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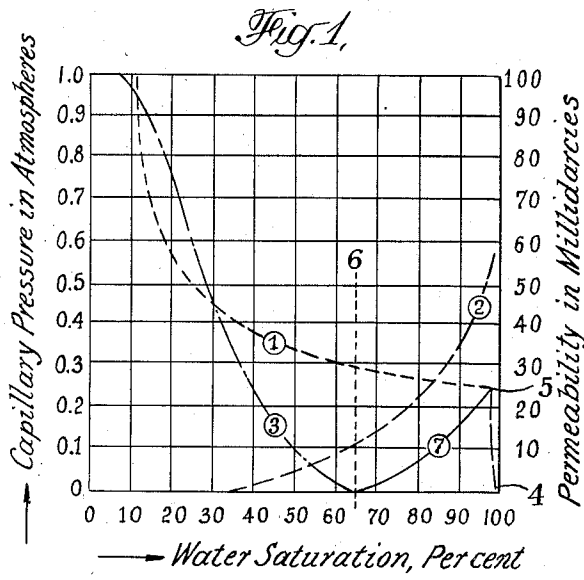
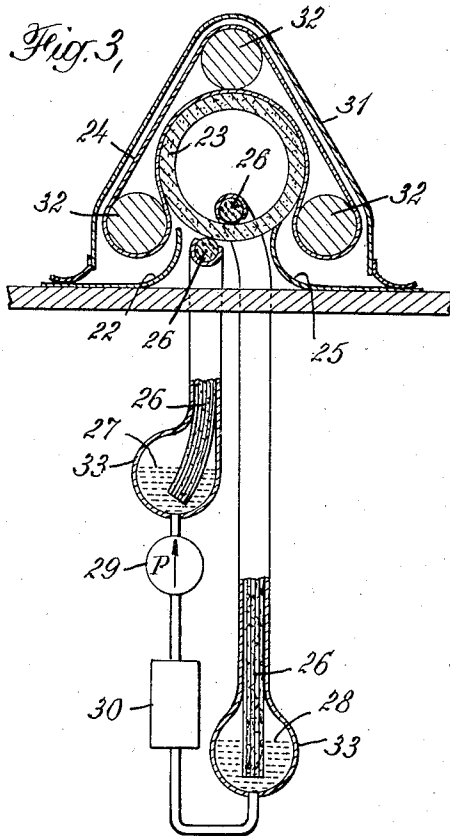
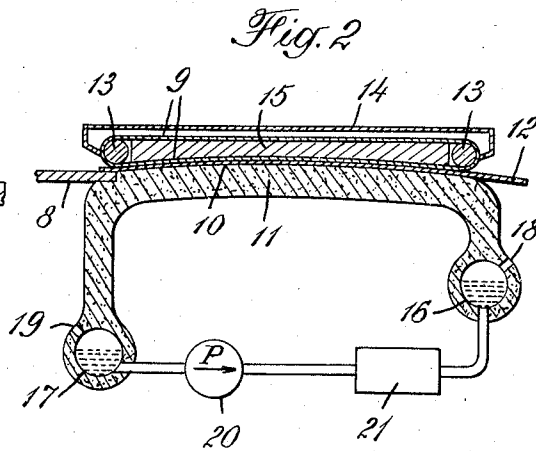
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2,431,041

MECHANISM FOR DEVELOPING PRINTED MATERIALS

Filed Jan. 6, 1944

3 Sheets-Sheet 1



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MECHANISM FOR DEVELOPING PRINTED MATERIALS

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3 Sheets-Sheet 2

Fig. 4.

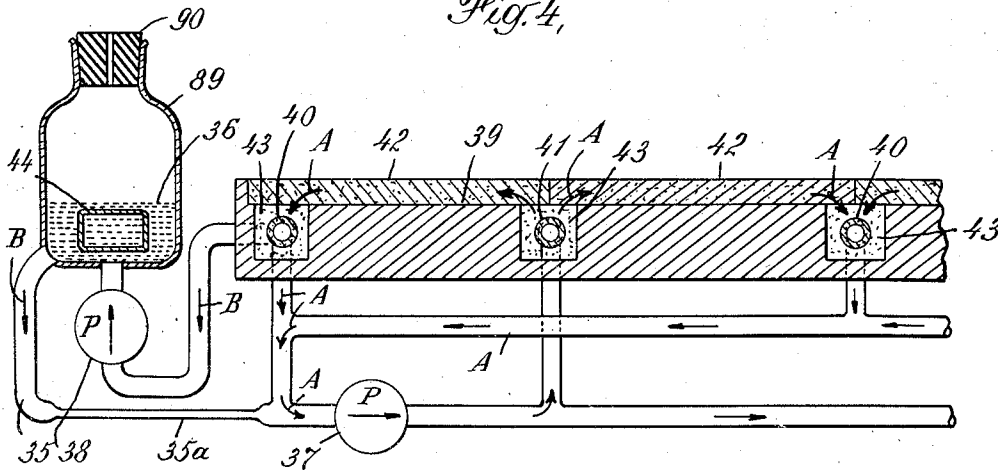
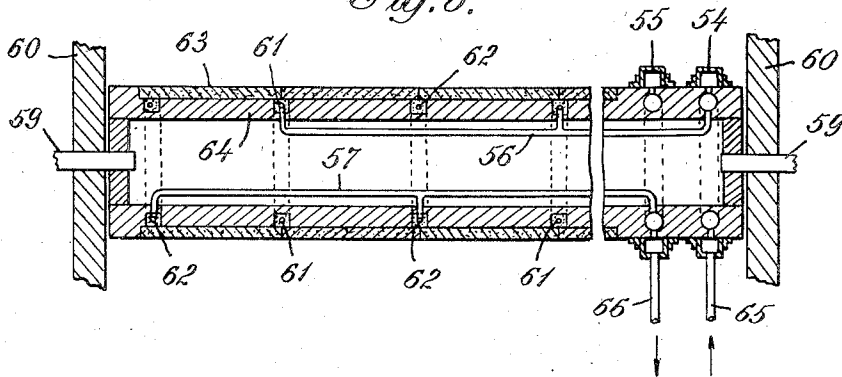


Fig. 6.



