

# PATENT SPECIFICATION

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## (54) IMPROVEMENTS IN AND RELATING TO APPARATUS FOR WASHING AND DRYING STRIP MATERIAL

(71) We, AGFA-GEVAERT AKTIENGESELLSCHAFT, a body corporate organised according to the laws of Germany, of Leverkusen, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 The invention relates to apparatus for washing and drying strip material, especially photographic strip material, wherein the washing liquid is required to be above ambient temperature as, for example, in the case of washing processed X-ray film.

15 It has previously been proposed to provide washing liquid at above ambient temperature by supplying hot and cold water to the apparatus and mixing the water supplies by means of a thermostatically controlled valve to ensure, a suitable and substantially constant washing temperature. This arrangement, however, has the disadvantage of relatively high cost due to the need for provision of the mixing valve and the fact that both hot and cold water connections must be provided during installation.

20 It is an object of the present invention to provide a washing and drying apparatus which, while providing a supply of washing liquid at above ambient temperature, does not require a hot water connection or a mixing valve.

35 The invention provides apparatus comprising means for washing strip material, means for drying the washed strip material by heat and heat exchange means which is in thermal contact with the drying means and which, in operation, is in thermal communication with washing liquid being supplied to the washing means.

45 In the apparatus of the invention, heat from the drying means is transferred to the washing liquid via the heat exchange means and thus a supply of relatively warm washing liquid is provided without requiring a hot

water connection or a mixing valve.

Advantageously, the said thermal communication is provided by arranging for the washing liquid to flow through the heat exchange means. In this arrangement, the heat exchange between the drying means and the washing liquid is especially efficient.

In general, the strip material will have been subjected to one or more processing stages before it is washed and dried. For example, developing and fixing will generally precede washing and drying of photographic strip material in apparatus according to the invention.

Advantageously, the apparatus includes a processing tank through which, in operation, strip material passes before entering the washing means, and there is then preferably provided a second heat exchange means in thermal communication with the first heat exchange means and arranged to be in thermal contact with processing liquid in the processing tank.

Thermal communication between the first and second heat exchange means is preferably provided by arranging for washing liquid to flow therethrough serially before passing to the washing means.

Advantageously, the apparatus also includes a second processing tank through which, in operation, strip material passes after passing through the first processing tank and before entering the washing means. When the apparatus is used for processing photographic strip material, the first-mentioned processing tank may be used for the developing process and the second tank may be used for fixing the developed material.

The apparatus may comprise a third heat exchange means which is in thermal communication with the second heat exchange means and which, in operation, is in thermal contact with processing liquid in the second processing tank. The heat exchange which occurs between the first and second processing tanks via the second and third

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heat exchange means will generally, in conjunction with direct heat transfer if (as will generally be the case) the tanks are adjacently located, provide sufficient heat to render a separate heater in the second tank unnecessary.

Preferably, in operation, washing liquid flows through the third heat exchange means, and is in thermal communication with the processing liquid in the second processing tank.

Advantageously, the first-mentioned processing tank is provided with a thermostatically controlled heater for the processing liquid. The apparatus then preferably comprises means for circulating the processing liquid in the first tank, the second heat exchange means is located in the vicinity of the inlet of the circulating means and the heater is located in the region of the outlet of the circulating means. The second heat exchange means cools the processing liquid entering the circulating means, and processing liquid flowing out of the circulating means is then heated by the heater, and it is found that this arrangement provides especially accurate control of the temperature of the processing liquid.

In practice, the temperature conditions prevailing in the (or the first) processing tank and the drier will generally be such that the washing liquid will reach the heat exchange means in that tank at a temperature not very far below that of the processing liquid. In consequence, the extent of heat transfer from processing liquid to washing liquid is low, and the resulting local cooling of the processing liquid is no greater than that consistent with accurate temperature control of the circulating processing liquid. The water issuing from the heat exchanger is then at a temperature which is kept to the smallest possible value for use in washing.

Advantageously, the first heat exchange means comprises a conduit for a heat exchange medium, said conduit being provided with externally projecting fins.

Preferably, the drying means comprises means for supplying warm air to the strip material, the first heat exchange means being arranged in the warm air path and the arrangement being such that, in operation, warm air does not reach the first heat exchange means before it contacts the strip material. In this way, the warm air is not cooled undesirably before it contacts the strip material. Desirably, the first heat exchange means is located in that part of the warm air path which is least usable for drying. The first heat exchange means may be located in an outlet conduit of the drying means.

