United States Patent [19]

Shimizu et al.

[11] **3,859,876**

[45] **Jan. 14, 1975**

[54] **CUTTING DEVICE FOR AN ULTRASONIC VIBRATION SYSTEM**

[75] Inventors: **Masami Shimizu; Akio Jindai,** both of Tokyo, Japan

[73] Assignee: **Citizen Watch Co., Ltd.,** Tokyo, Japan

[22] Filed: **June 20, 1973**

[21] Appl. No.: **371,855**

[30] **Foreign Application Priority Data**

June 23, 1972 Japan 47-62929

[52] **U.S. Cl.** .... **82/36 R,** 29/DIG. 46, 82/DIG. 9

[51] **Int. Cl.** **B23b 29/04**

[58] **Field of Search** .... 82/DIG. 9, 36 R, 36 A; 51/59 SS; 29/DIG. 46, 96

[56] **References Cited**

UNITED STATES PATENTS

2,748,298	5/1956	Calosi et al.	82/DIG. 9 X
3,056,320	10/1962	Findley	29/DIG. 46
3,580,136	5/1971	Bodine	90/64

FOREIGN PATENTS OR APPLICATIONS

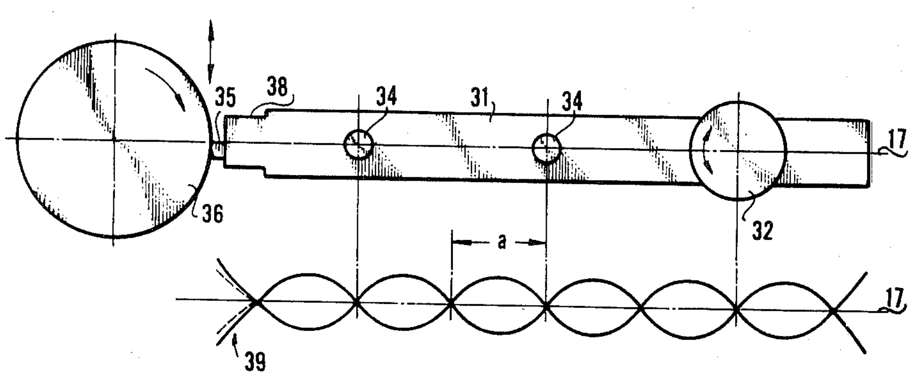
602,801	6/1948	Great Britain	51/59 SS
1,087,440	2/1955	France	82/DIG. 9

Primary Examiner—J. M. Meister
Assistant Examiner—W. R. Briggs
Attorney, Agent, or Firm—Ernest G. Montague; Karl F. Ross; Herbert Dubno

[57] **ABSTRACT**

A cutting device for an ultrasonic vibration system comprises an elongated tool having a cutting edge formed on the front end thereof, and a torsional transducer attached to the tool body at a nodal point of vibration thereof, as well as, if necessary, an amplifier horn is positioned between the tool body and transducer, so that the torsional transducer serves to apply an elastic vibration to the tool body.

