TELEDYNE REPORT

For the Year 1971

Seismology: Science of Earthquakes and Exploration

Center stripes on a highway near the Van Norman Reservoir in California were offset when the road shifted during the 1971 San Fernando earthquake. Vertical or horizontal ground offsets of 10 to 20 feet are not uncommon along fault lines in major earthquakes.

Results in fiscal 1971 declined from the peaks reached in 1970. Consolidated sales declined 9.4% to $1.1 billion. Net income was down 9.2% to $56.2 million, and earnings per share dropped 11.7% to $1.58. This was the first year that Teledyne did not record a year to year increase in net income and earnings per share.

On pages 16 and 17 we present tables breaking down revenues and net income by major product line. These tables show that net income and sales declined in Industrial Products and Services, Aviation and Electronics, and Specialty Metals. In Consumer Products and Services net income also declined, although there was a slight increase in sales. On the other hand, our Insurance and Finance subsidiaries showed significant gains in revenues, and Teledyne's equity in the net income of these unconsolidated subsidiaries rose substantially, offsetting to a large degree the income reductions in our other product lines.

Teledyne's financial condition continued strong throughout the year. Consolidated assets rose to $1.08 billion, and assets of unconsolidated subsidiaries increased to $963 million. Shareholders' equity at year end was $617 million. The ratio of current assets to current liabilities was over three to one. Net interest expense for the year declined to $16 million.

During the year all of the company's outstanding $3.50 series preferred stock was either converted into common stock or redeemed for $100 per share. At year end Teledyne held 368,358 shares of its own common stock in the treasury, which were purchased in the open market at a cost of $7.3 million.

George A Roberts
President

Henry E. Singleton
Chairman of the Board of Directors

Richter Scale 8.5-8.9

1906 Jan 31 Columbia, Ecuador-8.9 · 1933 Mar 2 Japan-8.9 · 1950 Aug 15 Assam-8.5
1960 May 22 Chile-8.5 · 1964 Mar 28 Alaska-8.5

Richter Scale 8.0-8.4

1904 Jun 25 Kamchatka-8.1 · 1905 Apr 4 Kangra, India-8.0 · 1905 Jul 9 S.W. of Lake Baikal-8.2
1905 Jul 23 S.W. of Lake Baikal-8.2 · 1906 Jan 21 Honshu, Japan-8.0
1906 Apr 18 San Francisco-8.2 · 1906 Aug 17 Aleutians-8.0 · 1906 Aug 17 Chile-8.4
1906 Sep 14 New Guinea-8.1 · 1907 Apr 15 Mexico-8.1 · 1907 Oct 21 Karatag-8.0
1910 Jun 16 Loyalty Islands-8.1 · 1911 Jan 3 Tien Shan, Turkestan-8.4
1911 Jun 15 Ryukyu, Japan-8.2 · 1912 May 23 Burma-8.0 · 1914 Nov 24 Marianas-8.1
1917 May 1 Tonga-8.0 · 1917 Jun 26 S.W. of Hawaii-8.3 · 1918 Aug 15 Caroline Islands-8.2
1918 Sep 7 Kurile Islands-8.2 · 1919 Apr 30 Tonga-8.3
1920 Jun 5 Formosa-8.0 · 1920 Sep 30 Fiji-8.0 · 1920 Dec 16 Kansu, China-8.2
1922 Nov 11 Atacama, Chile-8.3 · 1923 Feb 3 Kamchatka-8.3
1923 Sep 1 Kwanto, Japan-8.2 · 1924 Apr 24 Philippines-8.3 · 1927 Mar 7 Tango, Japan-8.0
1927 May 22 Kansu, China-8.0 · 1928 Dec 1 Chile-8.0
1929 Mar 7 Aleutians-8.1 · 1931 Aug 10 Atlas Mountains-8.0 · 1932 May 14 Celebes-8.0
1932 Jun 3 Mexico-8.1 · 1934 Jan 15 India-8.3 · 1934 Jul 18 Santa Cruz Islands-8.2
1938 Feb 1 Java-8.2 · 1938 Nov 10 Bering Sea-8.3
1939 Apr 30 Solomon Islands-8.0 · 1939 Dec 21 Celebes-8.0
1939 Dec 26 Anatolia-8.0 · 1940 May 24 Peru-8.0 · 1941 Jun 26 Burma-8.1
1941 Nov 25 West of Portugal-8.3 · 1942 Aug 24 Brazil-8.1 · 1944 Dec 7 Southern Japan-8.0
1945 Nov 27 Indian Ocean-8.2 · 1946 Aug 4 West Indies-8.1
1946 Dec 20 Japan-8.2 · 1948 Jan 25 Philippines-8.2 · 1949 Jul 10 Tadzhikstan-8.0
1952 Mar 4 Hokkaido, Japan-8.2 · 1952 Nov 4 Kamchatka-8.2
1953 Nov 25 Honshu, Japan-8.2 · 1957 Dec 4 Outer Mongolia-8.0

Richter Scale 7.5-7.9

1904 Jan 20 Panama-7.7 · 1904 Jun 27 Kamchatka-7.9 · 1904 Aug 27 Kolyma, Siberia-7.7
1904 Dec 20 Costa Rica-7.7 · 1906 Dec 22 Sinkiang, China-7.9
1908 Dec 28 Messina-7.5 · 1911 Feb 18 Ferghana, Pamirs-7.7 · 1913 Mar 14 Moluccas-7.9
1914 May 26 New Guinea-7.9 · 1915 May 1 Kamchatka-7.9
1915 Oct 3 Nevada-7.7 · 1916 Jan 13 New Guinea-7.8 · 1924 Jun 26 S.W. of Macquarie Island-7.8
1926 Jun 26 Rhodes-7.9 · 1931 Feb 2 Hawkes Bay, New Zealand-7.7
1932 May 26 Tonga-Kermadec Trench-7.7 · 1935 May 30 Quetta, Baluchistan-7.5
1937 Apr 16 Tonga-7.7 · 1942 May 14 Equador-7.9 · 1942 Aug 6 Guatemala-7.9
1942 Nov 10 South of Africa-7.9 · 1943 Apr 6 Andes-7.9 · 1943 May 25 Philippines-7.9
1943 Sep 6 Macquarie Island-7.8 · 1950 Feb 28 Hokkaido, Japan-7.7
1950 Dec 9 Andes-7.8 · 1951 Dec 8 Indian Ocean-7.7 · 1951 Dec 10 Kermadecs-7.7
1955 Mar 31 Mindanao-7.9 · 1956 Jun 9 Afghanistan: Kabul-7.7
1956 Jul 9 Agean Sea: Santorin-7.7· 1957 Jul 28 Mexico-7.8 · 1958 Jul 10 Alaska, British Columbia-7.8

SEISMOLOGY

This relatively young science has expanded from the classic study of earthquakes to become an important tool in oil and mineral exploration, detection of underground nuclear explosions and earthquake hazard reduction.

Earthquakes have been a scourge of man throughout the ages, as is evidenced by this woodcut (right) from an 1805 German pamphlet "containing an exact description of the fearful earthquake which devastated the city of Naples and the surrounding area on July 16, 1805, at about 10 p.m., and in which more than 4000 people were killed by debris falling from churches and houses."

Since about 1904, records of earthquakes have been kept on a more scientific basis through the instruments and methods of the science of seismology. At left is a listing of some of the earthquakes of magnitude 7.5 or greater that have occurred since that time.

Totals from historical records dating back to 1556 indicate that some 2.3 million persons may have lost their lives directly or indirectly as a result of earthquakes since that time. In the U.S. alone, total dollar losses from all earthquakes are estimated to exceed $1.8 billion.

Each year the earth is shaken by some 10,000 earthquakes of magnitudes 4 to 5 on the Richter scale. Most of these go unnoticed except on sensitive instruments because they happen in remote or uninhabited areas, or are masked by other vibrations. In a single year, however, there are also 10 to 15 quakes of magnitude 7 or greater. These major quakes represent one of the greatest natural hazards to man and his structures, with awesome amounts of energy released in localized areas.

A magnitude 7 earthquake, for example, releases an amount of energy equivalent to the seismic energy from a two megaton underground explosion. Since the Richter scale is logarithmic, each step up in magnitude involves ten times the energy release of the previous magnitude. Thus, a Richter 8 earthquake is ten times larger than a 7, and a hundred times larger than a 6. The largest recorded earthquakes in modern times, one in Colombia in 1906, and one in Japan in 1933, are believed to have reached a magnitude of 8.9.

No area of the earth can be considered completely free of earthquakes though major earthquake activity is centered in certain well-defined belts. It is interesting to note that while the West is the most active seismic area in the United States, one of the most notable series of earthquakes in history occurred near New Madrid, Missouri in 1811-12 and made vast changes in over 5,000 square miles of territory.

Can earthquakes be predicted? Do the tidal forces of the moon and sun trigger them? Are they cyclic or seasonal in nature? Are they related to the periodic changes in the earth's wobble about its axis? Will man ever be able to control them?

These are some of the questions that are being investigated through the discipline of seismology—the study of earthquakes and earth structure. These studies have resulted in a number of significant answers that contribute to the body of knowledge about our restless planet.

What causes earthquakes?

Theories about the origin of earthquakes have varied throughout the ages. The most generally accepted theory among seismologists at present is based on the study of plate tectonics. It postulates that the earth's crust is divided up into about a dozen rigid, continent-size plates that are slowly drifting in relation to one another and setting up strains at the plate edges that may be directly responsible for much seismic activity. The basic mechanism that causes the movement of the plates is believed to be convection currents in the earth's plastic mantle (down to 1800 miles) that carry the more rigid plates along with them.

There is a great deal of evidence to support this theory. Observations show, for example, that North America is moving away from Europe at a rate of one to three inches per year and that the Pacific Basin is rotating counterclockwise with respect to the continents around it. Earthquake fault patterns at some of the interfaces of these relative movements confirm this. Precise geodetic measurements also show that the Farallon Islands, west of San Francisco's Golden Gate, are moving in a northwesterly direction with respect to Mt. Diablo on the mainland. The situation is similar wherever points on opposite sides of California's 600-mile-long San Andreas fault are measured.

Slippage along the faults of these boundary areas occurs every day, frequently in the form of slow creep that can be detected only by sensitive instruments. Some fault zones become locked, however, and strain builds up for months or years. Whatever the initial source of energy is, an earthquake occurs when the accumulated strain exceeds the strength of the crustal rock which breaks and slips. The energy released by this breakage causes elastic waves to propagate through the earth creating the strong shaking and vibratory motion of an earthquake.

Earthquakes are definitely a near-surface phenomenon. Most occur at depths ranging from 10 to 100 miles. The deepest known quakes have been detected at depths of about 450 miles. While this may seem to be a considerable depth it is only about 11% of the distance from the surface to the center of the earth.

Strain accumulates most rapidly at the boundaries between plates, at oceanic ridges and trenches. For example, the collision of the Indian plate with the Asian continent is believed to have caused the uplift of the Himalayas and its associated earthquakes. The trenches and ridges present around the Pacific Ocean basin outline one of the earth's most active seismic regions.

What triggers earthquakes?

If stresses and strains within the earth's crust are the underlying cause of earthquakes, do other geophysical phenomena help trigger them? Earth scientists think this may be so in some cases.

