

[54] **METHOD OF MACHINING
FERROMAGNETIC WORKPIECES TO
TRUE FLATNESS**

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[51] Int. Cl. B24b 1/00, B24b 21/08

[58] Field of Search .. 51/326, 145 R, 145 T, 135 R,
51/135 BT, 141, 328, 281 R, 240 R; 269/8;
335/295, 289, 290

[56] **References Cited**

UNITED STATES PATENTS

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OTHER PUBLICATIONS

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Primary Examiner—Harold D. Whitehead

Assistant Examiner—Nicholas P. Godici

[57] **ABSTRACT**

A method of grinding a surface of a ferromagnetic workpiece to true flatness, by first rough grinding the same with a coarse grit endless abrasive belt-type grinder, in which the workpiece is pressed with great force against the convex abrasive surface of a drum-supported abrasive belt, followed by placing the workpiece after it has cooled, on an endless fine grit abrasive belt traveling across and supported by a horizontally oriented flat platten, and drawing the workpiece against the abrasive surface of the traveling belt by magnetic attraction emanating from an electromagnetic located beneath the top stretch of the belt.

7 Claims, 6 Drawing Figures

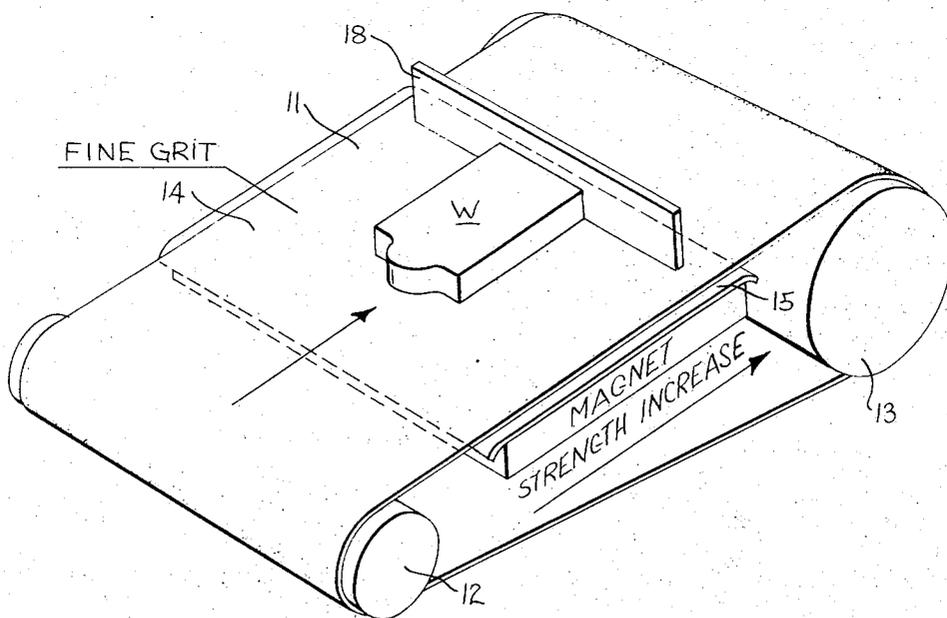


FIG. 1.

