July 17, 1973 A. J. BACHELDER ET AL 3,746,594

MANUFACTURING PHOTOGRAPHIC FILM UNIT

Original Filed July 15, 1968 2 Sheets-Sheet 1

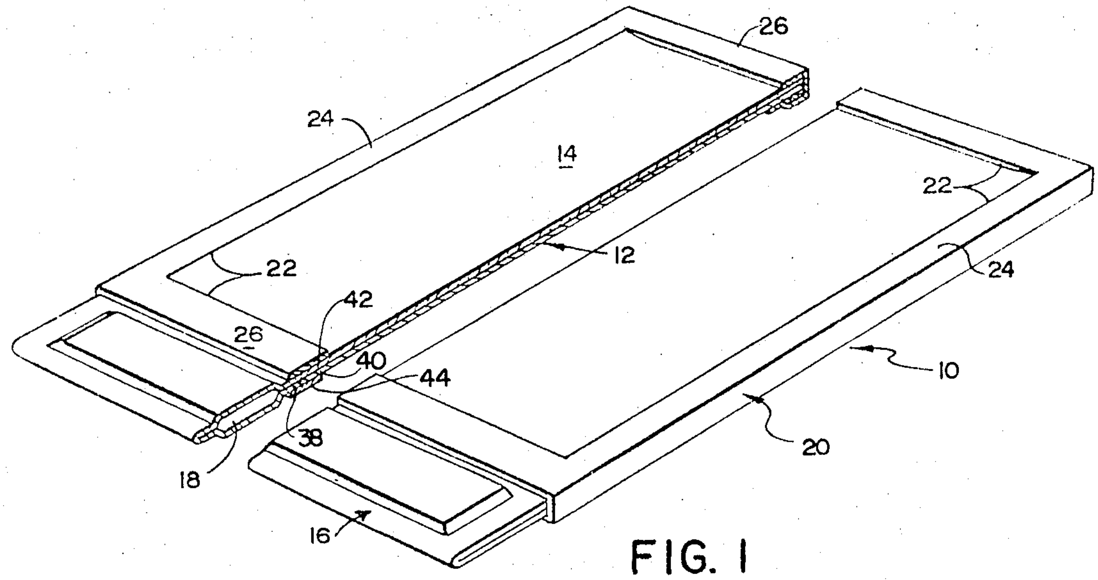

FIG. 1

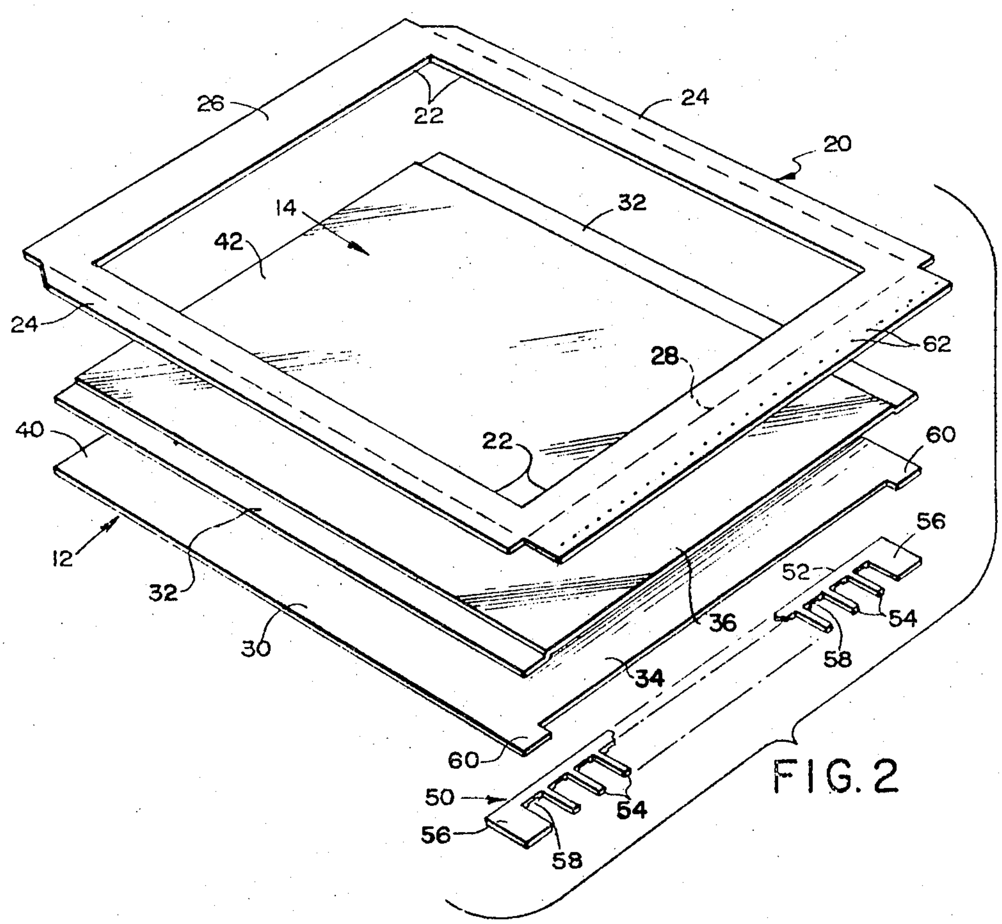

FIG. 2

July 17, 1973 A. J. BACHELDER ET AL 3,746,594

MANUFACTURING PHOTOGRAPHIC FILM UNIT

Original Filed July 15, 1968 2 Sheets-Sheet 2

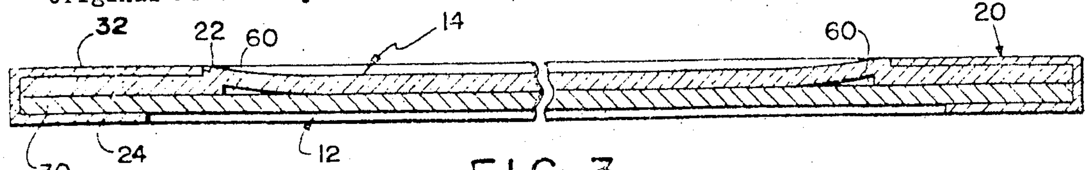

FIG. 3

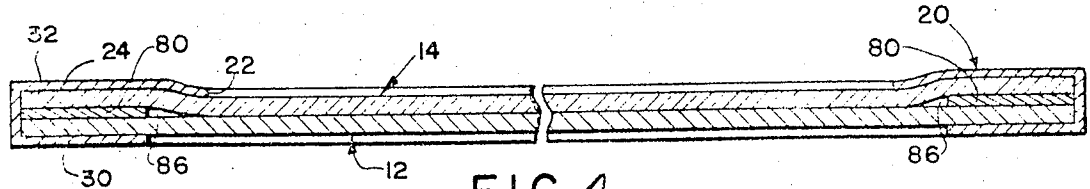

FIG. 4

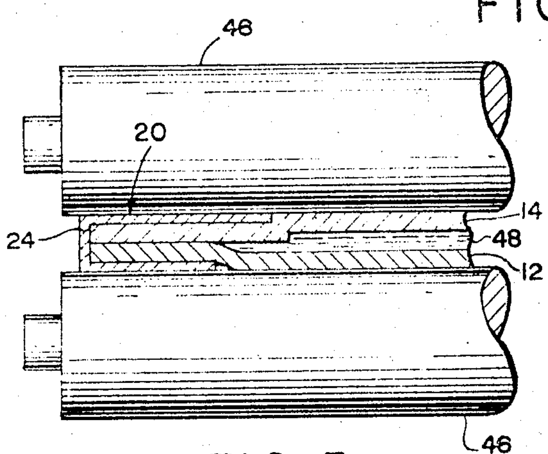

FIG. 5

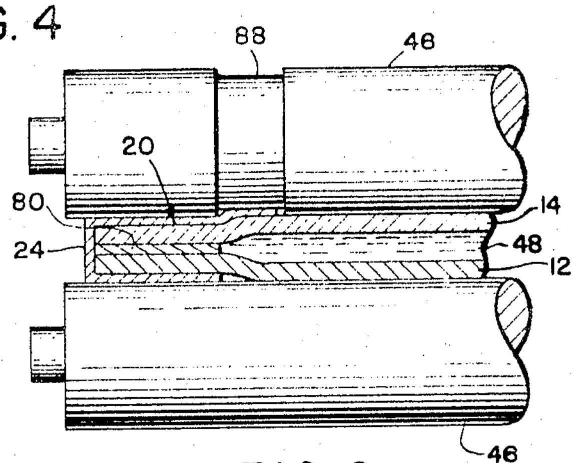

FIG. 6

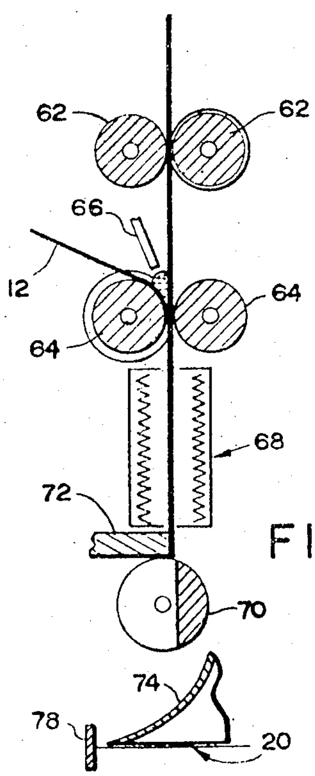

FIG. 7

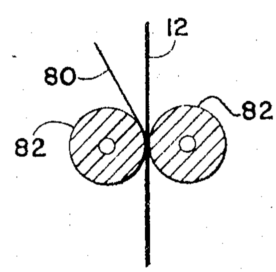

FIG. 8

United States Patent Office

3,746,594

Patented July 17, 1973

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3,746,594

METHOD OF MANUFACTURING PHOTOGRAPHIC FILM UNIT

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Original application July 15, 1968, Ser. No. 744,912, now Patent No. 3,652,281. Divided and this application Feb. 11, 1971, Ser. No. 114,701

Int. Cl. G03c *5/54*

U.S. Cl. 156—216 8 Claims

ABSTRACT OF THE DISCLOSURE

A self-developing, photosensitive film unit including a multilayer photosensitive element and a transparent image-recording element laminated to one another during manufacture and a rupturable container of processing liquid attached to the elements at one end for dispensing its liquid contents between the elements, and adapted to be processed by passing the film unit including the container and laminated elements between a pair of pressure-applying members. The film unit is formed by embossing, or attaching spacer strips, to the lateral margins of an elongated strip and then laminating the strip to a second strip by spreading a film-forming agent between the strips, severing the laminated strips to the required length to form sandwiches each comprising laminated photosensitive and image-recording elements, securing a binding around at least two sides of each sandwich and attaching a container of processing liquid to one end of the sandwich.

This application is a division of copending application Ser. No. 744,912 filed July 15, 1968, now Pat. No. 3,652,281.

In the copending United States patent application of Richard J. Chen, Ser. No. 726,252, filed May 2, 1968, there is shown and described a self-developing, photographic film unit of the general type embodying the present invention. The film unit includes a photosensitive sheet, a transparent, image-receiving sheet, a rupturable pod or container of processing liquid adapted, when distributed between the sheets following exposure of the photosensitive sheet, to produce a transfer image visible