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H. L. SIEBER
FLOW SYSTEM

3,098,787

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2 Sheets-Sheet 1

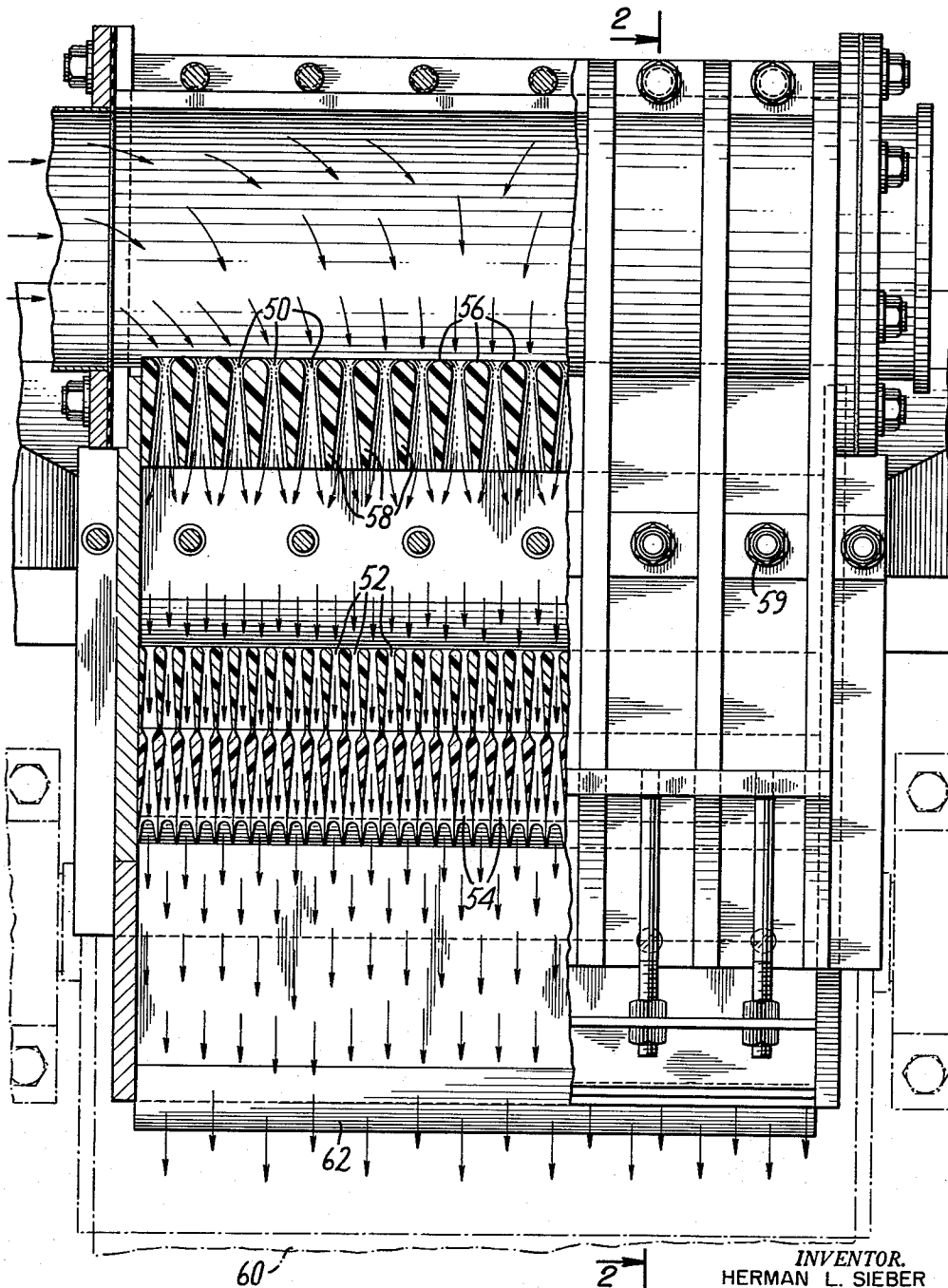


FIG. 1

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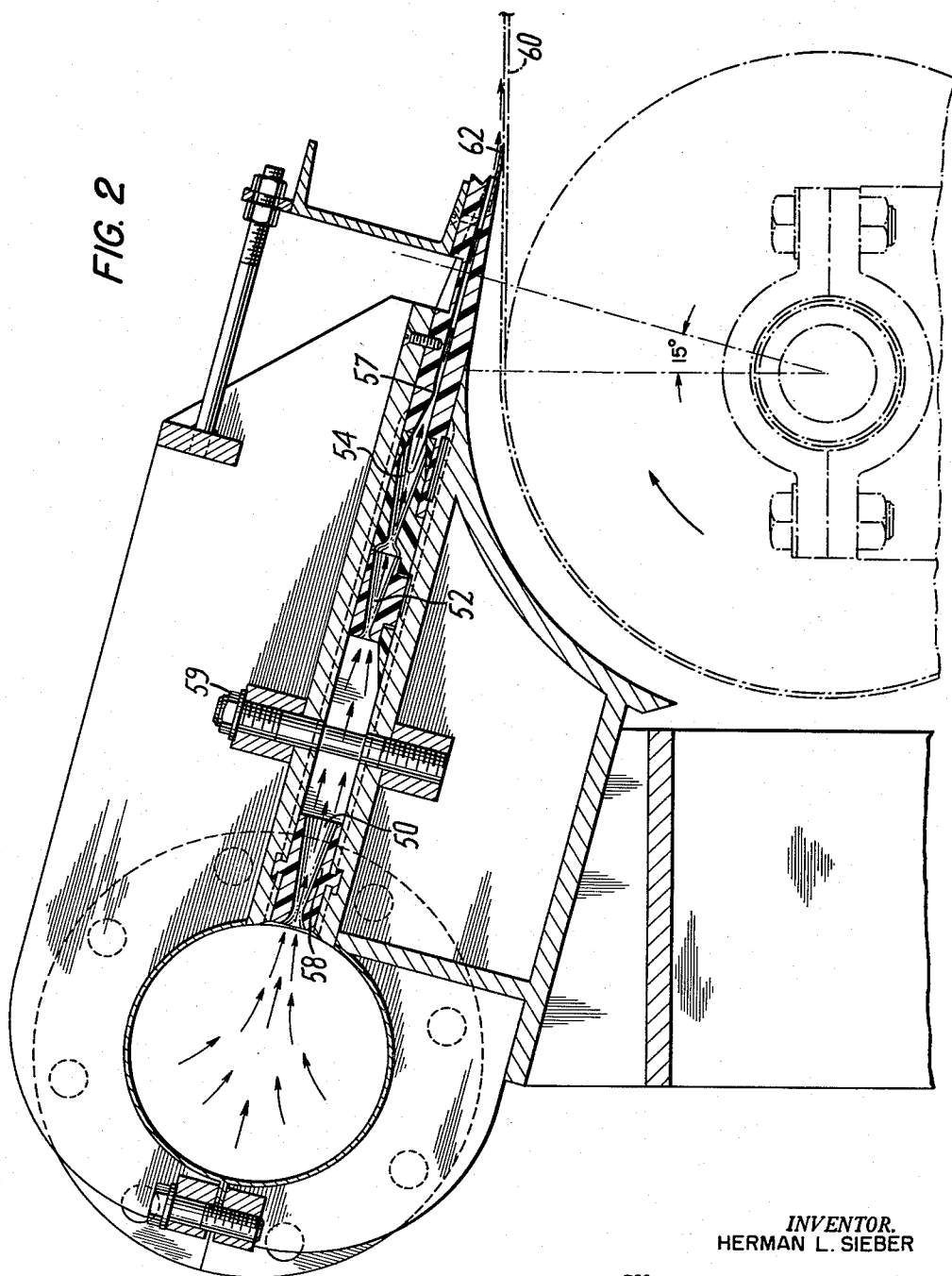
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3,098,787 FLOW SYSTEM

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This invention relates to a system in a paper making machine for obtaining a more homogeneous sheet of paper, and, in particular, to a closed stock inlet system for delivering to the wet end of a paper making machine a homogeneous formed layer of a pulp furnish which may be of high consistency.

