

Jan. 6, 1942.

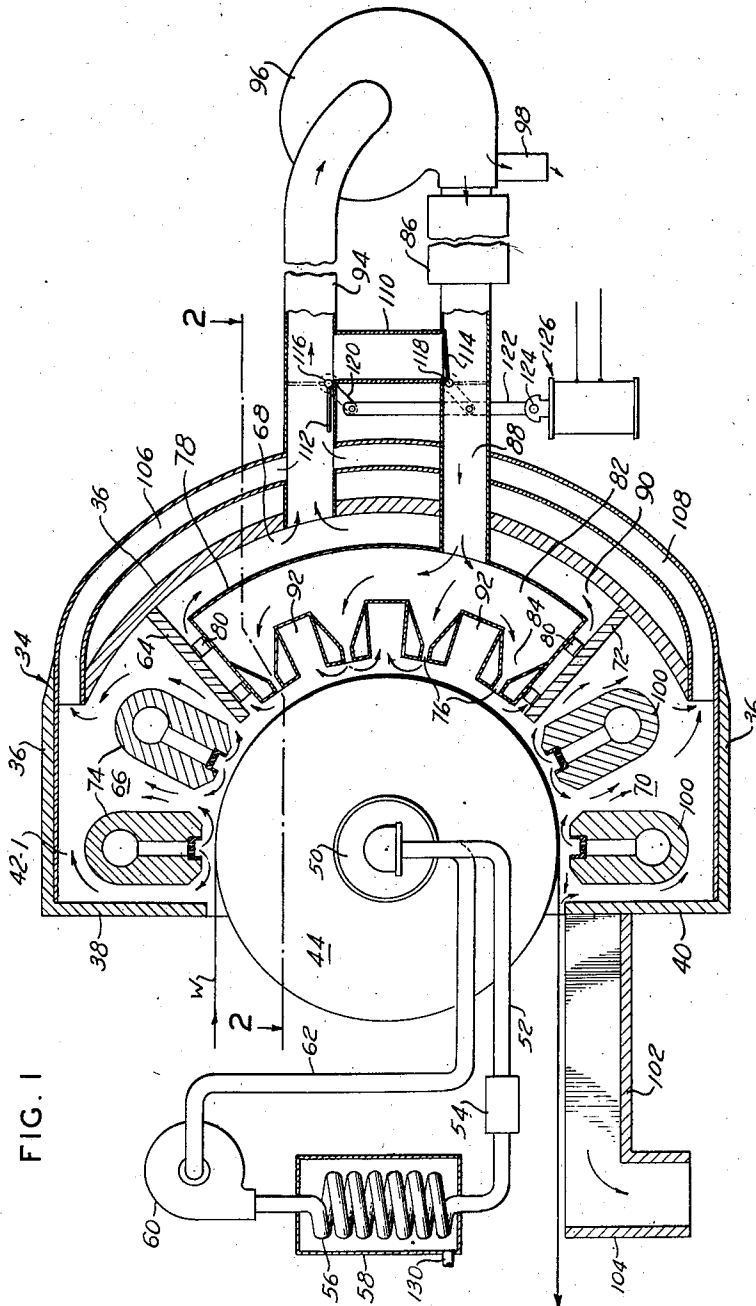
F. O. HESS ET AL.

2,268,988

METHOD AND APPARATUS FOR DRYING PRINTING INK

Filed Aug. 8, 1939

2 Sheets-Sheet 1



INVENTORS
FREDERIC O. HESS
BY CARL P. MANN
Francis O. Bee
ATTORNEY

Jan. 6, 1942.

F. O. HESS ET AL

2,268,988.

