March 8, 1960 H. B. HAANSTRA 2,927,505

MICROTOME

Filed Oct. 19, 1955 2 Sheets-Sheet 1

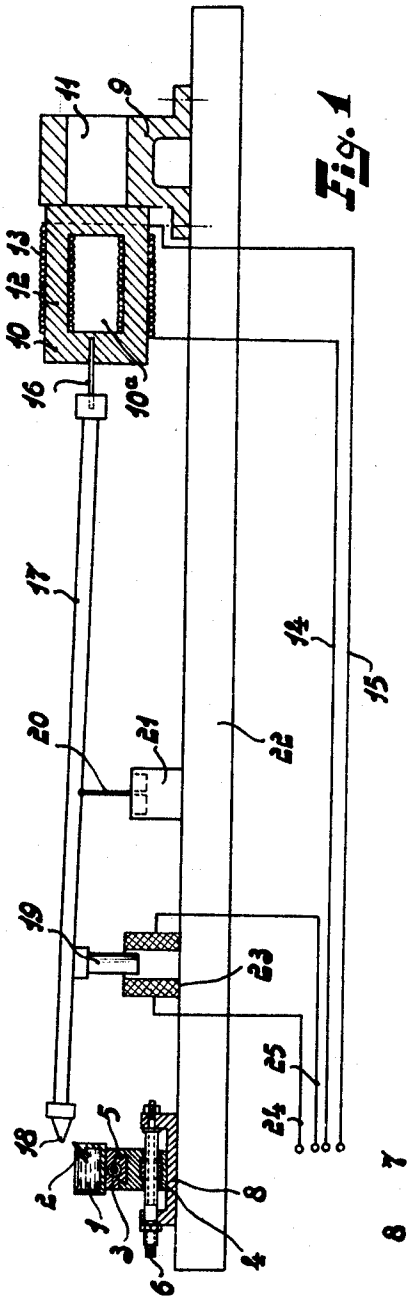

Fig. 1

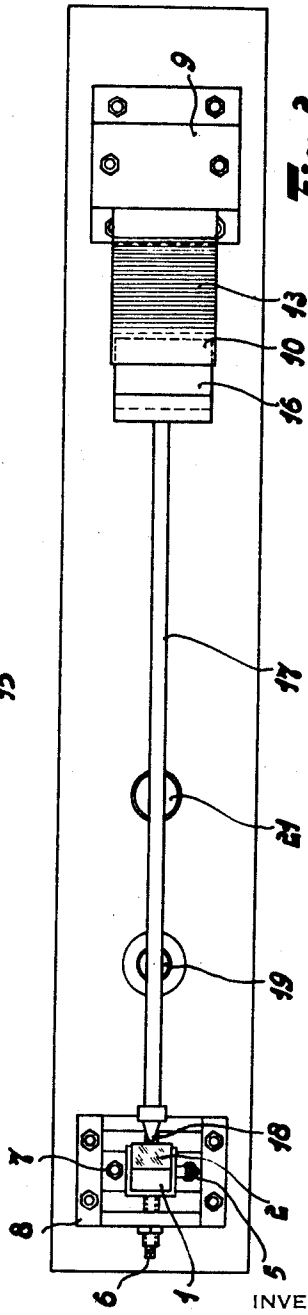

Fig. 2

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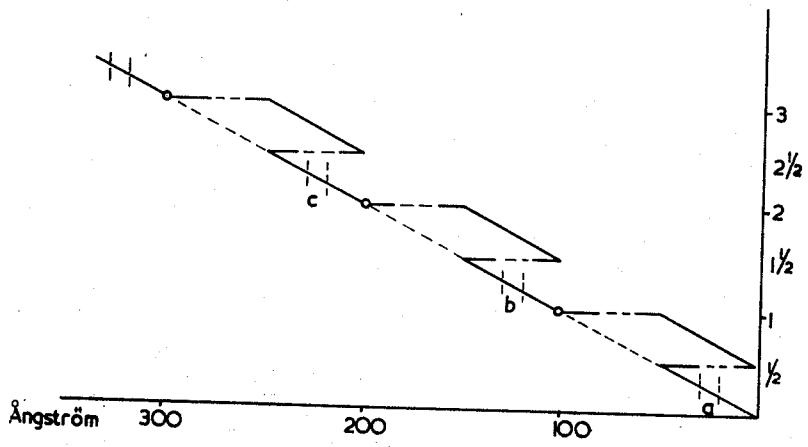

