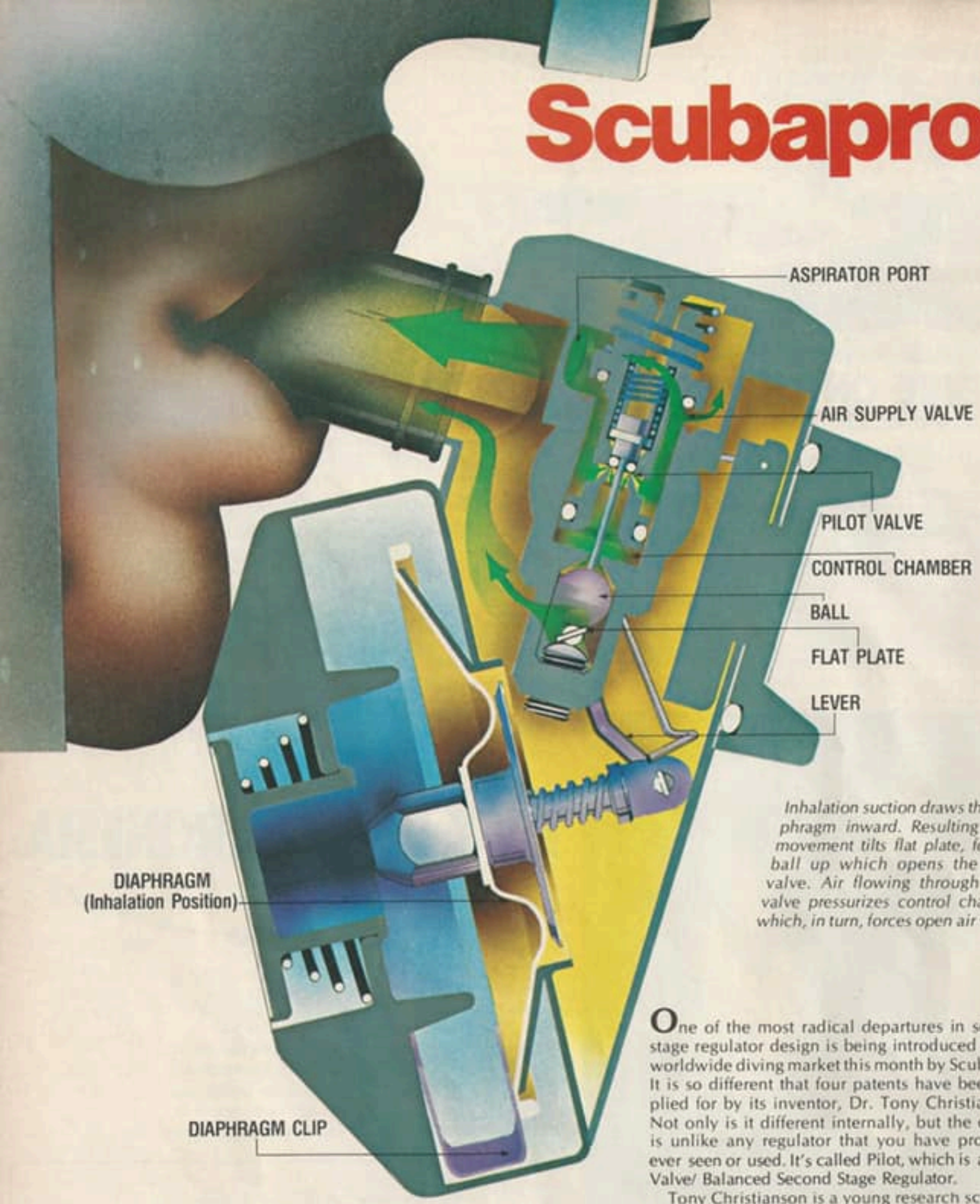
Scubapro's



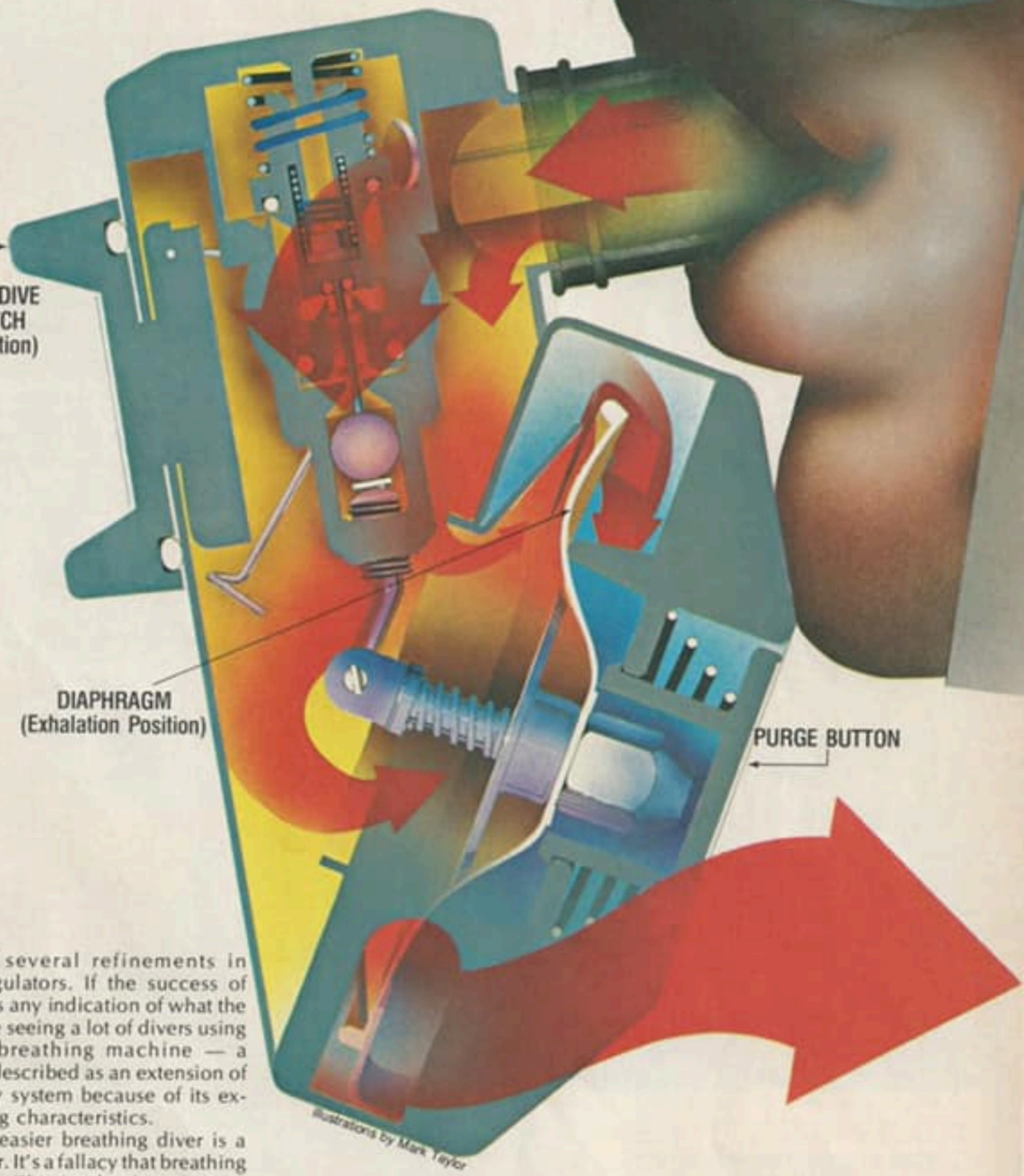
Inhalation suction draws the diaphragm inward. Resulting lever movement tilts flat plate, forcing ball up which opens the pilot valve. Air flowing through pilot valve pressurizes control chamber which, in turn, forces open air valve.

SDM PRODUCT REPORT **By Jack McKenney**

One of the most radical departures in second stage regulator design is being introduced to the worldwide diving market this month by Scubapro. It is so different that four patents have been applied for by its inventor, Dr. Tony Christianson. Not only is it different internally, but the casing is unlike any regulator that you have probably ever seen or used. It's called Pilot, which is a Pilot Valve/ Balanced Second Stage Regulator.