METHOD AND APPARATUS FOR DRYING PRINTING INK

Filed Aug. 8, 1939

2 Sheets-Sheet 2

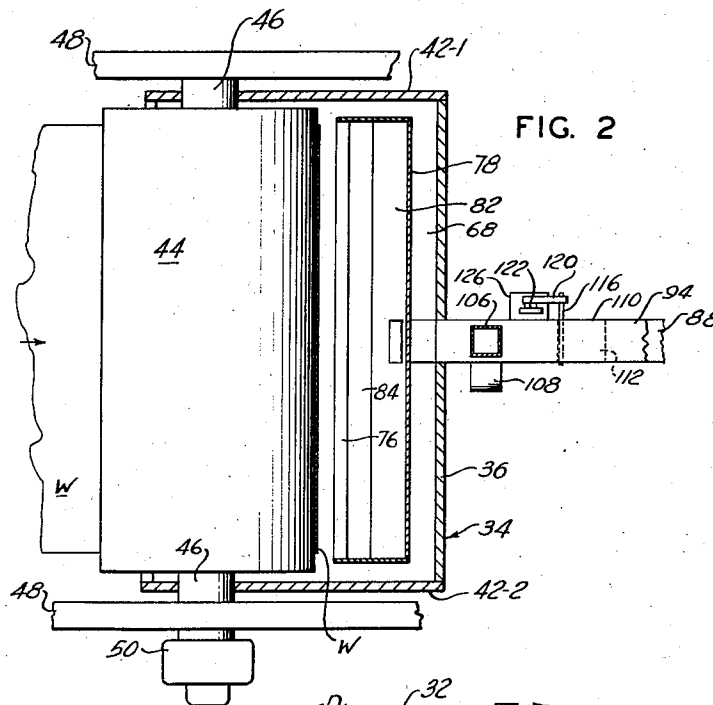


FIG. 2

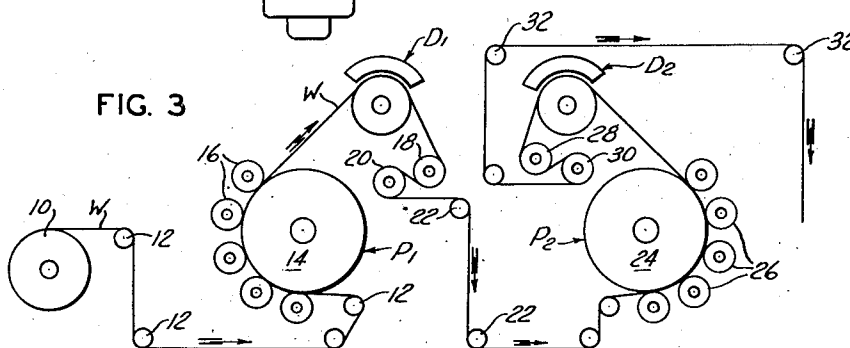


FIG. 3

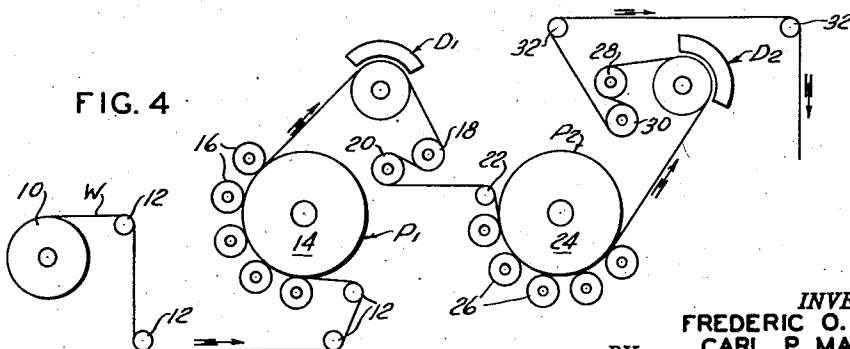


FIG. 4

INVENTORS
FREDERIC O. HESS
CARL P. MANN
Francis D. Becker
ATTORNEY

UNITED STATES PATENT OFFICE

2,268,988

METHOD AND APPARATUS FOR DRYING
PRINTING INK

Frederic O. Hess, Germantown, Pa., and Carl P. Mann, Riverton, N. J., assignors, by mesne assignments, to Interchemical Corporation, New York, N. Y., a corporation of Ohio

Application August 8, 1939, Serial No. 288,906

15 Claims. (Cl. 101-416)

This invention relates to printing and aims to provide an improved method and apparatus for printing and drying printing ink and other marking materials, and particularly, an improved method and apparatus having increased efficiency and flexibility for changes of operating conditions and materials, and adapted for use on all presses regardless of their size.

