July 9, 1946. E. W. SAMSON 2,403,461

METHOD AND APPARATUS FOR PRODUCING DESIGNED PAPERS

Filed Nov. 1, 1940 2 Sheets-Sheet 1

FIG.1.

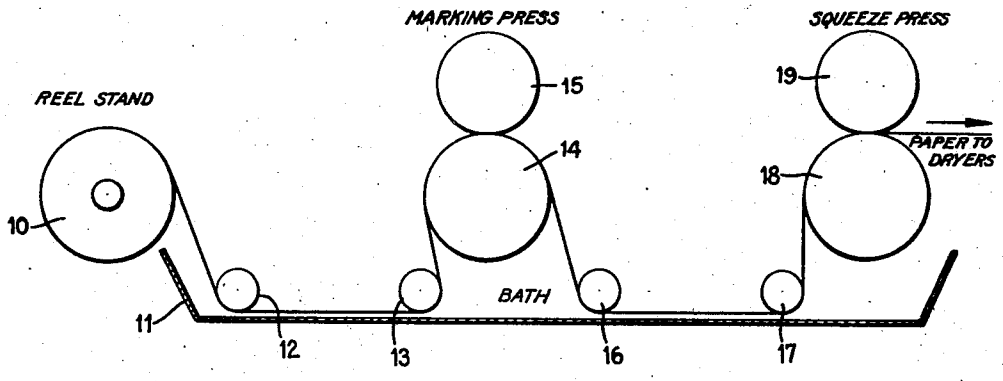


FIG.2.

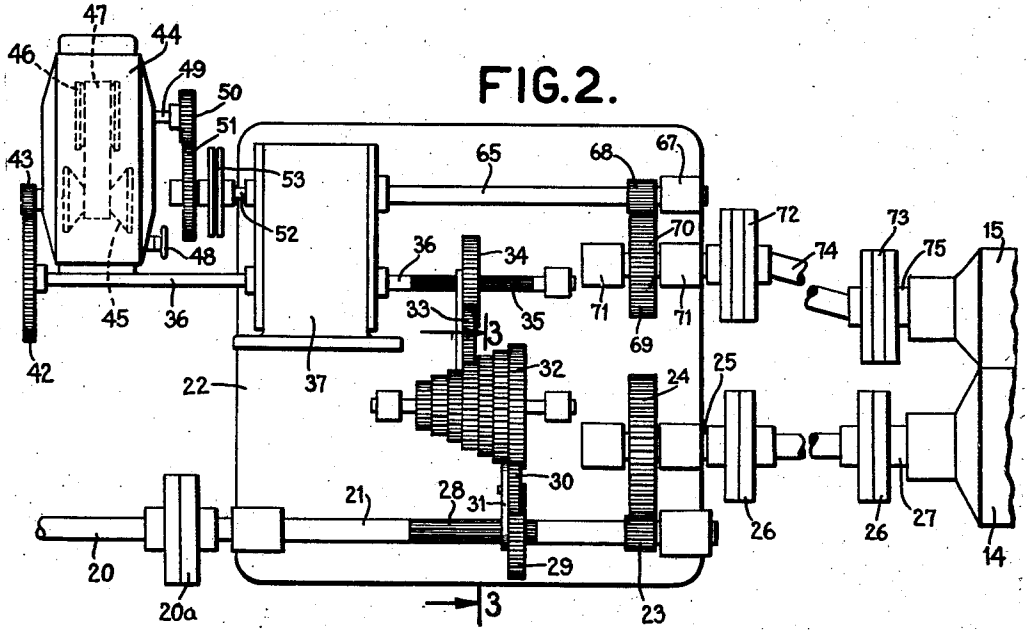
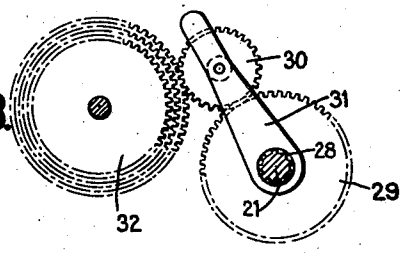


FIG.3.



INVENTOR.
EDWARD W. SAMSON

BY H. C. Kliesrath

ATTORNEY.

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METHOD AND APPARATUS FOR PRODUCING DESIGNED PAPERS

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FIG.4.