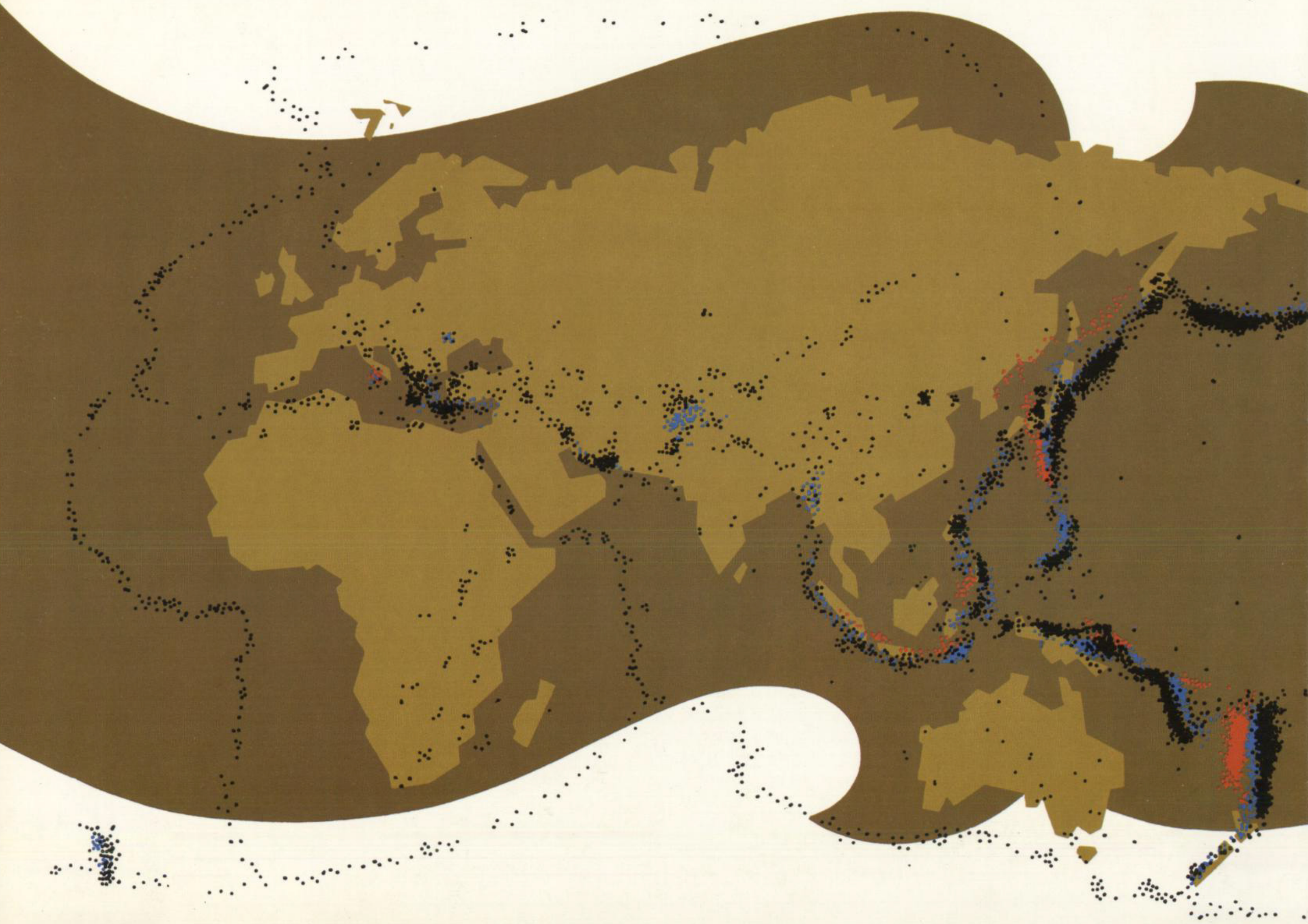
Earth tides, for example, may help set off a quake that is about to happen. The gravitational pull of the moon and sun cause a raising of the surface of the earth just as they do on the seas. In the case of the earth, the ground level only changes a few inches, but it can be detected with sensitive instruments. This change in the loading on the stressed faults may be enough to start a slippage.

Recent observations of moonquakes by seismometers placed on the moon by Apollo astronauts show a definite peak of seismic activity during the part of the month when it is closest to the earth.

Another geophysical phenomenon, the Chandler Wobble, seems to be related to earthquake activity also. The earth wobbles slightly as it spins, causing its axis of rotation to shift in relationship to the geographical North Pole. This shift can be as much as six inches a day and reaches a maximum displacement of over 70 feet during a 14-month cycle. The wobble also reaches a period of major activity every seven years. Studies have shown that earthquake activity reaches a maximum every seven years, coinciding with the peak of the Chandler Wobble cycle. Today, it is generally believed that the Chandler Wobble is caused by the continual redistribution of mass within the earth as a result of slippage along faults.

Man's activities apparently can also trigger earthquakes. The most dramatic example of this was demonstrated when the pumping of liquid wastes into deep wells in the Denver area was accompanied by series of moderate earth tremors. Over a period of many months, after the pumping was started and then stopped, a clear correlation with the incidence of tremors was established.

It has also been noted that seismic activity increases in areas where dams are built. This may be related to loading the earth's crust with many millions of tons of water, and



to water permeation of the geologic strata near the dams.

The shock waves of nuclear explosions have also triggered small series of minor quakes, probably allowing already stressed faults to slip.

Predicting Earthquakes

Past history of seismic areas shows that earthquakes of various sizes can be expected to occur in certain patterns in the future. Calculating the average annual strain accumulation along a fault and comparing it with the average displacement along that fault during an earthquake can give some general estimate of the timing of the next quake. But predicting exactly where and when these events will take place has so far eluded scientists. A number of clues have been uncovered, however, which may someday make more accurate predictions possible.

Just ten hours before a 4.3 magnitude quake in San Francisco last year, unusual readings were noted on tiltmeters in the area. The readings went back to normal after the quake. This was believed to be an example of dilatancy, in which rock expands just before it ruptures.

Other geophysical changes noted before various earthquakes include changes in the velocity of propagation of seismic waves, changes in the magnetic characteristics of the area, and an increase in the electrical conductance of the ground. But it is not yet known if these effects can be used as reliable indicators.

Controlling Earthquakes

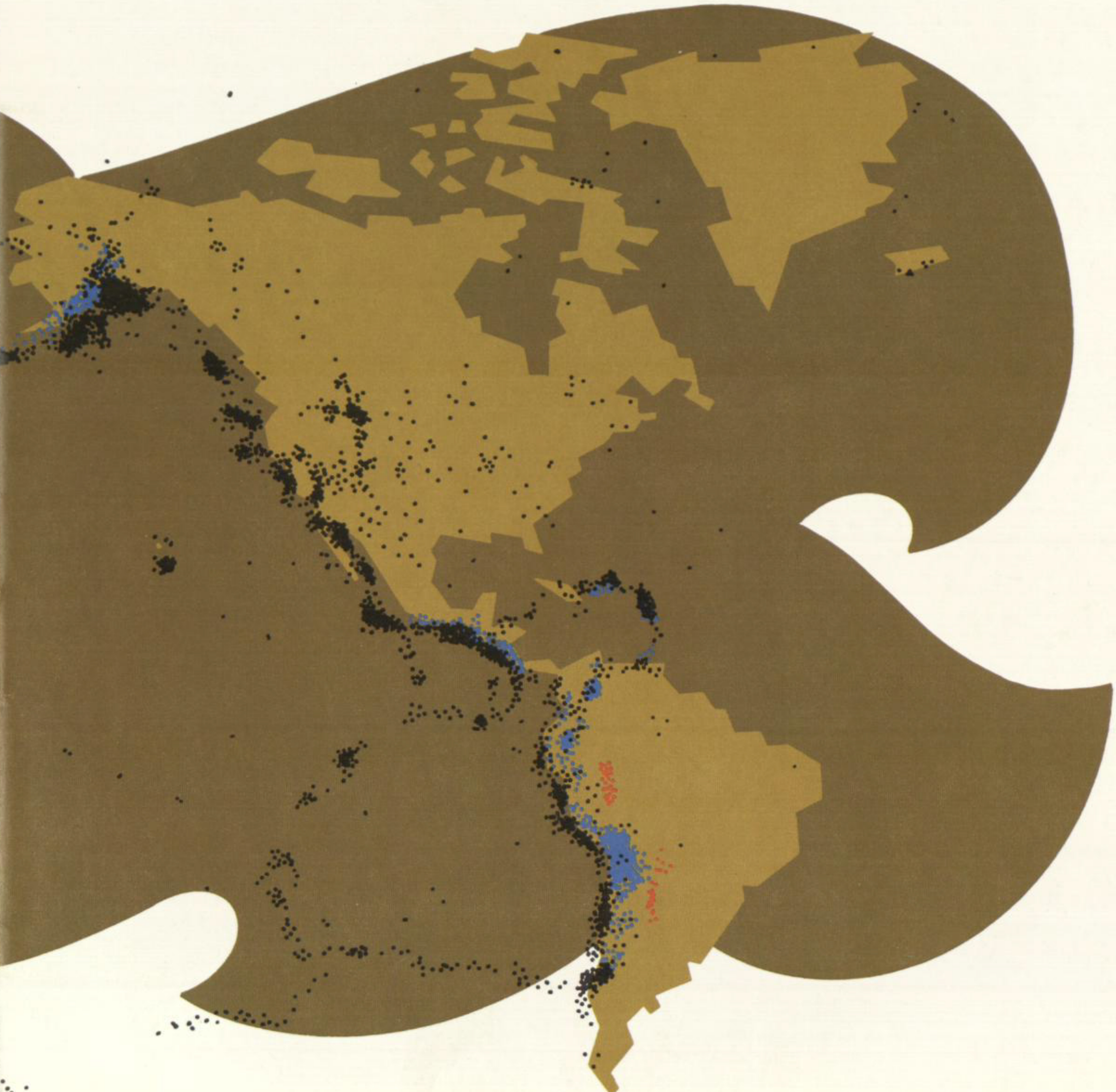
While accurate prediction is not yet on the horizon, some degree of man-made control of earthquakes may someday be feasible. The idea was derived from the effect observed in Denver when liquids were pumped into deep wells and seismic disturbances occurred. It has been proposed that this could be done along major fault lines to relieve stresses in small amounts before they become an earthquake threat.

Earthquake Hazard Reduction

At present the fact remains that earthquakes are unpredictable and uncontrollable natural events of great consequence. But their effect on man and his structures can be lessened in many ways. Most loss of human life in earthquakes is due to the collapse of man-made structures that could probably have been designed and built to withstand the shaking that destroyed them.

This realization has led to a great deal of activity in the area of earthquake hazard reduction, involving seismologists, geologists, earthquake engineers, architects, structural engineers, soil technicians and others. These specialists are working at the problem from several directions: How structures react to various types of shaking, how weakening can be detected in an apparently undamaged structure, and finally, how structures can be built that will withstand the highest probable level of shaking without collapse. Part of this problem is determining what soil types are suitable for foundations in seismic areas, and where faults are located.

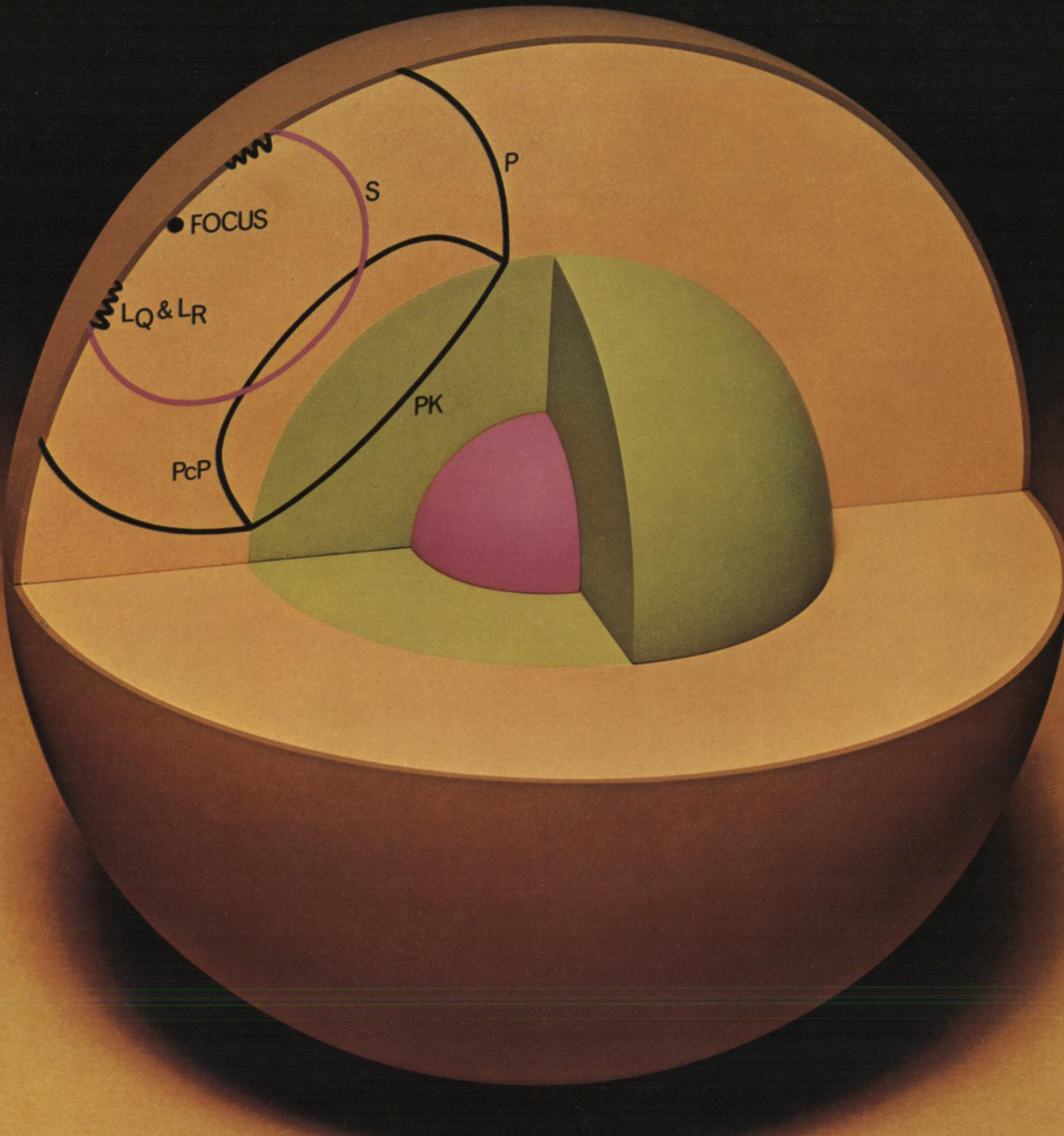
One of the more important tools in this effort has been the strong motion accelerograph. This is a



World distribution of earthquakes falls into patterns related to the earth's tectonic structure. Derived from a U. S. Department of Commerce publication, this map is based on data from 1961 to 1969.

