(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 843 215 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.05.1998 Bulletin 1998/21

(51) Int. Cl.^{6}: **G03D 3/04**

(21) Application number: **96203185.2**

(22) Date of filing: **14.11.1996**

(84) Designated Contracting States:
DE FR GB

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(54) Method and apparatus for processing photographic sheet material

(57) A method for processing photographic sheet material (S) comprises passing the sheet material (S) along a sheet material path (P) through a bath of processing liquid in a processing cell (12). The processing liquid is brought into the vicinity of said sheet material (S) in a direction generally normal to the surface thereof and is removed from the vicinity of the sheet material (S) in an opposite direction. More uniform processing of photographic sheet material is achieved.

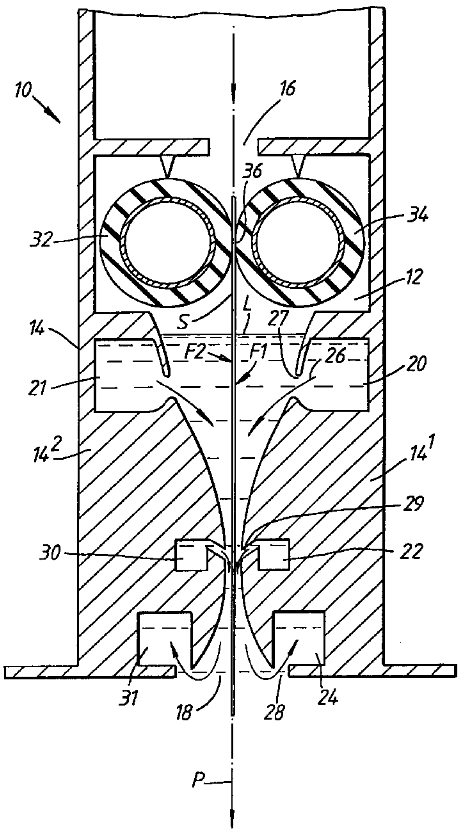

Fig.1

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2.16.3/3.4

Description

FIELD OF THE INVENTION

The present invention relates to a method for processing photographic sheet material, and an apparatus for carrying out such a method.

BACKGROUND OF INVENTION

A method is known for processing photographic sheet material by passing the sheet material along a sheet material path through a processing cell and causing processing liquid to contact the sheet material in the cell. The processing liquid in the processing cell is supplied into the vicinity of the sheet material in a direction which is generally parallel to the sheet material, that is the processing liquid flows across the sheet material from one edge thereof to the other.

Such a processing method does not always give uniform processing results. This is thought to be because the sheet material at the trailing edge of the liquid flow is exposed to a different chemistry from that to which sheet material at the leading edge of the liquid flow is exposed. Furthermore this difference in chemistry is not consistent, being dependant upon the degree of exposure of the sheet material.

OBJECTS OF INVENTION

It is an object of the present invention to provide a method for the more uniform processing of photographic sheet material and to provide an apparatus capable of carrying out such a method.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a method for processing photographic sheet material comprising passing the sheet material along a sheet material path through a bath of processing liquid in a processing cell, characterised in that the processing liquid is brought into the vicinity of the sheet material in a direction generally normal to the surface thereof and is removed from the vicinity of the sheet material in an opposite direction.

According to a second aspect of the invention, there is provided an apparatus for the processing of photographic sheet material, comprising a processing cell, means defining a sheet material path through the processing cell, a processing liquid supply manifold extending across the sheet material path to supply processing liquid to the vicinity of the sheet material in a first direction generally normal to the surface thereof and an exhaust liquid manifold extending across the sheet material path to remove processing liquid from the vicinity of the sheet material in an opposite direction.

The supply manifold will be positioned below the level of the processing liquid in the cell. This arrangement has advantages over liquid spraying techniques which are sometimes referred to in the art, in particular in terms of homogenous contact between the processing liquid and the sheet material and the avoidance of evaporation and oxidation. The exhaust liquid manifold is preferably positioned downstream of the supply manifold, so that the sheet material and the adjacent processing liquid move through the apparatus in the same direction, rather than in counter-current.

The processing liquid may be selected from photographic sheet material developing liquids, fixing liquids, bleach-fixing liquids, rinsing liquids and other treatment liquids. The invention is particularly beneficial however where the liquid is a developing or fixing liquid, because the homogeneous nature of the development and fixing processes respectively is particularly critical to the quality of the end result.

By the use of closed cells, that is where the cells are not open to the environment and there is no significant exchange of liquids or gases between one cell and another, liquid levels in the processing cells become more predictable, no liquids overflow from one cell to the next in an undesirable manner and liquid surfaces do not become churned up to a degree which increase evaporation and deterioration of oxygen sensitive liquids. The variation in liquid flow speed across the sheet material is reduced in a closed cell configuration. The use of a closed cell also ensures the same kinetics on both sides of the sheet material. Closed cells may be totally filled with processing liquid, so that there is no liquid level as such in the cell, or the space above the liquid may be filled with inert gases. In any event, even when such a space is filled with air, exchange between the liquid and the air quickly reaches an equilibrium where evaporation and oxidation are much reduced.

