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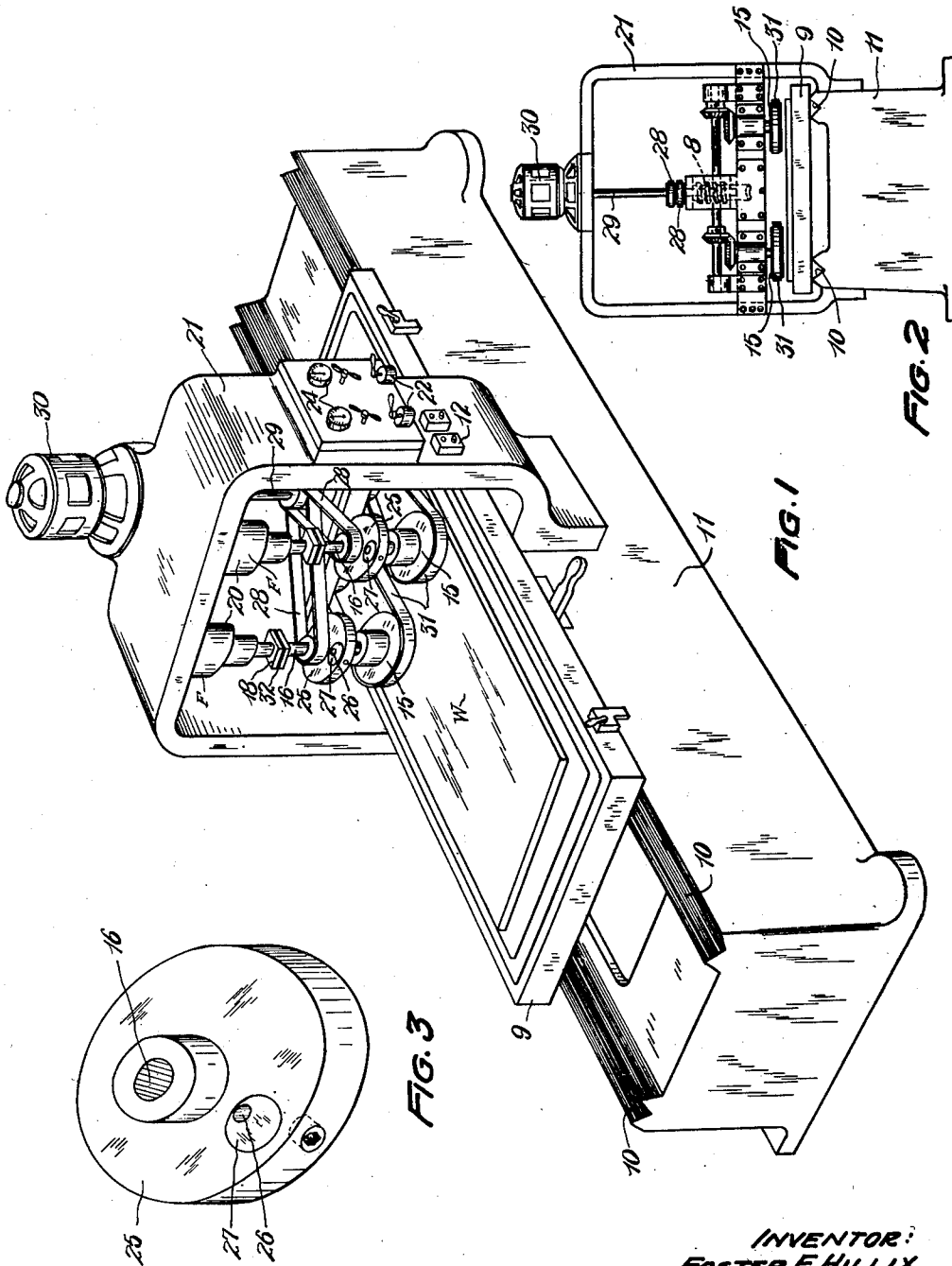
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2,070,944

