Jan. 3, 1967 G. W. ELLIS 3,295,495

THIN FILM FLUID APPLICATOR

Filed April 30, 1963

FIG. 1

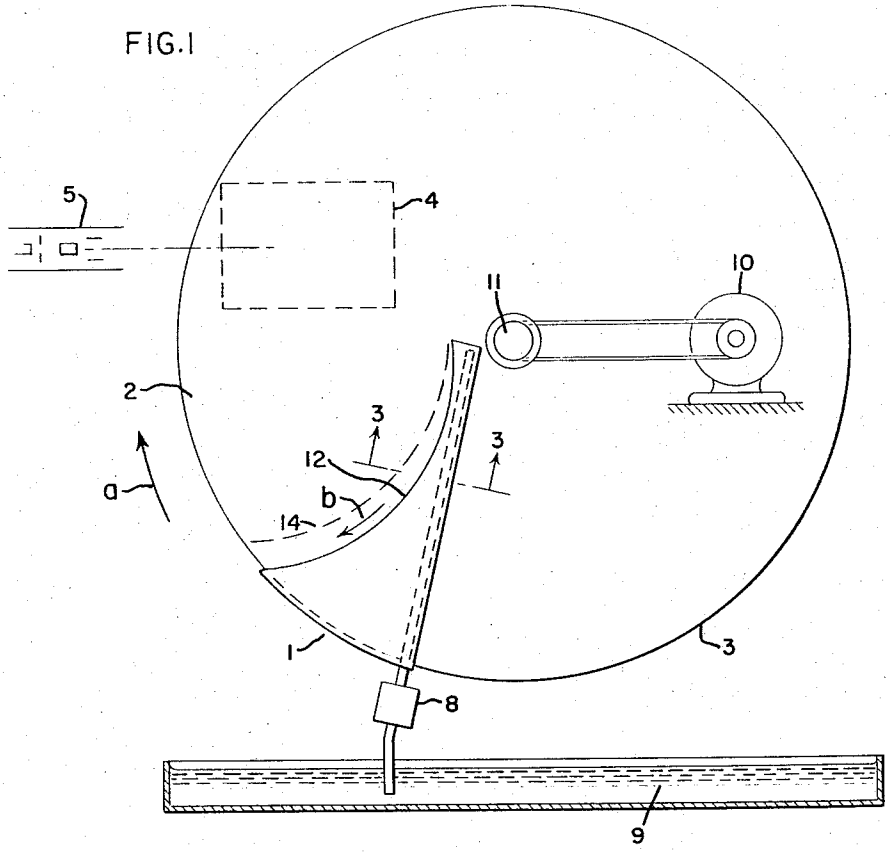


FIG. 2

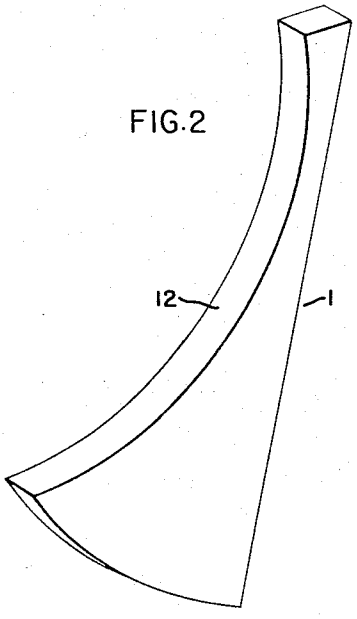
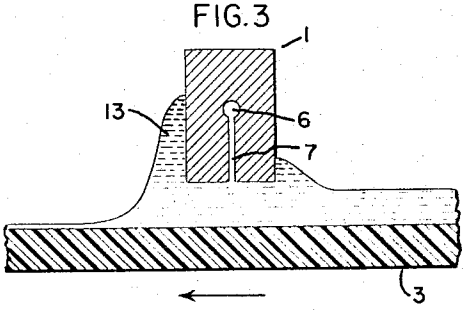


FIG. 3



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THIN FILM FLUID APPLICATOR

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The present invention relates to thin film fluid applicators, and more specifically to thin film fluid applicators employed for the deposition of deformable light modulating fluids used in phase modulation light projection systems.

