Nov. 4, 1969 J. K. ELSTEIN 3,476,112

SURGICAL INSTRUMENT FOR REMOVAL OF THIN LAYERS

Filed Dec. [illegible], 1966 2 Sheets-Sheet 1

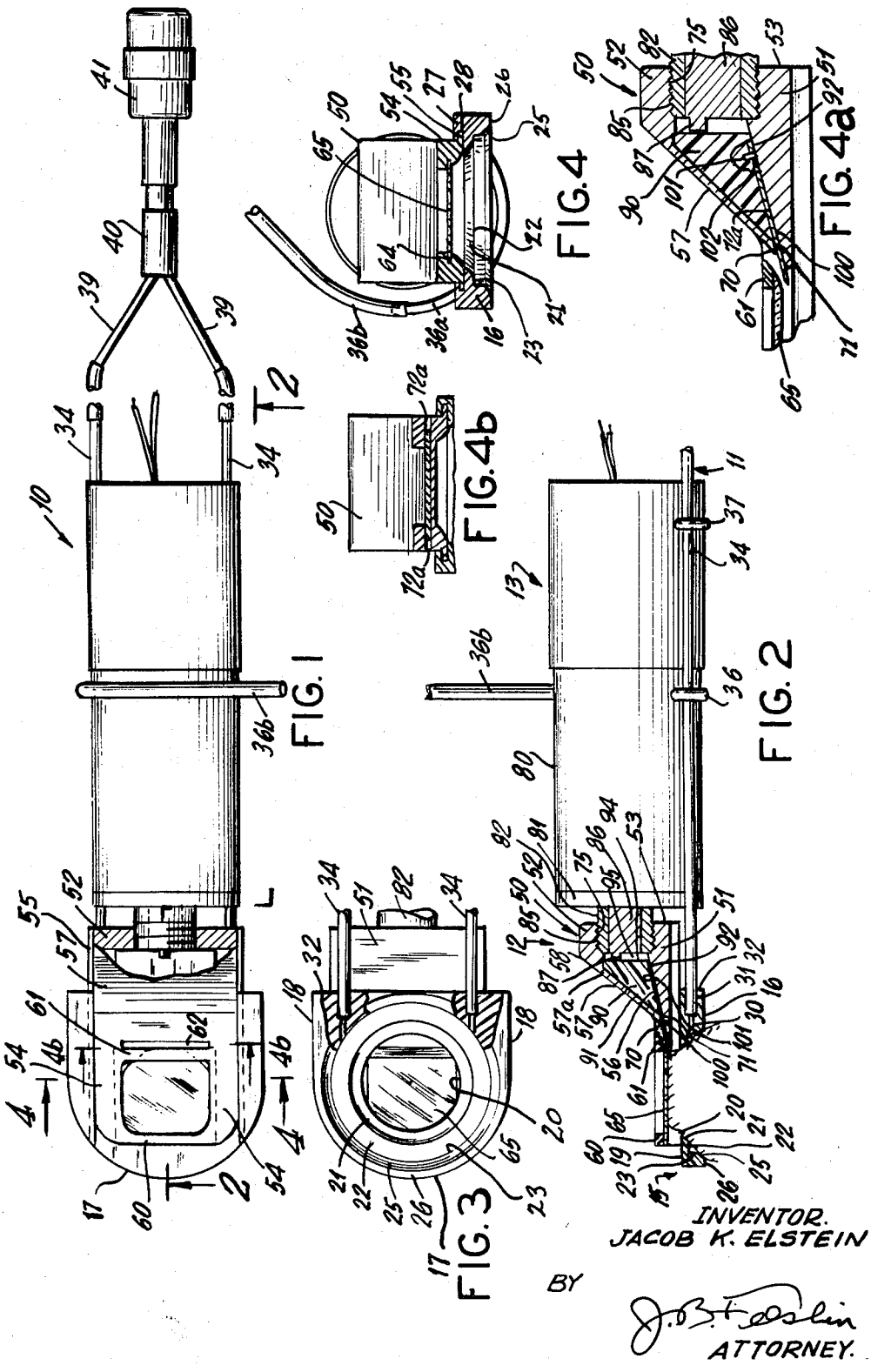

FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 4a

FIG. 4b

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SURGICAL INSTRUMENT FOR REMOVAL OF THIN LAYERS

Filed Dec. 5, 1966 2 Sheets-Sheet 2

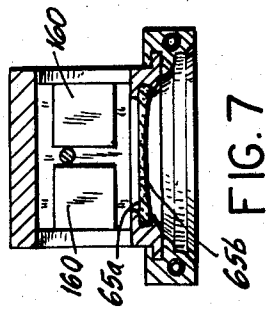

