Feb. 8, 1966 M. E. MAYNARD 3,233,435

FLUID-TREATING APPARATUS

Original Filed June 22, 1961 3 Sheets-Sheet 1

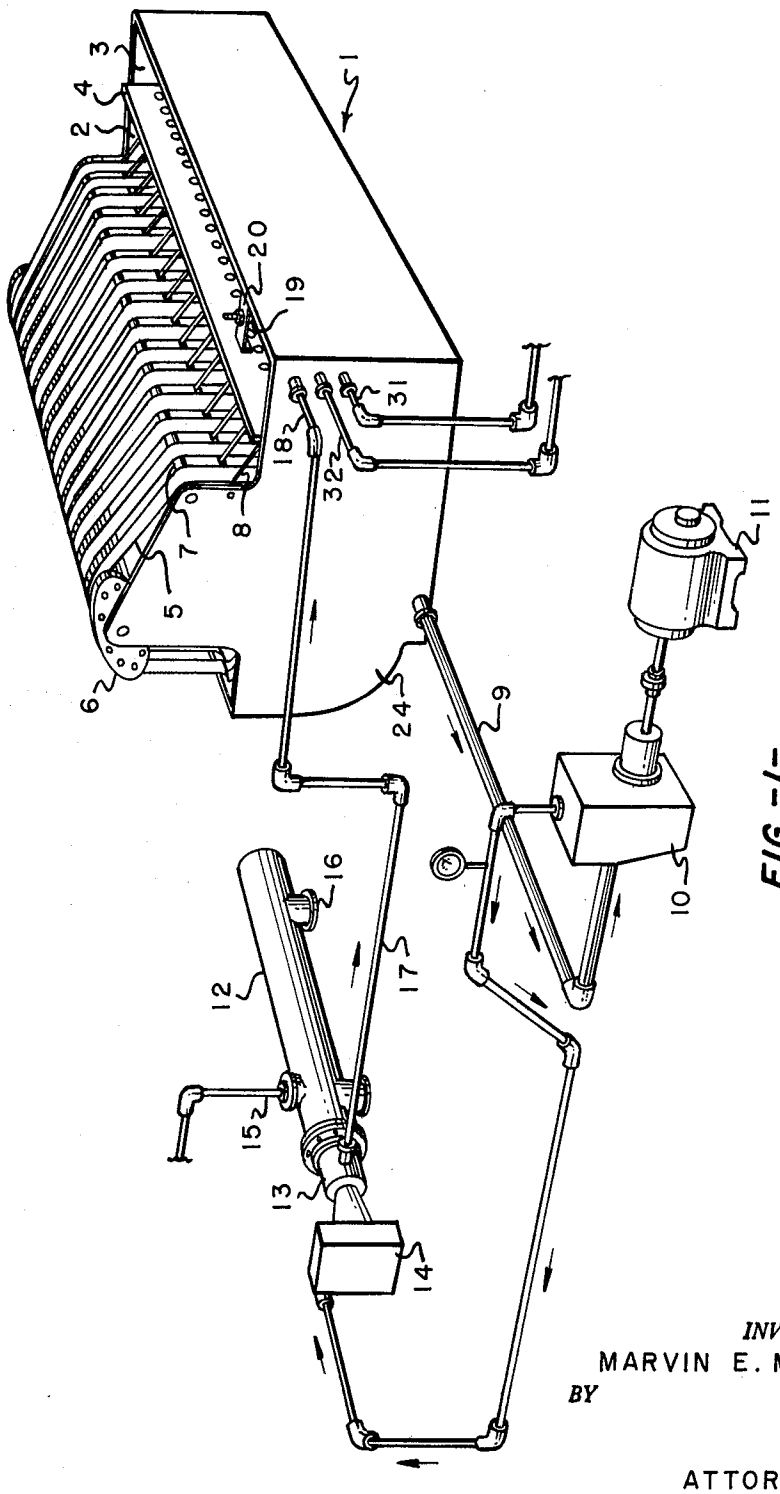


FIG. -1-

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FLUID-TREATING APPARATUS

Original Filed June 22, 1961 3 Sheets-Sheet 2

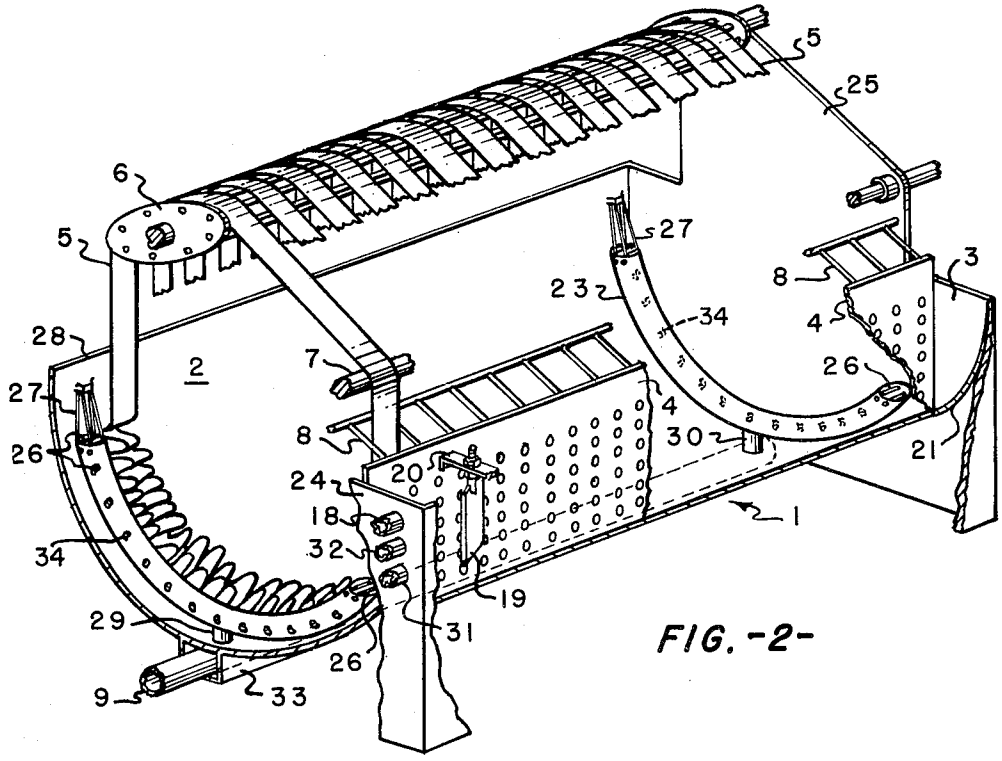


FIG. -2-

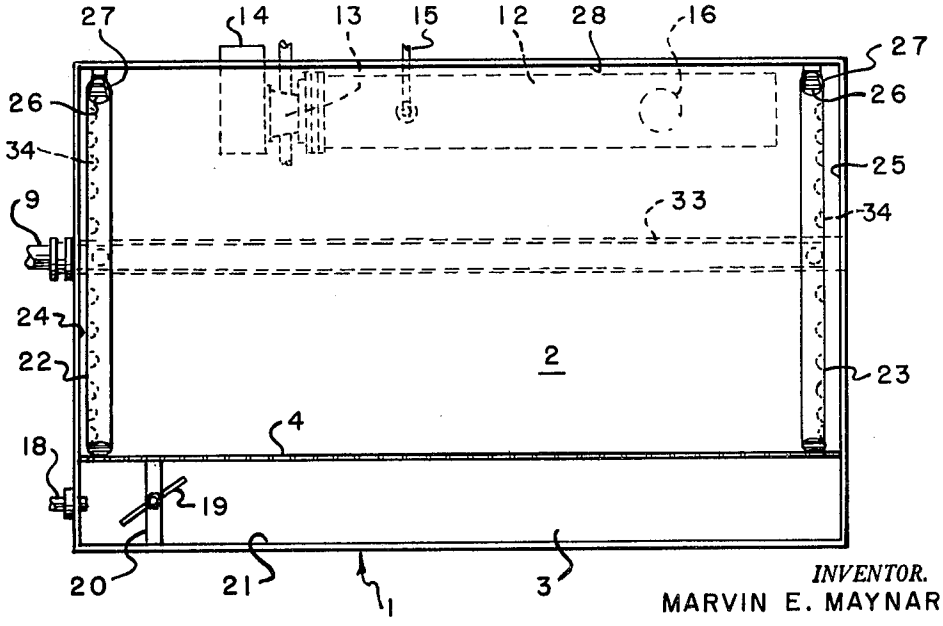


FIG. -3-

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FLUID-TREATING APPARATUS

Original Filed June 22, 1961 3 Sheets-Sheet 3

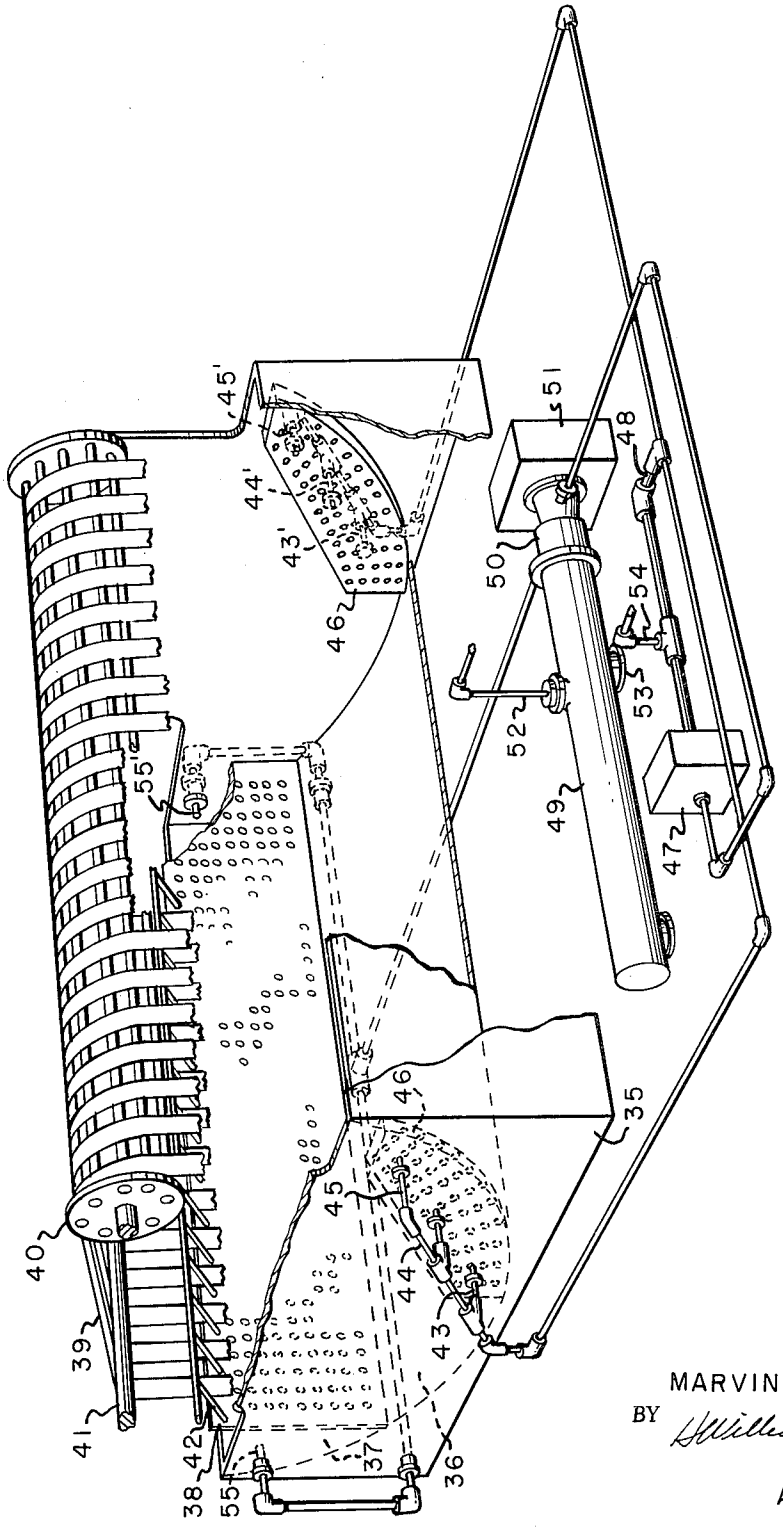


FIG. 4

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United States Patent Office 3,233,435 Patented Feb. 8, 1966

3,233,435

FLUID-TREATING APPARATUS

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Original application June 22, 1961, Ser. No. 118,985, now Patent No. 3,128,617, dated Apr. 14, 1964. Divided and this application July 3, 1963, Ser. No. 298,514
10 Claims. (Cl. 68—15)

This application is a divisional application of my copending U.S. patent application Serial No. 118,985, filed June 22, 1961, now U.S. Patent No. 3,128,617 of April 14, 1964.

This invention relates to novel apparatus for achieving improved control of variables in fluid-treating process, particularly in processes for dyeing textile materials.

Fluid-treating processes generally invlove the dissolution or dispersion of one material into another and the heating or cooling of the resulting system. The success of the process often hinges upon the degree of control over at least these process variables. Unfortunately, however, apparatus for providing the high degree of control required has not been developed to the same extent as the processes themselves, thereby forcing the operator to resort to alternative and less desirable practices.

