Oct. 12, 1971 S. I. ASHWORTH 3,611,639

ABRADING MACHINES

Filed Aug. 19, 1969 4 Sheets-Sheet 1

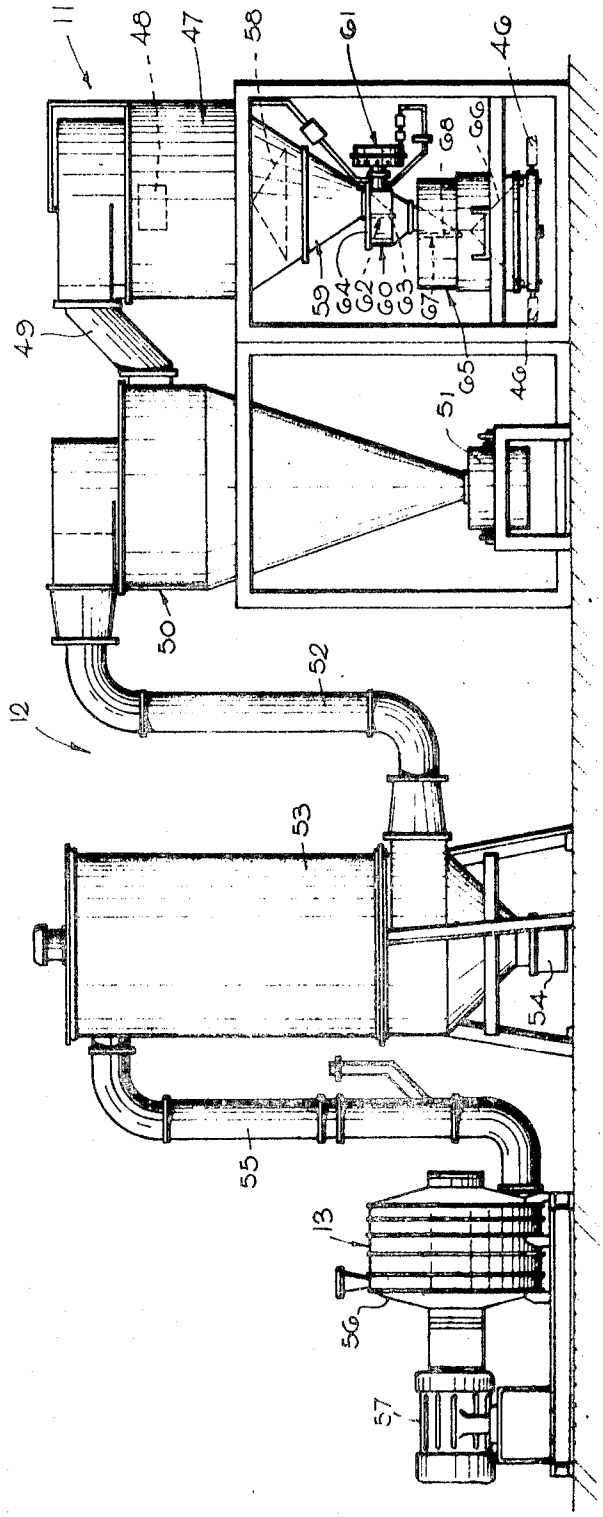


Fig. 1.

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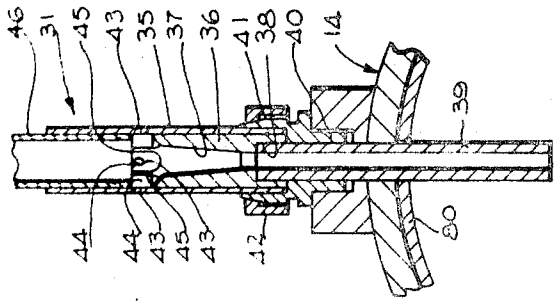
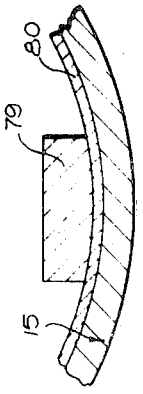


FIG 3.