For X-ray applications, processing conditions and the composition of processing solutions are dependent on the specific type of photographic material. For example, materials for X-ray diagnostic purposes may be adapted to rapid processing conditions. Preferably the processing apparatus is provided with a system for automatic regeneration of the processing solutions. The material may be processed using one-part package chemistry or three-part package chemistry, depending on the processing application determining the degree of hardening required in the processing cycle.

Applications within total processing times of 30 seconds and higher up to 90 seconds, known as common practice, are possible. The processing may take place in a glutaraldehyde containing hydroquinone/1-phenyl-3-pyrazolidinone developer marketed by Agfa-Gevaert NV under the Trade Name G138 having a high activity or in a cheap developer with a low activity having the following composition amounts given in g/l.

hydroquinone	13.3
phenidone	0.8
sodium metabisulphite	29.7
ethylenediamine tetraacetic acid, tetrasodium salt trihydrate	1.33
potassium hydroxide	27.9
sodium tetraborate decahydrate	8.8
acetic acid	5.2
5-methylbenzotriazole	0.04
5-nitrobenzimidazole	0.05
glutaraldehyde	3.0
diethylene glycol	12.8

Another suitable developer composition for X-ray sheets is the following:

Composition A	
potassium hydroxide composition (0.76 g/ml)	74 ml
demineralised water	100 ml
potassium sulphite solution (0.655 g/ml)	390 ml
Trilon B (0.524 g/l)	16 ml
Turpinol 2 NZ	4 g
diethyleneglycol	100 ml
potassium chloride	3.2 g
potassium carbonate solution (0.765 g/ml)	168 ml
hydroquinone	120 g
Cobratec TT 100	0.36 g
demineralised water to	1000 ml

Composition B	
acetic acid 99%	38 ml
phenidone	6 g
5 nitro-indazol	1 g

(continued)

Composition B	
polyethylene glycol 350	1 ml
diethylene glycol to	100 ml

Composition C	
glutaraldehyde	76 ml
potassium metabisulphite	36 g
demineralised water to	100 ml

Before use, 1 l of composition A is mixed with 2.8 l water, 100 ml composition B and 100 ml composition C.

Another suitable developer solution for X-ray sheets is the following:

Composition A	
ammonium thiosulphate solution (0.778 g/ml)	880 ml
sodium sulphite (anhydrous)	54 g
boric acid (sieved)	25 g
sodium acetate 3 aq.	70 g
acetic acid 96%	40 ml
demineralised water to	1000 ml

Composition B	
demineralised water	110 ml
acetic acid 96%	40 ml
aluminium sulphate solution (0.340 g/l)	100 ml

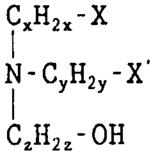
Before use, 3.750 l water is mixed with 1 l composition A and 0.25 l composition B.

Within the scope of the processing method of this invention, said method may be applied to any diagnostic film exposed with a laser directed by digitized data obtained after conversion of information captured by suitable means after exposure to radiation of part of the human body or exposed after conversion of X-rays by one or two intensifying light-emitting screen(s), wherein said film may comprise cubic and/or {111} or {100} tabular silver halide crystals rich in silver chloride, provided that with minimum amounts of silver coated a sufficient covering power is attained in the film after rapid ecological processing (with e.g. ascorbic acid and/or derivatives thereof as developing agent(s)) in a (preferentially) hardener-free developer and an odour-free fixer, optionally free from aluminum ions, thereby reducing sludge, with replenishing amounts for developer and fixer as low as possible and further provided that an optimized relationship is attained between sensitometry and image quality, especially sharpness, partly thanks to low cross-over exposure in the case of double-side coated films.

Photographic sheet materials designed for one sheet silver complex diffusion transfer reversal process (DTR process) may be developed with the aid of an aqueous alkaline solution in the presence of (a) developing agent(s) and (a) silver halide solvent(s).

Preferably the silver halide solvent is used in an amount between 0.01% by weight and 10% by weight and more preferably between 0.05% by weight and 8% by weight. Suitable silver halide solvents for use in connection with the present invention are e.g. 2-mercaptobenzoic acid, cyclic imides, oxazolidones and thiosulphates. Silver halide solvents that are preferably used are thiocyanates and alkanolamines.

Alkanolamines that are suitable for use in DTR processing may be of the tertiary, secondary or primary type. Examples of alkanolamines that may be used correspond to the following formula:



$$\begin{array}{l} C_xH_{2x}-X \\ | \\ N-C_yH_{2y}-X' \\ | \\ C_zH_{2z}-OH \end{array}$$

wherein X and X' independently represent hydrogen, a hydroxyl group or an amino group, x and y represent 0 or integers of 1 or more and z represents an integer of 1 or more. Preferably used alkanolamines are e.g. N-(2-aminoethyl)ethanolamine, diethanolamine, N-methylethanolamine, triethanolamine, N-ethyldiethanolamine, diisopropanolamine, ethanolamine, 4-aminobutanol, N,N-dimethylethanolamine, 3-aminopropanol, N,N-ethyl-2,2'-iminodiethanol, 2-aminoethyl-aminoethanol etc. or mixtures thereof.

The alkanolamines are preferably present in the alkaline processing liquid. However part or all of the alkanolamine can be present in one or more layers of the imaging element.

