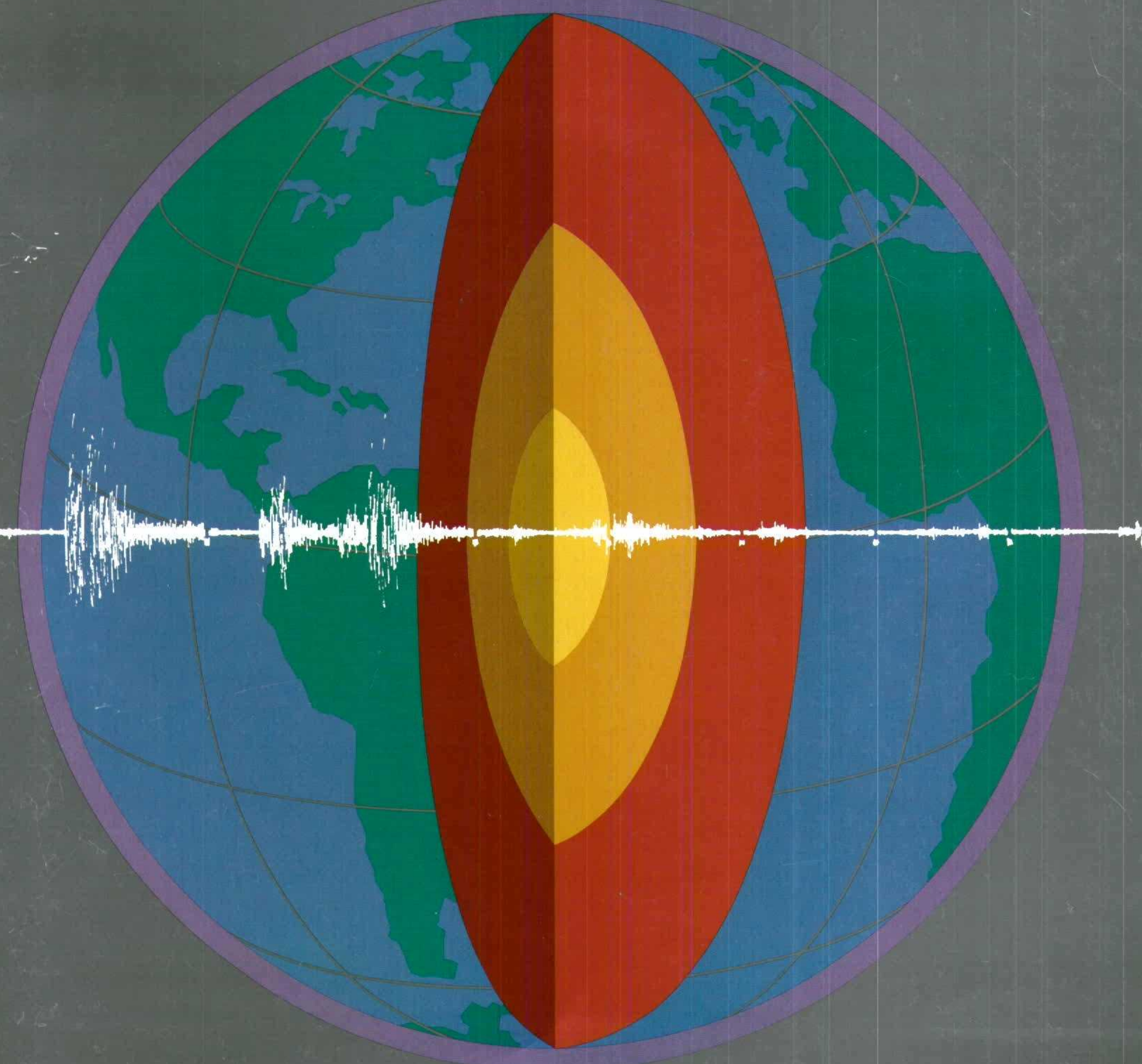
TeledyneReport
For the Year 1989
Seismology: Monitoring Tremors and Treaties



O U R   R E S T L E S S   E A R T H

We call it "terra firma," speak of being on solid ground and use other similar expressions, but anyone who has experienced even a moderate earthquake knows that this concept of our planet is only true in a very short-term sense. Our earth, in fact, is more like an old clipper ship lumbering its way through space, tugged and pulled by tidal forces of the sun and moon and other planets, racked by shifting interior cargo that makes its timbers creak and groan and shift, and makes its decks unstable beneath our feet.

Though earthquakes have been studied since the days of the ancient Chinese, it has only been in the last fifty years that highly sensitive instruments have come into widespread use for detecting, monitoring and recording the complex movements within the earth. And it has only been twenty-five years since a general agreement, based on the theory of plate tectonics, has been reached in the scientific community on the basic mechanisms that are believed to cause most earthquakes.

THE DRIFTING CONTINENTS

As early as the 17th century, observers had noted the remarkable similarities between the contours of the western coastline of Europe and Africa, with the eastern coastline of North and South America. It was proposed that somehow in the evolution of the earth these had been split apart from a single landmass. Even though considerable geologic and biologic evidence was amassed in support of this concept, called Continental Drift, it was still unaccepted for one basic reason: No one could explain how the massive continents could move over the equally massive bedrock of the sea bottoms.

After World War II a series of discoveries in diverse fields finally came together to explain how continents had actually been drifting about on the surface of the earth for millions of years. This story, far too complex to detail here, involved explorations and studies of the Mid-Atlantic Ridge and similar undersea formations that are now known to exist in deep oceans around the world. Phenomena as strange as periodic reversals of the polarity of the earth's magnetic field which left permanent records in the rocks of the world, techniques as abstruse as dating the age of rocks based on the decay of radioactive potassium into argon, and studies of the structure *(Continued Page 2)*

A single landmass (top) split apart into the various continents (below), according to the theory of plate tectonics.

SEISMOLOGY

Seismology is the science of detecting and measuring earth movements, and interpreting how the vibrations they create propagate through our planet. This technology has been used to better understand natural earthquakes, to detect and identify underground nuclear explosions, and to increase the recovery of oil and gas from the earth. Teledyne Geotech is a leader in the development and production of the precision instruments, computer systems and software that are used worldwide in this pursuit.

In the last twenty-five years, our understanding of earthquakes and the technology with which we monitor and measure them have both changed significantly. Teledyne Geotech has been a major developer and producer of precise seismological instrumentation for over 50 years, and is today recognized as a world leader in this technology. Since we reported on these activities in 1971, advances in the fields of computers, electronics and mechanical systems have made possible instruments that are smaller, more sensitive, require less power, and at the same time cover wider frequency bands and handle a wider dynamic range of earth signals. Microprocessors, digital signal processing and smart computer terminals that work in the realm of artificial intelligence and expert systems, enable seismologists to analyze and extract more information from the raw data, more quickly and with greater understanding than ever before.

This capability is used by scientists, whose goal is better understanding of natural earthquakes, and by those involved in worldwide government programs to verify treaties limiting nuclear testing by detecting underground nuclear explosions, differentiating them from natural events and estimating their size.

These developments in technology have been paralleled by a greater insight into the phenomenon of natural earthquakes that has come about since the theory of plate tectonics (see sidebar, inside front cover) became widely accepted about 25 years ago. This Report presents a brief summary of these developments.

Monitoring the Movements of the Earth

Seismology is the science of detecting, measuring and analyzing the vibrations and movements that occur within the earth as a result of natural or man-made phenomena. The basic instrument used in these studies, called a seismometer, is essentially a weight or inertial mass, delicately suspended in such a way that it can move freely along one axis in relation to the frame of the instrument. If the instrument, which is fastened securely to the earth, is moved by earth tremors, the inertia of the weight causes it to lag behind the movement of the instrument frame. This displacement is electronically detected and amplified. The signal produced provides a measurement of movement along one axis. To provide a full, three dimensional record of the earth's motion at that point, three individual sensors are mounted at right angles to each other.

The outputs of these sensors must then be recorded and analyzed to extract the information they contain. This has classically been done by writing the information on a paper covered drum to provide a graphic record of each tremor. This paper record shows the motion of the earth as traces that display the frequency, amplitude and exact timing of each event.

While seismic information is still often recorded in this manner (to provide a quick, visual, easily understandable record) it is now also usually converted into digital form and refined with other

(Continued From Inside Front Cover) of the earth's deep interior made possible by highly sensitive seismic instruments and analysis methods all contributed to the final evidence, that finally came into clear focus in 1966.

It is now known that the Mid-Atlantic Ridge and a network of other similar structures are Rift Zones or seams in the earth's crust along which magma (molten rock) from the earth's mantle is emerging, solidifying into solid rock and creating new crustal material. As this happens, the seafloor on either side of the ridges is pressed outward. The crust of the earth, about as thick in relation to the whole earth as an apple skin is to an apple, is divided by these seams into an irregular conglomeration of plates that push and jostle each other as these processes go on. As these plates slowly move and shift on the more plastic material beneath the crust, so do the continents and sea bottoms that are part of them.

PLATE TECTONICS

This whole concept, now known as plate tectonics rather than continental drift (since areas far larger than continents are involved), explains why a great amount of earthquake and volcanic activity is concentrated along certain lines on the earth's surface. The entire process is apparently driven by the heat engine of the earth's interior, which is believed may be as hot as 7,000 degrees F at its core. The origins of this heat may include residual heat from the time of the earth's formation, supplemented by heat generated through the decay of widely distributed radioactive elements such as potassium, thorium and uranium. It is theorized that giant convection currents, moving through the semi-plastic material of the inner earth with glacial slowness, bring up hot material in certain areas where some of it may break through the earth's crust and fuel the movement of the plates. Spreading beneath the plates and cooling, this material may then descend in other areas in a huge convection cycle that may be measured in millions of years.

It is the movement of these gigantic plates (see map, inside front cover) colliding with and grinding against adjacent plates that causes most of the world's earthquake and volcanic activity. In some cases, as along the western edge of the Pacific plate, the heavier seafloor rock slides under the lighter rock of the Asian plate, giving rise to the severe earthquakes and volcanic activity in that region.

This process, called subduction, also occurs where the eastern edge of the Pacific plate meets the Canadian west coast northward to Alaska and the Aleutians. The largest earthquake ever recorded in the United States occurred in Alaska in 1964 along this subduction zone. It registered 8.5 on the Richter scale and is estimated to have released energy equivalent to a 150 megaton nuclear explosion. Similarly, subduction

RIFTING

Rifting is the process in which magma (molten rock) from the interior forces its way to the surface along seams in the earth's crust, forming new crustal material and forcing existing plates apart.

SUBDUCTION

Subduction is the process in which one plate slides under another, creating great stress and friction along the zone and giving rise to severe earthquakes and volcanic activity.

of the Juan de Fuca plate off the Pacific Northwest is responsible for the volcanic activity of the Cascade range and the recent catastrophic event at Mount St. Helens.

In other cases, plates collide head on, crumpling the earth's crust and creating new mountain ranges. The Himalayas are believed to have been formed when India, moving northward from the Australian plate collided with Asia. It is still moving northward a few inches a year. Fossil evidence proves that Everest, the world's highest peak, is made of material that was once at the bottom of a shallow sea.

Interaction of a third kind takes place along the coast of California, where the Pacific plate slides northward along the edge of the North American plate on a series of faults among which the San Andreas is best known. Since these two immense plates cannot slide smoothly along each other, they stick until enough energy is stored up to overcome the lockup, and then release tremendous energy in a matter of seconds or minutes as happened at San Francisco in 1906 and again in 1989.

Also present within the earth are plumes of heat that reach up to the surface from the depths and, like candle flames, melt the crust from below, creating intense volcanic activity. The Emperor Island Chain, which culminates at the Hawaiian Islands, and its volcanoes, is just such a track of "hot spots." Yellowstone National Park is an example of a current continental hot spot.

Earthquakes also occur far from plate boundaries, as did the three great New Madrid, Missouri earthquakes in 1811 and 1812, all of which were comparable in size to the 1906 San Francisco earthquake. These events are thought to be due to the reactivation, by the heavy load of Mississippi River sediments, of ancient sutures in the North American continent that are remnants of its early geologic history. The effects of these earthquakes could be greater and more far reaching than those in California because of the amplifying properties of the extensive sediment blanket in the central United States.

Earthquakes and related phenomena have been a part of the earth's history since long before man and will not stop in any foreseeable future. Because of the immense forces involved, they probably will never be controllable and may never be more than generally predictable.

Since we must live with them—and no region of the earth can be considered completely immune from them—we must understand them as thoroughly as possible in order to make our cities and homes safe from their effects.

That is one of the many things that the instruments and technology of Teledyne Geotech are designed to help us do.

MOUNTAIN FORMATION
When plates collide head on, the earth's crust is crumpled and mountain ranges of great size may be created. The Himalayas are believed to have been formed by a plate collision of this nature.

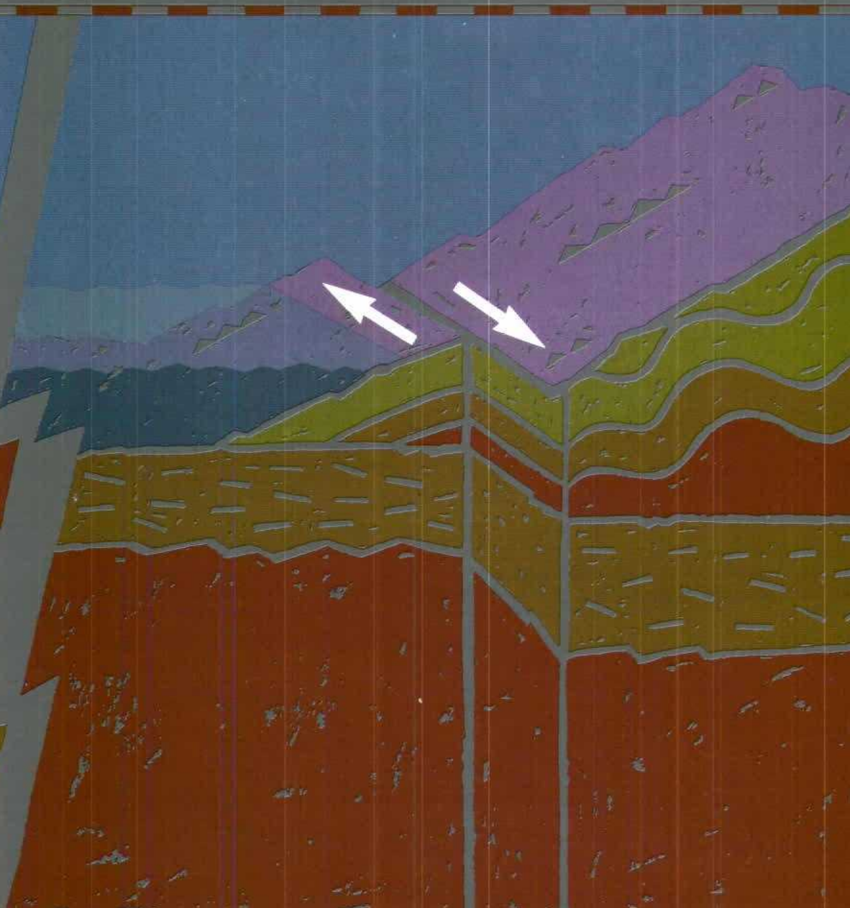


PLATE SLIP
In some areas, plates move horizontally in relation to each other. These zones usually remain locked until enough force builds up to suddenly rupture the rock, sometimes causing severe earthquakes. California earthquakes are typical of this type.

signal processing electronics so that it can be faithfully transmitted over long distances and recorded and analyzed by specialized computer systems.

