May 14, 1946. G. E. CLANCY 2,400,290

IMPULSE PUMPING SYSTEM

Filed April 20, 1942 2 Sheets-Sheet 1

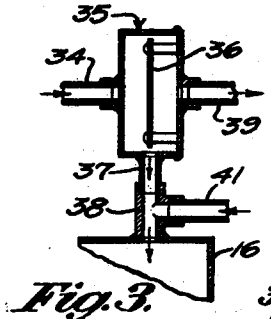


Fig. 3.

Fig. 1.

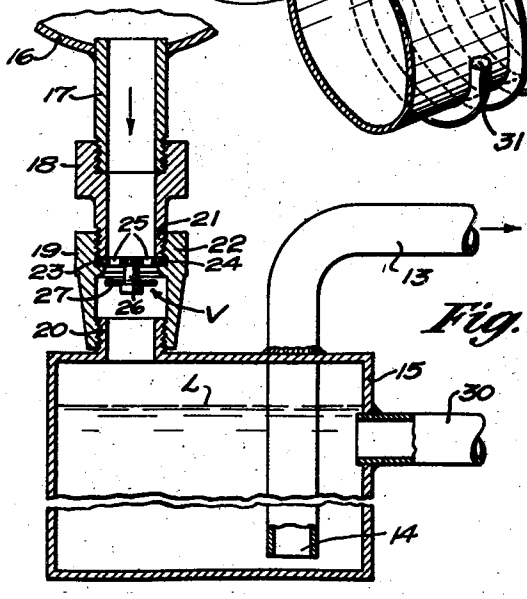


Fig. 2.

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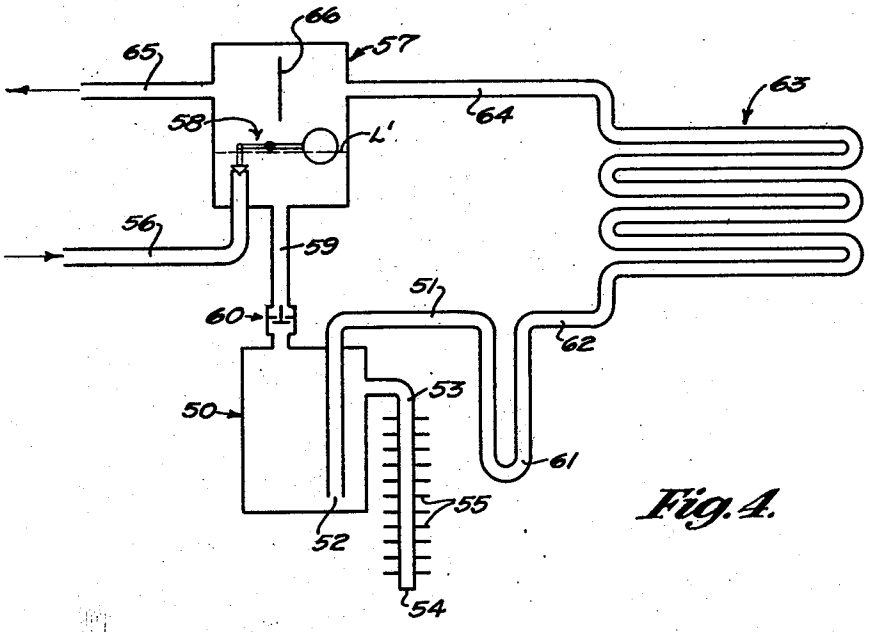


Fig. 4.

