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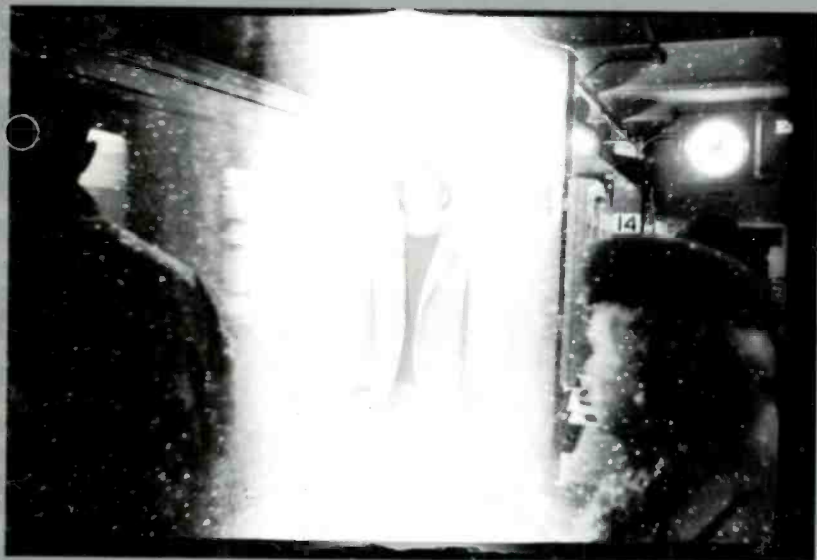

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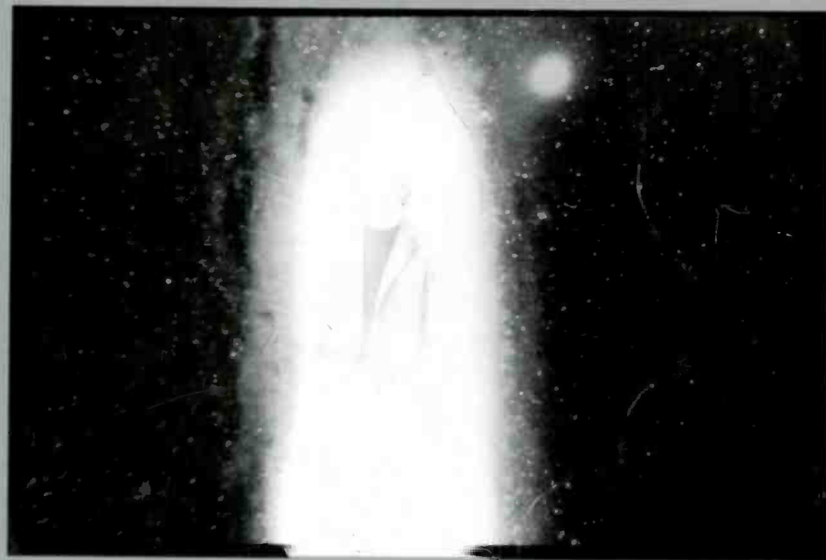
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The Progression of Time

"The Human Condition" (front cover) and "Chance Meeting" (back cover) are moments that capture an event and hint at past or future action. The various aspects of time and its relationship to the concept of space are discussed in an article that begins on page 6.

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The Scientists: Vanguard of a World Community?

International communication has become increasingly vital to the free exchange of knowledge and ideas among scientists.

by Harrison Brown

Although we often pay lip service to the concept of a world community, one need not travel far to appreciate how deeply divided nations, races, and cultures really are. In virtually all parts of the world we see antagonisms between social groups, tribes, nations, and races that transcend logic and prevent constructive action. In a world in which division is the rule, the scientific community, which numbers fewer than 1 million persons, is one of several outstanding exceptions.

Scientists, more than members of most groups, are generally able to communicate with each other without being overwhelmed by their cultural roots. As I travel about the world and talk with my colleagues, I find that from the point of view of communication it makes little difference whether I am in Chicago, Lima, London, Paris, Moscow, Accra, Cairo, Bombay, or Tokyo.

It isn't that scientists don't have their own prejudices. They do. It isn't that they aren't nationalistic or influenced by the cultures from which they emerged. They are. It isn't that they are unusually intelligent or clever — most of them aren't. Yet somehow, despite these barriers, their acceptance of a common scientific attitude has given them a kind of common culture that enables them to talk with and understand each other. In part, this results from a deep-seated realization that arguments cannot be settled with rhetoric. The laboratory is the final court of appeal.

Harrison Brown, a member of the faculty of the California Institute of Technology, is foreign secretary of the National Academy of Sciences

Perhaps the most obvious point to be made concerning the need for strong ties between the scientific community of any one nation and those of others is that a fact found in country X is valid the world over. The options of a nation are simple: it can learn a fact from the scientists of country X, its own scientists can discover that fact themselves, or its scientists can remain ignorant. Although a nation could in principle isolate itself scientifically from the rest of the world and conceivably get along, this would be an extremely wasteful policy and would eventually be self-defeating.

Even the United States, which has the strongest scientific community on earth and which produces about 40 per cent of the world's scientific literature, could not afford to isolate itself — for the rate of growth of science outside the United States far surpasses its own. Just as we went from the position at the end of World War II of being a larger producer of steel than the rest of the world put together to one where the rest of the world now produces more than three times as much steel as we do, so our scientific production is destined eventually to be but a small proportion of that of the world as a whole.

International communication among scientists takes place in many ways. Of primary importance are the thousands of scientific journals, the hundreds of abstract journals, and the diversity of complex private and governmental scientific information systems. Each year, the scientific and technical work in the world is described in some 2 million articles that are published in about 35,000 scientific and technical journals and written in as many as 50 languages. This tremendous output is condensed in abstract form in some 300 journals.

Of equal importance to the flow of printed and computerized information is the flow of scientists themselves. There is a large, random flow of scientists among Western European countries and between Western Europe and the United States. There are more formalized flows between Eastern European countries and the West. The movement of scientists to and from the less-developed countries is small because there is not much scientific activity in those areas.

The flow of scientists to and from international conferences and symposia represents an important element of scientific communication. Congresses of such organizations as the International Union of Pure and Applied Chemistry, the International Union of Geodesy and Geophysics, and the International Union of Biochemistry have become quite large. For better or worse, it is no longer unusual for more than 5,000 scientists to descend simultaneously upon a city from virtually all parts of the world for the purpose of discussing recent developments in their field. No form of communication quite equals in effectiveness that of face-to-face contact under circumstances in which conflicting views can be aired in both public and private.

The primary organization for promoting and nurturing international scientific cooperation and communication is the

The flags of nations that signed the Antarctic Treaty are unfurled at the South Pole Station during the 10th anniversary of the signing. The treaty, signed December 1, 1959, guarantees the peaceful use of that continent for scientific purposes.

ternational Council of Scientific Unions (ICSU). This unique nongovernmental body has, despite severe financial limitations, performed yeoman service for world science. It is basically a federation of 16 international scientific organizations, or "unions," representing as many branches of the basic and applied sciences, linked with about 60 "national" members. The unions have bound themselves together in this higher level of organization recognizing that they have many problems in common that must be dealt with in concert.

Once an international program is decided upon, the cooperation of national scientific bodies is essential if the program is to be successful. Recognizing this, ICSU created the category of "national membership" consisting of no more than one scientific organization per nation — usually that organization which can best represent the international interests of the national scientific community. National members include, among others, the Royal Society of London, the Japan Science Council, and the academies of science of France, the United States, and the Soviet Union.

The International Council of Scientific Unions goes to great lengths to maintain its nonpolitical status. It takes the view that scientists the world over should be able to participate in international scientific activities without being prejudiced by the political complexion of the countries in which they happen to live. Hence, appropriate organizations in East Germany, North Korea, and North Vietnam are members of ICSU, as are organizations in West Germany, South Korea, and South Vietnam. The Academia Sinica in Taiwan is a member of most of the unions as well as the ICSU, but the Academia Sinica in Peking has systematically withdrawn from all ICSU organizations to which the academy in Taipei has been admitted. The governing body of ICSU takes the view that scientists working in Taiwan as well as those working on the mainland should be able to participate in international cooperative scientific ventures and has made clear its standing invitation to the Academia Sinica in Peking to become a national member of ICSU once again. It is encouraging that recently, for the first time in years, scientists from the Chinese mainland have attended a scientific meeting in the West — one dealing with the future development of the marine sciences.

One of ICSU's most important operating principles is known as the Principle of Free Circulation of Scientists, which states in effect that no bona fide scientist should be prevented from engaging in an ICSU activity in a country because of his nationality. A congress or symposium will be scheduled in a country only if reasonable assurances are given that visas will be granted to scientists from all participating countries, even those which the host country does not recognize. Thus we have the interesting situation of the United States issuing visas to scientists from East Germany and the Soviet Union issuing visas to scientists from Israel.

ICSU recognizes the sovereign right of a nation to refuse visas to individuals as long as it is not done on the basis of nationality. Of course, a nation would not be expected to issue a visa to a known espionage agent or a criminal. But if discrimination on the basis of nationality is suspected, the case is brought to the attention of the Committee on Free Circulation of Scientists, which is chaired by a Swedish scientist and has one representative each from the Royal Society and from the French, Soviet, and U.S. academies. The committee investigates the incident and issues a report to the membership. Although the organization has no power in such situations, it does wield considerable influence.

There are almost always pressures placed upon ICSU to become political. For example, the UNESCO General Conference last fall passed a resolution indicating UNESCO's intention to sever all relationships, including financial, with all international nongovernmental bodies that have affiliates in South Africa and that cannot demonstrate to UNESCO's satisfaction that they do not cooperate with the South African government's apartheid policies. ICSU and its constituent unions have a very good record in this respect, and it may be that they can free themselves of the implications of this resolution, which assumes guilt until innocence is proved. If not, ICSU and the unions stand to lose all financial support from UNESCO, which is considerable. And UNESCO may be obliged to break all connections with ICSU, whose contribution is essential to the UNESCO scientific program.

The ICSU officers take the view that although they as individuals are opposed to apartheid, it is of great importance that the South African scientific community maintain contact with colleagues in the outside world. Further, it seems clear that were ICSU to compromise on this issue, the floodgates would be opened for a never-ending flow of similar political problems ranging from Soviet discrimination against Jews to Brazilian tortures of political prisoners to the use of defoliants in Vietnam.

ICSU maintains a variety of committees and commissions that perform essential services, coordinate international collaborative programs, and arrange for the sharing of tasks. For example, the Scientific Committee on Oceanic Research prepares plans for international oceanic research programs. The Scientific Committee on Antarctic Research is charged with the responsibility of further-ing coordination of scientific activity in Antarctica. The Committee on Space Research furthers the progress of all kinds of scientific investigations that are carried out with the use of rocket-propelled vehicles. The Scientific Committee on

"... arguments cannot be settled with rhetoric. The laboratory is the final court of appeal."

"No form of communication quite equals in effectiveness that of face-to-face contact under circumstances in which conflicting views can be aired in both public and private."

Helium-filled balloon with retrieval line can be used to rescue stranded scientists in research project at Antarctica.

Water Research has the task of studying the problem of international water resources in all its aspects and formulating collaborative research programs on the subject. The Special Committee on Problems of the Environment is charged with the responsibility of formulating worldwide cooperative research programs dealing with man-made environmental changes.

Some ICSU-sponsored programs have represented landmarks in international cooperation. The International Geophysical Year engaged the efforts of thousands of geophysicists the world over and achieved results that could not have been obtained by any one national group. Similarly, the International Indian Ocean Expedition, in which research ships from many countries made coordinated traverses of that body of water in a single year, gave a unique synoptic view of the local marine environment. It was during this exercise that, for the first time, Soviet scientists worked on American research ships and American scientists worked on Soviet research ships so that equipment could be intercalibrated.

The successes of the earlier collaborative efforts led to the organization of the International Biological Program, a continuing attempt to study biological production over all land areas of the earth as well as in fresh waters and the seas. The program also involves a study of the adaptability of human beings to changing environmental conditions.

ICSU also undertakes joint projects with intergovernmental organizations. Together with the World Meteorological Organization of the United Nations, a Global Atmospheric Research Program is now being undertaken. This program consists of the design and testing of a series of theoretical models of various aspects of the behavior of the atmosphere coupled with a series of observational and experimental studies of the atmosphere to provide data for the models and to help test their validity. This program may lead to longer range and more accurate weather forecasting, will yield economic benefits the world over, and help nations avert climatic disasters.

Of necessity, ICSU is concerned about the handling of the growing avalanche of scientific information, which threatens to get out of hand. In 1966, it created the Committee on Data for Science and Technology, which promotes and encourages the production and distribution of collections of critically selected data concerning the properties of substances of interest to science and technology. In partnership with UNESCO, a three-year study has been undertaken of the feasibility of developing a universal system of scientific and technological information. That study, now complete and published in four languages, will be the subject of an intergovernmental conference to be held in Paris in October. When the system is developed, the sharing of tasks recommended by the report should result in considerable economic benefits.

The benefits a nation derives from sharing global research tasks can be considerable. The United States, for example, pays only for its own program, and other countries pay only for their portions of the effort. International coordination often costs as little as 0.1 per cent of the total global cost of the program. In return, each nation receives the entire global product. In the case of the United States, this represents a saving of about 80 per cent of the total cost.

Of course, not all international scientific cooperation takes place under the ICSU umbrella. Many intergovernmental organizations, notably those in the United Nations family, have scientific programs. A number of nations engage in bilateral intergovernmental collaborative efforts. For example, a number of years ago, the governments of the United States and Japan instituted a successful science-cooperation program. Similar bilateral programs are in the process of being developed between the United States and France, Italy, Spain, Romania, and Brazil. Some international laboratories, such as the Center for Nuclear Research (CERN) in Geneva and the Center for Theoretical Physics in Trieste, have been created by intergovernmental action.

At the nongovernmental level, a number of academies of science engage in bilateral programs. The U.S. National Academy of Sciences, for example, has programs, most of them federally financed, with appropriate organizations in some 20 countries. The oldest of these is the Soviet-American Scientific Exchange Program — negotiated directly between the two academies and operated by them as a part of the intergovernmental cultural exchange agreement. Under the terms of the agreement, about 20 Soviet scientists undertake research in laboratories in the United States each year and an equal number of American scientists undertake research in the Soviet Union.

Similar programs have been developed by the American academy with Yugoslavia, Poland, Czechoslovakia, Romania, Bulgaria, and Hungary. In most Western nations, there is a steady, spontaneous flow of scientists between one country and another so that no formal agreements are necessary. With the socialist countries, however, the absence of formal agreements of this sort would mean that the flow of scientists back and forth would be considerably smaller than it is. Although we in the United States prefer not to handle exchanges in this way, we are willing to do so in the interest of maintaining at least a minimum level of personal communication.

The most active bilateral activities of the National Academy of Sciences are with our colleagues in developing countries. In recent years, it has become evident that the building up of an indigenous research and development (or "problem-solving") capacity is an essential element of the process of economic and social development. During the past decade, the academy has developed programs with sister organizations in Peru, Chile, Argentina, Brazil, Colombia, Taiwan, the Philippines, Indonesia, Thailand, India, and Ghana, aimed at strengthening scientific-technological problem-solving competence in these countries. In a typical program, we have brought together natural scientists, social scientists, and engineers from our two countries to discuss the problems of development, with particular reference to the role of science and technology. Recommendations that have emerged from such discussions have had considerable impact upon governmental policies. We have helped our colleagues plan constructive reorganizations of governmental structure, helped create research councils and research institutes, jointly developed new educational approaches, effected nutrition recommendations, and helped develop guidelines for industrial research.

Soviet scientists visit Detroit nuclear power plant with Glenn T. Seaborg (second from left) and Walter Cister, president of Power Reactor Development Company (right).

Recently, a new approach to international scientific collaboration has emerged: that of the consortium of academies and related organizations. In 1969, the academies of East Africa, the United States, United Kingdom, Netherlands, Sweden, West Germany, Switzerland, and Czechoslovakia joined forces to help create the International Center for the Study of Insect Physiology and Ecology in Nairobi. A similar group of academies is now planning the establishment of an International Science Foundation. Yet another group (including the academies of both the Soviet Union and the United States) is planning the creation of an international institute for application of the most sophisticated systems analysis to those problems which the industrially advanced societies share.

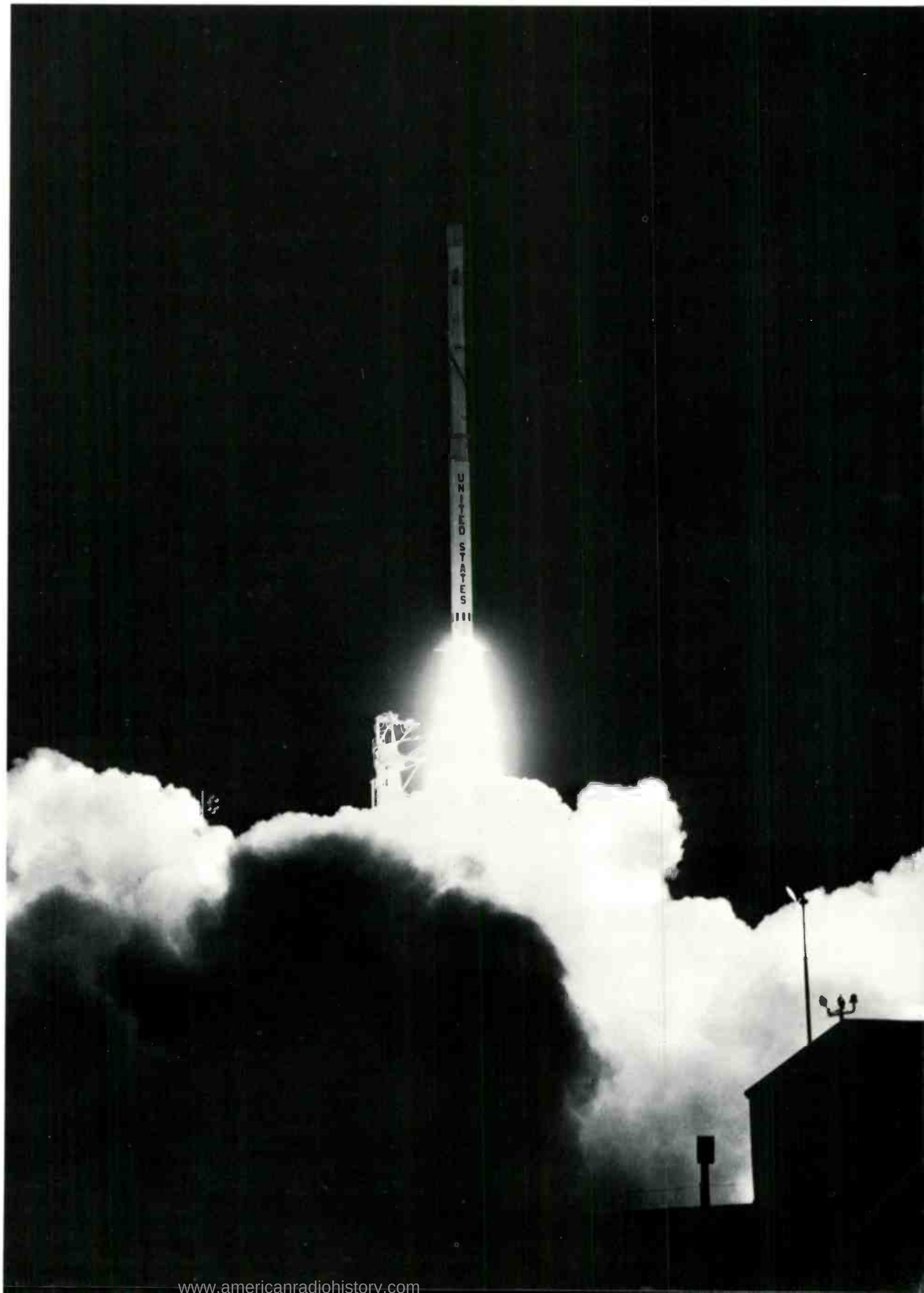
Finally, members of the scientific community try to help their colleagues overseas when they are in serious trouble.

