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ABRASIVE MACHINE AND METHOD

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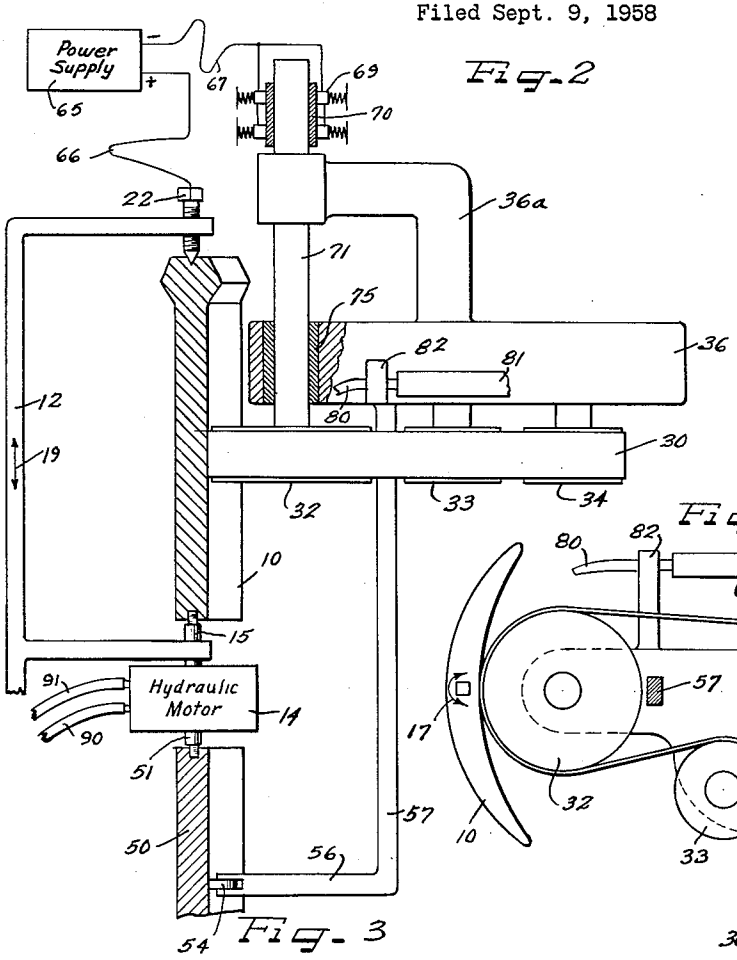


Fig. 2

Fig. 3

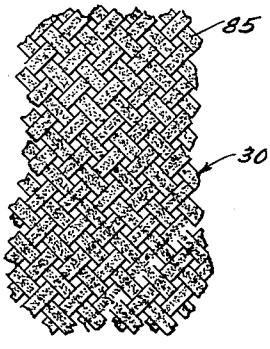
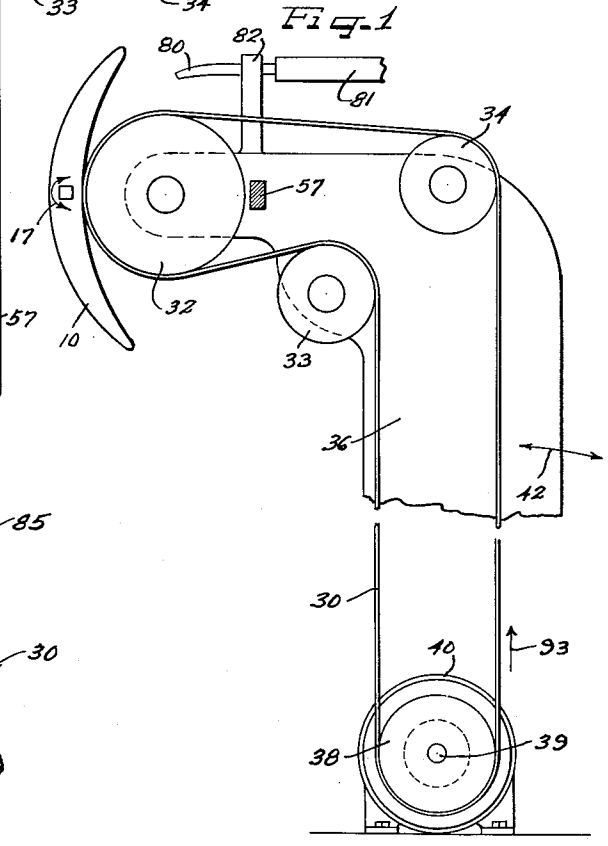


Fig. 1



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ABRASIVE MACHINE AND METHOD

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This invention relates to an abrasive machine and method and particularly to a method and means for machining turbine blades and the like.