These problems are particularly acute in the dyeing of textile materials, which involves the dissolution or dispersion of various dyestuffs in a suitable medium and periodically raising, lowering, and maintaining a given temperature. Some fabrics, such as those composed of wool or nylon fibers, have been extermely difficult to dye levelly because apparatus presently available is not capable of providing the control over the dyestuff concentration and temperature so necessary to level dyeing.

For example, the exhaustion of a dyestuff onto a textile material is an equilibrium reaction. In developing a dyestuff formulation to provide a desired shade, the dyer selects a group of dyestuffs which will give him the general color desired and then determines at which temperature the dyestuffs selected will exhaust onto the fabric to provide the desired shade of the general color selected. Once this temperature is selected, it is extremely important that it be controlled since variations in temperature at this point may reverse the exhaustion reaction or vary the rate of exhaustion, thereby providing a shade of color different from that desired.

In a typical situation, a blue, red, and a yellow dyestuff may be formulated to provide a grey color. The dyer then determines that the desired shade of grey, e.g., a greenish grey, will be provided at 205° F., at which temperature the requisite amounts of the various dyestuffs will exhaust onto the fabric to provide the desired shade of color. The dyer also determines that, at a temperature of 200° F., a greater amount of the blue dyestuff will exhaust onto the materials, so that a bluish-grey shade will result, whereas at a temperature of 210° F., a greater amount of yellow dyestuff will exhaust, so as to provide a yellowish-grey shade.

