June 27, 1939. A. J. JACOBSEN 2,163,687

CUTTING

Filed Jan. 10, 1938 2 Sheets-Sheet 1

Fig. 1

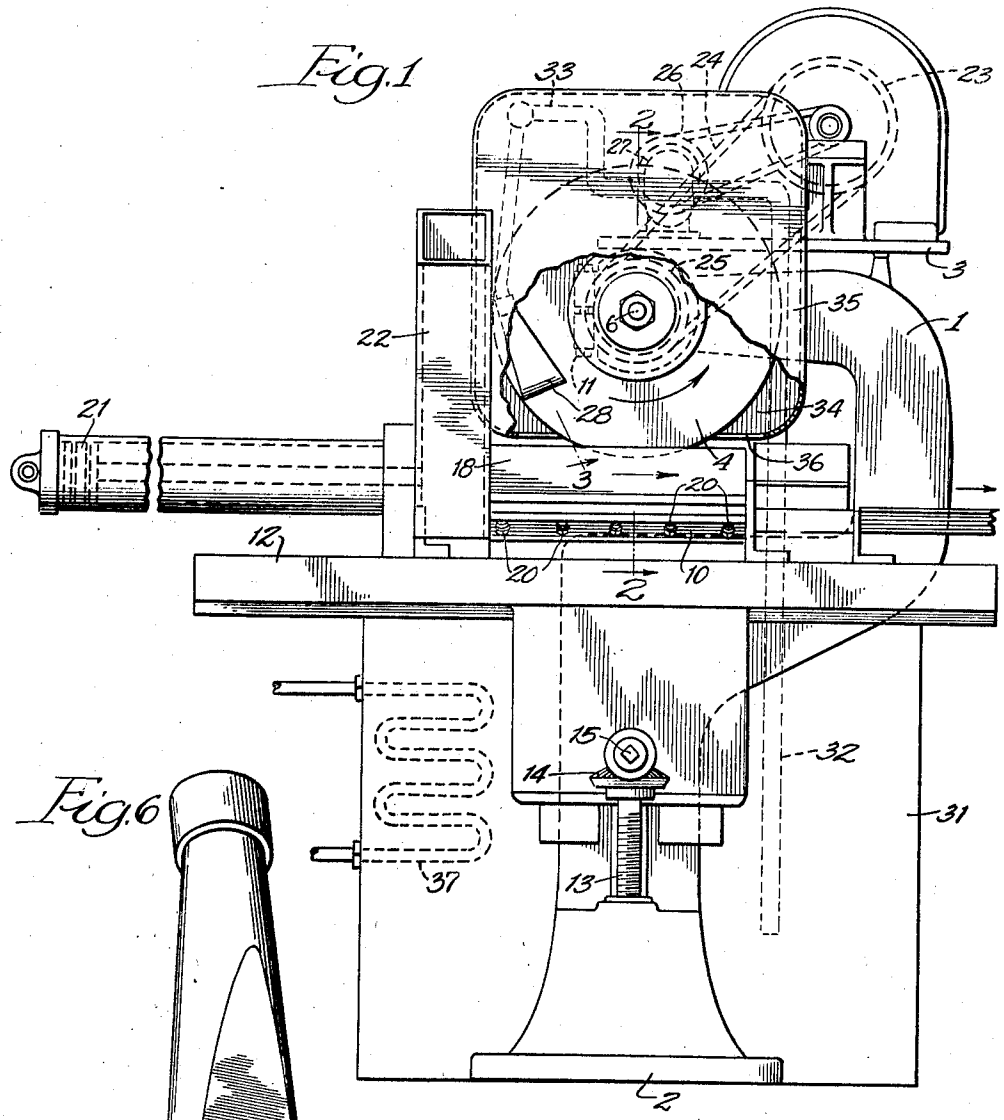


Fig. 6

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June 27, 1939. A. J. JACOBSEN 2,163,687

