United States Patent

[11] 3,538,837

[72] Inventor **Roland Moraw**
Wiesbaden-Biebrich, Germany

[21] Appl. No. **730,699**
[22] Filed **May 21, 1968**
[45] Patented **Nov. 10, 1970**
[73] Assignee **Keuffel & Esser Company**
Hoboken, New Jersey
[32] Priority **May 26, 1967**
[33] **Germany**
[31] **1,572,289**

[54] **PHOTOCOPY DEVELOPMENT METHOD AND DEVICE**
12 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** **95/94,** 95/89
[51] **Int. Cl.** **G03d 3/12**
[50] **Field of Search** ..... 95/89(GAS), 94(GAS), 89(MISC)

[56] **References Cited**

UNITED STATES PATENTS

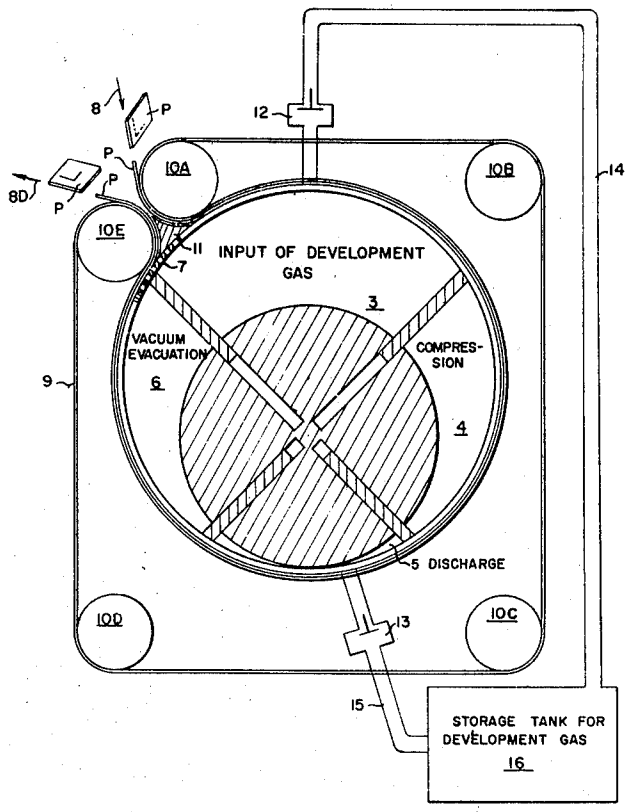
2,542,381	2/1951	Veyret	95/89(GAS)UX
2,878,742	3/1959	Trump	95/94(GAS)UX
3,417,686	12/1968	Hildebrand et al.	95/89(GAS)UX

FOREIGN PATENTS

317,152	12/1956	Switzerland	95/94(GAS)UX

Primary Examiner—Norton Ansher
Assistant Examiner—Richard L. Moses
Attorney—J. Russell Juten, Peter F. Willig, Lionel N. White and Milford A. Juten

ABSTRACT: A device and continuous method of developing photocopies with a developing vapor wherein a photocopy bearing a latent image is exposed to such vapor under varying operating pressures during development. Diazotype material may thus be conducted through a developing cycle and sequentially exposed, through a series of development chamber segments, to ammonia gas of increasing pressure to accelerate development and then to partial vacuum to remove entrained ammonia from the developed copy. A preferred device embodying the invention includes a vaned rotor located within the internal chamber and through rotation of the rotor effects a cycling expansion and reduction in the volumes of individual chamber sections. Ammonia gas within such chamber sections are thereby caused to be cyclically reduced and increasing in pressure during the development cycle. Exposed photocopy sheets are conveyed through the development cycle between an inner pervious belt and an outer impervious belt.