It becomes quite apparent that the dyestuff medium must be carefully controlled at the 205° F. equilibrium level if the desired greenish-grey shade is to be obtained. For example, the portion of the fabric which is contacted by the dyestuff medium at 200° F. will take on a bluish-grey shade, that at 205° F. the desired greenish-grey shade, that at 210° F. a yellowish-grey shade. Obviously, if the temperature varies from 200° to 210° F. across the fabric, the fabric undesirably takes on different shades.

Once this situation has arisen, the dyer may follow

any one of several alternative procedures. For example, he may attempt to bring a lighter shade, if this is the case, up to the desired shade by adding a sufficient amount of the color dyestuff required. If the fabric has been dyed a shade darker than desired, some dyestuffs may be removed by stripping agents, although with present day equipment level stripping is as difficult as level dyeing, so that this procedure is not often feasible. On the other hand, the fabric may be dyed a still darker shade, such as black, whereby a useable fabric is obtained, though, of course, not in the desired shade. These procedures increase materially the expense invloved in dyeing textile materials and numerous attempts have been made to overcome the conditions which raise these problems.

For example, a most common means of controlling the temperature of the dyestuff medium is by steam jets separated from the medium by a perforated wall. These jets are actuated when detecting devices indicate that the temperature is decreasing in the medium. This apparatus, as presently designed, frequently causes hot and cold spots in the dyestuff medium and, furthermore, often results in substantial dilution of the dyestuff medium which in itself causes shade variations in the fabric. While this latter difficulty has been solved by more expensive closed-end steam coils extending into the dye medium, hot and cold spots varying in temperature as much as 20–30° F., are still commonplace in present day commercial apparatus.

