



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
WASHINGTON, D.C. 20546

(NASA-Case-GSC-11074-1) DRYING APPARATUS N73-28489  
FOR PHOTOGRAPHIC SHEET MATERIAL Patent  
(Electronic Image Systems Corp.) 7 p

REPLY TO  
ATTN OF: GP

CSCL 14E

00/14 Unclas  
10069

TO: KSI/Scientific & Technical Information Division  
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for  
Patent Matters

SUBJECT: Announcement of NASA-Owned U.S. Patents in STAR

In accordance with the procedures agreed upon by Code GP  
and Code KSI, the attached NASA-owned U.S. Patent is being  
forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,744,148  
Government or : Electronic Image Systems  
Corporate Employee : Cambridge, Mass. 02139  
Supplementary Corporate : \_\_\_\_\_  
Source (if applicable)  
NASA Patent Case No. : GSC-11,074-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes  No

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

*Elizabeth A. Carter*

Elizabeth A. Carter  
Enclosure  
Copy of Patent cited above



[54] **DRYING APPARATUS FOR PHOTOGRAPHIC SHEET MATERIAL**

[76] Inventors: **James C. Fletcher**, Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Paul Epstein**, Brookline; **George Donovan**, Middleton, both of Mass.; **Eric La White**, Royalton, Vt.

[22] Filed: **Nov. 12, 1971**

[21] Appl. No.: **198,362**

[52] U.S. Cl. .... **34/160, 34/155, 34/162**

[51] Int. Cl. .... **F26b 13/00**

[58] Field of Search ..... **34/151, 154, 155, 34/160, 162**

[56] **References Cited**  
**UNITED STATES PATENTS**

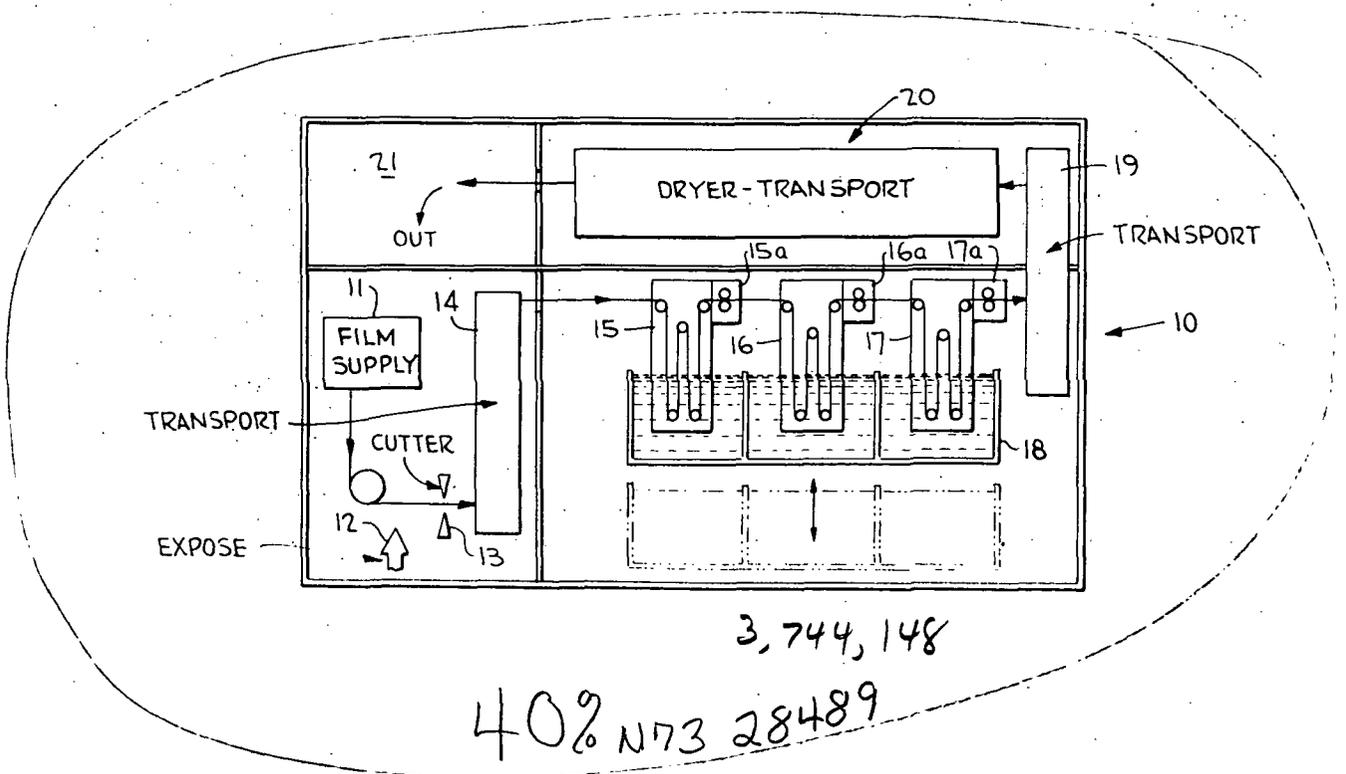
3,147,090	9/1964	Russell et al.....	34/160
3,429,057	2/1969	Thygeson.....	34/160
3,660,911	5/1972	Buckingham.....	34/160
3,579,853	5/1971	Martino.....	34/160
3,418,727	12/1968	Morris.....	34/162
3,009,257	11/1961	Scott.....	34/160

