**Title:** PAPER COLOURING APPARATUS

The invention relates to a paper colouring apparatus for especially water colours or water-based inks, wherein a driven running paper web (1) is positioned around a turning roller (2) constituting the counter pressure roller for an inker (3) and, together with the latter, are included in a roller train (4) adapted to convey ink (8) from a reservoir (9) to the inker (3). One has aimed at transferring ink to the paper (1) in so small amounts that after-drying of the paper (1) becomes unnecessary. According to the invention, said roller train (4) is adapted to be driven by means of the running paper web (1) and comprises five or more rollers (2, 3, 5, 6, 7).
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PAPER COLOURING APPARATUS

The present invention relates to a paper colouring apparatus for especially water colours or water-based inks, more specifically of the kind further defined in the preamble of the following claim 1.

Today, colouring paper in the form of a running web with water-based inks is effected by means of various kinds of colouring or painting apparatus and/or printing processes.

The main disadvantage of methods of today is that relatively large amounts of ink (more than 1.5 grams/m²) are transferred to the paper web. As water well may constitute 90% of the ink, this will lead to a relatively large water supply to the paper, involving a swelling of the paper fibres; the physical properties (dimensional stability, rigidity, etc.) of the paper getting lost or being substantially deteriorated. In order to stabilize the paper again subsequent to such conventional colouring, it is necessary to after-dry it by means of suitable equipment (hot air blowing, radiation using infra red rays, microwave-treatment, etc.). Usually, this is expensive, space-demanding and complex.

In a known colouring apparatus of the kind concerned, a colour roller rotates partly submerged into a colour basin, and cooperates with an overlying intermediate roller to which the colour roller transfers colouring matter. On its part, the intermediate roller transfers colouring matter supplied
there to an overlying inking-up roller which is adapted to
transfer colouring matter supplied thereto to a running paper
web. These three rollers have mutually parallel rotation
axes.

It has been found that the adjustment of the relative
positions of the rollers and pressure against each other
greatly influence the amount of colour transferred between
the rollers. A weak pressure from a roller gives another
transferred colour amount than a hard roller pressure.
Therefore, it is important that the pressure is constant
along the line of contact between the rollers, in order to
achieve an even colour transfer laterally of the paper web.

In today's methods, the roller positions are usually adjusted
by means of mechanical and/or electrical mechanisms,
requiring much time and high professional capability. Usually,
the adjustment have also to be tested out in order to control
them.

As the roller pressure influences the transferred amount of
colour, it will also influence the amount of water
transferred between the rollers when using water colours.
This can lead to great problems adhering to the adjustment of
the drying equipment, so that the paper subsequent to drying
receives the correct conditioning (water content).

Mechanical adjustment of rollers as well as controlling their
relative rotation speeds by means of either fixed gear
transmissions or electric motors of their own require more
energy for operation than the paper web is capable of
supplying without allowing the paper tension to increase too
much. Therefore, these roller systems require energy supply
in order to operate. This supply of energy is usually taken
from the main motor for the machine on which the paper
colouring apparatus is mounted. Usually, such a coupling
makes it more complex and expensive to find a suitable
positioning of the paper colouring apparatus at already
existing production machines.

An object of the present invention has been to eliminate or substantially reduce deficiencies, disadvantages and limitations of application of paper colouring apparatus of the kind concerned.

Thus, a specific object of the invention consists in eliminating or strongly restricting the need for afterdrying of the paper inked up, through reducing the transferred amount of colour substantially, e.g. to the order of 0,5 grams per m². With such an insignificant (in relation to conventional technique) amount of colour transferred, the transferred amount of water becomes so small that it will have a quite insignificant influence on the physical properties and stability of the paper, simultaneously as a satisfactory colouring/inking-up result is maintained.

Moreover, one has aimed at eliminating or strongly restricting the need for adjustment of roller position and pressure along the contact line of the rollers.

In accordance with then invention, said objects are realized through designing the paper colouring apparatus such that it exhibits the features defined in the following claims.

A paper colouring apparatus adapted for the transfer of water colours in so small amounts to a running paper web that after-drying of the paper is unnecessary or substantially unnecessary, distinguishes itself i.a. through comprising a roller train consisting of five or more rollers, preferably driven by the running paper web, and which, as known per se, transfers colours from a colour vessel through the roller train to the paper web.

Another feature of the invention consist in that each roller is rotatably suspended, with a breaking effect in the suspension securing an automatically correct distribution of
the colour through the roller train, such that colour can not accumulate within the roller train.

