Aug. 19, 1969 B. D. WHITLOW 3,462,089

MECHANICAL DEFIBERING MEANS

Filed Dec. 21, 1966 2 Sheets-Sheet 1

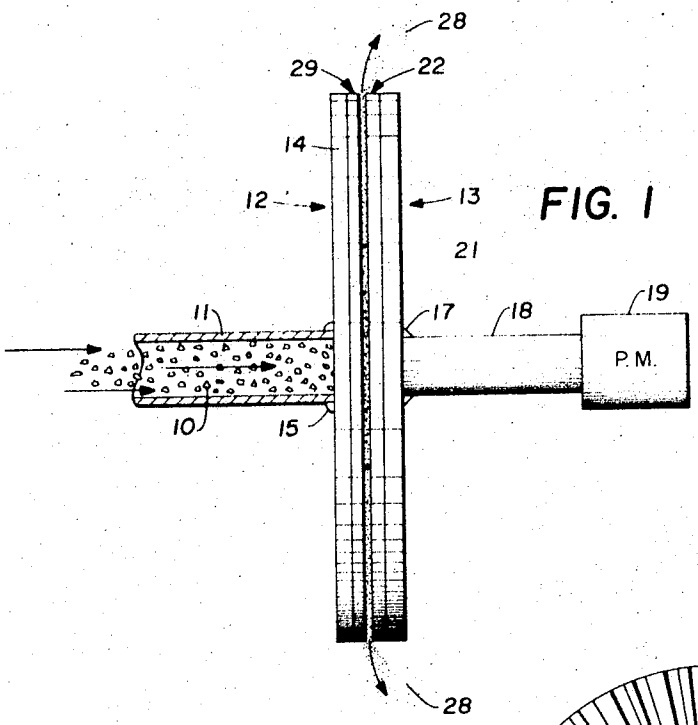


FIG. 1

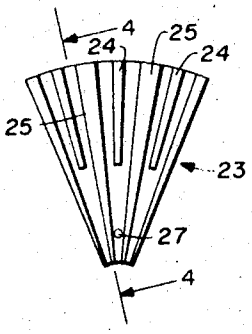


FIG. 3

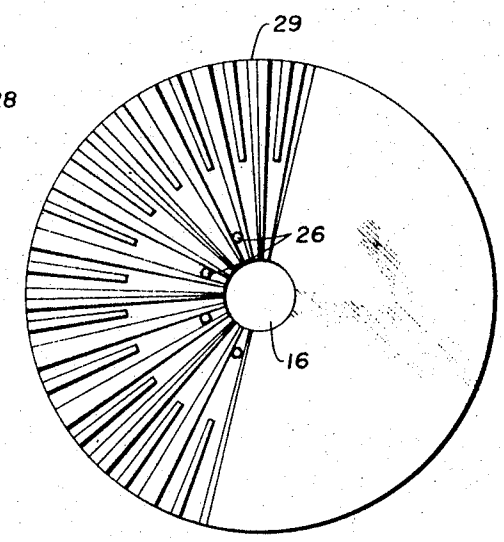


FIG. 2

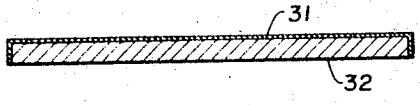


FIG. 4

INVENTOR
BAILEY D. WHITLOW
V. Bryan Medlock, Jr.
ATTORNEY

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MECHANICAL DEFIBERING MEANS

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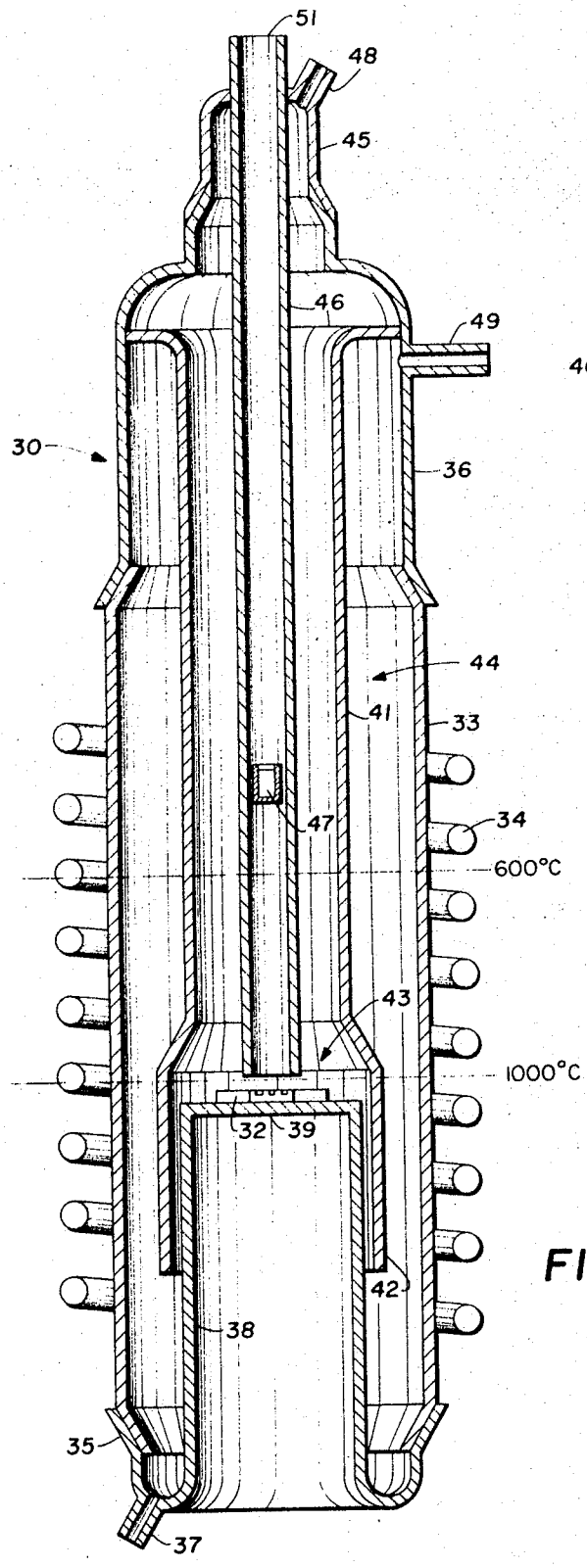


FIG. 5

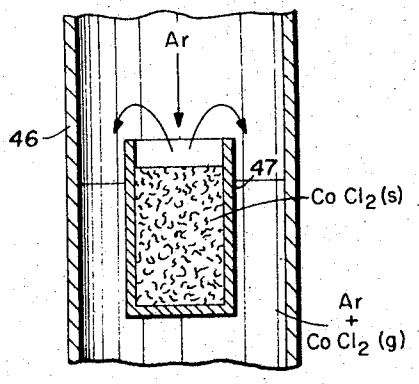


FIG. 6

INVENTOR
BAILEY D. WHITLOW

V. Bryan Medlock, Jr.
ATTORNEY

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MECHANICAL DEFIBERING MEANS

Bailey Duane Whitlow, Richardson, Tex., assignor to Texas Instruments Incorporated, Dallas, Tex., a corporation of Delaware

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Int. Cl. B02c 1/10, 7/12, 7/00
U.S. Cl. 241—296 6 Claims

ABSTRACT OF THE DISCLOSURE

A face plate for a pulp slurry refiner disk. The plate comprises a metal substrate provided with upstanding, sharp edged teeth and a relatively thin, dense, hard, wear and corrosion resistant, vapor deposited coating over at least that portion of the face plate conventionally exposed to the pulp slurry, the coating having a Moh's scale hardness of about 8 to 9 and preferably being a titanium carbide coating having a ductile metal dispersed therein.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to paper making and fiber liberation, and particularly to mechanical refining means utilized in the paper making process.

