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[54] **FILM DRYING APPARATUS**

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[58] **Field of Search**.....34/28, 31, 45, 46, 48, 155, 34/162; 219/388

[56] **References Cited**

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[57] **ABSTRACT**

A drier for strips of developed film has a housing wherein the film is transported downwardly and is dried by ascending streams of hot air furnished by several discrete blowers each of which is equipped with a composite air heating device. Each heating device has a first electric resistance heater which is started in response to closing of a master switch to furnish a basic heating action, a second resistance heater which is adjustable by a regulator having a manually adjustable potentiometer, and a third resistance heater which can be started by a temperature gauge. The latter monitors the temperature of air which circulates in or leaves the housing and starts the third resistance heater when the thus determined temperature is below a preselected value. Some of the spent air which leaves the housing is recirculated to the blowers.

10 Claims, 2 Drawing Figures

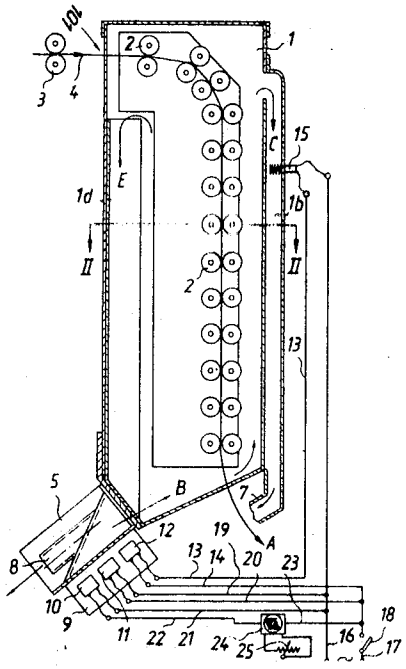
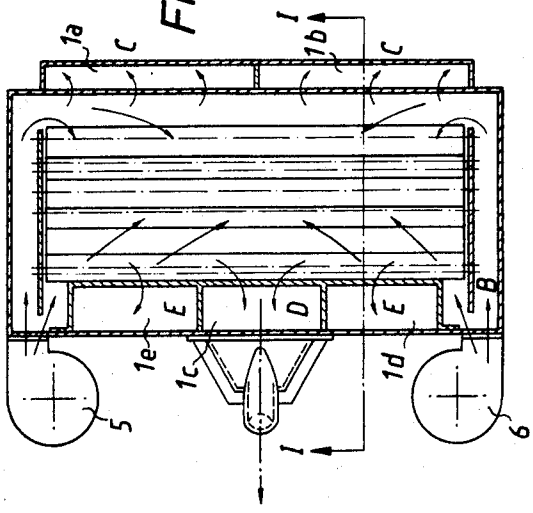