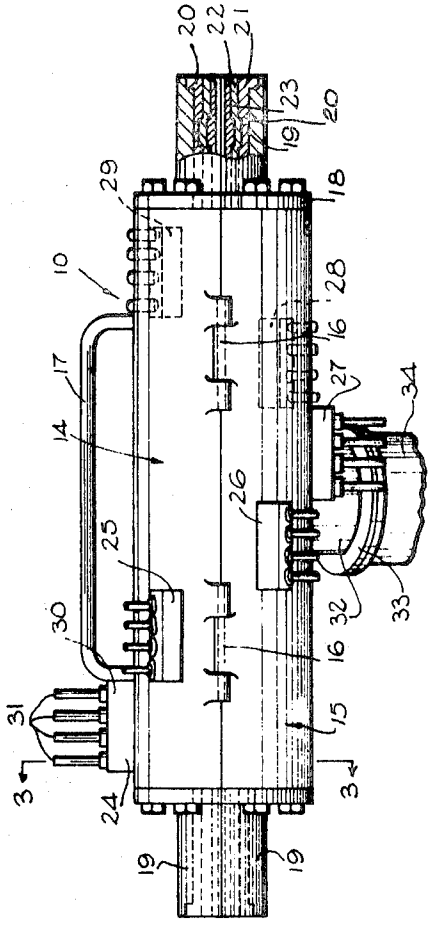


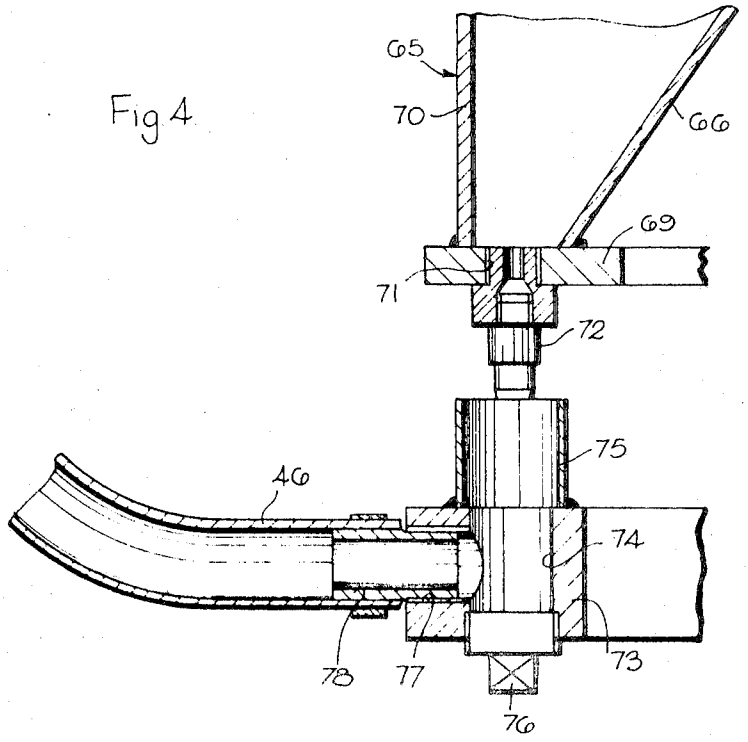
FIG. 2.

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Fig 4



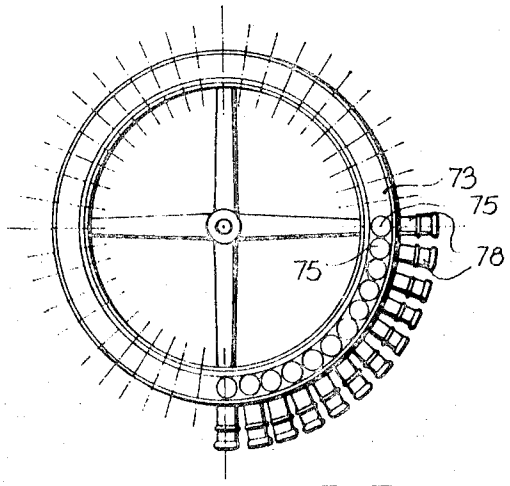


FIG. 5.

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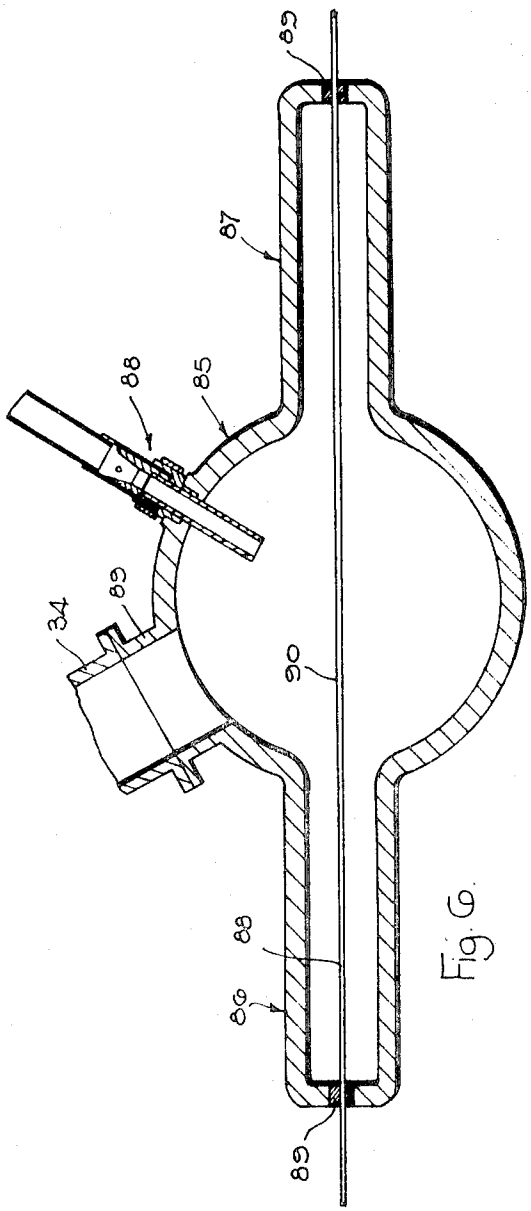