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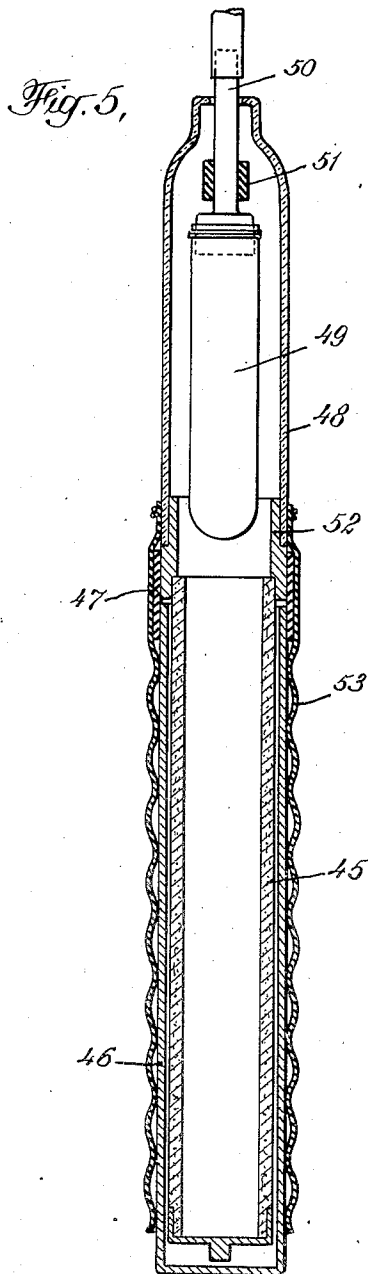
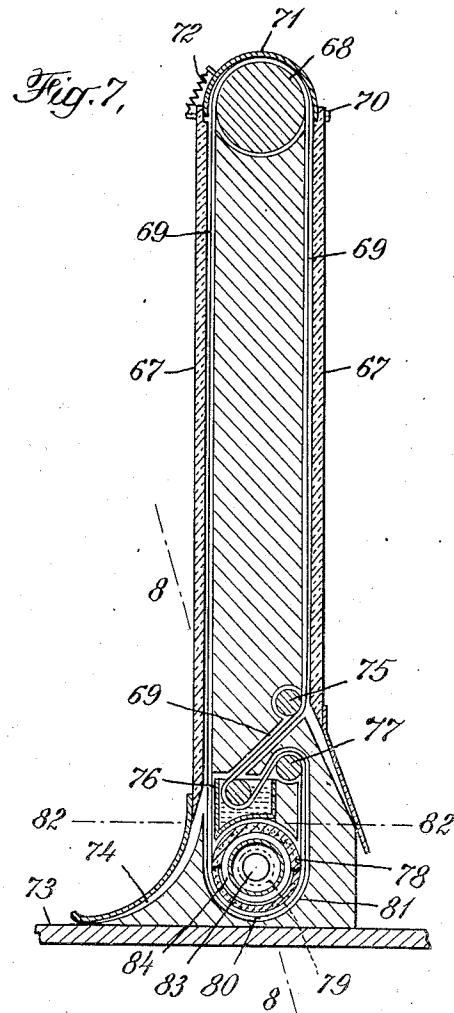
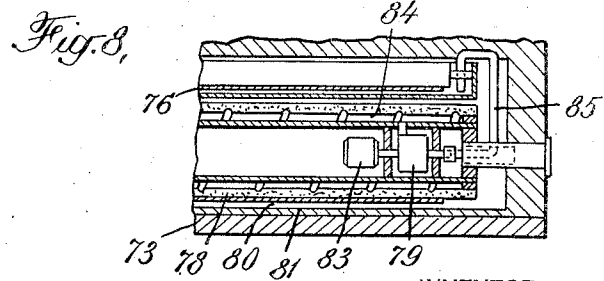
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MECHANISM FOR DEVELOPING PRINTED MATERIALS

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3 Sheets-Sheet 3



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2,431,041

MECHANISM FOR DEVELOPING PRINTED MATERIALS

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Application January 6, 1944, Serial No. 517,195

16 Claims. (Cl. 95—89)

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This invention relates to ammonia type developers, and more particularly to apparatus for developing exposed diazo type sensitized paper with a chemically active vapor.

It is well known in the art of mechanical drawing reproduction that a class of light sensitive papers can be prepared in which a diazo compound and the coupling component, actual or potential, are both present in the papers, and in which coupling is prevented prior to development, by control of the acidity. Such papers can be developed after printing with light by exposing them to ammonia vapors, whereupon the buffering acid is neutralized and the diazo compound and coupler form a dye in the unexposed portions. For example, the compound 1-diazo-2-naphthol-4-sulfonic acid exists in paper acidified with boric acid as a diazo-oxide incapable of coupling with phloroglucinol, but subject to destruction by ultra-violet light. After printing, this paper can be developed without wetting by bringing it into contact with moist air charged with ammonia for about ten seconds, and emerges ready for use and free from added reagents. Further precise delineation of the subject can be found in *The Aromatic Diazo Compounds* by K. H. Saunders, published by Edward Arnold, London (1936), p. 168.