There are marking materials and printing inks in extensive use at the present time which may be effectively and quickly dried by the application of heat to the web or sheet on which the materials or inks have been applied. One example of such a marking material is the typographic printing ink whose vehicle consists of a binder dissolved in a solvent which is substantially non-volatile at ordinary pressroom temperatures (about 25° C.) and which can be volatilized rapidly at temperatures of about 100° C. An ink of this general character is described in Gessler United States Patent No. 2,087,190. When such inks are applied to a web in a multicolor printing press, for example, it is necessary to dry the ink in the relatively short space between printing units and between the last printing unit and the rewind roller or other web treating device. Various methods and apparatus have been suggested and devised for this purpose. One practice comprises passing the web having the freshly printed ink upon its upper surface over a drum heated by means of super-heated steam so that the paper will be heated from the reverse side to a temperature at which the solvent will volatilize. Another method of drying these inks has consisted in applying a stream of hot air or other gas to the freshly printed surface, but it is difficult, under ordinary circumstances, to heat the ink sufficiently for proper drying. Moreover, with either the steam drum or the hot air methods of drying, it has been difficult to operate at the press speeds that are demanded today and many problems have been encountered in removing the volatilized solvent, in providing proper ventilation for the apparatus, and in preventing overheating and scorching of the paper when the press is stopped temporarily.

In order to dry the ink properly at web speeds greater than 400 feet per minute, direct flames and radiant heat produced by a plurality of gas burners are now being effectively used. With this procedure, the freshly printed web is passed through a furnace in which the printed surface is subjected to the action of a plurality of gas burners which are adapted to heat the ink to a temperature at which the solvent will volatilize

and to burn the solvent vapors. Inasmuch as these furnaces are adapted to produce very high temperatures and the materials operated upon are inflammable, it will be appreciated that many difficulties may be encountered during the drying operation. For example, whenever the press is stopped, unless additional precautions are taken, there is a possibility of scorching the paper and weakening it to a point where it may break when operations are again started. It is also difficult to design these furnaces so that they will safely and satisfactorily dry the printed web during the initial starting period of the press when the web is moving at slow speed, so that there may be considerable waste of both paper and ink until the press is brought up to its proper operating speed. With any of the prior methods of drying, i. e. the steam drum, hot air or the gas flame, there is a marked tendency for the web to dry and shrink, with the result that the shortening thus caused may produce difficulties in register or the tension in the paper may be increased to a point where the web will break. Furthermore, all of the difficulties inherent in prior methods and apparatus are increased with changes in the weight or type of paper being printed, the number of colors and type of ink being applied and the speed of travel of the web.

We have discovered that the above-mentioned and other difficulties may be overcome and that the efficiency and flexibility of methods and apparatus for drying printing ink containing a volatilizable and inflammable solvent may be increased by moving the material to which such ink has been applied over a supporting surface, which preferably is heated to a temperature below 100° C., and while the material is in contact with such surface, heating and drying the freshly printed ink with a combination of gas flames and heated gases projected against the freshly printed ink at high velocity.

In accordance with our invention, a web to which ink containing a volatilizable and inflammable solvent has been applied is passed over a rotating drum preferably heated to a temperature below 100° C. We have found that by maintaining the drum at a temperature below the boiling point of water, the under side of the paper will be heated so that the efficiency of the operation will be greatly increased, but there will not be a detrimental removal of the moisture present in the paper. The heated drum is rotated while the freshly printed web passes thereover and the ink on the printed side of the web is rapidly raised to a temperature at which the

solvent will volatilize. This is preferably accomplished by the use of one or more gas burners provided in a preheating zone of the dryer. The web then moves into the main drying zone where the freshly printed surface receives a blast, or a plurality of blasts or jets, of heated air and other gases, the extent and manner of application of this drying medium being such that all the solvents in the ink will be volatilized and rapidly removed from the web. Finally, the printed surface may, if desired, be subjected to the action of additional gas burners which are adapted to burn the solvent vapors that have been driven off during passage through the drying zone, and the thus completely dried web may be moved to the next printing unit or to any subsequent web treating device. With such a method and apparatus, the flames and jets or blasts of hot air and other heated gases may be projected against the web with any desired velocity and, since the web is maintained against the supporting surface of the heated drum, there is no danger of causing any breakage or weakening of the web. By employing a burner or burners in the pre-heating and post-heating zones of the drier, the air and solvent vapors heated thereby may be used and circulated in the drying zone. This greatly increases the efficiency of the drying operation. In addition, any desired combination of heating means may be obtained with such an apparatus. That is, during the starting period of the press, the heat of the drum alone may be sufficient to dry the printed surface. As the speed increases, heated air may be supplied to the printed surface; and when final operating speed is obtained the gas burners may be ignited. By increasing or decreasing the number of burners and hot air jets, or cutting out the action of existing burners or air jets, great flexibility is obtained so that different grades and types of paper and ink may be dried in the same apparatus.

