July 2, 1963 R. M. SCHAFFERT 3,096,198

METHOD FOR DEVELOPING LATENT FIELD IMAGES WITH LIQUID INKS

Filed Dec. 22, 1958 2 Sheets-Sheet 1

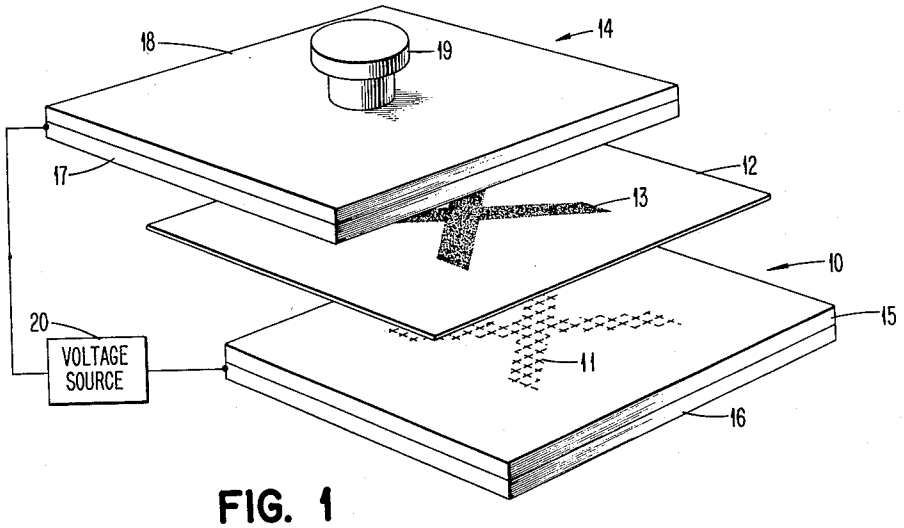


FIG. 1

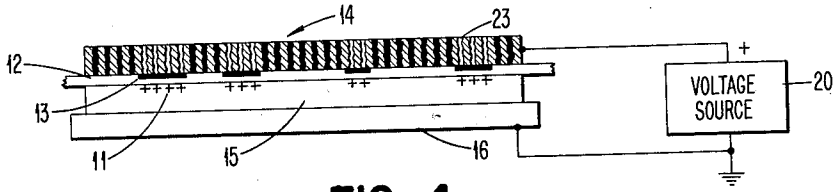


FIG. 4

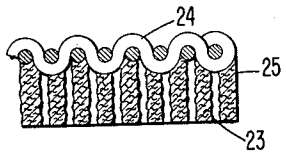


FIG. 3

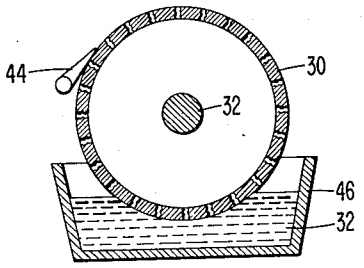


FIG. 7

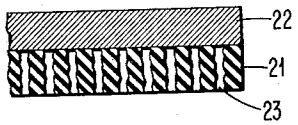


FIG. 2

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July 2, 1963 R. M. SCHAFFERT 3,096,198

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Filed Dec. 22, 1958 2 Sheets-Sheet 2

