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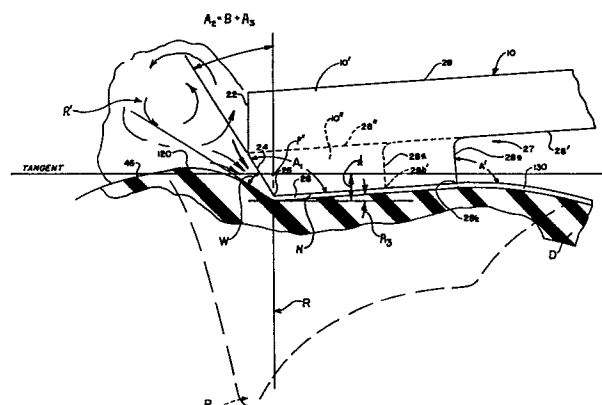
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Ink metering apparatus with obtuse metering member.

Ink metering apparatus comprising a resilient surfaced roller urged into pressure indented relation with a lithographic printing plate; a source of ink to apply an excess of ink to the depleted surface of the roller which has applied ink to the printing plate; and a resilient metering member (10) having two hard, flexible edges (25, 28b) formed on opposite sides of a support surface (26), resiliently urged radially of the roller and rigidly supported in a direction tangent to the roller surface for forming a film on the roller surface. Ink carried by the resilient roller surface impinges against a metering surface (24) on the metering member (10) adjacent the first polished edge (25). The angle formed between the metering surface (24) and the resilient roller surface at the first polished edge, and the pressure on the ink at this edge are adjusted, such that, a given angle and pressure relationship for a given viscosity of ink produces a given printing ink film. The second polished edge (28b) is positioned such that the angle of departure between the metering member (10) and the surface of the roller is sufficient to cause separation of the ink from the metering member to prevent a buildup of ink along the surface of the metering member. Pressure at the first polished edge is significantly greater than pressure at the second polished edge.



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INK METERING APPARATUS WITH OBTUSE METERING MEMBER

Inkers for printing plates which have achieved commercial acceptance generally comprise from two to four form rollers which are positioned in rolling engagement with a printing plate. Each of the form rollers is usually in rolling engagement with one or more vibrator rollers to which ink is applied by a multitude of rollers in a train of rollers of varying diameters arranged in pyramid fashion. Ink is delivered to the train of rollers over a doctor roller, which oscillates into and out of engagement with an irregular film of ink. The irregular film is formed by a flexible doctor blade urged into engagement with a hard surface on a slowly rotating ink fountain roller, by a multiplicity of ink keys.

The ink film formed on the ink fountain roller is too thick and too irregular for application directly to a printing plate for quality printing. These inkers which include a multiplicity of rollers are intended to reduce the thickness of the ink and to constantly deliver a film of a uniform controllable thickness to the printing plate. However, since the depleted ink film on each form roller is not totally replenished on each revolution of the form roller, image ghosting and ink accumulation and starvation is ever present.

In an attempt to eliminate both the expense and the disadvantages of multiple roller inkers, attempts have been made to develop inkers wherein a fresh film of ink

is metered onto a resilient form roller which is urged into pressure relation with a planographic printing plate to eliminate the train of rollers, to eliminate image ghosting, and to eliminate ink accumulation and starvation.

One system comprises two rollers of substantially equal diameter urged together in pressure indented relation to form a nip, surfaces of the rollers adjacent the nip moving in opposite directions. One of the rollers is completely cleaned by a pair of doctor blades and the rollers are urged together such that the local pressure at any point selected along the contact generatrix or nip is greater than a "critical pressure threshold," such that, theoretically, one of the rollers carries a film of ink of constant thickness, throughout the length of the rollers, to be applied directly to a printing plate without being contacted by equalizer rollers. However, since adjacent surfaces of the rollers at the nip move in opposite directions and since pressure is not uniform along the length of the nip between the rollers, temperature generated by adjacent surfaces moving in opposite directions would result in a substantial variation in temperature along the length of the rollers and of ink carried by the rollers. Substantial power is required for rotating the rollers and adjustment of the thickness of a film of ink metered through the nip is very sensitive because slight changes in surface speed of the roller which has been completely cleaned of ink results in drastic changes in the film of ink carried by the other roller.

Ideally, a stationary metering unit requiring no drive in addition to that required for rotating a single form roller would appear to be a solution to the problems presented by previous inkers. Attempts have been made to employ doctor blades as ink metering units, but these attempts have universally met with failure. Doctor blades are successfully used as ink wiping units in inkers having

a train of rollers for distributing and smoothing the ink, but such blades have not proven suitable for use as the sole ink metering unit for a resiliently surfaced form roller in a lithographic printing application.

Printing ink is generally an oily viscous substance which is highly pigmented and formulated to be sticky or tacky so that the ink will properly adhere to image areas of a lithographic printing plate. When the image area of the printing plate transfers ink directly to paper or to a blanket cylinder which in turn transfers ink to paper, small paper fibers, lint and fragments of coating material may adhere to the surface of the plate cylinder. The plate causes the foreign substance to be applied to the surface of the ink applicator roller. If the surface of the ink applicator roller is moved directly into the reservoir and then wiped or scraped by a conventional doctor blade, the foreign substance tends to collect at the edge of the doctor blade which results in formation of an irregular film of ink on the surface of the roller. For this reason, in addition to the erratic behavior of the surface of the resilient roller under dynamic conditions, no inking device has been devised heretofore which is capable of supporting a doctor blade for continuously metering a uniform film of ink directly onto the surface of a resilient roller in rolling engagement with a printing plate.

Uniform pressure cannot be maintained between a rigidly positioned edge and the surface of a resilient roller under dynamic conditions because the apparent modulus of elasticity of the resilient surface on the roller increases as the rate of cyclic loading increases. The dimensions of the resilient form roller vary under dynamic conditions, if the resilient surface is subjected to cyclic loading, since resilient materials have a memory and do not immediately recover to an original dimension after being

compressed. Further, vibration and fatigue failure in the resilient roller surface is induced by substantial indentation of the surface since the resilient cover is stacked up as a result of compressive loading on one side of the stationary rigid edge and is under tension on the other side of the edge. Vibration in the axis of the roller relative to a stationary rigid edge which results from movement of the surface of the roller into and out of the gap in the plate cylinder is not readily isolated from a rigidly supported edge.

The invention described herein addresses the problem of continuously forming a film of printing ink of uniform thickness on a resilient roller surface and moving the film of ink into engagement with the image area on a lithographic printing plate while eliminating trains of rollers in inking systems, eliminating the necessity for consumption of excessive power for metering a thin uniform ink film, eliminating problems attendant to collection of "hickeys", providing a metering member which does not detrimentally stress a resilient roller surface so as to impart vibration to the resilient roller surface, and providing a metering apparatus which forms a uniform film, the thickness of which is independent of press speed.

SUMMARY OF INVENTION

The inker disclosed herein relates to improvements in an inker of the type disclosed in U. S. Serial No. 142,596, filed April 22, 1980, the disclosure of which is incorporated herein in its entirety for all purposes.

The improved inker which is the subject of this application comprises a single resilient surfaced applicator roller adapted to be urged into pressure indented relation with a lithographic printing plate, in combination with an improved ink metering member adapted to form a thin controllable and uniform film of printing ink on the surface of the form roller, the thickness of the film of

printing ink being independent of the surface speed of the resilient roller.

The surface of the roller moving from engagement with the printing plate is moved through a reservoir of ink such that an excess of ink is applied to the surface of the roller to replenish the depleted areas of the film after printing to the plate. A metering member, having a metering surface arrangement for a particular ink viscosity, is positioned in relation to the resilient surface of the roller to form a wedge-shaped entrance to which the excess of ink is carried by the roller surface to form a thin, uniform film of printing ink which adheres to the resilient surface of the roller.

The thin, flat rectangular body of the metering member is positioned almost tangent to the roller surface so that ink impinges against the thin side or edge of the member. When positioned such that the angle between the metering member and a tangent is less than thirty degrees the member is rigid in a tangential direction and flexible in a radial direction. A trapezoidal shaped metering portion is formed on the thin edge of the metering member to establish an optimum geometric relationship to meter ink and to separate the metered ink from the metering member while the metering member is held substantially tangent to the resilient roller surface.

The metering member is mounted such that two polished flexible edges on the trapezoidal shaped metering portion are separated by a support surface and move radially relative to the axis of the resiliently covered roller. The edges are resiliently urged toward the resilient surface of the roller to maintain a substantially constant metering relationship relative to the roller surface along the entire length of the roller and circumferentially thereabout. The polished flexible edges of the metering member are, therefore, rigidly supported in a direction

generally tangent to the roller surface and the trailing edge is oriented to deform the resilient roller surface to minimize wetting of a substantial surface area of the metering member downstream from the polished trailing edge to cause separation of ink from the metering member adjacent the polished trailing edge. Therefore, the trailing surface on the trapezoidal shaped metering portion of the metering member is shaped such that ink on the indented resilient roller surface does not separate from the roller surface and attach itself to the trailing surface of the metering member when rebounding from a compressed position occupied as a result of passing the flexible polished trailing edge of the metering member.

A primary object of the invention is to provide an inking system for printing presses affording continuous precision control of the thickness of an ink film delivered to a lithographic printing plate to eliminate ghosting and resultant variation in color of printed images, which in turn caused considerable waste of time and material.

Another object is to provide an inking system in which a polished edge, formed between a metering surface and a support surface which intersect at an obtuse angle is urged into pressure indented relation with a resilient roller surface such that the pressure and specific angle of the metering surface relative to the roller surface at the metering edge is selected to form a particular ink film thickness required of a particular ink viscosity carried by a roller surface past the polished edge.

Another object of the invention is to provide a metering member having a metering surface and a support surface intersecting at an obtuse angle to form a metering edge which is indented into a resilient roller surface having improved surface characteristics to minimize wear between adjacent surfaces and to provide improved metering.

Another object of the invention is to provide an improved ink metering portion on a member and resilient support means associated therewith to position the metering portion relative to a resilient roller surface for forming an ink film on the roller surface, the thickness of the film being substantially independent of the speed of the roller surface to eliminate changes in film thickness with changes in roller speed and to eliminate streaks caused by minor velocity variations of the roller as it is rotated.

Another object of the invention is to provide an improved ink metering member particularly adapted to be urged into pressure indented relation with an applicator roller such that foreign matter in ink moving toward the metering surface on the metering member and carried by the surface of the form roller is diverted away from the metering member and contained or captured in a vortex of ink adjacent the metering member.

Another object of the invention is to provide a metering member having two smooth, superfinished surfaces intersecting to form an obtuse, blunt, smooth, superfinished metering edge capable of metering a thin, uniform ink film suitable for lithographic printing application to a printing plate.

Another object of the invention is to provide an improved method and apparatus for continuously forming a uniform film of ink on the surface of a resilient roller wherein the ink is metered through a wedge defined between the resilient roller surface and a metering surface, adjacent a flexible polished edge, resiliently urged toward the resilient roller surface so that the wedge automatically moves radially of said roller such that the thickness of the film of ink is substantially independent of the surface runout and waviness of the roller and does not

substantially vary circumferentially and longitudinally of the roller surface.

A still further object of the invention is to provide an improved method and apparatus for forming a uniform film of ink on the surface of a resilient roller by use of an edge mounted on a cantilever, the edge being moved into pressure relationship with an ink film on the roller surface past a threshold point where the ink film ceases to decrease in thickness when an increase in force is applied to the edge and begins to increase in thickness while becoming more nearly uniform.

Another object of the invention is to provide an inking system wherein a non-rotating metering member is positioned and adapted such that metered ink passing under the member does not separate and accumulate on a trailing surface of the metering member to ultimately be pulled again to the metered film to destroy uniformity.

Another object of the invention is to provide an improved inking system in which a polished edge on a metering member is resiliently urged into pressure indented relation with a resilient roller surface such that vibration in the printing press is isolated from the polished edge to eliminate streaks in the ink film formed by the inking system.

Another object of the invention is to continuously control the temperature of the ink in the reservoir to control the shear characteristics of the ink such that a controlled uniform film of ink is metered on the roller surface.

Another object of the invention is to provide a specific dampening system working in conjunction with an inking system providing a lithographic printing system which continuously and automatically provides controlled quantities of ink and dampening fluid to a lithographic printing plate.

Another object of the invention is to provide certain rollers strategically positioned on a single applicator roller before and after printing to a plate and before and after metering by a metering member and before and/or after dampening to condition the ink and dampening fluid film or films for proper application to a lithographic printing plate.

Another object of the invention is to provide specific pressure relationships between the metering member and the roller surface during start, stop and run to minimize wear and streaking.