A further suitable type of silver halide solvents are thioether compounds. Preferably used thioethers correspond to the following general formula:

$$Z\text{-}(R^1\text{-}S)_t\text{-}R^2\text{-}S\text{-}R^3\text{-}Y$$

wherein Z and Y each independently represents hydrogen, an alkyl group, an amino group, an ammonium group, a hydroxyl, a sulpho group, a carboxyl, an aminocarbonyl or an aminosulphonyl, R^1, R^2 and R^3 each independently represents an alkylene that may be substituted and optionally contain an oxygen bridge and t represents an integer from 0 to 10. Examples of thioether compounds corresponding to the above formula are disclosed in e.g. United States patent US 4960683 and European patent application EP-A-547662, which therefor are incorporated herein by reference.

Still further suitable silver halide solvents are meso-ionic compounds. Preferred meso-ionic compounds for use in connection with DTR processing are triazolium thiolates and more preferred 1,2,4-triazolium-3-thiolates.

At least part and most preferably all of the meso-ionic compound is present in the alkaline processing liquid used for developing the image-wise exposed imaging element. Preferably the amount of meso-ionic compound in the alkaline processing liquid is between 0.1 mmol/l and 25 mmol/l and more preferably between 0.5 mmol/l and 15 mmol/l and most preferably between 1 mmol/l and 8 mmol/l.

However the meso-ionic compound may be incorporated in one or more layers comprised on the support of the imaging element. The meso-ionic compound is in that case preferably contained in the imaging element in a total amount between 0.1 and 10 mmol/m^2, more preferably between 0.1 and 5 mmol/m^2 and most preferably between 0.5 and 1.5 mmol/m^2. More details are disclosed in European patent application EP-A-554585.

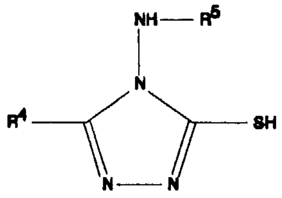
The alkaline processing liquid used preferably has a pH between 9 and 14 and more preferably between 10 and 13. The pH may be established by an organic or inorganic alkaline substance or a combination thereof. Suitable inorganic alkaline substances are e.g. potassium or sodium hydroxide, carbonate, phosphate etc. Suitable organic alkaline substances are e.g. alkanolamines. In the latter case the alkanolamines will provide or help maintain the pH and serve as a silver halide complexing agent.

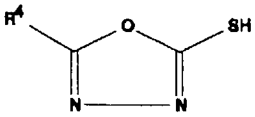
The alkaline processing liquid may also contain (a) developing agent(s). In this case the alkaline processing liquid is called a developer. On the other hand some or all of the developing agent(s) may be present in one or more layers of the photographic material or imaging element. When all of the developing agents are contained in the imaging element the alkaline processing liquid is called an activator or activating liquid.

Silver halide developing agents for use in accordance with the present invention are preferably of the p-dihydroxybenzene type, e.g. hydroquinone, methylhydroquinone or chlorohydroquinone, preferably in combination with an auxiliary developing agent being a 1-phenyl-3-pyrazolidone-type developing agent and/or p-monomethylaminophenol. Particularly useful auxiliary developing agents are the 1-phenyl-3-pyrazolidones. Even more preferred, particularly when they are incorporated into the photographic material are 1-phenyl-3-pyrazolidones of which the aqueous solubility is increased by a hydrophilic substituent such as e.g. hydroxy, amino, carboxylic acid group, sulphonic acid group etc.. Examples of 1-phenyl-3-pyrazolidones substituted with one or more hydrophilic groups are e.g. 1-phenyl-4,4-dimethyl-2-hydroxy-3-pyrazolidone, 1-(4-carboxyphenyl)-4,4-dimethyl-3-pyrazolidone etc.. However other developing agents can be used.

At least the auxiliary developing agents are preferably incorporated into the photographic material, preferably in the silver halide emulsion layer of the photographic material, in an amount of less than 150 mg/g of silver halide expressed as $AgNO_3$, more preferably in an amount of less than 100 mg/g of silver halide expressed as $AgNO_3$.

The alkaline processing liquid used for developing a DTR imaging element preferably also contains hydrophobizing agents for improving the hydrophobicity of the silver image obtained in the image receiving layer. The hydrophobizing agents used in connection with DTR processing are compounds that are capable of reacting with silver or silver ions and that are hydrophobic i.e. insoluble in water or only slightly soluble in water. Generally these compounds contain a mercapto group or thiolate group and one or more hydrophobic substituents e.g. an alkyl group containing at least 3 carbon atoms. Examples of hydrophobizing agents for use in DTR processing are e.g. those described in United States patents US 3776728, and US 4563410. Preferred compounds correspond to one of the following formulae:





wherein R^5 represents hydrogen or an acyl group, R^4 represents alkyl, aryl or aralkyl. Most preferably used compounds are compounds according to one of the above formulas wherein R^4 represents an alkyl containing 3 to 16 C-atoms.

The hydrophobizing agents are contained in the alkaline processing liquid in an amount of at least 0.1 g/l, more preferably at least 0.2 g/l and most preferably at least 0.3 g/l.

The maximum amount of hydrophobizing agents will be determined by the type of hydrophobizing agent, type and amount of silver halide solvents etc.. Typically the concentration of hydrophobizing agent is preferably not more than 1.5 g/l and more preferably not more than 1 g/l.