During the days of Hitler, organizations in the United Kingdom and the United States helped relocate scientists who had fled Germany. In 1956, at the time of the Hungarian uprising, the National Academy of Sciences helped relocate a number of scientists who fled. More recently, when the Ongania regime in Argentina decimated the science faculty at the University of Buenos Aires, our academy placed a number of Argentine graduate students in U.S. universities so that they could complete their research and studies for their doctorates.

Although the channels created for expediting worldwide communication and fostering cooperation are primarily for scientific purposes, it is clear that the scientific community has played a substantial role in increasing understanding among people who live under different social, economic, and political systems. For example, many views concerning the United States that have been held by Soviet scientists have been changed drastically within a few months of their residence here under the bilateral exchange program. There have been equally dramatic changes in attitude on the part of U.S. scientists visiting the USSR. In short, the evidence strongly indicates that extensive contact within the world scientific community is one of the more effective mechanisms for increasing international understanding in general.

It seems clear that within the scientific community there is a deep-rooted awareness of a number of world problems that have scientific-technological roots. These include such critical difficulties as excessive population growth, hunger, explosive urbanization, disease, dwindling natural resources, environmental deterioration, and the mushrooming of strategic weapons systems. The concern of the scientific community for these problems has played no small part in achieving some measure of world understanding and action.

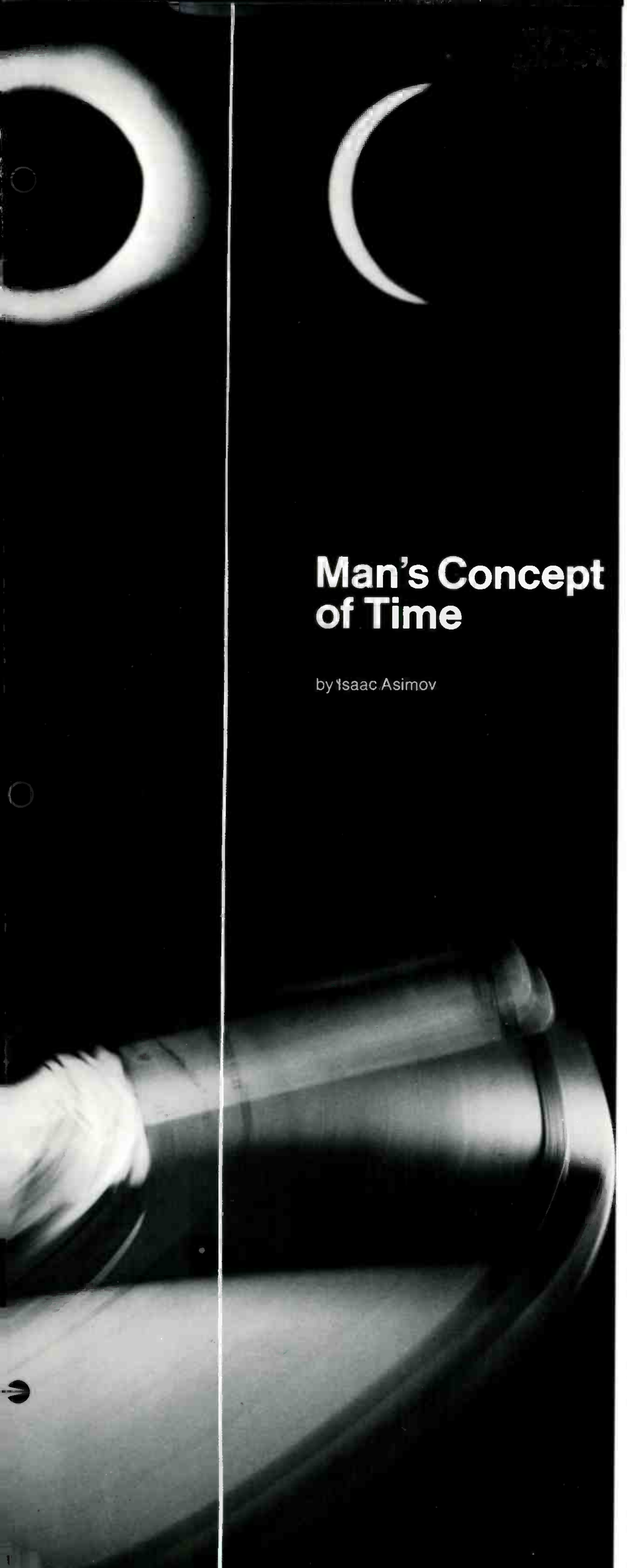
It seems reasonable to suggest that to the extent that an objective of mankind is to help create a world community in which nations can live securely and in peace with each other and in which people are freed from mankind's traditional scourges, expanded international cooperation among scientists should be vigorously encouraged by the nations of the world. Again, it isn't that they are any better or smarter than other people. They aren't. But they have managed to evolve a system for cooperation that seems to work. ■



In a cooperative program between the Federal Republic of Germany and the United States, a satellite is launched into near-polar orbit to study the earth's radiation belt, the auroras, and solar particle events.

"Subjectively, our concept of space is intertwined with our concept of time. We could get no sensation of separation in space without a separation in time, too."

Now and Then:



An eclipse of the sun is photographed during a time lapse of approximately one hour, here juxtaposed with a cricketer's swing — a matter of seconds.

Man's Concept of Time

by Isaac Asimov

How long a time is a long time? And how short is a short time? Depending on circumstances, the same period may seem long to one person and short to another. For, whereas the comprehension of space and spatial relationships involves the senses of sight and touch, the concept of time is much more subtle.

Now it is day, then it is night; now one eats, then one is hungry again. The inner sense of duration — now and then — implies the passage of time.

Learning to measure duration and getting a quantitative sense of time were more difficult for man than learning to measure distance and getting a quantitative sense of space. It was easy to pace off distance but not so easy to pace off duration.

In order to come to some agreement, men had to use some external phenomenon that was periodic — that is, one that was judged to be repeating its actions over and over at fixed intervals of time. The earliest periodic phenomena used for this purpose were the motions of the heavenly bodies. Summer came at yearly intervals, the new moon at monthly intervals, and sunrise at daily intervals.

It was not until the 17th century that a man-made periodic motion was found superior. The pendulum made possible the development of the modern clock, and, for the first time in history, man could measure time in minutes and seconds. The pendulum was followed by the vibrating spring and finally, in the 20th century, by the vibrating atom. Modern timetelling devices can thus split the second into a million parts, and time can be measured with greater facility and precision than space can.

But are space and time truly independent? Subjectively, our concept of space is intertwined with our concept of time. We could get no sensation of separation in space without a separation in time, too. We have to turn our heads to look from one thing to another, and this movement would have no meaning unless we looked first at one thing and then another. If, in pacing off distances, we find that one is twice as many paces long as another, we also find that it takes us twice as long to measure the longer. Space and time melt together. In buying a house, for instance, one has to consider its distance from a school or from one's place of business. There is the nearly automatic thought that location will affect travel time.

Of course, the melting isn't perfect. There are ways of measuring distance that are less direct than pacing off and not so immediately dependent on time. A long distance can be measured by triangulation, for instance, in about the same time as a short distance. Again, it may be possible to travel 100 miles by superhighway more quickly and easily than 10 miles through city traffic.

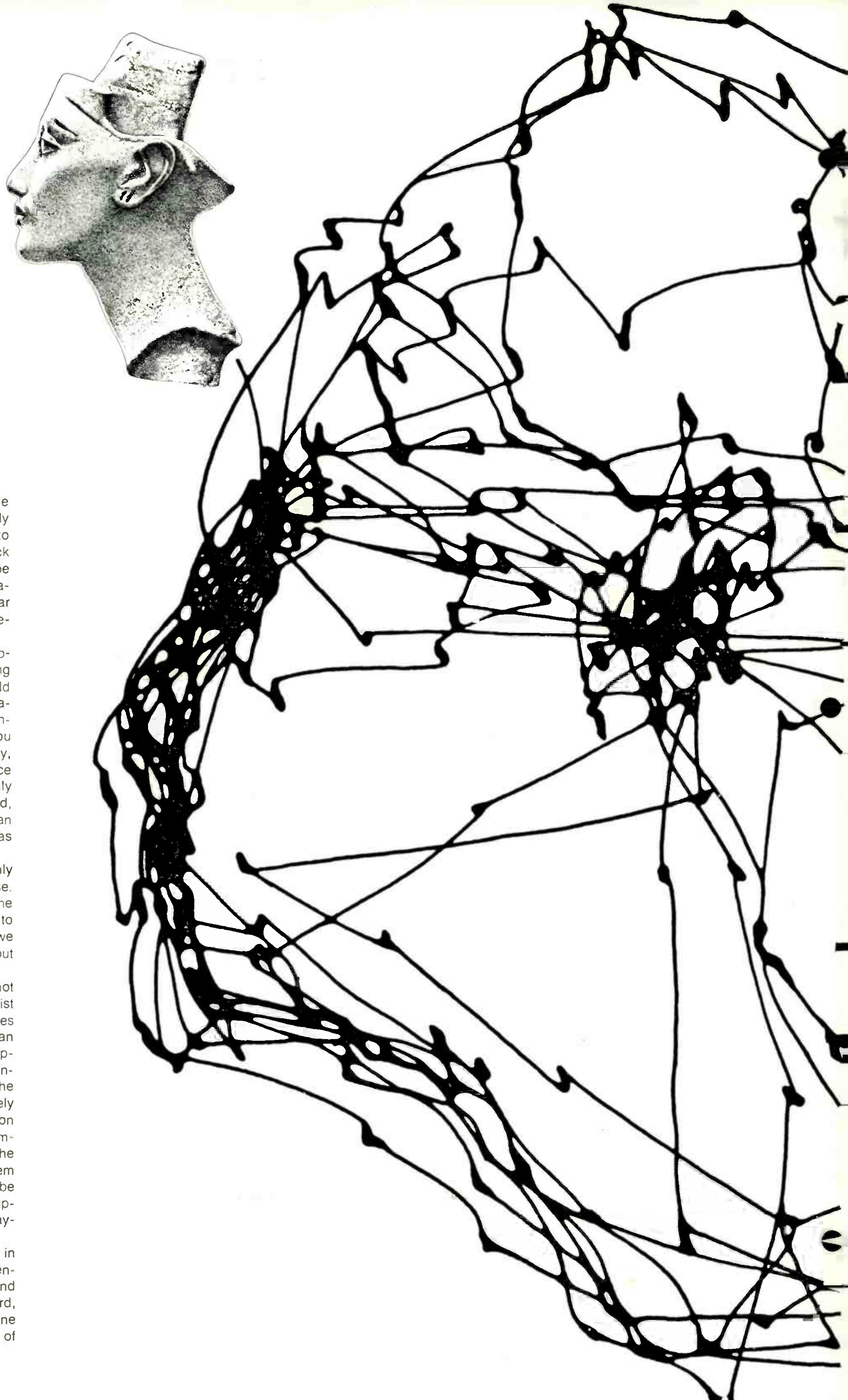
Then, too, advances in transportation have altered the relationship of space and time for mankind generally. First the train, then the airplane, and then the jet have associated the sensation of a given distance with a radically smaller sensation of duration. In colonial days, it was barely possible to breakfast in Poughkeepsie and lunch in New York City; nowadays, it is quite possible to breakfast in Paris and lunch in New York.

Invariably, the reaction to this is that "the world is getting smaller." The lessening of time is interpreted as a lessening of space. Truly, though, all this is subjective; and one can argue that a distance as a physical separation of two points possesses some quality that is not affected by any change in the time it takes to go from the one to the other.

But let us consider *objective* connections between space and time. Real objects in the universe can be located only if at least three measurements are taken. Suppose you have a glass cube with an air bubble in it sitting on a table and with its sides facing due north, south, east, and west. To locate that air bubble, you must measure how far it is above the tabletop, how far from the north side, and

Isaac Asimov is the author of numerous books on science and science fiction.

Regularities of a person's eye movements are recorded as he views a photograph of Queen Nefertiti. The diagram indicates that the eyes, in scanning the features of the head, follow fairly regular pathways rather than crisscrossing the picture at random.



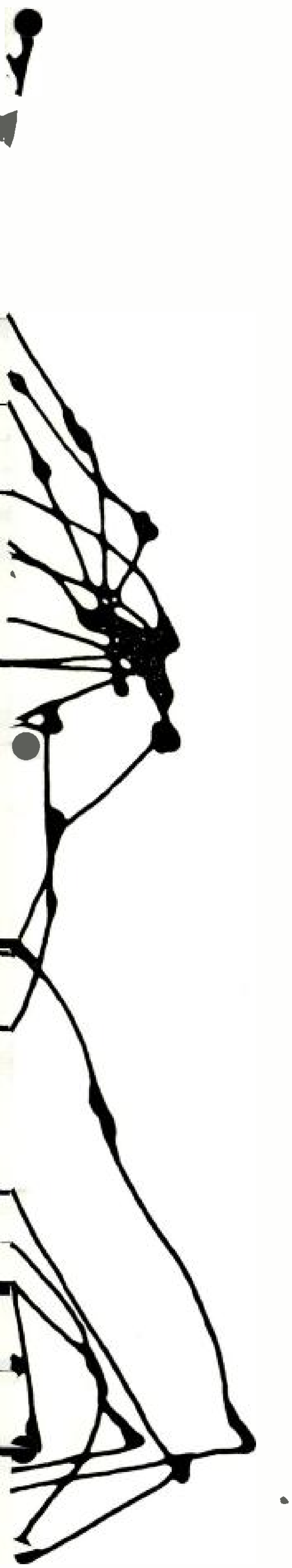
how far from the east side. This gives the exact position of the bubble, since only one point in the cube can correspond to all three measurements. You can pick some other system, but it will always be necessary to make at least three measurements in order to pinpoint a particular spot. Hence, space is said to be three-dimensional.

But suppose that, instead of an air bubble in a glass cube, you are considering a fly in an empty cubical room. You could try to locate the fly by giving three measurements; yet, if you look at the point indicated by those measurements, you might not find the fly there after all. It may, in flight, have changed its position since the measurements were made. Not only must the spatial distances be defined, then, but also the time, so that you can describe exactly both where the fly has been and when it was there.

Three dimensions are sufficient only for a motionless, unchanging universe. As soon as any motion is introduced, the measurement of time is also required to locate any object. The universe, as we know it, is not three-dimensional at all but four-dimensional.

And yet the four dimensions are not equivalent. We can take a cube and twist it so that what was east-west becomes north-south and vice versa. Or we can twist it so that east-west becomes up-down and vice versa. All three dimensions that seem to involve only space (the three spatial dimensions) are completely equivalent, depending on the orientation of the observer. However, time (the temporal dimension) is not equivalent to the others in this fashion. There would seem to be no way in which a cube can be twisted so that what was first in the up-down direction is placed in the yesterday-tomorrow direction and vice versa.

Then, too, there is free progression in any direction in all three spatial dimensions. One can move right, then left, and return to the starting place; or forward, then backward; or up, then down. One can move quickly or slowly in any of these directions.



A peculiar and exasperating psychological aspect of the relativity of time is not to be found in any textbook of physics. We are all subject to it: For as we grow older, time goes faster. That is definite. Agreement is universal.

We have all been young. We all remember that, as children, the length of time between Labor Day and Christmas was a vast temporal desert nearly four months long. Each day was long, each week an eternity.

Now, at maturity, we peer in perplexity at the passing time and mutter, "Where did it all go?" Christmas follows about a week after Labor Day, and the years come and go just about the way the months used to a couple of decades ago.

It's not really surprising. We measure time in our minds and consciousness, not in absolute terms but in connection with those experiences we have already had. To a 10-year-old, a year is 10 per cent of a lifetime; to a 50-year-old, only 2 per cent of a lifetime.

Again, the consciousness of passing time is largely a memory of novelties. In a period when nothing much happens, nothing much is remembered and it runs together. To a 10-year-old, almost everything is new; each day is filled with exciting events that stand out in memory and intensify the feeling that a "long time" has passed. To a 50-year-old, very little is new; the peaks are lower and fewer, so the time melts together and runs unnoticed through our minds.

The cure? Well, you can't make yourself younger, but you can force yourself to take more of an interest. Learn to enjoy the separate moments of life and to search for what excitement and novelty you can find or make. You may not live longer, but it will seem longer. And that's almost as good.

I. A.

In the temporal dimension, there seems no question of varying direction or speed at will. The whole universe seems to be moving along the temporal dimension in one direction and one direction only — from yesterday toward tomorrow — without any chance of reversing. What's more, the progression seems to be taking place at one constant, unalterable speed.

Science fiction writers have dreamed of finding some device that would make travel along the temporal dimension as easily controlled as that along any of the three spatial dimensions. First to do so was H. G. Wells in his 1895 novel, *The Time Machine*. Many, including myself, have since written stories involving the use of time machines, but such a device is not now practical — and, as far as science knows, never will be. Time travel, in the sense of moving freely backward and forward along the temporal dimension at will, is virtually impossible.

Still, if we can move only forward in time, it seems that it doesn't always have to be at a fixed, unalterable rate after all. In 1905, Albert Einstein advanced his special theory of relativity. This theory seemed bizarre at first, but physicists have checked it a number of times and in a number of ways. It has met all tests without exception and so triumphantly that no physicist now doubts its validity.

Among other things, the special theory pointed out that the measurement of distance depended upon the relative motion between the object being measured and the device doing the measuring.

Imagine two spaceships, A and B, each 360 feet long, passing each other in space in opposite directions and at equal velocity, with each able to measure the length of the other instantaneously as it passes. If they were to pass each other at the kinds of velocities we are used to here on earth, then each would be measured by the other as 360 feet long.

Actually, the length would be a bit less than 360 feet, but such a tiny bit less as to be unnoticeable. The shortening would become more noticeable as the velocity grew greater. Suppose they passed at a velocity of 1,000 miles per second relative to each other. Ship A would then measure B's length as 359 feet, and B would measure A's length as 359 feet. This discrepancy in perceived length would grow more extreme as the velocity relative to each other continued to increase. If they passed each other at 162,000 miles per second, each would measure the length of the other as 180 feet, only half its actual length. And, at 186,282 miles per second (the velocity of light in a vacuum), each would measure the length of the other as zero feet.

At all velocities, A and B would each seem normal to itself with its full length of 360 feet. The people aboard A would contend that they were motionless and normal and that it was B, flashing by at high speed, that was shortened. The people on board B would say the same thing in reverse.

And both would be correct!

Just as an American considers a Russian to be speaking a foreign language, a Russian considers an American to be speaking a foreign language. The quality of foreignness depends on who is doing the judging. The quality of length depends on who is doing the measuring. And, according to the special theory of relativity, the same thing happens to time.

Suppose that men on each ship have methods for testing the rate at which a clock on the other ship is going. As A and B flash by each other, it will seem to men on A that the clock on B has slowed down. Indeed, to the men on A, all motion on B — even atomic vibrations — will appear to have slowed down by an equivalent amount. In other words, it will seem to men on A that the progress of time itself has slowed on B, while it will seem to men on B that the progress of time has slowed on A.

If they flash by each other at a relative velocity of 162,000 miles per second, each will measure the progress of time on the other to be just half-normal. If the relative speed is 186,282 miles per second, each will measure the progress of time on the other to be zero. To the men on A, it will seem that time is standing still on B and to the men on B that it is standing still on A.

Can we still say that both are correct? In this case, perhaps not. To see why, let's go back to the dimension of length.

Suppose we wondered whether one of the two ships might really have shortened its length during the flash by. One way to decide that would be to have one of the ships slow down, turn around, and catch up with the other. When they were side by side, the lengths could be compared and we could see if one were shorter than the other.