Fig. 6

United States Patent Office 3,611,639 Patented Oct. 12, 1971

3,611,639

ABRADING MACHINES

Stewart Ives Ashworth, Malvern Link, and Anthony Gerard Field, deceased, late of Redditch, England, by Denis Cyril Field and Madeleine Helen Field, administrators, Crimond, Outhill, near Studley, England, assignors to Abrasive Developments Limited, Solihull, Warwickshire, England

Filed Aug. 19, 1969, Ser. No. 851,307
Int. Cl. B24c 3/04
U.S. Cl. 51—8 15 Claims

ABSTRACT OF THE DISCLOSURE

The specification discloses an abrading machine and method in which air and abrasive are directed at a workpiece in a blasting chamber which is sealed during operation by the workpiece. The abrasive is entrained in primary air, secondary air enters the chamber around the workpiece and tertiary air is allowed to mix with primary air carrying the abrasive before the latter enters the chamber. The chamber may be tubular and for treating wire or bar may be in two channel-shaped parts hinged together so that the chamber may be opened to lead the wire or bar through. Where strip is being treated the strip may pass through the tubular chamber transverse to the axis thereof.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to apparatus for abrading a surface on a workpiece with a mixture of abrasive and air.

Description of the prior art

In U.S. Pat. No. 3,286,406 issued Nov. 22, 1966, there is described apparatus for abrading a surface on a workpiece comprising a blasting chamber, a primary air inlet conduit connected at one end to the blasting chamber, means for entraining abrasive in the primary air flowing through the conduit upstream of its entry into the blasting chamber, aperture means in the wall of the chamber to be closed by the workpiece, means for applying suction to said chamber to draw primary air and abrasive into the chamber and remove air and spent abrasive from the chamber when said aperture means is closed by the workpiece, means for directing abrasive entering the chamber against said surface and means for restricting of the entry of secondary air into the chamber around the periphery of the aperture means when the latter is closed by the workpiece. Hereinafter such apparatus is referred to as being of the type specified.

SUMMARY OF THE INVENTION

According to one feature of the present invention, therefore, we provide apparatus of the type specified wherein the primary air inlet conduit is provided upstream of, and adjacent to, its entry into the blasting chamber with means allowing the entry of tertiary air to join the abrasive and primary air flowing along the air inlet conduit.

By virtue of allowing air, i.e. tertiary air, to enter the air inlet conduit adjacent to the blasting chamber, the speed of the abrasive and primary air in the part of the air inlet conduit upstream of the entry of the tertiary air can be reduced as compared with the case where no tertiary air is admitted since the mixture of primary air, abrasive and tertiary air is accelerated to the desired velocity in the last part of the air inlet conduit due to the inlet of tertiary air and thus the slower speed of the mixture of primary air and abrasive in the conduit upstream of the entry of tertiary air which is possible for a given velocity of impingement of the abrasive on the workpiece reduces the wear which takes place in the conduit.

In a preferred arrangement the directing means includes one or more nozzle assemblies, one end of the or each assembly entering the chamber and being directed at the workpieces and the other end of the or each assembly being connected to the air inlet conduit and including the means for allowing the tertiary air to enter the conduit. The tertiary air inlet means may comprise a number of holes in said other end of the or each nozzle assembly. The or each nozzle assembly may have a portion of greater internal cross-sectional area where the tertiary air enters the assembly and a portion of lesser internal cross-sectional area serving to direct the abrasive and air at the workpiece.

According to another feature of the invention we provide apparatus of the type specified for cleaning strip wherein the chamber is tubular, the aperture means comprises opposed slots in the wall of the chamber to allow a strip to pass through the chamber transverse to the length of the chamber, and the directing means comprises a nozzle assembly in the chamber wall and extending across the width of the strip and arranged so that air and abrasive enter the nozzle assembly from the air inlet conduit at one end of the nozzle assembly outside the chamber and are directed against the workpiece from the other end of the nozzle assembly, an inlet to permit tertiary air to mix with the primary air and abrasive being provided in the nozzle assembly between the ends thereof.