The alkaline processing liquid preferably also contains a preserving agent having antioxidation activity, e.g. sulphite ions provided e.g. by sodium or potassium sulphite. For example, the aqueous alkaline solution comprises sodium sulphite in an amount ranging from 0.15 to 1.0 mol/l. Further may be present a thickening agent, e.g. hydroxyethylcellulose and carboxymethylcellulose, fog inhibiting agents, e.g. potassium bromide, potassium iodide and a benzotriazole which is known to improve the printing endurance, calcium-sequestering compounds, anti-sludge agents, and hardeners including latent hardeners. It is furthermore preferred to use a spreading agent or surfactant in the alkaline processing liquid to assure equal spreading of the alkaline processing liquid over the surface of the photographic material. Such a surfactant should be stable at the pH of the alkaline processing liquid and should assure a fast overall wetting of the surface of the photographic material. A surfactant suitable for such purpose is e.g. a fluorine containing surfactant such as e.g. $C_7F_{15}COONH_4$. It is furthermore advantageous to add glycerine to the alkaline processing liquid so as to prevent crystallization of dissolved components of the alkaline processing liquid.

Development acceleration can be accomplished by addition of various compounds to the alkaline processing liquid and/or one or more layers of the photographic element, preferably polyalkylene derivatives having a molecular weight of at least 400 such as those described in e.g. United States patents US 3038805, US 4038075, US 4292400 and US 4975354.

Subsequent to the development in an alkaline processing liquid, the surface of the printing plate is preferably neutralized using a neutralization liquid.

A neutralization liquid generally has a pH between 5 and 8. The neutralization liquid preferably contains a buffer e.g. a phosphate buffer, a citrate buffer or mixture thereof.

The neutralization solution can further contain bactericides, substances which influence the hydrophobic / hydrophilic balance of the printing plate obtained after processing of the DTR element, e.g. hydrophobizing agents as described above, silica and wetting agents, preferably compounds containing perfluorinated alkyl groups.

The two-sheet DTR process is by nature a wet process including development of the exposed silver halide in the emulsion layer of the photosensitive element, the complexing of residual undeveloped silver halide and the diffusion transfer of the silver complexes into the image-receiving material wherein physical development takes place.

The processing proceeds in alkaline aqueous medium.

The developing agent or a mixture of developing agents can be incorporated into the alkaline processing solution and/or into the imaging material. When incorporated into the photosensitive element, the developing agent(s) can be present in the silver halide emulsion layer or is (are) preferably present in a hydrophilic colloid layer in water-permeable relationship therewith, e.g. in the anti-halation layer adjacent to the silver halide emulsion layer of the photosensitive element. In case the developing agent or a mixture of developing agents is in its total contained in the photosensitive element, the processing solution is merely an aqueous alkaline solution that initiates and activates the development.

Suitable developing agents for the exposed silver halide are e.g. hydroquinone-type and 1-phenyl-3-pyrazolidone-type developing agents as well as p-monomethylaminophenol. Preferably used is a combination of a hydroquinone-type and 1-phenyl-3-pyrazolidone-type developing agent whereby the latter is preferably incorporated in one of the layers comprised on the support of the imaging material. A preferred class of 1-phenyl-3-pyrazolidone-type developing agents is disclosed in European patent application EP-A-498968.

The silver halide solvent, preferably sodium or ammonium thiosulphate, may be supplied from the non-light-sensitive image-receiving element as mentioned above, but it is normally at least partly already present in the alkaline processing solution.

When present in the alkaline processing solution, the amount of silver halide solvent is in the range of e.g. 10 g/l to 50 g/l.

Preferred alkaline substances are inorganic alkali e.g. sodium hydroxide, sodium or potassium carbonate, sodium phosphate, sodium borate or alkanolamines or mixtures thereof. Preferably used alkanolamines are tertiary alkanolamines e.g. those described in European patent applications EP-A 397925, 397926, 397927 and 398435 and United States patent US 4632896. A combination of alkanolamines having both a pK_a above or below 9 or a combination of alkanolamines whereof at least one has a pK_a above 9 and another having a pK_a of 9 or less may also be used as disclosed in the Japanese patent applications laid open to the public numbers 73949/61, 73953/61, 169841/61, 212670/60, 73950/61, 73952/61, 102644/61, 226647/63, 229453/63, United States patent US 4362811 and 4568634. The concentration of these alkanolamines is preferably from 0.1 mol/l to 0.9 mol/l.

The alkaline processing solution usually contains preserving agents e.g. sodium sulphite, thickening agents e.g. hydroxyethylcellulose and carboxymethylcellulose, fog-inhibiting agents such as potassium bromide, black-toning agents especially heterocyclic mercapto compounds, detergents e.g. acetylenic detergents such as SURFYNOL 104, SURFYNOL 465, SURFYNOL 440 etc. all available from Air Reduction Chemical Company, New York, USA.

The DTR-process is normally carried out at a temperature in the range of 10°C to 35°C.

The pH of the processing solution is preferably in the range of 9 to 14, more preferably in the range of 10 to 13.