FIG. 5

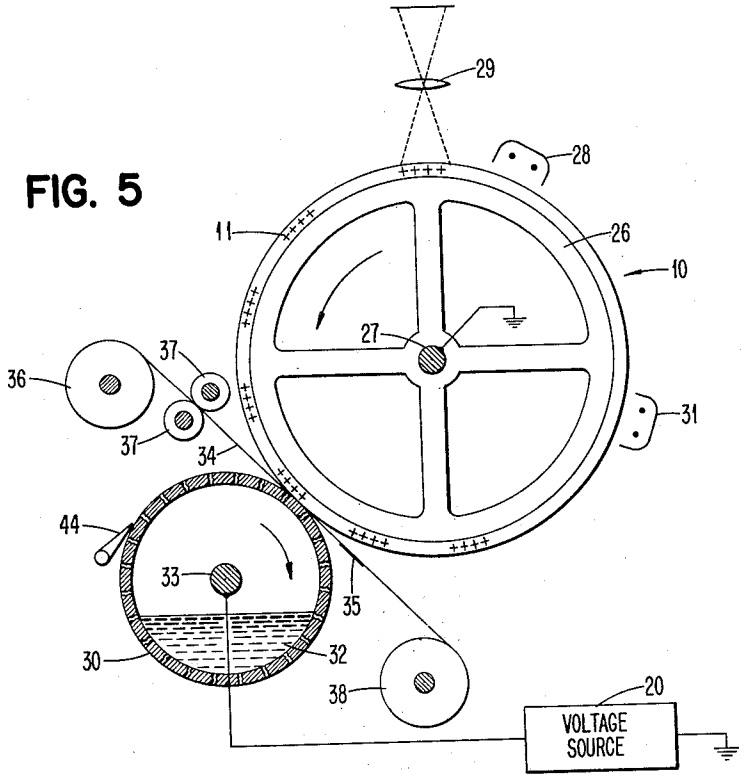
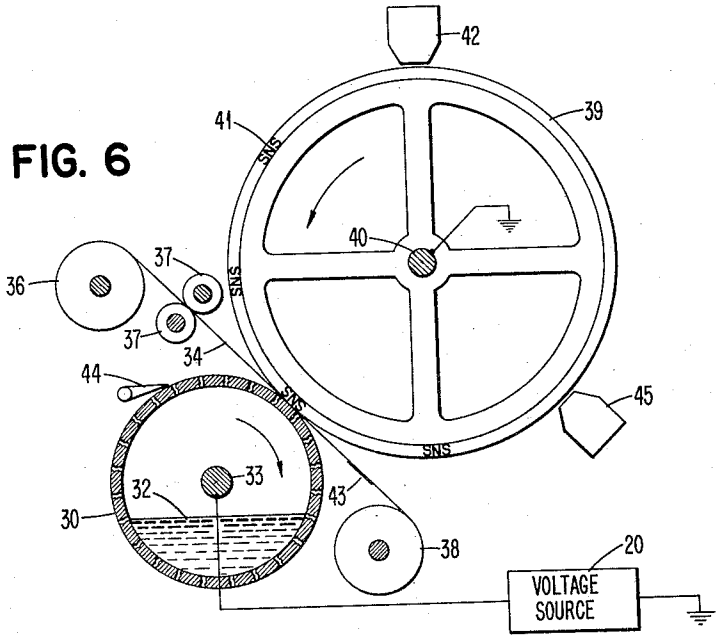


FIG. 6



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METHOD FOR DEVELOPING LATENT FIELD IMAGES WITH LIQUID INKS

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4 Claims. (Cl. 117—37)

This invention relates to the art of printing and more particularly to nonmechanical printing where latent field images are to be rendered visible with liquid inks.

In general, the art of nonmechanical printing involves the formation of latent images which manifest field properties, the development of a visual image from the latent image, and the utilization of the developed image for producing a more or less permanent reproduction. One well-known example of this type printing is commonly referred to as electrostatic printing according to which the latent image is formed of a pattern of electrostatic charge and development is obtained by the deposition of electroscopic pigmented particles on a surface of a carrier or print element bearing the image. Another type of nonmechanical printing is referred to as magnetic printing according to which the latent image is a magnetic flux pattern and development is obtained by the deposition of magnetically attractable particles over a surface bearing the image.

One of the principal difficulties associated with this type of printing is the formation of background. This is particularly true where it is desired to use liquid development material and where application of that material is to be made to a surface by impression.

Consequently, it is an object of this invention to provide an improved method for developing latent field images with liquid inks wherein application of said inks is by impression.

It is also an object of this invention to provide an improved method for developing latent electrostatic images with liquid inks by impression.

It is an additional object to provide an improved method for developing latent magnetic images with liquid inks by impression.

It is a further object of this invention to provide an improved method where printing with liquid inks and latent field images may be performed directly on a print medium.