As the art is now practiced, there is much difficulty in preventing the escape of ammonia gas into the atmosphere from the enclosure provided for developing the paper. The escaped ammonia gases are unpleasant to those near by and are destructive to the stock of unused diazo paper. One of the principal causes for the escape of ammonia gas is the large volume of gas which it is necessary to maintain in order to develop the paper fast enough.

This invention, therefore, has as one of its principal objects the provision of an improved system for avoiding the escape of ammonia vapor. To that end the exposed diazo type printing papers are maintained in very close juxtaposition to a strong solution of the treating substance, at the same time permitting the vapor to become wetted with water of the solution. That is accomplished by rolling or sliding the paper against a porous material which is wetted with a liquid solution of the gas, which liquid solution is held at a substantial vacuum with respect to the atmosphere around the paper, and which liquid solution is also refreshed by being caused to flow. The refreshing flow may lie on the surface and substantially parallel to it, or may be perpendicular to the surface in intermittent flow which is es-

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tablished during intervals when no paper is in contact with the surface.

Other objects and advantages of this invention will be apparent by reference to the following drawings and specification in which its preferred details and embodiments are shown and described, and in which:

Figure 1 shows a graphical curve which will facilitate an understanding of the principles employed in the present invention.

Figure 2 is a cross section of a developing apparatus for developing diazo-sensitized paper according to one form of the invention.

Figure 3 is a cross section in part and a frontal elevation of a belted capillary roller type developer in which the capillary suction is provided by means of wicks and a gravity head.

Figure 4 is a cross section in part showing the invention as applied to a horizontal porous plate type developer in which the capillary suction and flowing pressures are provided by mechanical means.

Figure 5 is a cross section of a porous roller type developing element in which the capillary suction is applied by an elastic membrane.

Figure 6 is a cross section of a cylindrical roller type developer element employing glands connected to an external pumping and reservoir system.

Figure 7 is a vertical elevation in cross section of a high speed type developer in which capillary suction is obtained indirectly.

Figure 8 is a cross section of Figure 7 through the plane on line 8—8 showing the means of connecting the capillary suction to a rotating roll.

In order to facilitate an understanding of the principles and terms employed in the present invention, curves are presented in Figure 1 which show graphically, (1) how the saturation of a typical porous material such as sandstone or brick is related to capillary suction which the pores exert upon the water within the material (curve 1, referring to the ordinates described at the left side), and (2) how the saturation of a typical porous material is related to its permeability to gas (curve 3), referring to ordinates described at the right side). The saturation as here defined is the ratio of volume of water to the total pore volume (water plus gas) in a porous material. The capillary pressure is defined as the difference between the pressure of the water in the porous material (generally less than the gas) and the pressure of the gas in the porous material (generally atmospheric). The unit of permeability is the millidarcy. Its definition is such that if

the rate of flow of liquid having a viscosity of one centipoise through each square centimeter of rock is one cubic millimeter per second when the pressure gradient is one atmosphere per centimeter, the rock has a permeability of one millidarcy.

To more clearly understand the significance of the curve, we can imagine a block of porous material such as sandstone, which has been fully saturated by prolonged soaking under water. As first removed from the water its condition is as shown at point 4 of Figure 1. It is completely impermeable to air as shown by curve 3, but it will be found that water flows through it readily as shown by curve 2, and since it has just been in contact with a free water surface during removal from the water, its water is at atmospheric pressure (i. e., the capillary suction is negligible). If now this piece of sandstone be dried out slightly, as by touching it with blotting paper, the capillary suction will immediately rise. At a critical value of capillary suction such as is shown at point 5 of Figure 1, and at no suction, less bubbles of air will be drawn into the rock. At this stage the surface of the sandstone will appear to be quite dry. It does not glisten because the suction has pulled some of the water away from the surface. A piece of paper pressed against the surface of the stone will not be wetted even though it be held in contact for several seconds. If the capillary suction be released while the paper is in contact as by adding a drop of water to the opposite side of the stone, the paper will be wetted immediately. At stage 5 air can be forced through the rock, but only by exceeding the displacement pressure.

If further withdrawals of water are made from the porous material so that bubbles of gas are sucked in, the permeability of the rock to the liquid will fall very rapidly as shown by curve 2, and capillary suction will increase slightly (or not at all if the pore size is perfectly uniform). Thus, it will be seen that the ability of the porous material to wet paper that is pressed against it, while its saturation is less than that at point 5 is not appreciably diminished, while the ability of the porous material to transfer the developing vapors to the paper which is measured by the permeability of the porous material to the liquid solution of those vapors, is greatly diminished. When the saturation is reduced to a critical value (sometimes called the "critical saturation") indicated by the vertical dotted line 6, the porous material will become permeable to gas in the sense that an infinitesimal pressure difference will cause a movement of gas. At saturation values higher than that indicated at line 6, no gas will be forced through a plate of the porous material unless a threshold value of the forcing pressure applied to the gas is exceeded. The nature of the variation of this threshold pressure with saturation is indicated by curve 7, which refers to the ordinate of pressures at the left of Figure 1. It will be observed that the maximum value of the threshold pressure is the displacement pressure.

