Aug. 12, 1969 C. A. DITTMAR 3,460,296

METALWORKING

Filed Oct. 24, 1966 4 Sheets-Sheet 1

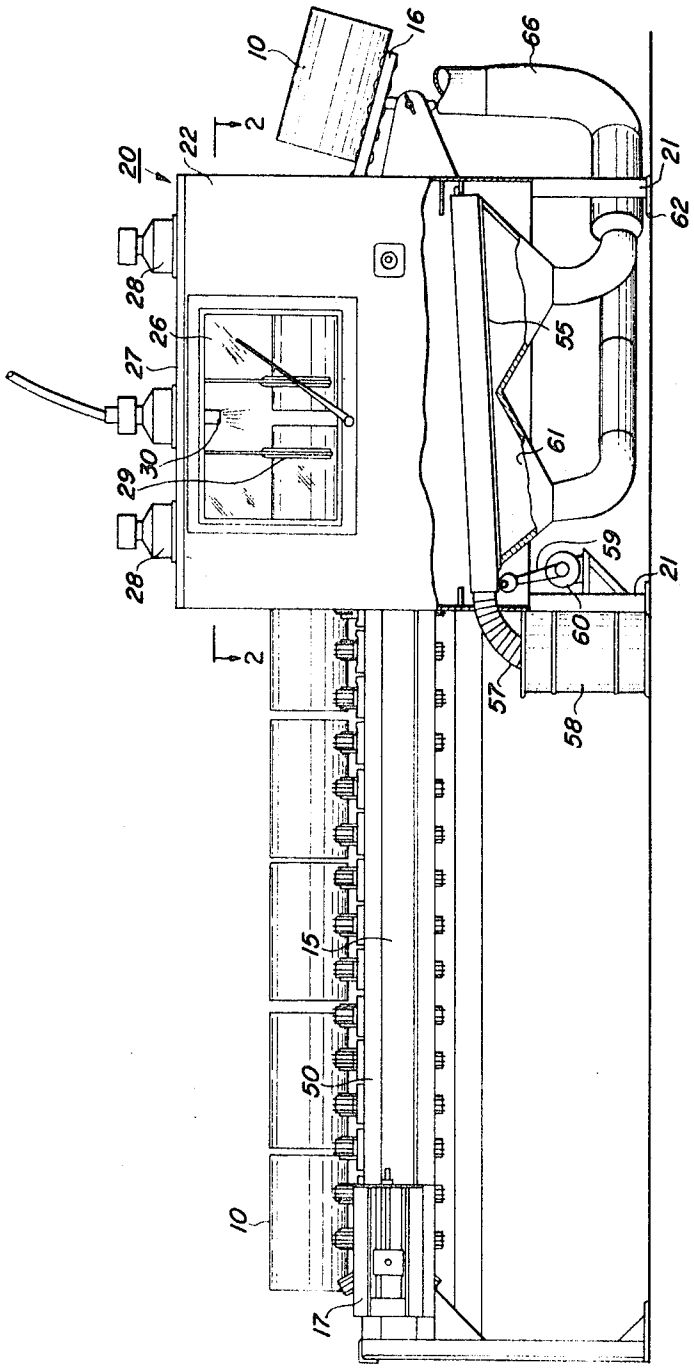