FIG. 7

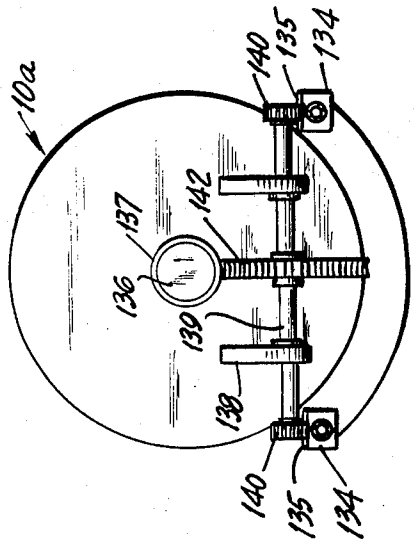

FIG. 8

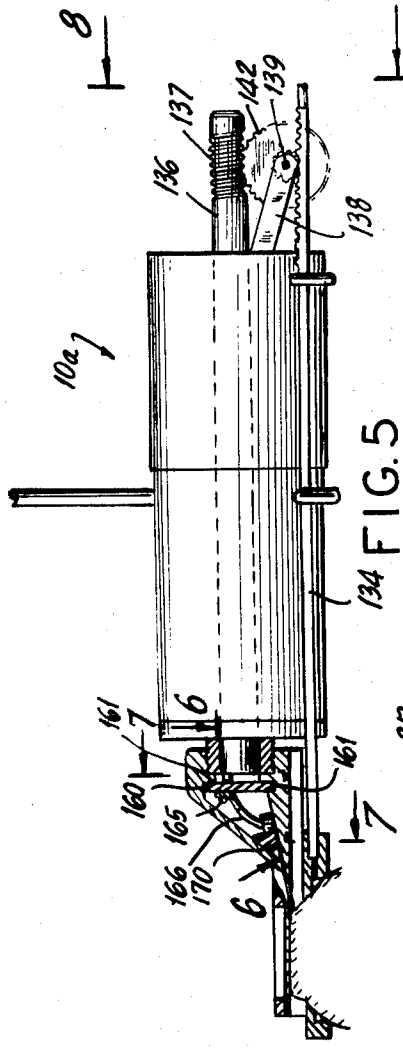

FIG. 5

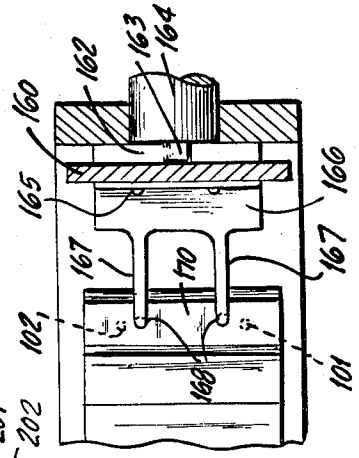

FIG. 6

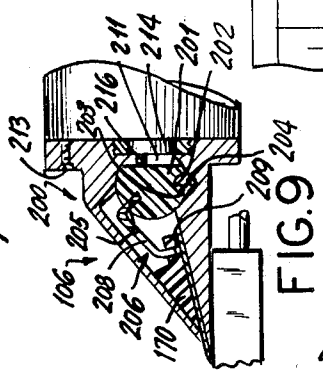

FIG. 9

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SURGICAL INSTRUMENT FOR REMOVAL OF THIN LAYERS

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Int. Cl. A61b 17/32; B26b 7/02
U.S. Cl. 128—305 20 Claims