3 Claims, 6 Drawing Figures



PATENTED JAN 14 1975

SHEET 1 OF 2

3,859,876

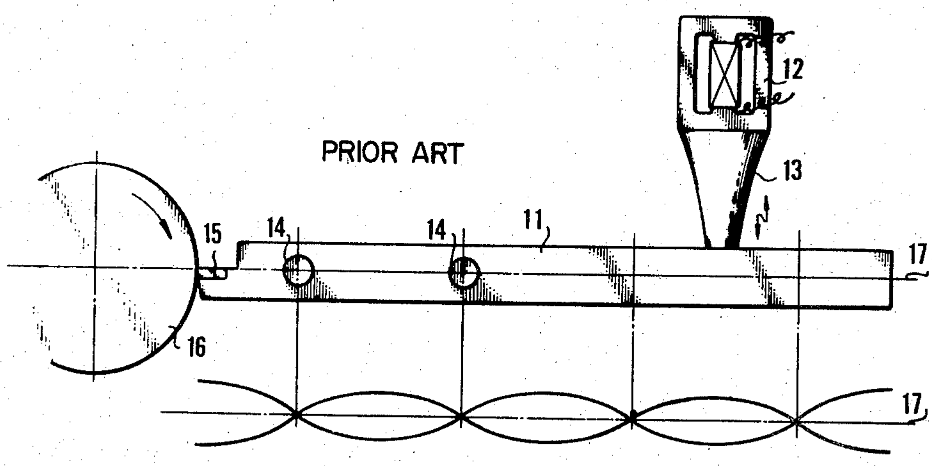
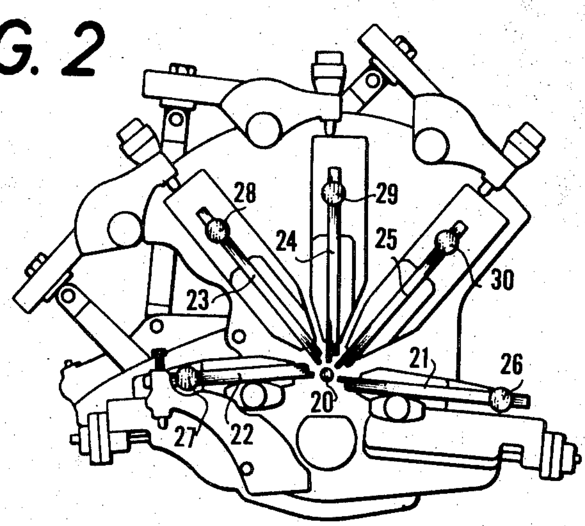