Briefly in practicing this invention, there is provided an impression member which is saturated with a liquid ink which is extractable from the impression member when contact is made with a surface on which development of the latent image is to take place. The extraction, as it is understood to exist in connection with this invention, may be attributable to forces exerted by the latent image acting upon charged particles of pigment or dyestuff suspended in liquid ink and mechanical forces associated with and resulting from the contact, such as adhesion, absorption, etc. However, in accordance with this invention, the mechanical extraction forces are counterbalanced by the application of an electric field which opposes such extraction of the pigmented liquid by virtue of the contact. Thus extraction of the liquid ink and its deposition on the development surface will occur only in those areas where a latent image exists having a field of force effective to produce such an extraction. Thus it will be appreciated that the invention provides a basis for printing with liquid inks by impression without undesirable background. It can be further appreciated that the degree of mechanical extraction can be counteracted by adjusting the electric force. Consequently, the present invention affords the

basis for printing directly on a liquid absorbent print medium or the like which overlays an image bearing member, such as an electrographic print element. Other advantages will become apparent as the following description proceeds, while the novel features of the invention are set forth with particularity in the appended claims.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of examples, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

FIG. 1 is an isometric view showing means for manually practicing one version of the subject invention.

FIG. 2 is a cross-section of a fragment of an impression member useful in practicing the subject invention.

FIG. 3 is a cross-section of a fragment of a further embodiment illustrating the construction of an impression member useful in practicing the subject invention.

FIG. 4 is a cross-sectional end view illustrating schematically the manner in which impression development is practiced in accordance with the present invention.

FIG. 5 is a schematic presentation of a continuous type of electrostatic printer apparatus incorporating the features of the subject invention.

FIG. 6 is a schematic presentation of a magnetic printer apparatus incorporating the features of the present invention.

FIG. 7 shows an alternate arrangement for supplying liquid inks to an impression member made in accordance with the present invention.

Referring to the drawings, FIG. 1 shows a print element 10 bearing a latent electrostatic image 11, a sheet of a print medium 12 having a visual image 13 thereon, and a saturable impression member 14.

Print element 10 preferably takes the form of a plate member having a dielectric surface 15 superimposed upon a conductive substrate 16 and may preferably be of the type well known to those skilled in the art as a xerographic plate. In that form, print element 10 therefore comprises a layer 15 which is a photoconductive insulator, e.g., amorphous selenium, which is rendered selectively conductive upon exposure to a photoimage to selectively dissipate electrostatic charge formed over the surface thereof. Impression member 14 may take a variety of different forms but in one embodiment comprises a conductive porous plate 17, such as porous bronze produced by well-known powder metallurgy techniques, which is capable of being saturated with a liquid ink absorbable by a print medium 12 or the like. For convenience in manual manipulation, impression member 14 may be provided with an insulating cover 18 to which is attached a handle 20. A voltage source 20, preferably adjustable, is connected to plate 17 and substrate 16 for applying a potential thereacross.

Alternate embodiments of an impression member suitable for practicing the subject invention are shown in FIGS. 2 and 3. In FIG. 2 the impression member comprises a composite of an impression layer 21 formed of porous insulating material, such as porous rubber or plastic, attached to a conductive backing plate 22. Liquid retaining pores are figuratively represented by numeral 23. In FIG. 3 the backing plate takes the form of a conductive metallic screen 24 to which is attached an impression layer of porous insulating material 25 which may be felt or the like also having liquid retaining pores 23. In the embodiments of FIG. 2 and FIG. 3, of course a connection of the voltage source 20 would be to backing plates 22 and 24, respectively. It is further under-

stood that the embodiment of FIG. 2 may include a felt insulating layer, and the embodiment of FIG. 3 may include a porous rubber or any other suitable insulating material.

In accordance with the practice of this invention where it is desired to develop images directly on a print medium as exemplified by the illustrative embodiment of FIG. 1, a latent electrostatic image is formed on print element **10** and a print medium **12** is superimposed thereon. Impression member **14** (i.e., layer **17** of FIG. 1 or layers **21** and **25** in FIGS. 2 and 3, respectively) is saturated with an image extractable liquid ink. Suitable liquid inks in general may be characterized as suspensions and would include any ink containing pigment or dyestuff particles dispersed in a suspended state in a liquid vehicle where the relation of the particle to the vehicle is such that a charge is produced on the particles, thereby making them and the liquid vehicle susceptible to control of the electric forces produced by the latent image and the control fields.