CUTTING

Filed Jan. 10, 1938 2 Sheets-Sheet 2

Fig. 2

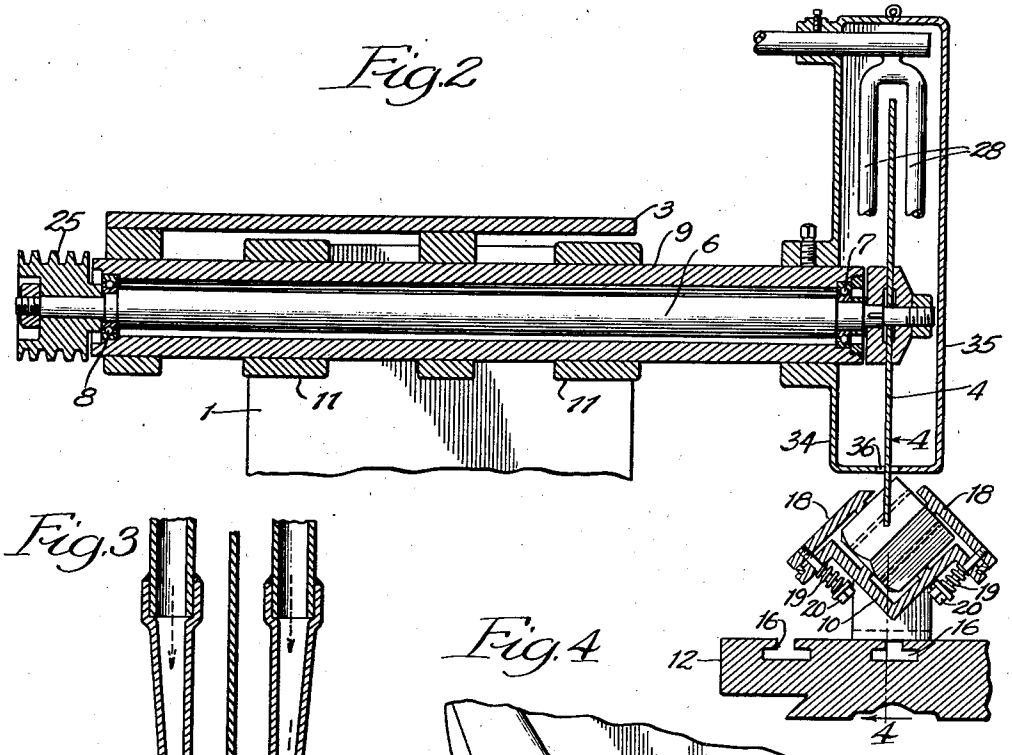


Fig. 3

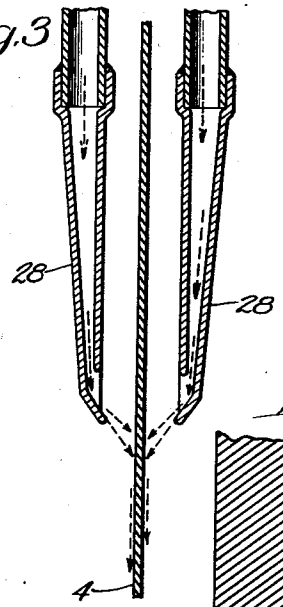


Fig. 4

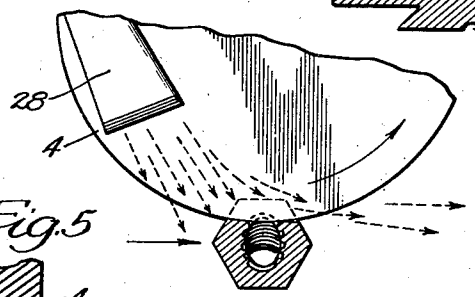
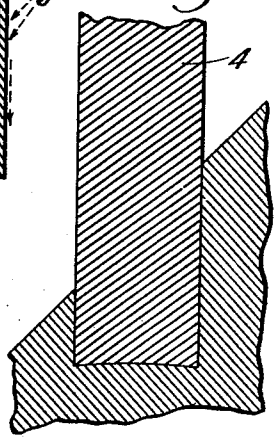


Fig. 5



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UNITED STATES PATENT OFFICE

2,163,687

CUTTING

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Application January 10, 1938, Serial No. 184,165

1 Claim. (Cl. 51—278)

This invention relates to the abrasive cutting of especially hard materials and is directed mainly to the cutting of the hardest of metallic compositions such as used in tools and in recently developed magnetic alloys.