Primary Examiner—Carroll B. Dority, Jr.  
Attorney—R. F. Kempf and John R. Manning

[57] **ABSTRACT**

An elongated drying chamber is provided with transport means for carrying photographic sheet material edgewise with the sheets in end-to-end relationship past a plurality of tubes that issue drying air streams directed against the liquiphilic surface of the sheet material. The tubes are slotted a distance equal to substantially the full width of the sheet material for complete, gentle drying by sheets of air. A common plenum supplies the tubes with heated air; the air being directed from the tube slots at a pronounced angle to the sheet surface so as to provide for arraying the tubes close to the surface for maximum drying effect while minimizing the danger of mechanical interference between the edges of the sheets and the slots in the tubes. The drive for the transport is housed in an enclosure between the plenum and the drying chamber and is provided with access through an overlying insulating chamber; an air return duct being provided along another side to complete insulation of the drying chamber from ambient conditions. Discharge openings for release of moisture-laden air are the entrance and exit openings for the passage of said sheet material, and make-up air is drawn through a filtered inlet in the return duct.

11 Claims, 6 Drawing Figures



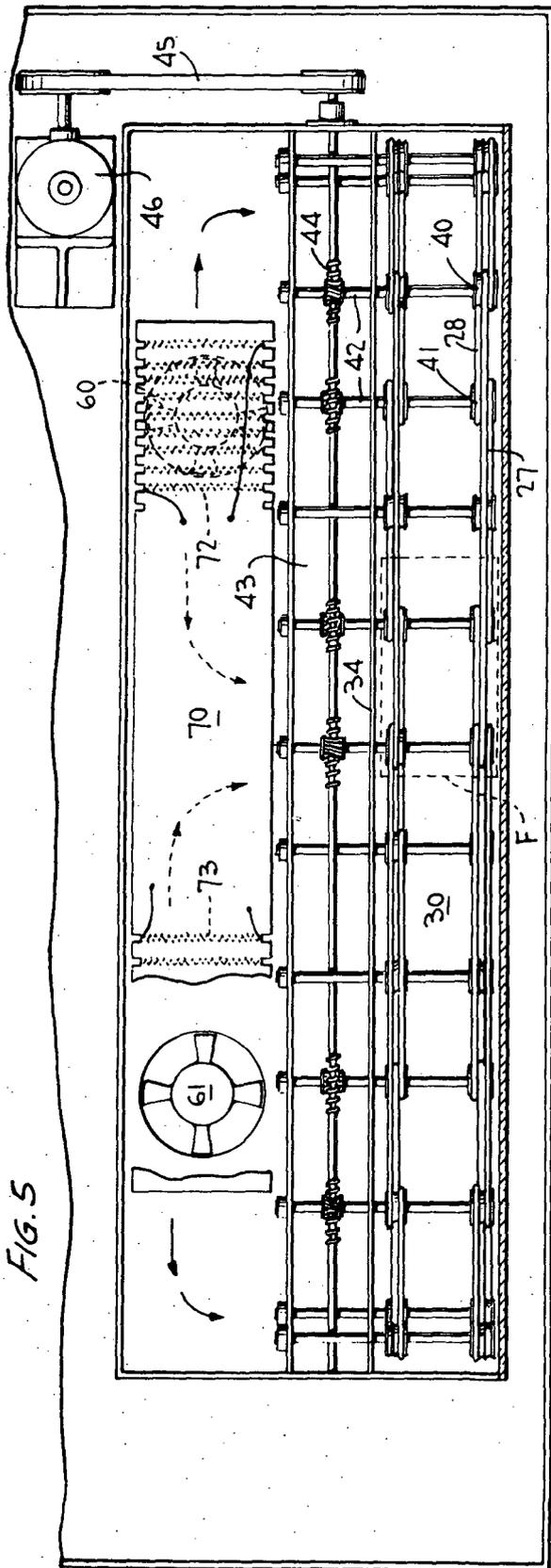


FIG. 5

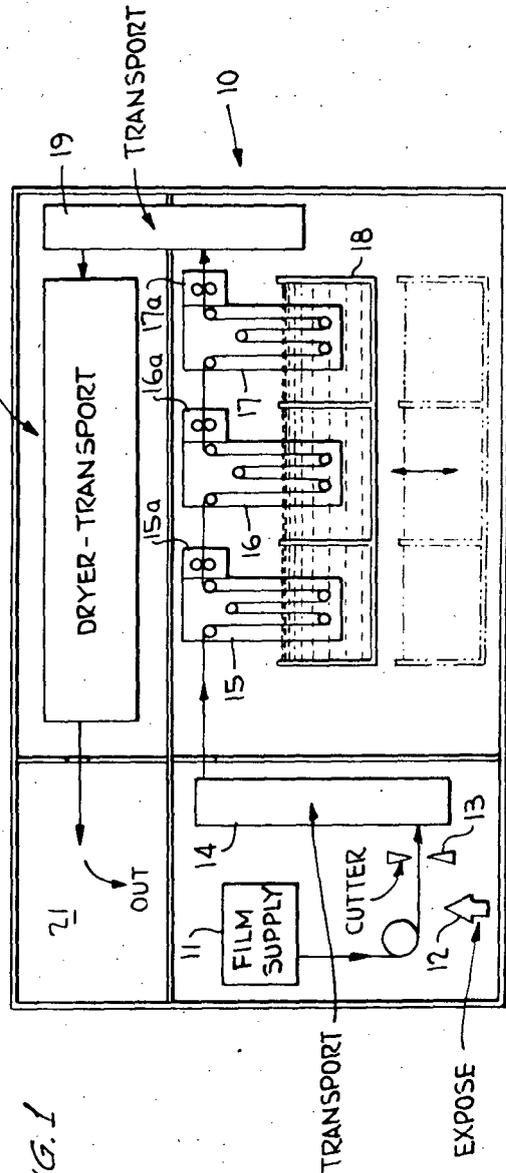


