

April 29, 1958

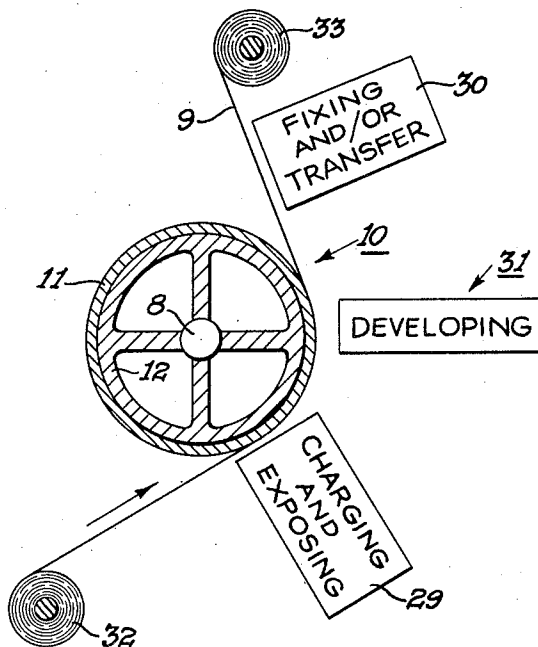
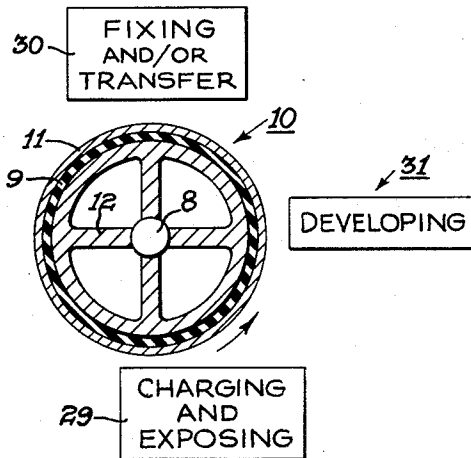
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2,832,311

APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGES

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2 Sheets-Sheet 1



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April 29, 1958

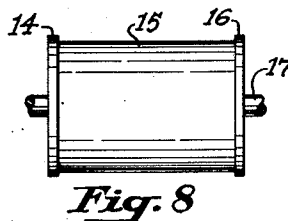
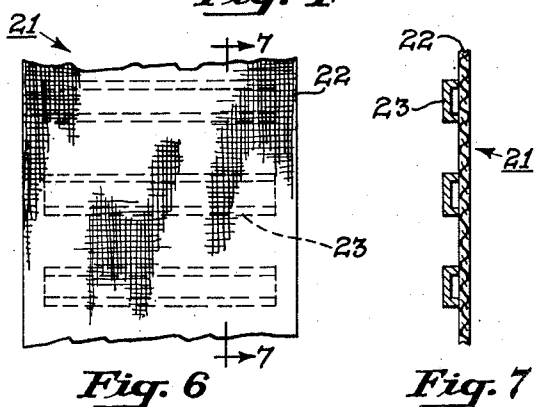
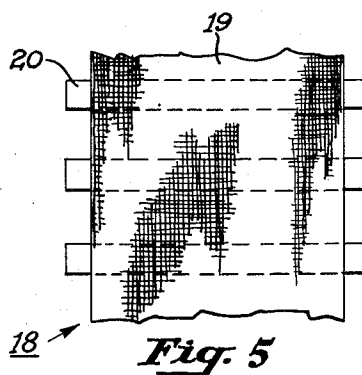
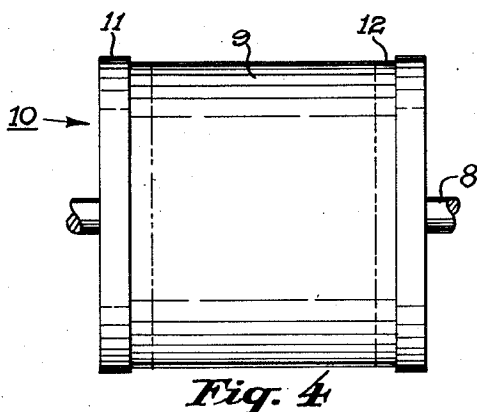
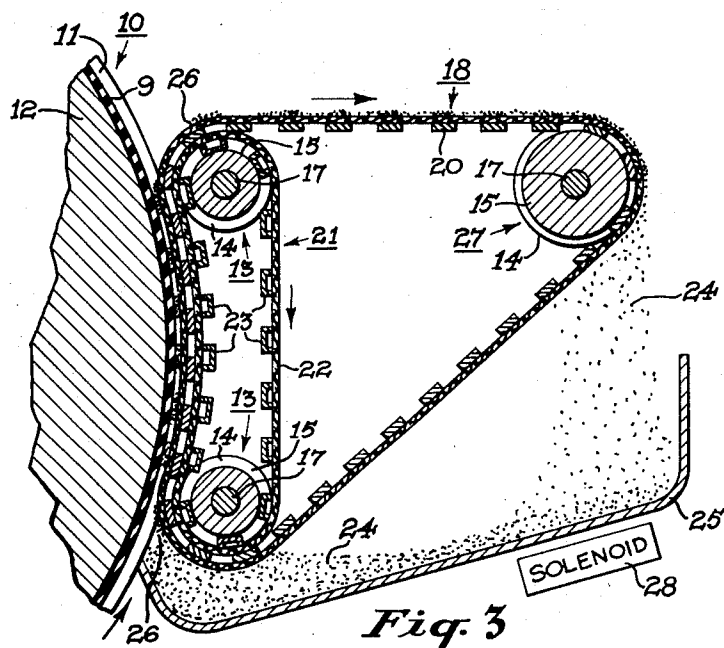
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APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGES

