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Andersson

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[54] **WEAR RESISTANT LINING FOR GRINDING MILLS**

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[52] **U.S. Cl.** **241/300;** 241/182; 241/183; 241/DIG. 30

[51] **Int. Cl.**[2] **B02C 17/22**

[58] **Field of Search** .... 241/181–183, 241/300, DIG. 30; 138/138, 147; 117/93.2, 79; 427/18, 47, 127

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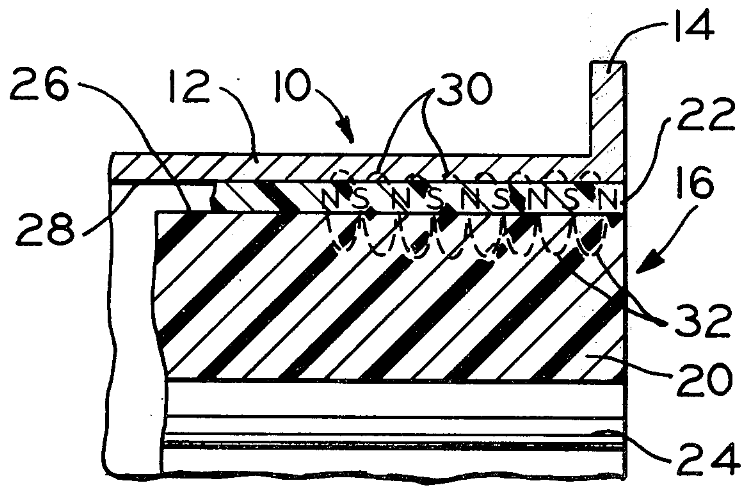
[57] **ABSTRACT**

A wear and abrasion resistant lining structure is disclosed for devices such as rotary grinding mills and chutes. The lining comprises a layer of resilient wear resistant material, such as rubber, which is magnetically retained in place with respect to the surface to be protected. Magnetic retention is achieved by a sheet of magnetic rubber bonded to the lining material. A thin steel sheet between the lining and magnetic rubber increases the magnetic retention capability.

16 Claims, 6 Drawing Figures



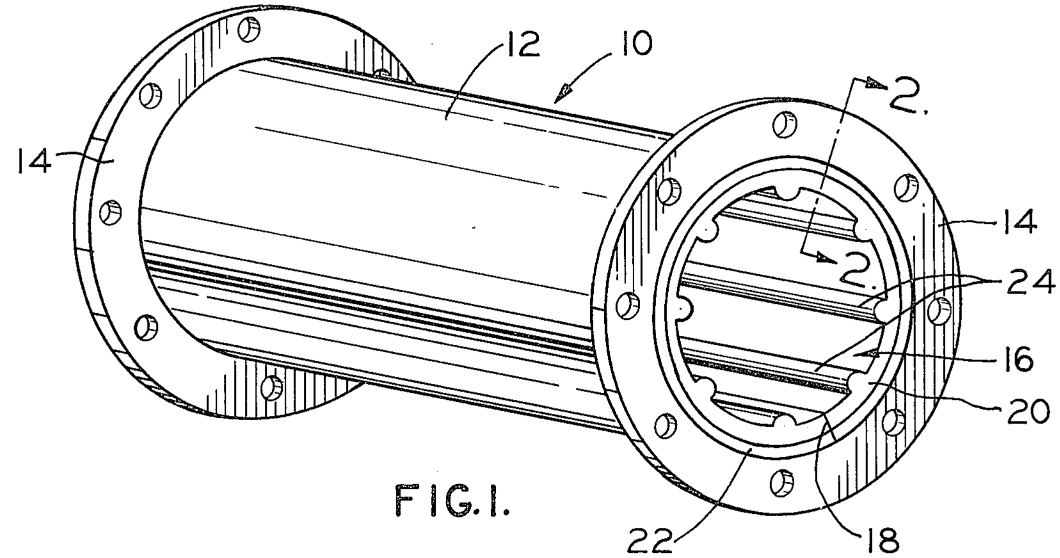


FIG. 1.

