July 16, 1968 C. L. LONG 3,392,701

DIFFERENTIAL SPEED GRAVURE COATING APPARATUS

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FIG. 1

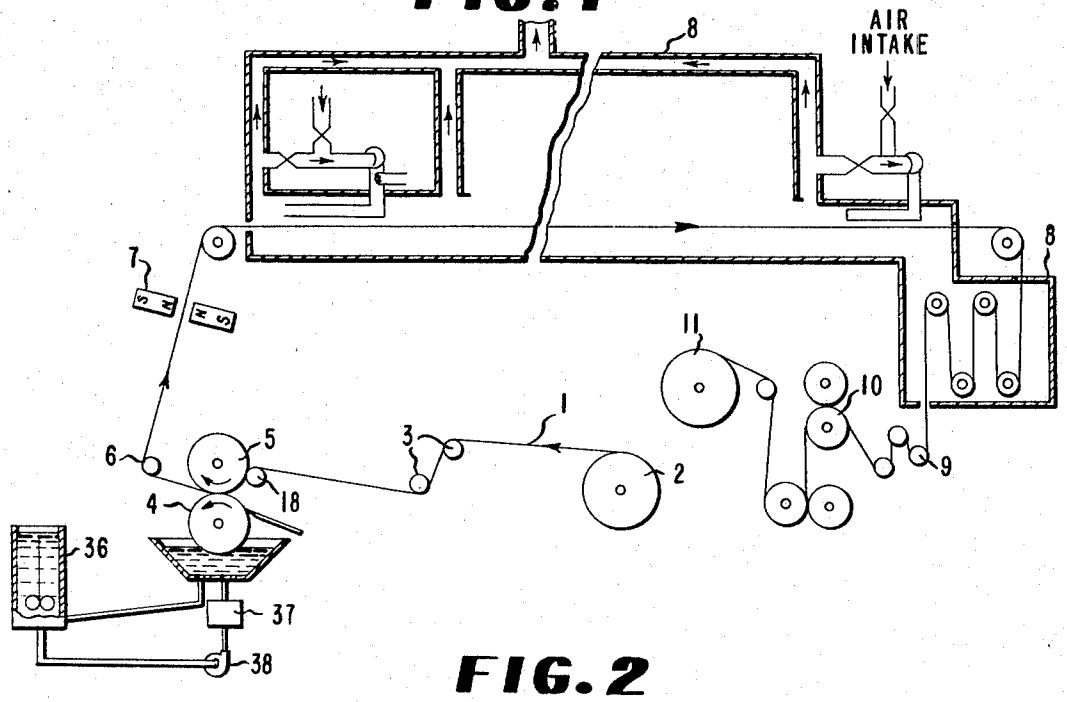
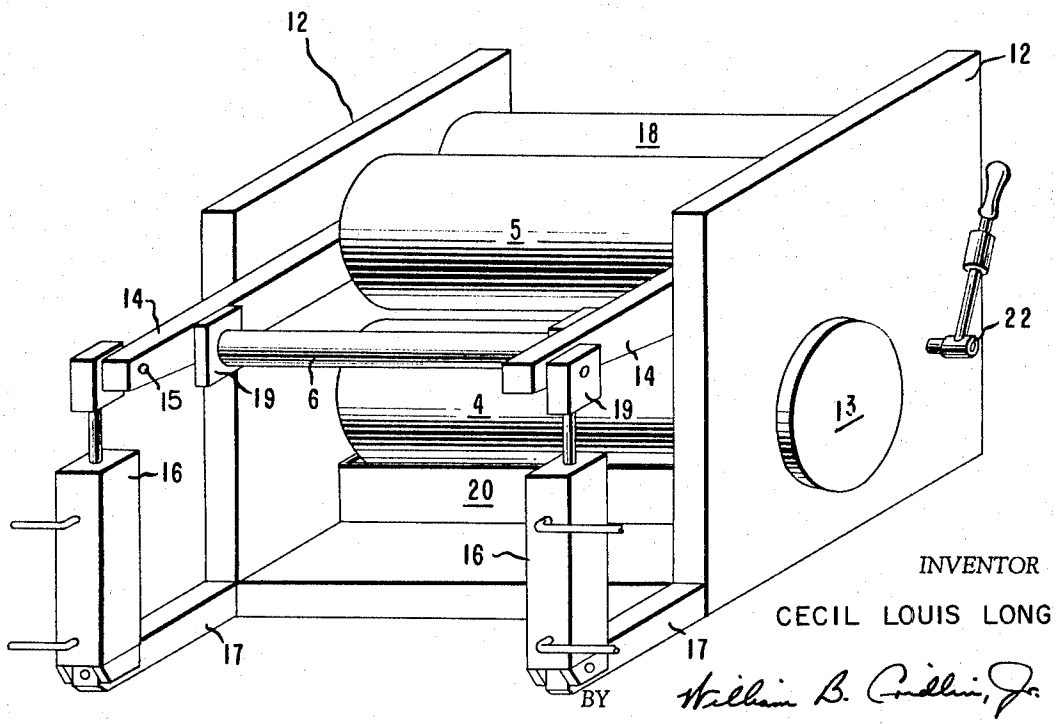