Other and further objects will become apparent upon referring to the following detailed description and to the attached drawings.

DESCRIPTION OF DRAWINGS

Drawings of a preferred embodiment of the invention are annexed hereto so that the invention may be better and more fully understood, in which:

Figure 1 is a cross-sectional view taken transversely through a lithographic printing press;

Figure 2 is an enlarged fragmentary cross-sectional view illustrating the relationship of the metering member relative to a resilient covered form roller in both static and dynamic operating conditions;

Figure 3 is an enlarged fragmentary cross-sectional view of the trapezoidal shaped metering portion on the working end of the metering member;

Figure 4 shows relationships of various surfaces of the metering member to each other;

Figure 5 is a graph diagrammatically illustrating that as force urging the metering member into pressure indented relation with a roller surface is increased, a minimum ink film thickness is reached for a particular angular relationship between the metering member and the roller surface;

Figure 6 is a graph similar to Figure 5 illustrating a family of curves for different angles of the metering surface relative to a radial line of the roller;

Figure 7 is a graph diagrammatically illustrating variation in color density laterally across a printed sheet in response to changes in force urging an edge of the metering member into pressure relation with a resilient surface;

Figure 8 is a graph diagrammatically illustrating variation in position of an edge on the metering member as a resilient covered roller rotates at a constant speed and also at changing speeds;

Figure 9 is a graph diagrammatically illustrating that ink film thickness is independent of press speed; and

Figure 10 is a diagrammatic illustration showing the color density on a printed sheet.

Numeral references are employed to designate like parts throughout the various figures of the drawings.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to Figures 1 and 2 of the drawing, the numeral 1 generally designates an inker having spaced side frames 2 movably secured to side frames 3 of a printing press having a conventional plate cylinder P, blanket cylinder B, and impression cylinder I mounted therein for printing on a web W or a sheet of paper.

Support means 5 is provided to adjustably secure metering member 10 between side frames 2 and to position metering member 10 in relation to a resilient covered applicator roller 40. Opposite ends of applicator roller 40 are rotatably secured to side frames 2 in suitable bearings and applicator roller 40 is driven by any suitable drive means such as a chain 4 drivingly connecting a sprocket on the plate cylinder to the sprocket on a clutch (not shown) at an end of applicator roller 40. The sur-

face speed of applicator roller 40 is preferably substantially equal to the surface speed of plate cylinder P.

End dams 6 are secured to support means 5 and are urged into sealing relation with opposite ends of applicator roller 40 and member 10 forming a reservoir R from which ink is metered onto the surface of applicator roller 40. One or more ink storage vibrator rollers 8a and 8b are positioned in rolling engagement with ink on the surface of applicator roller 40 for smoothing any surface irregularities which may appear in the ink film before the ink film is carried by the surface of roller 40 to the dampener D and to the surface of a printing plate P' on plate cylinder P. Ink storage rollers 8a and 8b are in rolling engagement with ink on the surface of applicator roller 40 and not only smooth surface irregularities, but also change a slick metered finish to a smooth matt-like finish for conditioning the ink film for proper dampening and application to an image on a printing plate.

It will be appreciated that as the surface of applicator roller 40 moves away from the surface of printing plate P', the surface is again smoothed and conditioned by ink and dampening fluid storage vibrator roller 8c prior to being submerged in ink where an excess of ink is applied thereto at the reservoir R.

As the inking system is employed for lithographic printing, dampening fluid is applied first to the ink on the surface of the applicator roller 40 and thence to the printing plate P' on plate cylinder P. Means are provided for evaporating dampening fluid from the surface of roller 40 to prevent accumulation of excessive dampening fluid in reservoir R. As illustrated in Figure 1 of the drawing, a hollow perforated or slotted tube 9 extends transversely between side frames 2 and has apertures formed therein through which dried compressed air is delivered for causing a stream of dry air to be directed toward the surface of

roller 40. At least one end of tube 9 is connected by a hose to a suitable air supply (not shown).

Also, when dampening fluid is used with the inker of the present invention, a greater than normal proportion of alcohol to water may be employed to print with less water and to speed evaporation of the dampening fluid which remains on the applicator roller as it moves away from the printing plate. In fact, the dampening solution could contain more than the normal 5 to 25% alcohol to insure rapid evaporation of the dampening solution from the applicator roller as it travels between the plate and the ink metering member. The alcohol, a roller 8c or multiple rollers 8c and the air, all contribute to the removal and re-distribution of excess dampening fluid after printing.

As will be hereinafter more fully explained, to provide precision control of the viscosity of ink in reservoir R and to vary the viscosity of the ink, if required, in reservoir R, flexible tubes 7 are connected to deliver a fluid, such as water at a controlled temperature and at a controlled flow rate, into one end of passage 5' in support member 5 and out of the other end of passage 5'.

For high speed printing, the physical properties of ink film 130 formed between metering member 10 and resilient cover 44 of roller 40 and of ink in reservoir R may be further controlled by temperature control of a fluid passing through vibrators 8a, 8b or 8c and through the passage in the core 42 of roller 40. It has been found that a high flow rate produces only a small temperature change along the length of a roller and that by monitoring and controlling the output temperature, heat can be dissipated and ink temperature controlled such that the physical properties of the generated film are held substantially constant throughout the length of a production run.

Therefore, by cooling or heating fluid passing through member 5; roller core 42; and through vibrators 8a, 8b or 8c; the ink viscosity at and prior to nip N is controlled to maintain a constant desirable ink film for proper printing to plate P.

INK METERING MEMBER

A preferred embodiment of ink metering member 10 is illustrated in Figures 3 and 4 of the drawings.

Referring particularly to Figure 4, the ink metering member 10 has a smooth, polished, highly developed, precision metering edge 25 which is formed at the juncture of metering surface 24 and support surface 26.

Metering edge 25 preferably extends in length for a distance within a range of from 10 to 80 inches, depending upon the press width, and is defined by the intersection of the polished surfaces 24 and 26. Polished surfaces 24 and 26 meet at an obtuse angle to form a wedge having an included edge bevel angle " A_1 " which is approximately 120° or greater.

The edge 25 is preferably formed on relatively hard metallic material having a hardness of about Rockwell C48-50 or higher. It is important that the polished edge 25, metering surface 24, support surface 26, trailing surface 28a and edge 28b be wear resistant since they are indented into the resilient surface 45 of form roller 40 during normal operating conditions.

Metering member 10 is preferably a resilient, i.e., flexible, metallic, material having a modulus of elasticity of approximately 30×10^6 psi, or less, to provide what might be termed a "stylus effect" to the metering edge 25 as the form roller 40 rotates.

Metering member 10 has been formed with good results from a strip of stainless spring steel with sheared edges which is commercially available from Sandvik Steel, Inc., Benton Harbor, Michigan, and distributed as Sandvik 7C27Mo2.

The strip of stainless steel was selected for its hardness, flatness, resilience, grain structure and fine surface finish to provide high wear resistance and good fatigue properties. The stainless steel strip had a thickness of 0.070 inches and a width of approximately 5.3 inches. The strip of material had been heat treated and had a bright polished surface finish, extra accurate flatness and normal straightness. The tolerance of the width was ± 0.016 " and the tolerance of the thickness was ± 0.00181 inches. The strip of stainless steel material was resistant to corrosion in the presence of air, water and most organic acid in dilute form at room temperature. The tensile strength was about 249,000 psi corresponding to the hardness of Rockwell C 49.

Initially, the edge, at the juncture of surfaces 22 and 26, had ragged notches forming a ragged edge contour. To form a precision straight edge to define an unbroken line across the extent of metering member 10, surfaces 24 and 26 were ground at a specified obtuse angle, then finished with a fine-grit stone as will be hereinafter more fully explained, as a first step in forming polished edge 25. The strip was then clamped in a special fixture. Surface 24 on the strip was superfinished at the specific angle by hand with a fine grit stone and then hand polished with 600 grit sandpaper.

As a final step, the stainless steel strip was positioned on a flat horizontal surface. Surface 26 was then superfinished by hand with a stone having a fine grit and hand polished with 600 grit sandpaper.

If a feather edge forms on the metering member while portions of surfaces 24 and 26 are being superfinished and polished, the feather edge should be removed with leather or a polishing material. When the feather, or wire-like irregular edge is removed, a smooth, continuous, uniform, blemish-free edge is formed on the strip. Thus,

in the process of polishing or "sharpening" the obtuse edge 25, the acuteness of the edge may be altered somewhat to form a non-cutting, non-film-piercing edge. This process produces a fine, continuous, smooth, straight, polished, highly developed, uniform, superfinished, edge 25, having minimal surface irregularities. There should be no small notches or protrusions in the edge. The developed edge 25, formed by polished surfaces 24 and 26, is an extremely fine edge which has been polished to bring it to a highly developed finish, and as nearly perfect condition as possible. Surfaces 24 and 26 are preferably finished to an RMS reading not exceeding RMS 4. The term "superfinishing" as used herein applies to a surface which has been ground and polished such that the peaks of the surface have been removed to form flat bearing surfaces, yet still having minute valleys or reservoirs for accepting and carrying the lubricant ink.

Edge 25 is finished to a surface finish approximating that of the edge of a razor blade. However, it will be appreciated that the obtuse angle "A₁" between surfaces 24 and 26 is significantly greater than the bevel angle on a razor blade and thus an obtuse, blunt, non-cutting and non-piercing edge is formed. Actually, surface 24 blends into surface 26 through edge 25 to form a continuous polished surface adjacent each side of edge 25.

The material used to form the edge 25 must not only be hard and capable of being formed to provide a blunt, fine, polished, unbroken, edge, but the material must also be dense yet flexible along the length of the edge 25. In fact, the edge 25 must be quite flexible in a lengthwise direction so that when urged into pressure indented relation with the resilient surface of applicator roller 40, the edge 25 will be flexed, yielding to the influence of the surface of roller 40, to conform the edge 25 and the surface of roller 40 to form a substan-

tially uniform indented area along the length of roller 40. As will be hereinafter more fully explained, the resilient cover 44 on roller 40 has a thickness in the range of approximately $3/8$ to $5/8$ inches, preferably $1/2$ inch, and a resilience of about 40 to 70 Shore A durometer, preferably 60 durometer, Shore A. This loading of edge 25 to obtain conformation with the surface of roller 40 should be possible without excessively indenting the surface of the roller when in a dynamic, running condition.

The edge 25 on metering member 10 should be mounted so that it is resiliently urged toward the surface of the applicator roller 40 and is free for movement along its entire length in a direction radial to the applicator roller. Also, the edge 25 must be rigidly supported in a direction substantially tangent to the applicator roller surface.

The ideal support for the edge 25 is a flexible cantilever beam which supports the edge 25 and provides the required bias and rigidity. Although the edge 25 may be a part of a separate trapezoidal like element, which is functionally associated with a cantilever beam, it is preferable to form the edge 25 of the trapezoidal portion 10 on the beam so that the two are an integral unit. To accomplish this, the beam must be flexible in two directions; namely, along the length of the edge 25 and also along the width of the strip, ie., the length of the cantilever beam.

The ink metering member illustrated in Figure 4 of the drawing, wherein the edge 25 is formed on the unsupported end 10' of the cantilever beam, has a substantially rectangular cross section bounded by front and rear edge surfaces 22 and 22', upper surface 28 and lower surface 29. Support surface 26 lies substantially in the plane of surface 29, when the cantilever beam is in a non-flexed condition. Metering surface 24 and support surface 26

intersect forming an obtuse angle "A₁" and intersect at an apex 25, which is substantially a straight line.

As an example, the cantilever beam which includes the obtuse edge 25 may be formed from a thin, flexible, elongated stainless steel strip or band, as hereinbefore described, having a thickness of 0.070 inches and a width of 5.3 inches, or less. The width of the beam, or the length of the strip of material, will preferably be within the range of from 10 to 80 inches, and the beam is supported to be flexible along the length of edge 25 as well as along the length of the cantilever beam. The modulus of elasticity E of the beam may be, for example 29×10^6 psi, which represents the stiffness of the material; that is, its resistance to deformation. When combined with the moment of inertia I, the EI factor represents the stiffness of the cantilever beam.

The specific dimensions and characteristics of the metering member 10 are presented by way of explanation, and such dimensions, characteristics and mounting may vary to meet specific conditions. Consequently, preferable ranges have been provided herein.

Metering member 10 also has a groove or relieved area 27 formed in the lower surface 29 of the strip of material from which metering member 10 is formed.

The portion of the strip of material which will be polished to form polished edge 25 is masked and the metallic material adjacent thereto is removed by grinding or by chemically milling to remove a portion of the metal without creating stresses that would cause the strip of material to warp.