In work of that nature, it is common practice at the present time to do the cutting with thin composition disks carrying abrasive particles in bonds of various substances of the nature of resinous compounds or vulcanite. The disks are thin, measuring about one-sixteenth of an inch in thickness, while often being approximately sixteen inches in diameter. The cutting disks are comparatively fragile, may be flexed, and are subject to softening by the action of heat. Nevertheless such disks are highly successful in cutting hard material relative to other tools in that work. The disks fail if glazed or not cleared of cut particles and allowed to become heated or when subject to unbalanced lateral pressure when at work. It is customary when operating these disks to deliver a cooling fluid to the disks or to run them in a coolant. But with all the present set-ups or methods of operating such cutting disks known to applicant, there are decided needless limitations as to their performance.

The present invention is intended to improve the operation of the type of cutting disks above specified and to cause them to do better work in less time than heretofore and enable them to successfully cut some extremely hard materials which could not be cut satisfactorily by usual methods.

A purpose of the invention is mainly to cut hard tempered metals without the heating of the metal at the cut sufficiently to affect the temper or color thereof, and to keep the tool protected by a proper scouring action of the coolant. A further purpose of the invention is to reduce the cost and time generally required for cutting hard materials and to obviate the necessity of any further treatment of the cut surface such as by grinding or polishing. These objects are accomplished by means of a different method of applying a cooling fluid to a cutting disk and to the cut surfaces of the material operated upon, which method includes coordination of the velocity and direction of delivery of the cooling fluid with the speed and direction of rotation of the disk, controlling temperature of the fluid according to the work performed by the disk, using the fluid as a hydraulic cushion for the disk, balancing of the fluid impact pressure upon the opposite sides of the disk, and by means of a construction as illustrated in the drawings, wherein:

Figure 1 is a front elevation of the cutting machine with part of its housing shown broken away.

Fig. 2 is a longitudinal section through the cutter spindle bearings, as indicated by the line 2—2 on Fig. 1.

Fig. 3 is a sectional detail through the cooling fluid nozzles and cutting disk, as indicated by the line 3 on Fig. 1.

Fig. 4 is an enlarged fragmentary view of the cutting disk showing the location of a cooling nozzle and work operated upon with respect to the disk.

Fig. 5 is an enlarged fragment in section of a cutting disk and article operated upon.

Fig. 6 is a perspective view of one of the cooling fluid nozzles.

The successful cutting of extraordinarily hard metals is rarely attained except at high cost and without much speed. Dry cutting, and what is known as immersed cutting, or cutting while the disk is cooled by merely flowing or spraying the cooling fluid on to the disk without controlled velocity, temperature and form of the fluid streams generally results in too much heating at the cut surface, which changes the character of the metal at that point as evidenced by a change in color. However, so far as known, the cutting of very hard metals or alloys must be done abrasively, and then to do exceptionally good work provision should be made to properly protect the disk and the material operated upon from the effects of overheating.

The improved method of cutting herein disclosed is presumed to be novel in the manner of application of a cooling fluid to the well-known composition abrasive cutting disks and to the cut surfaces of material operated upon.

In the performance of cutting operations of the character herein referred to, the chief considerations in addition to successful performance in cutting without drawing the temper of the material or overheating it, are maintaining a low cost per cut in regard to the time required, and the preservation of the cutting tool. It is essential to have substantial bearings for the cutting spindle or some certain provision for running the disk true with all lateral pressure thereon absolutely counterbalanced or equal on the two sides of the disk. Another absolute essential for accurate work and long life of the disks is to keep the disks entirely free from cut particles becoming embedded therein. So far as known to applicant, the short life and imperfect work had in some cases and the entire absence of capacity

for some cutting operations according to prior methods, is due to particles of the cut material becoming embedded in the disk. This causes the disk to glaze at its sides, wear with rounded edges, and to vary in thickness, with the result of excessive wear on the disk, imperfect work, and a short life of the disk.

It is found that such objections may be entirely overcome by applying the cooling fluid equally on both sides of the disk and with such form, velocity, temperature and direction toward the disk and into the cut that the particles cut from the work are driven clear of the disk.

With the machine herein illustrated, ribbons of water of equal volume and velocity are directed into contact with and along the sides of the disk in its direction of rotation along the cut entering areas of the disk prior to such areas reaching the cut. The rate of flow of the cooling water as it leaves the nozzles is commensurate with the operating surface-speed of the disk.