Depth of Focus

- 0 to 45 miles
- 46 to 185 miles
- 186 to 435 miles


P
S
FOCUS
L_Q & L_R
PK
PcP

How Seismic Waves Travel Through the Earth

Every earthquake causes elastic waves to propagate out from its focus in all directions. In great earthquakes, the earth reverberates with these waves like a giant bell. After the 1960 Chilean quake (magnitude 8.3) and the 1964 Alaskan quake (magnitude 8.5) the earth continued to vibrate for about two weeks before the oscillations finally died out.

These waves can carry tremendous energy and cause damage many miles from the actual epicenter of the quake. The Alaskan earthquake, for example, spilled water out of swimming pools in Texas. Sensitive instruments detected that it also caused the earth to rise and subside six inches in Dallas as gigantic earth waves passed. It was unnoticed by the average person because it took more than a minute and a half for each wave to reach its crest and return to normal.

Elastic waves have been the seismologist's most important clue to the nature of earthquakes and, at the same time, to the nature of the interior of the earth. Several types of waves are generated by each event. P waves are compressional waves, with motion in the direction of travel, that travel through the earth at the highest speed. S waves are shear waves with motion at right angles to the direction of travel. Both of these types are called body waves because they travel through the body of the earth in all directions. Other waves spread out only along the surface of the earth. These are called Rayleigh waves and Love waves, after the scientists who first explained them.

Since P waves are the fastest, they arrive at any given location first. The S waves arrive later and, by comparing the difference in arrival times, the distance from the seismic station to the earthquake can be calculated. Three or four observations by widely spaced observatories can pinpoint the location of an earthquake very closely, by using the relative times of arrival of the P waves.

The speed of travel of these various waves varies with the type of geologic formations through which they pass. Over the years tables of travel times for specific areas have been compiled and refined from repeated observations.

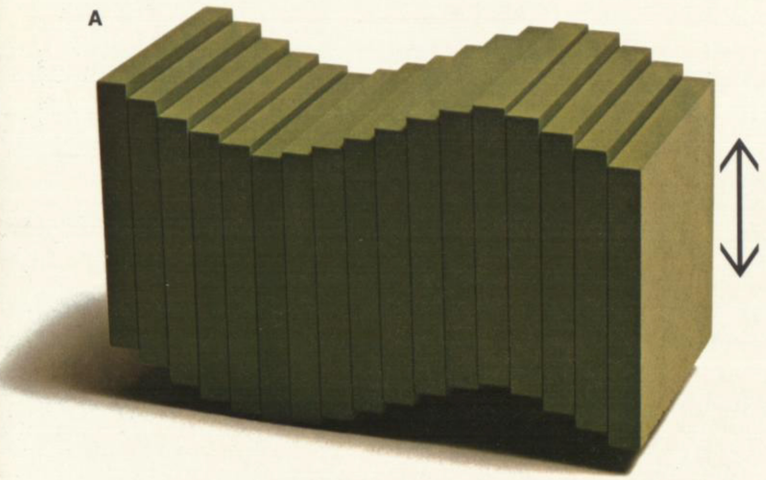
Inner Structure Of The Earth

Until the emergence of seismology as a science, there was little knowledge of the structure of the inner earth. The earth is calculated to have a mass of nearly 6.6 sextillion tons and a radius of 3960 miles. Man has penetrated that enormous bulk to a depth of less than 5 miles with his deepest drilled wells. Yet seismologists have been able to put together a fairly detailed picture of how the inner earth is structured by studying the propagation, reflection, and refraction of the various earthquake waves as they pass through it from the focus of an earthquake to a widespread network of seismological observatories.

The picture that emerges is this: We live on a thin crust that has an average thickness of about twenty miles, or about ½ of 1% of the earth's radius. This crust varies in thickness, being thicker beneath continents and mountains, and thinner beneath the oceans. A denser layer of material, called the mantle, extends from the bottom of the crust to a depth of about 1800 miles. Earthquake waves travel faster through this dense layer than they do through the crust.

At the bottom of the mantle a different zone begins, called the core. The outer part of this core is believed to be liquid or plastic, because it will continue to propagate P or compressional waves, but shear waves are not transmitted. The innermost part of the core is believed to be solid because P waves are again refracted or reflected at certain depths as they pass through the core.

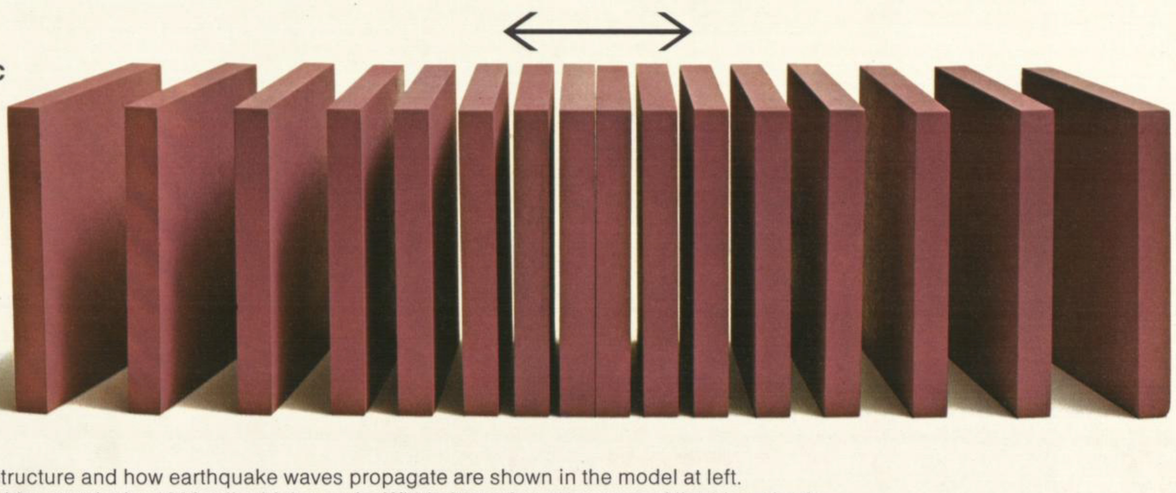
A



B

Movement of the earth's particles as earthquake waves pass is shown in these three models. Vertically and horizontally polarized S or shear waves are represented in Figures **A** and **B.** P or compressional waves are depicted in Figure **C.** Direction of wave travel in all three models is from left to right.

C



The earth's structure and how earthquake waves propagate are shown in the model at left. Beneath the thin crust is the 1800 mile thick mantle. Within it are the outer core, of liquid or plastic nature, and the solid inner core. The P wave is shown racing ahead of the slower S waves. PcP is a reflection from the mantle/core interface moving back toward the earth's surface. PK is the refracted P wave moving through the outer core. L_Q and L_R are surface waves that follow along the outer curvature of the earth.

seismograph designed to record high levels of acceleration—up to one g or more. It is used not only to determine the nature of an earthquake but also the response of structures to earthquake waves.

In some California cities it is mandatory that new buildings of six stories or more be instrumented with three strong motion accelerographs. (Teledyne is a major supplier of these instruments.) One is located in the basement of the building to record ground motion. Another is placed at the midpoint and the third at its top. The records produced give a clear picture of how the structure responds to complex shaking motion.

Bridges, dams, towers, pipelines, tanks and powerplants are also of interest to the earthquake engineer. In the case of nuclear power plants, seismic safety systems are included to provide automatic warning if g forces exceed a preset amount.

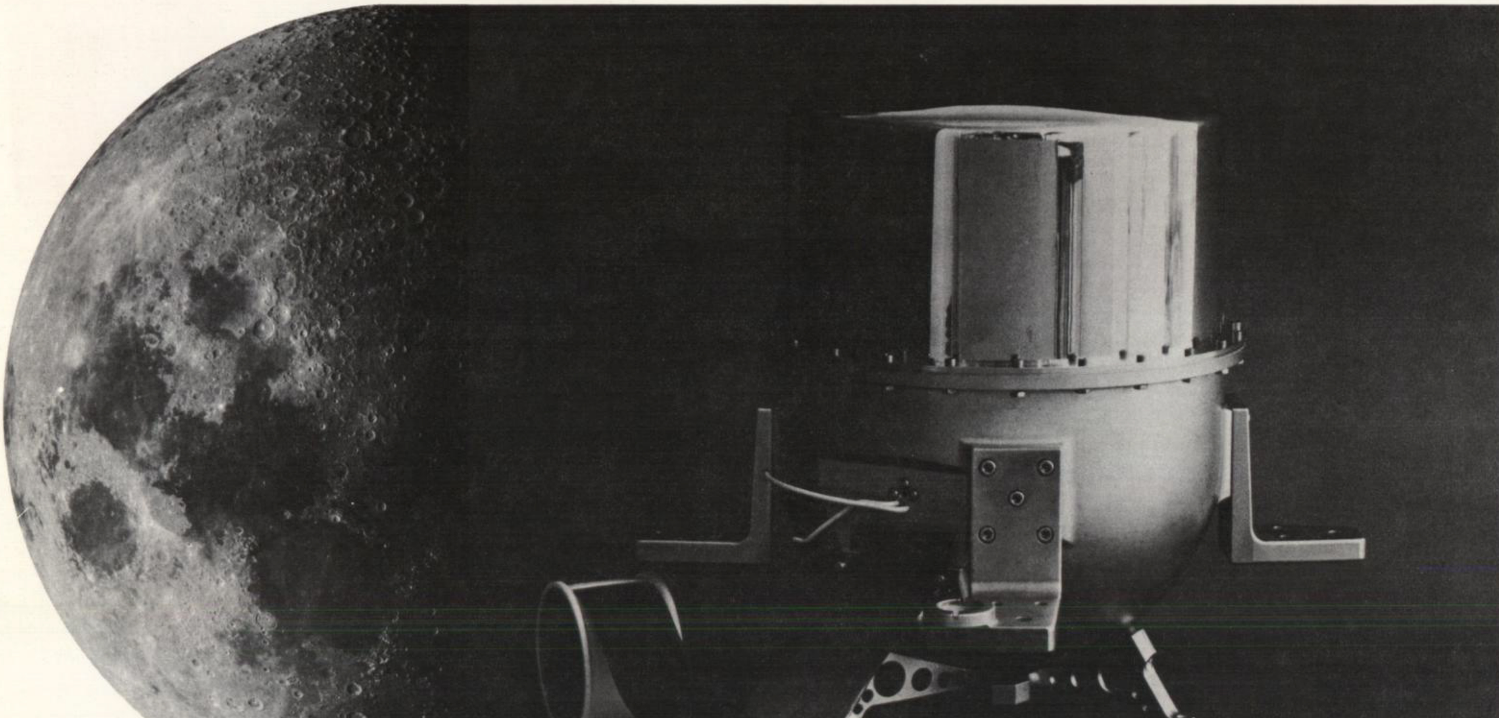
The result of these studies in recent years has been a bonanza of information about the response of structures to earthquakes. The single richest source of information was the San Fernando earthquake of 1971. During this quake, 272 strong motion instruments were triggered, resulting in a wealth of data about the response of various types of buildings at different distances from the earthquake.

