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(54) Improved shot blasted web conveying roller.

(57) A roller **10** for conveying a web **12** is characterized by a surface **14** prepared by blasting the surface of a base roller **16** with steel shot to create on the surface **14** a deep texture with well rounded down features **22** and sharp up features with peaks which are removed during a superfininshing step to form the final surface. Down features **22** of improved stainless steel and nickel web rollers have a depth in the range from 1000 microinches to about 2000 microinches. Improved aluminum web conveyance rollers of the invention have down feature **22** depths ranging from 1000 microinches to about 2500 microinches. Titanium web conveyance rollers of the invention have down feature **22** depths ranging from 500 microinches to about 2000 microinches. The blasted surface is finished with a grinding action for removing peaks **26** to produce plateaus **30** surrounded by interconnected channels **32**. The interconnected channels **32** of the surface **14** allow more of the air entrained between the roller surface and web **12** to be vented through channels **32** while web **12** is in contact with roller **10** thereby improving the tractive force of roller **10** relative to web **12** surface.

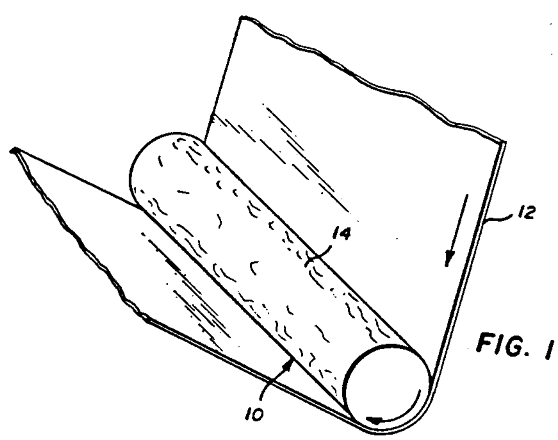

FIG. 1

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Background of the Invention

The present invention relates to a web conveying roller. More particularly, the invention is directed to improvements in rollers for conveying a web so that dynamic air entrained between the roller surface and the web can be vented from the roller surface when the roller and web are in contact.

In many manufacturing operations a web is trained around a plurality of rollers as it is conveyed through a series of stations. Some of the rollers are drive rollers used for advancing the web and other rollers are simply idler rollers. Typically the web conveyance system is designed to avoid relative movement between the surface of the rollers and the web in order to avoid scratching or other damage to the web. This is especially important during the manufacture of sensitive materials, such as photographic film, paper and magnetic media where such relative movement can produce a surface defect in the final product. Thus it is desirable that the surface of the rollers be sufficiently smooth to avoid damage to the web by the rollers whether the rollers are drive rollers or idler rollers. At the same time, it is important that there be sufficient friction between the rollers and the web to enable the drive rollers to advance the web and to enable the idler rollers to be rotated by the web at the same surface velocity of the web when the web is in contact with the idler rollers.

In a web transport system using drive or idler rollers air can become entrained between the roller and the surface of the web. More specifically, movement of the web can force air into the entrance nip between the web and the surface of the roller, especially when the web is moving at high speeds. This boundary layer of air can cause at least partial separation between the surface of the web and the surface of the rollers. When this occurs, there is a change in the ability of the drive rollers to advance the web, and the web cannot efficiently rotate the idler rollers. As a result, relative movement can occur between the rollers and the web, causing quality defects in the web. Moreover, when transport operating conditions increase, such as web speed and higher machine environment temperatures, scratches have been observed in the conveyed web. It is believed that inadequate roller traction or poor roller venting is the mechanism that causes relative movement between the roller surface and the web and, thus, is the source of the problem. Experience indicates insufficient surface channeling or interconnections formed by down pattern features shot blasted into the surface of prior art rollers restricts their effectiveness under accelerated machine conditions.

U.S. Patent Nos. 4,964,203, 4,970,768 and 4,977,656 each demonstrates that dynamic air entrainment between a roller surface and a moving web can be controlled. The web conveyance rollers of the subject patents further demonstrate that air can be vented from between a roller and a moving web without requiring a specially formed repeating pattern of grooves in the roller. The air flow path depth of channels in these rollers, however, is not sufficient for larger diameter rollers, high machine operating speeds and corresponding temperature conditions.