ABSTRACT OF THE DISCLOSURE

This instrument is for shaving thin layers of cornea or other tissues. The instrument comprises a guide, a head slidable longitudinal on the guide, a flat blade with a straight edge, mounted on the head for reciprocation transversely of the guide, means slidable on said guide with said head, to reciprocate the blade, and means on the guide, formed with an opening to receive a portion of the eye to be shaved as the head moves and the blade sweeps across said opening while it is being reciprocated.

This invention relates to a surgical instrument for dissection of lamellar (partial thickness) grafts from the ocular cornea, which instrument shall also be useful for removal of thin and uniform layers of flexible plastic lenses or of other tissues such as skin, cartilage and buccal mucous membrane for transplants. It is particularly directed to an instrument which shall be good for refractive keratoplasty corneal graft transplants for improvement of visual acuity and which shall be highly accurate, optically uniform, which shall be adapted for cutting parallel or cylindrical discs of pre-set thickness and diameter and which may be used to cut in vivo (on a living patient) or from a donor's enucleated eye.

An object of this invention is to provide an instrument of the character described which shall comprise a guide means provided with a ring, which may be placed over an eyeball or the part from which a layer is to be shaved, and suction means to create vacuum between the ring and said eyeball or part, to hold the eyeball or part in fixed relation to the guide means.

Yet another object of this invention is to provide means slidable with respect to said guide means and comprising an applanation plate to flatten down the eyeball or part held to the ring, a head movable with said flattening applanation plate and carrying a transversely reciprocating insert supporting a blade projecting beneath the applanation plate, and an electric motor movable with said head on said guide means and having means to reciprocate said insert whereby to cut or shave a layer from the eyeball or part.

Still another object of this invention is to provide in an instrument of the character described, means operated by the motor for automatically advancing the slidably mounted means relative to the guide means for cutting a layer from said eyeball or part.

Yet another object of this invention is to provide in an instrument of the character described, spring means interposed between the reciprocating insert and the blade.

A further object of this invention is to provide an instrument of the character described in which the applanation plate has a lower convex or concave surface of uniform transverse cross-section, so that the cut off disc may be of desired cross-sectional shape to correct astigmatism of the eye.

Yet a further object of this invention is to provide in an instrument of the character described, an applanation plate which is transparent, to permit direct visual control over the size of the disc and the cutting process.

Still a further object of this invention is to provide

in an instrument of the character described, a head having a slot leading from the underside of the applanation plate to an exposed inclined surface at the front of the head and extending upward from the slot, so that the sliced off disc slides off evenly and lays flatly on the inclined surface, from where it can be picked up easily.

Yet another object of this invention is to provide a compact and durable instrument of the character described which shall be easy to manipulate, inexpensive to manufacture, smooth and positive in operation and yet practical and efficient to a high degree.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter described, and of which the scope of invention will be indicated in the following claims.

In the accompanying drawing, in which are shown various illustrative embodiments of this invention,

FIG. 1 is a top plan view of an instrument embodying the invention, with parts broken away and in cross-section;

FIG. 2 is a side elevational view thereof, with parts broken away and in cross-section, and showing the fixation ring on an eyeball;

FIG. 3 is a bottom plan view of the front end of the instrument shown in FIG. 1 with parts broken away and and in cross-section;

FIG. 4 is a cross-sectional view taken on lines 4—4 of FIG. 1;

FIG. 4*a* is an enlarged view of a portion of the structure shown in FIG. 2;

FIG. 4*b* is a cross-sectional view taken on lines 4*b*—4*b* of FIG. 1;

FIG. 5 is a view similar to FIG. 2, but illustrating a modified construction;

FIG. 6 is a cross-sectional view taken on lines 6—6 of FIG. 5;

FIG. 7 is a cross-sectional view taken on lines 7—7 of FIG. 5;

FIG. 8 is a cross-sectional view taken on lines 8—8 of FIG. 5; and

FIG. 9 is a view similar to the front end of FIG. 2, and illustrating a still further modified construction.

