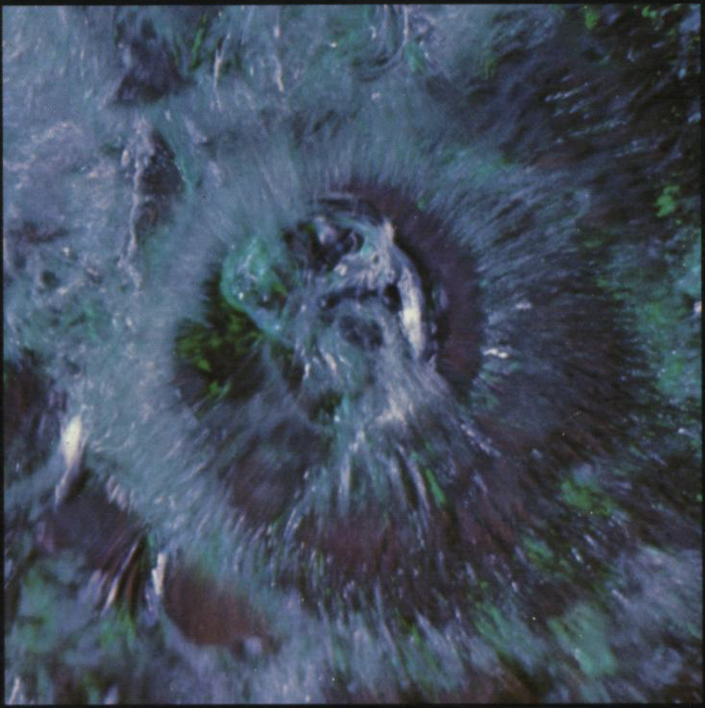
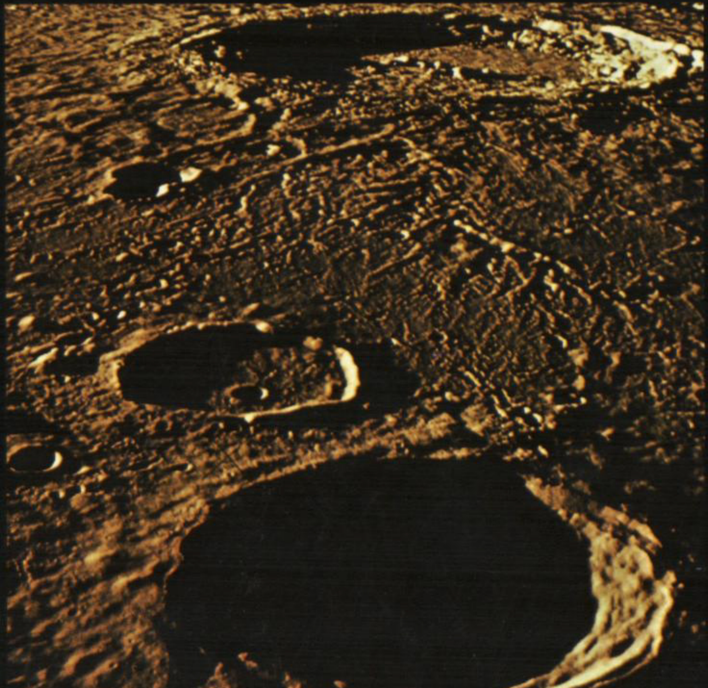
TELEDYNE, INC. ANNUAL REPORT 1969





Teledyne, Inc. Annual Report 1969

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Results for fiscal 1969 show that Teledyne again achieved new record highs in all significant areas of business activity. Thus we have ended our ninth year in business with nine consecutive years of record results. Sales passed the billion dollar mark for the first time, reaching $1.3 billion. Net income reached an all-time high of $60.1 million. On a fully diluted basis, net income amounted to $2.00 per share of common stock and common stock equivalents, which is equal to $1.94 per share after adjustment for the three percent common stock dividend to be paid on February 20, 1970.

As we enter the decade of the seventies it may be useful to look at Teledyne's growth in the perspective furnished by its nine year history. The financial highlights of those years of growth are presented on pages 38 and 39. During the sixties Teledyne grew at a rapid rate. Based on results originally reported each year throughout the period, shareholders' equity grew at a compound annual rate of 94 percent. Total assets increased at an annual rate of 100 percent. Net income grew at an annual rate of 138 percent. And the all-important figure of earnings per share compounded at a rate of 72 percent per annum.

Eight years ago, at the end of our first year of operations, Teledyne reported sales of $4.49 million. As shown on page 39 under the column for 1961, other companies, not then part of Teledyne, with combined 1961 sales of $293.1 million, were to join us before the end of the decade. These companies operate in areas of technology which have permitted them to enjoy rapid growth both before and after joining Teledyne. They have contributed to the smooth and steady progression of net income and earnings per share that has been achieved by the company as a whole. Based on the inclusion of these companies in Teledyne for the entire nine years, net income compounded at the rate of 34 percent and earnings per share at the rate of 32 percent annually throughout the period.

As a result of this sustained and rapid growth, as the sixties ended Teledyne had become a corporation of substantial size. Total consolidated assets were approaching a billion dollars, not including insurance and finance company assets approximating an additional $600 million which are under the management of Teledyne. Continuous growth had pushed shareholders' equity past the half billion dollar mark. Cash flow, the key financial measure of growth potential, was nearing the rate of $100 million annually. Short-term debt had been reduced to a very small percentage of capital, and since year-end has been further substantially reduced.

There can be no doubt that for Teledyne the decade of the seventies presents an entirely new set of challenges and opportunities. Our task during the sixties has been to strengthen and prepare Teledyne to meet these challenges and to accept the opportunities. During earlier years, our smaller size prevented us from undertaking very large projects. But the years of rapid growth have brought us to the point where we are able to undertake projects of considerable scope. The demonstrated managerial skills of Teledyne's people, coupled with our increased financial strength, permit us to take advantage of the new opportunities now opening to us.

During the sixties, as we grew rapidly through acquisition of other companies, we chose our areas of interest with special care. As the decade ends, some 40 percent of Teledyne's sales are in the area of Electronics and Control. As significant as electronics has become to our civilization in the fields of communication, computation and automatic control, its importance and influence in the future will increase. An additional 30 percent of our sales consist of Aviation and Industrial products. We expect the dramatic progress of aviation to accelerate and the expansion of our industrial business to continue in future years. And finally, 30 percent of our sales are in the area of Materials Technology. Continuing improvements in the materials we design and produce are critical to technical advances in many industries, as demonstrated by our superalloys for jet engines and zirconium for nuclear reactors. Tomorrow's engineered products for industry and the consumer may in fact be thought of as systems of materials, old and new, designed for optimum performance.

Having chosen areas of interest with great growth potential, and having rounded out our capabilities in these areas, we now expect acquisitions to play a less significant role in Teledyne's future. We believe that our chosen areas can best be cultivated by thoughtful and imaginative building on our present carefully constructed base. From our foundation of financial strength, and through our expanded and strengthened capability for taking advantage of the new opportunities in our areas of interest, we expect to see Teledyne achieve continued significant growth in the years ahead.

George A Roberts
President

Henry E. Singleton
Chairman of the Board of Directors

Superalloys

Materials that retain high strength at temperatures approaching 2000° F make the jet age possible.

Cobalt, nickel, chromium and molybdenum are the four major ingredients in the superalloys that make much of today's turbine engine technology possible through their ability to maintain high strength and corrosion resistance at temperatures up to 2000°F.

When the first jet engines were developed in the late 1930's, they produced a modest 1000 pounds of thrust. Today, modern commercial and military jet engines routinely produce thrusts in the range of 15,000 to 40,000 pounds and will shortly approach 70,000 pounds in the new SST engines.

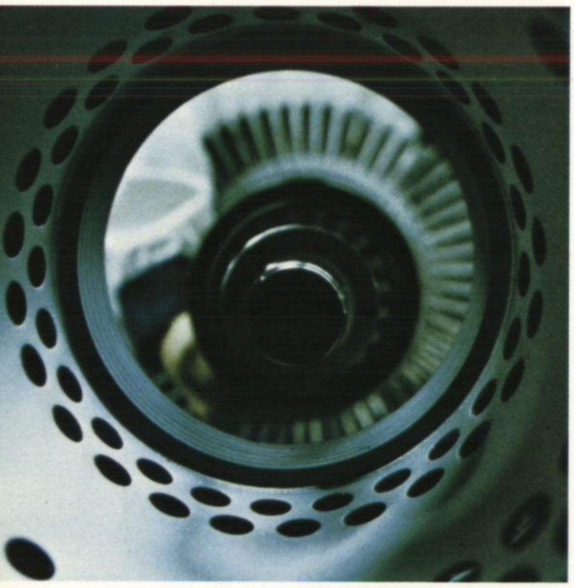
Yet, if the designers of those very first engines had had complete blueprints for one of our modern engines it is unlikely that they could have built an engine that would have operated for more than a few hours or minutes.

The reason is that the materials of that era—just 30 years ago—were simply not capable of withstanding the temperatures and stresses that occur in a high-performance turbojet engine. Like so many fast-moving areas of technology, jet engine design is largely dependent on materials technology.

To gain some insight into the problems faced by the design engineer, look at what happens inside a modern jet engine. The outside air is sucked into the intake opening of the engine and compressed by a rapidly rotating axial or centrifugal compressor. Depending on its size and application, a jet engine can have from one to a dozen or more stages of compression to increase the pressure of the air by 20 or 30 times. This compression of the incoming air can raise its temperature to more than 1000°F before any fuel combustion has taken place.

The compressed air enters the combustor section of the engine where fuel is injected, mixed with the air and burned to release energy. The hot gases in this section of the

Jet fuel injected into a stream of hot compressed air in this Teledyne turbojet combustor burns to produce the large volumes of high-temperature expanding gases that drive the engine's turbine rotors.



Turbine shaft assemblies such as this one from a Teledyne turbojet engine must be carefully checked for shaft runout and then be precisely balanced dynamically on special equipment in order to operate safely at speeds of up to 20,0000 rpm. Centrifugal forces at high rotational speeds can subject turbine blades to stresses approaching 100,000 pounds per square inch.

engine can reach temperatures of over 2000°F. At these temperatures copper melts, magnesium boils, common steel loses more than 99% of its strength and most alloys suffer from great corrosion and oxidation.

At this point, other problems are encountered by the turbine design engineer. The hot blast of gases must be directed across the vanes of a turbine wheel to extract useful energy from the gas stream.

The materials used for turbine blades must not only withstand these temperatures, they must do it while maintaining enough strength to retain their structural integrity under the centrifugal forces created by the rapid spinning of the rotor. In large turbines, rotor speeds on the order of 8000 rpm are common. In smaller turbines, speeds of 60,000 rpm or even more are achieved. Blade and rotor materials in this type of service are subjected to tensile forces approaching 100,000 pounds per square inch.

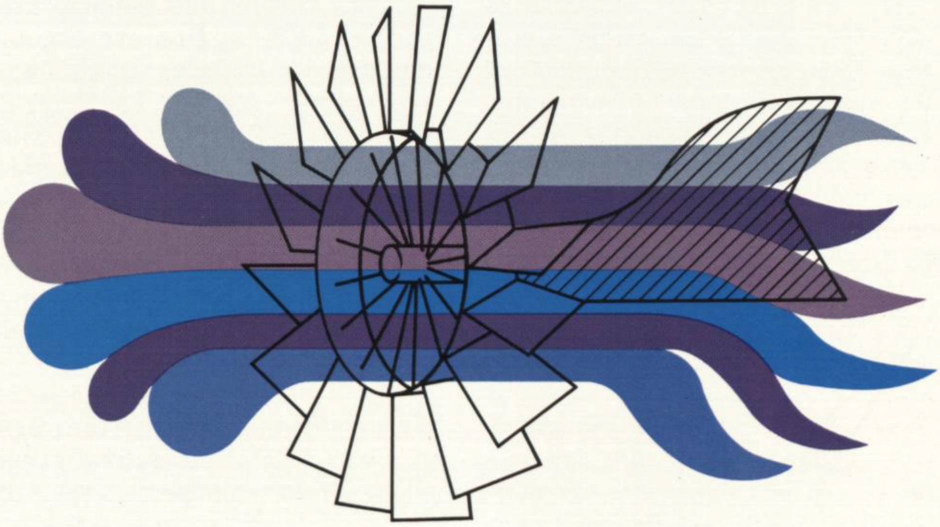
Finally, turbine blade materials must be oxidation and corrosion resistant enough at these temperatures to permit long intervals between maintenance, in order that the engines be economically feasible.

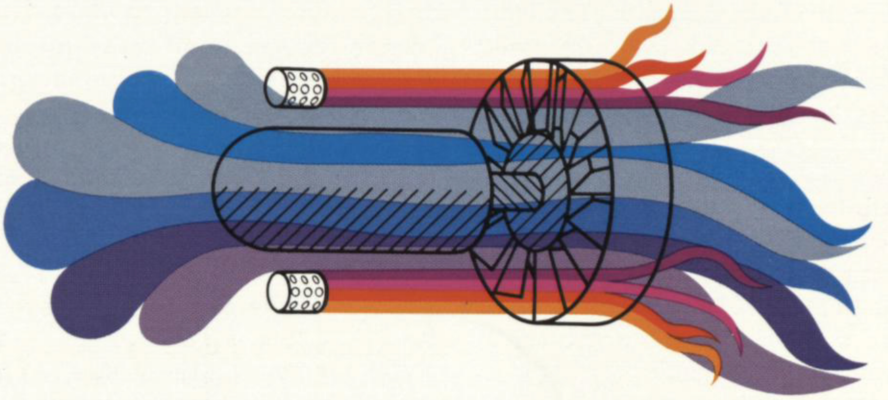
It is axiomatic in the design of turbine engines that the higher the operating temperatures, the greater the power output and efficiency of the engine. Thus the turbine design engineer constantly seeks ways to increase turbine inlet temperatures. The first gas turbine engines had maximum turbine inlet temperatures of about 1300°F. That was one of the primary reasons that their output thrust was so low—on the order of one pound of thrust for one pound of engine weight.

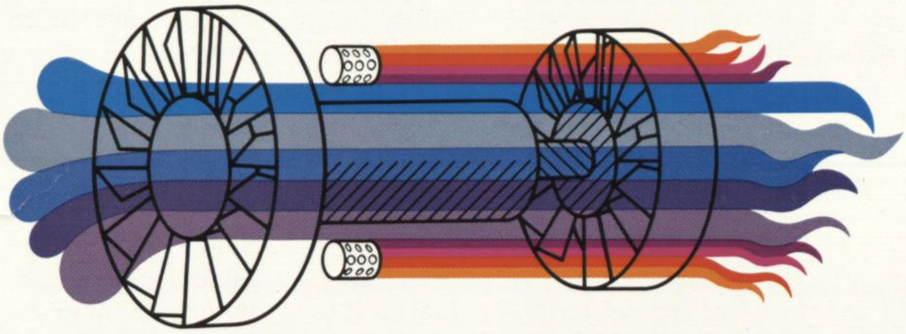
Today, turbine inlet temperatures in the 2300°F region are feasible and thrust-to-weight ratios of 5 to 1 are routinely achieved. The Teledyne CAE XLJ95-T-1 direct lift turbojet engine, designed for use in vertical take-off aircraft, has demonstrated the highest thrust per pound of engine weight in the world. A ratio of 22 to 1 was achieved by using the most advanced concepts in materials and fabrication technology.

Experimental engines with turbine inlet temperatures in the range of 2500 to 3000°F have already been built. Turbine engineers have hit upon ingenious ways of making turbine blades withstand temperatures in this range. One method is to bleed off air from the compressor section of the engine, duct it through hollows in the shaft and rotor disc of the turbine and let it bleed out through minute holes in the edges and tips of the hollow turbine blades. Even though this compressed air is already far hotter than the outside air due to compression it is still extremely cool compared to the temperature of the gases passing over the turbine blades. The cooling effect of this air permits the blades to operate in gas temperatures several hundred degrees higher than would be otherwise possible. Bleeding off this cooling air from the compressor reduces the efficiency of the engine, however, and is not entirely desirable due to the added complexity of building the engine.

Other experimental approaches to high-temperature turbine design have included liquid-cooled blades in which heat is transferred to the jet fuel itself by means of some interme-







How a gas turbine engine works

Jet engines and gas turbines are sometimes spoken of as if they were two entirely different kinds of device. Actually, the aeronautical jet engine is just a specialized form of gas turbine. In principle, the gas turbine is far simpler than the common piston engine that powers your car.

Consider the common windmill in the top drawing. A stream of gas in motion (wind) impinges on the shaped blades of the windmill and imparts a rotary motion to it that can be coupled to do useful work such as pumping water or generating electricity. If the wind could be made to blow much harder and more steadily, the windmill would be far more useful than it is.

Think of a gas turbine, then, as a specialized kind of windmill with its own controllable and virtually limitless sources of wind. To produce this wind, a fuel such as kerosene is burned with air to produce large quantities of hot, expanding gases as in the middle drawing. These gases are confined in such a way that they can only escape by passing through the blades of the rotor. The blades have been redesigned by turbine engineers to operate efficiently at extremely high gas velocities.

With this arrangement, however, the amount of fuel that can be burned, and thus the amount of power that can be produced, is limited by the amount of air supplied. In the gas turbine, shown in the bottom drawing, this problem is taken care of by adding a shaft on the nose of the turbine wheel and connecting it to a similar wheel that acts as a blower to provide more air for the fuel. This might seem impractical at first glance, but actually the compressor uses only a small part of the energy produced by the turbine.

When a gas turbine is designed to provide shaft horsepower such as a gasoline engine or electric motor does, the turbine is designed to extract as much energy from the gas stream as possible, often using a series of turbine wheels. Similarly, for greater efficiency at the compressor end, multiple compressor wheels are used.

However, when a gas turbine is designed to act as a turbojet for an aircraft, the only purpose of the turbine is to run the compressor, and the hot, high-velocity gas stream itself is exhausted from the rear of the jet to propel the aircraft on the reaction principle, just as the high-velocity gases of a rocket engine propel a spacecraft. The design technology and the materials required for either type of application are very similar.

The name gas turbine, incidentally, is not derived from gasoline. It is derived from the fact that hot gases are what drive the turbine wheel. Gas turbines will operate on many kinds of fuels—kerosene, gasoline, alcohol, jelled fuels and even natural gas.

diate liquid medium. In the final analysis, however, the exceptional temperature and strength requirements of turbine parts demand exceptional materials. To fill those needs, a special new class of materials has been developed. These materials are aptly named superalloys.

They are combinations of metals which offer high strength and corrosion resistance in the temperature range of 1200°F to approximately 2000°F. Methods of increasing this upper limit are constantly being sought and an increase of even 50 or 100°F is considered a valuable advance.