Photolithographic plates may be processed by compositions with an aqueous alkaline developer comprising at least one basic substance such as potassium hydroxide or sodium silicate, and one neutral salt such as sodium or potassium chloride. Examples of such developers include:

Composition A	
sodium metasilicate $5H_2O$	30 g
Aerosol OS (Trade Mark)	2.16 g
sodium chloride	30 g
Water to	1000 ml

Composition B	
sodium metasilicate $5H_2O$	4.0%
trisodium phosphate $12H_2O$	3.4%
monosodium phosphate	0.3%
sodium hydroxide (reagent grade)	0.7%
soft water	1000 ml

For the processing of graphic arts sheet materials, developers typically contain hydroquinone, together with alkali metal (sodium or potassium) carbonates, sulphites and bromides. These compositions are used at a pH level of typically from 10.5 to 13.5.

The processing liquid may be brought into the vicinity of the sheet material at a linear speed at least equal to the linear speed of the sheet material through the cell.

The invention is particularly suitable for sheet materials which carry photographic emulsion on both faces thereof, in particular X-ray film.

In an embodiment of the invention, capable of processing both faces of the sheet material, first supply and exhaust manifolds are positioned on one side of the sheet material path to supply processing liquid to, and remove processing liquid from, the vicinity of one face of the sheet material and second supply and exhaust manifolds are positioned on the opposite side of the sheet material path to supply processing liquid to, and remove processing liquid from, the vicinity of the other face of the sheet material.

In this embodiment, the second supply and exhaust manifolds are preferably provided in the same cell as the first supply and exhaust manifolds.

The second supply and exhaust manifolds are preferably provided immediately opposite to said first supply and exhaust manifolds.

This has the advantage of providing support on both sides of the sheet material. Alternatively the second supply and exhaust manifolds are staggered in relation to the first supply and exhaust manifolds. In such an arrangement it is preferable to provide sheet material support means, such as a support plate, roller or conveyor belt, positioned adjacent the sheet material path on the opposite side thereof from the supply manifold.

The invention is particularly advantageous when the processing cell is a closed cell.

In one embodiment, the cell is closed from the next adjacent cell by a rotatable roller biased towards a reaction surface to define a roller nip there-between through which the sheet material path extends and associated sealing means serve to provide a gas- and liquid-tight seal between the roller and reaction surface on the one hand and a cell wall on the other. The reaction surface will usually be the surface of another rotatable roller or may be in the form of a belt or a fixed surface with a low friction coefficient. Where this general description refers to the use of two rollers, it is to be understood that the second roller may be replaced by any other reaction surface, such as those referred to above. Such rollers constitute path-defining rollers and may be driven rollers or freely rotating rollers.

Typical rollers have a core provided with a covering of elastomeric material, although it is possible for the roller to be elastomeric throughout its cross-section. As the sheet material leaves a given liquid treatment cell it is necessary to remove any liquid carried on the sheet material as efficiently as possible, to prevent carry-over of liquid into a next treatment cell and to reduce edge effects which arise from non-homogeneous chemistry on the sheet material after squeegeeing. To do this job properly, the rollers must exert a sufficient and homogeneous pressure over the whole width of the sheet material. Also, to reduce edge effects, it is desirable that the opposite roller surfaces are in contact with each other beyond the edges of the sheet material. To put this problem in context, rollers used in conventional processing apparatus for example have a length of 400 mm or more and a diameter of from 24 to 30 mm. The sheet material typically has a width of from a few millimetres up to 2 m and a thickness of 0.05 mm to 0.5 mm. In view of the nature of elastomeric material, it is in fact impossible to totally eliminate any gap between the roller surfaces at the edges of the sheet material as it passes through the nip. It is desirable that the roller surfaces be in contact with each other within as short a distance as possible from the edges of the sheet material i.e. that the size of the leak zone should be minimised. It is important however that the force between the rollers is sufficient to prevent leakage when no sheet material is passing through. However, the force must not be so high as to risk physical damage to the sheet material as it passes through the nip.

The objective of a minimum leak zone referred to above can be achieved if the ratio of the diameter of the roller to its length is above a critical limit.

According to a preferred embodiment therefore, at least one of the rollers, and preferably each roller, comprises a rigid core carrying a covering of elastomeric material, the ratio (∅/L) of the maximum diameter (∅) of the elastomeric material covering to the length (L) thereof being at least 0.012, most preferably between 0.03 and 0.06. Where the reaction surface towards which the roller is biased to define the nip is the surface of another roller, it is preferred that the roller requirements referred to above apply to this, second, roller also. Indeed, it will be usual for the two rollers to be identical, although it is possible that the diameters (∅), and therefore the ratios (∅/L), of the two rollers need not be identical. It is also possible that the reaction surface may be formed by the surface of a second roller which does not conform to the above requirements, such as for example, a roller having no elastomeric covering, or for the reaction surface to be in the form of a belt.

The elastomeric material covering preferably has a thickness of between 1 mm and 30 mm. The elastomeric material may be selected from ethylene/propylene/diene terpolymers (EPDM), silicone rubber, polyurethane, thermoplastic rubber such as Santoprene (Trade Mark for polypropylene/EPDM rubber), styrene-butyl rubber and nitrile-butyl rubber. The hardness of the elastomeric material may be between 15 Shore (A) and 90 Shore (A), as measured on the roller surface. In one embodiment, the diameter (∅) of the elastomeric material covering is constant along the length of the roller.

Alternatively the roller may have a radial dimension profile which varies along the length thereof. In the latter case, the diameter (∅) in the expression ∅/L is the maximum diameter. In a preferred embodiment, such a roller comprises a non-deformable core, the thickness of the elastomeric material covering varying along the length thereof. Alternatively or additionally, the diameter of the core varies along the length thereof.