By this arrangement, the whole width of the strip can easily be cleaned and the tubular chamber and its associated nozzle assembly may be made of any desired width to fit the strip which is to be abraded.

Preferably, the means for applying suction to the chamber is so located that it is on the same side of the strip as the nozzle assembly. That is to say the abrasive is directed at one face of the strip and is removed by suction from the same face of the strip. This arrangement prevents undesirable effects occuring at the edges of the strip.

The chamber may include first and second outer parts extending radially in diametrically opposite positions from an inner tubular part so that in operation the strip is moved through the first outer part, then through the inner part and then through the second outer part, the outer parts being formed with the aperture means which restrict the flow of secondary air into the chamber and this substantially prevents the secondary air having any adverse effect on the blast pattern in the inner part during treatment.

While the above arrangement of a chamber having inner and outer parts is extremely useful for obtaining very uniform surface results, for example on lithographic plates or other printing plates, if such extreme uniformity of finish is not required, the outer parts of the chamber can be omitted. Where extreme uniformity of result is not essential then the means for applying suction can be arranged to be opposite to that face of the strip which is opposite to the nozzle assembly.

Apparatus of the type specified is particularly useful for cleaning wire, other filamentary material and bar stock. Wire is usually coiled in very long lengths, is drawn off its coil, passed through a cleaning machine and then re-coiled. In some cases, the wire may be substantially continuous, the adjacent ends of successive coils of the wire being welded together. Under these circumstances it is not always practicable to thread the end of the wire to be cleaned through a tubular chamber, particularly where a thin wire or a plurality of such wires is being cleaned, and therefore according to a further feature of the invention we provide apparatus in which the blast-

ing chamber is tubular and is formed in two generally channel-shaped parts which are hinged together, the aperture means being at the opposite ends of the chamber and the means for restricting the entry of secondary air into the chamber comprising apertured guides through which the workpiece in the form of filamentary material is passed.

When it is required to introduce wire as the workpiece for cleaning, therefore, the parts of the chamber may be opened, the wire introduced and the parts then closed about the wire so that the latter may now be pulled through the chamber.

The directing means may comprise a number of nozzle assemblies arranged to lie on a helix about the longitudinal axis of the tubular chamber.

The chamber will normally be lined to cut down wear and where nozzle assemblies are directed into the chamber there may be provided, opposite said assemblies, a target of natural gum rubber or other similarly soft synthetic rubber compound to protect the chamber wall.

The guide at each end may be formed of two parts secured to the chamber parts to open and close therewith. Thus the guide at each end may comprise two channel-shaped members which are secured to the chamber parts, each member having a removable insert. The insert, through which the wire runs, may have a lining of ceramic or suitable synthetic or hard metal material. By having inserts and linings of different sizes, the chamber may easily be converted for treating different sizes of wires merely by changing the inserts with their linings.

Usually there will be a plurality of primary air inlet conduits extending to the blasting chamber, each conduit feeding a nozzle assembly and it is a further feature of the invention to provide means whereby these primary air inlet conduits may be fed.

According to this feature of the invention we provide apparatus of the type specified wherein the means for entraining the abrasive in the primary air comprises a hopper, a ring of metering nozzles around the base of the hopper, and communicating with the interior thereof, a ring arranged beneath the nozzles, a plurality of tubular, open-topped receivers supported on the ring so that each receiver is opposite to a metering nozzle and a plurality of tubular spigots on the ring, each spigot communicating through the ring with one of said receivers and being connected to the blasting chamber by a primary air inlet conduit.

This arrangement gives an even distribution of abrasive around a number of nozzle assemblies and each spigot can be connected directly by its own primary air inlet conduit to the corresponding nozzle assembly thus simplifying the construction of the apparatus.

The hopper may have a conical bottom to distribute the abrasive to the ring of metering nozzles and the conical bottom may be surmounted by a perforated plate.

In said U.S. Pat. No. 3,286,406 there is disclosed a method of abrading a surface on a workpiece comprising the steps of forming an enclosure with said surface as a wall thereof, applying suction to said enclosure, producing a flow of primary air into the enclosure by removal of the air in the enclosure by suction while restricting the entry of secondary air from the surrounding atmosphere into the enclosure around the periphery of said surface, entraining abrasive in said primary air prior to the latter entering the enclosure, directing the abrasive entering the enclosure against said surface and entraining the spent abrasive in the air being removed from the enclosure by suction. Hereinafter such a method will be referred to as being of the type specified.