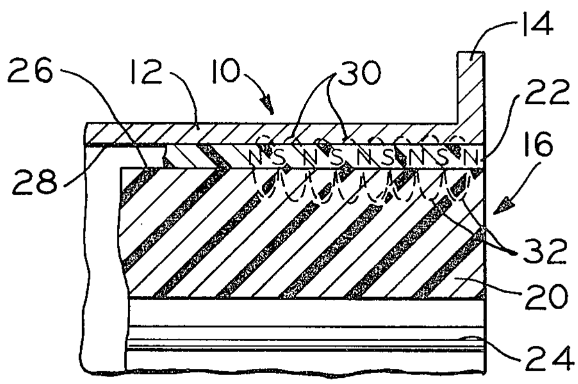


FIG. 2.

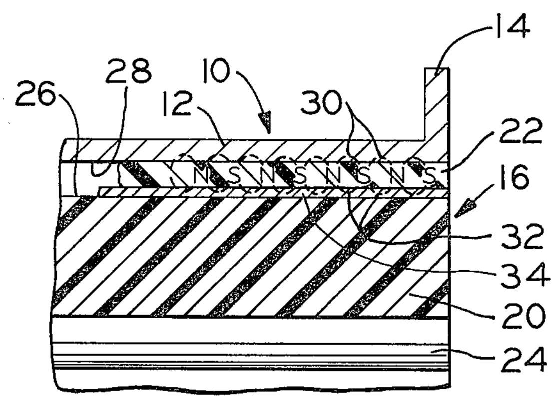


FIG. 3.

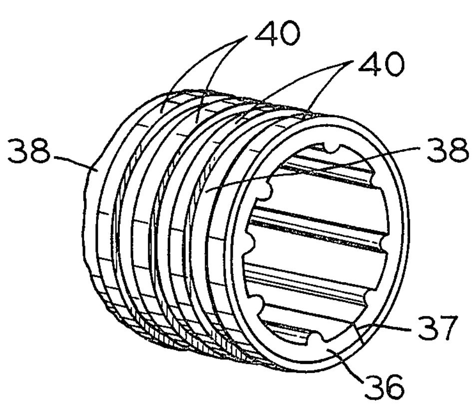


FIG. 4.

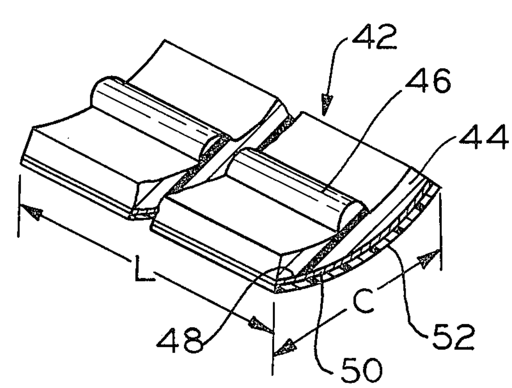


FIG. 5.

WEAR RESISTANT LINING FOR GRINDING MILLS

The present invention relates to the art of abrasive material treating or handling and, more particularly, to an abrasion and wear resistant lining structure for a grinding mill drum or an abrasive material conveying chute.

Rotary mills are well known apparatus used, for example, in mixing and/or pulverizing various types of materials. Such mills commonly include a metal shell or drum at least a portion of which is cylindrical and which is supportable for rotation about the longitudinal axis thereof. Metal balls, or the like, are placed in the drum together with the material to be treated, and rotation of the drum results in the desired grinding or mixing of the material. It is also well known that highly abrasive materials such as metal ores are conveyed from one location to another by gravity flow along a conveyor chute having bottom and side surfaces to guide material movement. Such chute walls are generally produced from metal plates such as steel.

In order to protect the metal shell or drum of a mill, or the bottom and sidewalls of a chute from the affects of abrasive and/or impact contact of material therewith, the drum or chute is provided with a protective wear resistant lining of an elastomeric material, such as natural or synthetic rubber. Such linings are generally defined by strips or segments of lining material ranging from about ½ inch to 2 inches in thickness and in hardness from about 40° to 80° on the Shore A scale.

A major disadvantage with regard to linings presently available for mills and chutes resides in the manner in which the linings are mounted on the device. Certain linings heretofore provided have been mounted by the use of bolt arrangements in which the head of a bolt is embedded in the lining material or is disposed in a slot provided therein, the shanks of the bolts projecting through corresponding openings in a wall of the device so as to receive nuts. Mounting arrangements of this nature involve steps in the production of the lining which add to the production cost and, moreover, assembly and maintenance time is increased as a result of having to manipulate mechanical fasteners. Further, such fasteners can come loose during use of the device and the resulting looseness of the lining can lead to increased wear, or damage to the lining.