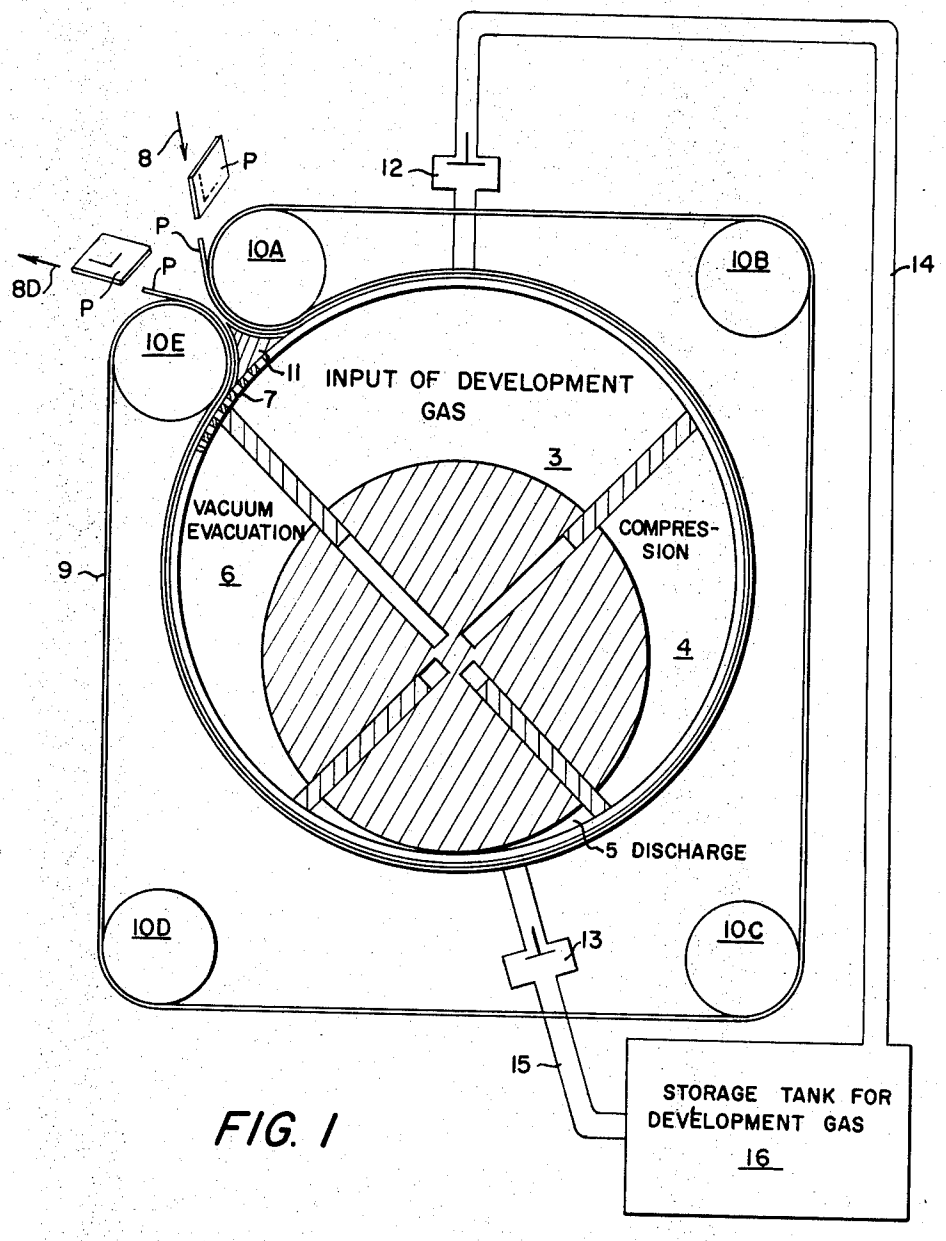


FIG. 1

Roland Snoraw
by Trifford A. Juten
atty.

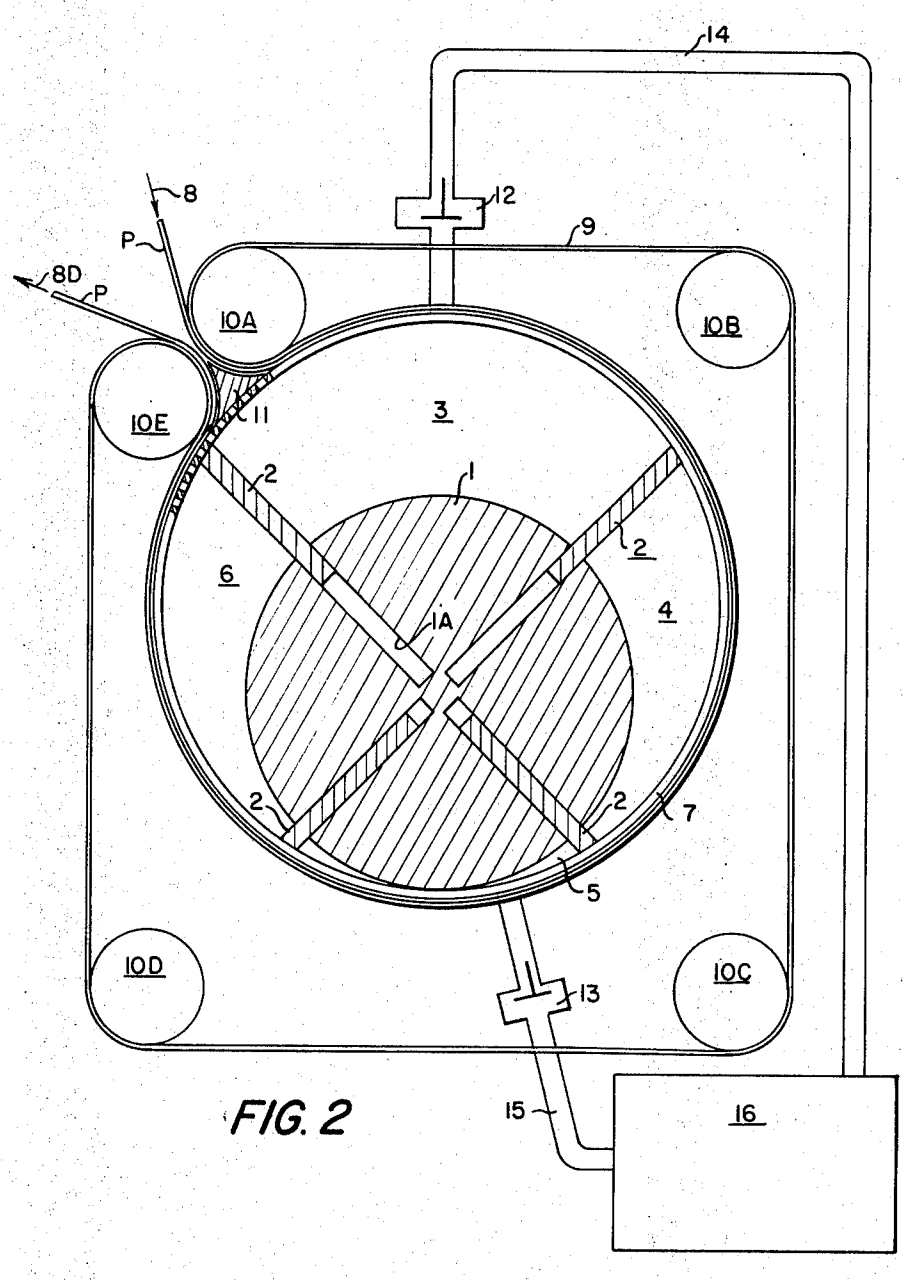


FIG. 2

Richard Morgan
by Milford A. Juten
atty.