According to a further aspect of the invention we provide a method of the type specified wherein, after the abrasive has been entrained in the primary air and before the mixture of primary air and abrasive enters the enclosure, tertiary air is admitted to join the primary air and abrasive mixture.

The advantage of carrying out the method in this way is as described above in that the abrasive and primary air can travel comparatively slowly until they approach the enclosure whereupon the tertiary air can be allowed to enter and as a result the air and abrasive mixture will be accelerated.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in detail by way of example with reference to the accompanying drawings in which:

FIG. 1 is an elevational view of the main part of an abrading apparatus embodying the invention with certain parts omitted;

FIG. 2 is a side elevation of an abrading chamber forming part of the apparatus of FIG. 1;

FIG. 3 is a partial cross-section through the abrading chamber of FIG. 2 on the line 3—3 of FIG. 2;

FIG. 4 is a detailed section showing means for entraining an abrasive in the air-stream;

FIG. 5 is a detailed plan view showing abrasive distributing means forming part of the apparatus of FIG. 1; and

FIG. 6 is a diagrammatic section through a second form of abrading chamber which can be used in apparatus embodying the invention and which is particularly adapted for treating the surface of strip.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 and 2, the apparatus shown comprises four parts, the blasting chamber indicated generally at **10** in FIG. 2, the means for separating reusable abrasive indicated generally at **11** in FIG. 1, dust collecting means indicated generally at **12** in FIG. 1 and suction means indicated generally at **13** in that figure. Referring now to FIGS. 2 and 3, the blasting chamber **10** is tubular and comprises two channel shaped parts **14** and **15** each part being of generally semi-circular cross section. The parts are hinged together at **16** along one pair of adjacent edges and may be swung about the hinges to open the chamber by means of a handle **17**. Means not shown is provided for releasably holding the parts **14** and **15** together to close the chamber during use.

The end of each part is closed by a semi-circular end plate **18** having a semi-circular extension **19**. Received in the extension is a channel section guide member **20** having a flange at each end, one of the flanges being indicated at **21** and being received in recesses in the extension **19**. Each guide **20** has a removable insert **22** which in turn has a lining **23** of ceramic or other hard material. The inserts **22** and linings **23** are removable and different sized inserts and linings may be replaced in guides **21** of the same size to provide for treating wire of different diameters.

It will be appreciated that when the chamber parts are opened by being pivoted about the hinges **16** the extensions **19** at each end of the chamber with their guides **21**, inserts **22** and linings **23** will also move apart and will allow a wire or bunch of wires to be threaded through the chamber.

The chamber is provided with six sets of nozzle assemblies indicated at **24** to **29** respectively. Each nozzle assembly is similar and comprises a block such as **30** for the nozzle assembly **24** carrying four nozzles **31** whose construction will be described with reference to FIG. 3. It will be seen that the nozzle assemblies **24** to **29** are arranged around the longitudinal axis of the blasting chamber **10** in a generally helical manner so that the centre point of each nozzle assembly lies on a helix. This arrangement of nozzle assembly is described and claimed in copending application No. 851,354 filed on Aug. 19, 1969 by Stewart Ives Ashworth. The blasting chamber has a spigot **32** having a flange **33** which is connected to a suction conduit **34**.

Referring to FIG. 3, each nozzle 31 is similar and comprises a steel tube 35 having a lining 36 of synthetic rubber which has a convergent passage 37 therein. Fitting within a rebate 38 in the lining 36 is the upper end of a nozzle tube 39 which is formed of any suitable material, for example ceramic. The nozzle tube is received in a mounting 40 which in turn is received in the block 30 and which is externally screw threaded at 41 and is split to receive a nut 42. The mounting receives the tube 35 and as the nut 42 is tightened the tube is clamped in position on the block 30.

The tube 35 is provided with a series of holes 43 which as will be described below permit the entry of tertiary air into the mixture flowing into the nozzle assembly, the lining 36 having recesses 44 into which the holes 43 open, the recesses being separated by ribs 45. A primary air inlet conduit in the form of a hose 46 is received within the upper end of the tube 35 and conveys a mixture of air and abrasive to the nozzle assembly.

As will be described hereinafter in more detail, air and abrasive is discharged from the nozzle tubes 39 against the workpiece passing through the blasting chamber between the guides 21 and the air and the abrasive together with any detritus produced as a result of the abrasive impinging on the workpiece are withdrawn through the suction conduit 34 and passed to the means for separating reusable abrasive indicated at 11.

