

Sept. 25, 1956

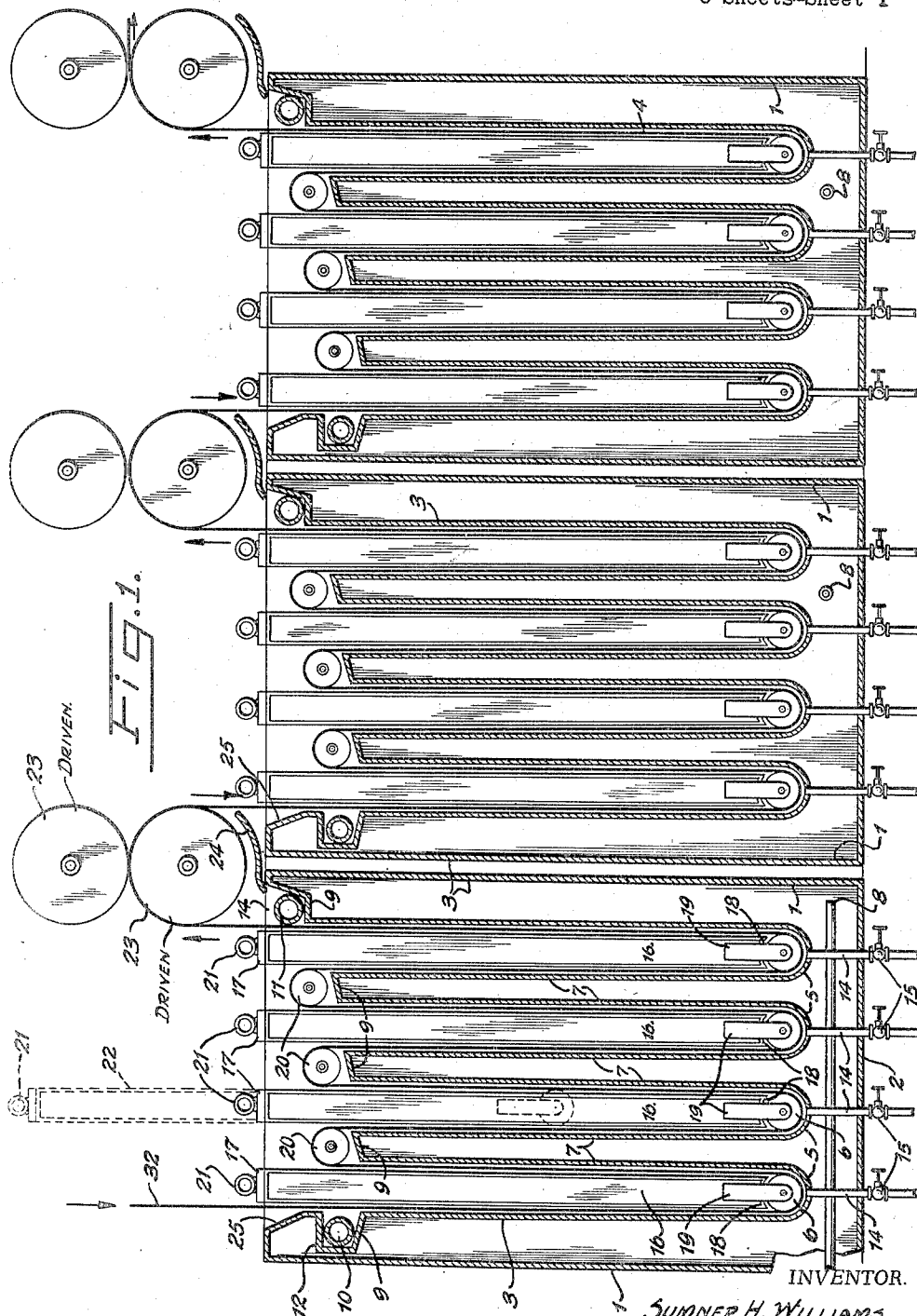
S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 1



INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph P. Bennett

ATTORNEY

Sept. 25, 1956

S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 2

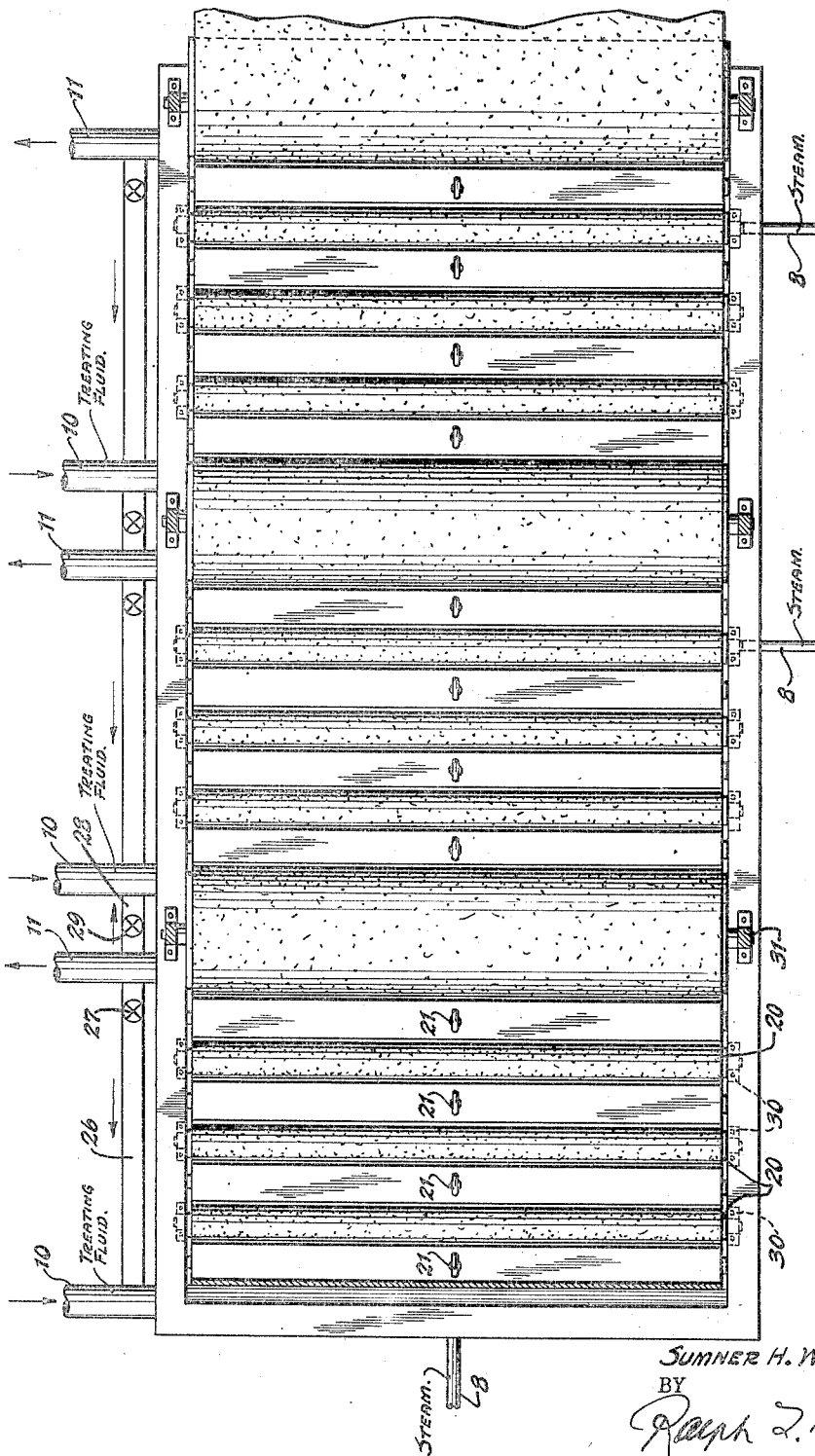


FIG. 2.

INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph T. Bassett

ATTORNEY

Sept. 25, 1956

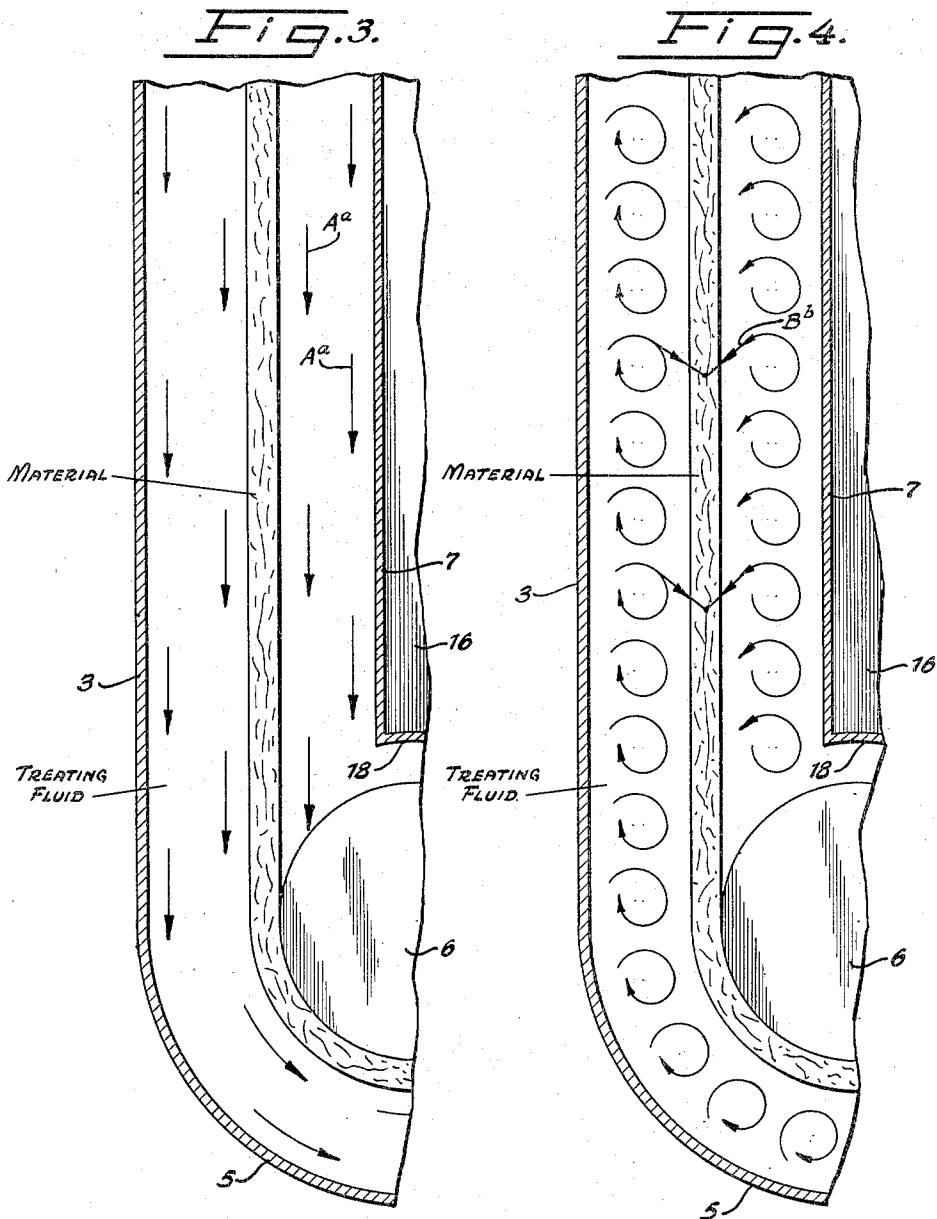
S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 3



INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph Z. Basett

ATTORNEY

Sept. 25, 1956

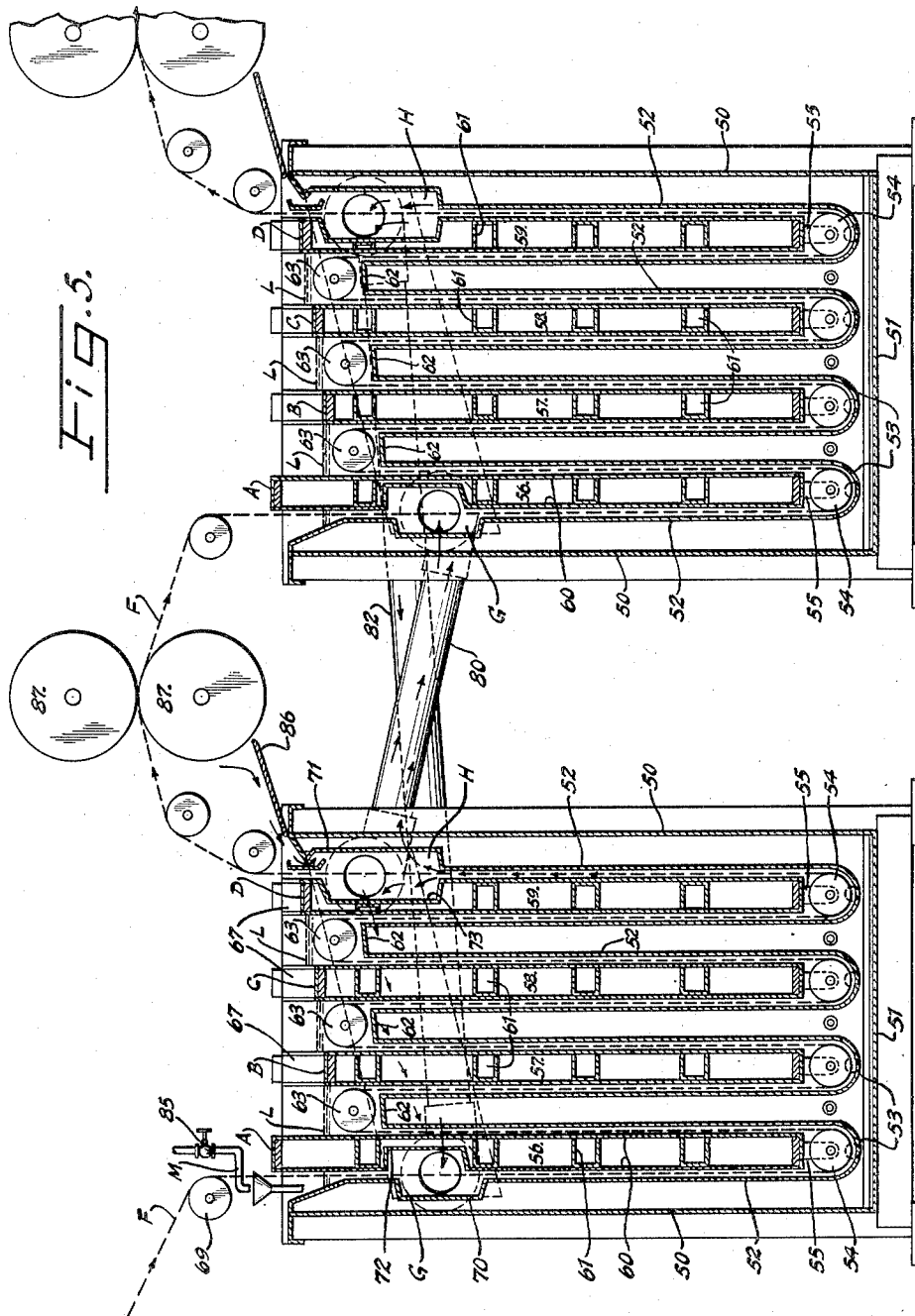
S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 4



INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph A. Barrett

ATTORNEY

Sept. 25, 1956

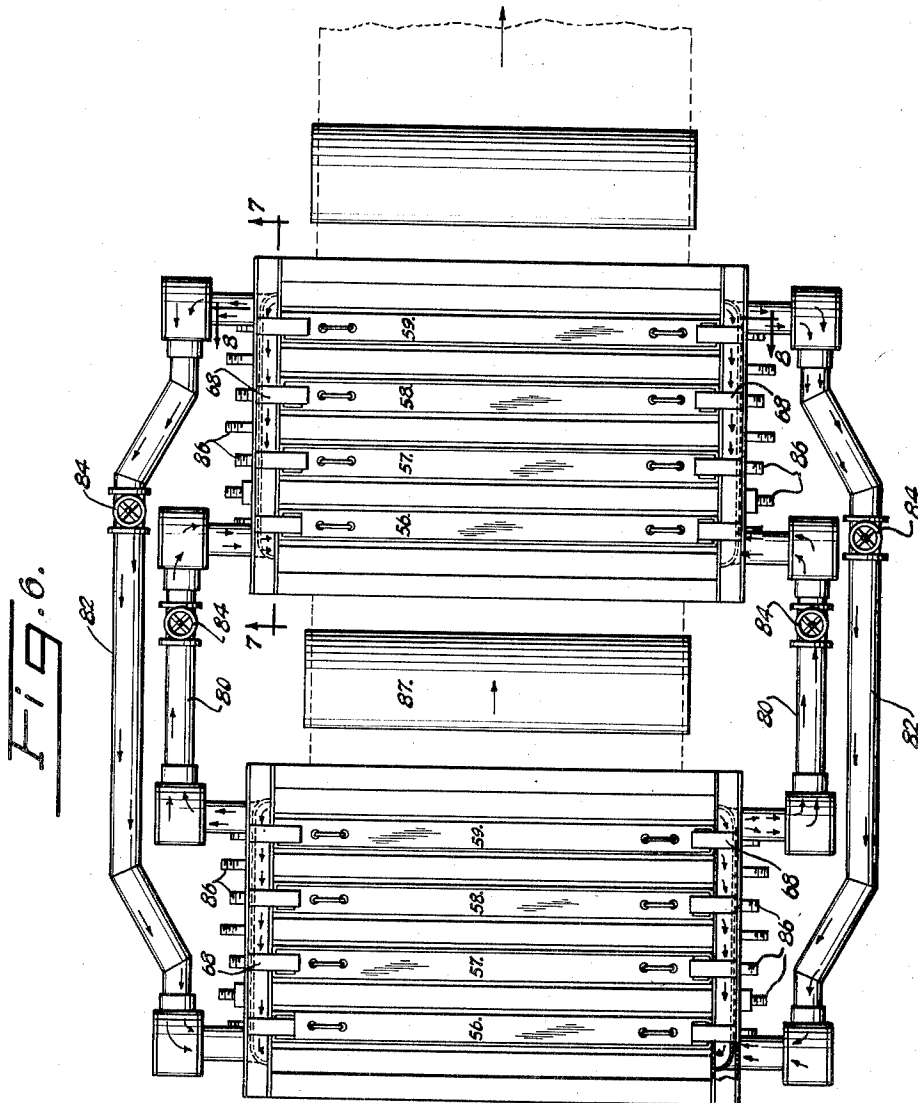
S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 5



INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph J. Bennett

ATTORNEY

Sept. 25, 1956

S. H. WILLIAMS

2,764,010

APPARATUS FOR TREATING TEXTILES

Original Filed Oct. 6, 1944

6 Sheets-Sheet 6

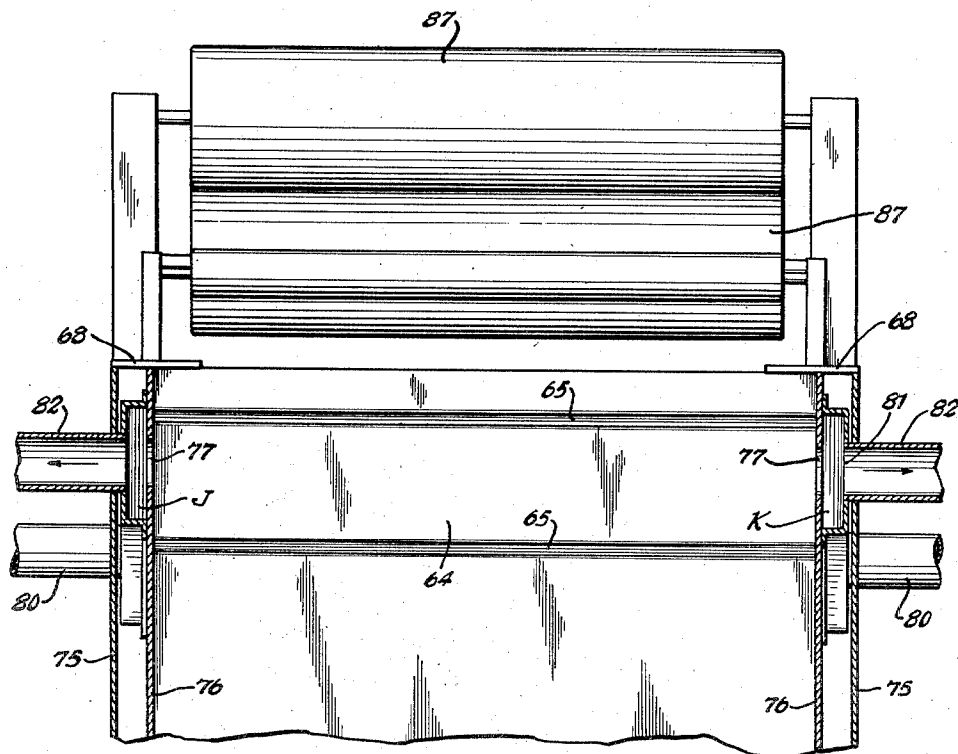
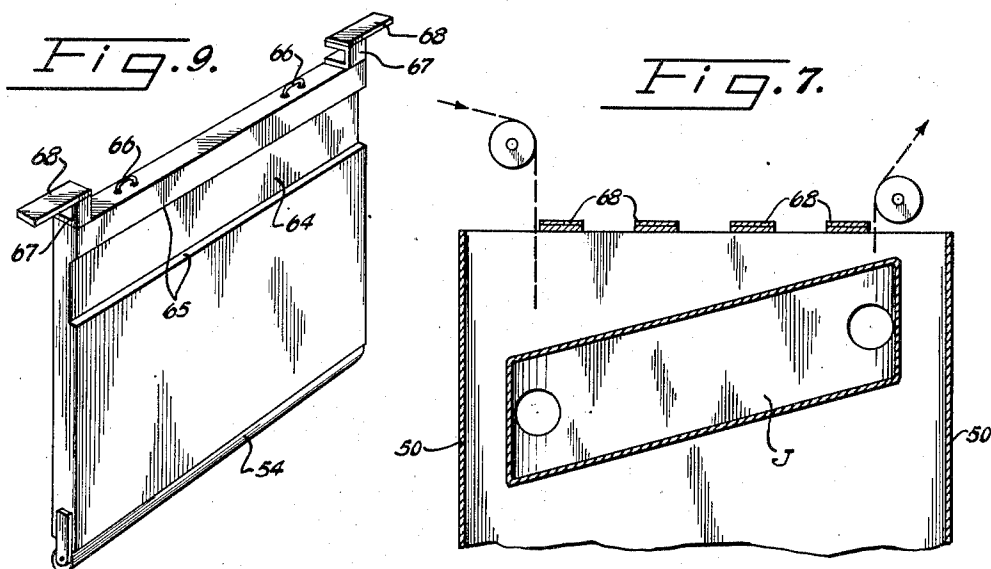


Fig. 8.

INVENTOR.

SUMNER H. WILLIAMS.

BY

Ralph J. Bassett

ATTORNEY

1

2,764,010

APPARATUS FOR TREATING TEXTILES

Sumner H. Williams, Charlotte, N. C., assignor to General Aniline & Film Corporation, a corporation of Delaware

Continuation of application Serial No. 557,458, October 6, 1944. This application May 10, 1949, Serial No. 92,359

9 Claims. (Cl. 68—27)

This invention relates to a process and apparatus of treating material of the general type of my prior Patents No. 2,364,838 and No. 2,445,504 and is a continuation of my co-pending application Serial No. 557,458, filed October 6, 1944, now abandoned.

The main object of the present invention is to facilitate the fluid treatment of fibers and fabrics and at the same time provide a substantial saving in the amount of treating material used.

A further object of the invention is to maintain a desired and exact control of the temperature of the material and reacting fluid.

Another object of the invention is to provide an apparatus and a process in which the fabric is continuously treated without exposure to the atmosphere.

A further object of the invention is to provide means for confining the treating fluid in such a restricted area that bleed off of the dye stuff is limited to a minimum, while at the same time the excessive speed of the traveling fluid which substantially exceeds the critical speed of the travel of the fluid in the wells will, due to friction of the moving web in the fluid, cause a flow of the fluid and a simultaneous increased turbulence in the fluid at each side of the web in the form of a multiplicity of cyclonic currents in which the velocity of the fluid is sufficient to penetrate the web to a depth at least beyond the medial portion thereof.

A further object of the invention is to provide an apparatus for the continuous treatment of a continuous web of fabric in which a plurality of wells are provided of gradually increasing elevation, with the highest elevation being at the point of exit of the web at the last well, whereby accommodation of the traveling fluid in the associated wells will be properly baffled and retained for the purpose of proper feeding and distribution of the fluid to the point of inlet of single and multiple treating units.

A further object of the invention is to provide in an apparatus of the type described, a structure in which a normal level of the fluid will be maintained at approximately the top of each well to insure complete submersion of the web traveling from well to well.

Another object of the invention is to provide an apparatus and a process in which definite critical fluid areas are provided with respect to the continuous fabric and at each side thereof to maintain maximum penetration of the fabric by the fluid and a minimum bleed off of the dye from the web, it being understood that the forces prevailing due to the travel of the fluid in cyclonic currents caused by the speed of travel of the web and the close proximity of the confining walls, create a condition in which a bleeding off of the dye stuff is definitely and critically controlled. Heretofore, in the art it has been generally understood that whenever a piece of material remains in contact with a dye solution, that the longer the length of time the fabric is brought into contact or left in contact with such solution, a heavier shade is produced. If is of course at all times important to produce

2

as much treated fabric as possible within a given time, but with the necessity of providing submersion of the fabric in the treating fluid a maximum amount of time to secure suitable desirable commercial results, speed in the treatment of a continuous fabric while desirable has never been obtained. In fact, it is generally understood that a maximum speed of travel of a continuous web under the old method and process of 30 yards per minute would, if possible, be considered extremely high proficiency. By the instant method and due to the critical relation between the quantity of fluid, the fluid movement, and the speed of travel of the web, it is found that the dye particles are forced into the face of the material and penetrate beyond the center of the fabric and that a control of the turbulent forces created in the dye solution by the present process and method produce results exactly contrary to the old theory and method. This is true to the extent that it is found that by proper regulation of the solution, critical positioning of the walls confining the fluid, and other factors, the faster the travel of the web in the confined fluid, the better the results of the fluid treatment in that bleed off is prevented and definite controlled penetration of the fluid by the creation of cyclonic currents is provided and can be controlled and regulated. As an illustration let us say that a web of fabric is moving between confined walls spaced one-half inch apart, the web being centrally positioned with respect to the walls and fluid being maintained between the walls. With a conventional relatively thin fabric, the area at each side of the fabric and between each side of the fabric and the adjacent wall would approximate one-fourth of an inch. If this web was caused to travel at a speed of 100 yards per minute the penetration of the fluid due to cyclonic currents created at each side of the web could have sufficient velocity to penetrate the web from each side to secure a through treatment, i. e. the cyclonic currents at each side would penetrate at least to and beyond the center of the web. If a thicker fabric should be moved between the same spaced walls certain conditions might exist, due for instance to the nature of the fabric construction, so that the desired complete penetration would not be present. Now contrary to the old theory that the fabric should remain in the solution for a greater length of time, applicant can, by increasing the speed of the fabric, create greater turbulence and velocity in the cyclonic currents and thus by movement of the thicker fabric, as an illustration, at 150 yards per minute secure the desired fixation of the dye or other treating solution which may be desirable. This enables an operator to control the speed of the web in accordance with the nature of the fabric so that the turbulent currents penetrate with extreme violence far beyond the center of the fabric to secure the maximum desirable results, and these cyclonic currents being directed against the fabric tend to maintain and do maintain the dye in the fabric rather than permitting it to bleed off. Thus, the bleed off is prevented by two factors, the movement of the violent currents towards the fabric to prevent a dispersion of the dye and the limited quantity of fluid capable of absorbing the bleeding dye from the fabric. In addition, the reduction of the time in which the fabric is subjected to submersion in the treating fluid and the utilization of the violent forces of the cyclonic currents to apply the treating fluid to the fabric results in a dispersion and evenness of treatment heretofore unknown in the art. Thus by the present invention four new and definite results are obtained, i. e. bleed off is prevented, even dispersion of the dye is provided, positive penetration of the treating fluid is accomplished, and heretofore unheard of speed is essentially present.

These and other objects will more clearly hereinafter

appear by reference to the accompanying specification and drawings, the latter forming a part of this application and in which like characters of reference designate corresponding parts throughout the several views, in which:

Fig. 1 is a longitudinal vertical section through the apparatus;

Fig. 2 is a top plan view of the apparatus;

Fig. 3 is a vertical section illustrating the movement of the web between the walls of the well and the movement of the fluid, with the web traveling at low speeds;

Fig. 4 is a view similar to Fig. 3 showing the movement of the fluid with the web traveling at high speed in accordance with the present invention;

Fig. 5 is a longitudinal vertical section through a modified form of the apparatus;

Fig. 6 is a top plan view of the apparatus shown in Fig. 5;

Fig. 7 is a fragmentary vertical section taken on line 7—7 of Fig. 6;

Fig. 8 is a sectional view on line 8—8 of Fig. 6; and

Fig. 9 is a perspective view of one of the partitions showing the well structure at the outlet end of the unit.

