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FOR THE TECHNICAL MEN IN MANAGEMENT

JUNE 1969 No. 90

The achievements of Apollo 10 incongruously appear next to the interviews, news and reports of the program proposals to put a man on MARS. It is difficult for me to reconcile Senator Edward M. Kennedy's protest in 1969 about the Apollo program with the late President John F. Kennedy's designation of this program as a "national objective" in 1961. The problems of the cities, the races, the environment—and a host of other evils—existed in 1961 as they exist in 1969. It would therefore seem that the discretion about man's problem on earth in 1961 is now replaced with the valor of the recognition of the same problems in 1969. This change of attitude seems to me to be transparent political expediency.

Are we in our right mind to talk about MARS before the Apollo project attains its goal? With Watts and Newark, with the pollution of our air and water, with the destruction of our ecological balance, with exploding population guaranteeing poverty and assuring famine, with the secrets of our oceans untapped, can we *really* talk about MARS?

Speaking of MARS, at this time, is doing a vast disservice to the scientific community. Furthermore, NASA should be addressing itself to problems of the ocean and the environment, for which it is eminently qualified. To put MARS on the front burner, now, is to invite the later charge of callous conduct. The promise of space is with us. But the pathos of earth is also with us. We cannot slight either. Both are related.

Space exploration has its priority, but so do the massive problems on earth. The talk of MARS has the budgetary blossom on it. The numbers are big. What it achieves is that it gives greater credence to Senator Kennedy's arguments. It places our major scientific agency in the same boat as the Department of Defense. The badly timed piece of strategy will hurt unless reason replaces rhetoric—it's not too late to correct the error of talking too soon. We think NASA is ideally suited to handle phases of nondefense-oriented scientific research and operations—particularly pollution programs, exploration of space, and the improvement of our ecological morass.

John Ledes

8 **URBANAIR**
EDWARD FERRAND *who faces the daily problem of keeping the air in one of the world's largest cities livable tells how his city measures and controls air pollution.*

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Methods of keeping our water resources pure and potable are aptly described by JOSEPH NEALE.

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Juan Genoves was born in Valencia, Spain, in 1930. A child of the Spanish Civil War, his paintings show a profound concern for the frightened and panicked victims of their environment. He "peoples" his work with images caught in the dilemma of massive, impersonal government and the industrial forces of contemporary life. Genoves' people are trying to run from the destruction of their world. They attempt escape, but there is really no place to hide. His work succinctly captures the problem of man's disruption of nature's subtle interplay of forces.

Juan Genoves lives and works in Madrid. He was awarded the XIV International Lissone Prize, Milan, in 1965 and honorable mention in the XXXIII Bienniale, Venice 1966.

The cover paintings, LAS SOMBRAS (The Shadows), was completed in 1969 and exhibited at Marlborough Galleria d'Arte, Rome: 59½" x 59½", acrylic on canvass. Courtesy Marlborough-Gerson Gallery, N.Y.C.

PICTURE CREDITS

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MORE TO COME

It has been possible to cover only part of the pollution picture in the space of this issue. S&T will, therefore, subsequently add to the story next month.

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FOR THE TECHNICAL MEN IN MANAGEMENT

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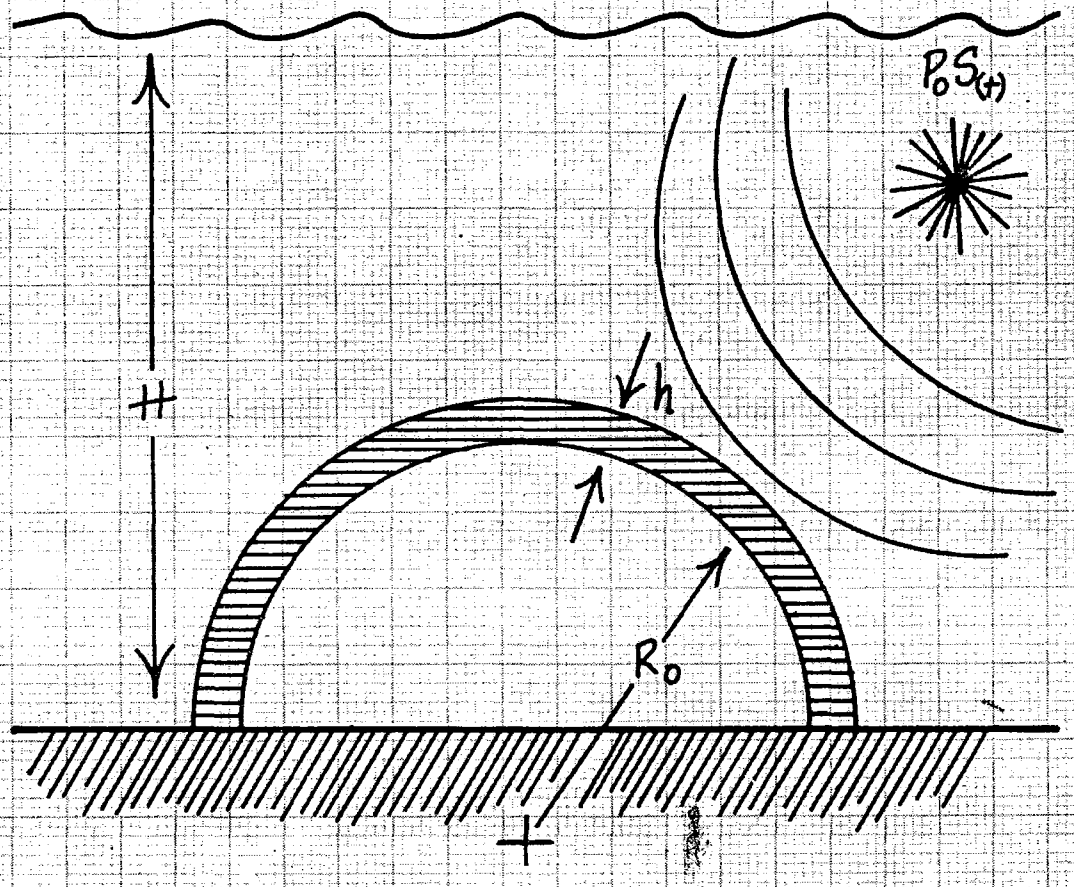
Structures Engineers



Given: Cylindrical shell with arbitrary cross-section and thickness, located on ocean floor.

Find: For a fixed amount of material, determine optimum cross-section for maximum stability.

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AUTHORS AND ARTICLES

TAINTED RADIATION 46

Some scientists claim that biological changes in man have been brought about by radiation-induced mutations. If that theory is correct—now that man has learned to imitate nature's radiation sources—he may hasten the denouement of his biological traits.

KARL Z. MORGAN has been Director of the Health Phyiscs Division at the Oak Ridge National Laboratory since 1943, where engineering and applied problems in the new science of health physics are being solved. A leader in this new field, when the Health Physics Society was founded in 1956, he became its president, and is now President of the International Radiation Protection Association. He also helped to inaugurate the first gold medal award of Sweden's Royal Academy of Science in 1962, receiving one of the first three medals. In 1968, on the anniversary of his professional activities in health physics. Dr. Morgan was honored by receiving the first Distinguished Service Award of the Western Chapter of Health Physics.





WASHING WATER 52

What processes are used to keep liquid waste from ruining our water resource? Basically there are three processes—with many variations. An industrial expert presents a knowledgeable overview of current anti-pollution methods popularly used in this connection.

JOSEPH H. NEALE is a P.E. and a Vice-President and General Manager of Cottrell Environmental Systems, Inc., a division of Research-Cottrell, having been manager of the Water and Waste Treatment Division of Struthers Scientific and International Corp. He has a broad background in waste treatment systems engineering.

CONTINENTAL WATER POLLUTION 28

Europe, of course, has peculiar problems with pollution control because many of its inland waterways flow through more than one country. The problem involving lakes on the Continent is also compounded because the shores of these lakes also abut, or lie in, the domain of two or more nations. Here is an abridged survey of the European water pollution control scene prepared by a team of skilled researchers.

THE BOOK END 51

Three books have been added to a growing list covering the field of air pollution monitoring equipment. One, published by the Government, is more than worth its price.

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SWEETWATER POLLUTION 20



Our fresh water supply is only a drop in the world's water bucket. And that drop, despite replenishment, is rapidly dwindling because man wastes enormous volumes and fouls much of the rest. The aesthetic ruin of sewer outflows are obvious. But it is only part of the total picture.

LARRY PAUL WASSERMAN received a physics degree from Rensselaer Polytechnic Institute in 1961 and became embroiled in military satellite communications. His scientific interests have since shifted downwards to the in-depth study of water-especially oceanography. Mr. Wasserman has since earned an M.S. in Environmental Health Science and founded Infinity, Ltd., a consulting firm in the oceanographic sciences.



URBAN AIR 8

The problem of preventing air pollution in large urban locales depends a great deal on being able to effectively measure the levels of various pollutants at all times. In so doing, systems can be set up that will preclude the occurrence of pollution epidemics. The author, whose task it is to be constantly involved in such a measurement and prevention program, tells how.

New York counts on certain experts, to tackle its pollution problem "up at the front." EDWARD P. FERRAND has been one of the key men responsible for the planning and implementing of the network for New York City's Department of Air Resources, Environmental Protection Administration since 1967 where he serves as principal science and technology advisor to the Commissioner and is in charge of special studies and research projects. Dr. Ferrand has taught for four years and was awarded a Science Faculty Fellow by the NSF.

SOLID WASTE TREATMENT 34



The growing population problem and the frenetic efforts of American industry to rack up increased production records each year are rapidly creating untenable piles of solid waste that not only pollute our water resources, but when processed in a certain manner also pollute our air. Here are various methods of treating solid wastes—with a pictoral essay of Japanese process thrown in as a bonus.

After serving several years as a military operations analyst, ALEX HERSHAFT decided to join the civilian strategists against air pollution. As a member of Research Department at Grumman Corporation. Hershaft plans research programs in environmental sciences.

MONEY MANAGEMENT 43

Here is a computer-aided survey of the stocks that stand to benefit the most, if the Federal Government begins to emphasize the pollution-control effort by switching funds from R and D for DOD to increasing aid to states, municipalities and industry.

CAPITOL COMMENTS 7

This month Ed Michaelson, our Washington observer, reports on Glenn Seaborg and his pollution control efforts.

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IN OUR OPINION

■ What is happening in our colleges and universities? Students rebel, faculties rebel, and Congress balks.

The students appear to be against many of Establishment's causes. But, since this magazine is devoted to science and technology, I don't intend to get involved with black power peevishness or student demonstrations for socio-economic benefits in American communities.

Still, many students have taken issue with several facets of institutional demeanor that are germane to the future course of science and technology.

A popular student cause is for a greater say in establishing academic curricula. Where students have fought for this right, they have generally succeeded. Not only have *they* achieved *more* influence, but in some instances —such as at Columbia University—the *faculty also* earned an increased say in the curricula. The question remains, however, whether students are capable of helping put into the curricula the proper courses they should study.

Perhaps I've been prejudiced by my own experience. I attended a university where all subjects, other than those in the first year, were electives. I chose my field—math and physics—and with some faculty guidance picked the courses I thought would do me the most good. I liked this idea at the time—and I still do.

Of course, what students are advocating today goes beyond this concept. But I believe bright students—and invariably the bright ones are selected for the curricula advisory staff—are aware of the state of the art in science and technology and can help set course studies. Moreover, they will tend to counterbalance the conservatives on the advisory staff who tend to retain courses in the curricula beyond their useful life.

Many students object to defense contract work in the universities. In addition, they object to any affiliation with the Defense Department. In this regard, their sympathies are shared by many faculty on the science scene. (Recall the MIT faculty walkout to establish their grievance over defense contract work.) But I take issue with their stand.

In many instances, the students react from a base of partial ignorance or distortion. Princeton's and Columbia's students raised hell over their universities' ties with the Institute of Defense Analysis. At Columbia one of its deans was a trustee of IDA while some faculty members consulted for the Institute. IDA at that time was a private corporation representing 12 universities. While predominantly a service arm of DOD it also contracted projects with other Governmental agencies. Although the Students for a Democratic Society had all its facts, it perverted them. Rightly or wrongly, SDS activity brought about university disaffiliation from IDA.

Yale students had objections to their school's defense contract ties. Yet such contracts constituted but two percent of the research grants performed by the university.