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2 Sheets-Sheet 2



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2,832,311

APPARATUS FOR DEVELOPMENT OF ELECTROSTATIC IMAGES

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Application January 10, 1956, Serial No. 558,293

6 Claims. (Cl. 118—637)

My invention relates to xerography and more particularly to improved means for applying electroscopic developer material on to a surface bearing an electrostatic image.

In xerography it is usual to form an electrostatic latent image on a surface. One method of doing this is to charge a photoconductive insulating surface and then dissipate the charge selectively by exposure to a pattern of activating radiation as set forth, for instance, in U. S. 2,297,691 to Chester F. Carlson. Other means of forming electrostatic latent images are set forth in U. S. 2,647,464 to James P. Ebert. Whether formed by these means or any other, the resulting electrostatic charge pattern is conventionally utilized by the deposition of an electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic latent image. Alternately, the electrostatic charge pattern may be transferred to an insulating film and the electroscopic particles deposited thereon to form the visible image. In any case this visible image, in turn, may be transferred to a second surface to form a xerographic print or may be fixed directly to the photoconductive surface.

The usual process of applying the developer to the latent electrostatic image is set forth in U. S. 2,618,552 to E. N. Wise and involves the use of a finely-divided colored material called a toner deposited on a slightly more coarsely divided material called a carrier. This two-component developer is cascaded across the electrostatic image areas. The toner and carrier being rubbed against each other while cascading impart an electrostatic charge to each other by triboelectric charging. To produce a positive of the electrostatic image a toner and carrier are selected such that the toner will be charged to a polarity opposite to that of the electrostatic image, the carrier being charged to the same polarity as the electrostatic image. When a carrier particle, bearing on its surface oppositely charged particles of toner, crosses an area on the image surface having an electrostatic charge, the charge on the surface exerts a greater attraction for the toner than the carrier and retains the toner in the charged area and separates it from the carrier particles. The carrier particles being oppositely charged and having greater momentum are not retained by the charged areas of the plate. When a toned carrier particle passes over a non-charged area of the plate, the electrostatic attraction of the carrier particles for the toner particles is sufficient to retain the toner on the carrier preventing deposition in such areas as the carrier particles momentum carries both toner and carrier past. By this mechanism, the image is developed, i. e. made visible.

