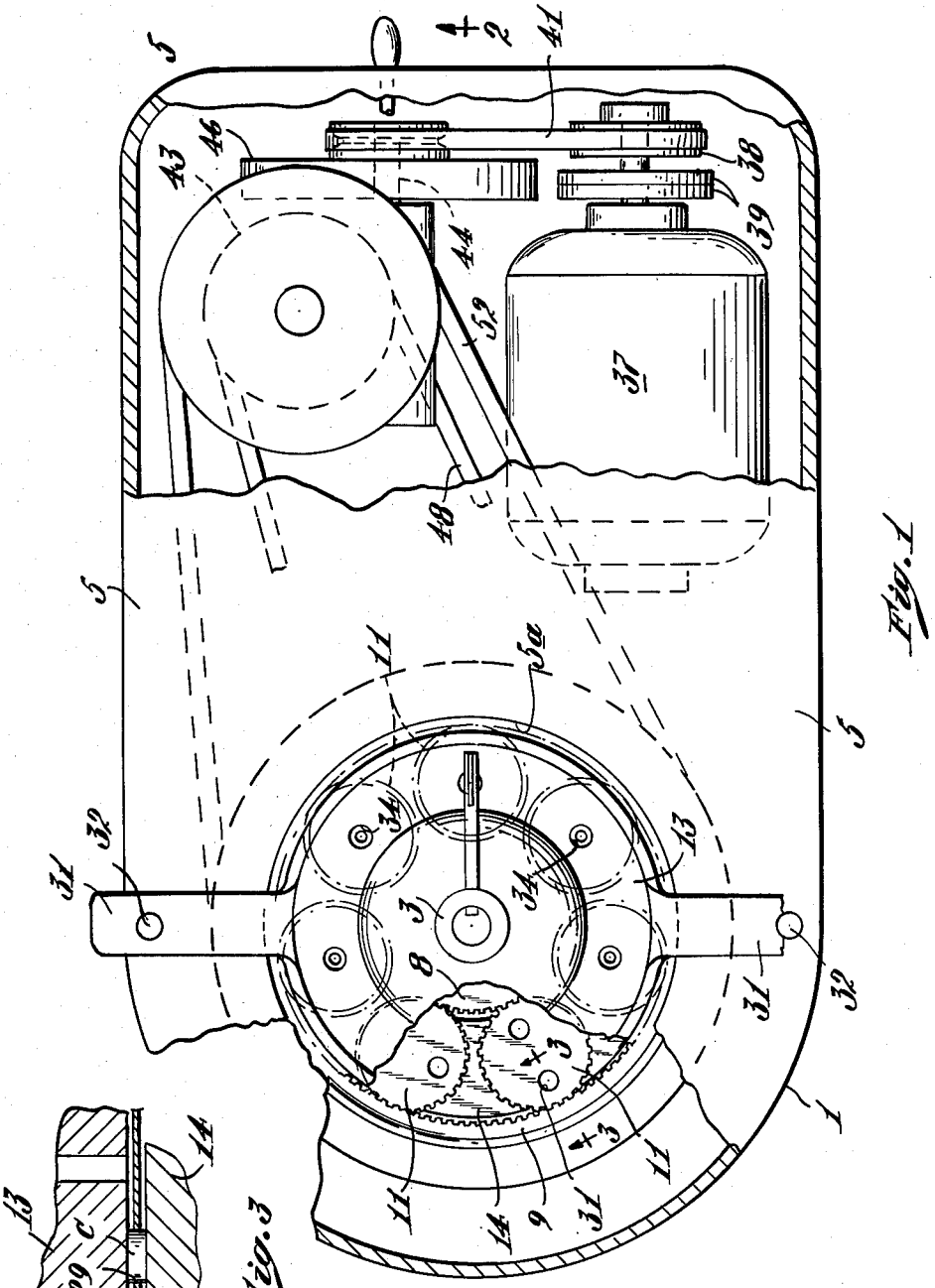


Fig. 1

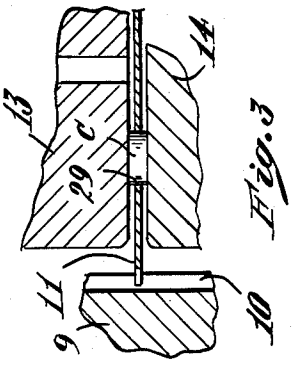


Fig. 3

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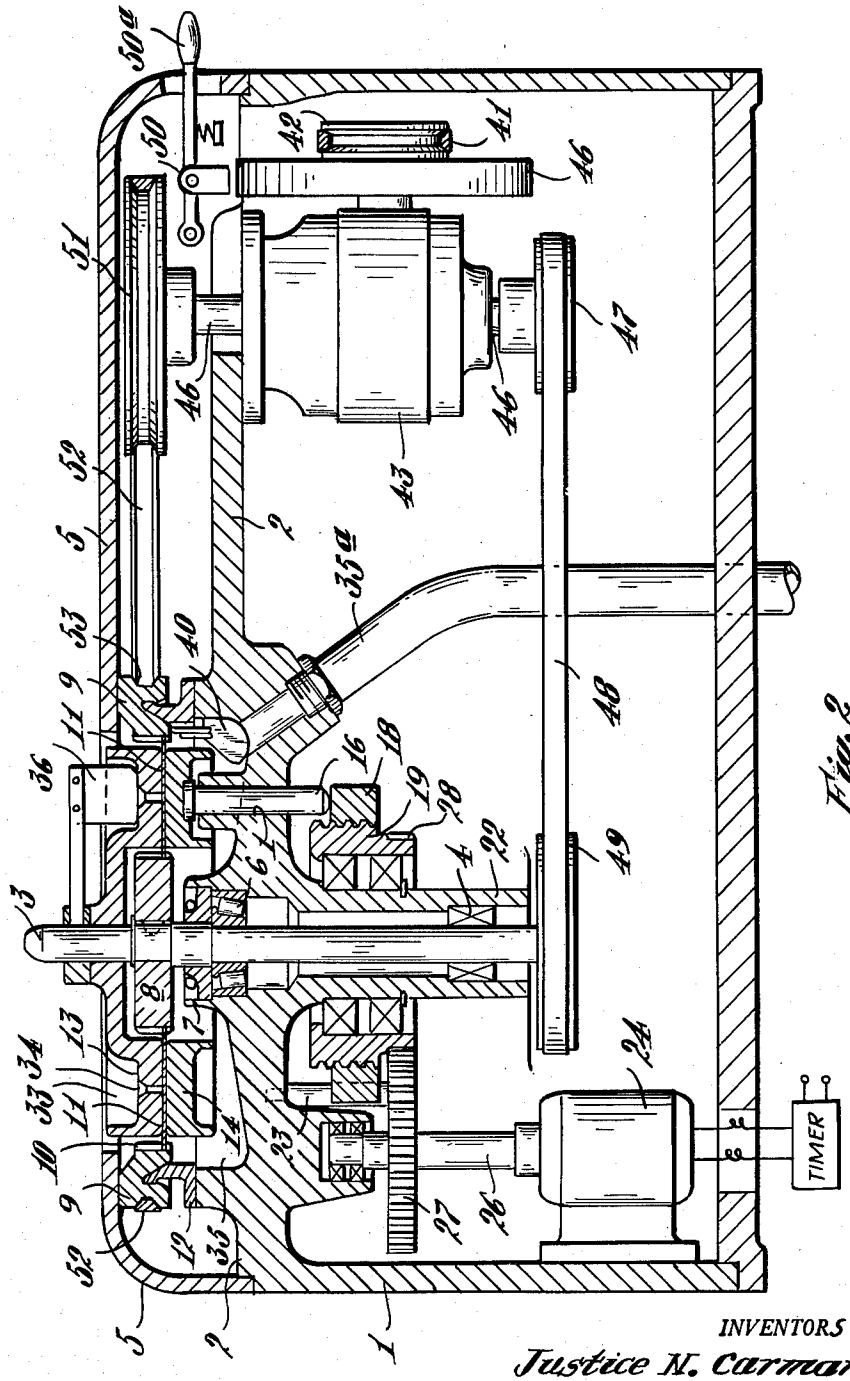


Fig. 2

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LAPPING MACHINE

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11 Claims. (Cl. 51—118)

This invention relates to a machine for lapping grinding thin plates such as semiconductor or piezoelectric crystals, and has for its objects to provide apparatus which will lap frangible plates to an extreme thinness while maintaining the opposite faces of the plate optically flat and parallel.