Teledyne Geotech Seismic Systems

Seismology is one of the few sciences in which data acquisition systems are needed that can precisely measure signal amplitudes over a range greater than one hundred million to one. Earth scientists must be able to measure the powerful forces of a strong nearby earthquake, as well as extremely faint signals from tremors on the opposite side of the globe. In a like manner, the ability to precisely measure frequencies of events that may take 10 or 15 minutes to go through one cycle, as well as those that occur a hundred or more times each second, is highly desirable. The ideal sensor and data system that can accomplish all this in a single instrument does not yet exist, but with the aid of advances in microelectronics and computer-based systems, Teledyne Geotech has made significant progress toward that goal in the last twenty years.

Today, the company provides the most complete line of portable, low power, ruggedized data processing systems and seismic sensors now available. They are widely used in earth studies, earthquake monitoring, nuclear test verification and for the diagnosis of the microseismic effects of fluid injection into oil and gas reservoirs. These systems are now in use in over 30 countries around the world and are recognized as the standards by which other systems are judged.

The Critical Sensors

In the last two decades, Teledyne Geotech has refined its line of seismometers to increase their frequency range toward both the lower and higher ends of the earthquake spectrum, and also widened the dynamic range of the signals that can be handled. The company's S-13 seismometer has been the unsurpassed high frequency workhorse of the seismic community for many years, offering ruggedness, reliability and precision at a moderate cost.

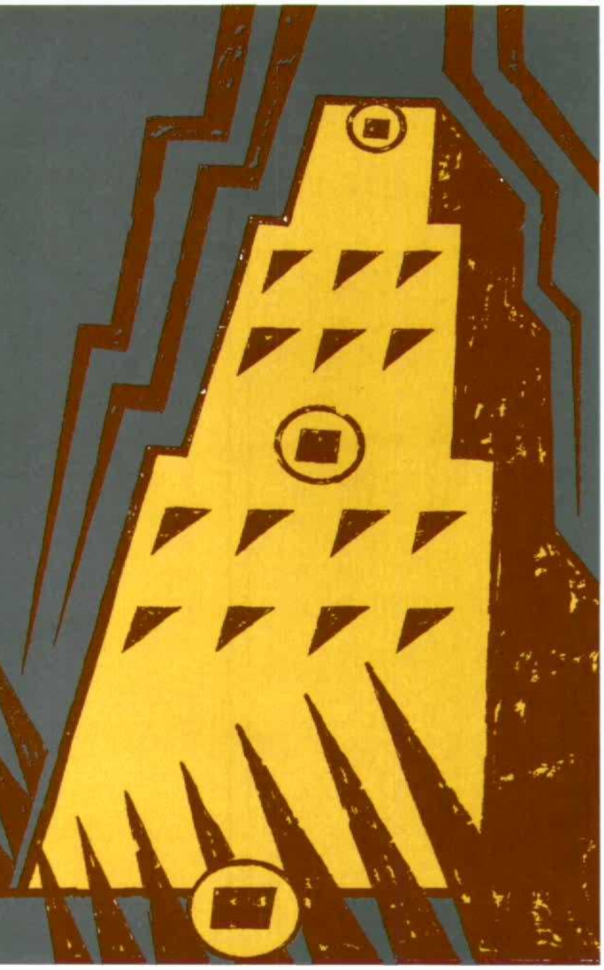
By applying emerging technologies to this basic design, Teledyne Geotech developed an advanced seismometer which covers a much broader frequency range. Another seismometer was also developed which provides ultra low noise performance at slightly higher cost.

Teledyne Geotech's seismometers are widely used throughout the world in seismic arrays which are dedicated to detecting and monitoring underground nuclear explosions in verification of international nuclear test treaties. These unique instruments were developed specifically for this work and are unsurpassed in the world.

Teledyne Geotech's A-700 strong motion accelerograph is widely used to detect, measure, and record strong earth motions that occur close to the source of earthquakes. The three sensors in each instrument that sense motion along three axes are shown in this photo, at right.

The Problem of Background Noise

One problem in detecting any type of seismic signal is natural background seismic noise that can obscure the signals of interest. Seismic noise in the earth comes from many natural sources such as wind and storms, ocean waves along coastlines, and turbulent rivers. In populated areas, man-made sources such as vehicle traffic, mining and quarrying and industrial activities add to this problem. Sites near cities are avoided when possible, and it was found that much of the natural noise can be avoided by placing the sensors at a depth of about 100 meters in the earth. To accomplish this, Teledyne Geotech designed its KS-series seismometers to fit in slender cylinders that can be lowered into the casing of boreholes that have been drilled into the earth, using standard petroleum industry techniques.



These remarkable, highly sensitive instruments have been deployed in large arrays in various parts of the world by the U.S. Air Force in its underground nuclear test verification program. Because they are deployed in difficult-to-access underground locations, and because of the vital nature of the programs they serve, these instruments must provide the utmost reliability and precision. Many of these Geotech instruments have been in position, operating without problem for ten years and more.

When it Comes to Strong Motion

At the other end of the dynamic spectrum from instruments designed to detect faint signals from distant earthquakes or explosions, are those that must measure the displacement of the ground and the reaction of man-made structures close to the origin of severe earthquakes. Appropriately named strong motion accelerographs, these instruments measure displacements and forces that would overwhelm the capacity of more sensitive seismometers.

Strong motion accelerographs are typically used to monitor high rise buildings, dams, bridges, power plants and other structures that might be damaged by strong earth movement, as well as to monitor severe ground motion in the areas of known active earthquake faults. Because strong earth movement only occurs randomly, and at long intervals, these instruments are designed to wait passively until they are triggered into action by a movement of a certain preset ground acceleration.

For years, strong motion accelerographs were largely mechanical devices that used magnetic tape or photographic film to record their data. Like any such device with mechanisms that might not be triggered into action for months or years, these instruments did not always respond reliably. Teledyne Geotech solved this problem with the introduction of its all-solid-state Accelocorder™ announced in 1975. The mechanical recording system is replaced by a CMOS semiconductor data storage system that can accommodate up to 18 minutes of three-channel data, in a form that is ready for computer analysis. Most maintenance, including loading of film or tape, is completely eliminated.

Strong motion accelerographs, such as the Teledyne Geotech A-700, are designed to measure forces from nearby earthquakes that would overwhelm more sensitive seismometers. They are typically installed in the basement, at the middle and at the top, of high rise buildings (illustrated at left) to measure and record the response of the buildings to strong earthquake forces.

In many areas, such as California, building owners are required by law to install three such instruments—one at ground level, one at midpoint and one at the top of any building over several stories high. Low cost, consequently, is of prime importance. Teledyne Geotech designed a low-cost accelerograph, the A-700, a highly successful innovation that is now widely copied in the industry. The original system included a data retrieval unit and an office playback unit for accessing and analyzing the recorded data. An updated version to replace the A-700 is scheduled for initial delivery in June 1990 and will utilize a simple personal computer for both data retrieval and analysis functions.

Data Processing Systems

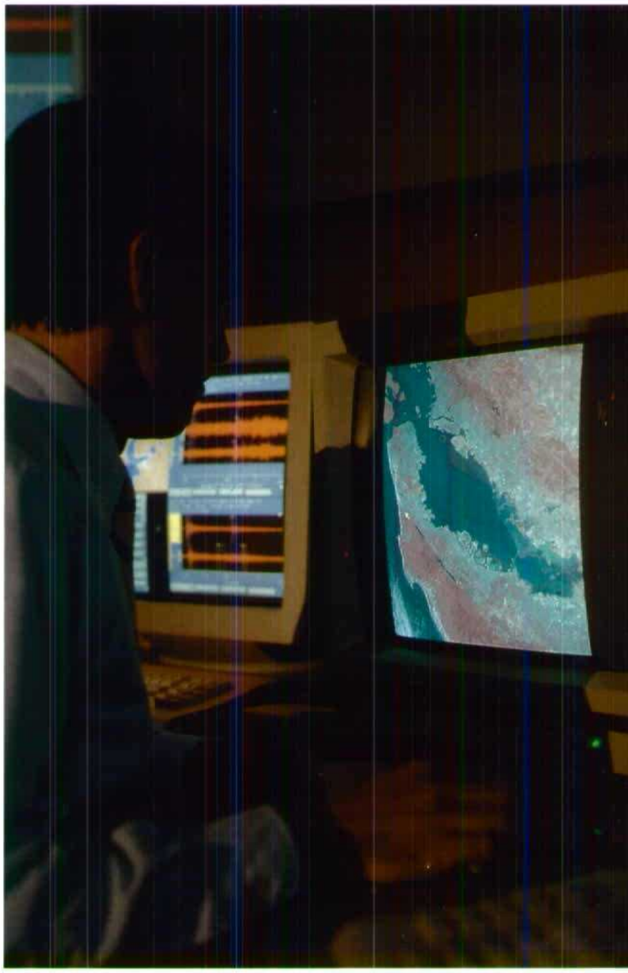
Sensing earth motion is only part of the job. The data obtained must be transmitted, recorded, analyzed and otherwise processed to be of use to scientists. Early seismometer systems were largely analog devices. The varying earth movement was converted to a varying electrical signal that was an analog of that motion. Analog signals are easily distorted in transmission and recording and are difficult to analyze efficiently, particularly when large volumes of data are involved.

Digitized data on the other hand, in which the varying electrical signal becomes coded as a series of binary numbers, can be transmitted and stored much more reliably and analyzed far more efficiently by computers. Twenty years ago, the output of a seismic system consisted of reams of paper records that had to be studied by trained analysts who worked with large mainframe computers. Today, smart PC terminals easily carry out analyses that were not possible then.

The great advances that have been made in microprocessor devices and computer technology in the last two decades, in fact, have brought about more progress in the science of earth seismology than any other factor. Those advances have largely been in the digital signal processing and data analysis portions of the science. Teledyne Geotech has been especially active and innovative in developing and applying both computer hardware and software systems to the unique problems of seismology and seismological instrumentation.

There is a significant advantage in digitizing the seismic data as close to the sensor output as possible, since the data can then be recorded or transmitted by wire, radio or satellite link with much less chance of distortion or degradation. The design and capability of the digitizing electronics in these systems is critical if the maximum dynamic range of the information is to be preserved.

The lower power requirements, light weight, small size and ruggedness of modern digital electronic systems has also made possible a portable, battery powered seismic system that can be easily and quickly deployed in remote areas. Teledyne Geotech's PDAS-100 is an example of these modern data acquisition systems. Data can be downloaded into a lap-top computer for retrieval and transfer to larger computers for analysis. The system can easily be carried and deployed by one man.

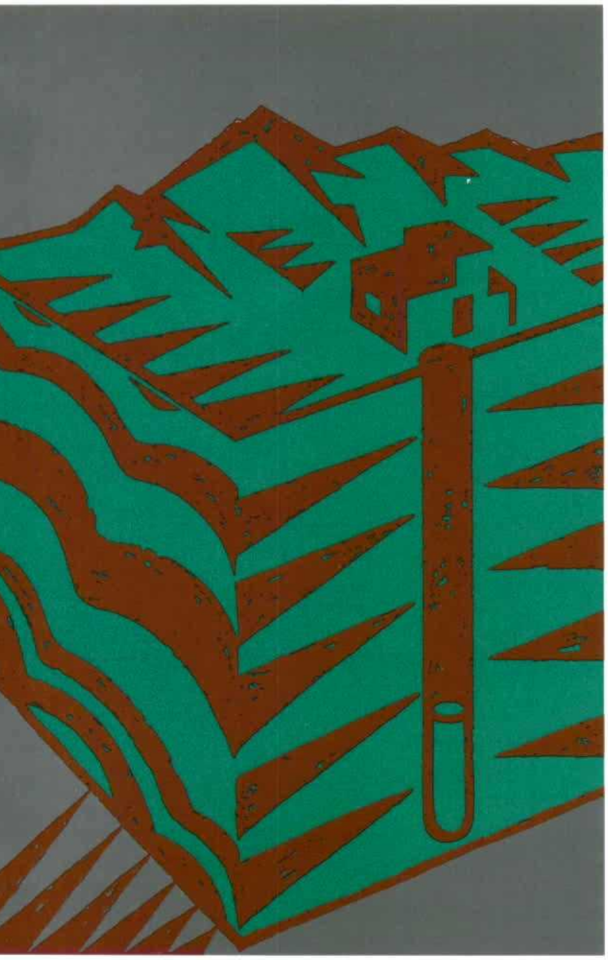


A scientist at the Center for Seismic Studies (CSS) displays and measures a seismogram on a computer workstation (pictured at right).

Automatic Analysis

Starting with the Analysis Automation (AA) system in the early 1960s, Teledyne Geotech has been a leader in the continuous development and refinement of computer based systems for automatic detection and processing of seismic data. In the late 1960s, Teledyne Geotech developed the Automatic Data Association and Processing System (ADAPS) for a seismological data computer program for the U.S. Air Force. ADAPS association and processing algorithms became a standard of comparison for other systems and many remain in use today.

As early as 1979, Teledyne Geotech had developed a system that automatically detected seismic signals and analyzed them to make a preliminary determination of the location and magnitude of an earthquake. These systems were installed in Romania, Bulgaria and Greece to provide those countries with earthquake detection and preliminary location and warning. Known as Seismic Data Processors, these



were the first real-time seismic array processing systems to become operational on a commercial basis.

Since that time, this system has been refined with the development of a series of optional individual software modules. A family of commercial seismic systems are now available with three levels of computer capability, depending on the degree of sophistication needed. These systems allow rescue efforts to be mobilized and dispatched quickly, even when an earthquake event occurs in a remote area.

Nuclear Test Treaty Verification

In 1963, the United States and the Soviet Union agreed to a Limited Nuclear Test Ban Treaty which prohibits nuclear explosions in the atmosphere, in outer space and under water. Two further treaties were drafted in 1974 and 1976 which, though unratified by the U.S. Senate, have been generally observed. The first, known as the Threshold Test Ban Treaty restricts underground nuclear weapons tests to yields no greater than 150 kilotons. The second, named the Peaceful Nuclear Explosions Treaty, also restricts nuclear explosions for peaceful purposes to yields of 150 kilotons maximum and aggregate yields of explosions detonated in salvo to 1500 kilotons.