Fig.2



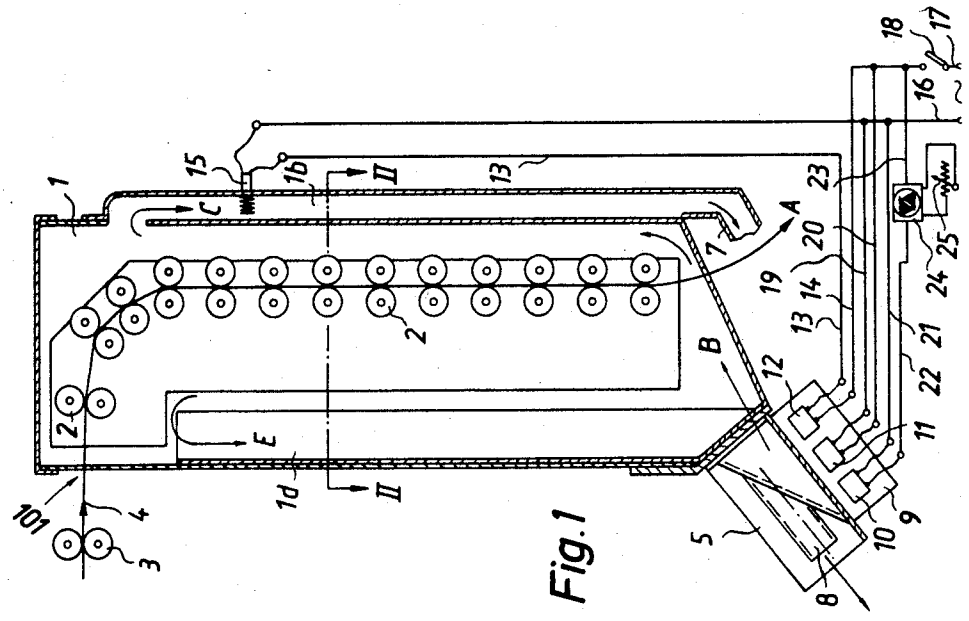


Fig.1

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FILM DRYING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for the drying of strip- or sheet-like materials, particularly for the drying of films.

It is already known to provide a film drying apparatus with a temperature gauge which automatically starts an auxiliary heater for circulating drying air when the temperature of air drops below a predetermined value. Such drying apparatus are satisfactory when the temperature and/or moisture content of surrounding air, as well as the rate of transport of the material to be dried, do not fluctuate within a rather wide range. It was found that an auxiliary heater which is controlled by a temperature measuring gauge is not always sufficient to rapidly compensate for abrupt and/or substantial changes in the temperature and/or moisture content of surrounding air. Such intermittently operated auxiliary heaters will function properly only when the characteristics of surrounding air, the nature of film and/or the rate of film transport do not fluctuate beyond a rather narrow range.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved drying apparatus for photographic film, X-ray film or similar sheet- or strip-like materials which are heated by one or more streams of heated air.

Another object of the invention is to provide a drying apparatus wherein the intermittently operated heating unit is not required to compensate for substantial deviations of the temperature of heating fluid from a desired temperature.

A further object of the invention is to provide a drying apparatus which can readily, rapidly and efficiently compensate for substantial fluctuations in the rate of transport of the material to be dried, for changes in the temperature of surrounding air, and/or for changes in the moisture content of surrounding air.

An additional object of the invention is to provide a drying apparatus wherein the heating and drying actions of one or more air streams can be regulated within a wide range independently of the auxiliary heater which responds only when the temperature of heating air is without the desired range.

Still another object of the invention is to provide a compact, economical and reliable drying apparatus which can be used in combination with presently known developing, fixing and/or other treating apparatus for film or similar sheet- or strip-like materials.

The invention is embodied in an apparatus for the drying of films or analogous strip- or sheet-like materials. The apparatus comprises a housing, transporting means for conveying the material to be dried through the housing (preferably along a path wherein the material is transported downwardly), at least one blower or an analogous air circulating device for circulating through the housing at least one stream of drying air which preferably flows countercurrent to and sweeps along one or both sides of the conveyed material, and at least one novel heating device for such air stream or streams. The heating device comprises a first heating unit which may include one or more electric resistance heaters and is arranged to subject the air stream to a first or basic heating action, a second heating unit which preferably includes one or more electric resistance heaters or analogous heating means and adjustable regulating means for adjusting the heating action of such heating means upon the air stream, and a third heating unit including one or more electrical resistance heaters or analogous heating means and a detector which monitors the temperature in a selected part of the housing (or in a part which receives spent air from the housing) and is arranged to start the heating means of the third heating unit when the thus determined temperature of air is below a predetermined value.

Thus, the first heating unit furnishes a constant basic heating action; the second heating unit furnishes a second heating action which is adjustable at the will of the operator and assists the action of the first heating unit when necessary (for example, when the surrounding air is a cold air or a very moist air or when the material is being transported at a high rate of speed); and the third heating unit furnishes a heating action which assists the action of the second and/or first heating unit when the latter is (or are) unable to heat the air at least to a predetermined temperature. As a rule, the operation of the heating means in the third heating unit is short-lasting.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims.

The improved drying apparatus itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic vertical sectional view of a film drying apparatus which embodies the invention, the section being taken in the direction of arrows as seen from the line I—I of FIG. 2; and

FIG. 2 is a horizontal sectional view as seen in the direction of arrows from the line II—II of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2 in detail, the improved drying apparatus (hereinafter called drier) comprises a housing 1 which accommodates sets of pairwise arranged transporting rolls 2 defining for a strip or sheet of film 4 an elongated substantially vertical path wherein the film is caused to move downwardly from an inlet 101 toward, through and beyond an outlet (not shown) provided in the lower part of the housing 1. The housing 1 receives the film 4 from a developing apparatus which includes film feeding rolls 3 located upstream of the inlet 101. The direction of film transport is indicated by the arrow A.