Other mounting arrangements heretofore employed have included bonding or vulcanizing the lining material in place with respect to a support member of the device. Bonding or vulcanizing is undesirable in that it is most difficult to remove a portion or all of the lining for repair or replacement purposes. Accordingly, replacement and/or maintenance is extremely costly and, moreover, the device must necessarily be withdrawn from use for a considerable period of time, whereby production is stopped or production rate reduced.

In addition to the mounting arrangements mentioned hereinabove, it has been proposed to retain a cylindrical liner within a mill drum by providing for the circumferential dimension of the liner to be slightly greater than the diameter of the drum, whereby the liner is retained in place by the peripheral compression thereof acting outwardly against the drum surface. Many disadvantages are attendant to lining a drum in this manner. For example, it is well known that the weight of the material being treated in the drum and its shifting motion impose tensional stress on the lining. Such tensional

stress would tend to overcome the compression force in the lining causing the lining to buckle inwardly of the drum. Moreover, extreme accuracy and care in producing such a lining would have to be exercised to avoid a state of over compression or under compression when the lining is mounted within the drum. In this respect, the compressive forces enhance buckling of the lining inwardly of the drum, and over compression resulting from the lining being too large in diameter would increase the likihood of buckling, such as by the tensional stress placed on the lining material as mentioned above. If, on the other hand, the lining diameter is too small, slippage is apt to occur between the lining and drum which, if too great, could affect the tumbling desired with respect to the material being treated.

In accordance with the present invention, a grinding mill or chute liner is provided with a mounting arrangement by which the foregoing disadvantages, and others, of mounting arrangements heretofore known are advantageously avoided. More particularly, in accordance with the present invention, a mill or chute lining is removably retained in place by magnetic attraction. The magnetic attraction capability can be achieved in any number of ways and, preferably, is achieved through the use of a sheet or strips of flexible permanent magnet material suitably attached to the mounting face of the lining material. The lining may be provided in a continuous strip, or by several strips or segments disposed in side-by-side relationship. In either case, it will be appreciated that the lining is readily mountable and/or removable from a drum or chute and, when mounted, is interengaged with the device against slippage relative thereto during use of the device, and without the necessity of separate fasteners, such as bolts or the like.

Preferably, the desired magnetic attraction of the lining to the drum is achieved through the use of thin permanent magnet material of the character including a body of non-magnetic material having permanent magnet particles therein. Such permanent magnet material is per se well known and includes, for example, a body of rubber, or plastic such as nylon, having particles of a magnetic material, such as barium ferrite embedded therein. The material is generally produced in sheet form following which the particles are magnetized to impart desired magnetic properties to the sheet material. Magnetization may be achieved in a number of different ways. For example, magnetization may provide for opposite surfaces of the sheet material to be of opposite polarity, or for adjacent areas across a face of the sheet to be of alternately opposite polarity.

In accordance with one aspect of the present invention, a sheet of such permanent magnet material, coextensive in area with a mounting face of a strip of lining material, is bonded or vulcanized to the mounting surface of the lining strip. As mentioned hereinabove, the lining strip may be a continuous strip coextensive with the support surface of the device or may be one of a plurality of strip segments disposed in side-by-side or end-to-end relationship. In either event, it will be appreciated that the permanent magnet material is attracted to the support surface to hold the lining strip or strips in place with respect thereto. In accordance with another aspect of the invention, the mounting surface of the lining material is provided with such permanent magnet material in discrete areas of the mounting surface. For example, narrow elongated strips of the magnet material can be bonded or vulcanized to the mounting face in generally parallel spaced apart relationship with respect to one another.

In accordance with yet a further aspect of the present invention, a thin metal plate of magnetic material, such as steel, is attached, such as by vulcanization, to the mounting face of the liner material, and the flexible permanent magnet material is mounted on the metal plate. Thus, when the lining is in place on the support surface, the permanent magnet material is sandwiched between the metal plate and the opposed support surface. The metal plate serves to reduce the reluctance in the magnet circuit by reducing the air gap adjacent the surface of the permanent magnet material facing the mounting surface of the liner material. By reducing the reluctance in this manner, the flux in the magnetic circuit is increased to increase the holding power of magnetic attraction between the magnet material and the liner supporting surface of the device.