These treaties immediately posed the problem of how compliance to these agreements could be monitored and verified. Sophisticated seismological techniques became the most effective means to monitor the size of explosions outside of each country, since underground explosions create seismic waves that travel through the earth just as natural earthquake waves do. Fortunately, the seismic waves produced by an explosion differ in subtle ways from natural events, and discrimination techniques for explosions exceeding the treaty thresholds were soon developed.

However, several methods were also identified by which the occurrence and size of underground nuclear tests might be concealed. They might be masked by timing them to occur immediately after a natural earthquake or simultaneously with industrial explosions used in mining or quarry operations. Another possible technique, called decoupling, would reduce the apparent strength of an underground blast by detonating it in a large underground cavity which would attenuate some of the energy before it reached solid earth.

None of these evasive techniques posed a major problem in determining the location and strength of underground nuclear blasts as long as the compliance limit was 150 kilotons. Now, however, there is interest in developing verification methods that would allow test limits to be reduced to the 10 or 5 or even 1 kiloton level. Extremely sensitive seismic systems and powerful mathematical computer algorithms

Teledyne Geotech has been involved in the development of the highly sensitive seismometers and related computer software that are used by the U.S. government in detecting, locating, and measuring the strength of underground nuclear explosions. The seismic sensing instruments are located in deep boreholes (illustrated at left) to isolate them from the effects of surface noise.

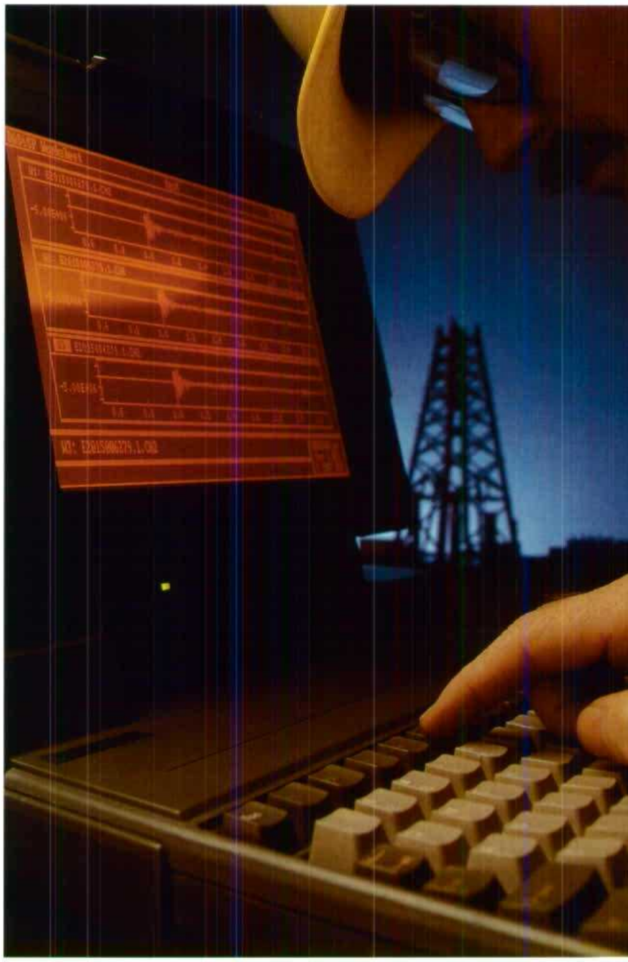
would be required to achieve this.

Teledyne Geotech has been involved in the development of both the seismic hardware and the computer software used in nuclear test treaty verification since the inception of these programs. Highly sensitive seismometers were developed specifically for these applications. These instruments are used in seismic listening arrays located throughout the world that convey their data via satellite links to a central Air Force facility in the United States. There, the signals are analyzed on a real time basis to sort out any possible nuclear explosions from the myriad non-nuclear seismic signals that are being generated throughout the earth at any given moment.

Teledyne Geotech has also supported the Air Force in this program with the development of advanced signal processing methods as well as the computer software and mathematical algorithms used to sort, identify and determine the location of suspect signals. Much of this work was performed at the company's Alexandria Laboratory which operated the Seismic Data Analysis Center (SDAC) for the Defense Advanced Research Projects Agency (DARPA). The SDAC was the primary data library and research center for much of the nuclear test treaty related seismic research conducted during the 1960s and 1970s. The laboratory currently operates the Center for Seismic Studies for DARPA, where research continues on investigations ranging from mathematical methods of discriminating nuclear from natural seismic events, to basic research into the physics of seismic wave propagation.

Teledyne Geotech is also doing research work for DARPA involving the development of theoretical mathematical models and software for related programs. In addition, Teledyne Geotech has developed a new generation of seismic field stations for DARPA. These systems include sensors, wide-range digitizers, and low-power, computer-based equipment for preprocessing and data storage. The data from these systems are transmitted to more powerful computer workstations for further processing. Several of these systems have been delivered to DARPA and are now being installed at sites in various parts of the world.

The possibility of obtaining data relevant to research on future treaties on nuclear testing that would limit underground explosions to much lower levels became more practical recently with agreements allowing the United States to place seismic monitoring stations on Soviet soil, and vice versa. Four U.S. seismic research stations are already in place in the Soviet Union and advanced



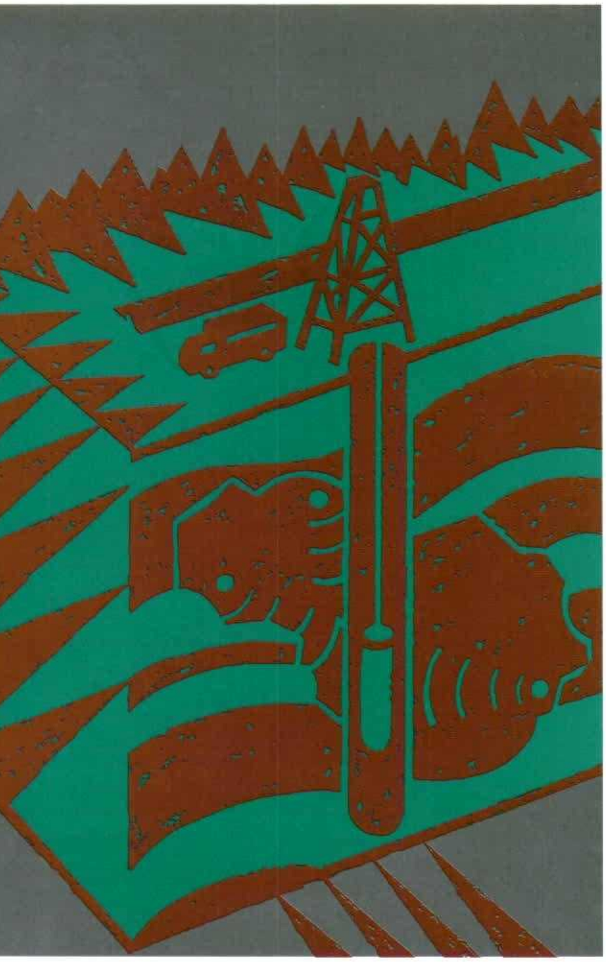
Increasing or extending the underground fractures through which oil or gas can flow to existing wells can be carried out by a process known as hydraulic fracturing. Using microseismic techniques, Teledyne Geotech provides the petroleum reservoir engineer (pictured at right) with a graphic analysis of the resulting fracture pattern.

equipment, including that manufactured by Teledyne Geotech, will be installed in these as well as at three additional sites by next spring. The Soviet Union will be given access to seismic data from U.S. equipment at five sites in the U.S. and will set up two of its own. The agreement will also give scientists access to seismic data from the Eurasian continent that will be valuable in basic worldwide earthquake studies.

Energy Research and Services

In yet another field, Teledyne Geotech has established itself as a leader and innovator in applying passive seismic technology in the energy production industry. A great deal of attention is now being focused by the petroleum industry on extracting the maximum amount of gas and oil from existing fields. This is partly because of the high cost of discovering and establishing new fields, as well as the need to utilize existing natural resources to the fullest.

Energy companies are relying heavily on technological innovation to improve



production from existing oil and gas reservoirs. Hydraulic fracturing is one method used to increase recovery from low permeability reservoirs. This technique involves the injection of fluids into the ground under high pressure to create new fissures and fractures through which oil or gas can flow more freely to existing wells. Reservoir engineers need to know where both new and existing fractures are located in order to recover the oil efficiently.

Over the last five years, under sponsorship of the Gas Research Institute, Teledyne Geotech has developed microseismic analysis techniques that are unique in the world for diagnosing the consequences of hydraulic fracture stimulation. They give the petroleum engineer a graphic picture of the fractures that exist deep underground.

This technique uses seismic sensors, lowered into boreholes in the oil or gas field, which detect and monitor tiny microseismic events that occur beneath the ground. Data is taken before the fracturing operation starts and for several hours afterward. This data is recovered in the field and taken to the Geotech facility where it is analyzed to produce a graphic picture of the orientation and extent of the fractures in the zone being studied, and the extent to which they have propagated. Teledyne Geotech has provided this microseismic surveying technique to more than a dozen major oil and gas companies with excellent results.

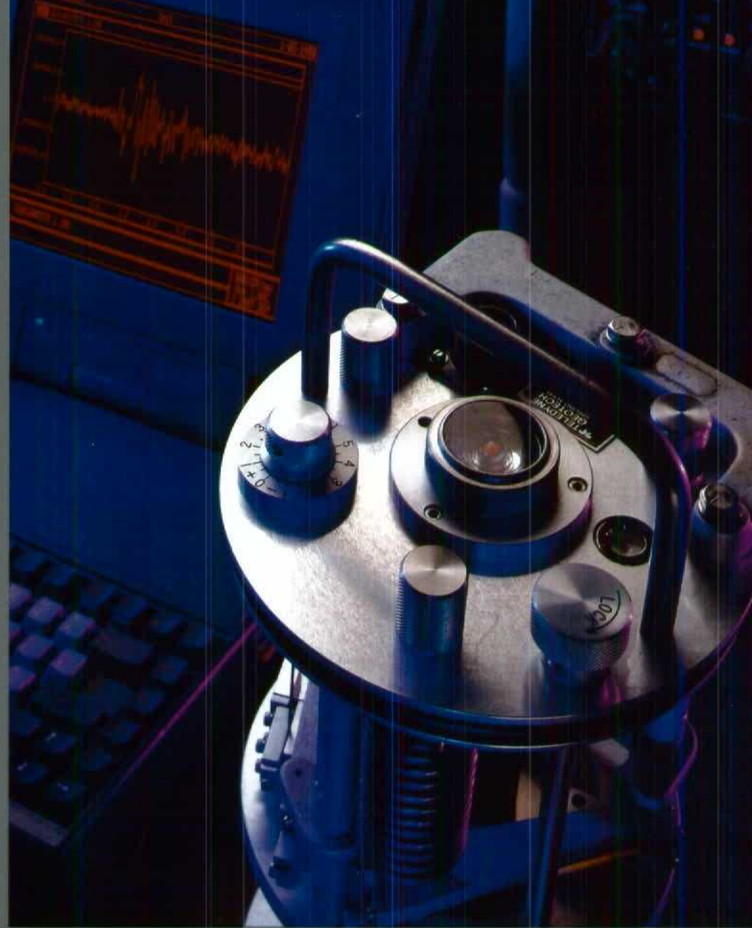
Monitoring and interpretation of microseismic activity is another service provided by Teledyne Geotech. For example, during 1978, the microseismicity induced by the filling of the Monticello reservoir in South Carolina was monitored to evaluate the possible seismic hazard. Studies of microseismicity associated with land subsidence caused by fluid withdrawal and failure of thick surface ice in arctic regions due to drilling platform loading have also been performed.

Teledyne Geotech, in cooperation with the Gas Research Institute, has developed seismic techniques that allow petroleum engineers to visualize the hydraulic fracture patterns in oil and gas reservoirs deep in the earth (illustrated at left). The technique helps maximize the recovery of petroleum products from existing fields.

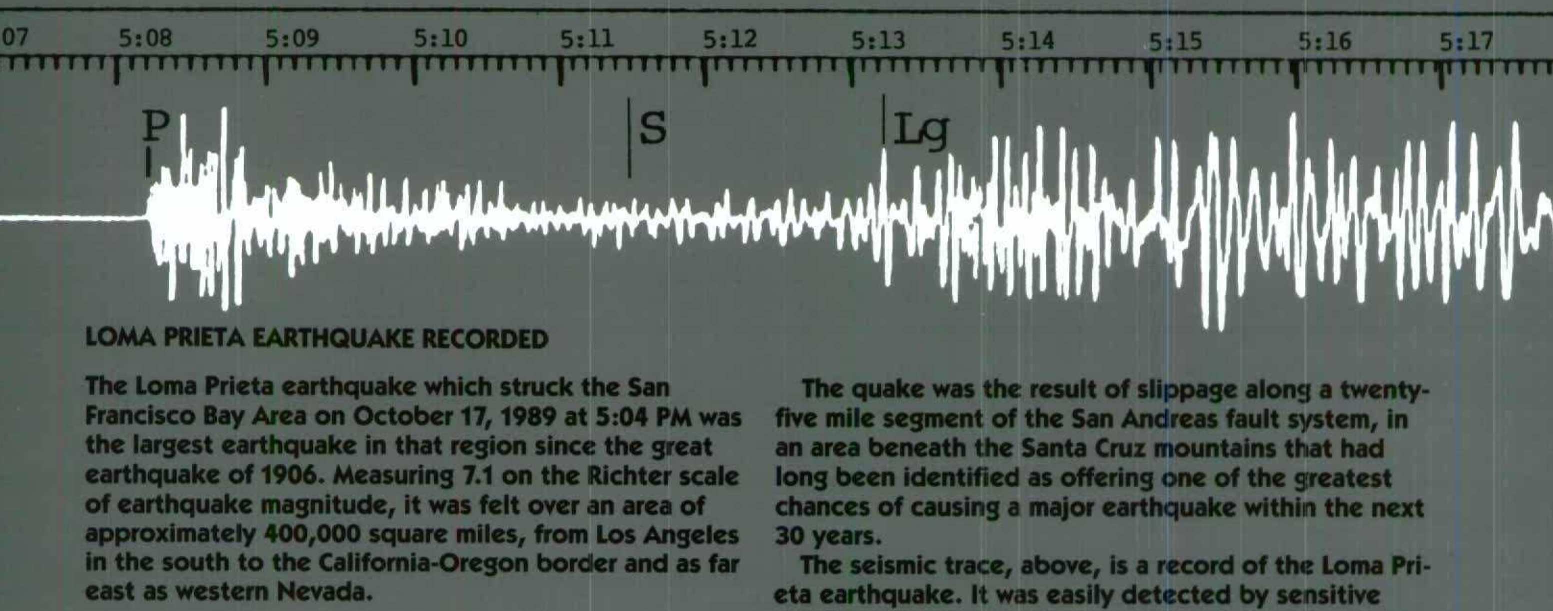
The Seismic Future

Seismic monitoring of the earth has only been done with any degree of scientific precision for about 50 years. There are many remote areas of the land that have never been instrumented and vast areas of sea bottom are virtually untouched. Nuclear test verification in years to come will undoubtedly require more widely distributed seismic arrays and more sophisticated instruments to monitor lower and lower yield levels. And the energy industry will need ever more refined seismic techniques to aid in the extraction of oil and gas from dwindling resources.