FIG. 1

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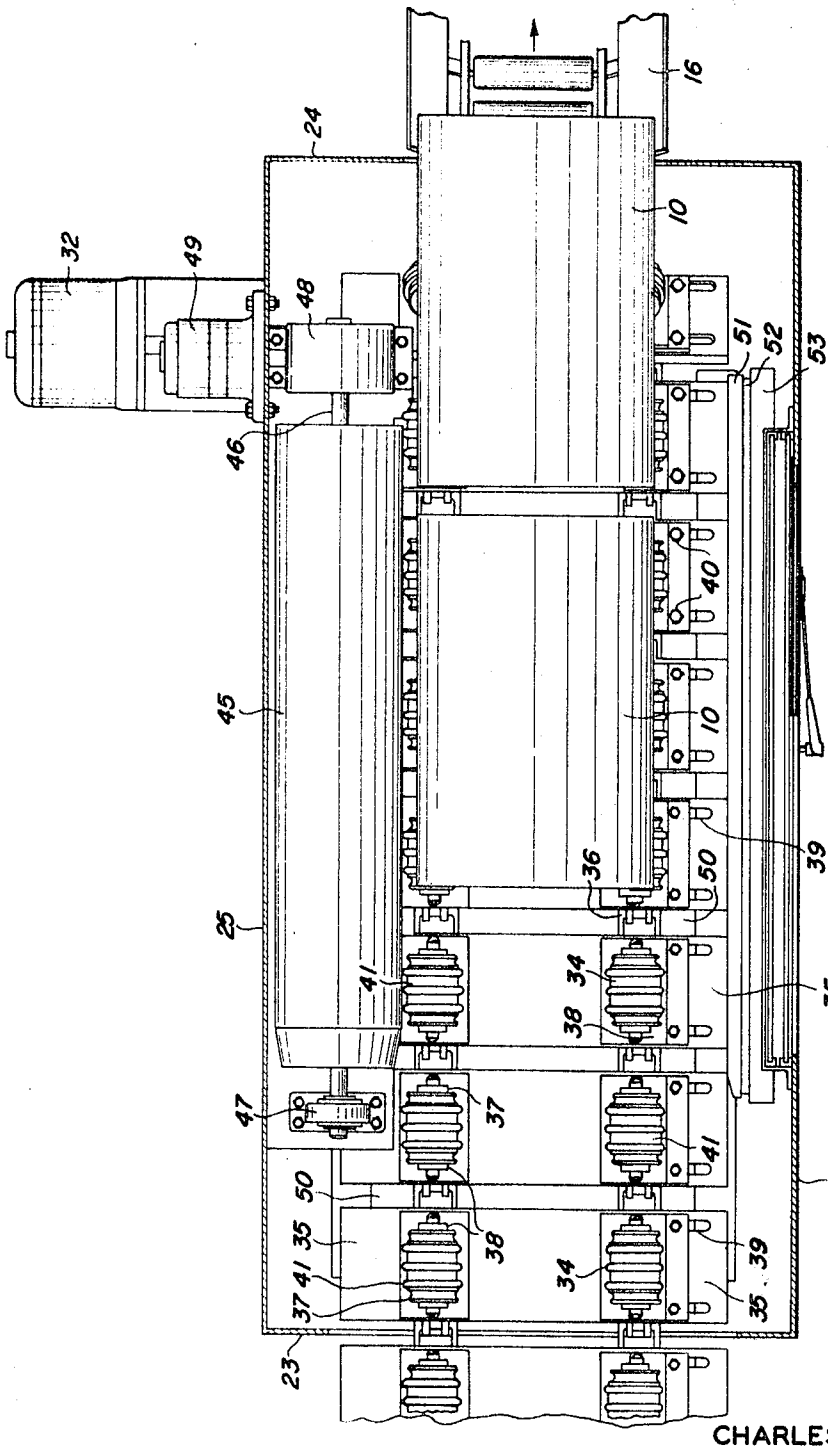


