R/T

by JOHN and FRED DELONG

Teledyne

TITAN Titanium Frame

One of the significant things noted at the Paris and Milan Bicycle Shows in October and November 1973 was the trend towards lightening the bicycle and its components through the use of high strength, ultra light materials. Steel bearing surfaces enclosed in or pressed onto hard aluminum alloy cups, or onto titanium axles, the use of titanium metal for pedal and wheel axles, titanium bolting instead of steel, and even a titanium wire undercarriage as used on the Ideale saddle provide acceptable performance with minimum weight.

Bicycle frames made entirely of titanium were shown. These were used by Merckx and Ocana in portions of grueling race events in 1973, including the Tour de France.

While the strength-to-weight ratios of many space-age materials is high, there have been some disadvantages. Material cost can be high, and often material rigidity is lowered in proportion equal to the weight decrease. Machining and joining methods may require a great deal more skill and expertise than that possessed by the usual builder. Errors in construction technique may be of far greater consequence than in conventional steel alloy frames.

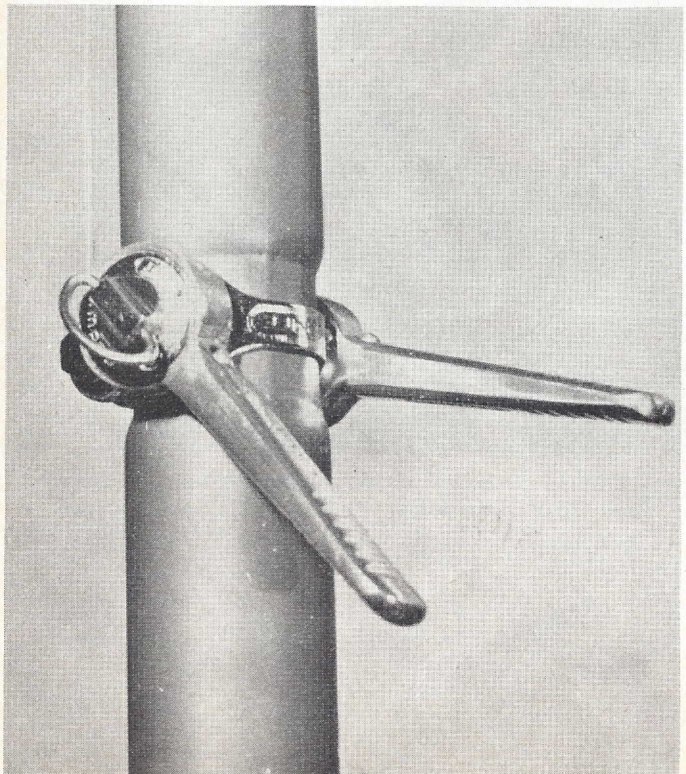
An all-titanium bike was exhibited at the New York Cycle Show in 1972. While light in weight, the frame and forks could be deflected considerably with just moderate pressure. Despite the radically different material characteristics, conventional bicycle design had been followed.

In 1970, English-born Barry Harvey, a British cycling champion who was connected with Harvey Aluminum (no relation) in their aluminum and titanium division, felt that titanium had a future in bicycle frame construction. He proceeded on his own to design and build several titanium models. Barry had emigrated to Canada where he made an enviable record on track and road, winning a Silver Medal in the British Commonwealth games and winning the National Championships in Sprint competition up to 10 miles. A severe cycling fall, however, had blunted his opportunity for even greater laurels, but his interest in the sport did not wane.

For over 20 years Teledyne Linair has been deeply engrossed in the manufacture of precise fittings and tubing assemblies for advanced aircraft and spacecraft. Every space vehicle has used Teledyne Linair stainless steel or titanium assemblies. To

Note the neatly fillet welded head assembly equipped with Shimano Dura Ace head fittings.

