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Hamaker

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[54] **FORAMINOUS SHEET REGISTRATION SYSTEM**

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[51] **Int. Cl.** **B65h 9/06**

[58] **Field of Search** 271/53, 60, 51, 172, 196, 271/197, 243

[56] **References Cited**

UNITED STATES PATENTS

2,208,045	7/1940	Durup et al.	271/53 X
3,477,558	11/1969	Fleischauer	271/197 X
3,633,543	1/1972	Pitasi et al.	271/53 UX

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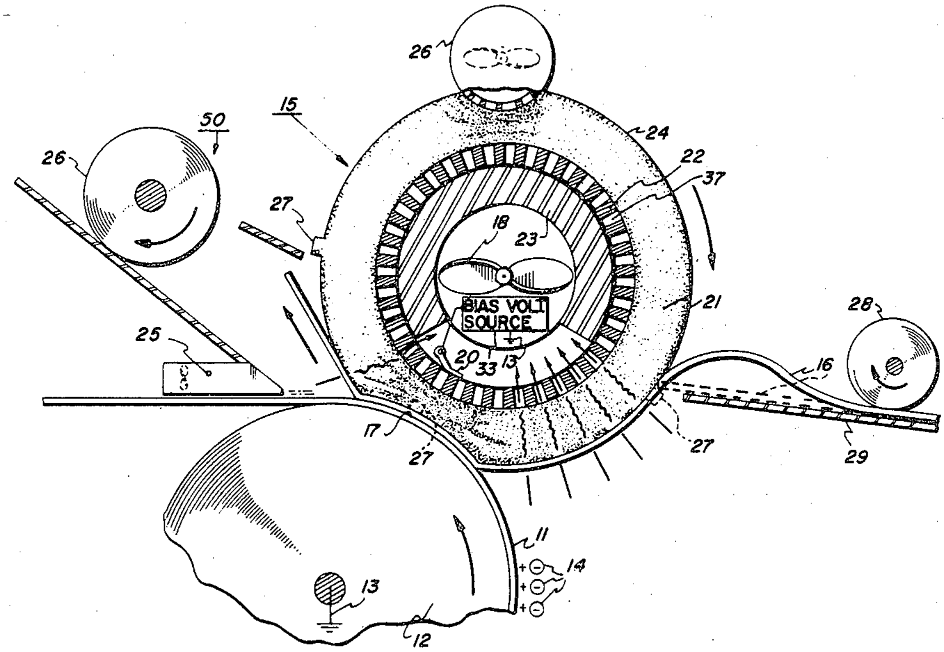
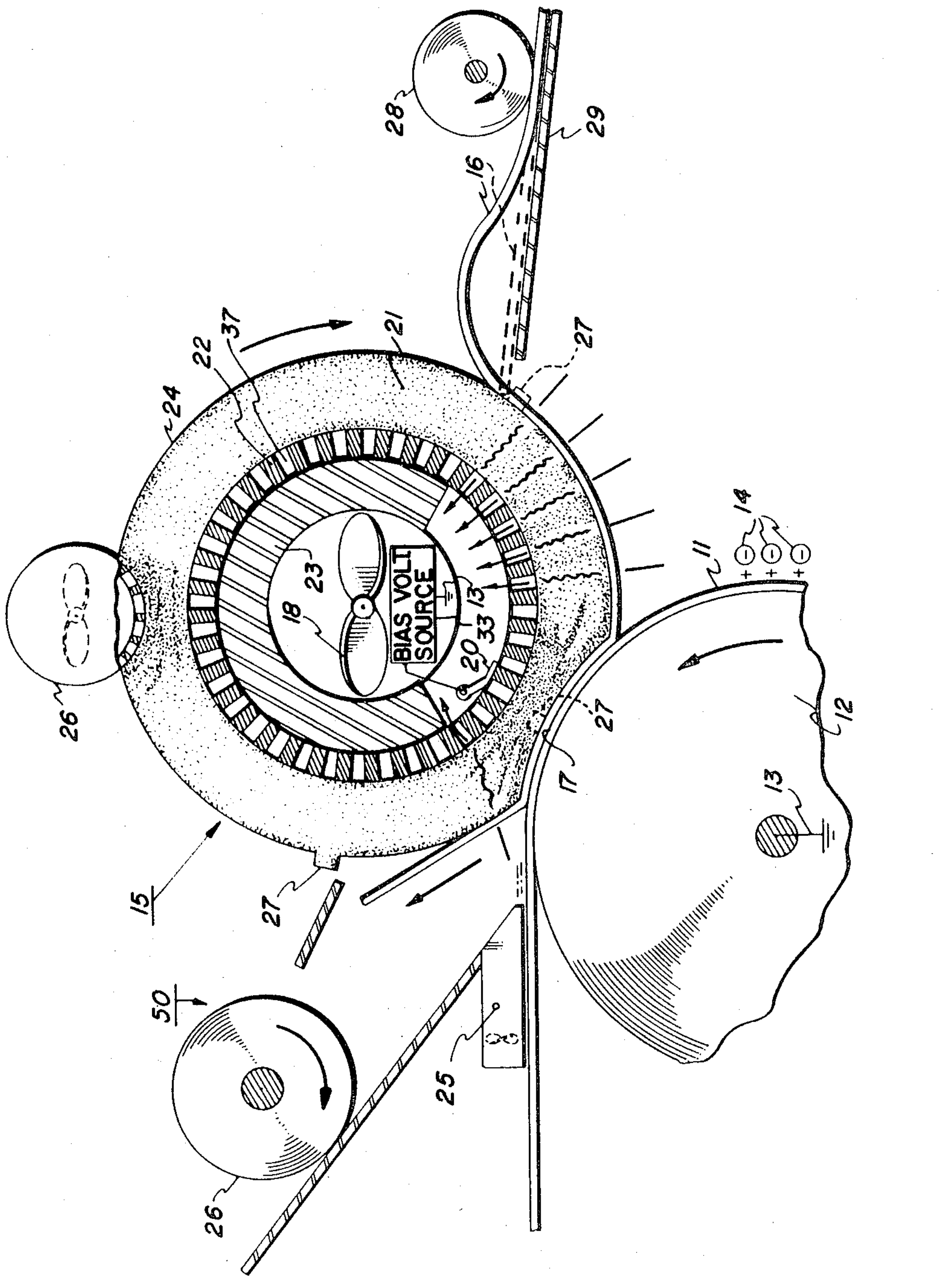
[57] **ABSTRACT**