It is an important object of the present invention to provide a method and means for machining turbine engine airfoil contours with minimum tool pressures.

Another important object of the invention is to provide a novel and improved contour grinding machine and method for turbine blades and other articles having very small transverse strength.

A more specific object of the present invention is to provide an improved endless belt type grinding machine for forming turbine blades and the like.

Other objects, features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIGURE 1 is a diagrammatic fragmentary side elevational view of an abrasive machine in accordance with the present invention;

FIGURE 2 is a diagrammatic plan view of the system of FIGURE 1 with certain parts broken away and in section; and

FIGURE 3 is a fragmentary elevational view of an abrasive belt for use in the system of FIGURES 1 and 2.

As shown on the drawings:

The present invention is directed to the grinding of workpieces **10** having very small transverse strength such as turbine blades. By way of example, the workpiece **10** may be mounted by means of a work holder **12** during the abrading operation and rotated by means of a hydraulic motor **14** and drive spindle **15** as diagrammatically indicated in FIGURE 2. The work may rotate in the direction of the arrow **17** shown in FIGURE 1 and may be traversed longitudinally as indicated by the arrow **19** in FIGURE 2 by any suitable feed mechanism. The workpiece **10** may be secured in the work holder by any suitable means such as indicated at **22** which accommodates rotation of the workpiece in operation of the machine and which is adapted to be releasable for replacement of a finished workpiece with another workpiece to be machined.

The abrasive means may comprise an abrasive endless belt **30** which travels over a backing roll **32** and idler rolls **33** and **34** carried on a frame **36** and is driven by means of a pulley **38** on a shaft **39** of a motor **40**. As the workpiece **10** rotates in the direction of the arrow **17**, the belt support frame **36** must move generally in the direction of the arrow **42**; for example the frame **36** may move arcuately about the axis of drive pulley **38** with the frame **36** mounted on a pivot shaft coaxial with the motor shaft **39**. In present commercial practice, the rotational movement indicated by the arrow **17**, the axial feed of the work indicated by the arrow **19** and the corresponding movement of the support frame **36** indicated by arrow **42** are all accomplished by an automatic machine. Such a machine might include an airfoil master cam such as indicated at **50** driven by spindle **51** of hydraulic motor **14** in synchronism with the rotation of the workpiece **10** and having a contour corresponding to the desired contour to be produced on the workpiece. A known commercial machine may also provide a cam follower roller such as indicated at **54** for riding on the surface of

the master cam **50** and controlling corresponding movement of the support frame **36**. While in commercial practice, suitable power amplification means may be interposed between the roller **54** and the means for moving the support frame **36**; in FIGURE 2, for diagrammatic purposes the cam follower **54** has been indicated as being mounted on an arm **56** which in turn is adjustably carried by means of a coupling member **57** secured to the frame **36** so that the frame **36** is illustrated as moving with the follower roller **54** to produce a contour of the workpiece **10** corresponding to the contour of the master cam **50**. Of course the master cam **50** would be supported with the work holder **12** by suitable means corresponding to the means **22** at its opposite end (not shown) so that the master cam **50** would move as indicated by the arrow **19** along with the workpiece **10**. For illustrative purposes, it may be assumed that the frame **36** is guided manually as the workpiece **10** is rotated by the motor **14** and traversed in the direction of the arrow **19** by any conventional screw feed mechanism, the feed mechanism being reversible to accommodate a number of traverses of the workpiece by the abrading assembly as desired.