Reduced section reinforced swedged section holds standard size derailleur controls.



utilize existing capabilities in a product diversification program, Teledyne Linair determined after market research that a prestige bicycle frame made entirely of titanium would be a viable product. Barry then joined Teledyne Linair as a marketing manager. Barry and T-L engineers felt that combining engineering and know-how, a superior frame for high performance was possible. And so, the problem was attacked in an engineering manner. A superior frame made from 531 tubing was evaluated in Teledyne's laboratory. Knowing that this frame had given excellent performance when used for racing by top riders throughout the country, an intensive stress and deflection analysis was made under various loadings, by means of strain gauges supplemented by load/deflection tests. The data was studied, and by computer analysis design criteria were developed to determine how equal or better performance could be obtained when using titanium. These criteria were proven out by extensive ride testing conducted by several Olympic-caliber riders.

Titanium possesses excellent corrosion resistance, but so do properly prepared and painted steel tubing frames. Titanium is only 57% of the weight of an equivalent volume of steel and can be joined by welding to produce joints of 100% strength if proper techniques are used. However, its resistance to bending and twist is only about 52% that of steel sections of equal dimension. Thus if tubing gauge is increased to obtain strengths equal to that of the better steel alloys, a less rigid structure is obtained, even though the weight is reduced by some proportion. Therefore, it was immediately evident that standard bicycle configurations were inadequate if titanium were to be used. Several samples of a design that utilized this research were made and ridden. One was shown at the 1972 NBDA Show and was well received. Still, Teledyne was not satisfied. Back to the computer, then to the drawing board!

The new fork design was computer programmed by a leading aerospace stress engineer, a specialist in aircraft landing gear.

The titanium selected for the machine that finally evolved was ASTM Type 338 in a controlled grade made to Teledyne specifications. It has a tensile strength of about 70,000 psi, and is even higher where cold swedged. Its yield strength (above which permanent stretching or bending occurs) is about 60,000 psi. Elongation before breaking is over 20%, with 34% reduction of area at the break—needed for a frame which will not fail from unrelieved impact stress during riding. The unalloyed titanium has the valuable property of maintaining its strength after welding. Most high strength steels used in bicycle frames loses a proportion of their strength due to the temperatures reached while brazing. As a result the titanium possesses strength not too far different from after-brazed steel alloys. While extra light gauge steel frames are now being made, these also require superior craftsmanship.

A steel frame made from 5/10 mm steel tubing may weigh about two-thirds less than the normal alloy steel frame, while one made with 3/10 mm gauge tubing may weigh about 1-1/3 pounds less. But lightening the gauge again reduces steel frame rigidity.

Teledyne Linair broke with tradition and increased tubing diameters to gain rigidity while maintaining lightness. Reinforcing liners were placed where needed at the joints where stress is concentrated. Tubes were swedged to a smaller diameter over inserted liners where needed to accommodate standard derailleur controls and cable tunnel. An extra liner was placed at the seat cluster, and the seat stays were constructed with a long joining weld which increases rigidity. Fork ends were made solid at the point of insertion into the tubes rather than inserted into slots cut into the tube ends. All joints are extremely smooth and welds are flawless due to the Teledyne-designed welding equipment and procedures. The entire frame, after completion, is given a special treatment that prevents the surface corrosion that develops from finger marks on their untreated titanium structure.

For space-age reliability, extreme care must be taken when welding titanium. Even very small amounts of impurities, particularly oxygen, nitrogen and hydrogen from the atmosphere and its humidity will embrittle a weld beyond the point of safe use. Molten titanium will absorb these impurities, and others, from entrapped air in the filler rod, finger marks or moisture on the rod, tungsten from the welding torch if it is moved too close to the weld, or from air if the rod is moved away too fast. The weld must be blanketed at all times by inert atmosphere until solidified. Skill, technique and absolute quality control of materials and procedures is a must.