A sheet registration system for registering the leading edge of a sheet being fed through the nip between a sheet feeding roller and an opposing surface including a sheet feeding roller of foraminous material having a sheet registration lip which is temporarily resiliently suppressed in the nip by compression into the foraminous material to provide a continuous uniform nip engagement between the roller and the opposing surface. A vacuum can be applied through the foraminous material to hold the sheet against the roller and registration lip.

7 Claims, 1 Drawing Figure

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FORAMINOUS SHEET REGISTRATION SYSTEM

The present invention relates to sheet registration in sheet feeding, and more particularly to the use of an endless foraminous sheet feeding member with simple sheet registration means which do not interfere in any way with a sheet feeding drive nip. It can also provide the advantages of vacuum sheet retention, and an improved electrostatographic transfer system as disclosed and claimed in a copending U.S. Pat. application Ser. No. 367,279 by the same inventor entitled "Foraminous Vacuum Bias Roll Transfer System" filed contemporaniously herewith and having the same assignee.

Foraminous sheet feed roller members have, of course, been previously utilized in paper handling. For example, U.S. Pat. No. 2,968,535 issued Jan. 17, 1961, to R. W. Gundlach in FIG. 3 and Column 10 briefly discloses a xerographic transfer system utilizing a soft resilient sponge rubber coated transfer roller, preferably electrically conductive.