It will be appreciated that the metal sheet can be either flexible or rigid. For example, it may be advantageous to provide for the sheet to be sufficiently flexible to enable production of the lining in the form of an elongated strip adapted to be formed into an annular configuration for introduction into a mill drum. In such case, the inherent resiliency of the lining material and the metal sheet would tend to return the lining to its initial straight contour, thus increasing the retention capabilities of the lining with respect to the inner surface of the drum. Alternatively, the metal plate could be substantially rigid or produced to have a predetermined curvature such as where a mill lining is defined by circumferentially adjacent lining segments, each of which would have a curvature corresponding to that of the inner surface of the drum. The pre-formed metal plate would, of course, serve to maintain the desired curvature for the corresponding segment of the lining.

It is accordingly an outstanding object of the present invention to provide a resilient wear resistant lining for a device having a surface subject to wear and which lining is retained in place with respect to the device by magnetic attraction.

Another object is the provision of a lining of the foregoing character which is retained in place with respect to the surface to be protected against slippage and/or displacement relative to the surface without the use of fastening components mechanically interengaging the lining and drum.

Yet another object is the provision of a lining of the foregoing character which minimizes the time required to mount or remove the lining or a portion thereof with respect to a support surface for the lining.

Still another object is the provision of a lining of the foregoing character which is structurally simple and economical to produce, and which is readily assembled and disassembled with respect to a mill drum, whereby the costs of production and maintenance are minimized, and maintenance time is minimized to decrease down time of a given grinding mill.

The foregoing objects, and others, will in part be obvious and in part pointed out more fully hereinafter in conjunction with the written description of preferred embodiments of the invention illustrated in the accompanying drawings in which:

FIG. **1** is a pictorial view of a cylindrical grinding mill drum provided with a lining made in accordance with the present invention;

FIG. **2** is a sectional elevation view of a portion of the drum and lining illustrated in FIG. **1**, the section being along line **2**—**2** in FIG. **1**;

FIG. **3** is a sectional elevation view similar to FIG. **2** and illustrating a modification of the liner construction in accordance with the present invention;

FIG. **4** is a perspective view of a further embodiment of a mill lining in accordance with the present invention; and,

FIG. **5** is a perspective view of a grinding mill lining segment structure in accordance with the present invention.

For purposes of brevity the invention will be described with regard to embodiments of a liner for a rotatable grinding mill. Accordingly, the showings in the drawings are for the purpose of illustrating such embodiments of the present invention only and not for limiting the invention.

A grinding mill drum **10** is illustrated in FIG. **1** which includes a cylindrical body portion **12** having apertured flanges **14** at the opposite ends thereof which provide means for mounting end plates or covers on the drum in a well known manner. It will be appreciated that drum **10** is merely illustrative of one of a wide variety of drum structures employed in the rotary grinding mill field, and that the lining of the present invention can be employed with drum structures other than that illustrated. Drum **10** is provided with a wear resistant lining **16** which, in the embodiment illustrated, is axially and circumferentially coextensive with respect to the corresponding dimensions of the inner surface of the drum. The circumferentially opposite ends of the lining abut along an axially extending line **18**.

Lining **16** is comprised of a layer **20** of a resilient wear resistant material, such as natural or synthetic rubber, and an outer sheet **22** of flexible permanent magnet material as described more fully hereinafter. The surface of layer **20** facing inwardly of the drum may be smooth or, as illustrated, may be provided with axially extending lifters **24** for elevating the material being treated in the drum as well as the ball, tube or rod elements employed to achieve mixing or pulverizing of the material. Lifters **24** are illustrated as radially inwardly projecting ribs integral with the material of layer **20**, but it will be appreciated that other lifter constructions integral with or separate from layer **20** and suitably interengaged therewith can be employed. The radial thickness of layer **20** in the areas between lifters **24** can vary from one lining to another depending on the particular mill design, but generally the thickness is between ½ to **2** inches.

