

Feb. 22, 1966

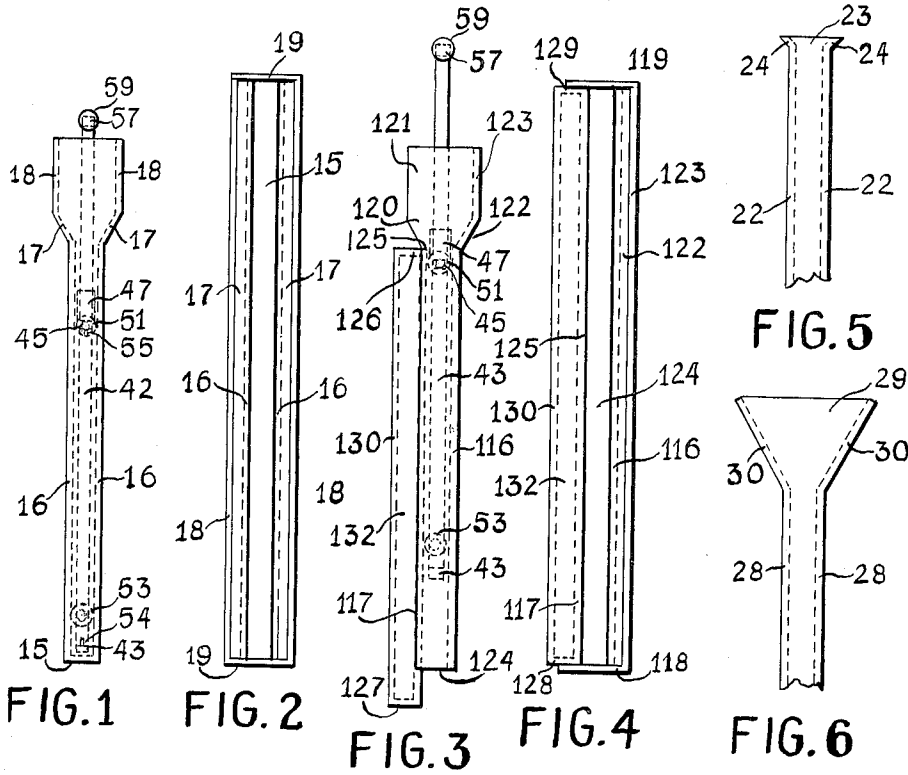
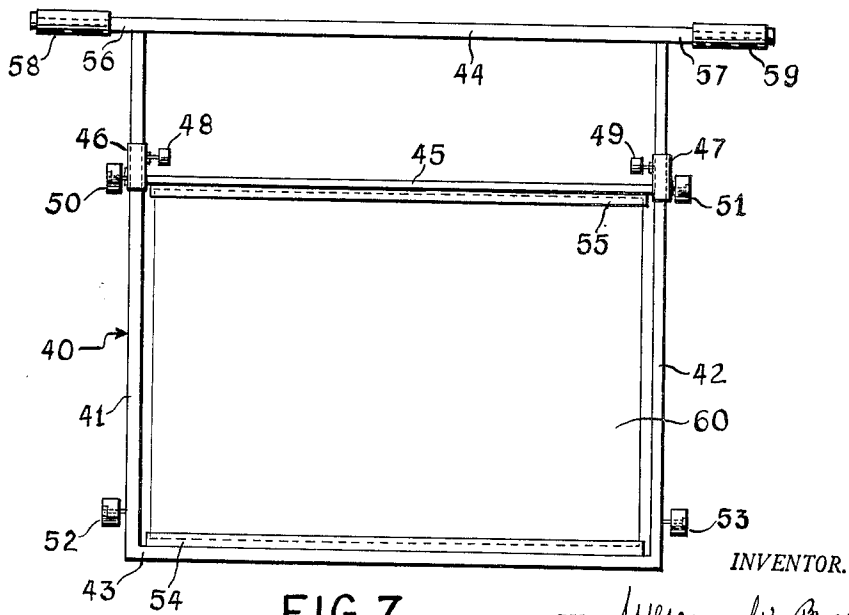
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3,236,649

PHOTOGRAPHIC PROCESS AND APPARATUS

Filed Aug. 29, 1960

3 Sheets-Sheet 1



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Feb. 22, 1966

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PHOTOGRAPHIC PROCESS AND APPARATUS

Filed Aug. 29, 1960

3 Sheets-Sheet 2

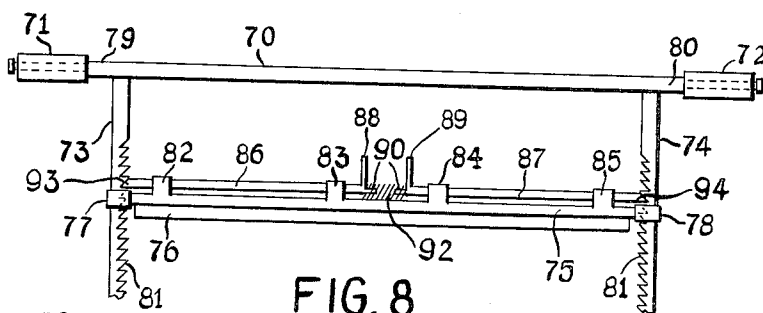


FIG. 8

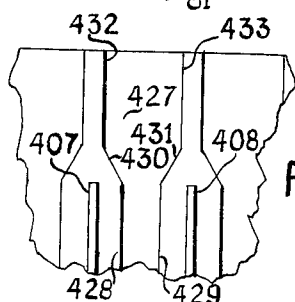


FIG. 9

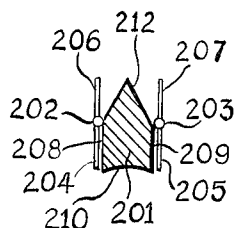


FIG. 10

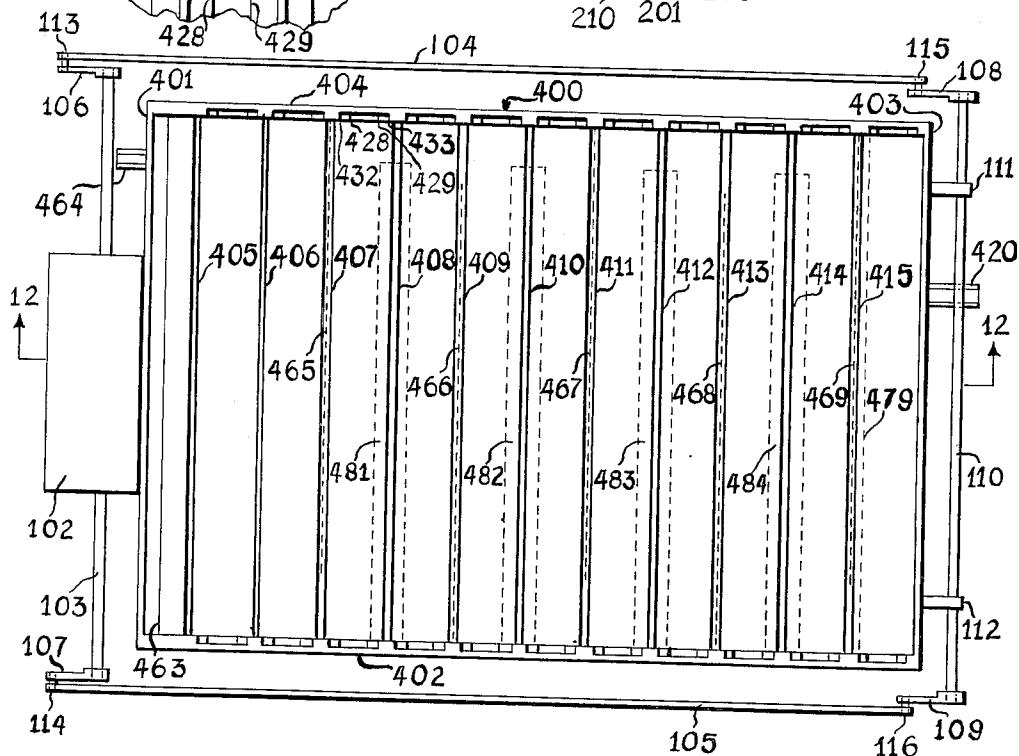


FIG. 11

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3,236,649

PHOTOGRAPHIC PROCESS AND APPARATUS
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Filed Aug. 29, 1960, Ser. No. 52,524

9 Claims. (Cl. 96—50)

This invention relates to method and apparatus for the treatment and processing of photographic sheet materials. Particularly, the invention is concerned with an improved method and apparatus for the processing of multilayer color materials, permitting the obtention of consistent, reproducible results in inexpensive, simple equipment.

Fully automatic equipment for the processing of photographic materials has been devised and is commercially available. Such automatic equipment has found ready acceptance in the commercial processing of color film and paper base material and has become indispensable in large-scale commercial operation of the various color processes. Mostly these commercial machines are designed to process large, continuous rolls of film or paper base material and have all the provisions necessary for a close control of the many variable in the process such as accurate temperature control, exact timing of the various steps of the treatment in the processing solutions and in the intermediary and final washing steps, control of the composition and effectiveness of the processing solutions, especially of the developer solutions.

The initial high price and the adaptation of the machines to the handling of large quantities of material, generally in the form of continuous rolls of film or paper base material make this type of equipment unsuitable for the amateur photographer and for the customs finisher, who handle only small quantities of materials and particularly individual sheets of precut color materials at a time.

