United States Patent

Mogaki

[15] **3,657,844**

[45] **Apr. 25, 1972**

[54] VIBRATION SANDER

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[73] Assignee: **Nitto Kohki Company Limited,** Ohta-ku, Tokyo, Japan

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[30] **Foreign Application Priority Data**

May 14, 1969 Japan.....44/37193

[52] **U.S. Cl.**.....**51/170 MT,** 259/1, 15/97, 74/87

[51] **Int. Cl.**.....**B24b 23/00**

[58] **Field of Search**.....51/170 R, 170 MT, 170 TL; 74/87; 15/22, 98, 97; 259/1, DIG. 42, DIG. 43

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Primary Examiner—William R. Armstrong
Attorney—Flynn & Frishauf

[57] **ABSTRACT**

A sanding pad covered over its external surface with sand paper or cloth receives vibration from a driving means, which includes a rolling member circulating at high speed along a continuous path in a circulator under the pressure of compressed air, a continuous rotational vibration being generated by the centrifugal force of the circulating rolling member.

20 Claims, 22 Drawing Figures

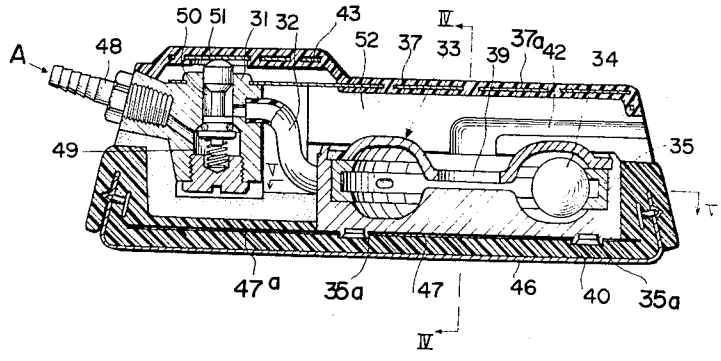


FIG. 1

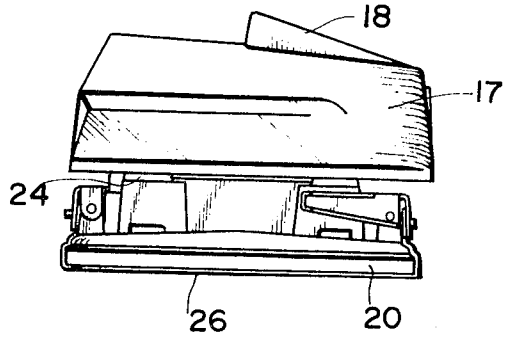
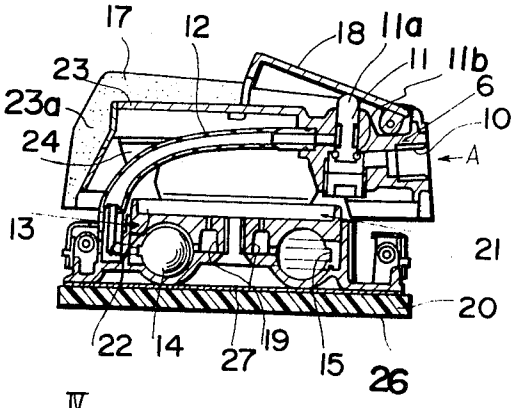