FIG. 1

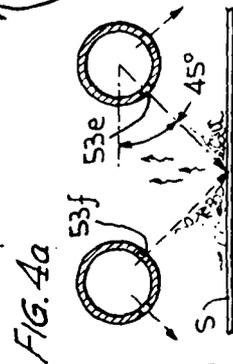
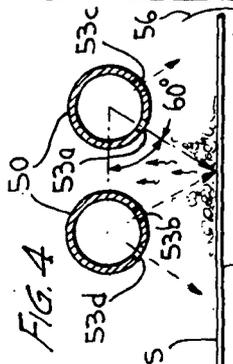
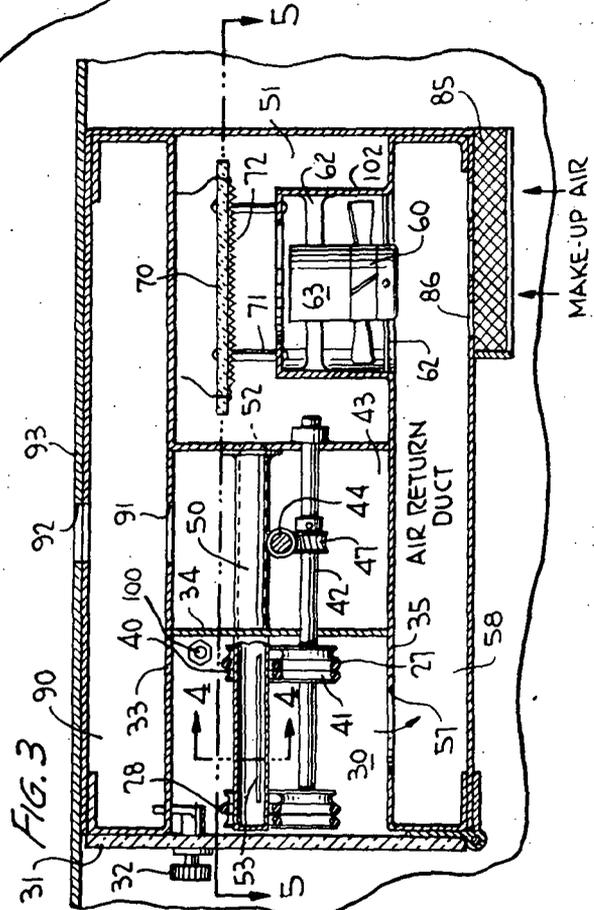
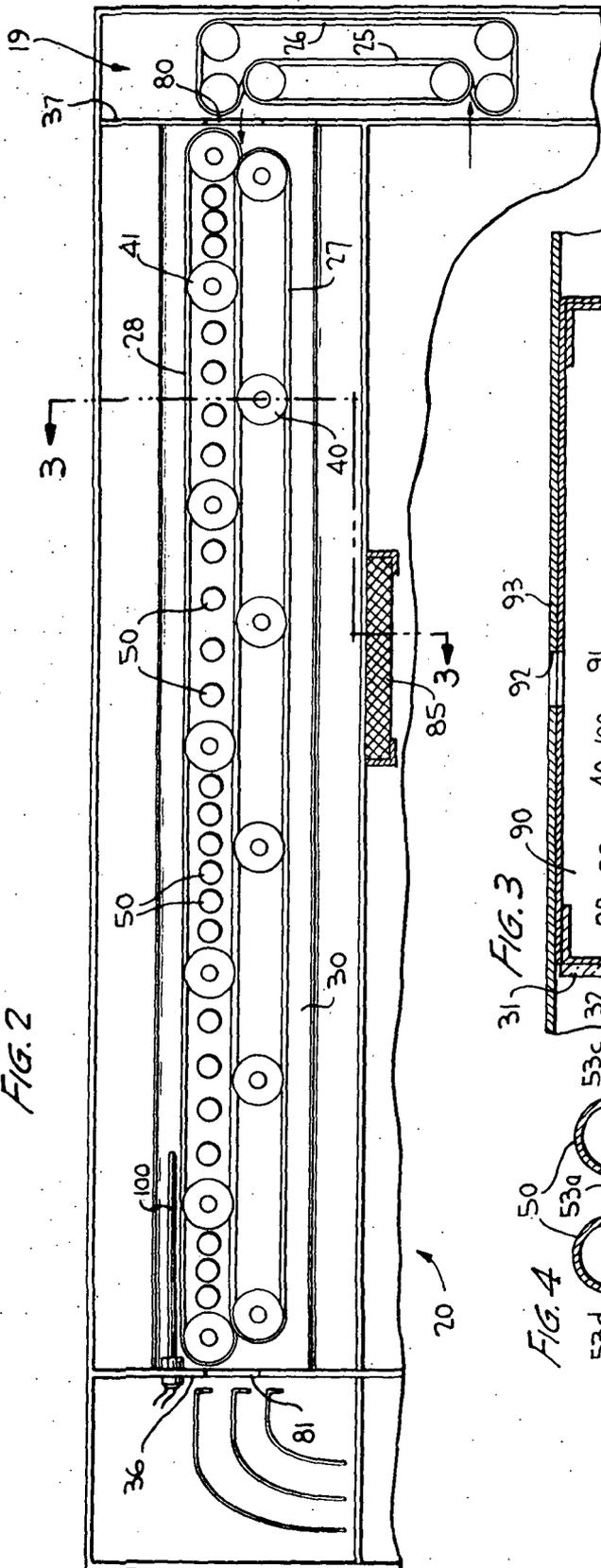
INVENTORS,  
 PAUL EPSTEIN  
 GEORGE DONOVAN  
 ERIC LA WHITE

BY

NEIL F. ...

ATTORNEYS

FIG. 2



INVENTORS,  
 PAUL EPSTEIN  
 GEORGE DONOVAN  
 ERIC LA WHITE  
 BY VALL B. SIEGEL  
 ATTORNEYS

## DRYING APPARATUS FOR PHOTOGRAPHIC SHEET MATERIAL

### ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

### FIELD OF INVENTION

The present invention relates to drying apparatus and, more particularly, to a dryer adapted for acting on the liquiphilic surface of photographic sheet material by heated air streams impinging upon said surface.