METHOD AND APPARATUS FOR FINISHING SURFACES

Filed Aug. 9, 1933

5 Sheets-Sheet 1



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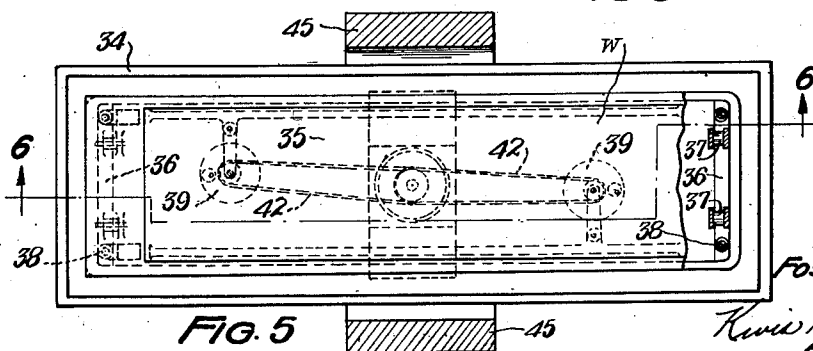
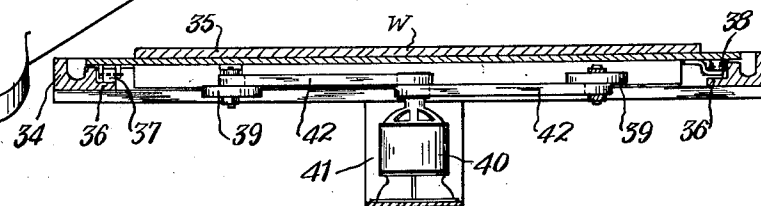
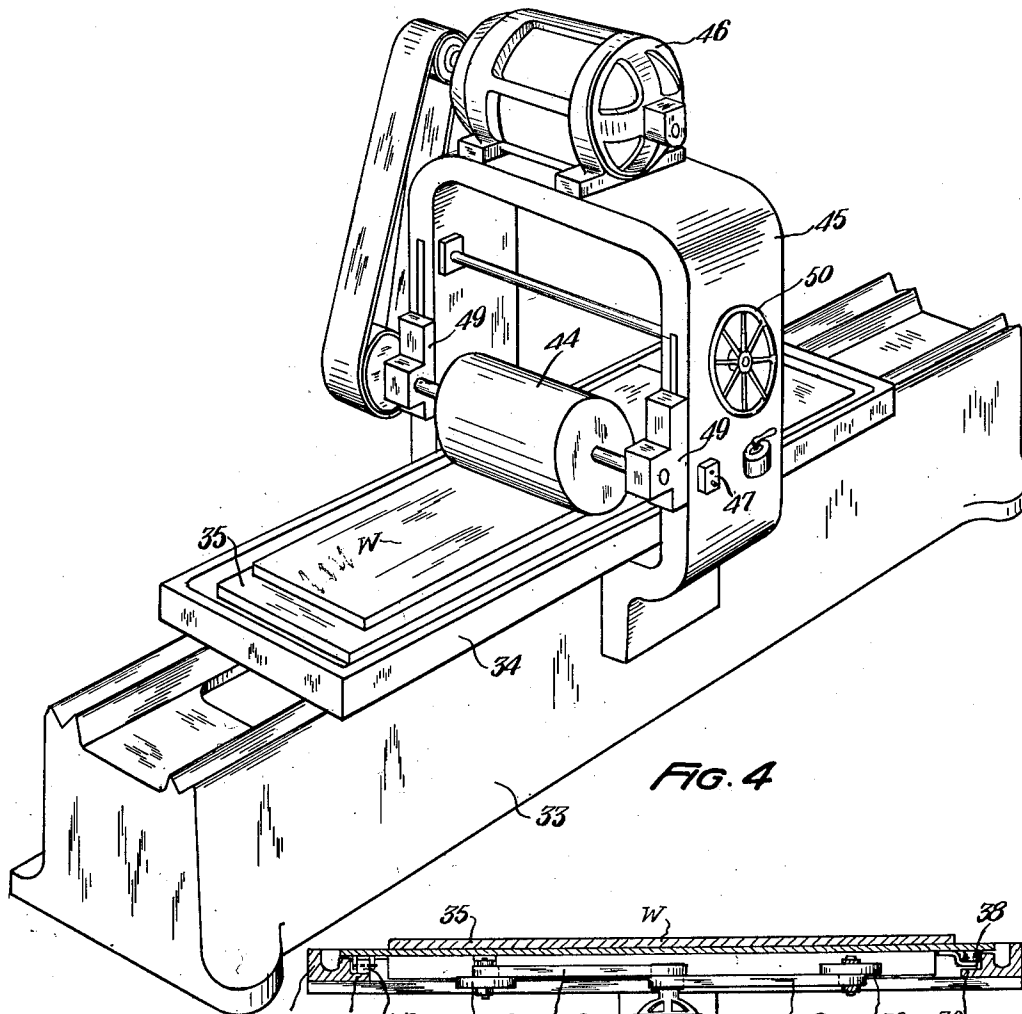
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5 Sheets-Sheet 2