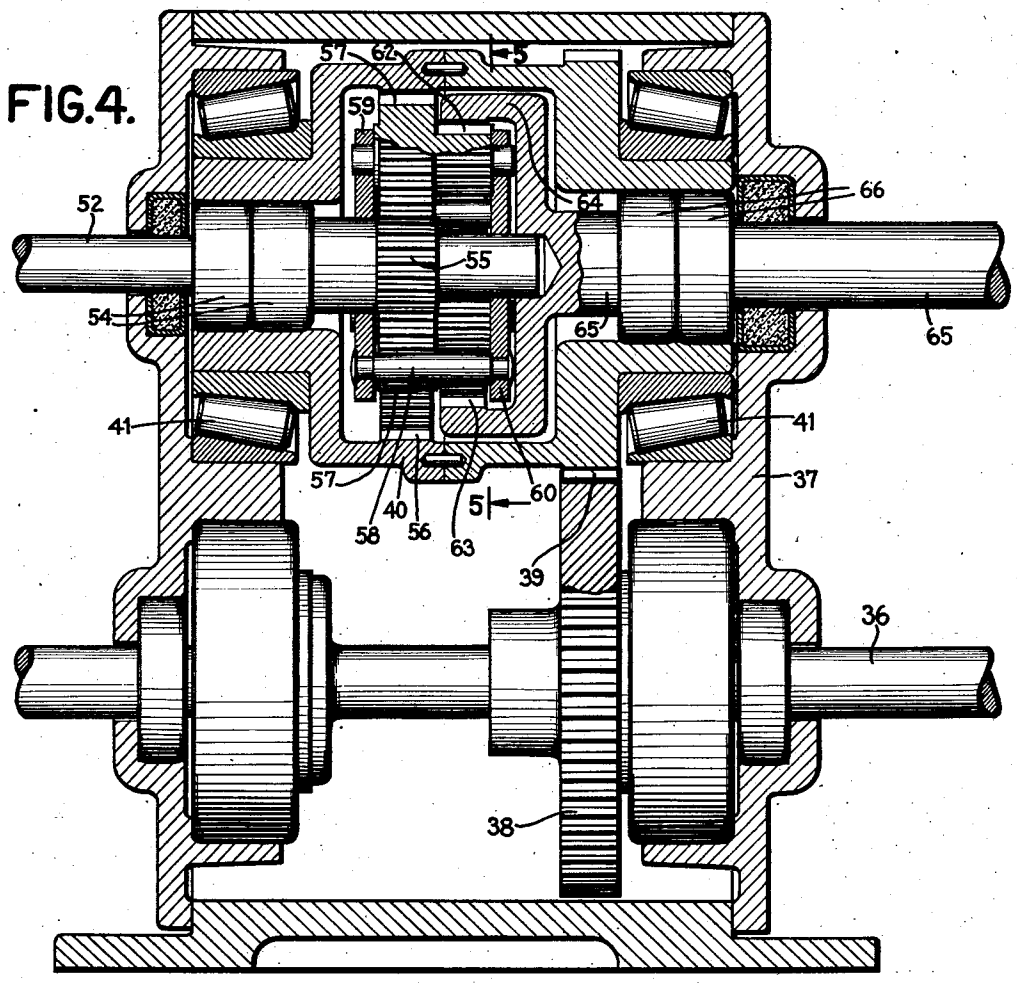
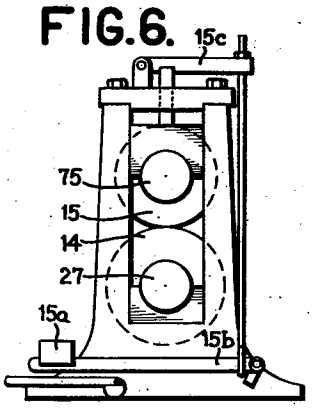


FIG.6.



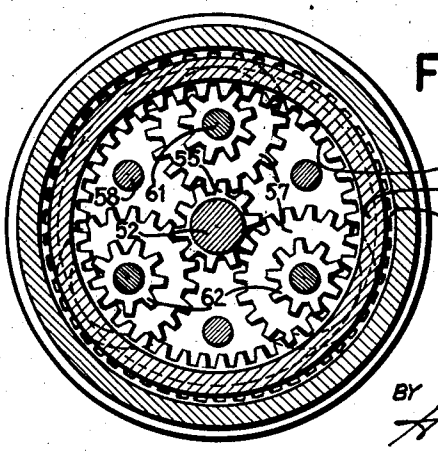


FIG.5.

INVENTOR.
EDWARD W. SAMSON
BY H. C. Wiseman
ATTORNEY.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR PRODUCING DESIGNED PAPERS

Edward W. Samson, Erie, Pa., assignor to Hammermill Paper Company, Erie, Pa., a corporation of Pennsylvania

Application November 1, 1940, Serial No. 363,809

23 Claims. (Cl. 8—7)

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This invention relates to the production of papers of various sorts having two-tone designs in one or both surfaces of either a single color or a plurality of colors. One important application of the invention is in the production of so-called "safety papers" employed in the preparation of special documents such as stock certificates, bonds, insurance policies, certificates, checks, coupons, money orders, lottery tickets, and the like. It is also applicable to the production of special papers for other purposes, such as papers which may normally appear to be white or of some other plain color but which, upon subsequent development with dyes or inks or by special treatment with chemicals or by heat, or light or other form of energy, will produce the two-tone effect or otherwise provide a visible pattern. Moreover, it may be used to advantage in the production of document or label or seal papers or lottery ticket paper and the like where protection against forgery or counterfeiting is important. Designs may be produced in accordance with the invention by delayed development of apparently plain colored paper which will be very difficult of reproduction by would-be forgers or counterfeiters. This type of developable paper might also be used to produce a novel greeting card or pictures for a child's game or the like.