When the first heat exchange means comprises a flow system and the drying means is a warm air drier, the first heat

exchange means may comprise two or more heat exchangers so connected that, in operation, the heat exchange medium flows through the heat exchangers in series or in parallel, each heat exchanger being located in a separate outlet conduit or exhaust zone of the drier.

The first heat exchanger conduit may comprise a part of the frame of the apparatus or may be located in a double-walled casing thereof.

When, in operation, the washing liquid flows through the first heat exchange means, the apparatus advantageously comprises control means responsive to the passage of strip material through the apparatus and a valve for controlling the flow of washing liquid through the first heat exchange means, the arrangement being such that, at least while strip material passes through the apparatus, the control means maintains the valve in an open position. The valve may comprise an electro-magnetically operable valve and the control means may comprise a switch.

The apparatus advantageously comprises means for producing pulses at a rate which corresponds to the rate of passage of strip material through the apparatus, means capable of storing a maximum number of the pulses, the storing means being connected to the valve, the arrangement being such that, in operation, when the number of pulses stored reaches the said maximum number the valve opens and the storing means ejects pulses at a rate equal to that at which it receives pulses, and continues to eject pulses until the store is empty, whereupon the valve closes. With this arrangement, when the end of a strip of material has passed the control means, the washing liquid continues to flow until the pulse store is empty, which allows sufficient time for the end of the strip of material to reach the drying means before the valve is closed.

An apparatus constructed in accordance with the invention will now be described, by way of example, with reference to the accompanying drawings in which:—

Fig. 1 is a diagrammatic side view, in section, of the apparatus; and

Fig. 2 shows a heat exchanger for use in the apparatus shown in Fig. 1.

Referring to Fig. 1 of the accompanying drawings, the reference 1 indicates photographic strip material in the form of a sheet film which is engaged by a pair of feed rollers 3 and 4 at the inlet of a developing apparatus 2. The pair of rollers 3 and 4 leads the film to a first pair 6 and 7 of a series of pairs of transport rollers mounted in a guide roller support 5, a so-called "rack". The transport rollers are arranged in pairs so as to guide the film downwards and back

upwards again along a U-shaped path to a further rack 8. The rack 5 is fitted in a tank 9, made, for example, of thermoplastic plastics material, which is filled with a developing fluid. The fluid level in the tank 9 is regulated by means of an overflow pipe 10 which is connected to a drain 11. At the base of the tank 9 a discharge aperture 9a is provided to which the intake pipe of a circulating pump 12 is connected. The output of the pump 12 is connected to a return flow aperture 9b and a thermostatically controlled heater 30 for the developer fluid is fitted in the region of the said output. The heater 30 may comprise a heating rod in the vicinity of the return flow aperture 9b. The intake pipe of the pump 12 is connected to the drain 11 via a valve 13.

On leaving the developing tank, the film 1 reaches the rack 8 which is arranged in a tank 14 for fixing fluid. The tank 14 adjoins the tank 9 and is of similar construction but not quite so deep. The film transport, level control, and bath circulation are effected in the same manner as for the tank 9.

Adjoining the fixing tank 14 a washing tank 15 is arranged in which the guiding of the film, the circulation, and the level control, are effected in the same manner as for the tank 14.

Adjoining the washing tank 15, the film runs between two squeezing rollers 16 and 17 and then past a drying roller 18 preheated by means of an adjoining drier. The film afterwards reaches a drier 19, where it is led along a downward-curved path by means of pairs of rollers 20 in the opposite direction to a flow of drying air 21. Having passed through the drying section, indicated by the pairs of transport rollers 20, the film drops into a collecting basin 22. The flow of drying air is produced by means of a blower of known construction (which is not shown) with a thermostatically controlled heating apparatus arranged in the air stream from the blower. The flow of drying air moving in the opposite direction of the film enters through a distribution shaft 23 and at the upper end of the drier is deflected into outflow channels 24 and 25. These channels are then connected to the intake side of the blower. A certain proportion of fresh air may also be added here, in order to prevent the moisture content of the drying air from exceeding a certain value.

Arranged in the outflow channel 24 there is a heat exchanger 26, the construction of which is shown in more detail in Fig. 2 of the accompanying drawings. A meandering pipe 26b is provided with disc-shaped or helical fins 26a on its outer surface so that there is a sufficiently large surface area available for heat transfer between moist warm air from the drier and cold water in the tube.

The heat exchanger 26 is connected to a

cold water pipe via an electromagnetically operable valve 27 which is controlled by a scanning device 28 co-operating with the rollers 3, 4. Control is effected in such a way that the electromagnetically operable valve 27 is opened at least during the time when a film is passing through the apparatus.