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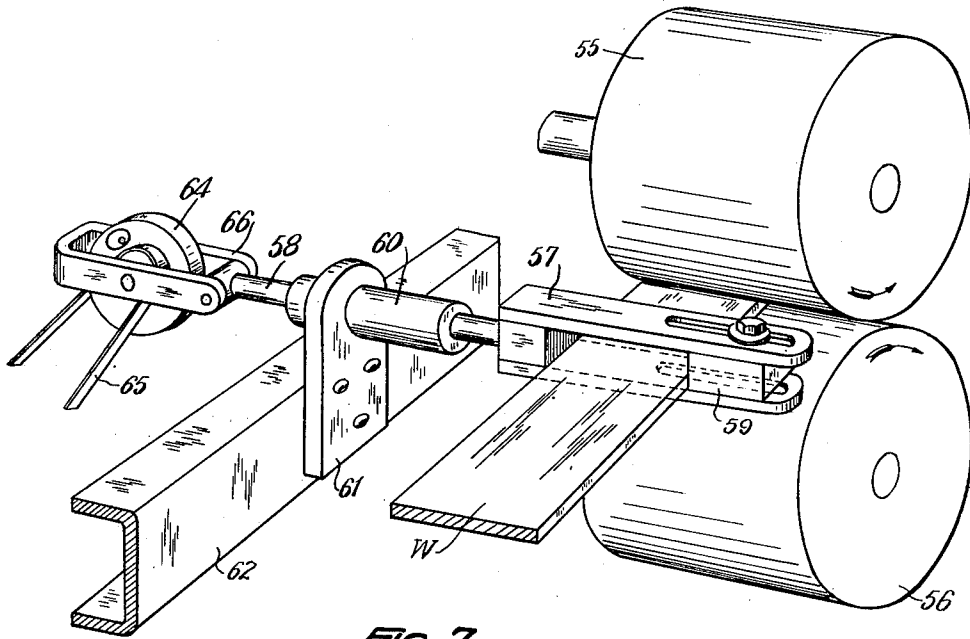


FIG. 7

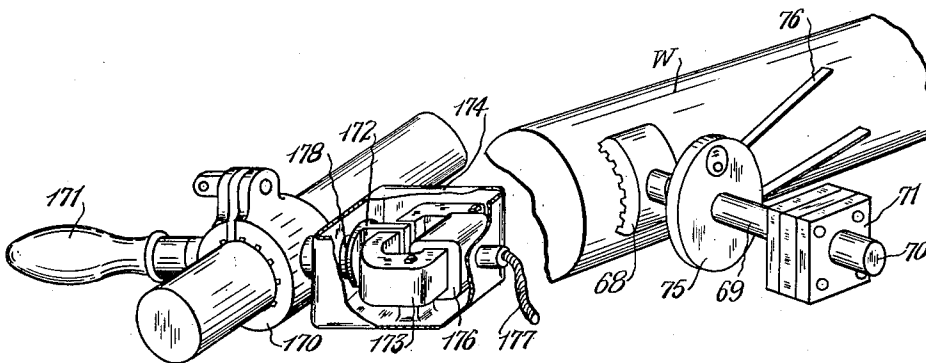


FIG. 8

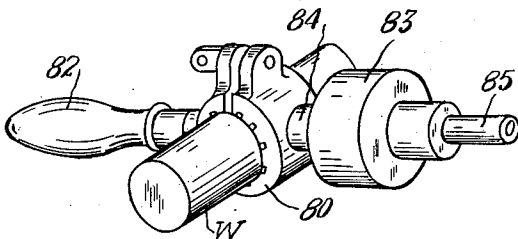


FIG. 9

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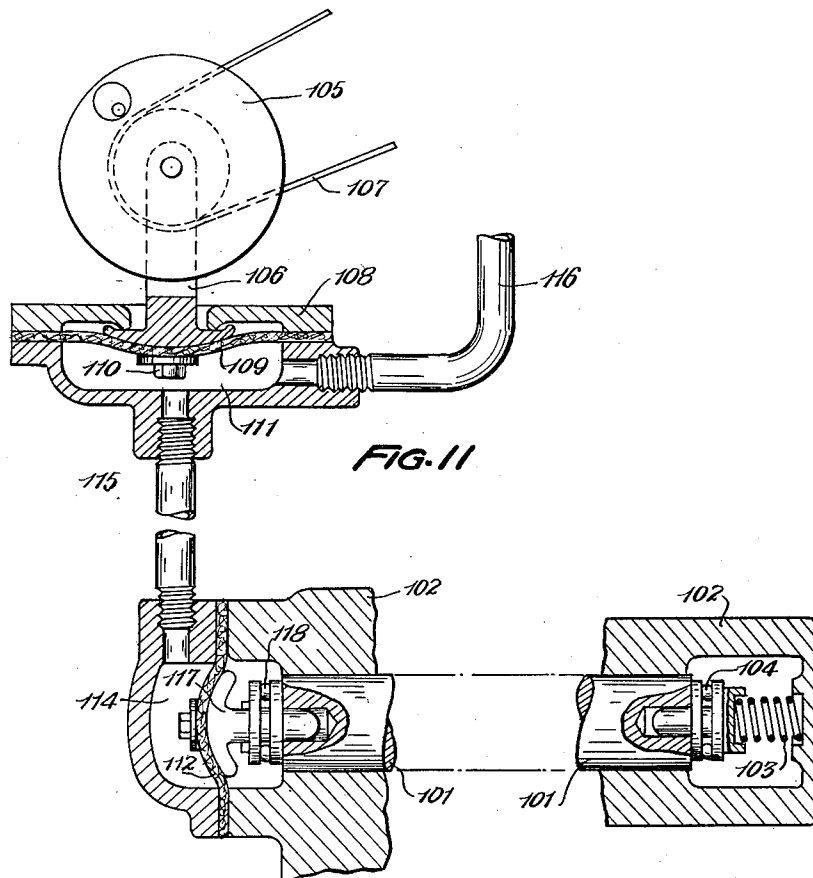
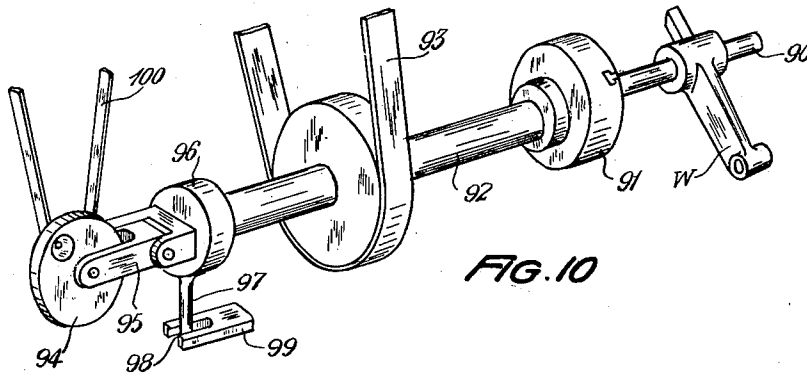
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5 Sheets-Sheet 4