Teledyne Geotech is committed to the development of the sophisticated instruments, software and analytic techniques that will be needed in these activities.



Teledyne Geotech's S-13 seismometer has been the unsurpassed workhorse of the seismic community for many years. It offers ruggedness, reliability and precision at moderate cost. In the background is the PDAS-100 data acquisition system that, coupled with the display device and S-13 seismometer, provides a complete, portable seismic monitoring station for field use.



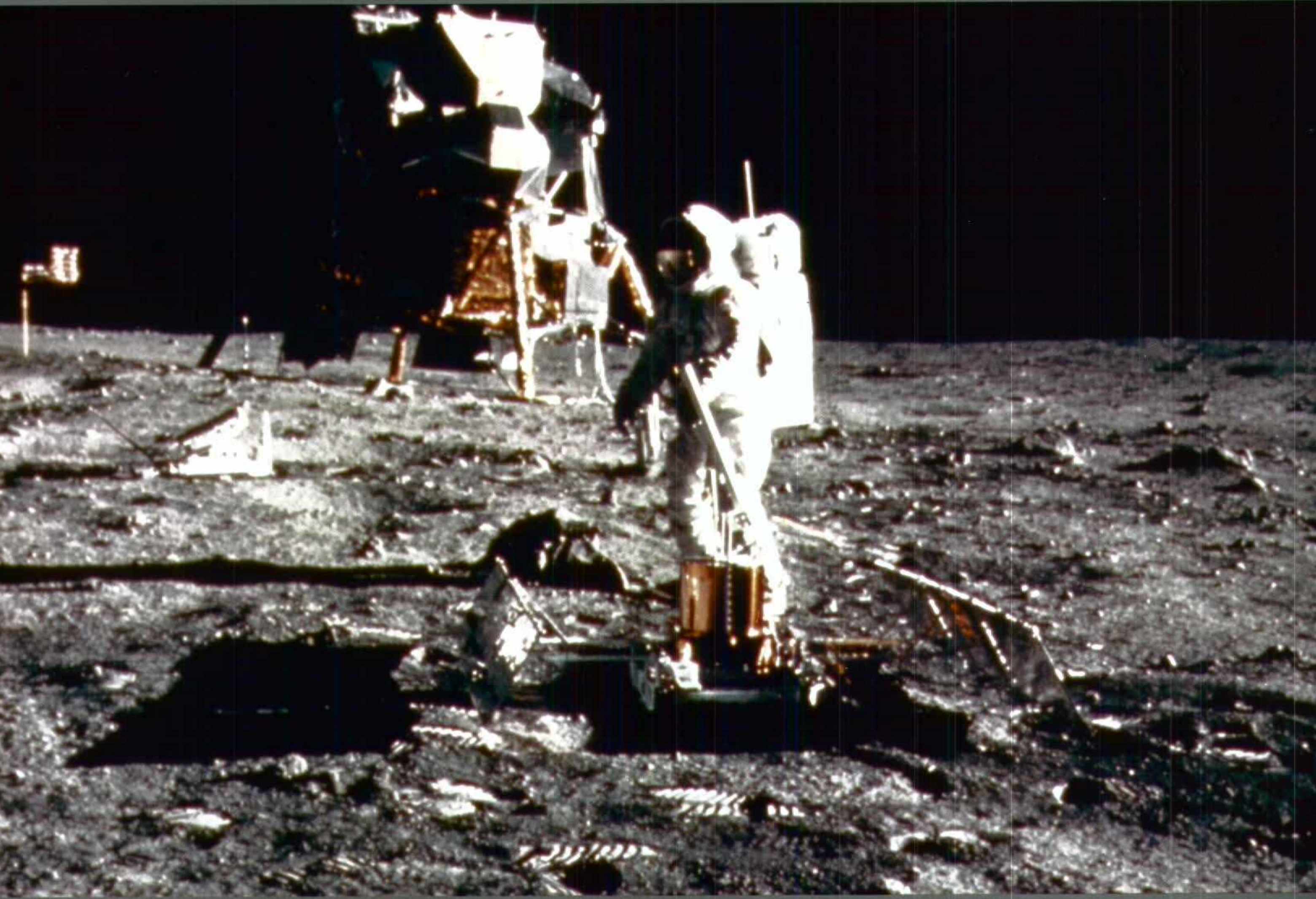
LOMA PRIETA EARTHQUAKE RECORDED

The Loma Prieta earthquake which struck the San Francisco Bay Area on October 17, 1989 at 5:04 PM was the largest earthquake in that region since the great earthquake of 1906. Measuring 7.1 on the Richter scale of earthquake magnitude, it was felt over an area of approximately 400,000 square miles, from Los Angeles in the south to the California-Oregon border and as far east as western Nevada.

The quake was the result of slippage along a twenty-five mile segment of the San Andreas fault system, in an area beneath the Santa Cruz mountains that had long been identified as offering one of the greatest chances of causing a major earthquake within the next 30 years.

The seismic trace, above, is a record of the Loma Prieta earthquake. It was easily detected by sensitive Teledyne Geotech equipment located at Lajitas, Texas where the "P" or compressional wave was recorded 4 minutes and 12 seconds after the event began, followed 3 minutes and 20 seconds later by the slower "S" or shear wave. The large amplitude group of guided waves (Lg) can be seen following the shear wave arrival. Lajitas is in one of the most seismically quiet areas in the world and is a highly prized site for seismological research because of its freedom from both natural seismic noise, and cultural noise associated with mining, quarrying, and land traffic.

Earthquakes of the Loma Prieta magnitude can be easily detected by sensitive seismological instrumentation anywhere in the world.



MOON SEISMOLOGY— LOOKING FOR EXTRATERRESTRIAL QUAKES

Teledyne Geotech's seismological expertise and its instruments went extraterrestrial in the late 1960s, when seismometers built especially for the purpose were carried to the moon by Apollo 11 astronauts. The photograph above shows the gold-plated Teledyne Geotech seismometer just after it was deployed by the astronauts. Activated by a signal from the earth, its operation was verified within minutes of being deployed.

One purpose of the experiment was to gain knowledge about the interior structure of the moon by detecting the reflection of seismic waves from its inner strata. Another was to determine if the moon is subject to seismological disturbances as the earth is. The seismometer was left in place on the moon and continued to send seismic data to earth long after the astronauts had gone.

On July 22, 1969, for example, according to the Smithsonian Institution Center for Short-Lived Phenomena, the seismometer recorded an event that represented a shock wave traveling across the surface of the moon rather than through its middle. The event, when measured, was comparable to an earthquake in California with a magnitude of 4 or 5 on the Richter scale when recorded on the East Coast of the United States. It may have been a bona fide moonquake or a meteorite impact. There was agreement that the shock wave, whatever its origin, had demonstrated that the body of the moon is composed of layers. It was generally agreed that the wave's behavior had shown that it had traveled through a crusty material that overlays a more solid interior.

Net income for 1989 was $258.9 million or $23.32 per share compared to $391.8 million or $34.03 per share for 1988. Sales were $3.53 billion in 1989 and 1988.

Net income for the fourth quarter of 1989 was $62.9 million or $5.68 per share compared to $98.2 million or $8.68 per share for the fourth quarter of 1988. Sales were $883.4 million for the fourth quarter of 1989 compared to $977.2 million in 1988.

In January 1990, the Board of Directors approved a plan to spin off the insurance and finance subsidiaries to the Company's shareholders, subject to various regulatory procedures. The units involved, to be subsidiaries of a new company called Unitrin, Inc., are United Insurance Company of America and subsidiaries, Trinity Universal Insurance Company and subsidiaries and Fireside Securities Corporation and subsidiaries. The results of operations for these subsidiaries are presented as discontinued operations. It is anticipated that these companies will cease to be subsidiaries of Teledyne at the end of the first quarter of 1990.

Income of continuing operations for 1989 was $150.3 million or $13.54 per share compared to $197.1 million or $17.12 per share for 1988. Income of discontinued operations for 1989 was $108.6 million or $9.78 per share compared to $194.7 million or $16.91 per share for 1988.

Income of continuing operations for the fourth quarter of 1989 was $38.8 million or $3.50 per share compared to $63.6 million or $5.61 per share for the fourth quarter of 1988. Income of discontinued operations for the fourth quarter of 1989 was $24.1 million or $2.18 per share compared to $34.6 million or $3.07 per share for the fourth quarter of 1988.

The Company experienced a decline in profit in 1989 in the aviation and electronics segment as a result of higher than anticipated costs on certain defense contracts and decreased demand in the defense sector. Results of insurance operations for the year ended December 31, 1989 included losses due to severe storms in the Southwest as well as the effect of strengthening reserves at the casualty insurance companies in the fourth quarter.

A cash dividend for the quarter ended December 31, 1989 of $1.00 per share was paid on November 29, 1989 to shareholders of record November 13, 1989. Cash dividends of $4.00 per share were paid in 1989.

In January 1990, the Board of Directors declared a quarterly cash dividend of $1.00 per share payable February 21 to shareholders of record February 7, 1990. In addition, the Board of Directors declared a five for one common stock split to be distributed March 8, 1990 to shareholders of record February 8, 1990. The financial statements and the information presented above have not been restated to reflect this event.

Sales and operating profit by business segment are presented in Note 8 to the consolidated financial statements on pages 24 and 25. Management's Discussion and Analysis of Financial Condition and Results of Operations is presented on pages 30, 31 and 32.

Henry E. Singleton	George A Roberts
Chairman of the Board of Directors	President and Chief Executive Officer

(In millions except per share amounts)

Year	Sales	Net Income	Net Income Per Share	Shareholders' Equity
1989	**$3,531.2**	**$258.9**	**$23.32**	**$2,326.9**
1988	**3,534.6**	**391.8**	**34.03**	**2,138.4**
1987	**3,216.8**	**377.2**	**32.25**	**1,976.0**
1986	**3,241.4**	**238.3**	**20.35**	**1,636.6**
1985	**3,256.2**	**546.4**	**46.66**	**1,577.4**
1984	**3,494.3**	**574.3**	**37.69**	**1,159.3**
1983	**2,979.0**	**304.6**	**14.87**	**2,641.2**
1982	**2,863.8**	**269.6**	**13.05**	**2,111.1**
1981	**3,237.6**	**421.9**	**20.43**	**1,723.2**
1980	**2,926.4**	**352.4**	**15.62**	**1,410.2**
1979	**2,705.6**	**379.6**	**15.02**	**1,288.6**
1978	**2,441.6**	**254.4**	**9.63**	**890.3**
1977	**2,209.7**	**201.3**	**7.53**	**702.2**
1976	**1,937.6**	**137.6**	**4.78**	**516.1**
1975	**1,715.0**	**101.7**	**2.57**	**489.3**
1974	**1,700.0**	**31.5**	**0.55**	**477.8**
1973	**1,455.5**	**66.0**	**1.01**	**532.8**
1972	**1,216.0**	**59.3**	**0.67**	**484.0**
1971	**1,101.9**	**57.4**	**0.62**	**606.1**
1970	**1,216.4**	**61.9**	**0.69**	**576.3**
1969	**1,294.8**	**58.1**	**0.68**	**502.0**
1968	**806.7**	**40.3**	**0.56**	**316.5**
1967	**451.1**	**21.3**	**0.38**	**152.6**
1966	**256.8**	**12.0**	**0.29**	**90.2**
1965	**86.5**	**3.4**	**0.16**	**34.8**
1964	**38.2**	**1.4**	**0.10**	**13.7**
1963	**31.9**	**0.7**	**0.06**	**8.6**
1962	**10.4**	**0.2**	**0.02**	**3.5**
1961	**4.5**	**0.1**	**0.01**	**2.5**

As reported in the Company's annual reports, adjusted for certain accounting changes, stock dividends and stock splits, except for the five for one split to be distributed on March 8, 1990.

Consolidated Balance Sheets

December 31, 1989 and 1988
(In millions except share and per share amounts)

	1989	*1988*
ASSETS		
Current Assets:		
Cash and marketable securities	**$ 236.4**	$ 221.7
Receivables	**455.5**	465.2
Inventories	**280.5**	267.2
Deferred income taxes	**67.0**	42.3
Prepaid expenses	**17.0**	12.0
Total current assets	**1,056.4**	1,008.4
Property and Equipment	**345.4**	301.9
Other Assets	**164.5**	121.7
Net Assets of Discontinued Operations	**1,880.8**	1,817.1
	$3,447.1	$3,249.1
LIABILITIES AND SHAREHOLDERS' EQUITY		
Current Liabilities:		
Accounts payable	**$ 156.9**	$ 152.5
Accrued liabilities	**293.3**	274.6
Current portion of long-term debt	**8.6**	3.7
Accrued income taxes	**2.9**	24.4
Total current liabilities	**461.7**	455.2
Long-Term Debt	**571.3**	578.0
Deferred Income Taxes	**50.8**	30.5
Other Long-Term Liabilities	**36.4**	47.0
	1,120.2	1,110.7
Shareholders' Equity:		
Common stock, $1.00 par value, 60,000,000 shares authorized 11,082,569 shares at December 31, 1989 and 11,189,969 shares at December 31, 1988 issued and outstanding	**11.1**	11.2
Additional paid-in capital	**78.8**	79.6
Retained earnings	**2,167.2**	1,989.5
Equity in net unrealized appreciation	**67.0**	54.8
Currency translation adjustment	**2.8**	3.3
Total shareholders' equity	**2,326.9**	2,138.4
	$3,447.1	$3,249.1

The accompanying notes are an integral part of these statements.

Consolidated Statements of Income

For the Years Ended December 31, 1989, 1988 and 1987
(In millions except per share amounts)

	1989	1988	1987
Sales	**$3,531.2**	$3,534.6	$3,216.8
Costs and Expenses:			
Cost of sales	**2,750.2**	2,709.9	2,460.6
Selling and administrative expenses	**505.9**	478.7	445.4
Interest expense	**69.6**	69.8	72.9
Other income	**(26.2)**	(38.5)	(35.6)
	3,299.5	3,219.9	2,943.3
Income of Continuing Operations before Income Taxes	**231.7**	314.7	273.5
Provision for Income Taxes	**81.4**	117.6	110.9
Income of Continuing Operations	**150.3**	197.1	162.6
Income of Discontinued Operations	**108.6**	194.7	214.6
Net Income	**$ 258.9**	$ 391.8	$ 377.2
Income Per Share:			
Continuing operations	**$ 13.54**	$ 17.12	$ 13.90
Discontinued operations	**9.78**	16.91	18.35
Net Income Per Share	**$ 23.32**	$ 34.03	$ 32.25
Income per share adjusted for the five for one common stock split to be distributed March 8, 1990:			
Continuing operations	**$ 2.71**	$ 3.42	$ 2.78
Discontinued operations	**1.95**	3.39	3.67
Adjusted net income per share	**$ 4.66**	$ 6.81	$ 6.45

The accompanying notes are an integral part of these statements.