According to the invention a machine for lapping a thin plate comprises a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, and means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel.

For the purpose of illustration a typical embodiment of the invention is shown in the accompanying drawings in which:

Fig. 1 is a plan view of a lapping machine;

Fig. 2 is a section on line 2—2 of Fig. 1; and

Fig. 3 is an enlarged section on line 3—3 of Fig. 1.

As shown in the figures the machine comprises a housing 1 at the top of which is formed an integral bed 2. Over the bed 2 is a cover 5 having a circular opening 5*a*. A shaft 3 is rotatively supported in the bed 2 by bearings 4 and 6, and is sealed by a stuffing box 7. Keyed to the shaft 3 is the sun gear 8 of a planetary gear system which includes a ring gear 9 with internal teeth 10 and planetary gears 11. The ring gear 11 is rotatively supported on an annular boss 12 on the top bed 2 while the planetary carrier gears 11 float between an upper lapping plate 13 and a lower lapping plate 14.

The lower lapping plate 14 is non-rotatively supported by three pins spaced 120° apart, of which one is shown in Fig. 2. Each pin 16 slides in a bore 17 in the top bed 2 and rests on an internally screw threaded ring 18. The threads of the ring 18 engage screw threads on a gear wheel 19 having internal bearings 21 which permit the gear wheel 19 to rotate in a vertically fixed position on a tube 22 depending from the top bed 2. The ring 18 is locked against rotation by a pin 23 anchored in the top bed. A reversible motor 24 whose shaft 26 is journalled in the top bed drives a spur gear 27 engaging teeth 28 on the gear wheel 19. The motor is controlled by a timer which periodically reverses its drive, for example at the rate of ⅛ cycle per second, thereby driving the gear wheel 19 alternately clockwise and counterclockwise. The gear wheel 19 in turn screws the ring 18 up and down thereby reciprocating the pins 16 and the lower lapping plate 14 at the same rate.

The lower lapping plate is annular in shape and reciprocates in an annular space between the sun gear 8 and ring gear 9 of the planetary system. The several planetary gears 11 extend across the annular space between the ring gear 8 and the internal teeth 10 of the ring gear. The planetary gears 11 each have circular

openings 29 through them for holding a disk shaped crystal or like workpiece C whose opposite faces are to be ground by the upper and lower lapping wheels. As shown in Fig. 3, each planetary gear 11 must be thinner than the workpiece C in order that the opposed lapping plates 13 and 14 bear on opposite faces of the workpiece C. Thus the planetary gears float in the very narrow space between the lapping plates. It will be understood that the thickness of the workpiece is exaggerated for the purposes of illustration, and that a slurry or lapping fluid is introduced between the lapping plates so that the planetary gears are confined sufficiently to maintain substantial parallelism with the lapping plates.

The upper lapping plate 13 fits slidingly over the sun gear shaft 3 and bears with its own weight on the upper surface of the workpiece in the planetary carrier gears 11. The upper plate 13 has handles 31 facilitating removal of the plate for access to the planetary gears. Each handle has an opening securing a locking pin 32 loosely set in the cover 5. The locking pins may be moved out of the handles 31 to permit the upper lapping plate to be turned before it is lifted off the shaft 3. It is desirable to turn the lapping plate prior to lifting in order to break the adhesion between the plate and the workpiece and planetary gears caused by the lapping fluid.

In the top of the upper lapping plate is formed an annular trough 33 for holding a supply of lapping fluid. Typically the lapping fluid is a slurry of Pella oil mixed with a fine abrasive such as aluminum oxide grits of 300 to 600 mesh. The slurry is fed to the lapping plates through passages 34 between the trough 33 and the lower face of the upper lapping plate 13. The slurry feeds slowly from the trough which need be replenished infrequently. The abrasive is kept in suspension in the oil by a paddle 36 keyed to the rotating shaft 3. The paddle maintains the proper slurry consistency until it is delivered directly through the passages 33 to the lapping zone on each side of the planetary carrier gears 11 between the plates 13 and 14. As the slurry is distributed inwardly and outwardly from the passages 34 it flows into an annular discharge trough 35 and thence to a discharge pipe 35*a*. The abrasive tends to settle out of suspension in the trough 35 but is agitated and swept to the discharge pipe by a wiper 40 carried by the rotating ring gear 9. The wiper conforms to the lower end of the annular trough.

