

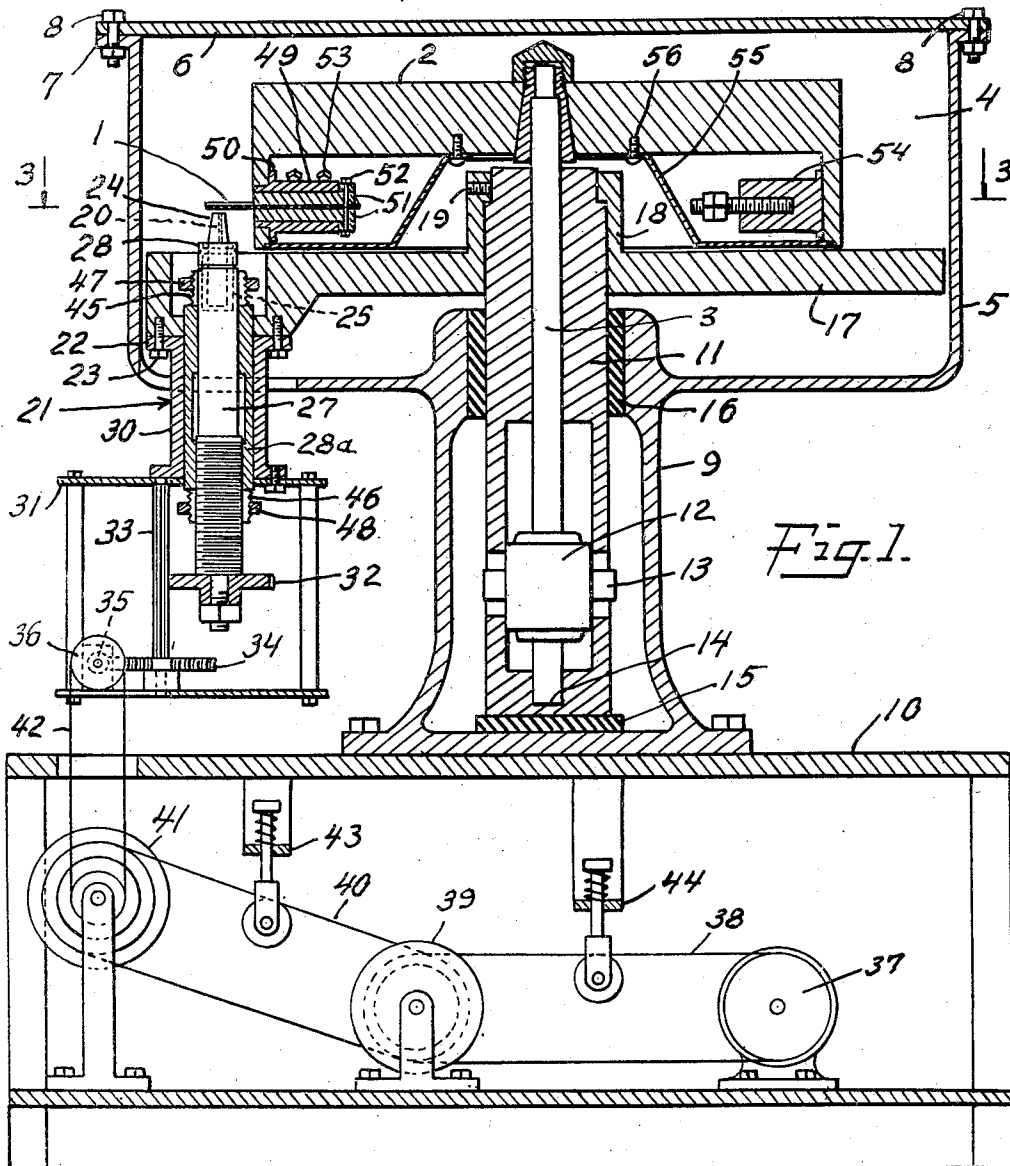
Sept. 27, 1949.