Various solid porous vacuum roll paper transport rolls are known in the art. U.S. Pat. No. 3,633,543 issued Jan. 11, 1972, to Carl R. Pitasi discloses a xerographic biased transfer roller having a resilient material surface layer capable of passing air therethrough for sheet retention. The specified material is either conductive rubber or a thin insulator, and the air passages are formed by pinholes through the material. This patent also discloses a depressed lip portion on the roll circumference for registration stopping of the copy sheet.

Although not limited thereto, the present invention is particularly advantageous in electrostatographic transfer systems where images are transferred by a biased transfer roller from a first to a second image support surface. Especially where the second surface is a cut sheet, it must be precisely registered with the image on the first surface prior to transfer.

Further, the transferring of electrostatographic imaging development materials between supports must be accomplished while controlling or suppressing arcing and undesired corona generations. This is primarily due to the fact that in practical such systems the transfer of materials must be effected while the two surfaces between which the material is being transferred are both moving at the same speed. This as a practical matter requires the material transferring electrode to be an effectively endless and smooth surface of a cylindrical roller or small endless belt. This in turn means that the surface of the roller or belt electrode must continuously and evenly move in and out of contact with the original support surface. Any surface irregularities on the transfer roller surface would create varying width air gaps in the nip region. Due to the fact that the breakdown voltage across an air gap is very non-linear with changes in the gap dimensions (this characteristic is known as the Paschen curve) control or arcing or ionization in such air gaps when there is a high biasing voltage on the electrode is very difficult if uniform contact is not maintained. The higher the applied bias voltage the more difficult such control becomes, yet in many applications high voltages are either required or highly desirable for efficient transferring of the material from the original surface or liquid suspension to the second surface. Further, since the field intensity for material transfer is a function of the spacing as well as the applied potential the biasing voltage charge is desirably applied as closely as possible to the original support, again further increasing the difficulty of preventing voltage breakdown by arcing or excessive corona generation in the nip itself as well as the pre and post-nip gaps. Further, both vector direction and intensity of the applied electrical fields varies at different locations and times relative to the roller electrode because the electrical fields are geometrically dependent upon the electrode configurations, and change as the electrode moves. The present invention provides a system in which such desired high transfer biasing voltages and close spacings may still be maintained while providing a simple and effective sheet registration arrangement on the same roller which does not interfere with transfer operations in any way.

In the above and many other sheet feeding applications the disclosed sheet feeding arrangement provides a sheet registrative lip means which allows smooth, continuous and even pressure sheet feeding without the vibrations, gaps or other feeding defects associated with conventional sheet roll gripper fingers or the like. The lip is fully suppressed in the sheet feeding nip without any appreciable pressure change by compression into a foraminous material layer.

An embodiment of the present invention is shown and described hereinbelow as incorporated in otherwise conventional exemplary electrostatographic apparatus and processes. Accordingly, said processes and apparatus need not be described in detail herein, since the above-cited and other references teach details of various suitable exemplary structures, materials and functions to those skilled in the art. Further examples are disclosed in the books *Electrophotography* by R. M. Schaffert, and *Xerography and Related Processes* by John H. Dessauer and Harold E. Clark, both first published in 1965, by Focal Press Ltd., London, England. All of the references cited herein are hereby incorporated by reference in this specification.

Further objects, features and advantages of the present invention pertain to the particular apparatus, steps and details whereby the above-mentioned aspects of the invention are attained. Accordingly, the invention will be better understood by reference to the following description and to the drawing forming a part thereof, which is substantially to scale, except as noted, wherein:

The FIGURE is a plan view, partially in cross-section, of an exemplary sheet feeding system in accordance with the present invention, incorporated in a xerographic bias roller transfer system.