FIG. 2



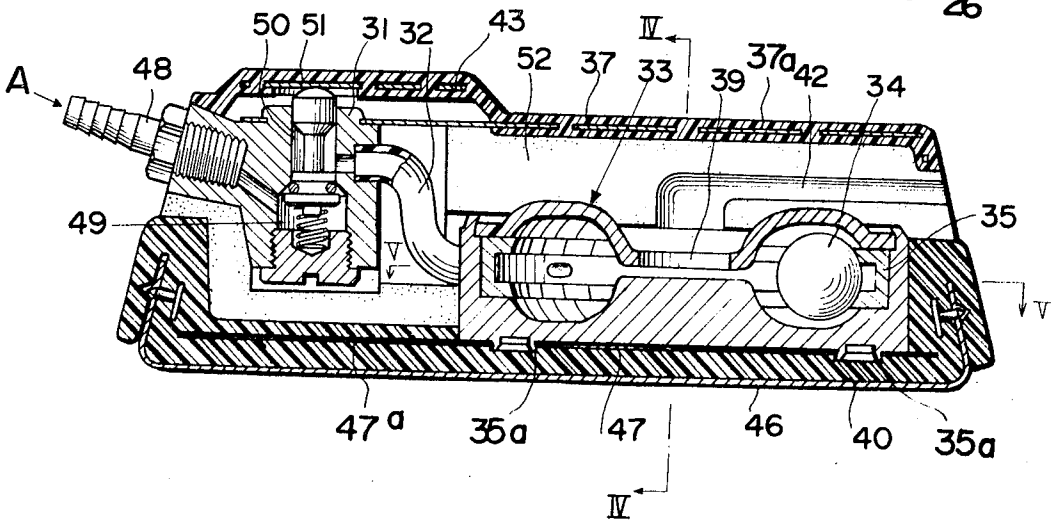


FIG. 3

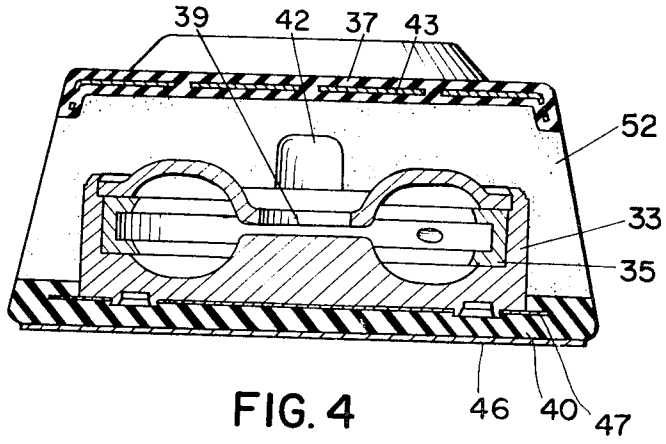


FIG. 4

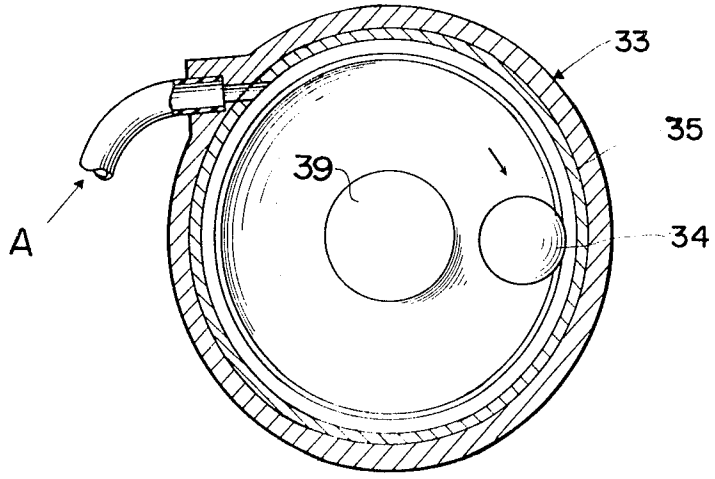


FIG. 5

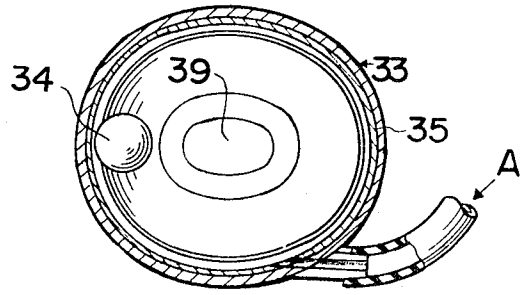


FIG. 6

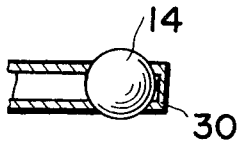


FIG. 7

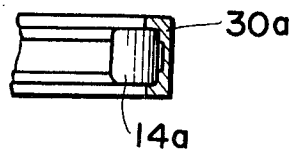


FIG. 8

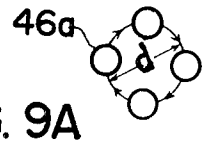


FIG. 9A

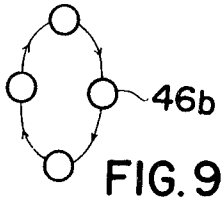


FIG. 9B

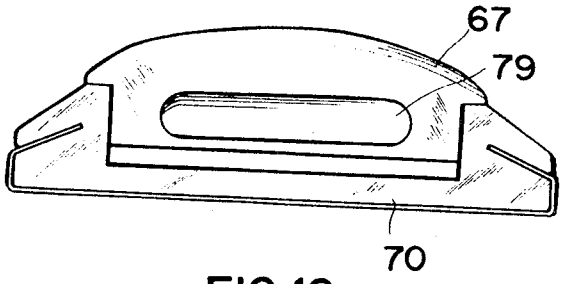


FIG. 10

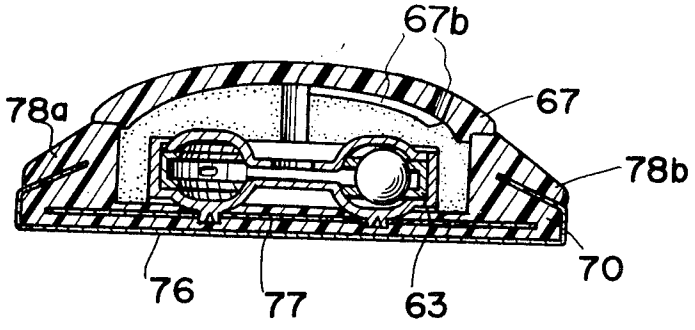


FIG. 11

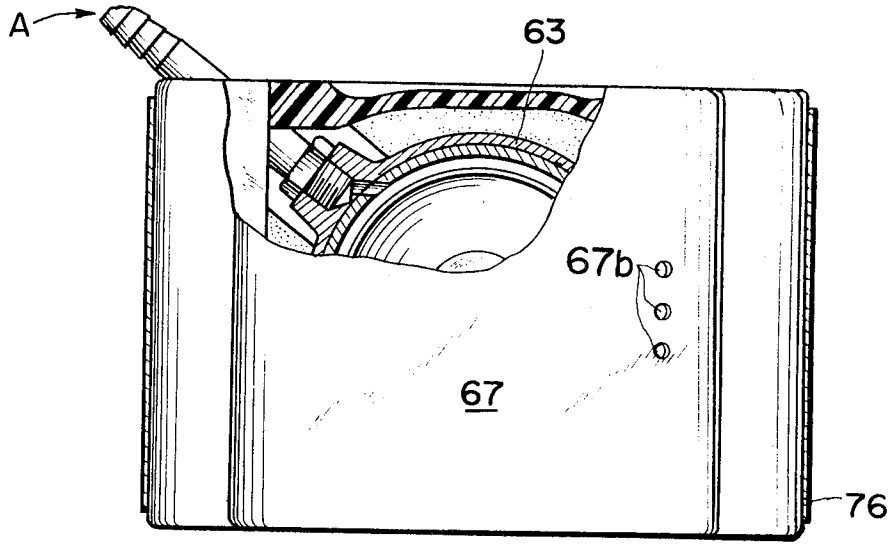


FIG. 12

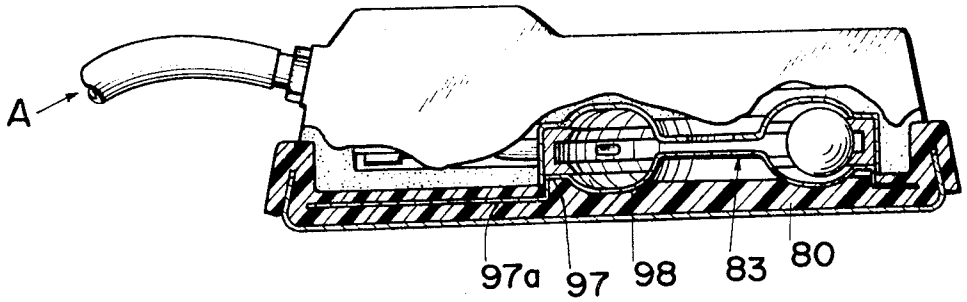


FIG. 13