through the image-receiving sheet, and a combination mask and binding element for retaining the sheets in face-to-race relation, coupling the container to the sheets and assisting in the distribution of the processing liquid between the sheets. The container of processing liquid is of the type which, when subjected to compressive pressure, discharges its liquid contents unidirectionally, and the film unit comprises means including the binding element for conducting the liquid between the sheets where it is distributed in a thin layer by advancing the sheets between the pair of pressure-applying members employed to compress and rupture the container. The combination mask and binding element aids in the proper spread and distribution of the processing liquid within the film unit between the sheets by securing the sheets to one another at their lateral edges so as to confine the processing liquid to the region between the sheets while permitting the sheets to separate to their edges and by spacing apart medial portions of the pressure-applying members. The film unit is designed to remain intact following processing, with the liquid spread between the sheets functionnig to laminate the sheets to one another.

In order to provide for an adequate supply of the processing liquid at the margins of the image area sufficient to form an image within these marginal regions, the margins of the image-receiving sheet are embossed as shown, for example, in the 726,252 application and in the copending application of E. H. Land et al., Ser. No. 622,286, filed Mar. 10, 1967, so as to displace the sheets apart from one another in at least the regions of the lateral margins of the image area during distribution of the processing liquid.

While film units of the type manufactured according to the method of the present invention basically comprise two separate sheetlike elements, a number of advantages can be realized by laminating the two elements during the manufacture and assembly process and delaminating the elements following exposure during spreading of the processing liquid. For example, a prelaminated integral film unit is easier to handle and manipulate during assembly and during exposure and processing within the camera; it is more compact and hence, permits smaller and less bulky film packs and cameras; it is less subject to buckling and distortion due to temperature and humidity changes and more likely to lie flat and remains planar during exposure; and processing, specifically, spreading of the processing liquid within the film unit is facilitated since there is little or substantially no air between the sheets to interfere with liquid distribution.

