

[54] BREATHING GAS HEATER

[75] Inventor: Douglas Larry Marcus, Baltimore, Md.

[73] Assignee: Joseph M. Schwartz, Lutherville, Md. ; a part interest

[22] Filed: Apr. 2, 1974

[21] Appl. No.: 457,204

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 314,373, Dec. 12, 1972, Pat. No. 3,815,573.

[52] U.S. Cl. 126/204; 62/2; 128/142.2; 128/142.4; 128/212

[51] Int. Cl. A62b 7/02

[58] Field of Search 126/204; 62/5; 128/142.2, 128/142.3, 142.4, 212

References Cited

UNITED STATES PATENTS

3,107,669 10/1963 Gross 128/212 X
3,182,653 5/1965 Mauleos et al. 128/212 X

3,770,938 11/1973 Agarate 128/142.4 X

FOREIGN PATENTS OR APPLICATIONS

1,187,932 2/1965 Germany 128/212

Primary Examiner—Carroll B. Dority, Jr.

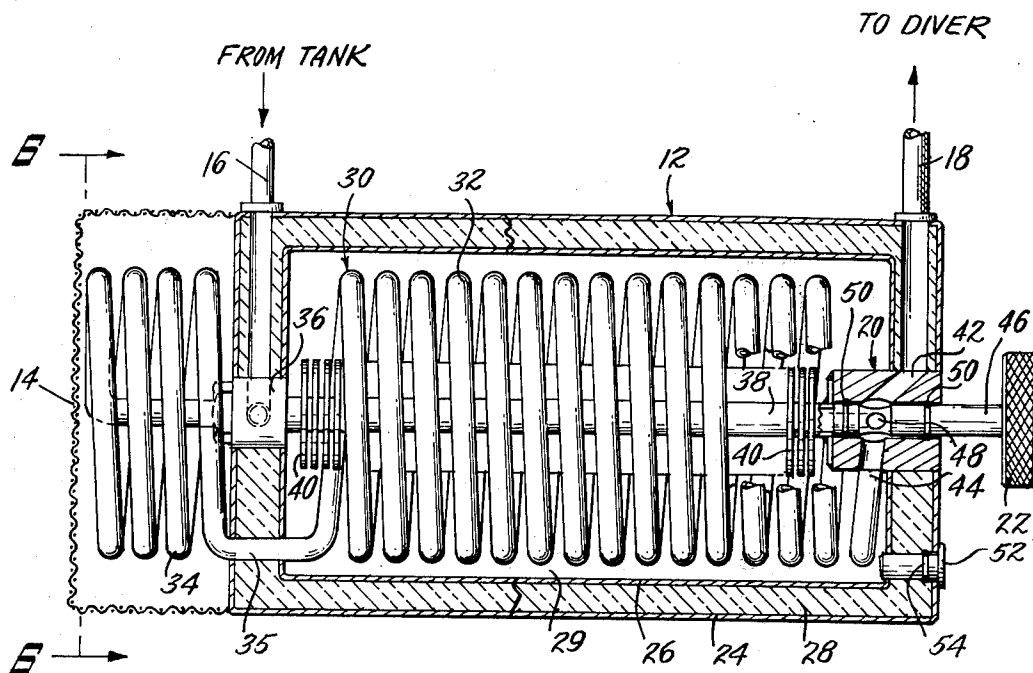
Assistant Examiner—Peter D. Ferguson

Attorney, Agent, or Firm—Abraham A. Saffitz

[57] ABSTRACT

A self-contained, portable breathing gas heating system to be used by a diver for prolonged submersion in a cold environment which consists of a Vortex tube used for supplementary heating of the compressed breathing gas, a heat exchanger in an insulated container, a preheated fluid through which the breathing gas circulates in tubes, and exterior tubes for heat exchange of the gas with the environment. Heat loss from diver respiration is thus compensated by heating the breathing gas to the diver's mouth and surrounding the diver's head.