But for those who argue about the principle and not the "how much" of the school-DOD tie, my retort is: The work will get done even if it entails creation of special Government institutions. If this happens the universities will, of course, suffer. As in the Soviet Union, many high calibre professors will be lured from their academic base into newly-formed Governmental research institutes. Moreover, the current clandestine siphoning of funds from DOD projects for other basic research that is now practiced by professors in many universities will be all but eliminated. I think it unfortunate that some universities have already absolved themselves from DOD work.

Not surprisingly, the student faculty furor making headlines has antagonized many members of Congress. Several Congressmen are pressing for laws that would penalize universities unable to quell student rowdyism through withholding of Federal funds. Considering the professed circumstances of student unrest, such action could only play into radical hands.

For good or for bad, change is inevitable in our universities. Never before has there been such violent upheaval. One educator estimates it will be a decade or more before our universities recover from the current catharsis. With respect to DOD—university ties, I suggest "educational" campaigns for both students and laymen to clarify *all* details of any association. Perhaps then Government-university associations—beneficial to both—will be preserved.

Paul Hersch.

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CAPITOL COMMENTS

by Edward Michelson

Prospects are dim this year—and next—for water pollution abatement incentive legislation. Numerous bills to provide tax incentives for companies investing in equipment to prevent atmospheric and water pollution are pending. Such proposals will get nowhere because of the agreement to repeal investment credit on outlays for new capital equipment and modernization. Railroads and others seeking exemption from suspension of the investment credit are finding Chairman Wilbur Mills, D., Ark, of the House Ways and Means Committee, adamant on this score.

On the other hand, moves to tax and to penalize polluters are gaining momentum. The "Torrey Canyon Bill" that cleared the House makes tanker operators and others involved in oil spills liable for cleanup damage regardless of fault. In addition, there are steep fines where fault is established (negligence, etc.).

The immediate concern of the new Nixon Environmental Quality Council (coordinated by Dr. Lee A. DuBridge) is abatement within a "reasonable time scale." There are 8 control regions in the U.S. set up by HEW's Air Pollution Control Administration. These include the metropolitan N.Y., Washington, Philadelphia, Chicago, Denver, and L.A. areas. In these and others to be designated, criteria have been set to limit pollution from sulphur oxides and particulates. In 1970, criteria will be set for motor vehicle pollutants: hydrocarbons, nitrogen oxides, and carbon monoxides. HEW also is examining future controls on some 30 other pollutants, including lead, fluorides and pesticides.

The notion that private industry is not cooperating or has been reluctant to cooperate with environmental programs is not true. Most industries have applied an increasing amount of their resources and technology to abatement. Government grants are helping finance this work. So far 43 state and 148 local and regional control agencies have received air pollution control grants. Total government spending—local, state, Federal—has risen from $12.7 million in 1963 to $45.5 million in 1969—and should keep rising. More important, significant cumulative results will begin to be visible as new criteria take effect and technologies being developed are applied.

Water pollution

Seaborg of the AEC cites the first systematic nationwide strategy for water quality management, the setting of standards for interstate and coastal waters, of 47 states—all of which have come up with agreements for compliance under the Water Quality Act and Clean Water Restoration Act. Washington meanwhile has made about 8,000 grants totalling $1 billion plus, to local communities. Seaborg reckons these grants have helped build more than $4.5 billion worth of municipal treatment works for 67,000 miles of water serving about 66 million people. And, Federal budgets on environmental programs continue to grow.

Industry's role

Manufacturing Chemists Association indicates that during 1962-1966 industry invested $266 million in pollution control facilities. Through to 1971, projected additional commitments will be twice that amount. And, this doesn't include operating cost of the facilities (more than $100 million a year). New technologies are being explored by industries. In textiles, for example, two major firms are exploring a new dyeing method employing a completely closed system process. Another process being developed requires 1/30th the volume of current water needs.

Solid waste disposal

A recent survey shows it costs $4.5-billion a year to dispose of 360-million tons of solid waste created annually in the U.S. Waste disposal ranks right after education and road construction in cost to municipalities. A new HEW report indicates it will take an additional $3.75-billion over the next 5 years to develop a satisfactory system.

In connection with railroad hauling of solid waste out of big cities, Seaborg says desert landfill with trash from San Francisco helped reduce pollution in the Bay, which is badly fouled. He also says there are about 8,000 abandoned U.S. mines in the U.S. with a surface area of some 8,000 square miles that make prime dumping areas.

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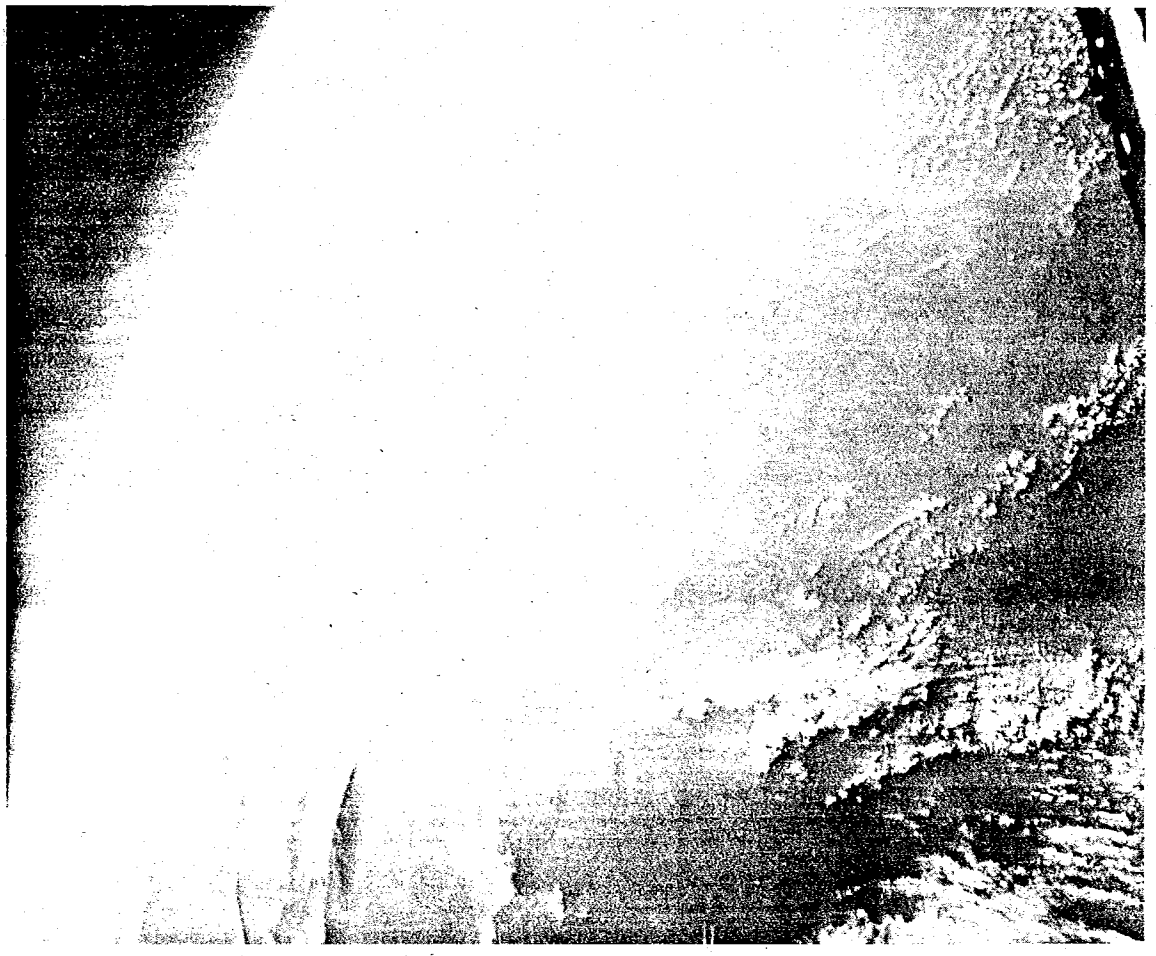

URBANAIR

Air pollution is a world-wide and local problem. And cities have much the worst of it

by Edward Ferrand

IN BRIEF: *Man's most vital resource is the air he breathes. But the great alarm that has spread all over the world, causing pollution control to suddenly supersede political thinking along military and defense subjects, is the preservation of this precious asset. To maintain a "pure" atmosphere, that is pure enough for human consumption, it is necessary to measure and to control the amounts of effluents cast into the air. The author treats these topics with a professionalism that comes from being directly involved in the war against our worsening air resource.*

In his dedication to gains and to progress, man has imposed few restraints on the squandering of his resources to the point of possible danger. Among the vital resources man is endangering is the very air he breathes.

Man pollutes his atmosphere by burning fuels to produce energy, by waste incineration, and by discharge of gas and aerosol by-products from chemical processing, manufacture, construction and demolition. Though the problem of atmospheric pollution is worldwide, it is primarily a problem of municipalities, where pollutants are concentrated and often become entrained in relatively small geographical

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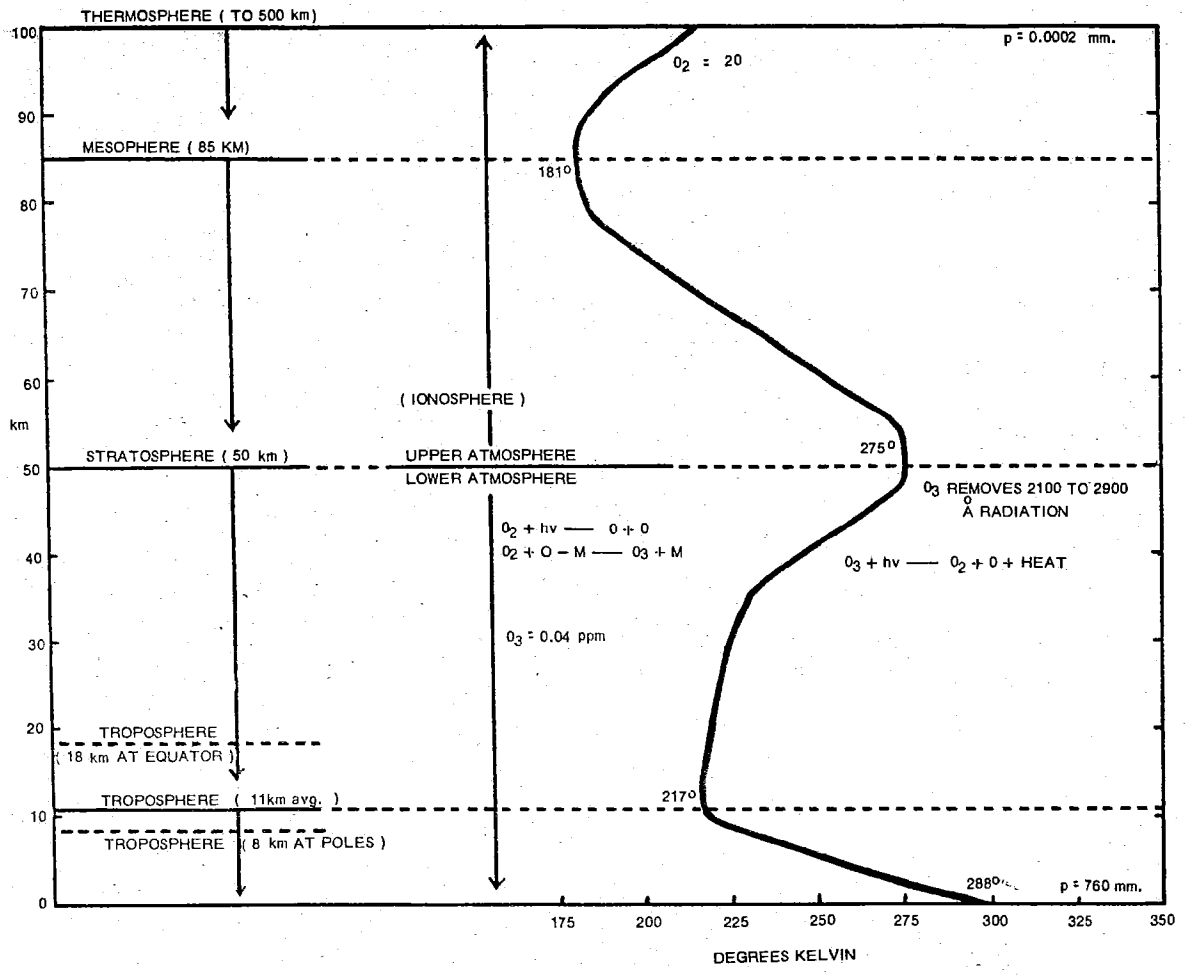

areas that are also densely populated. But to understand the urban plight, it is necessary to understand the world situation.