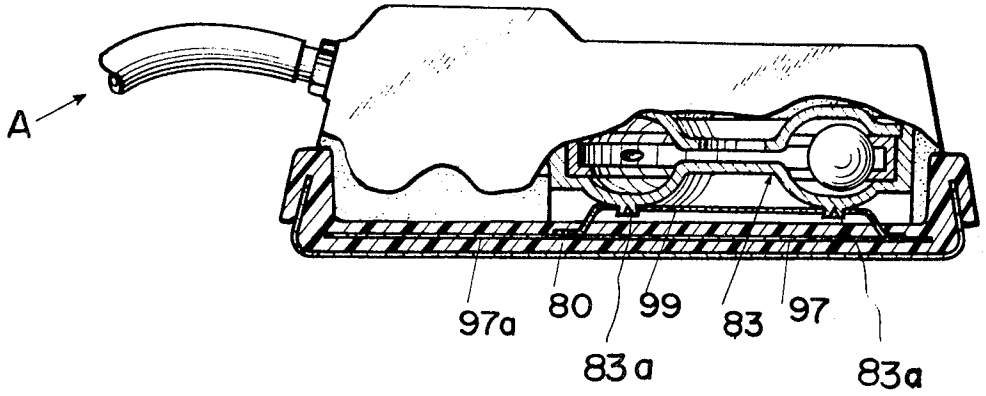


FIG. 14

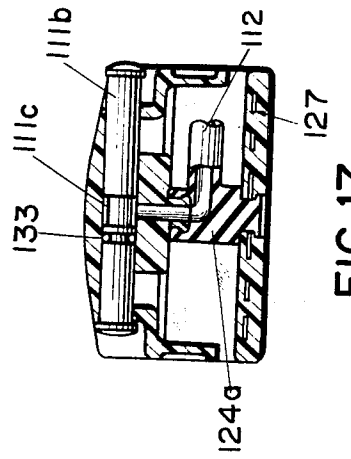


FIG. 17

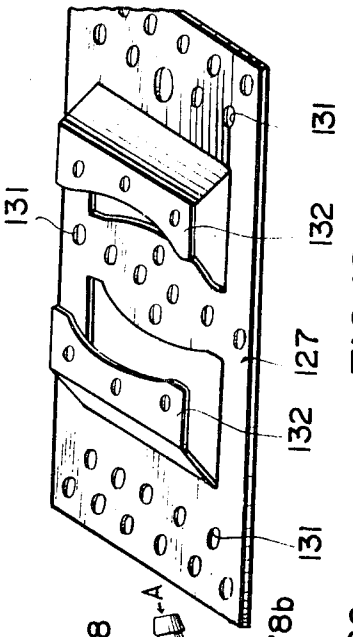


FIG. 18

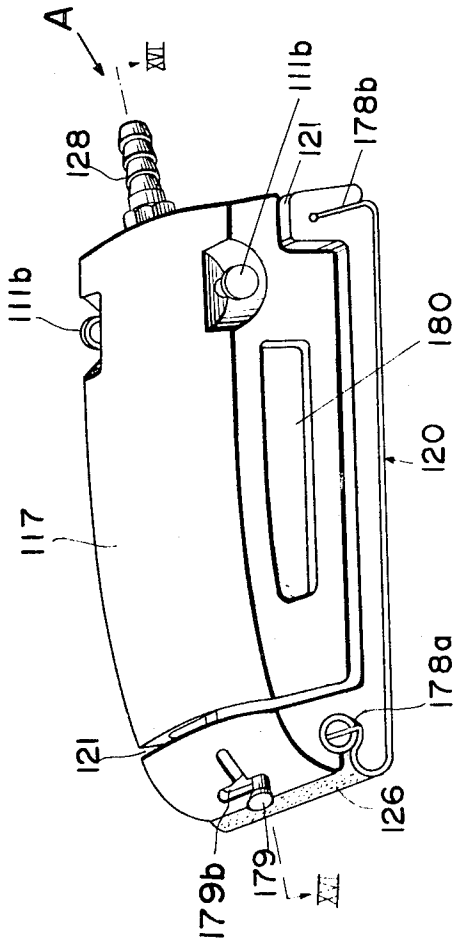


FIG. 15

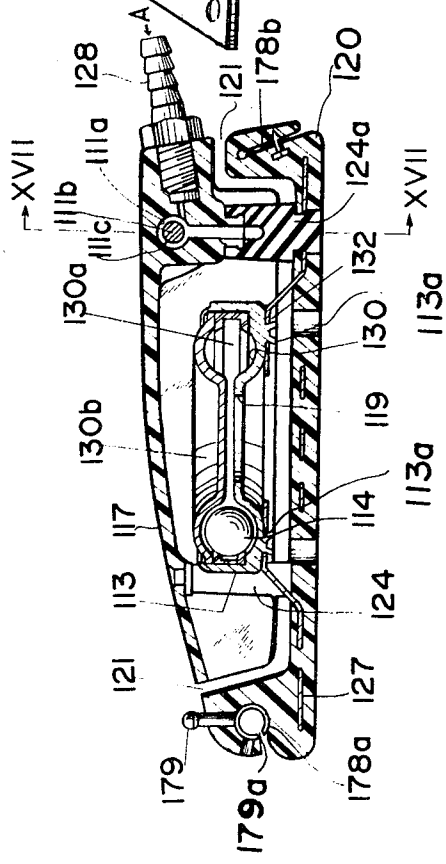


FIG. 16

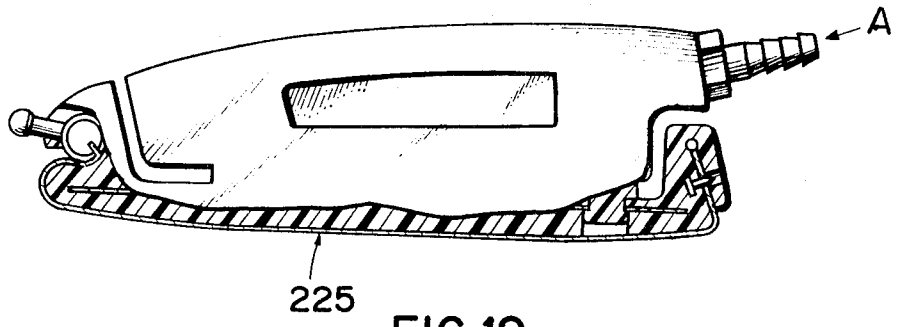


FIG. 19

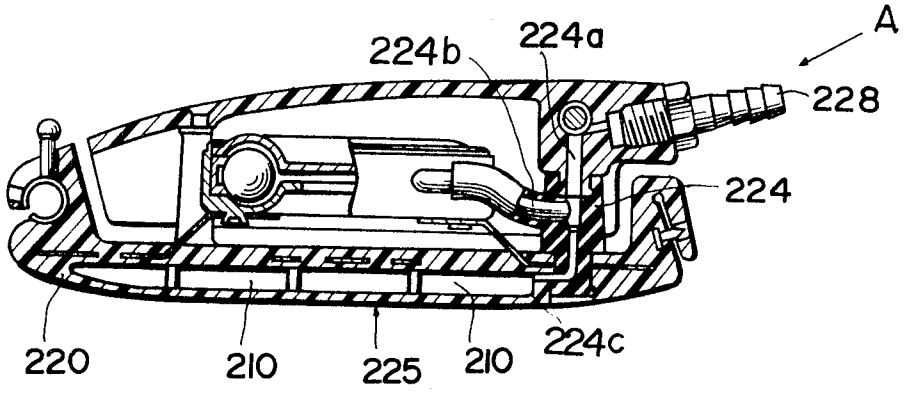


FIG. 20

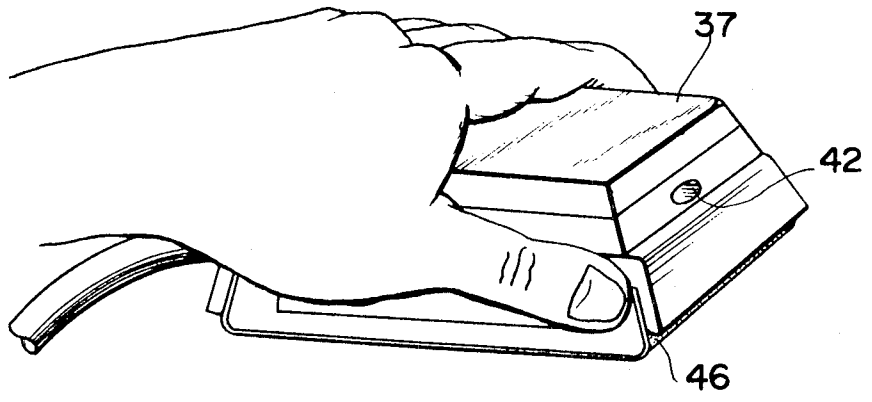


FIG. 21

tion receiving plate **27** on the other surface thereof. The sanding pad **20** is made of flexible materials such as rubber and the like so as to conform with the surface to be sanded to thereby obtain a large contact area, thus providing a high sanding efficiency. There are, however, some materials or shapes of the sanding pad which would absorb the rotational vibration generated by the driving means **13** if the pad **20** were secured directly to the driving means **13**. Accordingly, the vibration receiving plate **27** is employed to prevent the above absorption of the vibration in order to provide more effective sanding.

The second embodiment is described hereinbelow with reference to FIGS. **3–5**. This vibration sander is similar to the sander of FIGS. **1** and **2**, but differs in the construction of the upper cover and of the supply and exhaust means for the compressed air.