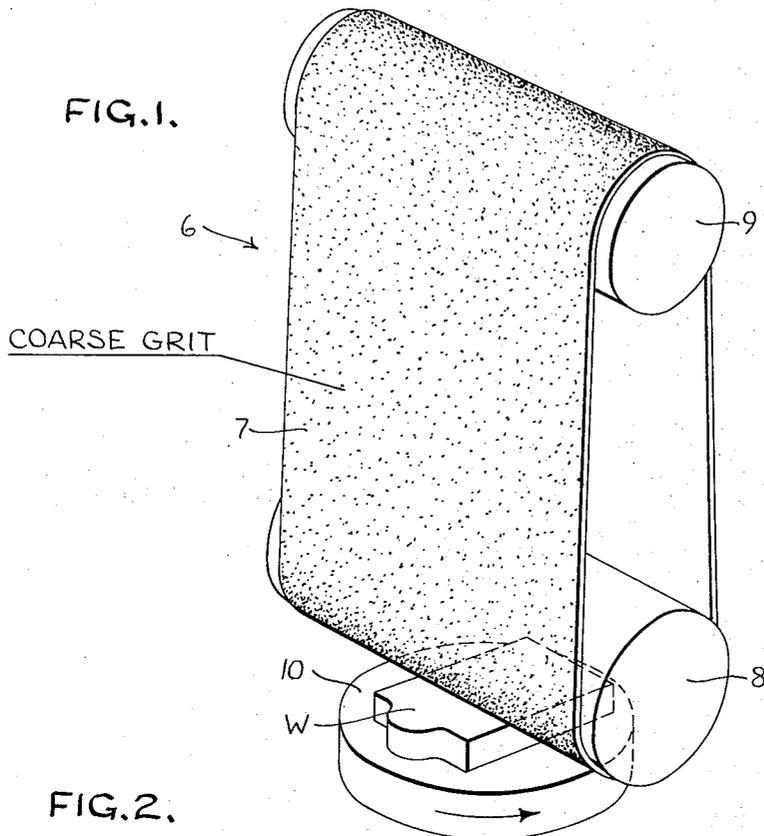


FIG. 2.

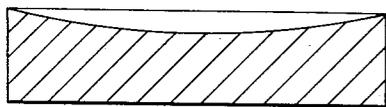


FIG. 3.

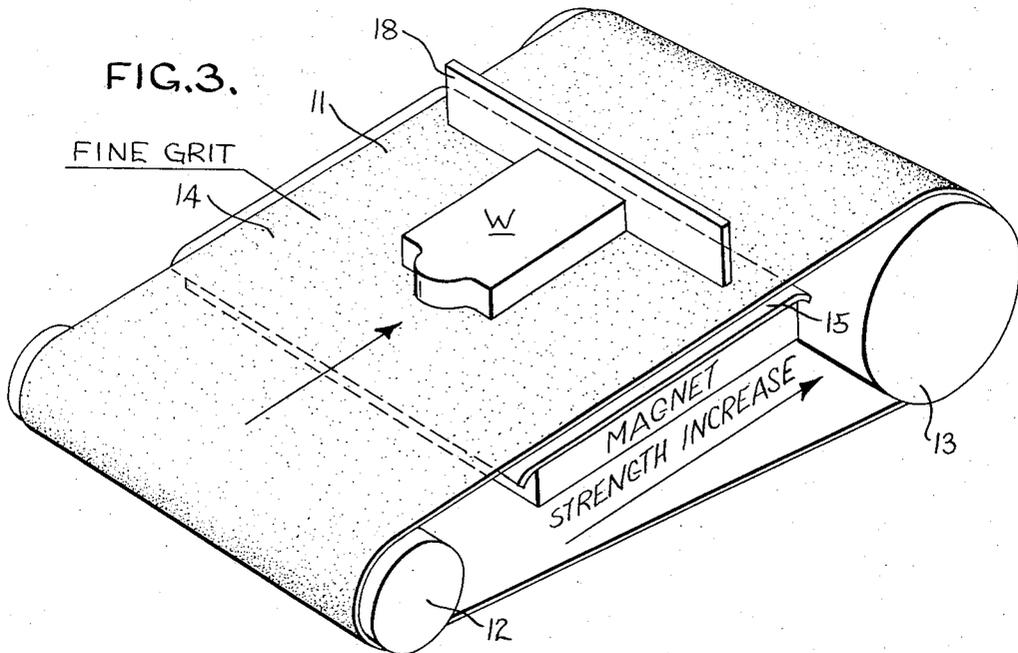


FIG. 4.

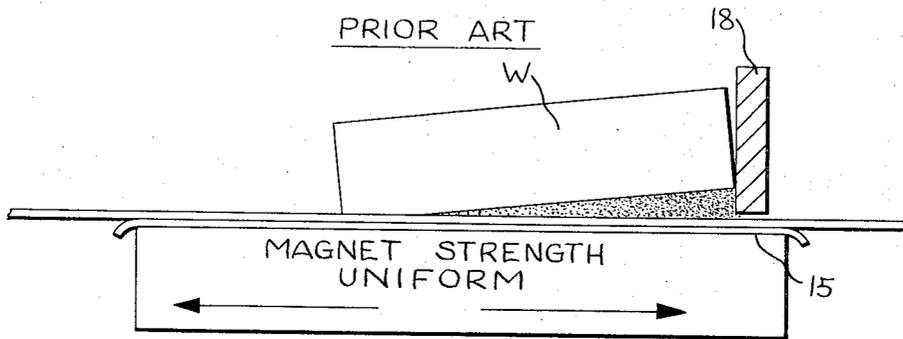


FIG. 5.