It has recently been discovered that when a developer mix comprising a toner and a ferro-magnetic carrier material is contacted with a magnet so that streamers are formed which constitute a brush-like mass, and the brush then passed over the surface bearing the electrostatic latent image whereby the brush contacts the image-bear-

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ing surface, the developer is both triboelectrically charged and deposits on the electrostatic latent image in a manner similar to that wherein the toner and carrier mix is cascaded across the image-bearing surface.

5 An object of the present invention is to provide a novel means for applying electroscopic developer powder to an electrostatic image-bearing member.

Another object of this invention is to provide suitable means as set forth, wherein the developer mix is applied by a magnetically maintained brush.

10 A further object is to provide developing means as set forth, wherein electrostatic images may be continuously developed and wherein the supply of developer powder may be continuously replenished without interrupting the development process.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a reading of the following detailed description in connection with the accompanying drawings in which:

20 Fig. 1 is a side elevation, partly schematic, illustrating apparatus for practicing the overall xerographic process including the instant invention.

25 Fig. 2 is a side elevation, partly schematic, illustrating apparatus according to another embodiment for practicing the overall xerographic process including the instant invention.

Fig. 3 is a side elevation partly schematic and partly in section illustrating apparatus constructed in accordance with the present invention.

30 Fig. 4 is a plan view illustrating the electrostatic image-bearing member of Fig. 3.

Fig. 5 is a plan view in section illustrating the continuous non-magnetic belt of Fig. 3.

35 Fig. 6 is a plan view in section illustrating the continuous magnetic belt of Fig. 3.

Fig. 7 is a side elevation in section taken along the line 7—7 of Fig. 6 and looking in the direction of the appended arrows and,

40 Fig. 8 is a plan view illustrating tensioning and moving means of Fig. 3.

The apparatus to be described employing the invention in illustrative form, in general, comprises a continuous magnetic belt, means for moving and tensioning the belt relative to a photoconductive insulating surface, on the side of this moving and tensioning means away from the photoconductive surface a second means for tensioning and moving a continuous belt, a continuous non-magnetic belt between the first means and second means whereby one side of the non-magnetic belt is yieldably urged toward but not into contact with the photoconductive surface while the other side is in contact with the magnetic belt, means for spacing the non-magnetic belt from the photoconductive surface, means for supplying magnetic developer particles in contact with the non-magnetic belt at a point in its direction of motion prior to its proximity to the photoconductive surface and while in contact with the magnetic belt.

Referring now to the drawings in more detail, there is shown in Fig. 1 suitable apparatus for xerographically reproducing an image pattern of light and shadow. The apparatus comprises a drum 10 mounted to rotate on its axis 8. The drum 10 comprises a photoconductive insulating surface 9 coated on a conductive surface 12. The outer edges of conductive surface 12 have extending flanges 11. Positioned around the periphery of the drum 10 in the direction of motion of the drum are charging and exposing means 29, developing means 31, and fixing and/or transfer means 30.

70 In operation, the drum 10 is caused to revolve whereby a given portion of the photoconductive insulating surface 9 first passes under suitable charging means followed

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by exposure to a pattern of light and shadow to be reproduced at charging and exposure station 29. Any suitable charging and exposure means known to those skilled in the art, may be used, such as those shown in U. S. 2,543,051 to Oughton and Bixby or in U. S. 2,690,394 to C. F. Carlson.

After leaving the charging and exposure station 29, the portion of the photoconductive surface 9, now bearing an electrostatic latent image, passes through a development station 31, to be described in more detail later, whereby the electrostatic image is made visible by the deposition thereon of electroscopic powder particles in conformity with the electrostatic charge pattern.

The powder image on the photoconductive surface 9 now passes through a fixing and/or transfer station 30 where, desirably, the image is first transferred to a suitable support material as paper, plastic or the like and fixed thereto. Any such transfer and fixing means known to those skilled in the art may be used, such as, for example, those illustrated in U. S. 2,701,765 to Codichini, Benson and Mayo.