FIG. 2



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DIFFERENTIAL SPEED GRAVURE COATING APPARATUS

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FIG. 3

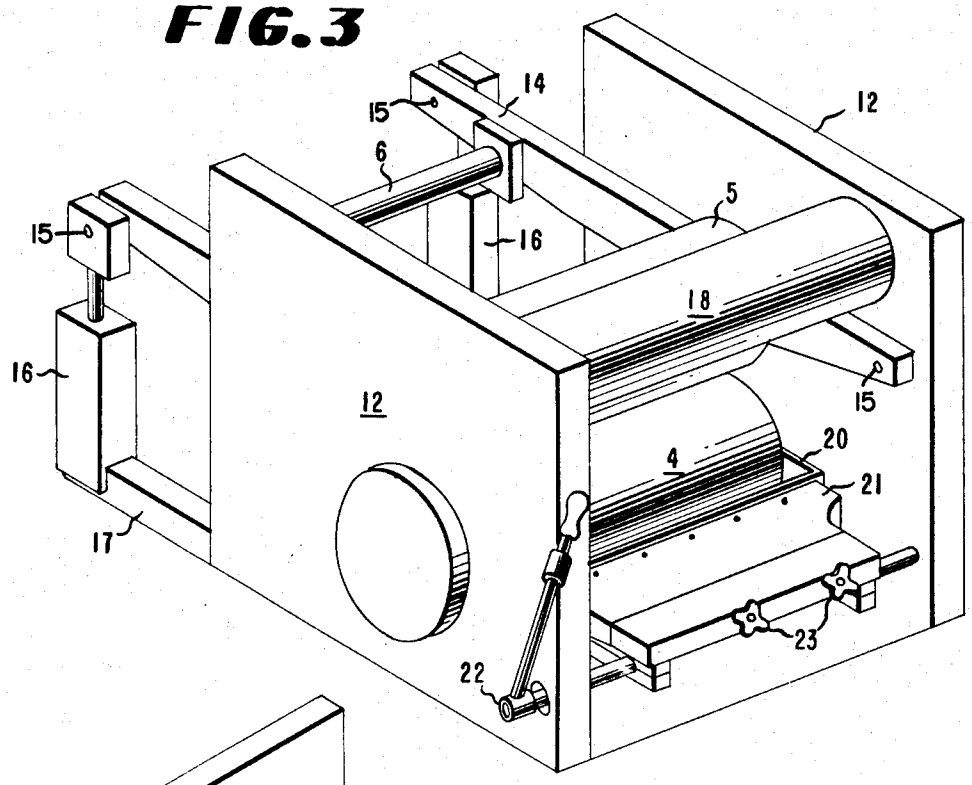
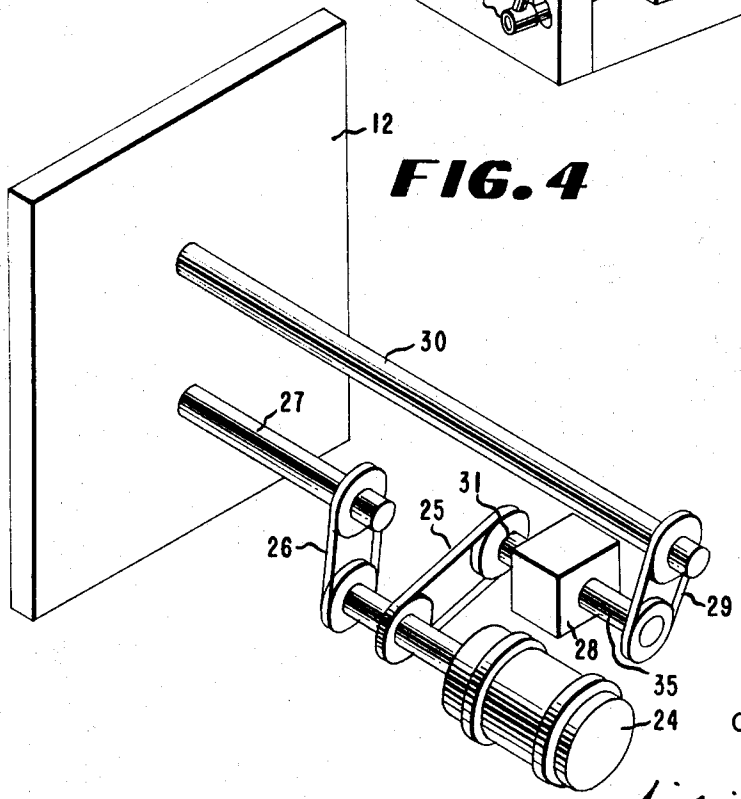