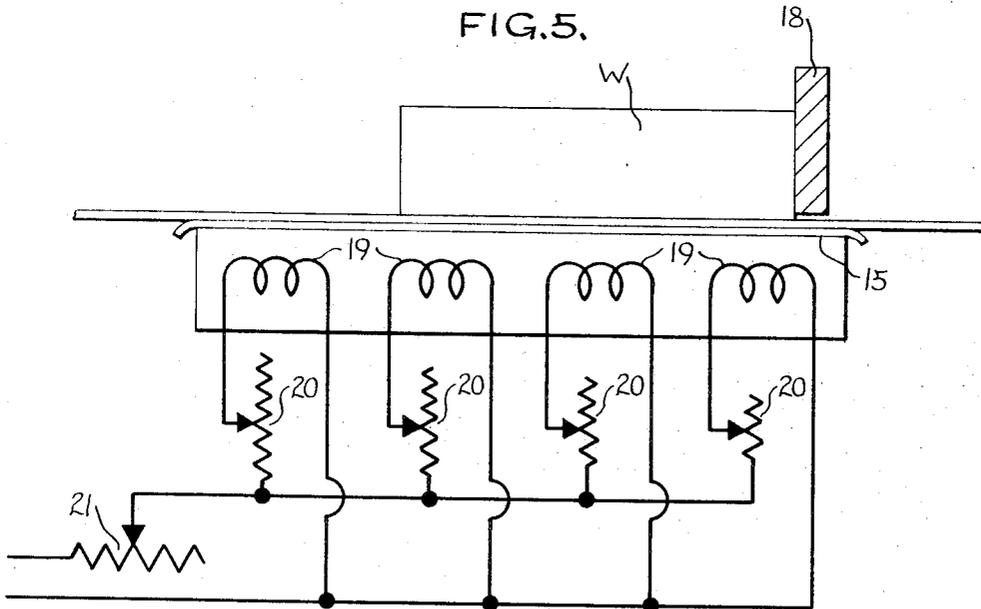
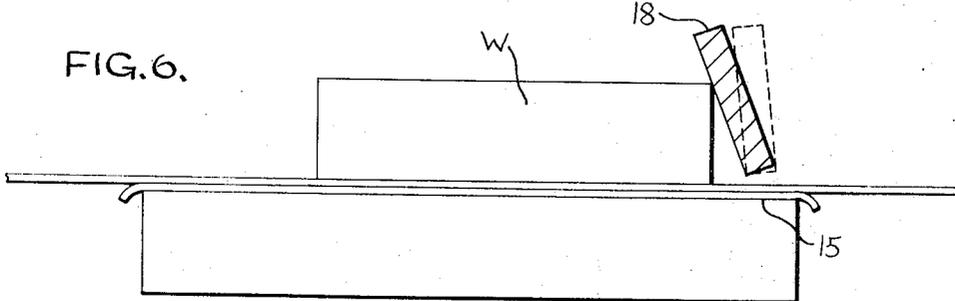


FIG. 6.



METHOD OF MACHINING FERROMAGNETIC WORKPIECES TO TRUE FLATNESS

This invention relates to the machining of metal workpieces by means of abrasive belt type grinders. The copending Grivna et al. application Ser. No. 242,111, filed Apr. 7, 1972, which is assigned to the assignee of this invention, discloses a grinder of that type.

In the machine of that application, the workpiece - fixed to a rotating turret - is pressed with considerable force against the convex surface of a drum-supported fast traveling endless abrasive belt. Because of the convex curvature of the abrasive belt, the zone of action where the belt contacts the workpiece extends across the workpiece like a diametrical stripe across a circular disc; and because the workpiece rotates about an axis perpendicular to that zone, the workpiece surface at the center of its rotation is in contact with the abrasive belt throughout the entire operation, but all other areas of the workpiece surface move into and out of contact with the abrasive belt.

As explained in the Grivna et al. application, it was discovered that surfaces ground on that machine were slightly conically concave instead of flat, as desired. This was especially noticeable on workpieces in which the ground surface was continuous.