Referring now in detail to the drawing, **10** designates an instrument embodying the invention and comprised generally of a fixation guide device **11**, a head **12** slidably mounted thereon, and an electric motor **13** attached to the head and also guided on the guide device **11**.

The guide device **11** comprises a front ring **15**. Ring **15** comprises a plate **16** having a semi-circular curved front edge **17** and parallel side edges **18** extending from said front edge. Said plate **16** has a flat top surface **19** formed with a circular opening **20**. Extending down from the opening **20** is an annular, outwardly flaring convex undersurface **21**. Surface **21** extends to a circular horizontal flat undersurface **22** parallel to surface **19**. Extending downwardly from the outer end of annular surface **22** is an inner cylindrical surface **23**. Extending outwardly from the lower end of cylindrical surface **23** is a downwardly and outwardly flaring transverse curved or convex surface **25**. Extending from the lower end of the surface **25** is a flat undersurface **26**. Extending upwardly from the flat upper surface **19** are parallel portions **27** formed at their inner sides with inwardly opening guide grooves **28** for the purpose hereinafter appearing.

Plate **16** is formed with drilled parallel openings **30** leading to the cylindrical surface **23** and communicating with enlarged drilled openings **31**, coaxial with the open-

ings **30** and leading to the rear transverse edge **32** of said plate **16**. Inserted into the openings **31** and fixed to plate **16** are parallel guide tubes **34** extending rearwardly. The tubes **34** are interconnected by spaced downwardly curved spaced transverse members **36, 37** which have openings through which said tubes pass to hold the tubes in parallel relation. Fitted onto the rear ends of said tubes **34** are flexible tubes **39** leading to an adaptor **40** which may be connected by any suitable coupling means **41** to a means for producing a vacuum.

The head **12** with the motor **13** attached thereto are slidably mounted on member **11**. The head **12** comprises a metal member **50** which may be made of stainless steel or other metal. Said member **50** comprises a transverse plate **51** from the rear end of which extends upwardly a transverse wall **52** having a rear surface **53**. Plate **51** has at its sides forward extensions **54**. Said plate and its extensions have outwardly extending parallel guide flanges **55** slidably received within the grooves **28** of plate **16** so that the head may slidably move forwardly and rearwardly relative to the fixation member **11**. Said plate **51** has an upper inclined surface **56**. The head has an upwardly and rearwardly inclined wall **57** from the upper end of which extends rearwardly, portion **58**, merging with the upper end of vertical wall **52**.

The side extensions **54** are interconnected at their front ends by a transverse strip **60**, and at the lower end of inclined wall **57**, by transverse portion **61**. Rearwardly of wall **61** is a transverse slot **62** communicating with the underside of plate **51**. The side extensions **54** are formed at their inner sides with parallel guide grooves **64** extending to the outer ends thereof. Received in said grooves **64** is an applanation plate **65** preferably made of transparent plastic. The plate **65** may be frictionally wedge in the grooves **64** but is preferably removable and replaceable. The upper surface of inclined wall **57** is preferably slanted downwardly and forwardly forming an acute angle with surface **56** and terminating in a transverse edge **70**. The lower forward under edge **71** of wall **57** is inclined forwardly and downwardly in parallel spaced relation above the inclined surface **56** forming a slot **72***a* therewith. The side extensions **54** are formed with slots extending to their outer surfaces and forming extension of the slot **72***a* formed between the lower end **71** of wall **57** and the surface **56**.

The rear wall **52** is formed with an internally screw threaded opening **75** centrally located and having a horizontal axis.

