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Hoffman

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[54] **OPTICAL MONITORING CHAMBER UNIT FOR TONER DENSITY CONTROLS**

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[52] **U.S. Cl.** **141/98,** 95/89, 141/286, 141/325, 355/10

[51] **Int. Cl.** **B65b 3/04**

[58] **Field of Search** .95/89 AR, 89; 355/10; 137/386, 137/604; 141/46, 95, 113, 286, 285, 100, 325, 98

[56] **References Cited**

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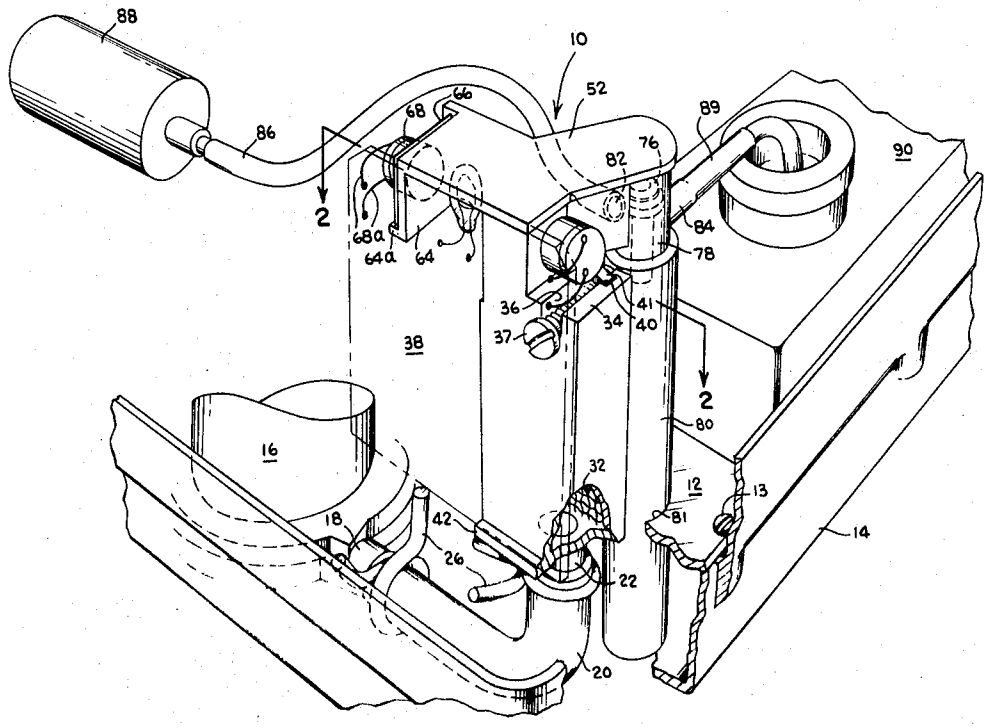
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[57] **ABSTRACT**

A unit included in a toner density control (TDC) for electrostatic photocopiers incorporates an optical monitoring chamber, a filter chamber, and a venturi suction chamber for selectively introducing toner replenisher to a developer liquid pumped therethrough. A circuit board is detachably clamped to the unit and mounts a lamp and a pair of photocells in operative positions relative to the monitoring chamber.