It has been found in practice that a maximum of permeability to the liquid solution is attained when the porous material such as sandstone, brick, carborundum, kieselguhr, kaolin, carbon graphite, etc., is essentially saturated with liquid, and consequently a more rapid rate of replacement of the liquid will occur for a given pressure gradient. In order to maintain a substantial vacuum in the liquid solution held by the porous material while at the same time keeping the saturation high, it is desirable that the surface of

the porous material be of very fine texture, so that the entering heads of gas that tend to be sucked into the low pressure solution will be constricted by the very fine pores of the surface so that they cannot enter. This pressure difference which a saturated porous material is able to maintain between the liquid phase within it and the gaseous phase outside it, by virtue of the small size of the pores through which the gas must enter, will hereafter be called the "displacement pressure." For the purpose of the present invention, a desirable porous material has at its surface a maximum of displacement pressure and a maximum of permeability to liquid.

The porous surface materials are made of felted or woven fiber or of a cemented assemblage of very fine particles which are of very uniform size. An irregular particle shape, such as is encountered with the siliceous bodies of diatoms in diatomaceous earth, will also provide the desired combination of high displacement pressure and high permeability to liquid. Similarly, finely ground comminuted materials such as carborundum, aluminum oxide, alundum, kieselguhr, kaolin, bentonite, ball clay, carbon graphite, etc., are effectively utilized. These finely ground materials are held together by thermoplastic resins, ordinary drying adhesives or by firing the ground materials with fusible clays. Likewise, the porous surface materials can be made simply by packing cloth bags with any of the above finely ground materials. Solid porous materials which are commonly used for bacterial filters can also be utilized effectively for the purpose of the present invention.

In Figure 2 there is shown a cross section of a simple developing machine in which an exposed diazo-sensitized paper is pushed from the feed board 8 under the moving belt 9 which conveys the paper across the surface 10 of the porous material 11. Fully developed paper is discharged from the side opposite the feed board as at 12. In this process it is necessary that the friction between the paper 12 and the belt 9 shall exceed the friction between the paper 12 and porous surface 10. The porous body 11 which is constructed from ordinary porous clay or earthenware is glazed and thus sealed externally at all surfaces except those which are protected from the atmosphere by the belt 9. The belt 9 and its rollers 13 are covered by the closely fitted casing 14, and all other spaces are filled as by the box 15 which is built into the space between belts 9 and rollers 13. The porous body 11 is cast in such a way as to permit space for cavities 16 and 17 for the ammonia solution. The ammonia has a free surface in these cavities and is put into communication with the external air through the small passages or labyrinth openings 18 and 19. It will be seen that in these circumstances all the capillary water in the surface 10 will be under suction, having a pressure which is less than atmospheric by virtue of its raised position with respect to the free surfaces within cavities 16 and 17. It will be seen further that a pressure difference will exist between the water in the porous material near 16 and the water in the porous material near 17, so that in further consequence of the permeability of the porous body a siphon flow of ammonia will take place from 16 up through the neighborhood of the developing surface 10 and down to the lower level of 17, thus continually maintaining a high concentration of developing gas in the water near the surface 10. The proper levels of the free surfaces of liquid in cavities 16 and 17 is main-

tained by a pump 20, a suitable replenishing unit 21, and interconnecting tubing. The replenishing unit 21 may be, for example, a chamber where the water is brought into communication with a large reserve tank of ammonia water or with a tank of anhydrous ammonia (not shown).

A second embodiment of the invention is shown in Figure 3, in which a sheet iron external cover 31 is placed over the developer unit in order to retain the ammonia vapors. Rollers 32 are positioned around the alundum porous cylinder 23 over which the belt 24 passes. Wicks 26 are so arranged as to emerge from containers 33 and make contact, one with the inner, and the other with the outer surface of the porous cylinder 23.

The exposed diazo-sensitized paper is caused by baffle 22 to enter between the porous cylinder 23 and the endless belt 24, and to be discharged by way of the combined baffle and pick-up 25. The development occurs because of the diffusion of the developing gas from the solution in the surface of the porous cylinder 23 to the paper during the period of contact. In this case the ammonia in the surface is refreshed by flow of stronger solution normally into the outer surface of the porous cylinder 23 from the wiping wick 26 which dips into the solution of the container 33 having a free surface at 27. The cycle of flow of ammonia is closed through the inside wiping wick 26, the lower free surface 28, the solution pump 29 and the replenishing unit 30. Because of the relatively short path of travel of the solution through the wall of porous cylinder 23, this system is adaptable to use with cylinders having an excess of contained gas bubbles, with consequent low permeability to liquid.

The structural features of the apparatus shown in Figure 3 may be so arranged that the porous cylinder 23 can be replaced with a porous belt suitably stretched by rollers, and that either the cylinder 23 or the belt may be best made with a thin outer layer of coarse material, to prevent liquid transfer without obstructing the vapor; likewise a very finely textured material may be employed immediately under this outer layer, in order to get a high displacement pressure near the surface. A main body of coarser, more open material is recommended in order to get greater permeability to the liquid and more effective diffusion of the developing molecules through to the surface. In such cases the preferred method of replenishing the developing solution and establishing the correct value of capillary suction in the porous flexible belt is to arrange for an addition of an excess of solution, such as for example by a dip trough, or a porous roller under partial suction, and subsequently withdrawing this excess by squeezing the belt or by passing it over a porous roller which is held at such capillary suction as to withdraw the excess solution. An example of this kind of developer is shown in Figure 7.

A third embodiment of the invention is shown in Figure 4, which shows the porous developing surface 39 constructed of diatomaceous earth and corresponding to 10 of Figure 2, and the associated equipment for supplying a solution thereto. The means for moving paper across the surface 39 in sliding contact is similar to that shown in Figure 2. The tube 35 conveys the developing solution from the free surface reservoir 36 to the circulating system which includes the pump 37 and the whole developer. The tube 35 is constricted as at 35a and has a relatively high resistance to flow. Its functions are to provide a

feed of fresh ammonia while resisting the suction of pump 38 and to maintain the inlet pressure of the pump 37 at the proper value in respect to the atmosphere when the pump 38 is stopped.

