

July 15, 1958

H. SITTE

2,843,014

MICROTOME, PARTICULARLY ULTRA-MICROTOME

Filed May 23, 1955

3 Sheets-Sheet 1

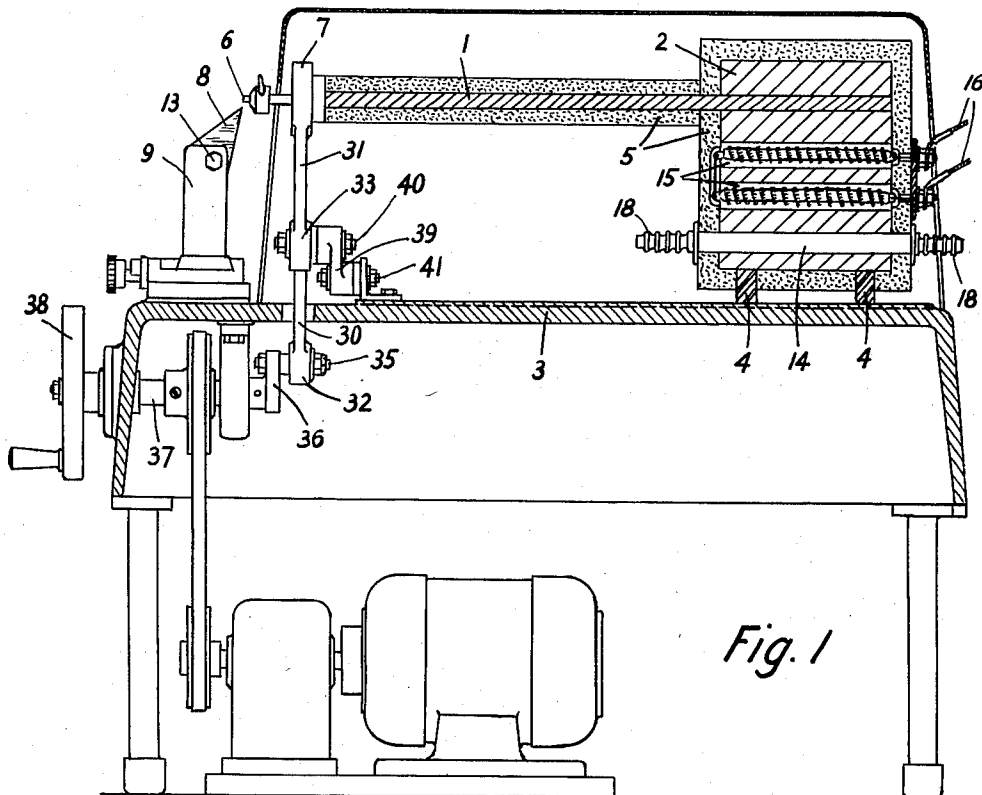


Fig. 1

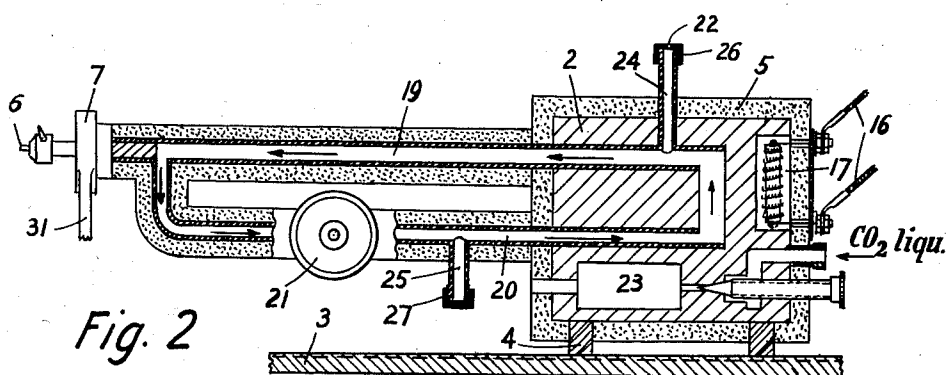


Fig. 2

INVENTOR:

Hellmuth Sitte

BY: Michael S. Stucker
agt.