The specific inks selected for saturation of impression member **14** would depend upon whether latent image **11** is formed of negative or positive charge or whether a positive or negative image is to be reproduced. An example of an ink suitable for developing electrostatic images having a positive polarity might be as follows: ⅛ to ¼ gram of Amaranth dye (Fisher Cat. No. A–789, Colour Index 184) is added to 150 cc. of toluene. The dyestuff is suspended in the toluene by mixing thoroughly in a Waring Blendor, after which the liquid dye mixture is strained through filter paper to obtain a finely-divided suspension of the dyestuff particles in the liquid. The dyestuff particles will be electrically charged to a negative polarity.

Where it is desired to develop images having a negative polarity, the ink may comprise ⅛ to ¼ gram of methyl violet 3B added to 150 cc. of hexane. The procedure for mixing is the same as in the preceding example. This provides a suspension in which the dyestuff particles have positive electrical charges.

Further examples of suitable liquid inks may be understood by reference to an article appearing in the Journal of Scientific Instruments, May 1956, volume 33, pages 194 and 195.

Saturation of impression member **14** may be effected by dipping plate **17** into a vessel (not shown) containing a supply of suitable liquid ink previously mentioned or cover **18** may be of any well-known construction intended to retain a supply of such ink internally in contact with the reverse surface of layer **17**. Where saturation is accomplished by dipping, it may be desirable to wipe the front surface of layer **17** with a doctor blade or the like to remove any excess ink adhering thereto. Subsequent to such saturation, the impression member **14** is then placed so that layer **17** is brought into contact with the upper surface of print medium **12**. During the period of contact, a potential from voltage source **20** is applied to the impression member **14** which produces an electric field opposing and counterbalancing the mechanical forces tending to extract the ink from the porous recesses of impression member **14** by virtue of the contact between the surface of layer **17** and the upper surface of print medium **12**. For a better understanding of this aspect of the invention, reference is made to FIG. 4 which illustrates the condition which prevails when impression member **14** is in contact with the print medium **12** and a potential has been applied by source **20** which counterbalances the extraction of ink from the pores **20** by the force attributed to the absorption by print medium **12**. In those areas of print element layer **15** on which electrostatic charge exists, ink will be extracted from the adjacent liquid filled pores for deposition onto the upper surface of print medium **12** where it would become absorbed therein, thus forming a visual image **13**. Following the impression contact, member **14** is removed, and sheet **12** is removed from the surface of print element **12**. The preceding steps may be repeated using the same or a different latent image. While FIG. 4 discloses the printing directly on a print medium **12**, it is to be understood that the invention can be practiced where impression member **14** is brought to bear directly on the upper surface of print element **10**. Printing directly on print medium **12** has the advantage of eliminating a transfer step and the need for cleaning the print element after development. Where development is effected on print element **10**, it is expected that the mechanical forces of extraction from the contact between the print element **10** and impression member **14** would be due in good measure to adhesive forces, rather than absorptive forces. In this case the visual image on the surface of print element may be transferred to a print medium in any known manner, and the surface of print element wiped clean before use to print a second copy.

FIG. 5 shows the invention as it is practiced in connection with a printer apparatus adapted for printing on a continuous basis using electrostatic images. As shown in FIG. 5, the print element **10** is cylindrical in form and is supported by and in electrical contact with a conductive drum **26** which in turn is suitably supported in electrical contact by a suitably mounted shaft **27** which may be driven by any well-known motive device, such as an electric motor, not shown. Arranged sequentially in a radial manner about the surface of print element **10** are a corona discharge unit **28**, a photoimage projection apparatus which may include lens **29**, a liquid development apparatus including an impression member in the form of a porous roller **30**, and an erasing optical unit **31**. In accordance with this invention, impression roller **30** is a conductive porous member adapted to retain a supply of image extractable liquid ink **32** therein and in the present embodiment is preferably a cylindrical form of the impression member of FIG. 4 or FIG. 3. In the latter instance it would be expected that screen **24** would be sufficiently perforated to permit flow of ink therethrough to effect the saturation of layer **25**. A shaft **33** supports and is in electrical contact with roller **30** and is positioned so as to sustain roller **30** in contact with a print medium, such as web **34**, which passes between roller **30** and the surface of print element **10** to have visible images **35** produced thereon. In passing through the development position, web **34** may be driven from a supply roll **36** between feed rollers **37** to a takeup reel **38**. The driving connections for the takeup reel **38**, the impression roller **30**, and the drum **26** may be of any suitable type and might include a common motive source to which each of the driven elements is connected in a manner which will effect synchronous operation, if desired. A voltage source **20** for applying an electric field to the impression roller **30** has one side connected to shaft **33** and the other connected to ground. Shaft **27** is likewise connected to ground.