Description of the prior art

In the manufacture of paper, trees are cut and shipped to a paper mill. There the trees are barked, cleaned and then cut into small chips. Chemicals are added to these chips in huge pressure cookers where the cellulose fibers are separated from other elements of the wood. These fibers, which are called pulp, are washed, blended, screened, bleached, cleaned and refined. At this point they are mixed and blended with various additives, such as dyes, pigments and resins, before they are ready to move on to the paper machine. There the pulp fibers are formed into a wet sheet on an endless bronze screen, stainless steel screen, or the like where water begins to drain off. This wet web of paper is then carried through press rolls and over steam-heated cylindrical dryers to complete the drying. While being dried it may be given a variety of different treatments to adapt it to various end uses.

In the refining step, to which this invention is directed, the pulp slurry, after digestion, is introduced proximate the center of and between two confronting and proximately abutting refiner disks. The refiner disks, one of which is usually fixed and the other of which is mounted for rotation, are provided with removable face plates having a plurality of sharp teeth which refine the pulp slurry as it passes radially outwardly between the plates due to fluid pressure behind the slurry and the centrifugal force created by the rotating disk upon which one of the plates is mounted. The pulp slurry contains various abrasive items, such as grit and metal shavings which over a period of time will wear the normally sharp edges of the teeth provided on the plate. When the teeth begin to wear, the plate becomes less effective and eventually must be replaced. Also, as the teeth wear, the consistency of the refined pulp slurry is changed, altering the quality of the eventual paper product.

The face plate of a refiner disk, depending upon the particular mill in which it is employed and the type of pulp circulated through the refiner, will usually require replacement at least once or twice a year, and in some instances as often as once a month. Replacement of the plates can require shutdown of the entire mill, or in the alternative, circulation of the pulp stream to other refiners. The loss of a refiner can reduce the amount of slurry being processed, thus reducing the amount of paper produced.

The installation of new face plates requires the time and efforts of a maintenance crew, increasing the expense of producing paper. Sometimes, due to the urgency of placing the refiner back on stream, the maintenance crews work overtime further increasing costs. After removal of a worn face plate, its condition permitting, the plate is sometimes machined to sharpen the teeth, and the more frequently the plate has to be replaced, the more time and effort will be expended in sharpening worn plates.

Face plates for refiner disks are commercially available in metals ranging from cast iron to various grades of stainless steel. While stainless steel disks will have a greater life than cast iron disks, the expense is also greater.

Summary of the invention

This invention may be generally described as a face plate for a pulp slurry refiner disk having a metal substrate provided with upstanding, sharp edged teeth, and a relatively thin, dense, hard, wear and corrosion resistant, vapor deposited coating over at least that portion of the disk which conventionally is exposed to the pulp slurry. The coating has a Moh's scale hardness of about 8 to 9 and preferably is a titanium carbide coating having a ductile material dispersed therein. The invention permits the use of a relatively inexpensively formed metal substrate which is then provided with an extremely hard and dense vapor deposited coating that greatly extends the life of the face plate requiring fewer shutdowns of the paper mill and thus lowering the expense of the process.

Brief description of the drawings

FIGURE 1 is a front elevational view of a pair of refiner disks which embody the present invention;

FIGURE 2 is a side elevational view, partially broken away, of the refiner disks illustrated in FIGURE 1;

FIGURE 3 is a side elevational view of one segment of a face plate illustrated in FIGURE 2;

FIGURE 4 is a section taken along line 4—4 of FIGURE 3;

FIGURE 5 is an elevational view in section of an apparatus suitable for vapor depositing a coating on a face plate; and

FIGURE 6 is an enlarged view of the receptacle used in the FIGURE 5 apparatus.