Heretofore in the production of various types of paper having a two-toned effect upon its surface, it has been a common practice to apply a dye-containing liquid to the surfaces of the paper and to then pass the paper through the nip of a pair of impression rolls, after which it is wetted by the desired dye and finally squeezed and dried. The pressure applied to the paper by the raised portion of the design on one of the impression rolls produces some effect upon the fibers of the paper which causes them to receive a greater amount of the dye than the fibers at points not subjected to such pressure, thus resulting in a two-tone effect. However, it has been difficult, if at all possible, in the ordinary practice of this method to provide uniformly a very sharp contrast, or clear-cut design, as between the darker tone of the pressed fibers and the background of lighter tone provided by the unpressed fibers.

In accordance with the present invention, the paper of appropriate base stock, depending upon the use to which the finished product is to be put, is preferably wetted or moistened on one or both of its surfaces by means of an appropriate liquid, such as a dye-containing liquid, and is then subjected to a combined pressing and rubbing action

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at selected points in accordance with any predetermined design. Subsequently, it is wetted on one or both of its surfaces, as by subjecting it to immersion in a bath of the dye or other liquid or to the application of the liquid to one or both of its surfaces by means of a spray, and it is then squeezed and dried.

It has been found that the combined pressing and rubbing action may be imparted to the paper in selected areas, according to any predetermined design, under the controlled conditions of the present invention without noticeably distorting the design and with the result that the design appears much more sharply in the finished product than the design imparted simply by the pressure method heretofore employed. The rubbing action apparently renders the fibers of the paper, at the points subjected to this action, much more uniformly receptive to the deposition of, or impregnation by, the dye or other substances from the solution than does the simple application of pressure to the fibers.

In addition to the contrast, uniformity, and sharpness of the design made possible by the rubbing action when a dye is used, a number of other improvements and advantages over prior methods, and the results thereof, have been noted. Whereas, heretofore in the practice of the method explained above, it has been found necessary to wet or moisten the paper by the application of the dye prior to the passage of the paper through the nip of the impression rolls, this pre-moistening of the paper, though generally desirable, is not entirely essential in the practice of the present invention and, in any event, need not be carried to the same extent.

An improvement in the product, made possible by the present invention, is the greater permanence of the design. This is made apparent by taking a sample of the improved paper and subjecting it to a bleaching and drying operation, which substantially obliterates the original design, and then immersing the paper again in a bath of the original dye; the design will be redeveloped with almost the same sharpness as the original design. Papers of similar character, however, made in accordance with prior methods, will be found usually to be incapable of re-developing the design to any satisfactory extent after bleaching and drying.

Another advantage of the improved method is that the immersion of the paper in the dye bath, or the like, following the pressing and rubbing action, may be delayed more or less indefinitely. When the paper is dried after the combined

pressing and rubbing action, without development, there is substantially no tendency to "heal" the modified condition of the fibers so long as the paper remains dry. Moreover, whatever deterioration takes place, as a result of the drying and the rewetting for development purposes after a relatively long period of delay, is not serious. However, when pressure alone is relied upon, the deterioration of the design due to the "healing," when an attempt is made to delay its development, is such as to render delayed development almost impracticable. Accordingly, the improved method opens up a new field for designed paper in uses requiring delayed development. Thus, it enables the sale of paper of a plain color which, upon subsequent treatment with a dye or the like will reproduce a desired design.

In addition to the improvement in the sharpness of the design, the present invention provides the further advantage of increased speed of operation. By the improved method very good results have been obtained at speeds up to the limit of capacity of the drying equipment used. The speed may well equal or even exceed 425 feet per minute without unduly sacrificing the sharpness of impression and contrast. In general, it may be said that by the improved method, a product of at least equal quality to that of the ordinary prior process may be produced at better than twice the speed of the prior process.

The rubbing action contemplated by the present invention is preferably produced by bringing about a relative slippage between the paper and the surface of the impression or marking rollers. Ordinarily, the marking rollers will be driven at the same speed and the paper will partake of the surface speed of the rollers. According to the present invention, however, the surface speeds of the two rollers will differ to a certain extent and the linear speed of the paper will fall between the two roller surface speeds. The relative slippage between the rollers and the paper may be brought about in any of a variety of ways. Ordinarily, only the lower, smooth roller, of a pair of marking rollers, will be driven while the upper roller, which carries the design, will simply be turned by friction at the same speed as the driven roller. The invention may be practiced with a construction of this character, by the application of a braking force to the upper roller. A prony brake arrangement may be employed for this purpose. Relative slippage may thus be produced between the two rollers and hence between the paper and both rollers.

However, in order to enable the accurate control of the relative slippage between the rollers and the paper, an arrangement is preferably provided by which both rollers may be positively driven. This, moreover, is preferably accomplished by means enabling the relative speeds of the rollers to be varied readily at will. A differential gear arrangement has been found most satisfactory for the purpose. This provides a positive drive for both rollers which may be accurately varied over an adequate range, say about 6%, while further variation may be afforded by suitable change gearing, thus not only permitting accurately controlled variation in the relative slip but also taking care of a variation in the relative diameters of different sets of marking rollers which may be employed in the machine. At the same time, the construction preferably employed is such that a relatively small amount of power, as compared with that required for driving the upper, or designed, roller, is transmitted through the controlling means, which varies the relative speeds of the two rollers, to either assist or resist the driving of the upper roller, depending upon whether this roller moves faster or slower than the paper. Much the greater portion of the energy required to drive the upper roller is supplied by the frictional torque from the lower roller or through a part of the differential which is in fixed or invariable driving relation to the lower roller when the change gears are once set. Therefore, the slip control devices may be relatively light whereas the part of the differential which is in invariable driving relation, as stated, would need to be considerably more rugged. The energy actually consumed in producing the desired relative slippage between the rollers and the paper is, however, not great since the distance through which the friction force acts, i. e., the extent of the slippage, is relatively small.