Figure 1 represents a simplified view of the earth's atmospheric envelope up to 500 kilometers. The troposphere is our primary interest; nevertheless, the other regions have effect upon what happens within the troposphere.

The sun emits electromagnetic energy over a broad spectrum with the maximum intensity in the visible region. Before the solar radiation reaches the ground, a portion of the ultraviolet region (0.21 to 0.29 microns) is absorbed by the ozone layer. Overall, some of the solar energy is scattered (predominantly at shorter wave lengths, thereby producing a blue sky), some is reflected from clouds (land and water), and some is absorbed. On the average, about 35% of the solar energy is reflected.

All bodies above absolute zero temperature radiate energy with a maximum at a wave length determined by Planck's Law. The energy absorbed from the sun by land, water and air, makes the earth a giant radiator whose maximum intensity is in the infrared region at approximately 10 microns. The wave lengths radiated by the earth are absorbed efficiently by atmospheric moisture (water absorbs strongly between 5.5 and 7.0 microns and above 27 microns) and carbon dioxide (these molecules absorb strongly between 13 and 17.5 microns). A portion of the solar energy that penetrates the atmosphere at wave lengths not absorbed by atmospheric constituents is reradiated by the earth at wave lengths in the infrared region. These become absorbed by some pollutants in the lower atmosphere causing a one-way passage of energy referred to as the "greenhouse effect."

Latitude's effects

The temperate zone (latitudes 30-60°) experiences more variability in weather than either the polar regions or the equator. Cold air masses are formed at the poles, and hot air masses in the tropics. Seasonal variations in these air masses, combined with the rotation and the roughness of the earth's surface, cause large pieces of these air masses to break off and move through the temperate zone. Then, as high pressure masses (anticyclones) and low pressure masses (cyclones), they migrate to produce the weather changes we observe. The transition regions between masses of cold and warm air are called fronts. The presence of a front is detectable by the

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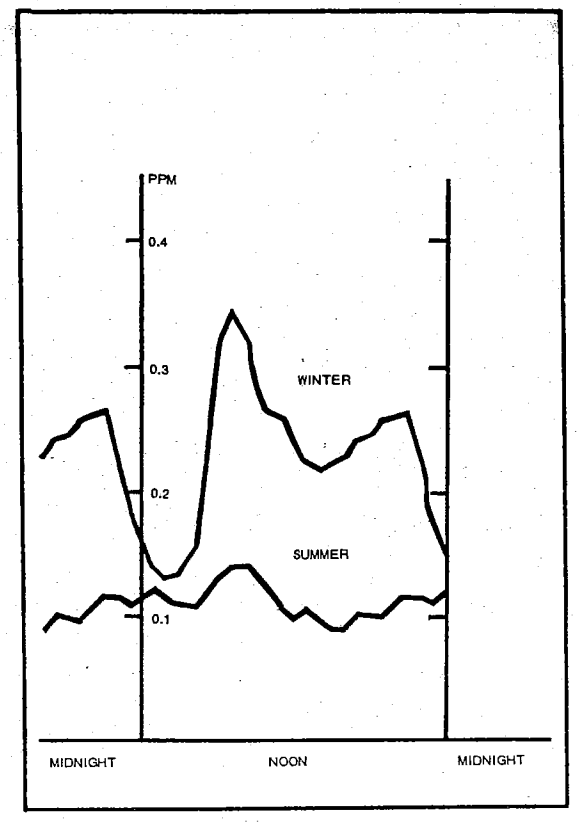
weather activity it produces. And high wind velocities that accompany passage of fronts are important in the dispersal of air pollutants.

The pollutants accumulating during low-wind conditions in a high pressure area become dispersed by the passage of the front preceding a low pressure area. But on the Western coast, a subtropical high pressure weather system occurs on a semi-permanent basis. This system is characterized by a relatively low subsidence inversion. An inversion forms when there is a layer of warm air above one of colder air. In such a situation, buoyancy effects cannot operate to produce vertical mixing and, in the absence of wind, pollutants will not be dispersed. A subsidence inversion is developed when a layer of air within a high pressure area, as a result of descending motion, warms and becomes compressed. The compression imparts additional heat to the sinking air mass, raising its temperature and causing it to act as an inversion lid over the colder air below.

Another type of inversion is produced by rapid cooling of the ground at night through radiative loss. The air in contact with the earth's surface will also cool to a temperature below that of the air above, creating an inversion. Usually—unless there are other complicating influences—the sun's heating of the surface will destroy this inversion the following day. During fall and winter, these inversions are more prevalent. The presence of these overnight inversions, combined with the increase in pollutant-producing activities—such as space-heating during early morning hours—act to produce well-defined diurnal variations in pollutant concentrations. Figure 2 shows the long-term diurnal behavior of sulfur dioxide in New York City.



Town and country

Understandably, air quality is strongly dependent upon weather. Superimposed on the influences of large weather systems are the complications introduced by cities themselves. Any urban complex—and, in particular, a large metropolitan area such as New York City—exerts a notable effect on its own climatology. The many large structures rising to different heights and arranged in different patterns, the properties of the materials used in these structures and the pavements that surround them, and the heat energy and effluents emitted by daily activities all play a role in creating a localized atmospheric system.

The differences in structural and behavioral characteristics between the city and the countryside are reflected in the urban heat island effect. Although much experimental verification is still required to define the boundaries of the urban heat island, it can be characterized as a dome of air over the city with a predawn temperature decrease with altitude ranging from an isothermal to adiabatic rate. Some of the causes are:

1. The presence of buildings reducing surface wind speeds.
2. The total surface available for absorption and radiation of energy—much larger for cities because of the number of building walls intercepting solar radiation.
3. Radiation reflecting back and forth between vertical surfaces and more likely to be absorbed by the urban atmosphere than that radiated upward from the countryside. This effect makes the city's vertical surfaces stay warmer for a longer time.
4. An appreciable amount of energy generated internally through space heating and other activities. It is estimated that New York City generates more energy during a winter's day (of 32°F mean temperature) than it receives from the sun. Along with this energy, it releases as much moisture from combustion processes as is evaporated from a rural area of comparable size.

The heat island behavior contrasts with that of the countryside where inversions develop

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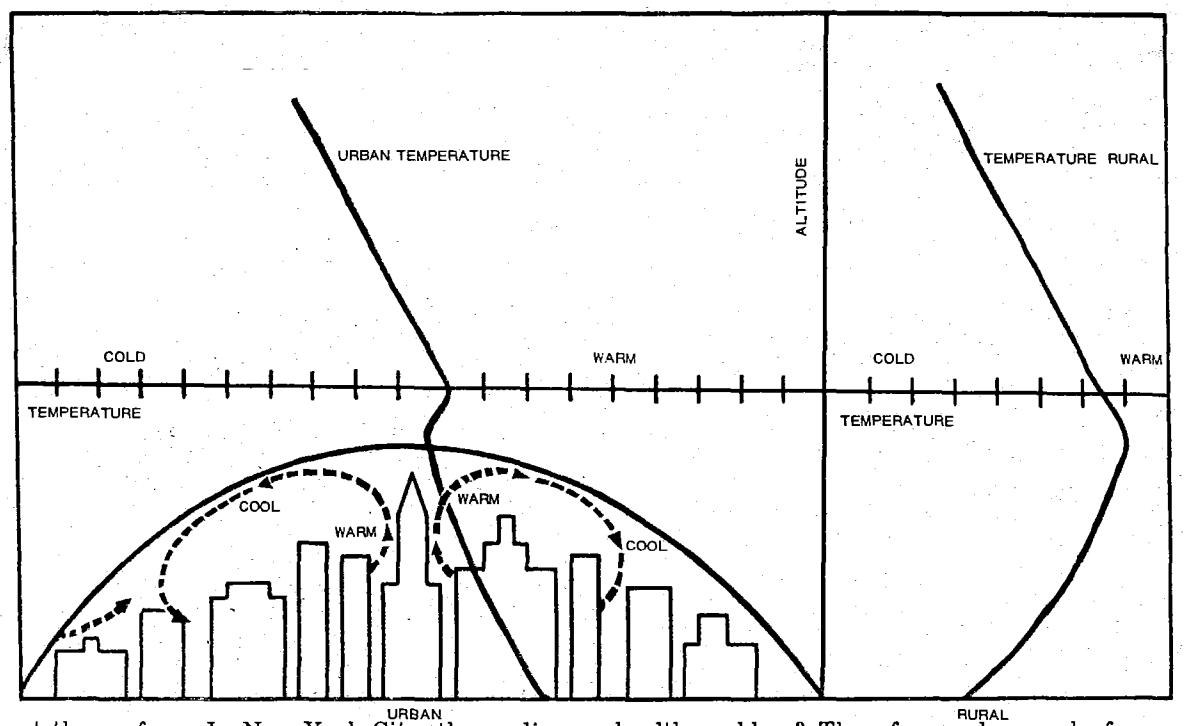

at the surface. In New York City, the median height of inversions has been found at 310 meters. Figure 3 is an idealized drawing of the urban heat island dome. It shows the temperature gradient compared with a nearby countryside. It is assumed that the highest temperatures occur near the structural center of the city and a vertical circulation is created in the manner depicted in the figure. However, evidence indicates that the center of the heat island in New York City is displaced downwind from the structural center.

In the absence of a prevailing wind, this system can become highly stabilized and trap pollutant emissions in a closed system. A characteristic haze dome is created over the city that tends to be self-perpetuating, since it serves to reflect and back-scatter appreciable quantities of solar energy before it reaches the surface. This effect delays the development of the kind of atmospheric instability that plays a major role in dispersing pollutants.

There is no doubt that a polluted atmosphere causes serious economic losses to society as a result of corrosion, defacement and soiling of materials. It is a blight to vegetation, causing extensive damage to many commercial crops with resulting financial loss. The aesthetic losses corresponding to decreased visibility, although difficult to translate into economic terms, are nevertheless very real. These deprivations by themselves justify serious effort to clean the air. But overriding all these considerations is the cost to society in terms of human health.

Baited breath

What is the nature of the air pollution health problem? Thus far we have only fragmentary answers—important answers, because they indicate the immediate paths to follow. And, in addition to technological importance, information about health effects helps to provide a strong basis for the legislative action so necessary to accelerate progress.

A polluted atmosphere can produce acute or chronic human effects. Studies of mortality and morbidity indicate that the adverse effects of air pollution on human health are most serious in urban communities having the greatest concentration of pollutants. The most dramatic foundation for the urgent need to control pollutants is the illness and the excess mortality attributed to air pollution episodes.

In Donora, Pennsylvania, a stable layer of air that persisted from October 26 to October 31, 1948 affected almost 6,000 out of a population of 14,000. Symptoms included coughs, eye irritation, nausea and diarrhea. Although all groups were affected, the elderly and those with a history of lung and cardiac disease suffered most severely. Of the twenty persons who died during this period, seventeen died on October 29th.

In London in 1952—and again in 1962—serious air pollution episodes occurred, in which 4,000 and 600 excess deaths were recorded respectively. Episodes have also been recorded in the Meuse Valley, Belgium (1960), and New York City (1953), (1963), (1966). One group of experts found increased mortality for the episodes in New York City. However, another group of critics opined that the results were not conclusive, since increased air pollution in New York City occurs without increased mortality much more frequently than

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with it. But overall evidence indicates there is little reasonable doubt that emissions combined with certain meteorological conditions can lead to serious illness and death.

In addition to damages caused by acute, short-lived, episodes, there is grave concern about the effects of less intense pollution exposure over longer periods of time. This is a difficult task for epidemiologists, who must search for correlations between health and pollution in the midst of a confusing multitude of variables—many poorly understood. For example, much remains to be discovered about the traces of organic and inorganic materials present in the atmosphere and, without doubt, there are substances still undiscovered.

In the real world, epidemiologists are not dealing with a situation in which a healthy receptor is exposed to only one irritant. They are concerned with millions of people whose health covers the entire range, from superb to nearly complete deterioration; from almost total general immunity to almost total susceptibility to many diseases. Epidemiologists are intensely concerned with an environment that contains many gases and aerosols (known and unknown), capable of producing undesirable health effects. Therefore, it is possible that a seemingly innocuous substance will be just the needed additional ingredient to produce a serious problem to many individuals. In this respect a quantum jump in disease causation is not as likely as aggravation of symptoms when new or more intense environmental insults are created.

Foreign justice

What men lack in knowledge must be compensated with effort and money. Thus, if there exists any reasonable doubt in the judgement of members of the medical community about the effects of a pollutant, the pollutant must be treated as guilty until proven innocent. Moreover, proof of innocence must be determined under conditions of exposure resembling reality as closely as possible.