4 Claims, 3 Drawing Figures



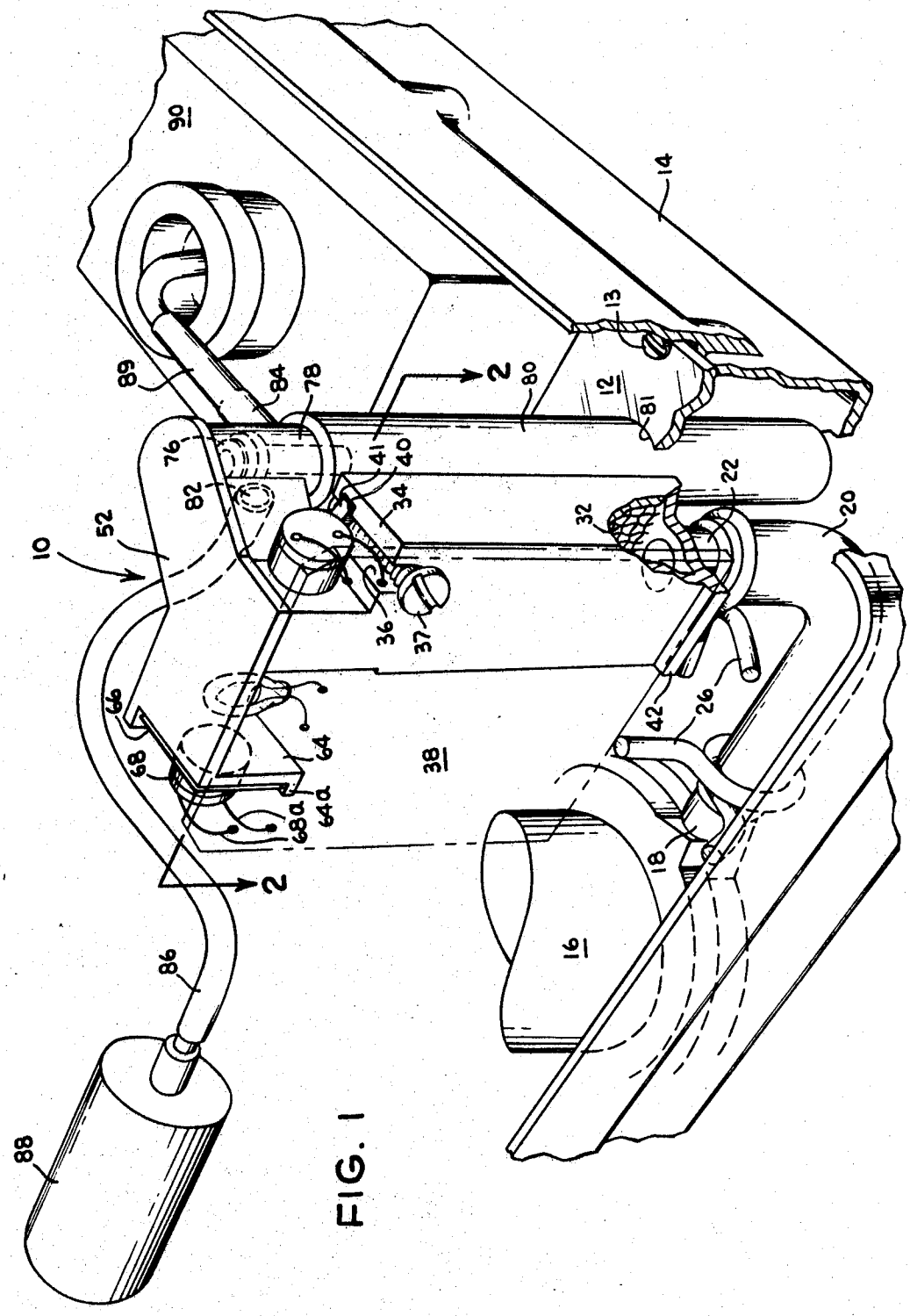


FIG. 1

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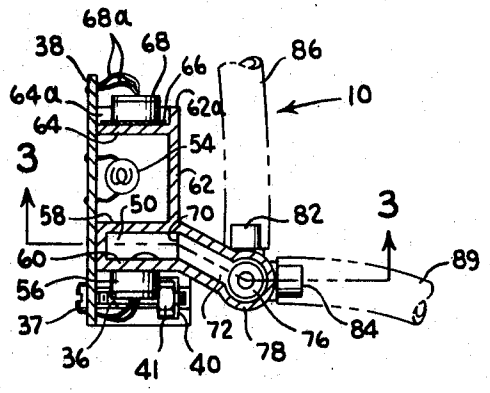