The free surface 36 in the reservoir 39 is placed in communication with the atmosphere through the hole in the stopper 90. Its level is adjusted just beneath the approximately horizontal surface 39 of the developer, and in communication with all of the space which contains the solution of developing gas through the resistance tube 35. When the machine is stopped, as during the overnight period, bubbles will thus tend to disappear from the system since the vapor pressure of gas in any bubble lower than the free surface 36 will be greater than the vapor pressure of gas in equilibrium at the free surface. In operation the pump 38 which is adapted to maintain a constant pressure difference, keeps the whole of the liquid flow system under a vacuum limited by a spring release by-pass set to release below the displacement pressure of the porous flow tubes 40 and 41. These tubes have very permeable walls because they are thin. They can be made of material having such fine texture as to show a very high displacement pressure without restricting the flow of liquid through the walls.

The connection between the pump 38 and the porous tube system 40 and 41 should preferably be at the high point of the system so as to cause all bubbles to be delivered by the pump 38 to the free surface 36. It is desirable to keep the flowing system free of bubbles in this way in order to avoid the loss of developing gas from the solution to the gaseous phase which takes place when bubbles are present and the liquid solution is placed under vacuum. The pump 38 is so adjusted that it does not suck gas through the porous tubes 40 and 41 by exceeding their displacement pressure. The pump 37 is arranged to produce a pressure difference between the inlet porous tubes 40 and the outlet porous tubes 41, so as to cause flow to take place through the porous plates 42 by way of the fine powder or other yielding capillary connecting medium 43 which is packed around porous tubes 40 and 41. A suitable means 44 for replenishing the developing gas in the solution may be installed in the free surface tank. These replenishing means are known in the art and need not be described in detail here.

The arrows shown in the tubes and porous material of Figure 4 indicate the direction of flow of developing solution when the machine is in operation. The flow takes place in two flow loops, the first loop being that associated with pump 37 and the second loop associated with pump 38. The loops as shown by arrows A provide simply for a circulation of the developing fluid to, through and from the porous surface 39. The flow loop indicated by arrows B has the function of regulating and maintaining any desired degree of suction within the loop A by withdrawals of liquid from loop A by pump 38 and by controlled return of liquid to flow loop A by the resistance indicated by the constricted passage 35a. The replenishing unit 44 is conveniently placed in the flow loop B because replenishment is best carried out at or near atmospheric pressure.

It will be noted that in principle the operation of the developing unit shown in Figure 4 is similar to that of Figure 2. The additional embodiment of Figure 4 is recommended for slow reactions in order to get suitably rapid flow in the surface 39 and to get higher values of capillary

suction through the use of pumps that are not limited by gravity. The plates 42 are chosen to offer low frictional resistance to movement of the paper and low surface permeability to liquid, the tubes 43 and 44 to have high displacement pressure. Moreover, the mechanism of Figure 4 permits the resting free surface to be established automatically at such a high level as to cause gas bubbles to diffuse away.

A fourth method of feeding fresh developing substance to the liquid at the developing surface of a porous medium is illustrated in Figure 5. This figure shows a means to charge a porous body or cylinder after it has been removed from the developing machine, in which it is normally used. Such a cylinder would most likely be found in a small developing unit, and in one used at intervals for short periods of time only.

In the figure, a porous cylinder 45 is shown in a soaking chamber 46 to which is attached a glass reservoir 48. Preferably, the reservoir is cemented to a coupling element 52, and the soaking chamber is connected to form a gas-tight unit by stretching a rubber sleeve or seal 47 over the butt joint between the two. An apron of rubber or other suitable flexible material is attached to the reservoir and encloses the sleeve and a greater part of the chamber. This apron acts as a hood when the soaking chamber is removed and prevents the escape of the ammonia gases at that time.

An elastic tube or balloon 49 is fixed to the end of pipe 50, which, in turn, passes through an opening in the upper end of the reservoir and is connected by a hose or other convenient means to a pressure line by which the tube may be inflated. A stopper 51 is a tight fit on the pipe and within the reduced end of the reservoir.

In operation of this device, which is relatively light and portable, the stopper is forced into the reduced end of the reservoir, a cylinder 45 having been cemented or otherwise connected to the coupling 52, and the soaking chamber 46 is fixed in place so that the unit is gas tight. A quantity of ammonia has been provided and the cylinder is soaked until its porous structure is completely saturated. To vent air from the enclosure, the stopper 51 is pushed in as shown in Figure 5, thus opening the top of the reservoir so that entrapped air may escape. Pressure is applied to the tube 49 until the level of the liquid rises above the stopper after which the stopper may be drawn up into its sealing position.

When soaking is complete, the cylinder is removed from the chamber by disconnecting the latter and raising the cylinder, reservoir and attached parts. The apron 53 is extended to cover the opening between the coupling and chamber. Pressure is then applied to the tube 49 and it is expanded, causing the excess of the solution to be driven from the cylinder back into the chamber.

Before the charged cylinder can be used, the chamber 46 is removed entirely and apron 53 folded back over the reservoir 48. Assuming that the cylinder is to be used in a machine something like that described with respect to Figure 3, the coupling 52 is preferably inserted within a clamp or holder (not shown) capable of rotation. Since this is a simple construction for use at infrequent periods, it is contemplated that hand operation will be sufficient, and thus the operator may rotate the cylinder employing the reservoir 48 as a handle. In such simple and relatively small machines the device for guiding or press-

ing sensitized paper into contact with the cylinder 45 may be a sheet of celluloid wrapped around the cylinder and held in one hand so that the paper is caused to slide beneath the celluloid and over the cylinder's surface as the other hand turns the cylinder using reservoir 48 as a handle.

