

A sectioning machine for teeth and other brittle materials

G. FOSSE, J. RÖLI & H. KNUDSEN

Institute of Anatomy, University of Bergen, Norway

Fosse, G., Röli, J. & Knudsen, H. A sectioning machine for teeth and other brittle materials. *Acta Odont. Scand.* 32, 299—304, 1974.

A reciprocating wire saw for the cutting of brittle material, such as tooth enamel, is described. It cuts 50 μm thick sections of tooth enamel routinely. The sections have planoparallel smooth surfaces and further grinding or polishing is not necessary subsequent to the cutting if the sections are to be studied in the light microscope. The cuts left by the wire in the specimen have a width of 130 μm . Ordinary 100 μm thick piano wire is used, and a slurry of 600 grit carborundum suspended in oil is applied as an abrasive. The cutting speed of the machine is only 0.1 mm/hr., as the feeding is controlled and slower than the speed of abrasion through the material to be sectioned. The stress on the specimen is thus very low, and results in whole undamaged sections.

Key-words: Tooth; dental enamel; microtomy

G. Fosse, Institute of Anatomy, University of Bergen, Årstadveien 19, 5000 Bergen, Norway

The purpose of the present construction was to safely obtain as many whole and undamaged sections as possible from small and very brittle biological specimens, such as fossil teeth of primitive mammals. It was also desirable to use inexpensive and easily available parts. It was further anticipated that accuracy and a minimum stress on the specimen would profit from a slow cutting speed of the machine.

SECTIONING MACHINE

Fig. 1 shows the sectioning machine which consists of a rigid cast iron base plate A, measuring $32 \times 17 \times 0.9$ cm. The base plate is supported by four 8 cm high cast iron legs.

The object carrier B is movable along guide rails in the fixed supporting piece C.

A leaf spring D forces the object carrier against the end of a micrometer screw E.

The actual cutting device consists of a 100 μm thick piano wire stretched between the clamps FF of the sawing arm G. This arm is adjustably fixed to the slide H which moves back and forth on a dovetailed guide rail on the slide carrier K.

An oil dispenser L lubricates the guide rail during operation. To the slide carrier K is fixed the motor which moves the slide with the sawing arm back and forth via a crank and connecting rod. The drive shaft of the motor rotates with a speed of 30 RPM. The whole slide carrier with the motor and its counter balance M is mounted on a steel column N by a true bearing that permits the carrier to rotate in a vertical plane perpendicular to the guide rails of the object carrier. During