Tony Christianson is a young research scientist who has a PhD in Biotechnology, Systems Engineering and Meteorology specializing in Man-In-The-Sea applications. He heads up his own company out of Manhattan Beach, Ca., and has been working on perfecting the Pilot design for almost two years. In that time, it has gone through a dozen specific design changes. This bright, energetic young man was the designer of the Scubapro Mark VII sonic regulator as well

Pilot is this the ultimate regulator?



as the initiator of several refinements in Scubapro's other regulators. If the success of Scubapro's Mark VII is any indication of what the Pilot will do, you'll be seeing a lot of divers using this new, modern breathing machine — a machine that can be described as an extension of one's own respiratory system because of its extremely easy breathing characteristics.

It's a fact that the easier breathing diver is a happier and safer diver. It's a fallacy that breathing hard will conserve air. This is what happens:

When a person inhales, the respiratory muscles increase the volume of the lungs by lifting the rib cage up and pulling the diaphragm down. Air flows into the increased volume of the lungs. Because the rib cage and diaphragm are elastic, a person exhales simply by relaxing his respiratory muscles. However, when breathing through a restriction — for example, breathing through

pursed lips — the respiratory muscles must exert more force to inhale and must take an active part during exhalation to force the air back out. Put a mechanical regulator into one's mouth and still more muscular effort is required to inhale and exhale. With more muscular effort being required to breathe, more oxygen is needed to feed these muscles. When a diver is swimming, a great amount of oxygen is required to feed the large leg muscles. But the harder he must work with a hard breathing regulator, the more oxygen is diverted to his respiratory muscles. Therefore, the harder it is to breathe, the less energy a diver will have for swimming and performing other strenuous tasks.

In dive tests that I've conducted, I've found this regulator to be the easiest breathing regulator I have ever used. Let's take a look at the mechanics of it to see why it is so different and why the breathing characteristics are so superb. But first, let's review a conventional 2nd stage and 1st stage design.

CONVENTIONAL SECOND STAGE DESIGN

Most second stage designs use a spring loaded downstream valve. Air pressure from the hose is trying to open up the valve but the spring holds it closed. A lever connected to the spring rides against the diaphragm, so when a diver starts inhaling, he mechanically pulls the diaphragm against the lever. Movement of the lever counteracts the spring load against the poppet, and then air flows through. In effect, the mechanical effort of his suction is the energy supplied to open and close the regulator. The orifice or opening from the hose into the second stage is typically around 1/8" in diameter. If it were any smaller, the diver couldn't get enough air; if it were any bigger, it would take a larger spring to counterbalance it and then more force would be required to open and close it.

FIRST STAGES

Most balanced first stages deliver between 110 and 180 psi from the first stage up through the hose to the second stage. Scubapro regulators deliver 140 psi. The harder a diver breathes, the faster the flow will be, resulting in a pressure drop through the flow passages in the first stage and in the hose. It may drop from 140 psi to as low as 100 psi. Because of this loss of pressure, the harder a diver breathes, the greater will be the inhalation effort in most second stages. This happens because the second stage is not balanced.

THE PILOT SYSTEM

Air Supply Valve and Pilot Valve — There are two valves in the Pilot. The larger air supply valve is connected directly to where the air comes in from the intermediate pressure hose. This opening is 3/8" in diameter as opposed to the normal 1/8" in most regulators, so it can handle a very high flow rate. Air pressure is utilized to open and close the air supply valve rather than the diver doing it mechanically. The diver, must of course, act as the controlling device to open and close the valve, but the demand isn't nearly as great as normally required because of a small pilot valve which slaves the air supply valve.