Once side by side, however, the two ships would be at rest relative to each other and each would measure the other as normal in length. Neither would be shortened.

Of course, one may have been shorter than the other while they were moving relative to each other. But that leaves no marks. There is no way of telling, by looking at a body at rest, that it was once shortened while it was moving.

Does the same thing hold true for time? Not quite. When the two ships come together again, the rate at which time is progressing is the same on both; and both ships will agree to that, for now each is at rest relative to the other. However, any past difference in rate-of-time passage does leave a mark.

Suppose the two ships had started their flight with a clock marking exactly the same time on board each. If the time rate on B were actually slower than that on A at any time, the clock on B would now be behind the clock on A. The situation would be reversed if A had been experiencing the slower time rate. The men on A have observed time to be moving more slowly than normal on B. Therefore, when B pulls up to A, the men on A expect the clock on B to be behind the clock on A. But the men on B have observed time to be moving more slowly than normal on A; and it is the clock on A that they expect to be behind.

". . . time travel is possible. By moving through space fast enough, one can move forward through time as well. But only forward . . ."

Which is it? Is neither clock behind? Do they record the same time? In that case, when did the one catch up with the other? If B was observed by A to be running on slow time, it would have had to catch up in order for the clocks to be equal; it would have had to race ahead to make up for lost time. And that seems impossible. There is nothing in relativity that would allow any clock, under any circumstances, to move at a time rate faster than normal. B could never catch up to A. But the men on B would argue, by precisely the same reasoning, that the clock on A could never catch up to the clock on B.

Actually, the special theory of relativity is inadequate to deal with this "clock paradox." It applies only to an object moving at a constant velocity—that is, at the same speed and in the same direction forever. This means that A and B, having flashed by each other, must continue to separate forever if the special theory of relativity is to be invoked. They can never come together again to match clocks; so there is no paradox. In 1916, however, Einstein broadened his concept to include objects that accelerate — that is, change their speed or direction of travel, or both. To do this, he introduced his general theory of relativity.

As long as two ships are moving at constant velocity with respect to each other, there is no way of choosing one over the other as the one whose measurements are more valid. As soon as one ship begins to slow down, turn about, and catch up, it is accelerating. The situation with regard to the two ships is no longer identical, for one is moving at constant velocity and one is not.

The general theory of relativity shows it is the ship that undergoes acceleration which experiences a real change in the rate of time. The ship that accelerates will end with its clock behind when the two ships approach and compare.

But was it B that accelerated? The men on B could argue they were at rest and that it was A that accelerated in such a way as to effect a meeting. After all, each ship seems motionless to the men on board, regardless of how matters seem to an outside observer.

One argument against this is that B had to use its rocket engines (or some other source of energy) to slow up relative to A, change its course, and approach A. No matter how the men on B might argue that they were at rest and that it was A that accelerated, the fact would remain — and the men on B would have to agree — that it was B that used its rocket engines and not A.

An even stronger argument rests on the fact that, when B used its engines to accelerate, it did so not only with respect to A but with respect to the sun, the planets, and all the stars and galaxies in the universe. This involves an enormous asymmetry. One can see that B had to observe not only A accelerating, relative to B, but the entire universe accelerating, relative to B, in a corresponding fashion. A, on the other hand, observed only B accelerating; the rest of the universe remained in place.

The slowing of time is real, then, and it holds for the object that is undergoing accelerated motion relative to the universe generally.

In fact, under the general theory of relativity, motion through time becomes so intimately related to motion through space that it is impossible to consider space and time separately. Instead, one has to speak of "space-time." And the equations of general relativity include all four dimensions, although time is treated with some mathematical difference.

Imagine a space traveler heading for a distant star and accelerating to a high speed in order to get there as soon as possible. If he reaches a speed of 162,000 miles a second heading away from us, and if we can measure the rate at which time is passing on his ship, it will seem to us that time is going by at half-speed for him. The space traveler will feel time to be progressing at its usual rate; but, if he could view earth (which is receding from him at 162,000 miles a second) and measure its time rate, it would seem to him that everything on earth was moving at half-speed.

It is, however, the space traveler who has accelerated with respect to the rest of the universe to reach his velocity with respect to earth. Earth did not have to accelerate with respect to the rest of the universe to reach its velocity with respect to the space traveler. It is, therefore, the space traveler who is really experiencing a slowdown in the rate of his progression along the temporal dimension.

Suppose a space traveler is moving at a velocity of 186,200 miles per second. For every hour that passes for him, 30 hours pass on earth. If he travels for a year in this fashion (having spent no time in acceleration) and then turns around and comes back at this speed (having spent no time in the turnaround), he will find that, while he has seemed to himself to have traveled two years, the men on earth would claim he had been absent for 60 years. Hence, if the space traveler had left at the age of 30, leaving behind a twin brother also aged 30, he would be 32 when he returned; but his stay-at-home twin brother would be 90 — which is why the "clock paradox" is sometimes called the "twin paradox."

Of course, it takes quite a long while to accelerate to a high speed and a long while to make a turn and head back again, so conditions aren't quite as clearcut as just described.

Still, suppose a space traveler could somehow travel at 186,282 miles per second — exactly the speed of light. Time would slow down to zero for him. It would seem to him, no matter how far he went, that no time at all had elapsed. Then, when he returned to earth (assuming again it would take him no time to reverse his direction), he might be surprised to find that men on earth were under the impression he had been away for a hundred years, a thousand, a million — depending on how far he had gone at the speed of light.

So time travel is possible. By moving through space fast enough, one can move forward through time as well. But only forward; it is strictly one-way time travel. Once our space traveler has moved 30 — or a million — years into the future, he can never move back again.

But what, one might ask, if he actually went faster than the velocity of light? Wouldn't the time rate become less than zero? Or, in other words, wouldn't it become negative? And wouldn't he then move backward in time?

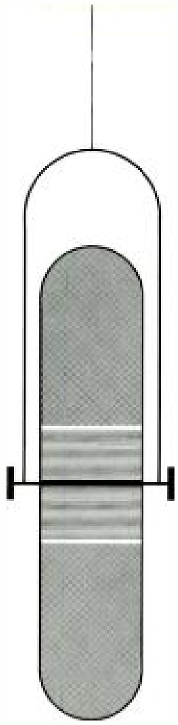
Alas, no. Scientists remain confident in the fundamental rule of the theory of relativity: that any object that moves more slowly than the velocity of light in a vacuum can never, under any circumstances, accelerate to the point where it is moving faster than the velocity of light in a vacuum. No one can ever go back in time by any method that as yet seems to fit in with the structure of the universe. And time itself can do no more than stand still. ■

The enigma of temporal existence is suggested by this now-fossilized snail.

All-Star Announcers

An interview with Tony Kubek and Frank Gifford

by Norman H. Solon



During the latter days of the 1970 National League East pennant race, the New York Mets' shortstop, Bud Harrelson, raced back for a short fly ball while outfielder Cleon Jones dashed in, seemingly on a collision course. In the television booth, announcer Tony Kubek, a former all-star shortstop with the New York Yankees and now the announcer providing background color on NBC's "Game of the Week," leaned over the shoulder of Curt Gowdy, who was doing the play-by-play, and shouted, "Look out, Buddy, look out!" An instant later, as Harrelson pulled up short and let Jones make the catch, Kubek turned to his broadcasting partner with a sheepish grin, realizing that he had violated a prime rule of sportscasting: Never interrupt an announcer at the mike.

"One of the problems I have in the booth, as an ex-athlete, is that I get so involved in the game that I start trying to help the infielders," Kubek explained. "Since I have this feeling for players who have gone the same route as myself, I sometimes see the game a little differently from an announcer who is not a former athlete."

At around the age of 35, when most men have not begun to reach the prime of their careers, professional athletes face retirement. A few of them, such as the former New York Yankees' third baseman, Dr. Bobby Brown, and Supreme Court Justice Byron (Whizzer) White, a former halfback with the Pittsburgh Steelers, begin the careers for which they had studied. Others, capitalizing on their names, go into franchise businesses. While many remain in sports as coaches, managers, and local radio and TV announcers, most gravitate into sales where their reputations as star athletes give them a natural advantage. Recently, an increasing number of former athletes — such as Frank Gifford, Kyle Rote, and Pat Summerall of the New York football Giants, Don Meredith of the Dallas Cowboys, and Sandy Koufax of the Los Angeles Dodgers — have exchanged their uniforms for the microphones of network television.

The transition from athlete to announcer is not always simple or successful. None of the major networks has a formal training program to turn all-star players into all-star broadcasters. In all cases, it has been primarily up to the athlete to prepare himself for his new career, either through formal education or on-the-job training. ABC's Gifford, for example, took several speech courses in college and spoke to many high-school and service-organization audiences during his playing days. Kubek recites poetry, reading aloud for 15 to 20 minutes a day during the off-season to improve his diction. Tom Seaver, the ace of the New York Mets' pitching staff, takes journalism courses at the University of Southern California to prepare himself for a future career in sports announcing.

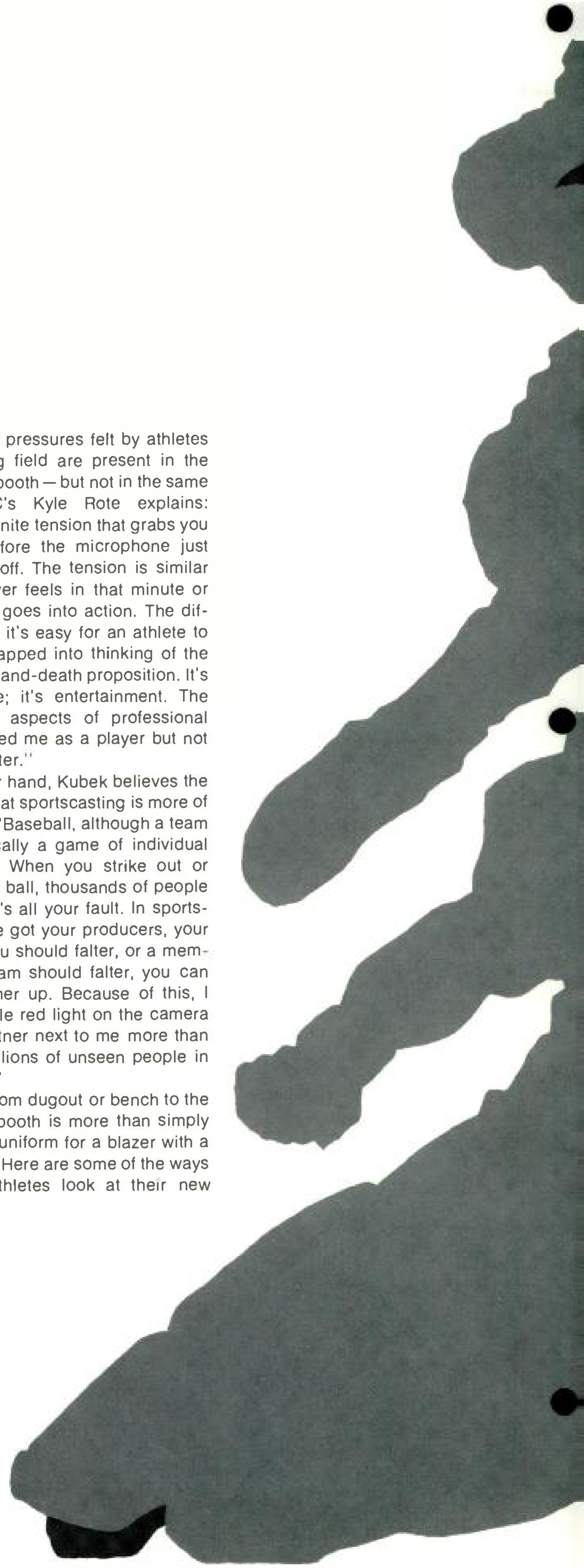
Many big-name candidates for network sportscasting positions never make it. Curt Gowdy of NBC, a recent Peabody Award winner for sportscasting, explains that "the day has gone when Joe Muscles could jump into the television medium as an instant and guaranteed success. The trouble with most former players is that they tend to talk too much. And many won't take direction. They won't admit to themselves that there is a genuine learning process that goes with becoming a successful sports announcer."

However, the role of the former athlete as a network announcer has been firmly established. As one of them recently put it, "It is not just a coincidence that sports have become successful on TV since the advent of the athlete-announcer. Audiences have become so sophisticated, so aware of the intricacies of every sport through TV, that they want more than ball one, outside, or first down and 10 to go. They want to hear about the inside of sports, and this can best be told by an ex-athlete."

Many of the pressures felt by athletes on the playing field are present in the broadcasting booth — but not in the same manner. NBC's Kyle Rote explains: "There's a definite tension that grabs you as you sit before the microphone just before a kick-off. The tension is similar to what a player feels in that minute or two before he goes into action. The difference is that it's easy for an athlete to find himself trapped into thinking of the game as a life-and-death proposition. It's not, of course; it's entertainment. The life-and-death aspects of professional sports motivated me as a player but not as a sportscaster."

On the other hand, Kubek believes the difference is that sportscasting is more of a team effort. "Baseball, although a team sport, is basically a game of individual performances. When you strike out or miss a ground ball, thousands of people see you and it's all your fault. In sportscasting, you've got your producers, your directors. If you should falter, or a member of your team should falter, you can back each other up. Because of this, I play to that little red light on the camera and to my partner next to me more than I do to the millions of unseen people in the audience."

The move from dugout or bench to the broadcasting booth is more than simply exchanging a uniform for a blazer with a network crest. Here are some of the ways two former athletes look at their new careers.



Norman H. Solon is on the RCA Public Affairs staff.

Sportscasters have been accused of simply being press agents for the sport or team that they are covering and, as a result, lacking any real depth in their presentations. Is this true?

Kubek: Well, this is getting into local play-by-play announcing, not network radio and TV. Local announcers do owe something to the ball club they travel with day after day. Obviously, when they are getting paid by the Yankees, Mets, or some other club, many announcers are going to promote that team and are going to be protective and maybe overprotective. It's different on the networks. Up in the booth, on the "Game of the Week," we represent baseball and NBC. We can view the game more objectively and can say and do things on the air that the local sportscaster would not be allowed to do.

Gifford: I guess a lot of people would say that, mostly newspaper people, because there is a built-in jealousy between newspapermen and broadcasters. I think that some of the attacks are probably fair, but so many are not. It has been said that sportscasters are advised what to say by networks or teams, and that just is not true. In 10 years, I have never been told what to say or what not to say. Speaking as a former player, I do not believe in knocking athletes unnecessarily. I try to look at the game in a more positive way than do some announcers. For example, when Gayle Sayers, of the Chicago Bears, makes a fine run against the New York Giants, I would rather look at it as a fine effort on the part of Sayers than dwell on the defensive quarterback who might have missed the tackle. There are always two sides to a play.

Do other sportscasters resent the new athlete-announcer?

Gifford: I think it would be unrealistic to think that there is no resentment. Most professional announcers came from the "minor leagues" of broadcasting and spent 15 or 20 years working their way up to the networks. Now, all of a sudden, they see a halfback hang up his cleats and walk right into the booth without serving an apprenticeship. Yet, I think we have very little of this type of resentment in football announcing.

Kubek: I think that announcers who show this resentment to an ex-ballplayer are very insecure people. I can sense their feeling. They say, "Who does he think he is? He's got a real job with NBC. What experience does he have? Why should he be there? Why aren't I there?" I like to throw back at them, "Listen, my father was a professional ballplayer and so were my three uncles. They gave me the benefit of a generation of baseball knowledge. I also became a big-league ballplayer, and I feel that if anybody is qualified to talk about baseball, I am."

As a former professional athlete, do you find it hard to be objective about your old team and teammates?

Kubek: I still have my own personal prejudice in favor of the Yankees. I was in the organization for 13 years, and I think I pull inwardly for the club. I probably shouldn't, but it's a natural tendency. And I think fans appreciate a little bit of loyalty. On the other hand, when we do a Yankee game, I sometimes find that I overcompensate and don't talk enough about my old team.

Gifford: Last season, while broadcasting a preseason Jets-Giants game on CBS, I remember saying, "I'm Frank Gifford here, along with Pat Summerall, and we're both trying to be neutral." I meant it. Most people who watch football know that I was associated with the Giants; yet, I don't think I overdo it. I don't stand up and cheer every time a Giant breaks out into the clear. But I do like to see the Giants do well.

In what ways have your relationships with players and coaches changed since you stopped playing?

Gifford: Unless you are really involved in the game as a player or as a coach, you can't have the type of relationship you had when you were a player. There is something about the game that makes pro football a kind of close little fraternity. Even when you play, if you get hurt and miss three or four games, you get a vague feeling of isolation. And when you retire — well, to the active players you're just not the same. You maintain your friendships, but they're different. However, these associations do help a great deal in broadcasting. I have much more rapport with the player I'm interviewing simply because I played the same game. He knows I understand what he is talking about and is not leery or concerned about me making him look foolish.

Kubek: I think these relationships have actually gotten better since I hung up my uniform. Ballplayers realize that, when a network crew is in town, it's there to promote baseball and the players. As an active player, you don't get much of a chance to socialize with the opposition, although a lot of them are your personal friends. Now I can eat out with Carl Yastrzemski when we are up in Boston, talk to Henry Aaron more often, see Willie Mays a little bit more. They no longer are my opponents, so to speak. They're simply friends of mine.

Because television can show the action of the game itself, sportscasters and reporters often tend to concentrate instead on personal and offbeat features. Do athletes object to talking about their private lives? Where is the borderline?

Kubek: I don't think there is a borderline. Today's players have become very aware of what is going on — not only in their own little baseball realm but in other areas as well. I can ask ballplayers these days almost anything within the bounds of good taste because I've played with them; we've been through the same thing. If a professional announcer tried to ask him certain personal questions, a ballplayer might become very defensive.

Gifford: I think there is an ever-growing tendency on the part of all reporters to look for offbeat angles. But, too often, they use this as an excuse to project themselves — their way of thinking, their way of life — into their broadcasts or articles. They forget, for example, that the reason they conduct an interview is so the public can see and/or hear a newsworthy individual, not to provide a forum for their own egos.

It would seem easy to bring your personal likes and dislikes into a discussion. Are you completely neutral in each interview?

Gifford: No. I think it would be unrealistic to say that I am. What one tries to do is tell himself, "I am doing the interview because whoever I'm interviewing is making news and is somebody my audience wants to listen to and wants to see." There are a lot of guys in this field who push their own thoughts in everything they do. That is their way of doing it, and I don't think it is the right way or the fair way.
Kubek: Let me answer that question with an example. After the first part of a two-part abridgment of Jim Bouton's book, *Ball Four*, appeared in *Look* magazine, I went to Bouton and told him I would like to have him on my program. I said to him, "Before you say yes or no, I am going to tell you exactly what viewpoint I'm going to express. I think that your book was no good for baseball, the people in it, or, in fact, yourself. If you still want to go along with me, come on." He agreed. During the interview, he said that he wrote the book as a humorous social commentary on the lives of baseball players — with some sociological value. I contended that he wrote it simply for money. For one thing, he tried to shoot down the Mickey Mantle image. He wrote about Mickey's elbow on the bar, indicating that, if he had spent less time in the bar and more time taking care of himself, he would have played longer and been a better player. If it was a social commentary, he would have tried to explain why Mickey kept his elbow on the bar. He might have explained that Mickey's father and two uncles all died young and that Mickey has a very fatalistic attitude toward life. However, even after that interview, I still have a strong friendship with Jim.

Now that you are a sportscaster, do you miss being a professional athlete?