Description of the preferred embodiment

With reference to FIGURE 1, a pulp slurry **10** is refined by introducing it through a conduit **11** which discharges proximate the center of and between confronting refiner disks **12** and **13**. Conduit **11** is fixed to the backplate **14** of stationary disk **12** by any suitable means, such as weldment **15** and discharges the pulp slurry **10** through port **16** (illustrated in FIGURE 2) in stationary disk **12**. Refiner disk **13** is mounted by weldment **17** to a cylindrical shaft **18** driven by a suitable primer mover **19**. To the backplate **21** of rotatable refiner disk **13** is bolted a face plate **22** comprised of a plurality of arcuate segments **23**, such as illustrated in FIGURE 3. Segments **23** include a plurality of upstanding, relatively radially short teeth **24** between which are disposed a plurality of upstanding, relatively radially long teeth **25**. Both teeth **24** and **25** are provided with sharp edges, the purpose of which is to effect refining of the fibers in the pulp slurry introduced through conduit **11**. Segments **23** are secured to backplate **21**, as by bolts **26**, illustrated in FIGURE 2, which pass through apertures **27** in segments **23** for en-

gagement with threaded mating recesses in backplate **21** (not illustrated). Segments **23** when assembled to backplate **21** form a continuous face plate **22**, as illustrated in FIGURE 2. Stationary disk **12** is also provided with a backplate **14**, as described before, which like backplate **21** of disk **13**, receives a plurality of identical segments **23** which are secured thereto in the same manner as segments **23** are secured to backplate **21**. Pulp slurry charged to the refiner will pass through conduit **11** and be centrally discharged between refiner disks **12** and **13** where fluid pressure on pulp slurry **10** and the centrifugal force generated by rotation of refiner disk **13** will combine to discharge the pulp slurry radially outwardly between refiner disk **12** and **13** causing an engagement of the pulp particles with the teeth **24** and **25** of face plates **22** and **29** which further defibrates the slurry resulting in the discharge at the outer periphery of disks **12** and **13** of a refined slurry generally indicated by the reference numeral **28**.

As explained before, after a certain operating period, it becomes necessary to replace the face plate **22** on disk **13** and the face plate **29** on disk **12** due to wear on teeth **24** and **25**. In order to extend the life of face plates **22** and **29**, each of the segments **23**, which when assembled comprise face plates **22** and **29**, are coated with a relatively thin, hard, dense, wear and corrosion resistant, vapor deposited coating **31**, such as illustrated in FIGURE 4. The coating is deposited upon a metal substrate **32** which conforms in configuration and has substantially the same dimensions as the segments illustrated in FIGURE 3. Coating preferably applied to the metal substrate is a titanium carbide coating having a ductile metal such as cobalt dispersed in the titanium carbide phase. Vapor deposited pure titanium carbide is quite brittle and lacks toughness, with the result that it exhibits inadequate resistance to shear forces, and is therefore not preferred. To impart toughness to the titanium carbide coating, a suitable ductile metal such as cobalt or nickle is simultaneously deposited with the titanium carbide upon the substrate. The dispersion that is formed is of the type in which titanium carbide is continuous phase and the ductile metal is the dispersed phase. In this type of dispersion, the ultra-hard characteristics of the pure titanium carbide are retained. Moreover, the dispersed particles of the ductile metal absorb energy, prevent high energy build-up from reaching the threshold energy density for fracture propagation and thereby function to stop the propagation of cracks which may originate in the titanium carbide matrix. Moreover, because of its greater coherence, such a dispersion strengthened material has considerably more impact resistance than ordinary titanium carbide. Metal substrates having the form of segments **23** may be coated in an apparatus such as identified in FIGURES 5 and 6.