July 15, 1958

H. SITTE

2,843,014

MICROTOME, PARTICULARLY ULTRA-MICROTOME

Filed May 23, 1955

3 Sheets-Sheet 2

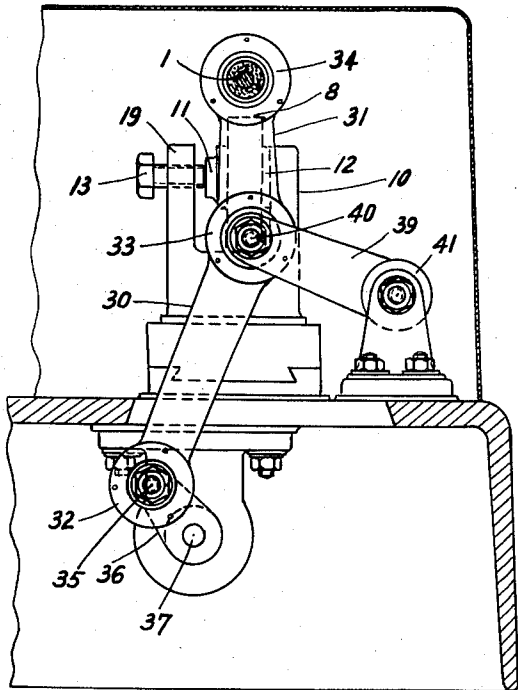


Fig. 4

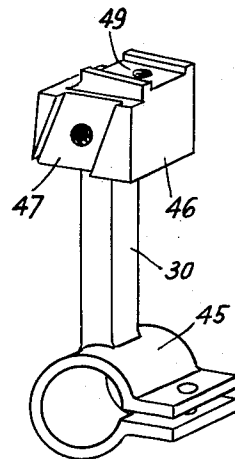


Fig. 8.

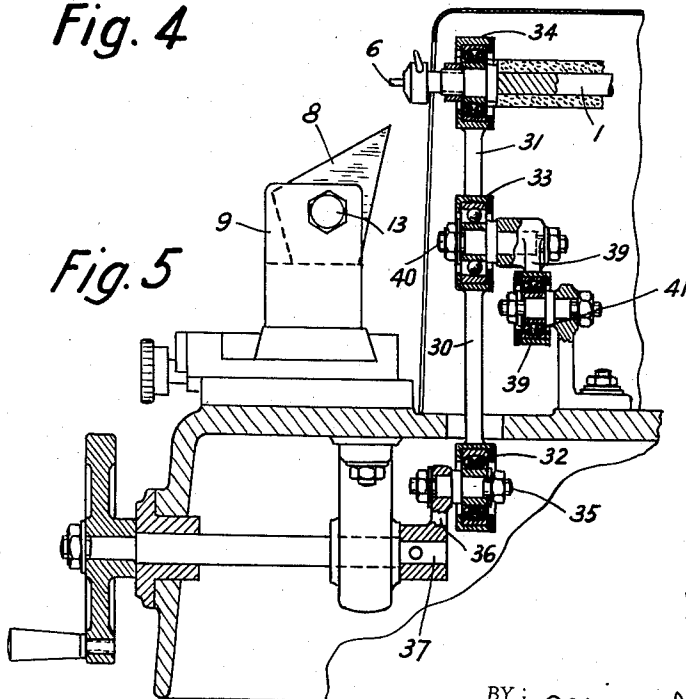


Fig. 5

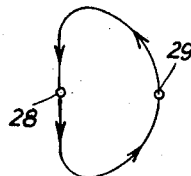


Fig. 3

INVENTOR:

Hellmuth Sitte

BY: Michael S. Sticker
agt.