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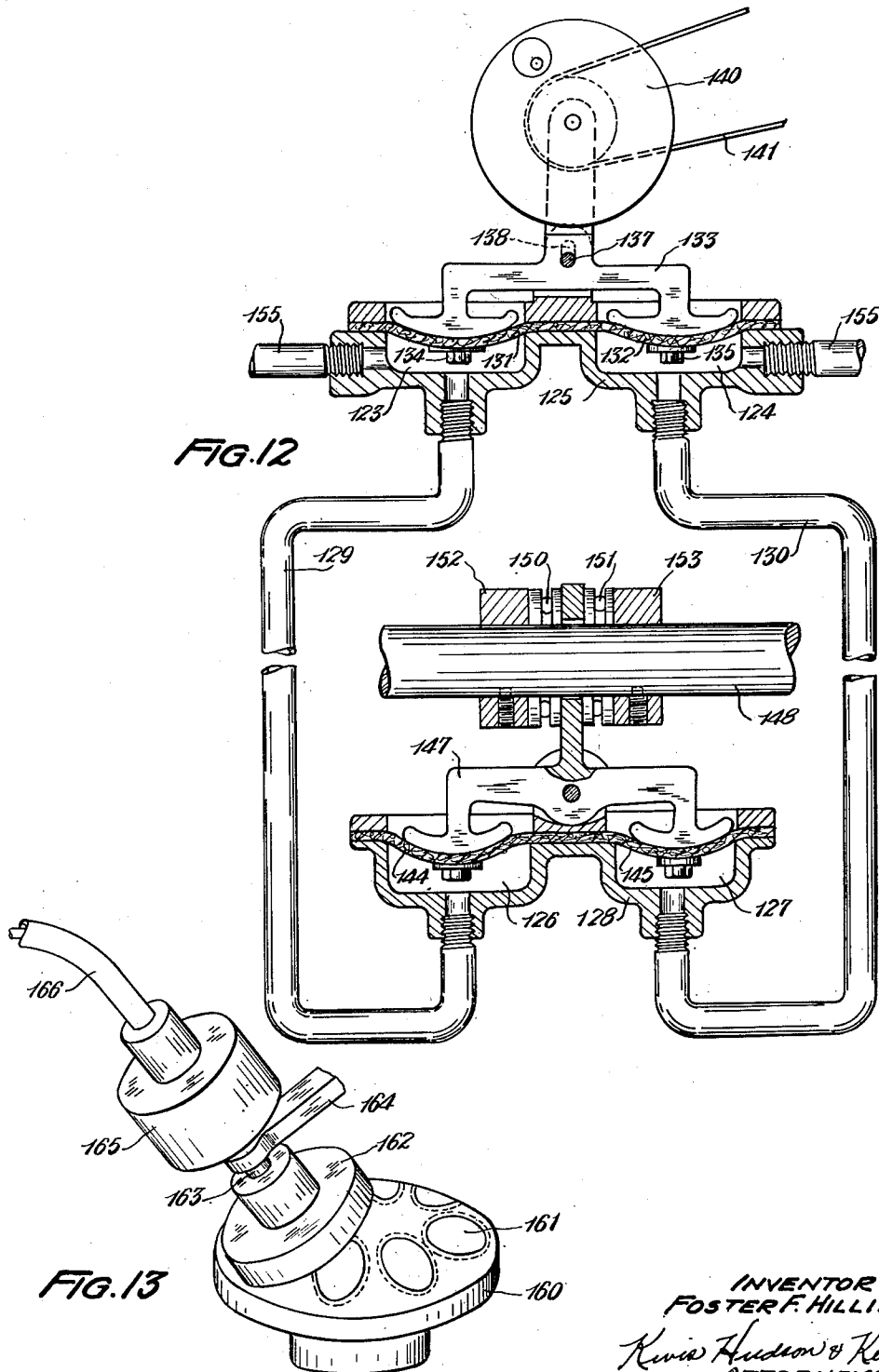
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METHOD AND APPARATUS FOR FINISHING SURFACES