In order to reduce the tool pressure on the workpiece during the forming of the turbine blade, a suitable power supply indicated at **65** has its positive terminal connected to the workpiece **10** as indicated by the line **66** and has its negative terminal connected with the backing roll **32** as indicated by line **67** in FIGURE 2 connected to a series of brushes **69** which are in sliding contact with a slip ring **70** secured to shaft **71** of the backing roll **32**. The shaft **71** is insulated from the frame **36** and from support arm **36***a* by means of suitable insulating bushings such as indicated at **75**. The connections between the power supply **65** and the workpiece **10** and backing roll **32** must be of sufficient capacity to carry a current of the order of 300 amperes. Suitable means should also be provided for insulating those parts conductively connected with the line **66**, for example by insulating the work holder **12** from the remainder of the machine. A suitable electrolytic fluid may be provided by means of nozzle **80** and supply hose **81**, the nozzle **80** being mounted by means of a bracket **82** on the support frame **36**. By way of example, the electrolytic fluid may comprise water rendered conductive by the addition of rust-inhibiting salts.

By way of example, the belt **30** may comprise an open weave fabric of insulating material coated with a suitable abrasive as indicated at **85**. The electrolytic action could then take place from the backing roll **32** through the open mesh of the belt **30** to the workpiece **10**, the belt **30** serving to prevent metal-to-metal contact between parts of opposite polarity. Alternatively, the belt could be a woven metal belt or woven from metal and fabric thread and coated with a suitable abrasive. In this case suitable means would be provided for preventing a direct metal-to-metal short circuit from developing between the back-up roller **32** and the workpiece **10** through the metal of the belt. As a further alternative, a fabric belt of insulating material could be coated or impregnated with a conductive adhesive which would then carry the abrasive material. In cases where the belt includes conductive material, it is only necessary to provide for fluid contact with the conductive portion of the belt and for electrical contact between the electrically conductive part of the belt and the electrically conductive backing roll **32**. As previously mentioned, means must be provided for preventing short circuit between the metal portion of the belt and the workpiece, for example by separating the conductive part of the belt from the

workpiece by means of an insulating fabric material or with an insulating abrasive material.

Summarizing the operation, the motor **14** is energized by suitable supply means including hoses **90** and **91** to rotate the workpiece **10** in the direction of arrow **17** in FIGURE 1. Motor **40** is energized to drive the belt **30** in the direction of the arrow **93** in FIGURE 1. A suitable traverse mechanism is also energized to move the work holder **12** in the direction of the arrow **19** at the desired rate. Lines **66** and **67** are energized from power supply **65** and a suitable electrolytic fluid is applied by means of nozzle **80** between the belt **30** and the workpiece **10** to produce the electrolytic removal of material from the workpiece **10** at the desired rate. As the workpiece **10** rotates in the direction of the arrow **17**, the belt support frame **36** is moved in the direction of the arrow **42** to accommodate this rotation and to form the workpiece **10** to the desired contour. This movement of the support frame **36** has been diagrammatically indicated as being controlled by means of a master cam **50** in conjunction with a cam follower roller **54** mechanically coupled to the support frame **36**.

The illustrated machine and method are especially adapted for very small thin turbine blades which have substantially no transverse strength. It is found that 90% of the material removed from the work blank by the machine results from the electrolytic action while 10% is removed by the abrasive action of the belt **30**. It is found that best results are obtained when the electrically charged back-up wheel **32** acts on the electrolytic liquid through an open mesh non-conductive belt such as shown in FIGURE 3.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. In an abrading machine, an abrasive belt, means for supporting said belt in operative relation to a workpiece, means for moving said belt progressively over said supporting means, and means for producing an electrolytic current at the region of operation of said belt with respect to said workpiece for electrolytically removing material from the workpiece, said belt being of open mesh configuration coated with an abrasive material and having means for insulating said belt supporting means from metal-to-metal contact with said workpiece.

2. In an abrading machine, an abrasive belt, means for supporting said belt in operative relation to a workpiece, means for moving said belt progressively over said supporting means, and means for producing an electrolytic current at the region of operation of said belt with respect to said workpiece for electrolytically removing material from the workpiece, said belt being of woven conductive material in electrical contact with said belt supporting means and for electrical contact with an electrolytic fluid interposed between said belt and said workpiece.

3. In an abrading machine, an abrasive belt, means for supporting said belt in operative relation to a workpiece, means for moving said belt progressively over said supporting means, and means for producing an electrolytic current at the region of operation of said belt with respect to said workpiece for electrolytically removing material from the workpiece, said belt being of insulating material impregnated with a conductive adhesive carrying abrasive particles at its operative surface, and said conductive adhesive being in direct electrical contact with said belt supporting means and being adapted for electrical contact with an electrolytic liquid interposed between the belt and the workpiece.

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