The relative concentrations of most gaseous components remain constant throughout the troposphere. And, an arbitrary definition of the gaseous compositions of the clean, normal atmosphere is listed in Table 1.

To understand how man ravages his air some, quantitative estimates of effluents into the atmosphere from man's activities are required. Much work has been done and is in progress in this area. The procedure involves the determination of emission factors for each process and its modifications on the basis of parameters which can be monitored. Table 2 summarizes total weights of pollutant by source for 1966 for the United States. (Consideration of the variations possible in almost any process should give some insight about the range of accuracy of these estimates.)

Los Angeles' air pollution has been attributed to the combination of its topography, sunlight and meterology and its large automobile population. Motor vehicles produce large amounts of several pollutants (Table 3). The key element in the generation of photochemical smog is nitrogen dioxide. In the presence of excess air, energy released within a gasoline engine by the combusion process, produces nitric oxide. After emission to the atmosphere, the nitric oxide is converted to nitrogen dioxide. This compound has a strong absorption band throughout the visible and ultraviolet part of the solar spectrum and, as a result, becomes a carrier of excess energy. The activated nitrogen dioxide molecules initiate a series of reactions that produce ozone and a variety of organic oxidants. The necessary organic precursors—particularly olefins and aromatics—are released from vehicles by evaporation and incomplete combustion. In the presence of low winds and a subsidence inversion (of the type common to Los Angeles), these secondary products are trapped—and increase in concentration until the distressingly irritating symptoms of photochemical smog become quite severe—usually during mid-afternoon or after the morning hydrocarbon peak has been produced by commuter traffic.

Red eyes and blackened tundra

The classic symptoms are eye irritation, plant damage, and reduced visibility caused by the orange-colored nitrogen dioxide and the aerosol formation. The latter results from reactions producing highly oxidized materials from hydrocarbons. In addition, aldehydes are produced both in the primary combustion process in the cylinder and in the secondary photochemical reaction in the atmosphere. They deserve *special* mention because the irritant properties of compounds from aldehyde and acrolein to human tissue make them an important component of the smog problem.

There's another facet. The ever-growing problem of carbon monoxide in the atmosphere is directly related to traffic patterns and traffic volume. In an urban atmosphere there are two parts to this problem: 1. a site-by-site problem; and 2. and atmospheric one. Figure 4 graphically summarizes results obtained at one particularly heavy traffic location in New York City. It has been found possible to character-

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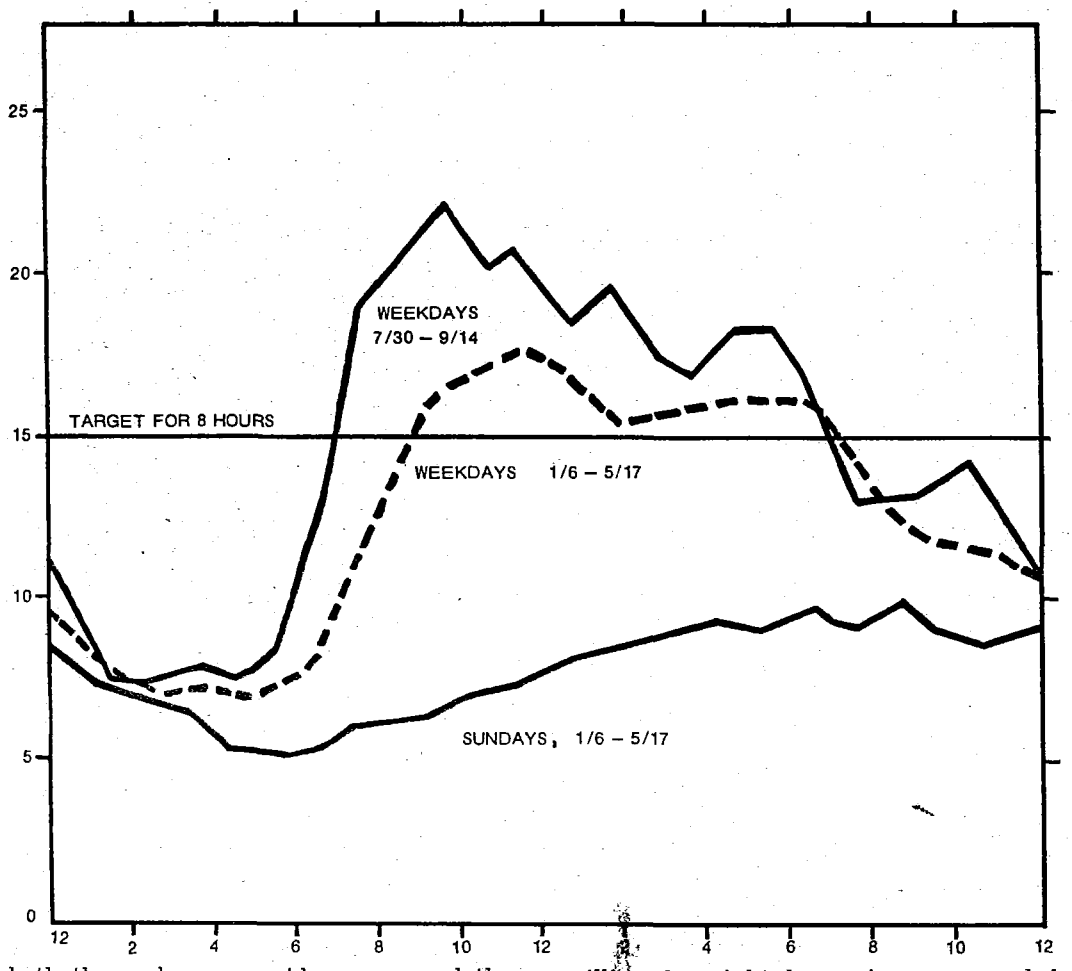

ize both the carbon monoxide curves and the very similar traffic volume curves by a Fourier series truncated after four or five terms. Carbon monoxide at street levels in heavy traffic areas becomes a site-by-site problem. Over the city—at elevations above street level—carbon monoxide levels are much lower and less sensitive to traffic variations. Meteorological conditions play an important role in this part of the problem.

To humans, carbon monoxide is important because of its impact on the oxygen transport system of the body. Blood hemoglobin forms a stronger complex with carbon monoxide than with oxygen. As a result, inhalation of carbon monoxide deprives body tissues of oxygen. But the human body itself generates carbon monoxide as a result of the decomposition of hemoglobin, at levels equivalent to two to three parts per million in the expired breath. Therefore, atmospheric concentrations at these levels are essentially in equilibrium and produce no change in carboxyhemoglobin content. At concentrations above 1000 parts per million, carbon monoxide causes death quickly. After several hours at 250 parts per million, dizziness, headache and loss of visual acuity become pronounced. A maximum of 50 parts per million for eight hours is recommended for industrial workers in the United States. For the general public, New York State has recommended a maximum of 15 parts per million for eight hours—not to be exceeded more than 15 per cent of the time—and 30 parts per million for eight hours—never to be exceeded. After an equilibrium carboxyhemoglobin concentration has been produced in the blood as a result of sufficient exposure to a certain level of carbon monoxide, a considerable length of time in clean air is required to return the blood to normal. An estimated three to four hours half-life is involved in the removal process. Cigarette smoking, by the way, can lead to carboxyhemoglobin levels comparable to high exposures.

There are many other pollutants such as aldehydes, ammonia, chlorine, hydrogen sulfide, sulfuric and hydrochloric acid, metallic compounds, and polynuclear hydrocarbons that are of interest because of possible effects on receptors. Incomplete combustion and post emission reactions of compounds in the atmosphere lead to a multitude of materials that require—and merit—serious investigation. Unfortunately, there exists a complex relationship between the amount of a pollutant emitted at

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one place (or over an area) and the ambient concentrations these emissions produce at a particular point. The complexity is introduced by the variability of the atmosphere, and by the possibility that chemical transformations can occur after emission.

Partners in pollution

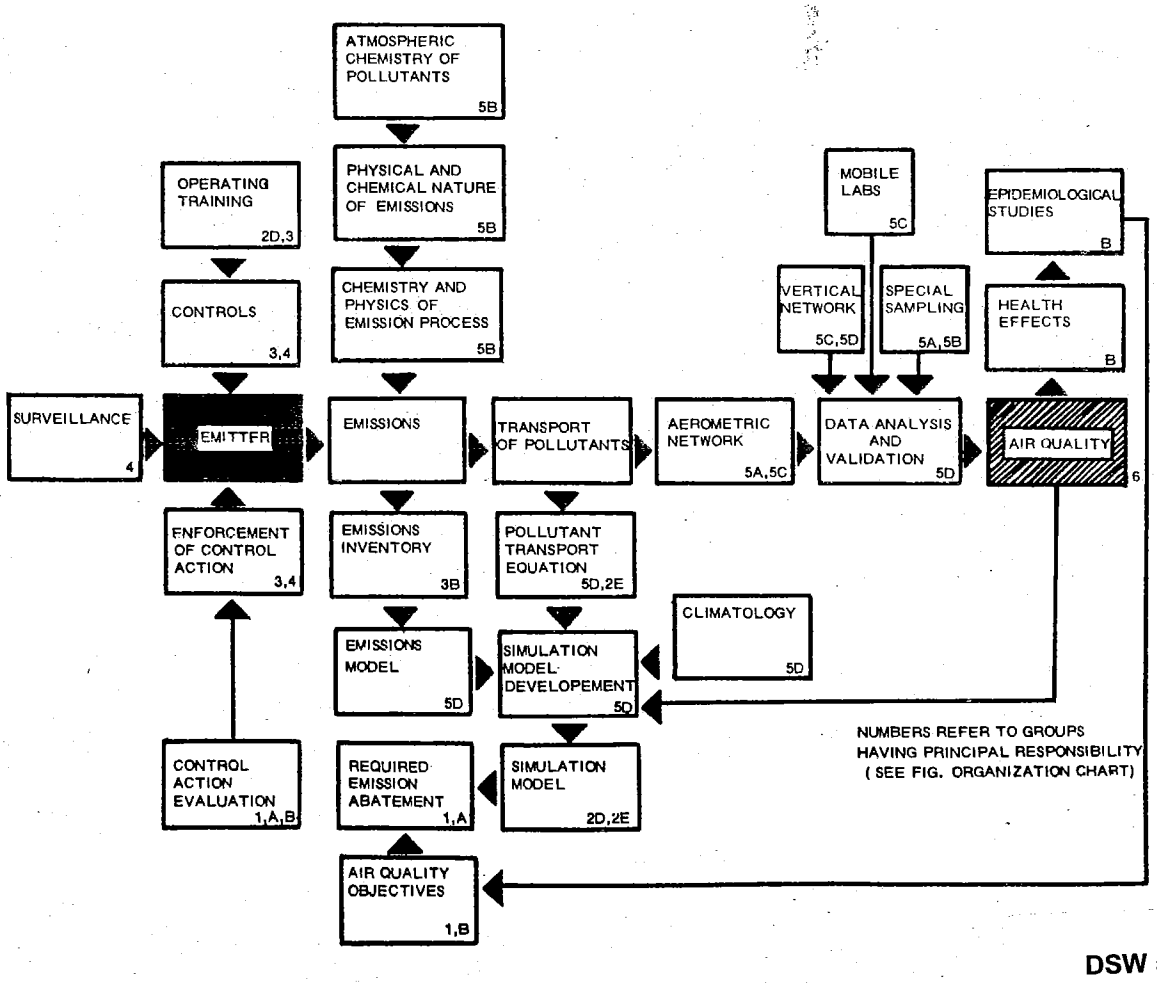
Besides gaseous pollutants there are particulates. There is also considerable opinion—and some evidence—that there are synergistic effects because of these two contributors upon health. Particulates are settleable (dustfall) or suspendable. Suspendable particulates have great importance because they include the range of particle sizes most able to penetrate the body's outer defenses. Particles below 10^{-3} microns have short lifetimes but are very important in determining the electrical properties of the atmosphere.

The question of particle size is critical with respect to health effects. Particles will deposit in the trachea, bronchi, bronchiole or alveolar sacs depending on their diameter and density. Those which deposit on the trachea, bronchi or bronchiole are normally removed by ciliary action and are swallowed. The percent of particles deposited in the lung is a function of particle diameter with a maximum near 1 micron. Particles above 10 microns can be considered non-respirable, while those less than 2 microns are 100 percent respirable.