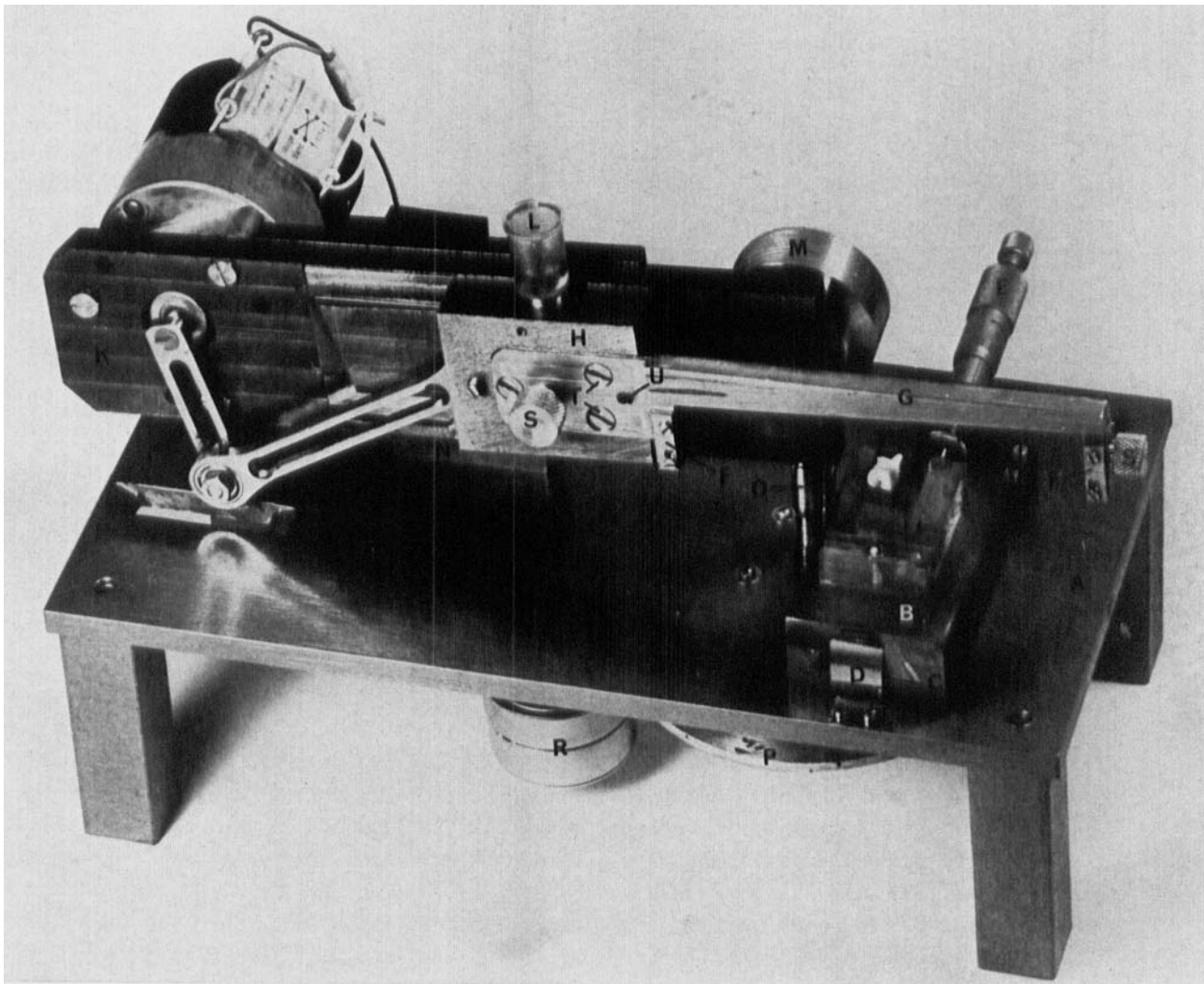


Fig. 1. Sectioning machine. For further description of parts, see text.

sawing the piano wire descends through the specimen by a very slow downward motion of the carrier with sawing arm.

The feed unit consists of a treated spindle O with a steel ball on the end. The carrier is balanced so that it rests lightly on the steel ball. The spindle O is screwed through a disk P which again is rotated by a friction wheel mounted on the shaft of a little feed motor R. The motor with the friction wheel is

pulled against the disk by a coil spring and may be disengaged by hand to rotate the disk P for adjustments of wire height.

The friction wheel has a diameter of 4 cm and a rotation period of one revolution in 6 hours. The diameter of the disk P is 12 cm and the screw pitch of the feed spindle is 1,5 mm per revolution. The resultant advance speed of the wire through a specimen is 0,1 mm/hr. (16 $\mu\text{m}/\text{min.}$). The reason for the selection of such

Sectioning machine for teeth	Målestokk	Tegn.: J.R. 8/6-74
	1:1	Tec.: L.S. 8/6-74 Ry. G.F. 9/6-74
ANATOMISK INSTITUTT BERGEN-NORWAY		300