FIG. 2

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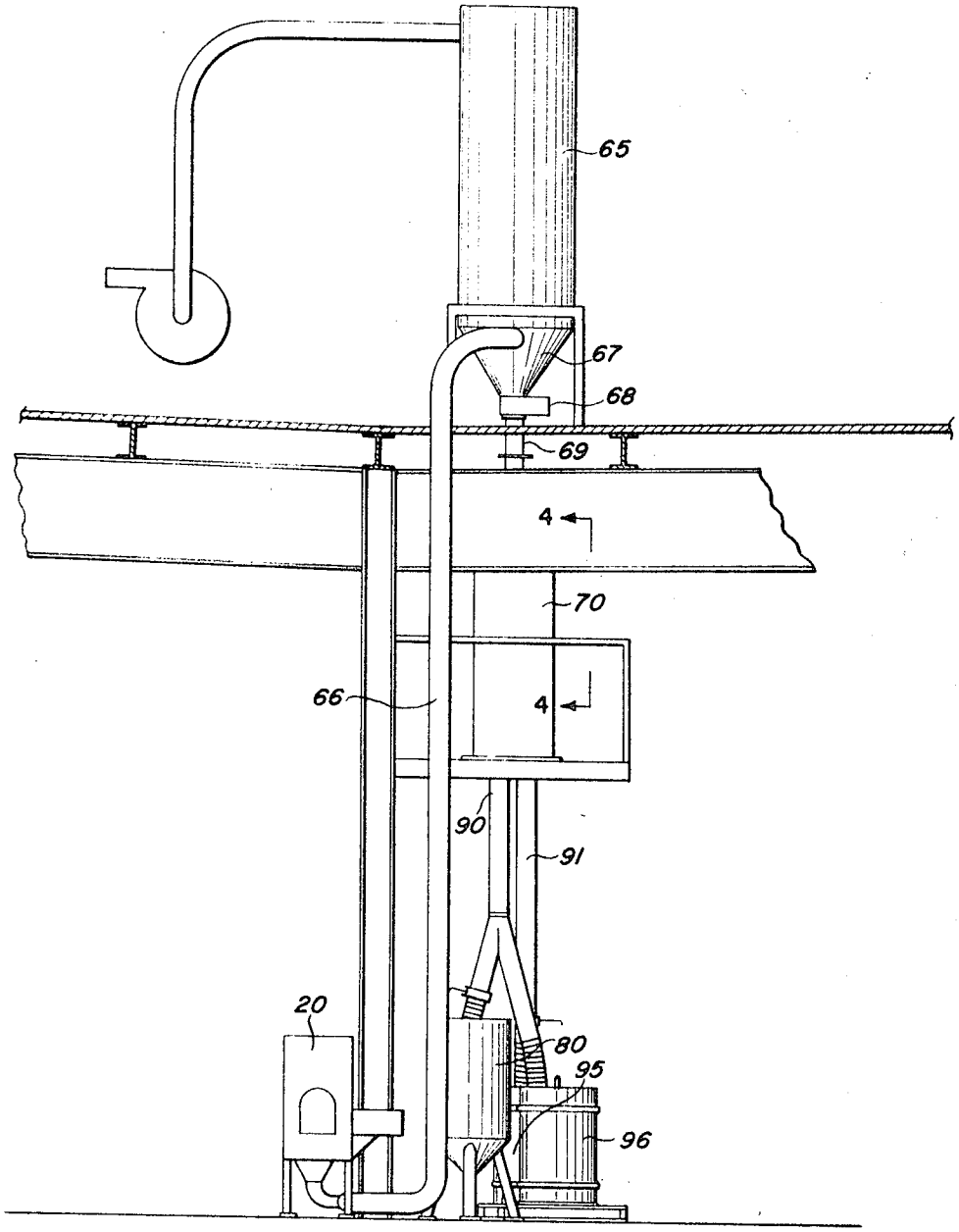


FIG. 3

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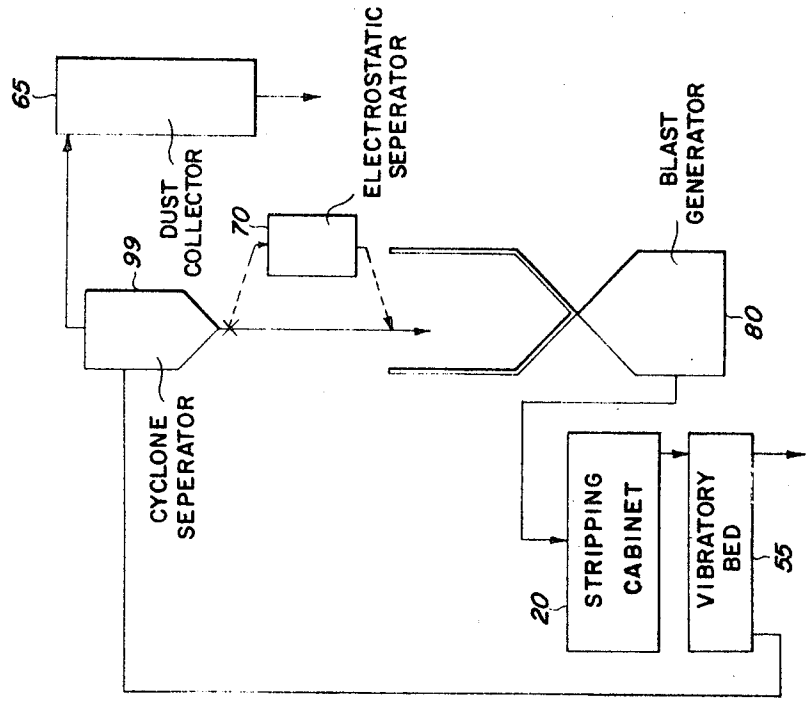