### BACKGROUND OF THE INVENTION

It is known in the photographic field to provide an apparatus for exposing a film, cutting the film to form a film clip, transporting the film chip through a series of liquid baths to develop the same and then drying the film chip, all in an automatic fashion without being touched by human hands. While these machines have been satisfactory and have represented great savings in terms of eliminating the need for operators to handle and process the film, much has been left to be desired in terms of speeding the process to a maximum extent.

To explain, while the automatic transport of the film chip through the baths satisfactorily saves processing time, heretofore, an efficient drying apparatus to replace manual drying by hanging up of material has eluded what might be considered total success. In some cases, too rapid drying occurs in the drying chambers which tends to burn or scorch the film thereby causing the film base, such as cellulose, to be subject to premature cracking, and thus rendering the same unuseable. This type of shortcoming usually results from embodiments having radiant dryers placed in direct proximity to the film or other sheet material of a photographic nature, which on occasion causes hot spots to occur due to the buildup of heat in the stagnant air between the heater and the sheet.

The opposite effect of scorching of the film is insufficient drying when the film chip is ejected from the dryer in a still moist condition. When the chip thus falls into the discharge hopper, it is subject to wrinkling and distortion and is, of course, not subject to immediate printing and storage. These previous machines have included blowing of air streams, sometimes heated, across the surface of the film but with certainly limited success in gaining a finished product that is assured of being satisfactorily dried. These previous attempts have been characterized as also being extremely large and bulky.

### OBJECTIVES OF THE INVENTION

Thus, it is one object of the present invention to provide a drying apparatus for film chips, or other photographic sheet material, that gains high efficiency in removing moisture therefrom.

It is still another object of the present invention to provide an apparatus to dry photographic sheet material that removes moisture from the liquiphilic surface of the sheet material by a large number of heated air streams impinging upon the sheet surface from orifices placed in close proximity thereto, thereby controllably drying said sheet material.

It is still another object of the present invention to provide a drying apparatus that is considerably reduced in size and power requirements yet gives improved drying efficiency over previous attempts in this field.

### BRIEF DESCRIPTION OF THE INVENTION

To briefly pinpoint some of the major concepts in the drying apparatus of the present invention, reference must first be made to arrangements wherein film chips are continuously transported edgewise and dried. In these arrangements, drying should be in a rapid fashion but without scorching of the relatively delicate emulsion on the film that bears the image, as well as without causing damage to the base material of the film itself. Thus, such a drying operation must be gentle, yet effective to remove moisture, and to do so under the most adverse conditions due to the fact that the emulsion is liquiphilic, that is, adapted to attract and retain moisture. The machine must also remove moisture rapidly so that the chip may be immediately used for printing of the picture. While film chips will be discussed in the application to describe the inventive machine and its operation, it is to be understood that the apparatus is equally adaptable to other photographic processes, such as drying of a print since essentially the same requirements of gentle, yet effective and rapid action are in effect.

Thus, the film chips are carried along by a continuous transport means and a plurality of spaced dryer tubes having aperture means directed toward the emulsion surface of the film chip are provided to eject heated air streams toward said surface.

The aperture means of the tubes is preferably a slot extending a distance equal to the full width of the sheet material so that drying action is gained uniformly over the complete surface area of the sheet.

The transport means must be driven, yet one side must be completely accessible for servicing and inspection of the transport path. At the same time, it is desirable to have insulation around the drying chamber to minimize heat loss to the surrounding air. For these combined reasons, the drive for the transport is situated between the drying chamber and the air plenum. An insulating chamber extends along one side of the drying chamber, plenum and drive enclosure for insulation purposes and an air return duct extends along the same on an opposite side for the same purpose. Discharge of moisture laden air is advantageously provided through the entrance and exit openings for the sheet material. An air inlet is provided along the air return duct for supplying filtered make-up air.

For best results, the heater means is mounted in the plenum downstream of the pressurizing fan and is situated so as to intercept the air flow from the pressurizing fan where the air velocity is high, thereby expediting heat transfer from the heating means to the incoming air. The plenum is thereby pressurized by heated air and so supplies all the drying tubes to maintain substantially constant flow of heated air from the apertures along the drying chamber.