W. A. LADD
MICROTOME WITH ROTATING CUTTER AND SPECIMEN
FEED-MECHANISM SUPPORTED THEREWITH

2,482,853

Filed Feb. 7, 1946

3 Sheets-Sheet 1



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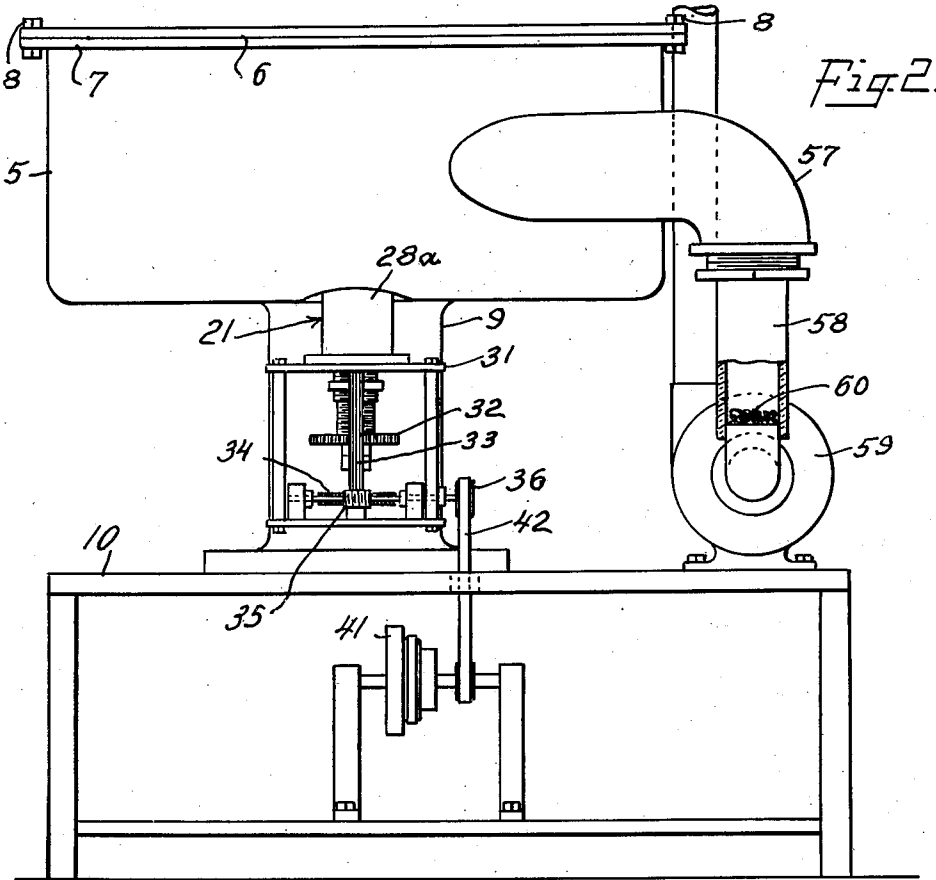


Fig. 4.

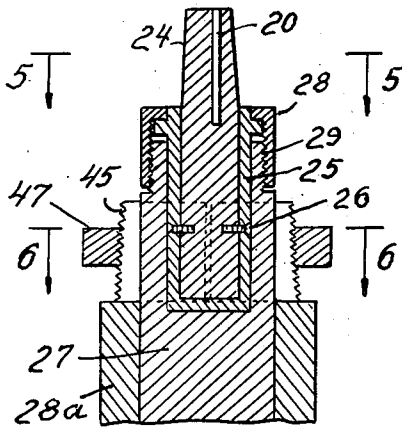
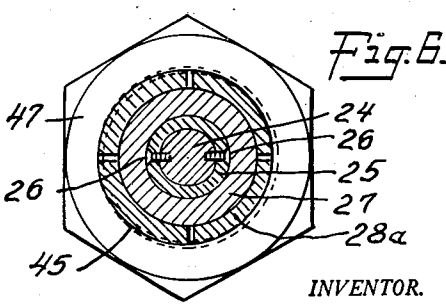


Fig. 5.



Fig. 6.



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Fig. 3.