Consolidated Statements of Cash Flows

For the Years Ended December 31, 1989, 1988 and 1987
(In millions)

	1989	1988	1987
Operating activities:			
Net income	**$258.9**	$391.8	$377.2
Adjustments to reconcile net income to net cash provided by operating activities:			
Income of discontinued operations	**(108.6)**	(194.7)	(214.6)
Depreciation and amortization of property and equipment	**97.8**	98.2	97.3
Increase in deferred pension cost	**(31.9)**	(36.2)	(27.4)
Increase (decrease) in accounts payable and accrued liabilities	**23.1**	(1.7)	44.5
Increase (decrease) in accrued income taxes	**(21.5)**	8.2	(13.7)
Increase in inventories	**(13.3)**	(23.2)	(33.0)
Decrease (increase) in receivables	**9.7**	(56.9)	(23.6)
Other, net	**(35.3)**	(27.5)	0.4
Net cash provided by operating activities	**178.9**	158.0	207.1
Investing activities:			
Purchases of property and equipment	**(144.6)**	(93.0)	(82.0)
Net decrease (increase) in short-term investments	**(71.8)**	65.1	(75.1)
Proceeds from the sales of marketable securities	**61.5**	52.6	191.1
Purchases of marketable securities	**(6.7)**	(56.2)	(248.5)
Other, net	**16.0**	25.8	19.9
Net cash used in investing activities	**(145.6)**	(5.7)	(194.6)
Financing activities:			
Cash dividends	**(44.5)**	(46.1)	(46.8)
Acquisition and retirement of stock	**(37.6)**	(155.6)	(14.5)
Reduction of long-term debt	**(9.1)**	(5.1)	(10.6)
Other, net	**1.5**	1.3	2.3
Net cash used in financing activities	**(89.7)**	(205.5)	(69.6)
Dividends from discontinued operations	**57.1**	54.2	58.5
Increase in cash	**$ 0.7**	$ 1.0	$ 1.4

The accompanying notes are an integral part of these statements.

Consolidated Statements of Shareholders' Equity

For the Years Ended December 31, 1989, 1988 and 1987
(In millions except share and per share amounts)

	Common Stock	Additional Paid-In Capital	Retained Earnings	Equity in Net Unrealized Appreciation	Currency Translation Adjustment	Shareholders' Equity
Balance, December 31, 1986	$11.7	$83.2	$1,479.4	$64.0	$(1.7)	$1,636.6
Net income	—	—	377.2	—	—	377.2
Cash dividends ($4.00 per share)	—	—	(46.8)	—	—	(46.8)
Acquisition and retirement of stock (41,500 shares)	—	(0.3)	(14.2)	—	—	(14.5)
Change in net unrealized appreciation	—	—	—	19.0	—	19.0
Currency translation adjustment	—	—	—	—	4.5	4.5
Balance, December 31, 1987	11.7	82.9	1,795.6	83.0	2.8	1,976.0
Net income	—	—	391.8	—	—	391.8
Cash dividends ($4.00 per share)	—	—	(46.1)	—	—	(46.1)
Acquisition and retirement of stock (478,009 shares)	(0.5)	(3.3)	(151.8)	—	—	(155.6)
Change in net unrealized appreciation	—	—	—	(28.2)	—	(28.2)
Currency translation adjustment	—	—	—	—	0.5	0.5
Balance, December 31, 1988	11.2	79.6	1,989.5	54.8	3.3	2,138.4
Net income	—	—	258.9	—	—	258.9
Cash dividends ($4.00 per share)	—	—	(44.5)	—	—	(44.5)
Acquisition and retirement of stock (107,400 shares)	(0.1)	(0.8)	(36.7)	—	—	(37.6)
Change in net unrealized appreciation	—	—	—	12.2	—	12.2
Currency translation adjustment	—	—	—	—	(0.5)	(0.5)
Balance, December 31, 1989	$11.1	$78.8	$2,167.2	$67.0	$ 2.8	$2,326.9

The accompanying notes are an integral part of these statements.

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

We have audited the accompanying consolidated balance sheets of Teledyne, Inc. (a Delaware corporation) and subsidiaries as of December 31, 1989 and 1988 and the related consolidated statements of income, shareholders' equity and cash flows for each of the three years in the period ended December 31, 1989. These financial statements are the responsibility of the Company's management. Our responsibility is to express an opinion on these financial statements based on our audits. We did not audit the consolidated financial statements of United Insurance Company of America and subsidiaries and the investee companies (Note 9). The investment in the net assets of United Insurance Company of America and subsidiaries and the investee companies represent 46 percent in 1989 and 1988 of consolidated assets and their net income represents 37 percent in 1989, 33 percent in 1988 and 32 percent in 1987 of consolidated net income. Those statements were audited by other auditors whose reports have been furnished to us and our opinion, insofar as it relates to amounts included for United Insurance Company of America and subsidiaries and the investee companies, is based on the reports of the other auditors.

We conducted our audits in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audits provide a reasonable basis for our opinion.

In our opinion, based on our audits and the reports of other auditors, the financial statements referred to above present fairly, in all material respects, the consolidated financial position of Teledyne, Inc. and subsidiaries as of December 31, 1989 and 1988, and the results of their operations and their cash flows for each of the three years in the period ended December 31, 1989 in conformity with generally accepted accounting principles.

Arthur Andersen & Co.

ARTHUR ANDERSEN & CO.

Los Angeles, California
January 25, 1990

Note 1. Summary of Significant Accounting Policies. *Principles of Consolidation.* The consolidated financial statements of Teledyne, Inc. include the accounts of all its subsidiaries, except its insurance and finance subsidiaries. The insurance and finance subsidiaries are presented as discontinued operations as a result of a plan to spin off these subsidiaries. All material intercompany accounts and transactions have been eliminated. Certain amounts for 1988 and 1987 have been reclassified to conform with the 1989 presentation.

Receivables. Receivables are presented net of a reserve for doubtful accounts of $9.4 million at December 31, 1989 and $9.2 million at December 31, 1988.

Inventories. Inventories are stated at the lower of cost (last-in, first-out and first-in, first-out methods) or market, less progress payments. Costs include direct material and labor costs and applicable manufacturing overhead. Sales and related costs are recorded as products are delivered and as services are performed, including those under long-term contracts. Costs relating to such long-term contracts are removed from inventory and charged to cost of sales at amounts approximating actual cost. Any foreseeable losses are charged to income when determined.

Cost in Excess of Net Assets of Purchased Businesses. Other assets include cost in excess of net assets of purchased businesses of $27.9 million at December 31, 1989 and 1988. Substantially all of this cost relates to businesses purchased prior to November 1970 and is not being amortized.

Depreciation and Amortization. Buildings and equipment are depreciated primarily on declining balance methods over their estimated useful lives. Leasehold improvements are amortized on a straight-line basis over the life of the lease. Maintenance and repair costs ($87.6 million in 1989, $79.9 million in 1988 and $71.2 million in 1987) are charged to income as incurred, and betterments and major renewals are capitalized. Cost and accumulated depreciation of property sold, retired or fully depreciated are removed from the accounts, and any resultant gain or loss is included in income.

Research and Development. Company-funded research and development costs ($69.2 million in 1989, $79.3 million in 1988 and $87.7 million in 1987) are expensed as incurred. Costs related to customer-funded research and development contracts are charged to costs and expenses as the related sales are recorded.

Income Taxes. Provision for income taxes includes Federal, state and foreign income taxes. Deferred income taxes are provided for timing differences in the recognition of income and expenses. Investment tax credits are amortized over the estimated lives of the related assets.

Net Income Per Share. The weighted average number of shares of common stock used in the computation of net income per share was 11,100,868 in 1989, 11,514,115 in 1988 and 11,693,660 in 1987.

Note 2. Inventories. Inventories at December 31, 1989 and 1988 were as follows (in millions):

	1989	*1988*
Raw materials and work-in-process	**$410.4**	$379.8
Finished goods	**65.5**	65.7
	475.9	445.5
Progress payments	**(195.4)**	(178.3)
	$280.5	$267.2

Inventories determined on the last-in, first-out method were $439.1 million at December 31, 1989 and $410.3 million at December 31, 1988. The remainder of the inventories was determined using the first-in, first-out method. Inventories stated on the last-in, first-out basis were $264.8 million and $241.3 million less than their first-in, first-out values at December 31, 1989 and 1988, respectively. These first-in, first-out values do not differ materially from current cost.

Inventories, before progress payments, related to long-term contracts were $189.7 million and $152.6 million at December 31, 1989 and 1988, respectively. Progress payments related to long-term contracts were $180.6 million and $154.8 million at December 31, 1989 and 1988, respectively.

Note 3. Long-Term Debt. Long-term debt at December 31, 1989 and 1988 was as follows (in millions):

	1989	*1988*
10% Subordinated Debentures, due 2004, Series A and C, $29.8 payable annually commencing in 1994 (net of unamortized discount of $62.5 in 1989 and $68.0 in 1988)	**$530.0**	$524.6
Other	**49.9**	57.1
	579.9	581.7
Current portion	**(8.6)**	(3.7)
	$571.3	$578.0

Long-term debt is payable $8.6 million in 1990, $1.8 million in 1991, $6.0 million in 1992, $2.8 million in 1993 and $30.1 million in 1994. Interest paid on long-term debt was $63.3 million in 1989, $63.5 million in 1988 and $64.1 million in 1987.

The Company has domestic credit lines with various banks totaling $125.0 million at December 31, 1989; no amounts were borrowed under these lines during 1989 or 1988. Commitments under standby letters of credit outstanding were $57.1 million at December 31, 1989. Compensating balance arrangements of an informal nature exist. Such arrangements had no material effect on the Company's consolidated financial statements at December 31, 1989.

Note 4. Supplemental Balance Sheet Information. Cash and marketable securities at December 31, 1989 and 1988 were as follows (in millions):

	1989	*1988*
Cash	**$ 8.7**	$ 8.0
United States Treasury notes, at amortized cost, which approximates market	**114.6**	134.5
Litton common stock, at cost plus cumulative earnings (market: 1989–$64.7; 1988–$60.2)	**43.5**	37.4
Bankers acceptances, at amortized cost, which approximates market	**42.6**	24.8
Other marketable securities	**27.0**	17.0
	$236.4	$221.7

Property and equipment at December 31, 1989 and 1988 were as follows (in millions):

	1989	*1988*
Land	**$ 29.3**	$ 23.4
Buildings	**220.4**	198.9
Equipment and leasehold improvements	**653.1**	654.6
	902.8	876.9
Accumulated depreciation and amortization	**(557.4)**	(575.0)
	$345.4	$301.9

Accrued liabilities at December 31, 1989 and 1988 were as follows (in millions):

	1989	*1988*
Salaries and wages	**$ 85.8**	$ 85.4
Interest, taxes and other	**207.5**	189.2
	$293.3	$274.6

Accounts payable includes $28.1 million at December 31, 1989 and $25.4 million at December 31, 1988 for checks outstanding in excess of cash balances.

Note 5. Shareholders' Equity. The Company is authorized to issue 15,000,000 shares of preferred stock, $1 par value. No preferred shares were issued or outstanding. In October 1988, the Board of Directors authorized the repurchase of up to one million shares of the Company's common stock, of which 286,400 shares have been purchased as of December 31, 1989.

Shareholders' equity includes net unrealized appreciation on equity securities, net of deferred taxes, held by the Company's insurance subsidiaries, excluding investments in investees (Curtiss-Wright Corporation, 44 percent and Litton Industries, Inc., 25 percent).

Note 6. Income Taxes. Provision for income taxes for the years ended December 31, 1989, 1988 and 1987 was as follows (in millions):

	1989	1988	1987
Current—Federal	**$ 68.9**	$ 80.4	$ 89.1
—State	**19.2**	23.3	19.8
—Foreign	**5.7**	5.9	5.2
	93.8	109.6	114.1
Deferred—Federal	**(6.9)**	11.1	4.1
—State	**(3.7)**	0.1	(2.0)
—Foreign	**—**	—	0.2
	(10.6)	11.2	2.3
Investment Tax Credits	**(1.8)**	(3.2)	(5.5)
	$ 81.4	$117.6	$110.9

Income of continuing operations before income taxes includes income from domestic operations of $219.9 million in 1989, $302.0 million in 1988 and $264.1 million in 1987.

Provision (credit) for deferred income taxes for the years ended December 31, 1989, 1988 and 1987 was as follows (in millions):

	1989	1988	1987
Long-term contracts	**$(13.9)**	$ 14.1	$ —
Pension	**10.9**	13.1	21.7
Other	**(7.6)**	(16.0)	(19.4)
	$(10.6)	$ 11.2	$ 2.3

The effective income tax rate on pre-tax income for the years ended December 31, 1989, 1988 and 1987 was as follows:

	1989	1988	1987
Statutory Federal income tax rate	**34.0%**	34.0%	40.0%
State and local income taxes, net of Federal income tax effect	**4.4**	4.9	3.9
Research and development credit	**(2.5)**	—	—
Amortization of investment tax credits	**(0.8)**	(1.0)	(2.0)
Other, net	**—**	(0.5)	(1.4)
	35.1%	37.4%	40.5%

Income taxes paid were $121.2 million in 1989, $126.0 million in 1988 and $95.3 million in 1987.

In December 1987, Statement of Financial Accounting Standards (SFAS) No. 96 was issued which requires a change in accounting for income taxes. This statement must be adopted no later than 1992. The Company has not yet determined the impact of the adoption of SFAS No. 96 on the financial statements or the date or method of adoption.

Note 7. Pension Plans and Post-Retirement Benefits. The Company sponsors defined benefit pension plans covering substantially all of its employees. Benefits are generally based on years of service and/or final average pay. The Company funds the pension plans in accordance with the requirements of the Employee Retirement Income Security Act of 1974, as amended.