Kubek: No, not really. Most players reach their mid-thirties and start thinking, "Should I give it one more year, two more years? Should I quit now?" In my case, the doctors came to me when I was 29 years old and said, "You get out of baseball or you will be injured severely. If you get hit in the head or knocked around too much, you will be paralyzed for life." So I really had no choice. Actually, the most difficult part of getting out of professional sports is knowing when to make the decision to get out.
Gifford: Yes, I do miss it. I played football for 20 years and enjoyed every moment. But I have to be a little realistic about it. Once you're over 30, it's hard to go out there. I would have liked to have played more, and I could have played more. But I couldn't have played well.

After being a player, can you revert to being just a spectator?

Gifford: Yes, I love the sport, and I've got the best seat in the house. Sports announcing is not just a job to me. I put in a lot of hours of preparation and work, but I enjoy that, too.
Kubek: I can enjoy each game simply because I don't travel with the same ball club every day. Each week, we cover the top game — the one that might decide a pennant race and that will feature a lot of "superstars." For that reason, I never get bored and I can look at each game as a fan.

Do you feel competition from today's players who aspire to a broadcasting career?

Gifford: Sure I feel it, but I'm not trying to discourage anyone or crowd anybody out of the field. On the contrary, I think I have tried to encourage a lot of my friends to make a career out of sportscasting because it is a great way of life. Pat Summerall's first broadcasting assignment was a result of my recommendation to the CBS Radio Network. I recommended Don Meredith to ABC, and we are now colleagues on "NFL Monday Night Football." Maybe I'm creating competition for myself, but I think it's a terrific way to live. It does seem that many sportscasters come from the New York teams. But it's simply because the broadcasting industry is centered in New York, and these players have long been associated with TV people — sponsors, packagers, producers. If you were a player in St. Louis, you might be more likely to wind up selling beer. In Los Angeles, for example, Roosevelt Greier and several other Rams players have gone into TV acting.
Kubek: I think competition is good. I know very well that Sandy Koufax and Mickey Mantle, both good friends of mine, have to be thinking of shooting for my job. I know Tom Seaver has been going to school to study broadcasting. I think this is great.

What were some of your most trying, amusing, or embarrassing moments in the broadcasting booth?

Kubek: Most funny things happen during an interview. My first interview was with my ex-teammate, Yogi Berra. Before air time I said to him, "Yogi, here are the questions I'm going to ask you. You know I'm going to be nervous. Give me long answers." When we went on the air, I asked Yogi the first question, and his reply was, "Would you please go on to the next one, Tony?" Dead silence for I don't know how many seconds. Before that interview began, the stage manager gave me the countdown: 10, 9, 8. When he got to about 3 — three seconds left — he commented, "Don't get nervous, but 25 million people are watching you. Go!"
Gifford: There are a lot of funny things that happen when you get in front of a mike. I can remember hosting the show after the 1968 Super Bowl game between the Green Bay Packers and the Oakland Raiders. I was talking to players and, all of a sudden, there was our producer, standing there with a guy I know as well as my own brother, except I simply didn't remember his name. At the time, I was talking to the Packers' right guard, Fuzzy Thurston, and the director was signaling me to bring on the next player. I kept on talking to Fuzzy, looking at him and thinking, "Good God, his name is going to come in a minute." Fuzzy just kept rattling on and on. Finally, the director whispered into my ear, "Come on, let's get some more players on." Again, I just kept talking. Finally, Forrest Gregg, whom I've known for years, caught on to what was happening and, off camera, mouthed his name. With relief, I shoved Fuzzy off camera and said, "Here's Forrest Gregg." I can assure you I had a panicky feeling for a while.

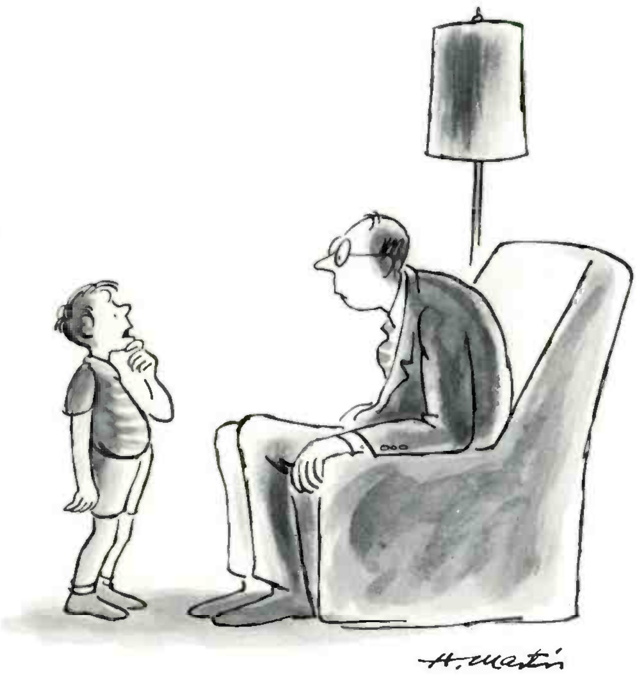
Do you pattern yourself after any favorite announcer?

Kubek: I don't think you can consciously pattern yourself after anyone without creating a phony or dishonest image, one the television audience can always see through.
Gifford: No, I don't think one announcer can pattern himself after another any more than one ballplayer can model himself after another athlete. During my playing days, there were many athletes I admired, but I never tried to take anything away from them as players. I tried to do it my way. I guess, in effect, that's what I try to do now.

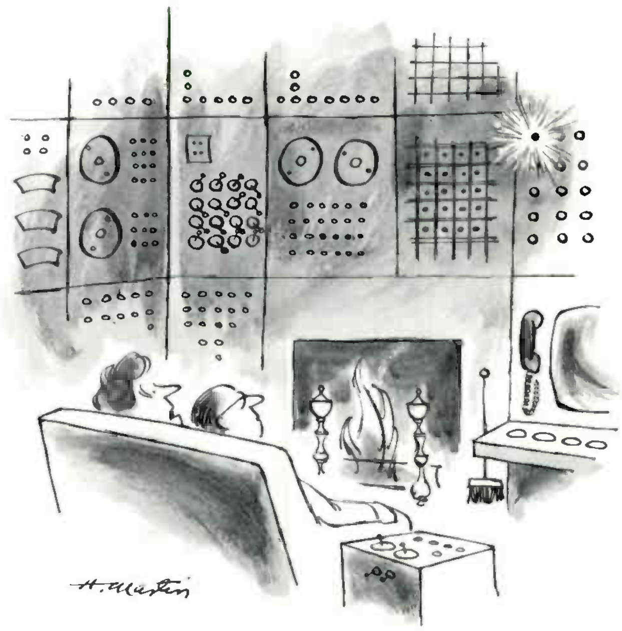
Now that the football weekend extends into Monday night, many people are worried about overexposure. Are we going overboard in televising professional football?

Gifford: I don't know. It's something the football commissioner's office and network officials are watching very closely. Television is a very intimate instrument of communication. You're in somebody's living room, and, if you are upsetting them, they can simply turn you off. Of course, the claims of some newspaper people, predicting the death of football due to television overexposure, are ridiculous. These writers are drawing some kind of kooky parallel with boxing. Yet pro football, with its TV commitments, has never been more popular. Although football has been around a long time, our society really met it only in the late 1950s. It is the perfect spectator sport for the type of world we live in. It's a violent sport. It's fun, it's exciting, it's something with which we can become emotionally involved. ■

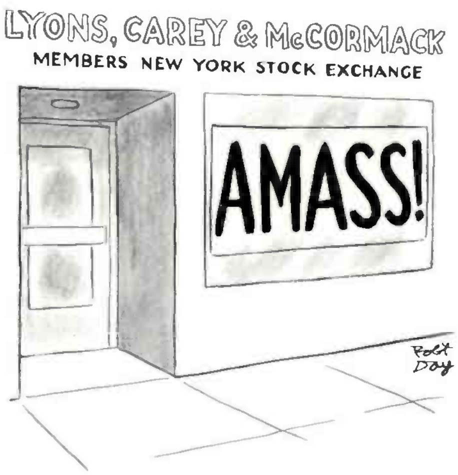
This Electronic Age...



"Well, let's see. Today we familiarized ourselves with the multipurpose, computer-based instructional systems, including curriculum materials and programming as well as systems hardware."

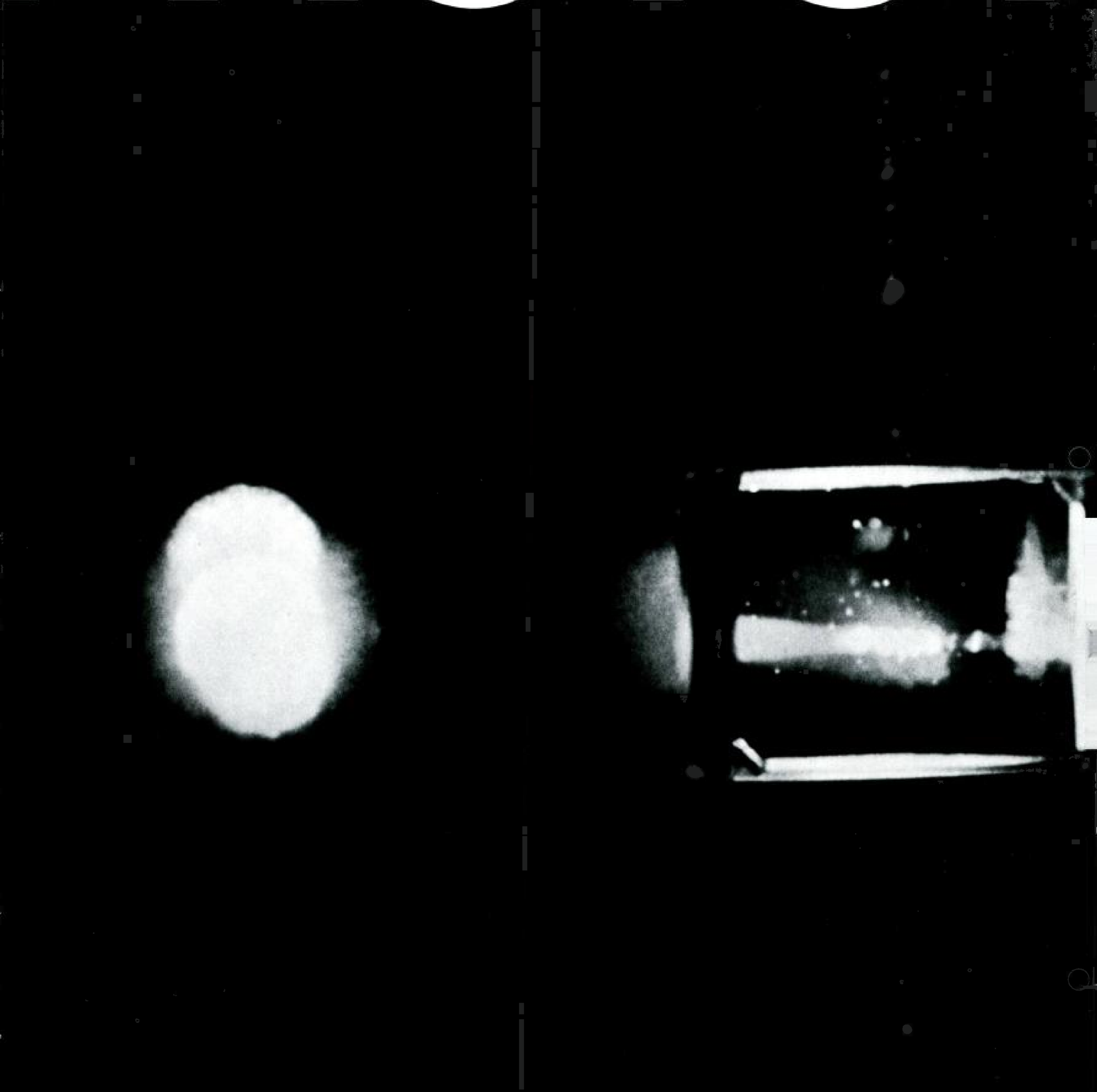


"What's that, Roger? The doorbell, the roast, the phone, the dishwasher, or overload?"



"This is going to set oceanography back 50 years."

PHOTOT



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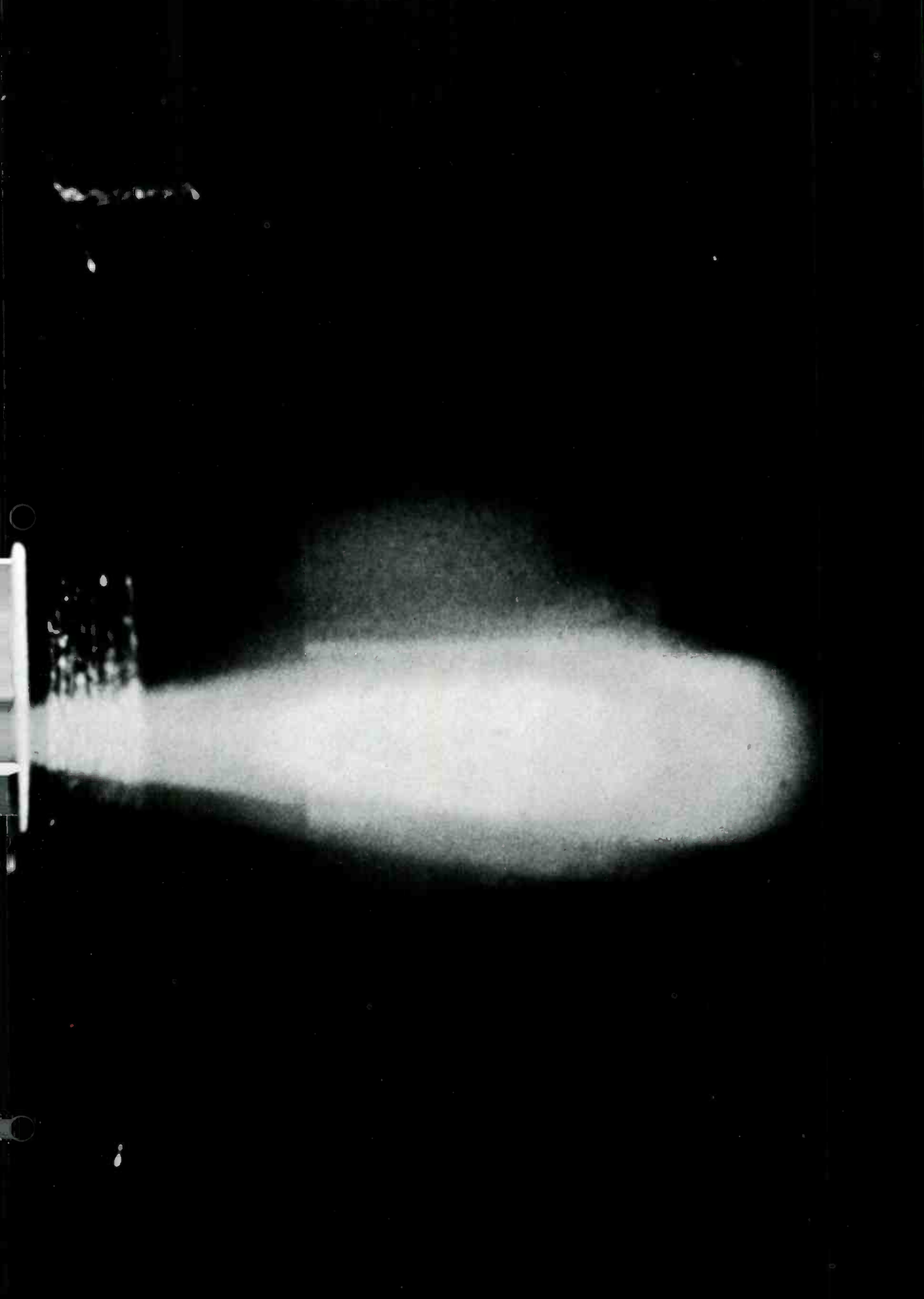


Taking pictures without film . . . thin-screen TV sets that can be hung on walls . . . a photo album that could hold several million pictures: These are some of the changes that electronics may bring about in the art of photography.

by W. Frederic Wilson

Laser beams may offer new image-producing techniques and are being investigated in many research laboratories.

"Phototronics . . . is likely to change photography as we know it today almost beyond recognition."

(Below) A thin, transparent layer of liquid-crystal molecules is sandwiched between two flat pieces of glass that have transparent, conductive coatings. Under the influence of an electric field, the molecules rotate so as to scatter light, changing the device from transparent to opaque. Liquid-crystal research currently under way at the RCA Laboratories in Princeton someday may lead to thin TV screens that can be hung upon the wall.

Imagine a photo album that could hold several million pictures or a TV set shallow enough to be hung on a wall like a painting. Or, instead of the camera you now use for still photography, suppose you had one that could shoot reusable "film" and store pictures for either printing or projection later.

Considering the rapid development of science in the 20th century, it was perhaps inevitable that electronics would influence the art of photography. Phototronics, the new technology arising from this combination, is likely to change photography as we know it today almost beyond recognition.

Some changes will be based on already existing technology; others now seem highly speculative. A major factor — one that makes current research especially urgent — is that photography is, essentially, a destructive medium. It is destructive of silver, paper, and chemicals. The finished print can never be remade on the same piece of paper, and the recovery of silver is difficult. Moreover, the chemicals used in processing are usually poured down the drain, causing both waste and environmental pollution.

The silver shortage is serious. Several years ago, this problem precipitated a crisis that caused the U.S. Treasury virtually to eliminate the silver content of coins and withdraw the silver certificate from circulation. These measures were temporarily effective, but the causes of the crisis remain.

Silver is used in many industrial products; and, for many of these products, substitute materials are not available. Recent estimates indicate that industry in non-Communist countries uses about 350 million troy ounces of silver a year, while annual mine production amounts to about 235 million troy ounces. That leaves an annual deficit of about 115 million troy ounces. And the photographic industry alone consumes between one-quarter and one-third of the total silver used.

Even though photography predates the Civil War, intensive research and development of new equipment have not been able to solve some of its original problems. Take the limitations of film, for example. Since photographic film is light-sensitive, the camera must be light-tight; this requires careful engineering and construction — and all too many repairs after construction. But is it necessary for film to be light-sensitive? Or, for that matter, to use film for the photographic medium at all? Videotape is a means of recording pictures that does not have the restrictions of light sensitivity.