FIG. 6 illustrates a continuous type printer apparatus in which printing is produced from latent magnetic images which are rendered visible in accordance with principles of the subject invention. In this embodiment the print element is a magnetic drum **39** supported by a shaft **40** and having a permanently magnetizable surface on which magnetic flux images **41** can be produced by a suitable generator **42**. As in FIG. 5, a print medium in the form of a web **34** has visible images **43** produced thereon as it passes in compression between roller **30** and drum **39** as it is moved from supply roll **36** over feed rolls **37** to a takeup reel **38**. The impression member **30** in the embodiment of FIG. 6 is also preferably a porous cylindrical member saturable with an image extractable liquid ink **32**, a supply of which is contained within the confines of the roller. In the embodiment of FIG. 6, impression roller **30** is a porous nonmagnetic material, and the liquid ink **32** is preferably an aqueous solution in which minute particles of magnetic material are dispersed.

A suitable ink for use in developing magnetic images

would be as follows: A slurry of iron oxide is prepared by precipitation of Fe_3O_4 from a solution of $FeCl_2$ and $FeCl_3$ with NaOH. A stabilizing solution is then made by adding two grams of cocoanut oil amine (mostly dodecyl amine), as obtained from Armour & Co., to about 10 cc. of normal hydrochloric acid to bring a pH of 7. The solution is then diluted with distilled water to 50 cc. and 20 cc. of the Fe_3O_4 slurry added. After thorough mixing, the whole system is brought to 150 cc. with distilled water and stirred vigorously in a Waring Blendor. It is finally diluted again to a total of 600 cc. to provide the final product. The suspended magnetic particles are charged positively, and the polarity of the applied voltage would be selected accordingly.

Since in some applications it may occur that the extractive force of the magnetic image may produce some deposition of the liquid ink on the outer surface of impression member **30**, it may be desirable to provide a wiping means, such as a doctor blade **44**, for cleaning the surface at some point preceding engagement with the print medium. A similar means may be provided for the same purpose in the electrostatic printer embodiment shown in FIG. 5.

It has been found that dispersions of magnetic particles in an aqueous solution contain an electrostatic charge thereon. For that reason the absorptive extraction forces of print medium **34** can be counterbalanced successfully by the application of an electric field to the impression member **30** in FIG. 6. To accomplish such a result, voltage source **20** is connected to shaft **33** with which impression roller **30** is in electrical contact and to ground. Shaft **40** which supports drum **39** is also electrically connected to ground. An erasing means **45** may be provided at a radial position following the development station to effect the removal of magnetic images, if desired, prior to the next printing cycle.

In FIG. 7 the saturation of the cylindrical impression member **30** is effected by causing the outer surface thereof to be partially submerged in a supply of liquid ink **32** contained in an open vessel of any suitable type **46**. In this case a porous member structure, such as shown in FIG. 2, may also be used. Any excess of liquid ink adhering to the outer surface of the impression member **30** will be removed by the wiping action of the blade **44** as the impression member **30** is caused to turn in a clockwise direction to be brought into engagement with the print medium (or the surface of the print element) as it moves through the development station.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to certain preferred embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A method of developing latent field images comprising

(*a*) contacting a liquid ink wettable development surface of a latent image-bearing record medium in the image and non-image areas alike with an impression member having a developing surface uniformly saturated with an image attractable development surface wetting electrostatic field controllable liquid ink,