As the cylinder requires recharging, it can be detached, the chamber 46 attached, and the process repeated. After the cylinder has been charged, and while the enclosure is relatively gas tight, the elastic tube 49 is to be deflated in such a manner as to create a slight vacuum. That tends to dry out the surface of the cylinder thereby preventing any wetting of the paper, especially when using the cylinder at a time when it has just been completely charged.

Tube 49 has been chosen, as to thickness and diameter, so as to produce a vacuum near the displacement pressure of the developing surface. It has been found that sufficient diffusion of ammonia takes place to keep the outer developing surface charged if the paper is applied intermittently and the developing machine provides good protection from the atmosphere. In such light service, therefore, suitably thin and permeable porous cylinder walls make it unnecessary to provide any convection flow of solution through the developing surface, since an adequate supply of developing vapor will be obtained by the diffusion of the developing vapor through solution (which is essentially at rest) by reason of the concentration differences that are caused by the loss of ammonia to the paper.

The developing cylinder is charged at any time by inserting it in the device of Figure 5 and applying pressure to the elastic tube 49, so as to force strong ammonia out to the surface for an instant. A suitable sponge or reservoir to collect drip (in a position similar to the wick and reservoir 26 and 27 of Figure 3) and to feed it back into the cylinder 45 when the elastic tube 49 is again deflated to supply suction, will enable the operator to augment the diffusion process should this become necessary with rapid work.

The developing unit of Figure 5 is especially well adapted to small equipment, in which, for example, the reservoir chamber 48 can be used as a handle, however, the same principles apply for any size of unit.

It is evident that the principles of flow parallel to the surface as in Figure 4 or of diffusion as with the cylinder of Figure 5 can be accomplished with a rotating cylindrical roller by the use of an external pumping and reservoir system connected to the roller by the use of glands, and further that any convenient external part of the pumping and reservoir system can be connected to the roller through the use of a gland or glands. Figure 6 shows a section of such a roller and the accompanying journals 59 and frame 60, wherein fixed tubes 65 and 66 lead the developing solution, under a proper vacuum and pressure difference, by way of the glands 54 and 55 into the rotating inlet channel 53 and from exit channel 57, which are connected internally of the roller. The roller 58 turns upon suitable journals 59 set into a fixed frame 60. The moving channels 56 and 57 communicate with porous, thin, ring shaped pipes having high displacement pressure. Those at 61 enter while those at 62 exit from the cylinder. They are kept in capillary communication with the cylindrical developing surface 63 by means of a powder pack. The porous cylindrical developing surface 63 may be made up of short cylinders extending between pipes

such as 61 and 62, since short pieces are more easily manufactured than a full length cylinder. The main structural body of the cylinder, shown sectioned as at 64, may be made of stainless steel or any other suitable material. Arrows indicate the direction of flow of the developing liquid during operation. In this construction it is desirable that spiral channels be formed at the inner surfaces of all tubes 56 and 57 which bear solution horizontally at low velocity so that any bubbles will be carried outward through the exit gland and vented from that part of the solution which is held under vacuum.

In Figure 7 the glass plate 67 serves as the outer shell which prevents leakage from the developer to the atmosphere and which provides a smooth surface against which the paper is carried along by the moving belt 69. The numeral 68 is applied to an idler roll around which the belt 69 moves and 70 is a bolt which fastens the flexible cylindrical surface 71 to the glass plate. A spring 72 keeps the flexible closure 71 pressed lightly against the moving belt 69. It is evident that if the part 71 were made rigid some binding might occur between the paper and the smooth surface along which it must be carried by the friction between the moving belt 69 and the incoming paper. Here the paper enters from the feed-board 73 through a passage 74 normally closed, but pushed apart as paper is inserted. The paper is developed by reason of its contact with the capillary belt 69. The belt 69, after discharging its developed paper at the deflecting idler 75, passes into the solution in the replenishing tank 76, is wiped partially on the idler 77, and loses all its excess liquid during contact with the porous cylinder 78, the porous interior of which is held at a predetermined vacuum by means of a by-pass pump 79 (Figure 8), while the machine is running. Successful operation of the belt 69 is obtained with use of a flexible porous material which will be reduced about fifty per cent in saturation by the suction applied at the porous cylinder 78. A pre-shrunk belt of canvas or duck works well, and is especially free of any wetting tendency if it be generously embroidered or sewed (at about one-eighth inch spacings) with coarse monofilament thread such as vinylidene chloride or other ammonia resistant plastic so as to hold the paper away from the cloth surface somewhat during long periods of exposure. Another good material is a screen made of plastic monofilaments, about sixteen threads to the inch, felted on one side with cotton. After the machine stops, the solution slowly drains back through the pump by-pass and fills the space 80 between the closely fitting tank 81 and the cylinder 78 so that, at rest, a free surface at approximately the line 82, at atmospheric pressure, stands above the porous cylinder 78. The capacity of the pump 79 and the permeability of the cylinder 78 are such as to permit quick transfer of the liquid from the space 80 to the higher replenishing tank 76, so that the machine is always ready to operate.