The motor **13** slidably rests on the transverse members **36, 37**. It comprises an outer casing **80** to which is fixed a front wall **81**. Fixed to the front wall **81** and extending forwardly therefrom is a tube **82**, the front end of which has external screw threads **85** which may be screwed into the threaded opening **75**. The motor may be of usual construction and comprises a front rotary shaft **86** extending to the front end of the internally screw threaded tube **82**. Extending forwardly from the motor shaft **86** is an eccentric pin **87**.

Slidably mounted within the head **12** is an insert **90**. The insert **90** has a front upwardly and rearwardly inclined surface **91** located at the inner surface of wall **57**, and a downwardly and forwardly inclined lower surface **92**. The surface **92** is parallel to and spaced above the surface **56** and makes a much smaller angle with the horizontal than does the surface **91**. The insert **90** has a rear vertical surface **94** formed with a central vertical slot **95** into which eccentric pin **87** projects. When the motor rotates eccentric pin **87** causes reciprocation of insert **90**. At the underside of insert **90** is a cutting blade **100** which lies on the inclined surface **56**. The insert **90** is of less transverse length than the head. It is of such dimension that its outer ends will move to the outer side surfaces of the head as said insert is reciprocated. The blade **100** is coextensive from side to side with the insert **90**. Extending downwardly from the underside of the insert **90** are a

pair of pins **101** projecting down into openings **102** in the blade **100**. The forward cutting edge of the blade projects forwardly of the forward edge of plate **51** and slightly forwardly of the rear edge of the applanation plate **65**. The cutting edge of the blade **100** projects beneath the applanation plate **65** by a distance equal to the thickness of the layer to be cut. As the motor operates both the insert and the plate reciprocate together sideways. As the motor is moved forwardly a layer will be cut by the blade.

In FIG. 2, the ring is shown placed over an eyeball I. The plate **65** flattens the top corneal portion of the eye. The suction applied to the tubes **34** creates a vacuum in the channel or circular space between the eyeball and the surfaces **22** and **23** of the ring. This channel is ring shaped and is of substantially triangular transverse cross-section. The suction holds the ring to the eyeball to prevent movement therebetween. The transverse member **36** may have an extension tip **36***a* into which may be inserted the lower end of a tubular handle **36***b*. The handle may be used for holding device **11** steady. The casing of the head is preferably made of stainless steel. The reciprocating insert may be made of Teflon or acrylic or other material having a low coefficient of friction. The applanation plate is interchangeable in the guide slots. A 25 volt motor may be used. It will be noted that one exact thickness may be cut at a time. The layer moves through a slot **62** unto the edge **70** and up the inclined surface of inclined wall **57** and lays there so that it can be easily removed. The corneal thickness varies from .5 mm. to .7 mm. Usually .3 mm to .4 mm is shaved off. Other thicker layers may be shaved off with this instrument. The motor and head may be pushed forwardly manually on the fixation guide.

The purpose of the corneal graft is to cut out diseased or scratched cornea so that one can replace it with a disc from a donor's cornea. The disc of a good cornea can also be cut with this instrument for improvement of the refractive status of the eye. The donors are mostly dead people with healthy eyes. Grafts usually are acceptable. The grafts could be made from live persons. The cornea could also be shaved off, then lathed into a lens and stitched back to correct vision.

There are known methods of shaping corneal tissue. The corneal disc can be frozen for lathing it to make a lens. It will now be understood that a novel feature of the invention is the provision of the ring and guide unit used for fixation of the eye and for guidance of the instrument head (called the Keratome head) and motor, and also the achievement of fixation by means of a vacuum.

