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J. E. THORNTON

CONSTRUCTION AND MANUFACTURE OF CINEMATOGRAPH POSITIVE FILMS

Filed Dec. 15, 1924

3 Sheets-Sheet 1

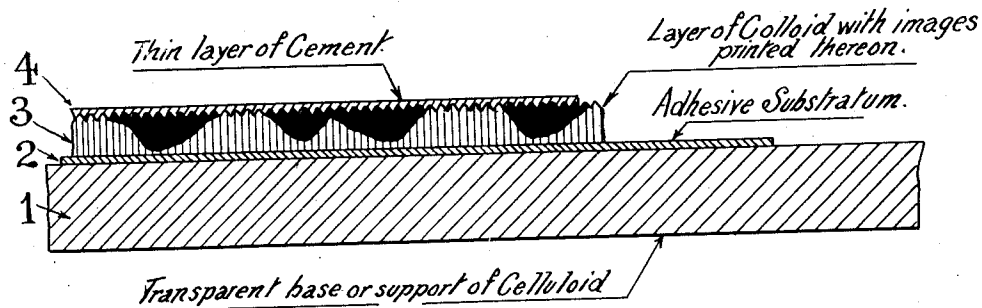


Fig. 2.

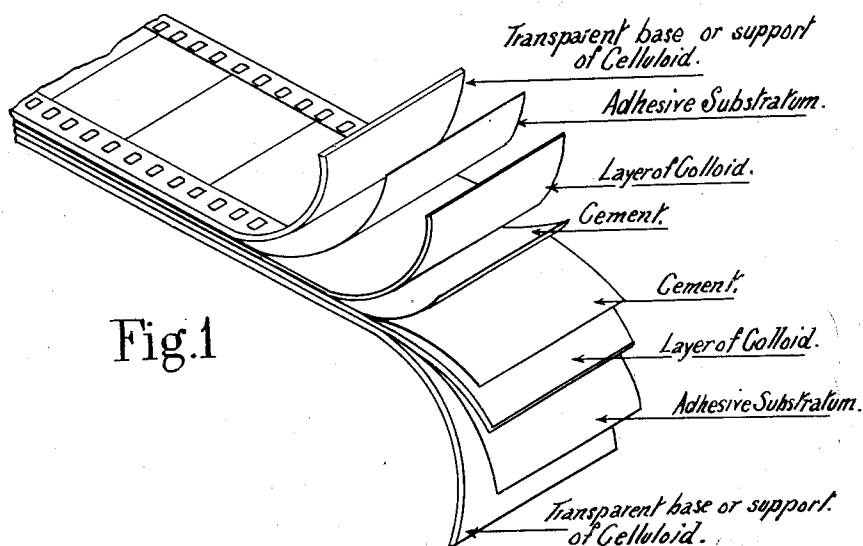


Fig. 1

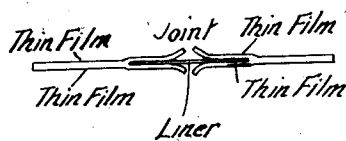


Fig. 3.