July 15, 1958

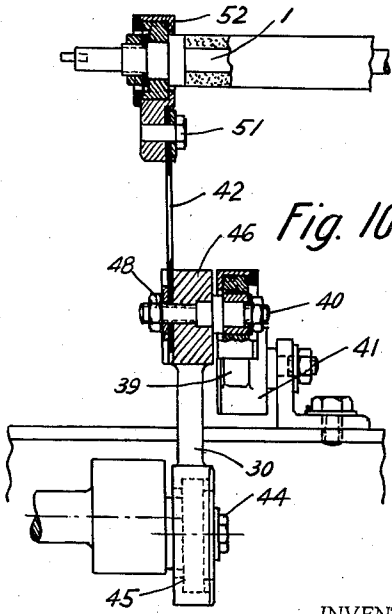
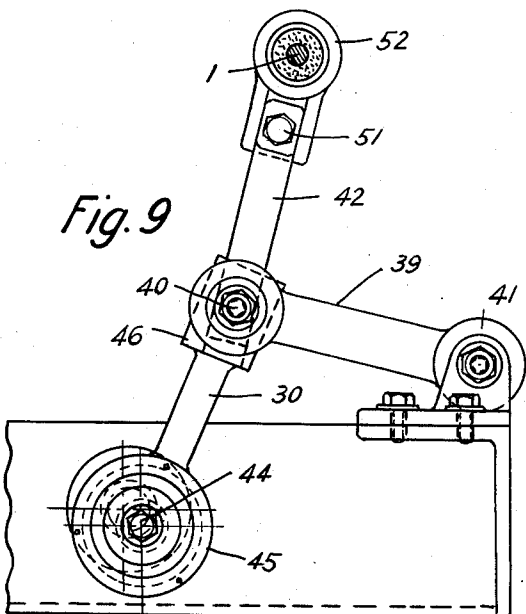
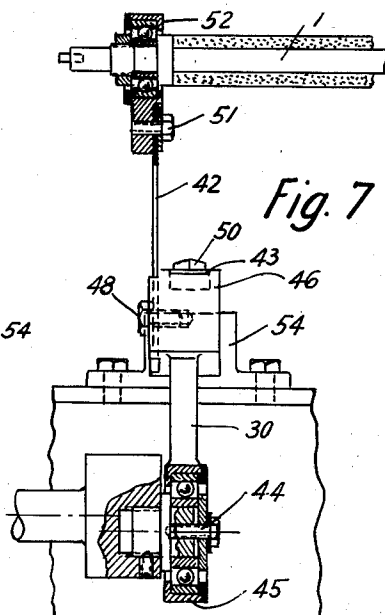
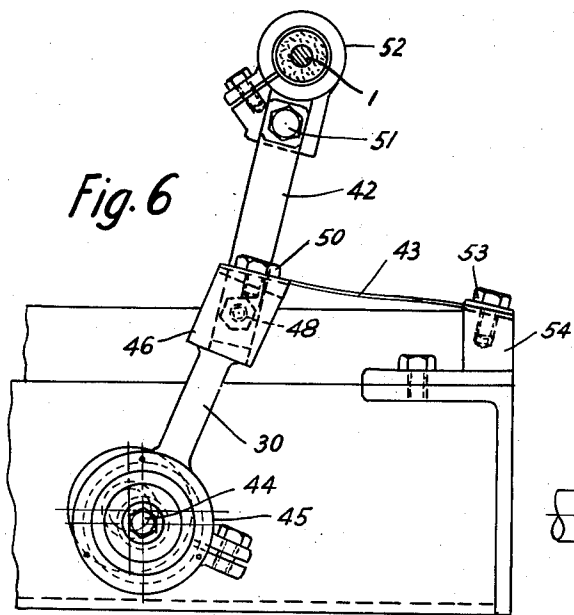
H. SITTE

2,843,014

MICROTOME, PARTICULARLY ULTRA-MICROTOME

Filed May 23, 1955

3 Sheets-Sheet 3



INVENTOR:

Hellmuth Sitte

BY: Michael S. Striker
agt.

1

2,843,014

MICROTOME, PARTICULARLY ULTRA-MICROTOME

Hellmuth Sitte, Innsbruck, Tyrol, Austria

Application May 23, 1955, Serial No. 510,264

Claims priority, application Austria June 1, 1954

11 Claims. (Cl. 88—40)

The invention relates to a microtome, particularly to an ultra-microtome for preparing particularly thin sections of tissue, which is particularly suitable for work with the electron microscope and for phase contrast microscopy.

The thicknesses of section achieved with normal microtomes lie generally between 1 and 50μ and for this reason are insufficient for observations with the electron microscope or phase contrast microscope. To be suitable for these purposes an ultra-microtome must provide sections less than 0.5μ thick. Normally the thicknesses of the sections should lie between 10 and 50μ whereas the optimum range regarding the quality of contrast and the resolution of finest structural details in examinations with the electron microscope is considered to lie between 10 and 25μ .

An increase in the precision of known microtome constructions, such as carriage-type microtomes, rocking microtomes and Minot microtomes or special constructions such as the supersonic microtome according to F. Krause, the various fast-cutting microtomes, the Porter, Sjöstrand and Watson microtomes, which comprise a precision rotor with an eccentrically mounted specimen, enable the cutting of sections as thin as 50μ , in repetitive work, or of even thinner sections in individual cases (about 20μ with the Sjöstrand microtome).

In this connection feeds by minimum amounts, e. g. in an order of 20μ are enabled inter alia by the thermal expansion of an appropriate material. A microtome based on that principle, having a feed of 50μ or less, must be free of vibration in its movable parts; it must not have static friction in its feed mechanism; and the cutting edge of the blade is to be contacted only once during one cutting cycle; cf. F. S. Sjöstrand, *Experientia*, vol. IX/3, 1953, pages 114 et seq. A device which complies with these requirements consists, e. g., of a cylindrical rotor which is most accurately centered and runs without vibration, with an eccentrically arranged specimen block, which is thermally advanced. That arrangement constitutes an extremely delicate and expensive specialized apparatus, in the manufacture of which a particularly high precision must be achieved.

The invention is based on the idea of providing a microtome, particularly an ultra-microtome, which enables the preparation of sections at least as thin in a simpler manner and without requiring special precision parts. To this end a special combination of a thermal feed system with a specimen guide means is used, in which an elastically flexible rod, which is unilaterally gripped, is caused to deflect. At the same time the requirement for sections below 25μ can be complied with, which consists in that the specimen is not to be returned over the blade but is to be guided sideways of the blade into the initial position after the cut.