The above and other features and objects of the invention will become apparent upon consideration of the following detailed description and the accompanying drawings, in which:

Fig. 1 is a longitudinal vertical sectional view, largely diagrammatic, of one form of printing ink drier embodying the apparatus features of our invention.

Fig. 2 is a horizontal sectional view taken substantially along the line 2—2 of Fig. 1; and

Figs. 3 and 4 are diagrammatic side elevational views of multi-color printing press arrangements in which our improved driers have been included.

Referring now to the drawings, and particularly to Figs. 3 and 4 wherein we have shown our invention applied to a multi-color web perfecting printing press, it will be observed that a web W of paper or other material to be printed, is led from a suitable supply roll 10 over guide rollers 12 to the first side printing unit P₁ comprising a large impression cylinder 14 and a plurality of printing cylinders 16 arranged about the periphery of said impression cylinder. In the printing unit P₁ the web W may be printed in a plurality of colors on one side thereof and after passing the last printing cylinder is led, preferably directly, to a first drying apparatus D₁ where the freshly printed ink is dried prior to second side printing. From the drier D₁ the web W may be passed over cooling rollers 18 and 20 and is then led over guide rollers 22, which may, if desired, include means for making adjustments in register, to a second printing unit P₂ where the

reverse side thereof may be printed in a plurality of colors. This printing unit is similar to the printing unit P₁ and comprises a large impression cylinder 24 and a plurality of printing cylinders 26 arranged around the periphery thereof. The second side of the web W is printed in a plurality of colors in the printing unit P₂ and the web is then passed directly to a second drier D₂ where the freshly printed ink is dried. Said web W may then be passed over colling rollers 28 and 30 and guide rollers 32 to any desired subsequent web treating device (not shown). The printing units P₁ and P₂ may be of any desired conventional construction and are preferably arranged with as short a web lead as possible. Either of the arrangements shown in Figs. 3 and 4 is suitable for the application of our present invention. The Fig. 3 arrangement has the advantage of being somewhat more symmetrical with more ready access to the various printing cylinders, while the Fig. 4 arrangement has the advantage of providing a somewhat shorter web lead between the two printing units P₁ and P₂. It will be understood, however, that these two arrangements are only shown for purposes of illustrating the practical use of our improved drier which may be used in conjunction with any printing press, regardless of size, arrangement, web width and the like.

As shown in Fig. 1, where we have illustrated a drier of the type indicated at D₁ or D₂ in Figs. 3 and 4, the drier comprises an arcuate shaped drier housing 34 having a curved outside wall 36, suitable entrance and exit walls 38 and 40, respectively, and side walls 42—1 and 42—2. The arcuate shaped housing 34 is positioned partially about the surface of a comparatively large metal drum 44 having a hollow shaft 46 which is suitably journaled in frame 48 forming part of or attached to the main frames of the printing press to which the drier is applied (Fig. 2). The hollow shaft 46 is provided at one end thereof, with a suitable fluid tight rotary joint 50 and is connected with a fluid heating system comprising an inlet pipe or conduit 52 having an automatic temperature control 54 therein and connected to one end of a heating coil for the fluid, which coil is disposed within a suitable housing 58 that may be either heated or cooled to a temperature below 100° C. in any desired manner, such as by direct heat or refrigeration or by the circulation of a heating or cooling medium there-through. The opposite end of the coil 56 is connected with a circulating pump 60 for the fluid, which pump receives the heating fluid that has passed through the drum 44 and is returned to the circulating pump through a return conduit 62 which runs between the rotary joint 50 and said pump 60. These parts are only diagrammatically represented in Fig. 1 and obviously may be mounted in any convenient position either within or without the frames 48. The automatic temperature control 54, which may be of any desired conventional construction, is set to maintain the heating fluid circulating through the heating (or cooling) system at a temperature of about 50–95° C. so that the drum 44 through which the fluid circulates may be heated to a corresponding temperature. The freshly printed web W with its printed surface uppermost passes over the drum 44 in order that the exposed freshly printed ink will be beneath the drier housing 34. In this way the reverse side of the web W will be heated to a temperature below the boiling point of water (100° C.) and there