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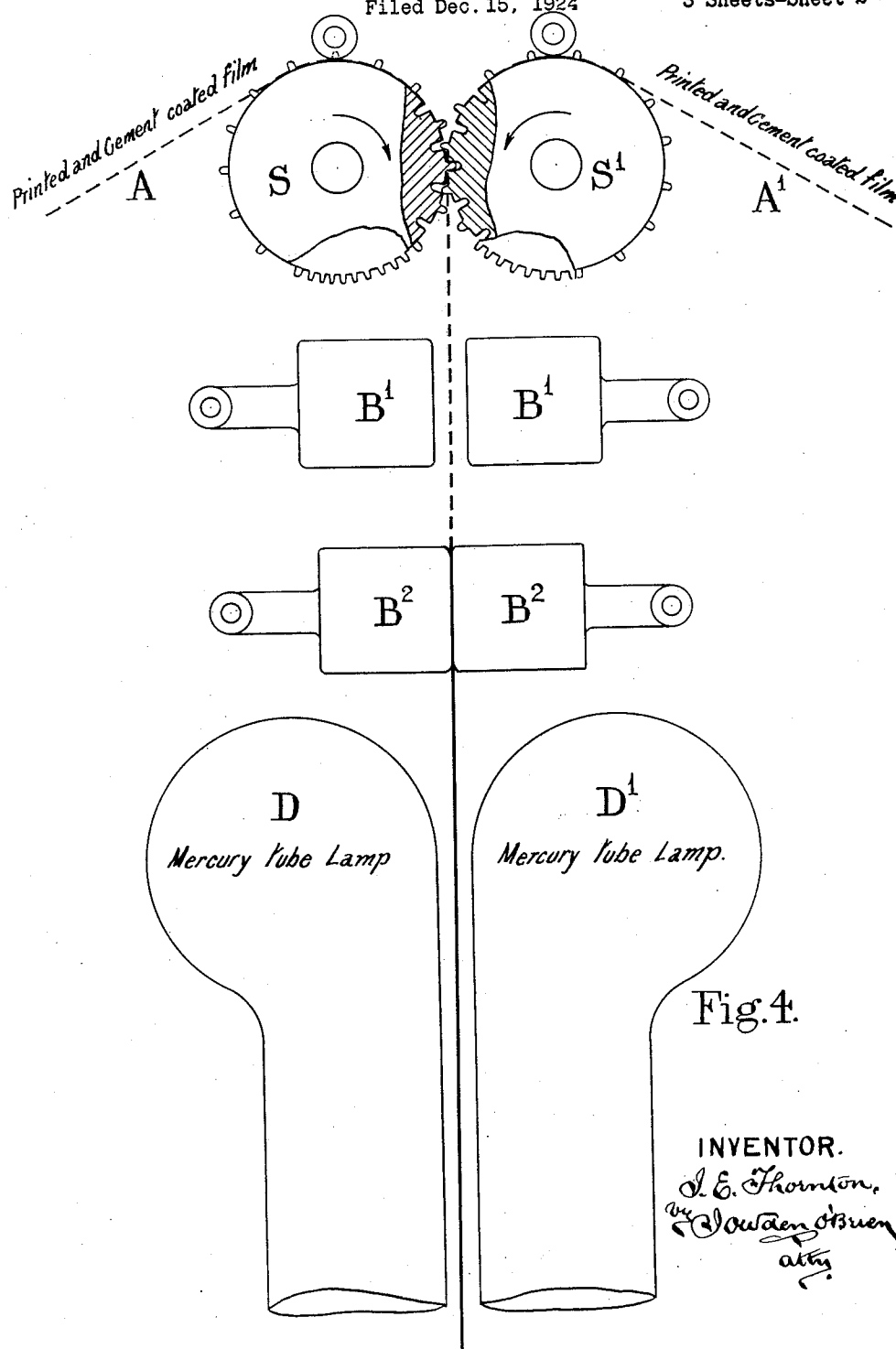
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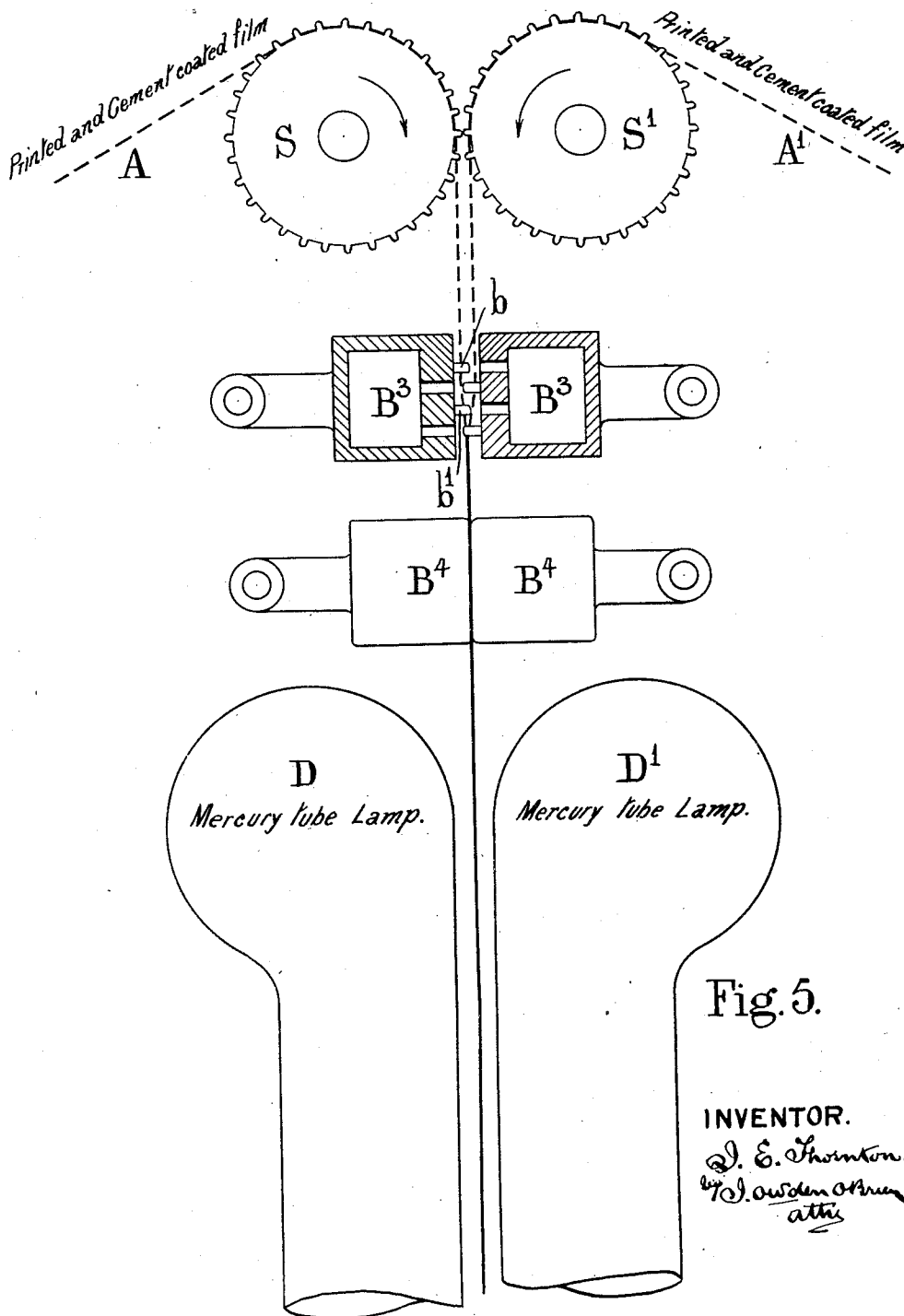
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CONSTRUCTION AND MANUFACTURE OF CINEMATOGRAPH POSITIVE FILMS