Ideally, the radial dimension profile of such a roller is such in relation to the force applied by the roller to sheet material passing through the nip as to be substantially even over the width thereof,

The radial dimension of the roller ideally decreases towards the ends thereof i.e. a convex profile, especially a parabolic profile.

Preferably, the core has a flexural E-modulus of between 50 GPa and 300 Gpa. Suitable materials for the rigid core include metals, such as stainless steel, non-ferrous alloys, titanium, aluminium or a composite thereof.

In one embodiment, the core is hollow. Alternatively the core may be solid.

The rollers may be biased together by a variety of methods. The rollers may be biased together for example by making use of the intrinsic elasticity of the elastomeric material, by the use of fixed roller bearings. Alternatively, use may be made of resilient means such as springs which act on the ends of the roller shafts. The springs may be replaced by alternative equivalent compression means, such as e.g. a pneumatic or a hydraulic cylinder.

The sealing means between the path-defining rollers and a housing wall of the cell may be formed in a number of ways. In one arrangement, the rollers are offset relative to each other and each roller is in sealing contact along its length, at least between limits of the nip, with a stationary sealing member. In an alternative arrangement, the rollers are positioned relative to each other such that end faces of one roller lie in substantially the same plane as end faces of the other roller, and stationary sealing means are provided in contact with each roller, having a continuous contact line which extends along the length of each roller and over the end faces of each roller, at least on the fluid side of the nip.

However, our preferred arrangement is where each path-defining roller is in contact along its length with a rotatable sealing member. By the use of a rotatable sealing member in place of a stationary sealing member, the torque which needs to be applied to the path-defining roller can be significantly reduced. This reduces the power needed by the processor, reduces wear on the path-defining roller, reduces the mechanical deformation thereof and thereby extends the expected life time. This construction also improves the control of pressure distribution over the sheet material.

The rotatable sealing member preferably comprises a sealing roller, and in particular the sealing roller may have a diameter less than that of the path-defining roller. For example, the sealing roller may have a diameter which is from one tenth to one third of the diameter of the path-defining roller, thereby enabling the torque which needs to be applied to be further reduced. The sealing roller preferably extends in a straight line parallel to the associated path-defining roller axis and preferably contacts the surface of the associated path-defining roller at a location which is between 45° and 315°, most preferably between 80° and 100° from the centre of the nip, on the fluid side.

The sealing roller may be formed of a material having a coefficient of friction (as measured against stainless steel) of less than 0.3, preferably from 0.05 to 0.2, for example highly polished metals such as steel, especially Cr-Ni steel and Cr-Ni-Mo steel, a metal coated with Ni-PTFE (NIFLOR - Trade Mark), a polymer material such as PTFE (poly tetra fluoro ethylene), POM (polyoxymethylene), HDPE (high density polyethylene), UHMPE (ultra high molecular weight polyethylene), polyurethane, PA (polyamide), PBT (polybutyl terephthalate) and mixtures and composites thereof.

In a preferred embodiment, the sealing roller is carried by a longitudinal bearing, secured within the cell, The longitudinal bearing may have face-to-face contact with the sealing roller over at least two contact regions, which are located, for example, at from ± 120° to 150° relative to the line joining the centres of a path-defining roller and its associated sealing roller, such as ±135° to that line. The width of contact between a sealing roller and its associated longitudinal bearing in each contact region is, for example, from 20° to 40° of the circumference of the sealing roller, which in the case of a sealing roller having a diameter of 8 mm may be about 2 mm per contact region.

The surface of the sealing roller opposite to the path-defining roller may be in contact with one or more fixed sealing members carried in, or formed as part of, the longitudinal bearing. The fixed sealing member may, for example, be retained within a longitudinal groove formed in the longitudinal bearing. The fixed sealing member may have a symmetrical profile section but a non-symmetrical profile section is also possible, its shape and resilience taking into account the hydrostatic and hydrodynamic pressures in the cell and the interacting forces with the sealing roller, allowing for the fact that the path-defining roller and the sealing roller may be adapted to rotate in both directions.

The ends of the sealing roller may be in contact in a leak-free manner with stationary bodies, such as an end plate secured to, or located in a fixed position relative to, the housing of the apparatus. For example, the end of the sealing roller passes into a blind aperture in the end plate. In an alternative embodiment, the end of the sealing roller is located in an open aperture in the end plate, this aperture being provided with a sealing ring, or other sealing member, formed for example of sintered PTFE, to prevent leakage therethrough.

It is important that the sealing rollers are retained in these end plates in a leak-free manner. A line contact between the sealing rollers and the end plates is preferred to a surface-to-surface contact. In one embodiment, the sealing ring surrounds the end of the sealing roller and is urged into line-to-surface sealing engagement with the surface of the sealing roller by a spring. We have found that line contact between the sealing roller and the end plates need not extend circumferentially completely around the sealing roller, and indeed there is an advantage in this line contact extending only part way around the sealing roller, but on the liquid side thereof. This construction makes the tolerances to which the sealing roller and the end plates are constructed less critical. It is preferred to use a sealing ring which is so constructed as to compensate for the wear thereof. This can be achieved by forming the sealing ring with a frusto-conical inner surface and by the provision of a spring force which acts in a direction to feed sealing material towards the wear surface. We prefer to use a material for the sealing ring which has good "creeping" characteristics to compensate for the wear under spring pressure, such as sintered PTFE.