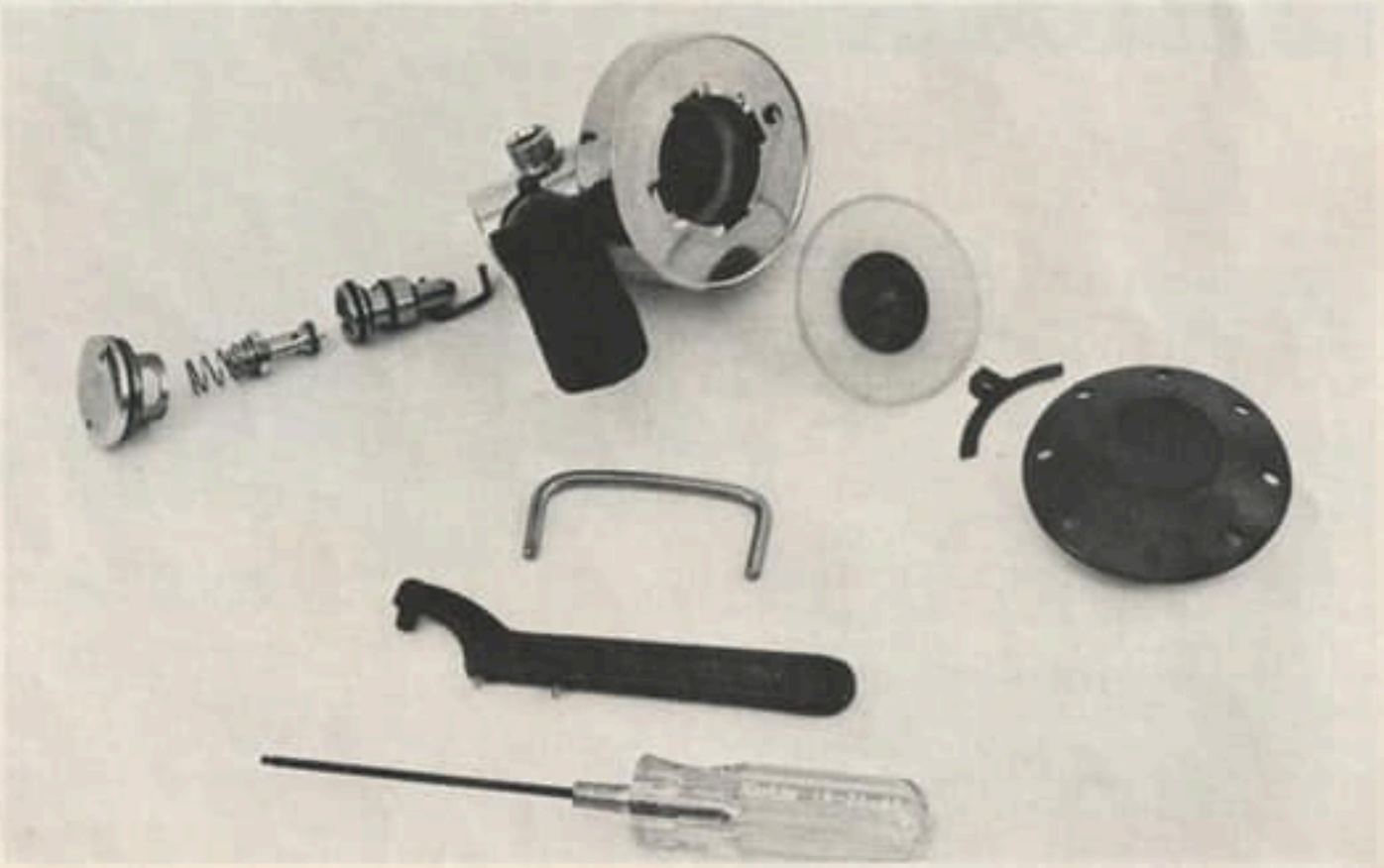
This small pilot valve is basically a downstream valve of conventional design actuated by a lever and diaphragm. Because this valve is so small, a very small spring load is required to counterbalance the pressure and less force is therefore necessary to open and close it. The pilot valve only opens .005" and opens and closes the air supply valve by flowing a small amount of air into a control chamber.

Because there is a piston opposite the valve opening which exactly counteracts the opening force of the air pressure, the air supply valve is balanced, and is unaffected by intermediate pressure variations due to flow restrictions in the first stage or hose. This is the only American made regulator where the second stage is balanced. Because it is balanced and always delivers the full air pressure load from the first stage, it can be used equally well with any first stage on the market.

This system of operation can be described as a pneumatically amplified second stage. It simply means that a small force (the pilot valve) is pneumatically amplified to move a large force — in this case the air supply valve.

Mechanical Linkage — The mechanical linkage between the diaphragm mechanism and the pilot valve is exceptionally simple, and it's amazing that someone hadn't patented it long before this. This is one of the four patents in the

The below photograph shows the Pilot regulator's disassembled second stage. Below it are the three tools that are required to take apart this second stage. It is recommended that only an authorized dealer make repairs.



Pilot. If you look at the illustration, you'll see a small ball resting against a flat plate. When the diaphragm is actuated, a lever tilts the flat plate which forces up the ball, opening the pilot valve.