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UNITED STATES PATENT OFFICE

2,070,944

METHOD AND APPARATUS FOR
FINISHING SURFACES

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mesne assignments, to The American Steel and
Wire Company, Cleveland, Ohio, a corpora-
tion of New Jersey

Application August 9, 1933, Serial No. 684,358

3 Claims. (Cl. 51—54)

The present invention relates to the produc-
tion of accurate, smooth surfaces of high finish,
and more particularly to a method of and ma-
chine for honing, lapping, grinding, buffing,
and/or polishing surfaces either plane or curved.

In the prior art, it has been common practice
in the production of smooth surfaces to reduce
the same by cutting or lapping operations em-
ploying wheels, such as abrasive wheels, and lap-
ping heads, wherein the surface is cut by a multi-
plicity of cutting points of irregular shape. The
surfaces thus produced are characterized by hav-
ing an unevenness identified by various terms,
such as "grain marks", "orange peel", etc., which
unevenness depends, among other things, upon
the fineness or coarseness of the wheel and/or
abrasive employed. Coarse wheels and/or abra-
sives are usually employed at first because they
remove the stock rapidly and finer wheels and/or
abrasive substituted therefor until the desired
finish is produced.

Before the present invention, it has always been
considered essential to eliminate all vibration
from both the tool or wheel and the work, to
which end the machines of the prior art have
been built very heavy and rigid. But it has been
found that controlled vibration of relatively high
frequency, preferably in the nature of from 3,000
to 40,000 vibrations per minute, may be imparted
to either the tool or the work, or both, with sur-
prising results not only in the increased smooth-
ness of the surface produced and its freedom from
scratches, but in the increased rate of production.

An object of the present invention is the pro-
vision of a novel method of finishing and/or
working surfaces, such as glass or metal, etc.,
wherein vibrations of relatively high frequency
are imparted to either the tool or work, or both.

Another object of the present invention is the
provision of a novel method of honing, lapping,
grinding, buffing, and/or finishing surfaces
wherein vibrations of relatively high frequency
are produced in either the tool or the work, or
both.

Another object of the present invention is the
provision of a novel machine for finishing and/or
working surfaces, such as metal surfaces, where-
in controlled vibrations of relatively high fre-
quency are imparted to either the tool or work,
or both.

Another object of the present invention is the
provision of a novel machine for honing, lap-
ping, grinding, buffing, and/or finishing metal
surfaces wherein controlled vibrations of rela-

tively high frequency are produced in either or
both the tool or wheel and work.

Further objects and advantages of the inven-
tion will be apparent to those skilled in the art
from the following description of the preferred
embodiment or embodiments thereof, described
with reference to the accompanying drawings, in
which:

Fig. 1 is a perspective view of a machine em-
bodying the present invention;

Fig. 2 is a rear view of the machine shown in
Fig. 1;

Fig. 3 is an enlarged view of the flywheel shown
in Fig. 1;

Fig. 4 is a perspective view of a modified con-
struction of the machine shown in Fig. 1;

Fig. 5 is a sectional view of the machine shown
in Fig. 4, taken immediately below the tool;

Fig. 6 is a sectional view taken on the line 6—6
of Fig. 5;

Fig. 7 is a perspective view of a machine em-
bodying the present invention particularly adapt-
ed for polishing strips;

Fig. 8 is a perspective view of a machine em-
bodying the present invention particularly adapt-
ed for honing or polishing cylindrical work;

Fig. 9 is a perspective view of a portable ma-
chine embodying the present invention;

Fig. 10 is a perspective view of a further modi-
fication of the present invention;

Figs. 11 and 12 are views of still further modi-
fications of the present invention;

Fig. 13 is a perspective view of a lens grinding
machine embodying the present invention, and

Fig. 14 is a perspective view of a further modi-
fication of the present invention.

Similar reference characters designate corre-
sponding parts throughout the several views of
the drawings.

Referring to the drawings, Figs. 1 and 2 illus-
trate a lapping or polishing machine suitable for
lapping and/or polishing plane surfaces of ma-
terial such as sheet metal, glass, etc. The work,
designated by the reference character W, is sup-
ported on the top of a table 9, and, if desired,
fixed thereto in any suitable manner. The table
9 is slidably supported on ways 10 formed on top
of a bed 11 and reciprocated thereon in any suit-
able manner well known in the art, preferably by
means of fluid pressure operated mechanism. The
mechanism for reciprocating the table 9 is
not illustrated herein as it does not, per se, form
a part of the present invention and is well known
in the art, wherein it may be found embodied in
a plurality of structures, but, suffice it to say

that the reciprocation is automatic and may be stopped and started at will by means of a push button switch 12.