Referring to the FIGURE, it may be seen that there is illustrated a sheet feeding registering system **50** incorporating a foraminous roller **15** with registration means in accordance with the invention, and providing a xerographic transfer station. Other details of the system **50**, such as the photoreceptor **11** and the related xerographic systems known in the art are taught in the above-incorporated references on bias roller transfer systems and need not be described in detail herein.

It may be seen from the partial cross-sectioning of this axial plan view that the roller **15** illustrated here is normally cylindrical and the vast majority of its cross-sectional area and outer volume comprises a roller body **21** of foraminous open cell material uniformly coaxially surrounding a smaller cylindrical hollow central core **22** of solid material, which here is a perforated metal roller. A vacuum is applied to the interior of the core 22 by conventional vacuum means, such as the blower 18 illustrated schematically. The foraminous material here is shown as normally cylindrical and bonded to the outside of the central core 22 surface, extending over the perforations 37. However, it will be appreciated that the terms "roller electrode" or "roller" as used herein are not intended to be limited to integral cylindrical rollers. They are also intended to read broadly on equivalent structures such as moving endless belts of the same foraminous materials with either rolling or stationary (sliding contact) backing members. Examples of such equivalent structures are disclosed in the above-cited references.

The foraminous material of the roller 15 here is open cell material rather than closed cell, i.e., having open voids or pores which allow expulsion or transfer of the contents of individual cells when the cells are compressed, and movement of air through the material. However, this is not essential if a vacuum system is not provided. This material is preferably highly formainous, i.e., the principal volume of the material in its normal uncompressed state comprises a multiplicity of convolute and separated random voids or pores closely interspaced throughout the material, so that the solid material itself can be considered primarily as discontinuous cell walls separating these voids and occupying only a minor portion of the total volume of the foamed material. Examples of suitable materials are 45 pore (45 cells per inch) or 100 pore open celled polyurethane foam, which may be commercially obtained, for example, from the Scott Paper Company. The present invention is applicable to many different foraminous materials, many of which are commercially available, and given the criteria and teachings herein such materials may be readily selected by one of ordinary skill in the art of foraminous materials.

It may be seen that the foraminous body 21 of the roller 15 is highly compressed from its normal uncompressed radius into close to the radius of the core 22. The maximum compression of the roller body 21, due to the curvature of the core 22 (which is not compressed), occurs at the normal nip area 17, and the compression is substantially less in the pre-nip and post-nip areas. However, the low durometer resiliency of the foam roller body provides a large area of roller surface contact with the photoreceptor 11 surface extending well into the pre-nip and post-nip areas and covering an area much larger than a normal solid roller nip contact area.

The minimum (compressed) distance between the core 22 and the outer surface 24 of the roller 15 is here preferably less than half the normal uncompressed thickness of the foraminous material, so that a substantial number of the normally open cells in the nip 17 are closed by compression. However, full compression (closing of substantially all cells in the center of the nip) is not desired because of the registration lip, as subsequently discussed. With 50 percent compression (not practicably achievable with a solid roller) the transfer field in the tip can be twice the field in the pre and post-nip air gaps. An uncompressed foraminous layer of approximately one centimeter in thickness can be utilized, or a deep "pillow" roller may be utilized.

In comparison, even very soft rubber rollers which are solid cannot achieve the desired dorms and close nip spacings of the disclosed foraminous roller electrodes. Solid rollers can only be somewhat deformed, rather than compressed, causing severe internal stresses on the material in an attempt to bring the roller core close to the support surface. Further, with a foam roller a much lower effective durometer can be achieved than with a solid roller without having to go to a material which is so soft as to have poor strength and wear resistance properties. The much greater roller surface deformation which can be achieved with relatively light compression pressures in foam rollers provides a much greater surface contact area for improved transfer and paper hold-down, with much more even and reduced pressures for reduced wear and reduced distortion of components, in addition to the significant electrical advantages disclosed.