The photoconductive insulating surface 9 may consist either of a continuous film of a photoconductive insulating material such as amorphous selenium, sulphur, anthracene, mixtures thereof either with each other or with various additional materials such as tellurium etc. Alternatively, the photoconductive material may be placed on the support in the form of finely-divided particles in a binder composed of a highly insulating resinous binder. Suitable photoconductors for application in binder form include not only the above named photoconductive insulators but also photoconductive phosphors such as the oxides, sulfides and selenides of zinc and cadmium, mixtures thereof with each other, titanium dioxide, etc. Suitable insulating binders include silicone resins, vinyl resins, etc, as is well known to those skilled in the art. The photoconductive insulator, either in a continuous film or in a binder, is coated on the conductive surface 12 such as aluminum, brass, conductively coated glass, etc.

Alternatively the photoconductive insulating surface 9, rather than being coated directly on the conductive backing 12 as in Fig. 1, may be applied to a web or sheet as of paper, plastic or the like which is supplied from feed roll 32 to take-up roll 33, so positioned as to move the paper through the charging and exposure 29 and developing 31 stations in electrical contact with the conductive backing 12 of the drum 10 as shown in Fig. 2. A material highly suited for such a device is a suitable photoconductor as described above in an insulating binder coated on a paper backing. The method of operation of the device is the same as in Fig. 1 except that here the powder image need not be transferred from the photoconductive surface but instead may be affixed thereto at the fixing station 30 as by heat, solvent vapors or the like. A flux concentrating backing bar may desirably be positioned within the drum bearing the electrostatic latent image adjacent to the development station.

The developing apparatus is shown in detail in Figs. 3 to 8. Positioned adjacent to the drum 10 bearing the photoconductive insulating layer 9 are additional drums 13 comprising flanges 14 extending above the drum surface 15, thereby creating shoulders 16. The drums rotate about axis 17. Positioned on the drums 13 is a continuous magnetic belt 21. This belt may be formed by any means known to those skilled in the art. As shown, it comprises a sheet or web 22, as of plastic, cloth or the like having attached to one side thereof permanent magnets 23. The dimensions of drums 13 are so chosen that the magnets 23 ride on drum surface 15 while the web or sheet 22 rests on flanges 14. The drums 13 tension the continuous magnetic belt 21 and yieldably urge the magnetic belt toward the surface 9 bearing the electrostatic latent image. Suitable means as springs, electric motors etc. are used to drive one or both of drums 13

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either in the same direction as drum 10 or in the opposite direction to drum 10.

On the side of drum 13 away from drum 10 is a fourth drum 27. A continuous non-magnetic belt 18 is positioned between drums 13 and drum 27. This continuous non-magnetic belt 18 comprises a sheet or web as of cloth, plastic or the like, each having attached thereto rigid guide means 20 as of metal, plastic, wood or the like. Drum 27 rotates on axis 17 and together with drums 13 serves to tension non-magnetic belt 18.

Belt 18 passes around drums 13 externally from magnetic belt 21 and is yieldably urged toward contact with the electrostatic image-bearing surface 9 by drums 13. During the period of contact of belt 18 with drums 13 there is also contact with magnetic belt 21. Desirably, drum 27 is provided with suitable drive means as an electric motor, springs etc. to drive belt 18 in the same direction of travel as drums 13 drive magnetic belt 21. Desirably, although not necessarily, the speeds of drums 13 and drum 27 are adjusted to move belts 18 and 21 at the same rate of speed thereby decreasing frictional wear between the two belts. This common direction of motion of the two belts may be the same as or opposed to the direction of motion of drum 10. While drums 13 yieldably urge magnetic belt 21 toward contact with the image-bearing surface 9, the non-magnetic belt 18 prevents such contact but is itself urged toward contact with the image-bearing surface 9. However, rigid guide means 20 in belt 18 ride on flanges 11 of drum 10, thereby preventing direct contact between web or sheet 19 and the image-bearing surface 9. Thus the flanges 11 together with guides 20 position web or sheet 19 at a precise distance from the image-bearing surface 9. This spacing is not critical as long as the magnetic brush makes actual contact with the image surface 9. The spacing should not be too close, however, to prevent unnecessary abrasion of the image surface 9. In general, a spacing of about $\frac{1}{8}$ " has been found to be operable although this may be varied widely without departing from the instant invention.