The objectionable lack of flatness was thought to result from the fact that the center of the rotating surface was subjected to the grinding action for a longer time than those areas of the surface that alternately passed into and out of contact with the abrasive belt. In the light of that observation the contact drum was slightly tilted to increase the contact pressure proportionately towards the periphery of the workpiece surface. Theoretically that adjustment should have eliminated the lack of flatness of the ground surface. It did not do so except when the grinding was done wet; but the available abrasive belts did not stand up very well under wet grinding conditions. Moreover, the tilting of the contact drum resulted in one-half the width of the abrasive belt wearing faster than the other, which of course was not desirable.

Some other way of achieving true flatness had to be found if the high production possibilities of the machine of the Grivna et al application were to be utilized. In seeking a solution to that problem, it was discovered that the heat generated in the workpieces by the grinding action was greater at the center of the ground surface than at the periphery, so that during the grinding action the uneven thermal expansion of the workpiece inevitably resulted in grinding more off the center than the periphery with the result that when the workpiece cooled, its ground surface would be dished.

While the lack of flatness was not great it was enough to be serious on some jobs. The present invention overcomes that objection, not by any modification of the high production grinding machine of the Grivna et al application, but by an improved method of finishing the workpiece surfaces. Thus, in accordance with this invention workpieces that have been rough ground on the high production machine of the Grivna et al application, after they are cool, are transferred to a novel finish grinding machine. This machine has a fine grit endless abrasive belt with a stretch thereof traveling across and supported by a horizontally oriented flat platten. The workpieces are set onto that stretch of the

belt with the rough-ground surface down. A magnet beneath the platten-supported stretch of the belt draws the workpiece against the abrasive belt, and a fence across the belt restrains the thus placed workpiece against traveling with the belt. It is of course understood that this operation requires that the workpieces be of ferrous metal.

A grinding machine of the type employed herein for the finish grinding is disclosed in the Gardner U.S. Pat. No. 2,007,967, but the method of machining ferrous metal workpieces to true flatness by first rough grinding the same, allowing the workpieces to cool and then finishing their rough-ground surfaces by a fine grit endless belt on which they are placed and against which they are drawn by magnetic attraction is new.

The invention also has as one of its objects to improve the finish grinding machine so that despite its tendency to grind more aggressively at the upstream portion of the workpiece surface than its downstream portion - with respect to the direction the abrasive belt travels - the grinding action will be uniform across the entire area of the surface being ground.

With these observations and objectives in mind, the manner in which the invention achieves its purpose will be appreciated from the following description and the accompanying drawings, which exemplify the invention, it being understood that changes may be made in the precise method of practicing the invention and in the specific apparatus disclosed herein without departing from the essentials of the invention set forth in the appended claims.

The accompanying drawings illustrate two complete examples of an embodiment of the invention constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a perspective view of the essential elements of one of the high production rough grinding machines illustrated in the Grivna et al. application, showing a workpiece being ground thereby;

FIG. 2 is a cross sectional view through the workpiece showing, greatly exaggerated, the dished shape of the ground surface after the workpiece has been allowed to cool;

FIG. 3 is a perspective view of the finish grinding machine of this invention showing a workpiece being ground thereby;

FIG. 4 is a side view of the workpiece on the finish grinding machine illustrating in an exaggerated way the objectional uneven grinding that is done with such a machine not equipped with the improvement that forms part of this invention;

FIG. 5 is a view like FIG. 4, but showing one embodiment of the improved machine of this invention, and

FIG. 6 is a view similar to FIG. 5, showing another way of eliminating the uneven grinding depicted in FIG. 4.

Referring to the accompanying drawings, the numeral 6 (FIG. 1) designates generally the rough grinding machine employed in the practice of this invention, and which is essentially one embodiment of the invention of the aforesaid Grivna et al. application. The parts of the machine shown, are its endless abrasive belt 7 which is trained over a contact drum 8 and an idler roll 9, and one of its turrets 10 to which the workpiece W is secured. The contact drum which is power driven is firmly supported in bearings (not shown) to rotate

about a horizontal axis, and the turret 10 is mounted to rotate about a vertical axis that intersects that of the contact drum. By feed force producing means (not shown) the turret is moved radially towards the contact drum to press the workpiece against the convex drum supported portion of the abrasive belt with considerable force. The grinding is done dry and in a very short time, during which the turret with the workpiece thereon makes only a few revolutions, the workpiece surface is rough ground to a predetermined level, but as explained hereinbefore the ground surface, when the workpiece has cooled, lacks true flatness. On the contrary it is slightly dished as shown in exaggeration in FIG. 2. Also, since the abrasive belt 7 has a coarse grit size in order to cut as rapidly as it does, the ground surface is not smooth.