5 Claims, 6 Drawing Figures



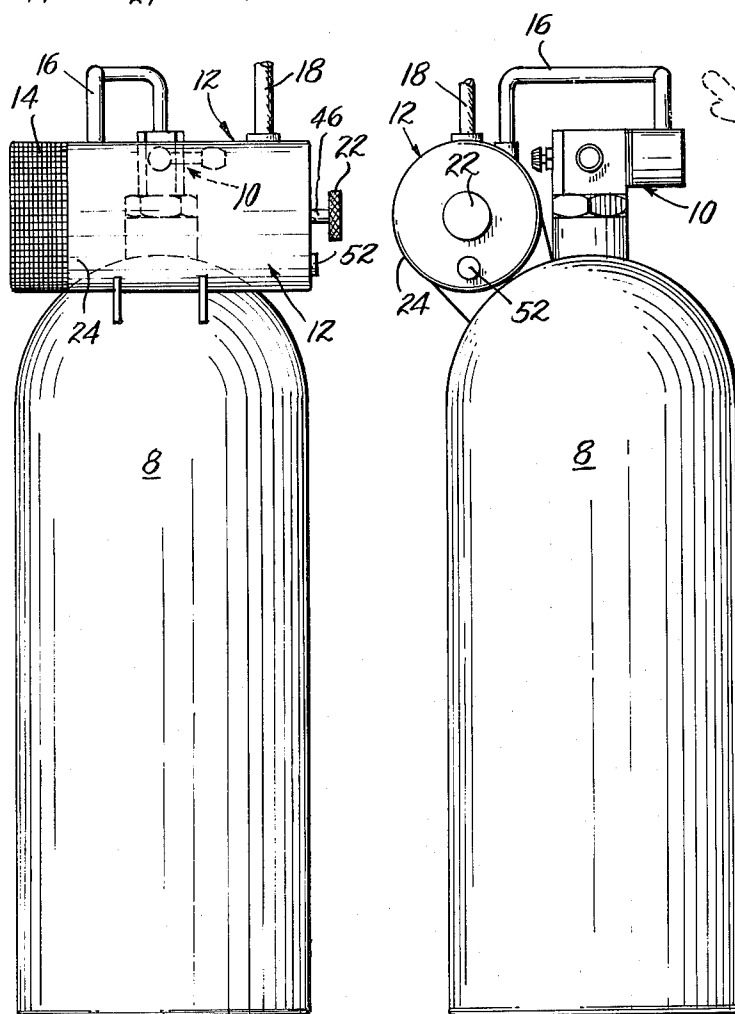
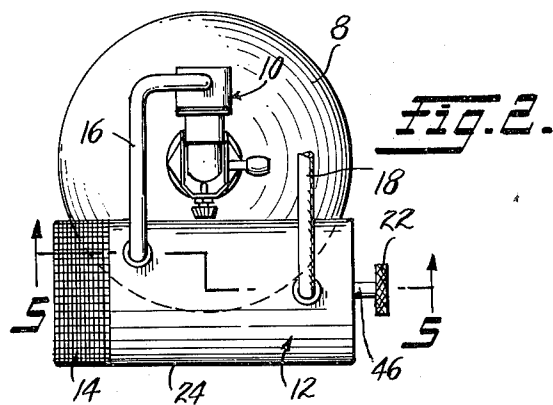


Fig. 3.

Fig. 4.