Summary of the Invention

It is, therefore, the object of the invention to provide a web conveyance roller having an improved ability to vent air from between the roller surface and a moving web thereby increasing the tractive force between the roller and web.

To achieve these and other objects of the invention, there is provided a web conveyance roller having on its surface generally spherical down features. Many of the down features overlap to form interconnected channels comprising at least 50% of the surface area of the roller.

In one aspect of the invention, the roller surface is either nickel or stainless steel and the depth of the down features is greater than about 1000 microinches to less than about 2000 microinches.

In another aspect of the invention, the roller surface is aluminum and the depth of the down features is greater than 1000 microinches and less than 2500 microinches.

A plurality of plateaus between the channels comprise at least 20% of the surface area of the roller.

The invention and its objects and advantages will become more apparent in the detailed description of the preferred embodiments presented below.

Brief Description of the Drawings

In the detailed description of the preferred embodiments of the invention presented below, reference is made to the accompanying drawings, in which:

Fig. 1 is a view of a web conveyance roller of the invention with a web trained around a portion of the roller surface;

Fig. 2 is a cross section view of the shot blasted stainless steel or titanium roller after it has been superfinished;

Fig. 3 is a cross section view of the aluminum roller surface after the surface has been hardcoated and polished;

Fig. 4 is a cross section view of the chrome plated nickel surface roller after the surface has been polished;

Fig. 5 is a photomicrograph of the final surface of a roller of the invention; and,

Fig. 6 is a graph showing fractive force (lbs) as a function of transport system speed for the test rollers.

Detailed Description of the Preferred Embodiments

Referring initially to Fig. 1, a web conveyance roller of the invention, generally designated **10**, is rotatable about its longitudinal axis in a clockwise direction as indicated by the arrow. A web **12** is trained around a portion of roller **10**. Roller **10** can be either a drive roller or an idler roller. In either instance, the velocity of surface **14** of roller **10** and the linear velocity of web **12** should be equal to each other so that there is no slippage between roller **10** and web **12**. This is especially important when web **12** comprises a material which is easily damaged, such as photographic film, paper, magnetic media or the like. Surface **14** of roller **10** is especially prepared in accordance with the process described in U.S. Patent Nos. 4,970,768, 4,910,843, and 4,914,796, incorporated herein by reference.

Referring now to Figs. 2,3 & 4, the process for manufacturing the final roller surface can be applied to cylindrical shells or base rollers of various kinds. The process is especially applicable to stainless steel, titanium, and aluminum base rollers generally designated **16**. The length and the diameter of the base roller **16** can vary and may, for example, be of a length sufficient to accommodate webs of 8 feet or more in width.

The surface of base roller **16** shown in Figs. 2,3 & 4 is achieved by initially shot blasting the roller **16** with steel shot to create on the surface a deep texture (not shown). Surface texture of the shot blasted roller has well rounded down features (not shown) and very sharp up features (not shown). The down features **22** are generally hemispherical in configuration and they extend the full length and circumference of the surface of base roller **16**, described more fully in U.S. Patents 4,910,844, 4,910,843, and 4,914,796.

The hemispherical down features **22** formed during the blasting operation have a depth that is determined by the momentum of the steel shot as it strikes the stainless steel surface. Preferably the size of the steel shot is substantially uniform so that the mass of each piece of steel shot is also constant. Thus the momentum of the steel shot is dependent only on the velocity of the shot. The velocity of the shot, in turn, is influenced by the nozzle geometry and the blasting pressure utilized. Since the nozzle geometry is constant during the blasting operation, the air pressure used is the only variable that determines the depth of down features **22**. Air pressure is controlled so that it is substantially constant during the blasting operation. Thus depth of the down features **22** is accurately controlled and a substantially uniform depth is obtained. Nominally air pressures about 50% higher than those used to produce the prior art down feature depths were used to produce the down features **22** depths of the present invention.

The number of down features **22** is determined by the shot size, which was not altered by the inventors to produce the new surfaces **14**, and the pattern depth. The larger the shot size and the deeper the pattern the fewer number of down features **22** will be present on the surface. Thus the number of down features **22** is inherently determined by the shot size and the pattern depth which are held within tight limits. For example, the shot size can range from about 0.006 inches to about 0.080 inches which will produce about 50 to 500 down features per linear inch. Many down features **22** at least partially overlap so that a random pattern of interconnected channels are formed in the surface of the finished roller surface, as described later in regard to Fig. 5.