FIG. 4



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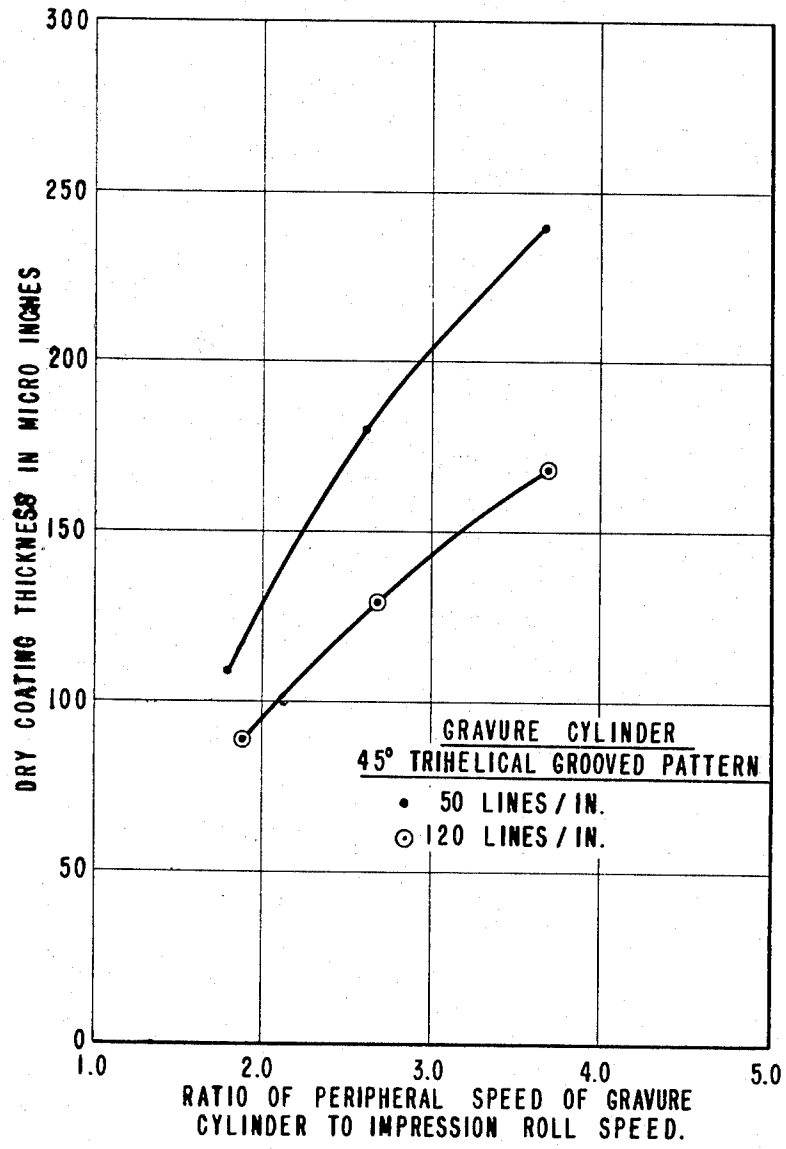
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DIFFERENTIAL SPEED GRAVURE COATING APPARATUS