Grinding mill drums are generally produced from steel which, of course, is a magnetic material, and the following description of the lining constructions of the present invention will be described in conjunction with a steel drum having a cylindrical inner surface on which the lining is mounted. It will be appreciated, however, that the inner surface of a particular drum on which the lining is mounted may be defined other than by the inner surface of the drum shell and that it is only necessary that the means defining the inner surface of the drum on which the lining is to be mounted be of a magnetic material.

In the embodiments disclosed herein, the permanent magnet material, designated by flexible sheet **22** in FIG. **1**, is a product commercially available from Minnesota Mining and Manufacturing Co. under the trademark PLASTIFORM. This material includes a body portion of rubber having particles of barium ferrite embedded therein during the production of the sheet or strip material. The magnet material is available in thicknesses of about 1/32 and 1/16 inch and in widths of ½ inch to 12 inches. Following production of the strip or sheet material, the particles are magnetized to provide the sheet with desired magnetic properties on the faces thereof. In the PLASTIFORM material, the particles are magnetized to provide alternate areas of opposite polarity along the plane of the sheet. It will be appreciated, however, that this particular polar relationship is not essential to the principles of the present invention, and that the particles in the body may be magnetized to provide, for example, for the opposite faces of the material to be of opposite polarity.

To facilitate the description and understanding of the function of the magnet material, sheet **22** of permanent magnet material is illustrated in FIG. **2** as having alternate north and south poles with respect to the longitudinal axis of the milling drum, as indicated by the letters N and S, respectively. Layer **20** of resilient wear resistant lining material has an outer or mounting surface **26** facing cylindrical inner surface **28** of the drum. Sheet **22** is bonded, such as by a suitable adhesive or by vulcanization, to mounting surface **26** of layer **20.** When the lining is inserted in the drum, permanent magnet material **22** is magnetically attracted to inner surface **28** of body portion **12** of the drum, whereby the lining is held in place with respect thereto. The alternate polarity along sheet **22** provides a plurality of magnetic circuits having flux paths including portions **30** through steel body **12** and portions **32** extending radially inwardly of the inner face of sheet **22.** In the embodiment of FIG. **1,** magnet material **22** is longitudinally and circumferentially coextensive with liner **20.** Since the particular magnet material described is available in **12** inch widths, it will be appreciated that, in the longitudinal direction of the liner for example, separate sheets of the magnet material may be required to cover the liner surface depending on the longitudinal dimension of the liner. It will be understood, therefore, that coextensive as used herein with respect to the magnetic sheet material is inclusive of an arrangement requiring two or more sheets in side-by-side relationship which together cover the surface on which they are mounted.

FIG. **3** of the drawing illustrates a modification of the lining of FIG. **2** and by which an increase in holding power or magnetic attraction between the lining and mill drum is achieved. The lining in FIG. **3** is similar in many respects to lining **16** in FIG. **2,** and accordingly, like numerals are employed in FIG. **3** to designate corresponding components of the two lining structures. In the embodiment of FIG. **3,** a thin metal plate **34** of magnetic material such as steel is interposed between mounting surface **26** of layer **20** and the sheet of permanent magnet material **22.** Plate **34** is bonded to layer **20** such as by vulcanization, and sheet **22** is attached to the exposed outer surface of the metal plate. Preferably, sheet **22** is bonded to plate **34** such as by vulcanization, or by a suitable adhesive.

When the lining of FIG. **3** is introduced into the mill drum, the lining is attracted toward inner surface **28** of steel body **12** in the manner described hereinabove with regard to FIG. **2.** In the embodiment of FIG. **3,** however, the reluctance of the magnetic circuits is reduced by the presence of steel plate **34** which shortens the air gap between adjacent north and south poles. Accordingly, flux paths **32** extend through plate **34,** whereby an increase in flux is achieved in the magnetic circuits to increase the holding power between the lining and steel body **12** of the drum. Preferably, steel plate **34** is of a thickness which will enable a flat lining sheet of the foregoing structure to be manually displaced into circular form for insertion into a drum. A thickness of about **1/64** to **1/32** inch will enable such manipulation, but other thicknesses can be employed. The thickness of the steel plate will depend in part on the thickness of the lining sheet and the overall flexibility desired. Generally, steel plate thicknesses of between about **1/64** to ⅛ inch will provide the desired results. Preferably, plate **34** is coextensive in length and width with lining sheet **20,** but it will be appreciated that the holding power provided by plate **34** can be achieved by other structural arrangements. Moreover, it will be appreciated that when the lining and steel sheet are produced in a flat form and then curved to fit a mill, the resilience of the rubber lining and steel plate together advantageously add to the holding power provided by the magnet material.