This difficulty has also restricted the dyestuffs which can be utilized in the dyeing process. For example, a dyestuff formulation which will give its intended shade at a temperature within a fairly restricted range, e.g., 206–209° F., can not be utilized in conventional apparatus because of the wide variations in temperature throughout this equipment.

Obviously, the cost of dyeing in conventional apparatus is higher in that greater amounts of dyeing assistants and dyestuffs must be utilized to obtain level dyeings in a given shade. In addition, the dyeing cycle is longer in conventional equipment because of the add-dyeing required and the longer times required to achieve a given temperature.

The factors which prohibit a uniform temperature in conventional apparatus also contribute to non-uniform dispersion of the dyestuff throughout the apparatus, so that level dyeing is difficult to attain regardless of temperature.

It is an object of this invention to provide improved control over process variables in fluid-treating apparatus.

A further object of this invention is to provide novel apparatus for dyeing textile materials at controlled temperatures, thereby solving many of the problems associated with dyeing procedures utilizing conventional apparatus.

It is a further object of this invention to minimize temperature variations in such apparatus in an economical manner and without diluting the dyestuff medium.

Still a further object of this invention is to provide such apparatus which will allow more uniform temperature control, both heating and cooling, at increased forced rates.

It is still a further object of this invention to provide such apparatus wherein the dyestuff is dispersed evenly throughout the apparatus, greatly facilitating level dyeing.

An additional object of this invention is to provide dyeing apparatus which permits shorter dyeing cycles because of the reduced time required to raise uniformly the temperature of the dyestuff medium to the desired equilibrium level and because of the shorter period of ex-

posure required at this level due to the high degree of control of the equilibrium level temperature.

Yet another object of this invention is to reduce materially or eliminate entirely add-dyeing, enabling the dyer to automate the dyeing process after establishing a dyestuff formulation and desired equilibrium temperature.

Still another object of this invention is to reduce the amount of materials required to provide the desired shade of color in a textile material, while increasing the number of dyestuffs which can be utilized because of the more exacting control of the dyeing equilibrium temperature, as is required for many desirable dyestuffs for which no suitable apparatus has heretofore been developed.

An additional object of this invention is to provide apparatus suitable for the level-dyeing of textile fabrics which are presently extremely difficult to dye evenly because of temperature variations in conventional equipment.

These objects are accomplished in accordance with this invention by creating a zone of fluid turbulence in a predetermined volume of the treating fluid while it is enclosed, e.g., surrounded, in suitable equipment. The fluid is directed transversely from the turbulent zone along the depth and width thereof and then toward a plurality of predetermined areas suited in a plane displaced from and oriented at a transverse angle to the turbulent zone. This flow pattern is maintained by recirculation, continuous in most instances, of the fluid from these predetermined areas back into the turbulent zone. Most efficient flow patterns are developed in lengthwise bodies of fluid, preferably separated into at least two portions, by disposing the predetermined areas in one portion at the ends thereof and then recirculating the fluid from these areas into another portion where turbulence is developed.

The turbulence in at least one of the zones may be created in any convenient manner, but is created most simply and economically by diverting the recirculating fluid from its delivery path as it enters the zone where turbulence is to be created.

This novel process is most conveniently conducted in fluid-treating apparatus comprising a container for the treating medium, e.g., a dyestuff medium, and at least one baffle means located within the container so as to separate the container into at least a first and a second inner chamber, the baffle means having a plurality of openings along its length and width, whereby the dyestuff medium is free to pass between the first and second inner chamber. An outlet means is provided for the first chamber and is preferably adapted for removing the dyestuff medium from the dye chamber at different depths of the medium. These means, which are also preferably located at both ends of the dye chamber, are connected to an inlet means in the second chamber by a conduit system which includes a pumping means and, preferably, a heat exchange means, so that the dyestuff medium may be constantly recirculated at the desired rate from the first chamber into the second chamber and heated or cooled as desired. At last one turbulence generating means is located within the second chamber to facilitate free flow of the dyestuff medium in this chamber into the dye chamber.

A preferred turbulence generating means comprises a deflector means intersecting at a transverse angle the delivery path of the dyestuff medium from the inlet means for the second chamber. When the recirculating dyestuff medium is directed against the deflector means, a high degree of turbulence is developed in the second chamber. The turbulent recirculating medium is preferably directed by the angle of the deflector means along the entire length of the perforated plate and downwardly across the width of the plate, thereby greatly facilitating the movement of the dyestuff medium from the turbulent second chamber into the first chamber at a rapid and uniform rate and at all strata of the dyestuff medium in the dye chamber.

Preferably, the baffle means separating the container into a dye chamber and a chamber of fluid turbulence is situated in a plane substantially parallel to and displaced from the longitudinal axis of the container, thereby providing lengthwise inner chambers.

The baffle means should be sufficiently open along its length and width to permit free flow of the fluid medium between the chambers. At the same time, the separator means should provide sufficient resistance to permit the development of fluid turbulence in the second chamber. These objectives are readily attained with a perforated plate, although heavy gauge screens, separated baffle plates and the like are similarly useful.

The dye chamber contains textile material, which may be passed continuously into and out of the first chamber or remain immersed, as in a package dyeing operation.