This invention relates to a process and an apparatus for the chemical treatment of such textile fabrics, regardless of their particular construction, and applicable to many operations, such as the dyeing of plain shades, the developing of printed fabrics, the developing and dyeing of printed fabrics in one operation, and the chemical treatment of materials to be bleached or washed, or treated with chemicals to impart a finish to the fabrics or fibers.

This invention, as described, is applicable to all fibers: vegetable, such as cotton, linen, etc.; animal, such as wool, silk, etc.; mineral, such as spun glass, asbestos, etc.; synthetic, such as nylon, rayon, aralac, etc. It is also applicable to these fibers in any of their manufactured forms, such as any yarn, groups of yarns, commonly known as warps, piece goods and knitted or tubular constructions, or in any other physical forms.

This invention further involves the application of all known coloring matters; examples set forth, showing the use and development of some of the major classifications or groups in use today, such as anthraquinone, indigoid, brome indigo, thioindigoid, Carbasol, sulphur colors, insoluble azo group, known to the trade as naptols; basic, substantive and diazo, acetate coloring matters, known as Cellitons; all acid and chrome dyestuffs used for animal fibers, organic and inorganic pigments requiring fixation with resins, starches or other chemicals to be printed and bound to the fibers mentioned. Examples are set forth showing their use as separate groups and also used together.

In many instances satisfactory treatment of the material is dependent upon avoiding unnecessary exposure to the air, either of the reacting solution or of the fabric undergoing treatment. In the treatment of a continuous web of material, it is important to insure even and uniform exposure of the material, throughout its length and width, to the reacting solution or solutions. In like manner it is necessary to bring the reacting solution into the most intimate contact with the fabric until the desired chemical and physical actions take place between the material and ingredients carried by the treating fluid. This invention provides for the dyeing, bleaching, developing of printed fabrics, or other chemical treatment of a continuous web of material in a manner that allows the material to be treated evenly on all sides as the layer of treating fluid completely surrounds the material and is held in close contact to the latter by the particular construction of narrow channels through which the material to be treated moves and thus is brought into contact with the treating fluid, which is also in motion, either in the direction of the material or in the opposite direction. This brings about a faster chemical treatment due to utilizing the full area of this fluid traveling in motion with the material.

One object of this invention is to maintain a positive control and a desirable ratio of treating fluid to the material under treatment. By the materials being surrounded with such a thin layer of fluid, the ingredients, which are either dissolved or held in suspension in the fluid, are forced by close contact to react evenly over the material for the purpose intended and without loss. This is in direct contrast to the prevailing practice, which either forces the chemical solutions through stationarily held materials or conversely agitates the material in a normally stationary treating solution.

My invention uses a basically different principle, that of causing the material to travel through the machine, so that the material is submerged in a minimum quantity of the fluid, so arranged as to bring the material in close contact with the treating fluid which may contain dyes, bleaching agents, or other chemicals. At the same time, the treating fluid is caused to travel in contact with the fabric until completion of the desired chemical reaction.

To define more clearly the treatment of material, either chemically or with dyestuffs, inasmuch as the chemicals or coloring matter may react not only chemically but physically, this invention covers the mechanical and physical reactions between the material to be treated and the ingredients, which are brought in contact with it, contained in the fluid; these ingredients in the fluid may be chemically inert and are mechanically forced on the material by close contact in processing same, by the method stated.

By this developing process we may use as treating fluid any of the known mediums. In some cases this fluid may be plain boiling water, and for the fixation of a number of colors common salt would be the chemical used in the fluid for the fixation of a substantive or direct type of dyestuff. Where sulphur colors are used, the treating fluid may contain sodium sulphide, alkali, common salt, etc. For all dyes in the class of vat colors the treating solutions may contain any reducing medium such as sodium hydrosulphite, alkalies, common salt, etc. The coloring matter may be printed or dyed together with a resin, and this resinous printed or dyed fabric would necessitate further chemical fixation, in order to obtain final fastness. The treating fluids in this case could contain either alkalies, acids or may be neutral, and high temperature applied to the treating fluid to bring about this chemical fixation. The treating fluid may be in the form of a gaseous medium, such as steam, and entered along with the fabric, allowing it to condense in the wells, to form sufficient moisture or fluid to be carried with the fabric until the chemical action is complete.

This process discloses a method of applying dyes and chemicals to the material, either in a printed form or completely covered, as in plain shades, that produces effects, saving considerable dyestuffs and chemicals, in a shorter period of time than has been produced heretofore.

This invention contemplates a means for the fixation of dyestuffs and chemicals on the material in close confinement, so that the treating fluids are forced to follow the material from one well to the other, and to maintain an even height of treating fluid above each of the successive rolls on a scale graduated upward from the point of entry to the highest point of delivery. The apparatus, as shown, was designed to permit this function. The close, restricted areas through which both the material and treating fluids are forced to pass exert an action between the two that accounts for the speed of chemical reaction between the treating fluid and the fabric to be treated. A controlled gravity feed, adjusted to the speed of the material, is necessary. By using a low ratio of treating fluid in the restricted area, and this treating fluid following the material, no contamination takes place in the treating bath, as the fluid is fed in and out at a ratio of speeds governed by the speed of the fabric. By

5

this process none of the particles of dyes or chemicals that require fixation can bleed off into the area of treating fluid and remain in the wells to dye or stain the unprinted portion of the fabric, such as colored objects being developed on white backgrounds.

As temperature plays an important part in the carrying out of any chemical reaction pertaining to the fixation of dyestuffs or chemicals, this apparatus is so designed that the wells into which the material and fluids pass are suspended into a larger tank which completely surrounds these wells with a large area of water suitably heated by the means of steam pipes. As the amount of treating fluid in the machine at one time is very small, filling only the narrow channels, the transfer of heat from the heating compartment to the wells is very efficient, allowing a more constant temperature control than would be possible to maintain when attempting to heat a large body of water indirectly. Steam may also be used in this inner jacket as a means of obtaining high temperatures. By filling this larger chamber with cold brine solutions, connected up with proper refrigeration, it has proven possible to very efficiently maintain low temperatures by the immersion of the treating wells in these cold solutions. Both heat and cold are transferred efficiently through the wells, due to the large area of contact of the heating or cooling solutions to the wells through which the treating fluid and materials must flow.

In the present process a continuous stream of fluid with the fabric to be developed in a confined area and by the feeding of a continuous flow of fresh treating fluids, the coloring matters are fixed in a quick period of time; they do not solubilize out into the white or unprinted area of the fabric, and the treating solution, following the fabric, is kept free from contamination throughout the process. Until the development of this process, it has been necessary to run such printed fabrics through steam, rather than through any fluid, in order to avert the printed objects from bleeding off into the unprinted area. As the steaming, aging, or curing operation has to be carried out separately due to the length of time it takes to develop the fixation of dyestuffs by conventional methods, this operation does not lend itself to be tied in to the continuous soaping or developing, which is done at much faster speeds. This invention, due to the high speed of fixation of the coloring matters or chemicals to the fabric, lends itself to be tied in to the other operations, such as oxidizing, soaping and finishing, thereby eliminating an entire operation in the handling of printed and printed and dyed fabrics.

It has been determined that the space between the walls, surfaces or boundaries which confine the fluid and medially of which the continuous web of fabric travels should not exceed one inch so that the thickness of the wall of fluid available across the area of the fabric at each side thereof should not be more than one-half inch and this spacing, as a minimum should not be less than one-eighth of an inch. The area below the bottom immersion roll in each well should be one-half inch or a distance approximating the thickness of the wall of fluid at one side of the traveling fabric, thus producing a restriction at the bottom of the well which necessarily retards the flow of solution and produces a more stabilized solution for the creation of the desired turbulence developing the cyclonic currents. It is of course understood that the fluid trapped at the bottom of the well is held only momentarily but this delay in the flow of fluid at this point creates a pressure in the wall of fluid particularly in instances where the travel of the web approximates extremely high speeds. This situation of course is relative with relation to the travel of the web. Generally the minimum travel of the web may be considered as at 75 yards per minute with a maximum of substantially 300 yards per minute, according to the nature of the fabric, the type and gravity of the treating fluid, and other factors which may prevail under the

6

numerous conditions and different types of treatments known to those skilled in the art. The critical spacing of the side walls at each side of the traveling web, which walls confine the fluid, definitely determine the velocity of the turbulent cyclonic currents and obviously the velocity of the cyclonic currents, as shown diagrammatically in Fig. 4, determines the amount of bleed off, if any, and the amount of desired penetration of the fluid into the fabric, it being understood that the penetration of the fluid at all times should, as a minimum, comprehend a medial point in the fabric structure and thus the currents flowing from each side fully penetrate the fabric to procure the desired results. The spacing of the wall confining the fluid at each side of the web must not exceed a distance so great that there will not be the proper reactance as a result of the movement of the web through the fluid such as to cause the rotational turbulence heretofore referred to as cyclonic currents and as shown in Fig. 4, which Fig. 4 illustrates the movement of the fluid as determined after careful study and by the use of clear fluid and the injection of color. The further the wall is spaced from the adjacent face of the traveling web, the less will be the velocity of the rotational currents in the turbulent fluid and consequently there will be a decrease in the ability of the fluid to penetrate the fabric, subject of course to the gravity of the fluid.

In the present disclosure there is shown a continuous process, whereby fabric may be pretreated by padding on dyes, chemicals, or other ingredients, or by printing object effects and taken directly in a continuous operation from pad or printing machine to continuous developing unit in one operation.