While a prelaminated film unit similar in some respects to the film unit of the invention was disclosed in United States Patent of Land, Ser. No. 3,053,659, issued Sept. 11, 1962, a number of problems remained to be solved, particularly those relating to distribution of the processing liquid in a layer of the required uniform thickness over the entire image area and providing sufficient processing liquid in the regions immediately adjacent the edges of the image area. Additional problems arise with a film unit of the type adapted to produce a diffusion transfer image in full color and incorporating a photosensitive element having a photosensitive layer comprising a plurality of strata including differently sensitized photosensitive materials, as well as additional strata such as barrier and insulating strata, filters, and strata containing other materials and reagents such as developing agents and the like. These special problems are unknown to a film unit such as disclosed in the aforementioned patent in which a single photosensitive layer or stratum, e.g., a gelatino silver halide emulsion, is formed by distributing the photosensitive medium as a layer between the supports comprising the two elements of the film unit, and include manufacture and assembly of the various strata comprising the elements, lamination of the elements during manufacture and assembly, and delamination of the elements during processing.

An object of the invention is to provide a novel and improved method of manufacturing and assembling a self-developing photosensitive film unit.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the method involving the several steps and the relation and order of one or more of such steps with respect to each of the others which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view, partially in section, of a film unit manufactured according to the method of the invention;

FIG. 2 is an exploded perspective view of the film unit of FIG. 1;

FIG. 3 is a transverse, sectional view of the film unit of FIG. 1;

FIG. 4 is a sectional view similar to FIG. 3 of another embodiment of the film unit;

FIGS. 5 and 6 are sectional views, illustrating the processing of the film units of FIGS. 3 and 4 respectively;

FIG. 7 is a somewhat schematic view, illustrating the method of manufacturing the film unit of FIGS. 1 through 3; and

FIG. 8 is a view similar to FIG. 7, showing the method of manufacturing the film unit of FIG. 4.

Although the film unit manufactured according to the method of the invention is adapted to the performance of a number of different image-forming processes, it is especially designed for the production of a positive photographic print in full color formed by a diffusion-transfer process in which a photographic image-recording medium including a photosensitive material such as silver halide is exposed to form an image (latent) therein and is treated by wetting with a liquid processing agent to develop the image in the image-recording medium, form an imagewise distribution of transferable image-providing substances and transfer the image-providing substances by diffusion to an image-receptive stratum in which they are immobilized to form a visible positive image.

A preferred embodiment of the film unit includes all of the materials and reagents required to produce a full color photographic print by a process such as disclosed in U.S. Pat. No. 2,983,606, issued May 9, 1961, in the name of Howard G. Rogers. This patent discloses a photosensitive element including a silver halide emulsion and a dye developer, that is, a dye which is a silver halide developing agent; a second or image-receiving element including an image-receiving layer of a dyeable material; and a processing liquid in which the dye developer is soluble. The photosensitive and image-receiving elements are superposed with the emulsion and image-receiving layers in face-to-face relation and the processing liquid is distributed in a uniform layer between and in contact therewith for permeation into the photosensitive layer where it initiates development of exposed silver halide. The dye developer is immobilized or precipitated in exposed areas as a consequence of development while in unexposed areas and partially exposed areas of the emulsion, the dye developer remains unreacted and diffusible thereby providing an imagewise distribution of unoxidized dye developer which is transferred, at least in part, by diffusion to the image-receiving layer without altering the imagewise distribution of the dye developer to form a reversed or positive color image of the developed latent image in the emulsion. Multicolor transfer images are obtained utilizing dye developers, for example, by employing an integral multilayer photosensitive element such as illustrated in FIG. 9 of the 2,983,606 patent, including at least two selectively sensitized overlying photosensitive strata on a single support. A typical photosensitive element of this type comprises a support carrying a red sensitive silver halide emulsion stratum, a green sensitive silver halide emulsion stratum and a blue sensitive silver halide emulsion stratum, the emulsions having associated therewith, respectively, for example, a cyan developer, a magenta dye developer and a yellow dye developer. Each set of silver halide emulsion and associated dye developer strata may be separated from other sets by suitable interlayers formed, for example, of gelatin or polyvinyl alcohol. In the example given, the dye developers are preferably selected for their ability to provide colors useful in producing a full color image by a subtractive process and may be incorporated in the respective silver halide emulsion with which they are associated or in a separate layer behind their respective silver halide emulsion. In certain instances, a yellow filter is incorporated located in front of the green sensitive emulsion and comprising a yellow dye developer or a separate layer of a yellow filter material.

Reference is now made to FIGS. 1 through 3 of the drawings wherein there is illustrated a photographic film unit 10 manufactured according to the method of the invention, the thickness of the materials being exaggerated for purposes of clarity of illustration. Film unit 10 comprises a photosensitive or image-recording sheet 12, a second or image-receiving sheet 14 and a rupturable container 16 holding a quantity of processing liquid 18. Sheets 12 and 14 are preferably rectangular and coextensive with one another and are arranged in superposed face-to-face contact with at least the lateral edges of each sheet aligned with the lateral edges of the other. A binding element 20, in the form of a rectangular sheet larger than either of the photosensitive or image-receiving sheets, is secured to the two sheets at the margins thereof for retaining the sheets in superposed relation. Binding element 20 is in the general form of a frame having a large rectangular opening 22 defining the extent of the image produced in the film unit, surrounded by lateral edge portions 24 and end portions 26 and 28. Sheet 12 includes lateral marginal portions 30 and an end marginal portion 34 and sheet 14 includes lateral marginal portions 32 and an end marginal portion 36 with the lateral and end marginal portions of the two sheets being located in face-to-face contact, preferably with the edges of the lateral marginal portions in alignment. The lateral edge portions 24 and end portion 26 of binding element 20 are secured around and to, respectively, lateral marginal portions 30 and 32 of sheets 12 and 14 and end marginal portions 34 and 36 of the sheets effectively binding the two sheets to one another along three sides thereof. In a preferred form of film unit adapted to produce a reflection print surrounded by a white border and viewed against a white background, at least binding element 20 is formed of an opaque, white material and container 16 may also include a white outer coating to provide a more aesthetically pleasing product.