The separating means 11 comprises a cyclone 47 to which the suction conduit 34 is connected at 48. The cyclone 47 separates reusable abrasive from the mixture of air and abrasive which it receives from the suction conduit 34, the reusable abrasive falling to the bottom of the cyclone as will hereinafter be described and the dust and air passing through a pipe 49 into a second cyclone 50 forming part of the dust collecting means. The dust falls to the bottom of the cyclone 50 and is received in a dust box 51 from which it may be removed. The air leaving the cyclone 50 passes through pipework indicated generally at 52 to the bottom of a bag filter 53 where any residual dust is separated out and received in a dust box 59, the substantially dust-free air then passing through pipework 55 to an exhauster fan 56 driven by an electric motor 57. It will be seen, therefore, that the exhauster fan 56 applies suction to the suction conduit 34 via the cyclones 47 and 50 and the filter 53 and thus is responsible for drawing primary air and abrasive into the chamber 10.

The reusable abrasive which falls to the bottom of the cyclone 47 is deflected by a baffle 58 and is received in an upper hopper 59. From the upper hopper 59 the abrasive can pass into a middle hopper 60 when the pressures in the two hoppers are equal. The pressure in the hopper 60 is varied by means of first valve means 61. Second valve means is interposed between the upper hopper 59 and the middle hopper 60, is indicated generally at 62 and comprises a flap 63 of hard rubber or similar material freely pivoted about its upper edge so as to be movable in response to the net resultant force exerted on it by the difference in the pressures between the hoppers 59 and 60 and any abrasive in the hopper 59 tending to open the flap 63. The middle hopper 60 is sealed at its top at 64 and is in air-tight relation with the upper hopper 59.

An open topped, generally cylindrical lower hopper 65 is provided having within its base a conical baffle 66. Third valve means, indicated generally at 67 is interposed between the middle hopper 60 and the lower hopper 65, the third valve means comprising a flap 68 mounted in a manner similar to the flap 63 i.e. pivoted about its upper edge so that it will move in response to the net resultant force exerted on it by differences in the pressures between the hoppers 60 and 65 and the weight of any abrasive in the hopper 60 acting on the flap 67.

The first valve means 61 operates so that the middle hopper 60 is alternately placed at the pressure of the upper hopper 59 and at the pressure of the lower hopper

65 i.e. atmospheric pressure. The operation of the first valve means may be as described in U.S. Pat. 3,307,296 issued Mar. 7, 1967 or may be as described in copending application No. 851,155 filed Aug. 19, 1969, now abandoned of Denis Cyril and Madeleine Helen Field, administrators of the estate of Anthony Gerard Field (deceased) the inventor. When the middle hopper 60 is at the pressure of the upper hopper 59, atmospheric pressure closes the third valve means 67 but the second valve means 62 can open to let abrasive pass from the upper hopper 59 to the middle hopper 60. When the middle hopper 60 is placed at atmospheric pressure i.e. the pressure of the lower hopper 65, the second valve means 62 is maintained closed by the atmospheric pressure acting on the flap 63 while the second valve means 67 can open to transfer abrasive from the middle hopper 60 to the lower hopper 65.

Abrasive delivered into the lower hopper 65 is guided by the baffle 66 to the lower peripheral portion of the hopper and from thence is entrained in input conduits formed by the hoses such as 46 described with reference to FIG. 3.

Referring to FIGS. 4 and 5 the base of the lower hopper is formed by a ring 69 to which is welded the lower edge of the baffle 66 and also the lower edge of the outer wall 70 of the hopper. In the ring 69 there is provided a plurality of circular threaded apertures 71 in each of which is threadedly received a nozzle member 72 through which the abrasive can pass at a metered rate. Arranged beneath the ring 69 is a further ring 73 which has a plurality of cylindrical apertures 74 therein, the apertures 74 being coaxial with the apertures 71. Welded to the upper surface of the ring 73 coaxial with each aperture 74 is a sleeve 75 into which the nozzle member 72 directs abrasive. The base of each aperture 74 is closed by a plug 76. The ring 73 also has a plurality of transverse apertures, one of which is indicated at 77, each transverse aperture intersecting an aperture 74 and threadedly receiving a union member 78 to which is clamped one end of a hose 46 which forms a primary air inlet conduit, the other end of the hose 46 being connected to a nozzle 31 as described in relation to FIG. 3. It will be appreciated that each of the nozzles 31 is supplied with air and abrasive along its own hose or primary air inlet conduit 46.

When suction is applied to the chamber 10, primary air is induced into the upper end of each sleeve 75 and draws abrasive out of the lower hopper 65 through the nozzle members 72. The mixture of primary air and abrasive then passes along the hoses or primary air inlet conduits 46 to the nozzles 31 where the mixture is directed at the surface of a workpiece passing through the chamber and the abrasive and air is then returned along the suction conduit 34 as has been described above. Opposite to each nozzle assembly there is provided a target 79 of natural gum rubber or other soft material as shown in FIG. 3 to protect the chamber walls which are also lined at 80.