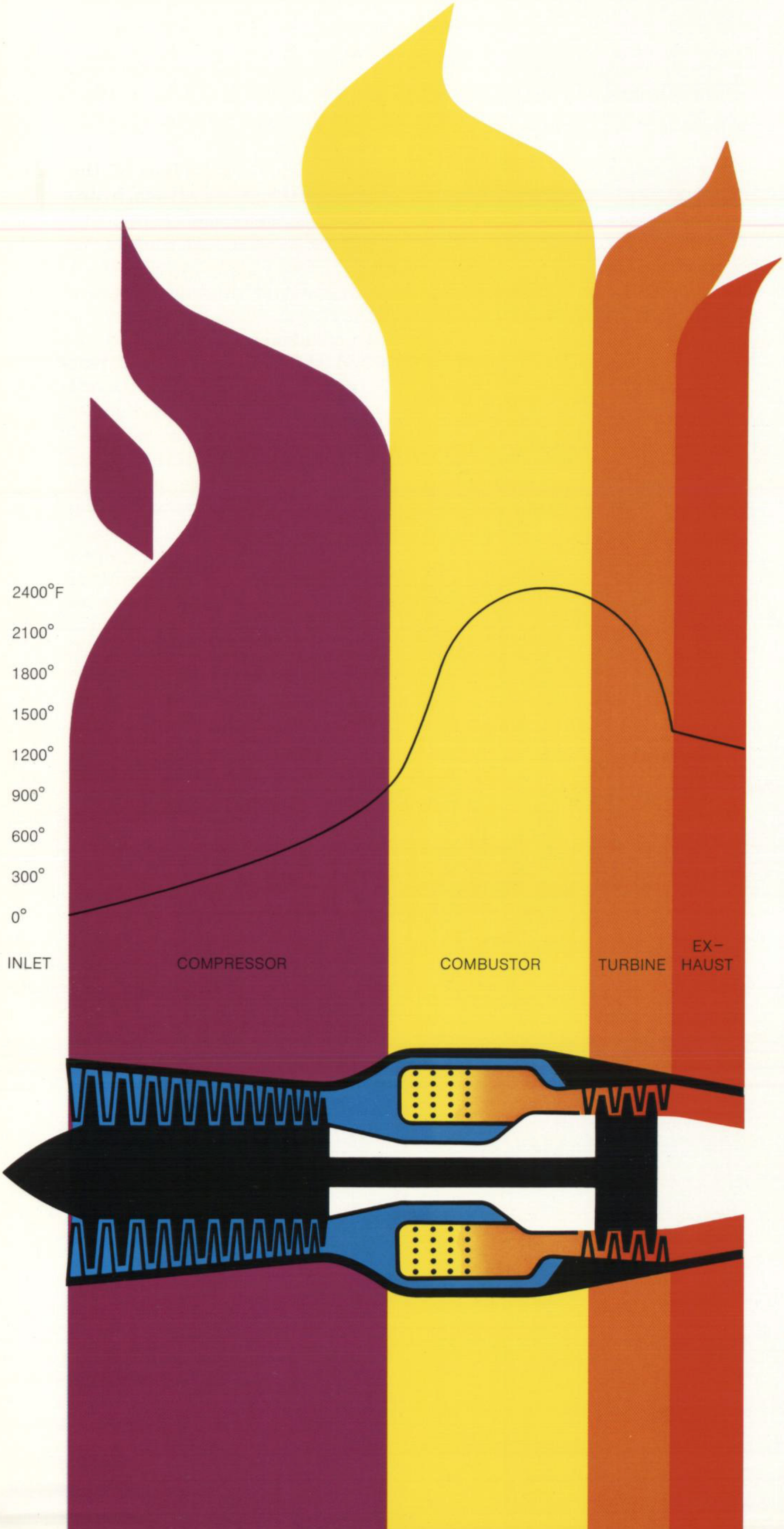
Most superalloys are based on formulas that have nickel or cobalt as the main ingredient with up to a dozen other elements alloyed with it. Chromium, molybdenum, titanium, aluminum, zirconium, iron, boron, carbon, columbium, tungsten, tantalum and vanadium are commonly found in these alloys.

These ingredients are routinely combined with accuracies of 50 parts per million or less for certain critical materials. Boron content, for example, is controlled to 10 parts per million.

Control of impurities is critical, too, in the production of high-quality superalloys, since these can degrade the properties of the finished alloy in various ways.

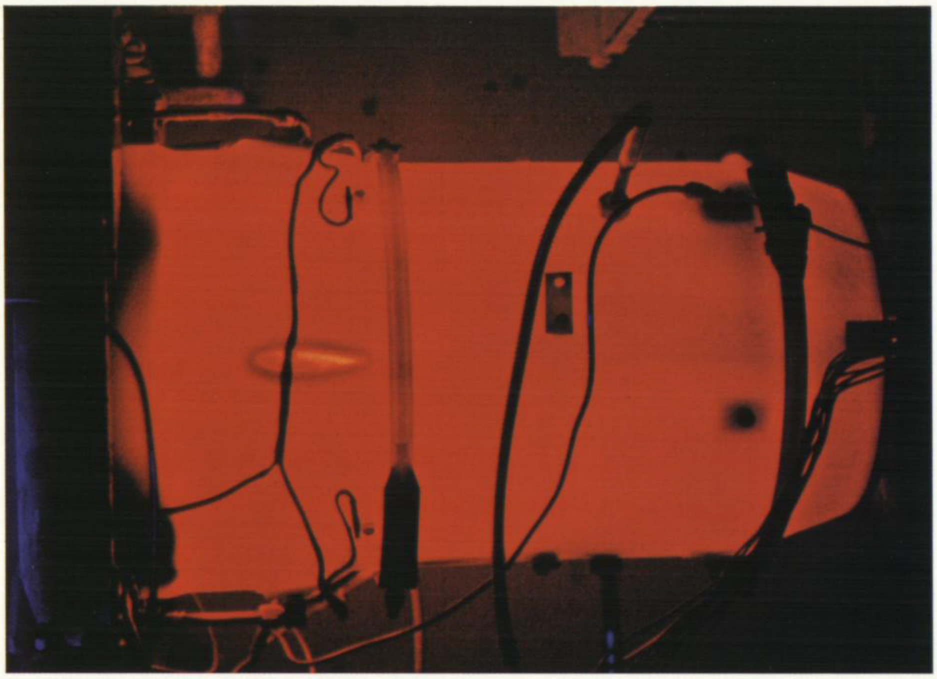
Alloys other than superalloys are commonly made under air-melt conditions. In an electric furnace, an arc is struck between large electrodes and the top surface of the metal in a crucible. The heat of this arc melts the alloy. During the process, the molten metal is only protected from the air by a coating of slag that ac-

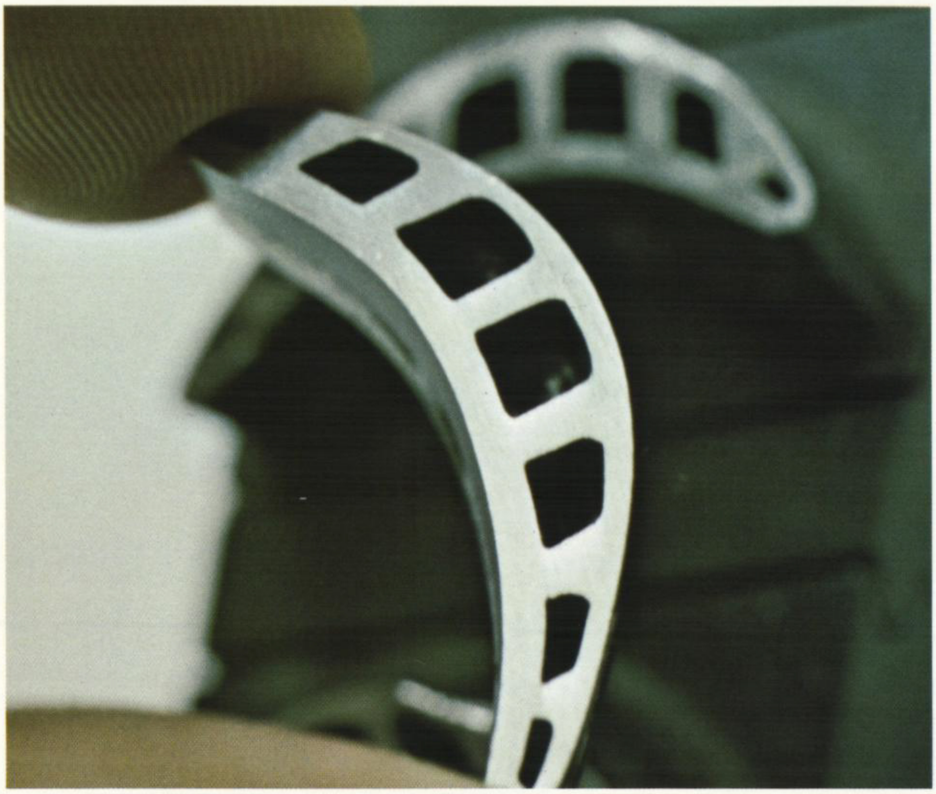
TURBINE ENGINE TEMPERATURE DISTRIBUTION



Temperatures in a modern turbojet engine increase rapidly as intake air passing through multiple compressor stages is heated by compression. Injection and burning of fuel in the combustor section then boosts gas temperatures up to 2000°F or more, depending on the engine design. Operating in this hot blast of gases, the turbine blades must withstand high centrifugal forces while approaching temperatures that would melt copper, boil magnesium and cause ordinary steels to lose 99% of their strength.

Heat distribution in the exhaust duct, tailpipe assembly and nozzle of a Teledyne turbojet engine is shown in infrared photography. Operating at full power in a high-altitude test chamber during USAF acceptance testing, the glowing portions of the engine have reached a temperature of about 1400°F.





Liquid cooling of turbine blades is one of the advanced techniques that permit turbine inlet temperatures to be raised for increased engine power and efficiency. This cross-section of a turbine blade shows internal cooling passages that are used in a steam-to-fuel heat-exchange system. The blade is capable of 2100°F operation.

cumulates on the surface of the metal. Gases such as oxygen, hydrogen and nitrogen can dissolve in molten metal, combine with some of the more active metals that are used, and degrade the valuable properties of the alloy.

To counteract this effect in air melted alloys, certain highly reactive substances are added to the molten metal to combine with the oxygen and remove it before the metal is cast into ingots. These "getters" as they are called cause impurities of their own and at best are partially effective.

High purity superalloys require a more stringent quality control which is only possible with an advanced double-vacuum melting process such as is used by Teledyne Allvac. The first step in this process is preparing the basic alloy in a vacuum induction furnace. Up to 8 tons of raw materials are placed in a crucible and heated by electrical induction from large coils that surround the crucible. In this method of melting, the strong magnetic fields from the induction coils stir the molten metal.

The entire apparatus, including the molds into which the metal will be cast, is encapsulated in a vacuum chamber about 40 feet tall and 20 feet in diameter that is pumped down to a vacuum of less than one part air in 750,000. Since the alloy is held in this chamber for from 8 to 12 hours while it is being melted and stirred by the magnetic fields, every portion of the entire batch of metal is exposed to high vacuum which helps boil out and draw off gaseous impurities. During the process, carbon is added to combine with resi-

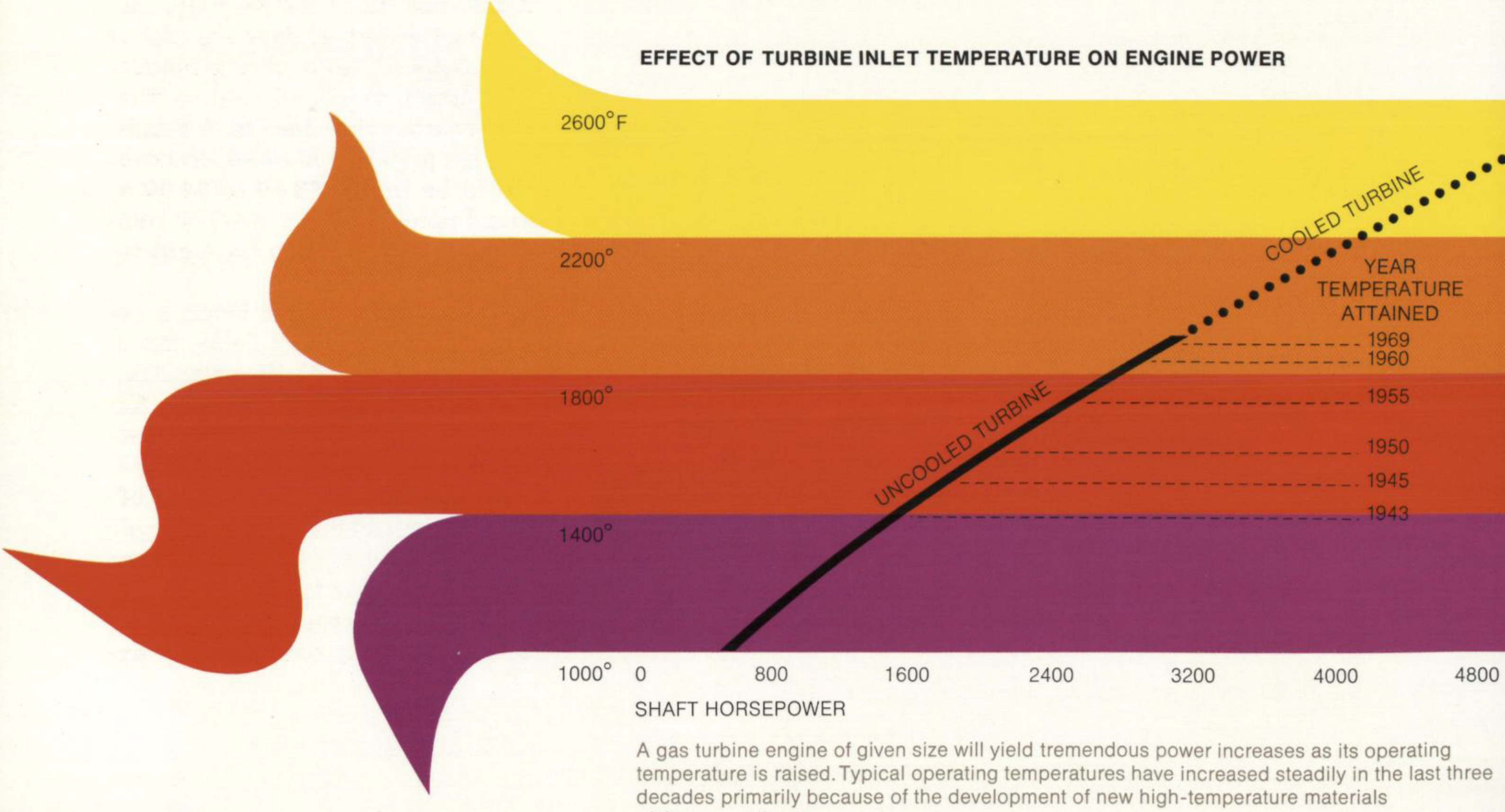
Turbine blades are cast, forged or machined from superalloy material into precisely-shaped airfoils that are aerodynamically-designed and wind-tunnel tested for maximum efficiency in extracting energy from the high-speed gas flow. Blade tips in modern jet engines operate at near the speed of sound.

dual oxygen in the alloy, forming carbon monoxide which can be drawn off by the vacuum pumps.

Vacuum locks are provided on the furnace to permit the highly reactive constituents of the alloys such as aluminum, zirconium, titanium and boron to be added late in the melting cycle. These "late additions" dissolve in the molten metal (without interference from impurities) to create precipitation hardening phases, imparting excellent high-temperature properties to the alloy. Through these same vacuum locks, in-process samples of the melt can be taken for chemical analysis and correction of any deviations before the batch is finished.

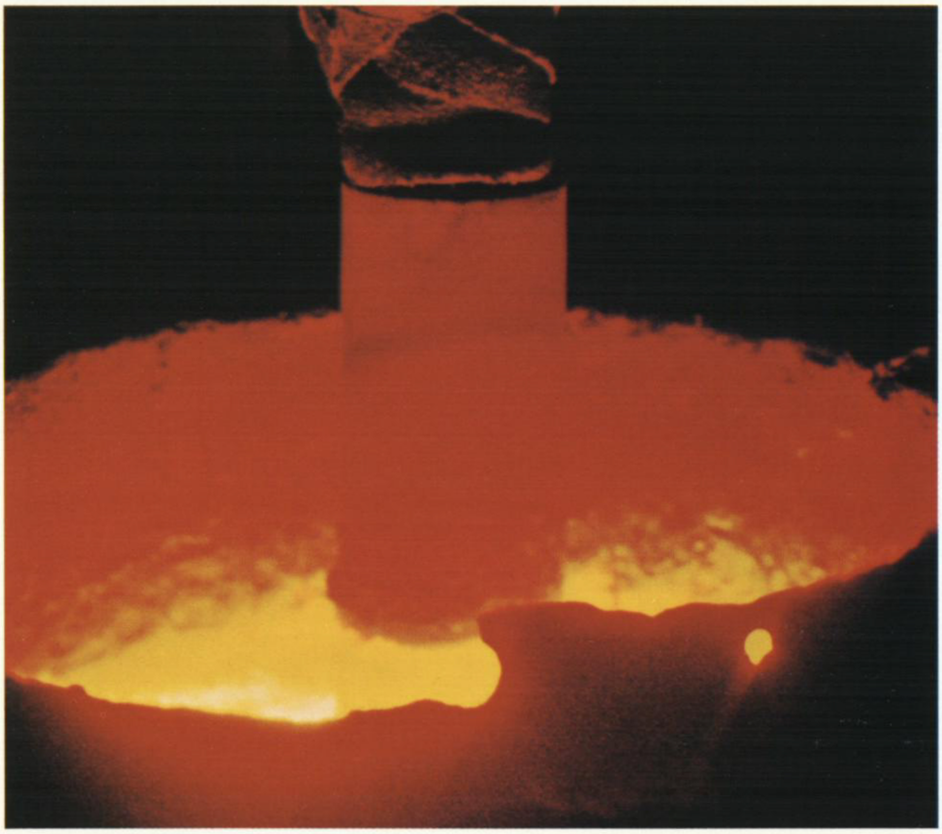
The second step in Teledyne Allvac processing of superalloys is also carried out under vacuum in what is called a "vacuum consumable arc furnace." The electrode formed in the vacuum induction furnace is placed vertically in the consumable arc furnace and lowered into contact with a water-cooled copper crucible that also serves as the mold for the final ingot. The furnace is evacuated and an arc is struck between the electrode and the bottom of the crucible. This arc melts the bottom of the electrode at temperatures of over 5000° F. The molten droplets of metal are again subjected to a vacuum that has less than 1 part air in 750,000, for final and thorough outgassing. The metal then resolidifies in the water-cooled copper mold.

Close control of melting voltage and current produces consistently high quality superalloy ingots weighing about 3000 pounds. Vacuum con-



A gas turbine engine of given size will yield tremendous power increases as its operating temperature is raised. Typical operating temperatures have increased steadily in the last three decades primarily because of the development of new high-temperature materials of the superalloy type.

Bottom pouring of molten superalloys permits the casting of superalloy electrodes without inclusions of impurities that float on the top of the metal. This bottom-pour teeming ladle, shown with the stopper rod raised, is manipulated by remote control from outside the vacuum chamber of the induction furnace.



The second step in Teledyne Allvac's double vacuum melting process of superalloy production takes place in a vacuum consumable arc furnace. A superalloy electrode, cast in the vacuum induction furnace, is remelted under vacuum by an electric arc at temperatures approaching 5000°F. The crescent shaped edge of the arc can be observed during the process through a filtered window and periscope system.

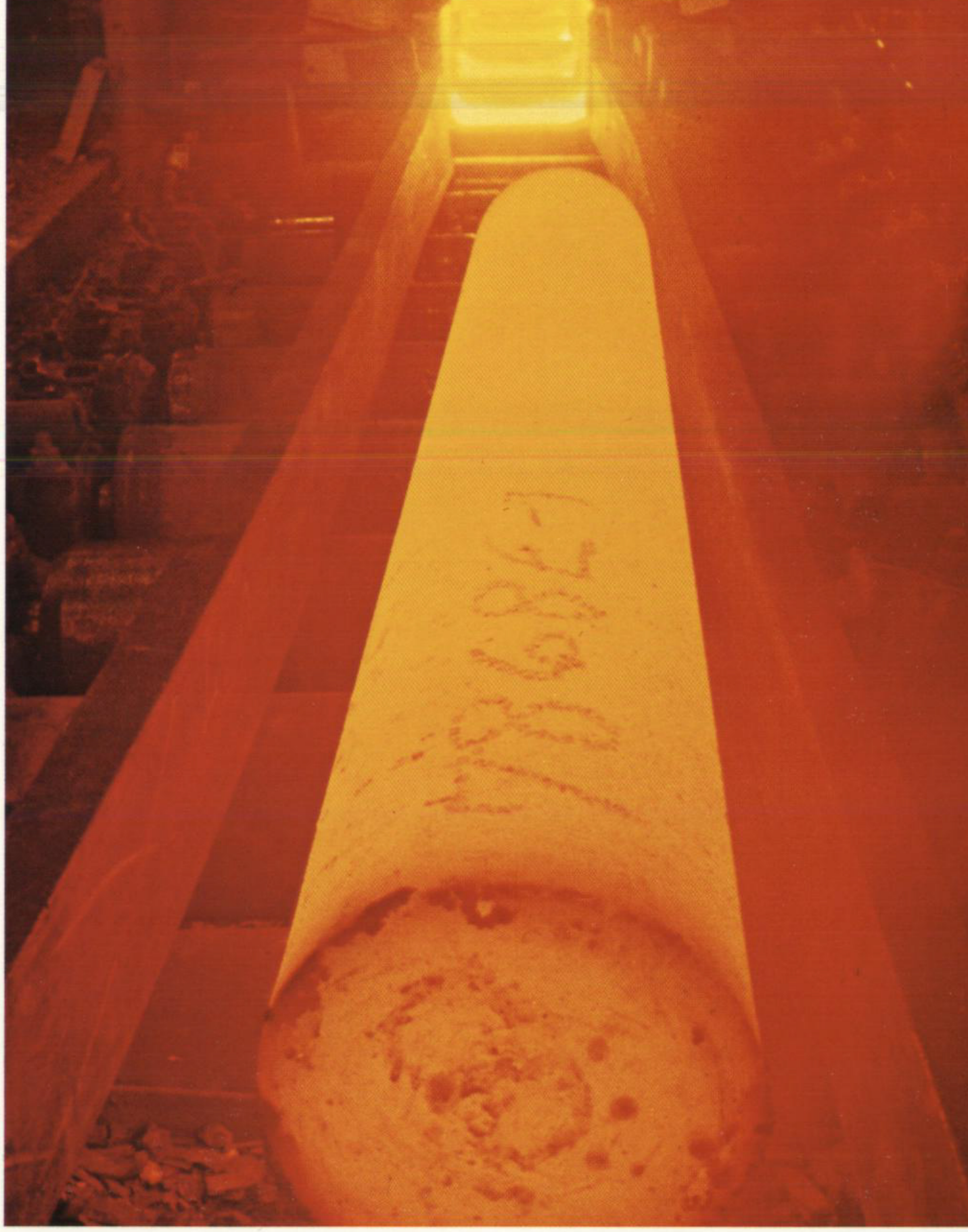
sumable ingots have excellent ingot structure, extremely low gas content, and have clean and uniform grain structure that is vital to high-strength properties.