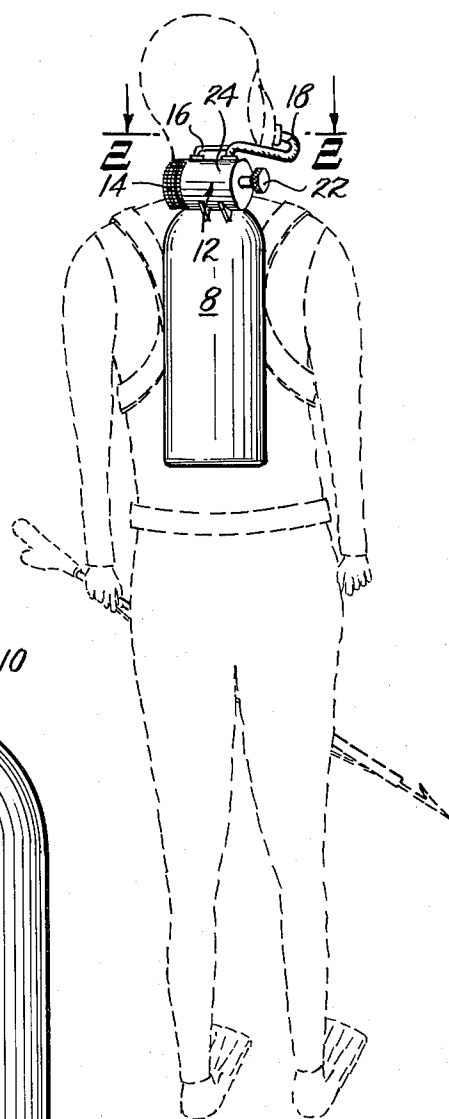
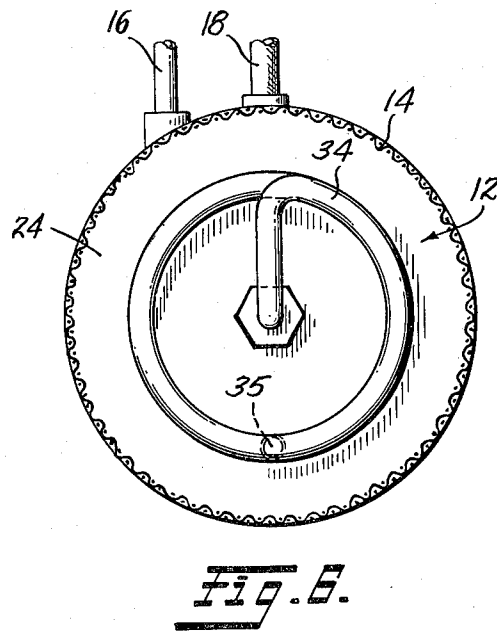
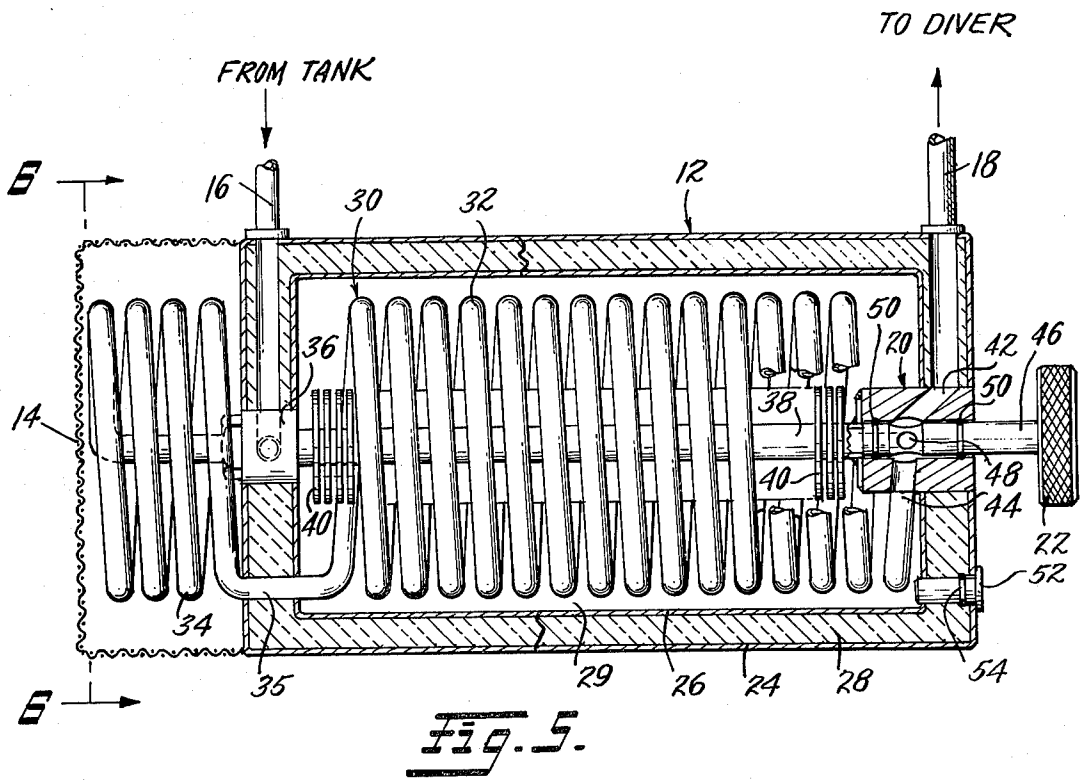


Fig. 1.