While for some purposes the results obtained by the fast grinding done on the machine of the Grivna et al application are satisfactory, there are many instances where absolute flatness of the finished surface as well as smoothness is required. To gain these objectives, the workpiece, after being allowed to cool, is placed on the abrasive belt grinder illustrated in FIG. 3. This grinder has a fine grit endless abrasive belt 11 trained about horizontally spaced drums or rolls 12 and 13, the latter being power driven in any suitable way. The top stretch 14 of the abrasive belt which travels towards the driven drum 13 is horizontal and is supported against downward displacement by a platten 15 equipped with a smooth perfectly flat wear plate 16 across which the belt slides with its abrasive surface up.

Beneath the stretch 14 of the abrasive belt, and if desired, incorporated in the platten, is a magnet 17 by which a workpiece set on the moving abrasive belt is drawn down against its abrasive surface, provided of course that the workpiece is of ferromagnetic metal. A stop or fence 18 that extends transversely across the top stretch of the belt adjacent to the downstream edge of the magnet, restrains the workpiece against traveling with the belt. As the abrasive belt passes under the workpiece it soon grinds the bottom surface of the workpiece to a fine smooth finish that is perfectly flat.

In the development of this invention, it was discovered that the abrasion of the workpiece surface was more pronounced at its upstream area than its downstream area, and that the difference progressed with a uniform gradient. Although the exact cause of this uneven grinding is not fully understood, several theories were considered. According to one, a given area of the abrasive belt cuts more aggressively as it first comes into contact with the workpiece than it does as it leaves engagement with the workpiece. Another theory is that there might be a progressively deeper accumulation of the ground-off material under the workpiece from its upstream edge to its downstream edge, as depicted greatly exaggerated - in FIG. 4. Still another possibility is that the restraint which the fence imposed upon the workpiece, coupled with the frictional force applied to the workpiece by the traveling abrasive belt, produced an upward force component upon the workpiece at its downstream edge.

Whatever the explanation for the observed uneven grinding might be, it has been eliminated by this invention. One way this is done is by providing progressively greater magnetic attraction in the downstream direction, so that the force drawing the workpiece down

onto the abrasive belt is greater at its downstream portion than its upstream portion. To that end the magnetic attraction is produced by a plurality of electromagnets, depicted by the coils 19 in FIG. 5, arranged in a row parallel to the direction of belt travel. By suitable adjusting means, as for instance variable resistors 20, the strength of these electromagnets is made progressively greater in the downstream direction so that the workpiece is drawn more firmly into engagement with the traveling abrasive belt at the downstream portion thereof than at its upstream portion.

The collective magnetic attraction produced by all of the electromagnets can be adjusted to accommodate different sized workpieces, by a master variable resistor 21, without disturbing the setting of the individual resistors 20.

Another way of offsetting the tendency of the downstream portion of the workpiece to lift off of the abrasive belt, is to tilt the fence 18 in the upstream direction as shown in FIG. 6. The specific angle at which the fence is set will depend upon the shape and size of the workpiece and hence is preferably adjustable. As will be evident, the inclination of the fence gives it a downward camming effect by which the downstream edge of the workpiece is restrained against upward displacement, and in fact urged downward.

Those skilled in the art will appreciate that the invention can be embodied in forms other than as herein disclosed for purposes of illustration.

I claim

1. The method of machining a surface of a workpiece of ferromagnetic metal to true flatness, which comprises:

- A. moving the workpiece radially towards and thereby pressing said surface thereof with considerable force against the convex abrasive surface of a contact drum-supported coarse grit abrasive belt and at the same time rotating the workpiece about an axis that passes through the workpiece and is substantially radial to the contact drum to thereby effect dry grinding of said surface, said dry grinding of the workpiece surface effecting an uneven temperature rise in the workpiece which is greatest at the center of its ground surface, so that upon cooling of the workpiece said ground surface assumes a dished shape;
- B. after the workpiece has been allowed to cool, placing the same with its just ground surface lowermost on the upwardly facing abrasive surface of a firmly supported flat stretch of a moving endless fine grit abrasive belt;
- C. drawing the workpiece down onto said stretch of the fine grit abrasive belt by magnetic attraction;
- D. restraining the workpiece against being carried along by the moving fine grit abrasive belt; and
- E. so controlling the magnetic attraction that, with reference to the direction the moving fine grit abrasive belt travels past the workpiece, the magnetic attraction exerted on the workpiece is greater on its downstream portion than on its upstream portion.