Conversion of these ingots into finished bar and rod stock is also a critical operation. The ingots are brought to a high, uniform temperature in a furnace. This temperature must then be maintained within close limits during the rolling process to assure that the finished product will have a homogeneous structure. For some alloys the rolling temperature must be held within a range as narrow as 100°F. The result of this careful processing is a premium quality alloy that has better workability, strength and high temperature properties than air-melt alloys.

Because of this complex production process, as well as the high cost of the constituent metals used, vacuum-melted superalloys are expensive compared to ordinary metals. They are priced and sold by the pound rather than the ton. A rough average price for most superalloys would be in the $3.50 to $4.00 a pound range. Common steel by comparison currently sells for eight to ten cents a pound.

Nevertheless, to the modern design engineer in many fields, superalloys are well worth the price. And their use is expanding each year. As design temperatures increase in jet engines and other gas turbines, more and more parts are being made of superalloys, and the total number of pounds used per engine is increasing.

The use of gas turbines for non-aeronautical purposes is increasing, too. Power utility companies, for ex-



A hot superalloy ingot is ready for breakdown into smaller shapes on a blooming mill. The barrel furnace in the background is an innovation that allows the ingot temperature to be controlled within close limits during rolling.

ample, are finding that gas turbines are ideal for standby or peak-load generating systems because they can be started and brought to full power in a matter of minutes as opposed to hours for conventional generating systems.

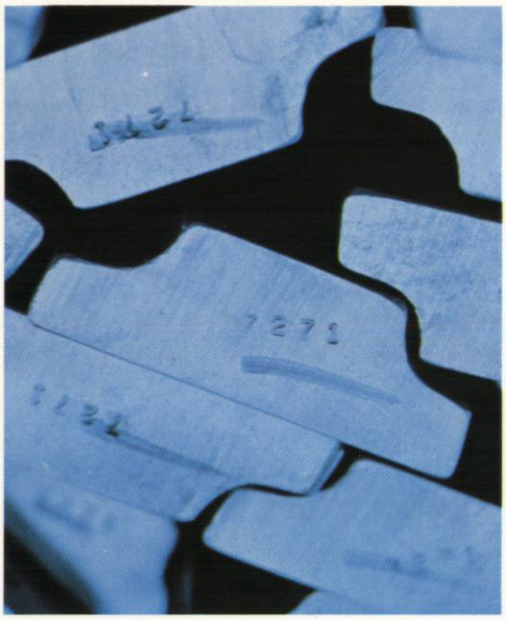
Smaller gas turbine generators are also being used as power sources for large buildings, hospitals and shopping centers. Designed to utilize exhaust gases for heating and air conditioning as well as to generate power, these units offer many advantages for regular use as well as emergency use.

Even portable auxiliary power systems using gas turbine power have been developed. They are ideal where arctic conditions prevail, because of their efficiency at cold temperatures, easy starting and low maintenance requirements.

Other promising areas for gas turbine application are in railroad locomotives and marine propulsion. In small ships, for example, the gas turbine requires less space and saves considerable weight over a corresponding boiler and steam turbine. Development and practical applications have gone on in both these areas for some time. Gas pipeline companies have also found that gas turbines, using the inexpensive natural gas itself as a fuel, are highly practical for powering pipeline pumping stations.

In addition to these gas turbine applications, there are other non-turbine uses for superalloys.

In the field of conventional piston engines, for example, superalloys are used for the exhaust valves of diesel engines which must withstand much the same temperature,



Metallurgical examination is made of superalloy materials at several stages in the production process, ranging from the raw ingot to the finished product. These macro slices for quality control inspection are cut from the ends of hot-rolled shapes intended for a jet engine application.

Grain-size determination of a superalloy sample at 100 times magnification is made on a metallographic microscope by comparison with an ASTM Standards chart. Metallographic inspection is a specification requirement of Teledyne Allvac superalloys to insure uniform distribution of particles and absence of contaminants.

stress and corrosion problems found in a turbine. The very first application of a small turbine driven by hot gases, incidentally, was in the turbochargers used on aircraft piston engines to supply extra air to the engines at high altitudes.

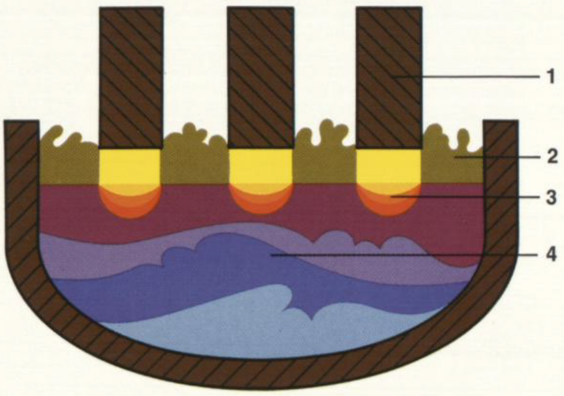
The petrochemical processing industry is another user of superalloys for various structures, pressure vessels and equipment used in high-temperature processing. This is true in the nuclear power generation and propulsion industry, too.

Perhaps the greatest challenge and the greatest opportunity for the superalloy industry lies in the development of the automotive gas turbine. Already being tested in long distance trucks and heavy earth moving machinery, the gas turbine offers many advantages for land vehicles. High power-to-weight ratios, inherent simplicity, few wearing parts, long intervals between maintenance and clean exhaust are just a few.

Gas turbines will undoubtedly be used in large trucks and heavy equipment in the near future. For the personal automobile one of the major problems is economics. The challenge to both superalloy producers and turbine designers is to lower the cost of producing small turbines on a mass production basis. Some of these problems are already being solved. New superalloys designed for casting purposes are making it possible to produce turbine rotors and blades in one piece, by investment casting methods, thus eliminating the costly machining and assembling of these parts. The automotive gas turbine may be just a matter of time—and the right superalloy.

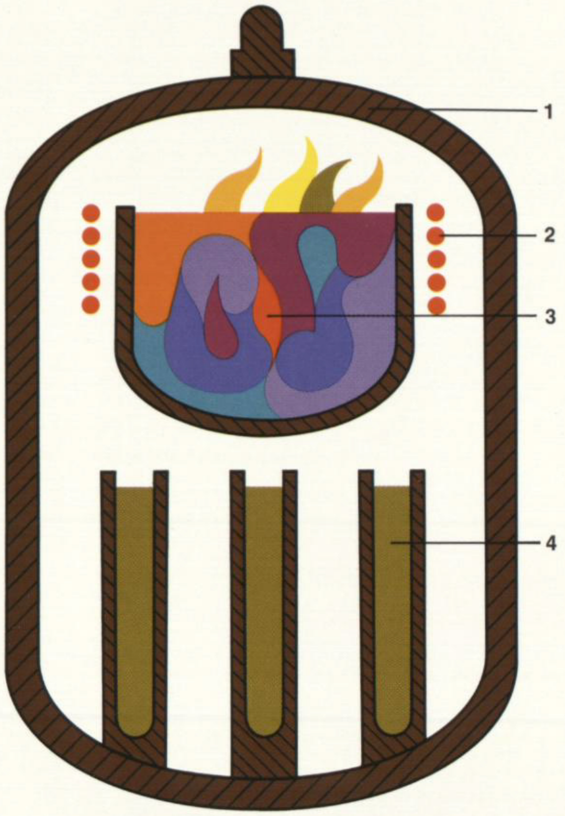
HOW SUPER ALLOYS ARE PRODUCED

Air Melt Electric Furnace



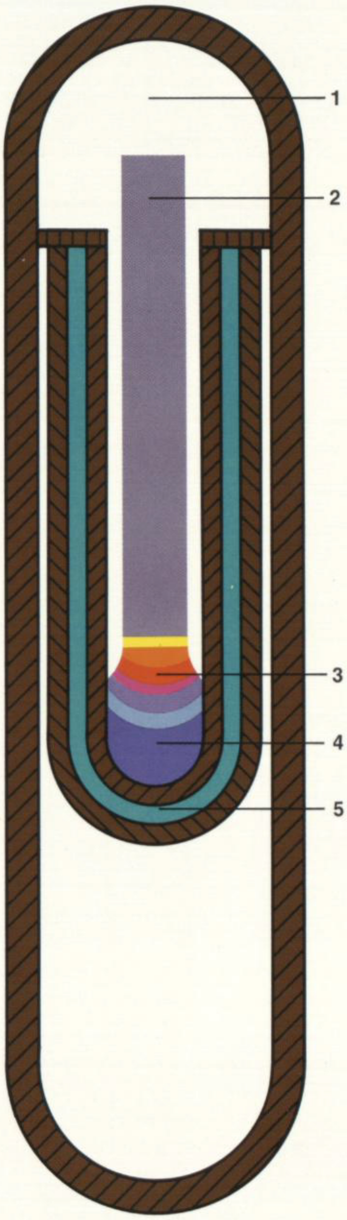
1: Electrodes **2:** Slag **3:** Arcs **4:** Molten metal

Vacuum Induction Furnace



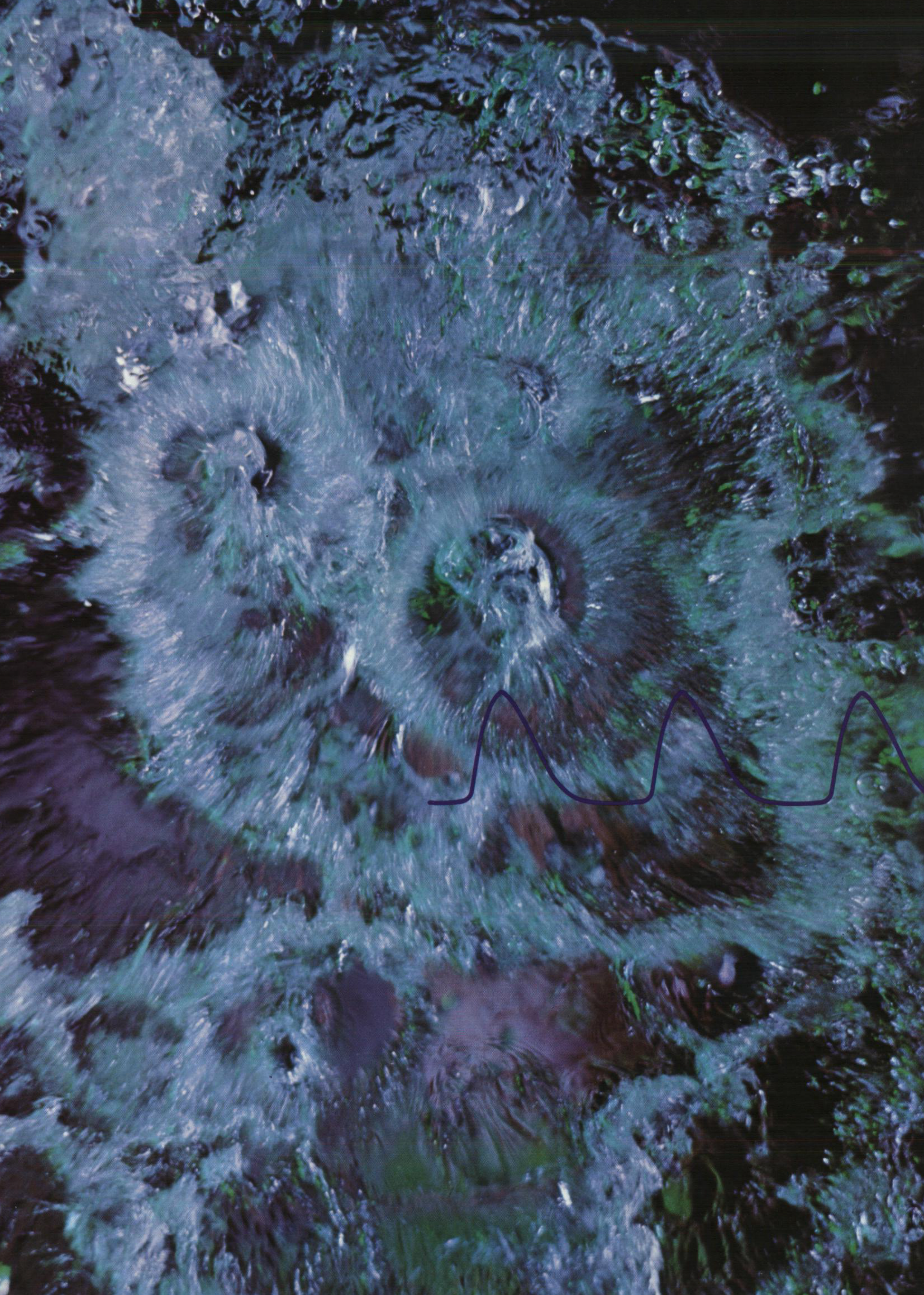
1: Vacuum chamber **2:** Electric induction coils
3: Molten metal **4:** Electrode molds

Vacuum Consumable Arc Furnace



1: Vacuum chamber
2: Superalloy electrode
3: Electric arc
4: Re-solidified metal
5: Water-cooled copper mold

Furnaces used in the preparation of metal alloys include air-melt electric arc, vacuum induction and vacuum consumable arc. Teledyne Allvac uses a two-step process that involves the production of an electrode under vacuum conditions in an induction furnace, and the remelting and refining of this electrode in a consumable arc furnace. This double vacuum melt technique produces ingots of the highest purity and quality.



Jets of Water for Dental Health

Studies show that high-pressure pulsed jets of water are a valuable aid in the care of teeth and gums.

The hydraulic effect of water impacting under pressure is the principle underlying a new method for cleaning food residue from hard-to-reach places in the teeth and gums. The efficiency of the action is enhanced by interrupting the jet twenty times per second to produce sharply rising pressure pulses of water.

A tiny jet of water, pulsing 1200 times a minute at pressures up to 90 pounds per square inch is proving to be one of the most effective adjuncts to good oral hygiene since the invention of the toothbrush. This jet is produced by a device called the *Water Pik* oral hygiene appliance manufactured by Teledyne Aqua Tec.

The *Water Pik* unit is a carefully-engineered, precision pump that delivers water through a flexible tube to a plastic nozzle with a fine opening. The pulsing jet of water it produces is applied along the margins of the gums and between the teeth to effectively flush away food particles that cannot be reached by ordinary toothbrushing alone.

The device was invented by an engineer whose family dentist was convinced that an apparatus that would produce a pressurized jet of water would be a great help in the dental care of his patients. At his dentist's urging, the engineer undertook the development of a motor-driven pump for this purpose. A number of experimental models of the device were made and then tested and evaluated with the help of the dentist and some of his patients.

This development work led to the first production model of the *Water Pik* device which was marketed directly to the dental profession as a prescription item for their patients. The simplicity, effectiveness and safety of this new supplement to oral hygiene soon led to its being marketed directly to consumers through retail stores across the country.

In the six years since the *Water Pik* appliance was introduced, dental research studies have established that it provides a number of distinct benefits in general oral hygiene and in the treatment by the dentist of certain periodontal conditions. In June of 1969, the American Dental Association announced recognition of the *Water Pik* oral irrigating device as "an effective aid to the toothbrush in a program of good oral hygiene."

Periodontal diseases are those that involve the supporting structure of the teeth as well as the gingival or gum tissue of the mouth, particularly at the interface between the gums and the teeth. Inflammations and infections frequently occur in the periodontal pocket that extends from the margin of the gums down along the shaft of the tooth. Because this area is not accessible to ordinary hygiene measures involving the toothbrush or passive use of antiseptic solutions, such conditions tend to become chronic and difficult for the dentist to treat.

Concern with the visible surface of the teeth is essential, but it is only one aspect of meaningful oral hygiene. Periodontal care—attention to the gum tissues which support and surround the teeth—is one of the other necessities.

Among adults, periodontal diseases are the major oral health problem and the principal cause of tooth loss. Research has shown that after the age of thirty-five more teeth are lost because of periodontal disease than because of decay.

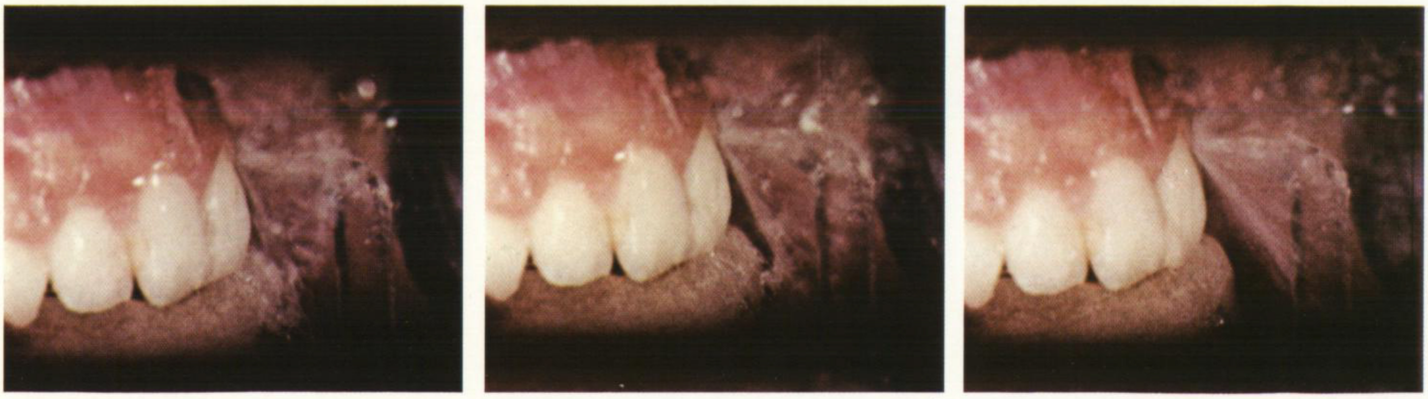
The most obvious benefit of active oral irrigation is the removal of food particles from areas that normal tooth brushing cannot reach, such as between the teeth and under various dental devices such as bridges and braces. But high-speed motion picture photography at up to 8000 frames per second has revealed two other remarkable effects of the *Water Pik* jet which make it valuable in the periodontal aspect of oral health.