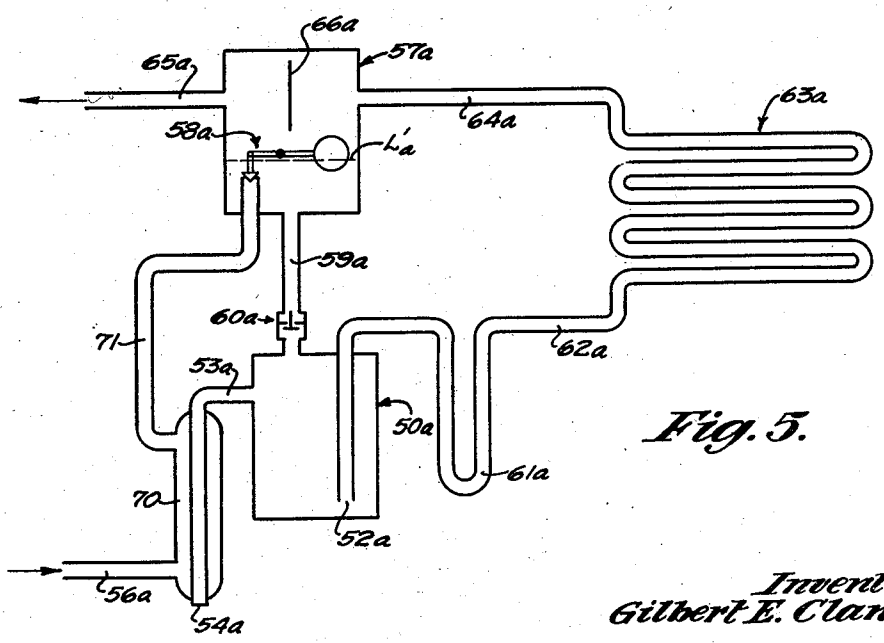


Fig. 5.

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IMPULSE PUMPING SYSTEM

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Application April 20, 1942, Serial No. 439,672

5 Claims. (Cl. 62—125)

This invention relates generally to systems for pumping liquids through evaporators, the general object of the invention being the provision of an improved liquid pumping system operable by virtue of periodic pressure impulses generated by periodic vaporization of a relatively small quantity of the liquid of the system.

The pumping system of the invention has several illustrative practical applications, a somewhat detailed consideration of which will lead to an understanding of the broad underlying principles of the invention itself. One of these is as a circulating pump for a waste-heat boiler system, such as may be used on aircraft for steam generation purposes. In such systems, some of the heat of the exhaust gases of the aircraft engine is reclaimed by means of a boiler or heat exchanger associated with the exhaust pipe. In accordance with the present invention, heat derived from the exhaust gases is utilized to periodically vaporize a relatively small quantity of water which collects in a leg of the system, thereby generating steam impulses which act in a pumping chamber to drive a larger quantity of water contained therein to and through the boiler.

Another illustrative application of the invention is as a pumping system for the refrigerant medium in a refrigeration system. In this case, a small quantity of refrigerant is periodically vaporized in a leg of the system, for instance, by subjection to surrounding atmosphere, or by heat transfer from the incoming refrigerant medium. This vaporized refrigerant acts in a pumping chamber to drive a larger quantity of liquid refrigerant contained therein to and through the cooling pipes. The advantages of this pumping system from a refrigeration standpoint will be discussed at a later point herein.

With this brief preliminary discussion in mind, the invention will be best understood by now referring to the following detailed description of certain typical illustrative embodiments thereof, as applied both to waste heat boiler systems and to refrigeration systems. For this purpose reference is directed to the accompanying drawings, in which:

Fig. 1 is a diagrammatic perspective view showing my impulse pump incorporated in a waste heat boiler system;

Fig. 2 is a section on line 2—2 of Fig. 1, with parts broken away;

Fig. 3 is a section on line 3—3 of Fig. 1;

Fig. 4 is a diagrammatic view of a refrigeration system incorporating my impulse pump; and

Fig. 5 shows a modification of the refrigeration system of Fig. 4.

With reference first to Figs. 1, 2 and 3, numeral 10 designates generally a conduit for hot gases; for instance, it may be the exhaust pipe of an aircraft engine. Arranged in heat absorbing relation to exhaust pipe 10 is a heating coil 11; here diagrammatically indicated in the elementary form of a coil of tubing 12 wrapped about the pipe 10 in contact therewith. The two elements 10 and 11 together typify a heat exchanger element or fluid heater or boiler in which liquid may be heated or evaporated. The element is here shown only in diagrammatic form, since it, per se, does not necessarily form a part of the present invention; for a disclosure of an efficient boiler or heater suitable for the purpose, see my copending application, Ser. No. 432,959, filed March 2, 1942, entitled Heat exchange apparatus.