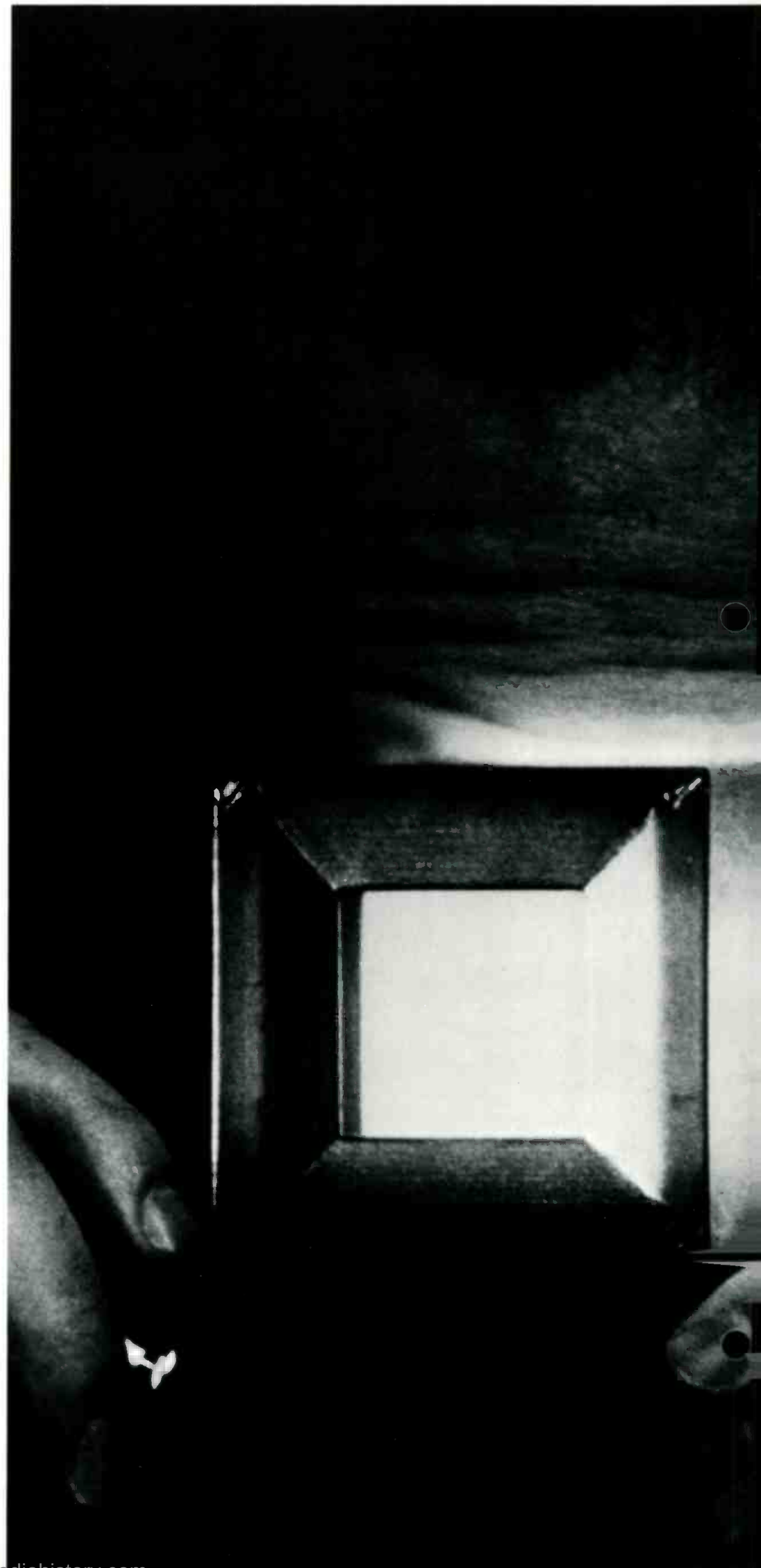
A picture cannot be taken properly unless the film speed is known and the lens aperture and shutter speed are adjusted to the light conditions for correct exposure. All these settings are made either manually or automatically (by using a mechanical computing system inside the camera). With a television camera, however, such settings are made electronically, resulting in faster operation and greater reliability. A similar technique eventually may be used in conventional photography.

But taking the picture is only the beginning. The film must be processed to be useful. Conventional processing in a darkroom involves working with separate chemical solutions. And, if one is not satisfied with the final print, the picture — with its silver content — may go into the wastebasket.

Through the application of new techniques, phototronics may provide one solution to the problem of how to conserve some of our natural resources. Indeed, electronics has already led to one economical way of producing a picture: television. There is a distinct advantage in not having to throw away the millions of pictures shown on a TV screen.

Take pictures without film? Impossible? Suppose someone had told a diamond cutter at the turn of the century that one day his jewelers' rouge would become a widely used means of recording a variety of seemingly unrelated phenomena: sound, pictures, and digital information for computers. He probably would have been unable to imagine these possibilities. And, yet, jewelers' rouge — a form of iron oxide — is used today in manufacturing the reddish-brown coating on tape used for all these purposes. Its magnetic properties make it an excellent medium for electronic recording.

The videotape recorder, for example, uses this medium to record pictures from a TV camera. Through a lens similar to the one used on a conventional camera, an image is formed on the face of the TV camera tube, which then converts the picture into electrical impulses. With some electronic processing, these impulses can then be recorded on videotape, which is electromagnetically sensitive rather than light-sensitive. The tape



W. Frederic Wilson is a free-lance writer specializing in photography.

(Right) The unaided eye can barely discern the man in the background; however, the low-light-level TV camera intensifies the image, which can be seen on the screen in the foreground.

"... electronics has already led to one economical way of producing a picture: television. There is a distinct advantage in not having to throw away the millions of pictures shown on a TV screen."

is reusable, since it can be erased by exposure to a magnetic field. It can be played back immediately and as many times as desired on a TV screen without degrading the image — a technique that has made possible the action replays on televised sports events. It is also possible to record sound on the same tape. For these reasons, videotape is replacing motion-picture film in many areas of operation. At present, it is gradually working its way into the consumer market; and, when its price comes down to the cost of movie film, then movies may go the way of flash powder.

With electronic recording techniques advancing so rapidly, how will a photographer — in, say, 10 or 20 years — record the pictures he takes? Most scientists feel that the image will still be recorded in picture form. It may not be quite the form we know today, but it will probably be a picture nonetheless. Color photographs, for example, will be made in black-and-white, with the color information supplied through the use of electronics. This technology would enable a picture to be seen on the face of a TV set in adjustable color or in black-and-white. Should one want a copy of the picture, there would be some method of printing it on paper, perhaps similar to one of the photocopy processes now in use. The electronic photo album that could hold millions of pictures, however, would exist in the form of either ultraminiature pictures on microfilm or electronically recorded information on videotape.

A major advance in phototronics is RCA's new television camera tube "with a memory." In order to store an image for an extended period of time, three scanning levels — high, medium, and low — are used for erasure, storage, and reading functions. The faceplate of the tube is first scanned by a high-energy electron beam to eliminate any charges on it. Then a picture is imaged through a lens onto the faceplate of the tube, which may be about one inch in diameter and may contain about 600,000 light-sensitive diodes per square inch. Each diode will store an electrical charge as the light hits it. Scanning the faceplate again with a medium-energy electron beam will store the picture. Scanning a third time with a very low-energy electron beam permits the picture to be read off (without being erased) and viewed on a TV set. Someday, perhaps, an extension of this technology may provide a way of making these tubes flatter and fabricating them into a strip of reusable "film" for a still camera. At present, however, this possibility seems very remote.

Another new technology that may have unexpected applications is liquid crystals, an area of research in which RCA is particularly active. Thin TV screens that can be hung upon the wall — the dream of scientists for years — may be realized through the use of this technology. In a liquid-crystal device, a thin, transparent layer of liquid crystals is sandwiched between two flat pieces of glass that have transparent, conductive coatings. Under the influence of an electric field, the molecules rotate so as to scatter light, changing the liquid-crystal device from transparent to opaque. Other types of liquid crystals change the device from light-reflecting to light-transmitting.

Images may be produced by means of two sets of parallel, electrically conducting wires that are perpendicular to each other, forming many thousands of small squares. One set of wires is evaporated onto one piece of glass, and the other onto the second piece of glass that makes up the liquid-crystal sandwich. By electronically indexing certain perpendicular wires, a square can be made either to absorb or reflect available light. By "scanning" these two sets of wires rapidly, a picture can be formed.

Liquid crystals that have reflecting properties are more valuable in producing pictures — the brighter the ambient light, the better the picture. Since more light produces a brighter picture, one could actually view such a screen on a sunny day at the beach.

Unlike TV picture tubes that create images by generating visible light of their own, liquid-crystal devices use available light to form an image and, therefore, need very little power supplied to them. They can also be made to produce a still or moving picture.

RCA is also researching the use of cathodochromic materials for image display. These, when coated on the face of a picture tube, make it possible to store a picture. An image is scanned onto the face of a cathodochromic tube by using an electron beam. The resulting picture resembles a black-and-white transparency, since light for viewing is supplied from behind the picture. After a picture has been recorded, the power supply can be turned off and the picture will remain. Because of this property, the tube could be used for making photographic prints or receiving pictures transmitted by telephone wire. The image is excellent, combining superior contrast and resolution with a very good range of tone from black to white — much better than that obtained with the phosphor-coated TV picture tube. Depending on the type of coating used, the picture can be erased by using heat or very high light levels.

One problem that has frustrated photographers has been the taking of pictures in dim light. Fast films have been made, and the speed of lenses has been improved. But these are still ineffective at very low light levels with shutter speeds normally used by photographers. The technique of image intensification provides another approach and effectively allows a camera to see in darkness as if the sun were out.

The complete process of image intensification consists of taking a picture, converting it to electrons, accelerating the electrons for intensification, and then changing the electrons back into a picture. Although the design and technology of image-intensifier tubes are rapidly changing, basic construction remains the same in most cases.

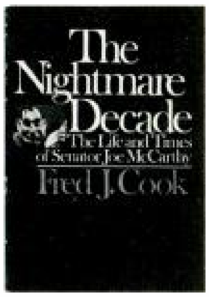
An image is formed on the face of the tube by a lens similar to the one on a conventional camera. The front face of the intensifier tube is made of a fiber-optics bundle that transmits the picture to a curved surface coated with a photoemissive material. This material emits electrons when struck by light. The electrons are focused by using an electrostatic field that has a high accelerating voltage, usually more than 10,000 volts. This accelerating voltage is the light amplifier, which performs approximately the same function as the silver does in photographic film. The accelerated electrons strike a phosphor similar to the coating on the face of a TV picture tube, except that this phosphor will emit light for a longer period of time. The phosphor is coated on the inside curved surface of a second fiber-optics bundle in the intensifier tube — the output bundle. The intensified image is emitted from the flat outer surface of the bundle, and a number of tubes can be linked together to intensify the image through as many stages as needed.

Image intensifiers have been in use for a number of years, but they have not reached a wide consumer market because of their high price. They have been used mainly in television cameras and for low-light surveillance. RCA has developed a television camera incorporating the light-intensifier tube for use by astronauts in transmitting live pictures from the moon. Unlike most light-intensifier cameras, which are susceptible to damage in ordinary bright light, the RCA camera can even be pointed directly at the sun. It can be used in both the particularly bright and the deeply shadowed areas of the moon.

Many electronically oriented companies have their research and development teams exploring almost every type of physical, electrical, and chemical change that might produce a picture. Does that mean that film companies may eventually stop making film? It seems unlikely at present. But, if an electronics company were to develop a simple, inexpensive still-picture recording medium, the film and camera manufacturers might have to change their products and marketing ideas quite drastically.

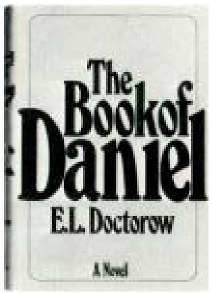
Since it may be only a matter of time until there will be no silver, paper, or chemicals used, the electronic future of photography seems assured. It will be easier and, in the long run, less costly. And it will extend the potential of photography and the fun of it for both the amateur and the professional. ■

Books at Random...



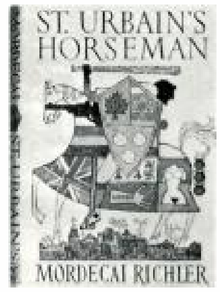
The Nightmare Decade
The Life and Times of
Senator Joe McCarthy
by Fred J. Cook (Random House)

Journalist Fred J. Cook has written a major biography of Senator McCarthy and the decade over which he cast his shadow. We follow McCarthy's early career: his years as a Wisconsin circuit court judge known for "quickie" divorces; the Marine Corps days when he played the wounded hero — cashing in on an injury caused by a practical joke; the murky financial transactions; and his senatorial campaign. The book re-creates the shouting matches on the Senate floor, the blacklisting of musicians and performers, the Owen Lattimore case, and the climactic Army-McCarthy hearings.



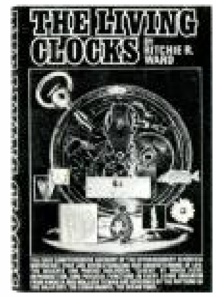
The Book of Daniel
by E. L. Doctorow (Random House)

Daniel Isaacson is a young man whose parents were executed for conspiring to steal atomic secrets for the Soviet Union. Though his mother and father have been dead for many years, he has not adjusted to their deaths. Memories — such as visiting his parents in the death house — persist. And, while Daniel is supposed to be writing his Ph.D. thesis, something quite different emerges: a confession of his most intimate relationships with people and an investigation into the past. Discoveries in the library stacks and interviews with people who knew his parents culminate in a judgment of everyone involved in the case and the Isaacson family itself.



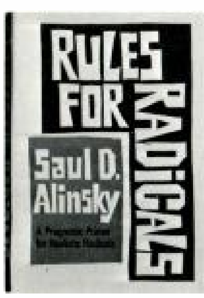
St. Urbain's Horseman
by Mordecai Richler (Alfred A. Knopf)

St. Urbain's Horseman is the story of a man on trial. Jake Hersh is a near-rich, near-famous film and TV director living in London — worlds away from St. Urbain's Street, the poor Jewish neighborhood in Montreal where he was raised. What has kept Jake worshiping and ever searching for his long-lost cousin Joey, missing since 18, now perhaps single-handedly defending an Israeli outpost? And what has brought Jake to his present crisis: a prisoner in the dock at Old Bailey, accused of an unspeakable crime? The whole texture of his life is conveyed in Richler's complex, moving, and comic evocation of a generation often consumed with guilt.



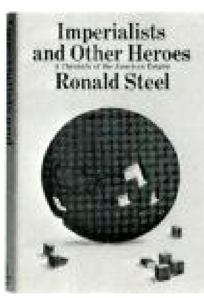
The Living Clocks
by Ritchie R. Ward (Alfred A. Knopf)

One of the most exciting developments in modern science is the discovery of biological "clocks" that govern the behavior of all life and link each of us with the rhythm of our planet. Living clocks are a central concern of biologists who seek to understand our total environment. They have led us to understand, for example, why long-distance airplane travelers experience "jet fatigue" and how a prolonged sojourn underground alters some body rhythms. These clocks also have been found to affect such phenomena as sleep, reproduction, and the functions of organs in the living body.



Rules for Radicals
A Pragmatic Primer for Realistic
Radicals
by Saul D. Alinsky (Random House)

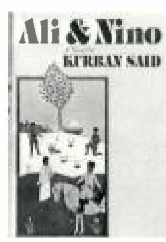
Machiavelli told the "haves" how to maintain themselves in power. Alinsky tells the "have-nots" how to take this power away. For more than 40 years, Saul Alinsky has been a professional radical and organizer. His book is addressed to the powerless everywhere — poor blacks and whites, students, industrial and agricultural workers. His hardheaded tactical advice provides an alternative not only to the powerlessness that threatens our democracy but also to the random violence and bitter alienation through which so much radical energy is wasted.

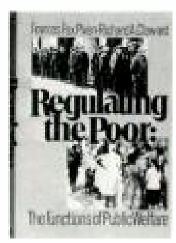


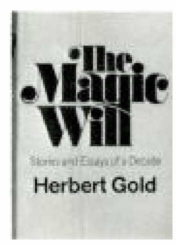
Imperialists and Other Heroes
A Chronicle of the American Empire
by Ronald Steel (Random House)

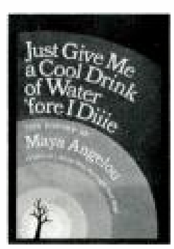
This volume of the author's essays on the American empire forces the reader to consider in a new light America's foreign policy and the leaders who have been responsible for it. A post-Cold War approach to foreign policy, the book reflects both the disenchantment of a generation that has turned from acquiescence to cynicism and the growing mood of doubt that is causing many Americans to question the assumptions of the last 25 years. Steel also discusses what he feels is the new commitment shaping American politics in the '70s.

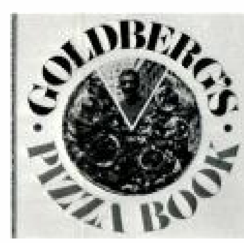
Other Recent Random House Books











New Tools to Study the Past

Today's archaeologists increasingly rely on modern technology to recover and study the remains of ancient history.

by Kenneth Witty

There was a time when all an archaeologist required was a pick, a shovel, and a well-read volume of Homer or some other ancient author. Such simple tools unearthed the fabled cities of Troy, Mycenae, Knossos, and Pompeii, to name just a few of the great finds of the past. The goals of archaeology, however, have become far more ambitious since the days a century ago when Heinrich Schliemann set out to prove that Troy was not a legend or some creation of Homer but historical fact.

Today, archaeologists want to know more than just the broad outlines of history. They are seeking to fill in the details of ancient cultures, the shadings and textures that will turn a sketch into a full-blown portrait of the past. To gain these insights, they have been collaborating with physicists, chemists, electronics engineers, and computer experts to develop new and sophisticated tools. The new technology that has resulted is helping archaeologists find, date, and analyze artifacts so that they can tell the story of ancient man's daily life, his art, his migrations, and his commerce.

One of the ways in which advanced technology is aiding archaeology is in the location of buried remains. For most of the past decade, one of the most important searches has been conducted by archaeologists and physicists from the University of Pennsylvania experimenting with new types of geophysical detection equipment in their search for the long-lost city of Sybaris, in southern Italy.

Sybaris was one of the largest and wealthiest cities of the Greek world in the sixth century B.C. It had been founded, in approximately 720 B.C., on a fertile coastal plain by the Gulf of Taranto by colonists from mainland Greece. In little over a century, the city became so rich and powerful that it dominated a vast region and sent out colonies of its own as far away as the Italian west coast. Among the Greeks, the Sybarites earned a reputation for their opulent and pleasure-loving ways. In 510 B.C., defeated in battle by the neighboring city-state of Crotona, Sybaris was leveled and burned.

Although the city was abandoned 2,500 years ago, its fame as the pleasure capital of the ancient Greeks has survived and bequeathed the word "sybarite" to the English language. Although attempts were made to rebuild there in Greek and Roman times, the original Sybaris vanished from the face of the earth — to become one of modern archaeology's most intriguing enigmas.

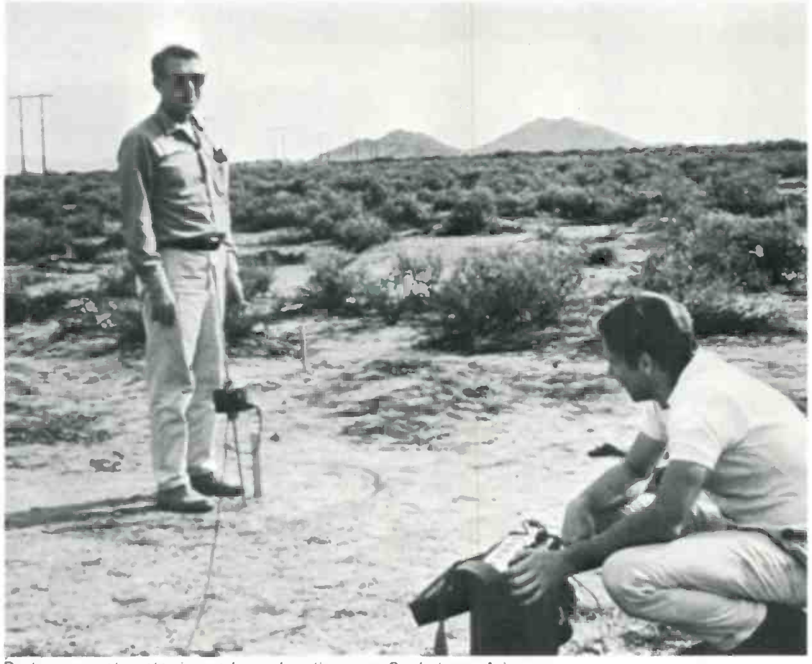
The University of Pennsylvania Museum and its director, Dr. Froelich Rainey, first became involved in the search for Sybaris in the early 1960s. The University Museum has been one of the pioneers in developing new instruments and techniques to aid archaeological research. Sybaris, Dr. Rainey felt, presented an ideal opportunity to test the effectiveness of electronic detection devices such as resistivity meters and magnetometers. His hope was that these highly sensitive instruments might succeed where more than a century of exploration with traditional methods had failed.