FIG. 5

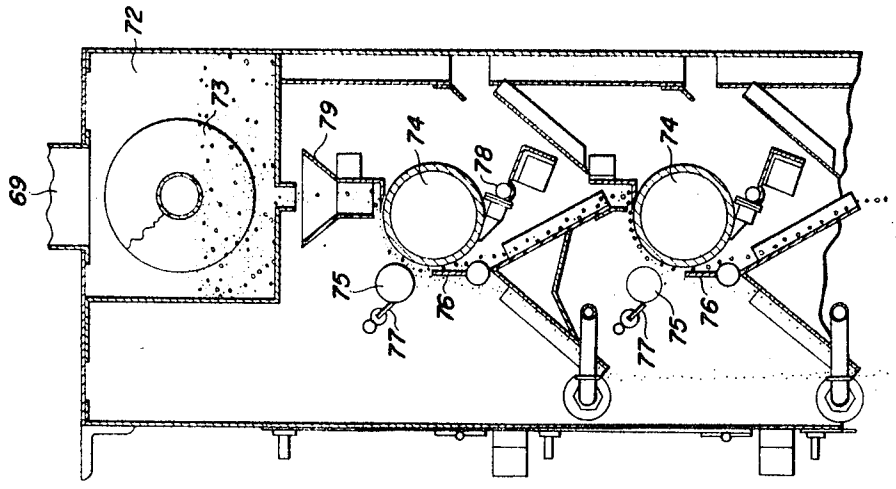


FIG. 4

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3,460,296

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METALWORKING

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Int. Cl. B24b *1/00*; B24c *1/00, 3/00*
U.S. Cl. 51—320 7 Claims

ABSTRACT OF THE DISCLOSURE

The method of removing a hard coating material from a relatively soft substrate by impacting the hard coating with plastic beads having a modulus of elasticity less than the modulus of elasticity of the relatively soft substrate.

This invention relates to a method for mechanically working metal and, in particular, to mechanically stripping a coating of relatively hard material from a soft support material.

More specifically, this invention relates to a method for mechanically removing a selenium coating from a soft metal support material such as aluminum without damaging the support material. Although the invention is described with reference to selenium and alloys of selenium, it is also applicable for working other materials. Basically, stripping is a process for separating two components which are bonded together in some manner so that one or both of the components can be reclaimed. Heretofore, mechanical stripping methods, that is, a mechanical means such as shot blasting or the like for removing one material from the other, were directed towards breaking down and/or abrading the outer component from the support component. This breaking down and/or tearing apart of the outer material oftentimes required high forces which caused the inner support material to be permanently damaged. This was especially true when the substrate was made of a relatively soft material unable to withstand these high localized mechanical forces without being damaged.

Heretofore, other than mechanical stripping means were employed when a soft support was wished to be recovered undamaged, chemical stripping and heat stripping being two examples of such non-mechanical means. These processes, however, have proven to be extremely slow and costly. Further, it has been found that heat and chemical stripping processes product as a by-product a toxic vapor which is injurious to health and, therefore, requiring costly precautions to insure the safety of people working in the area. In the chemical stripping process, the material removed is first dissolved in solution and then recovered by precipitation of this solution. This series of steps has added to the time and cost of such recovery operations.

A means of mechanically stripping or mechanically working a metal which is in wide commercial use today is the method of "shot blasting" in which a relatively hard material is hurled against the surface to be worked/or removed, the shot particle delivering sufficient mechanical energy required to perform the work. Generally in the shot blasting process, smooth shot such as glass beads or steel balls are utilized to break down the coating material by sheer force of impact. However, rough particles such as aluminum oxide, silica, or chilled iron are also used to abrade or tear away the coating material. As the outer surface coating is removed, the support material becomes exposed to the forces delivered by the shot stream. If the support material does not have the physical properties to withstand the forces so delivered, the support material

will be damaged to a point where it is no longer reclaimable without further costly operations being performed thereon.

Hight pressure water stripping is a commercial method in which a relatively inexpensive medium, water, is used to remove one component from the other. This mechanical method lends itself readily to uses in cases where one component is loosely adhered to the other. However, to remove closely bonded materials, water under extremely high pressure must be used. Because of these high pressures, the equipment is very costly and expensive to maintain. A high pressure water stream will break away particles of hard coating but the water stream continues to deliver energy to these removed particles embedding them in the relatively soft support material. It is believed that the particles become entrapped in the incompressible water stream and are then forced under high pressures into the exposed areas of substrate. This effect generally occurs when the coating material does not completely cover the softer substrate thus leaving a tapered edge exposed to the water stream. Coating material in the thinner sections of the edge being more elastic is driven into the substrate rather than being fractured and removed by the water.