The coil of tubing 12 receives liquid, typically water, though not necessarily so, by way of a conduit 13 whose open end 14 (see Fig. 2) is located inside and near the lower end of a closed impulse pump chamber 15. The chamber 15 receives its water by gravity flow from a header or tank 16 via pipe 17, the lower end of which is coupled by means of fittings 18 and 19 to a nipple 20 on the top of chamber 15, an inverted normally open check valve V being placed above nipple 20. As here shown, the tubular lower end portion 21 of fitting 18 is screwthreaded into the box 22 forming the upper part of the fitting 19, and confined between the lower end of tubular portion 21 and annular upwardly facing shoulder 23 formed inside box 22 is a check valve seat disk 24, furnished with perforations 25, and from the center of which depends a headed valve stem 26, the latter carrying a light, vertically movable check valve disk 27. This check valve disk 27 is adapted, upon development of pressure below it, to rise on stem 26 into engagement with the underside of plate 24, thereby closing perforations 25. A pipe leg or other conduit 30, opening at one end inside the upper portion of chamber 15, is arranged in heat absorbing relation to the hot exhaust pipe 10, being here shown as given a partial turn about pipe 10 in contact therewith. The end 31 of this leg 30 is closed, as indicated in Fig. 1. The leg may be of any suitable form; it is only necessary that it communicate openly only with chamber 15.

In the illustrative circulation system here instanced, the outgoing end of the tubing 12 is connected by line 34 into a separator 35, of any

conventional type, and indicated as equipped with a usual baffle 36, the water separated out draining via connection 37 and T-fitting 38 into header tank 16, and the steam being discharged from the separator to line 39. This steam flowing in line 39 may of course be utilized in any suitable apparatus to do its intended work, such apparatus being however omitted from the present drawings, which, for simplicity, indicate the line 39 as going directly to a condenser 40. The condensed water is returned by line 41 to the fitting 38, and thence to header tank 16.

Under some conditions of operation, there may be liability of freezing up in the line 41 between the condenser 40 and the tank 16. This may be avoided by placing the line 41 in heat absorbing relation to the steam line 39, thus, line 41 is shown in Fig. 1 as placed in contact with the steam line 39, the two being preferably surrounded by a metal sleeve 42 of good heat conducting properties, as copper.

Water is conveniently introduced to the system by way of a removable plug 44 screwed into the top of header tank 16. The quantity of water utilized in the system is not critical, it being only required that sufficient water be utilized to assure circulation and the desired heat absorption from the exhaust pipe. Valve 27 being in its lower or open position, water contained in tank 16 drains through pipe 17 into chamber 15. This water rises in chamber 15 until it flows into leg 30, and thence into heat absorbing relation with exhaust pipe 10. The water within the chamber 15 may at this time rise to a level such as indicated at L in Fig. 2. The water contained in leg 30, or some of that water, is converted into steam, which then discharges into chamber 15, creating a steam pressure therein causing valve 27 to be elevated and closed, and forcibly expelling a charge of water from chamber 15 by way of pipe 13 into the tubing 12 of boiler 11. A substantial quantity of water, which may equal approximately to the volume of chamber 15, is thus pumped through the boiler 11, wherein it is converted into steam, and from which the steam is discharged via line 34. This steam flows through separator 35, wherein any particles of water are separated out to be returned immediately to tank 16, and thence on via line 39, through any steam utilizing apparatus which may be connected in said line, finally to be condensed at 40, and the water delivered by the condenser is returned by line 41 to the tank 16. Immediately that the steam pressure so built up within the chamber 15 has been dissipated, valve plate 27 lowers and permits the chamber 15 to refill with water from tank 16, and the cycle is repeated. Thus, by a series of pressure impulses, generated through vaporization of the small quantity of water collecting intermittently in the leg 30 of the system, substantial charges of water are forced intermittently into the boiler, wherein they are converted into steam, and from which the steam is intermittently discharged via the line 34. The impulses follow one another at a frequency depending upon the rapidities with which the chamber 15 is filled with water, and with which the small charge of water in leg 30 is vaporized; and therefore upon such factors as the size of the chamber, the rate at which water flows into it, and the heating relation of leg 30 to its source of heat. It may be remarked that the leg may get its vaporizing heat from any suitable source; it is convenient that it take heat from the same source as the boiler.

The system as described furnishes a positive, intermittent flow through the boiler, and is capable of handling a relatively large quantity of flow per unit of time.