Means are provided for supplying magnetic developer particles in contact with the non-magnetic belt, at a point in its direction of motion, prior to its proximity to the image-bearing surface 9 and while in contact with the magnetic belt 21, are also provided. In this case, a tray or similar reservoir 25 holds a supply of magnetic developer particles 24 in contact with non-magnetic belt 18 at the point where non-magnetic belt 18 passes around drum 13 in contact with magnetic belt 21 and immediately prior to passing in proximity to the image-bearing surface 9. While passing through this reservoir the magnetic means 23 attached to magnetic belt 21 attract the magnetic particles to form a brush-like mass as described in application Serial No. 544,174 filed November 1, 1955, by J. C. Wilson and in application Serial No. 344,123, filed March 23, 1953 by Harold G. Greig. However, the interposition of non-magnetic belt 18 prevents the magnetic brush from forming directly on magnetic means 23. Web or sheet 22, as well as all of the materials of non-magnetic belt 18 being constructed of non-magnetic materials, in no way interfere with the lines of force of the magnetic field set up by magnetic means 23. Accordingly, the magnetic brush 26 is established on the surface of non-magnetic belt 18. This brush is retained by the magnetic lines of force so long as non-magnetic belt 18 and magnetic belt 21 are in contact. This is the period until the non-magnetic belt passes over the second drum 13 in its direction of motion. At this point the non-magnetic belt and the magnetic belt part company whereby the lines of force retaining the developer particles 24 in a brush configuration 26 are broken. The body of web or sheet 19 prevents the particles 24 from falling on the magnetic belt 21 and they remain on the surface of web 19 but now as separate powder particles loosely resting on web 19. On passing

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over drum 27 the bulk of the developer particles 24 fall from the surface of web 19 due to the force of gravity. In the apparatus shown, these developer particles are collected on tray or supply means 25 which is desirably sloped so that they are urged by gravity into the bulk of developer particles 24 retained against drum 13. Desirably, means 28 such as a solenoid are provided for agitating supply means 25 both to assure mixing of used with un-used developer particles and to prevent caking or compression of developer particles with consequent lack of contact between developer particles and combined belts 18 and 21.

Where the direction of motion of drums 13 and 27 is such as to cause magnetic and non-magnetic belts to move in the same direction as drum 10, as shown in Fig. 1, desirably the speeds of drums 13 and 27 while fixed to move at the same rate with regard to each other are desirably so regulated as to move at a different rate of speed either faster or slower, than drum 10 so as to provide a sliding contact between brush 26 and the image surface 9.

In operation, the photoconductive insulating surface 9 is caused to move by stations 29, 31 and 30 in that order by energizing drum 10 in Fig. 1 or take up roll 33 in Fig. 2. An electrostatic latent image is formed on surface 9 by first charging surface 9 to impart to the surface an electrostatic charge and then exposing the surface 9 to a light image in accordance with a desired pattern to be reproduced. As the paper leaves the charging and exposure station 29 it bears a charge image corresponding to the desired pattern of light and shadow to be recorded. Drums 13 and 27 are energized driving non-magnetic belt 18 whereby belt 18 passes around first drum 13 in its direction of motion where contact is made with the magnetic belt 21 and a supply of developer particles 24 held in contact with the belt by a tray or suitable means 25. Agitating means 28, as a solenoid, is energized causing intimate contact between developer particles 24 and non-magnetic belt 18. Additional developer may be added from time to time to tray 25 as needed without interrupting the operation of the device. The action of the magnetic lines of force through non-magnetic belt 18 cause a brush-like mass 26 to form on the surface of belt 18 thereby forming a magnetic brush. Drums 13 also cause magnetic belt 21 to move at the same rate of speed as non-magnetic belt 18 yieldably urging the two belts toward contact with the image surface 9. Rigid guide means 20 ride on flanges 11 preventing actual contact between the non-magnetic belt 18 and the surface 9 bearing the electrostatic latent image positioning web or sheet 18 at a defined distance from surface 9 whereby the magnetic brush 26 can make contact with surface 9. Drum 10 moves at such a rate as to cause sliding contact between brush 26 and image-bearing surface 9. This contact causes the electroscopic component of the magnetic developer to deposit on the image-bearing surface 9 in exact conformity with the lines of force of the electrostatic latent image thereon.