Components of pension expense (income) for the years ended December 31, 1989, 1988 and 1987 include the following (in millions):

	Expense (Income)		
	1989	*1988*	*1987*
Service cost—benefits earned during the year	**$ 35.0**	$ 30.2	$ 34.3
Interest cost on projected benefit obligation	**58.3**	53.4	51.2
Actual return on assets	**(159.3)**	(95.1)	(60.9)
Net amortization and deferral	**41.7**	(20.4)	(52.3)
Pension expense (income) for defined benefit plans	**(24.3)**	(31.9)	(27.7)
Other	**1.4**	1.4	1.0
Pension expense (income)	**$ (22.9)**	$(30.5)	$(26.7)

Actuarial assumptions used to develop the components of pension expense (income) for the years ended December 31, 1989, 1988 and 1987 were as follows:

	1989	*1988*	*1987*
Discount rate	**7.75%**	8.25%	7.25%
Rate of increase in future compensation levels	**4.50%**	4.50%	4.50%
Expected long-term rate of return on assets	**6.00%**	6.00%	6.00%

Plan assets in excess of projected benefit obligations at December 31, 1989 and 1988 were as follows (in millions):

	1989	*1988*
Plan assets at fair value	**$1,487.2**	$1,364.6
Actuarial present value of benefit obligations:		
Vested benefit obligation	**735.8**	604.0
Non-vested benefit obligation	**16.9**	38.7
Accumulated benefit obligation	**752.7**	642.7
Additional benefits related to future compensation levels	**130.0**	117.0
Projected benefit obligation	**882.7**	759.7
Plan assets in excess of projected benefit obligation	**$ 604.5**	$ 604.9
Plan assets in excess of projected benefit obligation:		
Included in balance sheet:		
Prepaid pension cost	**$ 95.5**	$ 63.6
Accrued pension liability	**(5.1)**	(1.1)
Not included in balance sheet:		
Unrecognized net asset at adoption of SFAS No. 87, net of amortization	**429.4**	468.4
Unrecognized net gain due to experience different from that assumed and changes in the discount rate	**109.9**	77.4
Unrecognized prior service cost	**(25.2)**	(3.4)
Plan assets in excess of projected benefit obligation	**$ 604.5**	$ 604.9

At December 31, 1989 and 1988, the plans' assets, consisting primarily of fixed maturities, include debt obligations of the Company (primarily Teledyne 10% Subordinated Debentures) with a market value of $83.6 million and $77.4 million, respectively.

A discount rate of 7.25 percent at December 31, 1989, 7.75 percent at December 31, 1988 and 8.25 percent at December 31, 1987 and a rate of increase in future compensation levels of 4.50 percent at December 31, 1989, 1988 and 1987 were used for the valuation of pension obligations.

The Company provides post-retirement health care and life insurance benefits to certain of its employees. The costs for these benefits, which are charged to costs and expenses as incurred, were $17.3 million, $17.5 million and $13.1 million in 1989, 1988 and 1987, respectively.

Note 8. Business Segments. Teledyne, Inc. is a diversified corporation comprised of companies which manufacture a wide variety of products. The Company's major business segments include aviation and electronics, specialty metals, industrial and consumer.

Companies in the aviation and electronics segment produce aircraft engines, airframe structures, unmanned air vehicles, target drone systems, equipment and subsystems for spacecraft and avionics. Other activities in this segment include the manufacture of semiconductors, relays, aircraft-monitoring and control systems, military electronic equipment and other related products and systems. Products in the specialty metals segment include zirconium, titanium, high temperature nickel based alloys, high-speed and tool steels, tungsten and molybdenum. Other operations in this segment consist of processing, casting, rolling and forging metals. The industrial segment is comprised of companies that manufacture turbine engines, a large range of air and water cooled, gasoline and diesel fueled engines, molded rubber mechanical products, machine tools, dies and consumable tooling. The consumer segment manufactures oral hygiene products, shower massages, water and air purification systems, swimming pool and spa heaters and provides other products and services.

Information on the Company's business segments for the years ended December 31, 1989, 1988 and 1987 was as follows (in millions):

	1989	*1988*	*1987*
Sales:			
Aviation and electronics	**$1,465.7**	$1,548.1	$1,439.3
Specialty metals	**922.7**	857.5	713.6
Industrial	**809.4**	805.5	768.6
Consumer	**333.4**	323.5	295.3
	$3,531.2	$3,534.6	$3,216.8

The Company's sales to the U.S. Government were $1.2 billion in 1989 and $1.3 billion in 1988 and 1987, including direct sales as prime contractor and indirect sales as subcontractor. Most of these sales were in the aviation and electronics segment. Sales by operations in the United States to customers in other countries were $372.8 million in 1989, $377.8 million in 1988 and $254.7 million in 1987. Sales between business segments, which were not material, generally were priced at prevailing market prices.

	1989	*1988*	*1987*
Income before Income Taxes:			
Aviation and electronics	**$ 92.1**	$146.4	$147.3
Specialty metals	**123.1**	118.6	84.1
Industrial	**78.0**	89.0	83.3
Consumer	**35.0**	38.0	39.4
Operating profit	**328.2**	392.0	354.1
Corporate expenses	**53.1**	46.0	43.3
Interest expense	**69.6**	69.8	72.9
Other income	**(26.2)**	(38.5)	(35.6)
	$231.7	$314.7	$273.5

The Company experienced a decline in profit in 1989 in the aviation and electronics segment as a result of higher than anticipated costs on certain defense contracts and decreased demand in the defense sector. The 1988 increase in operating profit in the specialty metals segment resulted principally from increased demand in the transportation, capital equipment and aerospace industries.

	1989	1988	1987
Depreciation and Amortization:			
Aviation and electronics	**$ 37.5**	$ 38.8	$ 38.5
Specialty metals	**24.1**	23.2	25.7
Industrial	**20.0**	20.7	20.1
Consumer	**7.3**	6.4	5.0
Corporate	**8.9**	9.1	8.0
	$ 97.8	$ 98.2	$ 97.3
Identifiable Assets:			
Aviation and electronics	**$ 390.6**	$ 395.9	$ 364.5
Specialty metals	**312.7**	288.7	263.0
Industrial	**270.7**	263.7	251.5
Consumer	**91.9**	86.8	79.2
Corporate	**500.4**	396.9	413.7
	1,566.3	1,432.0	1,371.9
Net assets of discontinued operations	**1,880.8**	1,817.1	1,703.6
	$3,447.1	$3,249.1	$3,075.5
Capital Expenditures:			
Aviation and electronics	**$ 28.3**	$ 31.9	$ 29.2
Specialty metals	**52.3**	25.4	21.3
Industrial	**34.0**	17.9	17.1
Consumer	**21.2**	8.3	5.7
Corporate	**8.8**	9.5	8.7
	$ 144.6	$ 93.0	$ 82.0

Note 9. Discontinued Operations. In January 1990, the Board of Directors approved a plan to spin off the insurance and finance subsidiaries to the Company's shareholders, subject to various regulatory procedures. The units involved, to be subsidiaries of a new company called Unitrin, Inc., are United Insurance Company of America and subsidiaries (United), Trinity Universal Insurance Company and subsidiaries (Trinity) and Fireside Securities Corporation and subsidiaries. The consolidated financial statements of Teledyne, Inc. and subsidiaries have been restated to present these subsidiaries as discontinued operations.

The following condensed statements summarize the combined financial position and operating results of the insurance and finance subsidiaries (in millions):

Combined Balance Sheets
December 31, 1989 and 1988

	1989	*1988*
Assets:		
Investments:		
Fixed maturities, at amortized cost (market: 1989—$2,172.3; 1988—$2,131.8)	**$2,157.7**	$2,158.7
Equity securities, at market (cost: 1989—$73.5; 1988—$67.3)	**176.6**	152.7
Investees, at cost plus cumulative earnings (market: 1989—$618.2; 1988—$572.7)	**431.7**	373.5
Other	**293.3**	219.0
	3,059.3	2,903.9
Receivables:		
Thrift sales contracts and loans	**337.5**	309.3
Other	**181.2**	183.4
	518.7	492.7
Deferred policy acquisition costs	**225.2**	171.9
Cost in excess of net assets of purchased businesses	**216.1**	154.1
Other assets	**97.7**	74.6
	$4,117.0	$3,797.2
Liabilities and Shareholder's Equity:		
Insurance Reserves:		
Life, accident and health	**$1,152.7**	$1,016.6
Property and liability	**292.6**	275.8
	1,445.3	1,292.4
Thrift investment certificates and passbook accounts	**347.5**	308.6
Unearned premiums	**186.4**	167.4
Accrued and deferred income taxes	**106.9**	94.1
Accrued expenses and other liabilities	**149.8**	117.7
	2,235.9	1,980.2
Shareholder's Equity:		
Common stock	**14.0**	14.0
Additional paid-in capital	**165.4**	161.0
Retained earnings	**1,633.6**	1,586.0
Net unrealized appreciation on equity securities	**68.1**	56.0
	1,881.1	1,817.0
	$4,117.0	$3,797.2

During 1989, United acquired Union National Life Insurance Company for $194.3 million which exceeded the fair value of net assets by $60.6 million. Various state insurance laws restrict the amount that insurance subsidiaries may transfer to their parent in the form of dividends, loans or advances without the prior approval of regulatory authorities. At December 31, 1989, $104.8 million of subsidiaries' shareholder's equity was unrestricted. Retained earnings of the insurance and finance subsidiaries at December 31, 1989 include $217.4 million representing undistributed earnings of investees.

Combined Statements of Income
For the Years Ended December 31, 1989, 1988 and 1987

	1989	1988	1987
Premium and Other Revenues:			
Premiums	**$ 835.5**	$ 808.2	$ 822.2
Net investment income	**210.2**	200.1	181.2
Thrift and loan revenues	**61.1**	57.2	53.2
	1,106.8	1,065.5	1,056.6
Benefits and Expenses:			
Benefits and loss expenses	**563.7**	524.4	538.2
Underwriting, acquisition and insurance expenses	**388.7**	362.8	347.8
Thrift and loan and other expenses	**66.5**	58.4	66.6
	1,018.9	945.6	952.6
	87.9	119.9	104.0
Gains on Sales of Investments	**0.8**	118.9	222.6
Income before Income Taxes and Equity in Net Income of Investees	**88.7**	238.8	326.6
Provision for Income Taxes	**24.0**	73.5	106.0
	64.7	165.3	220.6
Equity in Net Income of Investees	**41.6**	36.0	33.7
Net Income	**$ 106.3**	$ 201.3	$ 254.3

Net income of the insurance and finance subsidiaries includes gains on sales of investments of Brockway, Inc. (NY) in 1988 and Kidde, Inc. and Reichhold Chemicals, Inc. in 1987. Income of discontinued operations, as presented in the consolidated financial statements, differs from net income of the insurance and finance subsidiaries principally as a result of adjustments to these gains for income recognized previously on the equity method.

Information on the insurance and finance subsidiaries' business segments for the years ended December 31, 1989, 1988 and 1987 was as follows (in millions):

	1989	1988	1987
Premiums:			
Life	**$ 246.3**	$ 240.7	$ 235.1
Accident and health	**145.7**	144.6	163.8
Property	**244.7**	235.8	245.9
Liability	**198.8**	187.1	177.4
	$ 835.5	$ 808.2	$ 822.2
Income before income taxes:			
Life	**$ 4.3**	$ 3.9	$ 14.2
Accident and health	**5.2**	(2.4)	(20.7)
Property	**(28.1)**	36.5	37.9
Liability	**13.2**	(13.8)	(0.8)
Operating profit	**(5.4)**	24.2	30.6
Unallocated net investment income	**96.3**	94.9	85.0
Thrift and loan	**2.0**	5.1	3.8
Gains on sales of investments	**0.8**	118.9	222.6
Other	**(5.0)**	(4.3)	(15.4)
	$ 88.7	$ 238.8	$ 326.6

The operating profit of the business segments includes a portion of net investment income which was allocated based on investable funds generated by the segments. Results of operations for the year ended December 31, 1989 included losses due to severe storms in the Southwest as well as the effect of strengthening reserves at the casualty insurance companies.

Note 10. Commitments and Contingencies. The Company is defending a class action brought in the Chancery Court of Delaware alleging claims relating to the Company's offer to repurchase shares of its common stock in February 1976. The action seeks compensatory and punitive damages in an indeterminate amount and alternatively, rescission. The Company believes that the allegations made in the complaint are not meritorious and that the Company has adequate legal defenses.

Agreement has been reached with the Internal Revenue Service (IRS), subject to receipt of definitive documentation, that the Company has no accumulated earnings tax liability for either 1981 or 1980. The IRS had previously proposed the imposition of an accumulated earnings tax of $122 million for 1981 and $128 million for 1980 in connection with the audit of the Company's consolidated Federal tax liability. It is possible that the IRS may choose to assert the accumulated earnings tax issue for one or more subsequent years.

On May 5, 1989, agents of the Federal Bureau of Investigation and the Defense Criminal Investigative Service executed a search warrant on and removed a number of documents relating to contracts and pricing from the Company's Teledyne Systems unit. In addition, several Teledyne Systems employees received subpoenas to testify before a federal grand jury. Based on an ongoing internal review, and after consultation with counsel, the Company does not possess sufficient information to determine whether the Company will sustain a loss as a result of the investigation, or to reasonably estimate the amount of any such loss. Consequently, the Company has not been able to identify the existence of a material loss contingency arising from the investigation.

Note 11. Subsequent Events. In January 1990, the Board of Directors declared a five for one split of the Company's common stock. Teledyne shareholders of record February 8, 1990 will receive four additional shares for each share of Teledyne stock held. The shares are expected to be distributed on March 8, 1990.

The Board of Directors also approved a plan to spin off the insurance and finance subsidiaries to the Company's shareholders. Teledyne has received a ruling from the Internal Revenue Service that the distribution will be tax-free to the Company's shareholders and to Teledyne. The proposed transaction is expected to be effective March 31, 1990, if all regulatory clearances have been obtained.

The Teledyne Board of Directors declared a quarterly cash dividend of $1.00 per share payable February 21 to shareholders of record February 7, 1990.

Teledyne has authorized the redemption on March 15, 1990 of its 7⅞% Sinking Fund Debentures due 1994. The debentures are being called at a price of $1,010.92 plus accrued interest to the redemption date of $29.3125 per $1,000.00 principal amount of debenture. There are approximately $6.8 million principal amount of debentures currently outstanding.

Selected Quarterly Financial Data

(In millions except share and per share amounts)

Quarterly financial data for 1989 and 1988 were as follows:

	Quarter Ended			
	March 31	*June 30*	*September 30*	*December 31*
1989–				
Sales	$864.3	$907.7	$875.8	$883.4
Income of continuing operations before taxes	$ 57.1	$ 52.2	$ 67.7	$ 54.7
Income of continuing operations	$ 35.2	$ 32.8	$ 43.5	$ 38.8
Income of discontinued operations	35.3	14.0	35.2	24.1
Net income	$ 70.5	$ 46.8	$ 78.7	$ 62.9
Per share data:				
Income of continuing operations	$ 3.16	$ 2.97	$ 3.92	$ 3.50
Income of discontinued operations	3.16	1.26	3.18	2.18
Net income per share	$ 6.32	$ 4.23	$ 7.10	$ 5.68
Per share data adjusted for the 5 for 1 common stock split to be distributed March 8, 1990:				
Income of continuing operations	$ 0.63	$ 0.59	$ 0.79	$ 0.70
Income of discontinued operations	0.63	0.26	0.63	0.44
Adjusted net income per share	$ 1.26	$ 0.85	$ 1.42	$ 1.14
1988–				
Sales	$849.9	$868.8	$838.7	$977.2
Income of continuing operations before taxes	$ 75.6	$ 69.5	$ 66.6	$103.0
Income of continuing operations	$ 47.7	$ 43.9	$ 41.9	$ 63.6
Income of discontinued operations	101.1	23.5	35.5	34.6
Net income	$148.8	$ 67.4	$ 77.4	$ 98.2
Per share data:				
Income of continuing operations	$ 4.10	$ 3.77	$ 3.64	$ 5.61
Income of discontinued operations	8.69	2.03	3.10	3.07
Net income per share	$12.79	$ 5.80	$ 6.74	$ 8.68
Per share data adjusted for the 5 for 1 common stock split to be distributed March 8, 1990:				
Income of continuing operations	$ 0.82	$ 0.75	$ 0.73	$ 1.12
Income of discontinued operations	1.74	0.41	0.62	0.62
Adjusted net income per share	$ 2.56	$ 1.16	$ 1.35	$ 1.74

Amounts have been restated to reflect the Company's insurance and finance subsidiaries as discontinued operations.