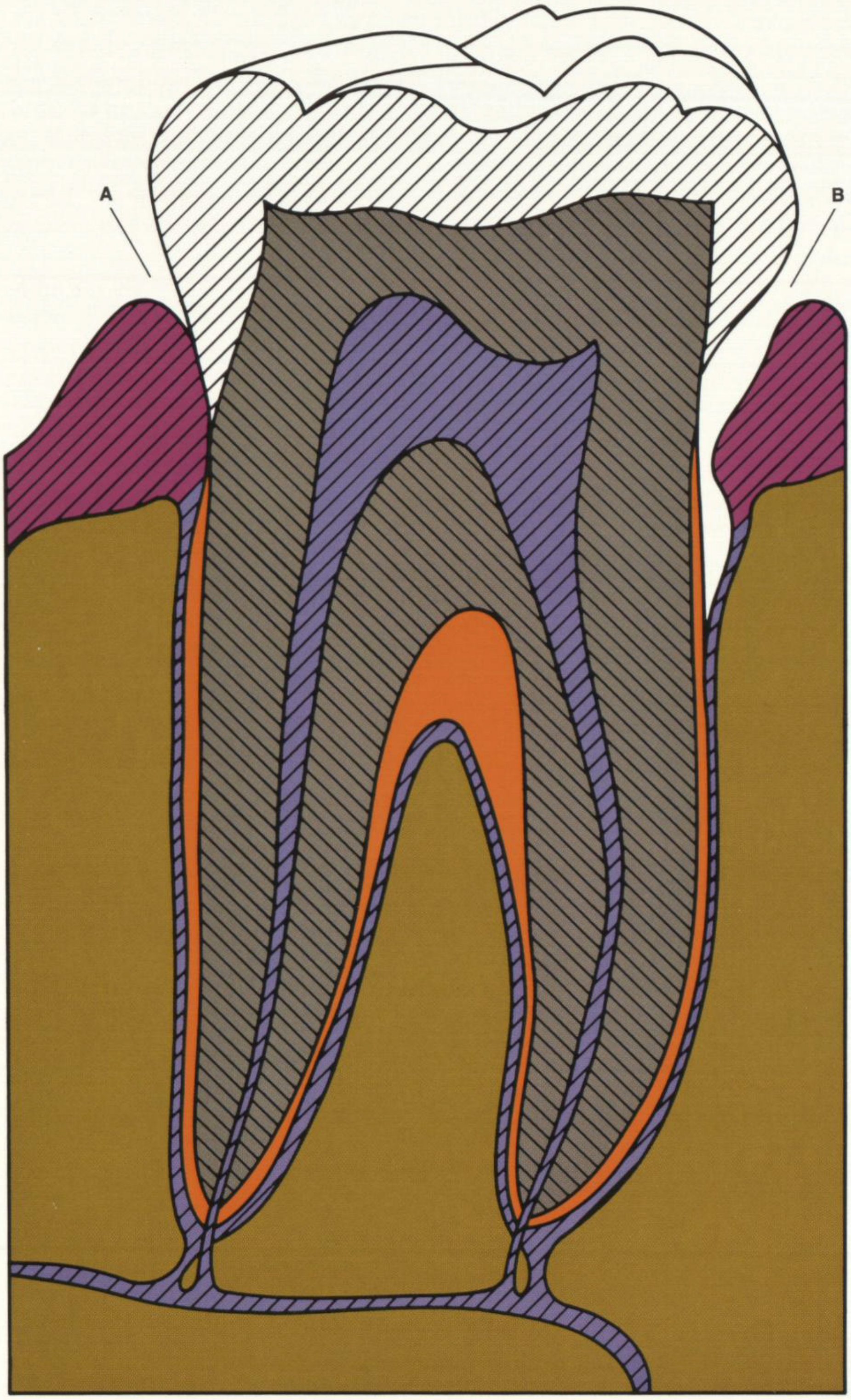
The cameras that were used to photograph the actual effect of the pulsating jet on the gum tissue of the mouth were able to slow events down by as much as 333 to 1. In other words, an event that actually took place in one second could be stretched out to more than 5 minutes of screen time. A single pulse of the water jet that occurred in 1/20th of a second could be studied on the screen for 16 seconds.

When the jet of water was directed at the margin between the gum and the tooth, the photographs

EFFECT OF WATER JET ON GINGIVAL TISSUE

Frames taken from a high-speed motion picture reveal the action of a single pulse of the water jet on the gums. As the pressurized pulse of water first hits the gum it splashes back almost at right angles to the axis of the jet, as it would in bouncing off of a flat surface. As the pulse of water continues to press on the gum the angle of the reflected water becomes sharper and sharper, indicating that a cup-shaped depression has been made in the gum tissue. In the pause that occurs after the 1/20th of a second pulse, the tissue rebounds to its normal shape. This pulsing massage action stimulates the capillary network of the gums and is generally accepted as being beneficial to the health of the tissue.





Normally, the gingival tissue surrounds the tooth closely as it does at "A", with only a small free margin between the tooth and the gum. Inflammations and infections can cause the gum to pull away from the tooth creating deep pockets as at "B". Bacteria and food particles trapped in these enlarged pockets can set up a continuing cycle of infection that can lead to complete loss of the tooth. Keeping these periodontal pockets clean is an important aspect of good oral hygiene.

showed that the jet actually lifted the edge of the gum and entered the periodontal pocket. During the pause before the next pulse of water, the pocket contracted and expelled the liquid. This pumping action effectively flushes out and cleanses these normally inaccessible pockets which can be the seat of disease.

The second revelation of the high-speed camera concerned the health of the gum tissue itself. This tissue depends on its network of fine capillary blood vessels to combat infections and inflammations. In healthy tissue this capillary network is fully developed and provides a rich blood supply. This network however tends to atrophy with age unless the tissue is stimulated in some way, such as by massage.

Each discrete jet pulse was shown by the camera to depress the gum tissue at the point of impingement, forcing the blood from the fine capillary tissues and causing it to blanch. During the pause before the next pulse the tissue had time to rebound and the capillary vessels began to fill with blood. This combined massaging and pumping action is generally accepted as being distinctly beneficial to the health of the gum tissue.

Both of these high-speed films showed the importance of a pulsed jet as opposed to a steady-stream jet such as is produced by some faucet-attachment irrigating devices. Furthermore, they showed the importance of the proper frequency or repetition rate of the pulsed jet.

Frequencies above the range patented by Teledyne Aqua Tec do not permit the tissue to rebound sufficiently to provide optimal massaging or pumping action. Those below the patented range require greatly-prolonged use of the device to achieve the same degree of stimulation and cleansing.

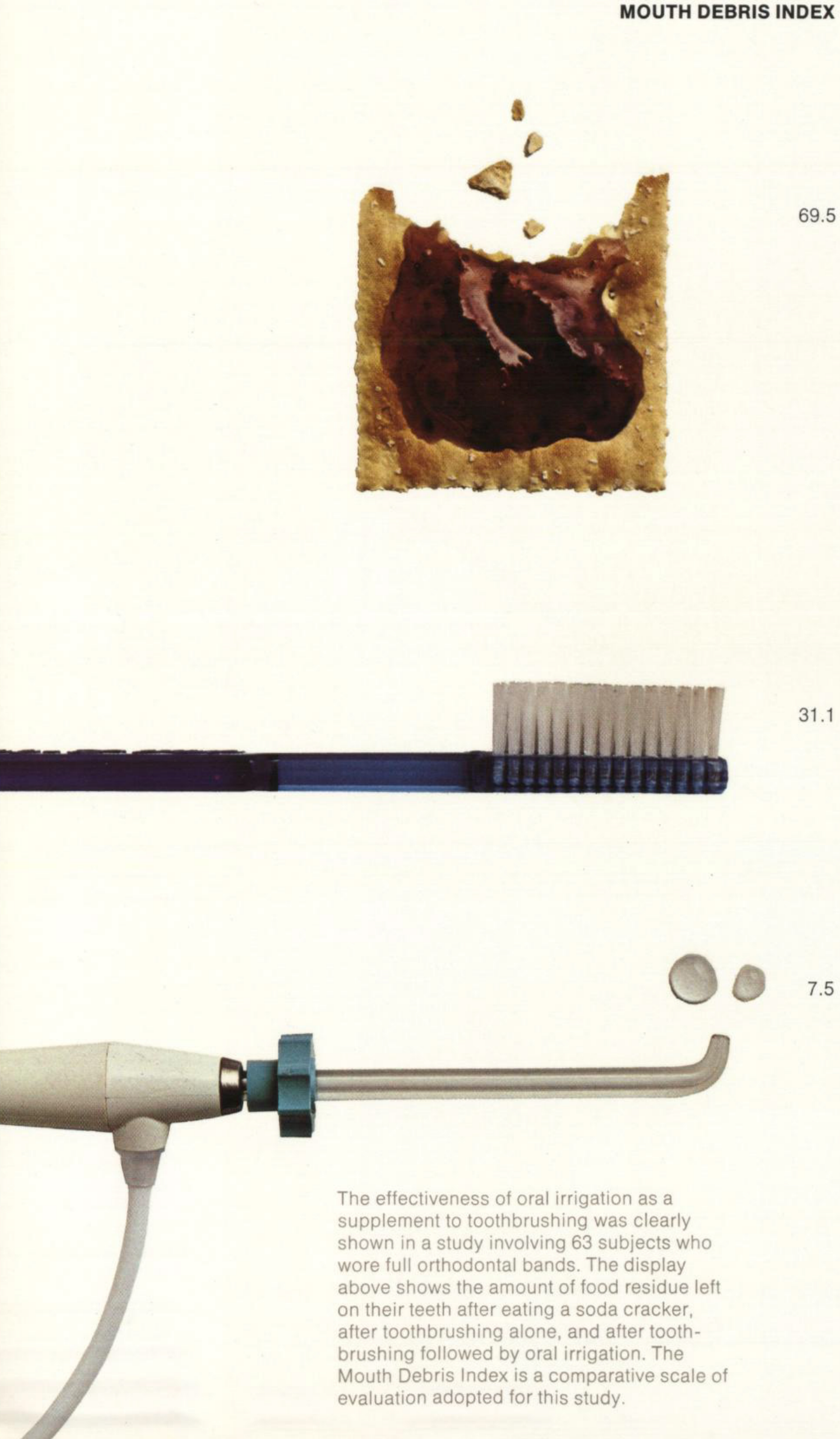
The accuracy of this analysis has been borne out by a number of scientific studies done by various university and dental groups. At the Forsyth Dental Center in Boston, for example, it was determined by Dr. Ralph R. Lobene that, when the *Water Pik* appliance is used as a supplement to the toothbrush, the accumulation of calculus and the incidence of gingivitis were both reduced by approximately 50%.

At Marquette University, Dr. J. E. Phillips found that when oral irrigation follows toothbrushing and rinsing, an average of 42% additional micro-organisms are removed compared to the number removed by brushing and rinsing alone.

By the end of his 60-day study, he determined that the number of micro-organisms being cleared from the mouth by both the oral hygiene procedures had been reduced to one-third the average obtained prior to the use of oral irrigation.

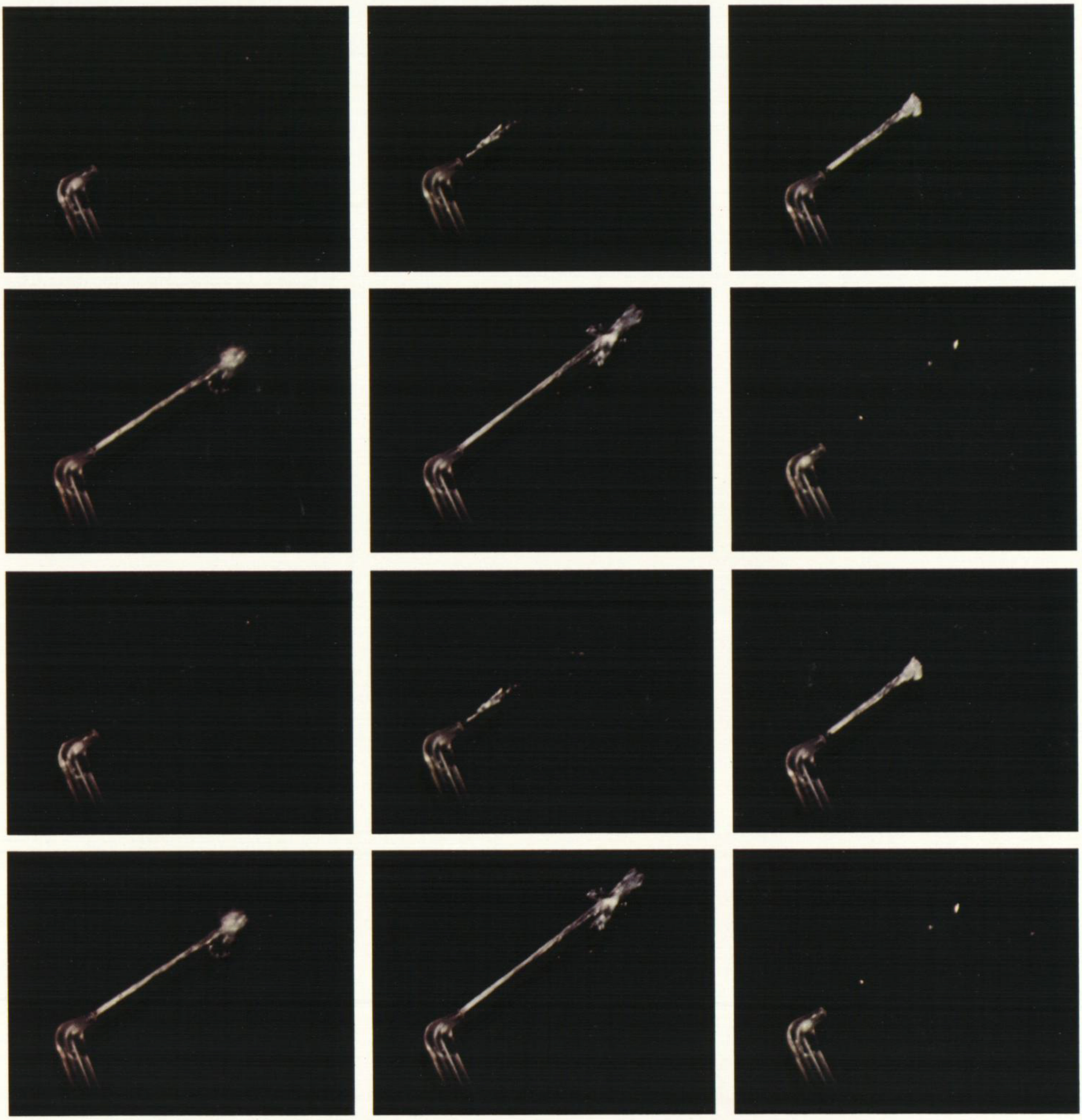
Graphically, the data produced showed that even at the end of the study the bacteria count was continuing to decrease. The gingival inflammation data followed a similar curve. By statistical analysis, a very strong correlation was found to exist between gum inflammation and the number of bacteria washed from the mouth.

Orthodontic patients who must wear braces or bands face a particularly difficult oral hygiene problem in cleaning around and under these devices. The effectiveness of an oral irrigating device in removing debris



The effectiveness of oral irrigation as a supplement to toothbrushing was clearly shown in a study involving 63 subjects who wore full orthodontal bands. The display above shows the amount of food residue left on their teeth after eating a soda cracker, after toothbrushing alone, and after toothbrushing followed by oral irrigation. The Mouth Debris Index is a comparative scale of evaluation adopted for this study.

HIGH SPEED PHOTOGRAPHS SHOW PULSING ACTION



The pulsed nature of the jet from a *Water Pik* appliance is clearly seen in this series of frames taken from a high-speed motion picture. The impingement of these pulses at a rate of 20 per second effectively flushes food residue from hard-to-reach dental areas and has a stimulating effect on the gums.

from the mouths of orthodontic patients was investigated by a clinic at still another university.

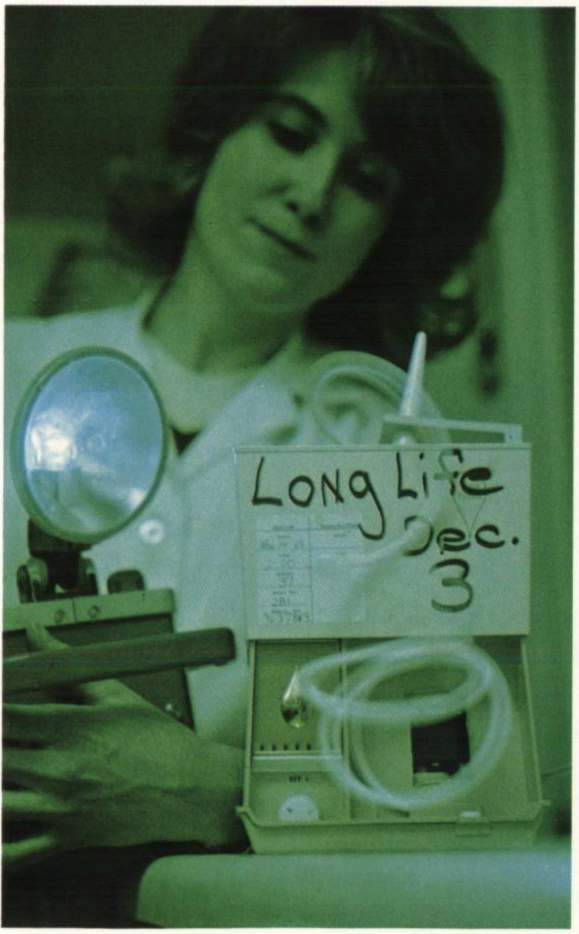
The study involved the evaluation of 63 subjects. Following the eating of a soda cracker, the amount of accumulated food residue was determined. After instructed toothbrushing each subject was evaluated again. Then, after eating a second soda cracker, brushing a second time and then using the irrigating device, a third evaluation was made.

The results showed an initial Mouth Debris Index of 69.5. This was reduced to 31.1 by instructed toothbrushing, and to 7.5 by toothbrushing and the use of the *Water Pik* appliance.

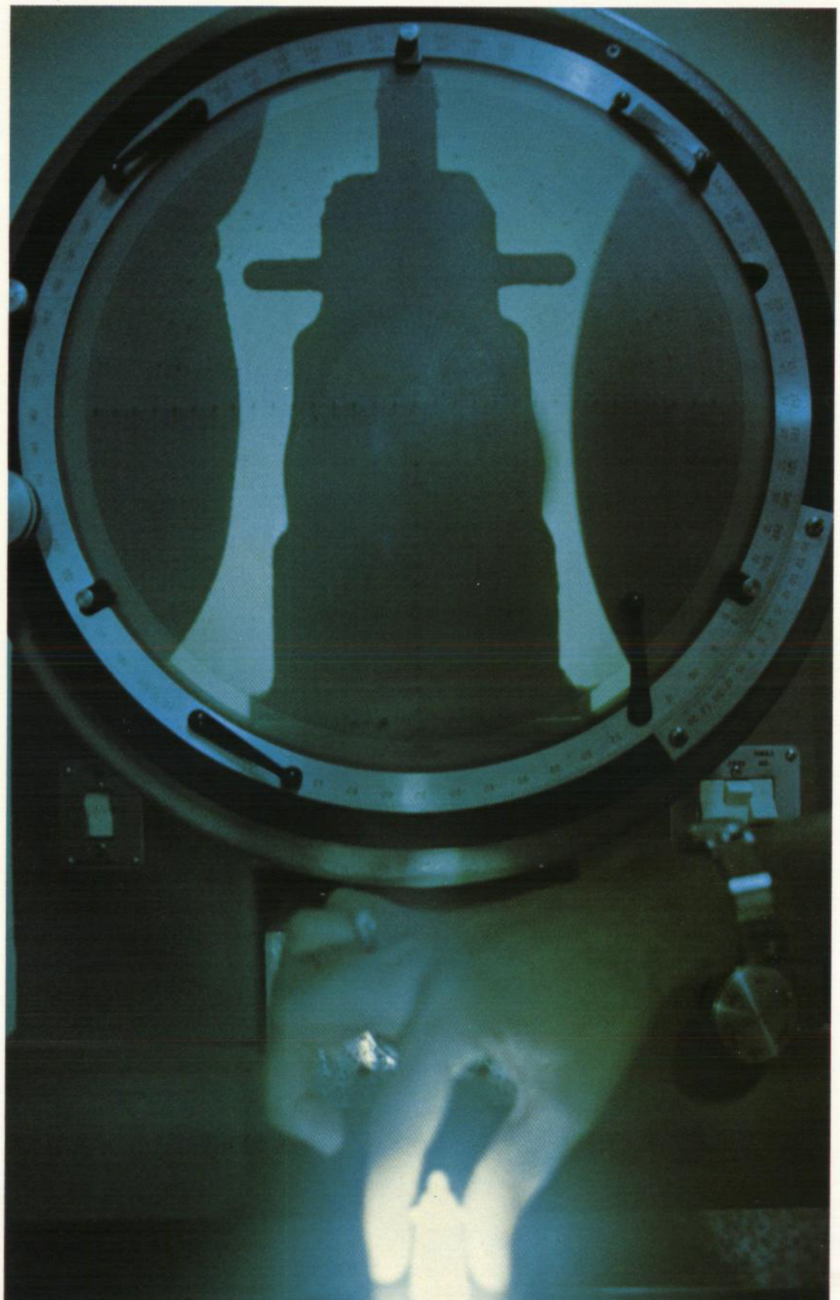
In concept, the device that produces all these desirable effects is simple. Yet a considerable amount of research and design sophistication have gone into making it the outstanding device of its class. In addition to the proper pulse repetition rate, it was found that a sharp pulse rise time was necessary for most efficient cleaning action. Many types of pumps were investigated and rejected because they could not achieve sufficiently sharp pulses. An efficient piston-type pump was chosen for the final design.