BREATHING GAS HEATER

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-Part of application Ser. No. 314,373, entitled DIVING SUIT HEATER filed Dec. 12, 1972, and now U.S. Pat. No. 3,815,573.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is in the field of a self-contained, portable breathing gas heating system to be used by a diver for prolonged submersion in a cold environment.

2. Description of the Prior Art

The prior art for the present invention is the discovery of Georges Ranque of France (U.S. Pat. No. 1,952,281, December, 1931) concerned with a method for automatically obtaining from a compressible fluid (gas or vapor) under pressure, a current of hot fluid and a current of cold fluid and the transformation of the initial fluid into two currents of different temperatures taking place without the help of any movable mechanical organ, but merely through the work of the molecules of fluid upon one another.

A fact as old as diving itself and becoming increasingly important as divers go deeper for longer periods, is that heat must be provided for the diver. The object of any dive is to achieve useful work - and a diver will achieve useful work safely and efficiently - if he is warm and comfortable.

Steps taken toward providing diver comfort have included the use of a wet suit, generally made of foamed neoprene as insulation, and the development of a water tight multiple clothing layered dry suit for colder temperatures. Due to heat losses encountered with the two different types of suits, it has become evident that a heat replacement system is necessary for deep or prolonged dives. At present, no suit alone is capable of keeping a diver in proper heat balance (77° F skin temperature) for very long periods of time. This heat must be provided from an external source.

SUMMARY OF THE INVENTION

Although, the ideal method of maintaining warmth for the diver would be to install a self-contained heating unit, the energy and space requirements for this type of equipment are very stringent since free swimmers are limited by both the size and weight of the heat source. Also, positive and accurate control of the temperature which is provided is a necessary condition and the system must be failsafe to insure that the diver cannot be burned. One most important item, overlooked in prior art is that the entire system must be simply constructed so as to appeal to manufacturers for its economic production requirements as well as to users for its low cost and low maintenance.

Many energy sources have been tried including isotope, electrical and chemical heat sources; all with the distinct disadvantages of high cost or excessive weight. It must be noted that in various experiments with subjects in heated suits; while the heat loss from the body surface remained minimal, core temperatures fell steadily. There is general agreement that supplemental heating is required for the diver, not only for his surface heat loss but for the heat loss from his respiratory tract.

Based on the fact that respiratory heat loss can amount to more than one-third of the total thermal loss, it is essential that a breathing gas heater, adaptable to the present compressed gas diving system be developed. In conjunction with some of the better diving garments available today, notably the inflatable dry suit type, a breathing gas heater would complete the total diver comfort system.

For this heated breathing gas system to function properly hot and cold streams of gas are required along with good insulation and heat transfer means. A source for hot and cold streams of gas is compressed gas at ambient temperatures used in the Vortex tube described in the U.S. Pat. No. 1,952,281 to Ranque. This same source is present on a diver in the form of a tank of compressed breathing gas.

Hot and cold streams are obtained by compressed gas passing through the initial stage of a diver's regulator to reduce tank pressure to approximately 150 pounds per square inch at ambient temperature and then through a Vortex tube. Upon separation, the resultant cold stream's temperature is well below ambient and therefore, the cold stream will readily absorb thermal energy from the environment when passed through a length of exposed coiled tubing.

The hot stream, passing through a finned tube in an enclosed fluid chamber transmits heat to the fluid. To reduce initial energy required, the fluid is preheated for proper heat transfer. The cold stream, having absorbed thermal energy from the environment, enters the fluid filled chamber, which functions as a heat exchanger, to receive further heating. As the fluid filled chamber is constructed much like a thermos bottle, the only measurable heat loss is through transfer to the cold stream. The heat removed is supplemented by the hot stream-finned tube arrangement which helps to maintain thermal balance for the time required to utilize the breathing gas volume. The cold stream, now fully heated for diver comfort, exits the double-walled chamber after mixing with the hot stream. This heated gas is breathed directly by the diver through the final stage of the regulator.