Combustion and other processes can produce large quantities of particles known as Aitken particles, ranging between 10^{-3} and 10^{-1} microns. The main mass of the aerosols in the atmosphere are in particulates of size greater than 10^{-1} microns. Settleable particulates (dustfall) have sizes greater than 50 to 100 microns. Smoke from combustion consists mainly of carbon or soot, tar and mineral matter, with large variations in these components. Because of higher furnace temperatures, industrial fuel burning and municipal incineration produce smoke with a much lower tar and organic content and higher mineral content than on-site heat generation and incineration.

Suspended particulates are measured by weighing the material collected on a special filter as a result of the passage of a known volume of air. The air sampling system is designed to prevent other than suspended particles from reaching the filter.

Another method of measuring particulates uses a sequential tape sampler. With this device, air is forced through a filter paper or membrane for a specified length of time. The



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degree of blackness of the spot—measured by either its transmission or reflectance characteristics—is an indicator of the soiling potential of the atmosphere. Detailed analysis of particulates shows the presence of many organic and inorganic compounds including polynuclear hydrocarbons such as the carcinogenic benz (a) pyrene and a great variety of metallic compounds. Although these substances are present at very low concentrations, exposures can be long—a lifetime, in fact. Therefore, from a health hazard standpoint they must be seriously considered.

Fossil fuels contain sulfur and their combustion releases sulfur dioxide and lesser amounts of sulfur trioxide. The widespread use of fossil fuels for space heating and power generation makes sulfur oxide pollution a problem throughout most of the world—particularly in densely populated areas. Sulfur oxides also are released into the atmosphere by smelting plants, petroleum refineries, sulfuric acid plants and many other activities related to man's technological society. Sulfur dioxide has received much attention and has been blamed as a major causative factor in many of the air pollution disasters—especially in conjunction with particulates.

Pollution control legislated

The Air Quality Act of 1967—successor to the Clear Air Act of 1963 and Public Law 159 of 1955—attempts to spell out Federal, state and local efforts in the combined attack on air pollution. It provides for financial aid in the form of grants to state and local agencies for expansion of the Government's research and development, for standards to control vehicular pollution, for machinery to permit Federal action in interstate air pollution problems, and for emergency action by the Secretary of Health, Education and Welfare. It also provides for designation of air quality control regions by HEW, for criteria (describing health effects and property damage, and control technology) to be published by HEW, for development of air quality standards by states and air quality regions, and for a study of national emission standards for stationary sources. In essence, the primary responsibility for pollution control rests with the states and local governments—with a mechanism available for Federal intervention if the municipalities fail in their responsibilities. In this regard, many great cities have installed Air Resource Management Programs. An air resource management program is based on detailed accurate information and the legislation needed to enforce the programs developed by analysis of the information. The information must be broad-based, that is, not restricted narrowly to air pollution, inasmuch as successful management requires promoting the productive capacity of the population, as well as the public health and welfare. It is edifying to examine the program instituted in New York City.

With respect to its Air Resource Management Program, New York City's Local Law 14 of 1966, amended March, 1968, is the legislative tool. This law is administered by the New York City Department of Air Resources, an administrative agency whose head is appointed by the mayor. As a result of a reorganization of departments, the Department of Air Resources became part of the Environmental Protection Administration. This Administration follows a total environment concept, and is responsible for water resources and sewage and solid waste disposal, as well as noise and air pollution.

The Department of Air Resources operates under a dual approach: (1) progress towards a long-range, sophisticated systems management capability; and (2) effective day-to-day action. The first approach builds on a firm scientific foundation to develop a system capable of evaluating many variables in reaching decisions. The second approach uses available information of the moment to make decisions. As the first approach generates information and analytical capability, these benefits are, of course, used to improve the basis for judgments in the second.

Through Local Law 14, New York City legislated against sulfur dioxide, by establishing a schedule for reduction of the maximum sulfur content permitted in fuels. This schedule has been met, and as a result of investigations of available low sulfur fuel by the Department, the timetable has been accelerated. The 1% limit originally scheduled for May, 1971 was reached by all city-controlled facilities and the local utility, Consolidated Edison, in 1968. A new city council law has been passed that required all fuel used in New York City to have a maximum of 1 per cent sulfur by September, 1969.

Other regulations of fuels include the prohibition of soft coal for heating purposes. Soft coal can be used for steam and power generation—if particulate control equipment certified 99 per cent efficient is installed. The law also requires that all operators of residual fuel oil and refuse burning equipment complete a course of instruction in air pollution control techniques. This has resulted in a mammoth training program undertaken by the

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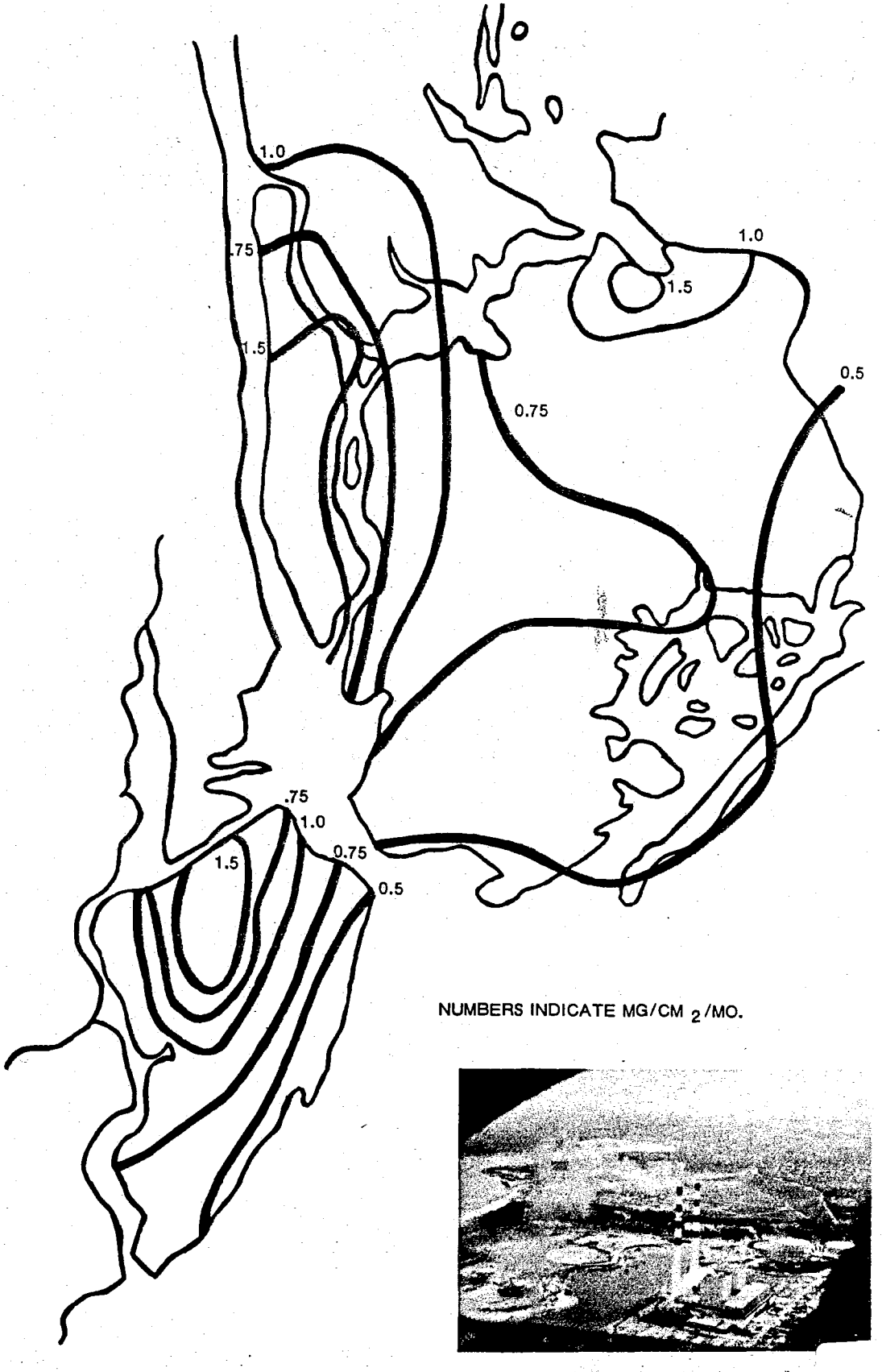
Department with the cooperation of the Board of Education.

An important control technique is the requirement for filing plans for all new constructions and obtaining permits before installation and issuance of any operating certificates. A somewhat novel aspect of the law is that a schedule has been set up for existing refuse burning and fuel burning equipment to obtain certificates of operation, requiring certain improvements. Considerable progress has been made with apartment house and com-



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mercial incinerators as a result of upgrading, closing down, or installation of refuse compactors.

The machinery

As shown in Figure 5, emitters are under surveillance by inspectors from the Bureau of Field Services, Department of Air Resources. Present surveillance includes automotive and helicopter mobile units capable of communicating by radio and walkie-talkie sets. Investigations into the use of television and light amplification detection techniques are in progress. Plans are under development to instrument major emitters for continuous recording or telemetering of pollutant emission rates. The controls on emitters are under continual study and evaluation by engineers in the Bureau of Engineering.

Investigating the chemistry and the physics of the emission process requires the latest tools and training if meaningful work is to be done. Therefore, a Special Services Research and Development division has been organized and equipped within the Bureau of Technical Services.

The physical processes in the atmosphere transport pollutants throughout the urban area after they are emitted. Therefore, an accurate profile of the air pollution problem requires measurement of both pollutants and meteorological variables at strategically located points.

In this connection, New York City has installed and is operating a 38-station aerometric network. The ten automated, telemetered stations measure sulfur dioxide, carbon monoxide, smoke shade, wind speed, wind direction and air temperature. Suspended particulates and dustfall are measured at these stations as well as at the manual stations. At the manual stations, automated samplers collect sulfur dioxide and smoke shade samples which are returned to the laboratory for analysis. A corrosion network consisting of racks of zinc and steel plates located at 13 stations is being used for long-term study of the corrosive effect of New York City's atmosphere. A vertical network including towers, buildings and an instrumented helicopter is in the planning stage. The helicopter instrumentation for monitoring sulfur dioxide, air temperature, dew point and pressure has been obtained and tested. Two mobile laboratories will soon be operating effectively. These laboratories will permit special studies at fixed locations as well as in-traffic studies. They will be capable of analyzing for all common pollutants as well as the meteorological variables.

The aerometric network and the other analytical tools obviously provide voluminous quantities of data for analysis and correlation. The data processing requirements are given to the Systems group for computer processing of the data. One of the key problems that must be solved is the relationship between emissions and air quality. The combination of pollutant and meteorological data is used to develop mathematical diffusion models designed to calculate the air quality resulting from certain emission conditions. Introduction of predictions for emissions and meteorological conditions then permit proper prediction of air quality.

Predictor control

The final state of this environmental research program is the attempt to combine all this information into a simulation model to determine required abatement in order to achieve air quality targets. These abatements must then be analyzed for feasibility within the existing social structure before being legislated and enforced. A working simulation model yields information about the effects of actions that might cost millions of dollars to test in the real world. Moreover, the air quality information generated by the network provides New York with a daily index of air pollution. These are compared with target data.