will be no detrimental removal of moisture from the web. However, the web will be heated by contact with the drum and the amount of heat thus applied thereto will not have to be applied by means of the apparatus associated with the drier housing 34 now to be described in more detail.

By the provision of a wall 64 within the housing 34, said housing has formed therein a pre-heating chamber 66. The wall 64, which may be insulated if desired, extends from the outside wall 36 into close proximity to the web W in contact with the heating drum 44 and is positioned near the entrance end of the housing 34. The central portion of the housing 34 forms a main drying chamber 68 and is separated at its lower end from a post-heating or final burning chamber 70 by means of an insulated wall 72 which is similar to the wall 64.

Suitably mounted in the side walls 42-1 and 42-2 of the housing 34 and disposed within the pre-heating chamber 66 are one or more gas pre-heating burners 74. These burners may be of any suitable construction but we prefer to use burners such as are disclosed in our copending application Serial No. 205,682, filed May 3, 1938, and in F. O. Hess Patent No. 2,228,114, dated January 7, 1941, which burners are adapted to produce an elongated ribbon of flame substantially as wide as the web W and are provided with automatic ignition and shut-off devices that are coordinated with the press operation so as to turn on the burners at any desired press speed and shut them off when the press stops. We have shown two of the burners 74 mounted within the preheating chamber 66 and said burners are adapted to heat the freshly printed ink to a temperature at which the solvent therein will volatilize.

With the freshly printed ink heated to a temperature at which the solvent or solvents therein will volatilize, said web W passes the wall 64 and into the drying chamber where it is subjected to the action of a plurality of jets or blasts of heated air or other gas, which jets are arranged to maintain the ink at proper temperature for volatilization of the solvents, and to remove them rapidly from the web surface. Such blasts or jets of hot air and other gases may be produced by a plurality of elongated slots or passages 76 spaced a uniform distance from the web W and formed in and as part of an air or heated gas applying and distributing member 78 disposed within the drying chamber 68. This member 78 may be formed of sheet metal or other suitable material and mounted within the chamber 68 and secured to the walls thereof in any convenient manner, such as by means of a plurality of supporting brackets 80. The inside of the hot air or gas distributing and applying member 78 is provided with a distributing chamber 82 and a plurality of V-shaped passages 84, the vortexes of which terminate in the longitudinal or elongated slots 76 that form the jets or blasts of air. Air and other gases, heated to proper temperature and there maintained by any suitable type of automatic temperature control functioning in conjunction with the heater, are supplied to the distributing chamber by means of a supply conduit or passage 88 which passes through the outer wall 36 of the housing 34 and is connected to the heater 86. As shown in Fig. 1, the walls of the air or gas distributing or applying member 78 are spaced from the walls of the drying chamber 68 so that heated air and gas return passages

90 are formed about said member. The sheet metal construction of the member 78 is also such as to provide a plurality of return passages or ducts 92 between the elongated slots 76. These return ducts may connect with the return passages 90 at the ends (adjacent the side walls 42-1 and 42-2) and throughout the length of the distributing member 78, if desired. The heated air and other gases are withdrawn from the various return passages and the drying chamber 68 through a return conduit 94 which extends from the outside wall 36 of the housing adjacent said drying chamber to a suitable circulating blower 96. Blower 96 is provided with an excess air vent 98 and is connected at its outlet to the air heater 86. We have found that when the web W is moving at a rate of about 400 feet per minute and the freshly printed ink is properly preheated to the volatilization temperature, four passages 76 supplied with gas heated to a temperature of about 115° C. are sufficient to remove substantially all of the solvent from the ink before the printed web passes the end wall 72 of the drying chamber 68. Since the web is supported on the drum 44, the blasts may strike the surface at high velocity and with relatively great force; and we prefer to supply the gases at high velocity so that they will create an effective lifting action for removing the solvent vapors from the web surface. It will be apparent that much of the solvent vapor removed from the ink as it passes beneath the air blasts or jets will be withdrawn through the return passages 92 and will subsequently be reheated and circulated to aid in the further drying of the web.

