

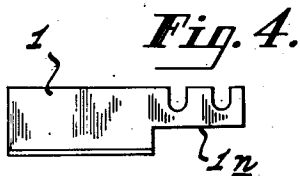
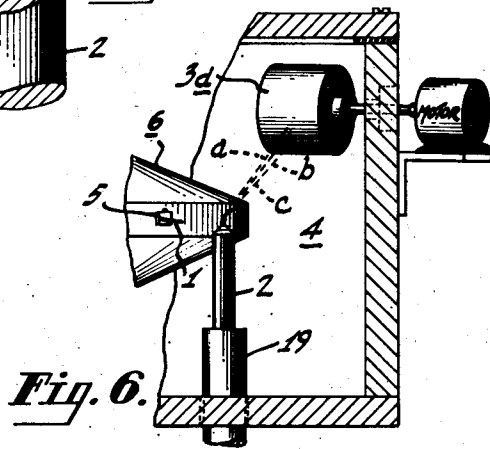
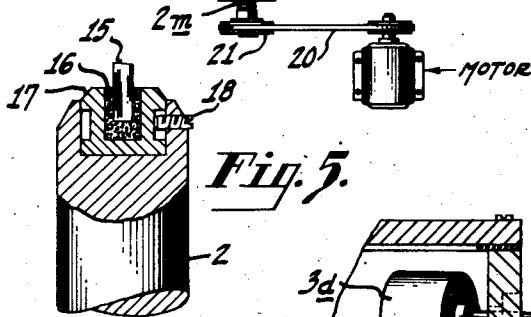
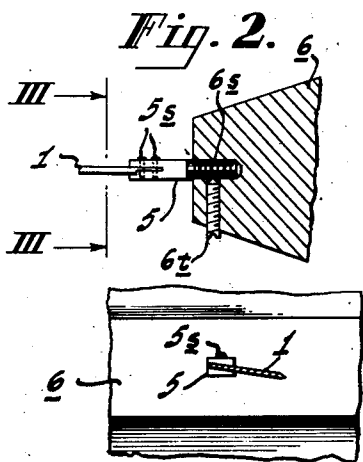
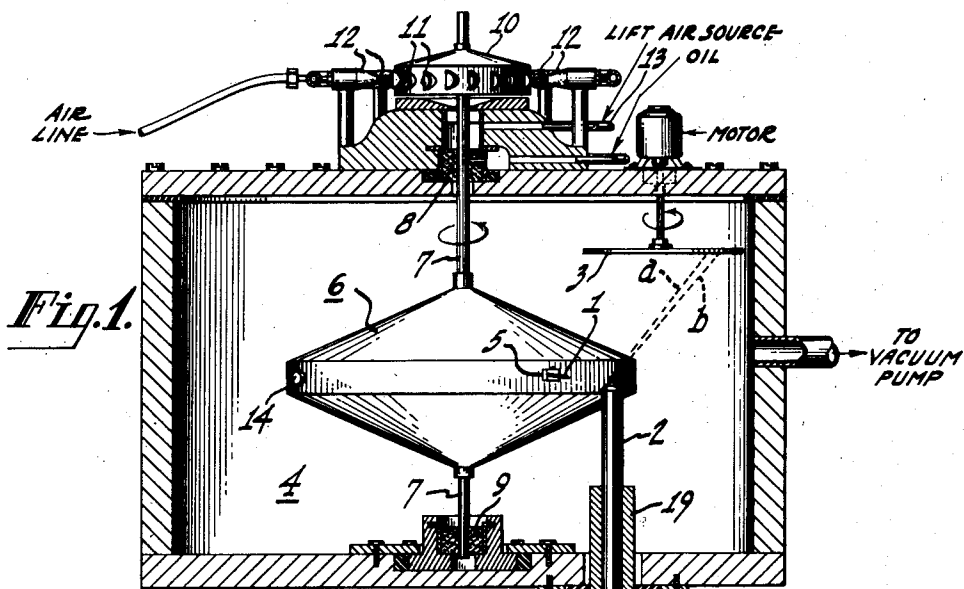
June 23, 1953

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2,642,774

HIGH-SPEED MICROTOME

Filed Oct. 29, 1947



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## UNITED STATES PATENT OFFICE

2,642,774

## HIGH-SPEED MICROTOME

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Application October 29, 1947, Serial No. 782,886

1 Claim. (Cl. 88—40)

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This invention relates to the art of cutting, sorting and collecting pellicle-like sections of a specimen for microscopic examination.