The wet developing of printed fabrics showing also the dyeing operation simultaneously

As practiced in the printing of fabrics, application of dyes or other coloring matter, after printing, they are at this stage not sufficiently fastened to the fiber in a manner that insures their proper fastness and complete color value. To properly affix these coloring matters, it has been necessary to further treat by aging, steaming, or curing in some manner, to properly bind these coloring matters to the fiber. In some cases steaming is carried out under pressure for prolonged periods of time. Most commonly used in the development of prints is the rapid steam aging process. For the steaming and fixation of vat colors, the fabrics are entered into a steam chamber, passed slowly through this steam atmosphere for periods of time from 5 to 10 minutes before the dyestuff is properly fixed to the fiber. For the fixation of rapidogens, alcosols, chrome colors, and other coloring matters, an acid steaming is required. This process is similar to that of steaming vat colors, with the exception that acids are entered in the ager, as the coloring matters require an acid atmosphere for their fixation to the fiber. Acid aging requires comparatively the same lengths of time for complete development of the colors as in the case of vat dyestuffs. By this invention we show a process of a wet fixation method, replacing the aging process, developing printed fabrics to complete color value and full fixation in the amazingly short time of from 5 to 10 seconds. By eliminating the slow aging processes, the apparatus, as shown, is directly connected to the washing and other finishing units, thereby not only accomplishing the fixation of the coloring matters, but also the fabrics can be soaped, after treated and finished in one continuous process.

Examples of the use of the instant development can be partially set forth as follows:

(1) Vat colors, such as known to the trade as indanthrenes, algols, hydrons, etc., printed on the fabric with a suitable carrier, dried and taken to the wet developing machine, the material entered simultaneously with the treating fluid, which contains sodium hydrosulphite, caus-

tic soda and common salt. Temperature of treating fluid 200° F. Time of development 10 seconds.

The finished print shows as complete fixation, with proper fastness, as the same print aged through a rapid ager for a period of 5 minutes, the accomplishment of this fixation being done in one thirtieth of the time required in normal practice.

(2) The same printed fabric is involved which has been developed and fixed in the same period of time. In this case to the treating fluid was added other vat colors which, during the process of fixing the printed object, the treating fluid, in turn, dyeing evenly on both sides what is known as the ground shade. To produce vat color prints of this character, in normal practice this ground shade would have to be either first dyed onto the material, or dyed after the printing and normal steaming operation. This invention shows the dyeing operation and the development of the prints of any fast colors being done simultaneously in a 10 second interval, eliminating an entire extra process for the production of this and similar effects.

(3) Rapidogens, algosols, chrome and other coloring matters are printed and dried and then run through the apparatus, as shown. The treating fluid in the case of these types of dyes is charged with 1 ounce per gallon of acetic acid 56% and one pound of common salt, temperature of treating fluid 200° F. By running the printed fabric through the apparatus in close contact with the treating fluid, which flows concurrently through the machine in a 10 second time, full development of these classes of colors has been produced.

(4) Another object of this invention is to produce a printed and dyed fabric in one operation, showing as an example the development of the printed objects on the fabric which may contain one or more groups of colors, such as vats, and to the treating fluid may be added any of the different types of coloring matters which may be compatible with the treating fluid, such as sulphur colors, dispersed pigments, etc., producing a multi-colored effect with chemically different types of dyestuffs in one operation.

From these examples the possibilities for the production of many multi-colored and plain ground shades, the mixing of various groups of dyestuffs by a shorter process than has ever before been used in the art, with controllable features, using an apparatus that allows the carrying out of these methods with satisfactory results.

The fixation of dyes and other coloring matters for the production of plain shades

A further object of this invention is for the dyeing of vat colors shown by Color Indexes, such as Anthra Yellow GC, Color Index No. 1095, Indanthren Olive R, Color Index No. 1150, Bromide Indigo MLB/4B, Color Index No. 1184, and Helindon Pink BN, Color Index No. 1211. These include the anthraquinone, the Indigoid, both bromide and the thio-indigoid types, including synthetic indigo, Color Index No. 1177 or Hydron Blues, Color Index No. 969 and 971, Carbasols, and the water soluble vat colors or leuco vats, such as known to the trade as algosols or indigosols (caledon jade green, Color Index No. 1101). All of these groups can be dyed successfully by this process by treating the material to be dyed with these dyes in pigment or in soluble form and entered into the continuous developing and dyeing unit, either wet or dry, into which is fed simultaneously the necessary reducing and dyeing chemicals, such as hydrosulphite of sodium, caustic soda and common salt, all traveling together, the materials, dyes and solution, through the narrow channels or orifices until the dye action is complete. By dyeing these colors in such a confined fluid medium, which travels with the material throughout the machine in close contact with each other, the material is surrounded by a thin layer of solution. The reduction and dyeing action takes place in such a confined

area that complete exhausts of dyes are obtained in a minimum space of time, producing results that heretofore have not been accomplished in the practical art of handling any groups of known dyestuffs. This is particularly true in the dyeing of what is known to the trade as heavy or dark shades of vat colors; such were still best applied by what is known as either jigg or pad-jigg method of dyeing. In this pad-jigg process it is necessary to pass the material a number of times back and forth through the solution, in order to properly obtain the correct shade and fastness; and during these passages, portions of various color combinations may come off or go back on unevenly, producing unpredictable results. In producing these same heavy shades by this invention, the pigment color, either in dispersed or soluble form, is first applied to the fabric by padding or other means and then carried or passed through this machine, either in one continuous operation or as a separate treatment. The material having contained the unfixed dyestuff, the colors must now be put in a soluble form by reduction, in order to be properly fastened to the fiber. The dyes of this group of colors are made soluble by entering them into a reducing solution. They have a natural tendency to bleed out into the area of fluid into which they are immersed. By this invention they are immersed in such a thin layer of fluid, the dyes are forced in contact with the material, preventing this bleeding off into a wide area of solution, which is a major factor in producing true shades, by holding the dyestuff on the material by running it through the closely fitted channels which prevent the dyes, as they become soluble, to leave the material and bleed out into a wide area of fluid. As this group of colors has been passed through this machine where the reducing and dyeing action takes place, they are then either in a separate or in a continuous operation, washed and oxidized in the usual manner necessary to treat this class of dyestuffs.

Additionally, these may carry out the dyeing and developing of the naphtol or insoluble azo group of colors, represented as a group of naphtol AS (beta-hydroxy-naphthoic acid anilide) developed with fast scarlet salt GGN (stabilized diazo salt of 2,5-dichloroaniline) and Naphtol AS-G (diacetoacetictolide) developed with fast red B base (5-nitro-4-aminotoluene). The same principles offer their advantages in this field where materials must be brought in contact with chemicals or developers to produce a chemical reaction or completion of process.

Sulphur dyestuffs, such as Immedial Green, Color Index No. 1106, and Immedial Orange C, Color Index No. 949, are applied in the same manner; that is, either by treating the fabric first with the unfixed dyestuff, either wet or dry, or by adding the dyestuff with the fabric in fixed proportions to the apparatus, adding the requisite chemicals, such as sodium sulphide and common salt to the treating liquid and causing the fabric and fluid to travel together in close contact. Here, again, the dyeing action is completed in a shorter space of time with a more complete control of final shade and less oxidation of the dyestuff.

A further example of continuously dyeing with direct or substantive dyes, is carried out with Diamine Sky Blue FF, Color Index No. 518, and Chrysophenine, Color Index No. 365, obtaining all depths of shades. The material was first treated with a direct color by passing the material through a bath containing the color in a water solution. The fabric was then taken to the illustrated apparatus, either wet or dry, where the dyeing and developing was accomplished by the further treatment of the material with the solution of common salt. This solution traveled in the thin area with the material at 200° F., forcing the proper fixation of the dyestuff to the fiber until the reaction was completed. The application of this group of colors surpasses in time and control the conventional methods in use for applying this group of dyestuffs.

An additional example is the dyeing of synthetic fibers,

such as nylon, aralac, etc.; animal fibers, such as wool, silk, etc.; a number of these fibers have little affinity for any of the known classes of dyestuff, and to absorb coloring matters out of a dyebath by regular practice takes prolonged lengths of time. In this case there is used a type of acid dyestuff known as Palatine, which is one of the hardest of the groups of colors to exhaust from a dyebath. The fabric is treated with this dyestuff in a pad or mangle, or similar machine. From this operation the coloring matter is loosely fixed and is not fast. By either a separate operation or in continuous alignment with the pad, the material is entered, either wet, dry, or partially dried, into the apparatus as shown which contains as a fixation medium the necessary amounts of sulphuric acid, to properly affix the wool or acid colors to the animal fiber. This chemical fixation has been accomplished in the time of one minute, as against 1½ hours normal dyeing time for dyeing of the same classes of colors on the same fabric, as used in conventional practice.

Still another example shows that synthetic fibers, such as acetate, have very little affinity for the acetate coloring groups that are used for the dyeing of this material and here again by conventional methods it takes prolonged passages of material through dye solutions to take up the required amount of dyestuff. By padding these synthetic fabrics with their respective groups of colors and drying, or in a wet state and by further treating by the method and apparatus as shown, with a treating fluid in close confinement at the proper temperatures, dyestuffs can be fixed in a proper manner in a one minute period of time.

In applying diazo or developed dyes such as Primuline, Color Index No. 812, or Diamine Black Black BH, Color Index No. 401, the first step is carried out in the same manner as with direct or substantive dyestuffs; but as these colors necessitate a further treatment, to produce their desired fastness and true shade, they are further chemically treated. Thus the fabric, which already contains the fixed dyestuff, is passed through the apparatus containing the solution with sodium nitrite and either hydrochloric or sulphuric acid. For the production of the final shade the fabric may be treated further in the same apparatus after rinsing, by applying such developers as beta naphthol or other suitable chemicals.