2. The method of claim 1, wherein the control of the magnetic attraction drawing the workpiece down onto the abrasive belt is such that said attraction increases uniformly in the downstream direction.

3. The method of machining a planar surface of a workpiece of ferromagnetic metal to true flatness with-

out disturbing the orientation of the plane of said surface with respect to the remainder of the workpiece, which method comprises:

- A. moving one stretch of an endless abrasive belt across a horizontally disposed flat platen with the abrasive surface of said stretch of the belt facing upwardly and firmly supported by and maintained in a flat condition by the platen;
 - B. placing the workpiece on the upwardly facing abrasive surface of said stretch of the belt with its surface to be ground facing downward;
 - C. drawing the workpiece down onto the abrasive surface of said stretch of the belt by magnetic attraction;
 - D. restraining the workpiece against being carried along by the moving belt;
 - E. holding that portion of the workpiece which is farthest downstream with reference to the direction said stretch of the abrasive belt travels, against the abrasive surface of the belt with greater force than other portions of the workpiece; and
 - F. producing said greater force by so controlling the magnetic attraction that, with reference to the direction the moving abrasive belt travels past the workpiece, the magnetic attraction exerted on the workpiece is greater on its downstream portion than on its upstream portion.
4. The method of claim 3, wherein the control of the magnetic attraction drawing the workpiece down onto the abrasive belt is such that said attraction increases uniformly in the downstream direction.
5. The method of machining a planar surface of a workpiece of ferromagnetic metal to true flatness without disturbing the orientation of said surface with respect to the remainder of the workpiece, which method comprises:
- A. moving one stretch of an endless abrasive belt across a horizontally disposed flat platen with the abrasive surface of the belt facing upwardly and firmly supported by and maintained in a flat condition by the platen;
 - B. placing the workpiece on the upwardly facing abrasive surface of said stretch of the belt with its surface to be ground facing downward;
 - C. drawing the workpiece down onto the abrasive surface of said stretch of the belt by variable magnetic attraction that varies predeterminedly in accordance with the length of the workpiece then engaging the abrasive surface of said belt;
 - D. restraining the workpiece against being carried along by the moving belt; and
 - E. by presettable control means, predeterminedly so adjusting the location and extent of the variable magnetic attraction exerted upon the workpiece in accordance with the dimensions of the workpiece surface then engaging said abrasive belt, that that

portion of the workpiece which is farthest downstream with reference to the direction said stretch of the abrasive belt travels, is drawn against the abrasive surface of the belt with greater magnetic clamping force than other portions of the same workpiece.

6. The method of machining a planar surface of a workpiece of ferromagnetic metal, which method comprises:

- A. moving one stretch of an endless abrasive belt in supported arrangement along a flat platen with the abrasive belt surface facing outwardly to be engageable by a workpiece;
 - B. placing a workpiece on the outwardly facing abrasive surface of said stretch of the belt with its surface to be ground engaging said abrasive belt surface;
 - C. magnetically urging the workpiece onto the abrasive surface of said stretch of the belt by adjustably different degrees of magnetic attraction at preselected areas, along the face of the workpiece to be ground;
 - D. restraining the workpiece in stationary grinding position by providing a single forward stop positioned to be positively engaged by the downstream edge of the workpiece; and
 - E. so presetting the different degrees of magnetic attraction exerted upon the workpiece, that the locations at which those different preset degrees of magnetic attraction are exerted bear a predetermined relationship to the downstream edge of the workpiece.
7. The method of machining a planar surface of a workpiece of ferromagnetic metal, which method comprises:
- A. moving one outwardly facing stretch of a continuous endless abrasive belt along a flat platen;
 - B. placing a workpiece to be ground on the outwardly facing stretch of said abrasive belt;
 - C. restraining the workpiece in stationary grinding position upon the outwardly facing abrasive stretch of the abrasive belt by providing a single stop positioned to be positively engaged by the downstream edge of the workpiece; and
 - D. maintaining the workpiece in work-performing engagement with the outwardly facing abrasive stretch of the belt by exerting different gradations of magnetic attraction upon the workpiece along the face thereof being ground, in such a manner that magnetic attraction increases in degree from the upstream edge of the workpiece to the downstream edge thereof, and increases in extent in accordance with the increased distance between said downstream and upstream edges of the workpiece.

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