The Company experienced a decline in profit in 1989 in the aviation and electronics segment as a result of higher than anticipated costs on certain defense contracts and decreased demand in the defense sector. Income of discontinued operations in 1989 included losses due to severe storms in the Southwest as well as the effect of strengthening reserves at the casualty insurance companies in the fourth quarter. Income of discontinued operations for the first quarter of 1988 includes gains on sales of investments of $63.8 million.

The Company paid cash dividends of $1.00 per share for each quarter in 1989 and 1988. The Company had average shares outstanding of 11,155,767 in the first quarter of 1989 and 11,082,569 for the second, third and fourth quarters of 1989. In 1988, the Company had average shares outstanding of 11,634,825, 11,616,578, 11,484,775 and 11,320,289 in the first, second, third and fourth quarters, respectively.

Selected Financial Data

For the Five Years Ended December 31, 1989
(In millions except per share amounts)

	1989	1988	1987	1986	1985
Sales	$3,531.2	$3,534.6	$3,216.8	$3,241.4	$3,256.2
Income of continuing operations before income taxes	$ 231.7	$ 314.7	$ 273.5	$ 183.5	$ 248.2
Income of continuing operations	$ 150.3	$ 197.1	$ 162.6	$ 105.7	$ 141.9
Income of discontinued operations	108.6	194.7	214.6	132.6	404.5
Net income	$ 258.9	$ 391.8	$ 377.2	$ 238.3	$ 546.4
Per share data:					
Income of continuing operations	$ 13.54	$ 17.12	$ 13.90	$ 9.03	$ 12.12
Income of discontinued operations	9.78	16.91	18.35	11.32	34.54
Net income per share	$ 23.32	$ 34.03	$ 32.25	$ 20.35	$ 46.66
Per share data adjusted for the five for one common stock split to be distributed March 8, 1990:					
Income of continuing operations	$ 2.71	$ 3.42	$ 2.78	$ 1.81	$ 2.42
Income of discontinued operations	1.95	3.39	3.67	2.26	6.91
Adjusted net income per share	$ 4.66	$ 6.81	$ 6.45	$ 4.07	$ 9.33
Working capital	$ 594.7	$ 553.2	$ 550.8	$ 380.3	$ 301.6
Net assets of discontinued operations	$1,880.8	$1,817.1	$1,703.6	$1,529.0	$1,620.9
Assets	$3,447.1	$3,249.1	$3,075.5	$2,685.3	$2,699.4
Long-term debt	$ 571.3	$ 578.0	$ 576.9	$ 577.1	$ 669.2
Shareholders' equity	$2,326.9	$2,138.4	$1,976.0	$1,636.6	$1,577.4

Years 1985 through 1988 have been restated to reflect the Company's insurance and finance subsidiaries as discontinued operations. In 1987, the Company changed its method of accounting for pension expense, as required by SFAS No. 87. Income of continuing operations before income taxes includes a credit of $22.9 million in 1989, $30.5 million in 1988 and $26.7 million in 1987 compared to pension expense of $47.8 million in 1986 and $47.4 million in 1985. The Company paid cash dividends of $4.00 per share in 1989, 1988 and 1987.

Management's Discussion and Analysis of Financial Condition and Results of Operations

The Company's consolidated operations consist of a large number of divisions operating in a variety of industries. For reporting purposes Teledyne's continuing operations are summarized in the segments presented in Note 8 to the consolidated financial statements. It is not practical to identify and explain fluctuations for any operating units or groups of units smaller than these segments.

Sales in the aviation and electronics segment increased from 1985 to 1988 but decreased significantly in 1989. Sales in the specialty metals segment increased each year since 1985 with a large increase in 1988. The industrial segment showed sales decreases in 1986 and 1987 with an increase in 1988. Consumer segment sales have increased steadily since 1985.

Operating profit decreased $63.8 million in 1989 after increasing $37.9 million in 1988 and $80.4 million in 1987. The 1989 decrease was principally in the aviation and electronics segment as a result of higher than anticipated costs on certain defense contracts and decreased demand in the defense sector. The 1988 increase in the specialty metals segment resulted principally from increased demand in the transportation, capital equipment and aerospace industries. The increase in operating profit in 1987 was the result of a change in the method of accounting for pension expense as required by the Financial

Accounting Standards Board (FASB). Operating profit included a credit of $22.9 million in 1989, $30.5 million in 1988 and $26.7 million in 1987 compared to pension expense of $47.8 million in 1986 and $47.4 million in 1985. In 1986, operating profit in the aviation and electronics segment decreased as a result of increased expenses on research and development contracts and lower margins. The 1986 decrease in the industrial segment was primarily the result of depressed economic conditions in various oil service related products. Operating profit includes gains on sales of investments of $36.7 million in 1985. The effect of inflation did not have a material impact on net income from 1985 to 1989.

The Company's effective Federal income tax rate decreased in 1988 as a result of the Tax Reform Act of 1986 which lowered the Federal income tax rate on ordinary income to 34 percent in 1988 from 40 percent in 1987 and 46 percent in 1986. The FASB has issued a statement which requires a change in accounting for income taxes. This statement must be implemented no later than 1992. The Company has not yet determined the impact of the adoption of this statement on the financial statements or the date or method of adoption.

In January 1990, the Board of Directors approved a plan to spin off the insurance and finance subsidiaries to the Company's shareholders, subject to various regulatory procedures. The units involved, to be subsidiaries of a new company called Unitrin, Inc., are United Insurance Company of America and subsidiaries, Trinity Universal Insurance Company and subsidiaries and Fireside Securities Corporation and subsidiaries. The consolidated financial statements of Teledyne, Inc. and subsidiaries have been restated to present these subsidiaries as discontinued operations.

Income of discontinued operations for 1989 included losses due to severe storms in the Southwest as well as the effect of strengthening reserves at the casualty insurance companies. Income of discontinued operations also included the $81.7 million income effect from the distribution of Litton debentures in exchange for Litton common stock in 1985 and gains on sales of investments of $68.8 million in 1988, $104.8 million in 1987, $17.0 million in 1986 and $148.6 million in 1985. Income of Argonaut Group, which was distributed to the Company's shareholders in September 1986, was $16.5 million in 1986 and $64.2 million in 1985.

During 1984, the Company acquired 8,661,053 shares of its common stock. This purchase of stock was financed through bank loans of $800.0 million and through internally generated funds, which were obtained from sales of equity securities. The bank loans were repaid as follows: $97.5 million in 1986, $402.5 million in 1985 and $300.0 million in 1984.

Shareholders' equity increased each year since 1985. These increases were the result of net income reduced by the acquisition and retirement of stock of $37.6 million in 1989 and $155.6 million in 1988, cash dividends of $44.5 million in 1989, $46.1 million in 1988 and $46.8 million in 1987 and the distribution of Argonaut Group of $217.2 million in 1986.

In January 1990, the Board of Directors declared a quarterly cash dividend of $1.00 per share payable February 21 to shareholders of record February 7, 1990. In addition, the Board of Directors declared a five for one common stock split to be distributed March 8, 1990 to shareholders of record February 8, 1990. The financial statements have not been restated to reflect this event. Management expects to recommend that future dividends will be set at an annual rate of $4.00 per share on a pre-split basis for each company, Teledyne and Unitrin.

Except for the potential effects of the matters discussed below, the Company has been able to meet all cash requirements during the past five years with cash generated from operations and is not aware of any impending cash requirements or capital commitments which could not be met by internally generated funds.

Capital expenditures have increased in 1989 over previous years. This increase has been financed through internally generated funds. It is probable that the 1989 level of capital expenditures will continue in 1990. Certain of the Company's units have initiated major technological improvements by which they intend to improve productivity. If funds are needed beyond those internally generated, the Company could obtain funds for future capital requirements, depending on prevailing economic circumstances, through the sale of equity securities or other securities with an equity component, the utilization of existing credit lines with various banks or other borrowings.

Agreement has been reached with the Internal Revenue Service (IRS), subject to receipt of definitive documentation, that the Company has no accumulated earnings tax liability for either 1981 or 1980. The IRS had previously proposed the imposition of an accumulated earnings tax of $122 million for 1981 and

$128 million for 1980 in connection with the audit of the Company's consolidated Federal tax liability. It is possible that the IRS may choose to assert the accumulated earnings tax issue for one or more subsequent years.

Company subsidiaries perform work on a substantial number of defense contracts with the U.S. government. Many of these contracts include price redetermination clauses, and most are terminable at the convenience of the government. In addition, virtually all defense programs are subject to curtailment or cancellation due to the annual nature of the government appropriations and allocations process.

As a defense contractor, the Company is subject from time to time to various audits, reviews and investigations by the U.S. government relating to the Company's compliance with federal contracting requirements. Were any investigation to result in an indictment, the unit involved, and conceivably the Company, could be suspended for an indeterminate period of time from receiving new government contracts or government-approved subcontracts.

On May 5, 1989, agents of the Federal Bureau of Investigation and the Defense Criminal Investigative Service executed a search warrant on and removed a number of documents relating to contracts and pricing from the Company's Teledyne Systems unit. In addition, several Teledyne Systems employees received subpoenas to testify before a federal grand jury. Based on an ongoing internal review, and after consultation with counsel, the Company does not possess sufficient information to determine whether the Company will sustain a loss as a result of the investigation, or to reasonably estimate the amount of any such loss. Consequently, the Company has not been able to identify the existence of a material loss contingency arising from the investigation.

The Company is subject to increasingly stringent laws and regulations concerning the environment. A number of environmental lawsuits, claims and proceedings have been asserted against the Company by governmental authorities as well as individuals. The Company intends to pursue vigorously any and all defenses available in these proceedings, and is seeking to establish insurance coverage with respect to certain of them. In the opinion of the Company, the ultimate resolution of these lawsuits, claims and proceedings will not in the aggregate have a material effect on its financial condition or results of operations.

Common Stock Price

	1989				1988			
Quarters	*1st*	*2nd*	*3rd*	*4th*	*1st*	*2nd*	*3rd*	*4th*
High	$373¼	$377¼	$380¼	$369¼	$344½	$348½	$339¼	$338⅝
Low	$331⅝	$345	$357½	$317½	$290¼	$320¼	$317	$321¾

Teledyne, Inc. common stock is listed on the New York and Pacific Stock Exchanges. As of December 31, 1989, there were approximately 15,000 record holders of common stock.

OUTLINE OF PRODUCTS AND ACTIVITIES

Aviation and Electronics: Products in the closely related fields of aviation and electronics range from the microscopic world of semiconductor devices to full-scale air frames and complete aircraft.

Teledyne's hybrid microcircuits are widely used in military, space, industrial and medical applications. These compact and complex electronic building blocks combine multiple transistors and integrated circuits in small packaging sizes, where reliability and light weight are of paramount importance. Thousands of these microcircuits, the size of postage stamps, have been produced, and are providing the precise control required for heart pacemakers and interplanetary missions, as well as many other uses.

On a still larger scale are Teledyne's high power traveling wave tubes, used to simultaneously transmit thousands of telephone conversations – or a dozen television channels–around the world via satellite networks.

Similar types of traveling wave tubes are used in the latest airborne and ground-based electronic counter measure equipment.

Other components include operational amplifiers, digital-analog converters, miniature relays, hybrid switching devices, radar augmenters, lower power microwave tubes, flexible printed-circuit interconnections, high reliability wire and cable, switches, terminals and a line of aircraft, military tank and truck batteries.

In the microwave industry, Teledyne is a leading supplier of ferrite components and switching devices, as well as filters, oscillators and integrated subsystems.

At the systems level, Teledyne produces equipment for telemetering data from remote sources, for electronic counter measures, and for information processing, as well as the aircraft integrated data systems used by dozens of major airlines to record in-flight performance and maintenance data on their jumbo jets.

Teledyne also performs systems engineering and integration for ballistic missile defense, space defense, shuttle payloads, computer software, and designs and produces military airborne training and evaluation systems.

Computing and inertial systems are also produced for the control and guidance of aircraft and space vehicles. Teledyne on-board computers have successfully controlled the launching of dozens of spacecraft, including both Viking missions to Mars.

Teledyne is heavily involved in electronic navigation systems, as well, with Loran and Omega navigators for long-range sea and air navigation and Raydist systems for precise radiolocation in coastal waters. Doppler radar systems produced by Teledyne were used on 24 successful space landings and guided each Apollo lander to the surface of the moon. Similar Doppler radars are used in military aircraft for anti-submarine warfare and search-and-rescue missions.

Teledyne avionic instruments and electronic systems contribute substantially to flight safety on both military and general aviation aircraft.

The use of the latest microcircuit technology and modern cryptographic algorithms permit Teledyne to supply very advanced identification equipment (IFF) used on military and commercial aircraft for peacetime air traffic control and for safe operation in a wartime environment.

Among Teledyne's many non-electronic products for aviation are controlled explosive devices that precisely time, sequence and actuate aircraft escape systems, and similar pyrotechnic devices used to separate the stages of space vehicles, and to eject or deploy instrument packages. Teledyne also produces parachute delivery systems for accurate airdrop of military cargo or emergency supplies.

Precise hydraulic and pneumatic actuating systems and components are made for fixed and rotary wing aircraft, as are ground support systems such as frequency and power converters and jet engine starters for commercial and general aviation use.

Continental piston engines have been powering airplanes for sixty years, and today about half of the general aviation piston engines produced in the United States are built by Teledyne and used worldwide. Teledyne turbine engines also power remotely piloted aircraft, military trainers and, in small, expendable versions, provide power for the Harpoon and other cruise missiles. Teledyne also services and overhauls turbines manufactured by others for both military and general aviation use.

The Company's expertise in airframe manufacture goes back to Charles Lindbergh's Spirit of St. Louis which was built by Ryan Airlines, Inc., forerunner of today's Teledyne Ryan Aeronautical. More than twenty-five types of remotely piloted aircraft–usually called RPVs–have been built by Teledyne, in both supersonic and subsonic versions. These recoverable and reusable vehicles are used for sophisticated military missions with the pilots safely flying them from remote control centers. Teledyne also builds the airframe for the Army attack helicopter and has produced thousands of feet of tapered, roll-formed stringers used in wide-body aircraft.