The apparatus described with reference to the accompanying drawings may be used in conjunction with a pulse store device as described in German Patent Specification No. 1237789. When strip material begins to pass through the apparatus, pulses are emitted by a pulse emitting device at a rate corresponding to the rate of passage of the strip material and the pulses are fed to the pulse store. When a predetermined maximum number of pulses have reached the store, the valve 27 is caused to open and washing liquid begins to flow, the strip material having, by this time, almost reached the washing tank 15. The pulse store, on receiving further pulses, ejects pulses at a rate equal to the rate of incoming pulses. When the end of the strip material has passed the pulse emitter, pulses are no longer fed to the store, but the store continues to eject pulses until it is empty, whereupon the valve 27 closes and the supply of washing liquid is cut off. In this manner, the washing process is continued until the end of the strip material has passed through the washing means.

In addition to the heat exchanger 26, a similar heat exchanger could be arranged in the outflow channel 25, being connected in parallel or in series with the heat exchanger 26. The outflow of the exchanger 26 is connected to the inlet of a second heat exchanger 29 in the form of a coiled tube in the developer tank 9. Water from the heat exchanger 29 flows through a further coiled tube 31 in the fixing tank 14 and finally flows into the washing apparatus 15.

The method of operation of the temperature control means for the fluids is as follows:

The cross-sectional area of the valve 27, when open, is such that the rate of flow of water through the valve is that required for washing when the machine is in continuous operation. For example, with a throughput of 400 films per hour, the required flow rate is 2 to 2½ litres per minute. Water flows at such a rate through the heat exchanger 26 (shown in Fig. 2) in the outflow channel 24 and, when provided through a heat exchanger in the outflow channel 25. A particularly intensive heat transfer is produced by means of the ribs 26a. The air flowing out of the drying chamber is at a temperature of approximately 45°C so that the water in the heat exchanger can be heated with relatively large heat gradients. The water passing through the heat ex-

changer 26, depending on the rate of flow, undergoes a temperature rise of approximately 20°C.

5 When a film passes between the rollers 3 and 4, the valve 27 is opened and the flow of washing water through the heat exchangers into the washing bath begins. The switch 28 is also provided with a retarding means which holds the valve 27 open until the film  
10 which causes the valve to open has passed through the drying apparatus. Any further film extends the opening time of the valve 27 accordingly. Any extra heating of the water standing in the heat exchangers which may  
15 occur then helps to off-set cooling-down of the washing bath when the apparatus is not operating. Even after a short starting-up period, the temperature conditions then settle down as for continuous operation.

20 Since air flowing out of the drier 19 may be heavily laden with moisture, water may condense on the fins 26a and the tube 26b, especially when the heat exchanger 26 is constructed according to the counter-flow principle. This effect may be very undesirable if the drier is not connected to a vent for used air. Provision should therefore  
25 be made for the condensed water to flow out at the cold end of the heat exchanger 26.

30 The temperature difference between the water leaving the heat exchanger 26 and the developer fluid in the tank 9 amounts to only a few degrees. This temperature difference, particularly when the second heat exchanger 29 is fitted in the vicinity of the intake aperture 9a of the pump 12, suffices to cool the water fed to the pump by a constant amount below the nominal temperature of the tank 9, any temperature  
35 fluctuations in the fluid reaching the pump being reduced by reason of the constant temperature of the fresh water coming out of the drier. With suitable regulation of the heater 30, a very good degree of constancy is obtained for the temperature of the  
40 processing fluid that has flowed out of the pump 12 and past the heater 30, the temperature fluctuating by only a few tenths of a degree. Although not shown in Fig. 1, it is preferable that the heat exchanger 29 is  
45 situated in the vicinity of the aperture 9a, and that the heater 30 is situated in the region of the aperture 9b. The coil 31 inside the fixing tank 14 receives water at a temperature which is not far below that of the developing bath 9. The fixing fluid is thus heated to a temperature which is considerably higher than room temperature and only slightly lower than the developer  
50 temperature. By reason of the heat transfer through the partition between the tanks 9 and 14, the fixing bath is heated further, so that separate heating devices for the fixing bath are unnecessary.

60 Water that has passed through the coil 31

is fed to the washing bath 15, the temperature of which is also considerably higher than room temperature and not far below the temperature of the developer bath. The washing results at this temperature are very good. Thus, even though relatively limited quantities of water are used satisfactory washing is achieved. The capacity of the pumps is approximately 22 litres per minute. Water containing  
70 chemicals flows out of the drier 19 through the overflow pipe to the drain 11 at the same rate as fresh water flows in.