What had thrown archaeologists off in the past was that the terrain of the region where Sybaris once stood, according to ancient sources, has undergone enormous physical changes during the last 25 centuries. Geological surveys done by the University Museum expedition showed that the plain of Sybaris had been altered many times by earthquakes; one especially severe quake had lowered parts of the plain by as much as 15 feet, allowing the sea to rush over the land and form a large lagoon. Since that time, the lagoon has silted up with clay, periodically rising and falling.

Today, the water table lies only three feet below the surface, while the ruins of Sybaris are calculated to lie somewhere between 12 and 20 feet underground. Excavation, the traditional method of archaeology, would prove to be extremely difficult and costly, if not altogether impossible. To confound the would-be searcher further, the plain of Sybaris covers an area of some 40 square miles.

Dr. Rainey and his team began their search by probing the plain with magnetometers. These instruments can detect minute differences between the magnetic intensity of soils and any intrusions, such as buried stone foundations or ceramics. Objects of fired clay — bricks,

Kenneth Witty is a newswriter specializing in science and cultural affairs.



Proton magnetometer is used on a location near Snaketown, Ariz.

roof tiles, pottery — register as more magnetic than the surrounding soil, while stone constructions register as less magnetic or nonmagnetic. Magnetometer results require very careful interpretation, but with experienced operators and the proper geophysical conditions large areas suspected of containing remains can be surveyed with relative speed.

The first instrument the expedition used was a proton magnetometer that had been employed on other searches. It soon became apparent, however, that this tool was not sensitive enough to penetrate to the depths where Sybaris was thought to lie. Although no signs of the buried city were found, the archaeologists began to uncover Roman ruins from much later periods. These were not precisely what Dr. Rainey was looking for, but they did provide a clue: a Roman settlement was known to have been built close to the original site.

In 1967, Dr. Rainey brought along a new type of detection device, a cesium magnetometer originally designed for space research. A hundred times more sensitive than the proton magnetometer, the portable cesium magnetometer can rapidly detect remains buried as deep as 20 feet. Surveying up to 10 acres a day with the instrument, the archaeologists began to pick up magnetic contrasts at depths where they calculated Sybaris to be. Test borings with power drills yielded bits of ceramic roof tile and pottery shards. A series of small trenches were dug, and the foundations of large buildings were revealed. To the north and south of these discoveries, the detector spotted ancient riverbeds, confirming accounts that the city had been built between two rivers.

Dr. Rainey's work at Sybaris was the first large-scale application of cesium magnetometers for archaeological exploration. Since then, these new instruments have been used to map entire sites, such as the Grecian city of Elis near Olympia. In Mexico last summer, Dr. Michael Coe of Yale University unearthed, with the aid of a magnetometer, the finest example of an Olmec head ever found.

Despite these successes, many archaeologists still look upon these new tools with reserve. "There is a resistance to the new techniques," says Dr. Rainey, "because archaeologists don't understand them. Only one in a hundred has

Excavation of an Indian site in southwest Missouri.

"While innovations such as the computer and atomic-dating processes are helping traditional archaeoolgy, recent technology has also created a whole new field of study under the sea."

Portable cesium magnetometer is moved to a site near San Lorenzo, Veracruz, Mexico.

any conception of modern physics and what it can do. It's really two worlds — the humanities and science." Ironically, even the most hardened traditionalists among archaeologists are relying increasingly on advanced technology in physics and chemistry to help them in one particular aspect of their research, the dating of artifacts.

The development that first brought about this collaboration between archaeologists and physical scientists was the discovery of radiocarbon dating by Willard F. Libby in 1949. Since its first application, thousands of radiocarbon dates have been established, changing profoundly our knowledge of early civilizations. We know now that the last Ice Age ended closer to 10,000 years ago than 20,000; that agriculture was practiced in Mexico by 5000 to 6000 B.C., almost as early as in the Near East; that men were constructing stone-walled towns in Palestine by 7000 B.C.

The ability of radiocarbon dating to tie down events to a particular century has revolutionized archaeology and given it a degree of precision it lacked previously. Prior to this, there had been no way of establishing the absolute age of an artifact and its related events. The radiocarbon technique is based on the fact that all living matter contains a small but virtually constant proportion of the radioactive isotope carbon 14. When an animal or plant dies, the radioactive carbon in the tissues is no longer replenished from the atmosphere and it starts to disintegrate at a constant rate — by one-half approximately every 5,730 years. By measuring the extent of carbon 14 disintegration in excavated organic remains, scientists can arrive at a fairly accurate determination of their age.

As valuable as radiocarbon dating has been, however, it is not infallible. Discrepancies in dating by radiocarbon methods have been noted, and one of the most effective means of cross-checking radiocarbon dates is through tree-ring dating. For example, radiocarbon dating established the age of Stonehenge at 3,670 years. Tree-ring dating proved that the site is actually some 500 to 700 years older. The shortcoming of carbon dating is that it can only pinpoint artifacts in time by association with organic material.

Suppose, for example, an archaeologist uncovers a cache of farming tools and wants to know their age. He can only determine this if he is lucky enough to unearth some organic material at the same elevation. There may be no such material; or if there is a pinch of charcoal, for instance, it may well have found its way there centuries or even millennia later. In most cases, archaeologists, like good detectives, can arrive at conclusions by piecing together the circumstantial evidence. Still, as long as dating is done indirectly, there is always an element of doubt.

To eliminate such uncertainty, scientists and archaeologists have been looking into ways of dating the artifacts themselves. Today, there are at least seven direct dating methods, all based on atomic physics. One of the most promising of these is thermoluminescence, a technique used in conjunction with pottery and other clay products. Ceramics are among the most common relics of ancient civilizations. And scholars used to establish chronological periods for various cultures by analyzing stylistic changes in pottery. However, any pottery sequence can serve only to provide a system of relative dates, while thermoluminescence offers a way to pin down dates in absolute terms.

The method depends on the uranium and thorium content in clays. The older the pottery, the more these radioactive elements have decayed, leaving trapped electrons in the clay. When heated in a kiln, the pottery will release these electrons in the form of light. This light, or thermoluminescence, can then be measured by very sensitive instruments. Since old clay glows brighter than newer clay, the age of the object can be determined. However, the technique is still subject to a margin of error of about 5 per cent, which is too great to satisfy the needs of many archaeologists. In the past few years, though, it has scored some notable successes.

Chemists at the University Museum have spotted several forgeries that had been passing as valuable Etruscan statues. One of the Museum's own treasures, the Etruscan Lady, turned out to be no more than 100 years old. Testing a second Etruscan figure, Diana the Huntress, owned by the City Art Museum of St. Louis, scientists discovered that it too was of 19th century origin — possibly a creation of the same Italian forger.

Typically, such new atomic-age technologies as thermoluminescence, neutron activation analysis, x-ray fluorescence, and mass spectrometry are used as laboratory aids in archaeology, either for dating or for chemical comparison of artifacts. Recently, however, these techniques also have been used to map the world's mineral deposits and correlate them with artifacts dug up in different parts of the world. With such "fingerprinting," chemists and archaeologists have been able to learn a great deal about prehistoric trade routes and migrations.

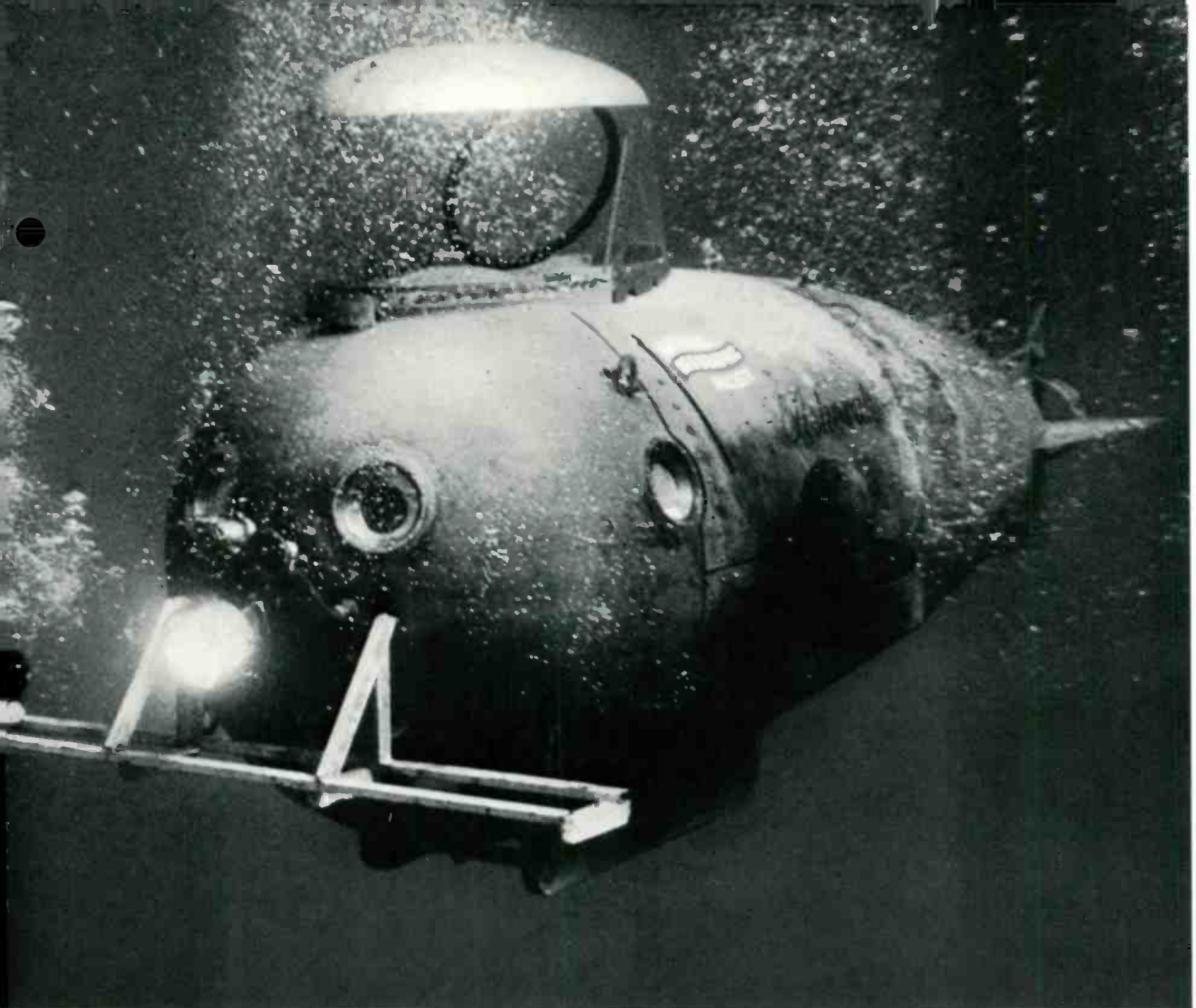
Dr. Curt Beck of Vassar College has been using an infrared spectrometer to map deposits of European amber. Although still in its initial stages, his research has already shown that, as far back as 1500 B.C., Greeks were using Baltic amber that was probably mined in Denmark. These findings bear out various ancient legends of trade between Aegean sailors and peoples of northern Europe.

At the Atomic Energy Commission's Brookhaven National Laboratory, Dr. Edward V. Sayre, a chemist, has been working with Dr. Ray W. Smith, an archaeological expert on ancient glass, to classify glassware spanning 2,700 years. Sayre puts glass samples that Smith has collected all over the world into a nuclear reactor. Neutrons produced in the reactor form radioactive isotopes, which emit radiation at different energy levels for each of the elements contained in the glass. By measuring the radiation intensities peculiar to each element, Dr. Sayre can identify the unique characteristics of each type of glassware without harming the valuable treasures in any way. The technique is called neutron activation analysis, and it has enabled archaeologists to learn what kinds of materials ancient peoples used for manufacture. In Dr. Smith's work, the technique has often helped to pinpoint where and when a particular piece of glass was made. He once traced a priceless vase found in Afghanistan to its origin in Syria around A.D. 300.

In 1966, Dr. Smith took time off from his studies of ancient glass to organize a joint American-Egyptian archaeological project. His aim was to re-create on paper the vast Aten Temple complex, at Karnak, from the rubble of tens of thousands of decorated sandstone blocks.

The blocks were first discovered at the turn of the century in the interior of giant gateways that were part of later structures on the site. Since they were not the main concern of the archaeologists who found them, they were put aside for future study. There were so many blocks that the idea of realigning them to get an idea of the original building had seemed an impossible task, until Smith saw them and proposed using a computer. According to his plan, each block was photographed and analyzed for the content of its decoration. A staff of 10 in the temple project's Cairo office set about coding significant features of each block: scale of the figures, depth of the carving in the stone, color, signs of hieroglyphics, et cetera. This information was then fed into a computer and matched against data obtained from other blocks, in an effort to solve one of the largest jigsaw puzzles ever attempted.

The temple that Smith and his coworkers are trying to reassemble was built 33 centuries ago by the revolutionary pharaoh, Akhenaten. The young ruler had the temple built in honor of Aten, the sun-disc god, as part of his campaign to establish a new religious order in 14th century B.C. Egypt. A gigantic structure



The *Asherah*, a small submarine especially designed for archaeological research, during an undersea exploration in the Mediterranean.

that may have extended for more than a mile, with colored reliefs on every wall, the temple stood for only about 20 years. After Akhenaten's death, Egypt returned to worship of its former gods and the temple was razed.

The task of making sense out of thousands of scattered blocks has been a monumental one, even with the enormous information-handling capacity of the computer. It has taken five years of painstaking labor to photograph, catalogue, and computer-sort the 35,000 decorated stones that have been located to date. Although the work is not yet finished, portions of the temple's exquisite ornamentation are beginning to take form. As photographs are matched, fragmentary scenes appear, depicting chariots and animal sacrifices, and portraits of Akhenaten and his beautiful queen, Nefertiti. Hundreds of painted reliefs have been reassembled, though only in incomplete form, and Smith and his colleagues fear they will remain so, since it is estimated that only about half of the original decorated stones will ever be found. The whole Aten Temple, archaeologists say, may have contained as many as a quarter-million decorated and undecorated stones.

To fill in some of the blanks, the project has employed artists trained in Egyptology. In scenes where enough blocks have been matched to form an outline of the original, the artists can sketch in the missing elements after studying similar reliefs from other temples.

Will the temple itself ever be rebuilt, using this reconstruction as a guide? Smith believes this would be an extremely costly undertaking. He suggests, instead, that selected scenes that have been matched should be actually reassembled to provide examples of the magnificent art from Akhenaten's short and turbulent reign. "Whatever happens," Smith says, "the value of the computer as an archaeological tool has been established without question."

While innovations such as the computer and atomic-dating processes are helping traditional archaeology, recent technology has also created a whole new field of study under the sea. Marine archaeology owes its existence to the invention of scuba-diving equipment after World War II. Two decades ago, Jacques-Yves Cousteau and other professional divers began to explore and salvage shipwrecks and their cargoes from the ocean floor. Despite the valuable contribution of these divers, however, underwater archaeology did not begin to make scientific headway until the early 1960s, when archaeologists themselves first donned scuba gear.

One of the pioneers among this new breed of archaeologist has been Dr. George Bass of the University Museum. Bass, whose specialty was Bronze Age Greece, had had considerable experience in land excavations in Greece and Turkey before making his first dive a decade ago. Since that time, he has devoted all his attention to the problems of underwater archaeology. Working with various types of engineers, Bass has developed a broad range of new tools that are making underwater excavations as exact as any on land.

The ability to do systematic archaeological work undersea is no mere novelty. Excavations of ships in the Mediterranean, Caribbean, and Baltic have added whole chapters to history by providing information on ship construction, navigation techniques, and trade routes of many periods.

"Even more important," says Dr. Bass, "when we find artifacts under water, they are usually much better preserved than those found on land. And almost everything that was made in ancient times was carried on ships at one time or another."

Furthermore, shipwrecks serve as buried time capsules whose contents can be very accurately dated. The only comparable situation found on land is that of a city such as Pompeii, which was destroyed by a sudden catastrophe – an archaeological rarity.

To mine this lode of information, underwater archaeologists have had to overcome the obstacles of working in an alien and often dangerous environment. If the task involved merely diving down and observing old ships, far greater progress would have been made to date. In fact, what divers and archaeologists call wrecks might better be described as refuse heaps of broken pots and ballast stones. No wooden ship survives very long against the voracious appetite of the ocean's teredo worms. If ship timbers are found, they most often represent only a fraction of the original hull and superstructure. Thus the archaeologist must reconstruct his find carefully from the vestigial clues that remain.

At first, Dr. Bass did his reconstruction survey work by sending down teams of divers to draw and photograph ship remains. He used a scaled grid system to diagram their observations. After several years of working out this procedure in the study of wrecks off the coast of Turkey, charting could be done with great accuracy. But the process was slow and costly, since divers can work for only short periods of time under water and must go through hours of decompression after working at any great depth. To locate the site of an eighth-century Byzantine cargo ship at a depth of 90 feet, for example, took Bass and 12 divers more than a month.

To speed up underwater surveying, Bass and the University Museum commissioned the construction of a small, highly maneuverable submarine, specifically built for archaeological mapping and exploration. Christened the *Asherah* after a Phoenician sea goddess, the pressurized craft can carry two men to a depth of 600 feet. It can stay down for as long as eight hours, travels at speeds as high as four knots, and is equipped with powerful searchlights for undersea exploration and a pair of stereophotographic aerial-survey cameras designed to take pictures that can be translated into a three-dimensional plan of a wreck site.

According to Dr. Bass, the *Asherah* functioned far beyond her designers' original dreams. When she was first used in 1967, it took only a half-hour to locate the wreck of a Roman ship – a tiny fraction of the time previously required.

Increasingly, Dr. Bass has turned his attention to finding new ways of locating wrecks, particularly those buried in deep water. His interest in finding effective search techniques is not purely academic. One summer, while Bass was working in Turkey, a sponge fisherman netted a beautiful bronze statue of a boy with negroid features wearing a toga. The statue was found some 300 feet below the surface. A few years earlier, the fisherman's uncle had hauled up another bronze, in this case a sculpture of Demeter, from the same depth a number of miles away. Dr. Bass knew from experience that, when one statue is found, there are likely to be others from the same wreck.

"To those of us interested in classical sculpture, shipwrecks are the only source of bronze statuary," he explains. "Bronzes that were not lost at sea were melted down in later times for the metal." Thus Bass suspected that the Demeter and the boy might have been part of a priceless cargo of classical art treasures.

Bass began a search, experimenting with television cameras, magnetometers, and a manned capsule known as the "Tow-Vane," which can dive to depths of more than 300 feet for visual observation while being towed behind a surface ship. After a season of searching with these various methods, no wrecks had been located. Bass concluded that the magnetometer and visual-exploration techniques were too limited in range for the vast areas involved. Still intent on finding a possible treasure ship, he turned the next year to a sonar detector, which can scan a path more than 1,000 feet wide by bouncing sound waves off the ocean floor.

With this new tool, it took only two days of runs across the suspected area to reveal a promising clue. The *Asherah* was sent down to investigate and at 285 feet settled directly on top of a cargo of ancient lamps, pottery, and amphoras. Bass had discovered a reliable search technique as well as one of the largest ancient wrecks ever found, a Hellenistic vessel from the third or fourth century B.C. Unfortunately, there were no signs of other bronze statues, although the next summer some of Bass' students did observe broken pieces of bronze around the wreck.

"The problem is that looters have been getting to these treasures faster than the archaeologists," Bass laments. "One of the biggest dangers facing underwater archaeology in the future is that historically valuable wrecks are being badly destroyed by looters and sports divers before trained professionals can get a chance to excavate them properly." But archaeology's new electronic devices may still help the scholars win this race against time. ■

The head from the figure of Ramses II is moved during the relocation of the temples of Abu Simbel for the Aswan Dam project in Egypt.

For the Records...