While the turbulence provided in the second chamber will improve greatly the rate and uniformity of flow from the second chamber into the dye chamber so as to improve the degree of control of temperature in the dyeing chamber, this control is greatly facilitated in a preferred embodiment of this invention wherein outlets are located at each end of the dye chamber and extend substantially along its entire width preferably conforming substantially to the cross-sectional configuration of the dye chamber, so that the dyestuff medium will be removed from the dye chamber at various levels throughout the depth of the dyestuff medium, as is highly desirable.

The direction of the openings toward and upwards of the adjacent end walls of the first chamber in this embodiment seems to draw the dyestuff medium toward both end walls and downwardly along the walls toward the openings, so that the dyestuff medium is in a state of flow at each point in the container, thereby insuring adequate heat transfer and dyestuff dispersion. As a result, the textile material being dyed is confronted on all surfaces with a dyestuff medium containing the same amount of dyestuff and dyeing assistants at a substantially uniform temperature.

The outlet tubes can lead into a common outlet drain, as shown below, or have separate drains as desired. Obviously, the drain may be placed in any convenient location.

In another embodiment of this invention outlets are placed in both end walls of the dye chamber, preferably at different levels along the depth of the dyestuff medium and across the width of the dye chamber. The outlets may lead by piping to an outlet tube as described above or to a header if desired. Alternatively, tubular outlets as described above may be placed in end chambers formed by the end walls and additional baffle means as utilized to separate the container into lengthwise chambers. In these latter embodiments, screens or other lint catchers are preferably placed at the outlets from the dye chamber.

In a highly preferred embodiment of this invention, the outlet means is combined with an inlet means which feeds into one end of the second chamber so that the recirculating dyestuff medium pumped therethrough will be directed lengthwise of the chamber against the deflector means. The deflector means is located in close proximity to the inlet means, preferably within the first third of the length of the second chamber from the inlet means.

The deflector means and inlet means are situated to obtain the maximum degree of turbulance along the entire length of the perforated plate. At least one plate, the preferred type deflector means, is required to provide the desired degree of turbulence, although a plurality of plates may be utilized along the entire length of the second chamber if desired. Preferably, the plate, or plates, is adjustable in two planes and is directed toward the baffle means.

The deflector means, as noted above, intersects the delivery path of the recirculating dyestuff medium from the inlet means into the second chamber to generate the desired turbulence. While it is preferred to place the inlet

means at one end of the chamber, the inlet means may be placed at any desired location leading into the second chamber, for example, at approximately the middle of the second chamber so that the recirculating medium is directed toward the baffle means separating the container into two chambers. In this embodiment of the invention, a V-shaped, perforated if desired, deflector plate may be utilized to direct the recirculating dyestuff medium toward both ends of the second chamber along the perforated plate.

In still another embodiment, inlet means may be located at each end of the second chamber with deflector means intersecting the delivery path of either or both inlet means. In fact, some degree of turbulence is provided, particularly at the middle portion of the chamber, when both deflector means are eliminated. The flow pattern thus produced may be suitable in some processes.

The recirculating dyestuff medium is prefarbly continuously heated by a heat exchange means located within the conduit system connecting the outlet and inlet means, in that far more exacting temperature control is provided in this manner. Preferably, the heat exchange means is adapted for both heating and cooling, so that the dyestuff medium may be forcibly heated or cooled at a rapid rate.

A preferred heat exchange means comprises a Formee heat exchanger combined with a four-way valve and timing mechanism therefor, so that the direction of the dyestuff medium through the heater may be reversed as desired, thereby providing a flushing action to remove any entrained material from the heater. This feature is particularly desired when textile materials comprising spun yarns are being treated, in that lint and other contaminants might clog the heat exchanger. The flushing action provided by the timed four-way valve obviates this problem. Clogging of the openings of the outlet means in the dye chamber may be obviated somewhat by screens, bars or other lint catchers.

While the fullest advantages of the apparatus of this invention are accomplished when the heat exchange means is located in the recirculating conduit system, the heat exchange means may be eliminated entirely and temperature control provided by jets of steam, preferably dry steam, leading into the turbulent chamber at spaced intervals. This latter expedient is made possible only by the excellent three-dimensional fan-shaped flow pattern developed by the apparatus of this invention, whereby the recirculating dyestuff medium is forced at an increased rate from the turbulent second chamber transversely into the dye chamber and is then drawn toward each end of the dye chamber along various levels of the medium, thereby minimizing the "dead" spots or "hot" spots which generally occur in apparatus heated by steam through either open jets or closed end coils. In addition, the recirculating medium is forced downwardly as well as along the length of the perforated plate, so that the medium is fed into the dye chamber at all strata of the medium in the dye chamber, again facilitating the elimination of non-uniformities in the medium temperature and concentration.

While a non-clogging open impeller type pump is preferred for use in the apparatus of this invention, various conventional pumping means or a plurality thereof may be utilized.

FIGURE 1 is a schematic view of one apparatus suitable for practising the process of this invention.

FIGURE 2 is a cut-away view of FIGURE 1, illustrating in a more detailed manner the interior of the apparatus of FIGURE 1.

FIGURE 3 is a top view of FIGURE 2 without the fabric moving apparatus.

FIGURE 4 is a schematic, cut-away view of another embodiment of apparatus suitable for practising the process of this invention.