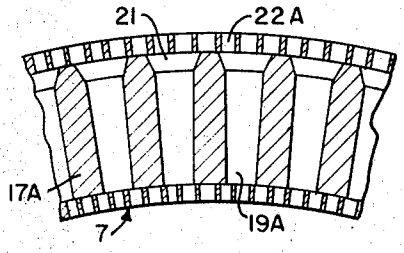


FIG. 3A

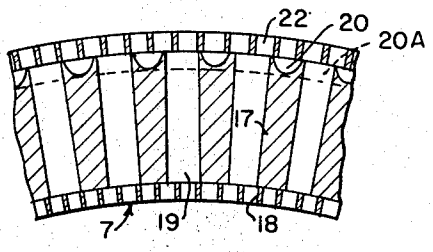


FIG. 3

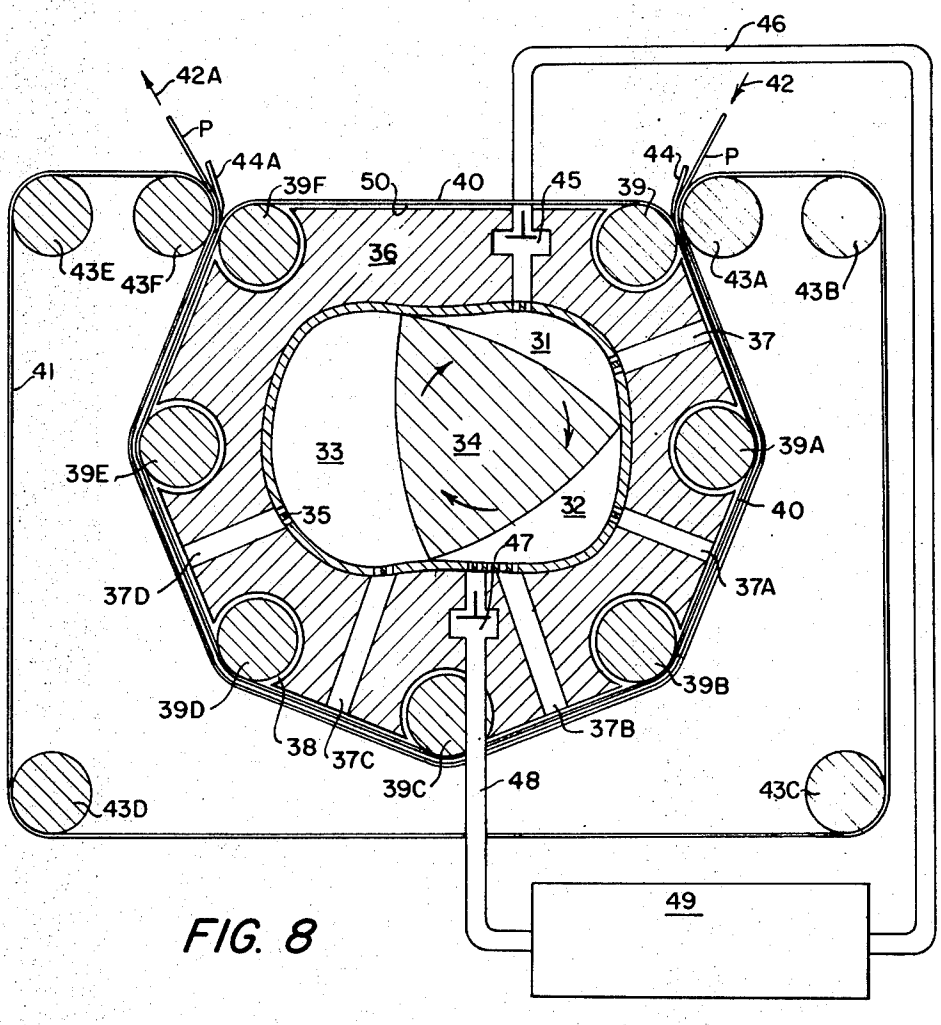


FIG. 8

Roland Thoraw
by Milford A. Juten
atty.