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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE.

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CONSTRUCTION AND MANUFACTURE OF CINEMATOGRAPE POSITIVE FILMS.

Application filed December 15, 1924, Serial No. 756,168, and in Great Britain January 9, 1924.

This invention relates to improvements in the construction and manufacture of cinematograph films.

In the manufacture of composite cinematograph films from two thin film strips it has been proposed to join them back to back (celluloid to celluloid) by applying a solvent of celluloid to one or both backs and in a similar way to cement the celluloid back of one to the colloid face of the other, but the joining of two colloid faces together by a celluloid varnish or by a solution of gelatine or glue has not proved permanently satisfactory.

The object of the invention is to provide a durable and permanent joint between the colloid faces of the two thin constituent parts of the film and consequent thereon a better and more durable cinematograph positive film in which the printed images will have a longer wearing life.

The tremendous strains, and the instantaneous jerks and changes of position which a cinematograph film has to undergo during almost continuous use and running in a projector, preclude all possibility of any gelatine-face-joint between two films holding permanently, unless one part is literally welded to the other part, so that they become virtually one, which is what I effect by this process.

According to the invention the colloid surfaces of the two films are prepared and rendered receptive of the jointing cement by roughening or graining or otherwise, to ensure that the cement layer will permanently interlock or amalgamate with the film surface partially physical and partially mechanical, and a fusible cement is applied to the surfaces of the film strips which will form a temporary joint and heat and pressure are applied to fuse the cement and cause it to flow in to the interstices of the prepared surfaces.