Conventional closed stock inlet systems generally include a slice having spaced lips forming an elongated slot capable of discharging pulp onto a forming wire, and means including a conduit flow system preceding the slice for delivering to it a substantially constant amount of stock. Despite considerable development in stock inlet systems, however, no system has been developed capable of successfully delivering to a forming wire a completely homogeneous flow of stock, i.e., one which is free of flocs of pulp, and of equal consistency throughout. It has therefore been conventional to employ means in combination with the forming wire, for instance, table rolls, to further homogenize the stock which means are characterized, however, by a significant lack of control over the formation of the paper sheet.

In accordance with the objects of the present invention, there is provided a pulp inlet system for a paper making machine including a slice, and a flow system immediately preceding the slice, the latter comprising a streamlined orifice or Venturi-shaped passageway, capable of forming at the slice a homogeneous stock suspension which is substantially free of flocs of pulp fiber. The chamber may be divided into a row, oriented in a direction transverse to the direction of flow, of a multiple number of adjacent, individual orifices or Venturi passageways, or additionally may be divided into a multiple number of successive rows of Venturi-shaped passageways or orifices acting on the pulp flocs.

The shape and dimensions of the Venturi are important to produce maximum disintegration of the flocs of pulp, and should comprise, in addition to specifically designed conical converging and diverging sections, an area of finite length in the throat of the Venturi, where the walls of the throat are parallel or slightly diverged in the direction of flow of the pulp, to produce, overall, a controlled rapid acceleration of the pulp, a controlled but more gradual deacceleration, and an intermediate area where the pulp is subjected to a high velocity and, accordingly, a high pressure drop.

The dimensions of the Venturi relative to those of the slice, or other flow constrictions which might be interposed between the slice and the Venturi are also important. In general, the dimensions of the Venturi should be sufficiently less than equivalent dimensions of a following constriction, or the slice opening, to achieve a large pressure drop across the Venturi throat, and often, should be calculated to produce in the throat portion of the Venturi a velocity sufficiently high to create a negative pressure therein capable of causing cavitation or boiling of the pulp.

In certain instances, better results may be obtained by going to velocities in the Venturi throat areas less than those capable of creating cavitation. For instance when a higher velocity is effected in the throat section, a longer diverging section is required, and because of the added length, there is a greater opportunity for flocculation. Hence, the use of several successive rows of Venturi ori-

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fices causing the pulp to be acted on a successive number of times without cavitation, may be more effective than providing means to act on the pulp a single time or lesser number of times with cavitation.

Regardless of whether the dimensions are calculated to produce cavitation in the throat area, or are calculated merely to produce a large pressure drop across the throat, it appears that the Venturi orifices acting on the pulp actually create an explosion or violent disintegration of the pulp flocs in the throat area, and thereby disperse the fibers more homogeneously in the suspension. Accordingly, the effectiveness of either design is dependent upon the ability of the design to achieve this explosive effect or rendering of the pulp flocs. This ability, in turn, is dependent upon such factors as type of pulp, consistency of the pulp thickness of the paper sheet to be formed, slice dimensions, and rate of production.

In the downstream section of the Venturi, the design and/or taper is important, and principal considerations are that the taper be sufficiently small to avoid cavitation, and yet large enough to provide a relatively short distance between the Venturi throat and the slice, for the purpose of avoiding undue flocculation, and undue power loss. In general, it should be designed to actually create a pulp structure or formation at the downstream mouth of the Venturi, and evidence has been obtained that a properly designed downstream or diverging section will create a locking of the fibers of the exploded homogeneous pulp suspension, and will actually build a pulp formation having a certain degree of structural strength.

The specific angle of convergence is not critical as long as a rapid acceleration is effected, and a number of configurations have been tried in this area with successes.