The 23-inch frame we tested as a complete 10 speed, with a bit of judicious lightening of the Shimano Dura-Ace chainwheel, Hi-E front hub and rim, 200 gram tires and high flange Campagnolo rear hub, weighed 18 pounds complete. The Hi-E bottle carrier we added did not even register a difference on the scale.

As one might expect from the steep angles and short wheelbase, the bicycle is very maneuverable. It can easily be pushed through corners at criterium speeds with confidence and stability. It rode stably hands off down hills. On the level the frame has rigidity comparable to a well-made steel frame, but on a hill its lightness and responsiveness corresponded to that obtained when riding a track bike. Increased effort appeared to give even improved results.

The most impressive part of this bike performance was the smooth ride obtained over rough road surfaces. The frame absorbed shocks, despite its short wheelbase, as did no other frame we have ridden. We could go down hills on patched roads without riding out of the saddle as is normally required. On an old concrete highway and on rough macadam surfaces normally unenjoyable, it was possible to ride with relative comfort. The resiliency of the frame should be of benefit to riders of long races, or for the tourist who enjoys putting away the miles.

We visited several bicycle stores; in each one customers gasped with disbelief when they lifted the machine. Even a three-year-old was able to lift it!

The clean lines make keeping the frame clean a snap. No intricate, dirt-catching lugwork. For the long distance, all-weather tourist, a bit more mudguard clearance might prove advantageous, and this seems possible to engineer into the design.

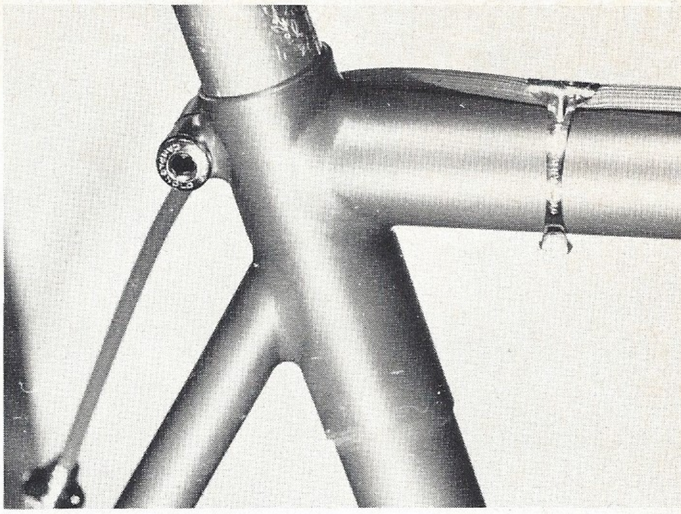
The high modulus of resilience obtainable with a material possessing high yield stress combined with low modulus of elasticity may be the reason for the excellent ride performance.