Preferably, every other roller in the roller train is stationary suspended, while each of the remaining rollers is floatingly suspended, using floating bearings, in that the floatingly suspended rollers individually are assigned pressure fluid operated piston cylinders adapted to displace the associated rollers into position towards the stationarily suspended rollers as well as out of contact with the latter. Thereby, a constant pressure along the contact line of adjacent rollers may be achieved automatically. Also, this pressure will be independent on the rotation speed of the rollers. The roller pressure is constant along the contact line, and the magnitude of the pressure is controlled directly through the regulation of the fluid pressure supplied to the piston cylinders.

The floating suspension of some rollers of the roller train makes the paper colouring apparatus insensitive to smaller variations in roller diameter because of temperature changes, wearing or grinding of rollers.

According to a further feature of the paper colouring apparatus, the roller train is graded, the ends of an overlying roller in the roller train being axially withdrawn in relation to the ends of an underlying roller. Thereby, the roller train receives an upwardly tapering shape from the colour vessel and up towards the uppermost roller (the counter pressure roller). Such a design prevents accumulation of colour on the roller ends.

As mentioned, the pressure along the contact line will be constant at varying speed, as the pressure between the rollers never can become larger than the pressure applied from the piston cylinders (presupposed one cylinder at each end of every floatingly suspended roller). The rollers will automatically increase the centre distance therebetween with
increasing speed, in order to reduce the pressure building up between the rollers due to rotation and transport of colour.

Altogether, this leads to the fact that the need for energy necessary to operate a paper colouring apparatus of the present invention is approximately constant and independent on the speed. Again, this renders it possible to operate the roller train by means of the running paper web only. In known systems having locked roller positions, the pressure and the energy need between the rollers will increase with increasing speed, rendering it practically impossible to operate the roller train by means of the running paper web.

Another advantage of the roller positioning system in the paper colouring apparatus of the invention is that one - without changing the adjustment - may replace rollers with others having different diameters, said system automatically causing the new rollers to be brought into correct position.

This is very important, as the roller diameter changes during operation due to wearing and tearing, temperature, etc. Recently grinded rollers can also be mounted directly without having to change the adjustment. This saves time and secures a uniform quality.

Further advantages and features of the paper colouring apparatus according to the invention is further explained in the following, reference being made to attached diagrammatic drawings, wherein:

Figures 1A and 1B show a paper colouring apparatus according to a first embodiment of the invention, seen in an end view and a side view, respectively;

Figure 2 corresponds to figure 1A, but shows two floatingly suspended intermediate rollers of the roller train withdrawn
to inoperative position, corresponding to stoppage;

Figure 3 shows in an end view two rollers of the roller train, wherein one (the overlying) roller has a higher rotational speed than the other, the figure illustrating the effect of relative speed on the distribution of colour amount from the underlying roller to the overlying roller of the roller train;

Figure 4A and 4B correspond to figure 3 and illustrate colour transfer and distribution with low braking force (figure 4A) and higher braking force (figure 4B) within the suspension for the lower roller;

Figure 5A and 5B correspond to figure 3 and 4A, 4B and illustrate how a colour/ink having higher (better) lubricating properties reduces the colour amount transferred, the colour used in figure 5B being assumed to have better lubricating properties than the colour used in figure 5A, wherein the colour offers a higher friction;

Figure 6 shows, also in an end view, two cooperating rollers included into a roller train of a paper colouring apparatus according to the invention, illustrating how the colour film is being split when passing through a roller nip between two rollers, leading to a reduction of the amount of colour transferred;

Figure 7 shows in an end view a paper colouring apparatus, wherein the roller train comprises seven rollers;

Figures 8A, B and C show in end views a roller train comprising six rollers, wherein the counter pressure roller may be moved toward the colouring roller by means of a pendulum suspension;

Figures 9A, B and C show a roller train, wherein the uppermost colouring roller is pendulum-suspended.
In a first embodiment of a paper colouring apparatus according to the invention, figures 1A og 1B, a running paper web is denoted by the reference numeral 1. The paper web is positioned around a counter pressure roller 2 which, through the paper web 1, cooperates with an inking-up roller or inker 3 which, together with the counter pressure roller 2, are incorporated into a roller train 4. The inker 3 cooperates with an underlying first intermediate roller 5 which, on its part, cooperates with an underlying second intermediate roller 6 which, again, cooperates with the colour reservoir roller 7, which is partly submerged into colour or ink 8 in an ink reservoir 9.