In the machine illustrated, the operation being performed is that of lapping, and a plurality of lapping heads 15 are shown in engagement with the upper surface of the work W. The lapping heads 15 are rotatably attached to the lower end of vertical shafts or rods 16, connected preferably by means of flexible couplings 18 to fluid pressure operated motors F. The motors F not only raise and lower the lapping units but afford a very desirable means of applying the laps to the work with any desired pressure. The motors F, as illustrated, are double action fluid pressure operated motors of the reciprocating type comprising cylinder 20 rigidly secured to a frame structure 21 formed integral with or attached to the bed 11. The flow of fluid to the motors F is controlled by three-way valves 22 secured to the frame structure 21. Gauges 24 indicate the pressure of the fluid applied to the motors and, in turn, the force with which the laps or tools are applied to the work.

It has been found that relative vibrations of small amplitude and high frequency between the tool and the work, in the plane of the surface being finished, produce a much superior surface or finish, and that the vibrations need only be in the nature of a few thousandths of an inch in amplitude and of a frequency from 1,500 to 20,000 cycles or 3,000 to 40,000 vibrations per minute to produce the desired result. It will be understood by those skilled in the art, from the foregoing description of the invention, that these vibrations may be produced by a plurality of different means and that they may be imparted to either the tool or the work, or both.

In the embodiment of the invention illustrated, high frequency vibrations of low amplitude are imparted to the laps by rotating at high speeds unbalanced flywheels 25 rotatably supported on the shafts or rods 16. The unbalanced condition of the flywheels is produced by having a hole 26 formed therein near the periphery. As illustrated, the hole 26 is eccentrically located in a member 27 rotatably supported in an aperture in the flywheel and adjustable therein in such a manner that the hole may be positioned radially of the flywheel to change the unbalanced condition thereof, thus increasing or decreasing the power of the vibrations. The flywheels 25 are driven by means of belts 28 and a vertical shaft 29 from a motor 30 supported on the top of the frame structure 21.

The lapping heads 15 are preferably rotated at a slow speed from the shaft 29 through the medium of a worm gear reduction 8, see Fig. 2, and belts 31, to equalize the wear on the lapping heads and distribute the abrasive which is preferably sprayed on the work in the form of a suitable liquid. Because of the small amplitude of the vibration imparted to the lapping heads 15, the flexible couplings 18 may be omitted but are preferably employed as they localize the strain. As illustrated, the flexible couplings 18 comprise two flanges bolted together with a piece of flexible material 32, such as rubber, between the adjacent surfaces thereof, but flexible couplings of other constructions may be employed with equal facility.

As previously stated, the relative oscillation or vibration between the work and the tool may be produced by vibrating either the tool or the work, or both. In the embodiment of the invention just described, the vibrations are imparted to the tool,

and Figs. 4 to 6 inclusive illustrate a modified construction of the invention wherein the vibrations are imparted to the work. This latter construction is often preferable, especially when the weight of the tool employed is such as to make the rapid vibration thereof difficult. The machine illustrated in these figures is particularly adapted for polishing steel plates, using a drum type of tool, preferably constructed in accordance with the invention disclosed in my copending application Serial No. 662,063 filed March 22, 1933 now Patent No. 2,015,646, dated September 24, 1935.

Referring to the drawings, the bed 33 and the table 34 are substantially the same in construction as those illustrated in Fig. 1, with the exception that the table 34 is provided with a movable or floating table top 35. The table top 35 is supported on ledges 36 at either end of the table 34 by rollers 37 attached to the under side of the table top. This construction permits free movement of the table top 35 transversely of the longitudinal axis of the table. Rollers 38, attached to the under side of the table top 35, engage the ends of the table 34 and prevent longitudinal movement of the table top 35 without interfering with the transverse movement thereof.

Vibrations of relatively low amplitude and high frequency are imparted to the table top 35 by unbalanced flywheels 39 similar in construction to the flywheels 25 already described. The flywheels 39 are rotatably supported on brackets fixed to the under side of the table top 35 and are driven, through the medium of belts 42, by a motor 40 supported on a bracket 41 fixed to the table 34. A drum type tool 44, rotatably supported above the table top 35 by a frame structure 45 somewhat similar to the frame structure 21, is driven at any desired speed by a variable speed motor 46 supported on the top of the frame structure 45. The motor is controlled by a push button switch 47. In order to accommodate work of variable thickness, etc., the tool 44 is supported in brackets 49 adjustable vertically along the front face of the frame structure 45 by a hand wheel 50, through the medium of lead screws, in a manner well known in the art.