Washing and cleaning fabrics

It has been developed by this process that by running a web of fabric concurrently with the treating fluid, it is possible to hold unfixed coloring matter to the material until the proper fixation takes place, allowing the treating fluid to act on the material. A further object of this invention is shown by reversing the flow of the treating fluid; that is, by entering the treating fluid to the last well or delivery point of the machine and to force it to run counterflow to the fabric, the pumping action that takes place in the area of the restricted channels tends to wash out of the fabric unfixed materials at high rates of speed. Such an operation may be used to an advantage in the cleansing of any fabric when used in this manner, the advantage being the ability to heat the cleansing fluid at high temperatures, and the small ratio of fluid held in the apparatus at one time can be quickly and entirely replenished, keeping the fabric running through clean treating fluids at all times during the operation.

In the disclosure of the instant application (Figs. 1 to 4) there is illustrated an apparatus providing three sections, each of which is of identical form, and the three sections are assembled to permit a continuous treating or a series of treatments of the continuously moving fabric. The three sections of the apparatus are used in line with each other for the dual purpose of using either one or more for the same operation, or by using the first unit for the development of dyeing, the second unit for oxidizing or further reduction, and the third unit for soap-

erations may be carried out with the three sections of the apparatus, using generally the same principle in each case but regulating and/or controlling the treating solution and the fabric movement whereby it is possible to complete complicated processes in a continuous manner.

Each section is identical in construction and includes outer side and end walls 1, of proper dimension and of such material that they will not corrode from the use of chemicals which may be contained in solutions involved in the different processes. The bottom of each section is indicated by reference character 2. An inner wall structure or liner is provided, this inner wall 3 being spaced a suitable distance from the outer walls and bottom of the vat to provide for proper temperature control as hereinafter more fully described. This inner wall or liner 3 is shaped to form spaced wells 4, illustrated as four in number in each of the sections, however, the number of wells may be varied in accordance with requirements. These wells are formed to include the curved bottoms 5, the contour of which corresponds to the contour of the peripheral surface of the guide rollers 6 which are accommodated therein. The completed well structures are formed by the spaced parallel walls 7, these walls 7 completing the two intermediate well structures; however, the two outer well structures are completed by the outer walls 7 and the adjacent walls 3. Each of the wells is illustrated with its bottom in the same common plane with the spacing between the wells sufficient to permit the proper heat exchange from the heating or cooling fluid introduced by means of the pipe 8. This pipe is shown as extending into the bottom portion of each of the sections but may be located in any suitable way and may include branch discharge portions for quickly creating contact between the heating and cooling fluid and the walls of the wells. The hollow walls between the wells are closed by top plates 9 and the series of wells are of gradually increased height from the inlet end of the section to the outlet end of the same section to maintain an even height of fluid above each of the successive rolls on a scale graduated upward. This stepped-up arrangement of the plates 9 is provided to facilitate a controlled flow of treating fluid at high speed operation. Each section of the apparatus includes an inlet pipe 10 and outlet pipe 11, the former being located in an offset chamber 12 formed in the end wall 3 and the latter being located in an offset chamber or trough 14 formed at the upper end portion of the opposite wall 3. The inlet and outlet pipes, which incidentally may be reversed as to their function, have their axis extending in a direction parallel to the walls defining the wells. At the bottom of each well is a discharge pipe 14 controlled by a valve 15, these outlet pipes being provided to discharge concentrate and sediment which may be present in carrying out certain processes with certain solutions.

A plurality of baffles 16 are suspended by the planks 17 and extend into the wells 4. The lower ends of the baffles 16 are curved, as at 18, and hangers 19 support the guide rollers 6 between the curved ends of the baffles and the concave end of the wells. The baffles are of a thickness to provide a relatively narrow passageway at each side of the baffle and between the baffle and the walls of the well, the width of this passageway being of vital importance to the successful operation of the process to be carried out. The rollers 6 are of a diameter slightly greater than the width of the baffles 16 so as to position the traveling fabric centrally between the walls 3—7 forming the wells, and the side faces of the baffles. This positioning of the rollers so that the space between the rollers and the bottom of the well is approximately the space between one side of the fabric and the adjacent vertical wall of the well provides a certain restriction in the flow of the fluid tending to create a temporary retarding of the flow and a slight pressure which is beneficial in producing the desired turbulence in the vertical

11

well portions. By this means, the traveling fabric is kept free from contact with the walls of the apparatus, and at the same time a constant and uniform amount of fluid is available for the entire area of the fabric as it travels through the apparatus. Guide rollers 20 are positioned centrally of the baffles 16 at their upper ends and between the partitions defining the wells, and these rollers 20 are of such diameter as to cooperate with the rollers 6 in maintaining proper spaced relation between the fabric and the adjacent walls.

Suitable means, indicated by reference character 21, may be provided for hoisting the baffles from the wells while cleaning the latter or when the wells are used in the festooning of the material into the wells and also aid in the threading up of the apparatus for operation. Reference character 22 illustrates in dotted lines one of the baffles in partly elevated position.

To cause a movement of the fabric through each section of the apparatus it is intended that the squeeze rollers 23 be driven by any suitable means. A trough 24 is arranged under the squeeze rollers to return any fluid to the initial section of the apparatus, these troughs discharging into the channel provided for the discharge pipe 11. It will be noted at the intake end of each section that the wall 3 is tapered upwardly as at 25 to provide clearance to assist in the setting up of the apparatus for operation.

Referring now to Fig. 2, it will be noted that the pipes 8 which are marked "steam" may also be used for the introduction of other heating medium or for the introduction of a refrigerant for cooling the walls of the well. If desired, other means may be provided for introducing a refrigerant. In Fig. 2 I have illustrated a connection 26 between the intake pipe and the outlet pipe 11, this connection being controlled by a valve 27. By this means the discharging fluid from the outlet pipe 11 may be returned entirely or partially to the intake 10. A further pipe connection 28 is provided between the outlet pipe 11 of the first section and the inlet pipe 10 of the next adjacent section. This pipe connection 28 is controlled by a valve 29 and would permit a flow from the outlet pipe of the first section, partially or entirely to the intake pipe of the second section.

The rollers 20 in Fig. 2 are illustrated as mounted in bearings 30, the structure of these bearings however does not form a part of this invention. Similar bearings 31 are provided for each of the driven rollers 23.

In the drawings (Figs. 1 to 4) which form a part of this application, I have illustrated the fabric by reference character 32 and the travel of this fabric about the baffle and into and out of each well, and from one section of the apparatus to another section of the apparatus through the squeeze rolls 23 can be readily observed.

By the structure heretofore described I have provided an apparatus in which unnecessary exposure to the air of both the solution and the fabric is avoided. In addition, the fabric is exposed uniformly to treatment by the solution, this uniformity of treatment being caused by the "close contact," due to the narrow channel structures and the motion of both the fluid and the fabric. By this close or intimate contact between the fabric and solution a predetermined result may be accomplished and exceedingly rapid physical and chemical actions obtained. The increased chemical and physical actions between the fabric and the solution, by use of the present apparatus, does not result in an increased quantity of solution but rather a substantial saving in the amount of solution utilized. By conventional processing, for each linear yard of fabric approximately 32 gallons of solution are required in normal continuous boxes for similar operations. By this new process, per linear yard of material only 4 gallons of treating solution are required. By running the fabric through all processes of this nature, for comparison, for every one pound of material entered and run through the machine, one pound of treating fluid is taken out.

12

This condition is the same by the processes now in use, or conventional methods. The accomplishment of my process, using these figures, is that it requires only one-eighth as much fluid to replenish completely the fluid in the apparatus as by conventional methods; that is, my treating fluid in motion turns over 8 times faster, with the result that such fluids and solutions are kept free from contamination by such a quick turnover in the channels of the apparatus. As chemicals and dyestuffs have a strength relation in a direct comparison with the amount of fluid necessary when treating a fabric, by the use of this process, with a ratio of treating fluid to the material one-eighth of the volume as required for conventional methods, it has been possible to save up to as high as 80% of the active chemicals in use in the treating fluid.

It will be noted that in the operation of the apparatus the fluid is forced from one well to another, at least substantially, by the movement of the fabric. The travel of the fluid by the movement of the fabric will be proportionate to the speed of the fabric, the speed of travel of the solution, i. e. gravity feed, the nature of the fabric, and the specific gravity of the solution. By virtue of the restricted channels through which the fabric travels an exceedingly low ratio of treating fluid to the amount of fabric, for carrying out the several processes, is necessary. Of course, it will be apparent that the fluid feed in and out of the separate wells represents a ratio directly proportional to the speed of the fabric and to some extent the kind of fabric under treatment. In addition to the foregoing, the arrangement of the stepped wells, the level of the liquid in the stepped wells, and the high point delivery of the liquid all tend to facilitate the operation.

As heretofore mentioned, temperature is essential in carrying out certain fabric treating processes. By the construction shown, a small amount of treating fluid is available in the restricted wells and the temperature of this treating fluid by heat exchange is exceedingly easy to control and initially quite rapid. The same is true where cold solutions are provided for reducing the temperature of the treating fluid. It will be obvious that the large heat exchange area and the relatively small treating fluid capacity of the wells is the basis of the quick and accurate control of temperature.

By the apparatus shown and by the rapid movement of the fabric, together with the restricted area through which the fabric travels, not only is a feeding of the solution possible but a perfect distribution of the solution is brought about so that the entire surface of both sides of the fabric is subjected to the same amount of solution. In addition by rapidly moving the fabric through the restricted or confined areas a certain amount of fluid pressure is built up which causes a positive application of the solution to the fabric throughout its entire structure. Thus, as heretofore stated, the element of speed of travel of the fabric in proper ratio to the confined area through which it passes, the nature of the fabric, and the solution, functions to decrease the time necessary for carrying out a multiplicity of processes with better results and the use of substantially less solution. This ratio between the speed of fabric travel and solution is definite for each operation in order that maximum results be obtained in distributing just the proper amount of solution with its treating ingredients over the desired area of fabric. Further the elevated discharge maintains a fluid level above the moving fabric thus preventing any exposure of the fabric to the atmosphere.