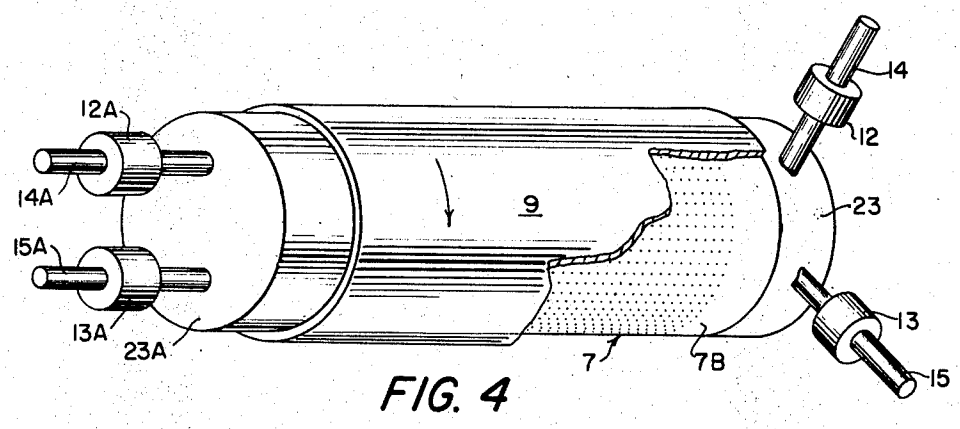


FIG. 4

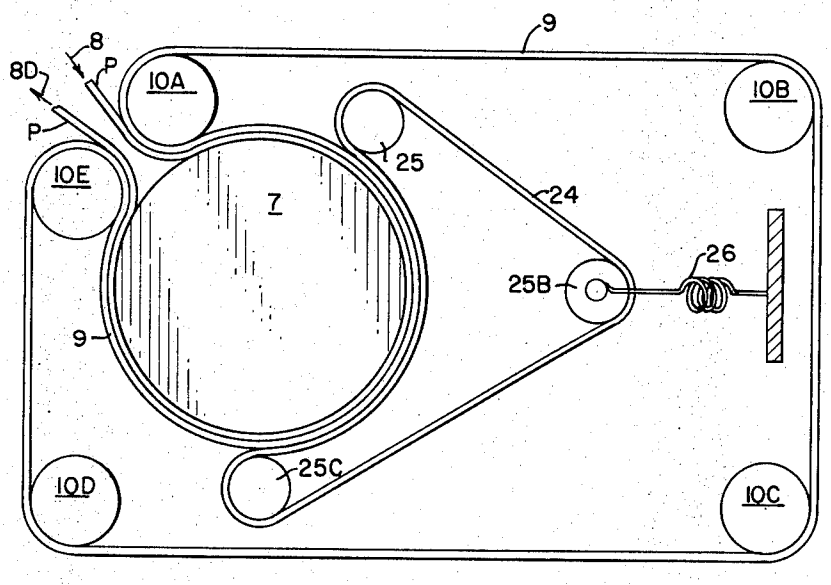


FIG. 5

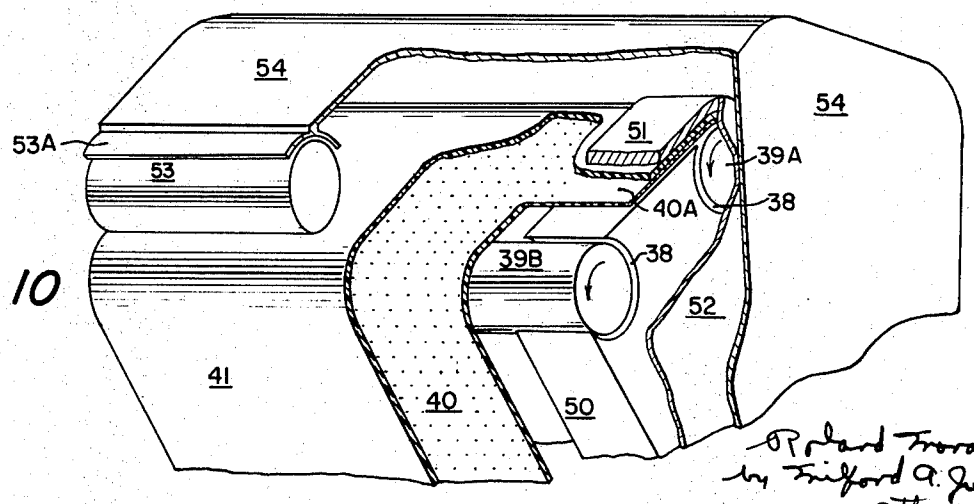


FIG. 10

Roland Trovaw
by Milford A. Juten
atty.