The compressed air A is supplied through a connector **48** threadably fastened at one end of a valve assembly **31**. The air A is supplied to the driving means **33** through the valve passages **49** and **50** inside the valve assembly **31** and through a flexible connecting pipe **32**. In driving means **33** there is arranged a circulator **35** enclosing therein a rolling member **34** which circulates at high speed along the circulation orbit by means of the compressed air A. In this embodiment, the means defining the orbital path of the circulator is channel shaped and contoured to fit to the spherical shaped rolling member **34**. A rotational vibration of the driving means **33** is generated by the centrifugal force of the rolling member **34** circulated at high speed along said orbit. The circulation orbit shape is designed according to the shapes of rolling members and in accordance with the application.

The exhaust air is passed out through an exhaust port **39** positioned at the middle of the driving means **33** and through the exhaust passage **42**. The sanding pad **40** having the sand paper or clots **46** thereover is mounted to the bottom surface of the driving means **33**. As shown in FIG. **3**, a vibration receiving plate **47** is positioned under the bottom surface of the driving means **33** and under the bottom of the valve assembly **31**. The plate **47** has holes therein receiving tabs **35***a* to couple the vibrations to plate **47**. The plate under the bottom surface of the valve assembly is called the extended vibration receiving portion **47***a*. The plates **47** and **47**a are mounted to pad **40** to improve vibration transmission to the surface being sanded, thereby improving sanding efficiency.

The upper cover **37** comprises a base plate **43** as the core material, and resilient material such as rubber **37**a provided outside thereof. A press plate **51** for manually switching on the valve assembly **31** is combined with the upper cover **37**. Driving means **33** is connected to the cover **37** by means of vibration absorbent materials **52** such as sponge rubber and the like, interposed therebetween. The operation of the valve assembly **31** in conjunction with the driving means **33** should be self-evident in view of the above description.

If the press plate **51** in the resilient upper cover **37** is forced down to open the switchable passages **49** and **50** of the valve assembly, the compressed air A is supplied into the circulator **35** from one end in the tangential direction of the orbital path thereof, as shown in FIG. **5**, for example, causing the rolling member **34** to circulate at high speed along the circulation orbit in the direction of the arrow, thereby generating the continuous rotational vibration due to the centrifugal force of said rolling member **34**. The continuous vibration may possible additionally provide an impact force, depending upon the shape of the circulation orbit.

The continuous rotational vibration is transmitted to the sanding pad **40** covered with the sand paper or cloth **46** to effect a sanding operation. More effective sanding is achieved by pressing the sander against the surface to be sanded and moving the sander in the same direction as the circulating direction of the rolling member **34**.

FIGS. **9**A and **9**B show the sanding conditions of respective sands **46***a* and **46***b* of the sand paper or cloth **46**, using circulators **35** having circular and elliptical shaped orbits, respectively. These figures show that the sand acts along the respective circulation orbits, thus providing very effective sanding.

Using the embodiment of FIG. **3**, the following data applies:

Inner diameter of circulator	50 mm.
Diameter of rolling member (steel spherical body)	12 mm.
Pressure of compressed air	3 kg.
Circulation rate of spherical rolling member approx.	4,600 r.p.m.
Diameter (d) of rotational vibration	d = 1 mm.

Referring now to FIGS. **10** to **12**, a third embodiment of the vibration sander is characterized by the manner in which the vibration receiving plate **77** and the driving means **63** are coupled together. This embodiment, however, is similar in its construction to those embodiments described above and the different parts will be explained hereinbelow.

The lower surface of the driving means **63** is coupled to a pad **70**, which is made of flexible materials such as rubber and the like and which has holding means **78**a and **78**b to grip and hold the sand paper or cloth **76** at the ends thereof. The driving means **63** is covered on the upper and side parts thereof with the upper cover **67** made of the vibration absorbent materials such as sponge rubber or the like. Concave portions **79** are provided in both upper surface sides to form a handle (see FIG. **10**). The rotational vibration generated by the driving means **63** is transmitted to the sanding pad **70** and then to the sand paper or cloth **76** held over the external surface thereof through the vibration receiving plate **77** which is directly coupled to the lower surface of the driving means **63**. Vibration receiving plate **77** has holes therein which receive extending portions **63**a of driving means **63**, thereby coupling vibration thereto. In this embodiment, the vibration receiving plate **77** is encased within the sanding pad **70** and extending portions **63***a* extend into pad **70** and engage the holes in plate **77**. In this manner the vibration of the driving means **63** can be transmitted to the sanding pad surface with little vibration loss. The vibration receiving plate **77** is preferably made of a flexible thin plate, such as spring steel, so the sanding pad will be flexible and will conform to the shape of virtually any curved surface to be sanded.

A valve means for compressed air is not shown in this embodiment and may be provided either within or external to the sander. If provided within, the same types of valves as previously described may be used. Air is received as shown in FIG. **12** and is exhausted as shown in FIG. **11** through exhaust port **67***b*. Details of the operation of this sander should be apparent to those skilled in the art.

FIGS. **13** and **14** show embodiments using different types of vibration receiving plates coupled to the driving means. In FIG. **13**, the vibration receiving plate **97** is directly combined with (or integral with) the bottom portion **98** of the driving means **83**. A portion **97***a* of plate **97** extends under the portion of the sander housing the valve means. The plate portion **97***a* and the portion **97***b* at the other end of plate **97** are embedded in sanding pad **80** to transmit vibrations thereto. In FIG. **14**, an intermediate plate **99** is positioned between the vibration receiving plate **97** and the driving means **83**. In this embodiment, the vibration receiving plate **97** is extended (via portion **97***a*) to under the bottom surface of the valve assembly (as also indicated in FIG. **3**), so that the vibration of the driving means **83** can be transmitted to the whole sanding pad **80** via the extended vibration receiving portion **97***a* as well as via the plate **97**. The plate **97**, **97***a* is embedded in pad **80** in this embodiment and intermediate plate **99** is secured to plate **97**. Plate **99** has holes therein which engage extended portions **83**a of driving means **83** for transmission of vibrations.