The microtome, particularly ultra-microtome according to the invention is characterized in that the feed

2

system consists of a thermally insulated arrangement of good heat conductivity and high heat capacity which consists of a block and an elastically flexible rod, which is rigidly affixed to the block and carries the specimen at its free end; the free end of the rod has connected thereto a guide device, which is formed according to the invention for moving that rod end according to a path which is similar to a circle or represents another closed figure, e. g., a compound curve, which is preferably approximately rectilinear adjacent to the cutting station.

In the known systems in which the object to be cut is fed against the blade by thermal expansion, the latter is caused by an electric heating coil of very low power which is wound directly around a larger or smaller part of the rod. If the coil is wound only around a relatively short part of the feed rod, the total feed in the range of substantially linear temperature rise and feed is relatively small, e. g., with Sjöstrand about 0.02 mm . Besides that, small heating coil does not permit of great variations regarding the individual feed increments, from cut to cut, as is desired for general views where softer matrices such as Esterwax or Cremolan are used, and for feeding the specimen into position for the first engagement by the blade. For this reason Sjöstrand, e. g., enables individual cuts only between perhaps 10 and 30μ . The cooling of the Sjöstrand system within short time must be effected with the aid of a fan so that the instrument will be ready within short time for the next series of cuts in repetitive work. On the other hand, if a larger part of the length of the rod is wound with heating wire or if a transfer of heat to the ambient air is restricted by a good heat insulation of the feed system, whereby a temperature rise of a larger part of the rod is achieved, such a device will have a sufficiently large total feed in the range in which the feed is substantially linear (up to about ten times the above value, i. e. $\leq 0.2\text{ mm}$.) but it is very difficult to cool the feed system within relatively short time, as appears essential for routine work.

As contrasted therewith the system according to the invention combines a large total feed with a cooling which will be fast enough even if the feed system is very well insulated. Specifically the system enables:

(1) A variation of the feed increments from cut to cut within wide limit, i. e. between about 10 and 30μ in the case of a normal cutting rate of about 10 to 60 cuts in 1 minute, or within wider limits at lower cutting rates;

(2) A total feed of at least $\frac{1}{4}\text{ mm}$., fully adequate for electron microscopy and phase contrast microscopy, resulting from the thermal expansion of the rod and block;

(3) In spite of the above, a cooling within relatively short time, at most ten minutes, by an appropriate cooling system.

Following the principle set forth the invention may be embodied in several forms. In the accompanying drawings it is shown with reference to three illustrative embodiments how structural solutions can be provided for the combination of the thermal feed device and the rod guiding mechanism. The invention is not restricted, however, to these specific illustrations and may be embodied also in microtomes in which another arrangement is provided for feeding the specimen and/or blade.

Fig. 1 is a longitudinal sectional view of an ultramicrotome comprising a block and feed rod;

Fig. 2 shows another embodiment comprising a tubular feed rod and a separate convection system;

Fig. 3 shows an example of the compound curve which may be described by the end of the rod;

Figs. 4 and 5 respectively are a front view, seen from

the block end, and a side view showing a rod guiding mechanism with a control lever and a guide lever;

Figs. 6 and 7 respectively are also a front view, seen from the block end and a side view showing a simplified rod guiding device comprising spring leaves;

Fig. 8 is a perspective view showing the rigid lever arm of that device, and

Figs. 9 and 10 respectively are front and side views showing a modified rod guiding device comprising only one spring leaf.

According to Fig. 1 a rod 1 is rigidly affixed to a block 2, which has an adequate thermal conductivity and a large heat capacity. The block 2 is rigidly connected by feet 4 of material of low thermal conductivity, e. g. Invar steel, to the base plate 3. If desired, the block may be affixed to the base plate only on its side remote from the rod. The entire feed system, consisting of the rod 1 and block 2, is thermally insulated on all sides to the highest degree possible by an insulation 5. This shields against external thermal influences and prevents a transfer of heat from the system to the air and base plate as far as possible. The specimen to be cut is blocked to a specimen holder 6 on the free end of the feed rod 1. The rod 1 consists of a material which enables the movement of the free end of the rod 1 with the specimen holder 6 in any desired directions at right angles to the longitudinal axis of the rod when not deflected, provided that the rod has an appropriate ratio of length to diameter. Where brass is used the ratio between the thickness and length of the rod may be, e. g., about 1/40 to 1/60; in the case of steel it is correspondingly less. The movement of the rod is limited by its material constants; if properly selected the same permit of the short-time, small deflections required for cutting the specimen without difficulty; these deflections will lie in any case within the load limit. When the device is out of use the rod guide device is adjusted so that the rod is practically in a position of rest (position 29 in Fig. 3).