I will now describe the application of my impulse pump to a refrigeration system. By way of introduction to this aspect of the invention, it may be noted that the employment of a means for positively inducing flow of the refrigerant medium through the cooling coils or pipes has several most definite and important advantages. First, the substitution of positively induced flow for the conventional method of establishing circulation by balancing a column of liquid against the vaporizing liquid in the cooling pipes eliminates all necessity for the otherwise requisite delicately adjusted balance between the static liquid head and the friction losses in the cooling pipes, and makes unnecessary the otherwise essential precautions which must be taken to assure the constant rise of the vaporizing liquid in those pipes. And not only does positive pumping render the system comparatively independent of friction losses, but it makes the system substantially independent of the mechanical configuration or arrangement of the cooling pipes, eliminating the necessity of rise from intake end to discharge end, and permitting them, if desired, to be all in one horizontal plane. Moreover, and not least in importance, positive pumping permits establishment of a greater quantity of liquid flow per unit time, with consequent increase in rate of heat transmission.

Reference is now directed to Fig. 4, showing diagrammatically one typical application of my impulse pump to a refrigeration system. Numeral 50 designates generally a pumping chamber, corresponding to the chamber 15 of Fig. 1, and numeral 51 designates a discharge pipe whose open end 52 is located inside and near the lower end of chamber 50. A heating leg 53 opens at one end inside the upper portion of chamber 50, and is closed at its other end 54. This leg 53 is to be understood as subjected externally to atmosphere, for instance to the atmosphere of the area which is to be refrigerated. As here shown, the pipe 53 is furnished with a series of heat absorbing fins 55.

A refrigerant supply line 56, understood to lead from a compressor or other source of refrigerant supply, discharges inside an accumulator 57 under control of a suitable valve, which may typically be a float controlled valve, such as diagrammatically indicated at 58. This float controlled valve may maintain the liquid within the accumulator 57 at some such a level as indicated at L'. Refrigerant contained within accumulator 57 is fed by gravity to pumping chamber 50 via line 59 containing an inverted normally open check valve 60, which may be of the same type as the valve V employed in the system of Fig. 1.

Pipe 51 leads from chamber 50 to a trap 61, which is connected by pipe 62 to one end of a set of refrigeration piping (heat absorbing coils) generally designated at 63, the other end of which is connected by pipe 64 into the upper end of accumulator 57. The pipes 63 may be arranged in any configuration, and need not be provided with the usual gradual rise between ingoing and outcoming ends such as is requisite in static head circulation systems. A line 65 leading from accumulator 57 conveys vaporized refrigerant to any suitable vapor recovery means, such as a compressor, absorber, or absorption system, not necessary to illustrate or describe.

Refrigerant in liquid form supplied via pipe

56, is, as previously described, discharged under control of flow valve 58 into accumulator 57, the float maintaining the level therein at some predetermined height, such as indicated. A certain percentage of the liquid refrigerant so discharged within the accumulator 57, perhaps as much as 25%, immediately vaporizes, and the effect of the vaporization is to cool the remainder of the refrigerant within the accumulator, the temperature being lowered say to about 10° F. This cooled refrigerant, in liquid form, flows via pipe 59 past check valve 60 into chamber 50, wherein it rises until it flows into and fills the leg 53. As previously explained, the leg 53 is surrounded by atmospheric air, or by the air within the region to be refrigerated. This air is at a temperature higher than that of the precooled refrigerant contained within the chamber 50 and therefore within the leg 53, and the effect of the heat transference from such air to the relatively small quantity of refrigerant contained within the leg 53 is to vaporize that refrigerant. The gas under pressure so developed discharges into chamber 50, closing check valve 60, and expelling the liquid refrigerant contained within chamber 50 by way of pipe 51, trap 61, and the cooling pipes 63. This refrigerant vaporizes and expands within the pipes 63, and the gas so produced is conveyed to accumulator 57 by way of pipe 64. The accumulator 57 may contain a separator baffle 66, designed to remove liquid particles from the gas, and the gas remaining is recovered by way of line 65. Any unvaporized liquid remaining in piping 63 after the movement of refrigerant through the pipes ceases will be caught in trap 61 if it tends to run back toward chamber 50. It is assumed that the proportions of the apparatus, and the volume of pressure gas, are such that all of the refrigerant liquid from 50 will have been pushed into the expansion piping 63 and that gas will stand in the trap 61 as the movement ceases when the excess gas pressure has subsided. As soon as the excess vapor pressure within chamber 50 has subsided, check valve 60 opens and permits the chamber to refill with pre-cooled refrigerant from accumulator 57. This completes the cycle, which then automatically repeats over and over, in a manner similar to that of the system of Fig. 1.