Fig. 3

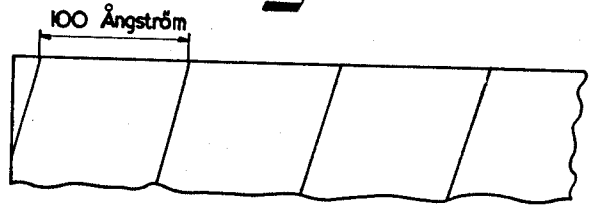

Fig. 4

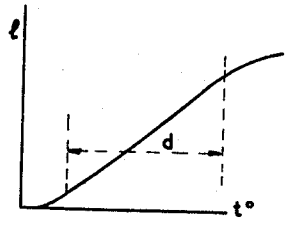

Fig. 5

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2,927,505

MICROTOME

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Claims priority, application Netherlands October 28, 1954

7 Claims. (Cl. 88—40)

For pathologic-anatomic investigations it is necessary to obtain thin sections of members which, after further treatment such as colouring, may be studied under a microscope. Such sections are required to be comparatively thin and hence in most cases have a thickness between approximately 1 and 20 microns. However, when using an electron microscope, it is necessary to have extremely thin sections and such sections must be cut not only from organic tissues but also from solid substances. In this case it is also necessary to obtain a large number of such sections of uniform thickness. It will be evident that such a reproducibility imposes very high requirements upon the mechanical structure of the microtome, as the cutting tool is called, more particularly if it is necessary to manufacture a number of sections each having a thickness of, say, 100 Angstrom units.

The microtome according to the invention can satisfy the above-mentioned requirements. Such a microtome, more particularly suitable for manufacturing sections having a thickness smaller than 1 micron and comprising a blade, which is immobile during operation, and a preparation holder is characterized in that the preparation holder can perform an oscillating movement such that the preparation is moved at right angles to the direction of length of the cutting edge of the blade and also performs a continuous reciprocating movement towards and away from the blade, the preparation holder being rigidly connected by means of a blade spring to a stationary body, the continuous movement of the preparation towards the blade being brought about by an expansion resulting from supply of heat and the movement in the reverse direction being brought about by a shortening which periodically occurs by the action of a magnetic or electric field, in such manner that the shortening is completely eliminated at the beginning of each cutting stroke. The microtome according to the invention permits the continuous manufacture of sections having a thickness of about 100 Angstrom and even thinner, all sections being of uniform thickness within narrow limits. Since centres of rotation resulting from shafts and bearings which can never be manufactured without play are absent, all movable parts being rigidly connected together, there is no play at all, so that firstly, reproducibility of the thickness of the sections is achieved and secondly, the manufacture does not impose high requirements upon the accuracy of the operation. Besides, the desired thickness is readily adjustable within certain limits.

In one advantageous embodiment of the invention the heating leading to the expansion of the holder or the stationary body is effected by means of an inductance coil surrounding a part of the holder or of the stationary body and which is periodically traversed by current, the heat capacity of the holder or of the stationary body and, as the case may be, of the coil materials being so chosen that the temperature of the holder or the body increases evenly due to the periodic supply of current. As an alternative, the heating might be effected by means of a bifilarly found coil continuously traversed by current, while

a second coil is periodically traversed by current and produces a magnetic field bringing about the shortening of the holder and the body by means of magneto-striction. However, the said embodiment of the invention affords the advantage that one coil only is required which brings about both the lengthening and the shortening. By suitable proportioning of the holder or the body, the lengthening is substantially continuous and uniform for a determined period, whereas the shortening takes place in a stepwise manner and is also completely eliminated in a stepwise manner when the magnetic field is suppressed.