Surface 28a adjacent the support surface 26 is smoothed by finish grinding to remove approximately 0.003 inch of rough surface material. Surface 28a may then be sanded with 600 grit paper to provide a very smooth surface

finish on the surface of 28a. Edge 28b is therefore formed as discussed previously for edge 25.

If the thickness, the distance between surfaces 26 and 28, of the strip of material is 0.070 inches, the depth of the relieved area 27 is preferably greater than 0.020 inches, for example, 0.035 inches, such that the thickness of the material between surface 28' and surface 28 is approximately 0.035 inches.

Surface 28a intersects the polished surface 26 at an angle A' in a range between 30° and 90° as shown. The upper portion of surface 24 of metering member 10 may extend to surface 28 or be bevelled as shown at an angle to form surface 22.

Surface 24 may therefore be only a small champher on original surface 22. Obtuse angle "A₁", not only forms a metering member having a blunt, obtuse, edge which is not fragile, but, primarily is specifically formed to a particular angle, or configuration, to enable the metering of a specific ink film thickness having a specific viscosity and strength of color to meter the film without an immediate change in direction of the roller surface and without significant indentation of the roller cover which causes rapid wear of the metering member edge and the roller cover.

In the illustrated embodiment of metering member 10, polished surface 24 extends upwardly from polished edge 25 a distance approximately equal to the depth of relieved area 27, or greater, to intersect surface 22. It should be readily apparent that polished surface 26 supports the polished edges 25 and 28b. If surfaces 24 and 28a are parallel, surface 26 can be refinished without changing the load bearing characteristics of the polished edge portion 25 of the metering member 10.

Surfaces 26, 24 and 28a, and therefore edges 25 and 28b, are readily renewable. By slightly refinishing sup-

port surface 26, both edges may be resharpened simultaneously; or, surfaces 24 and 26 may also be refinished. After considerable usage, a small radius or curve may appear at edge 25 to cause changes in metering characteristics. To avoid replacing the entire metering member, the hereinbefore stated, post-grinding and hand-finishing procedures may be again performed several times before the entire member is replaced. Normally one to three thousandths of an inch is removed from any one surface, depending upon the extent of wear to restore edges 25 and 28b.

A special fixture or fixtures may be used when refinishing surfaces 24 and 26 in order to prevent damage to the metering member. The fixture should not only hold the member, but also provide guide surfaces for the fine grit stoning and sanding operations to insure that only a minimum amount of material is removed and that the obtuse angle "A₁" and edges 25 and 28b are maintained.

The relief angle A' should be sufficient to cause an ink film carried by the surface of roller 40 to depart and separate from surface 26 without accumulating either on surface 26 or 28a to cause ultimate dripping of the accumulated ink to cause non-uniformity of printing.

APPLICATOR ROLLER

The applicator roller 40 comprises a hollow, rigid, tubular metallic core 42 having a resilient non-absorbent cover 44 secured thereto, the cover having a uniformly smooth, uniformly textured, and resilient outer surface 45. The cover 44 on applicator roller 40, while being resilient, is relatively firm, for example, in a range between 40 and 70 Shore A durometer.

The cover 44 on applicator roller 40 is preferably formed of a resilient urethane, polyurethane rubber or rubber-like material attached to a metallic core 42. Preferably the cover is made from Buna Nitrile rubber which

provides a natural surface having microscopic pores to receive and hold ink therein to enable metering a thin ink film suitable for lithographic printing applications.

The cover 44 on applicator roller 40 should have high tensile strength, excellent tear and abrasion resistance, and resistance to oils, solvents and chemicals. The cover should, furthermore, have low compression set, good recovery, and uniform ink receptivity. A suitable cover can be formed using urethane or rubber to form a resilient cover preferably of about 60 Shore A durometer.

A suitable urethane cover may be made from a blocked, pre-catalized material which is commercially available from Arnco in South Gale, California, under the trademark "Catapol". The material is pre-heated at 160°F for five hours, poured into a mold around the roller core, and then heated to 280°F for 8-1/2 hours, and allowed to cool prior to grinding and polishing.

A suitable rubber cover may be obtained from Mid-America Roller Company, Arlington, Texas, and specified as Buna-Nitrile which is conventionally formed over the core and ground with a high-speed grinder prior to polishing.

After a resilient cover 44 of either urethane or rubber has been formed, the roller may have a slick glazed outer skin or film over the surface thereof which is removed by grinding. After grinding with a 120 grit rock, the surface of resilient cover 44, if constructed of urethane, is sanded by using 180 grit sandpaper to form a surface of uniform smoothness over the surface 45 of the resilient cover 44. However, after grinding with a 120 grit rock, the surface of resilient cover 44, if constructed of rubber is sanded with 400 grit sandpaper to insure a velvet smooth, uniformly textured surface, free of "orange peel" or other surface irregularities.

Microscopic reservoirs into which ink is attached, help to assure that a continuous unbroken film of ink is maintained on the surface 45 of applicator roller 40.

Surface scratches, grind lines, and other surface irregularities should be removed so that the surface roughness of the surface of either urethane or rubber after sanding does not exceed 30 RMS. As will be hereinafter more fully explained, adhesive force between molecules of ink and molecules of the surface 45 of cover 44 must exceed cohesive force between ink molecules to permit shearing the ink to form a controlled, continuous, unbroken film of ink on the surface 45 of applicator roller 40.

It will be appreciated that it is physically impractical, if not impossible, to construct and maintain roller 40 such that surface 45 is perfectly round in a circumferential direction, perfectly straight in a longitudinal direction, and precisely concentric to the axis of core 42. The straightness or waviness of surface 45 on roller 40 can be economically manufactured within a tolerance of about 0.002 inches along the length of roller 40 and the radial eccentricity can be economically manufactured within a tolerance of about 0.0015 inches.

A Shore A durometer test is generally used to indicate the hardness of a resilient roller cover by measuring resistance to penetration at a constant temperature of about 76°F while the resilient cover is stationary. The apparent hardness of a resilient surface under dynamic conditions deviates radically from the hardness indicated by the durometer test under static conditions. The spring constant of a resilient material so increases slightly as deformation increases.

As the frequency of loading of a resilient member increases, the dynamic modulus or apparent modulus of elasticity increases causing the cover to appear as a harder, stiffer material. However, cyclic loading of a

resilient member results in generation of internal heat which increases temperature and results in a decrease in the durometer and therefore the modulus of elasticity of the resilient cover.

Further, since the surface 45 of cover 44 on roller 40 is preferably in pressure indented relation with the surface of a plate cylinder, the plate cylinder having a gap extending longitudinally thereof, this cyclic loading will result in generation of heat at an irregular rate circumferentially of the surface 45. Such temperature differences over surface 45 may cause an appreciable variation in the radial distance from the axis of the roller 40 to points over the surface 45, because the co-efficient of thermal expansion of elastomeric materials employed for forming resilient roller covers is several times the co-efficient of thermal expansion, of e.g. steel.

As shown, roller 40 can be different in diameter than the plate cylinder P without adversely affecting printing of the film 130 to the web W, or sheet, since metering member 10 produces a continuous ribbon of ink on the applicator roller surface regardless of the prior impression and regardless of thermal changes within the roller cover 44.

The applicator roller 40 should not be the same diameter as the plate cylinder P, because even the slightest defect, hole, flaw, etc. in the surface of the applicator roller 40, would repeat in the same place on the plate when the two are driven at the same surface speed and are the same diameter; i.e., repeat on a one-to-one basis. This repeat, especially when printing to a lithographic plate, eventually causes sensitizing of the non-image area. The flaw will then appear as ink on the printed sheet in the non-printing area. If the flaw occurs in the printing area, eventually heavy ink will appear in this area. Therefore, it is imperative that the surface

of the applicator roller 40 not repeat with the surface of the plate on the plate cylinder. It has been observed that with the absence of a repeat, the flaw, even when considered excessive, will not sensitize a lithographic plate in the non-printing area.

SUPPORT STRUCTURE

Referring to Figure 1 and 2 of the drawing, support means 5 for supporting metering member 10 in cantilever fashion comprises an elongated, rigid support bar 50 having a ground and true flat face 52 on one side thereof and a surface 54 angularly disposed relative to flat face 52 forming a shoulder 55 which extends longitudinally of support bar 50. Journals 56 extend outwardly from opposite ends of support bar 50 and are rotatably secured in self-aligning bushings 57 (not shown) in bearing blocks 60 having outwardly extending projections 58 adjacent opposite sides thereof.

Each of the projections 58 has an elongated slot formed therein through which anchor bolts 52 extend for securing bearing blocks 60 to inker side frame 2.

Four elevating screws 64 extend through threaded passages in projections 58 on bearing blocks 60 and engage surface 65 on inker side frame 2 for movement of support bar 50 in a vertical direction, as illustrated in Figure 1.

Lateral adjustment screws 66 extend through threaded apertures in outwardly extending lugs 68 on inker side frame 2 and engage end surface 66' on projections 58.

From the foregoing it should be readily apparent that the position of bearing block 60 is adjustable vertically and horizontally, as viewed in Figure 1 of the drawing, for movement of support bar 50 relative to the axis C of roller 40.

An arm 70 is bolted or otherwise secured to the end of journal 56 on support bar 50 and is urged by a piston

rod 71 of fluid pressure actuated cylinder 72 into engagement with an end of a stop screw 74 threadedly secured to an arm 75 bolted or otherwise secured to bearing block 60. It should be readily apparent that support bar 50 is rotatable relative to bearing block 60 by adjustment of the position of the end of stop screw 74 relative to arm 75.

Pressure regulator R" is installed in order to set inlet pressure in cylinder 72 sufficient to hold arm 70 firmly against screw 74 for all indentations of edge 25 into surface 45 of cover 44.

Metering member 10 is secured to the flat surface 52 on support bar 50 by bolts 76 extending through spaced apertures in clamp member 78 and through oversized spaced apertures extending through the cantilever beam adjacent the rear edge thereof. Bolts 76 are threadedly secured in threaded passages formed in support bar 50. Bolts 76 and clamp 78 cooperate such that the metering member 10 is uniformly attached or supported by support-bar 50 such that the edge 25 has a uniform spring rate along its length.

In the embodiment of the apparatus illustrated in Figure 1, stop screw 74 is remotely controlled by a direct current electrically driven motor 80 secured to arm 75 by a support bracket 81. A gear reducer is positioned between motor 80 and screw 74 to further control the speed of rotation of screw 74. A splined coupling 76 is connected between screw 74 and the output shaft of motor 80. Motor 80 is commercially available from Globe Industrials Division of TRW, Inc., of Dayton, Ohio.

Conductors 82 and 84 extend between motor 80 and motor position control unit 85 which is of conventional design and comprises a direct current source and a three position switch.

Motor position control unit 85 has a digital readout indicator 86 associated therewith to indicate the position

of a rotary potentiometer (not shown) at the end of stop screw 74 which engages arm 70 to provide visual indication of the position of the support 50 for metering member 10. Motor position control unit 85 is secured to the side frame 3 of the printing press in the embodiment illustrated in Figure 1 of the drawing. However, an additional motor position control unit 85 is preferably positioned adjacent the delivery end of the printing press or at a control console so that the position of metering member 10 can be adjusted remotely as printed sheets are inspected to adjust overall color density of ink as required.

Inker side frames 2 are pivotally secured by a shaft 90 to press side frames 3 adjacent opposite sides of the printing press. A fluid pressure actuated throw-off cylinder 92 is pivotally secured to lugs 93 secured to side frames 3 of the printing press and has a piston rod 94 pivotally secured to lug 95 welded or otherwise secured to inker side frames 2. An on-stop adjustment screw 96 is threadedly secured to a lug secured to the press side frame 3 and is positioned to engage inker side frame 2 when pressure between the surface 45 of applicator roller 42 and printing plate P' has been properly established. An off-stop adjustment screw 98 is threadedly secured to a lug welded or otherwise secured to printing press side frame 3 to engage inker side frame 2 when the piston rod 94 in throw-off cylinder 92 is extended to thereby separate surface 45 on applicator roller 40 from the surface of printing plate P'.

As hereinbefore described, end dams 6 are urged into sealing relation with opposite ends of applicator roller 40 and define opposite ends of reservoir R. An ink retainer member 100 is positioned in sealing relation with the surface 45 of applicator roller 40, as illustrated in Figures 1 and 2 of the drawing, and has opposite ends secured to end dams 6. The lower edge 102 of ink retainer

member 100 is preferably spaced slightly from surface 22 on ink metering member 10.

Ink retainer member 100 defines the entrance side of reservoir R.