The intention of the invention is to render successful high-speed, abrasive cutting-operations and to do this the cooling fluid is delivered in the direction of rotation of the cutting disk at at least approximately the same speed, but the principle followed out is applicable to lower cutting speeds. Also the rate of flow of the cooling water may be somewhat less than the adjacent surface speed of the disk for the reason that the drag of the disk on the water causes the water to approximate the speed of the disk. The coolant must be under appropriate pressure according to the travel of the cutting surface in feet per minute. The drag of the disk alone is insufficient to effect the necessary motion of the coolant as is proved by failures when the disk is merely immersed in a relatively stationary body of water. The water is then troughed by air drag and fails to prevent undue heating of the disk. From applicant's experience, the velocity of the water under its own pressure should be at least 75% or 80% of the disk's speed.

As an example of successful cutting by the improved method of the hardest of tool steels or magnetic alloys under conditions of relatively low disk speed and minimum water velocity, a fourteen inch diameter disk is driven at 2300 R. P. M. The water velocity as it leaves the nozzles is 6,425 feet per minute and the speed of the disk midway between the sides of the nozzles is 7,225 feet per minute. The depth of the cut is $\frac{13}{16}$ of an inch and the material is removed at the rate of approximately 1½ cubic inches per minute. The water is cooled somewhat below the normal room temperature.

The resulting cut is clean without injury to the material operated upon and the cutting disk comes through clean with remarkably little wear. According to this invention, when the speed of the cutting disk is increased, a corresponding increase in the water pressure and corresponding reduction in the water temperature is made.

With the older methods as comn only practiced at this time, where no particular attention is paid to the water pressure or its temperature, or as is common by performing the cutting operation while the tool is immersed in the cooling fluid, it will be found that not only is the material operated upon injured by the heat but that there is much greater wear on the cutting disk. The cooling fluid or air is then merely dragged by the disk through the cuts and fails to perform its function with maximum efficiency.

The construction illustrated in the drawings is designed for the purpose of avoiding the causes of failure, such as result from merely flowing the cooling fluid onto the disk or operating the disk when immersed in the cooling fluid. Such customary methods often result in overheating and ruining of the disk.

The new construction causes the fluid streams to travel in ribbon form toward the cutting disks and in the direction of rotation of the disks at a velocity and temperature consistent with the speed and abrading work performed. The article operated upon is slowly fed against frictional retarding means in a line tangential to the cutting disk and in the direction of its rotation.

The construction illustrated includes a heavy machine frame structure **1** extending upwardly from the base **2** and including a fixed motor support **3**. The cutting disk **4** is fast to a spindle **6** having bearings **7** and **8** in a tubular element **9** longitudinally adjustable in frame member **1**. Provision is made for axial adjustment of tube **9** so that the precise, desired location of cutting disk **4** may be determined with reference to a support **10** for work operated upon. For such reason the supports **11** for tube **9** are made in the form of clamps in order to hold the tube in any desired position. The support **3** for the motor and the pump is carried by tube **9** and moves with it and the distance between belt pulley centers remains fixed.

Support **10** is mounted upon a table top **12** which is vertically adjustable on a machine frame **1** by means of a screw connection **13** with frame **1**. Screw **13** is operated through beveled gear connections **14** with a shaft **15** intended for rotation by means of a crank handle. Different types of work supports **10** may be clamped to table **12** and fit the slots **16** therein.

The work support **10** as shown in Fig. 2 carries pressure plates **18** for frictionally engaging articles operated upon. The contact pressure between these plates on the articles is determined on springs **19**, which springs are compressed more or less by the bolts **20**.

The articles operated upon are fed along support **10** by means of a hydraulic ram **21**. Details of this ram and the control means therefor are omitted from the drawings, as it constitutes a customary feed means frequently used and is arranged for a slow forward feed and a quick return. Articles operated upon travel to the ram plunger by gravity through an inclined chute **22**. The lowermost article in the chute rests on top of the ram and drops in front of the ram on the return stroke thereof.

The motor **23** for driving the machine has a belt connection **24** with pulley **25** on spindle **6** and also a belt connection **26** to a fluid pump **27** for supplying fluid under pressure to nozzles **28**. One nozzle is located at each side of the cutting disk **4** and is formed as illustrated by Figures 3 and 6, with a restricted but wide or flaring outlet **29** and a deflecting wing **30**.