In an alternative embodiment, end portions of the sealing roller are formed of an elastomeric material, such as natural or synthetic rubber, and these end portions press against the end plates in a leak-free manner.

DETAILED DESCRIPTION OF THE INVENTION

The invention will be described by the following illustrative embodiments with reference to the accompanying drawings without the intention to limit the invention thereto, and in which:

Figure 1 shows one cell of a photographic sheet material processing apparatus embodying the present invention.

Referring to Figure 1, there is shown part of an apparatus 10 for the processing of photographic sheet material. The apparatus 10 comprises a number of cells stacked one above the other in a vertical configuration, of which one closed processing cell 12 can be seen in the drawing. The cell 12 is formed of a housing 14, having an inlet 16 and an outlet 18 which together define a vertical sheet material path P through a bath of processing liquid in the processing cell 12, the inlet of one cell constituting the outlet of the previous cell, and the outlet constituting the inlet of the next cell. While as shown the sheet material path P is straight, non-straight paths are also possible.

The inlet and outlet are each closed by pairs of rollers, of which the roller pair 32, 34 closing the inlet 16 can be seen in the drawing. The rollers 32, 34 of the roller pair are biased towards each other to form a nip 36 through which the sheet material path extends.

The housing 14 comprises two complementary parts 14^1 and 14^2, positioned opposite each other, The housing part 14^1 comprises a main liquid inlet cavity 20, constituting a liquid supply manifold, positioned below the level *L* of the processing liquid in the cell. The housing part 14^1 also comprises a secondary inlet cavity 22 and a liquid outlet cavity 24, constituting a liquid exhaust manifold.

The main liquid inlet cavity 20 extends across the width of the sheet material path P. Processing liquid is fed to one end, or more preferably both ends, of the inlet cavity 20 under pressure to supply processing liquid to the vicinity of one face F1 of the sheet material S in a first direction generally normal to the surface thereof, as indicated by the arrow 26. The main inlet cavity 20 includes a slit 27 through which the processing liquid passes, the slit 27 extending along the length of the cavity 20. The shape of the slit 27 and the cross-section of the cavity 20 are so chosen to ensure that the pressure of liquid exiting the slit 27 is substantially uniform across the width of the sheet material, otherwise cross currents of processing liquid may occur. In place of the slit 27, a number of closely spaced, appropriately shaped, liquid exit slots or holes may alternatively be provided.

The liquid outlet cavity 24 extends across the width of the sheet material path P, downstream of the inlet cavity 20. Suction is applied to each end of the liquid outlet cavity 24, and serves to remove processing liquid from the vicinity of the sheet material S in an opposite direction, as indicated by the arrow 28. The processing liquid from the outlet cavity 24 may be recycled to the inlet cavity 20.

Processing liquid is also supplied, under intermediate pressure, to the vicinity of the sheet material S from the secondary inlet cavity 22 which is positioned between the inlet cavity 20 and the outlet cavity 24. This secondary supply of processing liquid passes from the secondary inlet cavity 22 out through a slit 29 which extends across the width of the sheet material path P and serves to prevent contact between the sheet material S and the housing parts 14^1 and 14^2 at the point where the passage there-between is at its narrowest.

The complimentary housing part 14^2 is similarly formed to provide processing liquid to, and remove processing liquid from, the vicinity of the opposite face F2 of the sheet material S. Thus the housing part 14^2 comprises an opposite inlet cavity 21, an opposite secondary inlet cavity 30 and an opposite outlet cavity 31.

In use, sheet material S, such as X-ray film carrying photographic emulsion on both faces thereof, is passed along the sheet material path P through the processing cell 12. Processing liquid, which may be selected from developer, bleach, fixer and rinse liquids, is brought into the vicinity of the sheet material S in a direction generally normal to the surface thereof and is removed from the vicinity of the sheet material S in the opposite direction. The processing liquid is brought into the vicinity of the sheet material S at a linear speed equivalent to the linear speed of the sheet material S through the cell 12.

While the embodiment as shown in Figure 1 shows only one set of supply and exhaust manifolds in the cell, it is also possible to provide a number of such sets.

Claims

1. A method for processing photographic sheet material (S) comprising passing said sheet material (S) along a sheet material path (P) through a bath of processing liquid in a processing cell (12), characterised in that said processing liquid is brought into the vicinity of said sheet material (S) in a direction generally normal to the surface thereof and is removed from the vicinity of said sheet material (S) in an opposite direction.

2. A method according to claim 1, wherein said processing liquid is selected from developer, bleach, fixer, activator, stabiliser and rinse liquids.

3. A method according to claim 1 or 2, wherein the processing liquid is brought into the vicinity of said sheet material (S) at a linear speed at least equal to the linear speed of said sheet material (S) through said cell (12).

4. A method according to any preceding claim, wherein said sheet material (S) carries photographic emulsion on both faces thereof.

5. An apparatus for the processing of photographic sheet material (S), comprising a processing cell (12), means (16, 18) defining a sheet material path (P) through said processing cell (12), a processing liquid supply manifold (20) extending across said sheet material path (P) to supply processing liquid to the vicinity of said sheet material (S) in a first direction generally normal to the surface thereof and an exhaust liquid manifold (24) extending across said sheet material path (P) to remove processing liquid from the vicinity of said sheet material (S) in an opposite direction.