The invention is illustrated in the accompanying drawings.

Fig. 1. is a diagrammatic perspective view of a completed positive film.

Fig. 2. is a longitudinal section of one thin film drawn to a highly magnified scale.

Fig. 3. is a longitudinal section of completed film showing joint between two films.

Fig. 4. is a diagrammatic view of means for uniting the two thin films.

Fig. 5. is a similar diagrammatic view showing a modification.

In the drawings 1 is a thin transparent base of celluloid or other waterproof material. 3 is a layer of printed colloid, the printed images being shown more or less opaque, with a roughened and pitted or recessed face. 2 is an adhesive substratum which indissolubly unites layers 1 and 3. And 4 is a thin layer of fusible cement interlocked into the roughened face of the colloid layer 3.

Fig. 4. Shows one method of bringing and uniting the two thin films together after having been roughened and cemented as hereinbefore described.

The two films A, A¹ arrive in the assembling machines from their respective spools with their faces coated with fusible cement which is surface dry and therefore can be freely spooled. They first pass over the sprocket wheels S, S¹, one film being registered on the teeth of one sprocket and the other registered upon the other sprocket, the teeth of each sprocket being formed alternately and engaging alternately with the holes in the other sprocket. As the sprockets revolve in the direction of the arrows the films are first accurately positioned by their teeth which enter the perforations of the films and as the sprockets further rotate the films are nipped between the peripheries of the slightly heated sprockets and thus lightly joined together. The process is completed by the heavier pressure given by the pair of heated blocks B¹ or B², which open and close alternately so that whilst one is clamping, the other is opening or closing. This movement is effected by eccentric or crank motions (not shown), the shanks of the blocks sliding in collars or bearings (not shown). The two sprockets S, S¹ are geared together. After emerging from the lower blocks the films then pass between a pair of lamps D, D¹ by which the insolubilizing action that renders the cement non-fusible is started by the exposure to light thus made.

Fig. 5. shows another method. The thin perforated films A, A¹ are drawn by the teeth, of the sprockets S, S¹ which enter the films and accurately position them. The heated blocks B³ then hold them, each film on a block, by two pins b, b¹, and then

advance to clamp the films and fuse the cement, the pins of each block entering the holes of the other block. At the next step the blocks B² open but the film is previously caught and clamped by another pair of plain (pinless) blocks B⁴ (like B²) and the films pass between the lamp D, D¹.

The colloid surface of each of the film strips may be roughened, pitted or toothed either mechanically or chemically until it presents a vast number of exceedingly minute points or teeth with depressions or minute deep recesses between.

Mechanical tooththing.—The roughening or tooththing process may be carried out mechanically by passing the printed film whilst in a dry state between milling rolls, one of which is plain and the other of which has been prepared by sand-blasting or in any other way that will give it a finely milled or roughened grainy surface. This milled surface is again imparted to and reproduced upon the surface of the printed film by the operation of rolling under considerable pressure.

In the ordinary way this milling of the surface of the film-print produces a "ground-glass" effect so that the picture appears upon a translucent instead of a transparent film, but this translucency is removed and transparency restored by the application of the superimposed layer of transparent cement.

Chemical tooththing.—The roughening or tooththing process may be carried out chemically by etching, which is the method at present preferred.

A suitable etching solution is composed of calcium chloride and potassium ferricyanide and water. No exact proportions need be stated, because they require to be varied according to the make and kind of gelatine used, but as a guide 5 ounces of calcium, 5 ounces of ferricyanide, and 100 ounces of water may be taken as approximate figures. Other chemicals such as zinc-chloride, calcium-nitrate, ferric-chloride, or sodium-chloride are each useful. The etching solution is applied to the dry surface of the film strip.

Softening the colloid surface.—The film is further treated by passing it through an alkaline bath such as a dilute solution of ammonia or caustic potash. This bath has the effect of softening the hard surface and opening the pores of the gelatine, thus enabling the liquid cement to more easily penetrate the printed colloid and become better interlocked therewith.

Applying the cement.—The second step of the process is to apply to the roughened or toothed surface of the printed film an exceedingly thin layer of the cement, which is made up as a very dilute solution, the composition of which is hereinafter more specifically described.