In a further embodiment of the invention, the oscillating movement of the holder is achieved by magnetic means, so that mechanical constructions of any kind are avoided. In this case it is advantageous if, in again another embodiment of the invention, the holder comprises a permanent magnet which cooperates with a fixed inductance coil in such manner that the cutting movement of the holder is effected both due to gravity and by the action of the blade spring whereas the return movements of the holder is effected by energisation of the coil, the permanent magnet being pushed out of the coil, so that likewise in this case any mechanical construction is avoided.

In a further embodiment of the invention, a buffer which is active in both directions is provided between the oscillating holder and the frame of the microtome.

The thickness of the sections may be controlled in different ways and is preferably effected, in accordance with one embodiment of the invention, by controlling the duration of the perods during which current is supplied to the inductance coil.

The invention will be described with reference to the accompanying drawings in which

Fig. 1 shows a longitudinal section of a microtome according to the invention.

Fig. 2 is a plan view of the microtome shown in Fig. 1.

Fig. 3 shows a graph of the relationship between the number of cutting strokes and the forward movement of the preparation.

Fig. 4 is a cross-sectional view of the preparation, and

Fig. 5 shows a graph of the relationship between the increase in temperature of the holder or the body and the increase in length thereof.

In the figures, reference numeral **1** indicates a container, to which a blade **2** is secured in an inclined position in such manner that the blade, which may be, for example, a safety razor blade, slightly projects from the edge of the container. The container **1** during operation is filled with a liquid as diluted alcohol. The container **1** is mounted on a compound support constituted by a transverse slide **3** and a longitudinal slide **4**, which can be moved by screw spindles **5** and **6**, respectively, for adjusting the position of the blade. After adjustment, the two slides are fixed in position on a holder **8** with the aid of strong bolts **7**. A body **11** is rigidly secured in a carrier **9** and in turn has rigidly secured to it a body **10** made of nickel iron or another metal having negative magneto-striction, which is to be understood to mean that a reduction in length occurs when the metal is placed in a magnetic field, which reduction in length is completely eliminated when the magnetic field is suppressed and which phenomenon is exactly reproducible. The body **10** exhibits a groove **10***a* and the resulting limbs **12** are surround by windings **13**. The windings **13** are led to the exterior by means of two wires **14** and **15**, which are connected to a source of supply. The body **10** comprises, at its extremity, a broad short blade spring **16** which is rigidly secured therein. One extremity of a preparation holder **17** is likewise rigidly connected to the blade spring **16**, its other extremity carrying the preparation **18** to be cut, which is secured to the preparation holder in

a suitable manner. Furthermore, a permanent magnet 19 is secured to the preparation holder 17, while a piston rod 20 of a liquid buffer 21 is also connected to the preparation holder. The assembly is mounted on a heavy base plate 22, which carries in addition an inductance coil 23, the wire ends 24 and 25 of which are also led to the exterior. The cylinder of the liquid buffer 21 is also secured on the base plate 22.

The described device operates as follows:

After the preparation 18 has been placed in the holder 17 and the blade 2 in the container 1, the latter is filled with diluted alcohol in such manner that the liquid reaches to the cutting edge of the blade. Subsequently, a direct-current source is connected to the wires 14, 15 and the wires 24, 25 with the interposition of rotary switches in such manner that both the coil 12 and the coil 23 are periodically traversed by current, but the coil 23 each time receives current a little later than the coil 12 and the current traversing the coil 12 is also interrupted a little later than the current traversing the coil 23. Subsequently, by means of a microscope, the blade 2 is adjusted with the aid of the screw spindles 5 and 6 of the compound support in such manner that the preparation 18 just passes along the cutting edge of the blade when the preparation holder 17 is moved up and down. The downward movement, during which a slice is removed from the end of preparation 18, is brought about due to gravity and by the blade spring 16, while the energisation of coil 23 results in the magnet 19 being repelled, so that the preparation holder 17 moves upwardly against gravity and the action of blade spring 16. The liquid buffer 21 provides a uniform movement. However, in the meantime the coil 12 is also periodically traversed by current, resulting in the body 10 being heated, so that the preparation 18 continuously moves towards the blade 2. The passage of current through the coil 12 starts in each case at the moment, at which the preparation 18 is under the blade 2. By the action of the resulting magneto-striction of the body 10, brought about by the magnetic field of coil 12, the body 10 contracts a little. The passage of current through the coil 12 and hence the shortening of the body 10 lasts at least till the preparation holder 17, together with the preparation 18, has arrived again above the blade 2, whereupon the coil 12 becomes currentless. The heat capacity of the body 10 is chosen to be such that the increase in length of the body 10 is continuous and substantially uniform, so that the preparation 18 in the absence of periodic shortening of the body 10 would continuously move towards the blade despite the fact that the current supply does not take place continuously. This is shown diagrammatically in Fig. 3, in which the axis of abscissae shows a division in Angstrom whereas a number of complete strokes, that is one left-to-right and return movement of the preparation holder, is plotted on the axis of ordinates. At the beginning of a stroke the preparation moves to the left towards the blade solely by the action of thermal expansion of the body 10 as indicated by a full line. After a half stroke has been covered, the preparation would move further along the dotted line, but now the magneto-striction becomes operative, causing sudden retraction of the preparation to the right. This is indicated by a dashed line, since the distance which the preparation moves to the right by the action of magneto-striction is actually many times larger than the distance which the preparation has covered towards the blade as the result of thermal expansion. The last-mentioned distance may be, for example, 50 or 100 Angstrom and the return movement due to magneto-striction may be about 1 micron. However, the thermal expansion goes on during the shortening in length of the body 10, so that the assembly becomes still longer, but with a different "initial length." As soon as the whole complete stroke has been made and hence the preparation has again arrived above the blade, the magneto-striction is eliminated. The preparation again approaches the blade and this at a point which the preparation would also have reached if the shortening due to magneto-striction had not occurred. Subsequently, the preparation again moves along the blade and the whole cycle is repeated. It will be evident that the actual cutting time constitutes only a small portion of the whole stroke. The cutting time in the curve is indicated by the periods *a*, *b* and *c* and it will be seen that each section is 100 A. thick, since the preparation has moved to the left 100 A. between the starting points of each cutting period.

During cutting and hence during the periods *a*, *b* and *c*, the preparation continues to move towards the blade by the action of thermal expansion. However, as may be seen from Fig. 4, this does not influence the uniform thickness of each section, since the cutting lines after the first section invariably extend in parallel.

Since the thermal expansion is not uniform from the start as may be seen from Fig. 5 (the relationship between the temperature *t* and the length *l* cannot be indicated by a straight line immediately after switching on the current), the first sections after the device has been put into operation have no uniform thickness, but after a short time an expansion uniform with the time is reached and during the period indicated by *d* in Fig. 5, a uniform thickness of all sections is achieved indeed. Subsequently, a situation arises in which the length is no longer increased, the dissipation of heat then becoming equal to the supply of heat. It is then necessary for the device to be stopped, in order to enable the body 10 to cool down.

It has been found in a microtome manufactured in accordance with the invention that during about 20 minutes the preparation moved up towards the blade 0.6 micron per minute, 60 sections were cut per minute, each section having a thickness of 100 A. and totally 1200 sections being obtained. Since the return movement of the preparation is so much larger than the forward movement during cutting, the surface of the preparation is not destroyed during the return stroke, while the section which has been cut off just before and which keeps hanging on the edge of the blade till the next section has been cut is not taken along by the preparation. The sections themselves after moving up float on the surface of the liquid and may readily be removed therefrom by means of an object carrier.

It will be evident that it is fundamentally immaterial whether the stationary member or the preparation holder proper is lengthened due to heat and shortened by a magnetic field, but in view of the relative ease with which current is supplied to the stationary holder and the greater stability thereof, preferably the latter is subjected to heat and a magnetic field. Furthermore, it is possible to utilize electro-striction instead of magneto-striction. However, more materials are available for the use of magneto-striction, while in the case of electro-striction a separate supply of heat is desirable.