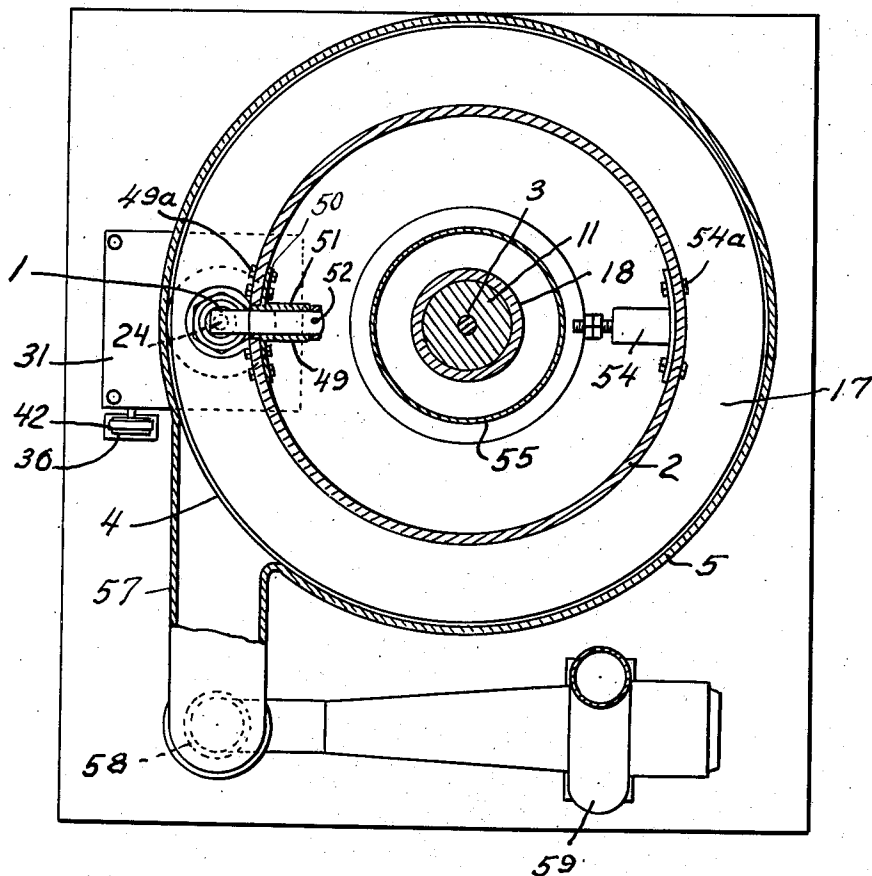
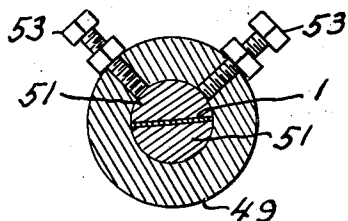


Fig. 7.



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MICROTOME WITH ROTATING CUTTER AND
SPECIMEN FEED MECHANISM SUPPORTED
THEREWITHWilliam A. Ladd, Brooklyn, N. Y., assignor to Co-
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The present invention relates to an improved
microtome, that is, an apparatus for cutting thin
section specimens for microscopic examination.

The advent of the electron microscope has in-
troduced a serious problem in the preparation of
specimens sufficiently thin for penetration by the
electron beam. Conventional microtomes are
rarely capable of producing specimens thinner
than 1 micron, in other words, 40 millionths of an
inch. Such specimens are so thick as to be
opaque to the electron beam of the electron mi-
croscope.

It has heretofore been proposed in the prepa-
ration of biological specimens to move the ob-
ject from which the section is to be cut into the
path of a knife traveling at a speed equivalent
to about 95 miles per hour. This expedient has
made possible the sectioning of biological speci-
mens of relatively good transparency to a thin-
ness which permits some examination with the
electron microscope. Satisfactory or even critical
resolution with specimens so cut has, however,
not been possible.

Intense research work in the field of natural
and synthetic rubber, for instance, has required
the microscopic examination of such rubber
after compounding with conventional ingredi-
ents, including carbon black, and vulcanization.
Due to the extremely small particle size of car-
bon black, for instance, it has been found desir-
able to use the electron microscope for such
examination. However, previously known mi-
crotomes have been found inadequate for the
cutting of rubber specimens of sufficient thin-
ness for satisfactory electron microscope exami-
nation.