Some of the findings were interesting—and sobering. While the quake was moderate in terms of Richter magnitude—6.6—the ground accelerations were very high. Many locations as far as 38 miles from the epicenter had ground accelerations of .25 g. A few reached .39 g. And one location several miles from the epicenter had peaks exceeding 1.0 g. These figures are put into perspective by the fact that local building codes are now based on designing structures to withstand a peak accelerative force of .13 g.

It is not merely the gross force acting on a structure, however, that determines the damage. Every structure—building, tower, bridge, etc.—has a certain natural vibratory period, like a tuning fork. If the ground moves at exactly the natural period of the structure, each to and fro motion of the ground reinforces the structure's natural swing, causing it to move in more and more violent arcs even though the amplitude of the actual ground motion is small.

Records from sensitive accelerometers can also be revealing about the condition of a building after a quake. By comparing records taken before and after the event, any change in the way the structure responds to the earth's natural seismic noise background can be seen. A change in response indicates that hidden damage may have occurred to the structure, and steps to locate it can be taken. This method is quicker, less expensive and more desirable than other methods of building survey.

The results of earthquake hazard reduction studies, if acted upon, can contribute to the design of better structures and more intelligent planning of land use in seismic areas. Earthquakes cannot yet be controlled, but their effect on people and property can be greatly lessened.



This passive seismometer, designed and manufactured by Teledyne, was left on the moon by Apollo 11 astronauts. It measured both seismic and tidal activity by recording frequencies, phase relationships, and signal amplitudes of seismic waves on the moon. Teledyne has participated in other extraterrestrial seismic experiments, including those carried out on the Apollo 15 mission.

PROJECT VELA UNIFORM

Undoubtedly the greatest strides in the field of seismology have been made in the last ten years through the government sponsored VELA UNIFORM project. VELA UNIFORM was initiated in 1959 under the supervision of the Department of Defense in cooperation with the Atomic Energy Commission to develop improved methods of identifying clandestine underground nuclear explosions. Since underground nuclear explosions release little if any radiation or radioactive material to the atmosphere, VELA UNIFORM was directed toward seismic methods of detection.

Since 1959, about $250 million has been devoted to the program, under management of the Advanced Research Projects Agency (ARPA) of the Department of Defense. Part of this expenditure went into the development of improved seismic detectors and improved methods of locating seismic events accurately. The largest effort went into methods of distinguishing underground explosions from natural earthquakes of comparable sizes. This has involved the study of earthquake source mechanisms, propagation of seismic waves, characteristics of earthquake and explosion signals, computerized signal processing techniques and data analysis.

Three large seismic detection arrays have been built to supply data to a central computing and analysis center at Alexandria, Virginia. The Large Aperture Seismic Array in Montana consists of 351 seismographs emplaced at the bottom of 200-foot boreholes in concentric circles that cover a 12,000 square mile area of the earth's surface. The second large seismic array of 154 seismometers (NORSAR) is located in Norway. At Fairbanks, Alaska, 19 long period triaxial seismometers form the Alaskan Long Period Array. These three arrays feed data on a real time basis to the computer center at Alexandria where analysis is made using a complex of eight digital and analog computers.

The result is a continually growing library of seismic data that not only fulfills the purpose of Project VELA UNIFORM but is contributing greatly to the understanding of the mechanism of natural earthquakes.

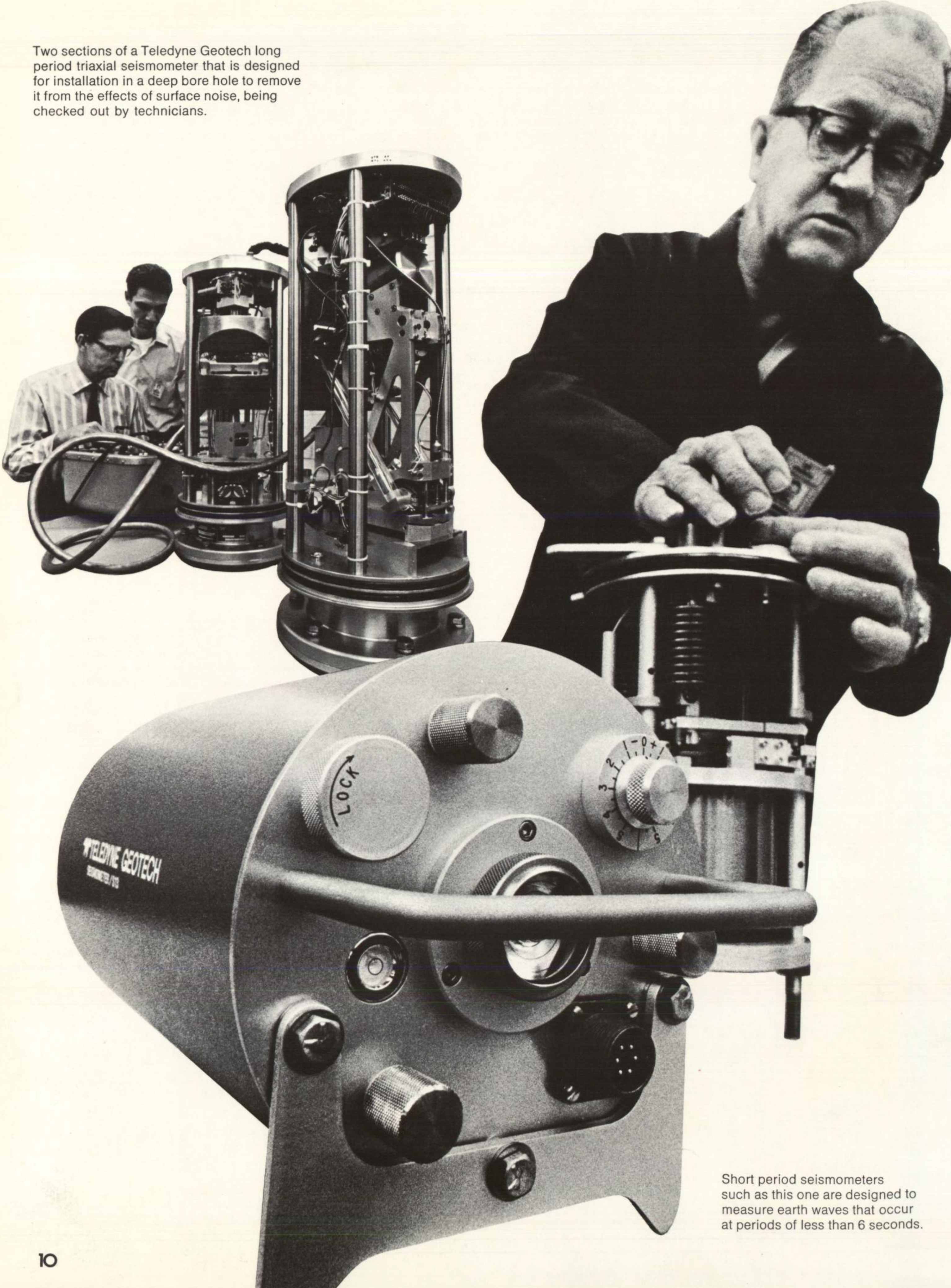
Teledyne Geotech has been active in this program since its inception. It was a major factor in development of improved seismometers and auxiliary equipment and has operated a large part of the seismic measuring program which led to the current large array network. Teledyne built and for a time operated the Montana array, as well as some of its predecessors in the program. It also built and currently operates the Alaskan Long-Period Array and is currently operating the Seismic Array Analysis Center in Alexandria, Virginia.

One of the major projects in the VELA UNIFORM program is the Seismic Data Laboratory which for ten years has served as both a repository for all VELA UNIFORM data and as a major research center in applied seismology. It is also located in Alexandria and operated by Teledyne Geotech.

Racks of computer tapes in the tape library of the Seismic Array Analysis Center in Alexandria, Virginia, represent the largest and most detailed collection of digital seismic records in the world.

Earthquake signals shown displayed on the control console at the Seismic Array Analysis Center are derived from data transmitted from seismic detector arrays in Alaska, Montana and Norway.

Two sections of a Teledyne Geotech long period triaxial seismometer that is designed for installation in a deep bore hole to remove it from the effects of surface noise, being checked out by technicians.



Short period seismometers such as this one are designed to measure earth waves that occur at periods of less than 6 seconds.

How Earthquakes are Studied

Seismology is a relatively young science. Devices for detecting earth movements were devised as early as 136 A.D. in China, but the first instruments capable of measuring earth movements with any degree of precision were invented in the 1880's. Modern instrumental seismology, however, really began in 1935 when Hugo Benioff invented an instrument with greatly improved sensitivity. Today, seismographs have been further improved by solid state electronic amplification and are as sensitive as need be for all practical purposes.

A seismograph is simply a device for detecting, measuring and recording earth movements. Most use the principle of a suspended inertial mass, or pendulum. If the earth beneath the seismograph moves, the inertia of the pendulum causes it to lag behind, and this relative motion between the pendulum and the base of the instrument is detected, amplified and recorded on photographic film, paper or magnetic tape. The resulting seismogram is a jagged line that shows the character and amplitude of the earth movement and its variations over a period of time.

Since the ground motion during an earthquake can be in all three dimensions, three separate pendulums are necessary to make a complete record. One responds to horizontal East-West motion, a second to horizontal North-South motion and a third to vertical motion. The outputs of these three sensing pendulums are recorded along with a series of precise timing pulses. The resulting seismograms can be used to determine either the amplitude of the ground motion or the acceleration or g forces that are present at the location of the seismograph.

Other types of seismographs use the principle of strain measurement to detect the amount of relative movement between widely-spaced concrete piers set in the earth. Related instruments called tiltmeters are used to detect minute changes in the level of the ground.

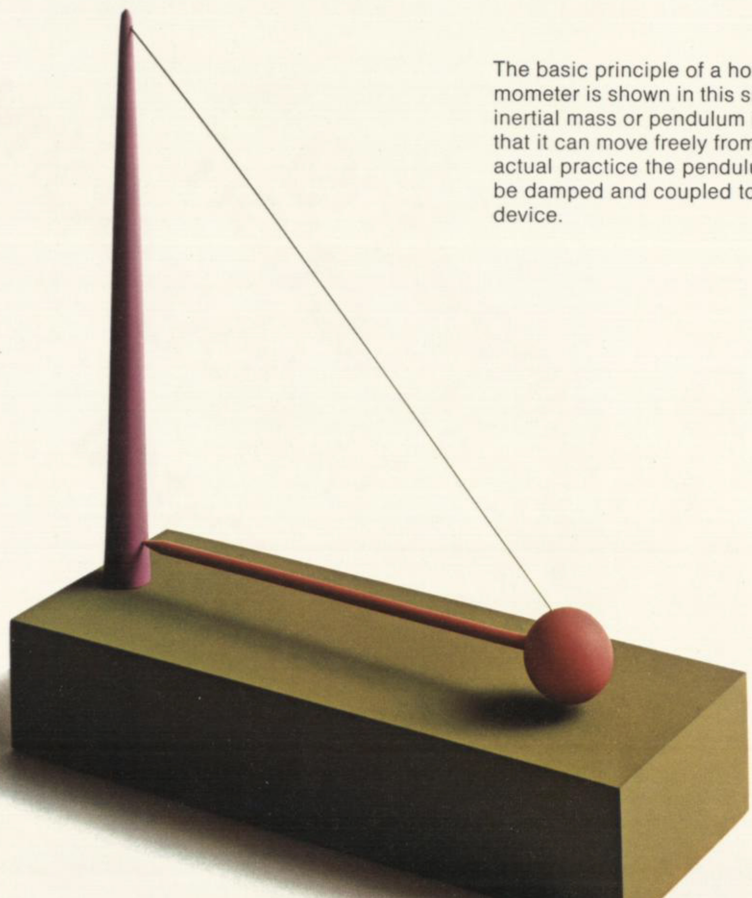
The ground displacement due to an earthquake can vary by a factor of 1 to 100,000,000 from the smallest excursion (about 1/100,000 the diameter of a human hair) to the largest. No single instrument can cover this range efficiently, so modern seismic observatories are equipped with both highly sensitive instruments to detect the weak motion of distant earthquakes, and more rugged, less sensitive instruments to measure stronger local earthquakes.