Another important function served by the network is to provide rapid information during unforseen air pollution episodes. In New York City and surrounding counties of New York State and New Jersey, an alert-warning system is triggered by a forecast from ESSA that stagnating air conditions will persist for at least 36 hours. As pollution levels rise, different stages of the episode are reached based on dosages of sulfur dioxide and smoke-shade or carbon monoxide. The consecutive stages following the initial forecast status, which is based strictly on meteorology, are Alert, Warning and Emergency. The City of New York has prepared an implementation manual that prescribes all the measures to be taken by different agencies and the public sector as soon as the Forecast status is announced. Measures become increasingly stringent as each stage is reached. It is believed that the combination of emission reductions already made, the rapid response of the aerometric system to conditions throughout the city and the carefully detailed procedures in the alert warning system will prevent any serious episodes in the future in the City of New York. ■

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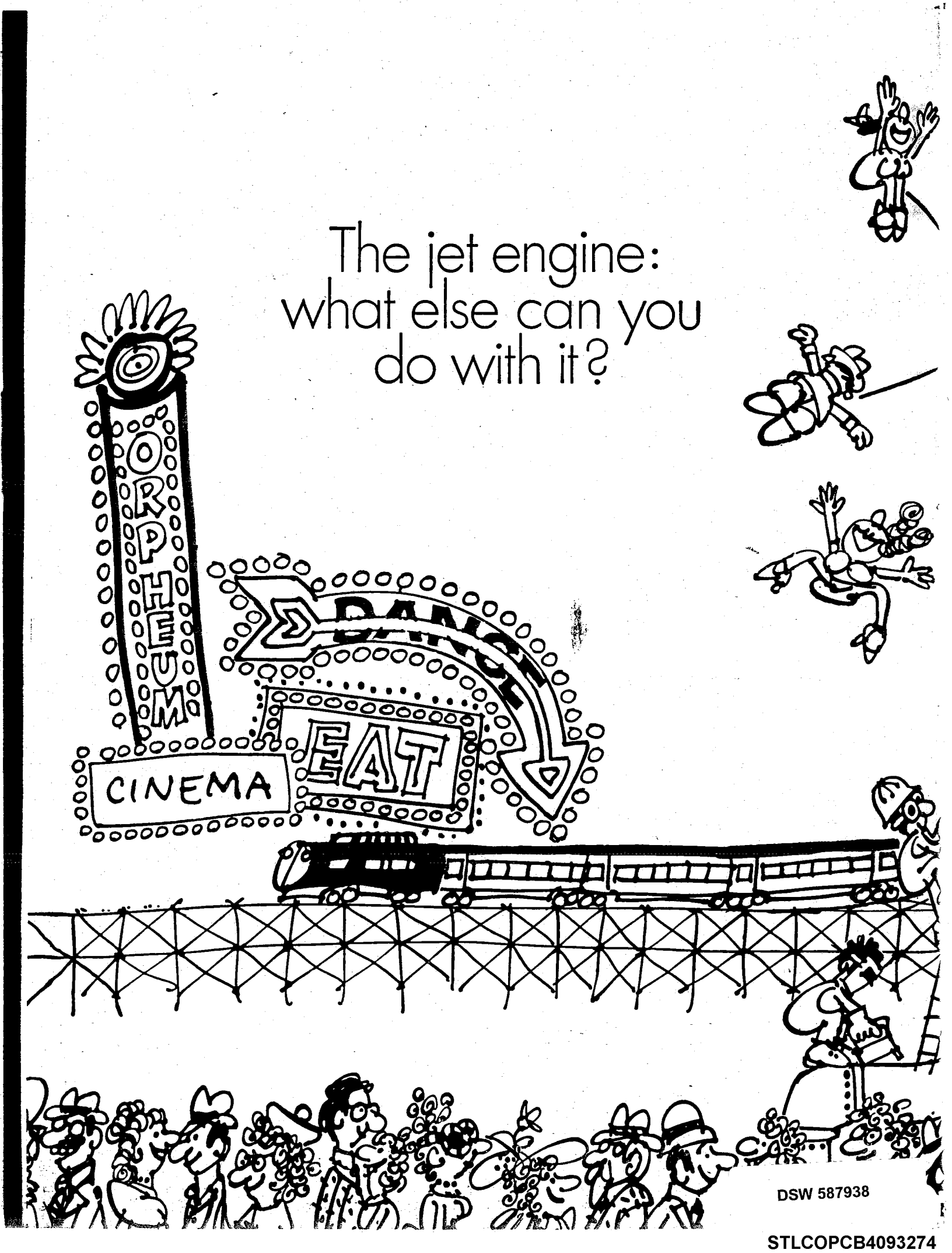
The jet engine: what else can you do with it?



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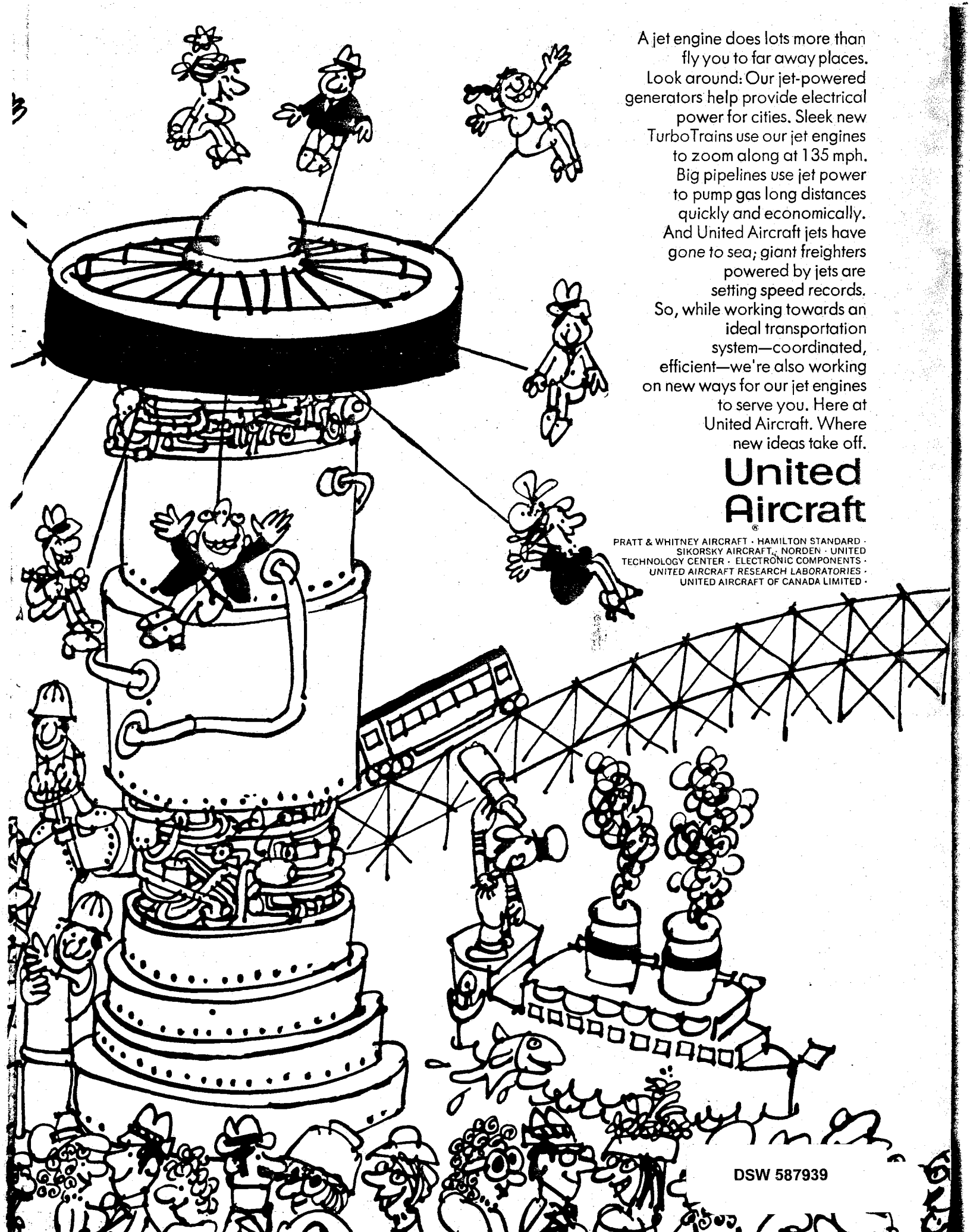

A jet engine does lots more than fly you to far away places. Look around: Our jet-powered generators help provide electrical power for cities. Sleek new TurboTrains use our jet engines to zoom along at 135 mph. Big pipelines use jet power to pump gas long distances quickly and economically. And United Aircraft jets have gone to sea; giant freighters powered by jets are setting speed records. So, while working towards an ideal transportation system—coordinated, efficient—we're also working on new ways for our jet engines to serve you. Here at United Aircraft. Where new ideas take off.

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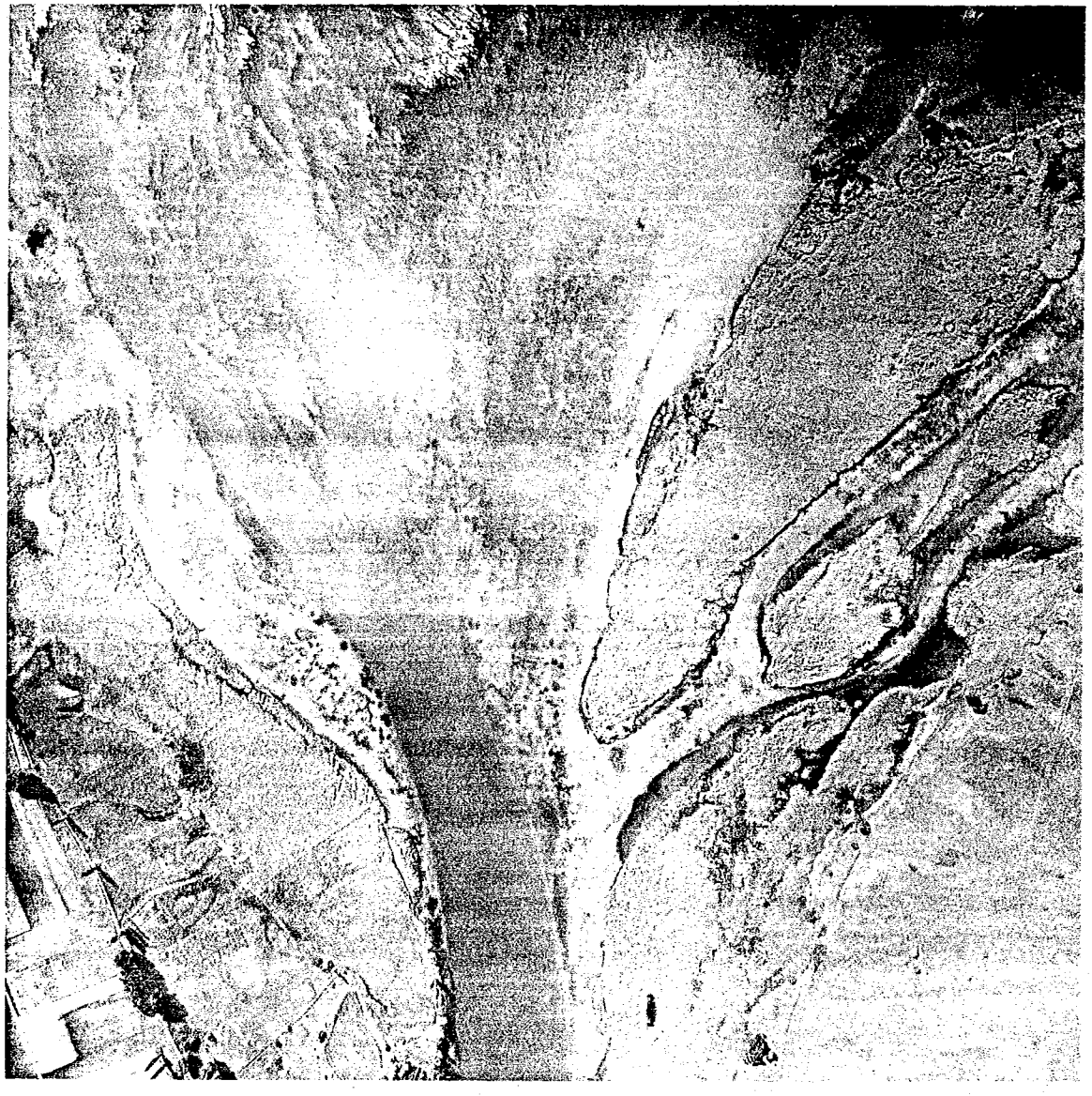
SWEETWATER POLLUTION



". . . and all the waters that were in the river turned to blood. And the fish that were in the river died; and the river stank."—Exodus 7:20-21.

by Larry Paul Wasserman

IN BRIEF: *Unlike the oceans, the earth's fresh water supply is not a constant, and polluting it is particularly undesirable. Although sweet water is replenished by rainfall from ocean stock, man's wanton use of his rivers, lakes and streams is depleting reserves. The problem arises not only from the wastes dumped and the water wasted, but also from insidious circumstances. Turning marshland into homeland, for example, can upset the ecological balance of inland waterways. This article reveals the many problems, some of which, unfortunately, include the red tape that constrains effective remedies.*

■ Malthus might have presented his famous revelation to the world in even more startling terms by saying: "The population of the world increases geometrically while the water supply on the earth is constant."

It is an eye-opening fact that the available fresh water on earth is only 0.325% of the earth's entire water supply. Surprising still is the fact that the Great Lakes contain 25% of the total found in all lakes. Table 1 shows the distribution of the world's estimated fresh water supply.

A review of something as complicated—and as far reaching—as the pollution of rivers, lakes and estuaries can begin at any one of

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many points. Perhaps the best way to begin is to review some of the more familiar forms of water pollution.