In an effort to adapt the high speed cutting
principle to the production of sufficiently thin
specimens of substances, such as rubber, I have
found it necessary to use materially greater cut-
ting speeds than those previously proposed. For
instance, I have found it frequently desirable to
employ a knife speed of the order of 200-300
miles per hour and to use a knife-carrying me-
chanism having high momentum. Even under such
conditions, considerable difficulty has been ex-
perienced in obtaining satisfactory specimens.

In order to attain such cutting speeds, it was
found necessary to mount the cutting edge on a
wheel or circular disc having considerable mo-
mentum and adapted to extremely rapid revolu-
tion. With such arrangement additional diffi-
culties were encountered because of axial preces-
sion of the wheel or disc carrying the cutting
edge, which precession caused uncontrollable

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change in the position of the cutting edge with
respect to the specimen and resulted in wide
fluctuations in the thickness of the sections.

Further difficulties have been encountered in
attempts to feed the specimen into the path of
the cutting edge at a uniform speed, and to avoid
rapid dulling of the cutting edge, and also in the
collection of such ultra thin section specimens.

The present invention provides an improved
microtome adapted to the cutting of specimens
of the thinness required for electron microscope
examination while avoiding the difficulties here-
before experienced. The microtome of the pres-
ent invention has been found to be particularly
useful in the preparation of such specimens of
rubber compositions, for electron microscope
examination, but is also useful in the preparation
of other specimens.

My present invention will be described with
reference to the accompanying drawings which
represent one embodiment thereof, and of which

Fig. 1 is a vertical view, partly in section;

Fig. 2 is a side elevation;

Fig. 3 is a horizontal section along the line 3—3
of Fig. 1;

Fig. 4 is a vertical section of the specimen and
specimen holder of a micrometer feeding me-
chanism;

Fig. 5 is a section of the specimen along the
lines 5—5 of Fig. 4;

Fig. 6 is a horizontal section of the specimen
holder along the line 6—6 of Fig. 4; and

Fig. 7 is a sectional view of the knife-holder.

Referring more particularly to Fig. 1, the knife
or cutting edge is indicated by the reference
numeral 1 and is supported by the flywheel 2,
fabricated from a heavy metal so as to have mo-
mentum. The flywheel is supported and adapted
to be driven by shaft 3, and is positioned within
chamber 4, formed by a bowl-shaped element 5
and a cover plate 6, the cover plate being securely
but removably fastened to the bowl as by means
of the flange 7 and bolts 8. The bowl is supported
by the base stand 9, shown resting upon bench 10.

The shaft 3 is rotatably mounted in and is
supported by the vertical bearing 11 of metal
projecting upwardly into chamber 4 and down-
wardly through the opening within the base
stand 9. The opening extending centrally
through the bearing 11 is enlarged near the
lower end thereof to receive the electric motor
12 for driving the flywheel, the brushes of the
motor extending through the walls of the bear-
ing at 13. The shaft of the motor is a continua-

tion of shaft 3, and is supported at its lower end by the thrust bearing 14.

The bearing 11 rests upon a rubber cushion 15 and is vertically, though non-rigidly, supported by a cushion bushing or sleeve 16 of rubber or other resilient material mounted in the upper end of the base stand 9.

A rigid circular disc 17, advantageously of wood or other light material of consequently relatively low momentum, for supporting a micrometer feed mechanism, and of sufficient thickness for rigidity, is rigidly supported by the upper end of bearing 11 by means of the collar 18 and set screws 19. The diameter of the disc 17 is slightly less than that of the bowl so as to provide a small clearance, say about $\frac{1}{8}$ inch.

The specimen 20 is supported by the specimen holder and micrometer feed mechanism 21, which in turn is rigidly supported by the disc 17 by means of the flange 22 and screws 23.

As shown more clearly in Figs. 4 and 5, the specimen 20 is embedded, as shown, in wax 24, such as conventionally used for this purpose. This specimen is preferably positioned off-center, as shown, for the reasons to be subsequently stated.