As previously indicated, the enclosed fluid is preheated. This is done to reduce equipment requirements such as a battery-immersion heater system or the like. As these are known to the art, they can be added for complete self containment of the system but are not necessary if hot fluid is available before a dive. This addition of fluid to the chamber before every dive aids in maintenance as it keeps the internal tubing clean and free of scale and algae which reduce heat transfer.

This system works satisfactorily enough to utilize hot tap water (160°F.) to produce hot breathing gas (90-100°F.) for more than one hour while submerged in a 48°F. environment. The cold stream as it exits the Vortex tube is reduced from ambient (48°F.) to 27°F. upon separation and then reheated to 47°F. by the environment acting as a heat pump. Any heated fluid can be utilized as the Vortex tube can be regulated to control breathing gas temperature for as long as breathing gas is available.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a rear elevational view of a diver with the breathing gas heater of the present invention shown in full lines;

FIG. 2 is a plan view of the breathing apparatus of FIG. 1 as seen on the line 2—2 thereof;

FIG. 3 is a rear elevational view of the breathing apparatus of FIG. 2;

FIG. 4 is a right side elevational view of the breathing apparatus;

FIG. 5 is a staggered diagrammatic longitudinal sectional view, through the heat exchanger of the breathing apparatus, taken on the line 5—5 of FIG. 2; and

FIG. 6 is a vertical sectional view, taken on the line 6—6 of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 5 and 6 schematically illustrate the embodiment of the breathing gas heater having tube means to supply gas to the heater and carry gas for breathing that are adaptable to standard diving equipment to make the unit a plug-in system. This system is designed to be worn atop the diver's tank 8, FIGS. 2—4 and sit behind the diver's head out of the way, FIG. 1 but with easy access to the temperature control 22, FIG. 1.

The Vortex tube 38, takes compressed gas from the diver's tank through any standard diver's pressure regulator 10 by way of hose 16. Separation of the two streams occurs in chamber 36. The hot stream passes through the hot side of the Vortex tube to dissipate heat to the fluid contained in the enclosed chamber 29. The cold stream, being lower than ambient temperature, passes through coiled tubes 34, to absorb heat from the surrounding water which flows through protective screen 14.

From the external tubes, the gas enters the hot fluid-filled chamber 29 through connector 35 and passes through the internal coiled tubing 32. The internal walls 36 of chamber 29 are highly reflective to avoid as much radiation heat loss as possible, and is separated from the outer wall 12 by insulation 28 to minimize conduction heat loss.

The gas, now fully heated, exits the internal chamber 29 through heat exchanger 30 along with the original hot stream via the mixing valve 20 through passages 44 and 48 controlled and regulated by valve stem 46. The heated gas exits through passage 42 and passes through tube 18 to the diver to be breathed upon demand through the final stage of the regulator.

The thermal energy removed by the gas is supplemented by the hot stream dissipating its heat through the fins 40 surrounding the hot side of the Vortex tube. O-rings 50, 54 are necessary for proper air and water seals in order that this system function correctly. Plug 52 provides access to the internal chamber for the addition or removal of hot fluid. Initial heating of the contained fluid (not shown in the drawing) could be accomplished through various chemical, electrical or mechanical means or isotope means known to the art, but for simplicity, provision of a heated fluid prior to any dive is sufficient.

The total encasement consists of the outer container 12 with protective jacket 24, insulation 28, and inner (reflective) container 26 could be manufactured as a single unit made from a foamed thermoplastic with the inner surface plated for required reflectivity. The foaming characteristic lends itself well of both thermal and noise insulation as well as strength.