In FIG. **4** of the drawing, there is illustrated yet a further embodiment of a drum lining made in accordance with the present invention. In this embodiment, the lining includes a layer **36** of resilient wear resistant material such as natural or synthetic rubber shown in circular form with the opposite ends abutting along axially extending line **37.** Layer **36** has a mounting surface **38** which faces the inner surface of a drum when the lining is disposed therein. Mounting surface **38** is provided with a plurality of strips **40** of flexible permanent magnet material such as that described hereinabove in conjunction with the preceeding embodiments. Strips **40** are bonded to surface **38** such as by vulcanization and, in FIG. **4,** define circumferentially continuous bands which are axially spaced apart along the length of layer **36.** The strips may, for example, be about one inch wide and may be spaced apart about one inch. The retention capability provided by strips of permanent magnet material as opposed to continuous sheets is sufficient to retain the lining in place within a drum against slippage relative thereto.

While strips **40** are illustrated as extending circumferentially of layer **36,** it will be appreciated that the strips can extend longitudinally of layer **36** in circumferentially spaced apart relationship with respect to one another. Further, it will be appreciated that metal strips of magnetic material, such as steel, or a plate of such magnetic material can be interposed between strips **40** and mounting surface **38** of layer **36** in the manner and for the purpose described hereinabove in conjunction with steel plate **34** of the embodiment in FIG. **3.** Moreover, it will be appreciated that other arrangements of flexible permanent magnet material relative to the mounting surface of layer **36** can be employed in place of strips to provide for the permanent magnet material to be disposed in spaced apart locations longitudinally and/or circumferentially of layer **36.** Still further, in the strip arrangement illustrated in FIG. **4,** or in other arrangements of magnet material in spaced apart locations on layer **36,** the magnet material can be placed in corresponding recesses in mounting surface **38** so that the outer surfaces of the magnet material are coplanar with surface **38.**

Another embodiment of the present invention is illustrated in FIG. 5 of the drawing. In this respect, a drum lining segment **42** is illustrated which has longitudinal and circumferential dimensions L and C with respect to the longitudinal and circumferential dimensions of a given mill drum. Dimension L may correspond to the longitudinal dimension of the drum, or a portion of the latter dimension, and the circumferential dimension of the drum would be a multiple of dimension C by any integer other than one. In other words, two or more segments **42** disposed side-by-side circumferentially of the drum would be required to completely line the drum circumferentially. Similarly, one, two or more of the segments would be required to provide a lining longitudinally coextensive with the inner surface of the drum.

Each segment **42** includes a layer **44** of resilient wear resistant material such as natural or synthetic rubber and which if desired, can be provided on its inner surface with a lifting element **46.** Layer **44** has a mounting surface **48** which faces the inner surface of a drum when the segment is mounted therein. In the embodiment illustrated, a thin metal plate **50** of magnetic material, such as steel, is bonded to surface **48** such as by vulcanization, and a sheet **52** of permanent magnet material of the character described hereinabove is attached to the exposed outer surface of metal plate **50.** Preferably, plate **50** and layer **44** are formed with a curvature which conforms with the curvature of the inner surface of a drum with which the segment is to be used. Further, plate **50** is preferably longitudinally and circumferentially coextensive with mounting surface **48** of layer **44,** and permanent magnet material **52** is likewise coextensive with the corresponding dimensions of plate **52.**

Segments **42** are, of course, individually mounted within the drum in circumferentially adjacent relationship, and each segment is magnetically attracted to the inner surface of the drum in a manner described hereinabove with respect to the preceeding embodiments. While steel plate **50** is preferred in connection with the lining segment described to provide for increasing the holding power between the lining segment and drum, it will be appreciated that sheet **52** of permanent magnet material can be directly bonded to the mounting surface of layer **44,** such as by vulcanization, without departing from the principles of the present invention.