First on the list

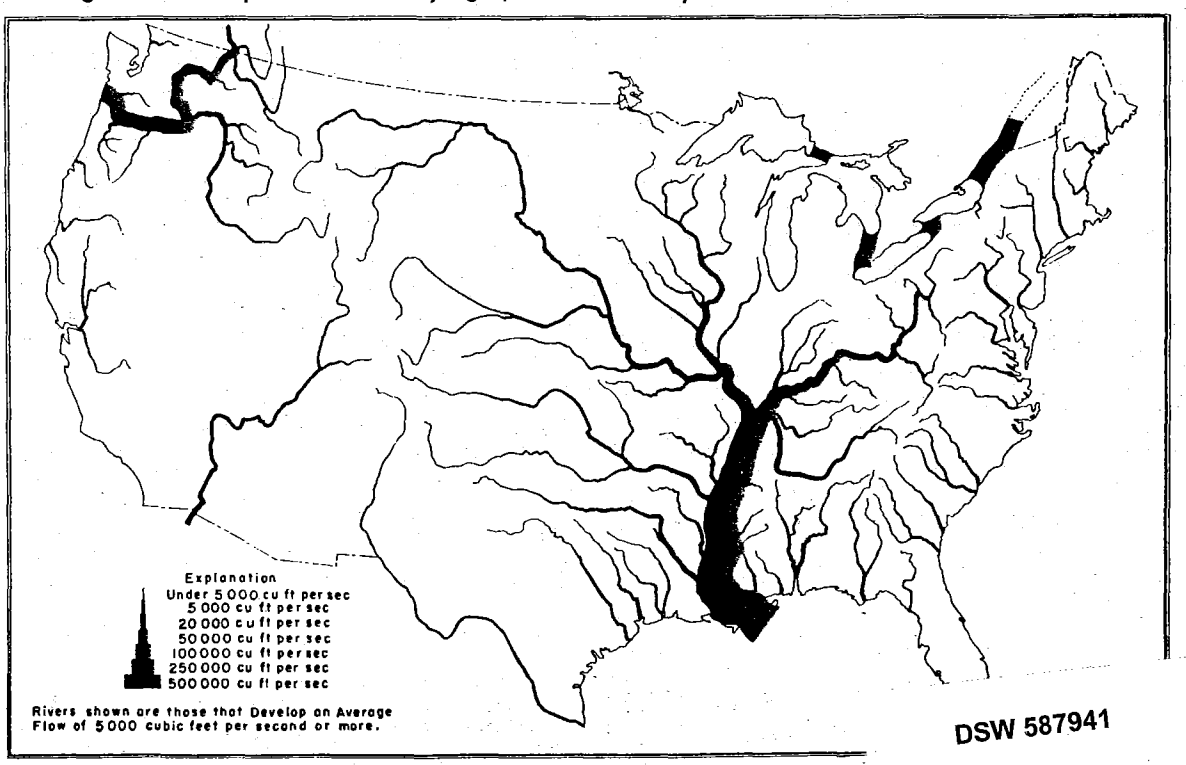
The most common form of pollution is the disposal of sewage into our natural waters. Raw sewage can be a definite menace and even treated sewage can cause pollution. A basic problem that arises from sewage in water is the pathogen or bacteriological problem, usually expressed in terms of a "coliform count."

Coliforms (Escherichia coli) are intestinal, mammalian bacteria, and their presence in the water indicates mammalian excreta. This may be due to natural causes (animals in the nearby woods), but more than likely is due to the presence of improperly or completely untreated human sewage. The coliforms themselves are more or less harmless (nonpathogenic). But, they may also signify the existence of pathogenic organisms—and these, if ingested, do damage. (A new, membrane filter method can check for pathogenic bacteria in 24 hours.) For drinking water the coliform count should be effectively zero. Higher coliform counts are permissible for irrigation, fishing, boating (but not swimming).

A second kind of pollution from sewage results from partially treated or untreated human wastes. The rate of bacterial decomposition increases, and there is a greater demand for oxygen with a resultant decrease in the natural dissolved oxygen content of the water. This reduction of the oxygen normally present in water is called Biochemical Oxygen Demand (BOD). It is a measure of how much oxygen is "demanded" during the process of bacteriological decomposition of organic matter. Dissolved oxygen is needed in order for the animal life to survive. Trout will not live below a Dissolved Oxygen (DO) level of 5 parts per million (ppm). Our suburban rivers, lakes, and estuaries are hard pressed to maintain 5ppm DO when they also contain organic matter with its BOD load. The test for BOD, by the way, is highly sophisticated but rather archaic. "Bugs" are grown in a test tube for five days and the oxygen consumed in the process is measured against a control—identical, but without organic matter.

Often something we eat and is perfectly harmless to digest can be a pollutant. For, even though a substance is perfectly edible or in no other way harmful, if it will decompose or cause bugs to feed upon it, that substance can become a pollutant. Make no mistakes

Average flow in major streams carrying 5,000 cubic feet per second or more.



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about it, sugar or molasses dumped into a stream or river can kill fish and animal life by robbing oxygen from the water. After all oxygen is depleted, additional "anaerobic" decomposition produces the smelly sulfur gases and decomposition products. Decomposition in the presence of oxygen produces carbon dioxide, whereas decomposition in an oxygenless environment produces methane, hydrogen sulfide, and even mercaptans (aliphatic compounds similar to alcohols in which the oxygen is replaced by sulfur). While the former may be preferable from an olfactory standpoint, conditions of urban life frequently create the latter. Neither is good.

Incidentally, because biological demand is not instantaneous, some unusual things occur: A sewer outfall pipe can cause utter degradation of the water 50 miles downstream as the "bugs" continue to feed on the flowing organic matter.

Raw sewage, of course, offends the olfactory sense. Perhaps, in part, because of this, a proper attitude towards use of this organic waste material in a beneficial manner is lacking. Presently, sewage is looked upon as something to be hidden where no one will see or notice. Consequently, such locations as the N. Y. Sludge Dumping Ground exist in the Atlantic Bight area. The blanket of sludge covers over fifteen square miles of continental shelf and has completely obliterated all benthic (bottom dwelling) animal life in the area.

But basically, sewage and organic waste products are very useful organic foods that may be used some day in the future as food for fish farms and for harvesting the products of seas and oceans.

Separate or combined

The disposal of domestic waste and rain runoff from our concreted, leveled, stripped-of-soil cities is a sad comedy of errors. Long before overpopulation became a problem, some smart but shortsighted engineer calculated that much money could be saved if domestic sewage efflux and the water runoff from street gutters and drains passed through the same piping system—in his day, a great idea. Unfortunately, urban dwellers must now live with the multi-billion dollar outdated piping system. Sewerage treatment plants, to which this piping system leads, are designed to handle a certain volume of water. Along comes a good-sized thunderstorm and the volume of water flowing into the street drains, and thence to the treatment plant, greatly exceeds the plant design capacity. Of course, there is an overflow provision: The excess water, thoroughly mixed with the city's sewage, spills into the nearest waterway without *any* treatment—no chlorination, no primary, no secondary treatment. Obviously, combined sewer and stormdrain piping systems were not the bargain intended. But because the capital investment in combined sewers is huge, they cannot economically be replaced within our lifetimes.

The Government is sponsoring research to find ways to eliminate or minimize the combined piping problem. One potential solution is concentric piping, i.e., running a new pipe for sewage inside the larger rain runoff tube. An additional incentive for installing separate sewage and water pipe facilities, if any is needed, is the rapidly approaching water shortage in the entire northeast. If separate systems exist, as they do in many small recent towns, it becomes possible to run the storm or fresh water runoff system to an underground recharge basin or reservoir.

Voluminous wastes

Industrial chemicals, acid mine drainage, pulp mill effluent, heavy metals, other industrial wastes, and insecticides are other common sources of water pollution. Industrial wastes tend to run in broad categories according to the location of the industry. There is acid mine drainage in Pennsylvania steel mills, slaughterhouse waste in the Midwest, pulp and paper mill waste on the West Coast, chemical and pharmaceutical waste in New Jersey, phosphate mining waste in Florida, and so on around the country.

Industry is coming to realize its responsibility and steps are underway to help meet this commitment. There are, however, many examples of unintentional and generally unrecognized pollution that must also be combatted.

Consider the subtle ways in which heavy metals can cause a problem. Shortly after a new coal-fired, steam electric generating station was activated, a considerable increase in green oysters was observed in the nearby river receiving the output cooling water from the plant's condenser. This "greening" began at stations nearest the outfall and spread with time downstream. While not verified, it is suspected that the greening was caused by increased copper concentration in the river due to condenser tube corrosion problems at the power plant.

Closely related with this subtle, unintentional poisoning of the environment by metals is that caused by certain agricultural chemi-

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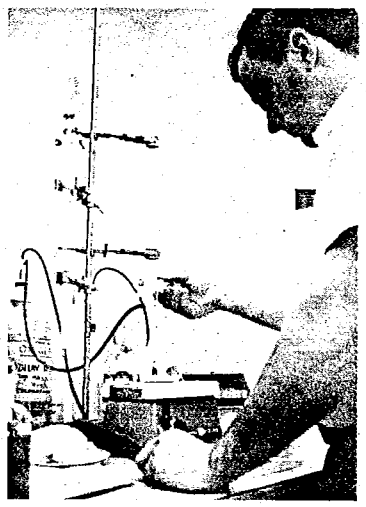

Checking for dissolved oxygen, an engineer, studying Lake Erie's water pollution, analyzes a prepared water sample.

cals. Large amounts of chlorinated hydrocarbons and other pesticides are spread over the surface of the land. During periods of rainfall, excess chemicals are washed into the surface waters or percolate into the subsurface aquifers. Hence, much of these materials eventually enters the bays of the region. In many cases concentrations approach levels known to have killed organisms. Some long-term studies have shown that there has been a substantial reduction during the past decade in local fauna sensitive to DDT. Rachel Carson's book *The Silent Spring* helped bring attention to the spreading dangers from indiscriminate use of pesticides and herbicides.

Eutrophication

One of the more widespread—and perhaps the most difficult form of pollution to avoid—is eutrophication. The term essentially implies the chemical enrichment or fertilization of water. Eutrophication is one of those handy-dandy words to casually mention after the second martini at your next sales meeting. "We have a eutrophication problem in our neighborhood," is a good opener. In some places eutrophication occurs naturally. The result is a swamp that fills to become a bog and eventually, solid land. You may have heard that the Great Lakes will solidify in a thousand years or so, even as a natural consequence of eutrophication; sooner still, with man's "help".

Phosphates and nitrates from fertilizers, sewage and detergents and many chemicals escaping sewage treatment by means used today become part of the ecological chain in a body of water and act as a liquid fertilizer. The water is so fertile that green algae, and microscopic animals and plants that are the lowest level of the food chain thrive in superabundance. Higher plant forms may also thrive. Ultimately however, they die and they decompose and in doing so, use oxygen from the water in much the same fashion as a piece of rusting iron absorbs oxygen from the air. The oxygen removed from the water by decomposing plants and organic matter can suffocate animal life in the vicinity.

Frequently the combination of nutrients, organic matter in the water, sunlight energy, temperature, and perhaps other factors that are unknown, will touch off what is known as a "bloom." These blooms are commonly seen as red tide, blue tide, or green tide, depending upon the particular microorganism that has had an explosive growth rate and thereby has driven out most other forms of life in the vicinity. Moreover, many of these blooms produce a toxic substance that paralyzes the respiratory organs. Hence fish and other forms of higher life that cannot avoid this bloom are killed.

Eutrophication can be harmful to humans as well. Oysters and clams in the vicinity of the blooms have been known to absorb enough toxin to produce respiratory problems in people eating these shellfish.

Superimposed on the other effects, the dead plants and animal matter will drift and settle on the shore line and on the bottom of the lake or other body of water. On the bottom, this organic matter tends to make the water shallow and will over many years fill in a small lake or an estuary. On the shore, this decomposing material produces an odor problem—only solvable by sending people with rakes and shovels to literally sweep the shore line clean of dead and decomposing organic matter.

Sewage is, of course, a major problem. But man is a technologist, and in his effort to make himself more comfortable, he is also inadvertently ruining his ecology by generally unrecognized processes of pollution.

Landfill

Another of the insidious forms of pollution is created by landfill operation, a form of which is called bulkheading. Basically, it occurs when a land developer, operating in a marsh, estuarine, or river shore line area, in order to get suitable land on which to construct a house or factory, brings in fill and raises the level of the land a few feet. Usually this occurs in the very shallow areas. The landfill or bulkhead operation, while apparently improving land, accomplishes exactly the opposite. Wetlands are not wastelands. A vital factor in our chain of natural resources is removed by destruction of low-lying lands. Bulkheading changes the drainage pattern, alters the land runoff, and destroys valuable breeding area for commercial and sports fish and other forms of life.