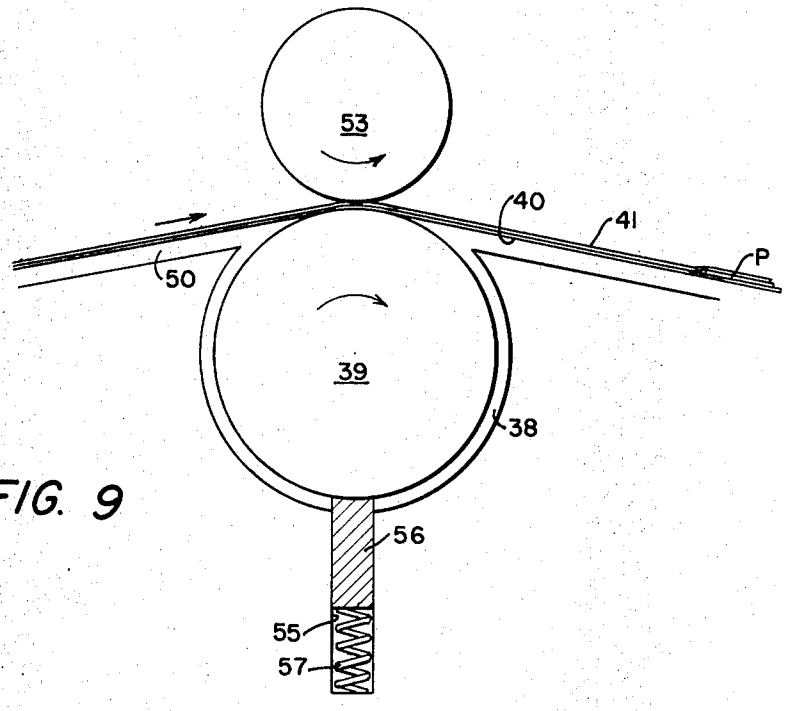


FIG. 9

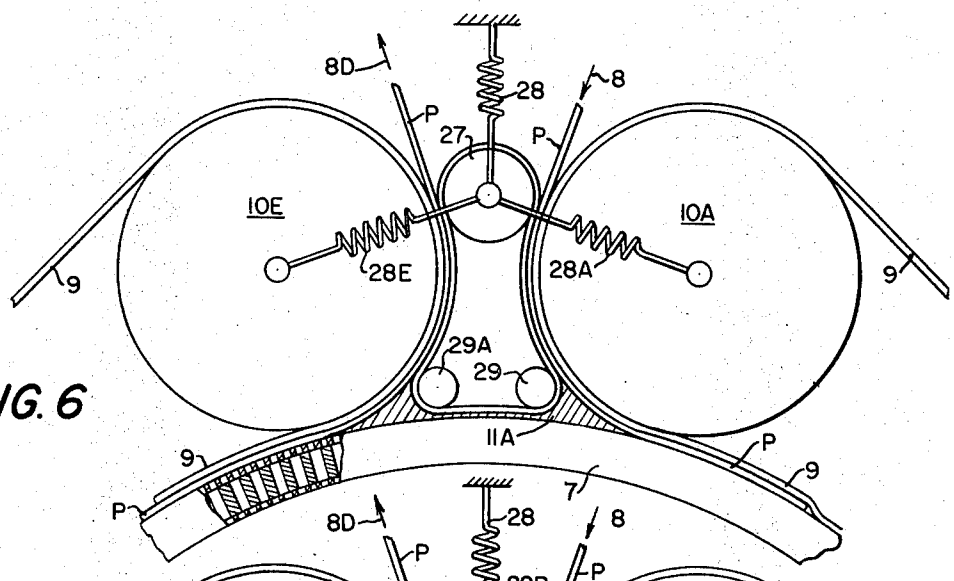


FIG. 6

FIG. 7

Roland Thomas
by Milford A. Juta
atty.

PHOTOCOPY DEVELOPMENT METHOD AND DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a process for developing exposed photoprinting material by means of a gaseous developer. Photoprints, such as diazotype copies, have been developed in a known manner in humid gaseous ammonia. The known devices used for this purpose contain a developing chamber in which the exposed print is guided through such gaseous ammonia and the ammonia gas escaping from the development chamber is blown off through a ventilating shaft into the atmosphere thereby polluting the atmosphere. However, traces of ammonia still adhere to the finished photocopies so that such finished photocopies retain the objectionable odor of ammonia.

The prior art apparatuses and processes have the disadvantage that the development proceeds comparatively slowly and this slow development limits the speed of making copies. The presently known powerful light sources for exposing the highly light-sensitive diazo compounds are capable of enabling the construction of copying devices having a considerably higher copying speed; however, it has not heretofore been possible to speed up the development which follows the exposure. In the combined apparatus where the exposure and development takes place in a single piece of equipment the relatively low developing speed is evident particularly when processing materials comprising plastic films as supports. Consequently, the prior art equipment does not take full advantage of the powerful light sources and the highly light-sensitive diazo compounds.

Heretofore it has been suggested to develop diazotype microfilms in a relatively small developing chamber by evacuating the chamber and then filling it with gaseous ammonia under pressure. This batch process results in a considerably shorter developing time, but this advantage is largely lost by the fact that the process works discontinuously and is therefore adaptable for use for specific purposes only with copying materials of small size.

SUMMARY OF THE INVENTION

An object of the present invention is to provide development apparatus and a method for high-speed gas development which overcomes the disadvantages of the prior art.

Another object is to provide for continuous developing process and apparatus therefor which is suitable for large runs of copies of normal size and which operate at higher speeds than the heretofore known processes and yields prints with less ammonia odor.

The present invention provides a continuous process for developing photoprinting material by means of a gaseous developer in which the material is conducted through a closed developing chamber. The material is progressively led through chamber sections or zones of different gas pressures which pressures are arranged in such a manner that the pressure acting upon the photocopy material increases to a pressure well above atmospheric pressure and then decreases to a pressure well below atmospheric pressure. Thus, each increment of the material to be developed is first exposed to a gaseous developer pressure which increases to a maximum value above normal pressure whereby the development is considerably accelerated by the additional pressure, and then, after completion of the development the photocopy is substantially freed from the gaseous developer. The gas which is normally ammonia, is removed from the photocopy by gradually decreasing the pressure until pressures below normal atmospheric pressure are obtained. This reduced pressure on the photocopy is applied just before the photocopy leaves the developing apparatus and such low pressure or vacuum removes substantially all of the gas so that the photocopy has very little odor of ammonia.

The process of the invention provides for more rapid development of the photoprints because of the increased pressure of the development gas in contact with the latent image.

Briefly, one form of a suitable apparatus is similar to a rotary pump having a plurality of radially movable vanes mounted in a rotating hub with the rotating hub eccentric to a hollow cylindrical casing or drum. The cylindrical portion of the casing is provided with pores through which development gas may pass and the porous cylindrical drum portion is adapted to rotate relative to end wall bearings and carry photocopy prints. The photocopy prints are maintained in gas-contacting relation with the outer surface of the porous rotatable cylindrical portion by means of an impervious belt which is guided by rollers and provides for an entrance and exit for the photocopy prints. As the photocopy prints pass over various portions of the modified rotary pump, development gas is brought into contact with the photocopy and such gas is compressed against the photocopy to increase the speed of development and after the photocopy is developed under the high pressure of the development gas, the development gas is removed through a control valve and piped into a storage tank for reuse. The photoprint is then subject to a reduced pressure or vacuum which removes substantially all of the remaining development gas which may be occluded and when the print passes though the exit, the print is substantially odorless.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic illustration of the invention illustrating the different pressure in the different zones and showing an exposed photocopy being fed into the machine and a completely developed odorless copy being delivered therefrom.

FIG. 2 is a central radial section of the apparatus in FIG. 1 showing the rotary pump impeller with four radially projectable vanes engaging the porous cylinder with the vanes radiating from a rotating hub eccentrically mounted in the housing.