An air permeable coating may be provided on the circumferential exterior surface 24 of the roller electrode 15 which is sufficiently elastic and resiliently conformable to the compression of the foraminous material. An example is 10 mil perforated polyurethane. Such a surface coating of non-compressable material can be used to permit surface speed synchronization of the system, and to provide increased wear resistance and cleanability.

Considering further the exemplary xerographic transfer bias roller 15, it has a foraminous roller body 21 with a conductive core 22 connected to a conventional transfer bias voltage source 33 by wiper contact 20. The bias source 33 may be connected through common grounds 13 to a conductive backing roll 12 against which the roller 15 is highly compressed with moderate pressure. Through the nip 17 between the two rollers passes a flexible belt photoreceptor 11 and paper or other final support sheet 16. Negatively charged toner particles 14 previously developed onto the photoconductor 11 surface are retained thereon by positive latent image charges until transfer is effected. Here, transfer by the bias source 23 occurs from the high fields in the nip area 17 created by the foraminous roller body 21 being highly compressed so that the conductive core 22 is closely spaced in the nip from the photoconductor.

The disclosed structure provides greatly improved control capabilities as compared to an ordinary transfer roller which maintains a generally cylindrical configuration and simple pre and post-nip air gap configurations. Not only is the shape and contact area of the nip different here, but also the foraminous material fills the space between the conductive core and the contacting support surface with a multiplicity of small discontinuities provided by the cells in the material, thereby providing a greatly improved air ionization control barrier. The foraminous material is significantly less compressed (less dense) in the pre-nip and post-nip areas than in the nip area. That is, it has a much greater thickness and porosity between the conductive core and the support surface in the normal pre-nip and post-nip areas. The foraminous material extends much further laterally into the pre-nip and post-nip areas, due to its greater deformation, i.e., it has a much larger surface contact area. This increasing thickness and porosity of the foraminous material can be utilized to provide a varying ionization control barrier in the pre-nip and post-nip areas provided by the degree of compression of the foraminous material in the nip. As the compression is increased, the individual cells may be collapsed, whereby the tops and bottoms of the cell walls contact one another. As more cells are collapsed, the electrical properties of the roller in the nip can change dramatically from those of the normal uncompressed porous material to those of a solid roller in the same material. This greatly adds to the effect of the increase in field strength due to the closer conductor spacing geometry of the nip.

It will be noted that the deformed radius of curvature of the roller 15 surface 24 at the post-nip exit is much less than the normal roll radius. This sharp curvature, together with the paper beam strength, assists in assuring stripping of the paper from the transfer roll 15.

The foraminous bias roller systems disclosed herein may be utilized in different material modes, with different operational properties and functions, although the above-described features and advantages are applicable to all of them. One mode is to provide a foraminous material 21 which is highly insulative, and therefore non-conductive to the bias voltage supply. Another mode is to provide a foraminous material which is resistive, but at least semi-conductive, such as an electrically relaxable material as disclosed in the above-cited references on bias transfer rollers. In this second mode at least part of the transfer bias charge will be conducted out toward the outer surface of the transfer roller.

The wide lateral extent of the roller contact area and its relatively even pressure insures that the air gap between the outer surface of the roller and the support surface is small and substantially constant to well outside of the normal nip areas, thereby suppressing arcing or undesired corona. No larger air gaps which would induce ionization are formed until the distance from the conductive core is so great that the field intensity or stress in the air gaps is below the ionization potential, i.e., the field intensity is greatly reduced by the time the larger pre or post-nip air gap is formed. With the foraminous roller, the normal position of the pre-nip and post-nip gaps can be greatly laterally displaced, yet simultaneously the distance between the conductors forming the transfer field can be made very small. These two inter-related desired criteria cannot be effectively met by a solid roller. They can be readily met by a foraminous roller body which is sufficiently thick and sufficiently compressible.