The apparatus described with reference to the accompanying drawings produces satisfactory developing results even in continuous operation, without necessitating a warm water connection or a mixing device to mix cold and warm water. It is within the scope of the invention to omit the coil 31  
80 from the fixing tank 14. The second heat exchanger 29 in the developer tank 10 serves mainly to improve the temperature constancy of the developer bath, so that when using another heating system or when the requirements regarding the temperature  
85 constancy of the developer bath can be reduced, the heat exchanger 29 in the developer tank could also be omitted.

A contribution to the heating of the washing water may also be made by other parts of the developing apparatus which it is not necessary or is undesirable to have heated by means of adjacent heat sources, for example, an apparatus frame made of welded tubes, or casing members, especially of the drier. The heat exchange in this case may be effected by means of pipes placed in double-walled casing members or by means of washing water led through the tubular  
90 frame.

#### WHAT WE CLAIM IS:—

1. Apparatus comprising means for washing strip material, means for drying the washed material by heat and first heat  
100 exchange means which is in thermal contact with the drying means and which, in operation, is in thermal communication with washing liquid being supplied to the washing means.

2. Apparatus as claimed in claim 1, wherein, in operation, the washing liquid flows through the first heat exchange means to provide said thermal communication.

3. Apparatus as claimed in claim 1 or claim 2 which includes a processing tank through which, in operation, strip material passes before entering the washing means, and a second heat exchange means which is in thermal communication with the first heat exchange means, and which, in operation, is in thermal contact with processing liquid in the processing tank.

4. Apparatus as claimed in claim 3,



changer 26, depending on the rate of flow, undergoes a temperature rise of approximately 20°C.

When a film passes between the rollers 3 and 4, the valve 27 is opened and the flow of washing water through the heat exchangers into the washing bath begins. The switch 28 is also provided with a retarding means which holds the valve 27 open until the film which causes the valve to open has passed through the drying apparatus. Any further film extends the opening time of the valve 27 accordingly. Any extra heating of the water standing in the heat exchangers which may occur then helps to off-set cooling-down of the washing bath when the apparatus is not operating. Even after a short starting-up period, the temperature conditions then settle down as for continuous operation.

Since air flowing out of the drier 19 may be heavily laden with moisture, water may condense on the fins 26a and the tube 26b, especially when the heat exchanger 26 is constructed according to the counter-flow principle. This effect may be very undesirable if the drier is not connected to a vent for used air. Provision should therefore be made for the condensed water to flow out at the cold end of the heat exchanger 26.

The temperature difference between the water leaving the heat exchanger 26 and the developer fluid in the tank 9 amounts to only a few degrees. This temperature difference, particularly when the second heat exchanger 29 is fitted in the vicinity of the intake aperture 9a of the pump 12, suffices to cool the water fed to the pump by a constant amount below the nominal temperature of the tank 9, any temperature fluctuations in the fluid reaching the pump being reduced by reason of the constant temperature of the fresh water coming out of the drier. With suitable regulation of the heater 30, a very good degree of constancy is obtained for the temperature of the processing fluid that has flowed out of the pump 12 and past the heater 30, the temperature fluctuating by only a few tenths of a degree. Although not shown in Fig. 1, it is preferable that the heat exchanger 29 is situated in the vicinity of the aperture 9a, and that the heater 30 is situated in the region of the aperture 9b. The coil 31 inside the fixing tank 14 receives water at a temperature which is not far below that of the developing bath 9. The fixing fluid is thus heated to a temperature which is considerably higher than room temperature and only slightly lower than the developer temperature. By reason of the heat transfer through the partition between the tanks 9 and 14, the fixing bath is heated further, so that separate heating devices for the fixing bath are unnecessary.

Water that has passed through the coil 31

is fed to the washing bath 15, the temperature of which is also considerably higher than room temperature and not far below the temperature of the developer bath. The washing results at this temperature are very good. Thus, even though relatively limited quantities of water are used satisfactory washing is achieved. The capacity of the pumps is approximately 22 litres per minute. Water containing chemicals flows out of the drier 19 through the overflow pipe to the drain 11 at the same rate as fresh water flows in.

The apparatus described with reference to the accompanying drawings produces satisfactory developing results even in continuous operation, without necessitating a warm water connection or a mixing device to mix cold and warm water. It is within the scope of the invention to omit the coil 31 from the fixing tank 14. The second heat exchanger 29 in the developer tank 10 serves mainly to improve the temperature constancy of the developer bath, so that when using another heating system or when the requirements regarding the temperature constancy of the developer bath can be reduced, the heat exchanger 29 in the developer tank could also be omitted.