Figure 8 shows a section through one end of cylinder 78 at the place indicated by the dotted line 8 of Figure 7. The pump 79 is driven by the electric motor 83 which is fed with current by slip rings (not shown) at the other end of the porous cylinder 78. The liquid is drawn into the pump from the recess 84, which is at the end of a helical groove inside the porous cylinder 78, and after being raised in pressure by an amount which is controlled by a pressure relief by-pass valve

(not shown), is delivered into the upper tank through the flexible tube 85. This tube is so guided that rotation of the cylinder and pump unit do not affect it. It is clear that while the developer is running, all excess ammonia will be drawn from the space 80 and from the porous belt, but that when the machine stops the solution will automatically be siphoned back into the space 80 until the level rises to the prearranged free surface position 82.

From the foregoing description it becomes apparent that my invention provides an improved, rapid and practical method for developing exposed diazo type papers and foils, since it provides a more intimate connection between the developing solution and the paper than heretofore has been possible without danger of actually wetting the paper with solution. In addition to the greater speed of development which accompanies the more rapid transfer of vapor from the solution to the paper, this invention provides for a closer confinement of the ammonia to the neighborhood of the developing machine so that the ammonia leakage nuisance is avoided. In the previous art a considerable volume of gaseous ammonia, whose evanescence was difficult to control, was required between the liquid surface of aqua ammonia (or the valve to an anhydrous ammonia tank) and the paper. In the practice disclosed herewith the volume of gas needed to provide a transfer medium for the diffusion of ammonia from the aqua ammonia is effectively nil.

The apparatus and method of this invention may be employed in practically any type of process for treating a substance with a chemically active vapor by holding the surface of the substance against or near a porous body which bears liquid under such capillary suction as to prevent transfer of the liquid while vapors escaping from the liquid cause the treatment and in which the surface next to the substance is replenished by diffusion.

In the foregoing detailed description certain preferred embodiments of the present invention have been explained. It is to be understood, however, that the invention is not to be considered as limited to the specific apparatus and methods herein disclosed or the arrangement of parts employed, since these may be varied within the range of engineering skill without departing from the spirit of the invention. Similarly, the present invention is not to be considered as limited to the use of ammonia since other soluble vapors capable of developing out exposed diazo-sensitized material may be employed. In particular that class of diazo-sensitized papers, films or foils which do not contain a coupler within them, couplers of high vapor pressure such as aniline may be employed at ordinary temperature, whereas resorcinol, phloroglucinol, etc., may be dissolved in an inert solvent and the solution may be brought at elevated temperature, i. e., the boiling point of the resorcinol, phloroglucinol, etc., close to the paper surface and there transferred to the paper as vapor. The mechanical system of the present invention may be provided with a heating element or the under surface of the porous body heated by suitable means to accomplish the latter alternative for employing developers other than ammonia.

By the term "diazo-sensitized material" as used in the present specification and claims, reference is had to that class of compounds described in U. S. Patents 1,444,469; 1,628,279; 1,803,906, and

1,816,989. Similarly, the term "porous body" is used in the specification and claims in a generic sense to include all solid ammonia insoluble inorganic substances which are in a finely ground comminuted form and comprise silicon carbide "carborundum," diatomaceous or infusorial earth such as kieselguhr, "celite," kaolin, bentonite, ball clay, aluminum oxide, graphite, carbon and similar substances which are held together by thermoplastic resins, by ordinary drying adhesives or by firing the powders with fusible clay. The above listed substances can likewise be packed into cloth bags and such bags used as the porous material.

While the various embodiments of my invention described above constitute the practical embodiments, it is understood that I do not limit myself strictly to the exact details herein illustrated, since manifestly they can be varied somewhat without departing from the spirit and scope of my invention as defined in the appended claims.

I claim:

1. In a device for developing diazo type printing material, the combination of a porous body having a porous surface, means to bring printing material into contact with and away from the porous surface of said porous body, a supply of ammonia solution and means for conducting the solution to and through the porous body while maintaining it at a substantially lower pressure within the body than the pressure existing at the surface of the body and means for replenishing the solution to maintain its strength.

2. In a device for developing diazo type printing material, the combination of a porous body, means to bring printing material into contact with and away from the surface of said body, a container for a supply of ammonia solution, a pump and connecting means to and from the container and porous body for circulating the solution while maintaining its pressure within the body at a value less than the pressure at the surface of the body and means for replenishing the solution to maintain its strength.

3. In a device for developing diazo type printing material, the combination of a porous body, an endless belt in contact with a surface of said porous body for advancing printing material over that surface of the body, said porous body extending downwardly at either end and terminating in cavities for ammonia solution, one said cavity being at greater elevation than the other, a pump for maintaining a predetermined level of the solution in each cavity and replenishing means for maintaining a predetermined strength of the solution.

4. In a device for developing diazo type printing material, the combination of a porous cylinder, an endless belt guided about at least a part of said cylinder for advancing printing material between the belt and rotating cylinder, two chambers, one above the other, for retaining ammonia solution and a wick in each chamber, one leading to and contacting with the outer surface of said cylinder while the other contacts the inner surface thereof, a pump for maintaining a predetermined level of solution in each chamber and replenishing means for maintaining the strength of the solution.

5. In a device for developing diazo type printing material, the combination of a porous plate, means for supporting said plate, porous tubing beneath the plate and within said supporting means, a reservoir for developing solution adapted to maintain a level of the solution at approximately the same height as the surface of

the plate, a restricted pipe leading from said reservoir to a pump and from said pump to the porous tubing, other pipes from the porous tubing to a second pump and from that second pump back to the reservoir, and other connecting pipes forming a loop for bypassing solution back to the first-mentioned pipe without returning that solution to the reservoir, the construction and operation being such that solution is maintained within said porous plate at a pressure substantially less than atmospheric pressure existing at the surface of the plate.