A much larger and more uniform mechanical contact area of a foraminous roller surface with any paper between it and a photoreceptor provides greatly improved mechanical tacking of the paper to the photoreceptor. Further, due to the fact that the foraminous material 22 of the transfer roller 15 expands to its normal thickness everywhere except in the nip area 17 (and its entrance and exit), the outer surface 24 of the roller can be substantially spaced from the conductive core 22. This allows a sheet of paper 16 or other second support to be held against the roll surface 24 before and after the sheet contacts the photoreceptor 11 without being charged by the bias voltage and in sufficiently low fields so that undesired arcing or corona in the feeding or stripping off of the sheet from the transfer roll 15 is not a problem.

The transfer roll 15 provides positive vacuum retention of the cut sheet 16 on its outer surface 24 from before the pre-nip area until substantially after the post-nip area. This is provided here by applying a uniform vacuum on the interior of the foraminous material in these areas so that the paper is uniformly positively mechanically tacked by air pressure to the surface 24. Even though the foraminous material 22 is relatively thick the open cell structure provides a multiplicity of small air passages from the outer surface 24 to the interior surface, where the air then passes through the perforations 37 in the perforated conductive core tube 22. Only the portion of the roller 15 encompassing the initial sheet registration, pre-nip and post-nip areas need to be subjected to the vacuum. Blocking of the vacuum to the rest of the roll may be accomplished as shown here by a stationary semi-cylindrical manifold tube 23 which slideably abuts most of the interior surface of the perforated tubular core 22 to block the air passageways 37 in all but the desired vacuum area (in which the manifold 23 is cut away). A Teflon or other lubricant surface may be provided therebetween. With this configuration the manifold 23 may also provide the support for rotation of the roll 15. However, the roll 15 may also be rotatably mounted by the core 22 providing suitable electrical insulation is provided at the ends of the tube. The vacuum means 18 may be applied at one end of the interior of the manifold 23, and the other end sealed.

The foraminous vacuum roller 15 provides significant advantages over a perforated roller in that the air path length is not limited to the thickness of the insulative material. Rather the foraminous open cell material has highly convolute air passageways therethrough. These passageways have extensive lateral convolutions and discontinuities and do not provide direct axial spark discharge paths therethrough. Thus, the foraminous material provides a substantial ionization control barrier capable of controlling or suppressing much higher intensity electrostatic fields than an air gap of equivalent thickness. The spark discharge air paths through the material are very much longer than the radius or thickness of the foam layer even when the material is uncompressed. Thus, the foraminous material provides a cellular structure which is sufficiently convolute so as to effectively not provide air breakdown paths, yet provides sufficient air permeability for applying a vacuum to its outer surface 24.

Additional means which may be provided in the transfer system 50 include a blower or puffer 25 for blowing air into the post-nip area. This assists in the stripping of the sheet 16 from the roller 15. As the leading edge of the sheet 16 comes out of the nip 17 it may tend to adhere to the photoreceptor 11 in spite of the vacuum being applied to it by the vacuum means 18 through the foraminous material 21 as the material expands in the post-nip area. This is because air cannot easily get under the paper 16 (between it and the photoreceptor) except by surface irregularities to provide the necessary air pressure differential lift. The puffer 25, although not essential, assists in blowing air under the sheet 16 and giving it sufficient lift to make its initial separation from the photoreceptor 11. Once that is effected the vacuum force from the transfer roller 15 is sufficient to overcome the gravitational and/or beam strength forces of the sheet and to hold the sheet on the roller 15 until the sheet passes through the post-nip region and reaches the area of the transfer roller 15 in which the vacuum force is cut off by the stationary manifold 23. At that point the spacing of the surface 24 away from the charged core 22 and the weight and beam strength of the paper allows the paper to readily strip itself away from the surface 24 so that it can be carried away by conventional sheet feed-out means 26.

It will also be noted that the convolute and small diameter air passageways through the foraminous layer provide a relatively high resistance to rapid air flow therethrough. This protects against excessive vacuum losses in areas of the roller surface 24 which are not covered by a sheet 16 at any given time, so that the vacuum in other areas is not effected.