Still other objects and advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description, wherein we have shown and described only the preferred embodiment of the invention, simply by way of illustration of the best mode contemplated by us of carrying out our invention. As will be realized, the inven-

tion is capable of other and different embodiments, and its several details are capable of modification in various obvious respects, all without departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

#### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram showing an automatic film chip processor including a dryer - transport section that identifies the environments of the present invention;

FIG. 2 is a front view of the apparatus showing the transport mechanism;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2 and showing the preferred embodiment of the drying apparatus of the present invention in its most complete form;

FIGS. 4 and 4a illustrate the cross section through the dryer tubes taken along line 4—4 of FIG. 3 and showing the arrangement of the orifices and depicting the impingement of the air streams therefrom upon the surface of the sheet material; and

FIG. 5 is a cross-sectional view taken along line 5—5 of FIG. 3 and showing the drying apparatus and transport mechanism from the top.

#### DETAILED DESCRIPTION OF THE INVENTION

With reference now to FIG. 1 of the drawings, one environment in which the apparatus of the present invention may be successively utilized is shown. Thus, there is illustrated a film chip processor 10 that supplies photographic film in roll form from film supply 11 to an exposure station indicated by the arrow 12, and thence through a cutter station 13 where a film chip is formed and fed into a first transport module 14. The film chip enters a processing section having individual processing modules 15, 16, 17 for immersing each film chip into separate liquid baths. As shown, the baths may be held in a segmented trough 18 that is capable of being lowered to an inoperative position for shutdown and cleaning purposes. Each module 15—17 is provided with a corresponding wringer module 15a, 16a, 17a to remove the excess liquid from the film chip after each bath. After leaving the final wringer module 17a, the film chip enters final transport module 19 and is delivered to a combination dryer-transport, generally designated by the reference numeral 20, and to which the present invention is directed.

Upon leaving the dryer-transport 20, the film chip is expelled in a completely developed and dried state to a suitable discharge station 21. It will be realized that insofar as the features of the inventive dryer-transport 20 are concerned, the processor 10 could just as well be a printer of photographic paper, whereupon the exposure station 12 would become a printing station and the film chip would more accurately be referred to as a photographic print. Thus, the film chip processor 10 has been selected merely to show an environment and a suitable operative or preferred form of the invention, and it is therefore to be understood that the drying apparatus of the invention has utility in both the developing and printing aspects of the photographic field.

In FIG. 2, the front view of the dryer-transport 20 is illustrated with adjacent parts broken away for clarity. Suffice it to say that a film chip leaving the engagement of opposed transfer belts 25, 26 of the final transport

module 19 are directed in accordance with the arrow between opposed transport belts 27, 28 that are made up of a plurality of belt sections (see FIGS. 3 and 5) grasp the film chip by its side margins and to hold the film chip (see dotted line outline F in FIG. 5) therebetween and convey the same in continuous motion along an elongated drying chamber 30.

As shown in FIG. 3, the drying chamber 30 is effectively closed by a transparent door 31 having a suitable latch 32 thereon; the film chips F along the transport path thus being easily viewed by the machine operator and easily accessible in the event of a jam up or premature shutdown of the machine. The chamber 30 is formed on other sides by a top wall 33, a rear wall 34, a bottom wall 35, and two end walls 36, 37, as shown in FIGS. 2 and 3.

Certain of the belt sections of upper and lower transport belts 27, 28 are driven by spools 40, 41 through drive shafts 42 extending through rear wall 34 (see FIGS. 3 and 5). The shafts 42 are positioned within a drive enclosure 43 and receive motive power from a longitudinally extending worm 44, in turn driven by a belt drive 45 and main motor 46.

The manner in which the film chips F are dried as they move along the drying chamber 30 will now be described, having reference to FIGS. 2—4. Thus, a plurality of dryer tubes 50 are spaced in close proximity to each other along the chamber 30 and extend there-through. The dryer tubes 50 enter the drying chamber 30 after traversing the drive enclosure 43 and receive heated air from a plenum 51 just to the rear of said drive enclosure 43. Each tube is provided with a mouth 52 opening directly into the elongated plenum 51 and each is provided at the opposite end in the drying chamber 30 with an elongated slot 53 for release of the air into operative working engagement with the film chip F. As shown in FIG. 3, the slot 53 extends substantially across the full width between the belts 27, 28 so that the film chip F is dried across the full width thereof.