Ink 8 from the reservoir 9 is transferred to the paper web 1 through the rollers 7, 6, 5, 3 of the roller train 4.

The rollers 2, 5, 7 are hard rollers, e.g. consisting of metal having a polished surface. These rollers are mounted stationary between side plates 10, figure 1B.

The rollers 3 and 6 are made from a soft material, e.g. rubber, and exhibit a smooth surface. These rollers 3, 6 are mounted in floating bearings arranged in the side plates 10, such that they may move freely in all directions. Each roller 3, 6 is mounted together with pneumatic or hydraulic piston cylinders 11, acting in pairs, one at each end of the respective roller 3, 6. These piston cylinders 11 may be mounted in various ways, either on the inner side or outer side of the side plates 10. In figure 1, an external mounting has been shown, wherein the roller shaft ends 3', 6' pass freely through holes in the side plates 10.

The roller train 4 is graded and tapers in an upward direction from the lowermost roller 7 to the uppermost roller 2, the rollers 7, 6, 5, 3, 2 successively exhibiting a shorter length than the underlying, such that the ends of an overlying roller, e.g. 5, are axially withdrawn in relation to the ends of the underlying roller, e.g. 6. Such a graded
roller train 4 involves the technical effect that accumulation of ink on the ends of the rollers is avoided.

In the embodiment of figure 1, and in so far the remaining, following embodiments, the individual rollers 2, 3, 5, 6, 7 are arranged without a drive device of their own, the roller suspensions of the paper colouring apparatus of the invention rendering it possible to operate the roller train 4 by means of the running paper web 1, which is very difficult or impossible with conventional paper colouring apparatus.

In order to start ink transfer to the paper web 1 through the rollers 3, 5, 6 and 7, said rollers are caused to rotate by means of the paper web 1, whereby ink 8 is conveyed upwards to the nip between the rollers 7, 6 and, further, to the nip between the rollers 6, 5, and therefrom to the nip between the rollers 5, 3, from where ink carried thereto is transferred to the paper web 1 from the roller 3, whilst the roller 2 acts as counter pressure roller.

Within each of the contact lines between the rollers, the ink will act as a lubricant. This will result in a situation wherein relative speed between the rollers is reduced downwards within the roller train 4, due to the fact that the rollers will slide in relation to each other. The transferred amount of ink will — due to the relative speed difference — be reduced upwards within the roller train.

Figure 2 shows a colouring apparatus of the embodiment according to figure 1, seen in an inoperative position, wherein the inker 3 and the intermediate roller 6 are withdrawn from contact with the other rollers 2, 5, 7 by means of the pneumatic or hydraulic piston cylinders 11.

The above-mentioned slide effect is illustrated in figure 3, wherein an upper roller A (e.g. roller 5 in figures 1A, 1B and 2) — due to said slide effect — has a larger speed than an underlying roller B (e.g. roller 6). Then, roller B will
distribute the amount of ink on roller A across a larger area; the latter roller, consequently, receiving a thinner layer of ink C2 than the ink layer C1 on roller B.

The magnitude of said slide effect will be dependent on the mechanical braking of the individual roller within the bearings thereof, and on the physical lubricating properties of the ink.

Figures 4A and 4B illustrate how increasing braking (figure 4B in relation to figure 4A) results in a thinner ink layer C2, figure 4B, using the same ink. A thin layer of ink transfers more power than a thicker layer C2, figure 4A, and balances, in this manner, the increased friction force F2, figure 4B.

Figure 5A and 5B illustrate how an ink having better lubricating properties reduces the amount of ink transferred. With the roller nip of figure 5A, an ink is used having lubricating properties inferior to those of the ink used with the roller nip according to figure 5B, wherein the ink C2 transferred from roller B to roller A has a layer thickness which is smaller than the layer thickness of the ink C2 transferred from roller B to roller A according to figure 5A.

Another effect influencing the ink film transferred consists in that the latter is being split when it passes through a roller nip between two rollers A and B, confer figure 6, wherein the splitting of the ink film is denoted C2" (ink layer following the roller A upwardly) and C2'. This effect also causes a reduction of the amount of ink transferred.

Figure 7 shows an embodiment of a paper colouring apparatus which, in relation to the roller train of figures 1A, 1B and 2, comprises two further rollers 12 and 13, namely a soft roller 12 floatingly suspended and equipped with flexible operating means in the form of pneumatic or hydraulic piston
cylinders 11, as well as a hard roller 13 stationary suspended.