Another embodiment of the vibration sander is shown in FIGS. **15** to **18**. In this embodiment a space is provided between the upper cover **117** and the sanding pad **120** so as not to transmit the vibrations to the upper cover. Also, the vibration receiving plate is specifically designed, the sand paper or cloth is capable of easy replacement, and the valve assembly is provided with an accurate valve switching means.

VIBRATION SANDER

BACKGROUND OF THE INVENTION

This invention relates to a vibration sander and more particularly to a vibration sander operated with compressed air.

Several kinds of motor operated sanders are known, such as disk sanders and belt sanders, which are used for rough sanding. However, fine sanding tools have not yet been proposed. In the painting of automobile bodies, high quality furniture, and the like, several undercoats of paint are applied prior to applying the finishing coat. The undercoats must then be manually sanded by a sand paper or cloth or wet-ground prior to applying the finishing coat, thereby diminishing the efficiency of the painting operation.

The main object of this invention is to increase the efficiency of a sanding operation by providing a vibration sander which facilitates a fine sanding operation and which has a high efficiency.

Another object of this invention is to provide a vibration sander which is relatively small, easy to use, and which has a simple construction.

Still another object is to provide a vibration sander having a highly flexible vibration surface over which the sanding pad is secured, to conform with the shape of the surfaces to be sanded, thereby reducing vibration loss.

Still another object of this invention is to provide a vibration sander wherein a greatly reduced amount of vibration is transmitted to an operator's hand.

SUMMARY OF THE INVENTION

In accordance with the present invention, a vibration sander for use with compressed air includes a driving means which receives the compressed air and a sanding pad mounted to the driving means to transmit continuous rotational vibrations generated by the driving means to a surface to be sanded. The driving means includes a circulator which defines a cavity having a continuous predetermined orbital path therein, the compressed air being fed to the circulator. A rolling member is located within the cavity to traverse the continuous orbital path at a high speed under pressure of the compressed air, thereby providing continuous rotational vibration to the driving means due to the centrifugal force of the rolling means as it traverses the orbital path. Also provided is exhaust means for exhausting air from the circulator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of one embodiment of the vibration sander according to this invention;

FIG. 2 is a longitudinal sectional view of the embodiment of FIG. 1;

FIG. 3 is a longitudinal sectional view of a second embodiment of the vibration sander according to this invention;

FIG. 4 is a cross sectional view taken along line IV — IV of FIG. 3;

FIG. 5 is a partial cross sectional view taken along line V — V in FIG. 3 illustrating the rolling member and the circulator;

FIG. 6 shows a cross sectional view of an oval shaped circulator;

FIGS. 7 and 8 are partial cross sectional views of a circulator showing the shapes of a rolling member;

FIGS. 9A and 9B are explanatory views showing respective conditions of the sand paper or cloth during sanding operations;

FIG. 10 is a side view of another embodiment of the invention;

FIG. 11 is a longitudinal sectional view of the embodiment shown in FIG. 10;

FIG. 12 is a fragmentary plane view of the embodiment of FIG. 10;

FIGS. 13 and 14 are side views of other embodiments of the invention with the sanding pad portions removed;

FIG. 15 is a perspective view showing a modified embodiment of the vibration sander shown in FIG. 1;

FIG. 16 is a longitudinal sectional view taken along line XVI — XVI in FIG. 15;

FIG. 17 is a cross sectional view taken along line XVII — XVII in FIG. 16, illustrating the supply and exhaust means for the compressed air;

FIG. 18 is a perspective view of the vibration receiving plate of the sander of FIG. 15;

FIG. 19 is a fragmentary side view of a vibration sander illustrating the slightly curved external surface of the sanding pad;

FIG. 20 is a fragmentary side view of the vibration sander illustrating an internal construction for a sanding pad; and

FIG. 21 is a perspective view illustrating the vibration sander in operation.

The illustrated embodiments of this invention will be described in detail with reference to the drawings hereinbelow.

Referring now to FIGS. 1 and 2, compressed air A is received and passes through the air supply openings 10, through the valve assembly 11 and through the flexible pipe 12 to the driving means 13. The driving means 13 is comprised of a circulator 15 containing therein a rolling member 14 which is circulated at high speed by the supplied compressed air. The circulator, which will be described in more detail below, defines a continuous path which the rolling member traverses. The valve 11 includes a valve member 11a which is forced up by the supplied compressed air to press upwards on the lever 18 which is pivotally mounted to the upper cover 17 and to press against valve seat 11b to prevent air A from entering the unit. When lever 18 is depressed, valve member 11*a* is lowered to open the air passage to operate the sander.

The exhaust air is blown out through an exhaust port connected to the circulator 15 via an exhaust passage 22, and the space 21 formed between the lower and upper portions of the sander.

The upper cover 17 is made up of a base plate 23 (which forms part of the valve assembly 11) as its core material and either rubber or synthetic resin 23a over the core 23. Cover 17 is connected to the lower sanding pad assembly of the sander by means of screws and rubber hollow core cylinders 24 to both ends of said sanding pad assembly, thereby substantially preventing the rotational vibration of the driving means 13 and the sanding pad 20 from being transmitted to an operator.