Container 16 is of the type shown in U.S. Pat. No. 2,543,181, formed by folding a retcangular blank of a fluid impervious sheet material medially and sealing the marginal sections of the blank to one another to form a cavity for containing processing liquid 18. The seal betwen longitudinal marginal sections 38 of the container is weaker than the end seals so that upon the application of a predetermined compressive force to the walls of the container in the region of the liquid-filled cavity, there will be generated within the liquid hydraulic pressure sufficient to separate longitudinal marginal sections 38 throughout the major portion of their length to form a discharge mouth at least equal in length to the length of the cavity and the width of opening 22 through which processing liquid 18 is discharged. Container 16 is attached to the sheets at the edges thereof opposite end portions 34 and 36, preferably with the longitudinal edge of the container butted against the edges of the sheets and with the discharge passage of the container aligned with the facing surfaces of the sheets. Sheets 12 and 14 include, respectively, end marginal portions 40 and 42 and the means for coupling the container to the sheets include end portion 28 of binding element 20 secured to end marginal portion 42 of sheet 14 and longitudinal marginal sections 38 of the container so as to bridge the container and sheet 14; and a strip 44 secured to end marginal portion 40 of sheet 12 and the other longitudinal marginal section 38 of the container to bridge the gap between the container and sheet 12. The binding element and strip 44 cooperate to provide a liquid-tight seal between the marginal sections of the container defining the discharge mouth thereof and sheets 12 and 14; and form a conduit for conducting the liquid from the container between the sheets at end marginal portions 40 and 42 thereof.

The most useful and advantageous film unit insofar as packaging, storing, handling, exposure and processing are concerned, is one characterized by an integral, unitary, laminate form of structure designed so that its integrity may be maintained during and after exposure and processing; and a structure that is sturdy, has some flexibility, resists buckling and warping, remains flat particularly during exposure, and can be handled and manipulated by mechanical means without damage to produce a useful and attractive photographic print. A useful and attractive photographic print can be described as being substantially flat or planar and without a tendency to curl as the result of temperature and humidity changes; as being relatively rigid and inflexible as opposed to being limp or easily bent; as having a uniform white border surrounding a well-defined rectangular image that extends to the border; and a protective coating or covering for the image permitting the print to be handled and stored without the necessity for taking special precautions to avoid damage and deterioration. The structure and composition of components of the film unit of the invention combine to provide a film unit meeting these criteria and specially adapted, when processed, to provide a useful and attractive photographic print, preferably in full color, having the foregoing characteristics.

In order to provide a rigid durable structure having an integrity which is maintained from the time of assembly (during manufacture) to the finished print and providing a protective environment for the photosensitive medium as well as the final image, while permitting exposure of the photosensitive medium and viewing of the final image, at least one of the sheets of the film unit is formed of a transparent material. In the embodiment shown the second or image-receiving sheet is transparent and the photosensitive medium is exposed and the final image is viewed through the image-receiving sheet which functions to protect both the image-recording medium and the final image. In other embodiments of the film unit the photosensitive sheet may be transparent depending upon the manner in which the image-recording medium is exposed and the final image is formed and viewed. The transparent image-receiving sheet may be formed of a conventional film base material such as cellulose triacetate coated on its inner surface with one or more layers providing an appropriate environment for the formation of a diffusion transfer image. In a film unit designed to produce a color image in terms of a dye developer, the image-receiving sheet may be prepared as disclosed in the following example, by coating a transparent cellulose triacetate film base in succession with the following layers:

(1) The partial butyl ester of polyethylene/maleic anhydride copolymer prepared by refluxing, for 14 hours, 300 grams of high viscosity poly-(ethylene/maleic anhydride (140 grams of n-butyl alcohol and 1 cc. of 85% phosphoric acid to provide a polymeric acid layer approximately 0.75 mil thick;

(2) A solution of hydroxypropyl cellulose in water to provide a polymeric spacer layer approximately 0.075 mil thick; and

(3) A 2:1 mixture, by weight, of polyvinyl alcohol and poly-4-vinylpyridine, at a coverage of approximately 600 mgs./ft.^{2}, to provide a polymeric image-receiving layer approximately 0.40 mil thick.

In a preferred embodiment of the film unit useful in color photography and incorporating an image-receiving sheet prepared as described above, the image-recording sheet is preferably opaque to actinic light and is prepared, for example, by coating in succession on a gelatin subbed opaque cellulose triacetate film base, the following layers:

(1) A layer of cyan dye developer 1,4-bis(β-[hydroquinonyl - α - methyl]-ethylamino)-5,8-dihydroxy-anthraquinone dispersed in gelatin and coated at a coverage of about 150 mgs./ft.^{2} of dye and about 200 mgs./ft.^{2} of gelatin;

(2) A red-sensitive gelatino-silver iodobromide emulsion coated at a coverage of about 200 mgs./ft.^{2} of silver and about 100 mgs./ft.^{2} of gelatin;

(3) A layer of gelatin coated at a coverage of about 200 mgs./ft.^{2};

(4) A layer of the magenta dye developer 2-(p-[β-hydroquinonylethyl]-phenylazo) - 4-isopropoxy-1-naphthyol dispersed in gelatin and coated at a coverage of 70 mgs./ft.^{2} of dye and about 100 mgs./ft.^{2} of gelatin;

(5) A green-sensitive gelatino-silver iodobromide emulsion coated at a coverage of about 100 mgs./ft.^{2} of silver and 60 mgs./ft.^{2} of gelatin;

(6) A layer of gelatin coated at a coverage of about 150 mgs./ft.^{2};

(7) A layer of the yellow dye developer 4-(p-[β-hydroquinonylethyl]-phenylazo) - 3-(N-n-hexylcarboxamido)-1-phenyl-5-pyrazolone dispersed in gelatin and coated at a coverage of about 40 mgs./ft.^{2} of dye and 50 mgs./ft.^{2} of gelatin;

(8) A blue-sensitive gelatino-silver iodobromide emulsion coated at a coverage of about 60 mgs./ft.^{2} of silver and about 50 mgs./ft.^{2} of gelatin; and

(9) A layer containing 4'-methylphenyl hydroquinone dispersed in gelatin and coated at a coverage of about 10 mgs./ft.^{2} of 4'-methylphenyl hydroquinone and about 30 mgs./ft.^{2} of gelatin.

The image-recording and image-receiving elements may incorporate other strata and coatings commonly employed in photographic products of this type such as optical coatings for preventing halation and reflection and otherwise improve the optical properties of the sheet material and to facilitate and improve exposure and viewing of the final image. For further details and examples of the composition and structure of image-recording and image-receiving sheets suitable for incorporation in the film unit of the invention, reference may be had to the copending U.S. patent application of Edwin H. Land, Ser. No. 638,817 filed May 16, 1967.