The exit side of reservoir R is defined by member 105 secured to support bar 50 by bolts 106. The lower seal 108 adjacent member 105 is positioned adjacent the upper surface 28 of metering member 10 to prevent flow of ink from reservoir R onto the upper surface 28 of metering member 10 to form an area of stagnation in which ink ceases to flow. Since lithographic ink is thixotropic, the viscosity of ink is significantly reduced when the ink is in motion as compared to the viscosity of ink which is not in motion.

As illustrated in Figure 1 of the drawing, a conventional agitator 110 is secured to ink retainer member 100 for agitating ink in reservoir R. Ink agitator 110 is commercially available from Baldwin-Gegenheimer of Stamford, Connecticut, and comprises a rack and pinion (not shown) which extends longitudinally across the upper portion of the reservoir R which carries a mixing head driven through a chain by a constant speed motor. As the mixing head approaches an end dam 6 adjacent one end of applicator roller 40, it reverses direction and moves to the other end of the reservoir. The agitator rotates within the ink to laterally stir, or shear ink to prevent irregularities in viscosity along said reservoir.

SET-UP AND OPERATION

The operation and function of the apparatus hereinbefore described is as follows:

Metering member 10 is aligned by two pins 51 pressed into support bar 50 which extend through precisely positioned alignment holes in metering member 10. The member 10 is attached to the face 52 of support bar 50 by bolts 76. Pins 51 in bar 50 extending through holes in member

10 assure a uniform cantilever of member 10 along the length thereof and therefore uniform deflection and loading at edge 25. Anchor bolts 52 are loosened to permit movement of bearing block 60 relative to inker side frame 2.

Elevating screws 64 are employed for paralleling face 52 to axis C and for adjusting the angular relationship between surface 26 on metering roller 10" relative to a tangent to a radial line of applicator roller 40 passing through edge 25.

Lateral adjustment screws 66 are employed for moving bearing block 60 relative to applicator roller 40 for alignment of edge 25 on metering member 10 relative to surface 45 on resilient cover 44 of applicator roller 40.

After edge 25 on metering member 10 has been aligned with the surface of applicator roller 40 and the angular relationship between surface 26 and a line tangent to applicator roller 40 has been established, anchor bolts 52 are tightened, rigidly securing bearing blocks 60 relative to side frames 2.

As seen in Figures 1 and 3, edge 25 on metering member 10 now intersects surface 45 on cover 44 of roller 40 at Point P" at a position of about eleven o'clock; that is, in the nine to twelve o'clock quadrant, assuming zero and twelve o'clock to be at the extreme top of the applicator roller 40 and numbering clockwise as the numbers on the face of a clock. Reservoir R is therefore formed as shown, which naturally, because of gravity, causes ink to be weighted against edge 25 of metering member 10 to ensure complete submergence of ink on the frontal surface of metering member 10 at roller surface 45 on cover 44 of roller 40 at Point P". Edge 25 is now positioned in "kiss" contact with the surface 45 of applicator roller 40. An amount of ink in excess of that needed to continuously ink the plate P' on the plate cylinder P is provided from

the reservoir R to the surface of the applicator roller 40 which is approaching metering surface 24 on metering member 10.

After edge 25 has been moved into "kiss" contact with the surface 45, stop screw 74 is rotated thereby rotating support bar 50 from the position illustrated in full outline in Figure 2 of the drawing to the position illustrated in dashed outline.

This results in deflection of the cantilever beam and the flexible polished edge 25 is urged into pressure indented relation to conform with the resilient surface of applicator roller 40. Rotation of roller 40 now continuously moves ink from reservoir R into contact with metering surface 24 and edge 25, thus shearing ink of an abundant quantity on the surface 45 to a film 130 which may be altered in thickness as will be hereinafter more fully explained.

Assuming that edge 25 is mounted on a cantilever beam rigidly supported at one end, the equation of the elastic curve is $Y = F(2L^3 - 3L^2 x + x^3) / 6EI$.

In a prototype, a distance between shoulder 55 and metering edge 25 on metering member 10, which would be the unsupported end of the cantilever beam, was 1.625 inches, the distance between surfaces 28 and 28' was 0.035 inches and a static load of twenty-five pounds per inch of width was applied at the edge 25. Support width S was 0.15 inches. The modulus of elasticity E of the metering member 10 was approximately 30×10^6 psi.

The moment of inertia I of a rectangular area is equal to $bh^3 / 12$, where b is equal to the width of the base of the rectangular area and h is equal to the height of the rectangular area. The moment of inertia I of metering member 10 having a thickness of 0.035 inches is calculated to be 3.5×10^{-6} per inch of width of the cantilever beam.

At the unsupported end of the cantilever beam, x is equal to 0, and the deflection Y is equal to $FL^3 / 3EI$. Therefore, it was calculated that the deflection of the unsupported end of the cantilever beam should be approximately 0.31 inches when a load of twenty-five pounds per inch of width is applied to the edge 25. Consequently, it was concluded that the spring constant for the cantilever beam would be 0.012 inches of deflection per pound of force applied to the edge 25 or 81 pounds per inch of deflection on one inch of the width of edge 25.

It is, of course, appreciated that the equation of the elastic curve set forth above is only approximate for calculating the deflection of the edge 25 since metering member 10 is not exactly rigidly supported or clamped at the shoulder 55 on support bar 50 and the 0.035 relief does not extend entirely to the shoulder. However, it will be readily apparent that edge 25 is resiliently urged in a direction radially of applicator roller 40.

The deflection, or the distance moved by the edge 25 on metering member 10, in the above example, was actually measured to be 0.14 inches when an average static force of twenty-five pounds per inch was applied to edge 25. Dividing the force of twenty-five pounds per inch by the deflection of metering member 10 is approximately 178 pounds per inch of deflection. The spring constant calculated from the actual deflection of resilient member 10 differs from the approximate spring constant calculated above. However, the differences in the spring constant as approximately calculated and as actually measured was predicted.

The wide support surface S of 0.15 inches was selected as such to provide an adequate support area to correspond with the large twenty-five pound force acting on surface 26 of metering member 10 and on the applicator roll cover 44 in the depressed area indicated by N on the

film of ink generated at edge 25, creating a pressure at N sufficient to indent the entire surface 26 and both edges 25 and 28b into the surface 45 of cover 44 of applicator roller 40. Static indentation was measured to be approximately 0.06 inches which immediately changed to 0.04 inches upon rotation of a 60 durometer applicator roll having a one-half inch thick cover 44. It is concluded, therefore, that for a desired deflection of edge 25 of the cantilevered portion of metering member 10, a certain force is required, and for that force, a given support surface is required which will provide a pressure to adequately indent a particular roller cover an amount sufficient to form between the roller surface and the metering surface at the first edge of the metering member, a wedge or orifice to meter a particular ink of a known viscosity to a desired film thickness as the film exits the second trailing edge of the support surface. Generally, small edge deflections require small forces to obtain the small deflection and can be supported by a small support area to adequately provide pressure sufficient to indent a particular cover a desired amount. Large deflections require correspondingly large forces to obtain the large deflection but must be supported by a large support area to obtain the same pressure and indentation on the same cover. Therefore, Figure 3 shows both a large support surface width S and a small width S'. S is shown to be greater than $\underline{t}$, i.e., approximately $2\underline{t}$ while S' is shown to be equal to or less than $\underline{t}$, i.e., approximately $\underline{t}$. Satisfactory results have been obtained with S between $\underline{t}$ and $2\underline{t}$. Large edge deflections are also desirable in order to provide a system which is responsive but yet not too sensitive to changes in position of stop screw 74.

As will be hereinafter more fully explained, the combined distance that the edge 25 is deflected plus the

distance that edge 25 is indented into the roller surface 45 should be substantially greater than the maximum space between points on roller surface 45 and edge 25 when the surface and the edge are urged into kiss contact. For example, irregularities or manufacturing imperfections in roller surface 45 and slight waviness of edge 25 might easily result in a maximum deviation of 0.002 inches error such that the surface 45 and edge 25 do not conform when first touched together. If edge 25 is deflected 0.16 inches and indented into surface 45 a distance 0.04 inches in a dynamic condition, the initial deviation of 0.002 would be only 1% of the combined distance of 0.20 inches. Since edge 25 and cover 44 are resilient, the edge and the surface will flex and conform to each other. When thus conformed, pressure along the stripe area N will be substantially constant and the effect on the ink film of small differences will be insignificant.

This combined distance of deflection and indentation in a dynamic condition is one hundred times the initial deviation, such that the maximum error after the edge 25 and surface 45 are urged into pressure indented relation is only one percent. Therefore, pressure and indentation variations at N become insignificant. This maintains an ink film thickness which will print what is considered by printers as more than acceptable uniformity of color density. Printers refer to "very tight" control when color density does not vary more than plus or minus five percent over the surface of a sheet.

As illustrated in Figure 3 of the drawing, the edge 25 on metering member 10 is urged into pressure indented relation with the surface of applicator roller 40 such that the resilient material is built up, up-stream from surface 24 forming a small bulge or wave 120 in the cover 44 while a groove or channel 27 is formed in the cover downstream from edge 25. The area in front of surface 24

forms a wedge through which ink is drawn; the wedge being bounded on one side by a portion of surface 24 and edge 25 and bounded on the other side by a portion of the surface 45, probably between a small portion of the bulge 120 and the portion of the surface 45 immediately adjacent polished edge 25. As the cantilever beam permits the flexible edge 25 to follow the contour of the applicator roller, the wedge automatically moves minutely radially relative to the axis C of the applicator roller 40. Since the wedge is formed by the cooperation of the opposing flexibly biased edge 25 and resilient surface 45 of the applicator roller 40, this movement is desirable if a constant pressure relationship is to be maintained on the ink extruded through the orifice. The surface of the applicator roller 40 will constantly change in contour as the roller rotates due to elastic memory, temperature changes, and variations in the dynamic modulus of elasticity, as hereinbefore discussed. Consequently, it is important that the edge 25 automatically move radially and flex lengthwise to follow this changing contour.

The resilient edge 25 of metering member 10 and resilient cover 44 of roller 40 might also be viewed as two opposing springs each having a particular spring constant K_1 and K_2 , respectively. The combined spring constant K is equal to $\frac{K_1 \times K_2}{K_1 + K_2}$

$K_1 + K_2$ which is less than either K_1 or K_2 . The following Table 1 and resulting calculations are proof of the above statement of K being less than K_1 or K_2 and further shows that the initial 0.002 inches error results in a final pressure error of only 1% of the static or dynamic pressure.

TABLE I

Data Item	F= Force (#/In)	A= Area (In ²)	P=F/A Press. (#/In ²)	D= Defl. (In.)	K=F/D Spring Constant (lb/in)	Load.
Metering Member	M 25	M .15	C 167	M .14	C 178	Static
Applicator Roller Cover	M 25	M .15	C 167	M .06	C 417 (for .15 in. ²)	
Metering Member	C 28.6	M .15	C 191	M .16	C 178	Dynamic
Applicator Roller Cover	C 28.6	M .15	C 191	M .04	C 715 (for .15 in. ²)	

$$K_{\text{Static}} = \frac{(178)(417)}{178+417} = 125 \#/\text{IN},$$

$$E(\%)_{\text{Static}} = \frac{(.002)(125)}{(167)(.15)} \times 100 = 1$$

$$K_{\text{Dynamic}} = \frac{(178)(715)}{178+715} = 143 \#/\text{IN},$$

$$E(\%)_{\text{Dynamic}} = \frac{(.002)(143)}{(191)(.15)} \times 100 = 1$$

M = Measured Therefore $\frac{E}{2}(\%) = \pm 1/2$
 C = Calculated

Therefore, the working end 10" of metering member 10, bounded by surfaces 22, 28a, and 26 and line 28", forms a

rectangular cross section, which includes the metering surface 24 and edges 25 and 28b, can be spring biased by any other means which performs the same function as the cantilever portion of the metering member 10, i.e., to support the working end along its entire length resiliently in a radial direction and rigidly in a tangential direction. When surface 24 is formed on the rectangular cross section, the working end of metering member 10, as seen in Figure 4, forms a trapezoidal like shape 10".

It should be noted that ink carried by the surface 45 of applicator roller 40 impinges against metering surface 24 and surface 22 creating a region of turbulent flow adjacent the crest of the bulge 120 on the resilient roller surface. Thus, although edge 25 is resiliently urged downwardly as viewed in Figure 3, metering surface 24 is shaped and positioned and edge 25 is sufficiently resiliently loaded against roller 40 to prevent changing of film 130 by hydrodynamic forces exerted on metering member 10 by the ink. This condition is also assisted by positioning polished edge 25 such that it is closer to the central axis C of applicator roller 40, or the same as any other point of surface 26 of metering member 10. The blunt, obtuse polished edge 25 favorably deforms the resilient cover 44 on applicator roller 40 to form a metering wedge angle W between surfaces 24 and 120 for forming a film of ink of precisely controlled thickness having an approximate pressure profile as shown in Figure 3 where the maximum pressure occurs at the first edge 25.