FIG. 2

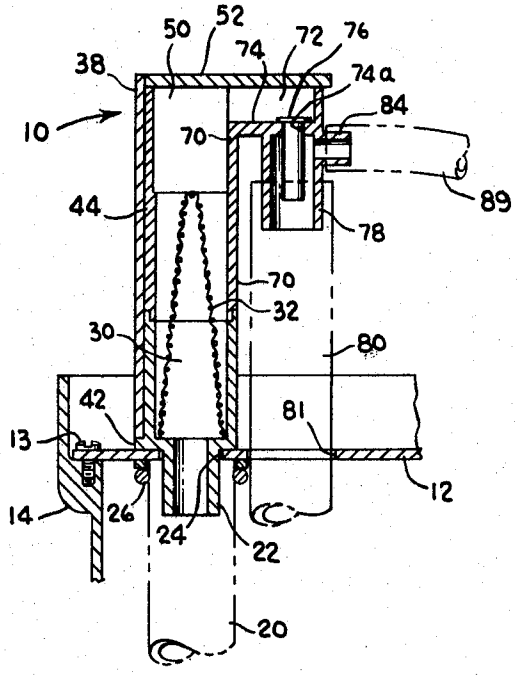


FIG. 3

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OPTICAL MONITORING CHAMBER UNIT FOR TONER DENSITY CONTROLS

BACKGROUND OF THE INVENTION

In all electrophotographic systems, the toner concentration suspended in the developer medium must be replenished on same basis. Typically this is done automatically so as to not unduly burden the operator. In some systems, toner replenishment is effected on an iterative basis. That is, after a predetermined number of copy cycles, a preselected arbitrary amount of toner concentrate or replenisher is automatically added to the developer medium. This technique is simple and economical to implement, however, it has the drawback in that the depletion of the concentration is rarely uniform for each copy cycle or predetermined number of copy cycles. Thus, it is not uncommon to develop over a period of time a toner concentration which is outside of the limits required for optimum copy quality. This situation can only be rectified through manual intervention by the operator or service personnel.

A more satisfactory technique, particularly in those electrophotographic systems employing liquid developer, is to actually monitor on a continuing basis the toner concentration or density, as suspended in the liquid vehicle, and to automatically initiate toner replenishment when its concentration falls below a predetermined level. Since the degree of toner concentration is directly proportional to the opacity of the developer liquid, one of the most convenient ways in which to monitor the toner density is optically. Such optical toner density controls (TDC) are well known and in wide use.

The typical practice is to continuously circulate the developer liquid through a monitoring chamber having transparent walls with a light source and a photosensor positioned on opposite sides of the chamber. The toner density of the developer liquid flowing through the chamber attenuates the intensity of the light beam incident on the photosensor and the proportional electrical response of the photosensor is processed pursuant to initiating toner replenishment when needed.

This technique works quite well until a highly light attenuating film invariable builds up on the chamber walls to efficiently swamp the light attenuating effects of the developer liquid, itself. The toner density control goes increasingly out of calibration and thus can no longer perform properly. The only recourse is to manually clean the monitoring chamber in order to remove the film buildup. This is a tedious task, requiring considerable time of trained photocopier service personnel. At the same time, the photocopier is out of service.

It is accordingly a general object of the present invention to provide a TDC monitoring chamber uniquely designed and incorporated into a low cost, "throw-away" unit, which is readily demounted not for cleaning, but for replacement typically on a periodic basis. A further important object is to provide in a single compact package of inexpensive design a unit which incorporates a TDC monitoring chamber, a filter chamber and a venturi suction chamber for introducing toner concentrate or replenisher to a developer liquid.

Other objects of the invention will in part be obvious and in part appear hereinafter.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided a compact and inexpensive unit for incorporation in a toner density control (TDC) included in an electrophotographic system utilizing liquid developer, which unit provides the TDC optical monitoring chamber. Moreover, the unit combines with the TDC monitoring chamber in a single package, a filter chamber and a venturi suction chamber of simplified design. The unit is of such low cost that it becomes eminently practical to simply periodically replace it entirely, rather than to expend the time and effort to periodically clean it. As a result the load on the manufacturer's service personnel is lightened and copier down time is reduced.

The disposable unit of the present invention is detachably mounted to the developer tank of a liquid development station. An inlet to the filter chamber is coupled to the outlet of a liquid developer circulating pump whose intake is submerged in the developer bath. The filter chamber includes a filter screen through which the developer liquid flows as it is pumped therethrough. The filter chamber opens into the monitoring chamber which accepts developer liquid flow therefrom. A circuit board carrying various electrical components required in the toner density control is detachably clamped to the unit. Among the components mounted by the circuit board are a lamp and a photosensor, which are automatically positioned on opposite sides of the monitoring chamber incident to clamping the circuit board to the unit. The lamp beams light through the transparent sidewalls of the monitoring chamber and the developer liquid flowing therethrough to the photosensor, pursuant to monitoring the developer liquid opacity.

From the monitoring chamber, the developer liquid flows through an orifice and back into the developer tank. In accordance with a feature of the invention, the orifice is constituted by an elongated eyelet mounted concentrically within a sleeve which serves as a suction chamber whose outlet is coupled back into the developer tank. In advance of the discharge end of the eyelet, the sleeve is formed with a pair of inlets. One of these inlets is coupled to a supply of toner concentrate or replenisher mounted by the developer tank. The other inlet is selectively vented. As the developer liquid discharges from the eyelet for return to the developer tank, a negative pressure is created in the area between the eyelet and the sleeve adjacent the two inlets. So long as the second inlet is vented, air is brought in to satisfy this negative pressure in preference to the heavier toner concentrate.

On the other hand, when the opacity of the developer liquid flowing through the monitoring chamber decreases below a predetermined level, indicating a depletion of the toner concentration therein, the resulting electrical response of the photosensor is used to initiate actuation of suitable means, such as a valve, which closes off this second inlet. The negative pressure condition is sufficient to draw toner concentrate from the supply which is combined with the developer liquid discharging from the eyelet.