This solution will flow into all the hollows

of the toothed surface, and after its application the coating is dried, preferably slowly, in a dust-filtered drying room.

Whilst good results may be obtained with only one application of a relatively concentrated solution of the cement, it is better to use a more dilute solution and attain the desired thickness by applying two or three or even more coatings, allowing each one to dry before the next is applied. The process can be carried out as a continuous operation, by apparatus which applies the several coatings at different points of the same strip simultaneously, the film passing from coating apparatus to drying chamber in alternate succession. In principle better results are obtained from a succession of extremely thin layers than from one layer of the same total thickness.

Effect of the cement coating.—Upon examination of the film after drying it will be found that the coating of cement which has flowed into the hollows has so contracted in the drying process that it has become tightly shrunk upon each one of the vast number of teeth or raised points, and has therefore become mechanically amalgamated with the printed film. At the same time, owing to the softened state of the surface of the colloid image-layer, the dilute solution of cement will have partially or almost wholly penetrated the colloid layer by means of its opened pores, and the first of the dilute layers of cement will therefore have also physically amalgamated with and become practically a part of the printed colloid layer itself. The next layer of cement applied penetrates and amalgamates in like manner with the first layer, and so on with each layer applied; so that the final result is that the cement layer itself, and throughout its entire thickness, becomes to all intents and purposes an integral part of the printed colloid layer.

Nature of the cement.—The principle underlying the composition of this cement embraces the following elementary conditions in the character of the cement:—

- (A) It must be very tenacious.
- (B) It must be very flexible and remain permanently flexible.
- (C) It must be fusible or liquefiable by the application of heat before the joint is finally made.
- (D) It must be capable of solidification after the liquefying process, by the application of cold or a lower temperature.
- (E) It must be capable of automatic self-insolubilization at the final stage of the process after the joint has been made.

These conditions can be met whilst allowing considerable variations in the composition of the cement, but the principles governing these conditions are satisfied by a combination of the following factors:—

- (A) The basis of the cement is preferably

a very good quality of glue or fish-glue and a small proportion of glacial-acetic-acid; this will produce a cement of great tenacity;

(B) Flexibility is secured by incorporating a small proportion of glycerine, treacle, sugar, or equivalent hygroscopic-maintaining ingredient;

(C) Fusibility is secured by incorporating a small proportion of treacle, sugar, glycerine, or equivalent, hygroscopic-maintaining ingredient;

(D) Solidification upon cooling will result from a mixture combining A, B, and C;

(E) Gradual insolubilization is secured by incorporating a small proportion of a bichromate salt, such as ammonium or potassium bichromate, to be acted upon by light; or chrome alum or an equivalent salt which will gradually react without light.

No exact proportions need be stated, as the quantities of each must be varied to suit the particular colloid used and the condition of its surface, but the following example may be taken as approximate proportions in an average case, to be adjusted as necessary:—

Ounces or parts.

Best quality pale glue	10
Glacial acetic acid	5
Glycerine	5
Golden syrup treacle	5
Ammonium bichromate	1
Water	100

The glue is soaked in 90 parts of water until soft, then melted by gently heating, in a jacketed vessel, and the glycerine and treacle are next added gradually and with constant stirring. The bichromate is dissolved in 10 parts of warm water, and added gradually with constant stirring to the glue solution. Finally the acetic acid is added, the whole thoroughly mixed by constant stirring, and then, after filtering, the cement is ready for use.

Variations in the ingredients named may be made provided they produce similar effects. For instance fish-glue, gelatine, or isinglass may be substituted for glue; sulphuric, nitric, or hydrochloric acid may be substituted for glacial acetic acid; sugar may be substituted for treacle; chrome alum may be substituted for bichromate; the proportions in each case being adjusted to suit these alternative ingredients. All these alternatives are good substitutes, but those first hereinbefore named are preferred.

Applying the cement to the films.—Before application of this cement the colloid faces of the two films are softened and the pores of the colloid opened as already described, taking care the process is not carried so far as to unduly soften or dissolve the colloid layer. The cement is then applied only just warm as a coating in an

exceedingly thin layer to each film, and it will partially penetrate and be absorbed by the softened printed colloid as already described. It is next dried, and the application may be repeated two or three times with good effect, being again dried between and after each coating.