It has been found that the relative slippage between the paper and each of the rollers should preferably be about 1.5% of the linear speed of the paper when a lower roller having a diameter of about 14 inches is used. This means that the difference between the surface speeds of the two rollers is preferably about 3%. The paper need not have the same percentage of slippage with respect to each of the rollers; in fact, with the paper running straight through the nip, with no wrap on either roll, there is usually a somewhat greater slip of the paper relative to the upper, designed roller than to the lower roller. Best results appear to be obtained when this condition is maintained. While about a 3% combined slippage between the paper and the two rollers has been found to produce the best results, good results may be obtained with either more or less slippage. For example, a slippage of a fraction of a percent, say .5%, has been found to produce results noticeably better than the results obtained when there is no slippage. The improvement in the results increases, however, with the increase in slippage, up to or even above a combined slippage of about 6%, but with higher slippage the improvement may be offset by other effects and may, therefore, taper off slightly.

By the use of a positive drive connection to each of the rollers, it is possible to provide either a positive or a negative slip between the upper or marking roller and the paper. By "positive slip" we mean that the marking roller has a surface speed less than the linear speed of the paper whereas by "negative slip" we mean that the surface speed of the marking roller is greater than the linear speed of the paper. Good results may be obtained with either positive or negative slippage. Of course, when there is positive slippage between the marking roller and the paper, there is a corresponding lengthening of the design whereas when there is negative slippage between these elements, there is a corresponding shortening of any dimension of the design which extends circumferentially about the marking roller. The slippage between the smooth roller and the paper has no lengthening or shortening effect upon the design.

The relative slippage between the rollers and the paper, as ordinarily provided in accordance with the invention, will not bring about any substantial distortion of the design nor any smearing of the lines. In fact the design is in all respects sharper and clearer as a result of the slippage. This is explained by the fact that the contact between the paper and the impression roller, as

any particular line across the paper passes through the nip of the rollers, is very brief. The length of the effective contact over which any pressing or rubbing action takes place is approximately only 3 millimeters in a machine of ordinary construction. Obviously a 1.5% slippage between surfaces in contact over an arc of only 3 millimeters in length will result in a broadening of any line to the extent of only .045 millimeter, which is insufficient to cause any noticeable smearing or distortion of the lines of a design. Thus, while the entire pattern will be stretched 1.5%, under the assumed conditions, the effect of the elongation of each increment of the pattern will be unnoticeable. The slight broadening of transverse lines is more than offset by the advantages of the rubbing action over simple pressure.

It is necessary to combine a certain amount of pressure with the rubbing action since the desired disturbance of the fibers cannot be accomplished with no pressure or only light pressure. However, high pressures are not nearly so necessary or important when the rubbing action is employed as when pressure alone is depended upon. Accordingly, there is no need to employ such pressures between the marking rollers as will be likely to produce transparency of the paper or to emboss it deeper than can be calendered out. Excellent results may be obtained by the use of pressures between 100 and 250 pounds per inch width of the paper when the pattern is such that the parts in relief occupy about one-third of the total area. In such case the actual pressure in the nip will be about 2500 to 6300 pounds per square inch of the raised parts of the pattern.

If desired, in the production of paper having a two-tone design on both surfaces, provisions may be made for lessening the differences between the two sides of the paper. Heretofore a very substantial difference has usually existed between the side of the paper toward the marking roller and the side toward the smooth roller. The marking roller side is almost invariably of higher grade. This two-sidedness of the paper may be eliminated or lessened by providing a greater slippage between the paper and the smooth roll than is provided between the paper and the marking roll in the practice of this invention. For this purpose the paper may be caused to lap around the marking roller to a certain extent but not at all, or to a less extent, around the smooth roller. In this way the relative slippage between the paper and the marking roller will be lessened while the slippage between the paper and the smooth roller will be increased. However, for most purposes it is preferable to provide a straight nip without wrapping around either roller. The rubbing between the paper and the roller, when a wrap is provided, has a somewhat deteriorating effect upon the surface of the paper and the design.

Some variation in the slippage between the paper and the rollers may be brought about, if desired, by appropriate tensioning of the paper either before or after the nip. This tension may be varied up to the point at which the paper tends to become wrinkled or at which there is danger of breakage. It has been found that the relative slippage between the paper and either roller may be either increased or decreased to any desired extent, up to about .75% of the linear velocity of the paper, by appropriately varying the tension on either side of the nip.

Other objects, features and advantages of the invention will appear from the detailed description of an illustrative form of apparatus that may be used in carrying out the same, which will now be given in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view illustrating the course of a web of paper as it is fed from the supply roller through the successive steps involved in the present invention.