The free end of the rod is engaged through the intermediary of a guide ring or bearing 7 by a guide device, which is affixed to the base plate, and will be described by way of example more fully hereinafter. That guide device will guide the specimen holder 6 with the specimen to be cut down a fixedly gripped blade 8 during the cut, and after the cut will guide the specimen holder sideways of the blade upwardly into its initial position over the blade, as is required for microtomes having a thermal feed. The blade and blade holder of the device are of the usual type, e. g., the glass fragment serving as a blade 8 is gripped with lead plates applied thereto on both sides, between the flanges of the blade holder (Fig. 1 shows only one flange 9) by means of a setscrew 13.

The heating of the feed system is suitably effected by an electric resistance heater 16, or an electric heating cartridge as used in electric soldering irons, or similar means. The heater 16 may be inserted in the block 2, e. g. in one or several bores 15 thereof. If desired the heater may be accommodated on the outside of the block 2, e. g. in a depression 17 (cf. Fig. 2) or may be arranged to engage the outside of the block and embedded in the insulation 5.

The feed system is provided with a cooling device, which is suitable for the flow of a cooling medium, e. g. of water, or for cooling by an expansion of compressed, liquefied carbon dioxide, or with the aid of liquid air or the like. The cooling by a liquid medium can be effected by flowing the same through a bore 14 of the block 2—that bore may carry hose connections 18, for instance—or by means of a cooling jacket or the like. The cooling with liquefied carbon dioxide is suitably effected with a chamber arrangement, similar to the known freezing tables of normal microtomes (cf. 23 in Fig. 2); that chamber arrangement may be provided in or at the block 2. The cooling device is incorporated at least in the block 2 (Fig. 1) and if desired also in the feed rod 1. It

permits of cooling the system within short time, e. g. within no more than 10 minutes, to such an extent that a new series of cuts can be started. A mercury thermometer, a thermocouple or another temperature measuring instrument, and suitably also a temperature regulator, e. g. a bimetallic contact, for automatically shutting off the heater, may be arranged on the outside of the block 2 or in a bore of the same.

When heated from room temperature to 90 deg. C. the device described provides a total feed of about 0.25 mm. and when cooled with water will be ready for the next series of cuts within about 10 minutes. A total feed of 0.2 mm. permits already of making 10,000 cuts of 20 μ each in a single, uninterrupted series. A larger number of cuts in one series is not practicable with the presently known and usual blade material for ultrafine cuts, i. e. with glass and metal blades, because the blade must be replaced or resharpened after no more than 10,000 cuts. This involves in any case an interruption of the series of cuts. In the arrangement according to the invention the temperature range may be readily increased to more than twice the foregoing extent, e. g. from -50 deg. C. to +150 deg. C. if carbon dioxide is used for cooling, because the elimination of the water cooling eliminates also the limit therewith which is set by the boiling temperature of the water. In that manner a total feed of at least 0.5 mm. can be achieved.

An effective improvement and increase in the total length of feed is possible according to Fig. 2. Where the feed system is arranged as in Fig. 1 only about 1/3 of the free length of the rod between the block 2 and the guide ring 7 will be heated even if the rod 1 consists of material of relatively high thermal conductivity (e. g. of brass, if the rod has a length of 40 cm.), whereas the rest of the length of the rod will not be heated owing to the slow propagation of heat and for this reason is ineffective for the feed. The arrangement according to Fig. 2 does not rely mainly on the propagation of the heat by conduction and uses the convection of heat. In this case the feed rod is replaced by a tubular body 19, which is flown through by the heat transfer medium, which may serve also as a cooling medium and consists, e. g., of water, silicone oil, or the like. A return pipe 20 arranged, e. g., outside the tubular body 19 and incorporating a mechanical conveying device (e. g. a centrifugal or diaphragm pump) 21, causes the heat transfer medium to circulate as uniformly as possible, e. g., in the direction of the arrows shown. A refilling opening 24 and a drain opening 25 with appropriate screw closures 26 (with capillary 22) and 27 enable a replacement of the convection medium. If the circulation system is properly dimensioned the circulation can be maintained only by natural circulation (thermosiphon), as in a central heating system, due to the unequal heat distribution in the system. The entire pipe system is suitably surrounded by the insulation 5.

In this system the entire free length of the rod between the block 2 and the guide ring 7 will be heated and will thus be fully utilized for the feed; in this arrangement a total feed of more than 0.5 mm. can be achieved using water, silicone oil or the like as a heat transfer and cooling medium.

In the construction shown by way of example in Fig. 2, comprising a cooling chamber 23 (or where a cooling bore 14 is provided, as in Fig. 1), the cooling is effected very quickly so that the expansion system has sufficiently contracted, e. g., after five minutes, at most, and a new series of cuts can be started immediately.