The present invention is particularly designed for use with a paper former as described in an application, Serial No. 1,261, filed January 8, 1960, by David E. Robinson. In that application there is described a wet end machine capable of withdrawing water from the pulp furnish immediately on discharge of the furnish from a slice and contact of the furnish with the wire. The principle involved is to create a completely homogeneous suspension in a flow chamber prior to discharge from the slice, leaving for the former the principal function of withdrawing water from the sheet and eliminating the function, for the former, of making the sheet more homogeneous. Accordingly, if the furnish obtained in the splice is highly homogeneous, it is desirable to have it at as high a consistency as possible to decrease the amount of time required for water removal, and thus the amount of time available for disturbance or disruption of the formation. Where conventional head boxes, holly rolls, and other slice equipment are incapable of handling a high consistency flow, it has been discovered that the present flow system is capable of very successfully handling it, and actually seems to provide better results with higher consistencies. Thus, where conventional systems use consistencies from .02 to 1.2%, the present invention obtains good results with consistencies from 1 to 6%. It should be understood that good results are also obtained with conventional lower consistencies.

Other objects and advantages will become apparent upon further consideration of the specification, and accompanying drawings in which:

FIGURE 1 is a top view of a representative embodiment of the invention; and

FIGURE 2 is a section view taken along line 2—2 of FIGURE 1.

FIGURES 1 and 2 show a multiple number of rows 50, 52, and 54, of adjacent Venturi orifices. In this embodiment, the system is designed for an 18 inch former. The first row 50 consists of 18 nozzles, spaced apart on one inch centers and the second and third rows 52 and

54, consist of 36 nozzles, each spaced on ½ inch centers. The particular dimensions of the Venturi orifices are important but may be varied depending on their application. The following are representative dimensions designed for an 18 inch former, and for the flow of a pulp stock having a 1½ to 6% consistency. For instance, good results were obtained with a 2.4% consistency of a 30% kraft 70% groundwood, pulp stock, under a line pressure of about 44 pounds per square inch, and a flow rate of about 200±10 gallons per minute.

The first row of nozzles 50 are formed with ¼ inch radii in the approach area 56 of the orifices, parallel walls in the throat area for a distance of ⅜ of an inch, an 8° taper for a distance of ¾ of an inch, and a 14° taper for the remaining distance 58 of a total distance of 2½ inches for the Venturi. The second row of nozzles 52 are provided with ¼ inch radii in the upstream portion or approach area of the Venturi, the throat of the Venturi having, for a length of .250 inch, a taper of 3°, the diverging section having a taper of 10°, to complete a total passageway distance of 2½ inches. The third row of nozzles 54 are provided with substantially the same angles and tapers as the second row, but have a constantly greater minor dimension and orifice diameter.

Cavitation, or a negative pressure, was achieved in the second and third rows of Venturi orifices, only, with no cavitation in the first row 50. To accomplish this the minimum slice minor dimension at point 57, was about .05 inch, expanding to about .068 inch maximum. The second and third rows of Venturi-orifices were provided with minimum throat diameters of about .175 and .185 inch respectively, the maximum chamber minor dimensions following the second and third rows of orifices being about .500 inch, and .700 inch respectively. The minimum throat diameter in the first Venturi was about .25 inch, a diameter which, in combination with the above slice and Venturi dimensions was too large to achieve a negative pressure in this area. This diameter may be made less to produce cavitation if desired. Also, in accordance with the objects of the invention, it may be found desirable to use throat diameters sufficiently large so that there is no cavitation in any of the throat areas, but here the dimensions must be calculated to effect an acceleration of the pulp into the throat areas, sufficient to achieve a rendering or explosion of the flocs of pulp.

The particular dimensions used may be determined in a number of ways. One way is to select a wire speed for forming a desired weight paper, thereby determining the production rate in tons/inch of slice width/24 hour day, which in combination with the degree of retention of the pulp on the wire and the consistency of the pulp determines the flow rate of the system. With the latter and the pressure upstream of the orifices, one can ascertain experimentally or otherwise the necessary minimum cross-sectional areas and pressure drops required in the orifices to produce cavitation or near cavitation.