By reference to Fig. 3 it will be seen that when the fabric 32 is moved between the walls 3-7 of the well at a low rate of speed, the movement of the fluid is generally parallel to the direction of travel of the web. The direction of travel of the web being parallel to the plane of the walls of the well, the only result of the fluid treatment is penetration of the fabric by the fluid by the relatively slow saturation process. The arrows A* indicate the fluid travel movement. Now by reference to Fig. 4

which illustrates the movement of the web at high velocity, for instance at a speed of 100 yards per minute, which was the speed of the test from which Fig. 4 has been prepared, the movement of the fluid is entirely different in that the fluid is caused to whirl in small cyclonic currents, which cyclonic currents at each side of the web are of great number. The movement of the fluid in this manner which is the result of many factors including friction and pressure results in the fluid being projected against the cloth with great violence causing instant penetration of the cloth to at least a distance represented by a medial line although this penetration may be greater due to increased speeds in pressures and perhaps due to a different chemical formula altering the physical characteristics of the fluid. The result of this speed, therefore, is that the cloth strikes the fluid with great violence and obtains a fluid penetration in this manner and in addition the fluid being given a cyclonic movement due to the restricted area between the walls and the cloth further penetrates as it completes its cycle as shown by the lines B^b. The angle of both penetrations may vary but the cyclonic currents, due to the restricted areas and uniform spacing tend to be more or less parallel so that the penetrations from each side are uniform and the fluid is projected from each side of the cloth, into the cloth and set up pressures within the cloth itself. This multiplicity of currents and fluid pressures produce the substantially instantaneous results obtained by the instant apparatus. In the disclosures of Figs. 3 and 4 the results were established substantially as follows: In Fig. 3 the fabric was moved through the apparatus at a low rate of speed, namely, one yard per minute with the fabric containing vat colors in pigment form, to be reduced with temperatures, and with every other factor remaining constant. The time necessary for complete fixation at this speed and under these conditions was approximately five minutes. With the same apparatus, and as shown in Fig. 4, the fabric movement was increased to 100 yards a minute. This increase in speed resulted in complete reduction and with complete fixation in 10 seconds. The cyclonic currents are in fact high velocity currents and the velocity of these currents may be slightly varied by moving the fabric through the fluid at a greater rate of speed, or by increasing the speed of the fabric with relation to the speed of the fluid travel itself. The movement of the fabric in the fluid greatly exceeds the critical speed of travel of the fluid in the wells, whereby the friction of the moving web in the fluid will in conjunction with the critical spacing of the side walls containing the fluid, cause a turbulence in the nature of cyclonic currents.

In the disclosure shown in the present application and including Figs. 5 to 9, inclusive, the identical principle of fluid treatment of a continuous web of fabric by pressure developed as the result of critical well dimensions and fabric speed is disclosed in Figs. 1 to 4, inclusive. In the modified form, which includes Figs. 5 to 9, the differences are to be found primarily in the handling of the fluid, the structure utilized for the handling of the fluid being such as to permit more accurate control, regardless of the speed of travel of the web under all conditions. As in the first disclosure, each section of the tandem unit of the modified form is identical, each including outer side and end walls 50 of proper dimensions and of such material that they will not corrode from use of chemicals which may be contained in solutions involved in the different processes. The bottom of each of the sections is indicated by reference character 51 and within the treating vats formed by the walls, a liner is provided, which liner is spaced from the end walls and bottom of the vat to permit the introduction of suitable fluid to provide the necessary temperature control. The inner liner is shaped to form spaced wells 52, as in the original form, illustrated as four in number in each of the sections. The bottom of each well is curved and substantially semi-circular as shown at 53, the contour of which corresponds

to the contour of the peripheral surface of the guide rollers 54 which may be supported by the hangers 55 suspended from the bottom of the baffles 56, 57, 58 and 59, each of the baffles being formed of spaced parallel walls 60, which walls are reinforced by suitably spaced channel elements 61 of any suitable number and arrangement, it being understood that other forms of spacers can be provided if they accomplish the same purpose. The vertical walls of each of the wells are parallel and the baffles are parallel and lie in a common plane with the spaced walls of the baffles, which latter are of such dimensions as to provide critical fluid areas which will be hereinafter more fully described.

The hollow walls defining the wells are closed by top plates 62, these top plates being gradually of increased height from the inlet end towards the outlet end to provide a fluid level of gradually and successive increased elevation. It will be noted that the top plates 62 are each inclined towards the inlet end and this stepped-up arrangement corresponds in substance with the disclosure of the device of Figs. 1 to 4.

The baffle structure is modified to the extent that the baffle A, which is arranged in the well at the inlet end, is of a height substantially the same as the height of the tank walls to provide for confining the fluid at the inlet end and prevent overflow due to foaming action of the rapidly moving chemicals which may be contained in the apparatus. The 2nd, 3rd, and 4th baffles indicated by reference characters B, C, and D are of gradually increasing height to maintain the fluid between the wells at stepped elevations as indicated by the reference character L, this fluid elevation being substantially above the guide rollers 63 as will be noted by reference to the disclosure of Fig. 5.

In Fig. 9 it will be noted that one of the end baffles is shown in perspective to indicate the relatively wide recess 64 defined by upper and lower longitudinal walls 65. In this figure it will be seen that the lower guide rollers 54 are suspended from the bottom of the baffles so that they may be removed with the baffle structure, hooks 66 being provided to facilitate the lifting operation. Spacer channels 67 are provided on the ends of the baffles and upon these channels are the hanger elements 68 which project substantially at each end of the baffle structure to overlie and rest upon the side walls of the vat. It will be understood that the spacer channels 67 are, as shown in the disclosure, of relatively greater height towards the outlet end of the vat, the spacer channels 67 for the baffle B being substantially of greater elevation than the spacer channel for baffle C, and similarly the spacer channel for baffle C being of greater elevation than the spacer channel for baffle D. By this structure the baffles are positioned so that the guide rollers 54 are substantially spaced with respect to the curved bottom 53 of each of the wells, this spacing between the guide rollers 54 and the curved well wall 53 being one-half the distance between the treating channels provided in the well at each side of the well walls and the adjacent baffle wall. It is to be understood that in feeding the continuous web of fabric F, the guide rollers 69 and the guide rollers 54 are so positioned that the web will travel centrally of the walls forming the confining chambers at each side of the baffles. This conforms to the arrangement in the disclosure of Figs. 1 to 4, inclusive.

At the entrance and exit sides of each of the treating vats I have provided below the liquid level accumulating chambers indicated by reference characters G and H, these chambers being formed by offsetting the outer walls of the first and last channels as indicated by reference characters 70 and 71, respectively, and offsetting adjacent outer faces of the respective well baffles as indicated by reference characters 72 and 73. It will be noted that the offset portions referred to are relatively of substantial depth, although the accumulating chambers formed by these offset wall portions vary in size so that the chamber G at the

15

inlet end is substantially smaller than chamber H at the outlet end, and is located below the outlet chamber to permit a gravity flow of a portion of the fluid accumulating at the outlet chamber H back to the inlet chamber G by virtue of fluid flow channels J and K. These channels are positioned between the spaced side walls 75 and 76 and as more clearly shown in Fig. 7 are inclined from the horizontal and downwardly toward the inlet end, the chambers G and H communicating with these channels by openings 77 formed in the end walls of the accumulating chambers. It will be noted that the accumulating chambers G and H are substantially of the same area at each side of the continuous web which is traveling there-through and that the ports 77 are centrally arranged with respect to the lateral wall spacing so that the discharge from the chamber H into the chamber G is uniform at each side of the web.

In the tandem unit shown in Figs. 5 to 9, inclusive, provision is made for discharging a portion of the fluid at the discharge end of the first unit to the intake end of the second unit, it being understood that the rapid movement of the continuous web tends to urge a relatively rapid flow of fluid from one well to another so that the accumulating chamber H of the first unit is normally provided with more liquid than is necessary for the operation of the first unit and this excess accumulation of fluid is discharged through the by-pass 80 from chamber H of the first unit to chamber G of the second unit. By reference to Fig. 8 it will be noted that the by-pass 80 opens at 81 into the gravity channels J and K and excess fluid accumulating in these channels will move through by-pass arrangements 80 due to suction created in the by-pass 80 as the result of the pull or friction of the web F moving rapidly through the first well. In addition, the by-pass 80 as shown in Fig. 5 is inclined downwardly at a substantial angle to provide a gravity flow in conjunction with the suction provided by the movement of the web in the first well. The accumulating chamber H at the discharge end of the second tandem vat, as shown in Fig. 5, is provided with a by-pass 82 at a substantial elevation, this by-pass feeding the surplus fluid that may reach this accumulating chamber H and discharging same at the entrance end or initial well of the first vat, the discharge through the by-passes 80 and 82 being indicated by arrows in Fig. 6. By the foregoing arrangement a percentage of the fluid is conducted by the channels J and K from the relatively large accumulating chamber H of the first unit to the accumulating chamber G of this same unit, while a portion of the fluid in the chamber H of the first unit is by-passed by gravity and suction through the ducts 80 to the entrance accumulating chamber G of the second tandem unit. In addition, the fluid in the accumulating chamber H of the second tandem unit is returned to the accumulating chamber G of the first unit, it being obvious to one skilled in the art that the amount of fluid accumulating in chamber H of the second tandem unit will be substantially less than the fluid accumulating in chamber H of the first vat, and that through the arrangement shown the fluid is distributed, comingled, and stimulated by the addition of such fluid as may be fed through the initial feed pipe M, see Fig. 5, into the first well. The amount of fluid which is provided at M in the first well in the first of the tandem units will be determined by the operation involved as determined by the nature of the fabric, the type of treatment, the speed of travel of the web F, and other factors.