The wax supporting the specimen is contained in the thimble 25, and is prevented from turning within the thimble by means of the screws 26 which project into the wax. The thimble 25 is adapted to fit snugly, though removably, into a recession in the upper end of the micrometer feed mechanism shaft 27, and is securely held therein by means of the screw cap 28 and threads 29.

The shaft 27 extends vertically through sleeve 28a, which in turn is supported by the housing 30, rigidly fastened to the disc 17, as previously described. The lower end of housing 30 supports bracket 31, which in turn supports a gear train. This gear train in the particular apparatus illustrated is designed to give a reduction ratio of 1667:1 and consists of a 100-tooth gear wheel 32 securely fastened to the lower end of the shaft 27. Gear 32 meshes with a 6-tooth pinion gear 33, attached at its lower end to a 100-tooth gear wheel 34, which in turn meshes with the worm 35. Worm 35 is directly connected to pulley 36, which is driven by motor 37 through belt 38, ratio control mechanism 39, belt 40, pulley 41, and belt 42. 43 and 44 represent belt tighteners. In the particular apparatus here illustrated, the motor 37 and the series of pulleys and belts connecting said motor with the worm 35 are such as to vary the speed of the worm from 100 to 1600 R. P. M.

The shaft 27 is threaded into the sleeve 28a, the threads being cut 52 per inch, so that the shaft 27 is fed upwardly, when rotated in the advancing direction, at the rate of 488 microns per revolution. The sleeve 28a is provided with split, tapered threads at 45 and 46 whereby any play may be taken up by the tightening of the threaded adjusting rings 47 and 48.

Because of the extremely rapid rotation of the flywheel carrying the knife 1, it is essential that the knife be securely and rigidly fastened to the flywheel. This is accomplished by means of the knife holder 49, positioned within the flywheel, and projecting through an opening in the circumference of the flywheel. The outer edge of the knife holder is flush with the circumference of the flywheel and is prevented from moving beyond this point by means of shoulders 50. The knife blade is securely held between two half-cylinders 51, held together by bolt 52. The half-cylinders holding the knife blade between them

are rotatably and removably mounted within the cylindrical housing of the holder 49 and are therein secured in the desired position by means of the set screws 53.

As special precaution against the knife's becoming loosened, I have in the apparatus illustrated provided the bolt 52 extending through a hole in the knife blade, and further have provided the half-cylinders 51 with flanges at their inner end to avoid all possibility of their being thrown out through the opening in the holder 49 by the terrific centrifugal force.

An adjustable counter weight 54 is placed diametrically opposite the knife so as to balance the flywheel. The under portion of the fly wheel is shown enclosed by members 55, removably fastened to the flywheel by any convenient means, as by screws 56. The cylindrical housing of the knife holder 49 and the counter weight 54 are fastened to the flywheel by screws 49a and 54a, respectively, passing through the flange thereof as shown in Fig. 3. A cross-sectional view of the knife holder showing the set screws 53 is represented by Fig. 7 of the drawings.

Because of the hazards involved in the operation of an apparatus of this sort at the required speeds, it is advisable that the bowl 5 and the cover 6 be fabricated of steel of sufficient strength to afford protection to the operator in the event of any part breaking or coming loose during operation. It is also desirable that lock nuts be used throughout the apparatus.

For the purpose of collecting the minute sections of the specimen cut by the operation, the apparatus is provided with duct 57, as more clearly shown in Figs. 2 and 3 of the drawings, leading from the chamber 4 through a glass or other transparent tube 58 to a suction device 59, such as a blower, with means, such as a screen, provided in the lower end of the transparent tube for supporting a layer 60 of fine fibers such as cotton, through which the current of air carrying the specimens may be drawn from the chamber 4, the specimens contained in said air stream being retained on the cotton. By this means the specimens are readily collected and during the collection may be observed for the purpose of determining whether the microtome is functioning properly.

In the specific apparatus illustrated, the cutting edge describes a circle of about $15\frac{1}{2}$ inches in diameter so that when the fly wheel is turning at a speed of 5000 R. P. M. the cutting speed is about 230 miles per hour. Under such circumstances it is difficult to maintain a true cutting edge. In the present apparatus this difficulty is alleviated by positioning the specimen off-center in the wax, as previously described, and by rigidly fastening the specimen to the revolving shaft 27 so that as said shaft revolves, feeding the specimen into the path of the cutting edge, the portion of the cutting edge which strikes the specimen is continually shifting, thus extending the useful life of the cutting edge between resharpenings.