It may be said, generally, that sections of a specimen thin enough for use in a light microscope are usually too thick for use in an electron microscope. This is so because of the relatively poor penetrating power of even the highest velocity electrons. However, the superior resolving power of the electron microscope has created a demand for thinner and yet thinner specimen-sections and has led to many improvements in the art of cutting such sections. In fact, present-day high-speed microtomes (such, for example, as the ones described by Fullam and Gessler in "The Review of Scientific Instruments" vol. 17, No. 1, January, 1946, pp. 23-35) are said to be capable of cutting specimen materials into slices less than one micron thick.

In the operation of present day high-speed microtomes the thin specimen-sections are cut and pile-up at the rate of many hundred per second and, because of the extreme thinness of such sections, it is very difficult to extract discrete whole specimens from the pile. Furthermore, in spite of the use of extreme care in mounting and adjusting the specimen holder with respect to the cutting blade it is impossible to achieve perfect uniformity in the shape and dimensions of the specimen-sections. Thus, some sections may be curled-up by the action of the blade, or may become distorted by impact with the pile of previously cut sections. Such lack of uniformity in the physical characteristics of the sections, plus the natural tendency of such thin films to adhere to each other, further complicates the problem of separating the pile into its individual elements and of selecting the usable from the non-usable elements.

Accordingly, the principal object of the present invention is to obviate the foregoing and other less apparent objections to present day methods of cutting and selecting specimen sections for microscopic examination.

Another and related object of the present invention is to provide an improved high-speed microtome, and one capable not only of cutting specimen-sections thin enough for use in an electron microscope, but one which shall direct the said sections into separate paths determined by their physical characteristics and shall separately collect the individual ones of the specimen sections in each of said paths.

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The invention will be described in connection with the accompanying drawing wherein:

Fig. 1 is a sectional elevation of a high-speed microtome constructed and operated in accordance with the principle of the present invention; Fig. 2 is an enlarged front view, partly in section, of the cutting blade of the device of Fig. 1; Fig. 3 is a section of the blade taken on the line III—III of Fig. 2; Fig. 4 is a plan view of the blade; Fig. 5 is an enlarged elevational view partly in section of the specimen holder shown in Fig. 1; and Fig. 6 is a fragmentary view of the microtome showing an alternative form of collecting surface for the specimen sections.

Microtomes constructed in accordance with the principle of the present invention consist, essentially, of a cutting blade 1, a specimen holder 2 for a specimen (15 Fig. 5), and a movable surface 3 (Fig. 1, 3d Fig. 6) upon which the discretely cut specimen sections (indicated by the broken lines *a, b* Fig. 1, *a, b, c* Fig. 6) are separately collected. These essential parts 1, 2 and 3 are shown mounted for relative movement, in a manner later described, in an evacuable chamber 4 which will be understood to be maintained at a vacuum of the order 100 microns or less.

In agreement with the generally accepted theory that the higher the cutting speed the thinner the cut, the microtome shown in the drawing is constructed to operate at the highest practical speed (ordinarily in the range of from 500 to 1200 revolutions per second), the upper speed limit being determined by the bursting point of the rotor. To this end, the blade 1 is mounted upon a holder 5 which projects from the periphery of a solid metal rotor 6 (say, four inches in diameter) having a shaft 7 which extends through a rubber or other suitable vacuum-tight bearing 8 in the lid of the chamber 4. Thus, at 500 revolutions per second, the flywheel will have a peripheral linear velocity of 1000 inches per second. The blade 1 will, of course, have a linear velocity somewhat in excess of 1000 inches per second, depending upon how far it extends beyond the periphery of the flywheel. The bearing 9 for the lower end of the shaft 7 is contained within the chamber 4. This shaft 7 terminates, exterior of the chamber 4, in a Pelton wheel 10 which is arranged to be driven by compressed air applied to the flutes 11 of the wheel through nozzles 12.

In order to minimize drag in the supporting bearing, the rotor 6 and its shaft 7 are mounted to permit of slight axial movement. Such movement is provided by an auxiliary source of air

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13 which operates to lift the wheel 10 (say, one or two thousandths of an inch) so that there is no load or thrust on the ends of the shaft 7. The shaft 7 is relatively thin (say,  $\frac{1}{8}$ " diameter) so that it can flex, making the rotor substantially free to seek its own center of rotation. The unbalance which might be occasioned by the presence of the blade 1 is compensated by small weights 14 suitably distributed on the periphery of the rotor.

As shown more clearly in Figs. 2 and 3 the holder for the blade 1 may comprise simply a short threaded rod 5, which is screwed into a complementarily threaded hole 6s in the periphery of the rotor, and having a bifurcated free-end containing two screws 5s which serve to clamp the blade 1 by its neck 1n (Fig. 4) in a position to be brought into cutting relation with respect to the specimen 15 in the specimen holder 2. The cutting angle may be adjusted simply by turning the blade holder 5 in its threaded seat 6s and clamping it by means of a set screw 6t.