To insure a complete and proper drying of the printed inks, we have found it desirable to mount two additional ribbon flame burners 100 in the post-heating chamber 70. These burners 100 may be identical with the burners 74 and those disclosed in our copending applications referred to above and are adapted to give the freshly printed ink a final blast of heat before it passes outside of the drier. They likewise will cause a burning of any of the solvent vapors that may pass into the post-heating chamber with the moving web and are preferably adjusted so as to effect a complete burning or combustion of the solvent vapors and thus through subsequent circulation permit the utilization of the heat of the solvents in the drying operation. Should it be found that any solvent vapors escape into the pressroom at the exit end of the drier and adjacent the wall 40, a hood 102 may be provided at this point and connected through a conduit 104 with any desired ventilating or vapor removal apparatus (not shown).

Products of combustion and burned solvent vapors produced by the two pre-heating burners 74 may be withdrawn from the pre-heating chamber 66 through conduits 106 connected with said chamber and leading to and connected with the conduit 94 associated with blower 96. Similarly the products of combustion and burned solvent vapors produced by the post-heating burner 100 may be withdrawn from the post-heating chamber through a conduit 108 and emptied into the conduit 94. In this way the heated gases produced by these burners (i. e. products of combustion and burned solvent vapors) may be circulated through the blower 96 and into the drying chamber. Since the heated gases will have a relatively high temperature, this recirculation greatly increases the efficiency of the entire apparatus.

As explained above, the burners 74 and 100 are arranged to be shut off when the press is stopped. When the air and gases circulated through the drying chamber are heated to temperatures on the order of 190° C., it may be desirable to prevent their passage into the drying chamber during temporary stopping periods of the press in order to preserve a proper heat balance in said drying chamber. This may be accomplished by the provision of a by-pass conduit 110 between the supply conduit 88 and the return conduit 94 leading to the blower 96. As indicated in Figs. 1 and 2, a first normally open damper 112 may be provided in the conduit 94 adjacent the by-pass 110 and a second normally closed damper 114 may be provided in the by-pass conduit 110 adjacent the supply conduit 88. The dampers 112 and 114 have actuating shafts 116 and 118, respectively, and may be provided at their ends with lever arms 120 which are adapted to be actuated by an actuating link or rod 122 pivotally connected at 124 to the plunger of a solenoid 126. Actuating rod 122 is arranged to be moved downwardly (Fig. 1) by means of the solenoid 126 which is connected in any suitable manner to the switch for the printing press motor (not shown) so that when the motor is stopped the solenoid will be energized. Due to the connection of the actuating rod 122 with the dampers through the lever arms 120, the downward movement of said actuating rod, brought about in this manner, causes both dampers to be moved to the dotted line positions shown in Fig. 1. This opens the by-pass conduit 110 and closes the return conduit 94 and supply conduit 88 so that the air and gases will not pass into the drying chamber but will circulate through the blower 96, heater 86, by-pass conduit 110 and the associated connecting conduits. In this way the heating medium may be maintained at proper operating temperature during stopping periods of the press without disturbing the heat balance in the drying chamber.

In operation, during the starting period of the press, the web W after being printed passes over the drum 44 and through the drier. While moving at slow speeds the web contacts the drum 44 which is heated by means of the heating system including the heater 58, and heated air may be supplied to the freshly printed surface through the distributing and applying member 78 in the drying chamber 68. We have found that either or both of these heating means may be sufficient for drying the web during such starting periods of the press when the web W is moving at comparatively slow speed. Since the burners 74 and 100 are not in operation, the heating medium supplied to the drying chamber during such starting period will not include any of the products of combustion or burned solvent vapors produced by said burners. However, as disclosed in our copending application referred to above, the burners are provided with automatic ignition devices and the gas supplied for said burners is arranged to be turned on automatically when the press reaches a predetermined speed of operation. Hence, when this speed is reached the burner 74 will be automatically ignited and cause the freshly printed ink to be preheated to the temperature at which the solvents therein will be or may be volatilized. Finally, at the proper operating speed the post-heating burner 100 will be automatically ignited and all parts of the drier will then be functioning in synchronism with the heated gases, products of combustion and