Fig. 2 is an elevational view of certain driving connections for the marking rolls.

Fig. 3 is a detail, in section along the line 3—3 of Fig. 2, illustrating certain change-speed gearing employed in the apparatus.

Fig. 4 is a central vertical section through the differential mechanism and related devices forming part of the drive illustrated in Fig. 2.

Fig. 5 is a transverse section through the differential along the line 5—5 of Fig. 4, and

Fig. 6 is an end view of the marking press rollers showing means for varying the pressure between them.

Referring now to Fig. 1, the paper to be treated in accordance with the invention may be carried by a reel 10 supported in a suitable stand. This paper may be of any appropriate character, preferably a sized, uncoated paper. The type of paper ordinarily employed in the class known as safety papers will be found best suited for most purposes. Other types of paper, such as writing, ledger and bond paper, may be employed if desired.

The paper fed from the reel 10 may be passed to a tank 11 containing an appropriate solution or suspension, such as one containing a dye or the like, of a desired color. The solution may, if desired, contain the usual chemicals for protection against chemical ink eradicators and the like. The web may be led around a pair of guide rollers 12 and 13 which serve to retain it beneath the surface of the liquid for a limited period during its travel through the tank. This provides a desired pre-immersion of the paper which results in moistening of its surfaces but is preferably not sufficient to cause complete penetration of the paper which would tend to weaken it and might result in breakage. It has been found that, so far as the sharpness or contrast of the impression or design is concerned, the immersion period may be varied considerably without any marked effect upon the design. A slight decrease in contrast results from longer periods of immersion. The pre-immersion should, preferably, be just sufficient to wet thoroughly the contact surfaces of the rolls and paper. Better protection is afforded against erasures if only the surfaces are colored. Good results in the production of a two-tone design with a relatively sharp contrast have been produced by the present invention with a pre-immersion period varying between .04 of a second and one minute. If desired, in lieu of immersion, the web, prior to passage through the nip of the marking press, may be simply sprayed on one or both of its surfaces, depending upon whether the design is to be imparted to one or both surfaces. The sprays, for this purpose, are preferably disposed adjacent to the marking press and are arranged to provide a thin film of the liquid at the nip of the rollers. If desired, the sprays may be employed to supplement the pre-immersion of the paper.

After appropriately moistening or wetting the surface of the paper, it is passed through the nip of a pair of rollers 14 and 15 constituting a marking press. Roll 14 preferably has a smooth outer surface while the roll 15 carries the desired de-

sign. This may be designated the marking roll. If desired, both rolls might be provided with appropriate designs. Both rolls are positively driven, and at different surface speeds. Ordinarily, the marking roll will be somewhat smaller in diameter than the smooth lower roll. Preferably the marking roll is between about 7 and 14 inches in diameter and the smooth roll is between about 12 and 16 inches in diameter. The ends of the rollers are mounted in suitable bearings, which may be urged together under variable pressure by means of a weight 15*a* and a lever system 15*b* and 15*c*, such as shown in Fig. 6.

After leaving the nip of the marking press rolls, the paper is led downwardly around a pair of guide rollers 16 and 17, which may be disposed in the tank 11 or in a different tank containing the same bath or a different bath for development of the design. While, as indicated diagrammatically in Fig. 1, the web is given a partial wrap around the lower roll 14, in actual operation the arrangement of guide rollers and the like is preferably such as to provide a straight course through the nip of the marking press rollers.

The period of immersion of the web for development purposes may also vary widely as in the case of pre-immersion. Good results in the production of sharp contrast have been had with a total immersion of ¼ of a second. Equally good results have been obtained with a total immersion of nearly two minutes. The development period has been varied with good results between 0.2 of a second and about a minute. This then provides a wide latitude in the operation of the machine; the immersion factor is no limitation upon the speed of operation. If desired, the developing solution may be sprayed upon one or both surfaces of the web after it has passed through the marking press, either in lieu of immersion or to supplement immersion. For this purpose, the sprays may be disposed close to the nip of the rollers 14 and 15, although in the production of the design by rubbing action it is not as important to develop the design promptly as in the prior pressure method. In fact, the development of the design may be considerably delayed if desired. For example, it may be delayed until after the paper has been sold and is being, or has been, put to some use, the design being then, or subsequently, developed to establish the genuineness of the paper or for some other purpose. In that case, the pre-immersion may be with plain water or with a clear, colorless solution of appropriate chemicals. The development, whether immediate or delayed, may be effected by any of the dyes commonly used in the production of safety papers or by various types of ink, such as recorder ink or writing ink. Even pigments may be used but they are generally less satisfactory. If dyes are used, they may be acid, basic, or direct dyes. Aniline or vegetable dyes may be employed. For certain purposes colorless chemicals may be used in the development, such that the design may later, say after sale and use of the paper, be rendered visible by an appropriate reaction producing agency.

After an appropriate period of development, the web of paper is carried out of the bath through a squeeze press formed by rollers 18 and 19. A great deal of the excess solution is removed from the paper in this way and the paper is then passed to dryers of any suitable construction and is then disposed of in any desired way. The machine may be operated to deliver the paper at almost any desired speed. Good impressions may readily be obtained at speeds of 25 to 425, or even more, feet per minute.