FIGURE 5 illustrates a reactor **30** comprising a cylindrical body **33** surrounded by a heating coil **34** and having two fitted end caps **35** and **36**. End cap **35** has exhaust outlet **37** and a hollow cylindrical portion **38** which extends upwardly into a portion of the tubular reactor **30**. The cylindrical portion **38** extending into the reactor has a flat surface **39** upon which the substrate **32** is positioned. End cap **36** mounted on top of the cylindrical body **33** has a reaction tube **41** formed therein which extends into the central portion of the body **33**. Reaction tube **41** has a flared portion **42** at its lower end which extends over the recessed cylindrical portion **38** of the bottom end cap **35**, thus enclosing the substrate **32** within the lower end of reaction tube **41**. The flared portion **42** extends down from the substrate carrier surface **39** of end cap **35** and acts as a guide to direct gasses passing over the substrate **32** downwardly between the walls of the flared portion **42** and the upwardly extending recessed portion **38** of end cap **35**. The zone at which deposition occurs generally is identified in FIGURE 5 by the reference numeral **43**.

Body **33** and tube **41** effectively divide the reactor into two separate chambers, namely the deposition chamber zone **43**, previously described, and a flush chamber **44**, defined between reaction tube **41** and cylindrical vessel **33**.

Reaction tube **41** is appropriately fitted with a cap **45** which carries a tube **46** extending therethrough and annularly down into the central portion of tube **41** to within one inch or so of the substrate **32**. A receptacle **47** containing metal halide granules, cobalt chloride, for example, is suspended within the tube **46** (shown in greater detail in FIGURE 6) at a point near the upper zone of the heating coils **34** surrounding the outside of cylinder **33**. The heating coils controllably maintain the interior of the reactor **30** within a temperature gradient of about 600° C. in the receptacle zone and about 1,000° C. in the deposition zone **43**, as shown. Heating coils **34** may be either RF induction heaters, resistance heaters or any other suitable heating means for controllably maintaining the desired temperature in the zone of the receptacle **47** and the substrate zone **43**.

A carrier gas stream of argon or helium gas is passed through the tube **46**, carrying the metal halide vapor toward the surface of the substrate **32**, as shown in FIGURE 6. Cap **45** is further provided with an inlet **48** through which titanium tetrachloride and carbon tetrachloride and a stream of hydrogen are introduced into tube **41** and passed downward outside the walls of the metal chloride tube **46**. Upon reaching the deposition site **43**, the metal chloride, titanium tetrachloride, carbon tetrachloride, hydrogen and cobalt chloride gasses mix and react to form a deposit of ductile metal in titanium carbide upon the substrate **32**.

The reactions may be represented as:

(1) $$TiCl_4 + CCl_4 + 4H_2 \xrightarrow{1000°C} TiC + 8HCl$$

(2) $$CoCl_2 + H_2 \xrightarrow{1000°C} Co + 8HCl$$

End cap **36** is fitted with a flush inlet **49**, through which a flush gas (argon, for example) is passed through the flush chamber **44**. The flush gas entering inlet **49** passes through chamber **44** between the walls of the cylinder **33** and the reaction tube **41** and downwardly over guide **42** to exit through exhaust **37** provided in the lower end cap **35**. The flush gas is used primarily to prevent contamination of the deposition chamber **43** by back-drafts passing upwardly between the guide **42** and the walls of the recessed portion **38** of end cap **35**.

In operation, purified helium or argon is first flushed through inlets **48**, **49** and **51** to purge atmospheric gasses from the reactor in preparation for the deposition. When the reactor has been sufficiently purged, the flow of argon through tube **48** is stopped. Argon is introduced through tube **49** at the rate of approximately 35 cc./min. The flow rate of argon (or helium) to tube **51** is varied according to the deposition rate of ductile metal desired. The chamber is then rapidly brought up to operating temperature within the gradient previously given. Titanium tetrachloride and carbon tetrachloride are admitted to the reactor through feed tube **48**, entrained in a carrier of hydrogen gas. This feed gas is prepared by bubbling hydrogen through bubbler bottles (not shown) containing the liquid titanium tetrachloride ($TiCl_4$) and carbon tetrachloride (CCl_4) at room temperature. The gas thus admitted through feed tube **48** is hydrogen saturated with $TiCl_4$ and CCl_4.