The embodiment of the film unit illustrated and described herein is adapted to be exposed and processed to produce a multicolor dye transfer image in a dyeable polymeric layer located between a transparent film on which the dyeable polymeric layer is supported and an opaque layer located between the image and the photosensitive medium. This opaque layer comprises the liquid contents **18** of container **16** provided in sufficient quantity to form a layer of predetermined thickness, e.g., of the order of .004 inch, when distributed uniformly between the sheets over an area at least coextensive with opening **22** in binding element **20**. In order to insure that the quantity of liquid **18** supplied in the container is at least sufficient to form a layer of the desired minimum thickness and extent, the processing liquid is provided in a quantity in excess of the minimum amount required. The processing liquid contained in container **16** comprises an aqueous alkaline solution having a pH at which the dye developers are soluble and diffusible and contains an opacifying agent in a quantity sufficient to mask the dye developers retained in the image-recording layer (laminate) subsequent to processing; and a film-forming viscosity increasing agent or agents to facilitate rupture of the container and distribution of the liquid processing composition and help in maintaining the layer of processing composition as a structurally stable layer tending to bind the sheets to one another.

As a general rule, the opacifying agent will be present in the layer of liquid spread between the transparent image-receiving sheet and the opaque image-recording sheet in a concentration sufficient to prevent further exposure of the image-recording medium by actinic radiation transmitted by the transparent image-receiving sheet. Because the silver halide emulsion or emulsions comprising the image-recording strata are thus protected against exposure by incident actinic radiation at one major surface by the opaque processing composition and at the remaining major surface by the opaque support sheet, it is possible to process the film unit subsequent to distribution of the liquid processing composition in the presence of actinic radiation and thereby eliminate the need to provide a processing chamber within the camera and/or make it possible to withdraw the film unit from the camera almost immediately following distribution of the processing liquid. Binding element **20**, strip **44** and the material comprising container **16** are also formed of a material opaque to actinic radiation to prevent exposure of the image-recording medium by light entering the laminated assembly at the edges thereof. The opacifying agent is selected for its suitability as a background for viewing the dye-transfer image formed in the dyeable polymeric layer as well as for its opaque property. Another factor considered in the selection of the opacifying agent is the requirement that it does not interfere with the formation and color integrity of the dye-transfer image in the image-receiving sheet and that the agent be aesthetically pleasing and does not provide a "noisy" background that may degrade the image or detract from the information content thereof. Opacifying agents particularly desirable for incorporation in the liquid processing composition are those providing a white background for viewing the transfer image and particularly those compositions conventionally employed to provide a background for photographic reflection prints and having optical properties particularly suited for the reflection of incident radiation.

As examples of suitable opacifying agents mention may be made of barium sulfate, zinc oxide, titanium dioxide, barium stearate, silver flake, silicates, alumina, zirconium oxide, zirconium acetyl acetate, sodium zirconium sulfate, kaolin, mica and the like. An opacifying agent especially preferred because of its highly reflective properties is titanium dioxide and where it is desired to increase the opaqueness of the processing composition containing, for example, titanium dioxide, beyond that ordinarily obtained, an additional opacifying agent such as carbon black may be added in a concentration of about one part carbon black to 100–500 parts titanium dioxide. A liquid processing composition suitable for incorporation in container **16** for use in combination with sheet materials of the type disclosed in the foregoing example is as follows:

Water	cc	100
Potassium hydroxide	grams	11.2
Hydroxyethyl cellulose (high viscosity) [commercially available from Hercules Powder Co., Wilmington, Del., under the trade name Natrasol 250]	grams	3.4
N-benzyl-α-picolinium bromide	do	1.5
Benzotriazole	do	1.0
Titanium dioxide	do	40.0

Reference may be had to the aforementioned copending application for additional details and examples of liquid processing compositions adapted for incorporation of the invention to effect the process thereof.

Subsequent to exposure, film unit **10** is processed as illustrated in FIG. 5 of the drawings, by moving the film unit with container **16** foremost relative to and between a pair of juxtaposed members for applying compressive pressure first to the container to eject the fluid contents of the container between the photosensitive and image-recording sheets **12** and **14** and then spread processing liquid **18** in a uniform, thin layer between sheets over an area at least coextensive with opening **22** in binding element **20**. As previously noted, the processing liquid includes an agent for increasing the viscosity of the liquid so as to promote opening of the discharge passage of the container throughout substantially its entire length and facilitate the discharge of the liquid from the container and spreading of the liquid between the sheets. For this purpose, the liquid should be quite viscous and contain the film-forming material in quantities sufficient to impart a viscosity in excess of 1000 centipoises at a temperature of 20° C., and preferably of the order of 1000 to 200,000 centipoises at said temperature.

Preferred means for spreading the processing liquid in a thin layer of uniform predetermined thickness comprise a pair of cylindrical rolls **46** mounted in juxtaposition for rotation about axes located in a common plane and biased toward one another and/or mounted a fixed maximum distance apart so as to apply compressive pressure to the container and elements of the film unit during movement thereof between the rolls. During movement of the film unit between rolls **46**, compressive pressure is initially applied to container **16** generating hydraulic pressure in liquid **18** effecting the rupture of the bond between longitudinal marginal sections **38** of the container and the discharge of liquid **18** in the form of an elongated mass between sheets **12** and **14** at end marginal portions **40** and **42** thereof. Continued movement of the film unit relative to and between spread rolls **46** causes advancement of the mass of liquid between the sheets toward the opposite end thereof and spreading of the liquid as a thin layer **48** of predetermined thickness between and in contact with the facing surfaces of the sheets. A number of expedients are possible for controlling the thickness of the layer of processing liquid distributed between sheets including means in the processing apparatus for appropriately gapping or spacing apart spread rolls **46** and/or components of the film unit capable of performing this function. The film unit illustrated in the drawings is adapted to be employed with cylindrical rolls with the thickness of the liquid layer **48** being controlled, as illustrated in FIG. 5, by components of the film unit itself. The spacing between spread rolls **46** and hence the thickness of the layer of processing liquid is determined by the thickness of the film unit at the lateral margins thereof. This thickness is in turn a function of the thickness of the photosensitive and second sheets **12** and **14** and the thickness of lateral edge portions **24** of binding element **20**. Since the photosensitive and second sheets are of substantially uniform thickness throughout, the thickness of layer **48** of processing liquid is determined by the thickness of binding element **20** and is approximately twice the thickness of the binding element. In a typical film unit, for example, the binding element may have a thickness of the order of .002 inch and provide for spreading of the processing liquid in a layer having an initial depth of the order of .004 inch.