For the handling and processing of quantities of pre-cut sheet materials in commercial finishing operations, tanks and associated special equipment have been devised and adapted to the requirements of commercial use. However, the initial investment in this specialized equipment is still high. This in conjunction with the relatively large space requirements make also this equipment unsuitable for the amateur photographer who may wish to process only an occasional few sheets of material in one session. The tanks used in this processing equipment have, by necessity, the width and height of the largest sheet to be processed therein, with a resultant liquid capacity of several quarts or gallons, depending on the maximum size of the sheets which they are designed to handle. Regardless of the number of sheets to be processed, whether it is one or a few or a hundred, the tanks must be filled to capacity with the rather expensive processing solutions. Though reuse of the solutions is possible, extended storage, particularly of the sensitive developer solutions, will change the processing characteristics and may in extreme cases render the solution unsuitable for later critical work.

Time consuming adjustment of the temperature of the processing solutions in the tank is required, or, in the alternative, large water baths and expensive temperature control devices, water mixing valves and other equipment must be provided if the temperature of the processing solutions is to be maintained constant and at the accurate level over the duration of each processing session which may extend over many hours.

Accordingly, the Eastman Kodak Company, a major manufacturer of photographic color materials, recommends in its "Ektacolor Data Book" (Kodak publication No. E-66, 1958) the so-called tray-processing method for use by the amateur photographer. The main advantage of this method is that at least some components of the required equipment are usually available to the amateur darkroom operator and only an additional reasonable investment will complete the equipment needed for the complex color processes. This method permits the obtention of satisfactory, good quality color prints and films of any desired size. However, due to the great number of steps forming part of the color processes and due to the intrinsic size of the flat trays, the space requirements are considerable even with trays accommodating only medium sized sheet materials such as those of the standard 11 by 14 inches size color printing paper. Accurate temperature control is difficultly to achieve without the use of bulky water baths, automatic water mixing valves or accurate control of the temperature of the darkroom at the desired 75° F. level. The various batches of wash water require separate temperature adjustment unless a continuous source of temperature controlled running water from a water mixing valve or similar expensive equipment is available. All this adds to the required initial investment, space requirement and complexity.

In the practice of the tray process, the operator carries the sheets through a multiplicity of steps constantly controlling and adjusting temperature, tilting trays and shifting prints at accurate time intervals within the tray and from one tray to the next. This must be carried out at exact reproducible processing conditions from one print to the next, from one batch to the next, and from one processing session to the following which may be spaced days, weeks or months apart. Only absolutely accurate control of all processing conditions guarantees pleasing results. All the processing variables must not only be accurately maintained but also reproducible because generally positive printing processes such as the Ektacolor printing process are based on empirical exposure and filter data which are established and recorded in preliminary runs or which are taken from the results of prior processing sessions.

Because of the exposure to air of a large surface area of the air sensitive developer in the tray method only fresh developer should be used in the interest of reproducibility. This adds to the cost of the process because it will be rarely possible to exhaust the required quantities of the expensive processing and developing solutions applied in any one session of the tray process. The operator cannot avoid contacting the processing solutions by his hands. Because of possible irritation the manufacturer recommends the use of rubber gloves with the resultant inconvenience, loss of feel, etc.

This and many other complications encountered in the operation of the tray process make it apparent that completely satisfactory results will be achieved only by the highly skilled and most versatile operator. The average amateur photographer who occasionally likes to do some darkroom work and who wishes to produce, for his own enjoyment, small numbers of highest quality, pleasing and satisfying colorprints from his own negatives to his own taste and who does not have the time and inclination of acquiring all the skills and experience, to become completely expert in the tray processing method, will not be attracted by the available method.

It is therefore the primary object of the present invention to provide a simple, semiautomatic process for the treatment and especially for the development of photographic sheet materials. It is a further object of the invention to provide a conveniently practiced process for the production of photographic prints on precut color sheet materials, which process is particularly adapted to the requirements of the less skilled photographic amateur. Another object of the invention is the provision of a photographic process which lends itself to automatic or

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semiautomatic operation and control of the treating conditions with a maximum of reproducibility of the final product.

A further object of the invention is the provision of an apparatus which is inexpensive, space saving and adapted to semiautomatic operation of multistep color processes, with considerable savings in the consumption of treating solutions and chemicals. Still another object of the invention is the provision of an apparatus which permits the operator to maintain reproducible, preset operating conditions with a minimum amount of attention during the photographic treating operation.

Other objects of the invention will become apparent from the following description and from the accompanying drawings. Generally, the objects of the invention are accomplished by a process which comprises contacting a plane sheet of photographic material with a quantity of photographic treating solution in which process the sheet of photographic material is, while substantially in vertical orientation, inserted into a thin vertical layer of the treating liquid and the plane configuration of the sheet is maintained substantially unchanged while the sheet is contacted and treated with the liquid.

The process may readily be put in practice in the novel device and apparatus provided by the present invention. The device comprises a vessel which basically forms a rectangular parallelepiped standing in vertical orientation, on one of its narrow sides with the upper opposite narrow side being open. The rectangular parallelepiped has a width and height at least slightly larger than that of the sheet of the maximum size to be processed therein, while its thickness is only a small fraction of the size of either one of the other two dimensions. The ratio of this fraction will vary and depends in part on the maximum sheet size which it accommodates and on the number of sheets one desires to treat in the vessel with one filling of the treating solution, and last not least on the treating capacity of the solutions used in the treatment. Generally, for purposes of the amateur photographer, the thickness or smallest dimension of the parallelepiped need only be one sixth and preferably less than one tenth and most advantageously less than one twentieth based on the height of the parallelepiped or the vessel, respectively.

Furthermore, the invention comprises a novel wash-vessel of dimensions and appearance similar to the treating vessel which permits a continuous stream of water to pass through the vessel to serve as the medium to wash a photographic sheet when inserted therein. The water wash-vessel is basically a rectangular parallelepiped of inside dimensions and orientation identical to those of the treating vessel with the distinction that in the water wash-vessel both the narrow bottom and narrow top sides are open. Included in the scope of the invention is also a novel support and holding means for the plane sheet adapted to be used in conjunction with the treating and washing vessels of the invention. The treating and/or wash-vessels may be inserted, in series in vertical, parallel arrangement, in a composite water bath, which likewise forms part of the invention. The water bath is preferably designed such that it accommodates the required number and type of vessels (of identical basic dimensions), one for each step of an intended multistep photographic treatment, such as the eleven step Kodak Ektacolor Positive Paper Printing Process which comprises in this order the steps of treatment in the first developer, a stop bath, a first fixing bath, a first washing bath, a bleaching bath, a second washing bath, a hardener and fixing bath, a third washing bath, a second hardening bath, a fourth washing bath and a buffer solution.

Further embodiments and modifications of the invention will become apparent in the following detailed description and drawings. The accompanying drawings show various modifications of the apparatus of the inven-

tion and extensions thereof without being restricted thereto.

FIG. 1 represents a vertical elevational view of the narrow side of a treatment vessel and FIG. 2 a top plan view of this vessel forming part of the present invention. The essential lower portion of the vessel is a rectangular parallelepiped, which is open at the top and which forms the receptacle for the treating liquid and the sheet of photographic material to be inserted therein. FIG. 1 shows also a side elevational view of a rectangular support inserted into the treating vessel in operating position (low position).

FIG. 3 is a vertical elevational side view and FIG. 4 is a top plan view of a wash-vessel useful in the process and apparatus of the invention. The wash-vessel likewise comprises as the basic component a rectangular parallelepiped standing on one of its narrow sides, with both top and bottom being open. A rectangular support is shown in a side elevational view, inserted in operating position (high position).

FIG. 5 is a vertical elevational view of the upper portion of a modified vessel, which likewise comprises the upright, rectangular receptacle for the treating liquid and sheet material.

FIG. 6 depicts a vertical elevation of still another modification of the upright vessel of the present invention.

FIG. 7 shows a vertical front elevation of a rectangular support, adapted to be inserted in any of the treating or wash-vessels of the present invention.

FIG. 8 is a front elevation of the upper portion of a preferred modification of the rectangular support.

FIG. 9 is a detailed view of an upper portion of the inside of a side wall of the bath depicted in FIGURES 11 and 12 with a recess designed to receive and localize the treating or wash vessel of the invention when inserted in the water bath.

FIG. 10 depicts a cross section of a portion of a modified adjustable bar member, having a pair of clamps, which may with advantage be used as a component in the rectangular support.

FIG. 11 is a top plan view of a composite multi-vessel apparatus for the treatment of photographic sheet material in a multistep process.

FIG. 12 is a vertical section of the apparatus of FIG. 11 taken along line 12.

The novel process and apparatus of the present invention may be widely used in photographic liquid treatments and especially in the development and fixing of flexible or rigid photographic positive and negative sheet materials such as films, reversal films, plates and paper base materials. The process and apparatus of the present invention are especially useful and beneficial in their application to the more recently introduced photographic color processes and they are particularly adapted to the processing of color positive and negative multilayer color sheet and cut films as well as the processing of multilayer positive color printing materials in sheet or cut form particularly those on a paper base such as Kodak Ektacolor Paper (formerly called Type C positive printing paper). My invention includes many modes of operation and many modifications of the process and apparatus which makes it particularly suited for application in the said multistep color developing processes.

Prefatory to a detailed description of the process and apparatus of the invention some of the more important terms used herein will be explained in order to provide a better understanding of the nature of the invention and of its scope.

The process of the present invention is primarily concerned with the treatment of photographic sheet materials, i.e. such materials which have definite size limitations. The sheets may be square or rectangular pieces of photographic material. Generally one dimension in the plane of the photographic sheet materials is larger than the

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second dimension. This applies particularly to the commercially sold photographic sheet materials which mostly have an oblong shape with somewhat greater length than width. The two dimensions may differ by an amount which is in the range from 10 to 50 percent of that of the shorter dimension. In exceptional cases the longer dimension may be up to twice the length of the shorter one and even a small multiple of the smaller dimension e.g. up to 3, 4 or 5 times the length of the smaller dimension. However, if the longer dimension exceeds the smaller dimension by more than 5 times its length, such material will, for the purposes of the present invention be considered as a continuous material rather than a sheet material. The benefits and advantages of the present invention will be realized to the best advantage with materials which have a length to width ratio in the range between 2 to 1 and 1 to 1. Irregular, non-rectangular shapes such as circular, oval, polygonal or other shapes may also be employed.