6. An apparatus according to claim 5, comprising first said supply and exhaust manifolds (20, 22) positioned on one side of said sheet material path (P) to supply processing liquid to, and remove processing liquid from, the vicinity of one face (F1) of said sheet material (S) and second supply and exhaust manifolds (21, 31) positioned on the opposite side of said sheet material path (P) to supply processing liquid to, and remove processing liquid from, the vicinity of the other face (F2) of said sheet material (S).

7. An apparatus according to claim 6, wherein said second supply and exhaust manifolds (21, 31) are provided in the same cell (12) as said first supply and exhaust manifolds (20, 24).

8. An apparatus according to claim 7, wherein said second supply and exhaust manifolds (21, 31) are provided immediately opposite to said first supply and exhaust manifolds (20, 24).

9. An apparatus according to any one of claims 5 to 8, wherein said processing cell (12) is a closed cell.

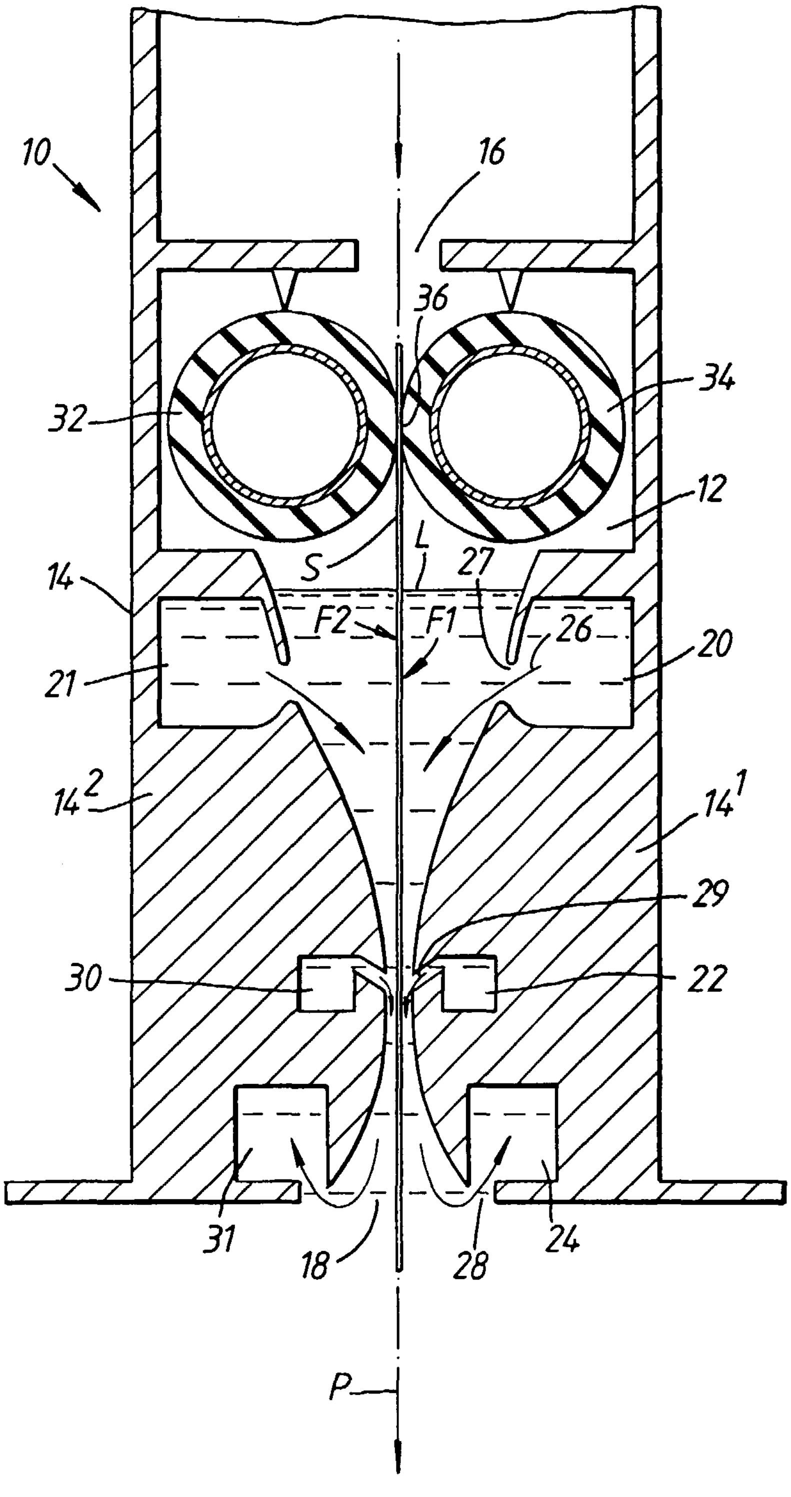


Fig.1

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 20 3185

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	US 5 023 644 A (KUREMATSU ET AL.) * abstract; figure 17 * ---	1-3 4,5,9	G03D3/04
A	EP 0 306 976 A (FUJI PHOTO FILM) * abstract; figure 9 * -----	1-5	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
G03D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 April 1997	Romeo, V

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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