It is therefore an object of this invention to mechanically remove one material from a support material to which it is bonded.

Another object of this invention is to improve the method of mechanically stripping a relatively hard material from a support of relatively soft material without damaging the softer support material.

Another object of this invention is to deliver mechanical energy to a work zone over a relatively long period of time rather than by sudden impact.

A still further object of this invention is to improve the method of removing a relatively hard coating of selenium from a relatively soft support material without damaging the support material.

Another object of this invention is to improve method of removing a selenium coating from a xerographic photoconductor so that the selenium is recoverable and the photoconductor is resuable.

Yet another object of this invention is to provide a continuous process for stripping xerographic drums.

These and other objects of the present invention are obtained by impacting the surface to be stripped with a stream of beads having properties such that they will deliver energy over a relatively long period of time rather than in a short contained burst at impact.

For a better understanding of this invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 is a side elevation of the blast cabinet and conveyor system related thereto containing the present invention;

FIG. 2 is a partial section through the blast cabinet shown in FIG. 1 and taken along line 2—2 of FIG 1;

FIG. 3 is a side elevation of a type of automatic stripping and recovering system utilized in the present invention;

FIG. 4 is a partial section of an electrostatic separator taken along lines 4—4 of FIG. 3;

FIG. 5 shows in schematic form a process for stripping selenium in accordance with the present invention.

In the xerographic process, a plate, comprising a conductive material upon which is coated a layer of photoconductive material, is uniformly electrostatically charged over its entire surface. The charged plate is then exposed to a light image causing the electrostatic potential stored

on the photoconductive material to be imparted to the conductive backing at a predetermined rate thereby forming a latent electrostatic image. This latent image can then be developed by any suitable means to produce a visual presentation of the original light image.

In high speed automatic xerographic machines, it has been found advantageous to shape the xerographic plate in the form of a cylindrical drum so that the plate can be continually passed through the various xerographic processing steps. A xerographic plate will, through continued usage, become either physically marred by foreign objects or the like, or the plate will become electrically fatigued in that it will lose its sensitivity to light. In either case, the xerographic drum must be replaced. Rather than discard the used drum, it has been found economically feasible to reclaim for reprocessing both the photoconductive coating material as well as the drum shaped conductive substrate.

The xerographic plate in widest commercial use today comprises a photoconductive layer of selenium which is between 10 and 75 microns thick. This photoconductive layer is generally placed upon a drum of conductive material such as aluminum or brass. Such a plate, as herein described, is disclosed by Bixby in U.S. Patent 2,970,906. Although the exact molecular structure of the selenium coating is not known with certainty, it is known that the selenium bonded to the support material is in a hard amorphous or vitreous form. Heretofore, it has been found commercially impractical to mechanically remove this relatively hard selenium coating from the soft conductive backing because the mechanical forces required were such as to seriously damage the soft conductive support and thereby render the support unreclaimable.

The present invention constitutes a new approach to mechanically working or removing material. In the present invention a particle is impinged against the work, the particle being capable of delivering mechanical energy over a relatively long period of time rather than in a sudden contained burst at impact. A particle is selected which has: (1) a modulus of elasticity below that of the soft surface to be impacted so that the bead rather than the soft material will be deformed upon initial impact; (2) a high yield point so that the bead can be deformed without exceeding its elastic limits; and (3) a high resilience (resilience being the ability of a body to absorb impact stresses as well as static loads) so that the bead will return to its original shape after the impact forces causing deformation are removed, the energy stored in deforming the particle then being imparted to a work surface contacted.

The amount of work required in deforming a body within its proportional limits is substantially equal to the energy stored within the body. A body so deformed will give up this stored energy as it returns to its original shape or posture. In operation a particle is hurled at the surface to be mechanically worked with a force high enough to impart sufficient energy to the particle to perform the required work. However, the impacting force is held below that at which the particle would be permanently deformed or fractured. It is believed that mechanical energy is delivered to the work surface by a particle of the type herein described in steps or increments rather than in a sudden or sharp burst of energy. The elastic particle releases all of its energy upon impact; part of this energy is delivered to the work surface at the moment of impact and part of the energy is returned to the particle in work energy used to deform the particle within its elastic limit. It should be noted that a slight amount of energy is lost as heat or friction, however, most of the total energy of deformation is stored as internal energy. The particle being resilient, it will continue to deliver this internally stored work energy to the impacted surface as the deforming force, that is, the force of impact, is removed. Because this resultant force is a sustained force rather than a pure impact force, a relatively soft material can be worked without fear of damage. That is, a large amount of mechanical work can be delivered by the shot particles without the harsh and oftentimes damaging effect of pure impact forces.