Surface 28a on metering member 10, immediately downstream from surface 26, is positioned so that the metered film of ink is in contact with metering member 10 only along surface 26 to cause the ink film 130 to immediately separate from metering member 10 at edge 28b to prevent trailing of the ink along surface 28a which would result in accumulation of ink, dripping, and consequently, er-

ratio flow which would destroy the uniformity of film 130.

The lower surface of metering member 10 has been formed such that surface 28a at the heel 28b of polished surface 26 and bounding relieved area 27 is angularly disposed relative to the direction of movement of ink film 130 such that roller surface 44 cannot rebound to a position wherein ink film 130 contacts surface 28' or accumulates on surface 28a.

Thus, in the embodiment of the invention illustrated in Figure 3 of the drawing, the metering member is shaped and positioned to cause ink film 130 to immediately separate from the metering member returning to its relaxed, non-indented, position.

Referring to Figure 3, edge 25 is shown to be indented an amount equal to d into the applicator roller surface 45 whose original radius is R having a surface velocity V , cover thickness T and durometer D .

Metering member 10 as shown in Figure 4 has a support surface width S , thickness t and relief r leaving a cantilever height of $t - r$. Distance L represents the cantilever and l the length of the relief. Metering surface 24 is inclined at an angle B to a height of $t - h$. Angle " A_1 " is the total included obtuse angle between surfaces 24 and 26 and is equal to $90^\circ + B$.

Referring again to Figure 3, angle " A_3 " represents the slightly inclined angle of surface 26 relative to a line parallel to a tangent to the roller radius R by the distance equal to indentation d measuring from P ". Point P " represents the point of intersection on radius R of surface 45 of a radial line and a tangent to the roller. Angle " A_3 " is preferably 0° , or slightly greater, to insure that edge 25 is indented an amount equal to or greater than any other point of surface 26. Nip N represents the ink between the support surface 26 of metering member 10

and the depressed roller surface in the zone between edges 25 and 28b represented by support width S. Actually, the thickness of N is substantially the same as film 130 generated past edge 28b on roller surface 45 which varies according to parameters previously mentioned. "A₂" is the angle between surface 24 and a radial line passing through Point P" and is equal to B plus "A₃". Angle W is the wedge or entrance angle between surface 24 and a tangent to an imaginary circle or curve having a surface 120 moving towards edge 25.

It is generally believed that the pressure at edge 25 and angle W largely determines the thickness of film 130 for a given viscosity of liquid μ .

The apparent pressure effect of such a metering member 10, properly utilized in conjunction with a resiliently covered applicator roll 40, is that the roller cover surface 45 of cover 44 experiences a pressure profile significantly different from the placement of other prior art metering devices on resiliently covered applicator rolls. In contrast to the prior art, where pressure is gradually increased to a maximum at a trailing edge which rapidly reduces to zero as in conventional blade wiping techniques for coating papers, etc., the invention disclosed herein as seen in Figure 3 causes an almost instantaneous or sudden increase in pressure on the roller cover as the obtuse first edge 25 indents the oncoming rotating roller, with the pressure reaching a peak or maximum P_M and then suddenly reducing somewhat as the roller passes the edge 25 and under the support surface 26 of the metering member and then again reducing rapidly to zero pressure as the roller exits the trailing edge 28b of the member. Said in a somewhat different way, the maximum pressure P_M of the metering device 10 disclosed herein is reached at the obtuse, first metering edge 25, of the metering member 10 and not at the second, trailing

edge 28b, as in prior art paper coating applications. Where some prior art ink metering devices may too instantly experience a pressure increase at a first edge, none have appreciated that an important second edge must also be provided and properly indented to the resilient applicator roll to prevent destroying the metering effects of the first edge.

Furthermore, in positioning and supporting the two edges along their lengths as proposed herein, the rigid tangential support of the edges and the flexible radial support thereof, co-act to provide automatic consistency and uniformity of metering as the roller rotates even when the speed is caused to vary.

During the testing of the apparatus hereinbefore described, it was discovered that as force urging edge 25 into pressure indented relation with surface 45 is initially increased, the thickness of film 130 is decreased to a minimum thickness; and then, with a further increase in force, the film 130 begins to increase in thickness while becoming uniform.

Referring to Figure 5 of the drawing, it will be noted that this surprising phenomenon occurs as force urging edge 25 on the cantilever beam metering member 10 toward the surface of roller 40 is increased. When a light force per linear inch of the length of edge 25 was employed for urging edge 25 into pressure relation with surface 45, color density decreased. However, with this light loading, color density was not uniform laterally across the length of roller 40. As the force was increased, the ink film thickness on the roller was reduced until a somewhat heavier load per inch along the length of edge 25 was reached. Ink film thickness then began to increase as force urging polished edge 25 toward the central axis C of roller 40 was increased. Otherwise stated, as force was increased, the film thickness first was reduced and

then began to increase as further load was applied. However, color density became extremely uniform laterally across the length of roller 40 and circumferentially thereabout when the load approached a static average force of twenty-five pounds per inch on the edge 25 and surface 26. Surface 26 was 0.15 inches wide. The roller cover thickness was 0.50 inches and the durometer was 60 Shore A. The resulting indentation was 0.04 inches and the roller radius was 5-1/8 inches. (See Table II, Example I)

This phenomenon, where at a threshold pressure, the ink film thickness suddenly ceases to decrease and begins to increase as force on the edge 25 becomes higher has been observed when the edge 25 constitutes the lower forward edge of a cantilever beam metering member. Figure 3 shows metering member 10 in such indented relation with surface 45 of roller 40 at a position such that edge deflecting load, pressure (which determines indentation), and therefore, ink film thickness (which determines color) is substantially constant.

Referring to Figure 5, it should be observed that the thickness of ink film 130 varies as a function of the indentation of polished edge 25 into resilient surface 44 of applicator roller 40. As described above, as the indentation increases, the thickness of ink film 130 decreases rapidly to a minimum and then begins increasing. Irregularities or imperfections in surfaces on metering member 10 and applicator roller 40 are easily seen in the metered ink film 130 until polished edge 25 is indented to a point where the variation in the initial edge to roller relationship along the length of edge 25 is small, as related to the total deflection, for example, less than plus or minus five percent. At this point, the ink film becomes more regular and uniform and remains sub-

stantially uniform as polished edge 25 is further deflected and indented into the surface of applicator roller 40.

It has been observed that the thickness of the minimum ink film, as depicted at the bottom of the curve in Figure 5, is controlled primarily by the pressure at edge 25 and by the angle of metering surface 24 relative to the roller surface 120 indicated by W at Figure 3 for a particular ink viscosity .

Referring to Figures 3 and 4 of the drawings, metering surface 24 is established by angles B and "A₃", so that metering surface 24 leans toward the crest of bulge 120, in a counter-clockwise direction as viewed in Figure 3. The minimum film thickness indicated in Figure 5 is established for a particular roller durometer and thickness, metering member support surface width, loading and ink viscosity. Thus, by changing the obtuse angle "A₁" built into metering member 10 and position angle "A₂" between metering surface 24 and a radius of the roller, a family of curves as illustrated in Figure 5 will be generated as illustrated in Figure 6.

From the foregoing it should be readily apparent that from the use of Figure 6, an angle "A₂" can be selected, and consequently obtuse angle "A₁" determined such that the desirable film falls well within the loading range which produces uniformity of film 130 without significant indentation and without such acuteness of "A₁" which produces heat and rapid deterioration of metering edge 25 or roller surface 45.

It has also been observed that the thickness of film 130 can be changed somewhat by varying viscosity of ink in reservoir R. Thus, by adjusting the temperature of water or other suitable liquid through tubes 7 and passage 5' in support bar 50, the viscosity of ink in reservoir R can be adjusted to adjust film thickness which changes color. Viscosity or the rheology of the ink may also be

altered somewhat to change color through the use of reducers and/or extenders.

It should be noted from Figure 6 that the minimum film thickness obtainable, as a result of establishing a particular angular relationship between metering surface 24 and a radius of roller 40 may result in completely removing ink from the surface of roller 40 prior to the point at which the film thickness begins to increase. Thus, to prevent rapid wear to the surface of roller 40 and/or to edge 25 of metering member 10, angle "A₁" should be selected as shown, i.e., 30° to produce uniformity while simultaneously providing a minimum and maximum film thickness without excessive pressure resulting in significant indentation and rapid component wear.

A curve and therefore angle "A₂" and consequently angle B is selected and determined which enables the minimum desirable color to be reached at approximately the same time the minimum obtainable film is reached. For example, "A₂" = 15° and "A₂" = 45° would not meet this parameter. Using process inks for lithographic offset printing on coated stock, the generally recommended or desirable color density for cyan is 1.25; for magenta, 1.30; for black, 1.60; and for yellow, 0.90. The range should be approximately ± 15 density points or a total of 30 density points.

Printing ink is generally an oily viscous substance, which is highly pigmented and formulated to be sticky or tacky, so that the ink will properly adhere to image areas of the printing plate. Ink generally employed for printing newspapers has a viscosity in a range of about 50 to 80 poise. Ink generally employed for letterpress printing and heat set inks employed for web offset printing have a viscosity in a range of about 150 to 200 poise. Ink employed in sheet-fed lithographic offset printing presses is generally in the range of 250 to 300 poise.

When different viscosities are encountered, curves marked 0° , 15° , 30° , 45° , 60° , etc., as seen in Figure 6, would not remain as labeled. Therefore, Figure 6 would hold true only for specific design parameters of roller and metering member and rheology and strength of a particular ink being used. For instance, for a more fluid ink than sheet-fed lithographic ink, such as letterpress newsprint black, the angle required to produce acceptable color for direct-lithography on newsprint stock would be in the order of 60° in lieu of 30° , as selected above. For extremely viscous and very strong inks, smaller angles of "A₂" would be selected to produce desirable printing results. Therefore, one can readily find optimum angles of "A₁" and therefore B, since "A₃" should be 0° , or slightly larger, after determining design parameters for the applicator roller 40 and metering member 10, for particular films and viscosities required, enabling color to be produced without significant indentation causing premature cover and edge failure of the applicator roller and metering member, respectively. The largest angle "A₁" and B, i.e. the most obtuse angle of metering member 10 should always be used to produce desired results.

Flow of ink in the reservoir toward the metering member is turbulent due to the structure of the metering member adjacent the reservoir, thus causing lint and other foreign matter to generally be rejected from an area of high pressure immediately adjacent the leading edge of the metering member. This lint and foreign matter is retained in the vortex of the reservoir and therefore lodging of particles against the edge of the metering member is minimized. Flow of ink carried by movement of the surface of the resilient roller toward the first polished edge of the metering member experiences an almost instantaneous increase in pressure and turbulent flow

becomes laminar immediately adjacent the first polished edge. Shearing of the ink is accomplished as it moves through a wedge between the resilient surface of the roller and the metering surface on the metering member adjacent the first polished edge.

The polished support surface and edges on the metering member are urged toward the resilient surface of the applicator roller by a force sufficient to indent the roller surface along the length of the edges and along the length of the roller surface. The required indentation is dependent upon the film thickness desired; the modulus of elasticity of the resilient roller cover; the thickness of the resilient roller cover; the temperature, strength, tack, and viscosity of the ink and other rheological characteristics and properties of the ink; the texture of the roller surface; the condition of the leading edge of the metering member; the support surface width; the angle of the metering surface of the metering member; the position of the support relative to a line tangent to the roll; the pressure between the applicator roller and the adjacent plate; conditioning of the ink prior to and after application to the plate; and fountain solution present in the ink being metered and fountain solution added to the metered ink film. The polished edges of the metering member slightly indent the surface of the resilient roller, for example about one-thirty second of an inch on a 60 Shore A durometer roller having a cover thickness of approximately 1/2 inch. As the roller rotates, the flexible polished edges of the metering member move relative to the axis of the roller to maintain a condition of equilibrium such that the edges automatically move radially along their length relative to the axis of the roller surface and circumferentially thereabout

although the roller surface is not perfectly round and not free of slight waviness.

Figure 7 diagrammatically illustrates the phenomenon hereinbefore discussed which results in increasing uniformity of color density of ink on a printed sheet as the force resiliently urging edge 25 into pressure indented relation with the surface 45 on roller 40 is increased.

As hereinbefore described in the remarks relating to Figure 10 of the drawing, color density of ink printed on a sheet was measured at points over the surface of the sheet. Maximum and minimum color density readings were recorded. Sheets were selected which were printed with different loads applied to the edge 25 on the metering member 10 to vary the overall color density.