In connection with the invention the movement of the free end of the rod takes place principally in a closed path in which the specimen engages the blade only during the cutting operation itself. The deflection of the rod may be effected manually, the hand gripping the rod 1 at the guide ring 7 and performing the cutting cycle along an appropriate guide template or the like.

To achieve ultra-thin sections, suitable for electron microscope work, it is essential that the object to be cut must engage always the same part of the cutting edge in all successive cuts, with displacements of 5μ , at most, appearing admissible.

It is suitable to guide the free end of the rod according to a compound curve. As is shown diagrammatically in Fig. 3 the specimen is disposed first at point 29, which corresponds practically to the position of rest of the undeflected rod. Following the direction of the arrows the specimen then reaches the point 28, where the cut is made. Before and after the cutting station the movement is substantially rectilinear. Obviously it is possible to use other forms of compound curves in which preferably at least one part of the curve is substantially rectilinear. This fact and the small dimensions of the surface of cut (cuts of 1×1 mm., at most, are used in electron microscopy), enable the use of very small dimensions for the path shown in Fig. 3, which may be considered as being about twice to three times natural size.

The specific guidance of the rod end for its movement along the path of such compound curve may be provided according to the invention by a mechanical guide device, which may consist of an arrangement formed by a control lever which is operated, e. g. moved up and down by a drive shaft, and a guide lever affixed to the control lever, whereas that device will permit of or take up the displacements caused by the feed and the deflection of the rod.

The resulting movement of the specimen along a straight line at the cutting station ensures perfect and uniform cuts of the required thickness practically without any rejects even if the path is very small in diameter (maximum diameter of the compound curve, e. g., 10-20 mm.). Comprising no precision parts the guide device according to the invention has a practically unlimited life.

Such a mechanical system, shown by way of example in Figs. 1 and 4 to 10, for elastically guiding the rod according to a compound curve, is not only suitable for the microtome described but, according to the invention, also for microtomes operating with a different type of feed, e. g. with a continuous thermal or mechanical feed of the specimen or blade between two cuts and may be used to advantage also for microtomes operating with a mechanical, discontinuous, intermittent feed of the blade or specimen.

It is obvious that the thermal feed system according to the invention does not depend on the specific mechanical guide devices described in the illustrative embodiments. Any other guide mechanism desired may be used if it allows for or takes up the displacements resulting from the feed and the deflection of the specimen carrier according to a path which is similar to a circle or a closed curve.

As has been mentioned, the guide device according to the invention, for movement according to a compound curve, may be embodied in instruments of widely different type. In the illustrative embodiments shown three constructions of the guide device according to the invention are shown, in conjunction with an elastically flexible rod, which has the object to be cut blocked to its free end. It is obvious that the invention is not restricted to these specific illustrative embodiments but may be applied also to microtomes having other specimen carriers, e. g. of an universally-jointed type.

The illustrative embodiment of such a mechanical guide device which is shown in Figs. 4 and 5 comprises as an essential element a two-armed control lever having two lever arms 30, 31 and three bearings 32, 33, 34. That control lever engages with its upper bearing 34, consisting of a self-aligning ball bearing, the free end of the rod 1 which is surrounded by that bearing. The bearing 32, also consisting of a self-aligning ball bearing, sur-

rounds a crankpin 35 of a crank 36 or an eccentric disc. That crank or eccentric disc is affixed to a shaft 37, which is rotated by means of a crank disc or a hand wheel 38 or an electric drive. To provide for the desired com-

5 pound curve the crank circle of the crankpin 35 or the eccentric disc is dimensioned so that it will not contact the imaginary extension of the longitudinal axis of the lever arm 31 of the control lever. The shaft 37 being parallel to the rod 1, the crank 36 or the eccentric disc will cause the control lever 30, 31 to perform an oscillatory up and down movement in a vertical plane intersecting the rod 1. To enable a desired control of that oscillatory movement of the control lever 30, 31 in accordance with a compound curve, the intermediate bearing 33 of the control lever, consisting e. g., of a grooved ball bearing, is engaged by a one-armed guide lever 39 through the intermediary of a pin 40. The one armed guide lever 39 projects outwardly from the vertex of the angle formed by the two lever arms 30, 31 and oscillates about a stationary fulcrum 41, formed as a self-aligning ball bearing, in a vertical plate intersecting the rod 1. That guide lever 39 guides the upper bearing 34 of the control lever 30, 31 and with it the rod 1 along an approximately straight path during the downward movement thereof, whereas it guides the upward movement of the control lever 30, 31 and of the rod 1 in a widely outhauling curve. The resulting movement is composed of the movement of the crankpin 35 on the crank circle and of the arcs of oscillation of the guide lever 39. In this connection it is essential that the bearings 32 and 34 consisting of self-aligning bearings and the self-aligning fulcrum bearing 41 enable the control lever 30, 31 to follow the feed and deflection of the rod.