While considerable emphasis has been placed herein on the fact that the linings in certain embodiments are both longitudinally and circumferentially coextensive with the inner surface of the drum, it will be appreciated that the linings can be produced in elongated strips having a length sufficient for the strips to be circumferentially coextensive with the drum, and having a width requiring one or more sections with respect to the longitudinal dimension of the drum. Retention by magnetic attraction advantageously enables the production of the lining in elongated strip form, cutting of the strip to a length corresponding to the circumferential dimension of the drum, rolling the strip and then inserting the rolled strip into the drum to complete the assembly. It is not necessary to bond the joint between the abutting circumferentially opposite ends of the strip, but such a bond may be provided if desired. In either event, the lining is readily removable from the drum by peeling the lining away from the inner surface of the drum and axially withdrawing the lining from the drum.

Moreover, while flexible permanent magnet sheet material of the character described hereinabove is preferred to achieve magnetic attraction between the lining and the support surface of a device such a mill drum or chute wall, it will be appreciated that other arrangements can be provided for this purpose without departing from the principles of the present invention. For example, small permanent magnet elements could be attached to or embedded in the mounting surface of the resilient wear resistant layer of material. Accordingly, as many possible embodiments of the present invention may be made and as many possible changes may be made in the embodiments herein illustrated and described, it is to be distinctly understood that the foregoing descriptive matter is to be interpreted merely as illustrative of the present invention and not as a limitation.

What is claimed is:

1. A lining for an abrasive material handling device having surface means of magnetic material comprising, a layer of wear resistant resilient material, and permanent magnet means attached to said layer for releasably retaining said lining on said surface means by magnetic attraction.

2. The lining according to claim **1,** wherein said magnet means includes a body of resilient non-magnetic material and magnet particles in said body.

3. The lining according to claim **2,** wherein said layer has a mounting surface, and said body of non-magnetic material is bonded to and generally coextensive in area with said mounting surface.

4. The lining according to claim **2,** wherein said magnet means includes a plurality of bodies of resilient non-magnetic material having magnet particles therein, and said bodies are attached to said layer in spaced apart relationship with respect to one another.

5. The lining according to claim **4,** wherein said layer has a mounting surface, and said bodies are strips bonded to said mounting surface in spaced apart generally parallel relationship.

6. The lining according to claim **1,** and thin plate means of magnetic metal between said layer and said magnet means and bonded to said layer of resilient material.

7. The lining according to claim **6,** wherein said magnet means includes a body of resilient non-magnetic material and magnet particles in said body.

8. The lining according to claim **7,** wherein said layer has a mounting surface, said plate means covers said mounting surface, and said body is sheet means covering said plate means.

9. The lining according to claim **8,** wherein said plate means is a steel sheet.

10. The lining according to claim **1,** wherein said device is a rotary grinding mill drum and said surface means is the inner surface of said drum, said layer of resilient material having first and second dimensions with respect to the longitudinal and circumferential dimensions of said inner surface, said first and second dimensions being generally equal respectively to said longitudinal and circumferential dimensions.

11. The lining according to claim **10,** wherein said magnet means is sheet means of flexible non-metallic material impregnated with permanent magnet particles, said sheet means being bonded to said layer and coextensive with said layer in the directions of said first and second dimensions.

12. The lining according to claim **11,** and a thin sheet of magnetic metal between said layer and magnet means, said metal sheet being bonded to and covering said layer.

13. The lining according to claim **10,** wherein said magnet means is elongated strips of flexible non-metallic material impregnated with permanent magnet particles, said strips being bonded to said layer and having their longitudinal dimensions generally parallel to one of said first and second dimensions, and said strips being spaced apart with respect to the other of said dimensions.

14. The lining according to claim **1,** wherein said device is a rotary grinding mill drum and said surface means is the inner surface of the device, said layer of resilient material having first and second dimensions with respect to the longitudinal and circumferential dimensions of said inner surface, said first dimension being no greater than said longitudinal dimension and said circumferential dimension being a multiple of said second dimension by an integer other than one.

15. The lining according to claim **14,** wherein said layer has a mounting surface and said magnet means is a sheet of flexible non-metallic material impregnated with permanent magnet particles, said sheet being bonded to said mounting surface and coextensive with said layer in the directions of said first and second dimensions.

16. The lining according to claim **15,** and a thin sheet of magnetic metal between said mounting surface and magnet means, said metal sheet being bonded to and covering said mounting surface.

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