It will be noted that with the disclosed arrangement that the transfer roller 15 is preferably positioned above the photoreceptor 11 at the nip, and that the segment of the transfer roller 15 to which the vacuum is applied (i.e., the pre-nip and post-nip areas) is in the lower-most sector of the transfer roller. With this arrangement the weight of the paper may be utilized in stripping it from the transfer roller 15. However, this arrangement is merely exemplary and if a reversed arrangement is utilized a positive air pressure may be applied in the area of the manifold 23 (rather than merely blocking the vacuum in that area) for positive paper expulsion from the surface 24, utilizing the same air passageways in the foraminous material.

Another feature which may be provided in the transfer system 50 is a system for cleaning the exterior surface 24 continuously as the roller 15 rotates. This is provided here by a stationary hollow vacuum tube 26 deformably engaging the surface 24 as the surface passes under it. The tube 26 is stationed substantially away from the nip 17 so as not to interfer with the transfer operation. A vacuum is applied through apertures in the wall of the tube engaging surface 24 for removing toner or paper lint, etc., which may otherwise accumulate on surface 24. It may utilize the same, or separate, vacuum means.

Accurate registration of the incoming sheet of paper 16 or other final support member in the transfer station 50 is extremely important. The sheet 16 must be accurately aligned with the position of the electrostatic latent image on the photoreceptor 11 in order for that image to transfer to the paper 16 in the proper position. This registration is normally accomplished by control of the position and timing of the lead edge of the paper 16 as it directly enters the transfer nip 17. However, there is disclosed and claimed herein, a simple and inexpensive novel registration means based on a formaminous roller. This is illustrated here by the exemplary registration lip 27 on the outer surface 24 of the roller 15. The initial registration operation is illustrated by the alternate (dashed line view) position of the paper 16 and the registration lip 27, in contrast to the solid line position of these elements. Another alternate position dashed line view of the registration lip 27 shows its fully flattened configuration in the nip 17.

As may be seen, the sheet 16 is fed in toward the roller 15 by a feed-in roller 28 and an underlying guide plate 29, or other suitable feed means. However, rather than being fed directly into the nip 17 with registration fully controlled by the feed roller 28, in this case the lead edge of the paper 16 is fed into abutment with the surface 24 of the roller 15 substantially spaced from the nip. This is shown by the dashed view (unbuckled) position of the paper 16. The rotation of the roller 15 is coordinated therewith so that the registration lip 27 at that point provides a stop for the lead edge of the paper 16. The input speed of the paper 16 provided by the feed roll 28 is such as to form a buckle of the sheet 16 between the feed roller 28 and the transfer roll 15 as shown. The registration lip 27, however, prevents the lead edge of the paper from sliding on the surface 24 and therefore maintains the registration of the sheet 16 at all times until it is fed into the nip 17. The vacuum applied to the sheet 16 holds it down against the surface 24 behind the registration lip 27 so that it cannot lift or be driven over this lip, i.e., the sheet lead edge may move slightly into abutment with the lip 27, but cannot pass over it.

The general function of grippers or paper stop recesses in transfer rollers and their function is known in the art, as exemplified by the above-discussed U.S. Pat. No. 3,633,543, and accordingly need not be discussed in detail herein. The unique structure and function of this particular registration means relates to the foraminous layer 21 of the roller 15. In prior art devices the sheet registration gripper or lip has generally necessiatated a discontinuity in the roller surface. This discontinuity, continuing as the registration lip passes through the nip region, interferes with the transfer operation by creating uneven fields or air gaps or by masking from transfer a portion of the lead edge. In contrast, the registration system disclosed herein provides position mechanical sheet registration lips which do not create any discontinuity or interruptions in the nip region and does not affect transfer in any way.