The illustrated drier comprises two discrete circulating devices for heated air here shown as blowers or fans 5, 6 adjacent to the narrower sides of the housing 1 and arranged to direct two separate streams of heated air upwardly, i.e., countercurrent to the transport of the film 4, as indicated by the arrow B. The streams of air which are caused to flow in the direction indicated by the arrow B are substantially parallel to the path for the

film 4. The countercurrent flow of heating air insures that the film can be heated intensively in spite of a relatively low consumption of electrical energy for the heating of air currents. Furthermore, since the freshly heated increments of air streams furnished by the outlets of the blowers 5, 6 impinge first on that portion of the film 4 which is remote from the inlet 101 and which has been heated during transport by the rolls 2 from the inlet 101 toward the lower portion of the interior of the housing 1, the air streams are less likely to produce on the gelatine layer streaks which are particularly bothersome in the evaluation of X-ray pictures. Streaks are likely to develop when a stream of heated air impinges at an obtuse angle against a gelatine layer which is still soft immediately after it leaves the developing apparatus. Though the improved drier could operate with a single blower, it is preferred to employ two or more blowers which are preferably uniformly distributed in a direction as considered transversely of the direction of film transport. Several blowers are more likely to bring about highly uniform heating of all zones of the travelling film between the two marginal portions thereof. Each of the several blowers is preferably provided with means for independent adjustment of the temperature of heating air in a manner to be described below.

A portion of the ascending drying air is caused to enter into evacuating channels 1*a*, 1*b* and 1*c* (see the arrows C and D shown in FIG. 2). These channels discharge spent air into the atmosphere by way of pipes 7 and 8. The remainder of heated air is caused to enter recirculating ducts 1*e* and 1*d* by flowing in the directions indicated by arrows E and to reenter the inlet openings of the blowers 5 and 6 for reheating and renewed circulation into contact with the film 4. The drier is designed for transport of relatively wide or relatively narrow films.

The heating arrangement for air which is being circulated by the blowers 5, 6 is shown in FIG. 1. Such heating arrangement comprises a composite heating device 9 for each of the blowers 5, 6, and each heating device 9 includes three discrete heating units 10-24-25, 11 and 12-25. The reference characters 10, 11 and 12 denote heating means each of which is an electric resistance heater having a single wire or two or more wires. The electric circuit of the heating means 10, 11 and 12 in the heating units of the heating device 9 comprises a pair of power leads 16, 17 which are connected to a source of a-c current and one of which contains a master switch 18. The power leads 16, 17 are connected with the heating means 12 by conductors 13, 14 and the heating means 12 is connected in series with a preferably adjustable automatic thermometer or temperature gauge 15 which constitutes a detector and scans or monitors the temperature of air in the housing 1. In the illustrated embodiment, the gauge 15 is mounted to scan the temperature of air in the evacuating channel 1*b* and serves to complete the circuit of the heating means 12 in the respective heating device 9 when the temperature of air in the duct 1*b* drops below a predetermined value. Of course, the circuit of the heating means 12 can be completed only when the master switch 18 is closed.

The heating means 11 in each heating device 9 is connected directly with the power leads 16, 17 by conductors 19, 20 so that it begins to heat air in the respective blower as soon as the master switch 18 is closed by the operator. The heating means 10 is connected with the power leads 16, 17 by way of conductors 21 and 22, 23 and is in series with a manually adjustable current regulator 24 including an adjustable potentiometer 25. The regulator 24 is connected between the conductors 22 and 23. The infinite adjustability of the potentiometer 25 enables the regulator 24 to change the heating action of the respective heating means 10 within a desired range and to furnish an infinite number of settings. It will be noted that one of the heating units in each of the devices 9 merely comprises a heating means 11, that another heating unit comprises a heating means 12 and a detector 15, and that the third heating unit comprises a heating means 10 and a manually operable regulator 24. The three heating units of each heating device 9 are connected in parallel.