As shown in Fig. 5, the specimen 15 is preferably embedded in a thermoplastic or other hardened "plastic" material 16 contained in a small cup-shape receptacle 17 which is secured by screws 18 on the upper end of the vertically movable holder 2. Referring again to Fig. 1; this rod-like holder 2 extends through a vacuum tight bearing 19 to the exterior of the chamber and is provided adjacent to its outer end with a micrometer screw 2m for moving the rod, and hence the specimen 15 thereon with respect to the plane of movement of the blade 1. This movement is preferably continuous and may be imparted to the holder by means of a motor driven belt 20 wrapped about a pulley 21 on the end of the threaded rod 2.

As previously set forth, in the high-speed microtomes of the prior art the cut sections of the specimen are deposited and pile-up upon a stationary collecting surface and it is exceedingly difficult to extract discrete whole specimens from the pile. This difficulty is obviated, in accordance with the present invention, by the provision of a movable collecting surface 3 Fig. 1 (3d, Fig. 6) upon which the cut sections are separately deposited.

The speed at which the collecting surface 3 is driven should preferably be great enough to permit the discrete sections to be deposited upon separate elemental areas of said surface without any overlapping of the sections. For example, in one embodiment of the invention wherein the sections (in this case sections of carnauba wax) were cut at the rate of 500 per second, and were about 0.1 of a micron thick and 1 millimeter diameter, the collecting surface (in this case a disc) was rotated at a rate of only 0.5 meter per second at the point of contact, without any overlapping of the successively deposited sections. Faster speeds were, of course, also satisfactory. A disc-shape collecting surface is ordinarily to be preferred to a drum, cone, belt or sphere because the plane surface of a disc lends itself more readily to a preliminary inspection of the sections under a light microscope. The surface of the collector may be coated with oil, or with an organic film (e. g. collodion) to cause the specimen sections to adhere more readily thereto. If desired the collector may comprise a fine-wire screen (say, 200 mesh) which may subsequently be cut (with a punch)

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about the individual specimen sections and the separate pieces of the screen mounted directly in the specimen holder of the electron microscope.

The direction of movement of the collecting surface 3 should preferably be the same as that of the rotor 6, as this reduces the relative velocity of the cut sections with respect to the said surface. By thus reducing the relative velocity of the arriving sections with respect to the collector 3 the possibility of damaging the said sections by the force of their impact upon the collector is materially reduced. When, as in the illustrated embodiment of the invention, the cut sections of the specimen are projected upwardly their velocities are still further reduced in overcoming the force of gravity. However, it is apparent that the principle of the moving collector surface may be applied irrespective of the direction (e. g. "up" or "down" or "side-ways") in which the cut sections are projected.

When, as contemplated, the forces applied to the specimen 15 by the blade 1 are of the proper direction and intensity to project the severed sections a substantial distance (say 2 or 3 inches) into space the trajectories of said sections are not always the same but will differ as determined by the physical characteristics of the said sections. Thus, curled-up pieces, and pieces of different mass will be deposited different distances from the edge of the collecting surface. By way of example, if as indicated by the dotted lines *a* and *b* of Fig. 1, the cut sections comprise only "large" and "small" pieces, the larger pieces *a* will not travel as far as the smaller pieces *b* and will be deposited nearer the center of the disc 3. As indicated by the several dotted lines *a*, *b* and *c* in Fig. 5 the cut sections may be of several sizes and hence be deposited in several "rings" or rows. However, since the section in all of the rows are separated one from another (by reason of the prescribed movement of the collecting surface) the selection of a given section or row of sections for microscopic examination is greatly facilitated.

It will now be apparent that the present invention provides an improved method of, and apparatus for, cutting and sorting and collecting extremely thin sections of a specimen for microscopic examination.

What is claimed is:

In a high speed microtome, means for simultaneously subjecting a specimen to a cutting force of sufficient intensity to sever discrete sections from said specimen and to a projecting force sufficient to project said severed sections into space along separate paths determined by the mass of said sections; said means including a rotatable member, a severing blade secured to the periphery of said rotatable member, and means for driving said blade at a linear velocity of at least 1000 inches per second; a collecting surface for collecting said severed and projected sections, said collecting surface being rotatably mounted in a position to intercept the separate paths of projection of said sections, means for rotating said collecting surface in a direction constituting substantially a continuation of the projection path of said sections and at a velocity determined by the velocity of said rotatable member whereby said specimens will be separately collected on said collecting surface; a vacuum tight chamber, said specimen, said blade, and said collecting surface being mounted within said

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chamber; and means for evacuating said  
chamber.

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