For example, it was found that during stripping tests of a xerographic drum having a selenium photoconductive layer of about 40 microns on an aluminum base that the selenium coating could be stripped at rates in excess of 2,000 square inches per minute using a substantially spherical plastic bead made of methyl methacrylate, the bead having a diameter of between 0.001 and 0.01 inch. An air generator supplying air pressure at about 70–80 pounds per square inch was used to propel the beads at a work surface located at varying distances from the nozzle. One test was conducted using beads of approximately 0.004 inch in diameter with the nozzle located 8 inches from the drum producing a strip rate of 2263 square inches per minute resulting in impinging dents in the support material of 19×10^{-5} inches. A second test was conducted under similar conditions with the nozzle located 6 inches from the work. In the latter test a strip rate of 2011 square inches per minute was obtained leaving impinging dents of 23×10^{-5} inches in depth. Marks of this depth are readily removed by a single polishing operation.

It should be obvious to one skilled in the art that higher strip rates are obtainable by varying the resiliency of the bead material, raising the pressure at the nozzle, or decreasing the distance from the nozzle to the work surface thus increasing the impact forces. However, it should also be clear that by altering these parameters to obtain higher strip rates, an opposite effect is had on the depth of impingement marks so produced, therefore, the various parameters should be optimized for each particular application.

Referring to FIG. 1 and FIG. 2, apparatus is shown for automatically stripping a xerographic drum. Drums **10** (FIG. 1) are loaded upon endless belt conveyor **15** which transports the drums through blast cabinet **20**. The blast cabinet, generally indicated **20**, is supported by legs **21** and includes front and rear walls and opposite end walls designated **22**, **25**, **23**, and **24**, respectively. Front wall **22** contains a window **26** through which the operator may view drums in the cabinet during the stripping operations. End walls **23** and **24** have ingress and egress ports, respectively, therein through which a drum seated on conveyor **15** can be transported in and out of the blast cabinet. Located at the egress port is a gravity roll conveyor **16** capable of transporting drums leaving the endless belt out of the blast cabinet.

Mounted along the roof **27** of the blast cabinet are a series of nozzle receptors **28** capable of receiving and holding a blast nozzle **30** so that the nozzle is directed towards the work being transported through blast cabinet **20**. Blast shields **29** are slidably mounted in the cabinet to contain shot particles and material removed from the drum within a defined work zone. The work zone is defined by the area over which the nozzle directs shot particles and the size of this work zone will vary as the number of nozzles and the angle at which the nozzles are mounted is varied.

Transport conveyor **15** comprises a series of flat base plates **35** which are flexibly joined by means of links **36** so that the plates cooperate to form an endless belt. The endless belt is driven in the direction indicated, by means of drive motor **32** (FIG. 2), or any suitable drive mechanism, acting in conjunction with a transmission (not shown) to control the speed of the endless belt. A belt adjuster **17** is also provided to control the tension on the endless belt.

Referring now to FIG. 2, each individual base plate **35** has affixed thereon two separate U-shaped cradles **38** having rotatably mounted therein cylindrical shaped trunnions **37**. As seen in FIG. 2, the two trunnions are mounted so that their center lines are substantially

parallel to each other and coaxial with the direction of belt travel. The rear or fixed trunnion, that is, the trunnion which is transported closest to rear wall 25 of the blast cabinet, is permanently affixed to the base plate 35 while the forward or adjustable trunnion is slidably mounted on the base plate in slotted holes 39. Drums of varying diameters can be accommodated by simply loosening bolts 40 and adjusting the distance between the two parallel rows of trunnion rollers so that a drum of desired diameter can be seated therebetween. Positioned along the cylindrical body of fixed trunnions 37, and coaxial therewith, are a series of rings 41 made of silicone rubber or similar resilient material having good wear properties as well as a high coefficient of friction. The drums shown in FIG. 2 are seated between the two rows of rollers and are in friction bearing contact with rings 41.

As previously noted, the nozzle/or nozzles located in the work zone are retained therein in a stationary position. In order to strip the entire surface area of the drum, the drum is rotated as it is transported past the nozzle stream so that the shot particles come in contact with the entire outer periphery of the drum. The drum is thus stripped in a spiral fashion much like the geometric shape described by a screw being turned in a nut.