To insure spreading of the processing liquid to the edges of the area defined by opening **22** in the binding element and formation of a transfer image extending to the edges of this area, image-receiving sheet **14** is embossed at its lateral margins to displace marginal portions **32** out of the plane of the medial portion of sheet **14** toward sheet **12** by a distance or depth approximating the thickness of binding element **20** or, one-half of the desired initial thickness of the layer of processing liquid. This construction provides for the formation of a layer of processing liquid extending substantially to the lateral edges of opening **22** in the binding element. The sheets commence to absorb the processing liquid, immediately as it is spread therebetween and to further insure the formation of a layer of processing liquid extending at least to the lateral edges of the opening in the binding element as well as to provide assurance that the liquid within the narrow linear regions between the sheets at the lateral edges of the image area will be available in sufficient quantity, the edge sections of lateral edge portions **24** and end portion **28** secured to marginal portions **32** and end portion **36** of sheet **14** are wider than the sections of lateral edge portions **24** and end portion **28** secured to marginal portions **30** and end portion **34** of sheet **12**. Strip **44** is also narrower than end portion **26** and as a result of this construction, during spreading of the processing liquid between sheets **12** and **14**, the inner surfaces of the sheets will be spaced apart in lateral and end regions extending outside of the edges of opening **22** (defining the image area) allowing processing liquid to enter these regions and provide a reservoir of liquid for effecting image-formation within the region of the exposed image-recording medium immediately adjacent the lateral and end edges of opening **22**.

Still another factor contributing to the assurance of a complete spread is the presence of an excess quantity of the processing liquid. The processing liquid is initially spread as shown in FIG. 5 in a layer having a depth approximately twice the thickness of the binding element and calculated to provide aqueous liquid sufficient to permeate the layer containing the photosensitive medium and effect formation of a diffusion transfer image. As the liquid permeates the photosensitive layer and is absorbed and/or dissipated by sheets **12** and **14**, the thickness of layer **48** is reduced and the film-forming agent becomes increasingly solid to provide a dimensionally stable opaque layer providing a background for the transfer image and tending to adhere the sheets to one another to form a laminate in which the integrity of the film unit structure is preserved. The depth of embossing of image-receiving sheet **14** approximates the final thickness of layer **48** to provide an integral, laminated structure of substantially uniform thickness throughout in which layer **48** and the image extend to the edges of opening **22** in binding element **20**.

As previously noted, the film unit of the invention is designed to be processed by movement between spread rolls **46** to distribute the processing liquid in a layer that is continuous, is of uniform depth and extends throughout the entire area within opening **22** of binding element **20**. During spreading, liquid **18** is advanced between the sheets as a mass located immediately ahead of spread rolls **46** and extending from side-to-side of the region defined by opening **22**. The binding elements at the lateral margins of the sheets function to prevent escape of the processing liquid while permitting the sheets to separate to their margins during spreading of the processing liquid.

As previously noted, in order to insure distribution of the liquid in a layer of uniform, minimum, predetermined depth over the entire exposed region to the trailing end thereof and allow some tolerance in the manufacture and filling of the container as well as the depth of the layer of liquid, it is considered necessary to provide excess processing liquid. This makes it necessary to provide for collecting and retaining the excess processing liquid within the film unit at the trailing end thereof and prevent the caustic liquid from escaping and contaminating the apparatus, e.g., camera, in which the film unit is processed or coming into contact with the operator. Collection and retention of the processing liquid is accomplished by providing a space or spaces within the film unit in which the processing liquid is trapped or collected and from which the processing liquid cannot be squeezed by the pressure-applying members employed to spread the liquid. The liquid collecting and retaining means must not only retain excess processing liquid within the film unit, but at the same time are required to release air from the film unit so that it does not interfere with spreading of the processing liquid.

In the preferred form of the film unit shown in the drawings, excess processing liquid is required to be collected and retained within trapping spaces provided within the bounds of the trailing end region of the film unit, that is, between the edge of the image area and the trailing edge of the film unit. It will be apparent that not only is the space available severely limited but that an excess liquid reservoir will be located in close proximity to the image-containing region between the sheets thereby presenting additional problems. First, the liquid collecting and retaining (also termed "trapping") system must be designed to prevent escape of the liquid and accordingly binding element **20** which forms a part of the liquid collecting and retaining system is preferably formed of a substantially liquid impermeable material such as a polymeric film, waterproof paper or the like, which is also substantially impermeable to gas. This means that air, advanced between the sheets ahead of the processing liquid, may also tend to be trapped together with excess processing liquid interfering with the complete spread of the liquid and accordingly, provision must be made for releasing, as well as minimizing, the air.

Excess processing liquid is collected and retained externally of the sheets between which the image is formed within the film unit between one of the sheets and a trailing end portion of binding element **20**. The trapping means includes an elongated, generally comb-shaped spacing element **50** adapted to be secured between the trailing end portion of one of the sheets, preferably photosensitive sheet **12**, and trailing end section **28** of binding element **20** to provide trapping spaces therebetween in which excess processing liquid is collected and retained. Spacing element **50** is substantially equal in length to the width of the sheets, is relatively narrow having a width approximating or slightly less than the width of the trailing end border and includes a longitudinal section **52**, uniformly spaced teeth **54** extending from the longitudinal section, and end sections **56** in the form of widened teeth extending from the ends of longitudinal section **52**. Longitudinal section **52** is formed with recess **58** located intermediate teeth **54**. Spacing element **50** is formed of a relatively incompressible material, organic plastics adapted to molding processes being preferred, and has a thickness of the order of one to three times the thickness of the photosensitive and second sheets, the thickness of the spacing element depending upon the quantity of excess processing liquid to be collected and retained.

Spacing element **50** is secured between trailing end portion **28** of binding element **20** and end marginal portion **34** of photosensitive sheet **12** with teeth **54** extending toward the trailing end of the film unit to at least the trailing edge of the photosensitive sheet to provide between the teeth, photosensitive sheets and binding element, spaces or reservoirs opening toward the trailing end of the film unit. End marginal section **28** of binding element **20** is adhered along its edge (trailing) to photosensitive sheet **12** adjacent longitudinal section **52** of the spacing element and may also be adhered to the outer surface of the spacing element with the inner surface thereof being adhered to the photosensitive sheet thereby further insuring integrity of the structure. At least the medial portion of the photosensitive sheet, i.e., the portion located intermediate end sections **56** of the spacing element, may be shorter than the second sheet **14** so that the trailing edge of the second sheet is spaced inwardly from the trailing edge of the second sheet. In the form shown in FIG. 2, the photosensitive sheet includes extended sections **60** at its lateral edges corresponding to end sections **56** and extending beyond the trailing edge of the medial portion of the photosensitive sheet to substantially the trailing edge of the second sheet.