Figures 8A, 8B and 8C show a further embodiment of the paper colouring apparatus according to the invention, wherein the roller train comprises six rollers, the extra roller in relation to figures 1A, 1B and 2 being denoted by reference numeral 14, and wherein the counter pressure roller 2 is pendulum-suspended 15 and being moved toward and away from the inker 3 by means of e.g. hydraulic or pneumatic piston cylinders 16. Figure 8A shows the paper colouring apparatus in an operative position, while figure 8B shows it in an idling position and figure 8C the same in an inoperative position.

Figures 9A, 9B and 9C show substantially the same embodiment as in figures 8A - 8C, but in the former figures, the inker 3 is pendulum-suspended 17 and assigned a flexible operating means in the form of e.g. hydraulic or pneumatic piston cylinders 18. The positions shown correspond to those in figures 8A - 8C.

The solutions shown in figures 8 and 9 enable the rollers to be driven by a motor of their own when the paper web 1 is not running. This may be an advantage in order to avoid that ink dries on the rollers.

Operating the rollers by means of the paper web 1 secures correct distribution of the ink. Ink can not accumulate at a higher level within the roller train, which automatically would have resulted in relative skidding of the rollers in relation to each other, as well as in an increase in the relative speed between the rollers, simultaneously as the amount of ink transferred would have been reduced. Thereby, according to the invention, a self-adjusting roller train has been provided, securing a correct and uniform distribution of ink from the ink reservoir 9 to the paper web 1.
Through increasing the braking of the individual rollers within the bearings thereof, the relative difference of speed between the rollers may be increased, thereby further reducing the amount of ink transferred.

At each roller contact line, one obtains a reduction of the amount of ink transferred, due to the difference between the relative speed of the rollers (figures 4A, 4B and figures 5A, 5B), as well as a splitting of the ink film (figure 6). Through the arrangement of a sufficient number of roller pairs, the amount of ink transferred may be reduced to a minimum.

Tests have shown that when using a roller train 4 comprising five rollers (figures 1A, 1B, figure 2), the amount of ink transferred can be reduced to 0.3 grams/m².
C l a i m s

1. Paper colouring apparatus for especially water colours or water-based inks, wherein a driven, running paper web (1) is positioned around a turning roller (2) constituting the counter pressure roller for an inker (3) and, together with the latter, are included in a roller train (4) adapted to convey ink (8) from a reservoir (9) to the inker (3), characterized in that the roller train (4) comprises five or more rollers (2, 3, 5, 6, 7; 2, 3, 5, 12, 13, 6, 7; 2, 3, 14, 5, 6, 7), of which at least some have a floating position in relation to the other, and that all rollers in the roller train each is resting directly against adjacent roller(s), respectively against the paper web (1), the roller train (4) being adapted to be preferably driven by the running paper web, through the direct contact between adjacent rollers, whereby some rollers in the roller train (4), e.g. every second roller (2, 5, 7), are hard rollers, e.g. metal rollers or hard rubber rollers, the remaining rollers (3, 6; 3, 6, 12) being soft rollers, e.g. rubber rollers, the rollers which are floatingly suspended are assigned flexible actuation/operating means, e.g. pressure fluid driven piston cylinders (11).

2. Paper colouring apparatus as set forth in claim 1, characterized in braking friction built in within each roller's (2, 3, 5, 6, 7, 12, 13, 14) bearing seals.

3. Paper colouring apparatus as set forth in claim 1 or 2, characterized in that the roller train (4) is graded, tapering upwardly; roller lengths being reduced from below, from an lowermost roller to an uppermost roller, the ends of an overlying roller (e.g. 5) being withdrawn in relation to the ends of an immediately underlying roller (e.g. 6).

4. Paper colouring apparatus as set forth in any one of the
preceding claims, characterized in that the counter pressure roller (2) constituting the turning roller for the running paper web (1), is supported by means of a pendulum-suspension (15) assigned flexible actuation/operating means, e.g. in the form of at least one pressure fluid driven piston cylinder (16), the inker (3) being stationary suspended (Figures 8A-8C).

5. Paper colouring apparatus as set forth in any one of the preceding claims 1-3, characterized in that the inker (3) is supported by means of a pendulum-suspension (17) assigned flexible actuation/operating means, e.g. in the form of at least one pressure fluid driven piston cylinder (18), the counter pressure roller (2) being stationary suspended (Figures 9A-9C).
A. CLASSIFICATION OF SUBJECT MATTER

IPC5: D21H 23/56, B05C 1/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: B05C, B41F, D21H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 15 October 1993

Date of mailing of the international search report: 20 -10- 1993

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

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