In general the cross-sectional area of the orifices in a downstream direction is increased so that the ratio of the areas of any two orifices is inversely proportional to the square root of the ratios of the absolute pressures immediately upstream of the orifices.

For instance, referring to FIGURE 5, if the absolute pressure, P_0 , upstream of the first orifice section 50 is 75 lb. per sq. in., the following relationships were found to exist:

Absolute pressure in area between orifice sections 50 and 52, $P_3=60$ lb. per sq. in.

Absolute pressure in area between 52 and 54, $P_5=45$ lb. per sq. in.

Absolute pressure in area between 54 and 57, $P_7=30$ lb. per sq. in.

Total area of nozzle section 50= a_1

Total area of nozzle section 52= a_3

Total area of nozzle section 54= a_5

Total area of nozzle section 57= a_7

$$a_3 = \sqrt{\frac{P_0}{P_3}} \times a_1 = \sqrt{\frac{75}{60}} \times a_1 = 1.12a_1$$

$$a_5 = \sqrt{\frac{P_0}{P_5}} \times a_1 = \sqrt{\frac{75}{45}} \times a_1 = 1.29a_1$$

$$a_7 = \sqrt{\frac{P_0}{P_7}} \times a_1 = \sqrt{\frac{75}{30}} \times a_1 = 1.57a_1$$

In the embodiment, illustrated in FIGURES 1 and 2, a space is provided between the first and second rows of Venturis, to permit ⅝ inch bolts, 59, to be inserted for holding the chamber walls together. Preferably, the successive rows of Venturi-orifices are spaced as close together as possible.

The following is a representative example of a flow system according to the present invention, similar to the embodiment described in reference to FIGURES 1 and 2, which, however, is comprised of a single row of a series of adjacent orifices as distinguished from the plurality of rows of venturis of the described embodiment. Good results are obtainable from the arrangement using consistencies from about .5% to 4%, at a production rate of from .05 to 2.0 tons/inch slice width/24 hour day, or higher.

The slice and pre-slice chamber included a single row of 36 Venturi-orifices spaced on ½ inch centers, the slice opening being about .07 inch, each Venturi having a minimum throat diameter of .18 inch, and converging and diverging portions designed in accordance with the second row of Venturi-orifices, 52, illustrated in FIGURE 2. Although the arrangement is suitable for the production of a number of different types of paper, the production contemplated is of a 25 pound sheet, of 70% ground wood and 30% chemical pulp, formed on a wire having a 95% retention of pulp fibers. (The former, described in application, Serial No. 1,261 achieved this degree of retention although a 70% retention is customary.) At a wire speed of 1500 feet per minute, a flow rate of .8 ton/inch of slice width/24 hours, of a stock having an .86% consistency would result in cavitation in the throat area, good break up of flocs, and the creation of a homogeneous pulp formation.

If the wire speed is increased to 3000 feet per minute, with the same flow rate and wire retention, a 1.72% consistency would produce the desired results.

Similarly, if the wire speed was increased to 4000 feet per minute, the consistency could successfully be increased to 2.5%.

The slice opening and Venturi throat diameters are minimum dimensions for the type of pulp used, and lesser dimensions might result in plugging of the openings. Similarly, pulp having a longer fiber, such as pure kraft stock, would necessitate larger dimensions, as would higher consistencies, for instance, 6%.

FIGURE 2 shows the slice and pre-slice flow system arranged at an angle of 15° relative to a forming wire 60, to demonstrate the usefulness of the system for making multi-layered paper. The lower framework can be modified suitably, and the system arranged to discharge pulp at successive points along the forming wire, every slice but the first one being arranged at the 15° angle. An arrangement so conceived will present a considerable saving in space as compared to conventional head boxes. A lower lip 62 is provided to effect contact with the wire 60, and to obtain a smooth discharge of the pulp onto the wire.