During processing of the film unit the processing liquid is advanced as a mass between sheets **12** and **14** by and ahead of pressure-applying rolls **46** toward the trailing end of the film unit and any excess processing liquid is spread beyond the trailing edge of the image area between the trailing end marginal portions **34** and **36** of sheets **12** and **14** and thence beyond the trailing edge of photosensitive sheet **12**. As the pressure rolls pass over the trailing end section of the film unit, they press together the inner facing surfaces of the trailing end marginal portions **34** and **36** securely laminating these portions to one another by virtue of the fact that these portions have been wetted by the liquid so as to activate the adhesive properties of the adjacent hydrophilic strata and there is no layer of liquid between the strata to weaken the bond formed by pressing the sheets and strata together. Moreover, the additional thickness of the film unit in this region provides for the application of increased compressive pressure further insuring the formation of a secure bond between the sheets in the region of the trailing edges. The teeth **54** of spacing element **50**, being incompressible, function to hold apart the facing surfaces of sheet **12** and trailing end portion **28** of binding element **20** in the same region thereby providing a space exterior of the two sheets into which the excess processing liquid is free to flow. End section **56** of spacing element **50** and extended section **60** of sheet **12** extend to the trailing edge of sheet **14** and cooperate to maintain the space within the binding element between the trailing edge of sheet **12** and the trailing edge of sheet **14** required to enable the excess processing liquid to flow from between the sheets into the trapping spaces between the teeth of the spacing element.

Recesses **58** are provided in longitudinal section **52** of the spacing element to permit air to escape from the trapping spaces between the teeth and two alternative constructions may be incorporated in the film unit for releasing air from between the binding element and sheet **12.** In the form shown in FIG. 2, end portion **28** of the binding element is formed with a plurality of very small perforations or pin holes **62** each located in alignment with a recess **58** and being large enough to pass air freely but too small to pass the viscous procesing liquid. It should be apparent that this is also a characteristic of recesses **52** which are also quite small and, accordingly will inhibit, if not absolutely preclude, the passage of the viscous liquid while allowing the free passage of air.

In an alternative construction both sheets **12** and **14** may be formed at their trailing ends with a series of indentations or notches providing spaces for trapping excess processing liquid, thereby obviating the necessity for an additional element (**50**) for trapping the excess processing liquid.

As previously noted, there are a number of advantages to be realized from laminating sheets **12** and **14** to one another during manufacture and assembly. For example, it should be apparent from the foregoing discussion that air between the sheets may interfere with spreading of the processing liquid and that there will be little or no air between sheets which are laminated in face-to-face relation and sealed at their edges to one another and to a container of processing liquid. Prelaminating the sheets has been found to further facilitate spreading of the processing liquid which, as it is being advanced as a mass between the sheets, causes the sheets to be forced apart from one another ahead of the mass of liquid due to the structural strength of the sheets, thereby causing rupture of the bond between the sheets immediately ahead of the mass of advancing processing liquid. The separation of the sheets as the bond is ruptured provides a region of reduced pressure, into which the processing liquid is drawn in the direction in which it is being spread. Moreover, by adhering the sheets in face-to-face relation, a thinner, more compact structure is obtained in which there can be no motion of the sheets relative to one another, and distortion or buckling of the sheets is prevented. These latter two factors are especially important during exposure when the photosensitive sheet is required to be located with a substantial degree of preciseness in the image plane of the camera lens and particularly, when a number of stacked film units are involved with the foremost film unit being urged by means at the opposite side of a stack into position for exposure with the second sheet of the film unit located against the positioning means.

The aforementioned Land patent suggests utilizing the inherent adhesive properties of the photosensitive layer, i.e., gelatin, to laminate the sheet of the film unit to one an- gelatin, to laminate the sheets of the film unit to one another. However, this may be impractical when the photosensitive layer comprises a number of selectively sensitized photosensitive strata as well as other strata. A major problem to be solved is separation of the sheets at the proper strata or layers during and in response to spreading of the processing liquid. Obviously, separation of photosensitive strata from another strata (e.g., photosensitive) of the same photosensitive layer cannot be tolerated, and it is difficult to vary the adherent properties of strata to insure proper separation when the strata, although differently sensitized, are essentially the same physically. The answer to this problem has been found to lie in distributing another material, specifically, a polymeric film-forming material, between the layers at which delamination is to occur. Such a film-forming material is selected to function both as an adhesive and to modify the adhesive properties of the layers of the two photographic elements, in the preferred embodiment, actually producing a bond between the adjacent layers of the two elements that is weaker than the bond which would otherwise be formed if it were not for the presence of the film-forming agent between the layers. Polymeric film-forming agent suitable for use with photosensitive and image-receiving elements of the type represented by the example given, should possess certain desirable physical characteristics including moisture resistance and resistance to blocking at high humidities.

In the manufacturing and assembling of a film unit according to the invention, the photosensitive and image-recording elements are laminated to one another as a step which is performed early in the assembly process. For example, photosensitive and image recording elements such as described in the foregoing example are manufactured by coating the appropriate layers on elongated support strips by conventional continuous coating practices, including baking the coated strips to form integral, finished laminates that can be handled and utilized, if defined, in their then existing conditions. For more detailed descriptions of the preparation of photosensitive and image-receiving sheets of the type incorporated in the film unit of the invention, reference may be had to the copending U.S. patent application of E. H. Land, Ser. No. 622,283, filed Mar. 10, 1967, now Pat. No. 3,415,644 and dated Dec. 10, 1968.

By way of example, a typical film unit manufactured according to the invention was formed by laminating photosensitive and image-recording sheets, such as described, by advancing the sheets into superposition between a pair of pressure-applying rolls while introducing an aqueous solution of a polymeric film-forming agent between the sheets at the nip of the rolls. As illustrated in FIG. 7, the image-receiving element **14** was first embossed by passing it between a pair of embossing rolls **62** and then advanced into superposition with photosensitive sheet **12** at the nip of a pair of laminating rolls **64**, one of which may be provided with flanges at its ends for containing the laminating liquid introduced between the sheets at the nip of the rolls through a tube **66** where the liquid is permitted to form a meniscus. In the example given, the laminating liquid comprised a solution of 1.23 grams of hydroxypropyl cellulose in 100 cc. of water, and the sheets were laminated by moving them at the rate of 45 inches per minute between a pair of hard rubber rolls (approximately 60 to 70 durometer) biased toward one another to exert approximately 62 p.s.i. pressure. The quantity of the film-forming agent distributed between the sheets was relatively small, approximately 1.45 mg. per square foot. The liquid was distributed in contact with the sheets and the sheets were pressed together so as to adhere them to one another over substantially their entire facing surfaces (as shown in FIG. 3) except for narrow linear regions, designated **60**, immediately adjacent the embossed lateral marginal portions **32** of the image-recording (photosensitive) sheet. The small quantity of film-forming agent has been found to contribute to the formation of a bond between the sheets that is secure under normal conditions encountered in manufacture, storage, and use, and having properties that are not unduly altered in response to changes in humidity, yet ruptures readily, easily, and cleanly, leaving the adjacent layers intact when subjected to tension as by spreading a mass of liquid between the sheets.