In accordance with the invention, the slots 53a, 53b, 53c, 53d of adjacent tubes 50 (FIG. 4) are directed toward the emulsion coated surface S of the film chip F. These slots 53a, 53b, 53c and 53d issue air streams in the form of flat sheets which impinge upon the surface S, as shown by the dashed line arrows of FIG. 4. FIG. 4a shows a similar arrangement, but representing the angular arrangement of slots and air streams presently preferred.

The significance of the arrangement shown is in the close proximity of the drying tube apertures to each other and to the emulsion surface of the film, so that the drying air impinges upon the emulsion while the air velocity is still relatively high, thereby effectively penetrating and displacing the layer of moisture-laden air next to the emulsion surface. Also, by providing a large number of tubes 50 in close proximity to each other, the arrangement provides a maximum number of such air streams in a minimum space, and arrayed in such fashion that they contribute to a compact and yet simple and reliable transport path. By this it is meant that the resulting transport path is not only quite short for practical convenience, but also has no sharp bends which might tend to cause the film chips to buckle during travel, whereby the chance for interference between the edges of the film chips and the tubes 50 (with possible jams as a result) is removed. In addition the

angular disposition of the slots 53 places their edges out of reach of the film chip edges even if a sheet should occasionally buckle sufficiently to contact the bottom of a tube. For best results the angular disposition of the slots should be so as to place their edges well above the tube bottom. At least a 20 degree angular displacement from the vertical should be used, and a 45° angle is presently preferred.

The air pressure also causes air flow around the ends of the film chip F (as denoted by the arrows 55, 56 in FIG. 4) so that the bottom, which of course carries much less moisture anyway, is also assured of being dried, and that portion of the air not exhausted by way of entrance and exit openings 80, 81 hereinafter described, is eventually moved toward exit openings 57 in the bottom wall 35 and into duct 58.

A temperature sensing element 100 extending into the drying chamber 30 is used to control, by any of well known power controlling devices not shown, the power supplied to certain heating units, to be identified hereinafter, thereby regulating the temperature of the air in said drying chamber. This allows the temperature of the drying air to be selected by the machine operator to suit the particular conditions encountered. In this way, the heaters are supplied with only sufficient power to maintain the selected temperature, thereby reducing wasted power and preventing the temperature of the air in the drying chamber from increasing to a degree where the film chip may suffer damage.

As previously indicated, a substantial portion of the air from drying chamber 30 is returned through air return duct 58, accelerated by two fans 60, 61 (see FIGS. 3 and 5), and thus, returned under pressure to the plenum 51. The fans 60, 61 are supported by spider elements 62 from fan housings 102. On an elongated asbestos plate 70, carried by suitable upstanding studs 71 from fan housings 102, there are provided in the areas immediately above the fans 60, 61, electrical resistance heating units 72, 73, hereinbefore referred to, that supply the heat to the air for drying the sheet material. Since the heating elements 72, 73 are thus downstream of the fans 60, 61, the air is forced thereacross at relatively high velocity for the most expeditious heat transfer relationship.

The plenum 51 is thereby filled with pressurized and heated air to supply the mouths 52 of the drier tubes 50.

Also, in accordance with the invention, the heater units 72, 73 and the cooperating fans 60, 61 are spaced along the elongated plenum 51. Thus, the air in the plenum is more uniformly pressurized and heated, thereby supplying all the mouths of the heating tubes substantially equally, to provide a more beneficial drying action.

Since the majority of the air is returned or recirculated from the drying chamber 30 to form substantially a closed circuit, the power requirements for the heating units 72, 73 are substantially reduced. This is particularly important in a unit of this type wherein intermittent operation is common and thus rapid heating of the drying air on initial start-up is required. Thus, when a first film chip in a series is exposed at station 12, the heating units 72, 73 and fans 60, 61 may be turned on then and by the time that the film chip has reached the dryer-transport 20, the air has been heated sufficiently to dry the film chip. This cumulative effect of heating the air by recirculation of preheated air allows the heat-

ing units 72, 73 to be of minimum capacity, conserves space, and gives an obvious reduction in initial cost of the apparatus.

Since moisture is constantly being taken up by the circulating air, it is important to release a portion thereof during normal operation. This is advantageously done in the present arrangement through entrance and exit openings 80, 81 formed in end walls 36, 37 (see FIG. 2) through which the film chips F respectively enter and leave the drying chamber 30. No additional exhaust port is needed in order to expel the moisture-laden air, and as such the conservation of heat in the unit through recirculation just described is maximized.