The driving means 13 comprises the circulator 15 and the rolling member 14 contained therein. FIGS. 5 to 8 show various circulator arrangements. Circulator 15 may be of a circular (FIG. 5), polygonal, elliptical (FIG. 6), a figure "8" or other desired regular or irregular shape, depending upon the particular sanding application. Though FIGS. 1 and 2 show a circular shaped circulator 15, other shapes may be used. The elliptical shaped circulator shown in FIG. 6 is more suitable for obtaining rotational vibration with additional impact force. The cross sectional shape of the circulator 15 is adapted to the shape of the particular rolling member 14 utilized in any particular embodiment. The rolling member 14 utilized in the embodiment of FIGS. 1 and 2 is a spherical body as shown in FIG. 7. The rolling member 14 is circulated at high speed along the circulation orbit 15*a* (see FIG. 5) of the circulator 15 under the substantially constant pressure of the compressed air A, so that the desired rotational vibration can be generated by means of the centrifugal force thereof.

The rolling member 14 may take various shapes, such as a cylindrical shape 14a shown in FIG. 8, a polygonal shape for impact rotational vibration or a plane shape for sliding along the circulation orbit of the circulator 15. In FIGS. 7 and 8, 30 and 30*a* denote the means defining the shape of the orbit of the circulator 15.

As the rolling member 14 traverses the path of the circulator 15 under pressure of the air A, the rotational vibration of driving means 13 is transmitted to the surface to be sanded through a sanding pad 20 mounted to the bottom surface of the driving means 13. The sanding pad 20 is provided with sand paper or cloth 26 on its external surface and with a vibra-

A connector **128** for receiving the compressed air A is threadably coupled to one side end of the upper cover **117** which is made of rubber or the like. The compressed air A is supplied via a pipe (not shown in the drawings) through the connector **128** to a valve chamber **111***a* located within the upper cover **117**. The valve switch **111***b* is movably mounted in valve chamber **111***a* and a space is provided, by means of a concave groove **111***c* (see FIG. **17**) arranged on the body of the valve switch **111***b*, between the valve switch **111***b* and the valve chamber **111***a*. When the switch is open, the compressed air A is passed through a supply pipe **112** (see FIG. **17**) which is connected to the bottom portion of the valve chamber **111**a and is then supplied to the circulator **130** of driving means **113**. The driving means **113** includes a rolling member **114** and the circulator **130** which has a circulation orbit therein. Also, a cover **130***b* is provided thereover. The exhaust port **119** is in the middle portion of the circulator **130** in this sander. The air openings to the circulator are arranged in approximately the tangential direction of the circulation orbit **130***a*. Air is supplied thereto via the supply pipe **112**.

Referring now to FIG. **18**, the vibration receiving plate **127** is shown in detail. The vibration receiving plate comprises a flexible thin plate **127** having a number of holes **131** bored therein. Plate **127** further includes raised portions **132** which are connected to the bottom surface of the driving means **113** to minimize the weight of this tool. The bottom surface of driving means **113** has extending portions **113***a* which engage holes in raised portions **132** to transmit vibrations thereto. The sanding pad **120** utilizes the flexible thin plate **127** as its core which is embedded in flexible materials, such as rubber or the like. Holding means **178***a* and **178***b* for the sand paper or cloth **126** (see FIG. **15**) are provided at both the front and rear ends of the pad **120**. The pad **120** is resiliently joined with the upper cover **117** at one location by means of a strut **124** made of synthetic resin (see FIG. **16**) and at another location by means of a hollow core cylinder **124***a* which also functions as one part of the supply pipe **112**. A space **121** is provided between the upper cover **117** and the sanding pad **120** so as to function as an exhaust passage for the air from circulator **130**.

In this embodiment of FIGS. **15–18**, the sand paper or cloth **126** can be replaced by means of the operation lever **179**. FIG. **15** shows the sand paper **126** in position and FIG. **16** shows the sander with the sand paper removed. The operation lever **179** has a slot **179***a* therein into which the sand paper is placed with the lever **179** in the position shown in FIG. **16**. Prior to this the paper is inserted into holder **178***b* at the other end of pad **120**. Then, the lever **179** is lowered to the position shown in FIG. **15** and is moved to the side to lock same in position in slot **179***b*. This simultaneously locks the sand paper in position and applies tension thereto so that it properly conforms to the shape of pad **120**.

A sealring **133** is provided on the valve switch **111***b* (see FIG. **17**). Both ends of valve switch **111***b* project from respective rear sides of the upper cover **117** for ease of operation. The upper cover **117** is provided at both sides of the middle portion thereof with concave portions **180** which act as handles to facilitate use thereof.

In the vibration sander of the above described construction, the compressed air is supplied to the driving means **113** when the valve switch **111***b* is moved to the position as shown in FIG. **17**. This embodiment is the same as those of the previously described embodiments with respect to the circulation of the rolling member and the generation of the rotational vibration. The compressed air supplied into the driving means **113** is blown out through the exhaust port **119** of this tool and is then passed out through the space **121** between the upper cover **117** and the sanding pad **120**. The rotational vibration is transmitted from the driving means through the connecting portion **132** and through the flexible thin plate **127** to the sanding pad **120** and to the sand paper or cloth **126**. In this embodiment, the valve switch **111**b can be operated without the necessity of applying pressure to the vibration sander against the surface to be sanded, thereby enabling more accurate sanding to be carried out.