To achieve good corrosion resistance and electrical safety, plastics were used as the major design material. Of the hundreds of specialized types of plastics, each with unique and specific properties useful for certain applications, eight were chosen to meet the special requirements of the 80 parts in the device.

The outer case and reservoir of the *Water Pik* unit are made of ABS plastic because of its high strength (it is used in football helmets) and because of the easy-to-clean high-



Samples from the *Water Pik* device production line are regularly evaluated in a life-testing program that includes running them for hundreds of hours without interruption.



Unusually tight tolerances are maintained in the fabrication of certain plastic parts of the *Water Pik* device. Dimensions are checked by inspection on an optical comparator. One critical polyethylene part is held to a tolerance of 5/10,000th of an inch.

Eight different types of specialized engineering plastics are used in the fabrication of the *Water Pik* appliance. Each is chosen for specific physical properties such as hardness, flexibility, wear or impact resistance, or low coefficient of friction needed in some of the 80 parts of the device.

gloss finish it provides. An acetal-type plastic, on the other hand, was chosen for the pump body because of its low friction properties and resistance to wear. Because of its flexibility, polyethylene was needed for the piston which must conform and seal tightly to the cylinder wall. Other materials used include polycarbonate and propionate.

It is interesting to note that the piston for this device is manufactured in mass production quantities by machining methods to a tolerance of 5/10,000 of an inch — far from the loose tolerances often associated with plastics. The design of this device is unique and, in fact, it received the Plastics World award for originality and design quality.

The basic idea for the oral irrigating device has led to other related products. An automatic toothbrush attachment has been introduced that attaches directly to the jet tip handle and uses the pulsating water stream to give 1200 vigorous brushing strokes per minute. Thus the *Water Pik* unit becomes a complete home oral hygiene system.

A heavy-duty model has been introduced for professional use by the dentist. For the medical profession, a special medical irrigator is proving its worth in the irrigation of ears and in the cleaning of wounds.

In all, there are over 30 different models of the *Water Pik* unit, distributed in over 40 countries. Eighty percent of practicing dentists in the United States now recommend the device, and more than six million people enjoy better oral health because they're users of the *Water Pik* appliance.

Review 1969

The past year saw greatly increased use of Teledyne integrated circuits in industrial and commercial products. This expansion took place in both digital devices such as high noise immunity logic circuits, and in linear devices such as operational amplifiers. These devices shown at the left are used in a variety of control systems including numerical controls for machine tools, and in computer interface equipment and anti-skid braking systems for commercial airlines.

Teledyne Geotronics photogrammetric techniques are being used in projects for the Atomic Energy Commission and the Corps of Engineers Waterways Experiment Station concerning crater analysis and ejecta studies. As consultants to the Navy, Teledyne is also successfully applying these techniques to oceanographic research and exploration.

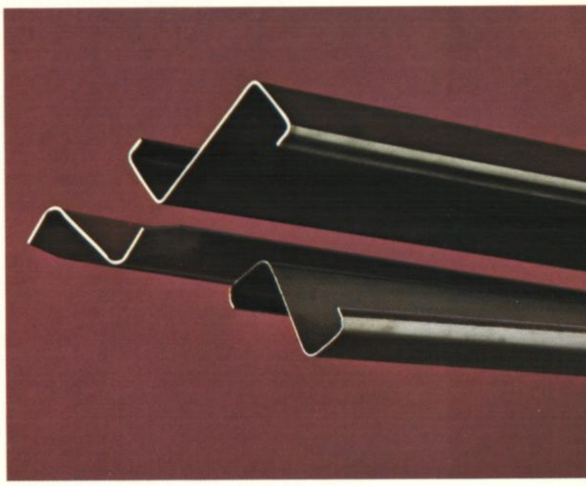
Teledyne Landis Machine gear roll-finishing machines representing a significant advancement in gear making are now installed at five different plant locations of Ford, Buick and Chrysler, producing planet pinions and sun gears for automatic transmissions. Teledyne gear-rolling machines are the only machines qualified and accepted for the roll-finishing of gears for standard or manual transmissions. Since the majority of cars produced outside the United States use manual transmissions, the development of the technique for rolling these gears broadens the world market for these machines.

An important step in the field of precise radio navigation was made recently with the delivery of new Loran receivers by Teledyne Systems. The receivers employ advanced signal processing techniques and use integrated circuit chips in Teledyne's unique MEMA package to achieve high reliability and producibility. Laboratory, field and flight tests have substantiated the predicted performance specifications of the systems.

A specially-designed series of cameras was built by Teledyne Camera Systems for use in the NASA Bio-Satellite program. A series of missions designed to study the biological effects of prolonged orbital flight will put monkeys in orbit for 30-day periods. During the flights the Teledyne cameras will photograph the activity and behavior of the monkeys during the sleep and waking periods for the entire mission. The satellite, monkey and camera are then recovered from orbit for analysis. The camera will take single frame pictures on pulse command, or up to 4 frames per second on a continuous basis. Specially-adapted lenses will permit the camera to record elapsed time on the picture along with the photograph of the animal.

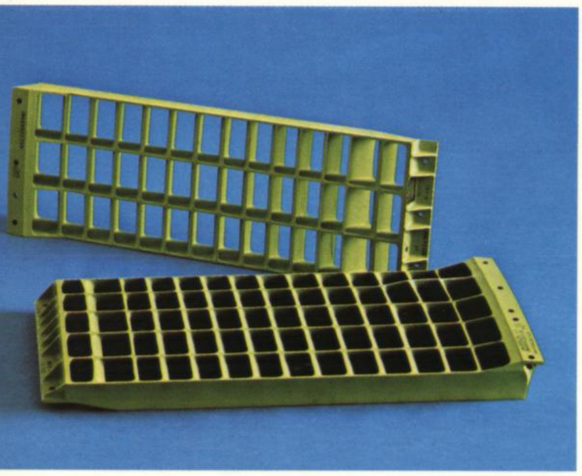
Teledyne Geotech was selected to supply the computer controlled automation system for a major water system in west Texas. The system includes two major lakes and three large pipelines with multiple pump stations. Control of 14 pump stations with expansion capability to 30 will be handled by a Teledyne computer-controlled data acquisition and control system. This system has application in low frequency data acquisition and plant process control as well as water utility applications.

The use of zirconium produced by Teledyne Wah Chang continues to grow in the chemical processing industry. The unique corrosion resistance of this metal places it in demand for pressure vessels, heat exchangers, pumps and valves, and other chemical equipment. Construction of seven large pressure vessels made from zirconium has been announced by a leading Gulf Coast chemical supplier. Diameters of the vessels range up to five feet with lengths to 20 feet. The substitution of zirconium for other metals results in a cost saving because of increased equipment life.



A new method of progressive cold roll forming has been developed by Teledyne Aero-Cal for producing the titanium stringers for the SST and the new family of jumbo jet aircraft. Titanium alloy can be formed in radii of two-and-one-half to three times the material thickness in lengths up to 50 feet with this new process. Bend radii of this sharpness result in weight savings in the finished product. By eliminating brake forming and minimizing hot sizing operations the process also reduces production costs.

Internal cleaning and lubricating of high-speed turbine handpieces that operate at speeds up to 500,000 rpm has been a chronic maintenance problem for dentists. Teledyne Densco has developed an air-actuated purging device that cleans the handpiece without disassembly and improves running speeds. It is also applicable to the maintenance of air motors used for industrial purposes.



A new casting technique developed by Teledyne Precision Castings is being used to make thrust reversers for the Boeing 747 aircraft. These magnesium alloy parts located at the forward part of the aircraft's four jet engines are used to reverse air flow after landing. There are 96 separate castings, 24 per engine, weighing four to eight pounds each, on every 747. By the use of magnesium alloy, which is as strong as aluminum but 30% lighter, the weight of each aircraft was reduced by 196 pounds.

A new light-sensitive TO-5 relay has been developed by Teledyne Relays that combines in one package the functions of a photo cell and a relay. The photo-relay is intended for a wide range of industrial applications, including such diverse uses as sensing paper levels in office copier machines, counting canned goods or other products on a manufacturing line, sorting by color or size, and other control functions. The device is designed with a small field of view that is ideal for precise focusing applications such as with laser systems.

Teledyne Canada Limited is the newly adopted name of Vascan Limited. The name was approved by Vascan shareholders at the 1969 Annual Meeting. Teledyne Canada, based in Toronto, reported sales for the 1969 fiscal year of $12,570,000 and earnings of 42 cents per share against 23 cents for the year earlier period.

Teledyne is a major supplier of cast and forged rolls for rolling mill conversion of ferrous and non-ferrous metals. Provisions have been made to increase manufacturing capability at Teledyne Ohio Steel to produce finished cast rolls weighing ninety tons for use as backing-up rolls in the aluminum industry. Sintered carbide rolls, manufactured by Teledyne Firth Sterling, are successfully being used to reduce heated billets, weighing up to 3000 pounds, to small diameter rod, at exit speeds of up to 10,000 feet per minute. The principal advantages derived from the use of sintered carbide are better control of size and surface finish plus much longer roll life between regrinds. Up to 75 tons of product can be rolled for each one-thousandth inch wear on the roll diameter.

The first of a new generation of large capacity, precision bending machines has been introduced by Teledyne Pines. The numerically-controlled tube bender incorporates a proprietary control unit for bending aircraft-quality, thin-wall stainless steel tubing up to six inches outside diameter into almost any configuration.

The SNAP-19 Radioisotope Generator has been chosen by NASA as the primary power for the Pioneer F and G Jupiter Flyby Spacecraft to be launched in 1972 and 1973, and for the Viking Mars Landers to be launched in 1975. The Pioneer power system will include four 40-watt SNAP-19 generators per spacecraft, and each Mars Lander will carry two units. These two space missions will be the first to depend wholly on nuclear power rather than solar cells. The Teledyne Isotopes generators provide a completely self-contained, independent source of electrical power and have increasing advantage over solar cells as spacecraft distance from the sun increases on missions to the outer planets.

A new application of lasers makes it possible to significantly improve industrial process control through exact surface measurements on such substances as paper, metal, fiberboard, cloth and even liquids. The newly-developed Teledyne Brown Engineering Spatial Intervalometer is a non-contact distance measuring device which operates by detecting the Doppler shift of laser beams scattered back from the surface being measured. An optional high accuracy velocity measurement output is also available.

The Teledyne Post Quantar Drafting System is a two-part chemical system using treated paper and a special colorless fluid in place of ink to produce easy-flowing, opaque, uniform lines in a variety of imaging applications. The low-viscosity Quantar fluid gives non-smear, no-skip black lines, even at high speeds, in automated drafting equipment and plotters, as well as in manual drawing. Quantar treated paper vellums and stabilized polyester films are now being sold.

In its 21st year, the versatile Firebee remote control target system is now supersonic. The new Teledyne Ryan Aeronautical Supersonic Firebee II is a sleek, 28-foot long, Mach 1.5 remote control target that offers military users the best in realistic target presentation.

Air terminals in four major cities will be equipped in 1970 with passenger loading systems developed by Teledyne Brown Engineering especially for the new jumbo jets. Los Angeles and San Francisco will each receive two systems and single systems are planned for Philadelphia and New York. The new telescoping systems permit faster and easier passenger loading and more efficient use of terminal facilities and equipment.

Fully automatic production of turned shafts directly from bar stock in one pass of the cutting tool is made possible by a new numerically-controlled centerless turning machine produced by Teledyne Taber. It has wide application in manufacturing operations and is particularly useful in the electric motor, automotive and business machine industries.

When the S.S. MANHATTAN made a successful run through the Northwest Passage, her speed on course was precisely monitored by a Teledyne Hastings-Raydist DR-S system. The Raydist system which is normally used for precise radiolocation purposes, was utilized to provide the speed information. Two Raydist base stations that were carried aboard the S.S. MANHATTAN were flown about 75 miles ahead of the tanker by a helicopter. A Raydist recorder aboard the ship continuously determined the exact distance to these base stations and this information was used to determine speed. Raydist equipment is capable of determining position to within a few feet at ranges of hundreds of miles from base stations.

Teledyne's MEMA (Micro Electronic Modular Assembly) technology was instrumental in the recent award to Teledyne Systems of a substantial subcontract for the development and production of a Computer Integrated Converter Unit (CICU) for the new F-14A swing-wing supersonic fighter being developed for the United States Navy by Grumman Aerospace Corporation. The CICU is the main signal junction point for the entire F-14A avionics system. It provides signal buffering and conversion functions, and automatic monitoring of the onboard checkout of all avionic systems. The digital portion of the CICU also calculates aircraft velocity and position from inertial platform data.

An Automotive Crash Recorder is being developed by Teledyne Geotech for the United States Department of Transportation, National Highway Safety Bureau, as part of an overall safety study. The recorder is to be installed in vehicles to retain the last "one second" of acceleration data from an impact. The information derived from this study will be utilized in establishing design criteria for both vehicles and highways.

During the year Teledyne Movible Offshore took delivery of a 500 ton derrick barge, for operation in the Gulf of Mexico. In the placement of the base and deck of a drilling rig the barge has already made what is believed to be the heaviest rotating offshore lift ever completed. The new equipment is capable of operating in depths of approximately 250 feet. About 80% of the construction and drilling work being done in the Gulf is within this depth limit.

Teledyne Rodney Metals thin-wide stainless steel and aluminum strip are used for almost every metal part on the new "Instamatic '44'" camera. The metal parts include the nameplate panel which is die-formed from aluminum strip, and internal working parts of close-tolerance stainless steel strip. Accuracy and special flatness are essential to the successful operation of the shutter, springs, and similar parts.

Teledyne Systems has received an add-on contract from NASA-Lewis Research Center for the continued development and production of an advanced airborne digital computer for use in the Centaur space vehicles. The Teledyne equipment will be an integral part of the guidance systems of future Centaur vehicles and will enhance airborne performance as well as simplify ground check-out of the vehicles.

Teledyne Continental Motors has taken a significant step toward limiting air pollution by being the first company to have an exhaust control system for industrial engines approved by the Air Resources Board of the State of California. Approval was for six series of Continental automotive/industrial engines in both gasoline and LPG versions. Advanced carburetor and intake manifold design has made possible more complete combustion and a marked reduction in toxic emission. Improved fuel economy is an interesting by-product of this better combustion efficiency. The new system is simple, durable and economical. It has no extraneous attachments or additional moving parts, and servicing is no more frequent or difficult than with any conventional carburetor.

New Doppler radar navigation design has been applied in the Teledyne Ryan Aeronautical Model 790 Advanced Doppler, now in production under a new contract for the Navy S-3A anti-submarine airplane. Design innovations include a solid state transmitter, a microwave stripline receiver assembly and an advanced automatic land-sea bias.

Pilots of the new DC-10 commercial aircraft will be alerted to special operating conditions in the aircraft's electrical and mechanical systems by an annunciator panel (foreground) installed directly above the windshield in the pilot's compartment. This warning, advisory or cautionary information will be displayed as lighted word messages on the annunciator system panels designed and manufactured by Teledyne Radar Relay. Up to 53 messages can be displayed in various colors that are associated with the importance of the message. Lighted pushbutton switches along the lower surface of the panel allow the pilot or co-pilot to acknowledge receipt of the message and permit self-testing of the system. The other 39 channel panel is installed in the flight engineer's compartment and displays similar information.

TWA's Boeing 747 aircraft will be one of the most extensively monitored aircraft ever flown. An Airborne Integrated Data System (AIDS) developed and produced by Teledyne Systems will monitor, process and record data from 311 sensors mounted at strategic locations in the aircraft. The AIDS system will record data at regular intervals during the flight. Data will be stored on a magnetic tape cassette which is removed from the aircraft at the end of each day's operation. It will then be transmitted electronically to TWA's main engineering and maintenance base for analysis by a computer system that will provide instant maintenance advisory information. A trend analysis of the performance of individual aircraft from day to day will make it possible to detect many types of incipient equipment failure, permitting repair or replacement before there is any danger of in-flight failure.

New elastomeric automobile bumpers developed by Teledyne Monarch Rubber for the Chrysler Corporation were put into production during the year. A microcellular blown elastomer polyurethane is poured into a mold holding an unfinished steel bumper that acts as an insert and method of fastening the unit to the car. The bumpers are finished in nine colors which perfectly match the acrylic body paints of the car. This type of bumper lends itself to distinctive styling concepts unattainable in steel.

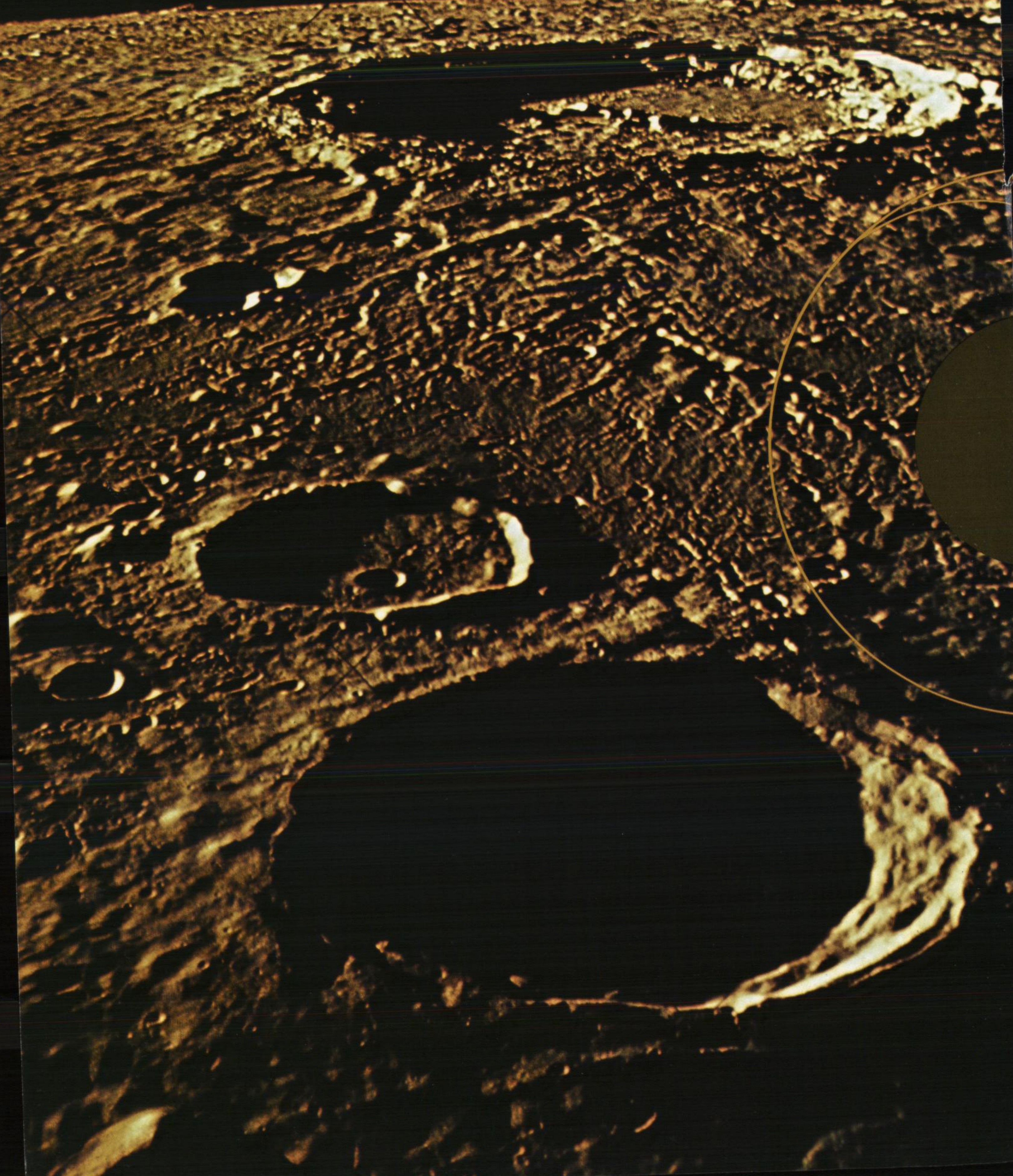
Among a number of new precision valves for specialized applications recently introduced by Teledyne Hydra-Power are two solenoid-operated valves for use in nuclear waste disposal systems. They are designed to work while immersed in radioactive boric acid water solution at operating pressures of 350 pounds per square inch, with zero internal leakage.