Turning now to the preferred means for driving the rollers of the marking press, reference should be had to Figures 2 to 5. A shaft 20, Figure 2, is arranged to be driven in any convenient way from a suitable power source, such as a motor, not shown. The shaft 20 is directly connected through the coupling 20*a* with a shaft 21 mounted in suitable bearings on a frame 22. This shaft carries a pinion 23 adjacent its opposite end meshing with a gear 24 on a shaft 25, likewise mounted in suitable bearings on the frame 22. Shaft 25, through couplings 26, is directly connected with the shaft 27 of the driven roller 14. The speed of the shaft 27 may be varied by appropriate variation in the speed of the motor or through variable speed reducing mechanism.

Intermediate the ends of the shaft 21 there is provided a splined portion 28 adapted to cooperate with the hub of a gear 29 for the purpose of driving the latter. A pinion 30 carried by an arm 31 loosely mounted on the shaft 21 is arranged to mesh with the gear 29 and transmit power from the latter to any one of a series of stepped gears 32. Any suitable means, such as a spring, not shown, may be employed to hold the pinion 30 in mesh with the selected gear of the group 32. By appropriate axial adjustment of the gear 29 and arm 31 along the shaft 21 the group of gears 32 may be driven at a desired speed. These gears, in turn, acting through a pinion 33 and a gear 34 slidable axially along a splined portion 35 of a shaft 36 mounted in bearings on the frame 22, will serve to drive the shaft 36 at a desired speed in relation to the shaft 21. As will be understood, the relative speeds of rotation of the shafts 21 and 36 may be varied by the shifting of one or both of the gears 29 and 34.

Referring now to Figure 4, the shaft 36 will be seen to extend into a housing 37 in the ends of which the shaft is suitably journaled. Housing 37 is preferably made substantially oil-tight so that it may be filled with a suitable lubricant for the differential gearing to be presently described. Secured to the shaft 36 within the housing is a gear 38 adapted to mesh with external teeth 39 carried by a sleeve or housing 40. As shown, the sleeve may conveniently be formed in two sections connected together in any suitable way and mounted for rotation within the housing 37. For this purpose, roller bearings 41 are preferably provided between the sleeve and housing.

As shown in Figure 2, the shaft 36 extends beyond the opposite side of the housing 37 and carries a gear 42 meshing with pinion 43 connected with the input shaft of a variable speed drive unit 44. This unit may be of any appropriate construction, preferably involving a pair of conical pulleys 45 and 46 connected for rotation together by a positive gripping belt 47 of V-shaped cross section. A hand wheel 48 may be provided for adjusting the pulleys to vary the ratio between the input and output speeds. The output shaft 49 of the variable drive unit carries a pinion 50 meshing with a gear 51 carried by a shaft 52, Figures 2 and 4. The construction is preferably such that the shaft 52 may be connected with or disconnected from the gear 51 by means of a clutch 53 which may be controlled in any convenient way.

The shaft 52 extends into the sleeve 40 and is suitably journalled therein, preferably by means of a bearing 54 provided between the shaft and a

reduced portion of the sleeve. Within the enlarged part of the sleeve 40 the shaft 52 is provided with gear teeth 55 radially aligned with internal gear teeth 56 provided on the inner surface of the sleeve 40. An epicyclic gear unit is provided between the teeth 55 and 56. This unit comprises a plurality of pinions 57, three such pinions being shown mounted upon studs 58 supported by a pair of discs 59 and 60. These are rotatably carried by the shaft 52 and may be connected together by pins 61 as well as by the studs 58. The pinions 57 are adapted to mesh with both the teeth 55 and 56.

Also mounted on the studs 58 are a series of pinions 62 which may be integral with the pinions 57 or otherwise secured thereto for rotation therewith. The pinions 62 are adapted to mesh with internal teeth 63 formed on an enlarged portion 64 of a shaft 65. If desired the part 64 may be a separate housing secured in any convenient way to the shaft 65. This shaft is journalled by suitable bearings 66 within a reduced portion of the sleeve 40 and extends outwardly from the sleeve through an opening in the housing 37. Adjacent its opposite end the shaft 65 is journalled in a bearing 67 carried by the frame 22. Near the bearing 67 a pinion 68 is secured to the shaft and this meshes with a gear 69 secured to a shaft 70 journalled in suitable bearings 71 on the frame 22. Through suitable universal joints 72 and 73 and a connected shaft 74, the shaft 70 is adapted to drive a shaft 75 which carries the upper, designed roll 15 of the marking press.

It will thus be seen that the upper roller 15 of the marking press is driven through two separate connections from the shaft 36 that is driven by the same shaft 21 that drives the lower roll. One of these connections is through the gear 38 and the sleeve 40 which is adapted to transmit most of the energy required to rotate the roller 15 by the coaction between the internal teeth 56 and the pinions 57. The other is through the variable speed unit 44, shaft 52 and gear teeth 55 acting upon the pinions 57. This provides for a desirable variation in the relative speeds of the two rollers and accomplishes this variation by the adjustment of a unit which transmits only a relatively small part of the energy required for rotating the upper roll. While an appropriate variation in the relative speeds of shafts 21 and 65, over a range of, say, 6%, is provided through the adjustment of the unit 44, a further variation is permitted, as previously explained, by the axial adjustments of the gears 29 and 34. Allowance may thus be made not only for a variation in the relative surface speeds of the rollers 14 and 15 but also for the substitution of rollers having different relative diameters.