Seismic Noise

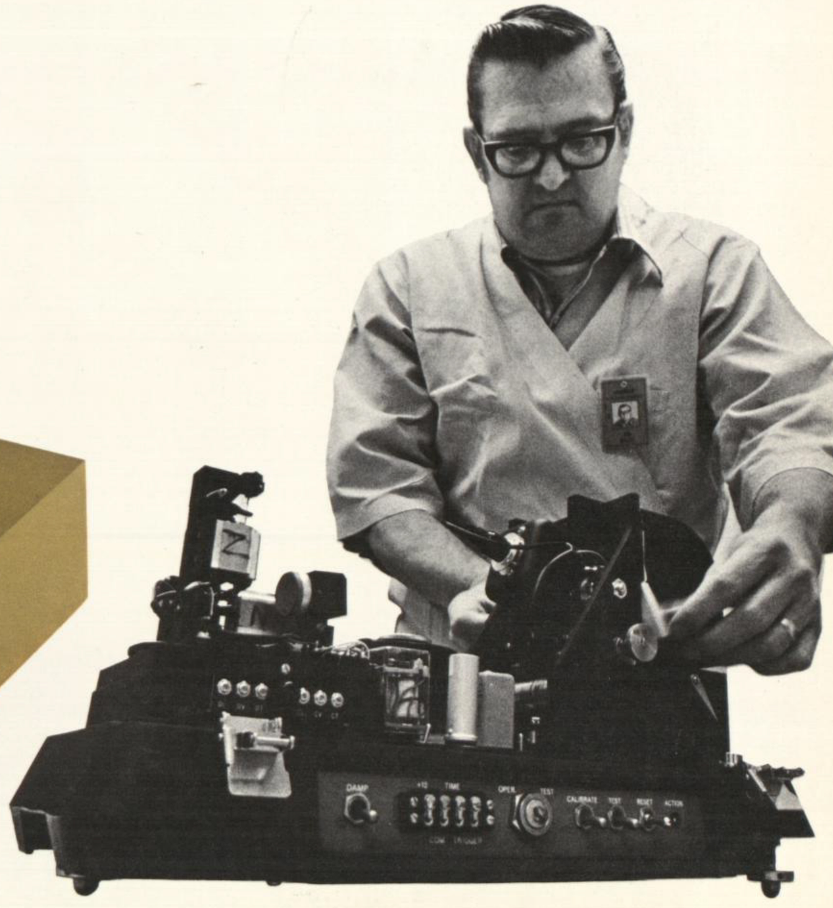
One of the major problems faced by seismologists is the matter of background noise. The earth is constantly agitated with a background of seismic chatter that comes from a variety of sources, including wind, weather fronts and other air pressure variations, ocean waves striking shorelines, wave action caused by storms at sea, industrial vibrations and vehicular traffic. This background noise may mask or obliterate the earthquake signals that are being sought.

Some locations on the earth — primarily remote, uninhabited areas of low seismic activity far from coast lines — are quiet areas, and these are highly suited for seismic observatories. Seismic noise originating in the oceans reaches an enormous peak of intensity near a period of six seconds. Seismologists consequently have divided their instruments into two classes: Short period instruments that respond primarily to periods of less than six seconds and long period instruments that respond to periods of more than six seconds.

Other noise-reduction techniques include installing seismometers at the bottom of deep drilled holes to remove them from the effects of surface noise, and using large arrays of many instruments placed over an area of hundreds of square miles. With these large arrays, computer techniques make it possible to filter out some of the noise, while enhancing the desired signals. The computer, in fact, has revolutionized the field of seismology, permitting analyses to be made in minutes that would have taken days or weeks by earlier methods. It has also made possible more sophisticated methods of detecting seismic signals and determining the detailed characteristics of the source. These advances have greatly enhanced the U. S. capability for differentiating underground nuclear explosions from natural earthquakes and this knowledge will contribute to an eventual ban on nuclear testing.



The basic principle of a horizontal seismometer is shown in this simplified model. An inertial mass or pendulum is suspended so that it can move freely from side to side. In actual practice the pendulum would have to be damped and coupled to a recording device.



Strong motion accelerographs are designed to record violent motions near the source of an earthquake that would send more sensitive instruments off scale.

The Market for Seismological Instrumentation and Services

In the last two decades seismology has emerged from the theoretical atmosphere of the university and become a full-fledged tool of applied technology in diverse government programs and commercial activities.

Government

The U.S. Department of Defense has invested more than $250 million over a ten-year period in project VELA UNIFORM (discussed elsewhere in this report) for seismic methods and instruments for the detection of clandestine underground nuclear explosions. Seismology has likewise been an important part of space exploration with active and passive seismic experiments carried out on both manned and unmanned probes. More than $15 million has been spent on seismic instrumentation and interpretation for these purposes.

Geophysical Exploration

Commercial expenditures on seismic instrumentation and services have been even greater. During 1969 (the last year for which complete figures are available at this time) $909.1 million was spent worldwide on geophysical survey work of all types. It is typical that 93.1 percent of this figure, or $846.8 million, went into seismic methods of exploration. Preliminary studies show that total geophysical activity in exploration was down about 10% in 1970 with the total dollar value slightly above $800 million. In 1971, preliminary indications were that the activity was back nearer the 1969 level.)

By markets, petroleum exploration on land and sea overwhelmingly dominates these geophysical activities with a total of $847.3 million spent in 1969. Of that total petroleum industry expenditure, $826.3 million was for active seismic exploration. (Active seismology consists of detonating explosive charges or using other energy sources on the surface of the land or in water; the seismic waves that are reflected by the various strata of the earth are then detected and recorded. Under good conditions, this method has given an accurate picture of the geologic structure to a depth of about 25,000 feet.)

Seismic ground motion studies also accounted for about 74 percent of the total engineering, ground-water and construction activity in 1969.

A new and little-known type of geophysical exploration is the search for natural geothermal steam as a source of energy for electrical power generation. Teledyne Geotech has developed sophisticated methods of locating probable sources by the seismic signature associated with underground steam.

Structural Safety

Public awareness and concern with the potential danger to man and man-made structures from natural earthquakes has increased in recent years. Seismic instruments known as "strong motion accelerometers" have been developed to measure the response of buildings and other structures to earthquake waves, to detect damage, and provide data for better structural design.

Approximately 500 of these instruments are now in use in the United States, or awaiting installation. Some California cities have had laws for a number of years requiring three of these instruments in each building of six stories or more. A new bill passed in California in October 1971 provides that a fee of .007 percent of the estimated construction cost of new structures be paid upon application for each construction permit. These fees will be used to acquire, install and maintain strong motion accelerometers throughout the state.

Strong motion accelerometers are also used to monitor nuclear power stations, off-shore drilling towers, bridges, dams and other potentially hazardous structures. The use of these instruments is spreading as more communities are becoming concerned with earthquake safety.

Other Seismic Applications

A very new development, growing out of military instruments used to detect movement of troops and vehicles by the seismic signatures they generate, has been the introduction of seismic intrusion detectors. Such security systems, now made commercially by Teledyne Geotech, can detect the approach of persons or vehicles to the perimeters of industrial facilities, power plants, and vital military installations.

WORLD-WIDE GEOPHYSICAL ACTIVITY BY PURPOSE AND AREA

Table by S. J. Allen, Courtesy of Geophysics, The Journal of the Society of Exploration Geophysicists
Based on 1969 data, last year for which complete figures are available.
(In Millions of U.S. Dollars)

Area	Petroleum	Mining	Engineering & Construction	Oceanography	Total
U.S.A.	$285.9	$ 6.6	$15.5	—	$308.0
Canada	98.8	12.7	.1	—	111.6
Mexico	24.2	.2	NR	—	24.4
Central/South America	71.6	.4	.2	—	72.2
WESTERN HEMISPHERE	$480.5	$ 19.9	$15.8	—	$516.2
Europe	$ 67.8	$ 1.7	$ 1.1	—	$ 70.6
Africa	125.4	3.6	.3	—	129.3
Middle East	52.1	.2	.1	—	52.4
Far East	89.7	.4	3.7	—	92.0
Australia/New Zealand	31.8	2.4	—	—	36.0
EASTERN HEMISPHERE	$336.8	$ 8.2	$ 5.2	—	$380.3
Unspecified	—	$ 5.5	$ 1.1	$6.0	$ 12.6
GRAND TOTAL	$847.3	$ 33.7	$22.1	$6.0	$909.1

Review

NEW TELEDYNE MEDICAL INSTRUMENTS HELP REDUCE WOUND INFECTION AND IMPROVE CANCER DETECTION

Hydrotherapy, the treatment of disease by the internal or external use of water, and its application to oral health has been the principal activity of Teledyne Aqua Tec since its inception. Nine years of clinical studies have documented the therapeutic value of the WATER PIK* oral irrigating device and demonstrated its effectiveness and safety in oral hygiene. Eighty percent of the practicing dentists in the United States now recommend the device produced by Teledyne Aqua Tec, and more than twelve million enjoy better oral health because they are users of the WATER PIK appliance.

At the 1971 American Medical Association Convention, the nation's physicians were introduced to three new medical instruments, engineered by Teledyne Aqua Tec, applying the principle of the pulsating water jet to the cleansing of wounds and the detection of cancer.

Reduction of Wound Infection

Already credited with saving many lives in Vietnam, the wound cleansing technique was developed by the U.S. Army Institute of Dental Research. USAIDR began investigating jet lavage techniques eight years ago when oral surgeons in the field expressed need for a more effective method of cleansing and disinfecting facial wounds. For the last several years, U.S. Army dentists in Vietnam have been provided with this new way to reduce facial wound infection, simply by aiming pulsating jets of water—1200 per minute—at the wound site. U.S. Army physicians applied the principle to other wounds.

Throughout both the investigative period and the combat experience, Teledyne Aqua Tec engineers worked closely with the researchers in developing the prototype instruments.

Results indicated that the pulsating water jet lavage was three times more effective in removing debris from tissues, and about seven times more effective in removing bacteria from wounds than a conventional bulb syringe. The addition of antibiotics to the water improves the effectiveness of the treatment. A mixture of streptomycin and penicillin was found to be five times more effective than water lavage without the antibiotics. These results, from USAIDR studies, have recently been released by the U.S. Army Medical R&D Command for publication in professional journals.

Other USAIDR studies show that pulsating jets have a compression and a decompression phase on the target tissues. Early USAIDR experiments were conducted with two specially designed instruments: one, a continuous water jet and the other, a pulsating jet device supplied by Teledyne Aqua Tec. The tests showed that a continuous water jet stream kept the tissues in a continuously compressed stage; whereas the pulsating jet produced a compression stage and a period between pulses during which the tissues were decompressed. During this decompression phase, debris was able to escape from a wound but a continuous compression interfered with the escape of the contaminants.

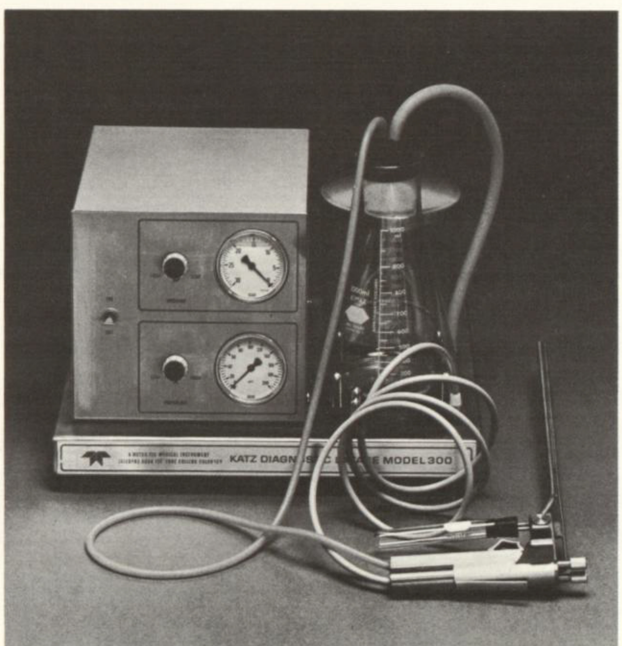
The concept, pulsating jet lavage, of the super WATER PIK instruments will soon be available for use by the medical profession, both in this country and abroad. Teledyne Aqua Tec will offer two units. A non-conductive, explosion-proof Surgical Lavage, Model SNB-100, is designed for use in a surgical operatory. A smaller, versatile emergency room model, Medical Lavage, Model 200 can also be used in the physician's office.