FIG. 3 is an enlarged fragmentary radial section of the hollow porous cylinder showing grooves to distribute the gas.

FIG. 3A is a fragmentary radial section of another embodiment showing flaring bores to distribute gas.

FIG. 4 is a side perspective of the rotating porous cylinder mounted in end bearing showing the impervious belt partly broken away to show the substantially solid end portions of the hollow cylinder and also showing two ways of supplying and removing gas from within the porous cylinder through the end bearings.

FIG. 5 is a diagrammatic illustration showing how additional pressure can be applied on the impervious belt by an auxiliary belt to permit higher development pressures.

FIG. 6 is a fragmentary enlarged view of one way for positive control of the admission and discharge of the photocopies using an auxiliary feed belt.

FIG. 7 illustrates another embodiment for feeding and removing the photocopies using a porous belt overlying the hollow porous cylinder with a loop in the porous belt for feed and discharge of the photocopies.

FIG. 8 is a radial sectional view of another embodiment of the apparatus using a porous belt guided by rollers over a polygonal-shaped pump casing.

FIG. 9 is an enlarged radial section of one of the guide rollers of FIG. 8, showing how one section is sealed from the pressure in an adjacent section.

FIG. 10 is a fragmentary perspective of a portion of the apparatus of FIG. 10 showing how one section of the chamber is maintained in sealed relation to an adjacent section by an auxiliary pressure roller.

PREFERRED EMBODIMENTS

Referring more specifically to the drawings, FIGS. 1 and 2 show one form of the apparatus using the principle of the rotary vacuum pump in which a rotating hub 1 is mounted for rotation in suitable end wall bearings 23, 23A and such hub is provided with slots 1A in which vanes or slides 2 are mounted for radial movement and in the position shown in FIG 2 the vanes define zones or sectors 3,4,5, and 6. A hollow cylindri-

cal porous wall 7 which is rotatably mounted in bearings 23, 23A defines the peripheral wall of the pump chamber and with the vanes 2 and hub 1 form the chamber sectors 3,4,5 and 6 to define the input, compression, discharge, and vacuum chamber sectors respectively, as indicated in FIG. 1. The cylindrical porous drum 7 has impervious end portions 7B, as shown in FIG. 4 and the drum is rotatably mounted on the end wall bearings 23, 23 for rotation in the direction of the arrow V2. An impervious endless belt 9 is guided by rollers 10A to 10E, respectively, around substantially the entire periphery of porous cylinder 7 and is of a width to overlap the nonporous end portions 7B and such belt is driven at a velocity V2 to carry photographic prints P in a circumferential path through the various development zones and discharge the developed print at the discharge roller 10E. A prism-shaped saddle guide 11 of generally triangular section serves to guide the prints into proper feed position and to assist in the discharge of the prints. Guide 11 may have teeth which extend into grooves in the outer periphery of the porous cylinders 7 to positively assure discharge of the completely developed print along line 8D. The belt 9 is driven by any suitable means at a speed V2 determined by the time required for development, which speed is the same as the speed of rotation of porous cylinder 7. The rotor 1 with the vanes 2 is rotated at a considerably higher speed V1 and as rotor 1 rotates the vanes 2 serve to produce a low pressure in the zone 3 to permit the flow of development gas from tank 16 through the inlet pipe 14 through controlled inlet valve 12 into the chamber sector or zone 3. The gas in sector 3 is carried into the sector 4 by the vanes 2 and is compressed therein by the reduction in the volume of the sector defined between the adjacent vanes, and adjacent portions of the rotor hub 1, the porous cylinder 7 and belt 9 so that a print P positioned on the drum in this zone 4 is subject to increased gas pressure with resultant increase in the speed of development of the print and as the rotor 1 continues to rotate the gas between adjacent vanes 2,2 is discharged from zone 5 through discharge control valve 13 and pipe 15 back to the storage tank 16 for reuse. As two adjacent vanes 2 move into zone 6, the volume between the vanes is increased thereby producing a vacuum in zone 6 and such vacuum is carried through the porous cylindrical member 7 to the print thereby removing the development gas from the print and the completely developed print is then discharged along device 11 as indicated by the arrow 8D. The speed of rotation V1 of the rotor is greater than the speed of rotation V2 of the porous cylinder 7, to maintain the relative pressures even though some leakage may occur. An example of the structure of the porous cylinder wall or drum 7 is shown in FIG. 3 where a section of a rigid hollow metal cylinder 17 is provided with numerous borings 19 between its arcuate interior and its arcuate exterior. The inner wall of such hollow metal cylinder is lined with a perforated metal sheet 18, advantageously a stainless steel sheet. Such sheet up to a thickness of 0.3 mm. may be perforated by means of electron beams, *e.g.*, providing pores of a diameter of about 10 to 100 μ and a density of 1000 to 2,000 pores per cm^2. The outer surface of hollow metal cylinder 17 is also provided with a porous layer 22. For better distribution of the developer gas on the surface of the photoprinting material, the outer surface of the rigid hollow cylinder 17 may be provided with intersecting grooves 20 which extend circumferentially and grooves 20A which extend axially to assure complete distribution of the gas over the surface of each photoprint P. According to the embodiment of FIG. 3A, the outer ends of borings 19A through hollow cylinder 17 have funnel-shaped flarings 21 to uniformly distribute gas and this outer surface is in turn covered with a porous material layer 22A similar to porous layer 18 or of other material such as feltlike material.