burned solvent vapors produced by the burners being returned to the blower 96 and recirculated through the drying chamber 68. In the event that the heat produced by the burners 74 and 100 and the heated gas applying means 78 causes the drum 44 to be heated above 100° C., the temperature control 54 will automatically cause the heater 58 to become inoperative. If desired, said temperature control 54 may be arranged to open a cooling water or refrigerating medium supply 130 so that the water or other heated fluid circulating through the system will be cooled rather than heated. In this way the temperature of the drum 44 may be maintained at a point below 100° C. so that the moisture in the paper or web W will not be detrimentally removed but will be retained therein. By retaining the moisture, the web W will be maintained in its original condition during drying and will not be caused to shrink. The low heating or cooling of the drums is also particularly important when the web consists of glassine, laminated material and the like.

From the foregoing description, it will be apparent that we have provided an improved drying apparatus and method of drying a freshly printed web which is possessed of great flexibility in operation and may be suitably adjusted for changes in the type of work being operated upon and the type of ink applied thereto. By recirculating the products of combustion from the pre-heating and post-heating burners, there is available a hot circulating medium for the drying chamber and little additional heat may be required to produce efficient drying in the apparatus. By only operating the heated drum 44 and the drying chamber 68 during the starting and stopping periods of the press, the web may be sufficiently dried during such periods and waste of both ink and paper eliminated. Due to the fact that the web is supported upon the drum 44 while passing through the drying apparatus, the heated gases supplied through the drying chamber may be applied to the web at any desired velocity and the flames from the burners 74 and 100 may likewise impinge against the web surface with any desired pressure without causing breakage or weakening of the web. Furthermore, by heating or cooling the reverse side of the web W to a temperature below the boiling point of water, the moisture will not be detrimentally removed, problems in register will be reduced or eliminated, and the texture or surface characteristics of the web will be maintained in their normal original condition.

Various changes may be made in the construction and methods herein described and certain features or steps thereof may be employed without others without departing from our invention or sacrificing any of its advantages.

What we claim is:

1. A method of printing which comprises applying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said web over a supporting surface which is heated to a temperature between 50° C. and 95° C. so as to prevent detrimental evaporation of moisture in said web; while the portion of said web which is to be dried is in contact with the heated supporting surface, heating the freshly printed ink on said portion only, to a temperature at which the solvents therein will volatilize; and maintaining the freshly printed ink at such temperature until substantially all of the solvents in said ink have volatilized.

2. A method of printing which comprises ap-

plying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said moving web over a rotating supporting surface which is heated to a temperature below 100° C. so as to prevent evaporation of moisture in said web; while the portion of said web which is to be dried is in contact with said heated supporting surface raising the temperature of the freshly printed ink on said portion only, to a point at which the solvents in said ink will volatilize, the initial raising of temperature being caused by means of a gas flame; and maintaining the freshly printed ink at that temperature until substantially all of the solvents in said ink have volatilized.

3. A method of printing which comprises applying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said moving web over a rotating supporting surface which is heated to a temperature below 100° C. so as to prevent detrimental evaporation of moisture in said web; while the portion of said web which is to be dried is in contact with said heated supporting surface, raising the temperature of the freshly printed ink on only said portion to a point at which the solvents in said ink will volatilize, the initial raising of temperature being caused by means of a gas flame; and maintaining the freshly printed ink at that temperature until substantially all of the solvents in said ink have volatilized, the freshly printed ink being maintained at such temperature by means of a high velocity stream of heated gas applied thereto.

4. A method of printing which comprises applying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said moving web over a rotating supporting surface; while the portion of said web which is to be dried is in contact with said supporting surface, volatilizing the solvent in said ink by the application of both direct flames and high velocity streams of heated gases to said portion only; and buring the solvent vapors thus produced.

5. A method of printing which comprises applying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said moving web over a rotating supporting surface; while the portion of said web which is to be dried is in contact with said supporting surface, volatilizing the solvent in said ink by the direct application of a gaseous heating medium to said portion only; burning the solvent vapors; and recirculating the products of combustion and burned solvent vapors, produced by the burning, with said heating medium.