Thus, in the embodiment shown in FIGS. **15–18**, by virtue of the space **121** formed between the sanding pad **120** and the upper cover **117** by virtue of the provision of mounting members **124** and **124***a*, very little vibration is transmitted to the upper cover during operation of the device. Further, the vibration receiving plate **127** is fabricated so as to reduce the overall weight thereof to produce a lighter and more easily handled sander. Further, the plate **127** is integral with the mounting members **132** so that additional coupling members do not have to be provided. This produces a simpler to fabricate and more structurally sound device. Further, this embodiment utilizes a mounting arrangement whereby the sand paper or cloth is capable of easy replacement and the valve member does not require constant pressure to be applied thereto for operation of the device. The valve switch **111**b is merely moved form side to side to either operate or turn off the sander. This provides more positive switching and enables more accurate sanding operations to be carried out.

FIGS. **19** and **20** show another embodiment of a vibration sander having the slightly bowed (i.e., convex) sanding pad. The bowed external surface **225** of the sanding pad provides higher sanding efficiency with small pressing force, since the pressing force is applied only to the contact area of the surface to be sanded. Consequently, the whole area of the sand paper or cloth can be used without any loss. FIG. **19** shows the sander with the sand paper or cloth in place and FIG. **20** shows the sander with the sand paper or cloth removed.

Referring to FIG. **20**, the sanding pad **220** is made of flexible material such as rubber and has air chambers **210** formed therein which are in communication with each other. Compressed air supplied via the connector **228** is fed through the valve assembly, through the branch passage **224***a* inside the strut **224**, and through passage **224***b* to the circulator. The air chambers **210** of the sanding pad **220** also receive compressed air therein via branch passage **224***c* in strut **224**. The air pressure makes the outer surface **225** of pad **220** slightly bowed outwardly as shown in FIG. **20**. Thus, the sanding pad **220** is particularly pressed against the surface to be sanded only at the bowed out contact area **225**, thus providing an effective sanding operation with a small pressing force. Moreover, the contact area of the sanding pad **220** is capable of free deformation due to the air chambers **210** which are formed within the flexible sanding pad **220**. Therefore the sanding surface will more easily conform to any surface to be sanded, even surfaces having complicated shapes.

The vibration sanders of the present application are particularly convenient and suitable for fine finishing sanding operations prior to applying a final finishing coat and especially for the sanding of automobile bodies, high quality furniture, and the like.

In the specific embodiments described above, various methods of securing the vibration receiving plate to the driving means are shown, such as the spread apart extending portions **35***a* of FIG. **3**. It should be clear that other mounting methods could be used. Also, various other valve arrangements could be used with the sanders of this invention.

While the invention has been described above with respect to specific embodiments, it should be clear that various other modifications and alterations could be made thereto without departing from the inventive concepts as set forth in the accompanying claims.

I claim:

1. A vibration sander for use with compressed air comprising:

a housing covering at least the upper portion of said sander;

driving means at least partially covered by said housing for producing rotational vibrations;

at least one hollow core cylinder of resilient material resiliently coupling said driving means to said housing with a space therebetween; and

a sanding pad means fixedly connected below and carrying said driving means with a short distance between said driving means and the working surface of said sanding

pad means, said sanding pad means receiving and transmitting said rotational vibrations to a surface to be sanded;

said driving means receiving said compressed air and including:

a circulator fixedly connected to and carried by said sanding pad means and having a continuous predetermined orbital path formed therein, said compressed air being fed to said circulator;

a rolling member adapted to traverse said continuous orbital path at a high speed under pressure of said compressed air, thereby providing continuous rotational vibration to said circulator and sanding pad means due to the centrifugal force of the rolling means as it traverses said path; and

exhaust means for exhausting air from said circulator.

2. A sander according to claim 1, wherein said orbital path is circular.

3. A sander according to claim 1, wherein said orbital path is elliptical.

4. A sander according to claim 1, wherein said rolling member is spherical.

5. A sander according to claim 1, wherein said rolling member is cylindrical.

6. A sander according to claim 1, wherein said sanding pad means is composed of flexible, resilient material.

7. A sander according to claim 1, wherein said sanding pad means includes a vibration receiving plate directly connecting said sanding pad means to said circulator to more efficiently transmit the continuous vibration of the circulator to the surface to be sanded.

8. A sander according to claim 7, wherein said vibration receiving plate is flexible.

9. A sander according to claim 8, wherein said vibration receiving plate is embedded in a sanding pad.

10. A sander according to claim 7, wherein said vibration receiving plate is integral with said circulator.

11. A sander according to claim 8, comprising an intermediate plate coupling said vibration receiving plate to said circulator.

12. A sander according to claim 1, wherein said sanding pad means comprises sand paper or cloth on the surface thereof remote from said circulator.

13. A sander according to claim 1, wherein the surface of said sanding pad means which contacts the surface to be sanded is outwardly bowed.

14. A sander according to claim 1, wherein sand sanding pad means is provided with at least one air chamber therein to enable the external surface of said sanding pad means to be freely deformable according to the shape of the surface to be sanded.

15. A sander according to claim 14, comprising means feeding a portion of said compressed air to said at least one air chamber.

16. A sander according to claim 1, wherein said compressed air is fed to said circulator in a tangential direction of said orbital path.

17. A sander according to claim 1, wherein said housing is comprised of vibration absorbent materials.

18. A sander according to claim 1, comprising a valve assembly coupling said compressed air to said driving means.

19. A sander according to claim 18, wherein said housing is comprised of vibration absorbent materials enclosing at least a portion of said sander, said cover including means coupled to said valve for actuating said valve.

20. A sander according to claim 1 wherein said at least one hollow core cylinder of resilient material couples said compressed air to said driving means through the hollow core thereof.

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