It has been found in practice that the apical angle of a safety razor blade is in certain cases too small for certain materials and that it is advantageous for this angle to be ground a little more obtuse, while the cutting edges must be finely polished.

The great uniformity of the sections is obtained due to the absence of any centre of rotation in the device proper, so that it is not necessary to make allowance for any play. The thickness of the sections may be regulated by controlling the current traversing the heating coil, but it is preferable to control the duration of the passage of current. It will be evident that at the moment at which cutting actually takes place there must be no passage of current, whereas passage of current is required during the return movement and certainly when the preparation passes along the blade. With control of the duration, the described microtome permits obtaining a thickness variation of from 50 A. to approximately 300–400

A. When use is made of control of current strength the shortening obtained due to magneto-striction also varies, but since this is already many times larger than the lengthening due to thermal expansion, the operation is not affected thereby.

What is claimed is:

1. Apparatus for cutting thin sections from a work-piece comprising means to support the work-piece, means to support a member having a cutting edge in a given direction relative to the work-piece, means to move the work-piece and the cutting edge relative to one another in a direction transverse to said given direction, said latter means including a member which changes in length with temperature and changes in length in response to the action of an electrical field in a direction opposite to the direction in which changes in length occur due to changes in temperature, means to couple said latter member to one of said supporting means while said other supporting means is at a fixed distance from the temperature responsive means whereby said supporting means is moved relative to the other supporting means as the temperature changes, means to change the temperature of said member thereby moving said work-piece and said cutting edge relative to one another, electrical field producing means positioned to coact with said latter member causing said latter member to change in length in response to said field in a direction opposite to the change in length resulting from the change in temperature, means to periodically energize said electrical field-producing means to thereby alternately advance and retract said work-piece and said cutting edge toward and away from one another, and means to move said work-piece and said cutting edge relative to one another in a direction parallel to said given direction when said work-piece and said cutting edge are in juxtaposition to thereby slice through said work-piece, each successive advance of the work-piece and cutting edge relative to one another being slightly greater than the preceding retraction thereby advancing the work-piece and cutting edge toward one another during successive slicing operations.

2. Apparatus for cutting thin sections from a work-piece comprising means for supporting, in fixed position, a member having a cutting edge in a given direction relative to the work-piece, a member coupled to said work-piece and consisting of a material which changes in length with temperature and changes in length in response to the action of an electrical field, said latter member being at a fixed distance from said cutting edge, means to change the temperature of said latter member and thereby advance the work-piece toward the cutting edge, means to periodically change the length of said latter member in a direction opposite to the change in length brought about by the change in temperature thereof, said latter means including electrical field-producing means positioned to coact with said member causing said member to change in length in response to said field, in a direction opposite to that resulting from the temperature change and means to periodically energize said electrical field-producing means to thereby alternately advance and retract said work-piece relative to said cutting edge, and means to move said work-piece and said cutting edge relative to one another in a direction parallel to said given direction when said work-piece advances to the position of said cutting edge to thereby slice through said work-piece, each successive advance of the work-piece being slightly greater than the preceding retraction thereby continuously advancing the work-piece relative to the cutting edge.

3. Apparatus for cutting thin sections from a work-piece comprising means for supporting, in fixed position, a member having a cutting edge in a given direction relative to the work-piece, a member at a fixed distance from said cutting edge coupled to said work-piece and consisting of a material which elongates upon heating and contracts in response to the action of an electrical field, means to heat said latter member and thereby advance the work-piece toward the cutting edge, means to periodically contract said latter member, said latter means including electrical field-producing means coacting with said member causing said member to contract in length in response to said field, means to periodically energize said electrical field-producing means to thereby advance and retract said work-piece relative to said cutting edge, and means to move said work-piece and said cutting edge relative to one another in a direction parallel to said given direction when said work-piece advances to the position of said cutting edge to thereby slice through said work-piece, each successive advance of the work-piece being slightly greater than the preceding retraction to thereby continuously advance the work-piece relative to the cutting edge.