FIGURE 1 illustrates a preferred embodiment of this invention wherein the container **1** is separated into a dye chamber **2** and a turbulence chamber **3** by perforated plate **4**. Continuous lengths of fabric **5** are passed continuously into and out of the dye chamber **2** over elliptically shaped feed roll **6** and guide roll **7** driven by a suitable motor, not shown. The plurality of fabric lengths are separated by separator bars **8** to prevent overlapping of the fabric lengths which would interfere seriously with the levelness of the dyeing operation. The dyestuff medium is withdrawn from the dye chamber from drain **9** through pump **10** driven by motor **11** and into a Formee heat exchanger **12**, by way of a four-way valve **13** controlled by timer **14**, so that at periodic intervals the dye medium is reversed in direction through the Formee heat exchanger **12**, thereby providing a flushing action. Heated or cooled fluids, for example steam or cold water, are directed in the Formee heat exchanger **12** through pipe **15**. The Formee exchanger **12** is also provided, for instances when steam is utilized, with a condensate trap **16**, which leads back into the boiler (not shown). The recirculation path is continued by passing the dyestuff medium through pipes **17** into inlet tube **18** leading into the turbulence chamber **3**.

As shown in the cut-away view of FIGURE 2, the dyebath medium is directed from inlet tube **18** against deflector plate **19** supported by bar **20** which is attached to the perforated plate **4** and front wall **21**.

As is seen, outlet tubes **22** and **23** conform generally to the cross-sectional configuration of a dye chamber **2**. Guard bars **26** are located across the end openings and perforations of the outlet tubes **22** and **23** to catch loose material, such as lint, which is drawn toward the outlet means during the operation of the recirculating system. Additional guard bars **27** are located at the end of the outlet means at back wall **28** of the container to provide additional protection from lint clogging at this higher disposed position. The outlet tubes **22** and **23** are connected by pipes **29** and **30** to the drain **9**, which extends lengthwise of the dyeing chamber from outlet **23** out into the recirculating system in false bottom **33**. Perforations **34** are provided in both outlet tubes through which the dye liquor is drawn for recirculation.

As shown in FIGURE 3, (a top view of FIGURE 2 without the fabric and fabric moving apparatus) the perforations of outlet tubes **22** and **23** are directed toward and upwards the end walls **24** and **25**. The location of the perforations at this point greatly enhances the flow pattern developed by this system during its operation as will be explained hereinafter.

Turbulence chamber **3** is also provided with a plurality of inlet tubes such as tubes **31** and **32**, for the addition of various dyeing intermediates, dye stuffs, scouring media, water and the like. The mixing of these materials is greatly enhanced by the turbulence provided when the stream is directed against the deflector plate **19**.

Operation of this apparatus is readily understood from these drawings. The container **1** is filled with the desired treating medium, e.g., a dyestuff medium, and the fabric lengths are moved into and out of the dye chamber portion **2** of the container by rotation of the feed rolls **6** and **7** in the conventional manner. As the fabric lengths move through the dye chamber, the dyestuff medium is continuously recirculated from the dye chamber **2** to the turbulence chamber **3** through tubes **22** and **23**, drain **9**, pump **10**, heat exchanger **12** into inlet tube **18**. As the dyestuff medium is pumped into the turbulence chamber **3** it strikes against deflector plate **19** whereby it is forced toward the perforated plate **4**, along its length and downwardly along its depth. This turbulent action forces the dyestuff medium through the perforations of wall **4** transversely into the dye chamber at all depths of the dyestuff medium where it is then drawn along substantially the entire width and depth of the dye chamber **2** toward outlet tubes **22** and **23** located at end walls **24** and **25**. Because the perforations of these outlet tubes are directed toward the end walls, the dyestuff medium is

drawn down the end walls as well, thereby eliminating the "dead" spots which normally occur in those locations. When the perforations of the outlet tubes are directed inwardly from the end walls, the dyestuff medium is not necessarily drawn down the end walls, although sufficient flow is usually provided to reduce the "dead" spots which normally occur. The desired flow path, however, is most readily obtained by directing the perforation of the outlet tubes toward the end walls and this embodiment is preferred for use in accordance with this invention. The continuous movement of the fabric lengths through the dye chamber as the dyestuff medium is being continuously recirculated in the desired flow pattern causes the dyestuff medium to be "pumped" back and forth between the dye chamber and the turbulent chamber. Consequently, the dyestuff medium is pumped continuously back and forth through the textile material also, thereby greatly facilitating the level dyeing of the textile material.

FIGURE 4 is a schematic, cut-away view of apparatus which does not employ deflectors in performing the process of this invention. As in the apparatus of FIGURES 1–3, the container **35** is separated into a dye chamber **36** and a turbulence chamber **37** by perforated plate **38**. Continuous lengths of fabric **39** are passed continuously into and out of the dye chamber **36** over elliptically shaped feed roll **40** and guide roll **41** driven by a suitable motor, not shown. Separator bars **42** are also provided as before.

In this embodiment of the invention, the dyestuff medium is withdrawn from the dye chamber through outlets **43**, **43'**, **44**, **44'**, **45**, and **45'** located in the end walls and placed at different levels of the dye chamber. Instead of guard bars, the outlets are covered by perforated cover plates **46** and **46'**, to catch lint and other debris.

The dyestuff medium is then pumped by means of pump **47**, driven by a suitable motor (not shown) into a manifold **48** connected to the pump by 5-inch tubing. The remaining tubing in the system is 4-inch diameter. From the pump, the dyestuff medium is forced through a Formee heat exchanger **49**, by way of a four-way valve **50** controlled by timer **51** as before, so that at periodic intervals the dye medium is reversed in direction through the heat exchange, thereby providing a flushing action. Heated or cooled liquids, for example, steam or cold water, are directed into the heat exchange through pipe **52**. The heat exchanger is also provided with a condensate trap **53**, which leads back into the boiler (not shown). Inlet **54** is provided in the pump inlet-tubing for feeding various additives, e.g., additional dyestuff, into the recirculating system as desired. The recirculation path is continued by passing the dyestuff medium into another manifold wherein the dyestuff medium is divided into two substantially equal volume streams which are then fed into oppositely situated inlets **55** and **55'**.