The planetary gears and the workpieces carried by them are moved in an orbit between the lapping plates by rotation of the sun gear 8 and ring gear 9. As shown in Fig. 1, the sun and ring gears are driven by a motor 37. The motor drives a pulley 38 through a slipping clutch having two plates 39. The clutch pulley 38 is connected by a belt 41 to a pulley 42 which is connected to a gear reduction box 43 by a shaft 44. To the shaft 44 is keyed a heavy flywheel 45 whose inertia reflects back to the slipping clutch 39. On one end of the shaft 46 of the gear box 43 is a pulley 47 connected by a belt 48 to a pulley 49 on the sun gear shaft 3. On the other end of the gear box shaft 46 is a pulley 51 connected through a belt 52 to a pulley groove formed in the periphery of the ring gear 9. The several pulley sizes are selected so that the ring gear and sun gear rotate at somewhat different speeds. For example the ring gear may be driven at 45 r.p.m. and the sun gear at 40 r.p.m. in the same direction. Such rotation of the sun and ring gears will impart to the planetary gears an orbital speed between 40 and 45 r.p.m. around the sun gear and a rotational speed around each planetary gear axis of approximately 4 r.p.m. when normal speed has been reached.

Because the workpieces lapped between the plate 13

and 14 are very thin and frangible, it is important that acceleration of the planetary system be very smooth. A smooth start is afforded by the use of the high inertia flywheel between the slipping clutch and the planetary system. Since this arrangement for a smooth start also causes very very slow stopping it is advantageous to control the stopping. For this purpose the flywheel is controlled by a simple friction brake 50 applied by a lever 50*a* to the periphery of the flywheel. A conventional belt brake is equally as effective in controlling the stopping of the flywheel.

A further and important advantage of the apparatus so far described is afforded by the vertical reciprocation imparted to the lapping plates and the planetary carrier gears between the plates. It is the object of the present apparatus to grind thin semiconductor crystals down to a thickness between 0.003 and 0.009 inch. As previously suggested the planetary carrier gears 11 must be thinner than the crystals, and therefore must be no thicker and a few thousandths of an inch. Such thin gears, meshing with the sun and ring gears in the presence of an abrasive lapping slurry would quickly wear away the teeth of the gears, and require frequent replacement of them. Since the planetary gears are small and readily accessible for replacement after removal of the upper lapping plate, wearing of the planetary carriers is a minor economic and operational factor. But the sun and ring gears are relatively very large and expensive and require considerable time for replacement. According to this invention wearing of these gears is radically reduced by vertically reciprocating the planetary carriers 11 relative to them. The vertical extent of movement of the upper and lower lapping plates and the planetary carriers previously described is approximately the thickness of the sun and ring gears. That is the thin teeth of the planetary gears are moved upwardly and downwardly along the teeth of the sun and ring gears continuously distributing wear over the vertical extent of the sun and ring gear teeth, preventing the lodging of any large abrasive particles in the mesh of the teeth, and at the same time permitting the upper lapping plate to bear on and lap the upper surface of the workpiece C.

Thus the present disclosure is for the purpose of illustration only and the invention includes all modifications and equivalents which fall within the scope of the appended claims.

We claim:

1. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, and means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel.

2. A machine for lapping a thin plate comprising a lower lapping wheel for lapping one side of the plate, a planetary gear system including sun and ring gears and a relatively thin planetary gear floating in mesh with said sun and ring gears, means to drive said gear system, said planetary gear including means to hold and rotate a plate on said lower wheel, an upper lapping wheel opposed to said lower wheel for bearing on and lapping the other side of said plate, and means to reciprocate the lower wheel on its axis thereby to reciprocate the plate and upper wheel and to move the planetary gear relative to the sun and ring gears thereby to distribute wearing of the sun and ring gears by the planetary gear.