In the circular channel the cornea protrudes through the circular opening **20** when the suction holds the eye to the ring and the corneal portion of the eye is flattened by the plastic plate so that one can see the whole disc to be cut. In cases of astigmatism, the flattened shape of the cornea may be oval instead of round. In making an operation the instrument is held on the 180° ocular axis of the eye. The ring may be of different heights and can be selected or interchanged for proper height of cut before slicing. With the suction "on" the motor is energized to reciprocate the blade. The motor may be moved forward with one finger against the casing in the cutting direction. The ring and guide member may be held by means of the handle. The cut disc slides up the take off surface **57***a* and lies flat on said surface so that it can be easily removed. Either lamellar thickness may be cut or penetrating thickness may be cut. Holding the instrument with the handle keeps the weight off the eye and stablizes the position of the eye. The patient should be anesthetized generally and locally for this operation.

In FIGS. 5–8 there is shown an instrument **10***a* embodying a modified form of the invention. This instrument is similar to the instrument **10** except for the parts referred to hereinafter. In the instrument **10***a*, guide tubes **134** are connected to a front ring similar to the front ring

of instrument **10**. These tubes, however, have rack teeth **135** in their upper sides. The motor shaft extends rearwardly as at **136** as well as forwardly. The rear shaft **136** is provided with a worm **137**. Attached to the motor casing and extending rearwardly therefrom, are bracket arms **138** supporting a horizontal cross shaft **139** journalled therein. On the cross shaft **139** are pinions **140**, meshing with the rack teeth **135**. Fixed to the central part of the shaft **139** is a worm wheel **142** meshing with the worm **137**. Thus when the motor is energized worm wheel **142** is slowly rotated. Rotation of the worm wheel **142** causes rotation of the shaft **139** which causes rotation of the pinions **140**. Due to engagement of the pinions **140**, with the rack teeth **135**, the motor casing is automatically moved forwardly for the cutting operation while the insert and its blade reciprocate.

Another difference between the instrument **10***a* and the instrument **10** is as follows. The insert **90** of instrument **10** is replaced by a plate **160** having upper and lower parallel edge portions slidable in upper and lower opposed grooves **161** in the head casing. Said plate **160** is formed with a vertical slot **162** at its rear side to receive an eccentric pin **163** in the front motor shaft **164**. Thus when the motor is operating, plate **160** reciprocates. Attached to the front end of the plate **160** by means of screws **165** is a flat plate spring **166** having downwardly and rearwardly curved spring fingers **167** inserted in openings **168** of a transversely moving member **170**. Attached to the underside of member **170** is the blade **100**. Member **170** has downwardly extending pins **101** projecting into openings **102** in the blade. The applanation plate **65***a* of instrument **10***a* may have a cylnidrical undersurface as shown at **65***b* in FIG. 7. This surface is uniform throughout the length of said plate. Otherwise the head of instrument **10***a* is the same as the head of instrument **10**.

In FIG. 9 there is shown an instrument **10***b* similar to instrument **10***a* except that the reciprocating member **160** and spring **166** are replaced by a modified reciprocating member and spring. In FIG. 9, the head **200** is bored transversely to receive a reciprocating plastic rod **201**. The rod **201** is prevented from rotating by a fixed plastic pin **202** received on a base section **203** in rod **201**, which matches with bore section **204** in the head **200**. Pin **203** may be cemented in bore section **204**. Rod **201** is formed with a transverse slot **205**. A spring **206** has a flange **207** wedged in slot **205** and spring fingers **208** similar to fingers **167** received in openings **209** and block **170**.

Block **170** is same as said block or reciprocating member **170** of FIG. 5 and has pins **101** received in openings **102** in the blade **100**.

Rod **201** has at its rear side, a vertical slot **211**. The motor casing **212** may be attached to head **200** by screws **213**. The front end **214** of the motor shaft has a forwardly projecting eccentric pin **216** projecting into slot **211**. Thus when the motor is energized, eccentric pin **216** causes reciprocation of the rod **201** which in turn, causes reciprocation of the blade **100**.

It will thus be seen that there is provided an apparatus, and article in which the several objects of this invention are achieved, and which is well adapted to meet the conditions of practical use.