Evidence of the effectiveness of the Venturi has been demonstrated in a number of ways. One way has been to photograph the pulp formation at the slice, placing a high speed flash and camera respectively above and below the slice. The photographs obtained clearly showed that the present invention resulted in a formation substantially more free of flocs of pulp, than obtainable from a conventional head box, and also a formation that had a certain degree of structural strength.

Also the effectiveness of the Venturi passageway was demonstrated by allowing a suspension formed by the Venturi orifices to settle in a glass beaker. A formation or suspension obtained using the concepts of the present invention, remained in suspension for a much greater length of time than a pulp suspension taken from a conventional headbox. For instance, a pulp formation obtained from the flow system, having a 2.5% consistency, when placed in a beaker, remained in suspension for a period of more than two hours, whereas a suspension of equal consistency taken from a conventional head box separated to a water phase and stock phase after thirty minutes. This test shows that the Venturi orifices actually build a stock formation, the suspension formed actually attaining a degree of structural strength.

Although the above example relates to a cavitation producing system, it may be preferable to use an additional number of rows of Venturi orifices creating in the throat areas a high acceleration without cavitation, which may effect the same floc break-up, but an improved pulp formation.

Thus, the present invention, in providing Venturi positioned immediately before the slice, effects a rapid, controlled acceleration in combination with a negative or almost negative, throat pressure and by the combination, creates a disentanglement of pulp fibers and a breakup of flocs producing a colloidal suspension of pulp in the stream. In the deacceleration stage the fibers become re-entangled without the formation of flocs and the stock actually forms a semi-rigid homogeneous suspension which is maintained substantially up to and even after extrusion of the suspension from the slice onto the wire, thereby, in effect, providing a means which actually forms the paper sheet before the slice, rather than, as conventionally, on the forming wire.

It is apparent that there is provided not only a system capable of more successfully breaking up flocs of pulp and forming a homogeneous pulp suspension, but one also capable of successfully handling flows of higher consistencies, for instance, consistencies of from 1.2 to 6%, as compared to conventional consistencies of .04% to 6%.

Although the invention has been described by referring to specific structure dimensions, tapers for the Venturi orifices and passageways, and the like, it is apparent that many modifications may be made within the spirit of the invention, and it is, therefore, intended that the scope of the invention be limited only as defined in the following claims.

I claim:

1. Apparatus for supplying a paper stock to a paper-making machine comprising a slice and a pre-slice flow chamber connected to said slice for directing a flow of paper stock to said slice, a portion of said pre-slice flow chamber defining a plurality of venturis disposed in a row substantially transverse to the direction of said flow.

2. Apparatus for supplying a paper stock to a paper-making machine comprising a slice and a pre-slice flow chamber connected to said slice for directing a flow of paper stock to said slice, a portion of said pre-slice flow chamber defining a plurality of venturis disposed in a row substantially transverse to the direction of said flow, and means for forcing said stock through said venturis at a speed sufficient to produce cavitation of said stock.

3. A method of supplying a paper stock to a paper-making machine comprising the steps of establishing a flow of paper stock in a pre-slice flow chamber, dividing the flow within said chamber into a plurality of parallel spaced-apart streams, passing each of said streams through a different one of a plurality of venturis disposed in a row substantially transverse to the direction of said flow, whereby flocs in said stock are first accelerated and disintegrated then decelerated to form a homogeneous semi-rigid suspension of entangled fibers devoid of flocs, and discharging said stock through a slice.

4. A method of supplying a paper stock to a paper-making machine comprising the steps of establishing a flow of paper stock in a pre-slice flow chamber, dividing the flow within said chamber into a plurality of parallel spaced-apart streams, passing each of said streams, at a velocity sufficient to produce cavitation of said stock, through a different one of a plurality of venturis disposed in a row substantially transverse to the direction of said flow, whereby flocs in said stock are first accelerated and disintegrated then decelerated to form a homogeneous semi-rigid suspension of entangled fibers devoid of flocs, and discharging said stock through a slice.

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