In the assembly process illustrated in FIG. 7, the laminated sheets are advanced from laminating rolls 64 into and through an oven 68 where they are baked to evaporate the laminating liquid and thence to cutting means such as rotary knife 70 and anvil 72 where the individual sandwiches are cut to length. Each sandwich is then guided by a guide 74 and stop 76 onto a strip or web comprising the retaining element 20 which may be pre-formed with appropriate openings and edge configurations and coated with a suitable adhesive. The remaining assembly steps include adhering retaining element 20 to the sandwich comprising photosensitive and second sheets 12 and 14 and attaching a container of processing liquid thereto. It has been found that prelaminating elongated strips of the photo- and image-recording sheet material and then severing them to the desired length has the added advantage of delaminating, or at least weakening the bond between, the two sheets in the region in which they are cut. This includes the leading edge portions of the two elements where they are coupled to a container of processing liquid and where delamination of the elements by the processing liquid is initiated. This delamination, or weakening of the bond, by cutting occurs in a region extending inwardly from the leading edges of the sheets a very small fraction of an inch, e.g., a few thousandths, and while it has no observable effect on the lamination of the elements of the film unit, it is very effective in facilitating initiation of delamination by the processing liquid.

An alternative embodiment of the film unit of the invention is illustrated in FIGS. 4 and 6 of the drawings. In this alternative embodiment, image-receiving sheet 14 is not embossed and the space between the sheets for providing the requisite processing liquid near the margins of the image area is provided by spacing elements in the form of narrow spacing strips 80 secured between the lateral marginal portions of sheets 12 and 14. Strips 80 extend inwardly from the lateral edges of elements 12 and 14 part way to the lateral edges of opening 22 in binding element 20 defining the image area, and in the preferred embodiment shown, the inner edges of strips 80 are located in alignment with the edges of lateral edge portions 24 of binding element 20 adhered to the outside of photosensitive element 12.

The method of manufacturing and assembling the form of film unit shown in FIG. 4 is illustrated in FIG. 8 and comprises essentially the same steps as illustrated in FIG. 7 except that the spacing strips 80 are adhered to sheet 12, for example, by advancing sheet 12 and strips 80 into superposition between a pair of heat-sealing rolls 82. Thereafter the process is essentially the same, including laminating sheets 12 and 14 to one another throughout the entire area of the facing surfaces of the sheets and spacing strips by spreading a film-forming agent between the sheets and pressing them together. As in the case of the embossed image-receiving sheet, the photosensitive sheet will be laminated to the receiving sheet and/or spacing strips 80 throughout the entire inner surface of the photosensitive sheet except in narrow linear regions designated 86 immediately adjacent the inner edges of spacing strips 80 underlying the edge portions of binding element 24 at the lateral edges of the image area.

While cylindrical rolls may be employed to process the embodiment of the film unit shown in FIG. 4 including spacer strips 80, in a preferred processing system, the roll 46 which contacts sheet 14 is formed with annular grooves 88 near its ends, having a depth approximately equal to the thickness of binding element 20. Each of annular grooves 88 has a width slightly exceeding the difference in width between a spacer strip 80 and the lateral edge portion 24 of binding element 20 adhered to the image-receiving sheet 14 and is positioned to receive the edge portion of the binding element which overlaps the underlying spacer strip 80 to provide for spreading of the processing liquid, as shown in FIG. 6, into the regions between the sheets underlying the binding element and outside of the image area thereby providing a reservoir of processing liquid for assuring proper image formation to the edges of the image area.

Since certain changes may be made in the above product and method without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In the method of forming a photographic film unit adapted to be exposed and thereafter processed by a liquid processing composition distributed within said film unit including the steps of:

advancing a first strip including a photo-sensitive, image-recording layer carried on a first support sheet, into superposition with a second strip;

laminating said strips to one another by distributing a liquid including a film-forming agent in a thin layer between said strips and applying compressive pressure to said strips as the latter are being advanced into superposition;

drying the last-mentioned layer of liquid to laminate said strips to one another with a bond strength weaker than the bond between any other layers comprising said strips;

severing said laminated strips transversely to form a plurality of sandwiches;

coupling a rupturable container of liquid processing composition to each of said sandwiches along a severed transverse edge; and

securing the lateral edges and remaining transverse edge of each sandwich to prevent the escape of processing composition distributed from said rupturable container therethrough;

the improvement wherein at least the transverse edge of each of said sandwiches to which said rupturable container is coupled is slightly delaminated during said severing prior to coupling of said rupturable container thereto.

2. The method as defined in claim 1 wherein said second strip includes a support layer and a layer coated thereover which is in face-to-face contact with said first strip.

3. A method as defined in claim 1 wherein said first strip is formed, prior to lamination with said second strip, by coating on said first support sheet at least a plurality of strata comprising differently sensitized silver halide emulsions and drying said strata.

4. A method as defined in claim 1 including the steps of embossing said lateral marginal sections of one of said strips out of the plane of the medial section thereof and superposing said strips with said embossed lateral marginal sections of said one strip in contact with the other of said strips and at least a portion of said medial section of said one strip spaced from said other strip.

5. A method as defined in claim 4 including the step of pressing said strips together to adhere said strips to one another over the major portion of their facing surfaces except in narrow linear regions at the boundaries of said embossed marginal sections.

6. A method as defined in claim 5 wherein said second strip is embossed.

7. A method as defined in claim 1 including the steps of adhering relatively narrow spacer strips to said lateral marginal sections of one of said strips, superposing said first and second strips engaged between said lateral marginal sections thereof, and pressing said strips together while distributing said liquid to adhere said strips to one another over the major portions of their facing surfaces except in narrow linear regions adjacent edges of said spacer strips.

8. A method as defined in claim **7** wherein said binding element is secured to said lateral marginal sections of one of said first and second strips in overlying relation to said spacer strips and said linear regions and to the other of said first and second strips in overlying relation only to said spacer strips.

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