It will be noted that the variation in color density between the maximum and minimum over the entire sheet decreased as force urging polished edge 25 into pressure indented relation with the resilient cover 44 on roller 40 was increased, as indicated by the length of lines D₁, D₂, D₃, and D₄ in Figure 7.

It will be appreciated that when force urging edge 25 into pressure indented relation with the surface 45 was increased, metering member 10 being a cantilever beam was deflected; the resilient cover 44 on roller 40 was deflected or indented; and edges 25 and 28b were deformed slightly along the length thereof such that the edge 25 and the surface 45 of roller 40 immediately adjacent thereto were conformed, even though edge 25 and the surface of the roller when positioned in kiss contact did not perfectly conform. Thus, deflection of metering member 10, deflection of edge 25 along the length thereof, and indentation of cover 44 all contribute to attaining the proper ink film thickness and uniformity of color density over the surface of a printed sheet.

Referring to Figures 5 and 7 of the drawing, it will be noted that the ink film thickness decreases to a minimum and then begins to increase as force urging edge 25 into pressure indented relation with roller surface 45 is increased. Thus, the same ink film thickness is achieved at two different points on the curve. However, as indicated by the difference in the lengths of lines D₂ and D₄ in Figure 7 of the drawing, variation in color density is different at the two points on the curve.

Referring to Figure 8 of the drawing, a dial indicator was attached to support bar 50 and positioned in engagement with the upper surface 28 adjacent metering surface 24 on metering member 10. As applicator roller 40 was rotated, a total dial indicator reading of 0.002 inches was observed. This indicated that the runout in the radius of the surface of roller 40 was 0.001 inches and that edge 25 on metering member 10 moved 0.002 inches upon each revolution of roller 40. As the surface speed of roller 40 was increased, the magnitude of movement of edge 25 remained substantially the same at different surface speeds of roller 40. However, the total deflection of metering member 10 increased somewhat as the surface speed of roller 40 increased. It was also observed that unless pressure to cylinder 92 was released, the edge 25 would move toward center C nearly 0.020 inches when the applicator roller was stopped. Thus, the polished edge 25 on metering member 10 automatically moves relative to the axis C of applicator roller 40 upon each revolution of applicator roller 40 in response to changes in speed and runout of applicator roller 40. In order to prevent compression set of the roller cover by the edges and support surface of the metering member and resultant damage to the roller cover and streaks in printed sheets caused thereby, the system should be designed such that pressure in cylinder 72 is reduced or released when the roller is stopped.

Upon starting, the air pressure should be restored to normal operating pressure against stop screw 74. In this manner the maximum indentation of edge 25 to roller surface 45 will be only when the roller is rotating under edge 25 with a lubricating film of ink N therebetween. If pressure is not reduced upon stopping, edge 25 will depress roller surface 45 almost twice the amount of the running indentation.

Referring to Figure 9 of the drawing, it will be noted that ink film thickness remained substantially constant over a broad speed range and therefore is substantially independent of the surface speed of applicator roller 40.

As hereinbefore described, the edge 25 on metering member 10 automatically moves radially as applicator roller 40 rotates. However, metering member 10 is positioned such that metering surface 24 and polished edge 25 are rigidly supported in a tangential direction. It will be noted that force imparted to metering surface 24 as a result of ink impinging thereagainst, is directed both tangentially and radially of applicator roller 40 and force against surface 22 of metering member 10 is directed only substantially tangentially and that metering member 10 is angularly positioned such that it is very stiff in a direction generally tangential to applicator roller 40. That is, in an operating, dynamic condition position, angle "A₃" of surface 26 is substantially 0°, or, may be slightly greater. The pressure wedge angle W produced immediately ahead of edge 25 of metering member 10 and acting against roller surface 120 and metering surface 24, because of the slight area of surface 24, cannot produce a force sufficient to lift edge 25 away from roller surface 45 or roller surface 45 away from edge 25 to cause a change in film 130 as speed is increased.

While it is necessary that metering member 10 be positioned to resiliently urge edge 25 in a radial direction, metering member 10 must be of sufficient thickness to permit formation of relief r and beam thickness t-r, metering surface 24, and polished edge 25 thereon. Metering member 10 should not be too thin because, when compressive force is exerted in a plane of a thin plate, it will tend to buckle and distort in much the same manner as a long, thin, axially loaded column.

The color density of ink printed onto a sheet was measured using a "SOS-40" digital reflection densitometer, commercially available from COSAR Corporation of Garland, Texas. The color density readings of process yellow longitudinally and transversely of the printed sheet are indicated in Figure 10 of the drawing. It will be noted that lateral color control is within a "very tight" range and that longitudinal control is also "very tight". Other process colors; namely, magenta, cyan and black were measured with equally good color control.

The data diagrammatically illustrated in Figure 10 of the drawing indicates that a uniform film is being metered by metering member 10 onto the surface 45 of applicator roller 40.

It has been observed that power required for driving a printing press having the inking system hereinbefore described mounted thereon is not significantly different from power required for driving printing presses equipped with conventional inkers and in most cases is somewhat less. However, as hereinbefore explained, the depleted ghosted image on the surface 45 of applicator roller 40 which is moving from plate P' toward the entrance side of reservoir R is completely replenished with fresh ink and a newly metered film is offered to printing plate P' upon each revolution of applicator roller 40. Thus, ink starvation or ghosting has been eliminated. Further, the meter-

ing member 10 constructed and supported as hereinbefore described is capable of metering a film which is sufficiently thin and sufficiently uniform for inking a printing plate without rapid wear of critical components to provide very high quality single or multi-color printing. Color density can be changed immediately by merely adjusting the position of stop screw 74, which is remotely controlled.

The metering member 10, when properly formed and positioned causes lint and other foreign matter in the ink to be rejected from the wedge formed between surface 24 of metering member 10 and the surface 120 of applicator roller 40. Metering surface 24 and surface 22 form a barrier above the edge 25 against which the excess ink on the applicator roller 40 impinges, creating an area of turbulence as hereinbefore described. Since the area of high pressure is formed immediately prior to movement of the ink past polished edge 25, lint and foreign matter will tend to be rejected from this area if a low pressure path is provided in the reservoir. Reservoir R is preferably at atmospheric pressure. Also light foreign particles become entrapped in the center of the vortex created in this low pressure area.

It is again noted that creation of abrupt surface 22 substantially radial prevents formation of hydrokinetic or hydrodynamic forces which would create a hydraulic pressure wedge which would tend to lift polished edge 15 and thereby cause the thickness of ink film 130 to be changed as the surface speed of roller 40 changes. Thus, edge 25 is hydrostatically supported by ink carried by roller surface 45.

Also, any tendency for the metering member to move away from the roller and vice versa is quickly and automatically overcome by opposing spring forces applied against

each other when both the roller cover and metering member are resiliently spring biased together as described herein.

Several factors influence the thickness of the film of ink which is metered onto the surface of applicator roller 45. These factors include: the front angle, the angle "A₁" between metering surface 24 and support surface 26; the angle "A₂" between the metering surface and a radial line; the condition of the metering edge 25; the width S of the support surface 26; the viscosity of the ink; the hardness or durometer of the resilient covered applicator roller; the thickness of the cover 44 on applicator roller 40; and the load or force applied to urge metering surface 25 into pressure indented relation with the cover 44 on applicator roller 40.

The stiffness of the working end 10' of metering member 10 influences uniformity.

As hereinbefore described, the metering edge 25 on the blade must be deformable across the length of the applicator roller 40 to accommodate manufacturing imperfections in the roller surface to provide lateral uniformity.

Test data indicates that the ink film 130 will increase in thickness in response to: (1) an increase in indentation of metering edge 25 into the cover of the applicator roller; (2) a reduction in the area of support surface 26; (3) an increase in force urging metering edge 25 toward the axis C of the applicator roller; (4) a reduction in the durometer of the cover 44 on the applicator roller; (5) an increase in the radius of curvature of metering edge 25; (6) an increase in the thickness of the cover 44 on the applicator roller; and (7) an increase in the angle "A₂" between metering surface 24 and a line R extending radially of the applicator roller. In addition, an increase in the viscosity of the ink in reservoir R'; a reduction in temperature of ink in reservoir R'; and an

increase in the roughness of the surface 45 on the applicator roller will also result in an increase in the thickness of ink film 130.

It will be appreciated that adjustment of any one of the first seven factors listed above will result in a reduction in the angle W , as illustrated in Figure 3 of the drawing. It has been found that adjustment of the indentation of metering edge 25; and adjustment of the angle " A_2 " by rotating metering surface 24 about metering edge 25 to change angle " A_3 " or by installing a metering member 10 having a different angle A_1 , provides the pressman with adequate ink film thickness control. In one test using letter-press ink of low viscosity, when a metering member having an angle A_1 of 160° was employed with a forty durometer applicator roller cover 44, the ink film 130 was too thick. The metering member was replaced by a metering member having an angle A_1 of 150° and the ink film 130 was satisfactory.

In another test a film 130 of sheet fed printing ink was too thick using a metering member having an angle A_1 of 120° on a thirty durometer roller. The thirty durometer roller was replaced with a sixty durometer roller and the ink film 130 was too thin. The metering member having an angle A_1 of 120° was replaced with a metering member having an angle A_1 of 130° and the ink film was satisfactory on the sixty durometer roller.

When a metering member having an angle A_1 of 90° was tried on the sixty durometer roller, the ink film 130 of sheet fed lithographic printing ink was much too thin.

The factors listed above which influence the metering of ink must be correlated to provide a thin metered film of ink suitable for application to a lithographic printing plate. As will be hereinafter more fully explained in connection with the several specific examples of the relationship of the working end 10' of metering member 10

relative to the surface of applicator roller 40, one or more of the factors listed above may be adjusted for changing the ink film thickness.

To clearly understand the operation and function of metering member 10 it is necessary to define several terms in order to clearly understand the function of the apparatus. Metering surface 24 influences the metering of inks of different viscosities and a change in the angular relationship of metering surface 24 relative to the surface of the applicator roller will change the ink film thickness. The primary reason metering surface 24 significantly influences the ink film thickness is that metering surface 24 intersects support surface 26 at an apex and is not significantly rounded. The thickness of ink film 130 is primarily determined by the relationship of metering surface 24 and metering edge 25 relative to the surface of the applicator roller.

As will be hereinafter more fully explained, support surface 26 does not significantly influence the thickness of the film of ink 130 formed on the applicator roller. Experimental data reflects that, within limits, the angular relationship of support surface 26 relative to the radial line R does not in of itself change the ink film thickness. Likewise, the trailing edge 28b does not appear to influence film thickness. However, surface 28a and support surface 26 must intersect at an apex so that the metering member 10 abruptly separates from the surface of the applicator roller so that ink will not accumulate on surface 28a.

The angular relationship between metering surface 24 and support surface 26 and the orientation of metering surface 24 and support surface 26 relative to the surface 45 of applicator roller 40 are critical. As hereinbefore described, a primary consideration in selecting the angle "A₁" between the metering surface and the support surface is the viscosity of the ink which is to be metered. In

Example II it will be noted that a metering member having an angle of 150° between metering surface 24 and support surface 26 was selected for metering letterpress ink which has a very low viscosity which might be referred to as "water-like." Lithographic printing ink has a higher viscosity than does letterpress ink and it will be noted that in Examples I and III that the angle " A_1 " between metering surface 24 and support surface 26 was significantly less than the angle " A_1 " of the metering member used for metering letterpress ink.

In Examples I-III the metering edge 25 was formed to provide a highly polished precision surface as hereinbefore described.

The width S of the support surface 26 does not in and of itself control the thickness of the film of ink formed on the applicator roller. However, the width of the support surface 26 is selected to provide the desired indentation of metering edge 25 into the resilient roller surface when a force of a predetermined magnitude is exerted on the metering member. The force urging metering edge 25 into pressure indented relation with the surface of applicator roller 45 should be sufficient to maintain metering edge 25 indented into the resilient roller surface, to permit some movement of metering edge 25 radially of the roller as the roller rotates, but sufficiently great to provide uniformity and to prevent uncontrolled vibration or chatter of metering edge 25 as the roller rotates. Since indentation of metering edge 25 is primarily a function of the pressure which is equal to force divided by the area of the support surface, the area of the support surface which is required for establishment of particular parameters can be established and the sensitivity of the device controlled.

The viscosity of the ink can be adjusted slightly by adding chemical thinners or thickening agents and by

adjusting temperature. However, certain characteristics of the ink should not be disturbed if quality lithographic printing is to result.