The guidance for the movement of the free end of the rod 1 is effected as follows: When the shaft 37 is rotated the crank 36 or the eccentric disc will perform a circular movement. The control lever 30, 31 is moved by the crankpin 35 or the eccentric disc and under the control of the guide lever 39 in a vertical plane intersecting the rod 1 in such a manner that the end of the rod will be moved in accordance with a so-called compound curve.

By a suitable selection of the factors decisive for the formation of the compound curve, i. e. the length of the levers or lever arms, the magnitude of the angle included by the two lever arms of the control lever 30, 31, and the relation between the shaft 37 and the fulcrum bearing 41, the guide device according to the invention enables to obtain for a given radius of the path of the eccentric disc or crankpin a path which is substantially straight in that part of the curve which is near the cutting station 28. Consisting of self-aligning ball bearings, the bearings 32, 34 and 41 will allow for the swing of the control lever 30, 31 out of the vertical plane due to the deflection and expansion of the rod 1.

The other solution, shown in Figs. 6, 7 and 8 of the guide device according to the invention differs from the first construction only in that instead of forming the bearings 32, 34 and 41 as self-aligning ball bearings the upper arm 31 of the control lever and the guide lever 39 consist of elastic spring elements 42, 43, which similar to the self-aligning bearings of the control lever 30, 31 enable the arrangement 30, 42 to yield laterally from the vertical plane in accordance with the feed and deflection of the rod.

To this end the lever arm 30 is formed, e. g., as a profile rod, which carries at its lower end the bearing 45 which surrounds the eccentric disc 44 and may be formed, e. g., as a bushing, whereas the lever arm 30 carries at its upper end a gripping head 46. That gripping head 46 has in one of its sides an aperture 47, in which a spring leaf 42, representing the second lever arm, is fittingly inserted with one end. The leaf spring is fixed in position by a clamping screw 48 which extends through the end of the spring leaf and is in engagement in the gripping head 46. The end face of the gripping head 46 is

flattened and has also a rest 49 for the end of a leaf spring 43 serving as a guide lever. That end can be screwed fast on the gripping head 46 by means of a screw 50. The spring leaf 42 forming the lever arm extends with its surface in the vertical plane intersecting the rod 1 and can deflect out of that plane owing to its elasticity. The upper end of that spring leaf 42 is affixed by means of a screw 51 in a rest formed in adaptation to the leaf end in the upper bearing 52, which may be formed as a bushing. The spring leaf 43 forming the guide lever is rigidly fixed with one end in an approximately horizontal position to the stationary fulcrum 54 by means of the screw 53 so that the spring leaf 43 can swing up and down in a vertical direction together with the control lever 30, 42.

In that construction of the control lever and guide lever the leaf spring 43 ensures the guidance of the control lever 30, 42 as the latter swings up and down, whereas the spring leaf allows for the deviation of the upper bearing 52 from the vertical plane intersecting the rod in its position of rest, in accordance with the feed and deflection of the rod, and owing to its torsional elasticity allows also for the slight lateral deflection of the rod, e. g. at the cutting station 28. Thus this guide device gives the same results as in the first embodiment but the practical realization is much simpler, is more exact owing to the use of springs, and is much less expensive owing to the elimination of special precision parts. This is true even if the two bearings 45 and 52 are formed as grooved ball bearings, as is assumed in Figs. 6, 7 and 8.

The microtome guide device according to the invention may be formed in such a manner that only one of the two levers has a spring leaf instead of a lever arm and the other lever is rigid in its entirety. In a suitable guide system, shown by way of example in Figs. 9 and 10, the upper lever arm of the two-armed control lever 42, 30 is formed by a spring leaf 42 and the one-armed guide lever 39 is rigid. The other parts of that guide device correspond to the embodiment according to Figs. 6 and 7.

What I claim is:

1. In a microtome comprising a stationary blade, the combination of a block of high heat capacity, an elastically flexible rod rigidly secured to and in heat transfer relation to said block and having a free end spaced from said block and arranged adjacent to said blade and adapted to carry a specimen to be cut, said block and rod being heat-insulated and consisting of heat-conductive material, means operable to vary the temperature of said block, and a guide device comprising a rotatable drive shaft, a rigid guide lever, and a control lever connected to said guide lever and having one arm operatively connected to said drive shaft and a spring leaf arm deflectable out of a plane normal to said rod and fixedly connected at one end thereof to said control lever, and at the other end thereof connected to said free end of said rod to move upon rotation of said drive shaft said free end of said rod along a closed annular endless path under control of said guide lever whereby the specimen is moved across said blade during movement of said free end along a first portion of said path and is returned laterally spaced from said blade during movement of said free end along a second portion of said path, said guide device being constructed to permit axial displacement of the free end of said rod.