Verdi: Aida
Leontyne Price, Placido Domingo, Sherrill Milnes, Grace Bumbry, Ruggero Raimondi, and Hans Sotin
Erich Leinsdorf conducting the London Symphony Orchestra LSC-6198

Since its triumphant première at the Cairo Opera House in 1871, Aida has been a favorite with opera audiences. To celebrate this centennial year, RCA Red Seal has assembled some of the greatest voices in music for this superbly engineered album. It is also the first opera to be recorded on eight-track, 30-inch tape. A history and analysis of the opera by Charles Osborne, an authority on Verdi, are included with the libretto to this three-record set.

Paderewski: Piano Concerto *and* Fantaisie Polonaise
Arthur Fiedler conducting the London Symphony Orchestra
Earl Wild, pianist LSC-3190

For his recording debut with the London Symphony Orchestra, Arthur Fiedler, who was the first to record the Paderewski Piano Concerto in A Minor, has chosen to make the first stereo version of the work. With this performance, the concerto takes an important place in the growing list of 19th-century Romantic revivals. Like the concerto, the second work on the album — the "Fantaisie Polonaise" — is based on folksongs of the composer's native Poland.

Strauss: Don Quixote and "Rosenkavalier Waltzes"
Fritz Reiner conducting the Chicago Symphony Orchestra
Antonio Janigro, cellist; Milton Preves, violist VICS-1561

Don Quixote, the legendary figure from the village of La Mancha, created by Miguel de Cervantes more than 350 years ago, was the inspiration for the sixth of Strauss' tone poems, composed in Munich in 1897. Originally recorded on RCA's Soria Series, this famed Fritz Reiner/Chicago Symphony recording has been newly released on the Victrola label. As a companion piece, the Reiner arrangement of Strauss' waltzes from "Der Rosenkavalier" is included.

Encore! José Feliciano's Finest Performances
LSPX-1005

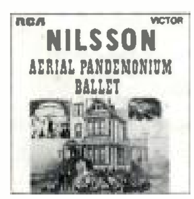
Twelve of the most popular José Feliciano recordings — including his instrumental version of Jim Webb's "Wichita Lineman" and his own original, "Life Is That Way" — appear on this RCA album. Feliciano is known for his ability to build an experience out of a performance and to mold that performance into art. The album demonstrates the range of his artistry in such classics as his performance of "Light My Fire" and "Malagueña," the longing insistence of "California Dreamin'," and the fragile plaintiveness of "Rain," another Feliciano original.

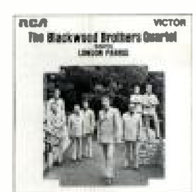
The Best of The Guess Who
LSPX-1004

By virtue of such smash hits as "These Eyes," "Laughing," "No Time," and "American Woman," The Guess Who has become the foremost Canadian rock group on the recording scene. In the two years since the group has moved from its home territory of Manitoba onto the international scene, it has led the way for many other Canadian rock performers. *The Best of The Guess Who*, a compilation of the group's Gold Records and hits from their other RCA albums, comes with a striking black-light poster of the five performers.

Rio Grande
LSP-4454

Rio Grande, the distinctive new five-man country rock ensemble whose debut album bears the name of the group, comes from the little-known town of Tyler, Tex. Under the guidance of veteran producer Dale Hawkins, Rio Grande demonstrates its unique sound with a collection of original songs written by two of its members, lead vocalist and guitarist Ronny Weiss and bassist David Stanley. The titles include "Wish I Could See You Again," "Me and My Wife," "End of the Battle," "Dog Song," and "So Good to Be Free."





Other Current RCA Releases

The Power Crisis

An increasing shortage of energy represents a major threat to our civilization.

by Tom Shachtman

Hydroelectric generators provide only about 4 per cent of the U.S. power supply.

The entire United States is in the midst of an energy crisis. A recent report from the Federal Power Commission warns us, "Some areas of the country may experience power-supply shortages this summer as a result of inadequate installed capacity to meet forecasted summer peak loads." In fact, only one of the nation's seven regions – the West, encompassing roughly the states west of the Rockies – has enough reserves to meet any sort of prolonged heat wave. In greatest danger of blackouts and brownouts is the southeast region, since the Virginia-Carolinas power pool has only a 6.3-per cent reserve.

The average per capita consumption of energy in the United States is six times the world average. The standard of living is five times the world average. Energy consumption, then, may be seen as an index to civilization. The more "civilized" and technologically expert a country is, the more energy it uses – and needs. And therein lies the problem for the United States.

In the years to come, the Edison Electric Institute and the FPC estimate that we will need increasing amounts of power. At the present time, we consume some 71 quadrillion (71 Q) BTUs, or British thermal units, of energy each year. By 1985, that figure is expected to double – even before the population of the country itself doubles, as it is expected to do by the year 2000. That amount of power is far beyond the present capacity of the U.S. power industry – though not, in theory, beyond the limit of our natural resources. It has been estimated that this country contains 5,162 Q BTUs of oil, 3,317 Q of natural gas, and 32,000 Q of coal. The problem is that much of this enormous reserve is not available, either because it is relatively inaccessible or because present technology is insufficient to obtain and utilize it in ways that are economical without being environmentally destructive. Consequently, the United States must rely heavily on foreign sources, consuming annually some 40 per cent of the energy-yielding fuels produced in the entire world.

Many people have mistaken impressions about where power comes from and who uses it. A commonly held misconception is that hydroelectric plants (water-driven generators such as those found in dams) provide much of our electric power. In fact, hydroelectric plants

Tom Shachtman is a free lance who writes frequently on scientific subjects.

"Sociologists and economists see the problem of generating the needed amounts of new power while protecting our environment as not only an important instance of our search for a better quality of life but also as a sore point between economically divided groups of people."

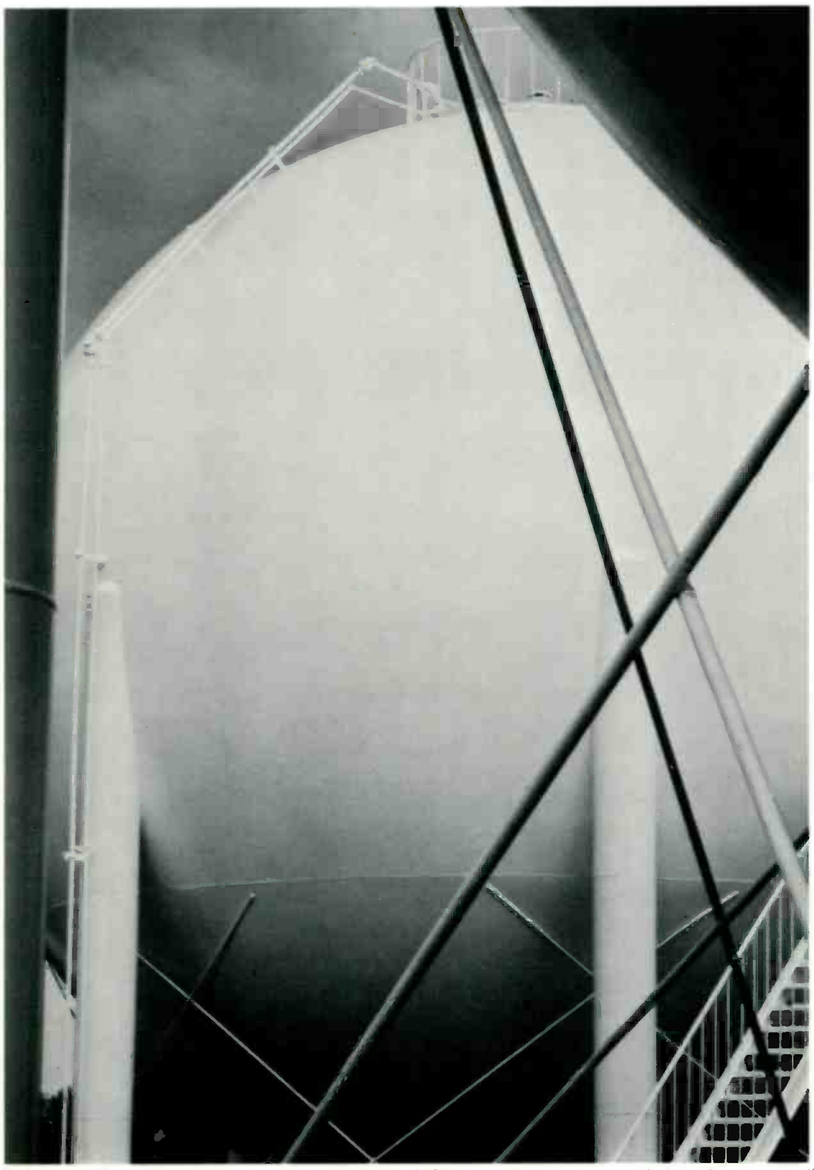
account for only 4 per cent of the U.S. power supply. Fossil fuels provide the vast bulk of power. Oil provides 43 per cent, gas 33 per cent, coal 19 per cent, and atomic energy only 1 per cent at present. Even with a great rise in the number of atomic plants in the coming years, utility men estimate that, by 1985, the country will be getting only 11 per cent of its energy from nuclear power. (And if we can get away with it, this figure assumes that, between 1980 and 1985, a new, giant 1,000-megawatt plant will come on-stream every two weeks.)

Where does this power go? Residential and small business demands account for only about 20-25 per cent of our entire yearly consumption. Another 20-25 per cent is used by our transportation systems. About one-third more goes to the industrial sector as a whole, and the remainder — currently about 16 per cent — goes to generate and transmit electricity itself. This last figure is expected to rise to 21 per cent by 1985 because of the relative inefficiency of nuclear power plant operation, thus reducing the proportional amount of energy available for residential, industrial, and transportation uses.

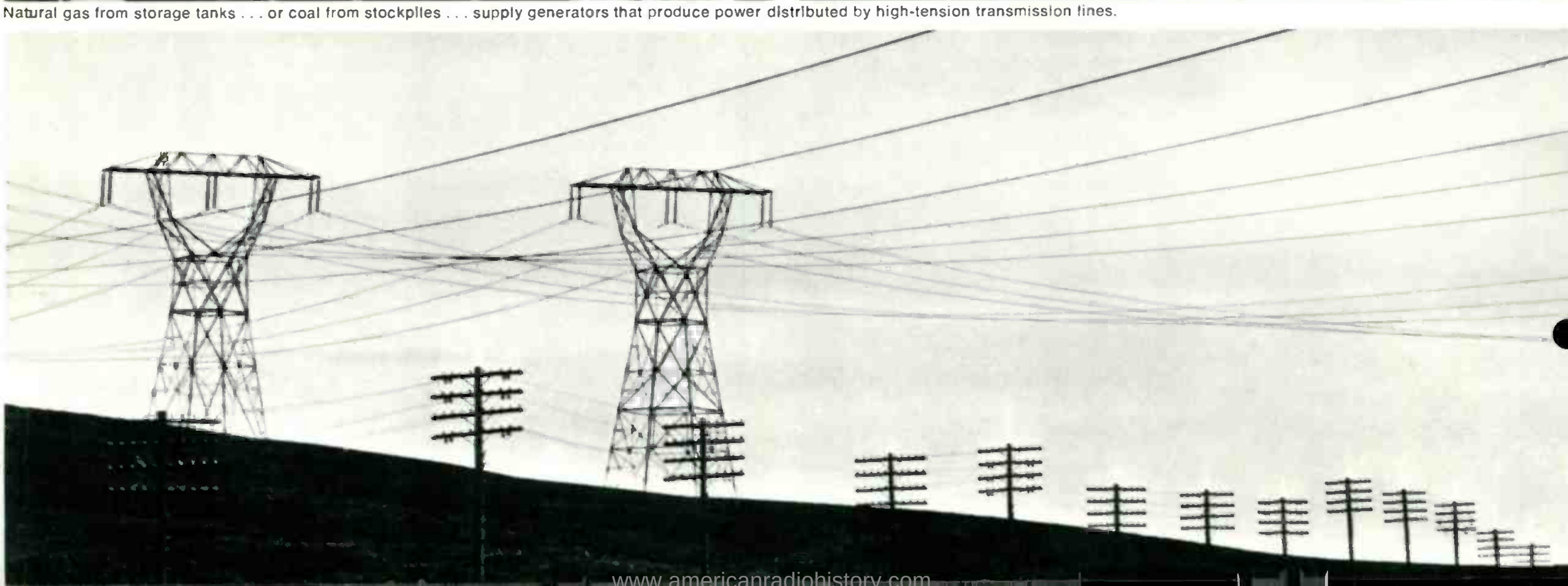
Delays in the completion of new power plants have accumulated in the past year — nuclear plants were 56 per cent behind schedule and hydropower units 35 per cent. One of the major causes of these delays has been court battles with groups seeking to block construction. For many ecology-minded people, power plants are major contributors to air, water, and thermal pollution. Indeed, fossil-fuel plants have long been known to have added substantially to pollution problems, especially around our cities.

Our increasing concern with the quality of our environment is a most important consideration for power production in the future. (In recent years, technological innovations have helped in the design of future power plants that will be more ecologically acceptable. But, the long lead time in design and development of power plants has caused some problems.) Sociologists and economists see the problem of generating the needed amounts of new power while protecting our environment as not only an important instance of our search for a better quality of life but also as a sore point between economically divided groups of people. For the middle class, improving the quality of life has come to mean, in recent years, improving the quality of the environment. But, for the economically disadvantaged, a better quality of life is

Fossil fuels, the major source of electric power, often produce pollution.



Natural gas from storage tanks . . . or coal from stockpiles . . . supply generators that produce power distributed by high-tension transmission lines.



"For the immediate future, 1971 to 1985, the energy crisis will continue to be severe, according to most forecasts."

something that might best be measured in terms of energy-consuming materials that the middle class has and takes for granted: clean and comfortable housing, modern conveniences, and work-saving devices.

The problems of meeting demands for additional power while maintaining the quality of our environment have become critical in the past several years and almost certainly will continue to be critical for as long as we can project, with certainty, into the future — until about 1985.

There are many reasons for these problems. Fossil fuels are in short supply at present. The closing of the Suez Canal and the Mideast situation have severely curtailed oil supplies in the world. Coal, seemingly so abundant in this country, is actually relatively scarce. A few years ago, many U.S. coal producers were forced to sign long-term supplier contracts with foreign companies, such as Japanese steelmakers, in order to remain economically viable. This has resulted in serious and chronic shortages of coal to supply power plants in the United States. In the recent past, the Tennessee Valley Authority (TVA), one of the largest users of coal to make steam for generators, had to cart its own short-term reserves of coal from one plant to another because it was unable to obtain any new supplies.

In addition, pressure by environmental interest groups has placed severe restrictions on the use of those fossil fuels which are available. Wilson M. Laird, director of the U.S. Department of the Interior Office of Oil and Gas, told a congressional committee last year that after East Coast states and cities set sulfur-content limits on industrial fuels, utilities and other industries were unable to obtain enough natural gas or low-sulfur coal to comply with antipollution standards. The demand for low-sulfur fuels was so large and so sudden, Laird said, that not all requirements could be met this past winter.

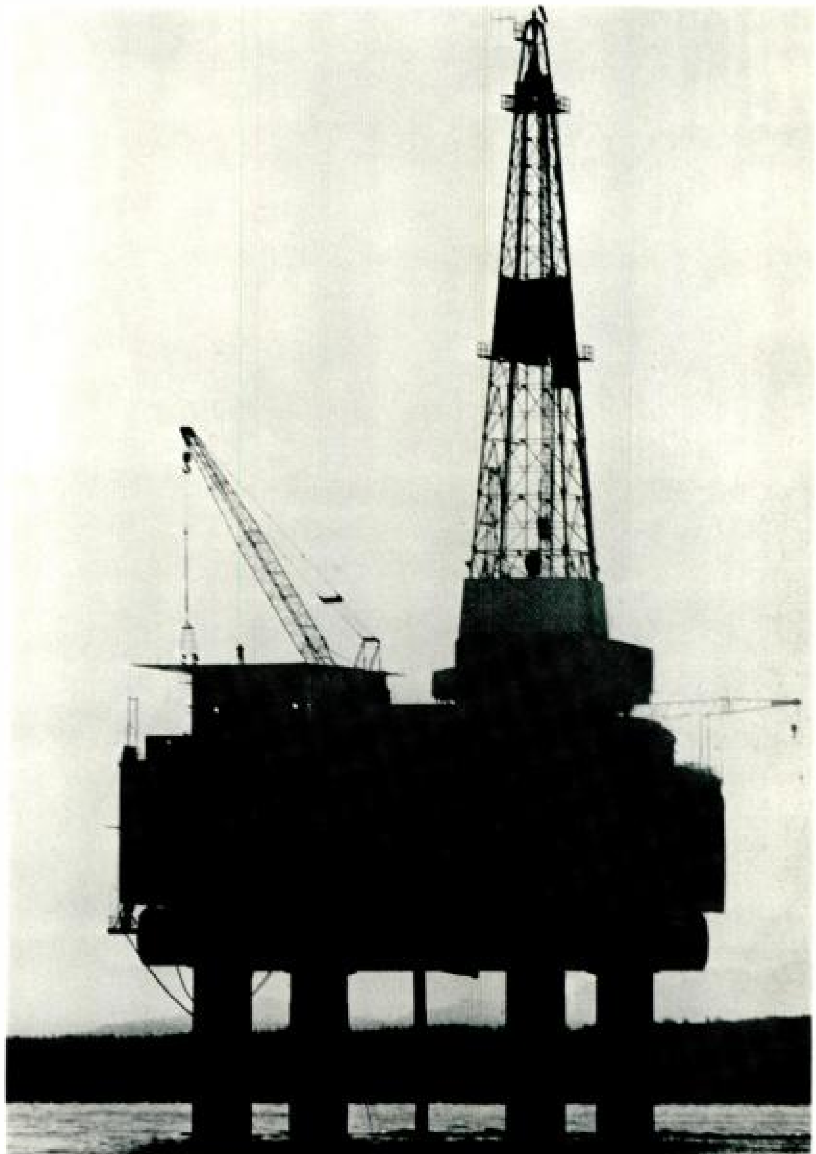
And what of the nuclear plants on which the electric utility industry has based so many of its hopes? The great promise of nuclear plants has not yet been fulfilled, and yet many utility companies are already looking askance at nuclear power: only seven new nuclear plants were ordered in 1969, as compared to 31 in 1967. Also, nuclear plants of the present type may soon run out of fuel. It has been estimated that plants now in existence and under construction will need, over their individual 30-year expected life, about 500,000 tons of uranium concentrate, roughly twice as much uranium as the present known reserves. Several years ago, the Atomic Energy Commission was estimating that, by the year 2000, about half the power for the United States would come from nuclear plants. This estimate, everyone now concludes, was unrealistic. The AEC's wrong guessing on this subject (a perfectly understandable wrong guess in the light of knowledge then available) was part of a deep mix-up and quagmire in our national energy picture.

Whereas many other nations and national blocs have centralized power-supply agencies, power in the United States is supplied by private utilities whose services are regulated by a variety of local and national government agencies.