FIG. 1

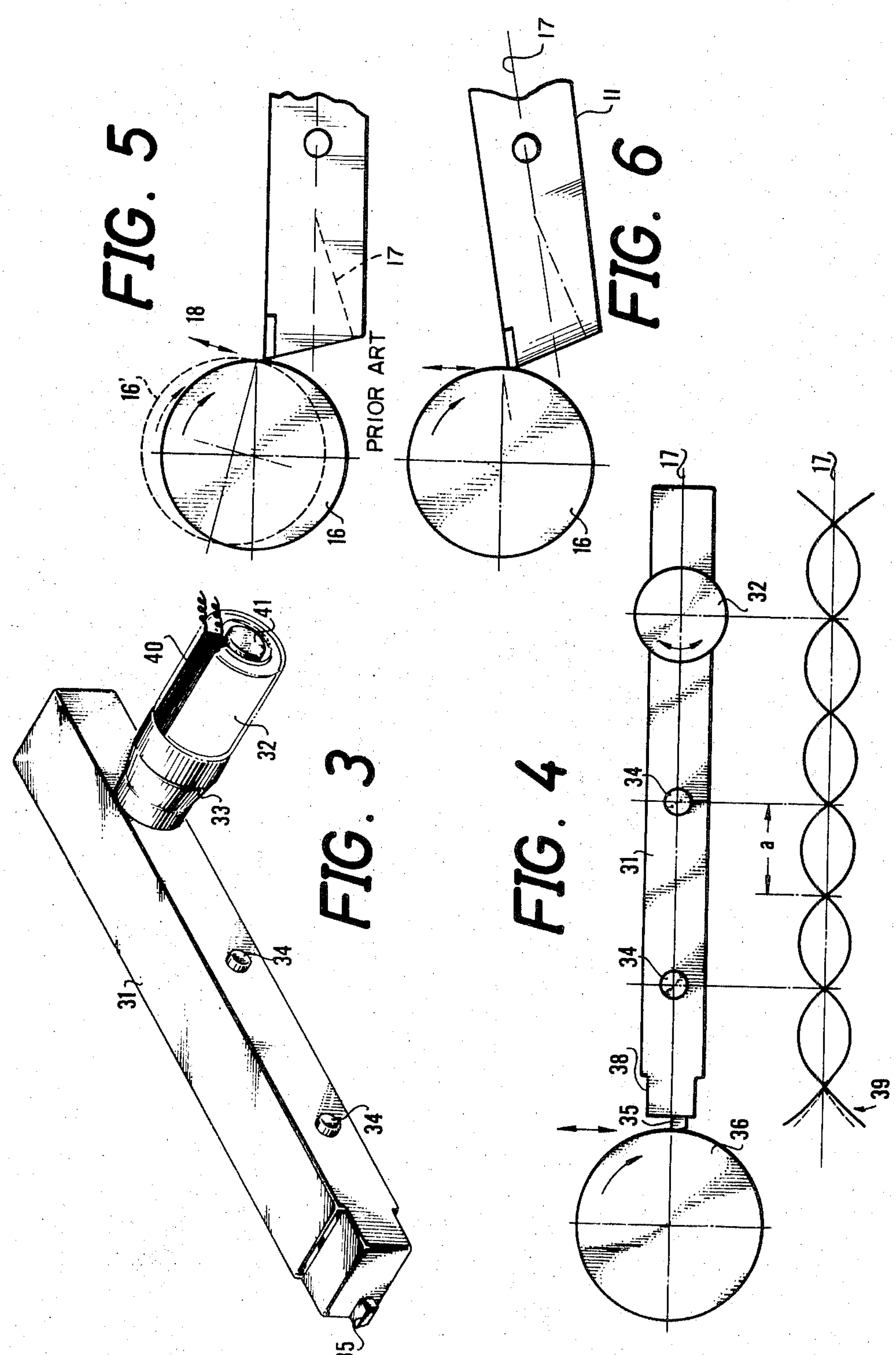
FIG. 2



PATENTED JAN 14 1975

3,859,876

SHEET 2 OF 2



CUTTING DEVICE FOR AN ULTRASONIC VIBRATION SYSTEM

SPECIFICATION

The present invention relates to a cutting device for an ultrasonic vibration system mainly used in a lathe and having a cutting tool elastically vibrated in a cutting direction.

It has been well known that ultrasonic vibration can be applied to a cutting tool body in a cutting operation so as to reduce the cutting resistance and thereby obtain a product having a smooth surface and prolong the tool life.

FIG. **1** indicates an ultrasonic vibrator for a prior-art cutting device operative with bending vibration as one of several systems using longitudinal vibration, torsional vibration or bending vibration. In this case, a longitudinal vibration generated by means of a transducer **12** is amplified by a horn **13** and applied to a point located at the center of a vibration wave defined for a cutting tool body **11** as shown in FIG. **1**, and at which the horn **13** is coupled to the tool body **11.** The tool body **11** is supported by setting pins attached thereto at two nodal points of vibration and undergoes transverse vibration on a neutral plane **17** on which are positioned the nodal points of vibration, so as to vibrate a chip **15** in a cutting direction as the cutting edge of said chip **15,** which is attached to the front end of the tool body **11,** engages the surface of a workpiece **16** rotated.

Since the longitudinal vibration of the transducer involved in this cutting device must be directed parallel to a direction to which the cutting edge of the chip is vibrated, such an ultrasonic vibration system can not be used in an automatic lathe having a plurality of tools **21** to **25** positioned as illustrated in FIG. **2,** because the cutting device does not have space sufficient to allow the transducer to be installed between the tool bodies.

An object of this invention is to provide a cutting device using an ultrasonic vibration system for an automatic lathe as mentioned above, even if the cutting device only has a slight space between tool bodies.

The cutting device of this invention is provided with a torsional transducer attached to the side of a tool body, preferably via an amplifier horn, so that the torsonal transducer serves to apply a transverse vibration to the tool body. The torsional transducer relative to this invention can be adapted to the automatic lathe as indicated by reference numbers **26** to **30** in FIG. **2** wherein the transducers **26** to **30** are attached to the tool bodies **21** to **25** in a manner so as extended in a direction perpendicular to a plane of the paper.

The features and advantages of this invention will become more readily apparent from the following detailed description with reference to the accompanying drawing, in which:

FIG. **1** is a side view of a cutting device according to the prior technique;

FIG. **2** is a front view of an automatic lathe using an ultrasonic vibration system according to this invention;

FIG. **3** is a perspective view of a cutting device of an ultrasonic vibration system embodying this invention;

FIG. **4** is a side view of the cutting device of FIG. **3**; and

FIGS. **5** and **6** are exaggerated side views of the prior cutting device wherein the action of the tool and workpiece is more clearly illustrated.