3. A machine for lapping a thin plate comprising a lower lapping wheel for lapping one side of the plate, a planetary gear system including a planetary carrier gear having means to hold a plate on said lower wheel, and including a sun and a ring gear having teeth in engagement with the teeth of the carrier for rotating the carrier and plate around said lower wheel, the teeth of said sun and ring gear being substantially thicker axially than said planetary carrier and being secured against axial movement, means to drive said gear system rotatively, an upper lapping wheel opposed to the lower wheel for bearing on and lapping the other side of the plate, means guiding movement of the upper plate along its axis, said planetary gear being thinner than the plate and floating between said two wheels, and means to reciprocate the lower wheel on its axis thereby to reciprocate the plate, planetary gear and upper wheel, the teeth of the planetary carrier gear moving axially of the teeth of the sun and ring gears so as to distribute wear of sun and ring gear teeth over the thickness of the teeth.

4. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, means on said upper wheel forming a trough for holding a lapping fluid, and a conduit through the upper wheel for delivering fluid directly from the trough to said plate.

5. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, means on said upper wheel forming an annular trough substantially coaxial with said lower wheel, and a plurality of conduits through the upper wheel and evenly distributed around the annular trough.

6. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, means on said upper wheel forming a trough for holding a lapping fluid, a conduit through the upper wheel for delivering fluid directly from the trough to said plate, and means connected to said drive means to agitate the fluid in said trough.

7. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, means on said upper wheel forming an annular trough for holding a suspension of lapping fluid, a conduit through said wheel for delivering fluid directly to the plate, the aforesaid gear system drive means including a rotating shaft extending through said upper wheel coaxially of the trough, and means on said shaft rotating therewith and extending into said trough to keep said fluid in suspension by agitation.

8. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, said drive means including a motor, a slipping clutch, and an inertial device between the clutch and said gear system whereby the gear system is accelerated slowly.

9. A machine for lapping a thin plate comprising a lower lapping wheel, a planetary gear system including a planetary carrier for holding and rotating one of said plates over said lower plate thereby to lap one side of said plate, means to drive said gear system, means for reciprocating said lower wheel and carrier relative to said gear system, an upper lapping wheel opposed to the lower wheel for lapping the other side of said plate, means guiding said upper wheel so that it rests on a plate in said carrier and is free to reciprocate with said lower wheel, a housing forming a fluid collection chamber below said lower plate, an outlet from said chamber, and means connected to said chamber for carrying fluid through said chamber to said outlet.

10. A machine for lapping a thin plate comprising a lower lapping wheel for lapping one side of the plate, a planetary gear system including a planetary carrier gear having means to hold a plate on said lower wheel, and including a sun and a ring gear having teeth in engagement with the teeth of the carrier for rotating the carrier and plate around said lower wheel, means to drive said gear system rotatively, an upper lapping wheel opposed to the lower wheel for bearing on and lapping the other side of the plate, means guiding movement of the upper plate along its axis, means to reciprocate the lower wheel on its axis thereby to reciprocate the plate, planetary gear

and upper wheel, means to introduce a lapping fluid between said wheels, a housing forming a fluid collection chamber below said lower wheel and an outlet from said chamber, and means carried by one of said sun and ring gears for carrying fluid through said chamber to said outlet.

11. A machine for lapping a thin plate comprising a lower lapping wheel for lapping one side of the plate, a planetary gear system including a planetary carrier gear having means to hold a plate on said lower wheel, and including a sun and a ring gear having teeth in engagement with the teeth of the carrier for rotating the carrier and plate around said lower wheel, the teeth of said sun and ring gear being substantially thicker axially than said planetary carrier and being secured against axial movement, means to drive said gear system rotatively including a rotating shaft connected to said sun gear and extending through said upper wheel, an upper lapping wheel opposed to the lower wheel for bearing on and lapping the other side of the plate, said planetary gear being thinner than the plate and floating between said two wheels, means to reciprocate the lower wheel on its axis thereby to reciprocate the plate, planetary gear and upper wheel, the teeth of the planetary carrier gear moving axially of the teeth of the sun and ring gears so as to distribute wear of sun and ring gear teeth over the thickness of the teeth, means on said upper wheel forming a trough holding a suspension of lapping fluid, conduit means through said upper wheel for delivery of fluid to said plate, and means on said shaft rotating therewith and extending into said trough to keep said fluid in suspension by agitation.

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