Filed April 7, 1966 3 Sheets-Sheet 3

FIG. 5



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3,392,701

DIFFERENTIAL SPEED GRAVURE COATING APPARATUS

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7 Claims. (Cl. 118—212)

ABSTRACT OF THE DISCLOSURE

A gravure cylinder coating apparatus adapted to allow the gravure cylinder to travel faster than the speed of the continuous web which is being coated.

This invention relates to an apparatus for coating a continuous web. More particularly, this invention relates to such apparatus used in gravure type coating and still more particularly this invention relates to improvements in gravure coating by the use of differential roll speeds.

The technique of coating by the use of a gravure cylinder is old in the art. The art discloses the conventional method of running the web and coating cylinder at the same speed. Where the gravure cylinder is run at the same speed as the web some disadvantages are inherent when attempting to coat a web. First of all, a gravure cylinder prints a pattern giving hills and valleys to the applied coating. If a magnetic tape is prepared by this method, the pattern is injurious to proper frequency response especially high frequency for the rougher the pattern the less response. To smooth out this pattern, material flow due to the surface tension of the coating is utilized. Where magnetic tape is involved magnets in the form of smoothing coils are used to help give a uniform surface. However, in a highly volatile solvent-binder solution used in coating many solutions and some magnetic tapes, as the solvent evaporates the viscosity increases making it difficult to achieve a smooth coating by material flow or by use of the smoothing coil magnets.

In the specialized coating of magnetic tapes, other coating techniques besides the gravure technique do not lend themselves to high frequency response necessary for magnetic tapes. For example, reverse roll coating which meters the coating solution onto the applicator roll and then onto the web is not accurate enough to meter very thin coatings on magnetic tape. Furthermore, three necessary rolls are running together giving the inherent disadvantage of pattern variations due to the run out of the rolls and roll clearance. Skim coating is too slow and any method using an air knife creates a problem of toxic fumes when dealing with an organic system using a low boiling point solvent.

The apparatus of this invention overcomes many of the prior art disadvantages in gravure coating. This novel gravure coating apparatus comprises:

(a) A gravure cylinder,

(b) An impression roll forming a nip with the gravure cylinder, said roll positively carrying the web,

(c) Drive means for rotating said cylinder and impression roll,

(d) Means for effecting a speed differential between the gravure cylinder and the impression roll causing the web to move over the gravure cylinder at a speed less than the peripheral speed of the gravure cylinder,

(e) Means for adjusting the nip pressure between the gravure cylinder and impression roll,

(f) A doctor blade operating on the gravure cylinder for removing excess coating fluid, and

(g) A coating solution supply means to contact the gravure cylinder with the coating solution.