Further, in achieving the final surface of roller **10** of the invention, peaks of up features (not shown) are removed and plateaus designated **30** are formed on the surface surrounded by the interconnected channels formed by the down features **22**. More specifically, the surfaces shown in Fig. 2,3 & 4 are superfinished and/or polished in accordance with U.S. Patents 4,910,844, 4,910,843, and 4,914,796. The superfinishing operation comprises an aggressive multi-direction grinding action which removes peaks from the up features and produces a series of randomly extending plateaus **30** shown in Fig. 2,3 & 4. Base roller **16** is rotated during this operation, and base roller **16** rotation rate, the force exerted during grinding, and the grinding rate in a longitudinal direction along the roller surface are all controlled, and are substantially constant, so that there is uniformity in height and smoothness in plateaus **30** throughout substantially the entire surface of base roller **16**.

More particularly, the superfinishing step comprises grinding the surface of base roller **16** with a 15 micron tape which establishes the plateaus shown at **30**. Those skilled in the art would appreciate that further surface refinement may be achieved by grinding the surface with a series of tapes of successively smaller grit sizes. Thus, this latter treatment could then be followed by, for instance, grinding with a 9 micron tape which eliminates scratches on plateaus **30** caused by use of the coarser 15 micron tape. A lower grit tape could then be used, for instance, a 3 micron tape, to remove the smaller scratches produced by the 9 micron tape. The final alternative step of the superfinishing operation, in the case of aluminum (Fig. 3) and nickel roller surfaces (Fig. 4), comprises polishing the surface of base roller **16** to round the edges of plateaus **30** so they do not scratch web **12**. This is preferably accomplished using a slurry comprising a suspension of 9 micron aluminum oxide polishing compound in water as described in greater detail in U.S. Patent Nos. 4,970,768 and 4,977,656.

The final pattern depth and the amount of channeling formed by interconnection of down features **22** is controlled by removing a predetermined amount of material from the blasted pattern. The greater the reduction in pattern depth during the superfinishing stage, from the "as blasted" pattern depth, the less channeling will be present. The reduction in channeling may be excessive if more than 50% of the depth of down features **22** is removed by the superfinishing operation. On the other hand, in order to eliminate the scratch potential of the shot blasted surface texture, it is preferred that at least 20% of the pattern depth be removed and that plateaus **30** have well rounded edges after the superfinishing step.

The nickel roller **10** shown in Fig. 4 is suitable for use after the superfinishing operation. However, in order to increase the durability of the surface of base roller **16** having a nickel layer **18** (described more fully in U.S. Patent 4,977,656) it is preferred to cover the superfinished surface with a thin layer of a hard substance. More specifically, it is preferred to electroplate a layer **32** of chromium on the surface of the roller **10**. Chromium is a hard durable material and can be applied in a very thin layer. A chromium layer **32** having a thickness of about 0.000100 inches is sufficient to provide a durable surface on base roller **16**.

The step of electroplating chromium layer **32** onto surface of base roller **16** leaves a very fine roughness on the roller surface. This roughness is removed by polishing. The polishing step can be carried out by using a slurry comprising a suspension of 9 micron aluminum oxide polishing compound in water. The polishing step removes the roughness from plateaus of chromium layer **32**. It also leaves well rounded edges on plateaus **30** so that plateaus **30** and edges thereof will not scratch or otherwise adversely affect a web **12** traveling along the roller surface.

Fig. 5 is a photomicrograph of a fragmentary portion of surface **14** of roller **10** of the invention. Surface **14** comprise plateaus **30** and a plurality of channels **32**. Channels **32** are produced by connection of down features **22** formed by the shot blasting operation. Most of channels **32** are interconnected to form pathways for air entrapped between web **12** (Fig. 1) and the surface **14** of the roller **10**. These pathways extend in a random manner both circumferentially and longitudinally along roller **10**. Thus air can travel both axially and circumferentially along roller **10** to escape from between roller **10** and web **12**. This assures good contact between plateaus **30** and the surface of web **12** to obtain controlled traction or friction characteristics between roller **10** and web **12**. The traction between roller **10** and web **12** is predictable because very little air is entrained or trapped between roller **10** and web **12**. If significant amounts of air became trapped between roller **10** and web **12**, the traction characteristics of roller **10** would be adversely affected.