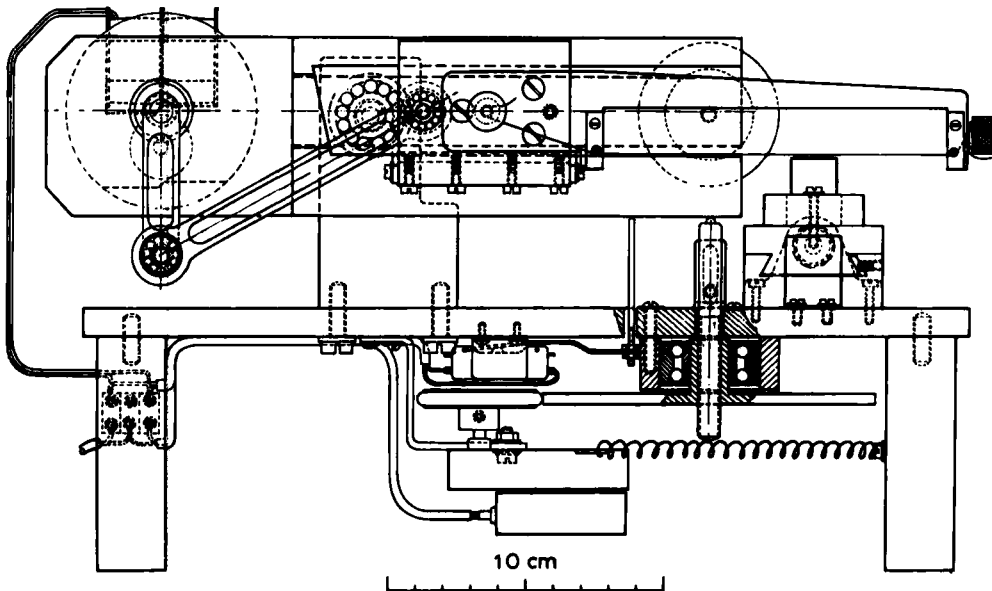


Fig. 2. Diagrammatic lateral sectional view of the machine.

a low speed of feeding will be given later.

Fig. 2 is a diagram showing the various parts of the machine.

Preparation of sawing wire. One end of a 15 cm length of a 100 μm thick piano wire is fastened in one clamp of a fret saw frame secured in a vice. The free end is fastened in a pin vice and the wire is twisted 15 times in one direction. Keeping it stretched the wire is then also fastened in the other clamp of the fret saw. Using a fine grit emery paper, the taut wire is now abraded lengthwise by hand on four sides so that it nearly acquires a square cross-section. 50 strokes on each side are sufficient. When the wire is released from the fret saw frame, it rewinds itself so that the abraded surfaces will have a helical course along it. Fig. 3 shows a short section of wire prepared in the manner described above.

Adjustments of the machine. The specimen to be sawed is fixed to the plastic platform on the object carrier by heated Kerr's dental impression resin.*)

The friction wheel of the feeding motor R is disengaged, the feeding disk P is turned by hand until the wire nearly touches the point where the first cut is to be made. The machine is started and if any lateral shift of the wire above the specimen can be observed through a magnifying glass the sawing arm is adjusted laterally as required by the screws U and T T. Next, the wire is observed from the side to see if there is any vertical shift above the point of contact with the specimen. A vertical shift is eliminated by turning an eccentric pin in one or both clamps of the sawing

*) Kerr Europe S. p. A., Impression compound, Tracing Sticks No. 2.

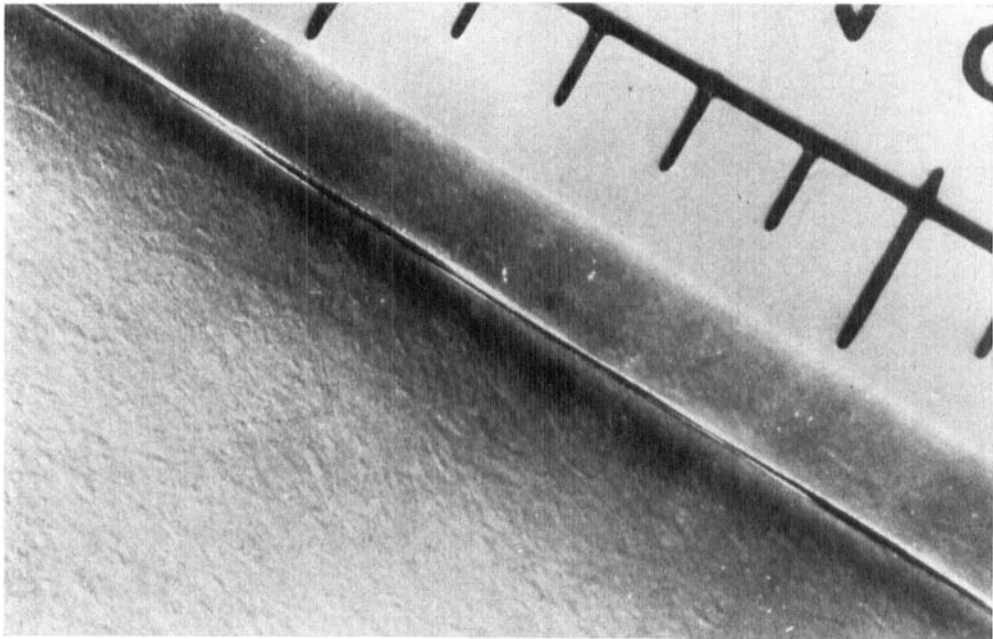


Fig. 3. 100 μm thick sawing wire with a square cross-section and the flat sides having a helical course. For preparation of the wire see text. Scale intervals 1 mm.

arm with a screw driver. The wire rests on these eccentric pins, see Fig. 2.