6. A method of printing which comprises applying an ink containing a volatilizable and inflammable solvent to the surface of a moving web; passing said moving web over a rotating supporting surface; while the portion of said web which is to be dried is in contact with said supporting surface, volatilizing the solvent in said ink by the direct application of a gaseous heating medium to said portion only; with sufficient force to cause the solvent vapors to be lifted rapidly from the surface of the web; burning the solvent vapors; and recirculating the products of combustion and burned solvent vapors, produced by the burning, with said heating medium.

7. Apparatus for drying a freshly printed material, comprising the combination with means for continuously moving a material to which ink has been applied, of means for rigidly support-

ing the printed material, means for heating said supporting means to a temperature of between 50° C. and 95° C., and means for applying a heated drying medium at high velocity directly upon the exposed surface of the printed material while it is in contact with said supporting means.

8. Apparatus for drying a freshly printed web, comprising the combination with means for continuously moving a web to which ink has been applied, of a rotatable supporting drum, gas burner means for pre-heating the freshly printed ink to a temperature at which the ink will dry, and means for applying a gaseous heating medium directly upon the pre-heated printed ink so as to cause it to be substantially completely dried.

9. Apparatus for drying a freshly printed web, comprising the combination with means for continuously moving a web to which an ink containing a volatilizable and inflammable solvent has been applied, means for rigidly supporting the printed web, gas burner means for rapidly pre-heating the freshly printed ink to a temperature at which the solvent in the ink will volatilize, and means for applying a gaseous heating medium directly upon the freshly printed ink so as to maintain it at such temperature until substantially all of the solvent in the ink has been volatilized.

10. Apparatus for drying a freshly printed web, comprising the combination with means for continuously moving a web to which an ink containing a volatilizable and inflammable solvent has been applied, means for rigidly supporting the printed web, gas burner means for rapidly pre-heating the freshly printed ink to a temperature at which the solvents in the ink will volatilize, means for applying a gaseous heating medium directly upon the freshly printed ink so as to maintain it at such temperature until substantially all of the solvents in the ink has been volatilized, and means for burning the solvent vapors.

11. Apparatus for drying a freshly printed web, comprising the combination with means for continuously moving a web to which an ink containing a volatilizable and inflammable solvent has been applied, means for rigidly supporting the printed web, gas burner means for rapidly pre-heating the freshly printed ink to a temperature at which the solvent in the ink will volatilize, means for applying a gaseous heating medium directly upon the freshly printed ink so as to maintain it at such temperature until substantially all of the solvent in the ink has been volatilized, means for burning the solvent vapors, and means for circulating the products of combustion and burned solvent vapors so produced with the gaseous heating medium.

12. Apparatus for drying a freshly printed material, comprising the combination with means for continuously moving a material to which ink has been applied of a pre-heating chamber including a gas burner for initially heating the ink to drying temperature, and a drying chamber including means for directing a stream of gaseous heating medium upon the thus pre-heated printed material.

13. Apparatus for drying a freshly printed material, comprising the combination with means for continuously moving a material to which ink has been applied, of a pre-heating chamber including a gas burner for initially heating the ink to drying temperature, a drying chamber for di-

recting a stream of gaseous heating medium upon the thus pre-heated printed material, and a post-heating chamber including a burner which is adapted to impart a final blast of heat to the printed material and burn any solvent vapors that may be present.

14. Apparatus for drying a freshly printed material, comprising the combination with means for continuously moving a material to which ink has been applied, of a pre-heating chamber including a gas burner for initially heating the ink to drying temperature, a drying chamber for directing a stream of gaseous heating medium upon the thus pre-heated printed material, a post-heating chamber including a burner which is

adapted to burn the solvent vapors, and means for passing the products of combustion and burned solvent vapors from the post-heating chamber into the drying chamber.

15. Apparatus for drying a freshly printed material, comprising the combination with means for continuously moving a material to which ink has been applied, of means for circulating a gaseous heating medium in contact with the printed material, and means for by-passing the gaseous heating medium so that it will not contact the printed material when the press stops.

FREDERIC O. HESS.
CARL P. MANN.