Referring once again to FIG. 2, the stationary or fixed row of trunnions 37 are brought into contact with cylindrical drive roll 45 so that the silicone rubber rings mounted on the rollers are in contact with the drive roll. Cylindrical drive roll 45 is rotatably mounted on shaft 46 which is journaled at one end in bearing housing 47 and at the other end in gear box 48. Driving power to the drive roll is supplied by drive motor 49 through gear box 48, the speed of rotation being controlled by selection of the desired gear ratio.

Rotational forces are imparted to the xerographic drum from cylindrical drive roll 45 through means of trunnion rollers 37 as the trunnions are being moved through the work zone. Upon entering the blast cabinet, the flat base plates comprising the endless belt ride into sliding contact with rails 50 which in turn place the fixed row of trunnions at the proper elevation so that the rubber rings mounted thereon contact the cylindrical drive roll at approximately its horizontal center lines. Guide plate 51, located in the front of the cabinet, is biased by means of resilient rubber member 52 against the flat base plates 35 as the base plates pass through the work zone. The biasing pressure in turn holds trunnions 37 in bearing contact with the cylindrical drive rolls 45 while in the work zone thus imparting a rotational motion to the xerographic drums mounted thereon.

It has been found that the rubber rings mounted on fixed trunnions 37, because they are in one point bearing contact against rotating cylindrical drive roll 45, will walk across the drive roll as they move through the work zone. It has further been found that, although there is some friction resulting from the rubber rings being moved laterally across the cylindrical drive roll, the resultant friction produced is very slight and does not appreciably hamper the operation of the apparatus or wear characteristics of the rings.

Referring once again to FIG. 1, located in the bottom of blast cabinet 20, is a vibratory bed 55 upon which particles of selenium and beads being dislodged from a drum fall. A screen is mounted in the bed which will pass all the plastic beads and the smaller selenium particles. The bed is inclined toward one end of the cabinet so that larger particles retained thereon will be transported towards this low end by the vibratory motion. Located at the low end of the bed is an opening to which is affixed flexible line 57 through which the large particles of selenium fall into recovery receptacle 58. The vibratory bed is motivated by means of eccentric arm 59 which is being rotated by drive motor 60.

Located in the work zone between the upper delivery section of the endless belt and the lower return section thereof is a series of baffle plates (not shown) which direct the flow of beads and particles leaving a work piece around the belt rather than through the lower return section so that all of the residue from the stripping operation falls on the vibratory screen rather than being carried out of the cabinet on the conveyor belt. The beads and smaller particles of selenium being passed through the screen fall into funnel shaped conveyors 61 and 62.

A negative air pressure is maintained in the blast cabinet by means of a fan and motor located in dust collector 65 which acts through line 66 (FIG. 3). Due to the negative air pressure being maintained on the system, the beads and smaller selenium particles collected in funnel shape conveyors 61 and 62 are transported through lines 66 to hopper 67 located just below the dust collector as shown in FIG. 3. Dust collector 62, which is similar to a household vacuum cleaning system, will exhaust from the system any dust or lint particles which may have entered the blast cabinet through the ingress and egress ports. The dust particles are collected in vacuum bags (not shown) and then removed from the system.

As shown in FIG. 3, located directly below hopper 67 is an electrostatic separator 70 used to divide the recovered selenium particles from the plastic beads. The flow of beads and particles from hopper 67 to the separator is controlled by means of control valve 68 which meters the flow of particles and beads passing through supply line 69.

It has been found that the plastic beads and selenium metal acquire different triboelectric charges when hitting or rubbing together as they do during transit, that is, one material will become triboelectrically more positive in reference to the other. Referring now to FIG. 4, the combined beads and selenium particles which have acquired a triboelectric charge due to their movement through line 66 are supplied to hopper 72 located in the electrostatic separator. Located in hopper 72 is screw conveyor 73 which spreads the material so that it will pass to the first separating stage evenly along the entire length of the separator. In operation the material to be separated is gravity fed between grounded roll 74 and charged electrode 75, the charged electrode being at a potential which is either positive or negative in reference to the grounded roll 74. In this embodiment the electrode is maintained at a potential to attract the triboelectrically charged selenium particles while the beads will be attracted toward the grounded roll 74. As shown in FIG. 4, the plastic beads pass towards the grounded side of separator bar 76 while the selenium is attracted to the opposite side of the bar so as to isolate one material from the other. Wiper arms 77 and 78, respectively, are biased against the charged electrode and the grounded roll so that any material adhering thereto will be cleaned from the roll.