The sheet material useful in the present invention may be obtained in precut form such as the commercial cut films and sheets of photographic paper or it may be cut from continuous rolls at any time before the material is subjected to the treating process of the present invention.

The photographic sheet material may be of any desired nature or composition and may serve any desired purpose. It may be positive or negative or reversal material, black and white or color, single layer or multilayer. It may be contained on any desired base material. To mention a few, the base may be cellulose acetate, nitrocellulose, polyester such as poly (ethyleneterephthalate) or paper, or glass. The base may be opaque or transparent as the case may be. As stated herein before, the invention is particularly adapted to be used with the positive color printing processes such as the processes recommended for the printing of color negatives on Kodak Ektacolor paper, where it offers the greatest and most striking advantages and benefits over the processes and apparatus of the prior art.

The term "treating liquids" comprises a multitude of liquid media which are capable of accomplishing a desired change or alteration in the photographic sheet material. They are mostly aqueous solutions containing in a dissolved state suitable chemicals or combinations of chemicals which are capable of developing latent pictures or designs contained in the light sensitive layer, or layers, or which are capable of fixing, bleaching, stabilizing, buffering, or performing many other photographic steps. They may also be used to deposit certain chemicals on or in the sheet materials (in the photographically active layer or layers or in the base), such as dyes, metals or metal ions, couplers and other organic intermediates, or they may be capable of dissolving or removing one or more constituents or impurities contained on or in the sheet material or in the photographically active layer or layers. Thus also water (tap water or distilled water) with or without suitable additives is, for the purposes of the present invention a treating liquid. Sometimes also organic solvents or other non-aqueous liquids may be the main constituent of the treating fluids useful in this invention. The term "plane" as used herein means that the sheet material is substantially flat falling into a plane or closely approaching this ideal configuration. A slight deflection or curvature in one or two directions does not detract from the operativeness of the process and apparatus of the invention.

The terminology "maintaining the plane configuration" is meant to denote that no substantial changes of the plane or substantially plane configuration, as defined above, should be permitted to occur or to be made during the treatment in the liquid medium. It cannot always be avoided that slight deformation takes place, as by the fact that the sheet material may change its dimensions when it is contacted with the treating liquid. This is particularly true with paper base materials which have a tendency to

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expand and swell when they are contacted with water or aqueous liquids. The deformation caused by the extension or shrinkage of the sheet material is tolerable and does not negatively affect the operation of the invention and is therefore to be considered as falling within the realm of the terminology "maintaining the configuration."

It need not be mentioned that generally all areas of the sheet material must be contacted with the treating liquid in order to achieve uniform results. Depending on the circumstances the sheet material may be held completely submerged in the treating liquid for the total duration of the individual treatment. This is generally preferred. It is, however, possible to intermittently lift the sheet material out of the treating liquid, partially or completely, followed by submersion and so forth. This mode of operation will be preferred, however, only if the treating liquid or the treated photographic layer or layers are not sensitive to air, particularly to oxygen which in some photographic processes would affect the photographic layer and/or the treating fluid contained thereon or therein, causing cloudiness or discoloration of the picture area or other undesirable effects and side reactions. Relative movement of the sheet within the treating liquid has the same beneficial effect of exposing the surface to continuously new quantities of treating liquid without exposing the photographic layer to the undesirable effects of the atmosphere.

As is apparent, the plane photographic sheet which will be called hereinafter "photographic sheet" or "sheet" must be inserted into the treating liquid in vertical or substantially vertical orientation.

FIG. 1 of the accompanying drawing depicts a vertical elevational view of the narrow side and FIG. 2 a top plan view of a vertical vessel which may be used with best advantage in the operation of the process of the present invention. The vessel is defined by narrow bottom 15, wide vertical wall sections 16, adjoining thereto slanted wall sections 17 and joined thereto vertical wall sections 18 and narrow vertical walls 19. Wall sections 16 and the lower portion of narrow vertical walls 19 form the narrow vertical portion of the vessel and wall sections 17 and 18 together with the upper wide portion of vertical walls 19 form the funnel-like extended upper portion of the vessel.

Another modification of the vertical vessel is shown in FIG. 5 which is a vertical elevational view of the upper portion of the vessel. The lower portion of the vessel is defined like that shown in FIG. 1 by wide vertical side walls 22, narrow vertical side walls 23 and a narrow rectangular bottom (not shown). The upper portion of side walls 22 is flared outwards continuing as short flanges 24.

Still another modification of the vertical vessel is shown in FIG. 6 which represents a vertical elevational view of the upper portion of the vessel. The lower portion of the vessel is defined by wide vertical wall sections 28, narrow vertical wall sections 29 and a rectangular bottom (not shown). The upper portion of side walls 28 is angled outwards to continue as slanting wall sections 30 which together with the upper widened portion of the vertical walls 29 form a trough-like widened upper section super-imposed on the lower, narrow and rectangular portion of the vessel.

Generally, it is preferred that only the lower, narrow portion of the vessel is filled with the treating solution. The upper widened portion serves as a reservoir for the liquid displaced by the photographic sheet and the holding means or supports, if such are used. The widened portion also serves as protection against liquid splashing around upon removal or actuation of the sheet and its support in the liquid. As is readily apparent, the upper widened portion of the vessel may be dispensed with, as is shown for instance in FIG. 5, if splashing and loss of the treating liquid is of no great concern. Conveniently, this type of the vertical vessel is not filled to the top to leave at least some room for the liquid displaced upon the insertion of

the sheet and its support. The embodiments of the vessel as shown in the drawings and described hereinbefore are merely exemplary. Many variations, particularly curved configurations (in cross section) of the upper portion and similar construction may be readily adapted for use in the present invention.

In the operation of the process of the invention the photographic sheet may be simply inserted into the vessel without any special support or holding means. However, insertion and removal of the sheets, particularly of the flexible kind, is rather difficult and inconvenient, if not assisted by some kind of holding means. It is therefore preferred to support the sheet material in some suitable fashion. Depending on the nature and stiffness of the material, wire baskets or clamps containing the sheet and having dimensions adjusted to the particular dimensions of the vertical vessel may be employed as the means facilitating insertion and removal of the sheet from the vertical vessel. This type of support, however, is not recommended with flexible materials such as sheet film and particularly paper base materials because of the considerable risk of scratching and otherwise damaging the soft surfaces of the photographically active layers of the sheet materials.

I have found that frame-like structures which securely hold the photographic sheet in the desired plane configuration, permit convenient operation of the process and pleasing, satisfactory results. A preferred modification of the frame-like support, specifically adapted to the requirements of the present invention is shown in FIGURES 1, 3 and 7 of the accompanying drawings. FIG. 7 is a vertical front elevation and FIGURES 1 and 3 show the narrow side in elevation. The support 40 is a substantially rectangular frame formed by two vertical parallel bar-like members 41 and 42, lower horizontal bar-like member 43 and upper longer bar 44 which is joined to the top ends of bars 41 and 42, extending outwards to the left and right. Extensions 56 and 57, thus formed are provided with wide rollers 58 and 59 respectively, which are rotatably contained thereon. A fifth bar-like member 45 is joined to collars 46 and 47, which in turn are slideably contained on vertical bars 41 and 42. Screws 48 and 49 are provided in each of the collars, facing each other. Roller 50 is provided rotatably on the left side of collar 46 and roller 51 on the right side of collar 47 forming an extension of movable, horizontal member 45. Rollers 52 and 53 of similar dimensions are provided, likewise rotatably, in corresponding positions, facing away from the frame, at the outside of the lower portions of vertical members 41 and 42 respectively. Clamp 54 is joined to lower member 43, facing upwards and clamp 55 is joined to movable bar 45, facing downwards. The manner in which the support 40 is employed in the process of the present invention comes readily to mind from the foregoing description. Opposite edges of the photographic sheet 60 are inserted into clamps 54 and 55 to hold it in place and to maintain its plane configuration all through the treatment. Bar member 45 is slideable and its position in the frame may be adjusted by temporarily loosening screws 48 and 49, sliding the bar in the desired position and arresting the bar in this position by tightening the screws. This procedure permits ready adjustment of the distance between the clamps so that any desired size sheet may be securely supported in the frame up to the maximum size for which the support is designed.

As shown in FIG. 1, the support is inserted in vertical orientation into the vertical vessel. Rotatable rollers 50, 51, 52 and 53, which have a diameter slightly smaller than the internal width of the vessel between wide walls 16, keep the support and thus the sheet contained thereon (not shown in FIG. 1) centered and parallel to the walls 16 of the vertical vessel. The rollers facilitate insertion into and removal from the vessel of the support and permit trouble free intermittent vertical reciprocation of the support with the sheet contained thereon. Extensions 56 and

57 and the rollers 58 and 59 may serve as the handle to facilitate insertion, reciprocation and removal of the support from the vessel.

Clamps 54 and 55 may be of any desired construction, adapted to the design and requirements of the present invention. The clamps may be of the type described in my copending application Ser. No. 23,313, and particularly spring loaded clamps which extend nearly over the full width of the frame.