The assembling and registering operations.—The two films are now ready for uniting. In their dry condition the two films are accurately superimposed face-to-face by means of an assembling machine, provided with registration pins which exactly fill the holes in the two films; the two films are automatically positioned by the machine so that the corresponding parts of each film are correctly assembled and registered upon the same pin.

Fusing and welding the two colloid faces.—At the next step the two films are automatically clamped, with considerable pressure, between two metal blocks, in the form of a fixed bed and movable platen which have a parallel motion towards and away from each other. Both blocks are heated by steam, gas, or electrical means, but preferably electrical.

The heat of the two blocks slightly melts the two coated surfaces of cement, owing to the glycerine and treacle contained therein; and, owing to the extremely adhesive character of the cement when slightly melted by heat, the two surfaces are therefore joined by amalgamation of their two slightly melted adhesive coatings (which are in turn already interlocked with their printed colloid layers by penetration and by teeth) and after setting and cooling of the cement become virtually like one; in fact the two films are in this manner literally “fused” or “welded” together. The duplex film is next cooled by being withdrawn from the two blocks and passed under a draught of cold air furnished by a fan.

An alternative means of applying the necessary heat and pressure is to pass the films between rolls, heated electrically or otherwise, and provided with suitably shaped and accurate sprocket teeth for registration purposes. One set is used to give the first uniting pressure, and further rolls (with or without teeth) to apply pressure over a sufficiently long period to complete the fusing and cooling process.

Flat pressure is however preferred, rather than rolling pressure, as more conducive to accurate registration. But the flat and roll systems can be used in combination with useful advantages.

Another important point in the joining process is that the operations, firstly, for accurately placing or registering the two section-films, and then, secondly, for immediately afterwards accurately uniting the two surfaces, should be effected in step-by-

step or picture-by-picture manner by intermittent steps rather than by a continuous rolling action, in order to ensure the highest possible degree of accuracy in superimposition of the two films.

Insolubilizing the cement of the joint.—Previous to this operation the layer of cement, now cold and solidified, still remains fusible under the influence of heat, and therefore might possibly come apart owing to the heat of lamp in the projector; but the following measures are taken to make that impossible.

The joined two-ply film first receives a short exposure to light by being passed between a pair of mercury lamps, placed to act one upon each side of the film through its outer protecting celluloid covers or windows.

Therefore at this stage the bichromate combined in the cement comes into play, for the moment that the cement is quite dry the reaction of the bichromate, having first been started by the exposure of the film to light, steadily proceeds until it causes the cement to become a completely insoluble and therefore non-fusible body.

This process of insolubilization, which is a continuing one, prevents any possibility of the cement ever being re-fused by the heat of the lamp in the projector (which would cause the joint to come apart); on the contrary the cement of the joint becomes more insoluble as time goes on. The quantity of bichromate enclosed in the two thin layers of cement is so minute that the slight yellow coloring produced is insufficient to make any appreciable difference in the color or transparency of the picture-image.

An alternative means for effecting the insolubility without any coloration whatever, is to substitute a small quantity of chrome alum for the bichromate, and to dispense with the light action. In that case also the joint will automatically become a permanent one, owing to gradual insolubilization of the cement by the chrome alum. This process will however take a very much longer time to effect complete insolubilization. Formalin might possibly be substituted for chrome alum, and also other possible equivalents.

Keeping the perforations clean.—In applying the cement to the colloid faces it is necessary to ensure that it does not leave the perforations with thin covers of dried cement. This is effected by passing the cement-coated film between two jets of compressed air, operating one upon the back and one upon the front of the film-strip, as it leaves the coating apparatus, the jets being placed not opposite but one in advance of the other, so that as the film travels past them any cement that has crept into the holes is blown clean out, by air-jets acting first from one side then from the other.

After the films have been finally united

by their cemented faces, the perforations may be finally cleared by passing the film between a pair of male and female clearing dies having teeth and holes corresponding exactly to the punches with which the perforations were originally made, but with the difference that the teeth are slightly tapered in order to readily enter and gradually clear the edge of each perforation as the full-size portion of the teeth are finally driven home.