Upon reference to FIG. 4 showing the hollow porous cylinder 7 is rotatably mounted in end bearing walls 23, 23A it will be noted that the end portions 7B of the porous cylinder 7 have the pores omitted and the the impervious belt 9 overlaps such impervious unperforated portions 7B of the hollow cylinder 7 to thereby provide a gastight chamber within the hollow cylinder 7 when the impervious flexible belt 9 is in sealing contact with the hollow cylinder 7.

FIG. 4 also shows supply pipe 14 from tank 16 connected through its control valve 12 in a radial direction to end wall bearing 23 and the discharge pipe 15 from tank 16 connected through its control valve 13 to the end wall bearing 23 in a radial direction. FIG. 4 also shows supply pipe 14A connected through control valve 12A in an axial direction to end wall bearing 23A and the discharge pipe 15A and its control valve 13A connected radially to such end wall bearing 23A and either or both systems of connection may be used.

In FIG. 5 an auxiliary endless pressure belt 24 passing over guide rollers 25, 25B and 25C is tightly pressed against impervious belt 9 to additionally increase the pressure thereon in the compression zone 4 to prevent leakage of the development gas and permit higher development pressures. The pressure of such auxiliary belt 24 is controlled by a spring 26 connected to the bearings of roller 25B and is adjustable to the desired pressure required to prevent leakage.

A special embodiment of the photocopy feeding and discharge guide is shown in FIG. 6 where a saddlelike device 11A is attached to the apparatus in a manner such that the hollow cylinder 7 may rotate therepast while being sealed thereby. An auxiliary feed guide belt 30 guided by rollers 29, 29A and 27 suitably mounted for rotation facilitates the transport of the copy during the feed-in and the delivery. Rollers 10A, 10E, and 27 are resiliently pressed upon one another by means of the diagrammatically illustrated coil springs 28, 28A, and 28E reacting through the bearings of the rollers 10A, 10E, and 27 to produce the feeding action.

The cylinder 7 is provided with circumferential parallel grooves similar to circumferential grooves 20 into which comb teeth formed on the member 11A extend to effectively strip the prints from the cylinder and guide such prints along the surface of belt 9 and feed belt 30.

In FIG. 7 another embodiment of feed-in and discharge structure is shown in which the cylinder 7 is surrounded by the porous outer layer 22B which is in the form of a belt. The belt 22 has pores 22C therethrough which are similar to the pores in the porous layer 22A, but the porous layer 22B may be porous plastic material, for example. A saddle member 11B may be provided to seal the exposed portion of the cylindrical porous member 7. The porous belt 22B is guided against impervious belt 9 by roller 27A which is resiliently supported to maintain a bight or loop in the porous belt 22B by springs 28, 28A and 28B.

FIG. 8 illustrates another form of apparatus which operates according to the principle of an internal combustion engine with revolving piston (known as "Wankel" engine), including a casing or casting 36 and rotor 34 and is similar to the apparatus shown in FIG. 2 in having different pressures produced in different sectors or zones of the chamber. The triangular rotor 34 is driven by planetary gearing and rotates eccentrically within the chamber dividing it into different zones or sectors 31, 32, and 33. Although the entire inner periphery of the chamber is shown covered by the porous layer 35, it is only essential to have the porous layer overlying the borings 37, to 37D, inclusive, which pierce the casing 36 of the chamber. Transport rollers 39 to 39F are rotatably supported on the casing 38 by means of bearings 38 of any suitable construction to effectively support such rollers 39. An endless gas-permeable belt 40 which may be a perforated polyester web passes around the rollers 39 to 39F to carry the prints P and permit gas to contact the prints from the chamber. A gas-impermeable belt 41 is superimposed upon the belt 40 and surrounds a major portion of the casing 36 and the two belts move together in the direction of the arrows 42 and 42A which indicate the admission and delivery of photocopies. The belt 41 is guided over guide rollers 43A, to 43F and the belts 40 and 41 come together at the copy inlet station adjacent a feed guide 44 where a photocopy is introduced along arrow 42 and the belts separate at the copy outlet station where a copy guide 44A facilitates removal of the developed print along

arrow 42A. The belts are moved by a suitable drive at a speed corresponding to the rate of travel of the material to be developed. Normally, the rotor 34, which may be driven by a planetary gearing, revolves at a much higher speed than the speed movement of the belts. This device operates in a manner similar to that described above according to the principle of the rotary slide pump. When the rotor 34 rotates clockwise, a partial vacuum is produced in chamber section 31 and ammonia gas is delivered from tank 49 by pipe 46 through a control valve 45 into the chamber section 31. When the gas reaches the chamber section 32, it is compressed so that the highest pressure is reached approximately in the vicinity of the outlet through control valve 47 connected to pipe 48 and thereby to tank 49. The rapid development of the print takes place in the zone 32 of increased pressure. Reduced pressure is produced within the sector 33 and the borings 37C and 37D connected with this sector of the chamber cause this reduced pressure to act through the porous belt 40 on the photoprinting material, thus removing the ammonia adhering to the developed photoprint.

One way of sealing one of the sectors or zones 31, 32, and 33 from each other in the apparatus of FIG. 8 is shown in FIG. 9 where a slot 55 is provided in the casing 36 and a slide or vane 56 is slidably mounted in such slot and maintained in fluid tight contact with the roller 39 by compression springs 57 to maintain sealing pressure of vane 56 against the roller 39, thereby sealing the sector of the chamber on one side of a roller from the sector of the chamber on the other side of the same roller.