The strip of material along the edges of the sheet which is permitted to be covered by the upper clamp member or claw is usually kept as narrow as possible, the only criterion being that a firm, secure grip is assured. Thus only a minimal portion of the sheet material, usually no more than about one millimeter to several millimeters wide, is covered and thus protected from the action of the treating liquid during processing. The narrow, untreated strips may be removed from the finished sheet, for instance, by cutting them off. The removal of any part of the sheet after completion of the treatment may, however, be unnecessary, if one or both claws of each clamp or clip are provided on their sides facing each other with small protrusions and especially with a row or pattern of dot-like protrusions which make contact with the surface of the clamped-in edges of the sheet. With sufficiently high pressure exerted by springs or similar means, the sheet will be held in place, while the minute areas covered by the protrusions will be reached by the treating liquids, by penetration or by diffusion. If the usual white, unexposed edges are provided all around the sheet, the contact points should fall into this narrow strip. Any undertreatment of the contact points would generally be of no detriment to the finished product. If, in exceptional cases, treatment faults should become apparent during extended storage, the unexposed edges may simply be cut off all around with no damage to the useful picture area.

Any other type of clip or clamp may be employed, preferably with suitable adjustment having been made to provide for the special requirements of the process and apparatus of the present invention. It is, for instance, possible to provide one or more narrow clips or clamps, preferably slidably, one each vertical bar member of the frame to hold each of the opposite edges of the sheet. If desired, other means for fastening the photographic sheet to the support may be used instead of the clamps, such as adhesive tape which may be applied to the backside of the edges of the photographic sheet as well as other means as they have been described in detail in my copending application Ser. No. 23,313.

The rectangular support or frame may be designed without the rollers 50, 51, 52, 53. Small protrusions, e.g. of a slippery plastic material may serve the function of the rollers. If desired, the vertical bar members 41 and 42 may directly serve as the means to guide the rectangular support in the narrow vertical vessel. In another modification of the rectangular support of this invention, the vertical bar members are designed as two-piece telescoping bars, which by simple extension or shortening permit the desired spacing of the horizontal bars with the holding means contained thereon. Each of the horizontal bars is connected with or joined to the corresponding components of the two-piece telescoping vertical bars. Other arrangements and modifications of the rectangular support come readily to mind and are within the scope of this invention.

Another, preferred, embodiment of the rectangular support with more convenient means for adjusting the relative distance between the holding means is shown in FIG. 8 which is a front elevational view of the upper portion of the modified rectangular support. Upper horizontal bar member 70 having joined to it vertical bar members 73 and 74 and having horizontal extensions 79 and 80 and rollers 71 and 72 rotatably contained thereon is very similar to that shown in FIG. 7. The opposing faces of vertical bars 73 and 74, i.e. the sides of the bars facing each other, are provided with a multitude of teeth

81. Adjustable bar 75 is joined at its ends with collars 77 and 78 which are slideably contained on horizontal bar members 73 and 74 respectively, including teeth 81. To the top of adjustable bar member 75 are joined circular sleeves 82, 83, 84 and 85 in spaced arrangement away from the center. The sleeves are designed to slideably receive rods 86 and 87. The rods are flanged upwards towards the ends pointing to the center of adjustable bar 75. The vertical portions of the rods, thus formed, are flattened to form levers 88 and 89. Small extensions 90, running in the general direction of the rods are designed to receive spring 92, which by pressing on the opposing ends of the rods pushes the rods against toothed vertical bars 73 and 74, respectively. The outer ends 93 and 94 respectively of rods 86 and 87 are pointed and shaped to fit into the notches left between the teeth of vertical bars 73 and 74. They are held therein by the outward pressure exerted by spring 92. To release and relocate adjustable bar member 75 with clamp 76 mounted on its underside it is only necessary to press levers 88 and 89 together, which pulls pointed ends 93 and 94 away from the geared horizontal bar members 73 and 74. By sliding the adjustable bar upwards or downwards and releasing the levers 88 and 89, the horizontal bar is arrested in any desired vertical position. Markings provided on horizontal bars 73 and 74, indicating the various distances in centimeters or inches and fractions thereof assist in finding the proper setting for each desired sheet size. The modification of the rectangular support just described is particularly beneficial in applications where constantly varying sizes of photographic sheets are processed in accordance with the present invention.

The insertion and operation of this type of support in the vertical vessel corresponds substantially to that described hereinbefore. If desired, rollers corresponding to those shown hereinbefore may be provided to assist in the insertion and reciprocation of the support within the vessel. The supports described in the foregoing are capable of receiving and holding one or two photographic sheets at a time. Two sheets may be inserted provided they are of the same width (distance between the clamps or holding means) and contain a photographically active layer on one side only. They may be simply laid together back to back and inserted in this manner into common holding means. However, when treated in this manner, it is sometimes difficult to remove, in the short time available for this purpose, the treating liquid which enters behind and between the sheets. In many treatments this may not necessarily be of detriment to the results obtained in the process. However, in some of the more sensitive photographic processes, the contamination of successive baths with the liquid of the preceding one would be considered as undesirable.

The modification of the rectangular support shown in FIG. 10 of the accompanying drawings does not have this shortcoming. FIG. 10 is a cross-section of a modified adjustable bar member with a pair of clamps pointing with their open end downwards, which bar member may be part of a rectangular support of the type shown hereinbefore in FIG. 7. In cross section, the adjustable bar member 201 represents a modified rectangle with a triangle 212 joined by one of its sides to the top side of the rectangle. The lower side of the rectangle is curved to form indenture 210. Pivots or hinges 202 and 203 are provided at the lines where the sides of the triangle and the rectangle meet. Holding members 204 and 205 are pivotally provided in pivots 202 and 203 pointing downwards, substantially parallel to the vertical sides 208 and 209 of the rectangular portion of the bar member. Holding members 204 and 205 continue upwards beyond the pivots 202 and 203 to form levers 206 and 207. Springs (not shown) press the levers away from the bar. Depression of either of the levers towards the triangular portion of the bar member opens the respective clamp permitting the insertion of the upper edge of the photo-

graphic sheet. Release of the lever permits the spring to close and hold the photographic sheet securely in place.

The lower horizontal fixed bar member of this modification of the rectangular support is constructed in similar manner. It is joined to the vertical bar members with the triangular portion pointing downwards. When both photographic sheets are inserted into the rectangular support, the treating liquids, upon insertion, can readily flow into the space left between the backs of the sheets by entering on the sides. Upon withdrawal of the support from the treating vessel, the liquid contained between the two photographic sheets flows out to the open sides of the arrangement. The last traces of liquid training from the backside of the sheets collect in indenture 210 of the lower reversed bar member and can be removed therefrom by light tilting of the support toward one of its sides. As can be readily seen the double clamp arrangement described hereinbefore permits the simultaneous treatment of two sheets without the risk of undue contamination of successive treating baths or under-treatment of the backsides of the photographic sheets. Only a fraction of the treating liquid, normally required in the conventional tank or tray development of the same size sheets, is required with the expedient of this invention of employing the vertical vessel which is very thin in relation to its height and width, in combination with the rectangular support. The saving in the amount of treating liquid required for each individual treatment of the photographic sheet material is of particular importance if only one or a small number of sheets are to be treated at one time or in one session with processing liquids which cannot readily be stored without being subject to deterioration or other undesirable changes.

In its application to the color processing techniques the vertical vessel is thus with advantage designed and dimensioned such that it accommodates an amount of the treating liquid which will safely process only the small number of sheets of the color material which is usually processed in the short sessions, say four, five or six sheets of the maximum size for which the apparatus is designed. If more than this predetermined number of sheets is to be processed, the liquid may be simply discarded and fresh liquid is placed into the vessel, or it may be replenished by the addition of the chemicals provided for this purpose. In multistep processes each vessel may be dimensioned for the particular effectiveness and treating capacity of the liquid for which it is designed, so that after each session or after the treatment of the predetermined number of sheets all the solutions or processing liquids used in the particular process may be discarded. This expedient has the additional advantage—aside from the savings possible by the complete exhaustion of each of the processing liquids to their safe limits—that always fresh processing liquids are used. This is an important factor in achieving absolute reproducibility of the results, particularly in the complex and sensitive color developing processes. It removes the need for the storage of partially used liquids in separate containers, or the risk of contamination and spoilage prevailing when the used portions of the treating liquids are poured back into the containers containing the supply of the fresh solutions. Thus the above described arrangement and steps of the present invention contribute considerably to the simplification of complex, multistep photographic processes and particularly also of the multistep color developing methods presently in use.

The following example demonstrates the requirements of processing liquid in a practical application of the narrow vertical vessel of the present invention. The data are given in approximation and rounded figures and apply to a vessel and support accommodating an 8 x 10-inch sheet. Specifically, the data have been applied to the first developing step in the Kodak Ektacolor Paper printing process. This process is described in detail in the Kodak Publication No. E-66 (Printing Color Nega-

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tives) First Edition 1958. According to this publication three and one half gallons of the first developing solution are capable of developing 90 sheets of the 8 x 10-inch size without the use of replenishers. Replenishment extends the capacity to 390 sheets of the same size. Correspondingly, approximately 150 ccm. of the solution are required for the development of one sheet of this size without the use of replenishers. A vertical vessel suitable for the treatment of the 8 x 10-inch photographic sheet, in accordance with the present invention is approximately 30 cm. wide and 8 mm. thick (inside dimensions). To permit complete submersion and intermittent vertical reciprocation of the photographic sheet of this size the developing solution should stand at least 26 cm. high. Approximately 600 ccm. of the liquid are required to fill the vessel to the indicated height. This amount of liquid permits the development of approximately 4 sheets of the 8 x 10-inch size paper sheet without replenishment. This number can be increased to up to approximately 15 sheets if replenisher is added to the usual manner.

The thickness of the vertical vessel may be kept even smaller, if it is desired to reduce the amount of developer required in any one session even further. In the device having the approximate dimensions given hereinbefore, about four 8 x 10-inch sheets can safely be developed in the first developing step of the said color process with one filling of fresh solution and without replenishment. As regards other processes or steps in a series of treating steps, the internal thickness of the vertical vessel may be adjusted to provide the proper volume correlated to the capacity of the solution or liquid in question. Depending on the circumstance and the intended use, the vessel may be designed and proportioned such that the internal thickness is as narrow as a few millimeters or it may be up to several centimeters if larger numbers of sheets are to be processed in one session without renewal or replenishment of the treating solutions.