The adjustments described above must be carried out the first time the machine is in operation, but later only when frequent changes of wire have worn grooves in the clamps.

OPERATION OF THE MACHINE

When the sawing starts, the wire should not yet touch the specimen. A drop of grinding compound consisting of 600 grit silicon carbide suspended in engine lubricating oil is applied to the specimen. The compound is quite viscous and it is safe to have the machine in operation overnight as a sufficient amount of compound remains on the specimen and in the slot above the wire.

The prototype described here is provided with a microswitch that stops the motors

when the wire has advanced to the surface of the specimen platform.

When the first cut is finished, the arm is raised by turning the feeding disk P and the micrometer screw is adjusted to the desired section thickness, always adding 130 μm which is the maximum width of the groove left by the wire.

Fig. 4 shows an incisor where 3 incomplete cuts have been made and where the interproximate distance was adjusted to 70 μm . The grooves were 1,2 mm deep and the cuts had been completed with one wire through 36 hours of continuous operation. It is quite feasible to cut intact enamel sections with a thickness of 50 μm longitudinal to the tooth, but then each section should be supported by Kerr resin melted to the outer surface and to the surface of the platform underneath.

Fig. 5 is a photomicrograph in polarized light of a 50 μm thick longitudinal section of human enamel and dentine, which had

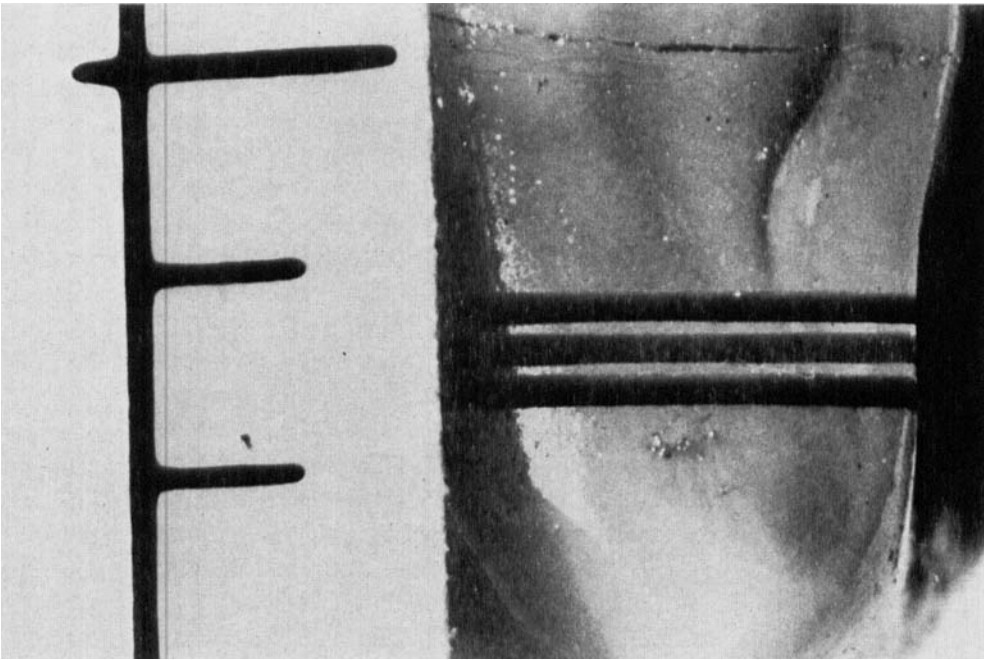


Fig. 4. Three consecutive and incomplete cuts in a tooth. The cuts have a width of $130\ \mu\text{m}$ and a depth of 1.2 mm. Their interproximate distance is $70\ \mu\text{m}$. Scale intervals 1 mm.