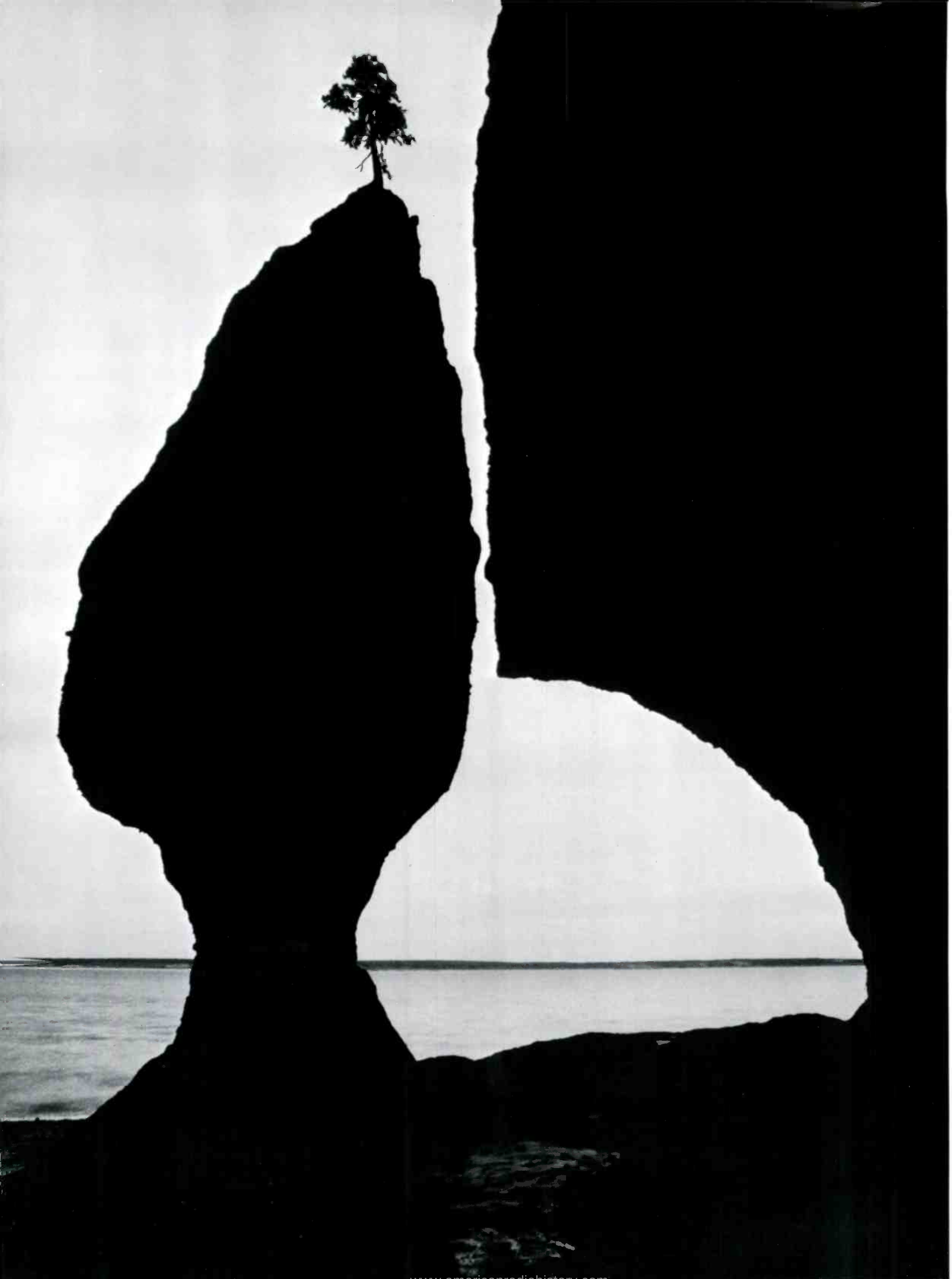
Among the federal agencies that have a hand in the regulation of energy and power distribution are the:

☐ Federal Power Commission (FPC), which oversees electric utilities and regulates the price of natural gas;
☐ Atomic Energy Commission (AEC), which licenses nuclear generating plants;
☐ Department of the Interior, which regulates oil import quotas, access to most offshore oil and gas fields, working conditions in coal mines (which influences the price of coal), and hydroelectricity through the Bureau of Reclamation;
☐ Department of the Navy, which regulates access to certain offshore oil fields;
☐ Interstate Commerce Commission (ICC), which sets freight rates on coal, among other commodities;
☐ Department of Health, Education, and Welfare (HEW), which sets air pollution standards; and
☐ The Treasury Department, which administers the oil-depletion allowance.

At this writing, the Senate Interior Committee is holding hearings on a national policy for energy and power, and it is hoped that committee recommendations will clear the way for such a policy. The President's Office of Science and Technology is cooperating with the inquiry, which is also being pursued in the House. There it takes the form of



Oil rig in coastal water at Cook's Inlet, Alaska.



"The more 'civilized' and technologically expert a country is, the more energy it uses — and needs. And therein lies the problem for the United States."

debate over a bill, introduced by Rep. Al Ullman of Oregon, to establish a National Commission on Fuels and Energy that would determine nationwide power needs for the rest of the century and recommend steps for meeting them.

What does all this mean in terms of power supply for the immediate, intermediate, and long-term future? For the immediate future, 1971 to 1985, the energy crisis will continue to be severe, according to most forecasts. But it will most probably be met with the introduction of oil from Alaska, gas from the North Sea, the expected reopening of the Suez Canal, new minings of coal and oil shale formerly considered too costly to recover, and the coming on-line of nuclear reactors now under construction. But most experts expect supply and demand to be nip-and-tuck all the way, and they expect costs to the consumer to rise rapidly. This will mean, according to the Edison Electric Institute, that home electric bills will be nearly twice as high as they are at present. The increase in the price of energy to industrial users will also result in increased costs being passed on to consumers in other ways.

After 1985, most planners conclude that we will be in very deep trouble unless we change the ways in which we obtain power. Most power sources are inefficient. Coal, oil, gas, and hydroelectricity produce electricity at an efficiency rate of only 40 per cent. Nuclear plants are even worse — their efficiency is around 30 per cent.

A fundamental problem of energy supply is to change the degree of efficiency so that 60 or 70 per cent of the energy in the fuel is not lost on its way to the power consumer. Several promising ways of raising efficiency have been found and are under development. Chief among them is the use of nuclear-breeder reactors, which produce more nuclear fuel than they consume and thus, when in full operation, do not need to be refueled continually. Several months ago, the President authorized stepped-up development of breeder reactors, over the objections of those who claimed that the reactors' "cleanliness" had not yet been raised to a level completely acceptable to the public.

Other promising developments have suffered from a lack of research and development funds in the past. According to S. David Freeman, director of the energy policy staff of the President's Office of Science and Technology, electric utilities themselves have had one of the lowest research budgets in American industry. Part of the reason for the low budget was an overconfidence in the capabilities of current technology to meet present and near-future needs. A 1964 report, widely circulated in the power industry and quite influential in planning and disbursement of research monies, underestimated demand and overestimated supply for the current period. Whereas it predicted power excesses for the present, power shortages, brownouts, and increasing worries about the future are actually the rule of the day.

The utilities were not alone in their small research budgets. The federal government also has not spent much money on future power development programs. Such shortsightedness has caused great delays in the development of a most important source: magnetohydrodynamics (MHD), a technology derived from the motion of an electrically conducting fluid through a magnetic field. While the Soviet Union is bringing its first MHD plant on-line this year, a U.S. prototype plant is considerably in the future. MHD is important because it burns conventional fuels with a 60-per cent, rather than a 40-per cent, efficiency. It is also environmentally important, for it is estimated that emissions from an MHD plant would be only one-third those of a similar voltage, conventional plant. The Office of Science and Technology predicts that full development of MHD could effect a total fuel savings of about $11 billion between 1985 and 2000, cutting costs as well as pollution. By 1985, MHD may be a reality but only if research funds are allocated at a faster rate.

The application of superconductivity to transmission lines also was neglected until very recently. High conductivity would be an all-important way of raising the output of our power-supply systems. The Edison Electric Institute has estimated that one full-scale, 345-kilovolt superconducting line only 20 inches in diameter could carry more power than is now used by the entire city of New York. The institute has started a crash program to develop the potential of these lines, and the program is endorsed by the Office of Science and Technology. A major problem at the moment is cost — not only of the superconducting lines but of any underground transmission lines.

Not too long ago, Dr. Glenn T. Seaborg envisioned a future in which fast-breeder reactors would distribute power via superconducting lines with a minimum of equipment, pollution, scenic spoilage, and so on. Only a few plants would then be needed to supply all the power the United States might need. Such a vision, experts point out, will not become reality unless research on both the breeders and superconducting lines is placed under high priorities and is given large amounts of development monies in the near future.

Other possibilities have been suggested. In California, the Pacific Gas and Electric Company operates the country's only working geothermal generator on natural steam. Geothermal, tidal, and solar power have all been proposed as future power systems. Tidal power could be tapped by hydroelectric-type devices placed in strategic offshore areas. Architect and visionary Buckminster Fuller believes that the tides in the Bay of Fundy could generate enough power for the demands of the entire United States. Plans for using solar energy via satellite technology, which would focus and transmit collected solar rays to a grid on the earth, have been proposed but are now languishing because of diminished emphasis on space research.

Fusion reactors, which could be fueled by hydrogen isotopes derived from ordinary seawater and which use the same kind of power released by the hydrogen bomb, are a possibility for the long-term future. Low-intensity fusion reactions (without power output) have been achieved in what are called "magnetic bottles" for small fractions of a second in experimental models at places such as Oak Ridge National Laboratory and Princeton University as well as in the Tokamak reactor at the Kurchatov Institute of Atomic Energy in Moscow. Fusion as a source of power is theoretically within reach and, with adequate funding, controlled fusion is expected to be demonstrated in the 1970s. But it will probably be several decades before fusion becomes a practical source of power.

Fundamental changes in energy power are destined to occur in the next 30 years or so. The supply of fuels will change and shift in the immediate future. The origins of these fuels will change as we outgrow present and easily available resources and are forced to find and recover far-off sources of fuels. In the intermediate future, there will be changes in the ways in which power is made and transmitted. During these years, too, we can probably expect the full impact of fundamental change in the industry itself, coming primarily from the ways in which the government regulates and controls it. And, by the turn of the century, we can expect the presently underdeveloped countries of the world to be putting increased pressure on those energy resources which remain. ■

Surging tides, such as have eroded these rocks, could be used by hydroelectric devices to generate enormous quantities of power.

Electronically Speaking...

Recent RCA Developments in Electronics

Optical Computer Memory

Under a NASA contract, RCA is building an experimental, entirely optical, large-scale memory system for computers. Development of this type of device — a prototype of which is six feet long and shaped like a telescope — could lead to a whole new species of mass-memory systems. The optical memory would be able to store as much data as the biggest disc systems made so far, but it would function about 1,000 times faster.

The system is expected to validate the optical memory concept and to establish a basis for the possible development of units that could be installed in space stations, earth resources satellites, and similar spacecraft that need to store and process extremely large volumes of data at high speed.

The optical memory appears suited for such applications because of its reliability and freedom from dependence on any sort of mechanical motion. Its information storage and retrieval processes are based on holographic techniques, and the data may be written, stored, read out, and erased repeatedly by laser light.

Since it combines extremely large data-storage capability with electronic access, the optical memory could eventually replace the entire hierarchy of magnetic tapes, discs, drums, and cores now in use, leading to great simplification in computer architecture and operation.

Computer Software Packages

RCA has put on the market two new advanced-application software packages as part of its over-all computer marketing program.

One of these is a communications-oriented computer software package that offers manufacturing firms a new means for cutting costs and maintaining control over their operations. This on-line system, called the Manufacturing Information Control System, is designed in a modular fashion. The system is the only one of its type to incorporate information on the six major manufacturing operations — marketing, distribution, production planning and control, materials planning and control, financial control, and operations analysis — into one unified system. It accommodates up to 30 on-line files, using a single data base common to all. These files may be used for engineering data control, inventory control, requirements planning, capacity planning, operation scheduling, shop floor control, purchasing and billing of materials, and other manufacturing functions.

Because the system is a totally integrated package incorporating all these manufacturing subsystems under one common data base, updating one file automatically results in a simultaneous updating of all interrelated files. Thus an up-to-the-minute status report on any segment of the manufacturing operation is readily available.

The other software package is an on-line Customer Information File (CIF) system for banks, which may be the most advanced software package of its type. Although initially designed to provide an on-line inquiry capability into corporate accounts and individual savings and checking accounts, the system is open-ended and will be able to accommodate many other applications.

Through use of CIF's visual display devices, a bank can obtain a total picture of a customer's records in a matter of seconds. Bank officials then can make almost instant decisions on matters ranging from personal loans to trading in "commercial paper" issued by large corporations. Such decisions could take days if conventional methods were used.

Improving Public Transportation

Electronic signposts soon may be used to locate and track public transportation vehicles operating in heavy city traffic. The feasibility of this proposal is being tested by RCA for the U.S. Department of Transportation. The RCA study is part of an Automatic Vehicle Monitoring (AVM) program conducted by the department's Urban Mass Transportation Administration that is aimed at helping bus and other vehicle-fleet operators provide better service to riders and deploy their fleets more effectively.

For this study, miniature low-power, low-cost transmitters have been placed in signposts at intersections and other selected points. Each transmitter broadcasts a unique code identifying that point. As a bus or other "signpost vehicle" passes within range of a transmitter, a small receiver on the vehicle picks up and stores the code number of that signpost transmitter until it passes within range of another signpost and stores a new number.

When interrogated by radio from a control center, the signpost vehicle's equipment automatically replies with the code of the last signpost passed and the vehicle's identifying number. A computer stores these data and can give the location of any vehicle to within several hundred feet of its true position.

TV Information Displays for the Home

A laboratory concept of a home TV information center that could be used to display individual TV pictures has been demonstrated by RCA. The experimental system is housed in a television console equipped with two screens, one for the continuing program and the other for displaying the single picture.

RCA engineers point out that the system could enable cable TV operators to offer valuable new services to subscribers. For example, the system could be made to "freeze" a certain feature — such as a stock market quotation or sports score listing — automatically as it came over the cable. Or it might be used by a housewife to select a recipe or a list of supermarket specials as it appears on the TV screen and retain the picture for more careful reading.

High-Speed Circuit for Weather Watch

RCA Global Communications has begun operating a new high-speed communications circuit to carry weather data between Washington and Tokyo. The 3,000-word-per-minute circuit will flash information between the U.S. National Weather Service and the Japan Meteorological Agency. The system, incorporating the first 3,000-wpm line geared for error control, will enable U.S. and Japanese meteorologists to eliminate incorrect information before it is transmitted halfway around the world.

The new circuit will be part of the World Meteorological Organization's global Weather Watch network and will replace the one installed in 1969. It can transmit almost three times as much data as the 1,050-wpm circuit now in use. According to present plans, the entire network will be on the 3,000-wpm standard by 1973.

Another advantage of the high-speed communications circuit is its ability to transmit facsimile. Early in 1962, the U.S. Weather Service asked RCA Globcom to aid in the facsimile transmission of weather maps to meteorological organizations throughout the world. Based in part on photographs taken by TIROS IV, these transmissions of detailed weather analyses were among the first practical applications of the U.S. space program.

Communications System for Classified Information

An Intrusion-Resistant Communications Cable System (IRCCS) has been developed jointly by RCA and the Anaconda Wire and Cable Company to permit transmission of classified data in uncoded form over TV, teletype, or computers from one security area to another. Any attempt to intercept information by tapping the cable system triggers the detection and alarm circuits, activating the alarms.

While the system was developed basically for military purposes, it is readily adaptable and available for commercial use in financial and other computer-oriented fields where security is needed. The cable core can be configured for a wide variety of user requirements and can accommodate various combinations of audio and video pairs. IRCCS is virtually maintenance-free, and what servicing is required can be handled by electronics technicians who do not need cryptographic training. It is adaptable to a variety of environments and can be installed in buildings, outdoors between poles, underground, or underwater.

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For centuries, archaeologists have used picks and shovels to excavate sites, such as this one in southwestern Missouri. An article on new electronic tools that facilitate archaeological investigation begins on page 24.

RCA

Electronic Age

Summer 1971

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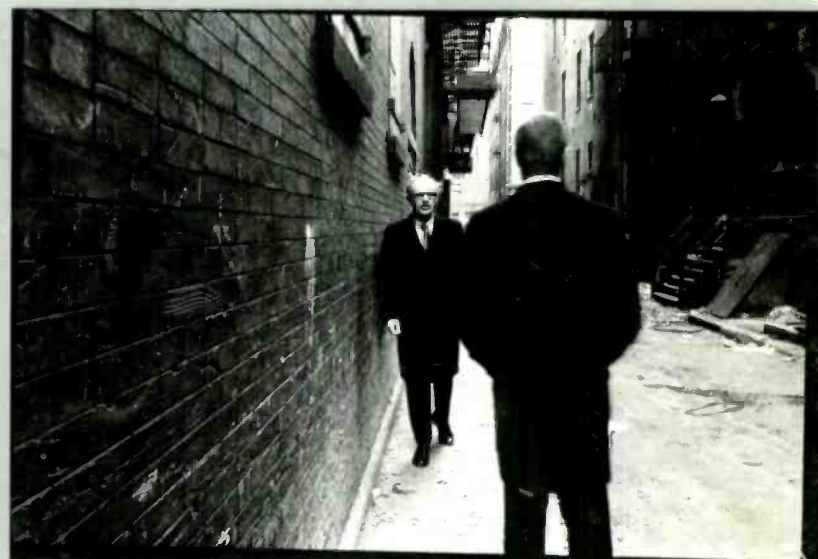
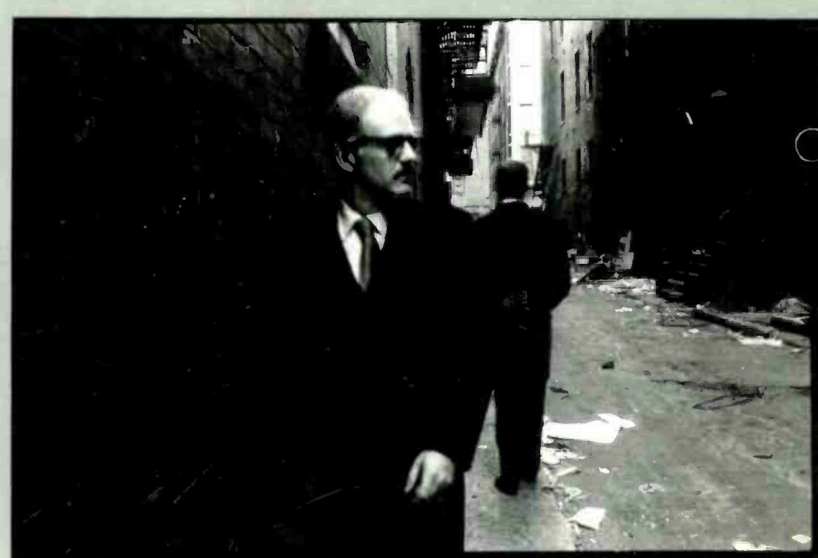


2

3



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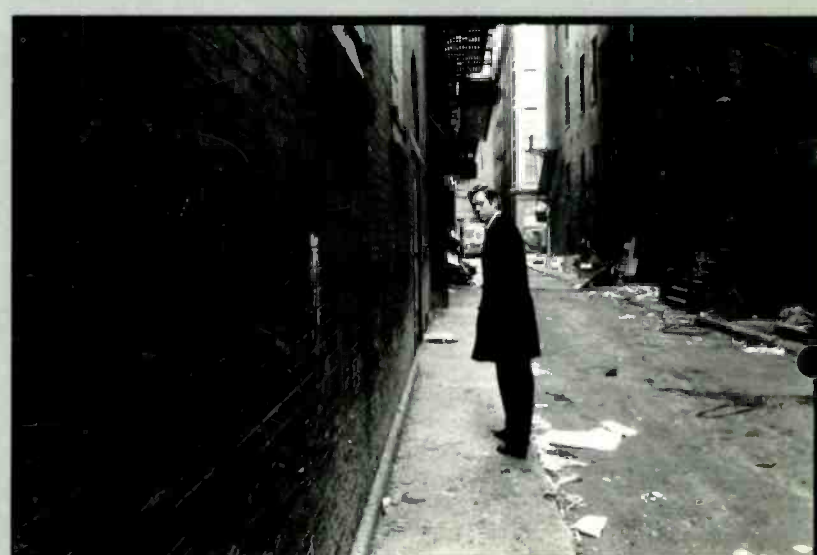

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