Through the production of sophisticated RPVs, Teledyne has also developed broad expertise in the use of advanced materials such as graphite composites, and has facilities for the numerically-controlled machining of airfoils from honeycomb materials.

Teledyne's participation in all these diverse areas of aviation, space and electronics has given the Company highly developed expertise in some of the most advanced technologies of our time.

Specialty Metals: The products of this business segment are representative of the practical application of metallurgical science and technology as it is known and practiced throughout the world. Their unique characteristics are derived from the nature of the metals produced, the particular properties of the alloys melted, and the various processes, methods, forms, shapes and end products manufactured.

In specialty metals, Teledyne is the most diversified producer of reactive and refractory metals in the United States. Teledyne produces all of the larger volume, commercially important metals and their alloys. Reactive metals production includes titanium, zirconium and hafnium; refractory metals consist of tungsten, molybdenum, niobium, tantalum and vanadium.

Teledyne is the leading U.S. producer of zirconium, a highly corrosion-resistant metal that is transparent to neutrons. It is used for fuel tubes and structural parts in nuclear power reactors, in the form of foil in photographic flash cubes, and for corrosion-resistant chemical industry applications. Hafnium, derived as a by-product of zirconium, is used for control rods in nuclear reactors due to its ability to absorb neutrons.

Teledyne is a producer of tungsten, starting from a large number of different tungsten bearing raw materials resulting in tungsten and tungsten carbide powders and mill products. Previously used cemented carbide parts are also recycled into tungsten carbide powder. Wrought or ductile tungsten products are used in diverse applications including light bulb filaments, inert gas welding electrodes, electrical contacts and aircraft counterweights.

Molybdenum, a sister metal to tungsten that also has a very high melting point, is produced by Teledyne in powder form and then shaped into solid forms through powder metallurgy techniques. It is an important alloying element for steels and is used for plasma arc spraying of piston rings, for electrodes in glass melting and for structural parts in high temperature furnaces.

Niobium, also known as columbium, is a high technology metal produced by Teledyne in various forms and alloys. It is used as an alloying element in the manufacture of many steels. The higher quality grades produced by Teledyne are used in superalloys for jet engines and special alloys for aerospace applications such as rocket nozzles. When alloyed with titanium, niobium is used in applications requiring superconducting characteristics for high-strength magnets. This rapidly developing field includes medical devices for body-scanning, accelerators for high-energy physics and fusion energy projects for future generation of electricity.

Tantalum, one of the most corrosion resistant metals, is produced by Teledyne for medical implants, chemical process equipment, and aerospace engine components.

Specialty metals include the special alloys that are central to the production of virtually every modern metal product available today.

Teledyne high-speed steels provide the high temperature hardness required for lathe bits, drills, milling cutters, taps and dies and other cutting tools. Related alloy steels, including a cobalt-free maraging grade, are produced for bearings, gears, special aerospace hardware and high-strength applications.

For the metalworking, mining and other industries requiring machine tools with extra hardness, Teledyne produces a line of sintered tungsten carbide products, made from tungsten carbide and various other metals under heat, to produce a material that approaches diamond in hardness. These cemented carbide products are used as super-hard cutters in the high-speed machining and cutting of steel and other applications where hardness and wear resistance are important. Technical developments related to ceramics, coatings and other disciplines are incorporated in these products.

Furthermore, Teledyne is an integrated producer of vacuum-melted nickel base, titanium base and iron base superalloys that are used worldwide to meet the high performance requirements of the aircraft, aerospace, gas turbine, nuclear energy and chemical process industries. These products, in various forms, are engineered to retain exceptional strength and corrosion resistance at temperatures through 2,000 degrees F and are used in critical, high-stress applications. Notably, this manufacturing facility installed one of the largest high precision rotary forging presses in the U.S. for more efficient working of these products.

Teledyne also processes metals by a variety of methods, including casting, forging, rolling, drawing and extruding, into finished forms used in a diverse number of industries.

For example, Teledyne is a specialist in the cold rolling of thin and ultra-thin metal strip in over 60 different metals and alloys for applications ranging from watch springs and flash bulbs to aerospace honeycomb materials and camera products.

Teledyne also casts a variety of metals into forms ranging from 90-ton steel mill rolls to lightweight aluminum and magnesium aircraft parts. Housings and parts are made for business machines, tools and automobiles by die casting methods. Cold-finished bar and shafting and cold-drawn stainless and custom fabricated tubing are also produced.

Other Teledyne companies are involved in roll-forming metals, forging heavy parts for construction and earth moving machinery and precision investment casting of difficult to produce parts.

Industrial Products: Engines of many sorts – air and liquid cooled, gasoline and diesel fueled – are products in this category. Teledyne piston engines range in power from lightweight, portable, air-cooled engines of a few horsepower up to heavy-duty turbo-charged diesel engines approaching 1,750 horsepower for use in military tanks and heavy construction equipment.

Another category of industrial products includes machine tools, dies and consumable tooling of all types. These range from numerically-controlled pipe and tube bending machines to a great variety of machines designed for the high speed production of precision machine threads by cutting, grinding and roll-forming methods, and a variety of similar equipment for the production of precision roll-formed gears. Presses, cut-off machines and can-making machines are also produced.

Other Teledyne production equipment includes transfer and assembly machines for the automated production of many kinds of products, as well as multi-gun automated resistance welding machines, single station manual resistance welding machines, welding power supplies, are welding equipment and consumable supplies, such as welding electrodes and tubular and solid welding wire.

Unusual among Teledyne's welding products are the world's largest welding positioners and manipulators with capacities to 450 tons. These immense Teledyne machines are used worldwide by the nuclear industry for welding and cladding nuclear reaction vessels with stainless steel.

Teledyne also produces complete automated bakery production lines and mixing and processing equipment for a variety of chemical, food and pharmaceutical products.

Related to the machine field are Teledyne's optical encoders and digital readouts which may be added to existing milling machines and other machine tools to modernize them, and to improve operator output and the accuracy of the work produced.

Specialized Teledyne encoders are also incorporated in many electro-mechanical devices such as robots in order to provide precise positioning information.

Teledyne also makes a variety of analytical instruments for pollution control, mine and industrial safety, petrochemical process control, and for medical and deep sea saturation diving applications.

These include percentage and parts per million oxygen detectors, hydrocarbon detectors and photometric instruments for measuring oil or phenol in water and dozens of other chemicals in the parts per million or billion range. Other related products include a variety of instruments for the physical testing of materials; meteorological instruments; equipment and services for the detection, monitoring and analysis of radioactive materials including dosimeters for monitoring the exposure levels of nuclear industry personnel; high-speed motion picture cameras; and equipment for the film recording of video images.

Computer-based control systems are provided to the petrochemical industry for controlling the flow of natural gas and oil through nationwide networks of pipelines. Electrically actuated control valves and large safety relief valves are supplied to this as well as to other industries.

Teledyne also produces a complete line of geophysical instrumentation and related computer systems that are used throughout the world in earthquake monitoring and oil exploration.

In addition, Teledyne carries out seismic surveys on land and under the sea bottom on a contract basis to locate likely oil-bearing strata for major oil companies.

Related activities include the fabrication and installation of large offshore platforms for the oil industry, as well as drilling and workover services and a variety of maintenance and salvage operations carried out in offshore areas.

The Company owns and operates sea-going derrick barges with up to 800-ton lifting capacity and numerous jack-up drilling rigs to carry on this work for the oil industry.

Sophisticated computer-designed gas lift equipment and services are also provided by the Company for increasing the flow from oil wells and controlling the flow on the surface. In addition, producing reservoirs are studied using radioisotopic tracer services provided by the Company.

Uninterruptible power supplies are produced for the computer industry to eliminate computer failures caused by substandard power or momentary power interruptions.

In the event of power failures, Teledyne emergency lighting equipment can provide safe illumination for continuing operations.

Thermoelectric generators fueled with propane or natural gas are made for use in remote, unattended locations where electrical power is required, and other Teledyne thermoelectric generators powered by radioisotopic materials provide power for deep space missions. This same Teledyne company also produces high purity electrolytic hydrogen generators that are used in many laboratory and industrial applications.

Among Teledyne's remaining miscellaneous industrial activities are the production of solid rubber urethane tires and molded products for the automotive industry.

Consumer: The Teledyne name is widely represented through its consumer products.

Teledyne's best known consumer products are sold under the brand name of Teledyne Water Pik. The Water Pik® oral hygiene appliance line includes a family of dental hygiene devices for use in the home, including oral irrigators, electric toothbrushes and an oral hygiene center combining both products.

Teledyne Water Pik also manufactures and markets a complete line of showerheads, including the Shower Massage® line of invigorating, pulsating showerheads and the Super Saver® line of energy saving, multi-mode spray showerheads.

The Instapure® line, includes both faucet mounted and under-the-counter water filters for improving the quality of water used in the home, as well as a line of air filtration appliances for the home and office that utilize a patented low temperature catalyst material to remove carbon monoxide and other noxious gases from the air.

In an entirely different consumer area are Teledyne Laars swimming pool and spa heaters. The company also produces a full line of water heating equipment that provides hot water for commercial, residential and industrial space heating.

Teledyne also makes supplies and equipment for dentists and dental laboratories. Among these are dental cements, impression compounds, filling materials, tungsten carbide and diamond drilling burs, air and electric drills, and articulators.

Teledyne produces drafting media and materials used for the creation of engineering drawings and diazo equipment required to reproduce and disseminate such information, as well as microfilm and microfiche.

Products often sold directly to consumers are battery powered lamps, lanterns, engineering drafting supplies for professional and school use, plastic cups, containers, and wood specialty products.

Officers

GEORGE A. ROBERTS, *President and Chief Executive Officer*

WILLIAM P. RUTLEDGE, *Executive Vice President*

HUDSON B. DRAKE, *Senior Vice President*

JERROLD V. JEROME, *Vice President*

LEO W. KILLEN, *Vice President*

ALLEN H. ORBUCH, *Vice President*

JUDITH R. NELSON, *General Counsel and Secretary*

GORDON J. BEAN, *Treasurer*

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This **Teledyne Report** explores Teledyne Geotech's activities in and contributions to the field of seismology, an earth science that deals with the technology of detecting, measuring and analyzing earth movements created both by natural phenomena such as earthquakes and by man-made events such as underground nuclear explosions. The company has been a major developer and manufacturer of precise seismological instrumentation for over fifty years and is recognized as a world leader in this field.

This instrumentation and supporting analytical software are used in monitoring of and research into earthquakes, in underground nuclear test verification, and in energy-related research for the oil and gas industries.

In addition to the geophysical product lines, Teledyne Geotech is a major supplier of gas and liquid pipeline Supervisory Control And Data Acquisition (SCADA) systems. Other products include pipeline hydrocarbon leakage alarm systems and meteorological instrumentation.

Teledyne Report, featuring subjects of particular interest among Teledyne activities, is issued on a quarterly basis. Previous topics include:

Instruments:
Measuring wear/measuring pressure.
Dies and Molds:
Making the tools that make the cars.
Aircraft Ground Power Systems:
New turbine technology.
Crash Fire Rescue Vehicles:
Getting there faster with more.
The Inner Zone:
Defending aircraft carriers.
Doppler:
New waves in navigation.
Superconductivity:
Turning up the heat.
Unmanned Airplanes:
Advanced developments.
Composites:
Ultra-light structures for aircraft.
Integrated Circuits:
Bridging the analog and digital worlds.
Microelectronic Hybrids:
State-of-the-art 1987.
Voyager Engine:
Around the world nonstop in 9 days.
Forming Metal:
Lightweight structures for aircraft.
Radon:
Measuring it from the ground up.
IFF:
Electronic passwords for aircraft.
Star Wares:
Products & services for space.
The Water Products:
For health and personal care.
An Ideal Package:
A look at collapsible metal tubes.
Airline Communications:
The digital connection.
High Performance Metals:
Tough alloys for tough environments.
Airframes:
Structures for aircraft.
The Ladle and the Hammer:
Casting and forging iron and steel.
High Tech Wire:
Taking the heat safely.
Electronic Counter Measures:
Protecting friendly forces.
Rubber & Metal:
Working together in automobiles.
Stress Analysis:
How much is enough?
Drafting:
Designs to build by.
Systems Engineering:
Creating complex systems.
Flexible Printed Circuits:
The space age connection.
Mixing:
A fine blend of art and science.
Aircraft Ground Support:
Saving the airlines millions.
Turbine Engines:
Smaller in size and cost.
Heating Water:
For health and home.
Relays:
Thriving in an ultraminiature world.
Truth In Radiation:
A matter of accurate measurement.
Remotely Piloted Vehicles:
Those ingenious flying machines.
Mining Tungsten:
From glowing ore to versatile metal.
Hi-Fi:
Music reproduction goes hi-tech.
Columbium:
From superconductivity to computers.
Energy:
Fueling spaceship earth.
Radar:
Sensing the unseeable.
Fluid Power:
Muscle for machines.
Pipeline Controls:
Operating petroleum pipelines.
The Aerospace Metals:
Superalloys and titanium.
Screw Threading:
Machine tools for industry.
Aerial Mapping:
Advanced digital techniques.
The Water Pik Story:
Innovative consumer product designs.
Dental Health:
Supplies for the dentist.
Space Navigation:
Computers that guide space launches.
Analytical Instruments:
Chemical detection for industry.
1776–1976:
Technology then and now.
Life Insurance:
Financial security and investment.
The Refractory Twins:
Producing tungsten and molybdenum.
The Instrument Makers:
Instruments and optical encoders.
Industrial Engines:
Small piston engines.
Job Corps:
Teaching young people new skills.
Friendly Explosives:
Aircraft emergency escape systems.
Microelectronic Hybrids:
The step beyond integrated circuits.
The Energy Options:
Nuclear fuel versus coal.
Drilling for Offshore Oil:
Getting the oil out.
The Search for Oil:
Finding new oil deposits.
High Speed Steels:
Premium alloys for machine tools.
Energy Crisis in the Computer Room:
Controlling power quality.
Raydist:
Super-precise radiolocation system.
Welding:
Advanced alloys for joining metals.
General Aviation Engines:
Piston power for aircraft.
Rubber:
Products for automobiles and industry.
Loran:
All-weather navigation system.
Seismology:
Instruments for earthquakes.
Casting:
Precision production of metal parts.
Aircraft Integrated Data Systems:
Monitoring commercial aircraft.
Thermoelectrics:
Direct conversion of heat to electricity.
Thin Metals:
How they are made and used.
The Reproduction of Music:
Speakers for high fidelity sound.
The Crowded Spectrum:
Microwave traveling wave tubes.
Science and Cinematography:
Motion pictures for scientific analysis.
Superalloys:
High temperature metals.
Jets of Water for Dental Health:
The Water Pik Oral Hygiene appliance.
The Last Eight Miles:
Doppler radar for moon landings.

TELEDYNE, INC.