The invention accordingly comprises the features of construction, combination of elements, and arrange-

ment of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is a fragmentary, perspective view of a liquid development station incorporating a disposable unit constructed according to a preferred embodiment of the invention;

FIG. 2 is a sectional view taken along line 2—2 of FIG. 1; and

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2.

Like reference numerals refer to corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

Referring to FIG. 1, the disposable unit of the present invention, generally indicated at **10**, is made of a suitable transparent plastic and is supported in an upright position on a deck **12** secured to a developer tank **14** located at a liquid development station of an electrophotographic copier. A pump **16** has an intake (not shown) submerged in the developer bath contained by developer tank **14** and a discharge **18** which is coupled by conduit **20** to an inlet sleeve **22** of unit **10**; the inlet sleeve extending downward through an opening **24** in deck **12** (FIG. 3). Hose clamps **26** secure the ends of conduit **20** on the pump discharge **18** and the inlet sleeve **22**. As best seen in FIG. 3, the hose clamp **26** clamping the end of conduit **20** on the inlet sleeve **22** is positioned immediately below deck **12** and thus serves to detachably secure unit **10** in an upright position on the deck.

As best seen in FIG. 3, inlet sleeve **22** opens into a vertically elongated filter chamber **30** of rectangular cross section. A mesh filter screen **32** in the form of an inverted "V" is accommodated in filter chamber **30** to screen out conglomerates as the developer liquid is pumped upwardly through the filter chamber. A portion of the upper end of filter chamber **30** is terminated by horizontal ledge **34** (FIGS. **1** and **2**). This ledge **34** is formed having an elongated surface groove **36** accommodating the shank of a bolt **37** which is passed through an aperture in a circuit board **38**. A recess **40** intersecting groove **36** captures a nut **41** in which bolt **37** is threaded to clamp circuit board **38** to unit **10**. As seen in FIG. 3, the lower edge of circuit board **38** rests on a ledge **42** extending from the lower end of sidewall **44** for filter chamber **30**.

The remainder of the upper end of filter chamber **30** laterally of ledge **34** opens into a monitoring chamber **50** bounded in part by upper extensions of the filter chamber sidewalls and a cover **52**. As best seen in FIG. **2**, the circuit board **38** mounts a lamp **54** and a photosensor, such as a photocell **56**, which, when the circuit board is clamped to unit **10**, are positioned on opposite sides of the monitoring chamber **50**. The light from lamp **54** is transmitted through opposed chamber sidewalls **58** and **60** and the developer liquid to photocell **56**.

Still referring to FIG. **2**, unit **10** is provided with a support wall **62** which serves to mount a window **64** on the opposite side of lamp **54** from monitoring chamber sidewall **58**. Mounting wall **62** is extended beyond window **64** to provide a ledge **62*a***, while the lower edge of the window is formed having a horizontally extending ledge **64*a*** which serves in cooperation with ledge **62*a*** and circuit board **38** to mount a sheet **66** of optical filter material on the opposite side of the window from lamp **54**. A second photocell **68** is mounted by resilient electrical leads **68a** to the circuit board **38**. The springy leads **68** serve to resiliently urge the face of photocell **68** against window **64**, thus to clamp the filter sheet **66** therebetween.

The provision of a second photocell in a toner density control is often resorted to in the field to afford compensation for variations in the lamp light output, while the optical filter **66** is utilized to establish an opacity standard for the developer liquid flowing through the monitoring chamber **50**. Applicant does not claim any invention in the use of the second, compensating photocell **68** or the use of an optical filter to establish an opacity standard. Applicant's invention is however concerned with the design of unit **10** to accommodate second photocell **68** and the optical filter **66**.

As seen in FIGS. **2** and **3**, sidewall **70** of the filter and monitoring chambers terminates short of cover **52** to provide a laterally extending passageway **72** accommodating the flow of developer liquid from the monitoring chamber. The floor **74** of this passageway **72** is formed having an opening **74*a*** in which is fitted an elongated eyelet **76**, formed of metal, for example. Depending from floor **74** concentrically about eyelet **76** is an elongated sleeve **78**, which, as will be seen serves as a suction chamber. The developer liquid passing from the monitoring chamber **50** through passageway **72** flows downwardly through the restricted orifice afforded by eyelet **76**. A hose **80**, inserted on the lower end of sleeve **78**, extends through an aperture **81** in deck **12** to return the developer liquid to tank **14**.