In order to obtain an improved venting surface with better capability of the surface to maintain traction, the shot blasted pattern of down features **22** preferably is greater than 1000 microinches deep as determined by a Rz parameter, and the surface pattern should have greater than 50% channeling (or less than 50% plateau areas **30**) as determined by visual inspection of the surface.

Preferably the depth of down features **22** in the final stainless steel, titanium, and nickel surfaces **14** (Fig. 5) of roller **10** is greater than about 1000 microinches and less than about 2000 microinches in order to reduce web **12** slippage at high transport system speeds. In rollers **10** having an aluminum surface **14**, depth of down features greater than about 1000 microinches and less than about 2500 microinches is preferred. Experiments conducted by the inventors indicate that down feature depths in these ranges produce an improved venting surface **14** with better capability of surface **14** to maintain traction. Fig. 6 shows the tractive force characteristics as a function of transport system speed for a prior art finished roller having down features with a depth of 710 microinches (curve **36**), i.e., a roller that exhibits slippage at high system speeds, and a roller of the invention having down features in the finished roller with a depth of 1550 microinches in accordance with the invention (curve **38**). Tractive force characteristics in Fig. 6 represent a web **12** tension on the rollers of 3/4 pounds per linear inch (pli). Tractive force is measured with a slip and torque meter which has two tachs, one on the test roller and the other on web **12**. At high transport speeds (>380 fpm), tractive forces (i.e., ability of web to adhere to the roller without web slippage) of roller **10** of this invention is about 4.5 to 12 times higher than prior art rollers disclosed in U.S. Patent Nos. 4,964,203, 4,970,768 and 4,977,656, depending upon web **12** tension level. This sharp and unexpected improvement in roller **10** tractive force is believed to be due to deeper and coarser pattern specifications and correspondingly improved venting characteristics, of rollers **10** of the present invention. Furthermore, those skilled in the art will appreciate that increased web tension speeds will result in additional increase in tractive force of the roller of the present invention. In addition, the plateaus **34** preferably comprise greater than 20% of the surface area in order to eliminate the scratch potential of the pattern.

The random nature of the pathways on surface **14** of roller **10** is very desirable, especially for photographic products. More specifically, any slight marks produced on web **12** by such a random pattern will not be as readily observed by the human eye as a regular or repeating pattern of marks.

The invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

Claims

1. A web conveyance roller characterized by a surface with generally spherical down features, many of the down features overlapping to form interconnected channels comprising at least 50% of the surface area of the roller, the depth of the down features being greater than about 1000 microinches but less than 2000 microinches, and a plurality of plateaus between the channels comprising at least 20% of the surface area of the roller.

2. The web conveyance roller recited in claim 1 characterized in that the surface is stainless steel or nickel.

3. The web conveyance roller recited in claim 2 characterized in that said nickel surface is hardcoated with a chromium layer that is smooth and substantially free of roughness that would damage a web.

4. The web conveyance roller of claim 3 characterized in that said chromium layer has a thickness of about 0.000100 inches.

5. A web conveyance roller characterized by a titanium surface with generally spherical down features, many of the down features overlapping to form interconnected channels comprising at least 50% of the surface area of the roller, the depth of the down features being greater than about 500 microinches but less than 2000 microinches, and a plurality of plateaus between the channels comprising at least 20% of the surface area of the roller.

6. A web conveyance roller recited in claim 5 characterized in that the down features have a depth greater than about 1000 microinches but less than 2000 microinches.

7. A web conveyance roller characterized by an aluminum surface with generally spherical down features, many of the down features overlapping to form interconnected channels comprising at least 50% of the surface area of the roller, the depth of the down features being greater than about 1000 microinches but less than 2500 microinches, and a plurality of plateaus between the channels comprising at least 20% of the surface area of the roller, the surface of the plateaus and down features being hardcoated, and the plateaus being smooth to avoid scratching a web conveyed by the roller.