However, in order to utilize the advantage of the present invention, internal thicknesses of the upright vessel ranging from about 0.4 cm. to about 2.0 cm. are preferred. This preferred range is relatively independent of the maximum size of the sheets which can be treated in any particular vessel. Generally, economical reasons make it desirable to stay in the lower range of about 0.4 to about 1.2 cm. If, for any reason more than the above stated minimum of developer or other treating solution is desired to be used the liquid may be filled to a higher level, as is possible for instance in the vertical vessel of the type shown in FIG. 1 or FIG. 6. As has been shown hereinbefore, the rectangular support with the sheet or sheets contained thereon may be vertically reciprocated to assist in the provision of a uniform, thorough treatment of the sheet in each treatment step.

If desired, the actuation of the rectangular support may be made automatic for instance, by the utilization of a motor in combination with mechanical means, known per se, which means translate the rotational motion of the motor into a reciprocating vertical motion. In either the manual or the automatic actuation, a stroke of one centimeter or less to 10 cm. or more, depending on the size of the sheet, the dimensions of the vessel and the nature of the treatment will generally be satisfactory. A stroke in the range from about 2 cm. to 6 cm. was found in most cases to give in combination with the stirring action caused by the special design of the rectangular support most satisfactory turbulence to produce excellent, reproducible results.

An embodiment of the automatic actuation which was found to be particularly beneficial in the multistep treatment in a multiplicity of the upright vessels is shown in FIGURES 11 and 12. FIG. 11 is a top plan view of a composite multi-vessel apparatus useful in the process of the present invention. FIG. 12 is a vertical section of the apparatus of FIG. 11 taken along line 12. Motor 102 provided at the upper left wall of the apparatus drives shaft 103 to the ends of which are fixedly joined

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cranks 106 and 107. One end each of bars 104 and 105 is rotatably connected to the free ends of the cranks over crank pins 113 and 114. The ends of bars 104 and 105 on the right are movably connected to the free end of cranks 108 and 109 over crank pins 115 and 116. Cranks 108 and 109 are fixedly joined to shaft 110 which is rotatably contained in supports 111 and 112 which in turn are joined to the upper portion of the right wall of apparatus 400.

Rotation of shaft 103 by the motor causes bars 104 and 105 to carry out a composite reciprocating motion with a vertical stroke approximately double that of the length of the crank. A rectangular support of the construction shown, for instance, in FIGURES 7 or 8, if laid upon the bars will make the vertical reciprocation with the bars. The provision of rotatable rolls 58 and 59 or 71 and 72 respectively, on the upper bar of the support permits to hold the support in a fixed position, while the bars slide back and forth in the horizontal underneath the support. Thus only the vertical component of the composite horizontal and vertical movement of the bars is utilized so as to give the rectangular support the desired vertical reciprocating motion. Other automatic means of actuation may be employed with similarly good effect.

In the alternative, the rectangular support may be designed without the rotatable rolls 71 and 72 in FIG. 8. The thus modified support is fixedly suspended and the upright vessel is reciprocated vertically to bring about the desired intermittent movement of the photographic sheet in the treating solution.

The simple, automatic actuation of the photographic sheet relative to the treating liquid or of the treating liquid relative to the sheet relieves the operator from paying any attention to this part of the process. Furthermore, by proper design and proportioning of the driving and driven means a predetermined rate of relative movement is achieved which will be uniform from operation to operation. Thus the expedient of providing automatic actuation, as described hereinbefore, does not only simplify the processing of the photographic sheet material but provides also the utmost in reproducibility from sheet to sheet and from day to day, eliminating a source of inconsistency which is always present in the uncontrolled tray method.

In any of the methods described for actuating the plane sheet relative to the treating liquid or vice versa the exchange of chemicals from the active layer or layers of the photographic sheet material can be achieved in well controlled manner by adjusting the rate of relative motion to the specific requirements of the process and materials used in each instance. Once the optimum rate of movement or motion has been found or established in a given apparatus and process it can be readily maintained in absolutely the same level and effectiveness and complete reproducibility of the process and consistency of the results are assured.

As stated, each of the treating containers such as the vertical vessel may be used singly or, as is more convenient, in groups of two or more, so that subsequent steps of a processing series may be carried out in sequence without the need for replacement, before each step, of the processing liquid contained in any of the containers. The photographic sheet may thus be transferred from one vessel to the next without removing it from its support, being carried through a predetermined sequence of steps in the proper treating liquids and for the predetermined periods of time. The present invention thus provides a convenient method for multistep photographic treating operations. The benefits of this arrangement come readily to mind, if one applies the process and apparatus to the complex multistep color processes which may require up to eleven or twelve individual treating steps.

In addition to the convenience and accuracy just described, the novel process and apparatus utilizing a multiplicity of vessels offer the further advantage of requiring

a minimum of space or working area as compared with the conventional flat trays or tanks. So, for instance, requires an arrangement of eleven upright vessels, of a size which accommodates the usual 8 x 10 inch sheets, a working area of approximately 0.16 square meter in a single row arrangement which measures approximately 46 centimeters long and 34 centimeters wide. The customary flat trays for the same size of sheets require an area of approximately 11 times 0.1 square meter or a total of 1.1 square meter which is nearly seven times the area required by the new apparatus of the invention. If it is desired to place the conventional flat trays in one line, as is usually the case, a continuous working area of three meters length is required. With larger sizes of photographic sheet materials the saving in working area and floor space made possible by the novel arrangement and apparatus of the present invention is even greater.

The modest space requirements and the compactness of the multicontainer arrangement make the apparatus and process particularly suitable for use in crowded or small darkrooms or in darkrooms which are improvised in kitchens, bathrooms or closets. The small size makes for easy storage also in the small home or apartment, still giving most of the advantages of the more expensive automatic equipment heretofore available.

The compactness of the multi-vessel arrangement is in itself an important factor in maintaining proper and constant temperature within the vessels holding the treating liquids. Temperature control can readily be achieved by placing the individual vessel or any number of vessels, into one or more water baths of proper size to accommodate the desired number of processing vessels. The compactness of the water bath required for the unique vessels of the invention and the absence of an excessive free surface area assist in the maintenance of the correct temperature once it has been established, for instance, by filling the water bath with water of the desired temperature. This permits to hold any desired temperature within the processing vessels for a relatively long time and may be quite satisfactory where either short operating periods are involved or where the requirements on the absolute temperature constancy are not too critical. Another expedient for holding the temperature in the desired limits is the maintenance of the room temperature within a narrow range of the desired operating temperature. The said water bath has in this instance a moderating effect, equalizing any temporary deviations of the room temperature from the desired mean value.

However, if maintenance of the proper room temperature is not feasible or desirable, or if operation over long periods of time is desired, the temperature may be maintained by the use of additional heating or cooling means which act directly on the water in the bath. Tubing or heat exchangers which are submerged in the water bath may be used for this purpose. Depending on the desired effect, viz. heating or cooling, liquids which are warmer or colder than the desired temperature in the bath can be circulated through the tubing or heat exchangers to the extent necessary to maintain the desired temperature in the water bath and thus within the treating liquids in the processing vessels. Uniformity and accuracy of the temperature control will be assisted by stirring the water in the water bath or by circulation of the water, e.g. by the provision of a small pump within or outside the water bath.

Instead of using warm liquids to raise the temperature of the water bath to the desired level and maintaining it there, electric energy may be used with advantage for this purpose. Any type of electric heater is suitable, those of the enclosed type which can be simply inserted or submerged in the water bath are preferred. The electric heaters, the same as the circulating means and the means for supplying heating and/or cooling liquids may be controlled by a thermostat which is contained in the water bath, or at a suitable point of the circulating system. A

position in a location in the water bath where temperature constancy is most critical is preferred.

In the complex multistep color processes such as in the Kodak Ektacolor Paper process, the first developer requires the closest temperature control and is most sensitive to temperature deviations from the predetermined level. Usually absolute temperature constancy within $\pm \frac{1}{2}^{\circ}$ F. is required for uniformity and consistency of results. Placing a sensitive thermostat combined with an electric heating element and, if desired, a stirrer into the water bath close to the location of the said first developer will readily permit maintenance of a temperature in the desired range, automatically and without attention of the operator. The parts making up the said temperature control system are inexpensive and commercially available and thus do not add unduly to the cost of the equipment.

Another modification of the process and apparatus of the present invention comprises the provision of a stream of water of controlled, substantially constant temperature passing through the water bath or baths, circumflowing the processing vessels contained therein. The supply of running temperature controlled water may be taken from a conventional water heating or mixing device such as the commercially obtainable thermostatic mixing valves which automatically mix hot and cold water in the proper proportions to maintain a constant temperature regardless of reasonable temperature and pressure changes in the supply lines.

The relatively high initial cost of these automatic mixing devices, their dependency on a source of running cold and hot water and the need for an initial adjustment of the desired temperature by trial and error make it preferable to use a source of running water which is provided by a novel method and device which form part of the present invention. The novel method and apparatus do not only provide a stream of water of a predetermined, constant temperature but provide also a constant predetermined velocity of the water stream, delivering substantially equal amounts of the temperature conditioned water per time unit. Thus not only accurately controlled temperature conditions are provided in the water bath but the stream of water may also serve in certain of the steps of the multistep processes as will be described hereinafter in more detail.

The novel device of the present invention for the control of the flow rate of a stream of water comprises as the major components means which are capable of controlling the flow of water such that at all times the water passes through at a predetermined rate and means which are capable of delivering a constant, predetermined amount of heat energy to the water stream. The heat is preferably supplied by an electric heater or heating elements.