The mechanical advantage from the diaphragm movement to moving the ball is incredibly large — that's why there is no perceptive breaking point in the breathing. It just seems to turn on. To give you an idea of what this mechanical advantage is, consider what happens when you use a stick on a fulcrum to lift a 50 pound weight. The stick would be one foot long from the fulcrum to the weight and about 25 feet long on the opposite end. A finger could move the weight because a force on the long end of the stick is multiplied 25 times. The mechanical multiplication of the pilot linkage is also one to 25. Conventional second stages have a ratio of about one to ten. The very small pilot valve in conjunction with a high mechanical advantage operating it, contributes tremendously to the ease of breathing.

Aspirator — If you look inside the regulator mouthpiece, you'll see a cylinder with an eliptical 3/8" hole in it. This is an aspirator port. The aspirator port is directed toward the mouthpiece tube inside the regulator, and generates a slight vacuum within the regulator case when air is flowing. As a result, the effort required to maintain air flow during inhalation is reduced. The aspirator is factory set for normal sport diving conditions, but can be set for positive pressure breathing. When set in this mode, it will actually force the air into the lungs like a resuscitator. It's great for commercial divers who have been trained to use this type of system because it reduces the amount of effort necessary to breathe at depth, but certainly isn't recommended for sport diving.

Exhaust Valve — The standard type of exhaust tee and exhaust valve have been eliminated from the Pilot design. Instead, the diaphragm doubles in function as an exhaust valve resulting in fewer moving parts and is therefore the biggest area exhaust valve of any American made regulator.

The diaphragm is free floating so a clip secures it at the bottom to prevent water from leaking in when the diver is in the inverted position. It's similar to clearing one's mask. If you

The photograph on the right shows Pilot regulator's second stage in use. Below is shown the air supply valve/ pilot valve/control chamber which, in operation, produces this regulator's breathing, balanced second stage.

Scubapro has eliminated the conventional exhaust tee on this regulator, as air is simply exhausted around the second stage's diaphragm. Diaphragm doubles in function as an exhaust valve resulting in fewer moving parts. The right shows the Dive/Pre Dive Switch.

this country to have the low pressure hose coming over the right shoulder, but in Europe it's just the opposite. With an octopus setup, you can rig one second stage for each side and use either one comfortably. Commercial divers might connect two low pressure hoses into the regulator with a hose coming over each shoulder. This will improve the flow performance even more. It's even possible to connect the one second stage into two separate first stages when using double tanks with two separate single valves.

PERFORMANCE

As mentioned previously, this regulator operates on about 1/2" of water column. A diver resting on the bottom watching fish may breathe approximately 10 to 12 litres of air per minute. And this rate may vary between certain individuals. Another diver tooling along the reef may require 30 to 45 litres per minute. And a diver in good physical condition really working hard at 50-60 feet lifting an anchor, for example, will perhaps require in excess of 60 litres per minute. That's really moving some air and physically it is very demanding. (It's interesting to note that an athlete running a race might move as much as 200 litres of air per minute. It would be impossible to move this much volume at depth because of the increased density of the air and the weight of the water on the chest and lungs.) I made a dive with the Pilot to 100 feet off Anacapa Island and swam hard for a few minutes trying to outbreathe it. I was puffing hard, but it delivered as much air as I could possibly use. As a matter of fact, it almost seemed too easy to breathe. But after using it for a couple of dives, I could really appreciate the tremendous air flow capacity of this regulator. Jim Cooluris, owner of the Seafarer Dive Shop in Oxnard, and Bill Miller, one of Jim's diving instructors, also tried it out, and their reaction was the same as mine — it is the easiest breathing regulator they have ever used!

MAINTENANCE

The Pilot doesn't require any special maintenance other than rinsing after the dive and periodic servicing by a dealer. If the regulator is removed from the tank, and then rinsed, do not press the purge button while in a rinse basin. If the button is pressed, water could enter the valves and low pressure hose. This of course applies to any regulator.

The Pilot is brand new, and of course, hasn't been tested to a large extent by the diving public, but all preliminary testing indicates that this new regulator is going to be extremely popular. It will be retailing for slightly more than Scubapro's current top-of-the-line 2nd stages but it still won't be the most expensive regulator on the market. Ask to see one at your nearest pro dive store. I think you'll be attracted to the aesthetics of the Pilot as well as its amazing breathing characteristics.