The lateral impervious edges of the porous belt 40 and the superposed impervious belt 41 are illustrated in FIG. 10 showing the edge portions of the belts being guided between a supporting surface 50 extending between adjacent guide rollers 39A, 39B and such marginal edges of the belts are enveloped by guide plates 51 which merge into the sidewall 52 at each edge of the apparatus and such guide plates may extend around the periphery of the rollers 39 to 39F thereby completely closing the ends of the apparatus with the sidewalls and the guide plates 51 integral therewith. It will be evident that suitable slots or openings will be provided for the emergence of the belt 41 and for the prints at the entrance 44 and the exit 44A.

FIG. 10 also shows a sealing roller 53 suitably supported in bearing means 53A which presses against the sandwich of belt 41 reacting against the belt 40 which reacts against its cooperating roller 39 to 39F to thereby seal off one sector of the pump chamber from another sector so that different pressures can be obtained in adjacent sections of the pump.

As explained above, different pressures are maintained in the different zones or sectors as the rotor of the pump rotates in the proper direction which is shown as clockwise in each of the illustrations and such rotor normally rotates at a higher rate of speed than the rotation of the belt or belts cooperating therewith and therefore the desired gas pressures can be maintained in the various sectors even though some leakage may occur.

The developing pressure of the gas to achieve an essential improvement should amount to at least several hundred millimeters of mercury, and the vacuum will be sufficient to remove the objectionable odor from the prints.

In the development of diazotype prints, heating elements may be provided in order to carry out the development at an increased temperature and thereby further accelerate the development process.

Exhaust devices are provided to remove small amounts of ammonia which may escape from the developing zones and such ammonia would collect within a housing 54 covering the apparatus and such escaping ammonia can be removed by suitable exhaust devices.

From the above description, it will be apparent that the present invention provides for rapid development of photoprints within a few seconds and the developed print has practically no odor of ammonia.

The above embodiments have been presented for the purpose of illustration and should not be taken to limit the scope of the present invention. It will be apparent that the described embodiments are capable of many variations and modifications which are likewise to be included within the scope of the present invention as set forth in the appended claims.

I claim:

1. Apparatus for the gas development of exposed photocopies having latent images thereon comprising:

a. a casing having a chamber therein;

b. a movable porous wall member mounted for movement with respect to said casing for supporting an exposed photocopy in communication with said chamber and defining a porous boundary wall of said chamber with the pores of said wall member communicating with said chamber;

c. a movable impervious wall member overlying said porous wall member and sealing said chamber against loss of gas;

d. said porous and impervious wall members being adapted to receive and confine an exposed photocopy therebetween convey said exposed photocopy through a development cycle, and discharge the developed photocopy at the completion of said cycle;

e. means within said chamber dividing said chamber into a plurality of chamber sections individually communicating with said porous wall, said chamber-dividing means being movable within said chamber while maintaining the respective integrity of said chamber sections, movement of said dividing means within said chamber effecting movement of said chamber sections in a path substantially concurrent with the conveyance of said exposed photocopy while individually cyclically reducing and expanding the volumes of said chamber sections;

f. a source of development gas;

g. inlet means communicating between said chamber and said source of gas;

h. outlet means communicating between said chamber and an atmosphere exterior thereof;

i. said inlet means, outlet means, chamber-dividing means being so relatively disposed that said inlet means and outlet means communicate respectively with different ones of said chamber sections; and

j. said inlet, outlet, and chamber-dividing means being so relatively disposed that at least one chamber section of cyclically reducing volume and at least one chamber section of cyclically expanding volume respectively communicate solely with said porous wall.

2. The invention according to claim 1 in which: said casing includes bearing end walls; said movable porous wall member is a hollow cylindrical drum rotatably mounted on said bearing end walls; and said impervious wall member is a flexible belt.

3. The invention according to claim 2 wherein: said chamber-dividing means comprises a rotor having a plurality of slidable vanes engaging the interior of said drum; said inlet means communicates with a chamber section of cyclically expanding volume; and said outlet means communicates with a chamber section of cyclically reducing volume.

4. The invention according to claim 1 wherein: said casing comprises a substantially solid casting comprising impervious walls defining the end walls of said chamber and bored walls defining sidewalls of said chamber; wherein said movable porous wall member is a flexible belt overlying said bored walls and having impervious edges forming a gas impervious seal with said chamber and walls; and wherein said movable impervious wall member is a flexible belt.

5. The invention according to claim 4 wherein rollers are provided for guiding said flexible belt and means are provided for cooperation with at least some of said guide rollers to effectively segregate one chamber section from another.

6. The invention according to claim 5 wherein sealing vanes cooperate in sealing relation with said guide rollers for said flexible belt.

7. The invention according to claim 2 in which an additional belt is arranged to apply a radially inward pressure on a said impervious flexible belt adjacent the chamber section having a pressure substantially above atmospheric.

8. A continuous method of gas development of exposed photocopies having a latent image thereon comprising feeding the exposed photocopy into communication with a first chamber section, introducing development gas at a relatively low pressure into said first chamber section, moving the photocopy into communication with a second chamber section while applying increased gas pressure in said second chamber section and thereby rapidly developing the photocopy in communication with the second chamber section, moving the photocopy into communication with a third chamber section, and removing the gas from said third chamber section and thereafter moving the photocopy into communication with a fourth chamber section and applying a greatly reduced pressure in said fourth chamber section whereby the development gas is substantially entirely removed from said photocopy.

9. The invention according to claim 8 in which the second and third chamber sections are in communication with each other.

10. The invention according to claim 8 in which heat is applied to increase the development speed.

11. The invention according to claim 1 wherein said outlet means communicates with said source of development gas.

12. The invention according to claim 4 in which an additional belt is arranged to apply a radially inward pressure on said impervious flexible belt adjacent the chamber section having a pressure substantially above atmospheric.