4. Apparatus for cutting thin sections from a work-piece comprising means for supporting, in fixed position, a member having a cutting edge in a given direction relative to the work-piece, a member at a fixed distance from said cutting edge coupled to said work-piece and consisting of a material which elongates upon heating and contracts in response to the action of a magnetic field, means to heat said latter member and thereby advance the work-piece in said given direction toward the cutting edge, means to periodically contract said latter member, said latter means including magnetic field-producing means which produces a magnetostrictive effect in said member thereby causing said member to contract, means to periodically energize said magnetic field-producing means to thereby alternately advance and retract said work-piece relative to said cutting edge, and means to move said work-piece and said cutting edge relative to one another in a direction parallel to said given direction when said work-piece advances to the position of said cutting edge to thereby slice through said work-piece, each successive advance of said work-piece being slightly greater than the preceding retraction thereby continuously advancing the work-piece relative to the cutting edge.

5. Apparatus for cutting thin sections from a work-piece comprising means for supporting, in fixed position, a member having a cutting edge in a given direction relative to the work-piece, a member at a fixed distance from said cutting edge coupled to said work-piece and consisting of a material which elongates upon heating and contracts in response to the action of an electrostatic field, means to heat said latter member and thereby advance the work-piece in said given direction toward the cutting edge, means to periodically contract said latter member, said latter means including electrostatic field-producing means which produces an electrostrictive effect in said member causing said member to contract, means to periodically energize said electrostatic field-producing means to thereby alternately advance and retract said work-piece relative to said cutting edge, and means to move said work-piece and said cutting edge relative to one another in a direction parallel to said given direction when said work-piece advances to the position of said cutting edge to thereby slice through said work-piece, each successive advance of said work-piece being slightly greater than the preceding retraction thereby continuously advancing the work-piece relative to the cutting edge.

6. Apparatus for cutting thin sections from a work-piece comprising means for supporting in fixed position, a member having a cutting edge in a given direction relative to the work-piece, supporting means for said work-piece, a member at a fixed distance from said cutting edge coupled to said work-piece supporting means and consisting of a material which elongates upon heating and contracts in response to the action of a magnetic field, means to heat said latter member and thereby advance the work-piece toward the cutting edge, means to periodically contract said latter member, said latter means including magnetic field-producing means which produces a magnetostrictive effect in said member causing said

member to contract, means to periodically energize said magnetic field-producing means to thereby alternately advance and retract said work-piece relative to said cutting edge. a permanent magnet coupled to said work-piece supporting means, and means to normally repel said permanent magnet, said permanent magnet being normally positioned to move by the action of gravity when said repelling means are deenergized, to thereby move the work-piece in a direction parallel to said given direction whereby when the work-piece advances to the position of said cutting edge, the work-piece moves relative to the cutting edge thereby producing a slice therefrom, each successive advance of the work-piece being slightly greater than the preceding retraction.

7. Apparatus for cutting thin sections from a work-piece comprising means for supporting in fixed position, a member having a cutting edge in a given direction relative to the work-piece, supporting means for said work-piece including a holder for said work-piece, a member consisting of a material which elongates upon heating and contracts in response to the action of a magnetic field, and means resiliently connecting said work-piece holder and said latter member, means to heat said latter member and thereby advance the work-piece toward the cutting edge, means to periodically contract said latter member, said latter means including magnetic field-producing means which produces a magnetostrictive effect in said member causing said member to contract, and means to periodically energize said electrical field-producing means thereby alternately advancing and retracting said work-piece relative to said cutting edge, a permanent magnet coupled to said work-piece holder, means to normally repel said magnet, said permanent magnet being normally positioned to move by the action of gravity when said repelling means are deenergized, thereby moving the work-piece in a direction parallel to said given direction, means to deenergize said repelling means when said work-piece advances to the position of said supporting means to thereby slice through said work-piece and thereafter to reenergize said repelling means, and means to damp the movements of said permanent magnet.

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