In the referred to light projection systems, often termed light valve or Schlieren projection systems, information in the form of electrical signals is written by an electron beam which deposits electrical charge onto the surface of a deformable light modulating medium. The electrical charge exerts differential electrostatic forces on the surface of the medium which deform same in accordance with the impressed information. A source of light may then be projected through the medium and modulated thereby to provide a large screen display of the impressed information.

It is essential that the deformable medium, which is normally a moderately viscous fluid characterized by a relatively high resistivity applied to a supporting substrate, be deposited as a thin fluid having a highly uniform thickness. This is necessary so that the surface of the fluid does not appear noisy, and so that the deformation provided on the surface of the fluid are uniform throughout the raster area and provide a projected picture of uniform brightness.

As a further consideration, it is a requirement that the fluid be replenished periodically since bombardment by electrical charge causes polymerization or cross-linking of the fluid molecular structure which alters its flexible characteristic and in effect creates a hardening of the material. It is also necessary to avoid excessive thinning of the fluid which can occur by continuous bombardment of electrical charges.

These various requirements have been achieved in the past by employing an applicator to apply the fluid continuously to a restricted area extending along a radius of a slowly rotating disk substrate upon which the raster is written. As the substrate rotates under the applicator, fluid is deposited onto its entire surface area. It has been found that merely flowing the fluid onto the surface of the rotating substrate will result in a nonuniform thickness, the thickness being a minimum at the center of the substrate and becoming increasingly greater towards the periphery as a function of the distance from the center. This nonuniformity is primarily due to the differential linear velocities of points on the substrate. A roller or scraper is commonly used to smooth the fluid on the substrate. However, because the desired ultimate thickness of the fluid is normally very small, on the order of 1 mil, it is a difficult matter to provide the mechanical tolerances required in the use of such roller or scraper to obtain the requisite uniform and small fluid thickness.

It is, accordingly, an object of the present invention to provide a novel fluid applicator for depositing thin film fluids onto a given rotating substrate which does not require high mechanical tolerances and which provides deposition with uniform thickness.

It is another object of the invention to provide a novel fluid applicator for applying a thin layer of fluid to a rotating substrate of the above recited characteristics and which may be readily and economically fabricated.

Briefly, these and other objects of the invention may be obtained by employing a fluid applicator having a discharging slit extending along the width of a rotating substrate for depositing fluid pumped from a reservoir to an input port of said applicator. The applicator is provided with a concave curvature of its surface facing in the direction of rotation of the substrate. The spacing of the applicator from the substrate may be many times the ultimately deposited fluid thickness, but sufficiently close so that a meniscus is formed between the surface of the substrate and the forward concave curvature surface of the applicator. The recited forward surface curvature acts to compensate for the differential linear velocities of elemental areas of the substrate so as to provide a deposition of the fluid with a uniform and small thickness.

While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention will be better understood from the following description taken in connection with the accompanying drawings in which:

FIGURE 1 is a front elevational view of a thin film fluid applicator in combination with a disk substrate to which fluid is applied, in accordance with the invention;

FIGURE 2 is a perspective view of the applicator of FIGURE 1; and

FIGURE 3 is a cross-sectional view of the applicator of FIGURE 1 taken across the plane 3—3.

Referring to FIGURE 1 there is illustrated a fluid applicator **1** which deposits a thin film of fluid **2** onto the surface of a substrate that may be in the form of a transparent glass disk **3**. In the application of the invention under consideration, but not limited to such application, the fluid is a moderately viscous oil composition of relatively high resistivity, e.g., a silicone or hydrocarbon oil, that is employed as a deformable light modulating medium in a light projection system of known type. Accordingly, information in the form of electrical charge is written on a raster area **4** of the deposited oil by an electron beam device **5**, schematically illustrated. The information deforms the oil surface in accordance with the impressed electrical charge and is projected by a light source, not shown.