The necessary make-up air for the air exhausted through the openings 80, 81 is introduced through a filter 85 and slotted openings 86 in the air return duct 58. The filter 85 prevents foreign matter from entering the system, and thus from being deposited on the film chips F; it being understood that all other potential openings to this substantially closed system are blocked against outgoing air flow during operation.

The retention of heat in the chamber 30 is further enhanced by providing warm air containing chambers along the bottom, that is, air return duct 58; along the back, drive enclosure 43; and along the top, insulating chamber 90. Thus, not only is direct transfer of the heated air from the closed system limited, but also the radiant transfer of heat is restricted.

Access to gears 44, 47 for inspection, lubrication, etc. can be readily had through openings 91 and 92 without affecting significantly the heat preservation integrity of the insulating chamber 90, and housing of the drive gearing so as to prevent any air exchange with the drying chamber 30 minimizes the danger for contamination of the work.

In summary, the present invention provides a drying arrangement wherein the moisture is more efficiently removed from photographic sheet material by a plurality of sheet-like air streams impinging upon the emulsion bearing surface of said sheet material. The dryer apparatus is of a compact design due to the method of placement of the apertures supplying the air streams in close proximity to the emulsion side of the sheet material, but in such a way as to prevent interference and jams. Furthermore, heat is conserved by recirculation of the bulk of the air and exhausting only through the entrance and exit openings 80, 81. The plenum 51 is designed with heating units 72, 73 so as to efficiently distribute the air uniformly into the mouths of dryer tubes 50, that in turn, release the heated air into the drying chamber 30. Air return duct 58, drive enclosure 43 and the insulating chamber 90, limit loss of heat.

In this disclosure, there is shown and described only the preferred embodiment of the invention, but, as aforementioned, it is to be understood that the invention is capable of various changes or modifications within the scope of the inventive concept as expressed herein.

We claim:

1. An apparatus for drying photographic sheet material previously processed in liquids and having a liquid-coated surface comprising a drying chamber, transport means for supporting said sheet material and moving the same edgewise continuously through said chamber, a plurality of spaced dryer tubes extending into said chamber, aperture means in said tubes open-

7

8

ing adjacent and directed toward said surface for directing drying air streams against said sheet material on said transport means, an air plenum connected to said tubes, heater means for air, fan means for affording pressure to said air in said plenum and forcing the heated air through said tubes and out said apertures, and drive means for said transport means in a drive enclosure interposed between said plenum and said chamber, said drive enclosure acting to protect against possible contamination of the drying air chamber.

2. The drying apparatus of claim 1 wherein the apertures are so positioned that the air streams are directed at an angle to the sheet surface.

3. The drying apparatus of claim 2 wherein said aperture means comprise a slot on each tube extending a distance equal to substantially the full width of said material for complete drying thereof.

4. The drying apparatus of claim 1 wherein said dryer tubes traverse said drive enclosure.

5. The drying apparatus of claim 1 wherein said drying chamber is provided with discharge openings for release of moisture-laden air, said openings being positioned at the entrance and exit to said transport means and allowing passage of said sheet material, and an air inlet communicating with said plenum for supplying make-up air.

6. The drying apparatus of claim 5 wherein said inlet is provided with filter means to prevent foreign matter

from contacting said sheet material.

7. The drying apparatus of claim 5 wherein said heater means are mounted in said plenum, said fan being mounted upstream of said heater in said plenum to direct air against the same to receive the heat.

8. The drying apparatus of claim 7 wherein said plenum is elongated, extending substantially along the length of said chamber.

9. The drying apparatus of claim 8 wherein said heater means includes a plurality of heating units spaced from each other and the ends of said plenum, whereby heated air is directed generally along the longitudinal axis of said plenum and into the mouths of the tubes, whereby the heating effect is substantially constant along the length of said drying chamber.

10. The drying apparatus of claim 9 wherein is provided an air return duct connecting said chamber to said plenum along the length of both for substantially constant flow and to insulate the same against ambient conditions to conserve heat.

11. The drying apparatus of claim 1 which further includes an insulating chamber extending across one side of said drying chamber, an air exchange duct extending across another side of said chamber, and in which said insulating chamber, said air exchange duct, said plenum, and said enclosure, act to insulate the drying chamber against ambient conditions to conserve heat.

\* \* \* \* \*

30

35

40

45

50

55

60

65