Fig. 5 shows a modification of the refrigerator system of Fig. 4, in which the refrigerant in the leg connecting with the pumping chamber is vaporized by heat transfer from the incoming refrigerant, rather than from atmosphere. For convenience, corresponding elements in the systems of Figs. 4 and 5 are designated by like reference numerals, but with the sub-letter *a* annexed in Fig. 5. The incoming liquid refrigerant line 56*a* in Fig. 5 is connected to one end of a jacket 70 surrounding leg 53*a*, and leading from the other end of said jacket is a pipe 71 which discharges within the lower portion of accumulator 57*a*, under control of float valve 58*a*, as will be apparent. The remainder of the system may be as in Fig. 4.

The incoming liquid refrigerant, at a temperature of, for instance, 90° F., flows through jacket 70 on its way to accumulator 57, its temperature being reduced perhaps 10° in passing through jacket 70 because of heat absorbed by leg 53*a*. As in the instance of Fig. 4, a certain percentage of the liquid refrigerant so discharged within accumulator 57*a* is vaporized therein, substantially lowering the temperature of the remainder, which drains via line 59*a* and check valve 60*a* into chamber 50*a*. Chamber 50*a* thus fills with liquid refrigerant, at a temperature of perhaps 10° F., which refrigerant finally flows into and fills leg 53*a*. Heat absorbed from the refrigerant in jacket 70 vaporizes the quantity of refrigerant contained within leg 53*a*, and the gas pressure so developed closes check valve 60*a* and expels the charge of refrigerant contained within chamber 50*a* via line 51*a* and refrigeration piping 63*a* in the same manner as described in connection with Fig. 4.

It will be evident that there is no broad fundamental distinction, insofar as the pumping system of the present invention is concerned, between the boiler system of Figs. 1 and 2 and the refrigeration systems of Figs. 4 and 5. In each instance, a quantity of liquid in a leg connected with the pumping chamber is subjected to a vaporizing temperature. In the boiler system, the liquid may typically be water, and the vaporizing temperature will be above atmospheric; in the refrigeration systems, the liquid will be any suitable refrigerant, and the vaporizing temperature may be atmospheric, though not necessarily so. It is contemplated, however, that in addition to the inventive subject matter common to the boiler and refrigeration systems here instanced, each of said systems individually includes subject matter of invention peculiar to itself, which it is my purpose to cover within the scope of the appended claims. And it is to be further understood that the illustrative applications and forms of the invention here given are merely illustrative of and not limitative on the invention, and further, that various changes in design, structure and arrangement of the physical instrumentalities here instanced may be made without departing from the spirit and scope of the invention or of the appended claims.

I claim:

1. Fluid pumping means adapted for use in a refrigeration system that includes a source of refrigerant and refrigeration piping having inlet and outlet ends, said pumping means comprising: a tank arranged to receive liquid refrigerant from said source of refrigerant, valve means controlling inflow of refrigerant to said tank and establishing a predetermined liquid level therein, a pump chamber having a liquid inlet connected to said tank, a check valve between said tank and chamber adapted to be closed upon development of fluid pressure within said chamber, a liquid outlet leading from said chamber from a point substantially below the upper end thereof and connecting with the inlet end of said refrigeration piping, and a heat absorbing liquid conduit communicating at one end with said chamber at a point above the liquid outlet from said chamber and otherwise closed, said conduit being adapted to take refrigerant from said chamber when liquid rises to a predetermined level in the chamber, to be vaporized in said conduit by heat absorption, and the vapor so produced discharging into said chamber to close said check valve and to pump the liquid contents of said chamber through said liquid outlet and to and through said refrigeration piping.