Earlier Cancer Detection

The third instrument shown at the convention provides an improved method of examination for cancer of the colon which may lead to earlier detection and diagnosis. Known as the Katz Diagnostic Lavage, the device was developed by Dr. Seymour Katz, M.D. at the Memorial Hospital for Cancer and Allied Diseases in New York. Teledyne Aqua Tec acted as technical consultants and produced the equipment.

The Katz instrument, which is simple enough for use in the doctor's office, utilizes pulsating jets of saline solution fed down one tube and a suction apparatus to bring back the lavage through another. Both tubes fit into a sigmoidoscope used for rectal exams. Portions of the return flow are trapped for the pathologist to examine. Apparently, these specimens have greater yield in about one-third the time necessary for previous diagnostic techniques. In the past, the infusion of water and return was accomplished by hand instruments.

In a large sample of patients, the Katz device has demonstrated an excellent correlation to surgical findings in the detection of cancer of the colon within range of the standard sigmoidoscope exam. The use of the Katz instrument has presently yielded over 66% positive correlation of left-sided colonic cancer beyond reach of the proctosigmoidoscope via aspiration of the saline spray compared with operative diagnoses. The collected cells and debris are analyzed in the manner of a cervical Pap Smear.



Diagnostic Lavage for cancer detection.

*Registered TM Teledyne Aqua Tec

ATLAS CONSORTIUM CHOOSES TELEDYNE AIDS/EFDARS

The European ATLAS consortium of airlines, which includes Air France, Alitalia, Lufthansa, Sabena and Iberia, recently awarded Teledyne Controls a contract for AIDS/EFDARS equipment for use on their DC-10 and 747 aircraft. This equipment includes airborne data recording instruments and related ground read-out devices. The systems will fulfill regulatory agency flight recording requirements and may also be used to provide maintenance advisory data for the airline ground crews. Teledyne AIDS/EFDARS systems were described in detail in the Second Quarter 1971 Teledyne Report.

NEW RADIATION DOSIMETER

Thermoluminescence Dosimetry is an advanced technique for measurement of nuclear radiation in medical or industrial use. Teledyne Isotopes has developed a new TLD dosimeter reader that makes reading of radiation dosages by this method an easy, routine matter. Unlike conventional readers, the new Teledyne instrument automatically prepares the samples for reading and makes them available for immediate reuse after the dose information is extracted. The instrument has proved very successful in the U.S. since its introduction in mid 1971 and has generated considerable international interest.

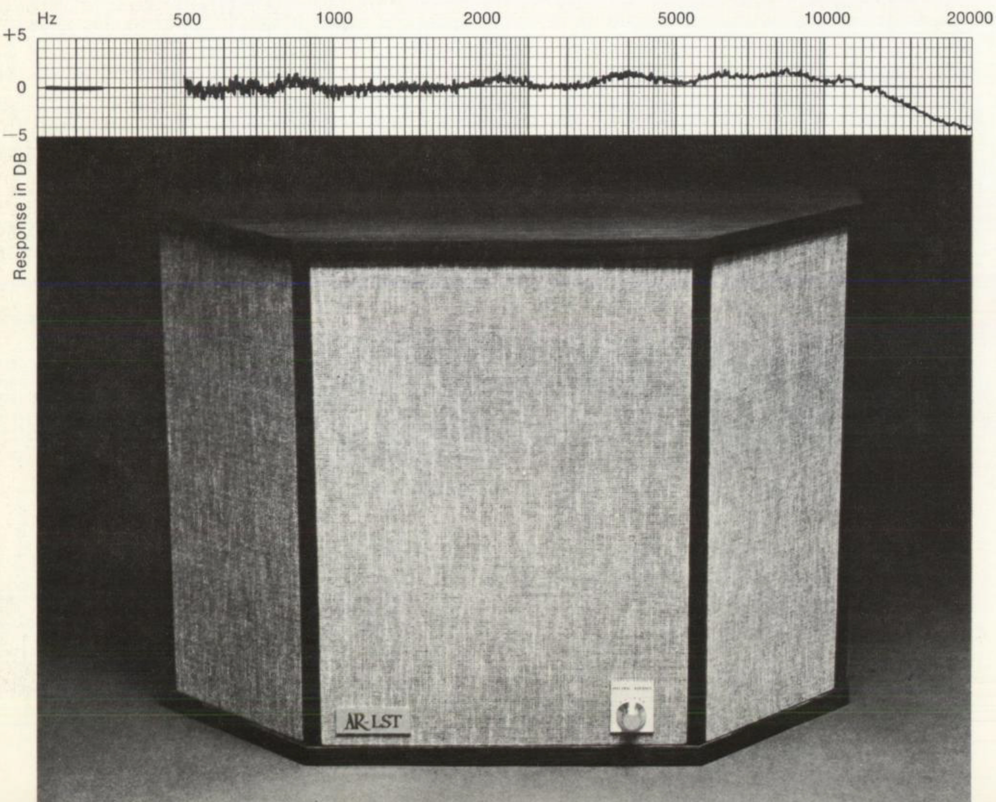
THE AR LABORATORY STANDARD TRANSDUCER

Acoustic Research has introduced its first loudspeaker system designed specifically for professional and scientific applications. The AR Laboratory Standard Transducer—or AR-LST—fills the need for a speaker system of unprecedented accuracy and flexibility, combined with a greater power-handling capability than is normally found in speakers designed primarily for use in the home.

The AR-LST should find wide acceptance as a broadcast and recording monitor, a laboratory calibration instrument, in audiometric and psychoacoustic research, and in medium-power sound reinforcement systems requiring maximum fidelity. The system provides a choice of six energy-slope profiles—all accurately calibrated and repeatable at the turn of a switch which is located on the front of the cabinet.

The graph shown represents the acoustic power output of the AR-LST at switch position #2, the "flat" position. (The line at the left indicates the relative bass level.) It is believed that the output uniformity obtained in the "flat" position as well as the predictable and controlled deviations establish a new state of the art.

Although the AR-LST will be marketed primarily through professional channels, it will also be made available to the sophisticated audiophile market.



NEW SEISMIC EXPLORATION EQUIPMENT

Teledyne Exploration has introduced a new portable seismic source called the "Mini-Sparker" for seismic marine engineering and shallow sub-bottom marine exploration surveys. The device in combination with other equipment that makes up the Teledyne Model 305 Marine Engineering Profiler System, can be used to detect channels or fill on the sea or river floor, underwater fault outcroppings, and the nature and the structural attitudes of the shallow sub-bottom formations. Primary advantage of the new equipment is the improved resolution it provides of shallow sub-bottom features.

The unit has application as an ecological tool related to determining proper location for offshore drilling and production platforms and pipelines. It has also been successfully used in locating buried shell beds for the shell dredging industry.

HAFNIUM FOR IMPROVED JET ENGINE SAFETY

Another promising application has been found for hafnium, the nuclear-age metal produced by Teledyne Wah Chang. The addition of a critical 2 percent of the metal to high temperature, nickel-base alloys results in a marked improvement in ductility and the tensile and creep strength of the alloy. The new alloys will enable jet aircraft to operate more safely with reduced maintenance. The improved ductility of the alloy provides an additional safety factor, should a foreign object enter the jet engine.

RPV STUDY CONTRACT

Teledyne Ryan Aeronautical was awarded an eight-month contract in October by the Air Force for systems concept studies and preliminary design of remotely piloted vehicles (RPV's). The work calls for the assessment of technologies for RPV's in areas such as materials, avionics, manufacturing techniques and propulsion. Based on this assessment and the missions defined by the Air Force, Teledyne Ryan will develop system concepts and preliminary designs of unmanned vehicles to perform air-to-air, air-to-ground, and reconnaissance/electronic warfare missions.

AMERICA'S FIRST SPACE STATION

The launch of Skylab, America's first space station, in 1973 will represent the culmination of several million man-hours of effort by Teledyne Brown Engineering in its research and development support to NASA. The company's role in Skylab includes the design of the Apollo Telescope Mount. This mount is part of a cluster of hardware that will give solar scientists their first look at the sun's activity undistorted by the effects of the earth's atmosphere. Other company activities in the Skylab program include the manufacture of battery charger regulators and the development of training mockups to simulate weightlessness.

31% SAVING THROUGH USE OF FORGINGS

Teledyne Portland Forge specializes in producing forged gear blanks for industry, including accessory parts for "off the highway" earthmoving equipment. It was recently cited by Caterpillar Tractor Co. of Peoria, Illinois, for its achievement in cost savings for that company. The savings were the result of replacing a machined part that was formerly cast, with a forging. The former part did not have sufficient fatigue properties and a large percentage of scrap was generated due to defects in the metal. The forged part is stronger and more dependable and is produced at a savings of 31%.

CHAIN AMPLIFIER SUPERCOMPONENTS

By combining several microwave amplifier components into one unit, Teledyne MEC has developed microwave supercomponents that can amplify rf signals of a few microwatts to a level of several hundred watts. This new approach saves the customer the difficult job of critically matching a number of individual components to achieve the same result. The supercomponent concept has received wide acceptance by major manufacturers who build radar, electronic countermeasure and communication systems. Production quantities of these supercomponents have been built by Teledyne, under recent contracts with systems manufacturers, to exacting standards that were not previously attainable.

EFFECT OF PESTICIDES ON ENVIRONMENT

The effect of pesticides on the aquatic environment in the southeastern United States is being studied by Teledyne Brown Engineering under a contract from the U.S. Environmental Protection Agency. The company is assessing current practices and will recommend future research and suggest new regulations and alternatives.

The studies have already revealed that inefficiencies in pesticide applications result in a low percentage actually reaching the target species. Alternatives such as the radiological sterilization of male screw worm flies, development of disease and pest-resistant crop strains and biological controls are potentially valuable replacements for some pesticides and are currently undergoing further evaluation.

QUIET PROPULSION FOR STOL AIRCRAFT

Teledyne CAE has completed design of a full scale wing section which will be tested by NASA as part of an effort to develop a quiet propulsion system for future STOL aircraft. The design effort was completed as part of an engineering services contract award to Teledyne CAE by NASA, Lewis Research Center, in July, 1971. The wing when installed at Edwards Air Force Base test facility will stand 17 feet in a vertical position with triple slotted flaps capable of being adjusted in a cruise, takeoff or landing mode. Impingement of engine exhaust gases on blown flaps is known to be an appreciable noise source and NASA will use this test wing to measure noise levels and develop various sound suppressive techniques.

TELEDYNE CONTINENTAL ENGINE POWERS NEW AGRICULTURAL PLANE

The Tiara-powered Pawnee II agricultural plane built by Piper Aircraft was shown publicly for the first time in Dallas in December. It is the first general aviation plane to be made available with Teledyne Continental's revolutionary new Tiara engine. With a gross weight of 3,800 pounds, the new aircraft is larger than any agricultural plane ever produced by Piper Aircraft.

Tiara is an entirely new series of Continental aircraft engines that have been under development for over six years. They incorporate major advances in performance, simplicity, light weight, reliability and economy of installation and maintenance.

Highlights of Financial History

	1971	1970	1969	1968
Sales	$1,101,872,000	$1,216,448,000	$1,294,775,000	$874,905,000
Net income	56,179,000	61,864,000	58,119,000	45,161,000
Net income per share (1)	1.58	1.79	1.77	1.48
Total assets	1,075,706,000	1,042,958,000	1,110,878,000	766,680,000
Shareholders' equity	616,846,000	584,349,000	501,961,000	362,780,000
Average common shares (1)	34,240,254	33,470,907	32,164,806	30,361,247

(1) Fully diluted and adjusted for a 3% stock dividend payable March, 1972.

Revenues by Product Line

	1971		1970	
Industrial Products and Services	$ 375,990,000	24.3%	$ 424,266,000	26.4%
Aviation and Electronics	331,479,000	21.4	379,964,000	23.6
Specialty Metals	263,815,000	17.0	285,450,000	17.7
Consumer Products and Services	130,588,000	8.4	126,768,000	7.9
Subtotal	1,101,872,000	71.1	1,216,448,000	75.6
Insurance and Finance	446,620,000	28.9	392,423,000	24.4
Total	$1,548,492,000	100.0%	$1,608,871,000	100.0%

(2) Excludes minority interest in Unicoa net income.