The applicator **1**, shown in perspective view in FIGURE 2, is typically constructed of a metal, plastic or other suitable material. It may be fixedly mounted by conventional means to the disk supporting structure, not illustrated. As is more clearly shown in FIGURE 3, the applicator **1** has a central cylindrical passageway **6** which is coupled to a thin slit **7** extending generally in the direction of a radius of the disk substrate **3**. The fluid to be deposited is pumped, by means of a pump **8**, from a reservoir **9** through the input port of the passageway **6** and is emitted under substantially equal pressure through the slit **7** onto a restricted area on the surface of the substrate, flow being to either side of the slit. As indicated in FIGURE 3, the spacing between the under surface of the applicator **1** and the substrate surface may be substantially greater than the ultimate fluid thickness so that close mechanical tolerances between the undersurface and the substrate are not required. However, the spacing should be close enough so that a meniscus will form at the forward surface of the applicator, for reasons to be considered presently. For example, when considering an ultimate fluid thickness of one half to one mil, the spacing may be on the order of twenty mils.

The plane of the disk substrate **3** is preferably in the vertical direction or in a direction having an appreciable vertical component. In this manner the applied fluid is subjected to gravitational forces which readily draw the excess fluid from the surface and permit deposition of the fluid as a thin film layer. The disk substrate **3** is slowly rotated, typically at a rate on the order of one to six revolutions per hour, in a direction indicated by the arrow "*a*" under the action of a motor **10** mechanically coupled to the disk by a central shaft **11** so that

the fluid on the disk surface is replenished once every rotation. Replenishment of the fluid is necessary because a continuous bombardment by the electrons of the writing beam tends to cause polymerization of the molecular structure and after a time changes the physical characteristic of the fluid, making it brittle and undeformable to the influence of deposited electrical charge.

The raster area **4** is seen to be located in the upper region of the disk and the applicator **1** located in the lower region of the disk. The entire disk surface, therefore, becomes coated as the disk rotates, the thickness of the freshly applied fluid remaining approximately constant during successive rotations. The rate of rotation of the disk may be used to control the ultimate thickness of the fluid, the thickness being inversely related to the disk speed.

Since the disk is continuously rotating, wherein the speed of points on the disk is proportional to the distance from said points to the axis of rotation, fluid emitted by the slit **7** tends to be deposited on the disk surface with a thickness proportional to the distance from the center. For example, it has been found that on the order of a four to one differential thickness of the fluid will occur when applying fluid along the radius of the disk without providing means for compensating for this nonuniform thickness.

In accordance with the present invention this nonuniformity is compensated for by providing a concave curvature of the forward surface **12** of the applicator in the direction of disk movement. With the spacing previously indicated between the applicator **1** and the disk **3**, a meniscus **13** is formed on the forward surface **12** by the fluid emitted by slit **7**, as illustrated in FIGURE 3. Accordingly, the excess fluid building up in the meniscus will run down the forward surface **12** under the force of gravity in a direction indicated by the arrow "*b*," extending from the central region of the disk to the periphery thereof. The width of the forward surface **12** should be large enough so that substantially all of the flowing fluid runs off the end of the applicator **1**, emptying into the reservoir **9**. This flow of the fluid in combination with the configuration of the forward surface **12** is found to compensate for the tendency toward a nonuniform deposition of the fluid and provides a fluid layer having an ultimate thickness that is uniform and small commencing along a line directly forward of the meniscus, indicated as line **14** in FIGURE 1. The ultimate uniform and small thickness extends over essentially the entire disk surface.

It may be seen from FIGURE 1 that the configuration of the curvature, which at the innermost region approximates the vertical direction and at the outermost region approximates the horizontal direction, contributes toward equalizing the vertical distances between the line **14** and forward surface **12**. Accordingly, the fluid at various points along the line **14** appears as though it were emitted from corresponding points of the slit **7** equally spaced in the vertical direction.

The referred to small thickness of the fluid is desirable in providing what is termed a quite mode of operation, i.e., one wherein the surface of the fluid may be deformed evenly so as not to cause spurious light deviations during projection. In a noisy mode, i.e., normally above one mil, the fluid surface is deformed in a somewhat turbulent manner and will produce undesirable spurious responses. To apply the fluid as a thin film for operation in the quiet mode, without compensating for nonuniformity, tends to introduce excessively thin areas, normally towards the central region of the disk. Excessively thin fluid layers, e.g., of micron dimensions, are undesirable because they will not deform sufficiently for most projection applications. Providing a uniform deposition of the fluid on the substrate surface in accordance with the present invention readily permits operation in the quiet mode and yet avoids applying the fluid in excessively thin layers. The uniform deposition of the fluid also provides a projected picture of uniform thickness.