This invention will now be described more fully with

reference to the accompanying drawings which form a part of this application and wherein the same reference numerals refer to the same parts throughout the several figures.

A magnetic tape coating process is used to show the application of this invention but this is only the illustration of its use. The coating technique may be used in other coating processes as coating a photographic emulsion on a film base where the associated process equipment is used.

In the drawings:

FIGURE 1 is a flow diagram of a coating process.

FIGURE 2 is a front view of the coating station.

FIGURE 3 is a rear view of the coating station.

FIGURE 4 is a view of the coating station drive system.

FIGURE 5 is a graph showing the relationship of speed differential versus dry coating thickness.

Referring now to the drawings, FIGURE 1 is a coating line flow diagram showing a coating process of which the coating station, the subject of this patent, is an integral part. In the process of coating, e.g., a magnetic tape, a flexible film base 1 is threaded from an unwind roll 2, through velveteen rolls 3 and into a nip formed by the gravure cylinder 4 and impression roll 5 where the coating solution is applied. From the nip the web moves over the web exit idler roll 6, through particle orienting magnets 7 into a drying system 8, over dancer rolls 9 and onto a heated calender roll assembly 10 to help in smoothing the surface before rewind onto a rewind roll 11.

More particularly referring to FIGURE 2 a detailed drawing of the coating station, a gravure cylinder 4 is journalled into an anchored base frame with vertical sides 12. On one side of the base frame is a cover plate 13 for access to the gravure cylinder 4 so that it may be changed when a different gravure pattern is desired or when there is maintenance work to be done. Under the gravure cylinder is a coating pan 20.

Above the gravure cylinder 4 and on the inside vertical faces of base frame 12 are mounted two pivot arms 14 which pivot about pivot pins 15 near each end of the arms. Journalled into pivot arms 14 is an impression roll 5 covered with a resilient material. This type of impression roll is well known in the art. A lay-on roll 18 is utilized to place the web in contact with the impression roll prior to the gravure nip. Also, mounted on pivot arms 14 are two brackets 19, one on each arm capable of vertical sliding movement. Brackets 19 are located between the impression roll mounting point and the pivot point attachment of the air cylinders 16. Journalled into these brackets is exit idler roll 6. This roll controls the exit angle of the web as it leaves the coating nip and may be adjusted to give any desired exit angle.

After the gravure cylinder picks up coating solution and before it contacts the web, the gravure cylinder is doctored by a doctor blade in the form of a wiper. This blade may be made of many types of material; Teflon® fluorocarbon resin has been successfully used. The doctor blade 21 is mounted on a turning shaft which is rotated in and out of place by weighted lever arm 22. The resting position of the blade against the gravure cylinder is adjusted by adjusting screws 23.

The drive system for the coating station is made up of the following components as shown in FIGURE 4. A variable speed-output motor 24 can be used as a drive means. A suitable device for this purpose is an A.C. powered constant speed induction motor with an integral magnetic clutch in a common housing. Motor 24 drives two pulleys. One belt-pulley unit 26 runs to the gravure cylinder drive shaft 27 and the other belt-pulley unit 25 runs to the input side of a variable speed drive 28. The output side of the variable speed drive 28 drives a belt,

pulley unit **29** running to the impression roll drive shaft. This variable speed drive is the component used to achieve a precise speed differential between the gravure cylinder and the impression roll. A suitable variable speed drive is the Cleveland Speed Variator manufactured by the Cleveland Worm and Gear Company, 3261 E. 80th St., Cleveland 4, Ohio and described in its Technical Bulletin K–200.

The operation of this coating equipment will now be described as it was used in coating magnetic tape.

Several critical variables which must be regulated in coating with the apparatus of this invention are (a) speed differential between the traveling web and the gravure coating cylinder, (b) nip pressure between the gravure cylinder and the back-up roll, and (c) the viscosity of the coating fluid. Other variables which are governed in the standard gravure coating apparatus such as gravure cylinder pattern, wiper blade pressure against the gravure cylinder, the hardness of the backup roll and the exit angle of the web as it leaves the gravure cylinder must also be considered wh ignesnueth0. 2os 20
considered when using the present apparatus.