The beads attracted to the grounded roll are sent through a second and third separating pass similar to the first. Likewise, the selenium metal which is separated during these first three passes is reprocessed in the fourth stage of the separator. The selenium metal is then gravity fed from the separator through line 91 to collecting receptacle 95 (FIG. 3). The middlings, that is, the unseparated material which remains after the fourth separating pass, are conveyed back to the separator for further processing by means of a conveyor or the like (not shown).

As shown in FIG. 3, line 90 conveys the beads from the separator to blast generator 80 where they are reused in the stripping process. Over a period of time the plastic beads may become contaminated with metal or may become fractured through usage and, therefore, it may become desirous to recharge the system with new beads. Line 90, which conveys the beads from the separator to the generator, is divided into two separate branches with one line supplying the blast generator and the other waste

receptacle 96. To recharge the system, the used beads leaving electrostatic separator 70 are first conveyed to the waste receptacle while new beads are loaded directly into blast generator 80.

The utilization of the various electrostatic separating stages may be altered to best facilitate the triboelectric properties of the various material stripped.

A second process for stripping selenium embodying the features of the present invention is shown schematically in FIG. 5. It is possible to strip a xerographic drum at a reduced rate by recharging the blast generator with a mixture of shot particles which are somewhat contaminated with selenium material. Utilization of this method results in an economic saving because the beads need only be electrostatically separated periodically rather than once during each processing cycle.

As shown in FIG. 5, the xerographic drums are first stripped in blast cabinet 20 with the used bead and stripped selenium particles falling upon vibratory screen 55. The larger particles of selenium removed during the stripping operation are retained upon the screen while the smaller beads and selenium particles are passed through the mesh. The residue passing through the screen is then transported to a cyclone separator with the finer particles of selenium, fractured beads, and any dust which may have entered the system are separated from the whole beads and intermediate selenium particles. The separated dust, selenium, and fractured bead particles are removed from the system and collected in dust collector 65. The beads and selenium particles remaining after the cyclone separation are used to recharge blast generator 80 (solid path line) or are periodically processed through the electrostatic separator 70 (dotted path lines).

When the electrostatic separator is bypassed, that is, beads mixed with some selenium particles are being fed directly into the blast generator, steady drop-off in the stripping rate is initially noticed. This drop off continues until the rate of stripping is about 25% that obtained with new beads after which the stripping rate remains relatively constant. To prevent an excessive build up of selenium in the shot blasting process, it is found advantageous to periodically electrostatically separate the intermediate selenium particles from the plastic beads.

While this invention has been described with reference to structure disclosed herein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. The method of mechanically removing a hard coating from a relatively soft substrate by impacting resilient particles against the surface to be removed with sufficient force to strip the coating from the substrate, said particles having a lower modulus of elasticity than the modulus of elasticity of the substrate material.

2. The method of claim 1 wherein said particles are capable of absorbing high impact stresses without inducing permanent deformation.

3. The method of claim 1 wherein said particles are substantially spherical in shape.

4. The method of mechanically removing a selenium coating from a relatively soft substrate by impacting the selenium coating with a substantially spherical particle of methyl methacrylate.

5. The method of claim 4 wherein the particles are between 0.001 inch and 0.010 inch in diameter.

6. The process of removing and recovering a hard coating from a relatively soft substrate including

impacting the hard coating with resilient beads with sufficient force to strip said coating, said beads having a lower modulus of elasticity than the modulus of elasticity of the substrate leaving fine, intermediate, and heavy coating particles,

separating the fine and heavy coating particles from the beads and the intermediate coating particles after the last mentioned stripping operation,

electrostatically separating the beads from the intermediate coating particles, and

reclaiming the beads for reuse in the stripping operation.

7. A process of removing and recovering a hard coating of selenium from a relatively soft support material including

stripping the selenium coating by impacting the selenium with resilient beads having a lower modulus of elasticity than the modulus of elasticity of the support material,

separating a portion of the selenium from the beads after the last mentioned stripping operation and collecting said beads,

periodically electrostatically recovering the remaining selenium particles from the collected beads, and

reclaiming the beads for reuse in the stripping operation.

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U.S. Cl. X.R.

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