Where this image-bearing surface 9 is a sheet of paper bearing thereon a photoconductive insulating layer, as in a suitable binder, the resulting developed powder image may be fused directly thereto on leaving the development station. Where the photoconductive surface is permanently attached to the drum 10, as in the case of a layer of amorphous selenium coated directly on conductive surface 12, the developed powder image may be transferred from the photoconductive surface 9 to a suitable recording means as plastic, paper or the like and fixed thereto as is well known to those skilled in the art.

There has thus been provided an improved novel means for applying electroscopic developer powder to an electrostatic latent image wherein the powder is deposited by means of magnetically formed and maintained brush-like

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masses and wherein the supply of developer powder may be continuously replenished without interrupting the operation of the applying means.

By the term "non-magnetic" as used herein is meant a material which does not interfere with the lines of force of a magnetic field, i. e., a material having a permeability not substantially different from that of free space.

I claim:

1. A rotatable drum having a conductive surface, a paper web having coated on one side thereof a layer of photoconductive insulating material, said web contacting said conductive surface at least at one point, a rotatable, flexible belt with a plurality of magnetic field-producing means arranged in spaced relationship about the periphery of said rotatable flexible belt, means for moving and tensioning said rotatable flexible belt relative to said photoconductive insulating layer, on the side of said moving and tensioning means away from said photoconductive insulating layer a second means for tensioning and moving a second belt, a continuous non-magnetic belt positioned between said first moving and tensioning means and said second moving and tensioning means whereby one side of said non-magnetic belt is yieldably urged toward contact with said photoconductive insulating layer when said photoconductive insulating layer is in contact with said conductive drum surface and while the other side of said non-magnetic belt is in contact with said rotatable flexible belt, means for spacing said non-magnetic belt from said photoconductive insulating layer, means for supplying magnetic developer particles in contact with said non-magnetic belt at a point in its direction of motion prior to its proximity to said photoconductive insulating layer and while in contact with said rotatable flexible belt.

2. Apparatus according to claim 1 wherein the photoconductive insulating layer comprises finely divided zinc oxide in a resinous binder.

3. Apparatus according to claim 1 wherein said photoconductive insulating layer comprises finely divided zinc oxide in a resinous binder, said rotatable flexible belt comprises a cloth web, and said non-magnetic belt comprises a plastic film.

4. A rotatable drum having coated thereon a continuous uniform layer of a photoconductive insulating material, means for rotating said drum, a rotatable, flexible belt with a plurality of magnetic field-producing means arranged in spaced relationship about the periphery of said rotatable flexible belt, means for moving and tensioning said rotatable flexible belt relative to said photoconductive insulating layer, on the side of said moving and tensioning means away from said photoconductive insulating layer a second means for tensioning and moving a second belt, a continuous non-magnetic belt positioned between said first moving and tensioning means and said second moving and tensioning means whereby one side of said non-magnetic belt is yieldably urged toward contact with said photoconductive insulating layer while the other side is in contact with said rotatable flexible belt, means for spacing said non-magnetic belt from said photoconductive insulating layer, means for supplying magnetic developer particles in contact with said non-magnetic belt at a point in its direction of motion prior to its proximity to said photoconductive insulating surface and while in contact with said rotatable flexible belt.

5. Apparatus according to claim 4 wherein the photoconductive insulating material comprises selenium.

6. Apparatus according to claim 4 wherein the photoconductive insulating material comprises selenium, the rotatable flexible belt comprises a cloth web, and said non-magnetic belt comprises a plastic film.

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