Fig. 7 illustrates a construction of machine particularly adapted for polishing work W, in the form of a strip, between a pair of rollers 55 and 56. The machine frame structure for supporting and the means for rotating the rollers are not shown as they are well known in the art and may be found embodied in a plurality of different structures and means. A bracket 57 supported by a shaft 58 extends on either side of the strip W and is provided with an adjustable block 59 to accommodate different sizes of work. The shaft 58 is reciprocally supported in a bearing member 60 attached to a bracket 61 bolted or otherwise secured to the machine frame 62. Vibrations of relatively high frequency and low amplitude are imparted to the shaft 58 and, in turn, to the work W as it is fed to the rollers 55 and 56 by an unbalanced flywheel 64 rotatably supported by a bracket 66 fixed to the rear end of the shaft 58. The flywheel 64 is similar in construction to the flywheels 25 and 39 previously referred to and is driven by means of a belt 65 or in any manner well known in the art. A similar arrangement may be employed on the other side of the rollers 55 and 56, if desired.

Fig. 8 illustrates a modified construction of machine embodying the present invention and particularly adapted for lapping or honing cylindrical work. The work W is rotatably supported

and driven at a desired speed in any manner well known in the art. A lap or hone 68 is fixed to one end of a shaft 69 connected to a shaft 70 by a flexible coupling 71 similar to the coupling 18 previously described. The shaft 70 is reciprocally supported in any desired manner by the machine frame. The mechanism for supporting and rotating the work and for supporting the shaft 70, etc., is not illustrated as it does not, per se, form a part of the present invention and may be found embodied in a plurality of structures well known in the art.

High frequency vibrations of relatively low amplitude are imparted to the lap or hone by means of an unbalanced flywheel 75 rotatably supported on the shaft 70. The flywheel 75 is similar in construction to the flywheels 25 and 39 and is driven at any desirable speed by a belt 76. Vibrations in the neighborhood of 15,000 per minute overcome any tendency of the lap or tool to ring the work, and produce a very much finer surface than one would expect from the grain size of the tool. It is also possible by this method to use loose grain suspended in a proper medium and obtain a surface free from scratches.

While an unbalanced flywheel, directly connected to either the tool or the work support, has been employed to produce the vibrations referred to in all the machines thus far described and illustrated, it is to be understood, as stated above, that other means may be employed within the scope of this invention. For example, referring to Fig. 8, it will be understood that relative vibration may be produced between the work W and the lap or hone 68 by merely moving the lap or hone longitudinally of the work axis by means of a fluid operated piston working against a back pressure, and producing rapid impulses in the pressure of either the operating or back pressure fluid.

Fig. 9 illustrates a portable lapping machine capable of carrying out the improved method and embodying the present invention. The lap 80 is adapted to be clamped about the work W which is rotatably supported in any convenient manner. The work W is rotated at a desired speed by mechanism not shown, and the lap is manually moved longitudinally thereof. A handle 82 is provided for this purpose. The high frequency vibrations of low amplitude are imparted to the lap by means of an unbalanced flywheel (not shown), located within the housing 83 supported on a stub shaft 84 attached to the lap 80, and driven by a flexible shaft 85 in a manner well known in the art.

Fig. 10 illustrates the application of the present invention to a small grinding machine for finishing the surface of holes especially when there are no bottoms or shoulders. As illustrated, a tool 90 is supported by a chuck 91 fixed on a spindle 92 rotatably supported by the machine frame (not shown) and driven at any desired speed by a belt 93. The spindle 92 is vibrated longitudinally of its axis by an unbalanced flywheel 94, similar in construction to the flywheel 25, rotatably supported in a member 95 pivotally connected to a member 96. The member 96 is rotatably supported on the rear end of the spindle 92, and rotation of the member 96 with the spindle 92 is prevented by the engagement of a lever 97 formed integral therewith in a slot 98 in a bracket 99 attached to the machine frame. The flywheel 94 is driven by a belt 100 or in any convenient manner. The small amount of movement of the wheel has no detrimental

effect on the belt drive or the motor. The work is indicated at W.

In the case of large grinders, it is more practical to use fluid pressure to transmit the vibrations to the tool or work, and mechanism for transmitting longitudinal vibrations to a grinder spindle employing fluid pressure means is shown in Figs. 11 and 12. Referring to Fig. 11, the reference character 101 designates a grinder spindle of which only the ends are shown. The spindle 101 is rotatably supported by the machine frame 102 and carries a suitable tool (not shown) intermediate the ends thereof. The spindle 101 is continuously urged towards the left, as viewed in Fig. 10, by a compression spring 103. A thrust bearing 104 is interposed between the spindle 101 and the spring 103.

The spindle 101 is vibrated longitudinally of its axis by a vibrating unit comprising an unbalanced flywheel 105 similar in construction to the flywheel 25. The flywheel 105 is rotatably supported on a bracket 106 and driven at any desired speed by a belt 107. The bracket 106 projects through an opening in a member 108 and is provided with an enlarged head which rests upon or is supported by a flexible diaphragm 109 to which it is attached by a bolt 110. The diaphragm 109 forms a cover for a fluid chamber 111 in the member 108, which chamber is a part of a closed fluid pressure system for transmitting vibrations produced by the rotation of the flywheel 105, from the diaphragm 109 to a similar flexible diaphragm 112 forming one side of a fluid chamber 114 in the machine frame 102. The fluid chambers 111 and 114 are connected by a pipe 115, and a pipe 116 leads to an accumulator which maintains the system full of fluid. Vibrations imparted to the diaphragm 112 are transmitted through the medium of a thrust bearing 118 to the spindle 101 by a member 117 bolted thereto. It will be apparent that a fluid pressure means similar to that applied to the left hand end of the spindle 101 may be substituted for the spring 103 for moving the spindle towards the left, as viewed in the figure.