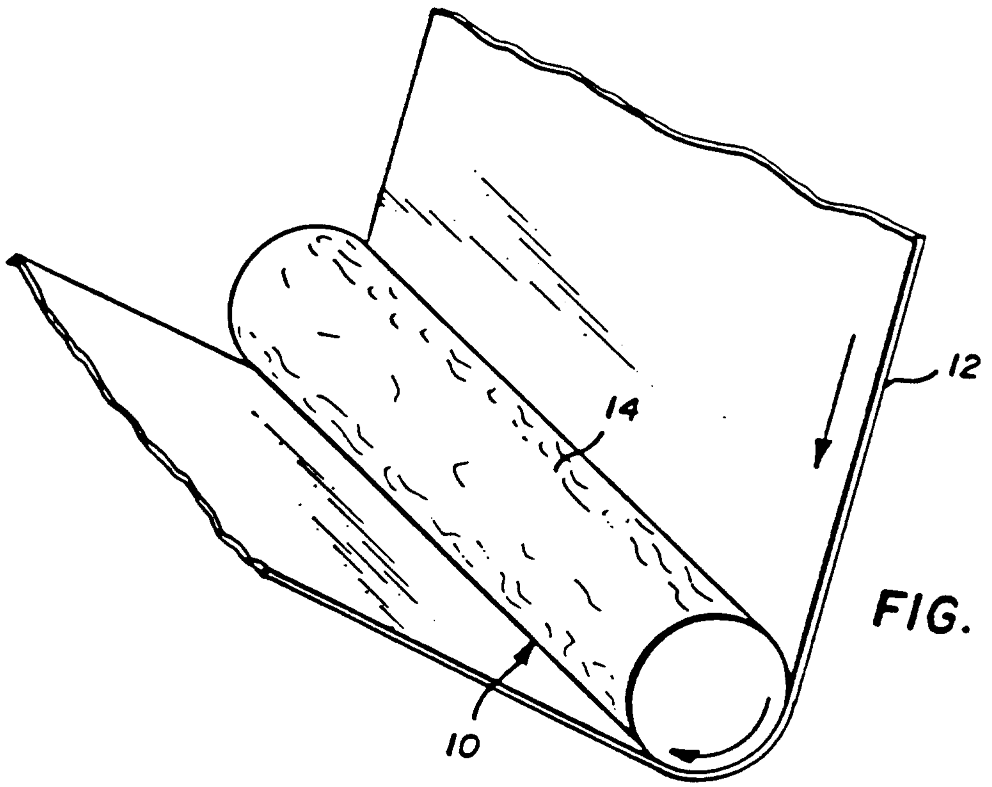

FIG. 1

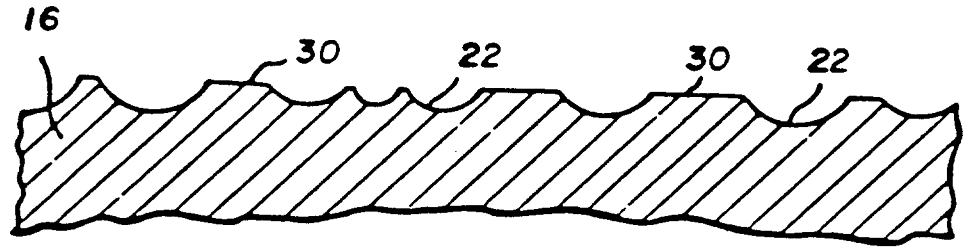

FIG. 2

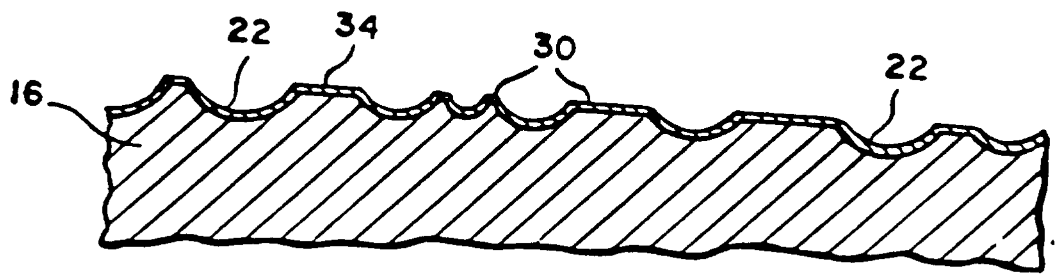

FIG. 3

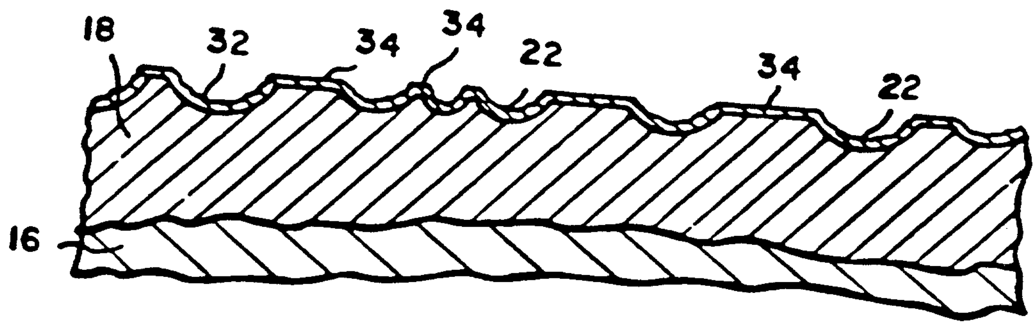

FIG. 4

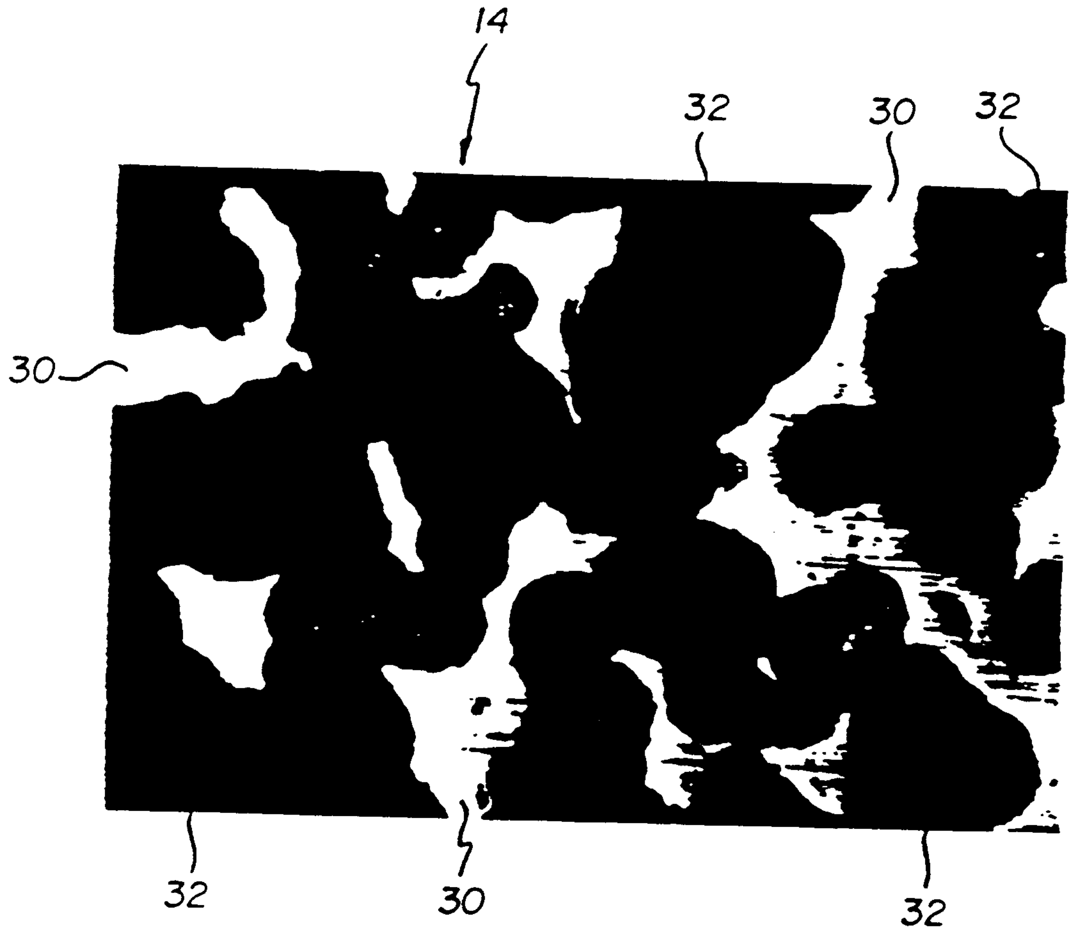

FIG. 5

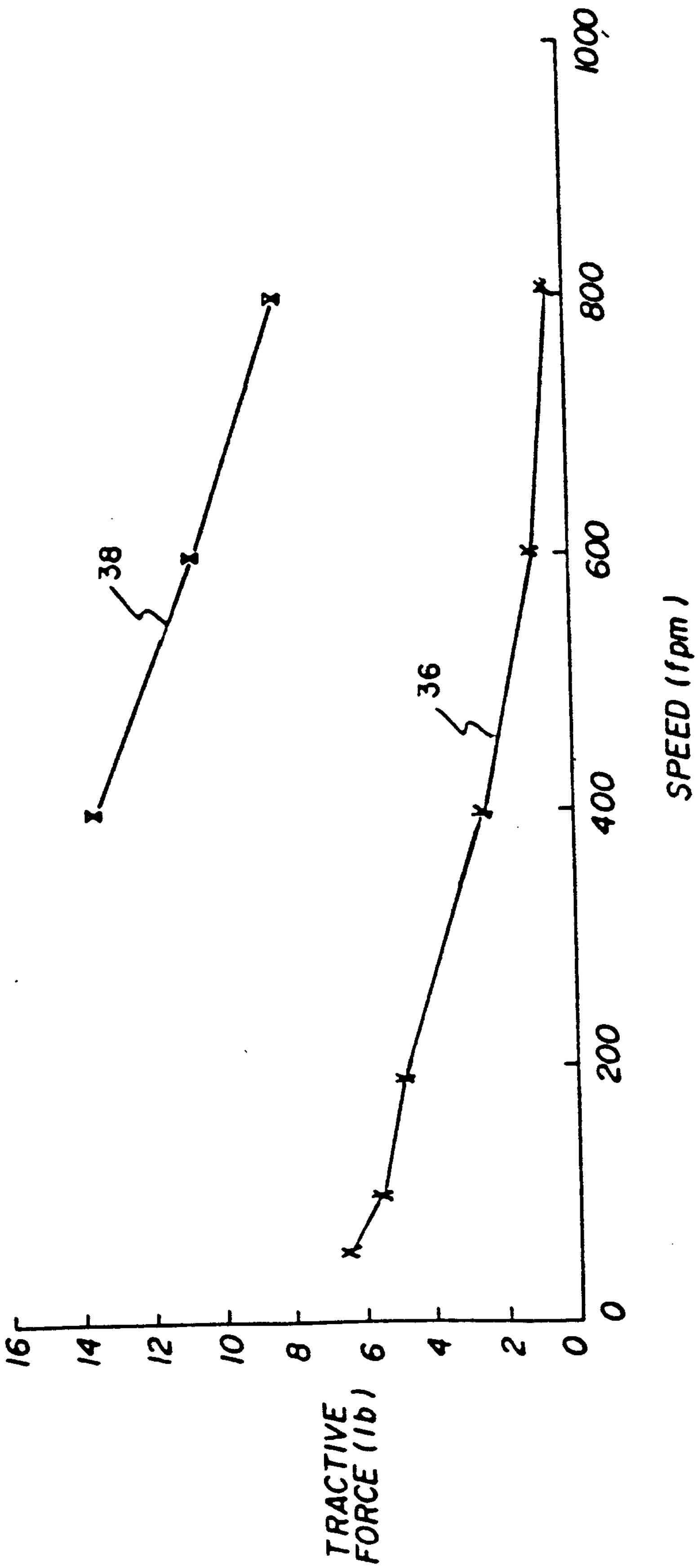
TRACTIVE FORCE (lb)
16
14
12
10
8
6
4
2
0
0
200
400
600
800
1000
SPEED (fpm)
36
38

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 12 0252

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US-A-4 914 796 (EASTMAN KODAK COMPANY) * the whole document * ---	1-7	B65H27/00
Y	EP-A-0 046 236 (AGFA-GEVAERT) * the whole document * -----	1-7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

B65H
B41F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 MAY 1993	LONCKE J.W.

CATEGORY OF CITED DOCUMENTS

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