The novel water and temperature control device of the invention operates substantially on the following principles. Water taken from the ground or from the faucet of the conventional water supply lines generally has—after it has run for a certain length of time and after the water lines and other parts of the supply system, through which the running water passes have taken on the temperature of the running water—a substantially constant temperature which is usually lower than the processing temperature required for most photographic processes. Many color developing processes are adjusted to be carried out most accurately at a standard 75° F. temperature. Only in extreme cases such as in heat waves in summer will the tap water in some localities have a temperature which exceeds the recommended processing temperature just mentioned. Thus, generally the addition of heat energy will be necessary to raise the temperature of the water supply to the level of the desired processing temperature. Equal amounts of water of constant temperature require identical amounts of heat energy in order to raise the temperature of the running stream of water to a constant higher temperature. In the practical operation,

it is only necessary to measure the temperature of the water supply and determine, by simple calculation, the heat energy required for the desired increase of the temperature of the water passing at a constant, predetermined rate over the source of heat energy. As long as the three factors, namely temperature of the water supply, amount of water supplied to the heating means per time unit and amount of electrical energy supplied and converted into heat energy are kept constant, the temperature of the water emerging from the heating device will be constant and exactly at the predetermined and desired level.

The principles of this novel process of the invention can be put into practice by help of simple steps and apparatus. The first step in the process comprises opening the water supply line and taking a few readings of the temperature from time to time. As soon as the temperature of the emerging water has reached a constant level which will normally be the case after about 5 to 15 minutes running time, depending on the local circumstances and on the time of the year, a final reading of the temperature is taken and recorded as temperature A. Conveniently the thermometer indicating the temperature of the tap water is built into the water supply line.

By well-known physical principles the amount of water flowing by gravity through an orifice of given size is dependent on the hydrostatic pressure of the water at the location or level of the orifice. Conversely, at constant hydrostatic pressure, constant amounts of water per time unit flow out of an orifice of controlled size thus providing a flow of water at constant rate. By the application of this principle, viz. keeping the hydrostatic pressure of a free flowing water supply constant while the water is flowing through an orifice of a predetermined size the process of the present invention provides the desired constant flow rate of the water supply. There are several means available which permit the maintenance of a constant hydrostatic pressure directly at the orifice. Generally applicable for this purpose are the commercially available pressure valves, which by diaphragm and springs or other means provide an even, predetermined water pressure at the orifice regardless of reasonable pressure variations which might occur upstream in the water supply line. However, reliable, accurately operating instruments of this type are rather expensive and may require constant maintenance and service to keep them in top operating conditions.

In accordance with my invention a simple device may be used for the control of the rate of flow of the water. In spite of its apparent simplicity the novel device operates trouble-free for long periods of time, requiring only a minimum of care and maintenance.

The apparatus and its modifications, operating on the basis of the above described principles, have been described in detail in my copending application Ser. No. 23,313. In one modification of the apparatus a column of water of constant height is provided by suitable means. By the operation of gravity a stream of water of constant flow rate leaves an orifice contained in the lower part of the apparatus. The column of water having constant height may be provided by feeding the water to the apparatus at a rate higher than that leaving the lower orifice, the excessive amounts of water leaving through an overflow which is fixedly provided at the desired height of the column.

The proper amount of heat energy required to heat the stream of water leaving the device at a constant flow rate may be provided in various ways. Advantageous, convenient means and methods to accomplish this, preferably electrically, have been described in detail in my copending application Ser. No. 23,313 and may be employed with great advantage in the process of the present invention.

The electrical method employs with advantage a multitude of electrical heating elements the number and capacity of which is designed such that by switching in and

out from the electric circuit one or more of the heating elements any desired heat input may be generated to raise the temperature of the stream of water to the desired level. Suitable switching devices and heating chambers useful to accomplish this have been described in detail in the said copending application. This arrangement is advantageously combined with an adjuvant heating element of smaller capacity which is continuously variable, e.g. by the provision of a rheostat or variable transformer. The full capacity of the adjuvant heating element should be at least large enough to bridge the smallest step left by the above mentioned major heating elements. A capacity somewhat larger than the gap will assist in compensation, manually, or thermostatically, for unforeseen variations and abnormal deviations of the temperature of the water stream from the desired constant temperature.

In the alternative, variable transformers, rheostats, resistors, if desired in combination with thermostats or other suitable control means may be used to achieve the temperature control in the flowing stream of water, regardless of whether or not it has a constant flow rate. If necessary, automatic voltage regulators may also be included.

As stated, the heating elements may be contained in a heating chamber through which the stream of water flows, so that the water passes continuously over or by the heating elements taking up the heat energy provided by them. The heating chamber, which has been described in detail in said copending application Ser. No. 23,313 may be a self contained unit which by inlet and outlet members in combination with tubing or pipes may be connected into the flow pattern of the water of the present invention. In another, preferred, modification of the process and apparatus of the present invention, the heating chamber forms an integral part of the treating apparatus and is contained underneath the bottom of the water bath, containing a multiplicity of the narrow vertical vessels.

FIG. 11 is a top plan view of a composite water bath and heating chamber 400 and FIG. 12 is a sectional vertical view of the device of FIG. 11 taken along lines 12. The rectangular heating chamber forms the lower portion of the composite device and is defined by horizontal bottom 462, shorter vertical side wall sections 472 and 473, longer vertical front and rear wall sections (not shown) and the bottom 460 of the bath. The heating chamber thus formed is divided by slanting baffle 461 into two distinct, wedge-shaped compartments which are connected with each other by slot-like aperture 474. The lower compartment has at the left-hand side inlet 464 and is subdivided by baffles 465, 466, 467, 468 and 469 into six distinct cells, which are interconnected by rectangular openings provided in alternating fashion between the front and rear wall sections respectively and the free ends of each of the baffles. The baffles, being shorter than the wall sections 472 and 473 are alternately joined to the longer rear wall sections and to the front wall sections, respectively, as is indicated by broken lines 465, 466, 467, 468 and 469 in FIG. 11. This arrangement of baffles and correlating openings converts the lower compartment into a passageway following a zigzag pattern. Each of the central four cells, making up the central portion of said passageway contains one of the heating elements 481, 482, 483 and 484. The upper wedge-shaped compartment of the heating chamber has, on the left hand side, an outlet formed by rectangular aperture 463 in the bottom 460 of the water bath.

The stream of water, entering through the inlet 464 at the left, passes over the heating elements 481, 482, 483 and 484, in this order, as it flows along the passageway making up the lower compartment. It is thereby heated to the desired temperature as has been described in detail hereinbefore. Leaving the lower compartment through rectangular aperture 474 at the right, the water reverses its general direction of flow and passes through

the upper compartment which it leaves through slot-like aperture 463 to serve as the temperature conditioning medium in the water bath. This design and arrangement of the composite apparatus provides a streaming layer of temperature conditioned water underneath the bottom of the water bath, thus assisting in the maintenance of an accurate, even temperature in the water bath.

The use of a continuous stream of water of a constant, predetermined temperature as the temperature conditioning medium has many advantages over a stationary water bath. By suitable design of the flow path of the water stream in the water bath, for instance by the provision of baffles and separation walls, underflows, overflows and so forth the stream of the temperature controlled water can be directed in such manner that all parts of the water bath receive a constantly replenishing supply of water of the accurate temperature. Pumps for circulating the bath or stirrers and other mechanical means for disturbing or mixing the water are dispensable. The temperature conditioned stream of water is preferably introduced into the bath at a place where the highest accuracy of temperature is required. Any temperature changes and deviations from the desired accurate temperature level, which may occur in the bath due to heat losses, become effective after the water has left these critical parts of the water bath and has reached places where a minor deviation of the temperature from the mean, predetermined temperature is tolerable. This is true, for instance, in the color developing processes, especially in Kodak's Ektacolor Positive Printing Process. In this process, generally a deviation of only $\pm 0.5^\circ \text{F.}$ from the required temperature of 75°F. is tolerable in the first developer, while deviations of $\pm 1^\circ$ and sometimes up to 2°F. are permissible in the subsequent steps of fixing and bleaching etc. without adverse effects on the performance.

One of the most important advantages offered by this modification of the invention resides in the possibility of utilizing the flowing water as the medium for carrying out the various washing steps required in the more complex photographic processes. Obviously, the most accurate temperature control of the processing bath and/or of the processing liquids is futile, if the photographic sheets are subjected to intermediary washing steps at temperatures which substantially deviate from the desired, predetermined mean temperature. If the washing step is carried out without proper control of the temperature of the wash water the sheet material will assume a lower or higher temperature, as the case may be, than the desired mean temperature. Generally it will take a certain time after its insertion into the next temperature controlled bath, until its temperature is brought back to the desired level. However, chemical processes and changes are going on in the interim at an uncontrolled temperature with correspondingly falsified results and lacking reproducibility resulting therefrom. These shortcomings have, as is well known, very undesirable effects on the quality of the prints obtained in the color developing processes. Continuous sources of flowing water, of a predetermined constant temperature, are not readily available in the darkroom of the average amateur photographer. Stationary washing baths are undesirable because of their lacking effectiveness resulting from the increasing contamination which they receive during use over a period of time and because of the inherent difficulty of maintaining and controlling their temperature over extended periods of time.