Studies by Teledyne Materials Research of the mechanical response of large ships to the motion of the sea continued and included stress measurements on a containership, the type of vessel which is rapidly replacing the traditional cargo ship. In addition, the first commercial installation of the Teledyne bending stress monitor was accomplished by Teledyne engineers on a 1000-foot tanker at a shipyard in Japan. Stress analysis techniques also were used on valves ranging up to 24 inches in size to predict safe operation in nuclear power service. As many as 130 strain gages were used for measurements on a six-inch valve rated at 2500 psi for 600°F service. A number of finite-element computer programs contributed to the concurrent theoretical determination of predicted safe service life.

A Teledyne Wisconsin Motor 30-horsepower gasoline engine has been selected to power a new all-purpose, all-terrain vehicle designed specifically for use in wet, rugged areas. The engine will provide power to carry 1000-pound loads over difficult terrain, through mud and swamps, and across inland water barriers. The versatile vehicle can be adapted to serve as a utility truck, plow tractor, mobile medical clinic, ambulance and in numerous other roles.

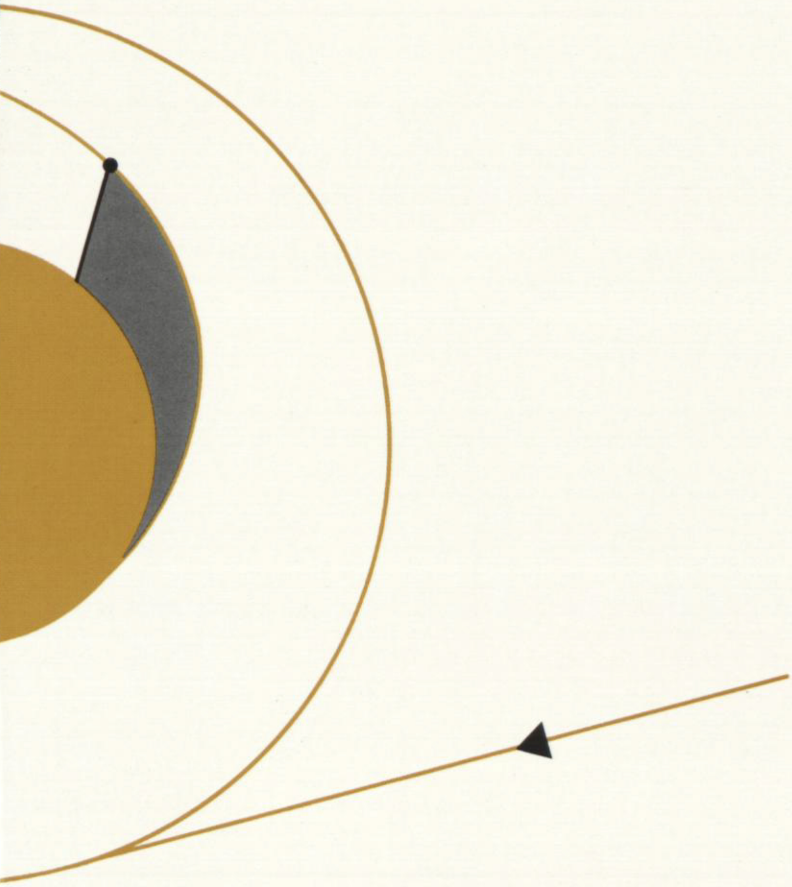
Teledyne Exploration has recently been awarded a contract for provision of three complete seismic systems to the U.S. Naval Oceanographic Office. The systems are of Teledyne design and include capacitor-discharge acoustic sources, hydrophone arrays, amplifier systems, recorders and all peripheral gear such as winches and hoists. Selection of this system by the Navy was largely due to the excellent results obtained in the 1969 survey of the Gulf of Mexico using an identical system. The systems will be installed on three of the Navy's primary oceanographic survey ships.

Advanced techniques have made possible a 40% size reduction in a new line of miniature low-noise microwave amplifiers. These Teledyne MEC amplifiers incorporate traveling wave tubes and integral power supplies. This significant size reduction has accelerated the acceptance of these units for advanced electronic counter measure applications.



The Last Eight Miles

The controlled descent to the surface of the moon was accomplished through use of a century-old principle called the Doppler effect.



Successfully leaving lunar orbit and making a controlled descent to the surface of the moon, as was done in the Apollo XI and XII missions, required precise information on the changing velocity of the spacecraft in relation to the moon. It was provided by a modern radar application of the century-old Doppler principle.

One small portion of the Apollo XI and XII journeys to the moon — the last 8 miles — would have been far more difficult if it had not been for a technology based on a principle discovered over a hundred years earlier. The technology, called Doppler radar, is named for an effect discovered by Christian Johann Doppler.

Doppler was an Austrian mathematician who lived in an age when the wave theory of sound, light and electromagnetic radiation was just being developed. It was learned that the pitch of a sound depended on the number of 'waves' (or compression/rarefaction cycles) that reached the eardrum of a listener in a given time. The color of a light beam was similarly thought to be determined by the number of 'waves' of light that reached the eye of an observer in a given time.

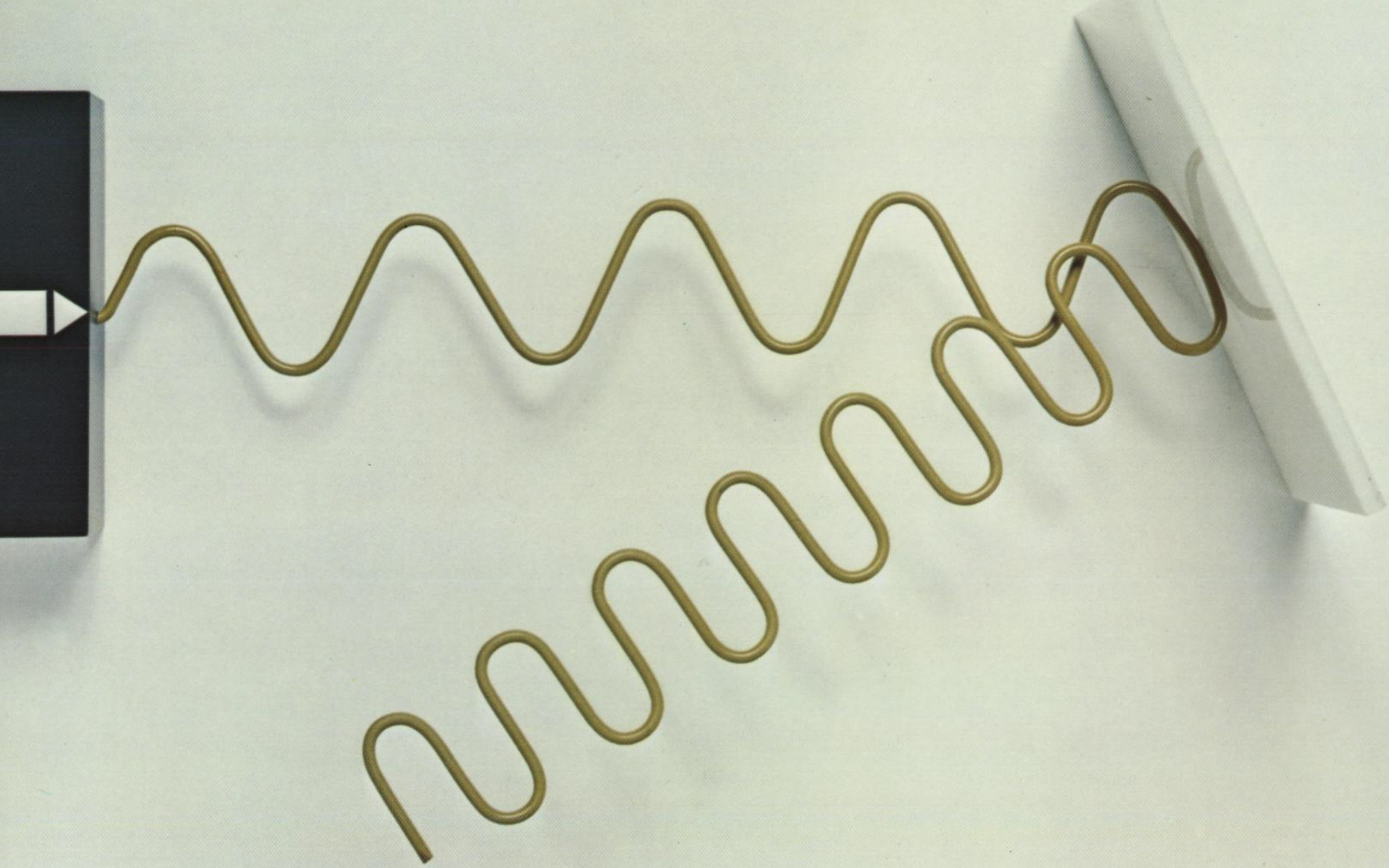
Christian Doppler surmised that his ears would intercept more waves in a given time if he were rapidly approaching a sound source, fewer if he were moving away, and that therefore the pitch of the sound he heard would be shifted up or down.

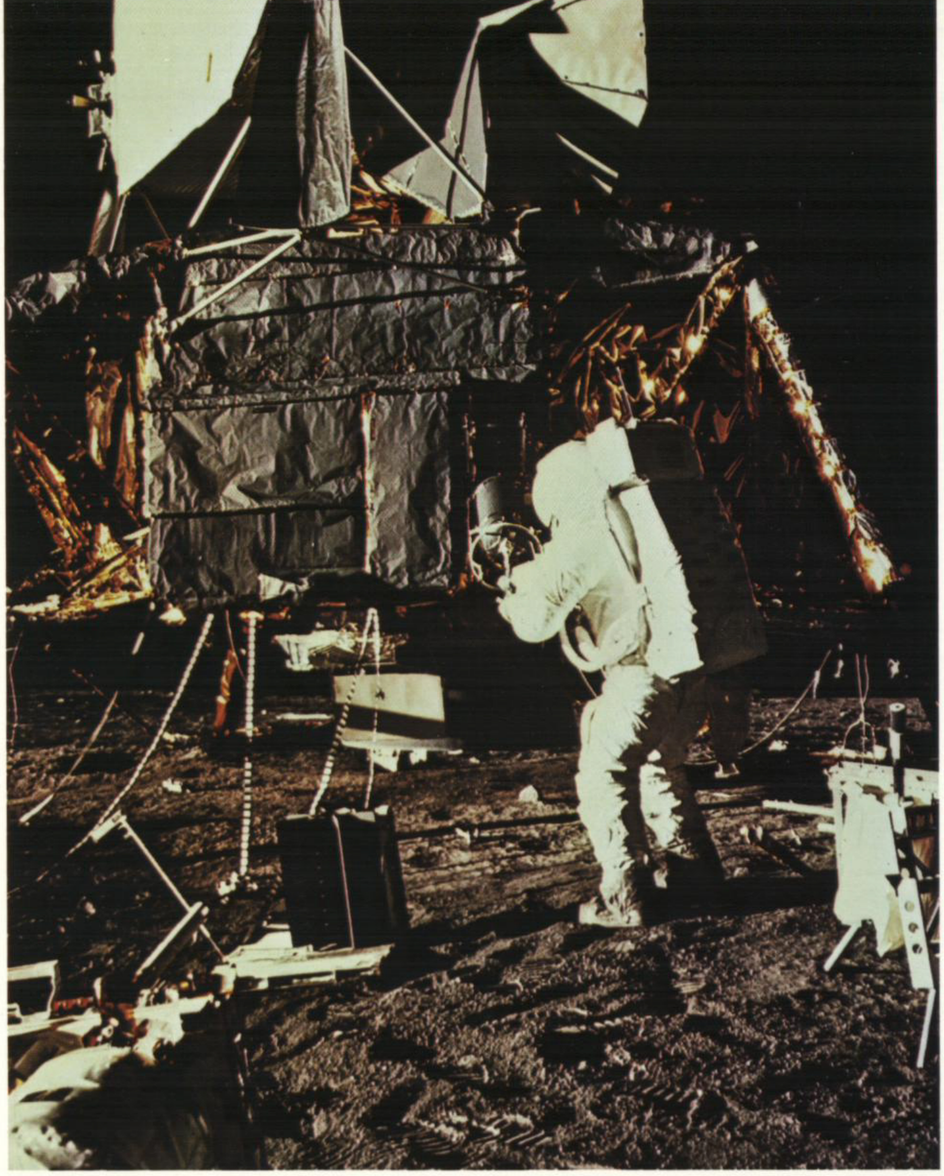
He was convinced this was true for both sound and light. The sound theory was later easily proved by an experiment involving a moving locomotive, its whistle and a group of professional musicians who acted as judges.

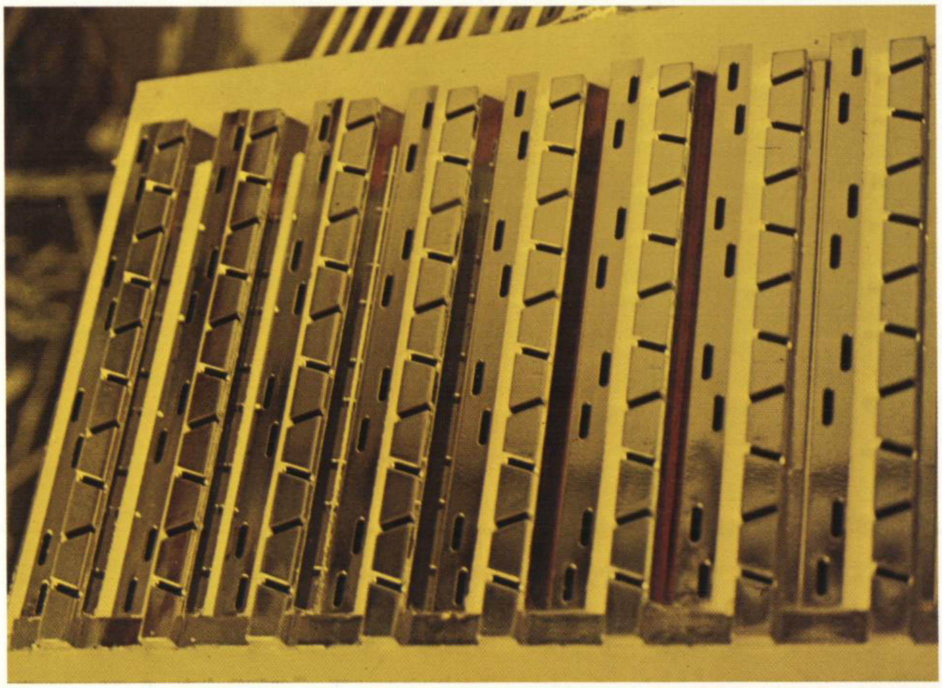
In a remarkable piece of deductive reasoning, he presented his theory regarding light in a paper entitled: "On the Color of Double Stars" which explained why these twin stars, revolving around each other, seemed to change in color

DOPPLER EFFECT

When sound, light or radio waves are reflected from a surface that is moving toward or away from the signal source, the frequency of the reflected signal is altered. The same effect occurs if the reflector is stationary and the signal source is moving. Doppler radar uses this principle to determine exact velocity information from the frequency shift of the reflected signal.







Top: Five Surveyor unmanned vehicles and two Apollo manned missions have been successfully guided to soft landings on the moon by Teledyne Ryan Aeronautical Doppler radar sensors. After having performed its landing mission, the Doppler system, seen on the bottom of the spacecraft, is left on the moon with the lower section of the vehicle.
Bottom: This slotted planar array transmitting antenna is part of the antenna cluster used on the Lunar Module Doppler Radar System. The spacing and positioning of the slotted waveguides were determined by computer analysis. Velocity and altitude sensor transmitters are interlaced in the unique design.

over a period of time. They were, of course, alternately approaching the earth in their orbits and then receding from it at tremendous speeds, causing a Doppler shift in the observed frequency and hence color of the light. The same principle was later found to hold true for other electromagnetic radiation such as radio frequency waves.

The Doppler principle was put forth in 1842, but it was not until over a hundred years later that it was put to any practical use in a system called Doppler radar. The title is actually misleading since the word "radar" originally stood for Radio Detection And Ranging. This classic "search" radar is based on the fact that radio waves of certain high frequencies reflect from solid objects much as light does. A pulse of radio energy is sent out in a narrow beam in a specific direction. If it strikes a solid object within its range, an echo signal is reflected back to the transmitting site. By carefully timing the interval between the transmitted pulse and return echo, the distance to the reflecting object can be calculated. In practice, the direction of the beam and the timing information are displayed on a cathode ray tube. Scanning a given area with many pulses builds up a graphic analog on the screen showing the position and range of reflecting objects such as terrain, buildings, aircraft or ships.

Doppler radar, on the other hand, gives an entirely different kind of information. It is only capable of determining the relative velocity that exists between two bodies or surfaces. Radio energy of precisely-controlled frequency is continuously projected out in a narrow beam. If this beam impinges on a solid surface, some of it is reflected back to the transmission point. If there is no relative motion between the two points, the frequency of the return beam is identical to the transmitted one. If the two points are moving apart, a Doppler shift occurs and the return frequency is lower than the transmitted one. Just the opposite frequency shift occurs if the two points are moving toward each other. It doesn't matter whether one or the other or both points are moving, as long as there is a relative motion between them.

With this information, it is possible to determine the relative velocity between the two points by measuring the difference in the transmitted and received frequencies. By combining the input of three separate beams that are projecting at angles to each other, it is possible to get complete three-coordinate information on the motion of an aircraft or space vehicle—forward motion, drift and altitude change—relative to a surface such as the earth or the moon.

Exactly this kind of information was needed in the Apollo XI and XII missions to land the Lunar Module on the moon. The problem was to make a controlled landing at a specific spot on a rugged airless satellite, from orbital altitude and speed. Because of the lack of atmosphere there was no possibility of measuring velocity with airspeed indicators such as are useful on earth. Nor was any type of barometric altimeter possible. The logical solution was Doppler radar.

Teledyne Ryan Aeronautical,

Completed electronic assembly of the Apollo Lunar Module landing radar is readied for final acceptance testing and shipment. Frequency trackers, signal data converters and power supply are packaged with the unit, which measures approximately 7 x 7 x 16 inches.

which has been building Doppler radar sets since the early 1950's, produced the Doppler sensing equipment for the successful moon missions. To date, their radar has successfully soft-landed five Surveyor unmanned vehicles and two Apollo manned missions on the moon.

The lunar landing radar used in the manned landing is a two-unit package weighing about 43 pounds. One unit, containing the power supply, frequency trackers, velocity and range data converters and signal data converters is mounted inside the spacecraft.

The other, called the antenna unit, containing the transmitting and receiving planar array antennas, solid state transmitters, mixers and preamplifiers, is mounted outside the spacecraft where it is subjected to severe high temperature conditions from solar radiation, engine skirt radiation and the exhaust plume.