1967	1966	1965	1964	1963	1962	1961
$777,745,000	$700,211,000	$559,680,000	$465,304,000	$423,246,000	$388,420,000	$297,564,000
34,164,000	31,693,000	27,044,000	20,195,000	15,917,000	11,291,000	5,678,000
1.17	1.12	1.02	0.81	0.65	0.45	0.20
601,037,000	437,845,000	371,131,000	311,667,000	284,493,000	259,247,000	199,128,000
272,042,000	229,372,000	205,762,000	173,069,000	155,844,000	134,536,000	118,599,000
28,621,070	27,033,764	25,178,015	23,119,374	22,240,348	21,343,477	20,275,693

Net Income by Product Line

	1971		1970	
Industrial Products and Services	$14,280,000	25.4%	$14,925,000	24.1%
Aviation and Electronics	6,360,000	11.3	14,988,000	24.2
Specialty Metals	7,176,000	12.8	11,224,000	18.2
Consumer Products and Services	4,491,000	8.0	5,587,000	9.0
Subtotal	32,307,000	57.5	46,724,000	75.5
Insurance and Finance (2)	23,872,000	42.5	15,140,000	24.5
Total	$56,179,000	100.0%	$61,864,000	100.0%

Consolidated Balance Sheets

October 31, 1971 and 1970

Assets

	1971	1970
Current Assets:		
Cash	$ 53,536,000	$ 32,164,000
Marketable securities, at cost which approximates market	6,889,000	423,000
Receivables, less reserve of $7,113,000 in 1971 and $6,912,000 in 1970	158,143,000	159,007,000
Inventories (Note 3)	184,657,000	215,492,000
Prepaid expenses	13,279,000	13,830,000
Total current assets	416,504,000	420,916,000
Investments in Unconsolidated Subsidiaries (Note 1):		
Unicoa Corporation (Note 7)	172,889,000	160,845,000
Argonaut Insurance Company (Note 8)	143,666,000	110,835,000
Other	15,374,000	13,871,000
Property and Equipment, at cost:		
Land	16,230,000	19,510,000
Buildings	100,682,000	101,872,000
Equipment and improvements	376,635,000	366,431,000
	493,547,000	487,813,000
Less — accumulated depreciation and amortization	218,814,000	202,738,000
	274,733,000	285,075,000
Other Assets:		
Cost in excess of net assets of purchased businesses (Note 1)	33,681,000	33,681,000
Other	18,859,000	17,735,000
	52,540,000	51,416,000
	$1,075,706,000	$1,042,958,000

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

Liabilities

	1971	1970
Current Liabilities:		
Accounts payable	$ 49,069,000	$ 51,875,000
Accrued liabilities	76,757,000	75,136,000
Federal income taxes	3,600,000	4,600,000
Current portion of long-term debt and subordinated debentures	5,477,000	14,730,000
Total current liabilities	134,903,000	146,341,000
Long-Term Liabilities:		
Long-term debt (Note 4)	145,520,000	143,833,000
Deferred Federal income taxes (Note 10)	32,400,000	22,700,000
Accrued pension benefits (Note 9)	6,187,000	6,298,000
Minority interest	5,106,000	4,690,000
Subordinated Debentures (Note 4)	134,744,000	134,747,000
Shareholders' Equity:		
Preferred stock (1971 liquidation preference $37,152,000—Note 6)	714,000	1,259,000
Common stock (Notes 4, 5, 6 and 11)	30,985,000	28,390,000
Additional paid-in capital	393,253,000	388,652,000
Retained earnings (Notes 4 and 6)	199,223,000	166,048,000
	624,175,000	584,349,000
Less—treasury stock, at cost (368,358 shares)	7,329,000	—
Total shareholders' equity	616,846,000	584,349,000
	$1,075,706,000	$1,042,958,000

Consolidated Statements of Income

For the Years Ended October 31, 1971 and 1970

	1971	1970
Sales	$1,101,872,000	$1,216,448,000
Costs and Expenses:		
Cost of sales	883,006,000	953,440,000
Selling and administrative expenses	156,655,000	164,143,000
Interest expense, net (Note 1)	4,404,000	8,741,000
Provision for Federal income taxes	25,500,000	43,400,000
	1,069,565,000	1,169,724,000
Income Before Equity in Net Income of Unconsolidated Subsidiaries	32,307,000	46,724,000
Equity in Net Income of Unconsolidated Subsidiaries (Note 1)	23,872,000	15,140,000
Net Income	$ 56,179,000	$ 61,864,000
Net Income Per Share of Common Stock and Common Stock Equivalents (equal to net income assuming full dilution—Notes 2 and 3)	$1.63	$1.84
Adjusted for 3% stock dividend payable March, 1972 (Note 11)	$1.58	$1.79

Consolidated Statements of Retained Earnings

For the Years Ended October 31, 1971 and 1970

	1971	1970
Balance, Beginning of Year	$171,208,000	$141,364,000
Adjustment of certain inventories to last-in, first-out method (Note 3)	(5,160,000)	(2,904,000)
Balance, Beginning of Year (as adjusted)	166,048,000	138,460,000
Add or (Deduct):		
Net income (Note 3)	56,179,000	61,864,000
Fair value of common stock dividends (Note 6)	(18,355,000)	(28,496,000)
Dividends on preferred stock	(4,649,000)	(5,780,000)
Balance, End of Year	$199,223,000	$166,048,000

The accompanying notes are an integral part of these statements.

Consolidated Statements of Capital Stock and Additional Paid-in Capital

For the Years Ended October 31, 1971 and 1970

	Preferred Stock ($1 Par Value)	Common Stock ($1 Par Value)	Additional Paid-In Capital
Balance, October 31, 1969	$1,542,000	$24,942,000	$337,017,000
Add or (Deduct):			
Common stock dividend	—	792,000	27,704,000
Pension and profit sharing contributions	—	1,011,000	13,396,000
Stock option and purchase plans (Note 5)	2,000	236,000	4,052,000
Conversions of debentures and preferred stock	(285,000)	1,409,000	6,483,000
Balance, October 31, 1970	1,259,000	28,390,000	388,652,000
Common stock dividend	—	854,000	17,501,000
Stock option and purchase plans (Note 5)	—	158,000	2,652,000
Redemption of $3.50 preferred stock	(145,000)	—	(14,371,000)
Conversions of debentures and preferred stock	(400,000)	1,583,000	(1,181,000)
Balance, October 31, 1971	$ 714,000	$30,985,000	$393,253,000

The accompanying notes are an integral part of these statements.

Auditors' Report

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

We have examined the consolidated balance sheets of TELEDYNE, INC. (a Delaware corporation) and subsidiaries as of October 31, 1971 and 1970, and the related statements of income, capital stock and additional paid-in capital, retained earnings and changes in financial position for the years then ended. Our examinations were made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances. The consolidated financial statements of Unicoa Corporation and subsidiaries which are summarized in Note 7 to the financial statements were examined by other auditors. Our opinion, insofar as it relates to the amounts included for Unicoa Corporation and subsidiaries, is based solely upon the reports of the other auditors.

In our opinion, based upon our examinations and the reports of other auditors, the accompanying consolidated financial statements present fairly the consolidated financial position of Teledyne, Inc. and subsidiaries as of October 31, 1971 and 1970, and the results of their operations and changes in financial position for the years then ended, all in conformity with generally accepted accounting principles consistently applied during the periods.

ARTHUR ANDERSEN & CO.

Los Angeles, California,
November 23, 1971.

Consolidated Statements of Changes in Financial Position

For the Years Ended October 31, 1971 and 1970

	1971	1970
Working Capital Was Provided By:		
Net income	$ 56,179,000	$ 61,864,000
Add or (Deduct):		
Equity in net income of unconsolidated subsidiaries before interest expense	(29,189,000)	(21,014,000)
Depreciation and amortization (principally straight-line)	33,361,000	32,496,000
Deferred Federal income taxes	9,700,000	9,036,000
Working capital provided from operations	70,051,000	82,382,000
Issuance of long-term debt and subordinated debentures	8,000,000	14,939,000
Issuance of common stock:		
Conversions of debentures and preferred stock	1,586,000	8,728,000
Contribution to pension and profit sharing plans	—	14,407,000
Employees' stock purchase and option plans	2,810,000	4,290,000
Dispositions of property and equipment	3,226,000	3,317,000
Other, net	(1,560,000)	4,217,000
	84,113,000	132,280,000
Working Capital Was Applied To:		
Additions to property and equipment	32,338,000	35,612,000
Investments in unconsolidated subsidiaries, less $6,836,000 property contributed to Argonaut Insurance Company in 1971	10,353,000	(12,324,000)
Purchase of minority interest in subsidiary	—	21,721,000
Redemption and conversions of preferred stock	16,102,000	1,119,000
Purchase of treasury stock	7,329,000	—
Decrease in long-term debt	6,316,000	21,438,000
Dividends on preferred stock	4,649,000	5,780,000
	77,087,000	73,346,000
Increase in Working Capital	$ 7,026,000	$ 58,934,000

	1971	1970
Working Capital Increase (Decrease):		
Cash	$ 21,372,000	$ (8,449,000)
Marketable securities	6,466,000	(856,000)
Receivables	(864,000)	(54,336,000)
Inventories	(30,835,000)	(14,426,000)
Prepaid expenses	(551,000)	(5,886,000)
Notes payable	—	116,272,000
Current portion of long-term debt and subordinated debentures	9,253,000	(10,193,000)
Accounts payable	2,806,000	14,368,000
Accrued liabilities	(1,621,000)	2,943,000
Federal income taxes	1,000,000	19,497,000
	$ 7,026,000	$ 58,934,000

The accompanying notes are an integral part of these statements.

Notes to Consolidated Financial Statements

(1) Principles of consolidation: The consolidated financial statements of Teledyne, Inc. include the accounts of all its subsidiaries except its insurance and finance companies. Investments in unconsolidated subsidiaries are carried at cost plus equity in net income which, after allocated interest expense, was as follows:

	1971	1970
Equity in net income of—		
Unicoa Corporation (Note 7)	$ 9,732,000	$ 9,601,000
Argonaut Insurance Company (Note 8)	17,787,000	9,633,000
Other	1,670,000	1,780,000
Equity before interest expense	29,189,000	21,014,000
Interest expense, net	(11,626,000)	(13,101,000)
Related Federal income tax credit	6,309,000	7,227,000
	$23,872,000	$15,140,000

Teledyne's equity in the net assets of its unconsolidated subsidiaries was $148,556,000 in 1971 and $109,555,000 in 1970, including its equity of $84,655,000 and $55,466,000 respectively, in their retained earnings. The 1970 financial statements have been restated to include the accounts of certain subsidiaries not previously consolidated. Cost in excess of net assets of purchased business is not being amortized. Research and development costs are expensed as incurred.

(2) Computation of net income per share: Net income per share is based on the weighted average number of common shares and equivalents outstanding during each year (33,242,965 shares in 1971 and 32,496,026 shares in 1970), including all convertible debt, $3.50 and Series B preferred stock and all dilutive options and warrants. Each common stock equivalent has been considered outstanding from the beginning of each year or date of issuance, and the related dividend requirement or interest has been eliminated.

(3) Inventories: Inventories are stated at the lower of cost or market, as follows:

	1971	1970
First-in, first-out method	$133,860,000	$154,219,000
Last-in, first-out method	94,249,000	107,226,000
	228,109,000	261,445,000
Less—progress billings	43,452,000	45,953,000
	$184,657,000	$215,492,000

In 1971, the Company changed its method of valuing certain inventories to last-in, first-out, reducing 1971 and 1970 net income by $1,500,000 and $2,256,000 respectively. The 1970 financial statements have been restated to reflect this change. Inventories stated on the last-in, first-out method are at amounts which are $28,442,000 and $24,635,000 less than their first-in, first-out values in 1971 and 1970, respectively.