Operation of this embodiment of the invention is the same as the embodiment of FIGURES 1–3, except that the desired turbulence is created by the two streams being directed against one another in the turbulence chamber. This turbulence, in combination with the multilevel withdrawal of the dyestuff medium from the opposite side of the dye chamber inter alia provides the type of fluid flow necessary to control conditions in the dye chamber.

Example 1

Apparatus as illustrated in the drawings is utilized to dye a wool fabric. A standard Rodney Hunt Company Trushade 12 foot dye beck, separated into two chambers by a plate having 1 inch perforations across its entire area and located 16¼ inches from the front wall, is equipped at each end with 3 inch diameter U-shaped tubes, as shown in the drawings. Three perforations, 1¾ inches in diameter, are located at equal distances along the length of each tube. A 5 inch drainpipe connects both outlet tubes to a non-clog impeller type pump. Model No. 14A2, sold by the Gormon-Rupp Co., having a capacity sufficient to recirculate the dyestuff medium every minute. This pump is equipped with a 4 inch diameter outlet tube leading into the four-way valve of a standard Formee heat exchanger, heated by steam and cooled by tap water. The four-way valve is equipped with a timing device so that the direction of the material pumped therethrough may be reversed at periodic intervals to prevent clogging of the heater by lint and other contaminants from the dyebath solution. The Formee heater is connected to the dyebath chamber provided by the perforated wall and the front wall of the dye beck by a 4 inch tube. The 4 inch inlet tube is located 18½ inches from the top and 11 inches back from the front of the dye beck. Located 12 inches from the inlet tube and directly in the path of material being pumped from the inlet tube is a solid rectangular plate (6 inches wide by 13 inches long) directed toward the perforated wall at an angle of about 20°. This plate is adjustable in two dimensions, i.e., pivotable about its major axis and also toward the end walls.

Utilizing this apparatus, the dye beck is filled with about 1050 gallons of tap water. A plurality of fabric lengths in rope form is then loaded onto the guide rolls, driven by a suitable motor, and run through the cold water for ten minutes to completely wet-out the fabric. The dye beck is then emptied, refilled and 3.06 lbs. of sodium hydroxide, 1.53 lbs. tetra-sodium pyrophosphate, 1.91 lbs. of Triton X–100, a non-ionic alkaryl polyether alcohol and 15.34 lbs. of Varsol, a refined aliphatic hydrocarbon solvent are added to the water as scouring agents. The temperature of the scouring solution is raised to 180° F. and the fabric is run therethrough for 60 minutes. The scouring solution is drained from the dye beck and the fabric is rinsed twice for 20 minutes at 160° F. and 120° F., respectively.

The dye beck is once again filled with water, raised to 120° F. as the fabric movement continues. After the addition of 5.75 lbs. of both Irgasol DA, a high molecular weight aromatic condensate and Avitone T, a sodium hydrocarbon sulfonate and 12 gallons of NaCl brine, as dyeing assistants, and 0.296 lb. of Neolan black WAN Extra, 0.245 lb. of Irgalan black RBL, 0.115 lb. of Cibalan yellow GRL, 0.92 lb Lumicrease grey 3LR and 0.138 lb. of Lumicrease yellow 3LG, as dyestuffs, the temperature of the resulting solution is raised to 190° F. at 2° per minute intervals and held at this temperature for 45 minutes. The dyebath is then cooled at 2° per minute intervals to 160° F., by passing cold water through the Formee heat exchanger instead of steam. At this reduced temperature, 12 gallons of brine and 15.34 lbs., ammonium acetate, as exhausting agents are added to the dyebath, which is then heated to 195° F. at 2° per minute intervals and held for 60 minutes. After cooling as before to 160° F., the dyebath is drained from the dye beck and rinsed twice with water at 80° F. Swatches of the fabric so treated are removed from the fabrics throughout the dye beck and, after drying, are compared with standard fabrics. The uniformity and levelness of dyeing is highly satisfactory and compares perfectly with the control so that no add-dyeing is necessary. During the entire operation, the instant treating media is recirculated through the recirculating system from the dyeing chamber into the turbulence chamber. Temperatures at equally spaced intervals along the length, width and depth of the dye beck are measured, the maximum variation being 3° F. The maximum variation at any fixed temperature level, e.g., the 190° F. equilibrium temperature, is about 1° F. The same fabric is dyed in a second Rodney Hunt Company Trushade 12 foot dye beck using the standard steam jets to increase the temperature of the dye beck at desired intervals. Cold water is utilized to cool the dye beck. Using this apparatus, however, 3.78 lbs. of caustic, 1.89 lbs. of tetra-sodium pyrophosphate, 9.46 lbs. of Tri-

ton X–100 and 18.92 lbs. of Varsol are required to provide similar scouring. In addition, greater amounts of deystuffs and dyeing assistants are required to provide the same degree of dyeing. For example, 9.46 lbs. of Irgasol DA, 9.46 lbs. of Avitone T, and 24 gallons of brine are required as dyeing assistants, while 0.416 lb. of Neolan black WAN Extra, 0.30 lb. of Irgalan RBL, 1.41 grams of Cibalan yellow GRL, 1.13 lbs. of Lumicrease grey 3LR and 1.51 lbs. of Lumicrease yellow 3LG are required, as determined in a preliminary laboratory experiment prior to the actual dyeing operation performed, to provide dyeing equivalent to that provided by the lesser amounts utilized by the apparatus of this invention.