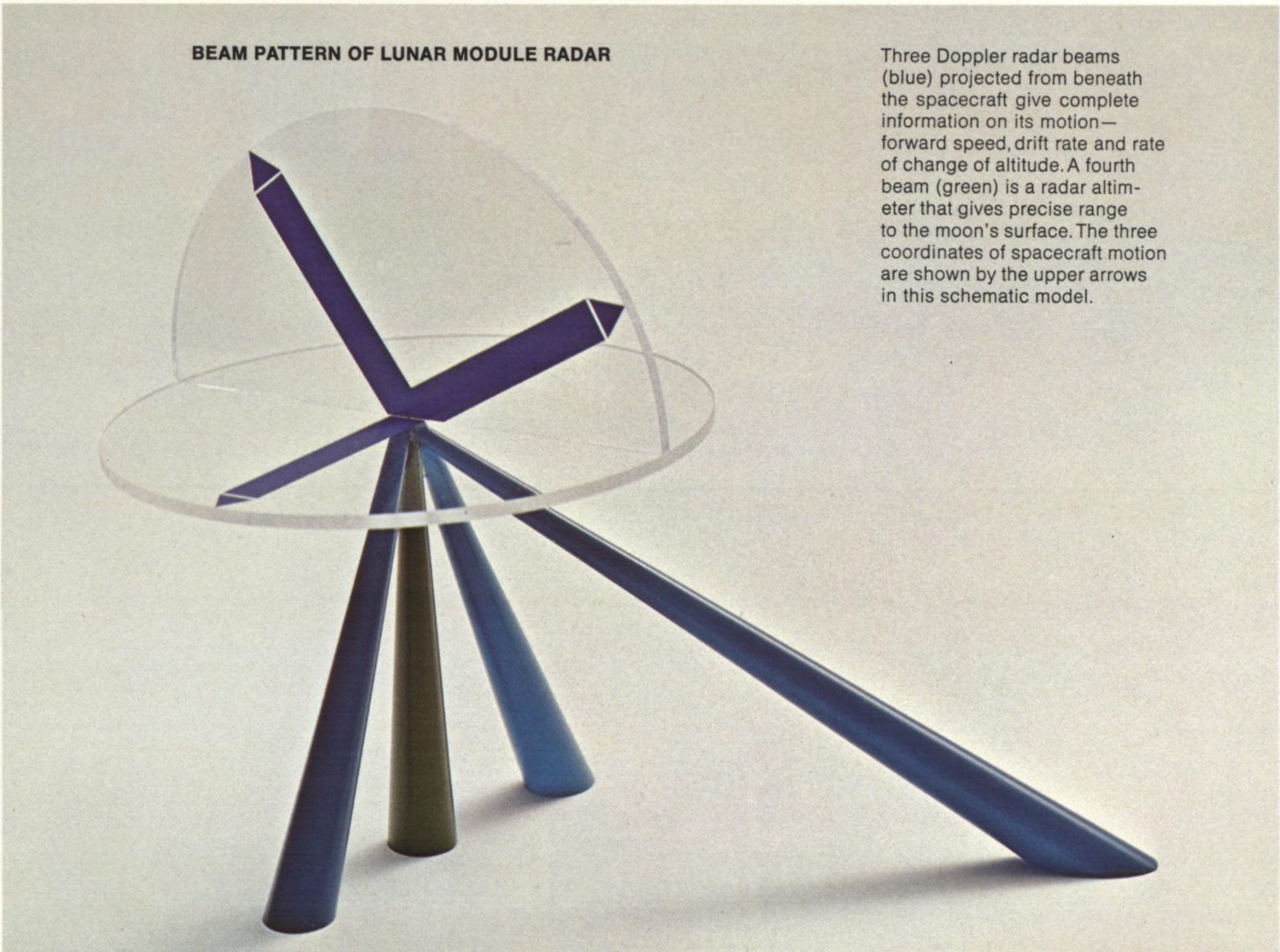
A three-beam velocity-sensing Doppler system is used in the Apollo landing radar. A fourth beam is used to provide altitude information through an FM/CW range or altimeter sensor. The entire system operates on less than one watt of transmitted power.

The typical lunar descent trajectory begins with engine turn-on at the low point of the elliptical Lunar Module orbit, nominally at 50,000 feet and about 5500 feet per second velocity. The landing radar is turned on at this time. The altimeter begins to register at about 41,000 feet, and the velocity sensor acquires a return signal at a nominal altitude of 28,000 feet. Velocity at this time is approximately 2000 feet per second. Upon descending to an altitude of between 1000 and 100 feet, the descent rate is slowed to a near hover to allow for pilot assessment of the landing site. A vertical descent rate of five to ten feet per second at this time gives optimum landing radar accuracy. The complete lunar descent can be automatically controlled by the Lunar Guidance Computer or manually over-ridden at any time.

While Doppler radar is ideal for such space missions as landing vehicles on the moon or rendezvous—docking of vehicles in space, it also has a number of important non-space applications.

The hover of a helicopter over water presents many of the same problems that a moon landing does. Since the water's surface looks the same all over, a helicopter pilot can-

BEAM PATTERN OF LUNAR MODULE RADAR

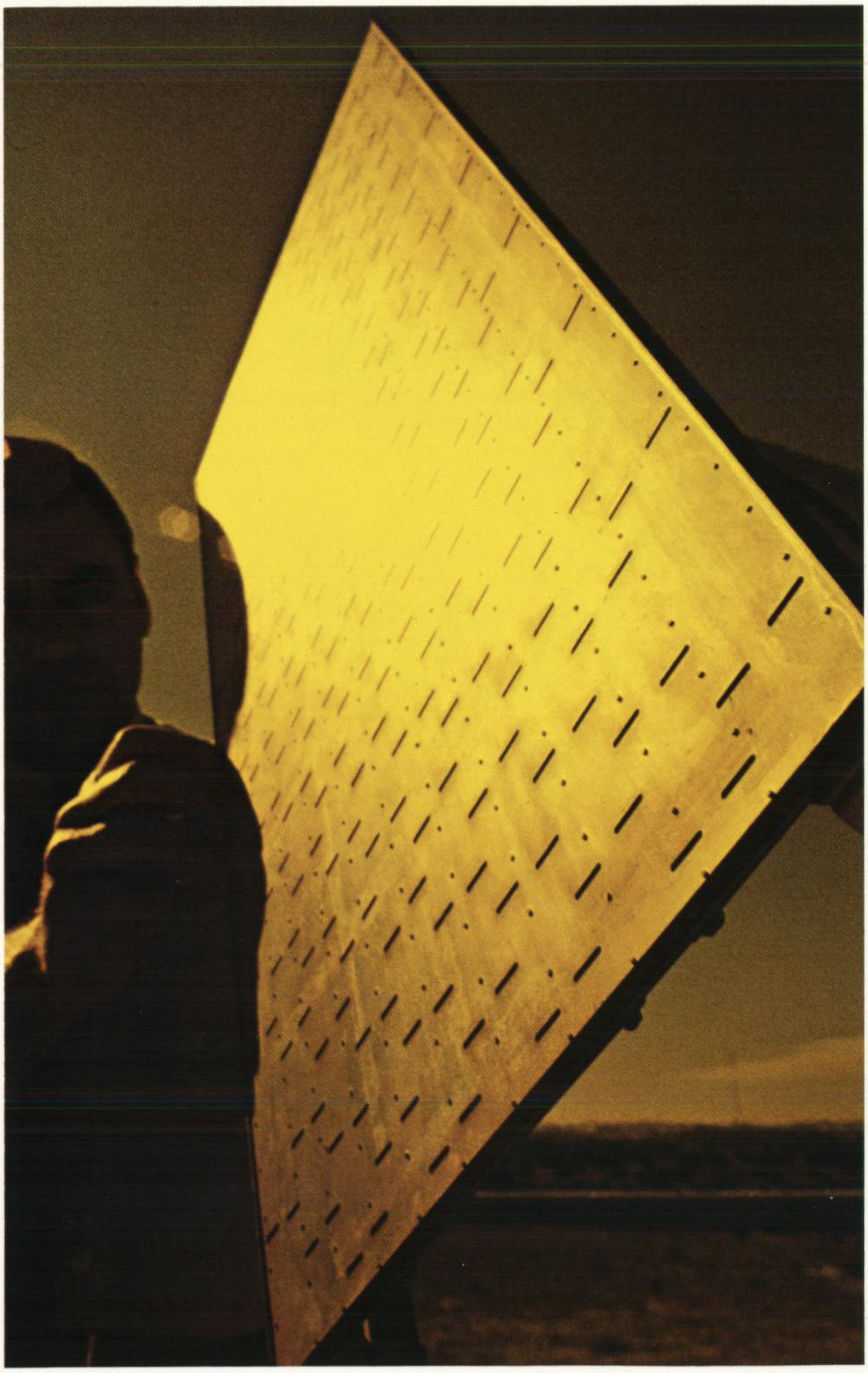


Three Doppler radar beams (blue) projected from beneath the spacecraft give complete information on its motion—forward speed, drift rate and rate of change of altitude. A fourth beam (green) is a radar altimeter that gives precise range to the moon's surface. The three coordinates of spacecraft motion are shown by the upper arrows in this schematic model.

not tell by looking at it when he is stationary in reference to a point on it. Air-movement sensing instruments would be useless because they could only tell him when he is stationary regarding the air. If a wind is blowing he is still drifting with respect to the surface.

Doppler radar solves this problem by giving him an exact picture of his motion relative to the water's surface. This stationary hover capability is important in air-sea rescue operations under poor visibility and in the use of antisubmarine warfare hydrophones. In this latter application the helicopter assumes a hover about 40 feet from the surface of the water. It then lowers a sound-sensing hydrophone into the water on the end of a long cable. The hydrophone is often lowered to a depth of several hundred feet. Any sideways motion of the helicopter during this procedure can subject the cable to severe and undesirable stresses. Teledyne Ryan was the first company to make a Doppler radar that permitted helicopters to make a true motionless hover, and later was the first to make this system completely automatic so that a zero hover would be maintained without attention by the pilot.

Hard landings caused by excessive sink rate of an aircraft at touch down may cause unpredicted stresses and fatigue in the structural members of the aircraft. Such stresses and fatigue are suspected of being the cause of many accidents. Available data indicates that the effects of hard landings may be cumulative. An accident may not occur until several landings after the



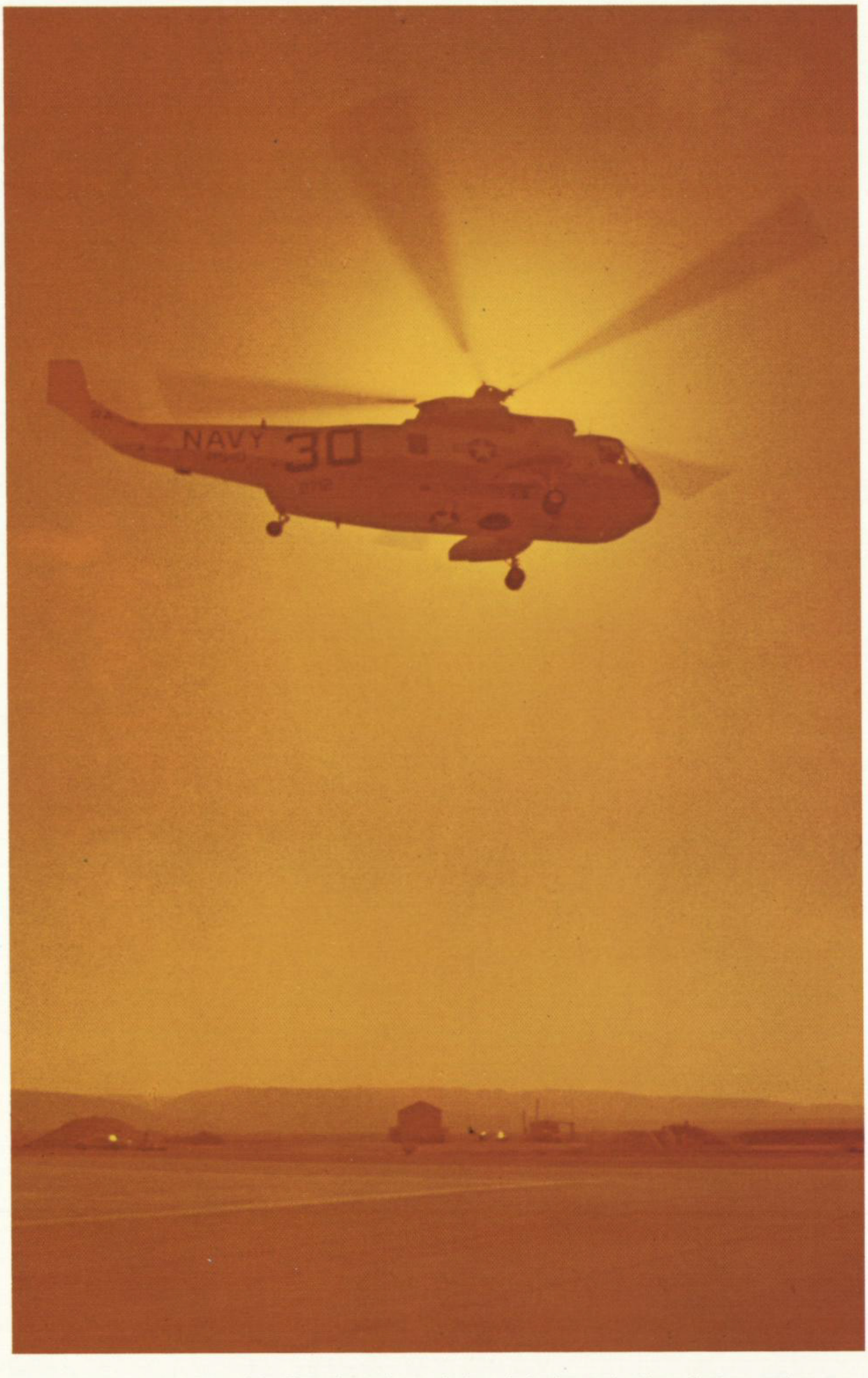
Doppler radar transmitter arrays are tested for beam pattern on an outdoor antenna test range that permits boresight accuracies of plus or minus two degrees of arc. This aluminum assembly is a four-beam planar phased array transmitter for aircraft application.

one which overstressed the aircraft.

A specialized Sink-Rate Radar, using the Doppler principle was developed for the Navy by Teledyne Ryan to assist in solving this problem. It collects data on the sink-rate of each craft on landing that can be used to indicate the need for overhaul or maintenance after a particularly hard landing. It is also useful as a pilot training tool and can be used to measure the closure rate between aircraft during air-to-air refueling.

One of the widest potential applications for Doppler radar is in the navigation of both fixed wing and rotary wing aircraft. Since Doppler radar gives a continuous sensing of the velocity of the aircraft in all directions, this information can be electronically processed to form a highly-precise method of dead reckoning that is tied directly to the earth's surface without need for compensation of wind speed and drift that create inaccuracies in some other types of navigation. It is also essentially independent of visibility or terrain conditions. Accuracies on the order of one-tenth of one percent are currently possible—or an error of only one mile in one thousand. Doppler navigation is being increasingly used in military applications and by commercial airlines.

Doppler radar and its related technology will undoubtedly continue to have widening civilian and commercial applications. The commonly seen police speed radar systems are just one more example of the more-than-a-century-old principle of Christian Johann Doppler in action.



An important application of the Doppler radar technique is in the navigation of rotary and fixed wing aircraft. Doppler navigation equipment can reference an aircraft directly to the earth's surface—without need to compensate for wind-speed or drift—with an error of less than one mile in one thousand.

Financial Statements

Highlights of Nine Years Operations

Green figures are restated to reflect subsequent poolings of interests.
Black figures are historical results of Teledyne, Inc., as originally reported.

	1969	*1968*	*1967*
Sales and service revenues	$1,294,775,000 1,294,775,000	$874,905,000 806,747,000	$777,745,000 451,060,000
Income before Federal income taxes	114,603,000 114,603,000	85,992,000 78,220,000	63,053,000 40,745,000
Provision for Federal income taxes	54,500,000 54,500,000	40,400,000 37,500,000	28,400,000 19,000,000
Net income	60,103,000 60,103,000	45,592,000 40,720,000	34,653,000 21,745,000
Net income per share of common stock and common stock equivalents	1.94 1.94	1.58 1.55	1.25 1.08
Working capital	297,706,000 297,706,000	237,773,000 217,030,000	222,075,000 149,942,000
Total assets	944,237,000 944,237,000	661,225,000 604,248,000	541,526,000 337,703,000
Shareholders' equity	504,865,000 504,865,000	363,700,000 317,389,000	272,531,000 153,092,000
Average number of common shares and common share equivalents outstanding	30,356,183 30,356,183	28,647,007 26,411,485	27,006,723 20,688,261

Net income per share and average number of common shares outstanding assume full conversion of all common stock equivalents, and are adjusted for all stock splits and for all stock dividends including the three percent stock dividend payable February 20, 1970.

1966	*1965*	*1964*	*1963*	*1962*	*1961*
$700,211,000	$559,680,000	$465,304,000	$423,246,000	$388,420,000	$297,564,000
256,751,000	86,504,000	38,187,000	31,925,000	10,438,000	4,491,000
57,593,000	49,544,000	37,295,000	29,017,000	21,591,000	9,578,000
22,185,000	6,502,000	2,979,000	1,505,000	344,000	133,000
25,900,000	22,500,000	17,100,000	13,100,000	10,300,000	3,900,000
10,150,000	3,100,000	1,538,000	774,000	187,000	75,000
31,693,000	27,044,000	20,195,000	15,917,000	11,291,000	5,678,000
12,035,000	3,402,000	1,441,000	731,000	157,000	58,000
1.19	1.08	0.86	0.68	0.48	0.21
0.79	0.43	0.29	0.16	0.05	0.03
139,911,000	119,257,000	104,041,000	90,018,000	71,565,000	62,581,000
60,543,000	30,803,000	14,220,000	9,263,000	2,546,000	1,614,000
463,420,000	371,131,000	311,667,000	284,493,000	309,247,000	199,128,000
170,369,000	66,544,000	35,040,000	23,901,000	10,844,000	3,731,000
258,447,000	205,762,000	173,069,000	155,844,000	134,536,000	118,599,000
90,205,000	34,765,000	13,672,000	8,629,000	3,527,000	2,477,000
25,510,535	23,761,314	21,820,847	20,992,281	20,146,893	19,140,405
15,270,576	7,677,724	4,769,560	3,907,082	3,095,698	2,316,336

Consolidated Balance Sheets

October 31, 1969 and 1968

Assets

	1969	1968
Current Assets:		
Cash	$ 28,250,000	$ 31,219,000
Marketable securities, at cost which approximates market	1,279,000	1,992,000
Receivables, less reserve	213,343,000	151,899,000
Inventories, at the lower of cost (principally first-in, first-out) or market, less progress billings of $64,896,000 in 1969 and $38,199,000 in 1968	236,022,000	169,399,000
Prepaid expenses	17,419,000	4,961,000
Total current assets	496,313,000	359,470,000
Property and Equipment, at cost:		
Land	19,288,000	14,069,000
Buildings	96,847,000	81,856,000
Equipment and improvements	347,736,000	254,054,000
	463,871,000	349,979,000
Less—Accumulated depreciation and amortization	182,425,000	165,624,000
	281,446,000	184,355,000
Other Assets:		
Investment in and advances to unconsolidated subsidiary (Note 1)	124,295,000	79,962,000
Cost in excess of net assets of purchased businesses	23,861,000	22,319,000
Other	18,322,000	15,119,000
	166,478,000	117,400,000
	$944,237,000	$661,225,000

The accompanying notes are an integral part of these balance sheets.