The operation:

When the master switch 18 for the one or both heating devices 9 is closed, it also completes the circuit of the motor or motors which drive the feeding rolls 3 of the developing apparatus and the transporting rolls 2 in the housing 1. Furthermore, the closing of the master switch 18 preferably results in completion of the circuit of the motor or motors which drive the blowers 5 and 6. It is assumed that the power leads 16, 17 are common to both heating device 9 and that the drier comprises a single master switch 18. When the latter is closed, the heating means 11 of both heating devices 9 automatically begin to heat the streams of air which are circulated by the blowers 5 and 6 because the completion of the circuit of each heating means 11 merely necessitates the closing of the master switch 18. Thus, the heating means 11 constitute the basic heating units of the devices 9 which insure that the circulating air is heated at least to a minimum temperature. The action of the heating means 11 can be selected in such a way that they insure a satisfactory heating of the respective air streams at a particular temperature and/or moisture content of the surrounding air and/or for a particular type and speed of transported strip-shaped material.

The operator will start and/or adjust the heating action of one or both heating means 10 in dependency on the nature of film 4, on the temperature of surrounding atmospheric air and/or on the rate at which the film is being transported by the rolls 2. Such adjustment merely involves proper setting of the respective potentiometers 25. As mentioned before, each potentiometer 25 is preferably designed to allow for an infinite number of adjustments of the temperature of the respective air stream by way of the associated regulator 24 and heating means 10.

The gauge 15 monitors the temperature of air which is allowed to escape by way of the channel 1*b* and starts the heating means 12 when such temperature drops below a preselected value. Thus, the heating means 12 will normally be operated only for relatively short intervals of time, namely, when the temperature of air streams fluctuates beyond a preselected range, to thus eliminate the deleterious effect of such short-lasting fluctuations.

It will be seen that each heating device 9 includes a unit 11 which furnishes a basic heating action and which need not (but may) be adjustable, a second unit

including the heating means **10** which is preferably adjustable within a reasonably wide range and infinitely to thus enable the operator to change the temperature of air streams at will, and an automatically controlled third unit including the heating means **12** which responds to a drop in air temperature below a predetermined value to thus insure that the travelling film **4** is treated by streams of air whose temperature is invariably above such predetermined value.

The manually adjustable current regulator **24** preferably consists of a phase control circuit as for instance disclosed in a different connection by Gemmer et al. in U.S. Pat. No. 3,402,636.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. Apparatus for the drying of films or analogous strip- or sheet-like materials, comprising a housing; transporting means for conveying the material to be dried through said housing; at least one air circulating device for circulating through said housing at least one stream of drying air which sweeps along the conveyed material; and at least one heating device for said air stream, comprising a first heating unit arranged to subject the air stream to a first heating action, a second heating unit including first air heating means and regulating means for adjusting the air heating action of said first heating means, and a third heating unit having second air heating means and detector means arranged to monitor the temperature of air in said housing and to start said second air heating means in response to a drop in the temperature of air in said housing below a predetermined value.

2. Apparatus as defined in claim **1**, wherein said transporting means is arranged to convey the material to be dried downwardly and wherein said circulating device is arranged to furnish an ascending air stream which travels countercurrent to the material to be dried.

3. Apparatus as defined in claim **2**, further comprising duct means for returning a portion of said air stream from said housing to said circulating means.

4. Apparatus as defined in claim **1**, wherein said detector means comprises a temperature gauge and said second air heating means comprises at least one electric heating element whose circuit is completed by said gauge when the latter detects that the temperature of said air stream is below said predetermined value.

5. Apparatus as defined in claim **1**, wherein said regulating means comprises potentiometer means adjustable between a plurality of positions each corresponding to a different heating action of said first heating means.

6. Apparatus as defined in claim **1**, wherein said circulating means comprises a plurality of discrete blowers spaced from each other as considered in a direction transverse to the direction of transport of the material to be dried.

7. Apparatus as defined in claim **6**, further comprising duct means for recirculating at least some of the heated air from said housing to said blowers.

8. Apparatus as defined in claim **6**, comprising a discrete heating device with three heating units for each of said blowers.

9. Apparatus as defined in claim **1**, wherein each of said heating units is operated by electric current and further comprising master switch means actuatable to simultaneously connect all of said heating units with a source of electrical energy.

10. Apparatus as defined in claim **9**, where said heating units are connected in parallel.

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