TELEDYNE TITAN FRAMESET SPECIFICATIONS

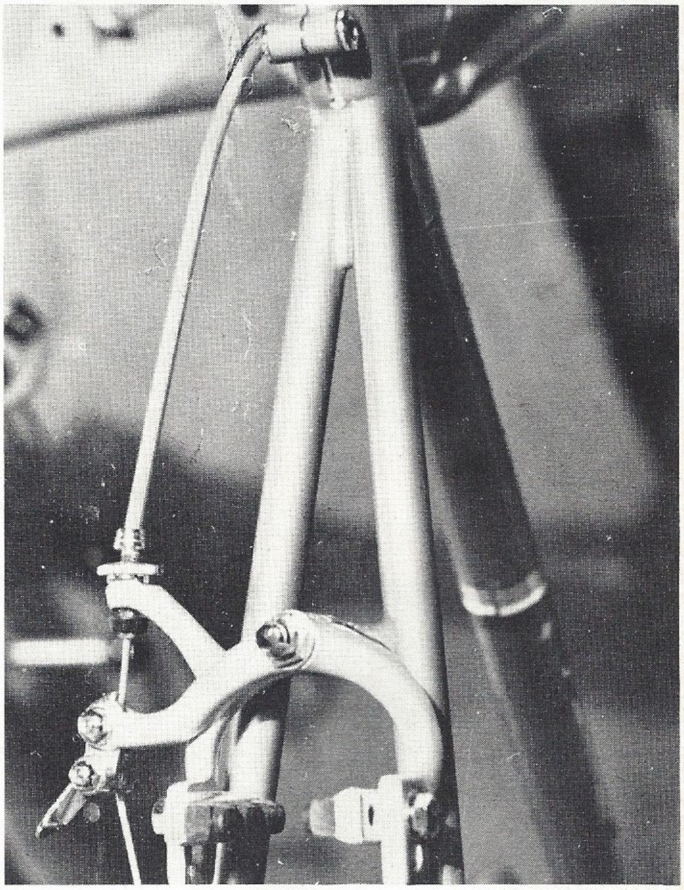
FRAME: ASTM 338 Grade 3 Titanium
top tube: 21.86", 1-1/8" OD
seat tube: 1-1/8" OD with 1-3/16" external reinforcement
chain stay: 7/8" diameter tapered to 9/16" diameter, length - 16"
fork rake: 2-1/8", 1" OD tapered to 5/8" OD at butt.
fork end thickness: 4.5 mm; rear fork offset: 2.14"; trail: 35 mm
bottom bracket height: 10-3/8" (Criterium Seta tires) 2.75" drop
wheelbase: 39"
head tube angle: 74°
seat tube angle: 74½°
weight: 18½ pounds, complete with brakes, gears, saddle, Sakae Royal seat post, handlebars and stem. With titanium bracket spindle, 18 pounds.

CHAINSET, as tested: Shimano Dura Ace 52/47

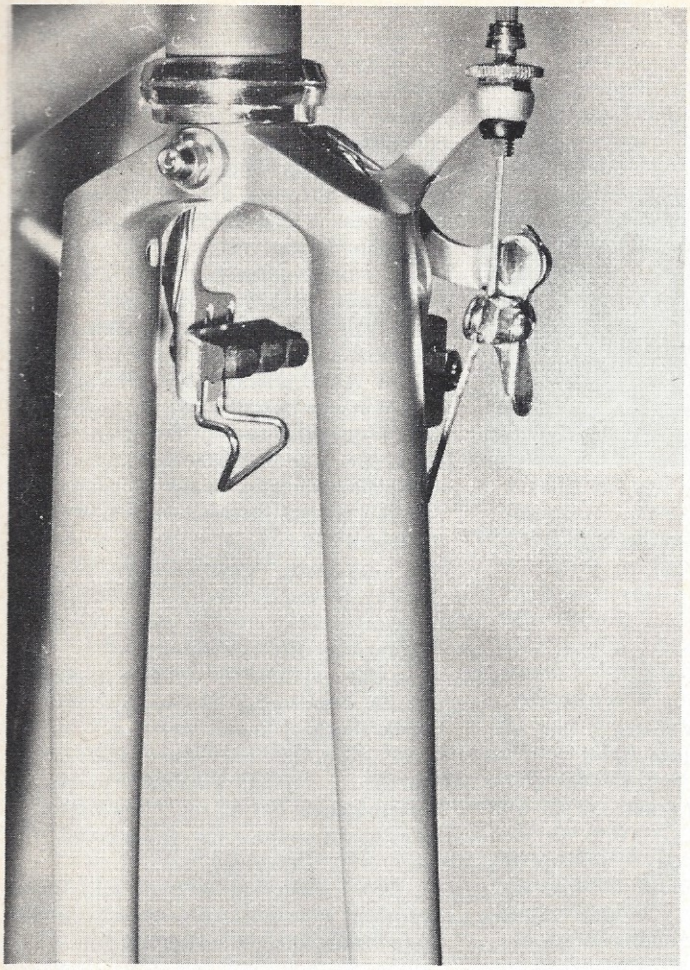
PRICE FOR THE FRAMESET: Estimated at $365.00