The nozzles serve to direct a ribbon-like band of cooling fluid to each side of the cutting disk toward the working portion of the disk. The direction of the cooling fluid is toward the cut in the direction of rotation of the disk.

The direction of the flow of the fluid is first diagonally inward toward the disk, as illustrated by Fig. 3 and its course is somewhat changed by the drag of the disk as indicated in Fig. 4.

The temperature, direction and velocity of flow

of the cooling fluid is critical with reference to the speed of the disk for the cutting of the hardest metallic substances.

It is clear from experience in this character of work that merely washing the disk at low pressure results in failure, or poor and slow work when operating upon extraordinarily hard materials. This also applies to cutting with the disk immersed. Immersion is not sufficient in itself to prevent the disk from overheating.

Standard cutting disks, as used in the machine illustrated, are generally a few inches more than one foot in diameter and a normal speed for the spindle 6 is 2500 R. P. M. Then by following the idea of this invention of controlling the temperature and velocity of the cooling streams according to the speed and work performed by the cutter, it is easy to provide the correct conditions for cutting any known metal without injury to or changing the character of the metal. If, with a given metal of known hardness, a cut may be successfully performed at 2500 R. P. M. of the spindle, at a water velocity substantially equal to the feet per minute speed of the disk and a fluid temperature of 40° F., then to cut a harder metal successfully at the same spindle speed, the temperature of the cooling fluid is decreased. But if the spindle speed is increased, then the pressure on the cooling fluid is increased and its temperature is lowered accordingly.

With that method of operation, the wheel may remain clean and its cutting edge is not worn rounded outwardly but substantially flat or slightly concave as illustrated in Figure 5.

The fluid delivered to the cutting disk through nozzles 28 is cooled below normal water or room temperature in the settling tank 31 from which the fluid is lifted through a conduit 32 by the pump 27. From the pump the fluid passes through conduit 33 to the nozzles.

The cutting disk 4 is enclosed by a casing 34 and a door 35, except for the slot 36 at the bottom between the casing and the door through which the disk projects into the line of travel of articles worked upon on the support 10.

The cooling fluid is controlled as to temperature by use of a coil 37 through which a refrigerant is circulated. By use of thermostatic means in tank 31 for controlling the flow of the refrigerant in coil 37, a constant temperature of the cooling fluid is maintained, irrespective of the amount of heat developed by the work performed.

Except for the formation of nozzles 28, and perhaps particular arrangement of the friction elements 18 of the stock feed means, individual structural features of this machine are in principle old in many machine tools. The method of forming the cut with the assistance of band-like jets on opposite sides of the disk and at a particular temperature, angle and velocity with reference to the speed of the disk as assumed to be new.

In the operation of the construction, disk 4 is driven at a speed proportional to the speed of pump 27 from the same source of power motor 23. Thus the speed of the cutting edge of the disk is proportional to the pressure and volume of water pumped.

The rate of travel of the fluid projected on both sides of the disk from nozzles 28 is intended to approximate that of the cutting edge of the disk. The fluid also travels with and across the cutting edge of the disk through the cut and at the temperature required to keep the disk cool according to the work performed.

The fluid has the usual function of removing heat and cut particles from the disk and from the articles worked upon. The fluid enters the cut and washes around it and is successful in preventing any of the cut particles becoming embedded in the disk.

A very common fault in abrasive cutting is due to cut particles adhering to the disks and crowding the disks in the cut. The disk is thereby dulled and increases in thickness to the point of jamming in the cut and burning the metal. When that occurs, the cut cannot be perfect and the sides of the disk take an excessive work load. Also the edge of the disk becomes rounded and the disk is less likely to remain rotating parallel to an absolute plane at right-angles to its axis.

I claim:

The method of cutting with a thin, flexible abrasive disk which consists in rotating the disk and causing its edge to contact with the material to be cut while projecting independent fluid streams in ribbon form, one to each side of the disk in the direction of rotation of the disk and toward the cutting edge thereof, projecting said streams at equal angles, rates, and velocities, to the sides of the disk and at a velocity to cause the fluid to travel with the disk and into the cut at, at least approximately, the peripheral speed of the disk.

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