In one operating embodiment of the invention, the curvature of the surface **12** was along an approximately 90° arc of a circle having a radius of approximately two and one-half inches while employing an eight inch diameter disk, the center of curvature of the surface **12** being located on the horizontal diameter of the disk. Using a silicone oil fluid having a viscosity of approximately 200 centistokes at room temperature and for a disk rotation of approximately three revolutions per hour, an oil thickness of one-half mil was deposited uniformly over the disk surface to within 10%.

The applicator of the present invention is effective in providing a significant improvement in the uniformity of fluids applied to a slowly rotating substrate for fluids ranging in viscosity from less than fifty centistokes to several thousand centistokes. It may be appreciated that optimum curvatures of the applicator forward surface for fluids of differing properties and at different rotational speeds of the disk substrate will be found to vary slightly from the above indicated specifications.

Numerous modifications may be made to the device herein disclosed which do not exceed the basic teachings set forth. Accordingly, the forward concave curved surface need not be integral with the portion of the applicator that deposits the fluid but can be displaced therefrom, e.g., be in the form of a flexible band the curvature of which is readily adjustable. Further, although the undersurface of the applicator is illustrated as essentially parallel to the disk surface this is not critical or necessary, it being required only that the spacing between the forward surface and the disk be proper for providing a meniscus that supports fluid flow down the surface.

The appended claims are intended to encompass the invention as disclosed plus any and all modifications falling within its true scope.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A fluid applicator for depositing a thin layer of fluid of uniform thickness onto a planar surface of a rotating substrate lying in a plane having an appreciable vertical component, comprising:

(a) a body member having an elongated passageway adapted to transport fluid introduced therein;

(b) an elongated output opening coupled to said passageway for emitting said fluid under substantially equal pressure along its length;

(c) said output opening being located in a planar surface of said body member; and positioned in the proximity of, substantially parallel to, and in facing relationship with, said substrate surface and generally along a radius of said rotating substrate;

(d) said planar surface further including a portion extending forwardly along the entire extent of, and from, said slot and in the direction of movement of said substrate;

(e) a surface of said body member extending normal from the leading edge of said forwardly extending portion and being concave in character; such that said leading edge is dimensionally furthest from the elongated opening at about the vicinity of the periphery of said substrate and dimensionally nearest to said opening at about the vicinity of the center of rotation of said substrate.

2. A fluid applicator as in claim **1** wherein the configuration of said forward surface concave curvature describes approximately ninety degrees of arc.

3. In combination:

(a) a rotatable substrate having a planar surface lying in a plane having an appreciable vertical component and adapted to be coated by a thin film of fluid,

(b) a fluid applicator having an input opening coupled to an elongated output opening, said output

opening extending along a planar surface of said applicator and adapted to have forcibly emitted therefrom fluid that is introduced under pressure to said input opening,

(c) means for positioning said applicator to place said output opening substantially parallel to, in the proximity of, and in facing relationship with, a portion of said substrate planar surface and generally along a radius of said rotatable substrate,

(d) said planar surface of the applicator including a portion extending forwardly along the entire extent of, and from, said output opening and in the direction of movement of said substrate, a surface of said applicator extending normal from the leading edge of said forwardly extending portion and being concave in character, such that said leading edge is dimensionally furthest from the elongated output opening at about the vicinity of the periphery of said substrate and dimensionally nearest to said output opening at about the vicinity of the center of rotation of said substrate, said concave surface being adapted to support fluid flow, fluid emitted from said output opening forming a meniscus along said concave surface whereby a thin film of fluid is deposited

on the substrate surface forward of said meniscus as the substrate is rotated.

4. A combination as in claim **3** wherein the configuration of said forward concave curvature describes approximately ninety degrees of arc.

5. A combination as in claim **3** wherein the spacing between said forward surface and said planar surface is many times greater than the thickness of the deposited fluid.

6. A combination as in claim **3** including means to apply to said input opening a fluid comprising an oil composition having a viscosity in a range between fifty and one thousand centistokes.

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