Briefly summarizing the operation of the equipment, the paper of suitable character, preferably of a white base stock, is fed from the roller 10 into the tank 11 where it is subjected to pre-immersion, either in a bath of dye of the desired color or in plain water or in a clear solution of an appropriate chemical or in some combination thereof, depending upon the desired purpose of the final product. The paper is then passed through the nip of the rollers 14 and 15, both of which are positively driven from the power-receiving shaft 20, but at different speeds, preferably such that one roller has a surface speed about 3% faster than the other. The rollers 14 and 15 should be urged together under an appropriate pressure, preferably about 5000 pounds per square inch of raised pattern surface in the nip, which may be applied and varied in any manner well known in the art, such as that indicated in Fig. 6.

After leaving the nip of the rollers, the paper may be passed through another portion of the tank 11 for immersion again in the bath to develop the design, or, as explained, the development may be effected in other ways. In lieu of a single tank and single bath, separate tanks for different liquids, such as different dye baths, may be employed, in which latter case a two-tone effect in different shades or colors may be produced. After development of the design, the web is passed through the squeeze press, rollers 18 and 19, and then through the dryers to any suitable point for further disposition. The further treatment may include calendering, if desired. If the finished paper is used for counterfeit-prevention purposes or the like, its pre-immersion may have been effected in plain water and its development may be delayed until the paper is actually put into use. In that case the web is led directly from the nip of the marking press rollers to the squeezing press and then to the dryers.

Should it be desired to replace the rollers 14 and 15 by another pair having a somewhat different relationship between their diameters, the gears 29 and 34 will preferably be shifted to vary the relative speeds of the shafts 21 and 36 and the more precise adjustment of the relative surface speeds of the rollers for the desired slip will then be produced by appropriate adjustment of the hand wheel 48 of the variable speed unit 44.

An illustrative form of apparatus, embodying features of the present invention and capable of carrying out the improved method, has been described in considerable detail, but it will be understood that numerous changes may be made in the construction and arrangement of the parts and in the steps of the process without departing from the general principles and scope of the invention. While the invention is especially adapted for use in connection with paper of the characters mentioned, it may also be employed in connection with textiles of various sorts. The terms used herein have been employed as terms of description and not of limitation.

What I claim is:

1. A method of producing a two-tone design on paper which comprises subjecting the paper to a combined pressing and rubbing action at selected points conforming with the desired design, the rubbing being effected by slight relative slippage between a surface carrying the desired design and a cooperating surface of the paper, said rubbing being so effected as not to roughen the surface of the paper perceptibly, and subsequently developing the design by the application of a dye to the surface of the paper.

2. A method of producing a two-tone design on paper which comprises moistening the surface of the paper, then subjecting the paper to a combined pressing and rubbing action at selected points conforming with the desired design, the rubbing being effected by slight relative slippage between a surface carrying the desired design and a cooperating surface of the paper, said rubbing being so effected as not to roughen the surface of the paper perceptibly, and subsequently developing the design by the further application of a dye to the surface of the paper.

3. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers at least one of which is marked to impart a substantial pressure at selected points on the paper

to compress the same in accordance with a predetermined design, and producing a slight relative slippage of from .2 to 6% between the paper and the surface of at least one of said rollers which is marked.

4. A method of producing a two-tone design on paper which comprises moistening at least one surface of the paper with a dye, passing the paper through the nip of a pair of pressure rollers at least one of which is marked to impart a substantial pressure at selected points on the paper in accordance with a predetermined designed, producing a slight relative slippage between the paper and the surface of at least one of said rollers which is marked, said slippage being such as not to roughen the surface of the paper perceptibly, and applying a dye to at least said one surface of the paper after it leaves the nip.

5. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers arranged to impart a substantial pressure at selected points on the paper to compress the same in accordance with a predetermined design, and producing relative slippage between the paper and the surfaces of both of said rollers, said slippage being such as not to roughen the surface of the paper perceptibly.

6. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers arranged to impart a substantial pressure at selected points on the paper to compress the same in accordance with a predetermined design, and producing a constant relative slippage between the paper and the surfaces of both of said rollers to the extent of about 1.5% of the linear velocity of said paper.

7. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers arranged to impart a substantial pressure at selected points on the paper to compress the same in accordance with a predetermined design, and rotating said rollers at different surface speeds to produce relative slippage between the surfaces thereof and said paper, said slippage serving to rub the paper but being such as not to roughen the surface of the paper perceptibly.

8. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers arranged to impart a substantial pressure at selected points on the paper to compress the same in accordance with a predetermined design, and rotating said rollers at different surface speeds to produce relative slippage between the surfaces thereof and said paper to the extent of about 1.5% of the linear velocity of said paper.

9. A method of producing a developable design on paper which comprises passing the paper through the nip of a pair of pressure rollers arranged to impart a substantial pressure at selected points on the paper to compress the same in accordance with a predetermined design, and rotating said rollers at different surface speeds to produce relative slippage between the surfaces thereof and said paper to the extent of between .2 and 6% of the linear velocity of said paper.