2. A microtome comprising, in combination, a block of great heat capacity; means for varying the temperature of said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a member engaging said free end portion of said rod, and

moving means connected to said member for moving said member and thereby said free end portion and specimen holder along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

3. A microtome comprising, in combination, a block of great heat capacity; means for varying the temperature of said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a guide lever mounted for movement about one end thereof, a control lever movably mounted on the other end of said guide lever and having a free end secured to said free end portion of said rod, and moving means connected to said control lever for moving the same in such a manner that the combined movement of said guide lever and control lever effects movement of said free end of said control lever along an endless annular path located in a plane transverse to said rod so that said free end portion of said rod and said specimen holder move along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

4. A microtome comprising, in combination, a block of great heat capacity; means for varying the temperature of said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a guide lever mounted for movement about one end thereof, a control lever movably mounted on the other end of said guide lever and having a free end secured to said free end portion of said rod, and moving means connected to said control lever for moving the same in such a manner that the combined movement of said guide lever and control lever effects movement of said free end of said control lever along an endless annular path located in a plane transverse to said rod so that said free end portion of said rod and said specimen holder move along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block, said guide lever and said control lever guiding said free end portion and said specimen in such manner that said first portion of the path is substantially rectilinear whereby the blade cuts through the specimen during rectilinear movement of the same.

5. A microtome as set forth in claim 4 wherein said second portion of the path is a compound curve.

6. A microtome comprising, in combination, a block of great heat capacity; heating means for heating said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions, said

block and said rod consisting of heat-conductive material and being in heat-conductive engagement; means for thermo-insulating said block and said rod; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a member engaging said free end portion of said rod, and moving means connected to said member for moving said member and thereby said free end portion and specimen holder along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

7. A microtome comprising, in combination, a block of great heat capacity; heating means for heating said block; a cooling system located in said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions, said block and said rod consisting of heat-conductive material and being in heat-conductive engagement; means for thermo-insulating said block and said rod; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a guide lever mounted for movement about one end thereof, a control lever movably mounted on the other end of said guide lever and having a free end secured to said free end portion of said rod, and moving means connected to said control lever for moving the same in such a manner that the combined movement of said guide lever and control lever effects movement of said free end of said control lever along an endless annular path located in a plane transverse to said rod so that said free end portion of said rod and said specimen holder move along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

8. A microtome as set forth in claim 7 wherein said control lever is mounted on said other end of said guide lever shiftable in longitudinal direction of said rod, said control lever being shifted during thermal expansion and contraction of said block and said rod.

9. A microtome comprising, in combination, a block of great heat capacity; means for varying the temperature of said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a guide lever mounted for movement about one end thereof, a control lever movably mounted on the other end of said guide lever and having a free end secured to said free end portion of said rod, said control lever being at

least partly yieldable out of a plane normal to said rod to permit movements of said free end portion of said rod during thermal expansion and contraction, and moving means connected to said control lever for moving the same in such a manner that the combined movement of said guide lever and control lever effects movement of said free end of said control lever along an endless annular path located in a plane transverse to said rod so that said free end portion of said rod and said specimen holder move along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

10. A microtome as set forth in claim 9 wherein said guide lever is a leaf spring fixed at said one end thereof and being flexible in said plane transverse to said rod for pivotal movement about said one end thereof, and wherein said control lever is fixedly secured to the other end of said leaf spring.

11. A microtome comprising, in combination, a block of great heat capacity; means for varying the temperature of said block; an elongated flexible rod rigidly secured at one end thereof to said block and having a free end portion spaced a substantial distance from said block, said rod having a regular cross section to permit transverse movements of said free end portion in all directions; a specimen holder secured to said free end portion; means for holding a cutting blade in the region of said specimen holder; and operating means including a guide lever mounted for movement about one end thereof, a control lever pivotally mounted on the other end of said guide lever and having a free end secured to said free end portion of said rod, the portion of said control lever between said free end thereof and said guide lever being a leaf spring deflectable in longitudinal direction of said rod, and an eccentric moving means connected to said control lever for moving the same in a plane normal to said rod in such a manner that said control lever pivots about the free end of said guide lever while said guide lever performs a pivotal movement so that the combined movement of said guide lever and control lever effects movement of said free end of said control lever along an endless annular path located in a plane transverse to said rod so that said free end portion of said rod and said specimen holder move along an endless annular path located in a plane transverse to said rod so that said specimen is moved across the blade during movement along a first portion of said path and is returned laterally spaced from said blade during movement along a second portion of said path, said specimen holder being advanced by thermal expansion of said block.

References Cited in the file of this patent

UNITED STATES PATENTS

2,651,236	Kahler	Sept. 8, 1953
2,739,507	Cocks et al.	Mar. 27, 1956
2,753,761	Hillier	July 10, 1956

FOREIGN PATENTS

1,065,788	France	Jan. 13, 1954
148,943	Sweden	Feb. 22, 1955