2. Fluid pumping means adapted for use in a refrigeration system that includes a source of refrigerant and refrigeration piping having inlet and outlet ends, said pumping means comprising: an accumulator connected to said source of refrigerant, valve means controlling inflow of refrigerant to said accumulator and establishing a

predetermined liquid level therein, a pump chamber having a liquid inlet connected to said accumulator at a point below said liquid level, a check valve between said accumulator and chamber adapted to be closed upon development of fluid pressure within said chamber, a liquid outlet leading from said chamber from a point substantially below the upper end thereof and connecting with the inlet end of said refrigeration piping, a fluid connection between the outlet end of said refrigeration piping and said accumulator at a point above the liquid level therein, a heat absorbing liquid conduit communicating at one end with said chamber at a point above the liquid outlet from said chamber and otherwise closed, said conduit being adapted to take refrigerant from said chamber when liquid rises to a predetermined level in the chamber, to be vaporized in said conduit by heat absorption, and the vapor so produced discharging into said chamber to close said check valve and to pump the liquid contents of said chamber through said liquid outlet and to and through said refrigeration piping, the liquid refrigerant vaporizing within said piping, and the vapor being delivered to the accumulator.

3. In combination with a fluid heater having a heat source and an inlet and an outlet for a fluid medium, a circulating pump comprising a pump chamber having a liquid inlet and a liquid outlet, said liquid outlet leading from the chamber at a point substantially below the upper end thereof and leading to said heater inlet, the passage from the chamber outlet to and through the heater being freely open at all times, a source of liquid connected with said chamber inlet, a check valve between said source of liquid and said liquid inlet adapted to be closed upon development of fluid pressure within said chamber, the passage from the source to and through said liquid inlet being otherwise freely open, and a liquid conduit openly communicating at one end with said chamber at a point above said chamber outlet and otherwise closed, said conduit being adapted to take liquid from said chamber when liquid rises to a predetermined level in the chamber, and said conduit being arranged in heat absorbing association with said heat source, whereby liquid collected in said conduit will be vaporized by heat absorbed from said heat source and the vapor so produced discharged under pressure into said chamber to close said check valve and to pump the liquid contents of said chamber through said chamber outlet and to and through said heater.

4. In combination with a fluid heater having a heat source and an inlet and an outlet for a fluid medium, a circulating pump comprising a pump chamber having a liquid inlet and a liquid outlet, said liquid outlet leading from the chamber at a point substantially below the upper end thereof and leading to said heater inlet, the passage from the chamber outlet to and through the heater being freely open at all times, a source of liquid connected with said chamber inlet, a check valve between said source of liquid and said liquid inlet adapted to be closed upon development of fluid pressure within said chamber, the passage from the source to and through said liquid inlet being otherwise freely open, a liquid conduit openly communicating at one end with said chamber at a point above said chamber outlet and otherwise closed, said conduit being adapted to take liquid from said chamber when liquid rises to a predetermined level in the chamber, and said conduit being arranged in heat absorbing association with said heat source, whereby liquid collected in said conduit will be vaporized by heat absorbed from said source and the vapor so produced discharged under pressure into said chamber to close said check valve and to pump the liquid contents of said chamber through said chamber outlet and to and through said heater, and a fluid circulation line leading from said heater outlet and returning liquid finally to said source of liquid.

5. Fluid pumping means for use in a refrigeration system that includes a source of refrigerant and refrigeration piping having inlet and outlet ends, said pumping means comprising: a tank connected to the source of refrigerant, valve means controlling the inflow of refrigerant to said tank and establishing a predetermined liquid level therein, a pump chamber having a liquid inlet connected to said tank, a check valve between said tank and chamber adapted to be closed upon development of fluid pressure within said chamber, a liquid outlet leading from said chamber from a point substantially below the upper end thereof and connecting with the inlet end of said refrigeration piping, and a heat absorbing liquid conduit communicating at one end with said chamber at a point above the liquid outlet from said chamber and otherwise closed, said conduit being arranged in heat absorbing relation to said refrigerant supply line, and said conduit being adapted to take refrigerant from said chamber when liquid rises to a predetermined level in the chamber, to be vaporized in said conduit by virtue of heat absorbed from the refrigerant flowing in said refrigerant supply line, the vapor so produced discharging into said chamber to close said chck valve and to pump the liquid contents of said chamber through said liquid outlet and to and through the said refrigeration piping.

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