(4) Long-term debt and subordinated debentures:

Long-term debt—

	1971
7⅞% Sinking Fund Debentures due 1994, $1,400,000 payable annually commencing in 1975	$ 30,000,000
6½% Sinking Fund Debentures due 1992, $1,350,000 payable annually	28,712,000
7% Promissory Notes due 1989, payable $750,000 in 1973 and $1,500,000 annually thereafter	25,000,000
6⅜% to 6¾% Notes due 1973 and 1974	12,530,000
7% Notes due 1973	12,500,000
7% to 7½% Notes due 1975 and 1976	12,350,000
Other (including $13,115,000 secured by land and buildings) due in various installments to 1984	29,905,000
	150,997,000
Less—current portion	5,477,000
	$145,520,000

Notes to Consolidated Financial Statements

Subordinated debentures—	
3½%, due 1992, $3,000,000 payable annually commencing in 1978 (convertible into common stock at $53.97 per share)	$ 59,819,000
6½%, due in annual installments from 1979 to 1983	37,500,000
7%, due 1999, $1,871,000 payable annually commencing in 1989	37,425,000
	$134,744,000

At October 31, 1971, long-term debt and subordinated debentures are payable $5,477,000 in 1972, $22,128,000 in 1973, $16,837,000 in 1974, $16,739,000 in 1975 and $9,068,000 in 1976. Net interest expense was $16,030,000 in 1971 and $21,842,000 in 1970 including $11,626,000 and $13,101,000 allocated to unconsolidated subsidiaries.

Under the various borrowing agreements, the Company has agreed to maintain minimum amounts of working capital and net worth, and has agreed to certain restrictions with respect to borrowings, purchase and sale of assets and capital stock and payment of dividends. At October 31, 1971, these agreements were complied with and retained earnings were not restricted as to payment of dividends either by the agreements or by the liquidation preference of preferred stock.

The Company has reserved 1,108,375 shares of common stock for issuance upon conversion of the subordinated debentures.

(5) Stock options and warrants: At October 31, 1971, 305,352 common shares were reserved for issuance under outstanding options at prices from $7 to $48 per share (options for 60,450 shares were exercisable) and 596,165 common shares were reserved for the granting of additional options. At October 31, 1970, 413,861 common shares were reserved for issuance under outstanding options and 588,889 common shares were reserved for the granting of additional options. During 1971 no options were granted; options to purchase 101,233 shares were exercised; and options covering 7,276 shares were canceled.

At October 31, 1971, 372,900 shares of common stock were reserved for issuance under warrants, each of which provides for the purchase of 9.94 shares at $50.33 per share until October, 1978. In addition, 16,688 shares were reserved for issuance under other warrants.

(6) Capital stock: At October 31, 1971 and 1970, the Company's capital stock consisted of the following shares:

		Outstanding	
	Authorized	*1971*	*1970*
Cumulative convertible preferred stock, $1 par value	15,000,000		
$6 series		517,532	518,024
$3.50 series		—	536,948
Series B		175,692	181,933
Series C		21,045	21,607
Common stock, $1 par value	60,000,000	30,984,732	28,390,362

The 1970 financial statements and related notes, except for shareholders' equity, have been restated to reflect a 3% stock dividend paid in February, 1971.

The holders of the $6 series preferred stock are entitled to voting rights and cumulative annual dividends at the rate of $6.00 per share. Such stock is redeemable at $100 per share after April 22, 1978, and is convertible at any time into 1.34 shares of common stock. The $3.50 series preferred stock was redeemed in July, 1971. The holders of the Series B preferred stock are entitled to voting rights and cumulative annual dividends at the rate of $3.20 per share. Such stock is redeemable at $80 per share and is convertible at any time into 2.33 shares of common stock. The holders of the Series C preferred stock are entitled to voting rights and cumulative annual dividends at the rate of $6.00 per share. Such stock is redeemable at $100 per share after January 25, 1973, and is convertible at any time into a maximum of two shares of common stock. The Company has reserved 1,145,000 shares of common stock for conversion of all preferred shares.

At October 31, 1971, 309,000 shares of common stock were reserved for issuance to employees under a stock purchase plan.

(7) Unicoa Corporation and subsidiaries: The following condensed statements summarize the consolidated financial position and operating results of Unicoa Corporation and subsidiaries. Teledyne owned 67.4% and 60.4% interests at October 31, 1971 and 1970, respectively.

Consolidated Balance Sheets

	September 30	
	1971	1970
Assets:		
Bonds, at amortized cost (market: 1971—$137,000,000; 1970—$89,000,000)	$162,078,000	$128,658,000
Stocks, principally at cost (market: 1971—$46,000,000; 1970—$51,000,000)	52,997,000	61,091,000
Mortgage loans	171,059,000	173,486,000
Real estate, at cost less accumulated depreciation	41,308,000	38,719,000
Loans to policyholders	9,227,000	9,590,000
Premiums deferred and uncollected	10,687,000	8,810,000
Excess of investment in subsidiaries over underlying net assets	13,720,000	13,670,000
Other assets	19,860,000	21,086,000
	$480,936,000	$455,110,000
Liabilities:		
Policy reserves and liabilities	$341,278,000	$321,303,000
Mortgage loan payable	10,800,000	11,378,000
Subordinated debentures	22,600,000	22,600,000
Other liabilities	24,212,000	22,033,000
Shareholders' equity—		
Common stock	18,732,000	18,732,000
Additional paid-in capital	1,975,000	1,975,000
Retained earnings	96,695,000	82,717,000
	117,402,000	103,424,000
Treasury stock, at cost	(35,356,000)	(25,628,000)
Total shareholders' equity	82,046,000	77,796,000
	$480,936,000	$455,110,000

Consolidated Statements of Income

	Year Ended September 30	
	1971	1970
Income:		
Premiums and other insurance income	$172,607,000	$160,972,000
Investment income, less expenses	19,663,000	17,085,000
Other income	2,531,000	3,327,000
	194,801,000	181,384,000
Expenses:		
Benefits paid or provided	88,371,000	80,536,000
Insurance expenses	87,277,000	80,399,000
Federal income taxes	5,446,000	5,198,000
	181,094,000	166,133,000
	13,707,000	15,251,000
Gain (Loss) on Sale of Investments, Less Applicable Federal Income Taxes	271,000	(258,000)
Net Income	$ 13,978,000	$ 14,993,000

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

Retained earnings as of the beginning of 1970 have been retroactively reduced $3,600,000 to record additional policy reserves applicable to years prior to 1970. Net income for the year ended September 30, 1970 has been retroactively reduced $700,000 to reflect the additional reserves applicable to that period. Teledyne's financial statements have not been restated to reflect these items since its equity in these adjustments is not material.

At September 30, 1971, approximately $39,000,000 (at current tax rates) would be required for possible Federal income taxes which might become due, in whole or in part, in any future years in which approximately $82,000,000 of gains from operations since January 1, 1959, presently included in retained earnings, might become includable in the insurance companies' taxable income under certain conditions, including distributions in excess of $30,000,000 as dividends.

Notes to Consolidated Financial Statements

(8) Argonaut Insurance Company and subsidiaries: The following condensed statements summarize the consolidated financial position and operating results of Argonaut Insurance Company and subsidiaries.

Consolidated Balance Sheets	September 30 1971	September 30 1970
Assets:		
Bonds, at amortized cost (market: 1971—$244,000,000; 1970—$182,000,000)	$234,596,000	$193,230,000
Stocks, at cost (market: 1971—$46,000,000; 1970—$27,000,000)	43,592,000	29,128,000
Agents' balances and uncollected premiums, less reserve	38,918,000	33,957,000
Other receivables	13,813,000	14,130,000
Deferred policy acquisition costs	20,570,000	17,340,000
Property and equipment, at cost, less accumulated depreciation	11,660,000	4,549,000
Cash	15,538,000	10,655,000
Cost in excess of net assets of purchased businesses	8,589,000	8,589,000
Other assets	6,902,000	7,036,000
	$394,178,000	$318,614,000
Liabilities:		
Loss and claim reserves	$159,511,000	$135,048,000
Accrued loss adjustment expenses	24,263,000	20,420,000
Unearned premiums	91,857,000	77,703,000
Federal income taxes	11,947,000	7,089,000
Other liabilities	23,823,000	23,315,000
Notes payable to Teledyne	—	2,000,000
Shareholders' equity	82,777,000	53,039,000
	$394,178,000	$318,614,000

Consolidated Statements of Income	Year Ended September 30 1971	Year Ended September 30 1970
Income:		
Net premiums earned	$222,766,000	$186,524,000
Investment income less expenses	15,794,000	12,059,000
	238,560,000	198,583,000
Expenses:		
Losses and loss adjustment expenses	155,796,000	141,566,000
Underwriting expenses	60,194,000	51,203,000
Provision for Federal income taxes (credit)	5,209,000	(1,450,000)
	221,199,000	191,319,000
	17,361,000	7,264,000
Gain on Sale of Investments, Less Applicable Federal Income Taxes	426,000	2,369,000
Net Income	$ 17,787,000	$ 9,633,000
Dividends Paid	$ —	$ 228,000

The above statements have been prepared on the basis of generally accepted accounting principles which differ from statutory insurance accounting practices. During 1971, Teledyne contributed to Argonaut all of the stock of its other domestic property and casualty insurance subsidiaries. The 1970 financial statements have been restated on a consolidated basis to reflect Argonaut's ownership of the other companies.

(9) Commitments and contingent liabilities: Annual rentals under long-term leases expiring between 1974 and 1987 are approximately $3,500,000 through 1976, and $1,000,000 thereafter.

The Company accrues pension expense at amounts equal to normal cost plus interest on unfunded prior service cost, and for certain plans, a portion of prior service costs. Total pension expense was $10,358,000 in 1971 and $12,369,000 in 1970. The Company contributes accrued pension costs on a current basis. At October 31, 1971, the actuarially computed value of vested benefits for all plans exceeded the total of the pension funds and balance sheet accruals by approximately $4,000,000.

(10) Federal income taxes: Deferred Federal income taxes result from the deduction for tax purposes of accelerated depreciation and other items. The available investment tax credit, which is not material, is amortized as a reduction of the provision for Federal income taxes over the expected lives of the related assets.

(11) Subsequent event: In December, 1971, the Board of Directors declared a 3% common stock dividend payable March 3, 1972, to shareholders of record January 4, 1972. The financial statements and related notes have not been adjusted to reflect this dividend.

This Teledyne Report features a description of modern seismological technology and its application to a basic study of the earth and planets; earthquake hazard reduction; engineering geology; nuclear test detection; and petroleum and mineral exploration. Seismological instruments and associated systems manufactured by Teledyne can be found in observatories, dams, buildings, nuclear power plants, and other similar installations throughout the world. In fact, Teledyne is the world's foremost manufacturer of instruments for the study of earthquakes and earthquake hazards. Teledyne also operates land and marine seismic exploration crews in the USA, Canada, Canadian Arctic, Africa, South America, Australia, and Indonesia.

Customers for Teledyne's seismological instruments and services include most of the governments of the world, universities, oil companies, mining companies, construction companies, power companies, and many others. For further technical information on products and capabilities, write to Teledyne Geotech, P.O. Box 28277, Dallas, Texas 75228, or Teledyne Exploration, P.O. Box 36269, Houston, Texas 77036.

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

Casting: The simple process a small boy uses when he casts a tin soldier is the basis of a high technology industry that produces items ranging from high temperature turbine blades to 90-ton steel mill rolls.

AIDS: Aircraft Integrated Data Systems keep a running record of the vital functions of the new jumbo jets and provide airlines with an important tool for lowering costs associated with maintenance, fuel management and crew proficiency testing.

Thermoelectrics: Generators that convert heat directly into electricity are providing a practical new power source for applications ranging from space exploration to remote unattended weather stations.

Thin Metals: Less becomes more when space-age metals are rolled out into thin strip and foil. These new materials, already being used in thousands of products, are making new metal-working techniques possible.

The Reproduction of Music: Men began experimenting with methods of recording sound over 150 years, but it remained for electronics and some very recent developments to allow music to be reproduced with concert-hall realism.

The Crowded Spectrum: The lower portion of the radio spectrum is already overcrowded with hundreds of wireless services. Microwave devices such as the traveling wave tube are opening higher frequencies for practical use.

Science and Cinematography: Modern techniques of slow motion cinematography let scientists and engineers analyze actions and events that happen too fast for the eye to follow.

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

Jets of Water for Dental Health: Studies show that high-pressure pulsed jets of water are a valuable aid in the care of teeth and gums.

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

Oil Beneath the Sea: New techniques of reflection seismology speed the profiling of the strata beneath the ocean floor in the search for oil.

Electronic Navigators Find the Way: High speed air and space travel as we know it today is made possible by a wide variety of sophisticated guidance systems.

From Sand to the Reactor: Sand from the beaches of Australia provides two atomic-age metals needed for the operation of practical nuclear power generators.

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