10. A method of producing variable deposition of a chemical substance on the surface of a continuously advancing web of paper which comprises wetting the surface of said web, subjecting the surface at selected points to a combined pressing and rubbing action, said rubbing action being effected by a slight relative slippage between said web as it advances and a moving rubbing surface, said rubbing being so effected as not to roughen the surface of the paper perceptibly, and treating the surface of the web with chemicals capable of causing deposition of the desired substance.

11. A method of imparting a design to the surface of a web of paper which comprises rubbing successive areas of said surface in accordance with a predetermined pattern by a relative movement between said web and a surface bearing the desired pattern, the rubbing stroke employed at any point on the web being so short as to cause no appreciable smearing effect on the resulting pattern and no preceptible roughening of the surface of the paper, and subsequently applying a liquid containing a dye to said surface.

12. A method of imparting a developable design to the surface of a web of paper which comprises rubbing successive areas of said surface in accordance with a predetermined pattern by a relative movement between said web and a surface bearing the desired pattern, the rubbing stroke employed at any point on the web being so short as to cause no appreciable smearing effect on the resulting pattern and no perceptible roughening of the surface of the paper.

13. A method of imparting a developable design to the surface of a web of paper which comprises rubbing successive areas of said surface in accordance with a predetermined pattern by a relative movement between said web and a surface bearing the desired pattern, the rubbing stroke employed at any point on the web being so short as to cause no appreciable smearing effect on the resulting pattern and no perceptible roughening of the surface of the paper, and subsequently treating said surface with a chemical capable of causing color change upon later treatment with another chemical.

14. A method of producing variable deposition of a chemical substance on the surface of a web of paper which comprises subjecting the surface at selected points to a combined pressing and rubbing action, said rubbing action being effected by a slight relative slippage between said web as it advances and a moving rubbing surface, said rubbing action being such as not to roughen the surface of the paper perceptibly, and treating the surface of the web with a liquid containing the chemical substance to be deposited.

15. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, said rollers being arranged to impart a substantial pressure to said paper sufficient to compress the same and modify its receptivity at selected points conforming with a desired design as the paper passes through said nip, and means for producing relative slippage between said paper and at least one of said rollers.

16. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, said rollers being arranged to impart a substantial pressure to said paper sufficient to compress the same and modify its receptivity at selected points conforming with a desired design as the paper passes through said nip, power means, and connections from said power means to said rollers for driving the latter at different surface speeds.

17. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said

rollers, said rollers being arranged to impart a substantial pressure to said paper sufficient to compress the same and modify its receptivity at selected points conforming with a desired design as the paper passes through said nip, power means, and connections from said power means to said rollers for driving the latter at different surface speeds, said connections enabling variation in the relative surface speeds of said rollers.

18. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, said rollers being arranged to impart a substantial pressure to said paper at selected points conforming with a desired design as the paper passes through said nip, power means, and connections from said power means to said rollers for driving the latter at different surface speeds, said connections to one of said rollers including differential gearing having one element thereof connected in invariable relation with the other of said rollers and having another element arranged to be driven at variable speed in relation to said other roller for varying the relative surface speeds of said rollers.

19. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, said rollers being arranged to impart a substantial pressure to said paper at selected points conforming with a desired design as the paper passes through said nip, power means, and connections from said power means to said rollers for driving the latter at different surface speeds, said connections to one of said rollers including epicyclic gears arranged to drive said roller, said gears being driven in part by an invariable connection with the other of said rollers and in part by a variable speed connection with said other roller.

20. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, said rollers being arranged to impart a substantial pressure to said paper at selected points conforming with a desired design as the paper passes

through said nip, power means, and connections from said power means to said rollers for driving the latter at different surface speeds, said connections to one of said rollers including epicyclic gears arranged to drive said roller, said gears being driven in part by an invariable connection with the other of said rollers and in part by a variable speed connection with said other roller, said invariable connection being constructed and arranged to transmit the major portion of the power applied to said one roller.

21. In apparatus of the character described a pair of marking rollers urged together, means for directing paper to and from the nip of said rollers, means for wetting the surface of said paper before entering and after leaving said nip of the rollers, said rollers being arranged to impart a substantial pressure to said paper sufficient to compress the same and modify its receptivity at selected points conforming with a desired design as the paper passes through said nip, and means for producing relative slippage between said paper and at least one of said rollers.

22. In apparatus of the class described a smooth roller, a figured marking roller urged against said smooth roller, means for directing a web of paper into and out of the nip of said rollers, power means, connections therefrom for driving said smooth roller, and connections including a differential driven at two separated points by said power means for driving said figured roller at variable surface speeds in relation to said smooth roller.

23. In apparatus of the class described a smooth roller, a figured marking roller urged against said smooth roller, means for directing a web of paper into and out of the nip of said rollers, power means, connections therefrom for driving said smooth roller, connections including differential means driven by said power means for driving said figured roller, and means for modifying the transmission of power by said differential means for varying the relative surface speeds of said rollers.

EDWARD W. SAMSON.