Flexibility and insolubility of the completed film.

Flexibility of the completed film.—The question of flexibility of the inner core comprising the colloid image-layers and the cementing layers is of extreme importance. Unless suitable provision is made to ensure flexibility the gluing together of the two films would result in a film too stiff and too inflexible.

This condition is however satisfactorily met by the proportion of glycerine or treacle (or both combined) included in the composition of the cement. Ordinary sugar may be substituted for treacle if preferred. A part of this is absorbed by the printed colloid image-layers. Or if preferred the colloid layers may be treated in a dilute glycerine bath before the cement is applied to them, and the application may be made as a separate bath treatment or by incorporating the glycerine with the softening solution. It does not matter at what stage the glycerine is introduced so long as the respective layers contain sufficient to maintain flexibility and sufficient to prevent absolute drying of the layers yet allowing of approximate surface dryness.

Insolubility of all layers of the completed film.—Total insolubility of all layers when the film is complete and finished is also desirable, but it must be associated with permanent flexibility.

As already described this condition of permanent flexibility is ensured by the presence in the several colloid layers of a very small quantity of glycerine or treacle.

Permanent insolubility of all the layers is obtained by a gradual transfusion of the bichromate or chrome alum from the cement-layer throughout all the other layers; and such transfusion and hardening is a continuing and very gradual process.

Splicing the ends of two films.

The usual way of joining the ends of two films, known as splicing, is to remove (by a scraper) the picture-image colloid-layer of each film for about one eighth of an inch, and then join the two ends by applying celluloid cement to the narrow bare portions, placing them to overlap, and pressing the two narrow bare celluloid parts together until the cement is dry.

Such a join or splice is always a source of trouble in using the film unless made with the utmost care; in any case it is always a short splice (usually about one eighth of an inch); and as one strip overlaps the other the film is thicker at the splice.

prepared for interlocking in the special manner herein described;

(4) An exceedingly thin layer of special cement as herein described attached to such surface partly by impregnation of its pores and partly by interlocking with its surface teeth;

Second film.

(5) An exceedingly thin layer of special cement as herein described, attached to the printed colloid surface 6 partly by impregnation of its pores and partly by interlocking with its surface teeth;

(6) A colloid layer superimposed upon the substratum 7, and having either a series of partial pictures complementary to and completing those on colloid layer 3; or alternately unprinted, plain colloid without pictures;

(7) An adhesive substratum superimposed upon the base and indissolubly uniting layers 6 and 8;

(8) A base of celluloid or other transparent waterproof material, which forms firstly a support for layers 6 and 7 of the unprinted film, and also finally the other outer cover of the completed film; the first film comprising layers 1, 2 and 3, being indissolubly united by its cement layer 4 to the cement layer 5 of the second film, which comprises layers 6, 7 and 8, by the application of heat and pressure until they are completely welded or fused together.

What I claim as my invention and desire to protect by Letters Patent is:—

1. A method or process of producing a cinematograph positive film which consists in printing upon and finishing two thin films, each of approximately half standard thickness, preparing the printed-colloid faces of both films to receive a cement, applying to the prepared printed-colloid-faces a fusible cement, temporarily joining the two films together and subsequently converting the temporary joint into a non-fusible permanent face joint by the application of heat and pressure to the films.

2. The process of attaching two thin positive films together which consists in preparing the printed-colloid-surfaces by forming thereon a vast number of minute projections and recesses applying thereto a fusible cement which will interlock therewith to form a fusible temporary joint and subsequently converting it into a permanent non-fusible joint by rendering the cement insoluble by the action of light.

3. In the production of cinematograph positive films the process of attaching two thin films together which consists in preparing the printed-colloid-faces by etching thereon by a chemical process a vast number of minute projections and recesses, and ap-

In a two-ply film a much better splice can be made by making the celluloid back of one complete picture to join at the top mask-line division and the other celluloid back to join at the bottom mask-line. Thus the splicing of the two thin celluloid supports do not coincide but are separated by one picture space, and a strong splice is made without much increase in the film's thickness at the splice. The splice therefore consists of two single-film layers and the total thickness is not as greatly increased as in the films now in use.