The staging for a coating run begins by threading a web **1** from the unwind roll **2**. Many different types of webs may be coated, for example, paper, cloth, polyester webs such as a polyethylene terephthalate web, and webs of polypropylene, polyethylene, polyvinyl chloride and polyvinyl acetate. The base or support must be able to conform to the distortion of the nip so that proper contact is made with the gravure cylinder **4**.

The coating fluid loop system is then charged with a coating solution. Coating material is placed in the vessel **36** that is provided with an agitator and pumped through a filter **37** into the coating pan **20** by pump **38**. A return line from the coating pan **20** to the vessel is used so that a circulation system is maintained.

The coating material used was a chromium dioxide containing magnetic tape coating composition with workable viscosities between 7 and 17 poises. The coating dispersion contacts and is picked up by the gravure cylinder **4** as the cylinder rotates through the bath. Though the gravure cylinder is in motion, as long as the nip is open, no contact of the web will occur. At this time, the doctor blade **21** is positioned against the gravure cylinder **4**. The blade is adjusted so that there is a clean wiping effect across the full length of the cylinder face leaving the grooves full of dispersion. Doctor blade pressures against the cylinder have been used ranging from 0.5 to 19 pounds per inch of width.

The selection of a particular surface pattern of gravure cylinder is important since it plays a major part in determining the range of coating weights and also defines the viscosity limitations of the coating solution. There are many types of gravure cylinders. Some contain a simple line pattern, others a cross-hatched pattern and still others a dot pattern (many small, circular wells). In differential speed coating, the simple line pattern has proven to be particularly effective. Gravure line patterns ranging from 36 to 120 lines per inch have been used to give good smooth coatings. Depending on viscosity of coating material, speed of coating and other factors different patterns and dimensions can be selected. It should be emphasized that one particular gravure cylinder will still give a variety of coating thicknesses when utilized in the present improved apparatus.

The impression roll **5**, which opposes the gravure cylinder **4** must contain a covering resilient enough to allow for the necessary nip distortion which insures proper coating contact. Materials testing between 40 and 90 Shore A durometer hardness have been successfully used.

Next the differential speed variation is set to the desired speed ratio wanted between the gravure cylinder and the impression roll. Both the gravure cylinder and impression roll are positively driven. With the web threaded in tension against the impression roll by passing over lay-on roll **18** and thereby nipped against the impression roll, it is easily seen that the speed of the impression roll wil control the web speed. The desired speed differential is determined empirically for each web to be coated. The best coating results have been obtained with the gravure cylinder running faster than the impression roll.

With the web in motion and the gravure and impression roll moving, the air cylinders **16** are activated to form a nip between the gravure and impression roll. A proper nip is very important for the following reasons. The actual transfer of coating material depends on the web coming into positive contact with the liquid in the grooves. If the web loses its planarity, e.g., if the web buckles, proper contact is lost and a misprint results. Similarly positive web control is necessary through the coating station; otherwise, the web will flutter giving improper pull-away causing wrinkles and misprints. Nip pressure between 2 and 60 lbs. per inch of width have been used successfully with the preferred range being 2 to 20 lbs. per inch of width.

With the nip pressure properly adjusted and the peripheral speed of the gravure cylinder greater than the passing web, a smearing effect results which aids in the elimination of the hills and valleys formed by the gravure cylinder. Furthermore, with the gravure cylinder rotating faster than the web, the gravure pattern is contracted on the web giving a much finer coating pattern. For example, if the gravure cylinder is moving twice as fast as the web, the result is that 100 lines per inch is transferred to the web from a roll having 50 lines per inch. This combination of smear action and formation of more lines per inch of material on the web results in excellent smooth coatings.