The cutting device illustrated in FIGS. **2** to **4** comprises a tool **31** having a bar-shaped body **31*a*** and a chip **35** mounted on the front end of the tool body **31**a, and a torsional transducer **32** of convenient type which comprises a cylindrical ferrite core, a coil **40** attached to the core, and a ferrite pole **41** inserted through the assembly of the core and coil. The cutting device preferably involves an amplifier horn **33** connected with the ferrite core and attached to the side of the tool body **31*a*** by soldering or means of threaded screws. The attaching position of the horn **33** to the tool body should be a nodal point of vibration of the tool body. Though the transducer **32** is here connected through the horn with the tool body, it may be connected directly with the tool body at a nodal point of vibration. The cutting tool **31** has two set pins **34** in order to set the tool body **31*a*** to a tool holder (not shown). The set pins **34** are attached to the tool body **31*a*** at the nodal points of vibration of the tool body. The pins may be fixed to the side of the tool body, although we prefer to pivot the tool body with the pin end rotatably inserted into a journal bore formed in the tool body side and if necessary, to lubricate it by a graphite or molybdenum disulfide.

In the cutting operation, the turning center of a workpiece **36** preferably agrees with and is aligned with or lies in a neutral plane **37** of the nodal points of vibration and the cutting edge of the chip **35.**

The chip **15** of the prior cutting tool as shown in FIG. **1** is attached to the front end of the tool body with its cutting edge parallel to a central plane **17** apparently defined to the middle portion of the tool width and deviating slightly from a true neutral plane **17′**. Accordingly, the cutting edge of the prior cutting tool is vibrated with an error angle to a tangential direction of the rounded surface of the workpiece **16,** because a quantity of the tool body is distributed asymmetrically to the central plane by the cutting chip being one-sided, whereby the cutting edge is really vibrated in a direction indicated in FIG. **5** by an arrow line **18.** In this case, in order to compensate for the vibrating direction of the cutting edge, the workpiece must be adjusted to a position as indicated in FIG. **5** by a dotted line **16′**, or the tool body must be inclined as illustrated in FIG. **6** so as to align the vibrating direction of the tool with the tangential direction of the workpiece. Nevertheless, such compensation is unsighted and very difficult to perform.

In contradistinction with the above-mentioned prior technique, the cutting tool of this invention has a cutting edge effectively vibrated for an elongated amplitude as illustrated in FIG. **4** by a reference number **39,** because the front end portion **38** of the tool body is made in a thickness thiner than that of the other portion of the tool body. Of course, the top end portion **38** may be made with a width narrower than that of the other portion of the tool body. Such a cutting tool results in improved cutting speed.

Furthermore, though the vibration of the cutting edge is generally damped due to the cavitation generated as cutting oil supplied to the cutting edge avoidably flows to the supported portion of the tool body ("cavitation" in this case means that the vibration of the solid member is damped by liquid vaporized in expansion as the liquid material is brought into contact with the solid member under ultrasonic vibration so as to produce the vacuum space between both materials.).

The cutting tool of this invention as shown in FIGS. 3 and 4 conveniently includes a stepped form which prevents the flowing of the cutting oil toward the based portion of the tool body, so that the effective vibration of the cutting edge is maintained.

This invention also contemplates the use of a plurality of torsional transducers which, though not shown in the drawing, are attached to the tool body at nodal points of vibration, if necessary, via a plurality of horns.

We claim:

1. A cutting device in an ultrasonic vibration system comprising:

an elongated tool body having a symmetry plane through the center of said body;

means forming a cutting edge at a front end of said body substantially at said plane;

means for mounting said body so that the natural transverse bending vibration mode of said body has nodal points lying in said plane whereby said plane coincides with the neutral plane of vibration of said body;

a torsional transducer operatively coupled to said body with its axis of torsional vibration lying in said plane and transverse to the longitudinal extension of said body at one of said nodal points; and

an amplifier horn interposed between said body and said transducer to transmit bending vibration from said transducer to said body.

2. The cutting device defined in claim **1** wherein a plurality of such transducers and respective amplifier horns are provided at respective nodal points along said body.

3. The cutting device defined in claim **1** wherein said body has a front end portion of a thickness thinner than that of the rest of said body so as to increase the amplitude of said cutting edge in a direction transverse of said body.

* * * * *