The operation of the apparatus as described is as follows. The exhauster fan 56 is driven by the motor 57 so that the suction conduit 34 is placed under suction through the cyclones 47 and 50, the filter 53 and the pipework 49, 52 and 55. Suction applied to the suction conduit 34 removes air from the chamber 10. As the pressure in the chamber 10 decreases, primary air is forced to flow into the sleeves 75 and along the primary air inlet conduits 46 to the nozzles 31. The flow of primary air into the sleeve 75 induces abrasive to flow from the hopper 65 through the nozzles 72 into the sleeves 75 and the abrasive is mixed with the primary air and is transported by the primary air along the air inlet conduits 46 to the nozzles 31.

The mixture of air and abrasive then enters the passage 37 in the lining 36 in each nozzle 31 and as the mixture flows past the holes 43 tertiary air is drawn in to mix with the primary air and abrasive and the mixture of primary and tertiary air and abrasive passes down the

nozzle tube **39** to be directed at a workpiece passing through the chamber between the guides **21**. The addition of tertiary air through the holes **43** accelerates the mixture of primary air and abrasive so that for a given speed of impingement of the air and abrasive on a workpiece the speed of the primary air and abrasive in the primary air inlet conduits **46** will be lower due to the provision of tertiary air than it could be were the provision of tertiary air omitted.

The blasting chamber **10** shown in FIG. 2 is intended primarily for treating wire or bar (hereinafter both referred to as wire), and the end of the wire is fed into the chamber at one end thereof and leaves at the other end. The wire is initially threaded through the chamber by pivoting the parts **14** and **15** about the hinges **16** thus separating at each end of the chamber the guides **21** with their inserts **22** and linings **23**. The wire can then be threaded through the chamber and the parts **14, 15** closed with the wire received now between, at each end, the guides **21** with their inserts **22** and linings **23**. The length of wire between the ends of the chamber then treated with air and abrasive discharged against the wire from the nozzles **31** while air, used abrasive and detritus are withdrawn from the chamber through the spigot **32** and the outlet conduit **34** and are delivered to the cyclone **47** at **48**. The wire is moved continuously through the chamber so that a length of wire is continuously treated. When the end of the length has passed through the chamber, e.g. at the end of a coil of wire, the exhauster fan **56** is stopped, the chamber **10** is opened by pivoting the parts **14** and **15** and a fresh length of wire is threaded through the chamber to be pulled therethrough.

The primary air and abrasive is impelled into the chamber by suction applied to the conduit **34** as described above. Secondary air enters the chamber around the workpiece where it enters and leaves the chamber i.e. between the linings **23** and the workpiece and tertiary air joins the primary air and abrasive by flowing through the holes **43** in the nozzles **31**. The air, abrasive and detritus removed from the chamber **10** is passed to the cyclone **47** which separates out the reusable abrasive which falls into the hopper **59** and the spent abrasive and dust passes along the pipe **49** to the cyclone **50** and the filter **53** which separates out the small particles and the air is then discharged to atmosphere by the fan **56** in a substantially dust-free condition.

The resuable abrasive deposited in the upper hopper **59** is transferred to the lower hopper **65** by operation of the valve means **61, 62** and **67**. The first valve means **61**, acts so as cyclically to place the middle hopper **60** at the pressure of the lower hopper **65**, in this case atmospheric pressure, and the pressure of the upper hopper **59** so that the second and third valve means **62** and **67** alternately open and close thus allowing abrasive to be transferred from the upper hopper **59** to the lower hopper **65** and thus for resuse without unduly disturbing the low pressure in the system.

The blasting chamber **10** shown in FIGS. 2 and 3 is very useful for the cleaning of wire but FIG. 6 shows a form of blasting chamber which is suitable for cleaning strip.

The chamber has a generally cylindrical portion **85** and wing-like portions **86** and **87**. Strip material **88** passes through guides **89** in the wing-like portions **86** and **87**. A nozzle assembly is indicated generally at **88** and comprises a plurality of nozzles similar to those described in relation to FIG. 3. The central portion **85** of the chamber has a suction outlet **89** which may be connected to a suction conduit such as **34**. It is believed that the operation of the blasting chamber will be self-evident, suction applied to the chamber will evacuate the same thus causing air and abrasive to be directed against the surface **90** of the strip **88** by the nozzles of the nozzle assembly **88**, the nozzles being arranged to induce a flow of tertiary air there into as described in relation to FIG. 3. It is to be noted that the abrasive is directed at the face **90** and the suction is applied opposite to the same face. The guides **89** control the entry of secondary air into the chamber and being spaced from the cylindrical portion **85** this inflow of secondary air does not affect the blast pattern and a very uniform blast pattern is obtained.