This is possible because the registration lip 27, even though it may extend radially substantially above or below the normal surface 24 of the roller 15, can be fully crushed or compressed in the nip to the same surface level as the adjacent areas of surface 24. As long as the foraminous material 21 is not compressed or crushed in the nip to its full extent (its solid height) the lip will not even cause a "bump". Thus, in addition to eliminating any air gap discontinuities, vibration or uneven pressure problems associated with the passage of the registration lip through the nip are also eliminated. The lip is easily compressed into the layer of underlying foraminous material 21.

The registration lip 27 is preferably monolithically molded as an extending rib in the same formation process as the rest of the foam material 21 so as to be homogeneous therewith. However, where, as here, the depth of foraminous material underlying the lip is substantially greater than the height of projection of the lip above the surface 24, it can also be formed of solid rubber or other suitable materials which are integrally molded or bonded in or to the foraminous material. As long as the foraminous material is not fully compressed, the registration rib will simply emerse itself in the foraminous material in the nip as shown and not affect the nip 17 characteristics. The lip member (or lip forming recess) is pressed into smooth, even alignment with the rest of the surface 24 in passing through the nip, to provide smooth even contact with the opposing sheet feeding surface (the photoreceptor 11 in this case). The lip forming rib is shown here as rectangular in cross section. However, it could be provided in various other configurations, such as a saw-tooth, etc., since only a trailing face or notch is needed for registration of the sheet lead edge. It will also be appreciated that the term "sheet" used herein includes both cut sheets and the lead edge of a web from a roll supply which is subsequently severed to define a sheet.

The drive means for sheet feeding in the disclosed embodiment is the moving photoreceptor 11, which in turn may be driven by its support roll **12.** This frictionally drives the roll **15** and sheet **16** through the nip. However, the roll **15** itself may be rotatably driven if desired.

In conclusion, it may be seen that there has been described herein a foraminous roll sheet registration system providing greatly improved operating properties and paper handling. It will be obvious that the disclosed system is applicable to many sheet registration applications other than the one specifically discussed above.

The exemplary embodiments described herein are presently considered to be preferred; however, it is contemplated that further variations and modifications within the purview of those skilled in the art can be made herein. The following claims are intended to cover all such variations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A sheet registration system comprising:

a sheet feeding roller having a thick layer of compressible foraminous material and a generally smooth outer sheet feeding surface;

at least one sheet registration lip comprising a sheet edge detaining discontinuity in said outer surface of said roller;

an opposing sheet feeding surface against which said foraminous material layer is compressed with moderate pressure to provide a sheet feeding nip therebetween; and

drive means providing sheet feeding movement of said outer surface of said roller and said registration lip through said nip,

said registration lip being temporarily resiliently suppressed by compression into said foraminous material layer smoothly and evenly with said outer surface of said roller in passing through said nip, and

said roller providing continuous even contact between said outer surface thereof, including said registration lip, and said opposing surface in said nip,

wherein said registration lip is monolithically formed from said same foraminous material.

2. The system of claim **1** wherein the thickness of said foraminous layer is substantially greater than the dimensions of said registration lip discontinuity.

3. The system of claim **1** wherein said roller is generally cylindrical and has an axis of rotation and said registration lip comprises an integral rib extending radially above and axially along said roller outer surface parallel to said axis of rotation.

4. The system of claim **1** further including sheet feeding means for feeding a sheet into buckling engagement with said registration lip while said registration lip is substantially spaced from said nip.

5. The system of claim **1** further including vacuum means applying a sheet retaining vacuum to said outer sheet feeding surface of said roller through said foraminous material.

6. The system of claim **1** further including vacuum cleaning means deformably engaging the outer surface of said roller.

7. The system of claim **1** wherein said roller is generally cylindrical and has an axis of rotation and said registration lip comprises an integral rib extending radially above and axially along said roller outer surface parallel to said axis of rotation, and wherein the thickness of said foraminous layer is substantially greater than the dimensions of said registration lip discontinuity.

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