In addition, 28.38 lbs. of ammonium acetate are required as exhausting agent, as compared to the 15.34 lbs. required in the modified apparatus.

The above dyeing procedure is followed exactly except that the temperature is increased at 1° per minute intervals and held, after the addition of the exhausting agent, for two hours, rather than being raised at two minute intervals and being held for one hour as is possible with the modified apparatus.

The test swatches reveal that the fabrics are not dyed levelly and uniformly throughout the dye beck. To overcome this deficiency, the above dyeing cycle is repeated with the addition of 10 grams of Neolan black WAN Extra and 4 grams of Cibalan yellow GRL. The test swatches again reveal non-uniformity and the dye cycle is repeated with the addition of 0.02 lb. of Irgalan black RBL and 0.01 lb. of Cibalan yellow GRL. Once again, none-uniformity occurs and it is necessary to repeat the dyeing cycle with the addition of 0.02 lb. of Neolan black WAN Extra to obtain a fabric comparable in quality to the fabric treated with the modified apparatus.

Thermocouples situated at the same locations as on the modified apparatus indicate temperature variations of from 10° to 30° F. during the dyeing cycle.

While the apparatus of this invention if particularly adapted to the dyeing of textile fabrics, the apparatus may also be utilized in any fluid-treating apparatus wherever control over temperature, degree of dispersion, concentration or other variables is required. Most advantageous results are provided when the apparatus of this invention is utilized in the dyeing of other textile materials, such as stock, roving, top, yarn or skeins. The recirculating system and turbulence generating means may be utilized with aqueous or solvent-based systems and to modify any of the apparatus conventionally used in the dyeing of any of these various textile materials, for example, open or closed dye becks, package dyeing equipment such as the Burlington dyeing machines (with or without increased pressure) and others.

Apparatus which may be advantageously modified to include the recirculating and turbulence generating features of the apparatus of this invention includes apparatus utilized to bleach, mercerize, size or otherwise fluid-treat textile materials.

That which is claimed is:

1. Fluid-treating apparatus comprising an elongated container for said fluid; baffle means located within the container so as to separate the container into at least a first and a second adjacent chamber, said baffle means having a plurality of openings along its length and width to permit free flow of fluid between the first and second chambers; outlet means located at each end of said first chamber adapted for removing fluid from the first chamber at uniform strata along the depth of the fluid, said outlet means being in opposing relationship and in planes substantially parallel one to the other, said planes being at a transverse angle to the longitudinal axis of said first chamber; inlet means located at each end of said second chamber so that the delivery path of the fluid as it is recirculated from the first chamber runs lengthwise of said second chamber, said inlet means being in opposing relationship and in planes substantially parallel one to the other, said planes being oriented at a transverse angle to the longitudinal axis of said second chamber; a conduit system adapted for recirculating the fluid from the outlet means for the first chamber into the inlet means for the second chamber; fluid turbulence being generated in said second chamber as said liquid is recirculated from the outlet means into both inlet means lengthwise of said chamber.

2. The apparatus of claim **1** further comprising means for heating the fluid.

3. The apparatus of claim **2** wherein said first chamber has a generally arcuate cross-section and the outlet means conform substantially to the cross-sectional configuration of said first chamber.

4. The apparatus of claim **1** wherein the outlet means comprise openings in each end of said first chamber at spaced intervals along the depth of said chamber.

5. Apparatus for dyeing textile materials comprising an elongated container for the dyestuff medium; baffle means located within the container so as to separate said container into at least a first and a second adjacent inner chamber, said baffle means having a plurality of openings along its length and width to permit free flow of the dyestuff medium between the first and second chambers; outlet means located at opposing ends of said first chamber adapted for removing the dyestuff medium from the first chamber at uniform strata along the depth of the dyestuff medium, said outlet means being in opposing relationship and in planes substantially parallel one to the other, said planes being at a transverse angle to the longitudinal axis of said first chamber; inlet means located at each end of said second chamber so that the delivery path of the dyestuff medium as it is recirculated from the first chamber runs lengthwise of said second chamber, said inlet means being in opposing relationship and in planes substantially parallel one to the other, said planes being substantially perpendicular to the longitudinal axis of said second chamber; a conduit system adapted for recirculating the dyestuff medium from the outlet means for the first chamber into the inlet means for the second chamber; and means for heating said dyestuff medium; fluid turbulence being generated in said second chamber as said fluid is recirculated from the outlet means into both inlet means lengthwise of said chamber.

6. The apparatus of claim **5** wherein the means for heating said dyestuff medium comprises a heat exchanger located in the conduit system.

7. The apparatus of claim **5** which further comprises means for moving textile material into and out of said first chamber.

8. The apparatus of claim **5** wherein the delivery paths of the inlet streams of dyestuff medium into said second chamber are directly opposing.

9. The fluid-treating apparatus of claim **1** wherein said conduct system is adapted for dividing said fluid into at least two portions, and directing at least one of such portions into one end of said second chamber at the inlet means thereof and at least one other of said portions into the inlet means at the opposite end of said second chamber.

10. The fluid-treating apparatus of claim **9** wherein the conduit system comprises means for dividing said fluid into two substantially equal portions; means for combining said portions into a single stream; heating means for said single stream; means for dividing said single stream into two substantially equal streams; means for directing one of said streams into the inlet means at one end of said second chamber; and means for directing the other of said streams into the inlet means at the opposite end of said second chamber.

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