In each of the by-passes 80 and 82 suitable valves 84 may be provided to regulate the gravity discharge in accordance with the operation although in many instances the normal flow will be sufficient to balance the movement of the fluid to secure the desired treatment as the feeding of the fluid through the valve 85 in the inlet supply pipe M will inherently comprise a function of the fluid flow. Referring to Fig. 6 it will be noted that suitable pipe

16

connections 86 have been provided for introducing and discharging temperature controlling fluid between the spaced walls of the wells.

In Fig. 5 a drip plate 86 is provided for removing the excess fluid from the squeeze rollers 87 to discharge the same into the accumulating chamber H, the amount of fluid which may be removed by the squeeze rollers, if any, being controlled by the operation involved in the use of the assembly.

It has been determined as the result of extensive tests and subsequent commercial production that the spacing of the walls at each side of the rapidly moving fabric is definitely critical and that this spacing should be in the nature of one inch or less, so that the wall of fluid at each side of the centrally positioned continuously moving web should be one-half inch and this one-half inch diameter should comprehend the spacing of the bottom guide roller from the bottom of the well. This critical arrangement of spacing and the critical provision of fluid walls at each side of the web results in the cyclonic currents comprehended by Fig. 4 of the drawings of the present application, and contrary to the theory that the longer the fabric stays in the fluid the more positive the fixation, applicant finds that the greater the speed and consequently the less time the fabric remains in the fluid, the greater the dispersion of the fluid and more definite the penetration of the fluid through the fabric from both sides. In normal running of fabrics it has been found that a one-half inch spacing at each side of a baffle, so that there is one-fourth of an inch wall of fluid at each side of the fabric will produce maximum efficiency, and that the turbulence created by a closer spacing, in the dyeing of most fabrics, will have a greater penetrating force. The one-half inch wall of fluid providing one-quarter inch lateral spacing on each side of the web is substantially the minimum to provide the desired velocity of the cyclonic currents and also such a spacing is more or less critical due to the web structure. It is realized that the spacing of the well must be sufficient to accommodate the fabric and to provide the fluid wall in which the turbulence is created.

By the disclosure shown and described and the use of the foam baffle at the entry of the fluid in a vat, and the relatively large well to accommodate the up-liquid, and to provide for its distribution, a control is provided which by suitable adjustment will facilitate substantially an automatic operation and liquid feeding situation extremely desirable and heretofore unknown in the art. By by-passing proportionate amounts of fluid from the accumulating chamber of the first vat to handle the up-liquid and to deliver the surplus liquid automatically to the entrance accumulating chamber of the first vat and the entrance accumulating chamber of the second vat provides a stabilization of the fluid quite desirable in producing a uniform fabric treatment and this situation is further enhanced by the return from the uplift accumulating chamber of the second vat to the accumulating chamber of the first vat, and permits a proportionate feeding of fresh liquid to provide maximum results.

In referring to the travel of the fluid and the limited amount of fluid to which a particular portion of the traveling web may be subjected the fact must be kept in mind that a definite ratio is created and maintained between the width of the well in which the web is traveling, the gravity of the fluid, the speed of travel of the web, the amount of fluid initially fed into the first well, and the choking or valve action by the restriction at the bottom of each well, as provided for by the definite spacing of the lower face of the bottom roller with respect to the well surface. All of these factors must be balanced to accomplish two definite results, the first result being a limitation of the amount of fluid to which a particular surface area of the web is subjected; and the second, the restraining of the fluid to facilitate the generation of the cyclonic penetrating currents, the velocity of which

is vital in all of the treatments. It will be understood that in choking the bottom of each well, by the spacing of the roller with respect to the bottom of the well surface, to restrict the fluid flow as created by gravity and by the speed of movement of the fabric, two different situations are presented at the down-flow and up-flow sides of each baffle, and the conditions at each side of the baffle necessarily is modified by gravity and the web movement. A balancing of the fluid flow at each side of the baffle is essential in order to produce uniform treatment and penetration by the cyclonic currents. Obviously the fluid at each side of the web and at each side of the baffle is flowing and at the same time the turbulent cyclonic currents are generated with required velocity. The speed of flow of the fluid determines the amount of bleeding off which may occur in a treatment as it determines the amount of fluid to which any definite portion of the fabric may be subjected, and this bleeding off is further regulated by the cyclonic currents, the impact of which tend to disperse and move inwardly the dye, rather than to permit its movement into the fluid.

What I claim is:

1. An apparatus for the fluid treatment of a rapidly moving continuous web of fabric, a tank, a series of transverse vertical partitions defining wells in said tank, each well being formed with an upwardly facing, arcuate surface at its bottom, baffles arranged medially in each of the wells and defining a tortuous course for the travel of the web, upper rollers positioned at each side of each baffle and lower rollers supported by the bottom portions of said baffles to guide the continuously moving fabric downwardly and upwardly through the fluid at each side of the baffles, the upper rollers and the tops of said partitions being successively arranged in upwardly stepped relation in the direction of the web travel, and the lower roller being spaced from the curved bottom portion of the well a distance one-half the width of the fluid well at each side of the baffle to provide a fluid restriction, accumulating chambers formed in the first and last wells at the inlet and outlet sides of the baffles and at each side of the web, the accumulating chamber at the outlet side of the last well being spaced substantially above the accumulating chamber at the inlet side of the first well, ports formed in the side walls of the tank at each end of each of the accumulating chambers, and means for transferring the fluid from the accumulating chamber in the exit end of the tank to the entrance well.

2. An apparatus for the fluid treatment of a rapidly moving continuous web of fabric, a plurality of tanks arranged in tandem, each of said tanks being formed with a series of transverse vertical partitions defining wells, baffles in each of the wells defining a tortuous course for the travel of the web, upper rollers positioned at each side of each baffle and lower rollers supported by the bottom portions of said baffles to guide the continuously moving fabric downwardly and upwardly through fluid at each side of the baffles, the upper rollers and the tops of said partitions being arranged in upwardly stepped relation in each of the tanks and in the direction of the web travel, accumulating chambers formed in the first and last wells of each tank and at the inlet and outlet sides of the baffles of each tank and at each side of the web, the accumulating chamber at the outlet side of the last well in each of the tanks being spaced substantially above the accumulating chamber at the inlet side of the first well of each tank, ports formed in the side walls of the tank at each end of each of the accumulating chambers, and ducts opening into said ports and connecting the accumulating chambers at the outlet end of each last well of each tank with the inlet well of the adjacent tank.

3. The substance of claim 2 characterized in that the accumulating chamber at the outlet side of the last well in the first tank is connected to the accumulating chamber in the first well of the same tank by a duct, and

means are provided for deflecting a portion of the liquid from the outlet well of the first tank to the inlet well of the same tank through said duct.

4. The substance of claim 2 characterized in that the spacing between each side of each baffle and the adjacent vertical partition is not more than one inch, while the roller at the bottom of the baffle is spaced from the bottom of the well substantially one-half the width between the partition and its adjacent side wall to provide a restriction for controlling the movement of the fluid due to the rapidly moving continuous web of fabric.

5. In an apparatus for the fluid treatment of a rapidly moving continuous web of fabric, a pair of tanks arranged in tandem, both of said tanks being formed with a series of transverse vertical partitions defining wells, the bottom walls of said wells being arcuate in cross-section, baffles in each of the wells defining a tortuous course for the travel of the web, said baffles being positioned centrally in each well to provide restricted panels of fluid medially of which the web is moved, upper rollers positioned at each side of each baffle and lower rollers supported by the bottom portions of said baffles to guide the continuously moving fabric downwardly and upwardly through the fluid at each side of each of the baffles, the upper rollers and the tops of said partitions being arranged in upwardly stepped relation in both of the tanks and in the direction of travel of the web, accumulating chambers formed transversely of the tanks and in the inlet and outlet sides of the first and last wells in each of the tanks, said chambers being formed by offsetting parallel portions of the walls of the baffles and the wells, the accumulating chambers at the outlet side of each of the tanks being of greater elevation than the accumulating chamber at the inlet side of each tank, ducts connecting the outlet accumulating chamber of the first tank with the inlet accumulating chamber of the same tank, ducts connecting the outlet accumulating chamber of the first tank with the inlet accumulating chamber of the second tank, and ducts connecting the outlet accumulating chamber of the second tank with the inlet accumulating chamber of the first tank.

6. The substance of claim 5 characterized in that ducts are provided which open into the tanks and feed a heat exchange medium between the wells for the purpose of tempering the treating fluid in the wells.

7. The substance of claim 5 characterized in that the ducts transferring fluids to and from the accumulating chambers are provided with control valves for determining the movement of the fluid in accordance with requirements.

8. The substance of claim 5 characterized in that the first baffle of each tank extends above the height of the other baffles of each unit to provide a foam protector to prevent the escape of scum to the material being treated.

9. The substance of claim 5 characterized in that each of the baffles is provided with lateral arms at their upper end portions for supporting engagement with the side walls of the tanks.

References Cited in the file of this patent

UNITED STATES PATENTS

659,343	Fries	Oct. 9, 1900
1,029,866	Haskell	June 18, 1912
1,037,280	Matter	Sept. 3, 1912
1,375,389	Haskell	Apr. 19, 1921
1,402,765	Haskell	Jan. 10, 1922
1,497,075	Elliot	June 10, 1924
1,652,649	Tice	Dec. 13, 1927
2,199,233	Williams	Apr. 10, 1940
2,203,678	Dursteller	June 11, 1940
2,203,793	Lovett	June 11, 1940

(Other references on following page)

2,764,010

19

UNITED STATES PATENTS

2,209,950	Nai -----	Aug. 6, 1940
2,253,083	Mees et al. -----	Aug. 19, 1941
2,364,838	Williams -----	Dec. 12, 1944
2,396,908	Womble -----	Mar. 19, 1946
2,445,504	Williams -----	July 20, 1948

20

FOREIGN PATENTS

235,256	Germany -----	Feb. 8, 1910
609,728	Great Britain -----	Oct. 6, 1948

OTHER REFERENCES

Amer. Dyestuff Reporter, May 19, 1947, page 256.