Upon reaching deposition zone **43**, the hydrogen, titanium tetrachloride, and carbon tetrachloride from tube **48** and the metal halide vapors from tube **46** mix and are simultaneously reduced by the hydrogen gas into a mixture of titanium carbide and ductible metal which is deposited upon the substrate **32**. The spent gas is passed outwardly between the guide **42** and the recessed portion **38** of end cap **35** to exit through exhaust outlet **37**. A coating of from ½ to 1 mil in thickness is suitable for a face plate, such as used on refiner disks, and only the surface of the segments **23** which conventionally contact the pulp slurry need be coated, as principal wear occurs on this surface.

With the apparatus illustrated in FIGURE 5, the face of the segment **23** which conventionally contacts pulp slurry will be coated, as will the sides of the substrate **32**, but the bottom of substrate **32** will not be coated as it is isolated from the deposition vapors by the supporting piece **39**. The time required to deposit a desired thickness of titanium carbide having cobalt dispersed therein will vary with the size of the substrate **32** and the flow rates of the reactants. With a specimen metal substrate, and the following flow rates:

Millimoles/min.:

$TiCl_4$	1.342
CCl_4	1.342
H_2	122.000
$CoCl_2$	0.029

the deposition rate was found to be .13 mil per hour. The titanium carbide coating having cobalt dispersed therein has a Moh's scale hardness of between about 8 and 9, which is the preferred hardness. While cobalt is a desired ductile metal to be dispersed in the titanium carbide coating, it is to be understood that other ductile metals, such as nickel, for example, may be dispersed in titanium carbide by selection of the appropriate reactants, flow rates and temperatures. Moreover, it will be clear to one skilled in the art, after reading the above, that halides other than chlorides may be employed.

Indeed, various designs and types of reactors may be employed, it only being necessary to provide an apparatus capable of depositing a dense, hard, wear and corrosion resistant coating on the metal substrate, though a titanium chloride carbide coating having cobalt dispersed therein is preferred.

It is also possible to use flame spray techniques to apply a coating such as chromium oxide to the metal substrate, but such a technique is not preferred since the coating will not be as hard as the vapor deposited coating.

A titanium carbide coating having a ductile metal deposited therein, such as described above, may also be applied to the blades of a Jordan, a refiner usually employed downstream from the refiner described above and utilized to further reduce the size of fibers in the pulp slurry. Such a coated blade will also have the advantages described in connection with the refiner disk face plates.

Because of the greater life of apparatus embodying the present invention, a desired consistency of the refined pulp slurry can be maintained for longer periods resulting in a finished product having more uniform quality.

While rather specific terms have been used in describing one embodiment of the present invention, they are not intended, nor should be construed, as a limitation upon the invention as defined in the following claims.

I claim:

1. A pulp slurry refining member having sharp edges for engagement of wood particles in the pulp slurry and comprising:

a metal substrate provided with sharp upstanding teeth; and

a relatively thin, dense, hard, wear- and corrosion-resistant, vapor deposited, continuous titanium carbide coating containing a ductile metal dispersed therein over at least that portion of said member conventionally exposed to the pulp slurry, said coating having a hardness from about 8 to about 9 on the Moh's scale.

2. The article of claim **1**, in which:

the ductile metal dispersed in said titanium carbide is cobalt.

3. The article of claim **2**, in which:

said coating has a thickness of between about ½ and 1 mil.

4. The article of claim **1**, wherein said pulp slurry refining member comprises a face plate for a disk adapted to be positioning in proximate confronting abutment with another disk mounted for rotation relative thereto.

5. The article of claim **4**, in which:

the ductible metal dispersed in said titanium carbide is cobalt.

6. The article of claim **5**, in which:

said coating has a thickness of between about ½ and 1 mil.

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ROBERT C. RIORDON, Primary Examiner

D. G. KELLY, Assistant Examiner