The roller hardness or durometer must be correlated with the angle "A₂" between the metering surface of the metering member and the roller surface to establish a wedge W in the area between metering surface 24 and the surface 45 of the applicator roller immediately adjacent thereto and immediately upstream from metering edge 25 to form a film of a desired thickness. It should be apparent that the same metering member will be urged deeper into a softer roller surface than it will be urged into a hard roller surface if the same force is applied to the metering member. Thus, as illustrated in FIG. 3, the angle W between metering surface 24 and the surface 45 of the applicator roller would be reduced as the durometer of the applicator roller surface is reduced.

The thickness of the cover 44 on the applicator roller influences metering because the spring constant of the resilient roller is not linear as force is increased. If the roller surface is highly compressed its resilience or its ability to be deformed will be reduced. Thus, if the thickness of the cover 45 on the applicator roller is reduced the apparent hardness of the resilient cover will increase.

As hereinbefore described in connection with the width of the support surface 26, the load on the metering member should be selected to assure that metering edge 25 moves radially, if necessary, while the roller rotates. However, the force must be sufficiently great to deflect the member 10 and to indent metering edge 25 into the roller to establish an angular relationship between metering surface 24 and the surface of the applicator roller adjacent metering edge 25 which is necessary for uniformly metering a particular ink.

The angle "A₃" between support surface 26 and a line tangent to the surface of the applicator roller is not particularly pertinent and does not in of itself influence metering so long as the trailing edge remains indented into the resilient roller surface if the force urging support surface 26 into indented relation with the resilient roller surface is sufficiently great to prevent hydroplaning. However, if a very light force, for example, one pound per inch of length of the metering member, is employed to indent metering edge 25 into the roller surface, it is necessary to then position support surface 26 substantially perpendicular to a plane which lies radially of the resilient roller surface to preclude application of a lifting force under dynamic conditions which would cause the thickness of the film of ink to increase as the press speed increases.

The following examples are presented in order to show specific examples of application of the invention described herein using different lithographic printing inks having different viscosities.

The following are used in each of the following examples as constants: $L = 1.625"$; $l = 1"$; Angle "A₃" $\cong 0^\circ$; $t = 0.070"$; $r = 0.035$; $h = 0.02"$; $t-h = 0.05"$; and $t-r = 0.035"$.

EXAMPLE 1

SHEET-FED LITHOGRAPHIC INK (OFFSET)

DATA

Ink (Color)	Process - Magenta & Cyan
Paper Stock	Mead Offset Enamel - 70#
Plate	Tri-Metal - Metalgamma
Blanket	Reeves #714 Compressible
Press	Harris LUM -- 2/c
Speed	2000 - 6000 IPH
Roll Width	38"
Angle B	40°
Angle "A ₁ "	130°
Angle "A ₂ "	Approximately 40°
S	0.150
A'	60°
T	1/2" (Buna N Rubber)
D	60 Shore A
d	0.04"
R	5-1/8"
Color Density	1.20 - 1.40
Fountain Solution	60°F - Acid with 25% Alcohol
Stripe - F.R. to Plate	1/2" - 5/8"
Plate Cylinder Diam.	10"
Speed Ratio bet.	
Applicator	
Roll & Plate	
Cylinder	1:1

EXAMPLE 2

LETTERPRESS NEWS INK (DIRECT LITHO)

DATA

Ink (Color)	Black
Paper Stock	Newsprint
Plate	Western Front Page-Wipe-On
Blanket	N/A
Press	Goss Universal
Speed (V)	300 - 900 FPM
Roll Width	36"
Angle B	60°
Angle "A ₁ "	150°
Angle "A ₂ "	Approximately 60°
S	0.090"
A'	90°
T	3/8" (Urethane)
D	40 Shore A
d	Unknown
R	3-1/2"
Color Density	1.10 - 1.20
Fountain Solution	70°F - Alkaline (No alcohol)
Stripe F.R. to Plate	1/2"
Plate Cylinder Diam.	13-1/2"
Speed Ratio bet. Appl.	
Roll & Plate Cylinder	1:1

EXAMPLE 3

WEB OFFSET LITHOGRAPHIC INK (TEST STAND)

DATA

Ink (Color)	Process Cyan
Paper Stock	N/A
Plate	N/A
Blanket	N/A
Press	N/A
Speed (V)	100 - 1200 FPM
Roll Width	18"
Angle B	45°
Angle "A ₁ "	135°
Angle "A ₂ "	Approximately 45°
S	.125"
A'	90°
T	1/2" (Buna N)
D	60 Shore A
d	Unknown
R	4"
Color Density	Film thickness estimated to be proper for web offset printing application
Fountain Solution	N/A
Stripe - F.R. to Plate	N/A
Plate Cylinder Diam.	N/A
Speed Ratio bet. app.	
Roll & Plate Cylinder	N/A

When the working end 10' of the metering member 10 is supported by a cantilever beam, as hereinbefore defined and disclosed, i.e., to provide a resilient radial force and a rigid tangential force, uniformity is largely obtained through a rather large force and resultant deflection of the metering member against the roller surface. However, a large force may excessively indent a roller cover, and especially a soft cover, unless a sufficient support area 26 is provided between the two edges of the metering member to minimize the pressure and therefore indentation of the roller cover. Harder roll covers are therefore recommended which also are more durable. Pressure at a first metering edge, created by slightly deforming the hard, durable cover, generally meters a thin, light film unless a certain inefficient pressure wedge is formed by an obtuse angle on the indented working end of the metering member. The rate of depression of the hard cover by a slightly indented obtuse edge gives long life to the edge and to the roller cover.

From the foregoing, it should be readily apparent that ink metering member 10 when associated with applicator roller 40 accomplishes the objects of the invention hereinbefore enumerated.

It should further be appreciated that other and further embodiments of the invention may be devised without departing from the basic concept thereof.

1. An inker for a lithographic printing press comprising: an applicator roller having a resilient surface urged into pressure indented relation with a printing plate; an ink metering member comprising an elongated metallic strip; support means supporting said metering member to form a cantilever beam having an unsupported end urged into pressure indented relation with said resilient surface on the applicator roller; and means to rotate said applicator roller to move an excess of ink into engagement with the unsupported end of the cantilever beam, the improvement comprising: a metering portion on the unsupported end of the cantilever beam;

a metering surface, a support surface and a trailing surface formed on said metering portion, said metering surface and said support surface being inclined at an obtuse included angle and intersecting at an apex to form a metering edge, and said trailing surface and said support surface intersecting at an apex to form a trailing edge;

said support means positioning said support surface substantially parallel to a line tangent to the resilient roller surface and passing through the line of contact between the metering member and the resilient roller surface, said support means positioning the body of the metering member at an angle of less than 30° relative to the tangent line, said support means positioning said trailing surface such that the angle between the tangent line and the trailing surface is greater than 30° , and said support means positioning said metering surface such that the angle between the tangent line and the metering surface is less than 90° ; said metering member and said applicator roller surface being positioned such that rotation of the applicator roller moves an excess of ink into impingement with said metering surface on the metering portion on the unsupported end of the cantilever beam and causes the ink

to separate from said metering member at said trailing edge.

2. A liquid metering device for metering and controlling a finite, thin, uniform, liquid film, having a given viscosity, from a reservoir of an excess quantity onto a liquid carrier;

an endless rotatable liquid-carrying member having a smooth, firm, resilient, outer cover which has a textured surface capable of supporting a continuous liquid film;

an elongated metering member being substantially trapezoidal in cross section and flexible along the length thereof, said trapezoidal shape formed by two substantially parallel upper and lower surfaces, one surface being a top surface and the other a smooth, hard support surface, and further formed by a smooth, hard metering surface and a smooth, hard trailing surface, said support surface intersecting said metering surface and said trailing surface, forming two smooth, hard edges along the entire length of the support surface, wherein the metering surface forms an obtuse angle with the support surface such that a hard, durable, polished, obtuse edge is formed at the intersection thereof;

said endless rotatable liquid-carrying member being indented by the support surface and both edges of the elongated flexible metering member, along the length thereof, wherein the metering surface of the metering member forms a barrier to the excess of liquid carried by the textured resilient outer cover surface of the liquid-carrying member and wherein the obtuse edge of the metering member is resiliently biased along the length thereof against the resilient cover of the liquid-carrying member and wherein the trapezoidal section is further rigidly supported in a plane substantially parallel to the support surface, opposing a force from the resilient cover

against the obtuse edge and against the support surface of the metering member;

means to rotate the endless carrier surface relative to the metering member such that the liquid is impinged by the barrier surface and obtuse metering edge of the metering member;

wherein a thin, substantially unbroken, continuous film of liquid is sheared and metered onto and uniformly carried away from the trailing surface and trailing edge of the metering member by the textured surface of the outer cover of the carrier member;

the resilient force acting upon the flexible, elongated support surface of the metering member being sufficient to resiliently indent the resilient cover of the carrier member along the edges of the metering member to cause the substantially unbroken, continuous film of liquid to be substantially constant along the length of the metering member and along the path of the metered film as it exits the trailing edge of the metering member;

with the pressure acting on the liquid mass at the entrance of the metering surface of the metering member and the surface of the resilient surface of the outer cover of the carrier surface, adjacent the obtuse metering edge of the metering member, and the obtuseness of the metering edge, being preselected and sufficient to meter the liquid having a given rheology to a desired film thickness without significant indentation to cause rapid deterioration of above metering member or carrier surface.

3. An inker for a lithographic printing plate comprising: a resilient covered applicator roller; means to urge the applicator roller into pressure indented relation with the lithographic printing plate; a metering member having a metering surface, a support surface and a trailing surface intersecting to form an obtuse metering edge and a trailing edge; means to rotate said applicator roller to move ink on the roller surface toward said metering surface on the metering member; means to position the support surface substantially tangent to and in engagement with the surface of the roller such that the angle between the metering surface and a line extending radially of the roller is in a range between 10° and 70° , the metering surface being inclined from the radial line toward the approaching roller surface, said metering edge being formed to assure that a change in the angle between the metering surface and the radial line will change the thickness of a film of ink formed adjacent said metering edge on said roller surface; and means to urge said metering edge and said trailing edge into pressure indented relation with the resilient roller surface.