As possible embodiments might be made of the above invention, and as various changes might be made in the embodiments above set forth, it is to be understood that all matter herein set forth or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

1. In combination, guide means, a head, means to slidably mount said head on said guide means for forward and rearward movement thereon, a flat blade having a straight cutting edge, means to control said blade in said head for reciprocation transversely of said head, and means to reciprocate said blade controlling means for reciprocating said blade in a direction at right angles to the direction of sliding movement of said head.

2. The combination of claim **1**, said guide means having a ring portion formed with an opening to receive therethrough, a portion of a body to be shaved by said blade, and said blade having a cutting edge positioned to sweep across and above said opening as said head is slidably moved relative to said guide means.

3. The combination of claim **2**, and said ring portion having an annular channel at its underside, surrounding said opening and adapted to be closed by said body, and means to create vacuum in said channel to hold said body to said ring portion.

4. The combination of claim **3**, and said means to reciprocate said blade controlling means comprising a motor having a casing attached to said head, and said means to mount said blade for reciprocation in said head comprising a member slidable transversely of and within said head and having a vertical slot, and said motor having a rotary shaft provided with an eccentric pin projecting into said slot.

5. The combination of claim **3**, and means on said head to flatten the portion of said body projecting through said opening in said ring portion.

6. The combination of claim **5**, said flattening means comprising a transparent plate slidably mounted on said head.

7. The combination of claim **5**, and said head having means to support said blade in a downwardly and forwardly inclined position, and said blade having a forward cutting edge disposed below said flattening means.

8. The combination of claim **7**, and said head having a rearwardly and upwardly inclined front wall, and being formed with a slot disposed rearwardly of said flattening means and above said blade and leading to the front surface of said front wall so that a shaved layer may slide through said slot up onto said front surface.

9. The combination of claim **3**, and means controlled by said means for reciprocating asid blade controlling means, for automatically causing sliding movement of said head relative to said guide means.

10. The combination of claim **3**, said guide means comprising a pair of tubes attached to said ring portion and communicating with said channel, and said means to create vacuum being connected to said tubes.

11. The combination of claim **1**, said head comprising a bottom wall having a downwardly and forwardly inclined upper surface extending to the underside of said bottom wall, said blade lying on said inclined surface, said head having a front upwardly and rearwardly inclined wall the lower edge of which forms a slot with said inclined surface, said blade passing through said slot, said head having a portion extending forwardly of said bottom wall and forming a slot with said front wall of said casing, and a flattening plate on said forwardly extending portion, said blade having a forward cutting edge disposed below the underside of said plate and forwardly of the front end of said inclined upper surface.

12. The combination of claim **11**, said flattening plate being transparent and removably mounted on said forwardly extending portion.

13. The combination of claim **11**, said blade controlling means comprising an insert transversely slidably mounted in said head, and having means to releasably interengage said blade for transverse movement therewith.

14. The combination of claim **13**, and said means to reciprocate said blade controlling means, comprising an electric motor mounted for forward and rearward sliding movement on said guide means, means to attach the casing of said motor to said head and said motor having a rotary shaft, and an eccentric pin on said shaft and said insert being formed with a slot receiving said pin.

15. The combination of claim **1**, said means to slidably mount said head on said guide means comprising sliding

interengaging parallel, longitudinal flange and groove means on said head and guide means.

16. The combination of claim **1**, and said blade controlling means comprising means to resiliently press the blade forwardly.

17. The combination of claim **1**, said head having a transverse cavity open at its ends and said blade controlling means and said blade being insertable into said cavity in said head through its open ends.

18. The combination of claim **1**, said blade controlling means comprising a round rod slidable transversely in said head, and a spring atached to said rod and releasably engaging said blade to reciprocate said blade.

19. The combination of claim **1**, said means to reciprocate said blade being slidable on said guide means for forward and rearward movement together with said head.

20. The combination of claim **2**, and means in said head to flatten said portion of said body, and said flattening means comprising a plate having a concave undersurface of uniform longitudinal cross-section.

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