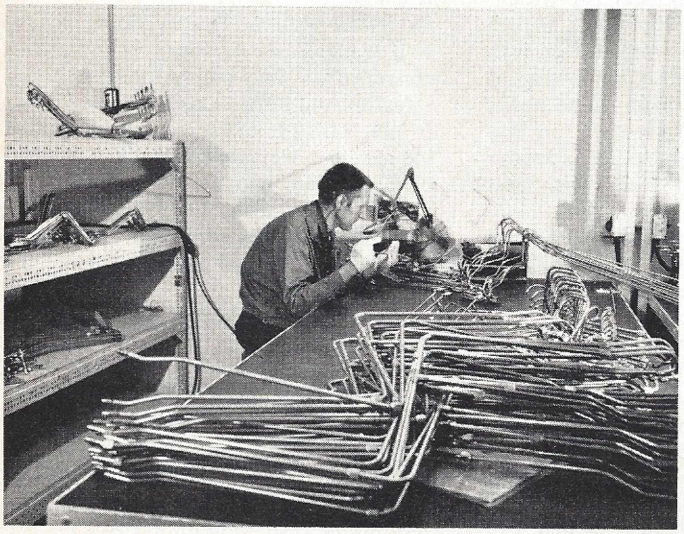
The welded seat cluster has an external sleeve for additional reinforcing and is fitted with Sakae Royal seat pillar.



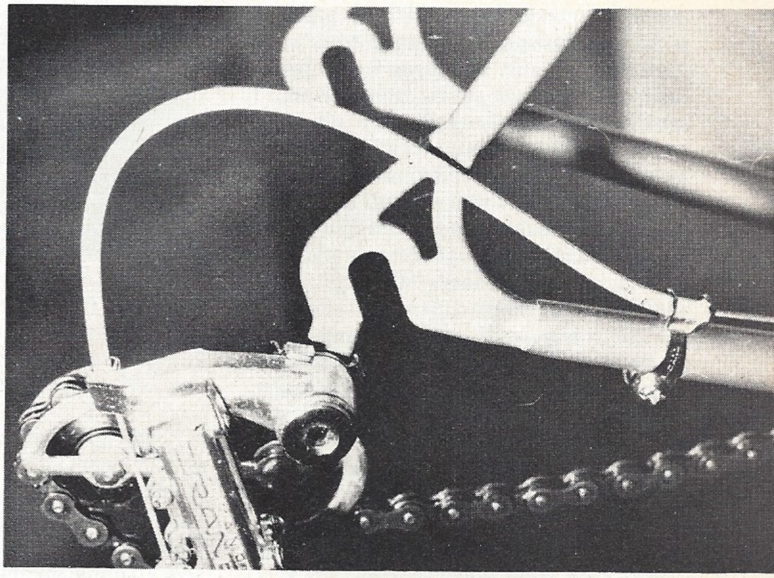
Additional detail of the welded seat cluster shows the seat stay bridge and Shimano Dura Ace brake.



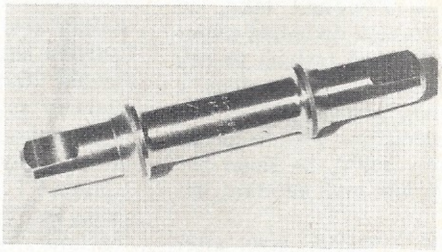
The solid fork crown and reinforced fork blades were designed with the aid of computer programming.



A technician inspects some of the complicated aircraft tubing assemblies made by Teledyne-Linair Engineering and used on such aircraft as the Douglas DC-10.



Straight drop-out rear fork ends are solidly plug-inserted in the seat and chain stays rather than slipped into slots and welded.



The titanium bottom bracket spindle has shrunk-on bearing quality steel bearing races.