6. In a device for developing exposed, light-sensitive material, the combination of a porous body having a porous surface, means to guide and pass such material over the porous surface of the body, means for maintaining a quantity of developing liquid within the body and at a pressure less than that existing at the porous surface of the body, and other means for replenishing the developing liquid to maintain its strength.

7. In a device for developing diazo-type printing materials, the combination of a body having a porous interior and a porous developing surface over which a conveying means may guide and pass exposed diazo-type material, a supply of ammonia developing solution and circulating means for conducting the solution to the porous body and for withdrawing it therefrom in such a manner as to maintain less than atmospheric pressure on the liquid within the body, and means from which said circulating means can replenish the strength of the solution.

8. In a device for developing diazo-type printing material, the combination of a porous body having a porous developing surface and downwardly extending porous portions at either end terminating in cavities for ammonia solution, means for advancing exposed printing material across the surface of the body which includes a belt, rollers about which said belt is tensioned, and means for guiding the sensitized material to enter between the belt and the surface of the body, one of said cavities being at a greater elevation than the other and having leading thereto a circulating line from the other cavity in which is a circulating pump for maintaining a predetermined level of ammonia solution in each cavity, and means connected with said circulating line containing ammonia for replenishing and maintaining the strength of the solution.

9. In a device for developing diazo-type printing material, the combination of a porous, rotating cylinder, a belt passing about part of said cylinder and having means associated therewith for guiding exposed, sensitized material between the belt and cylinder and other means for removing the sensitized material from the cylinder and discharging it from the device, means for supplying an ammonia solution to the cylinder including two chambers, one above the other and means cooperating with said chambers for conducting ammonia solution from the uppermost chamber to the cylinder and other means for withdrawing solution from the cylinder and conducting it to the other chamber, and means including a circulating line and pump functioning between the two chambers to maintain a predetermined level of ammonia solution in each of them.

10. In a device for developing diazo-type printing material, the combination of a rotating, porous cylinder, a belt passing about part of said cylinder, guiding means for said belt, means to

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introduce exposed, sensitized material between the belt and surface of the porous cylinder and other means for stripping that material from the cylinder after it has been subjected to developing gases while confined between the cylinder and the belt, means for supplying ammonia solution to the porous cylinder including two chambers, one above the other, a wick in the higher of the two chambers communicating with the outer surface of the cylinder for conducting the solution to the cylinder, means for withdrawing solution from the cylinder and thereby maintaining the liquid in the cylinder at less than atmospheric pressure including a second wick and means by which said wick is conducted downwardly to the lowermost of the two chambers, and means for maintaining a predetermined level of solution in the chambers including a pump and conduit for drawing solution from the lower chamber and raising it to the higher one.

11. The mechanism as defined in claim 10 and including in addition thereto, means for replenishing and maintaining the strength of the solution in the higher chamber.

12. In a device for developing diazo-type printing material, the combination of a porous body, means for supporting said body and other means carried by the support and in communication with said porous body including conducting elements which are porous and to which are connected conduits leading to a source of ammonia solution, and other conduits interconnecting the adjacent, porous conducting elements, means for withdrawing solution from the said porous conduits including a pump in that conduit which leads from the porous elements to the supply of ammonia, and other means for causing a circulation of ammonia solution from the supply and also from one porous element to another which includes a tube having a constricted portion and a pump in those conduits interconnecting the plurality of adjacent porous elements and the tube having the constricted portion.

13. In a device for developing diazo-type printing material, the combination of a porous body, means for supporting said body and other means for communicating with said porous body including conducting elements comprising porous tubes to which are connected conduits forming circulating systems one of which conducts developing solution from a supply of ammonia solution through the porous tubes, and to the porous body, and the other of which functions in returning the solution to the supply and in maintaining a desired degree of suction within the porous body.

14. In a device for developing diazo-type printing material, the combination of a porous body, means for supporting said body and other means carried by the support and in communication with said porous body including porous tubes, some of which are adapted to conduct developing

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liquid to the porous body and others of which conduct the liquid away from the body, a system of conduits interconnecting the supply of developing solution and also forming interconnecting loops between adjacent porous tubes, pumps in said system, one for withdrawing liquid and returning it to the supply and another for forcing the liquid into the porous tubes and circulating it from the supply and between one group of tubes and the other group of tubes, and means whereby the pump circulating the liquid and withdrawing it from the supply is resisted thereby to set up a suction within the system so as to maintain the liquid in the porous body at less than atmospheric pressure.

15. In a device for developing diazo-type printing material, the combination of the porous body, a support for said body, porous tubes spaced along the length of the body and in communication with it, a supply of ammonia developing solution, certain ones of said porous tubes being inlet tubes and others being outlet tubes, a conduit from one of the inlet tubes to the supply and a pump in said conduit for withdrawing solution and returning it to the supply, another conduit from said inlet tube and in connection therewith, circulating systems including conduits leading from the other inlet tubes to that conduit and from it to the outlet tubes, a pump between the first-mentioned conduit leading from the inlet tube and the circulating line which leads therefrom to the other outlet tubes, and a conduit having a constricted portion for conducting solution from the supply to that line containing the pump.

16. In a device for developing sensitized material of the diazo coated type, the combination of a porous body having a porous surface of such form as to contact the sensitized surface of material to be developed, and means for introducing and for renewing a supply of ammonia solution within the body under a pressure less than atmospheric, and means for bringing the coated side of the diazo sensitized material into contact with the porous surface of the body for a time sufficient for developing a latent image thereon.

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