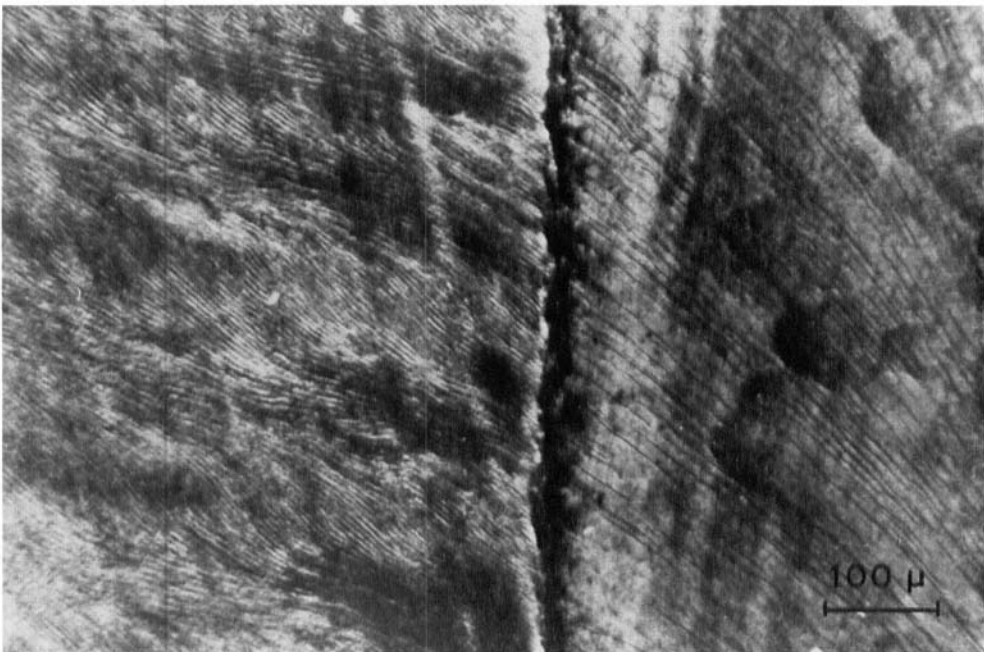


Fig. 5. Photomicrograph in polarized light of a routinely cut $50\ \mu\text{m}$ thick longitudinal section of a human tooth. After the sectioning no subsequent grinding or polishing was carried out. Incremental lines are seen in enamel and dentine.

been routinely cut in the machine, rinsed in xylene and mounted without subsequent grinding or polishing.

The slow descent of the wire through the specimen is the cause of the accurate operation of the machine. It prevents any pressure between wire and specimen as the carborundum particles wear off specimen material faster than the wire descends. Thus local changes in the hardness of the specimen will not deflect the straight downward course of the wire. Its square, helical cross-section is designed to rotate and shift the particles on the bottom of the cut groove and prevent them from being forcibly embedded in the material to be cut.

If a wire breaks while cutting, which may happen while cutting specimens thicker than 10 mm, corresponding to 100 hours of continuous operation, the sawing with a new wire may be resumed from a little above the bottom of the cut. If the adjustments of the wire are correct, its thickness will only be reduced to 70 μm before breakage and this corresponds to an operational life of 100 hours.

Accurate performance of the machine depends on the precision of the slide guidance. Only a minimum of lateral or vertical slackness of the slide on the guide rail must be tolerated. For this reason the sloped contact surface of the slide

on the lower track of the dovetailed guide rail consists of a separate spring-loaded 3 mm thick piece of cast iron which thus acts to press together all bearing surfaces between slide and carrier (Fig. 2). However, a lateral oscillation of the wire in the range of 10 μm was not to be avoided. We consider this as a permissible tolerance in the slide guidance. The machine has been tested and in operation for a year and the slackness has not increased through this time.

The width of the cut, and the smoothness of the cut surfaces did not vary for materials of different hardness. This was shown by sectioning teeth embedded in plastic. Neither did the plastic reduce the durability of the wire.

The machine was constructed for sectioning of small, brittle and irreplaceable specimens, such as fossil teeth, with a minimum loss of material, and where operational speed is less important than accuracy and reliability. Routine sectioning of replaceable specimens thicker than 1 cm is more economically done with a diamond cutting wheel. Still, rare specimens of this size may be sectioned successfully by changing wires, or they may be divided for partial sectioning. The surface of a cut deeper than 1 cm will have steps of about 15 μm .