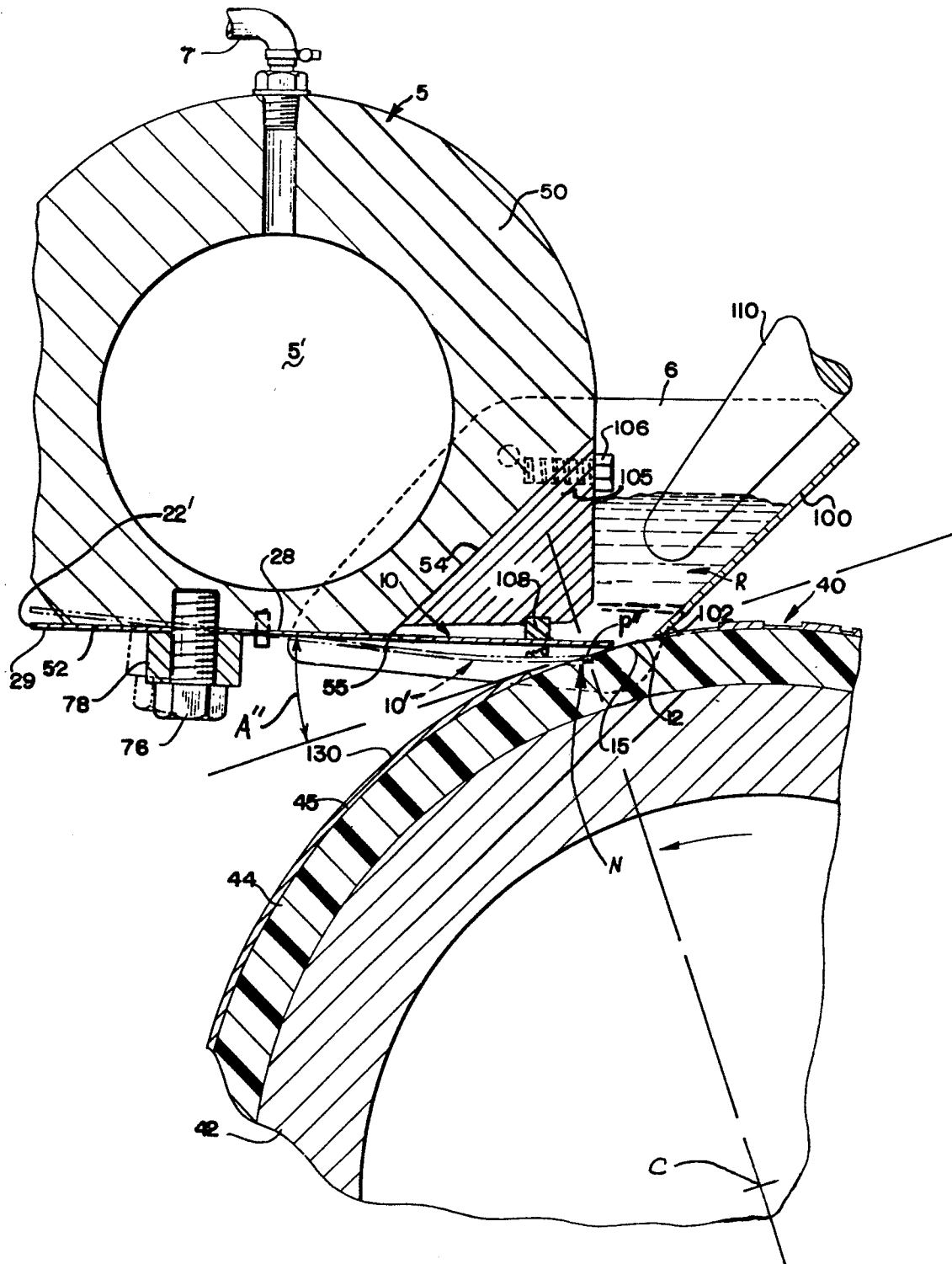


FIG. 2



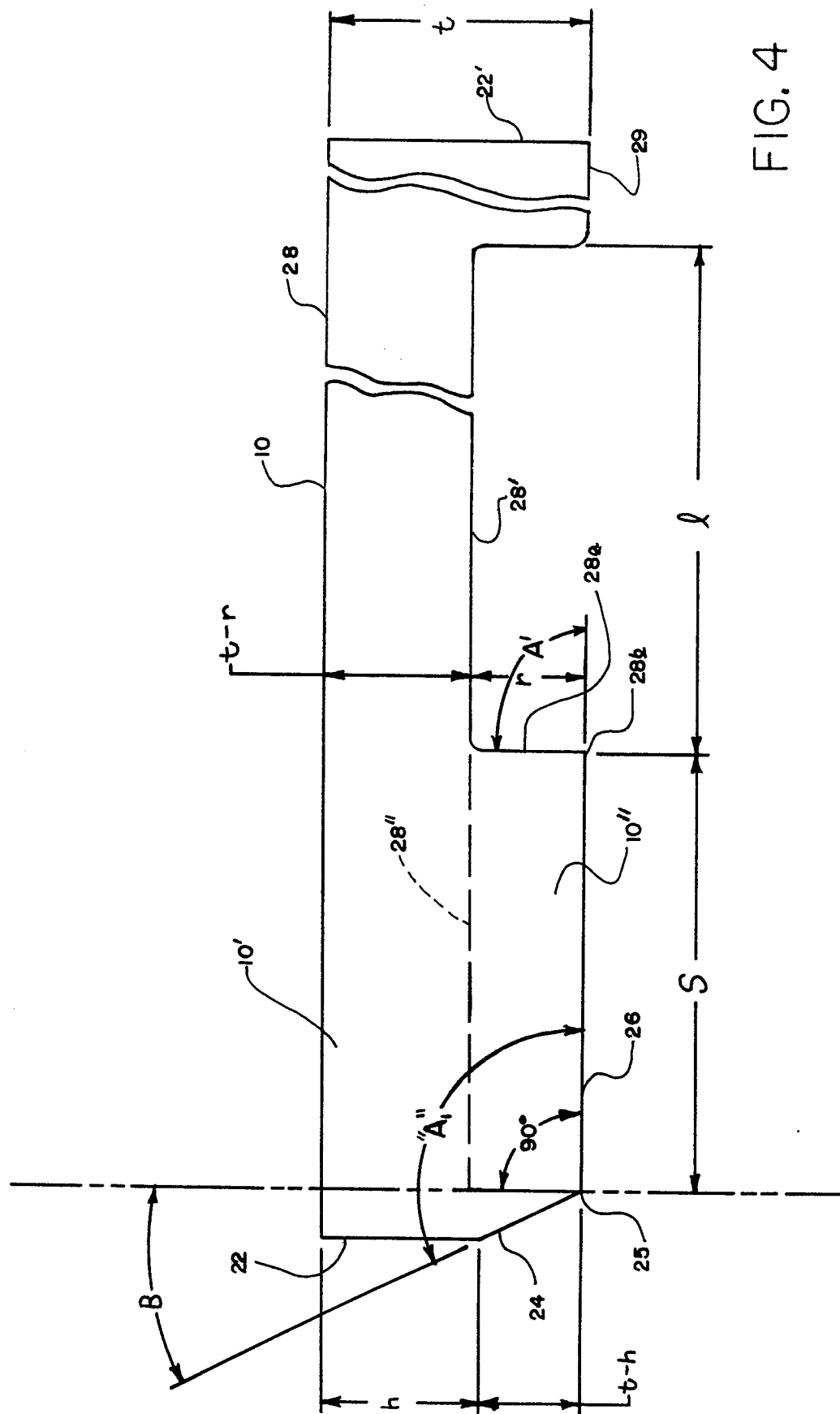


FIG. 4

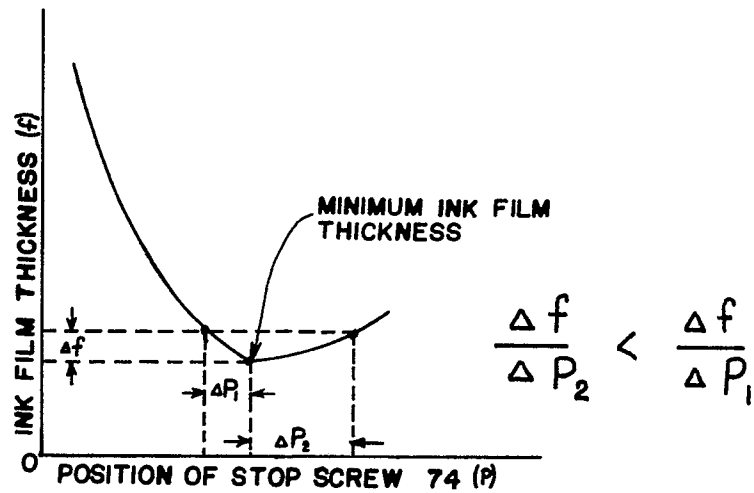


FIG. 5

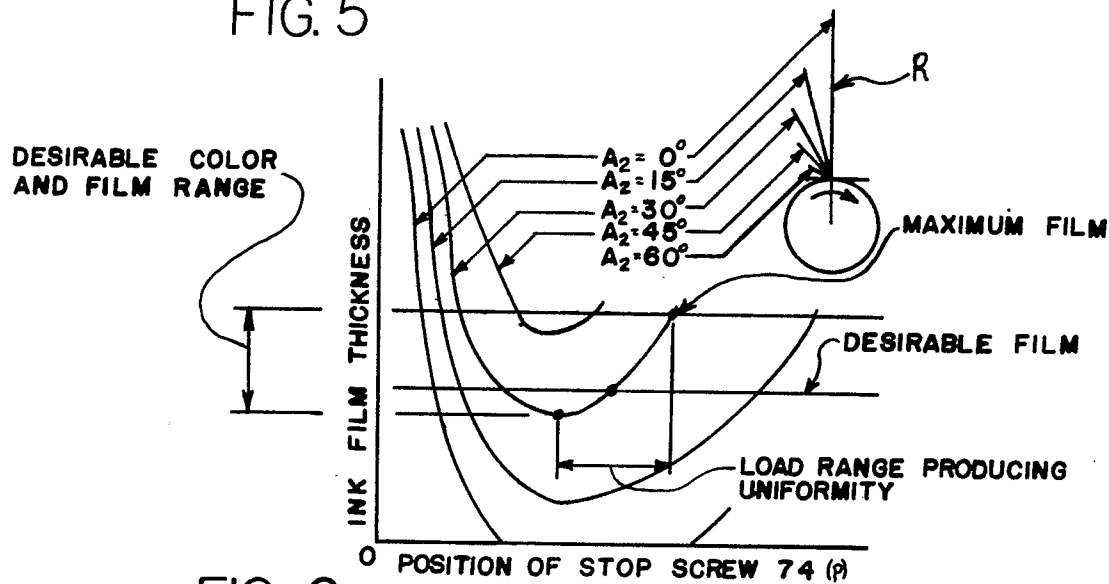


FIG. 6

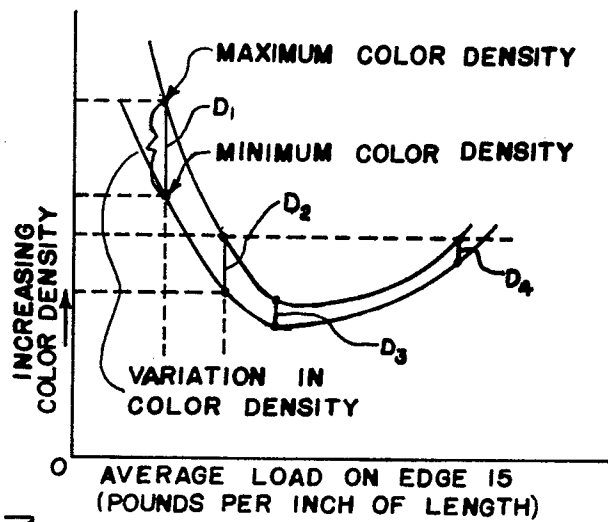


FIG. 7

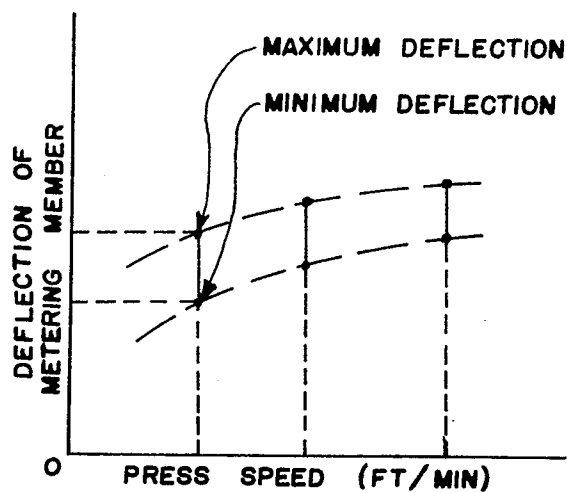


FIG. 8

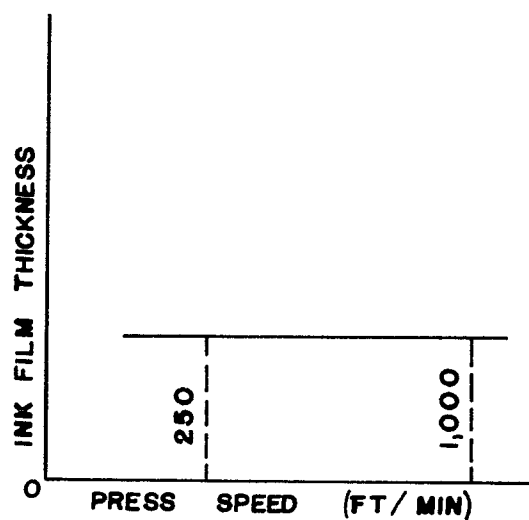


FIG. 9

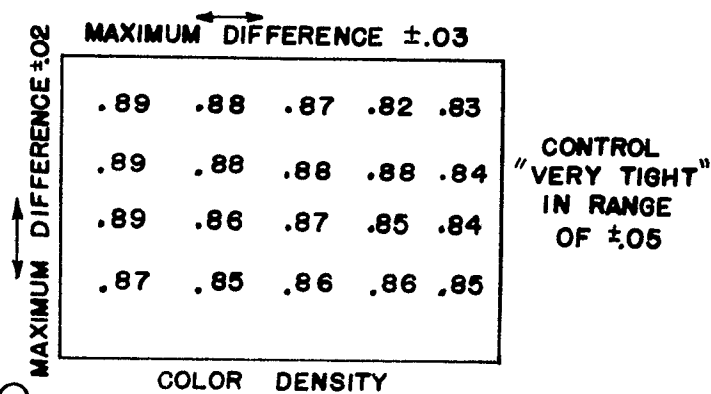


FIG. 10



European Patent
Office

EUROPEAN SEARCH REPORT

0070484
Application number

EP 82 10 6199

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. 3)
X	FR-A-2 408 458 (DAHLGREN) *The whole document*	1,2,3	B 41 F 31/04
A	US-A-2 534 320 (CHAMPION PAPER) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			B 41 F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 07-10-1982	Examiner LONCKE J.W.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	