What is claimed and desired to be secured by Letters Patent is:

1. A portable gas heating system for attachment to a pressurized gas source to provide heated breathing gas to a diver's mouth and head and to reduce the body's thermal heat loss in a cold aqueous environment by utilizing a small heat input where thermal loss is the greatest comprising:

a Vortex tube which separates high pressure gas from a diver's tank into cold and hot streams;

metal tubing connected to said Vortex tube which carries the cold stream of separated gas to an outer section for exposure to the aqueous environment and for heat absorption and to an inner section into a heat exchanger for further thermal energy addition before being mixed with the hot stream and breathed by the diver;

a double walled insulated chamber containing said Vortex tube and the inner section of said metal tubing which maintains a heated fluid so that all thermal energy therein is conducted to the gas passing through it in the metal tubing;

a heated fluid which is contained in the double walled insulated chamber for heating the cold stream of gas prior to breathing selected from the group consisting of fresh water, sea water and ethylene glycol;

fins surrounding said Vortex tube for heat transfer which dissipate heat of the hot stream of gas passing through the Vortex tube prior to mixing with the heated cold stream;

a valve means connected to the outlet of said Vortex tube and the outlet of said inner section to control gas flow and temperature which allows optimum setting of cold stream volume and hot stream volume and mixes the two streams prior to breathing; tube means to supply gas to the heater and carry gas for breathing that are adaptable to standard diving equipment to make the unit a plug-in system; and, a protective housing to improve continuity of the heater's design and protect the exposed coiled tubing from damage while allowing ambient water to pass through for heat transfer with the cold stream inside the tubing.

2. The combination as set forth in claim 1 in which the insulated chamber's inner walls are highly reflective to minimize radiation heat loss.

3. The combination as set forth in claim 1 in which the double walled insulated chamber is molded from a foamed thermoplastic.

4. A portable gas heating system for attachment to a pressurized gas source to provide heated breathing gas to a diver's mouth and head and to reduce the body's thermal heat loss in a cold aqueous environment by utilizing a small heat input where thermal loss is the greatest comprising:

a Vortex tube which separates high pressure gas from a diver's tank into cold and hot streams;

metal tubing connected to said Vortex tube which carries the cold stream of separated gas to an outer section for exposure to the aqueous environment and for heat absorption and to an inner section into a heat exchanger for further thermal energy addition before being mixed with the hot stream and breathed by the diver;

a double walled insulated chamber containing said Vortex tube and the inner section of said metal tubing with highly reflective inner walls minimizing radiation loss which maintains a heated fluid so that

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all thermal energy therein is conducted to the gas passing through it in the metal tubing;
a heated fluid which is contained in the double walled insulated chamber for heating the cold stream of gas prior to breathing selected from the group consisting of fresh water, sea water and ethylene glycol;
fins surrounding said Vortex tube for heat transfer which dissipate heat of the hot stream of gas passing through the Vortex tube prior to mixing with the heated cold stream;
a valve means connected to the outlet of said Vortex tube and the outlet of said inner section to control gas flow and temperature which allows optimum setting of cold stream volume and hot stream volume and mixes the two streams prior to breathing;
tube means to supply gas to the heater and carry gas for breathing that are adaptable to standard diving equipment to make the unit a plug-in system; and,
a protective housing to improve continuity of the heater's design and protect the exposed coiled tubing from damage while allowing ambient water to pass through for heat transfer with the cold stream inside the tubing.
5. A portable gas heating system for attachment to a pressurized gas source to provide heated breathing gas to a diver's mouth and head and to reduce the body's thermal heat loss in a cold aqueous environment by utilizing a small heat input where thermal loss is the greatest comprising:
a Vortex tube which separates high pressure gas from

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a diver's tank into cold and hot streams;
metal tubing connected to said Vortex tube which carries the cold stream of separated gas to an outer section for exposure to the aqueous environment and for heat absorption and to an inner section into a heat exchanger for further thermal energy addition before being mixed with the hot stream and breathed by the diver;
an insulated chamber containing said Vortex tube and the inner section of said metal tubing which maintains a heated fluid so that all thermal energy therein is conducted to the gas passing through it in the metal tubing;
a heated fluid which is contained in said insulated chamber for heating the cold stream of gas prior to breathing;
heat transfer means which dissipates heat of the hot stream of gas passing through the Vortex tube prior to mixing with the heated cold stream;
a valve means connected to the outlet of said Vortex tube and the outlet of said inner section to control gas flow and temperature which allows optimum setting of cold stream volume and hot stream volume and mixes the two streams prior to breathing;
tube means to supply gas to the heater and carry gas for breathing; and,
a protective housing to protect the exposed coiled tubing from damage while allowing ambient water to pass through for heat transfer with the cold stream inside the tubing.

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