Fig. 12 shows a modified construction of the arrangement shown in Fig. 11 adapted to be applied to or used in machines where the wheel or tool overhangs the spindle. The vibrating unit is similar to that shown in Fig. 11, except that there are two fluid chambers 123 and 124 formed in a member 125 operatively connected to two fluid chambers 126 and 127, formed in the machine frame 128, by pipes 129 and 130, respectively. The chambers 123 and 124 are closed by flexible diaphragms 131 and 132, respectively, connected to a bracket 133 by bolts 134 and 135. The bracket 133 is rockably supported by the diaphragms 131 and 132 and held in position by a pin 137 which extends through an elongated slot 138 formed in the bracket. An unbalanced flywheel 140, similar in construction to the flywheel 25, is rotatably supported at the upper ends of the bracket 133 and driven at any desired speed by a belt 141.

Flexible diaphragms 144 and 145 which form covers for the fluid chambers 126 and 127 are operatively connected to a bracket 147 pivotally supported by the machine frame. The upper end of the bracket 147 surrounds the tool or wheel spindle 148 and is held between thrust bearings 150 and 151 positioned therebetween and collars 152 and 153 fixed to the spindle 148. From the foregoing description it will be apparent that vibrations set up in the bracket 133

by the flywheel 140 will be transmitted to the spindle 148 through the medium of the fluid in the closed fluid system, and the bracket 147, etc. The pipes 155 lead to an accumulator which maintains the pressure in the system.

Fig. 13 illustrates an application of the present invention to a lens grinding machine. A rotatable work support, indicated at 160, is adapted to support a plurality of lenses 161. The tool or grinding head 162 is rotatably connected to a short shaft 163 supported adjacent the work support 160 by a bracket 164. Vibrations of the desired frequency and amplitude are imparted to the tool or grinding head 162 by an unbalanced flywheel (not shown), similar in construction to the flywheel 25, enclosed within the housing 165. The flywheel is driven by a flexible shaft 166 and the tool or grinding head is slowly rotated by the friction between the same and the work.

Fig. 14 illustrates a modified construction of the portable lapping machine shown in Fig. 9. In the embodiment of the invention illustrated in this figure vibrations of high frequency and low amplitude are produced in the tool by electrically operated mechanism. The lap 170, provided with a handle 171, is adapted to be clamped about the work W and moved thereby by manual or mechanical means. The work is rotatably supported and driven at any desired speed by mechanism not shown. An armature 172 secured to the lap 170, opposite the handle 171, projects between the poles of an electric magnet 173 and is vibrated thereby. The electric magnet 173 is secured to a housing 174 by bolts 175 and has an electric coil 176 wound about the center thereof. The coil 176 is adapted to be connected to any suitable source of electric current by leads enclosed in the conductor 177. A rubber bushing 178 positioned between the armature 172 and the housing 174 at the point where the armature extends through the housing, keeps the armature centered between the poles of the magnet. The frequency of the vibration can be changed and/or controlled by changing and/or controlling the frequency of the current supplied to the electric coil.

It will be understood that while an unbalanced

flywheel has been shown in Figs. 1 to 13 inclusive for producing the vibration, electrical means similar to that employed in the device illustrated in Fig. 14, or any other means may be employed with equal facility.

From the foregoing description of the preferred embodiments of the invention, it will be apparent that the objects of the invention have been attained and that a novel method of and novel machines for finishing smooth surfaces of material, such as metal or glass, have been provided. The invention has been described with reference to the preferred embodiments thereof, but it is to be understood that the invention may be embodied in other structures, such as broaching, planing or milling machines, etc., with equal facility, and I do not wish to be limited to the particular constructions illustrated and described, and particularly point out and claim as my invention the following:

I claim:—

1. In a machine of the character described the combination of a base, a table slidably supported by said base, means for reciprocating said table, a frame fixed to said base and comprising a fluid pressure operated reciprocating motor comprising a piston rod, a shaft adapted to support a tool, a flexible connection for operatively connecting said shaft to said piston rod, an unbalanced flywheel rotatably supported by said shaft, and means for rotating said flywheel.

2. The method of working surfaces which comprises producing relative movement between a tool and a work-piece and superimposing vibrations of a frequency of more than three thousand per minute and of an amplitude of the order of a few thousandths of an inch upon said relative movement in the plane of the surface of the work-piece.

3. The method of working surfaces which comprises producing relative movement between a tool and a work-piece, and simultaneously vibrating the tool in the plane of the surface of the work-piece, said vibrations being of a frequency of more than three thousand per minute and of an amplitude of the order of a few thousandths of an inch.

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