A contribution to the heating of the washing water may also be made by other parts of the developing apparatus which it is not necessary or is undesirable to have heated by means of adjacent heat sources, for example, an apparatus frame made of welded tubes, or casing members, especially of the drier. The heat exchange in this case may be effected by means of pipes placed in double-walled casing members or by means of washing water led through the tubular frame.

#### WHAT WE CLAIM IS:—

1. Apparatus comprising means for washing strip material, means for drying the washed material by heat and first heat exchange means which is in thermal contact with the drying means and which, in operation, is in thermal communication with washing liquid being supplied to the washing means.

2. Apparatus as claimed in claim 1, wherein, in operation, the washing liquid flows through the first heat exchange means to provide said thermal communication.

3. Apparatus as claimed in claim 1 or claim 2 which includes a processing tank through which, in operation, strip material passes before entering the washing means, and a second heat exchange means which is in thermal communication with the first heat exchange means, and which, in operation, is in thermal contact with processing liquid in the processing tank.

4. Apparatus as claimed in claim 3,



wherein, in operation, washing liquid flows through the second heat exchange means.

5 5. Apparatus as claimed in claim 3 or claim 4, which comprises a second processing tank through which, in operation, strip material passes after passing through the first processing tank and before entering the washing means.

10 6. Apparatus as claimed in claim 5, which includes a third heat exchange means which is in thermal communication with the second heat exchange means and which, in operation, is in thermal contact with processing liquid in the second processing tank.

15 7. Apparatus as claimed in claim 6, wherein, in operation, washing liquid flows through the third heat exchange means, and is in thermal communication with the processing liquid in the second processing tank.

20 8. Apparatus as claimed in any one of claims 3 to 7, wherein the first-mentioned processing tank is provided with a thermostatically controlled heater for heating the processing liquid.

25 9. Apparatus as claimed in claim 8, which is provided with means for circulating the processing liquid in the first processing tank and wherein the second heat exchange means is located in the vicinity of the inlet of the circulating means and the heater is located in the region of the outlet of the circulating means.

30 10. Apparatus as claimed in any one of claims 2 to 9, wherein the first heat exchange means comprises a conduit for a heat exchange medium, said conduit being provided with externally projecting fins.

40 11. Apparatus as claimed in any one of claims 1 to 10, wherein the drying means comprises means for causing warm air to contact the strip material, the first heat exchange means lying in the path of the warm air and the arrangement being such that, in operation, warm air does not come into thermal contact with the first heat exchange means before it contacts the strip material.

50 12. Apparatus as claimed in claim 11, wherein the first heat exchange means is located in an outlet conduit of the drying means.

55 13. Apparatus as claimed in claim 11 or claim 12, wherein the first heat exchange

means comprises two or more heat exchangers so connected that, in operation, a heat exchange medium flows through the heat exchangers in series or in parallel, each heat exchanger being located in a separate outlet conduit of the drying means. 60

14. Apparatus as claimed in claim 10, wherein at least part of the conduit serves as part of the frame of the apparatus or is located in a double-walled casing thereof. 65

15. Apparatus as claimed in claim 2 or any one of claims 3 to 14 when dependent on claim 2, which comprises control means responsive to the passage of strip material through the apparatus and a valve for controlling the flow of washing liquid through the first heat exchange means, the arrangement being such that, at least while strip material passes through the apparatus, the control means maintains the valve in an open position. 70

16. Apparatus as claimed in claim 15, wherein the valve comprises an electromagnetically operable valve.

17. Apparatus as claimed in claim 15 or claim 16, wherein the control means comprises a switch. 80

18. Apparatus as claimed in any one of claims 15 to 17, which comprises means for producing pulses at a rate which corresponds to the rate of passage of strip material through the apparatus, means capable of storing a maximum number of the pulses, the storing means being connected to the valve, the arrangement being such that, in operation, when the number of pulses stored reaches the said maximum number the valve opens, the storing means ejects pulses at a rate equal to that at which it receives pulses, and continues to eject pulses until the store is empty whereupon the valve closes. 85

19. Photographic developing apparatus which includes apparatus as claimed in any one of claims 1 to 18. 90

20. Photographic developing apparatus substantially as hereinbefore described with reference to, and as shown in, Figs. 1 and 2 of the accompanying drawings. 100

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