Another form of join or splice which can be made only in films made according to this invention is effected by placing between the two films, for a length of say one or two pictures of each of the two ends to be joined, a thin splicing-liner consisting of a strip of very thin celluloid coated upon each side with a thin layer of jointing cement. This splicing-liner is perforated, adjusted in position, and then heat and pressure applied to the entire joint, so that the two film-faces are adhered to the splicing-liner which is placed inside between the two films. Though such a splice makes the film slightly thicker than in the first example, it makes a much better and smoother and infinitely stronger form of join than the method at present used in standard film, and the liner can be tapered off to a "feather-edge" at each end in the manufacture of the splicing-liner material.

The finished scratchless-image film.

When all the processes are completed the finished film-strip of positive pictures will comprise a single-width strip of perforated film of standard thickness, but with its images buried within its interior, and composed of the following layers arranged in the following order, but indissolubly amalgamated as one film:—

First film.

(1) A base of celluloid or other transparent waterproof material, which forms firstly a support for layers 2 and 3 of the unprinted film, and also finally, one of the outer covers of the completed film;

(2) An adhesive substratum superimposed upon the base, and indissolubly uniting layers 1 and 3;

(3) A colloid layer superimposed upon the substratum 2, and having a series of complete pictures or parts of pictures printed thereon; the printed colloid having its face

plying thereto a fusible cement which will interlock therewith, to form a fusible temporary joint and subsequently converting it into a permanent non-fusible joint by rendering the cement insoluble by the action of light.

4. In the production of cinematograph positive films of two thin section films united face-to-face, the process of attaching the two thin films which consists in softening and opening the pores of the printed-colloid-faces of the two thin films, producing on the said faces a vast number of minute projections and recesses, amalgamating a layer of fusible adhesive cement to and with the colloid faces by applying to each face a solution of the cement, allowing the cement to partially penetrate the opened pores of the colloid, and also attach itself to the roughened surface and become firmly interlocked therewith, to form a fusible temporary joint and subsequently converting it into a permanent non-fusible joint by rendering the cement insoluble by the action of light.

5. In the production of cinematograph positive films united face-to-face, the process which consists in softening and roughening the printed-colloid-faces thereof, applying a solution of a fusible cement thereto to interlock with the said faces assembling the two thin films in correct order and position face-to-face, pressing the two films together with sufficient heat to fuse the cement upon both faces, and finally allowing the cemented film to cool and the cement to re-solidify.

6. In the production of cinematograph positive films united face-to-face the process which consists in softening and roughening the printed colloid-faces thereof, applying a solution of a fusible cement thereto to interlock with the said faces, assembling the two films in correct order and position face-to-face; accurately registering the corresponding section of each picture clamping

the films together between two metal blocks which are sufficiently heated to fuse the two cement layers; and finally allowing the cemented films to cool and the cement to re-solidify; and repeating the process until the entire length of two films have been joined by a series of step-by-step intermittent movements.

7. In the production of a scratchless-image positive film, comprising two thin section-films, united face-to-face by an insoluble permanent face joint, and in the construction of such joint, supplementing the process claimed in claim 4 by a process of insolubilization, by which the still fusible face-joint is converted into an insoluble, non-fusible, permanent one, by the reaction of a chrome salt upon the glutinous colloid of the cementing material to effect a completed joint.

8. In the production of a scratchless-image positive film comprising two thin section-films, united face-to-face by an insoluble permanent face joint, and in the construction of such joint, supplementing the process claimed in claim 4 by a process of insolubilization, by which the still fusible temporary face-joint is converted into an insoluble, non-fusible, permanent one, by the action of light upon a bichromate salt and glutinous colloid which form part of the cementing material, to effect a very rapidly-completed joint.

9. A cinematograph positive film comprising in its construction two thin films of cellulosic waterproof material, a roughened colloid printed surface on each thin film laid face-to-face, and a flexible fusible cement, with which is incorporated a hygroscopic ingredient and a chrome salt, between the faces of the two thin films by which they are cemented together.

In testimony whereof I have hereunto set my hand.

JOHN EDWARD THORNTON.