(*b*) and subjecting said liquid ink to an external electrostatic transfer control field while the developing surface is in contact with said record medium and said liquid ink is in contact coincidentally with the image and non-image areas alike of said record medium development surface by applying an external transfer control potential to said impression member and said record medium,

(c) said external electrostatic transfer control field having a polarity and magnitude opposing and counterbalancing the transfer of said pigmented liquid ink to the non-image areas while permitting transfer of said pigmented liquid ink from said impression member in response to field force of said field images in said image areas

(*d*) whereby said pigmented liquid ink is deposited on said image areas and is prevented from depositing on the non-image areas of said development surface of said image bearing record medium on separation of said developing and development surfaces.

2. A method of developing latent electrostatic field images comprising

(*a*) forming a latent electrostatic field image on an electrographic print element having a liquid ink wettable development surface,

(*b*) impregnating a liquid saturable impression member with an image attractable liquid ink comprising electrically charged pigment particles in a development surface wetting dielectric liquid medium,

(*c*) impressing the developing surface of said impregnated impression member on said development surface to thereby bring said pigmented liquid ink into contact coincidentally with non-image and image areas alike of said liquid wettable development surface,

(*d*) subjecting said liquid ink to an external electrostatic transfer control field while said impression member development surface and said print element development surface are in contact by applying an external control potential to said impression member and said print element,

(*e*) said control field having a magnitude and polarity opposing and counterbalancing the mechanical forces effecting transfer of said pigmented liquid ink from said impression member to said development surface of said print element while permitting transfer in the image areas thereof under field force attributable to said electrostatic images

(*f*) whereby said pigmented ink in contact with the image areas is transferred from said impression member to said development surface and said pigmented ink in contact with the non-image areas of said development surface is retained on said impression member on separation of said developing and development surfaces.

3. A method of developing latent magnetic field images comprising

(*a*) forming a latent magnetic field image on a magnetizable print element having a liquid ink wettable development surface,

(*b*) impregnating a liquid saturable impression member with an image attractable liquid ink comprising electrically charged magnetizable pigment particles in a development surface wetting liquid medium,

(*c*) impressing the developing surface of said impregnated impression member on said development surface to thereby bring said pigmented liquid ink into contact coincidentally with non-image and image areas alike of said liquid wettable development surface,

(*d*) subjecting said liquid ink to an external electrostatic transfer control field while said impression member developing surface and said print element development surface are in contact by applying an external control potential to said impression member and said print element,

(*e*) said control field having a magnitude and polarity opposing and counterbalancing the mechanical forces effecting transfer of said pigmented liquid ink from said impression member to said development surface of said print element while permitting transfer in the image areas thereof under field force attributable to said electrostatic images

(*f*) whereby said pigmented ink in contact with the image areas is transferred from said impression member to said development surface and said pigmented ink in contact with the non-image areas of said development surface is retained on said impression member on separation of said developing and development surfaces.

4. A method of preparing print copy comprising;

(*a*) forming a latent field image on an electrographic print element,

(*b*) superimposing a liquid ink absorbent print copy medium on said print element,

(*c*) impregnating an impression member with a pigmented image attractable liquid ink comprising electrically charged pigmented particles suspended in a print copy medium absorbable liquid vehicle,

(*d*) impressing said impression member on said superimposed print copy medium so as to apply said liquid ink to said print copy medium coincidentally to regions thereof superimposing image and non-image areas of said print element,

(*e*) subjecting said liquid ink to an external electrostatic transfer control field while said ink saturated impression member and said print copy medium are in contact by applying an external control potential to said impression member and said print element,

(*f*) said control potential being applied with a magnitude and polarity opposing and counterbalancing absorptive forces of said print copy medium on said pigmented liquid ink in said impression member while permitting absorption of said pigmented ink

under field force of said image in the areas of said print copy overlaying the image areas of said print element

(*g*) whereby said pigmented liquid ink in contact with with the print copy overlaying said image areas is transferred from said impression member to said print copy and said pigmented ink in contact with the print copy overlaying said non-image areas of said print element is retained on said impression member on separation of said impression member and said print copy medium.

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