The process of the present invention offers a convenient and reliable solution to this problem. The stream of temperature controlled water may be utilized as wash water for the intermediary and/or final washing steps required in any given multistep process. The "Kodak Ektacolor Paper Printing Process" requires four intermediary washing steps under closely controlled conditions. The flowing, temperature controlled water stream of the present invention offers the means to accomplish the washing in an accurate, well-controlled manner cre-

ating thus the desired reproducible operating conditions. The unidirectional flow pattern in the water bath, where the washing steps may be carried out, makes it impossible that chemicals or other materials introduced in a later step, are carried back to an earlier stage of the process with possible contamination and detrimental effects on the process. By proper interspersing of the washing steps between the preceding and the succeeding processing steps the wash water will have precisely the mean temperature between said treating steps. Thus any uncontrolled temperature changes in the reactive layers of the photographic sheets are effectively eliminated. In the most preferred modification of the invention one or more cells or chambers are provided between the vessels in the water bath through which the stream of water flows on its path from around the neighbouring vessel to the next. To effect the washing the sheet is simply transferred from the vessel to the washing chamber or cell, retained therein for a predetermined time, and thereafter transferred into the next treating vessel. The washing step may be made more effective, if the water passes over the sheet material in form of a thin layer. This provides for an increased flow velocity and thus in higher effectiveness in removing and carrying away the chemicals from the sheet material. The washing action and its effectiveness may be further increased by movement of the sheet material relative to the stream of water surrounding it. Such relative motion produces small turbulences at and around the surface of the sheet material and promotes the diffusion of the chemicals and the contact of less saturated water with the surface area of the sheet material.

A highly effective washing action may be achieved in accordance with the present invention in a preferred embodiment of the apparatus which comprises a vessel of dimensions and appearance similar to the vessel used for the processing steps described hereinbefore. However, the waterwash vessel is distinguished by the omission of the bottom and by the provision of a wide slot-like opening in the upper wall section. A preferred modification of the upright waterwash vessel has been depicted in FIGURES 3 and 4 of the accompanying drawings. FIG. 3 is a vertical elevational view of the narrow side and FIG. 4 a top plan view of the wash-vessel. The vessel is defined by wide vertical wall sections 116 and 117, narrow vertical wall sections 118 and 119. The latter are slanting outwards at the top to form a trapezoidal section 120. The uppermost portion of the walls continues in vertical direction to form an upper rectangular wider section 121 of the side walls. The wide vertical wall section 116 at the right is joined at its upper end with slanting section 122 to which is joined vertical wall section 123, wall sections 122 and 123 following the contours of and being joined to the right edge of vertical side wall sections 118 and 119. Vertical wide wall section 117 at the left extends somewhat lower down than the corresponding right section 116. Rectangular opening 124 is located at the bottom of the vessel and limited by the lower edges of wall sections 116, 118, 119 and by the inner side of longer wall section 117. The upper edge 125 of vertical wall section 117 and the inner faces of the upper portions 120 and 121 of the narrow side walls define a rectangular opening in the upper part of the vessel with its lowest edge defined by edge 125 of wall 117.

Other modifications of the water-wash vessel may be derived from the modifications of the vertical treating vessel shown, for instance, in FIGURES 5 and 6 of the drawings, by omitting the upper portion of one side wall section and the bottom of the vessel, if desired with a downwards extension of one of the sidewalls as explained hereinbefore. The elongated wall is preferably the one which provides the upper rectangular opening.

The photographic sheet material may be inserted into the water-wash vessel in much the same way as has been described with respect to the treating vessel. Advan-

tageously, the wash vessel has the same general dimensions as the treating vessel permitting the use of the identical support for the sheet material. This avoids the need for removing the sheet from its support and the sheet may be transferred from a treating vessel to the wash vessel and vice versa by simply transferring the support with the sheet contained thereon. The preferred support, described hereinbefore, may be actuated in the wash vessel to facilitate the washing by rendering the washing treatment more effective. A support of this kind is shown inserted in FIG. 3, in elevated position. The actuation of the support within the wash vessel may be accomplished mechanically and automatically in much the same manner as has been described hereinbefore.

The stream of water, effecting the washing treatment of the sheet material, may be introduced at the top by flowing it over edge 125 of sidewall 117, leaving the vessel through rectangular opening 124 or it may be introduced through the bottom opening 124 so that it leaves the vessel over edge 125. Either manner of flowing the water is satisfactory. Due to the narrow dimensions of the wash-vessel the stream of water flows at a relatively high speed over and around the sheet contained in the support. Vertical actuation of the support produces additional eddying and turbulence in the water stream, thus contacting constantly fresh portions of wash water with the surfaces of the sheet material to be treated.

Though it is generally not desirable that water carrying chemicals serves as the washing medium, it is in the present process, with its constantly flowing stream of water not a major problem. In most photographic processes, later steps are not very sensitive to chemicals used in an earlier step. This is inherently so, because it is not always possible to quantitatively remove the chemicals in intermediary washing steps and the chemicals are selected with this in mind. Furthermore, chemicals carried through from an earlier washing step usually have been washed away or are so diluted that adverse effects can be ruled out. Harmful decontamination of a processing bath or of the sheet material in an earlier stage by chemicals used in a later step is virtually impossible because of the unidirectional flow-pattern of the water in the process of the preferred embodiment of the invention. Thus, one of the gravest sources of failure or less than perfect results have been safely eliminated by the unique design and arrangement of the preferred process and apparatus of the invention. In a process like Kodak's Ektacolor Positive Paper Printing Process, the intermediary washing steps are usually relatively short. The varying durations of the other processing steps require proper spacing of consecutive runs so that overlapping or simultaneous carrying out of two or more intermediary washing steps can safely be avoided.

A composite apparatus in accordance with the present invention wherein the stream of temperature-conditioned water serves the two functions of maintaining the desired temperature in a series of processing vessels and serving also the function of the wash-water in one or more washing steps is shown in FIGURES 11 and 12 of the accompanying drawings. FIG. 11 is a top plan view of photographic treating apparatus 400 which is designed and adapted to accommodate an eleven step photographic treating process such as Kodak's Ektacolor Positive Paper Printing Process as it is presently recommended by this company. FIG. 12 is a vertical section taken along lines 12 of FIG. 11. The rectangular apparatus comprises two shorter vertical sidewalls 401 and 403 and longer vertical sidewalls 402 and 404 which form with the bottom 460 the rectangular water bath. The water bath is subdivided into eleven individual rectangular cells of equal size, which are defined by the dividing wall sections 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415 and side wall section 403 respectively, two each of these sections being coordinated with corresponding portions

of side walls 402 and 404 and of bottom plate 460 to which the divider walls are joined. Each cell is open at the top. An additional cell is formed at the left by side wall 401, divider wall 405 and corresponding portions of side walls 402 and 404, and a portion of bottom 460. This cell is likewise open at the top and communicates with the heating zone below through rectangular slot 463. All divider sections are of equal height or substantially so and terminate at a level substantially below the upper edge of the water bath. Into each of the cells may be removably inserted a treating vessel or a wash vessel to provide any desired arrangement.

In FIG. 12 are shown closed treating vessels 430, 431, 432, 434, 436, 438 and 440 of a kind depicted in FIGURES 1 and 2 and described hereinbefore in detail and wash vessels 433, 435, 437 and 439 of a type and kind as shown in FIGURES 3 and 4 and described hereinbefore. The vessels have been inserted in a number and order to accommodate all the steps of the Kodak Ektacolor Positive Paper Printing Process in the sequence the steps are to be carried out.

The water wash vessels are provided with an integral rectangular closed body 132 at their left as is shown in FIGURES 3 and 4 of the drawings. This body is formed by wall section 117 of the wash vessel to the outside of which are joined in rectangular fashion narrow horizontal top and bottom sections 126 and 127 and vertical narrow sections 128 and 129 of the same width. The opposite side is closed off by vertical wall section 130 which is joined to the narrow wall sections to complete the closed box-like body 132. The closed box-like body 132 thus formed has a width to slip-fit the space left between wall 117 of the wash vessel and any of the divider walls such as wall 408, when the wash vessel is inserted in the water bath.

To facilitate insertion and removal of the treating and wash vessels into the water bath and to insure proper centering and fixed position when inserted, the opposing side wall portions in each cell are provided with a recessed area or indenture, following the contours of the inserted vessel as is shown, for instance, in FIG. 9 and in FIG. 11 of the accompanying drawings. Divider walls 407 and 408 are part of a cell. The recessed area or indenture is defined by edges 428 and 429 which are parallel to each other and extend downwards close to the bottom of the bath and which continue upwards in the slanting edges 430 and 431 and parallel edges 432 and 433. The dimensions angles and extension of the recessed area 427 correspond to those of the treatment and/or wash vessels to permit their insertion with close fit. As can be seen either a closed treating vessel or a wash vessel may interchangeably be inserted into each pair of recessions or indentures provided in each cell or compartment. The apparatus thus provides for flexibility in the order in which the two kinds of vessels are arranged in the bath. The box-like body 132 provided at one side of the wash vessel is as can be seen in FIG. 4, somewhat recessed so that it lies closely to the inner surfaces of the narrow wall sections of the cell when the wash vessel is fully inserted, as can be visualized in FIG. 11 of the accompanying drawings. Vertical narrow side wall 119 of the wash vessel is completely recessed in wall 404 of the water bath. Narrow side 129 and wide vertical plate 130 of box-like body 132 are shown tightly fitted against wall 404 and bath divider 407 respectively, giving a substantially liquid tight seal. The actual washing area is enclosed by vertical walls 116 and 117, side wall 119 and wall sections 122 and 123, the latter rising to a level above the upper edge 125 of wall 117. The path of the water continues through bottom opening 124 and from there upwards through the space defined by the wall 116 and divider 408.

The stream of temperature conditioned water coming from the heating chamber below the water bath and entering the left rectangular cell through aperture or inlet

463 rises in this cell to the level determined by the upper edge of divider section 406 into the square cell containing vessel 430 which it underflows rising on the right side of the vessel flowing over divider 406 into the next cell containing vessel 431 and from there into the cell containing vessel 432. Thereafter the water stream flows over box-like body 132 and edge 125 of the wash vessel 433, which it leaves through bottom opening 124 to rise upwards in the right open section of the cell which it leaves by flowing over the upper edge of divider section 409 and so forth until it has passed all cells leaving the water bath through outlet 420.