We claim:

1. Apparatus for abrading a surface on a workpiece comprising a blasting chamber, a primary air inlet conduit connected at one end to the blasting chamber, means for entraining abrasive in the primary air flowing through the conduit upstream of its entry into the blasting chamber, aperture means in the wall of the chamber to be closed by the workpiece, means for applying suction to said chamber to draw primary air and abrasive into the chamber and remove air and spent abrasive from the chamber when said aperture means is closed by the workpiece, means for directing abrasive entering the chamber against said surface, means for restricting the entry of secondary air into the chamber around the periphery of the aperture means when the latter is closed by the workpiece and means in the primary air inlet conduit upstream of, and adjacent to, its entry into the blasting chamber to allow the entry of teritary air to join the abrasive and primary air flowing along the air inlet conduit.

2. Apparatus according to claim **1** wherein the directing means includes a plurality of nozzle assemblies, one end of each assembly entering the chamber and being directed at the workpiece and the other end of each assembly being connected to the air inlet conduit and including the means for allowing the tertiary air to enter the conduit.

3. Apparatus according to claim **2** wherein the tertiary air inlet means comprises a number of holes in said other end of each nozzle assembly.

4. Apparatus according to claim **2** wherein each nozzle assembly has a portion of greater internal cross-sectional area where the tertiary air enters the assembly and a portion of lesser internal cross-sectional area serving to direct the abrasive and air at the workpiece.

5. Apparatus according to claim **1** for cleaning strip wherein the chamber is tubular, the aperture means comprises opposed slots in the wall of the chamber to allow strip to pass through the chamber transverse to the length of the chamber, and the directing means comprises a nozzle assembly in the chamber wall and extending across the width of the strip and arranged so that air and abrasive enter the nozzle assembly from the air inlet conduit at one end of the nozzle assembly outside the chamber and are directed against the workpiece from the other end of the nozzle assembly, the means for allowing the entry of tertiary air being located between the ends of the nozzle assembly.

6. Apparatus according to claim **5** wherein the means for applying suction to the chamber is located so that it is on the same side of the strip as the nozzle assembly.

7. Apparatus according to claim **5** wherein the chamber includes first and second outer parts extending radially in diametrically opposite positions from an inner tubular part so that in operation the strip is moved through the first outer part, then through the inner part and then through the second outer part, the outer parts being formed with the aperture means which restrict the flow of secondary air into the chamber.

8. Apparatus according to claim **1** wherein the blasting chamber is tubular and is formed in two generally channel-shaped parts which are hinged together, the aperture means being at the opposite ends of the chamber and the means for restricting the entry of secondary air into the chamber comprising apertured guides through which the workpiece may be passed.

9. Apparatus according to claim **8** wherein the directing means comprises a number of nozzle assemblies arranged to lie substantially on a helix about the longitudinal axis of the chamber.

10. Apparatus according to claim 9 wherein the chamber is provided internally with a target of soft resilient material opposite to the outlets of the nozzle assemblies to protect the chamber wall.

11. Apparatus according to claim 8 wherein the guides are formed of two parts secured to the chamber parts to open and close therewith.

12. Apparatus according to claim 11 wherein each guide comprises two channel-shaped members which are secured to the chamber parts, each such member having a removable insert.

13. Apparatus according to claim 1 including a plurality of primary air inlet conduits extending to the blasting chamber, and wherein the means for entraining the abrasive in the primary air comprises a hopper, a ring of metering nozzles around the base of the hopper and communicating with the interior thereof, a ring arranged beneath the nozzles, a plurality of open-topped receivers supported on the ring so that each receiver is opposite to a metering nozzle and a plurality of tubular spigots on the ring, each spigot communicating through the ring with one of said receivers and being connected to the blasting chamber by a primary air inlet conduit.

14. Apparatus according to claim 13 wherein the hopper has a conical bottom to distribute the abrasive to the ring of metering nozzles.

15. In a method of abrading a surface on a workpiece comprising the steps of forming an enclosure with said surface as a wall thereof, applying suction to said enclosure, producing a flow of primary air into the enclosure by removal of the air in the enclosure by suction while restricting the entry of secondary air from surrounding atmosphere into the enclosure around the periphery of said surface, entraining abrasive in said primary air prior to the latter entering the enclosure, directing the abrasive entering the enclosure against said surface and entraining the spent abrasive in the air being removed from the enclosure by suction, the improvement comprising admitting tertiary air into the primary air after the abrasive has been entrained in the primary air and before the mixture of primary air and abrasive enters the enclosure.

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