Further, by rotatably mounting the half-cylinders which hold the knife blade, the cutting angle of the knife may be adjusted to any desired angle.

Microtome knives currently available have in general been found too soft for the high speed cutting of specimens, such as rubber, herein described. For use in my present apparatus I prefer to use a blade of highly tempered steel.

In the operation of the apparatus herein de-

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scribed, it is desirable to bring the flywheel to speed and then gradually feed the specimen into the path of the knife. In discontinuing the operation, the specimen should be lowered before reducing the speed of the flywheel, for the reason that in operation there is a tendency for the head or flywheel to ride at a higher level at top speed than at rest or at lower speeds.

A further advantage in the mounting of the specimen off-center is that by so doing one obtains the effect of direct and oblique cutting at all angles with respect to any grain in the sample.

It will be understood from the foregoing description of the apparatus that the specimen is held relatively stationary except for its rotation and slow advancement into the path of the knife. The flywheel carrying the knife is, as previously described, designed to operate at very high speeds. At these high speeds, very slight inaccuracies in balancing the flywheel will result in the axis of rotation precessing, similar to a spinning top. Any attempt to stop this precessing by rigidly holding the upper end of the shaft 3 by an additional bearing, or by fastening bearings 11 and 14 rigidly to the base stand 9 would set up terrific stresses sufficient to bend or break the shaft. In the apparatus shown, axial precession is permitted by the resilient bushing and, by reason of my novel arrangement for rigidly supporting the specimen by the bearing 11, any precession of the flywheel is accompanied by a corresponding movement of the specimen so that no relative movement of the specimen with respect to the cutting edge is occasioned by axial precession.

By reason of this arrangement, specimens of satisfactory thinness for electron microscopy may be cut, the actual thickness being controlled by speed of the knife, the rate at which the specimen is fed into the path of the cutting edge, the thickness of that cutting edge, and the elimination of relative motion of cutting edge and specimen caused by precession of the high speed rotating knife or cutting-edge carrier.

I claim:

1. A microtome comprising a shaft rotatably mounted in a bearing, with at least one end thereof projecting beyond one end of the bearing, a cutting edge supported by and rigidly connected with a projecting end of said shaft, means for rotating said shaft within the bearing, a micrometer feed mechanism rigidly supported by said bearing and adapted to hold a specimen to be cut and feed said specimen into the path of the cutting edge, said feed mechanism comprising a shaft adapted to rotate slowly as it moves toward the path of said cutting edge, and means for

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rigidly mounting the specimen on that end of the last said shaft toward the path of the cutting edge, so that the specimen is slowly rotated as it is moved into the path of the cutting edge.

2. A microtome comprising a shaft rotatably mounted in a bearing, with at least one end thereof projecting beyond one end of the bearing, a cutting edge supported by and rigidly connected with a projecting end of said shaft, means for rotating said shaft within the bearing, a micrometer feed-mechanism rigidly supported by said bearing and adapted to hold a specimen to be cut and feed said specimen into the path of the cutting edge, said feed mechanism comprising a shaft adapted to rotate slowly as it moves toward the path of said cutting edge, and means for rigidly mounting said specimen on that end of the last said shaft toward the path of the cutting edge in a position eccentric to the axis of the last said shaft, so that the specimen is slowly rotated as it moves into the path of the cutting edge, at the same time moving across the cutting edge.

3. A microtome comprising a housing, a resilient bushing extending through a wall of said housing and supported thereby, a bearing extending through the bushing and housing and into the chamber within said housing, a shaft extending through said bearing and supported thereby and projecting from the inner end of said bearing into the chamber, a flywheel mounted on the inner end of said shaft, a cutting edge supported by and rigidly connected to said fly wheel, means for rotating said shaft and flywheel within said chamber, a micrometer feed-mechanism adapted to hold a specimen to be cut and feed it into the path of the cutting edge, said feed-mechanism being rigidly supported by the inner end of said bearing and otherwise independently of the housing.

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