Sleeve **78** is provided with a pair of inlets **82** and **84** communicating with the interior of the sleeve at a level above the discharge end of eyelet **76**. Inlet **82** is connected by a hose **86** to a valve **88** (FIG. 1), while inlet **84** is coupled by a hose **89** to a supply of toner concentrate or replenisher held in a container **90**. Normally valve **88** is conditioned by the toner density control to vent inlet **82** to the atmosphere. Thus, the vacuum created by the flow of developer liquid from the small bore of the eyelet **76** into the larger bore of sleeve **78** causes air to be drawn in through inlet **82**. However, when an addition of toner concentrate to the developer liquid is called for by the toner density control, valve **88** is actuated to close off inlet **82** and thus the vacuum created in the area between eyelet **76** and sleeve **78** is sufficient to draw toner concentrate from container **90**. The toner concentrate enters through inlet **84** and is combined with the developer liquid as it flows from the discharge end of sleeve **78**. When the toner density control determines that sufficient toner concentrate has been added to return the developer liquid to its proper opacity, valve **88** is again actuated to vent inlet **82**, thereby terminating the replenishment of the toner concentration in the developer liquid.

From the foregoing description, it is seen that unit **10** is of an extremely simple and low unit cost design, thus making it highly practical to merely replace the unit in

its entirety rather than to clean the film buildup from the monitoring chamber walls in order to re-establish proper TCD operation. To replace unit **10**, bolt **38** is removed to demount the circuit board **38**. It will be noted that as the circuit board is moved aside, it carries with it the two photocells and lamp **54**. Deck **12** is detached by removal of screws **13** and lifted from developer tank **14** to provide access to hose clamp **26** for disconnection of the conduit **20** from the intake sleeve **22**. After the disconnection of hoses **86** and **89**, the unit is completely freed for removal and replacement.

It is also seen that the unit **10** is of extremely compact design with the monitoring chamber mounted atop the filter chamber and the suction chamber or sleeve **78** depending from passageway **72** laterally extended from the monitoring chamber. Thus, the flow path for the developer liquid is folded on itself in an inverted U-shaped configuration, occupying very little horizontal surface area of tank **14**.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A disposable combined toner optical monitoring and toner concentrate injecting device for use in an electrophotographic liquid developing system including a tank of liquid developing toner and a circulating pump located in the tank, said device comprising:

A. a unitary, generally elongate and vertically oriented housing being removably supported by a portion of the toner tank,

B. wall means forming a portion of said housing to define a first vertical passageway extending substantially the height of said housing through which toner in the tank is adapted to pass, at least a portion of said first vertical passageway being formed of transparent material and defining a monitoring chamber for permitting optical monitoring the opacity of toner passing therethrough, the lower end of said first vertical passageway having means removably connected to an outlet of the pump in the toner tank,

C. additional wall means of said housing defining a lateral passageway communicating at one end with the upper end of said first vertical passageway,

D. further additional wall means of said housing defining a second vertical passageway which communicates with the other end of said lateral passageway, the lower end of said second vertical passageway being adapted to communicate with the interior of the toner tank whereby toner in the tank is pumped through said first vertical passageway, said lateral passageway and said second vertical passageway back into the tank without passing outside of said housing,

E. means in said vertical passageway defining a restricted orifice through which the toner passes to form a suction chamber in said second vertical passageway adjacent said orifice,

F. means defining a first inlet to said suction chamber and adapted to be normally connected to atmosphere for venting said suction chamber, and

G. means defining a second inlet to said suction chamber and adapted to be connected to a source of toner concentrate whereby toner concentrate is drawn into said suction chamber through said second inlet and injected into the toner passing therethrough when said first inlet is blocked to prevent the venting of said suction chamber.

2. A device as set forth in claim 1 wherein another portion of said first vertical passageway beneath said first portion defines a filtering chamber and there is further included in said disposable device a mesh screen filter in said filtering chamber for filtering toner passing into said monitoring chamber.

3. A device as set forth in claim 1 wherein said means defining said restricted orifice comprises an elongate eyelet mounted in one of the wall means defining said second vertical passageway, said eyelet cooperating with said wall means defining said second vertical passageway to define said suction chamber therebetween.

4. A device as set forth in claim 1 wherein said housing includes additional wall means defining an open chamber located laterally adjacent said monitoring chamber for accommodating a lamp and also forming support for an optical filter in spaced relation with said monitoring chamber on the side of said open chamber remote from said monitoring chamber, whereby a lamp placed in said open chamber can project light in opposite directions through an optical filter mounted on said support and through toner passing through said monitoring chamber.

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