Operation of the motor and actuation device as described hereinbefore provides automatic reciprocation of the support within each of the treating or wash vessels wherein it is contained. In carrying out any multistep treating process it is thus only necessary for the operator to forward the support with the sheet secured thereon from vessel to vessel at predetermined time intervals.

If desired, the square cells may be used directly for the washing of the sheet without the use of the washing vessel, if suitable supporting means and guides for the support are directly provided in the cell.

As has been pointed out the water bath may also be designed without the integral heating chamber shown in FIGS. 11 and 12 and the temperature conditioned water may be taken from any desired source including a separate heating chamber, water mixing valve and so forth.

The vessels, sectional wall divisions forming the cells, and the washing vessels and other parts making up this apparatus are preferably inserted exchangeably. This permits ready rearrangement of the parts to accommodate any other flow pattern of the stream of water and thus of the sequence of steps. The number of basic units may be higher or lower than that shown in the preferred apparatus. A similar apparatus may be combined with the eleven step apparatus if more than 11 steps are required. Or, the apparatus may be constructed in two or more units having any desired number and arrangement of the basic cells which units may be connected by tubing or pipes to permit passing of the water stream through the combined apparatus.

The operation of the apparatus comes readily to mind from the foregoing description of the apparatus and the various auxiliary devices and means. The operator opens the water supply, takes temperature reading A, adjusts the heat-input on the switching device in accordance therewith, fills the respective vessels with the required treating solutions and prepares his photographic sheet material for the treatment, e.g. by exposing the sheet in an enlarger containing the negative material. As soon as the treating solutions in the vessels have acquired the exact treating temperature he may begin with the multistep treatment. He places and fastens the sheet onto its support, inserts it into the first vessel 430 where it is left for the required length of time. From there it is transferred to vessel 431. After passage of the required time it is transferred to the next vessel and so forth until it has been treated in the last vessel, from where it is removed for drying and other after treatment.

The simplicity of the arrangement of this modification of the invention reduces the complex eleven step color positive printing process to a semi-automatic easy procedure enabling even the little experienced or the unexperienced amateur to attempt the heretofore difficult color developing processes with satisfactory results.

If desired, the bath may be simplified and designed to contain the vessels or troughs without the expedient of the cellular subdivision. One or more washing areas may be established in the same bath or in a separate bath or container which latter may be completely separate from the bath containing the vessels with the processing liquids. The wash-water may be supplied from the latter bath by connecting tubing or piping or it may

be supplied from an independent temperature controlled source of water. However, the advantages given hereinbefore make, for most applications, the unitary bath containing processing vessels and washing vessels in one unit and using a common stream of water for temperature control and washing the most desirable.

The apparatus and device of this invention may be constructed of a variety of materials. Those parts of the construction which merely serve as supports and are not contacted during the operation with chemicals other than those contained in the tap water used as the temperature conditioning medium and in the wash-water may be made in conventional manner from copper, brass, steel or other suitable metals or from a variety of plastics, glass or other inorganic construction materials available for this purpose. The water bath may likewise be constructed from metals such as steel or sheet iron with or without protecting coating such as enamel, metal plating, plastic coatings or paints or if desired from stainless steel, copper, brass with or without protective layers, hard rubber, plastics, etc. As stated, resistance to chemicals is of minor importance with these parts of the apparatus, while rigidity and mechanical stability are of prime importance. The preferred materials for the construction of the heating elements are metals, which may be used to form a sheath or cover around the heating elements carrying the electric current. Proper insulation between the heating elements and the water-tight sheaths or covers is of importance in order to render the operation safe from the point of view of shock and leakage of electric current.

The vessels or troughs used in the apparatus are constantly contacted with the various processing liquids used in the process. Some of the liquids encountered in photographic processes are rather corrosive and careful selection of the materials for the construction of these parts of the apparatus is therefore indicated. The use of separate individual containers for each step of the process makes it possible to use materials of varying composition and chemical nature for each individual vessel or trough which are especially adapted to the character and corrosiveness of the liquids used in each of the individual containers. Considerable savings in the construction of the apparatus are thus possible, because usually the more resistant materials are higher priced. Detailed instructions for the selection of construction materials for photographic equipment are contained in a booklet published by the Eastman Kodak Company in 1957 under the title: "Construction Materials for Photographic Processing Equipment." This booklet and the original literature cited therein provide a wealth of data and information which may be applied with advantage in the selection of the most suitable and economical construction material for the apparatus, and particularly for the treating vessels and troughs of the present invention.

If desired, the compact apparatus of the invention may be enclosed in a light tight box or enclosure which need be opened only for the transfer of each cylindrical sheet to the next processing vessel. The transfer may also be effected by suitable forwarding means which can be operated from the outside of the box without a need for opening the enclosure during the operation of the process. With this expedient the whole operation can be carried out in a lighted room.

Many photographic treatments capable of being carried out in the apparatus of the present invention will be benefited by the provision of an accurate timer with each step. The commercially available electric or spring-actuated timers may be used with advantage or, if desired, a simplified inexpensive timer, as it has been described in my copending application 23,313 may be employed, with suitable modifications in the process and apparatus of the present invention.

As many prints as desired can be processed successively and simultaneously, the only limitation being that

each new sheet should be inserted in the first step at time intervals which are not shorter than the time required for the step of the longest duration. Kodak's Ektacolor Positive Printing Process requires 12 minutes for the first development step which is of longer duration than any of the other steps. The apparatus and process of the invention thus permit to start the treatment of 5 to 10 prints per hour in one device, without any undue strain on the operator.

The advantages of the successive processing over the heretofore practiced batchwise method come readily to mind. Maladjustment of the processing conditions and mistakes in the choice of filters, exposure, temperature etc. become apparent after running a single print. Adjustment can readily be made as the processing goes on, while a whole batch might be lost before any error or mistake is discovered in the batch-method of the prior art.

For the convenience of the less experienced operator some additional modifications of the process and apparatus of the present invention may be made. In order to avoid or prevent errors in the sequence of applying the treatment solutions in the individual steps, particularly in the multistep color developing processes, the vessels and the storage bottles may be color coded. Selecting one and the same color for the labels, caps etc. of packages or bottles containing the ingredients for that particular solution, for the storage bottles containing the prepared treatment solutions and for the vessel to be used for the particular step and its section of the water bath where it is to be placed makes it virtually impossible that mistakes in the proper sequence of the steps of the particular process are made.

The code color may appear on the outside or inside or on both sides of the vessel. Usually it is sufficient if only the upper portion of the vessel is marked in this manner. Generally it is desirable that the colors selected are such that their distinction remains perceivable in the monochromatic light usually employed in the darkroom for the particular process in question. The effectiveness of the color-coding means may be further improved by the provision of geometrical designs in the marking areas, such as dots, lines, crossing lines, circles, squares etc. These in combination with a few colors or simply black and white areas which are clearly distinguishable in the darkroom light permit complete marking and distinction of a multitude of treatment solutions and their storage and treatment containers.

As is readily apparent, treating liquids accidentally flowing over or being spilled, particularly during the transfer of the plane sheet will fall into the water bath surrounding the vessel where they will be diluted and quickly washed away by the flowing stream of the temperature conditioning medium or water. Thus contamination of the surrounding working area by harmful chemicals is virtually impossible.

I claim:

1. Process for the multistep treatment of a plane sheet of photographic material at a predetermined temperature in a multiplicity of separate treating steps which process comprises the successive contacting of said sheet with a multiplicity of different treating solutions, each being in the form of an upright vertical layer of treating solution, having two opposite major vertical faces, and the vertical layers being arranged in spaced, side-by-side relationship with their major vertical faces essentially parallel to each other, and maintaining the temperature in each of said layers at about said predetermined temperature by flow-a unidirectional stream of temperature conditioning water of about the same temperature and in form of a layer successively in a zig-zag pattern around each of said upright layers of treating solutions such that said stream of temperatures-conditioning water flows in the case of each layer in a path downwardly along one of the major

vertical faces, passes underneath the layer and thereafter flows upwardly alongside the opposite major vertical face of each of said layers.

2. The process of claim 1 in which the streaming temperature-conditioning water serves also as the washing medium in at least one washing step by being formed into at least one separate, upright vertical streaming layer of a shape and size similar to the layers of treating solutions.

3. The process of claim 1, in which the quantity of treating solution in each layer of treating solutions is adjusted by varying the width of each layer, in such manner that all treating solutions are substantially exhausted to safe limits after the treatment of the same number sheets.

4. The process of claim 1, wherein the stream of temperature conditioning water flows at a constant rate and has been electrically heated from a lower temperature, than the desired treating temperature to the approximate treating temperature, required by the process.

5. The process of claim 2 in which said upright layers of streaming washing medium are interposed in spaced relationship between the layers of the treating solutions with their major faces substantially parallel to the major faces of the treating solutions, in the order in which the washing steps are to be carried out in the treating process such that the plane sheet may simply be forwarded from step to step to the neighboring layer.

6. The process of claim 2, wherein the photographic sheet is a multilayer color material and wherein the temperature of the treating solutions and of the stream of temperature conditioned water is adjusted to and maintained at about 75° F.

7. The process of claim 5, in which a multiplicity of sheets is carried through the treatment in successive overlapping fashion with the proviso, that the time lapse between the insertion of successive sheets in the first treating solution is longer than the duration of the longest step in the treatment sequence.

8. The process of claim 5 in which the sheet of photographic material is agitated in the treating solutions by giving it an intermittent reciprocating vertical motion relative to the treating medium while keeping it successively immersed during the treatment in each of the treating media, said reciprocating vertical motion being produced by automatic mechanical agitating means.

9. The process of claim 5 in which the sheet is forwarded from one vertical layer of treating medium to the next vertical layer of treating medium by mechanical forwarding means.

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