Liabilities

	1969	1968
Current Liabilities:		
Notes payable	$ 26,272,000	$ 13,651,000
Current portion of long-term debt and subordinated debentures	4,537,000	5,135,000
Accounts payable	66,243,000	40,578,000
Accrued liabilities	76,555,000	48,333,000
Federal income taxes	25,000,000	14,000,000
Total current liabilities	198,607,000	121,697,000
Long-Term Liabilities:		
Long-term debt (Note 3)	107,661,000	83,978,000
Deferred Federal income taxes (Note 9)	13,664,000	5,524,000
Accrued pension benefits (Note 8)	7,374,000	7,318,000
Subordinated Debentures (Notes 3 and 10)	98,494,000	75,621,000
Minority Interest	13,572,000	3,387,000
Shareholders' Equity:		
Preferred stock (Note 5)	1,542,000	1,119,000
Common stock (Notes 3, 4, 5, and 10)	24,942,000	11,687,000
Additional paid-in capital	337,017,000	223,601,000
Retained earnings (Notes 3 and 5)	141,364,000	127,293,000
Total shareholders' equity	504,865,000	363,700,000
	$944,237,000	$661,225,000

Consolidated Statements of Income

For the Years Ended October 31, 1969 and 1968

	1969	*1968*
Sales and Service Revenues	$1,294,775,000	$874,905,000
Equity in Net Income of Unconsolidated Subsidiary (Note 1)	10,521,000	4,916,000
	1,305,296,000	879,821,000
Costs and Expenses:		
Cost of sales and services	1,007,542,000	662,674,000
Selling and administrative expenses	171,015,000	123,554,000
Interest expense	12,136,000	7,601,000
	1,190,693,000	793,829,000
Income Before Federal Income Taxes	114,603,000	85,992,000
Provision for Federal Income Taxes (Note 9)	54,500,000	40,400,000
Net Income	$ 60,103,000	$ 45,592,000
Net Income Per Share of Common Stock and Common Stock Equivalents (equal to net income assuming full dilution — Note 2)	$2.00	$1.63
Net Income Per Share of Common Stock and Common Stock Equivalents Adjusted for 3% Stock Dividend Payable February, 1970	$1.94	$1.58

Costs and expenses include provisions of $29,616,000 in 1969, and $21,803,000 in 1968 for depreciation and amortization (principally on a straight-line basis) of property and equipment.

Consolidated Statements of Retained Earnings

For the Years Ended October 31, 1969 and 1968

	1969	*1968*
Balance, Beginning of Period (Note 1)	$127,293,000	$120,128,000
Add or (Deduct):		
Net income	60,103,000	45,592,000
Fair value of common stock dividends (Note 5)	(34,721,000)	(29,642,000)
Difference between cost and book value of common stock acquired by subsidiary	(5,321,000)	—
Cash dividends paid or accrued on preferred stock	(5,181,000)	(2,105,000)
Dividends paid by pooled businesses prior to pooling	(809,000)	(5,882,000)
Cost of treasury stock acquired by pooled businesses prior to pooling	—	(406,000)
Net income or loss of pooled businesses for periods excluded from or duplicated in the consolidated statements of income	—	(392,000)
Balance, End of Period	$141,364,000	$127,293,000

The accompanying notes are an integral part of these statements.

Consolidated Statements of Capital Stock and Additional Paid-In Capital

For the Years Ended October 31, 1969 and 1968

	Preferred Stock ($1 Par Value)	*Common Stock ($1 Par Value)*	*Additional Paid-In Capital*
Balance, October 31, 1967 (Note 1)	$1,277,000	$10,665,000	$140,461,000
Add or (Deduct):			
Stock issuances—			
Common stock dividend	—	286,000	29,356,000
Purchases of businesses	50,000	372,000	46,142,000
Stock option and purchase plans (Note 4)	—	70,000	1,765,000
Conversions of debentures and preferred stock	(208,000)	294,000	(97,000)
Sale of warrants	—	—	3,750,000
Stock issued by pooled businesses prior to pooling	—	—	2,224,000
Balance, October 31, 1968	1,119,000	11,687,000	223,601,000
Add or (Deduct):			
Stock issuances—			
Common stock dividend	—	349,000	34,372,000
Purchases of businesses	655,000	25,000	89,530,000
Stock option and purchase plans (Note 4)	5,000	97,000	2,040,000
Two-for-one common stock split and conversions of debentures and preferred stock	(237,000)	12,784,000	(12,526,000)
Balance, October 31, 1969	$1,542,000	$24,942,000	$337,017,000

The accompanying notes are an integral part of these statements.

Auditors' Report

To the Shareholders and
Board of Directors, Teledyne, Inc.:

We have examined the consolidated balance sheets of TELEDYNE, INC. (a Delaware corporation) and subsidiaries as of October 31, 1969 and 1968, and the related statements of income, capital stock and additional paid-in capital, and retained earnings for the years then ended. We have also examined the consolidated balance sheets of Teledyne United Corporation and subsidiaries as of October 31, 1969 and 1968, and the related statements of income and equity for the years then ended. Our examinations were made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. We did not examine the consolidated financial statements of Unicoa Corporation and subsidiaries which are summarized in Note 6 to the financial statements; however, we were furnished with the reports of other auditors thereon.

In our opinion, based upon our examinations and the reports of other auditors referred to above, the accompanying consolidated financial statements present fairly the consolidated financial position of Teledyne, Inc. and subsidiaries as of October 31, 1969 and 1968, and of Teledyne United Corporation and subsidiaries as of October 31, 1969 and 1968, and the results of their operations for the years then ended, all in conformity with generally accepted accounting principles consistently applied during the periods.

ARTHUR ANDERSEN & CO.

Los Angeles, California,
November 25, 1969.

Teledyne United Corporation and Subsidiaries

Consolidated Balance Sheets

October 31, 1969 and 1968

	1969	*1968*
Assets:		
Cash	$ 564,000	$ 863,000
Time deposits, redeemable in 1975 and 1976	12,350,000	10,000,000
Marketable securities, at cost which approximates market	7,535,000	7,876,000
Installment loans receivable, less reserve	58,311,000	47,701,000
Investments, at cost plus equity in net income (Note 1):		
Unicoa Corporation (a 51.7% interest—Note 6)	150,933,000	142,438,000
Property and casualty insurance subsidiaries (Note 7)	114,882,000	18,997,000
Cost in excess of net assets of purchased business	4,894,000	4,854,000
Other assets	7,556,000	6,996,000
	$357,025,000	$239,725,000
Liabilities:		
Notes payable to banks	$ 90,000,000	$ 45,000,000
Investment certificates	50,909,000	44,515,000
Accounts payable, accrued taxes and other liabilities	3,943,000	3,343,000
Long-term debt (Note 3)	41,424,000	22,500,000
Subordinated debentures (Note 3)	37,500,000	37,500,000
Deferred income	8,954,000	6,905,000
Advances from Teledyne, Inc.	9,419,000	49,251,000
Teledyne, Inc. equity:		
Capital stock and additional paid-in capital	88,589,000	14,261,000
Retained earnings	26,287,000	16,450,000
	$357,025,000	$239,725,000

Consolidated Statements of Income

For the Years Ended October 31, 1969 and 1968

	1969	*1968*
Income:		
Equity in net income of insurance subsidiaries (Notes 6 and 7)	$ 14,466,000	$ 7,945,000
Interest earned and other income	11,379,000	741,000
	25,845,000	8,686,000
Expenses:		
Operating expenses	8,185,000	418,000
Interest expense, less income tax benefits of $6,910,000 in 1969 and $2,947,000 in 1968	5,933,000	3,310,000
Provision for Federal income taxes of consolidated subsidiaries	1,206,000	42,000
Net Income	$ 10,521,000	$ 4,916,000

Consolidated Statements of Equity

For the Years Ended October 31, 1969 and 1968

	Capital Stock and Additional Paid-In Capital	*Retained Earnings*
Balance, October 31, 1967 (Note 1)	$ 5,225,000	$ 13,389,000
Add or (Deduct):		
Net income	—	4,916,000
Cost of business contributed by Teledyne, Inc.	8,785,000	—
Dividends paid by pooled business prior to pooling	250,000	(1,160,000)
Income of pooled business duplicated in consolidated statements of income	—	(677,000)
Other	1,000	(18,000)
Balance, October 31, 1968	14,261,000	16,450,000
Add or (Deduct):		
Net income	—	10,521,000
Cost of business contributed by Teledyne, Inc.	74,328,000	—
Dividends paid by pooled business prior to pooling	—	(684,000)
Balance, October 31, 1969	$88,589,000	$ 26,287,000

The accompanying notes are an integral part of these statements.

Notes to Consolidated Financial Statements

October 31, 1969

(1) Principles of consolidation: The consolidated financial statements of Teledyne, Inc. include the accounts of the Company and all of its subsidiaries, except Teledyne United Corporation. The Company's investment in and advances to Teledyne United Corporation are carried at cost plus equity in net income. Consolidated financial statements of Teledyne United Corporation and subsidiaries are included herein; such financial statements include the accounts of all subsidiaries except the life insurance and property and casualty insurance companies, the condensed financial statements of which are set forth in Notes 6 and 7.

The 1968 financial statements of Teledyne, Inc. and Teledyne United Corporation and the combined financial statements of the property and casualty insurance subsidiaries shown in Note 7 have been restated to include businesses acquired during 1969 and accounted for as poolings of interests. The results of operations of purchased businesses are included since acquisition.

(2) Net income per share of common stock and common stock equivalents: The computation of net income per share is based on the average number of common shares outstanding during each year, including common stock equivalents ($3.50 and Series B preferred stock, 5½%, 4% and 3½% convertible subordinated debentures, options and warrants, and contingently issuable shares). Each common stock equivalent has been considered outstanding from the beginning of each year or date of issuance, and the related dividend requirement or interest has been eliminated. All convertible securities, options and warrants which result in dilution have been included in the computation of net income per share. The fully diluted net income per common share is equal to the net income per share of common stock and common stock equivalents.

(3) Long-term debt and subordinated debentures:

Teledyne, Inc. long-term debt—

6½% Sinking Fund Debentures due 1992, $1,350,000 payable annually commencing in 1972	$ 30,000,000
7⅞% Sinking Fund Debentures due 1994, $1,400,000 payable annually commencing in 1975	30,000,000
7% Promissory Notes due 1989, $750,000 payable in 1973 and $1,500,000 payable annually thereafter	25,000,000
5¾% Promissory Notes due 1981, $410,000 payable annually commencing in 1969	4,590,000
Other (including $7,729,000 secured by land and buildings) due in various installments to 1984	22,608,000
	112,198,000
Less—Current portion	4,537,000
	$107,661,000

Teledyne, Inc. subordinated debentures—

3½%, due 1992, $3,000,000 payable annually commencing in 1978, convertible into common stock at $57.26 per share	$ 59,821,000
7%, due 1999, $1,128,000 payable annually commencing in 1989	22,563,000
4%, due 1971, convertible into common stock at $72.58 per share	8,500,000
5½%, converted into 290,669 shares of common stock in November, 1969	7,610,000
	$ 98,494,000

Under the various borrowing agreements, the Company has agreed to maintain minimum amounts of working capital and net worth, and has agreed to certain restrictions with respect to borrowings, purchase and sale of assets and capital stock and payment of dividends. At October 31, 1969, these agreements were complied with and retained earnings of $94,120,000 were not restricted as to payment of dividends.

The Company has reserved 1,452,600 shares of common stock for issuance upon conversion of the subordinated debentures.

Teledyne United Corporation long-term debt—

Notes and loans payable to banks—	
7% to 7½%, due 1975 and 1976	$ 12,350,000
6⅜% to 6¾%, due 1973 and 1974	11,640,000
7¾%, due in annual installments from 1971 to 1974	4,934,000
	28,924,000
7% notes due 1973	12,500,000
	$ 41,424,000

Teledyne United Corporation subordinated debentures—

6½% due in annual installments from 1979 to 1983	$ 37,500,000

The current notes payable to banks and the long-term debt and related interest of Teledyne United Corporation and subsidiaries are guaranteed by Teledyne, Inc. and the subordinated debt and related interest of Teledyne United and subsidiaries is guaranteed on a subordinated basis by Teledyne, Inc.

(4) Stock options and warrants: At October 31, 1969, 441,235 common shares (of which options for 199,189 shares were exercisable) were reserved for issuance under outstanding options at prices from $7 to $60 per share and 610,387 common shares were reserved for the granting of additional options. At October 31, 1968, 400,420 common shares were reserved for issuance under outstanding options and 159,266 common shares were reserved for the granting of additional options. During 1969, options to purchase 171,344 common shares were granted; options to purchase 108,128 shares were exercised; and options covering 22,752 shares expired or were canceled.

At October 31, 1969, 15,730 shares of common stock were reserved for issuance under warrants assumed in connection with the acquisition of businesses. In addition, 351,488 shares of common stock were reserved for issuance under warrants, each of which provides for the purchase of 9.37 shares of the Company's common stock at $53.40 per share until October, 1978.

(5) Capital stock: At October 31, 1969 and 1968, the Company's capital stock consisted of the following shares:

		Outstanding	
	Authorized	*1969*	*1968*
Cumulative Convertible Preferred Stock, $1 par value	15,000,000		
$6 series		519,107	251,015
$3.50 series		808,062	597,588
Series B		192,883	247,440
Series C		21,728	23,064
Common stock, $1 par value	60,000,000	24,942,442	11,686,591

The 1968 financial statements and related notes, except for shareholders' equity, have been restated to reflect the 3 percent stock dividend paid in January, 1969, and the two-for-one common stock split paid in March, 1969.

The holders of the $6 series preferred stock are entitled to voting rights, cumulative annual dividends at the rate of $6.00 per share, and preference of $63 per share ($32,704,000 at October 31, 1969) in liquidation. Such stock is redeemable at $100 per share after April 22, 1978, and is convertible at any time into 1.34 shares of common stock. The holders of the $3.50 series preferred stock are entitled to voting rights, cumulative annual dividends at the rate of $3.50 per share, and preference of $60 per share ($48,484,000 at October 31, 1969) in liquidation. Such stock is redeemable at $100 per share after June 30, 1971, and is convertible at any time into four shares of common stock. The holders of the Series B preferred stock are entitled to voting rights, cumulative annual dividends at the rate of $1.60 per share through June 2, 1971, and $3.20 per share thereafter. Such stock is entitled to preference of $16 per share ($3,086,000 at October 31, 1969) in liquidation, is redeemable at $80 per share after August 29, 1970, and is convertible at any time into 2.196 shares of common stock. The holders of the Series C preferred stock are entitled to voting rights, cumulative annual dividends at the rate of $6.00 per share, and preference of $82.50 per share ($1,793,000 at October 31, 1969) in liquidation. Such stock is redeemable at $100 per share after January 25, 1973, and is convertible at any time into a maximum of two shares of common stock. The Company has reserved 4,395,000 shares of common stock for conversion of all preferred shares.

At October 31, 1969, 24,500 shares of $3.50 preferred stock and 225,500 shares of common stock were reserved for issuance to employees under stock purchase plans.

(6) Unicoa Corporation and subsidiaries: The following condensed statements summarize the consolidated financial position and operating results of Unicoa Corporation and subsidiaries:

Consolidated Balance Sheets	*September 30,*	
	1969	*1968*
Assets:		
Bonds, at amortized cost	$121,096,000	$117,087,000
Corporate stocks, at cost	50,843,000	36,063,000
Mortgage loans	168,777,000	160,317,000
Real estate, at cost, less accumulated depreciation	35,645,000	37,121,000
Loans to policyholders	9,485,000	8,715,000
Cash	2,822,000	4,992,000
Other assets	32,039,000	28,192,000
	$420,707,000	$392,487,000
Liabilities:		
Policy reserves and liabilities	$293,657,000	$274,628,000
Mortgage loan payable	11,837,000	12,312,000
Other liabilities	20,699,000	27,116,000
Shareholders' equity:		
Common stock	18,715,000	18,711,000
Additional paid-in capital	1,975,000	1,945,000
Retained earnings	73,824,000	57,775,000
Total shareholders' equity	94,514,000	78,431,000
	$420,707,000	$392,487,000

Consolidated Statements of Income and Retained Earnings	*Year Ended September 30, 1969*	*Nine Months Ended September 30, 1968*
Income:		
Premiums and other insurance income	$158,074,000	$116,832,000
Investment income less expenses	17,341,000	11,101,000
Other income	2,177,000	1,576,000
	177,592,000	129,509,000
Expenses:		
Benefits paid or provided	79,271,000	56,834,000
Insurance expenses	79,033,000	57,249,000
Provision for Federal income taxes	4,380,000	3,390,000
	162,684,000	117,473,000
	14,908,000	12,036,000
Gain (loss) on sale of investments	1,141,000	(38,000)
Net income	16,049,000	11,998,000
Retained earnings at beginning of period	57,775,000	50,266,000
	73,824,000	62,264,000
Cash dividends	—	4,489,000
Retained earnings at end of period	$ 73,824,000	$ 57,775,000

The above statements have been prepared on the basis of generally accepted accounting principles which differ in certain respects from statutory accounting practices for life insurance companies.

Included in the consolidated retained earnings of Unicoa Corporation at September 30, 1969, is $31,000,000 (at current tax rates) which might become due, in whole or in part, as Federal income taxes in any future taxable year should certain parts of the insurance companies' gains from operations since January 1, 1959, presently included in retained earnings, be paid as cash dividends. The insurance companies do not presently intend to pay any such cash dividends.

(7) Property and casualty insurance subsidiaries: The following condensed statements summarize the combined financial position and results of operations of the property and casualty insurance subsidiaries of Teledyne United Corporation.

Combined Balance Sheet	*September 30, 1969*
Assets:	
Bonds, at amortized cost	$169,111,000
Stocks, at cost	32,344,000
Agents balances and uncollected premiums less reserve	27,118,000
Deferred policy acquisition costs	16,023,000
Other receivables	11,528,000
Property and equipment, at cost, less accumulated depreciation	4,394,000
Cash	7,010,000
Other assets	7,200,000
	$274,728,000
Liabilities:	
Loss and claim reserves	$111,032,000
Accrued loss adjustment expenses	16,801,000
Unearned premiums	68,717,000
Other liabilities	22,424,000
Federal income taxes	7,162,000
Notes payable to Teledyne United Corporation	2,000,000
Shareholders' equity	46,592,000
	$274,728,000

Combined Statements of Income	*Year Ended September 30, 1969*	*Year Ended December 31, 1968*
Income:		
Net premiums earned	$110,211,000	$ 46,003,000
Investment income less expenses	6,025,000	2,458,000
	116,236,000	48,461,000
Expenses:		
Losses and loss adjustment expenses	75,310,000	29,829,000
Underwriting expenses	34,451,000	16,894,000
Provision for Federal income taxes	1,434,000	180,000
	111,195,000	46,903,000
	5,041,000	1,558,000
Gain on sale of investments	491,000	86,000
Net income	$ 5,532,000	$ 1,644,000
Dividends paid	$ 736,000	$ 1,160,000

The above statements have been prepared on the basis of generally accepted accounting principles which differ in certain respects from statutory practices prescribed by regulatory authorities.

(8) Commitments and contingent liabilities: Annual rentals under long-term leases expiring between 1972 and 1984, are approximately $3,400,000 through 1974, and $1,100,000 thereafter.

The Company charges pension expense at amounts equal to normal cost plus interest on unfunded prior service cost, and for certain plans, a portion of prior service costs. Total pension expense for the years ended October 31, 1969 and 1968, was $14,479,000 and $6,297,000, respectively. The Company generally contributes accrued pension costs on a current basis, but for certain plans, it contributes the actuarial value of pension benefits commencing upon the employee's retirement. At October 31, 1969, the actuarially computed value of vested benefits for all plans exceeded the total of the pension funds and balance sheet accruals by approximately $4,000,000.

(9) Federal income taxes: Deferred Federal income taxes result from the deduction for tax purposes of accelerated depreciation and other items. The available investment tax credit is amortized as a reduction of the provision for Federal income taxes over the expected lives of the related assets. Federal income tax provisions for 1969 and 1968 include deferred taxes and investment tax credits totalling approximately $6,000,000 and $14,000,000, respectively.

(10) Subsequent events: In December 1969, the Board of Directors declared a 3 percent common stock dividend payable February 20, 1970, to shareholders of record January 14, 1970. The financial statements and related notes have not been adjusted to reflect this dividend.

In December 1969, Continental Motors Corporation was merged into Teledyne. In connection with the merger, Teledyne agreed to issue $14,862,000 principal amount of 7% Subordinated Debentures due 1999.

TELEDYNE, INC.

Board of Directors

HENRY E. SINGLETON, *Chairman*
ROBERT C. JACKSON
GEORGE KOZMETSKY
GEORGE A. ROBERTS
ARTHUR ROCK
CLAUDE E. SHANNON

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JERROLD V. JEROME, *Treasurer*
THEMISTOCLES G. MICHOS, *Secretary*

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New York, New York 10005

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124 Fourth Street
Los Angeles, California 90013

First National City Bank
111 Wall Street
New York, New York 10015