FIGURE 5 is a graph showing the results of conducted tests relating the parameters of the ratio of peripheral speed of the gravure cylinder to the peripheral speed of the impression roll and web speed plotted against the dry coating thickness under the stated nip pressure This chart is based on the use of standard gravure cylinders rated at 50 and 120 lines per inch. Each diagonal line represents the dry coating thickness obtained at varying differential speeds. The coating solutions and nip pressure remained constant for each line.

While the invention has been described with respect to certain particular arrangements, it is evident that various changes and modifications may be made without departing from the scope and spirit of the invention.

The apparatus may be used to coat many different types of webs or sheets and is not limited to coating magnetic tapes. The primary consideration in coating solutions would be the viscosity of the solution in order for it to fill the grooves and to transfer efficiently out of the grooves at the coater nip.

The driving and differential system may be modified by using two separate variable speed motors, one driving the gravure cylinder and the other driving the impression roll, or by using various pulley arrangements, or by other appropriate differential speed systems.

The various parts of the machine can be made from conventional materials of construction. The base frame may be made of metal including steel, steel alloys, aluminum, copper, plastic materials, etc. They may be painted or provided with protective surfaces.

Many types of gravure cylinders are useful and interchangeable to achieve different coating results. The cylinders may be constructed of metal, plastic, glass, etc. The impression roll may be covered with many different types of material such as rubber, neoprene, plastics, etc. Nip pressure may be controlled by hold-down screws, a hydraulic pressing system or any mechanism which will hold the two coating rolls in proper reference.

The coating fluid can be applied by a pan as disclosed or with other techniques known in the art such as controlled extrusion onto the surface of the gravure cylinder.

The practice of this invention gives rise to the primary advantage of highly improved coating uniformity.

Another distinct advantage is the ability of this system to apply drastically different coating weights (i.e., coating thicknesses) from the same gravure cylinder merely by changing the differential speed ratio between the gravure cylinder and the web. Heretofore this was done only by changing the gravure cylinder itself. Of significance is the fine and predictable adjustments in coating weight that can be attained by merely controlling this speed differential.

As the web passes through the nip of a standard gravure cylinder and impression roll, a certain amount of embossing occurs which hinders uniform coating. In this invention the operable nip pressure may be so low that embossing of the base is reduced to a point that it is almost nonexistent.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A gravure coating apparatus for coating the flexible web which comprises:

(a) a gravure cylinder,

(b) an impression roll forming a nip with the gravure cylinder, said roll positively carrying the web,

(c) drive means for rotating said cylinder and impression roll,

(d) means for effecting a speed differential between the gravure cylinder and the impression roll causing the web to move over the gravure cylinder at a speed less than the peripheral speed of the gravure cylinder,

(e) means for adjusting the nip pressure between the gravure cylinder and impression roll,

(f) a doctor blade operating on the gravure cylinder for removing excess coating fluid,

(g) a coating solution supply means to contact the gravure cylinder with the coating solution, and

(h) means to govern the angle at which the coated web is removed from said nip, said doctor blade being spaced from said coating solution supply means in the direction of rotation of said gravure cylinder and being spaced from the nip in the direction opposite to the rotation of said gravure cylinder.

2. An apparatus as defined in claim **1** where said impression roll has a surface which positively engages said web to maintain the speed of said web below the speed of said gravure cylinder.

3. An apparatus as defined in claim **1** where said coating solution supply means comprises a reservoir pan with a pump to continually circulate the coating solution.

4. An apparatus as defined in claim **1** where said nip pressure adjusting means is a fluid actuated system which moves either cylinder (a) and impression roll (b) into nip relationship with one another.

5. An apparatus as defined in claim **4** where said fluid actuated system is a pneumatic cylinder which moves said impression roll.

6. An apparatus as defined in claim **1** where drive means for said roll and cylinder are independent of one another.

7. An apparatus as defined in claim **2** where a lay-on roll is in nip forming relationship with said impression roll to bring said web into contact with said impression roll before the web is to pass through the nip formed by said gravure cylinder.

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