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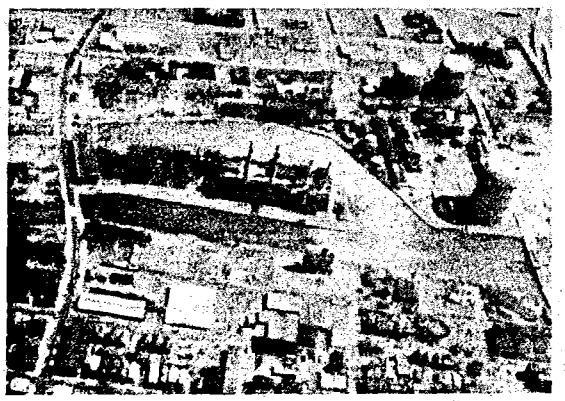

Sewer outflow from industry

In shallow areas along the shore line or in swamps is found an environment very suitable, even necessary, to juvenile forms of animal life. They receive adequate sunlight and food because land is near and nourishment is washed into the water. In the same region are found large amounts of nutrients entering the water and these in turn provide the proper environment for the microscopic food particles upon which juvenile forms of life feed. A marsh may be likened to a food factory. It produces many tons of organic matter per acre for the minute forms of life essential to the viability of higher forms. In addition to food, the marshes provide a highly integrated system for reproduction, growth and protection from predators and the elements for a variety of shellfish, finfish, waterfowl and other wildlife.

Another important use of the shallow or swampy regions is as a buffer between the water and the land. Wet lands are nature's flood and hurricane protection. The large fields of swamp grass serve as a breakwater for storm waves and surges.

Alpha, beta, gamma

With man's increased use of radioactivity and nuclear power plants, he is confronted with avoiding a new form of pollution problem. The radiation pollution story is covered separately in this magazine (p.xx.) But I want to emphasize an effect having particular relevance to water dwelling animals—and ultimately man. The greatest danger coming from the release of radioactive substances to our environment is not that any one release, in general, is at a harmful level. What has been found, however, is that various forms of animal life will concentrate the radioactive material and increase its dangers. The actual mechanics and biological mechanisms by which this concentration is accomplished are not completely understood. Thus, scrutiny of the wildlife in a pond receiving runoff from the Savannah River Plant near Aiken, South Carolina, disclosed that while the water in that pond contained only infinitesimal traces of radioactive zinc-65, the algae that lived in the water had concentrated the isotope by nearly 6,000 times and the bones of bluegills, an omnivorous fish that feeds both on algae and on algae-eating fish, showed concentrations more than 8,200 times higher than the amount found in the water.

Study of the Columbia River, on which the Hanford Washington Reactor is located, showed that the radioactivity of the river plankton was 2,000 times greater than that of the water while the radioactivity of the fish and ducks feeding on the plankton was 15,000 and 40,000 times greater, respectively. Moreover, the radioactivity of the egg yolks of water birds contained more than a million times the radioactivity in the water. Here then are clear illustrations of the ways in which traces of radioactivity in air, water, or soil may progressively concentrate, so that by the time it ends up on man's plate it can be a tidy package of poison.

It is not known if there might be a bend in the river of a ripple pool behind some rock where radioactive particles might have a tendency to settle. For this reason long-lived radioactive material should not be released to the environment even in minute quantities.

The thermal threat

Among the forms of rising pollution these days are the large amounts of heat released to waterways. Heat is, of course, generated by the decomposition of sewage. But because decomposition isn't spontaneous, the refuse, and hence heat from decay can diffuse. In addition, large quantities of concentrated heat are being released into the waterways at an increasing rate from electric power stations and, during summer months, from building interiors. Basically, in cooling a building or a power plant's (especially nuclear power plant's) steam cycle, the unwanted heat is pumped to a colder body—usually the nearest body of water. The vast numbers of BTUs are enough to raise the temperature of even a large, fast flowing river. For example, the BTUs removed from the World Trade Center building in lower Manhattan by its air-conditioning plant will raise the temperature of the Hudson River in the vicinity of the condenser water outlet as much as 10 degrees Farenheit. At times of low flow or slack tide the temperature rise will be even more appreciable.

Heating a river to 90° or 100°F does pretty much to the fish what 100° F in the shade on a muggy day does to humans. A few die, some pass

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out, and the rest are uncomfortable. Raise the temperature to 110° F and a lot more will die.

For waterlife, another danger—asphyxiation—is linked to water temperature. The solubility of dissolved oxygen, necessary for life, is an indirect function of the water temperature. The hotter the water, the less dissolved oxygen at saturation. Superimpose thermal pollution on a water already poor in oxygen and animal life is certain to die.

In the Pautuxent River area in 1966, an estimated 40,000 dead blue crabs were found in and around the discharge canal area of a coal-fired steam electric station that, depending on pumping rates, heats the water 11.5° to 23°F above ambient temperature.

Thermal pollution must be carefully regulated since the total BTU contribution from many "harmless" additions may be fatal to animal life. The danger lies in the fact that technology for producing these heat sources exceeds the funds and technology for studying the effects of the source on the environment.

Changing hydraulic

A quite serious "invisible" form of pollution not generally recognized by the average person is what I broadly call hydraulic changes. Certain of man's activities cause the water patterns or the amount of water normally flowing in an area to change. A very fine example of this occurred in the northeast during the recent 5-year drought.

The Delaware River is tapped for water supplies by many communities—especially New York cities. During normal conditions, there is enough flow of fresh water in the Delaware to hold back the salty ocean water at a point a few miles below Philadelphia (which also gets its drinking water from the Delaware River). There happen to be some seed oyster beds in Delaware Bay along the New Jersey Coast. Oysters have a wide-ranging salinity tolerance. One of the predators of oysters, called an "oyster drill" can only tolerate the more salty region within the oysters' range. Obviously, oysters bedding in low salinity water can escape the oyster drill. But after prolonged drought, because fresh water from the Delaware continued to be withdrawn for population's use, the ocean salt water could not be kept back in its usual position.

The oysters, growing nicely in very favorable environmental conditions, began experiencing a salinity increase. This did not bother the oysters. However, the oyster drills now found that they could move well into Delaware Bay and still survive. It was a feast for the oyster drills! Nearly the entire oyster bed was ruined.

A most serious condition emerged for the city of Philadelphia, when the salt water wedge moved up the Delaware River and almost reached the fresh water intake pipes of the city's water supply. Only the end of the drought at that time prevented the contamination of Philadelphia's drinking water supply by salt water.

The State of Florida has experienced similar problems in the draining of the various swamps, ostensibly for such good purposes as providing additional housing land. During the drought years there were fires in the swamps and many of the animals died due to lack of water.

Through such calamities a slow realization is beginning to emerge about how, by merely changing the hydraulic regime of a region, very grave problems can ensue.

Cost-benefit analysis may have *proved* such hydraulic recourses useful. But the ultimate outcome indicates only perfunctory effort to determine the true "costs."

Log-clogged waterways

Although limited in extent to harbors where extensive amounts of rotting, wooden piers exist, the drifting log problem has only recently been made the object of a full scale, all out cleanup program. New York Harbor will become the testbed for a comprehensive attack on the floating wood problem by the Army Corps of Engineers. Old piers and rotting hulks will be dismantled. The first problem is what to do with the wood. Burning it would create air pollution. Weighting and dumping it on the continental shelf has been suggested and strongly opposed by this author and others at public hearings.

In rivers and lakes the dumping problem is not as great but more recreation contact with the waterway takes place. On a smaller scale, the rapid growth of pleasure boating has resulted in an appreciable increase in dumping of litter, including such material as plastic food wrap, and glass, metal and cardboard containers. Much of this material floats and is carried onto beaches and other areas, resulting in destruction of their aesthetic value.

Particle "rainfall"

Unnatural sedimentation causes a fine cloud of particles to rain down upon the bottom in regions of calmer water. This ever growing blanket of "dirt" will eventually smother any life that occurs on the bottom. In addition, the cloud of particles will decrease the ability of light to penetrate the water causing less oxygen to be produced during daylight hours by photosynthetic plants. The particles of silt

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may act as an abrasive causing severe damage to the fish gills. Smaller forms of life can also be harmed by this cloud of silt material.

Sedimentation can be caused by any action that stirs up bottom deposits or washes great amounts of soil from the land. One of the worst causes of sedimentation in localized areas is created by present dredging methods. The dredge is such that it stirs up enormous quantities of bottom deposit. Up to 90% of the fine silt sucked into the dredge goes right back into the water via the hopper overflow. It then flows downstream. Any construction activity in water will also cause silting. Silting will not occur when the water velocity is high enough to keep the bottom rock bare.

Solutions and a cure

I have established the problems. But what steps can be taken to control the situation? A difficulty of pollution control is an absence of cost evaluation of pollution caused damage. In a recent study conducted for the Estuarine and Oceanographic Programs branch of the FWPCA, I found that there are many pollution statements by various people on the extent of the problems encountered. But there are very few documented, scientific cases where a competent investigator has analyzed a problem, to the extent of performing autopsies on dead fish or chemically analyzing water quality to establish a dollar value on the loss or damage from pollution. This makes it difficult to assess the benefits that arise from pollution abatement.

It is known, however, that in areas where the use of DDT has been restricted or eliminated altogether, animals in danger of extinction, such as the osprey and eagle, have responded by repopulating the area almost immediately.

One of the little known side effects of pollution is that, in doses not enough to kill the animal life, pollution can cause environmental stress that will lower the number of species of plant and animal life found in our waters. The form that ultimately predominates is generally of a less desirable nature. For example, the trout is the first fish in a stream succumbing to pollution. Too high a water temperature, too low a water velocity, increased sedimentation, industrial chemicals, or loss of its mosquito or fly food supply can completely eliminate this very desirable fish. If pollution continues to increase so that all fish cannot live, other forms of life may predominate. In regions near sewer plant outfalls, huge snail populations often exist.

All forms of pollution need more research in better treatment methods. Present methods of treatment and analysis in many cases have been in use for thirty years or more.

Current approaches are merely "stopgap" programs. A better approach is environmental planning to eliminate the waste that characterizes our society. Coordination of all levels of mining, manufacturing, use and disposal is needed with operations research, systems analysis, and plain old common sense.

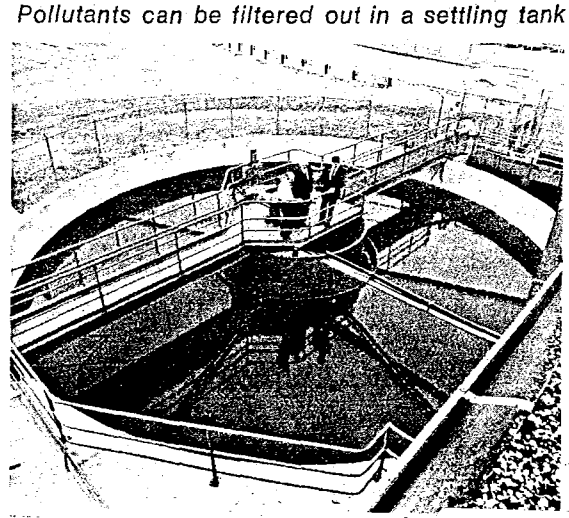
For example, sewage can possibly be treated with secondary treatment plants. With Federal and state assistance many plants are currently under construction or planned. A plant is only as good, however, as the quality of its operators. In order to make training and a well-equipped laboratory economically possible, the concept of large regional treatment plants —rather than small, multiple, municipal types—is now advocated.

The analysis problem is exemplified by the BOD test. The BOD test takes too long, i.e. 5 days before there are any results. Should a ton of molasses spill into the water and a laboratory sample obtained, five days have to pass before anyone can have an idea of just how much oxygen is being robbed from the water by the bugs feeding on the sweet syrup. We need more real-time detection instruments.

Who pays? Who benefits?

The principle ingredient needed to counteract our growing water pollution dilemma is money. It takes funds to run a conservation organization that really alerts the public. It takes money to preserve land and set aside marsh areas, buy up shore lines, and set aside bird refuge. It takes money to build treatment plants and coordinate and oversee programs on a national and state level. It takes money to collect information and process it and maintain the data banks necessary to establish trends both past and future—of our water resources.

Pollutants can be filtered out in a settling tank



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Studying pollution effects on underwater life

There are programs being funded or assisted with Federal monies. The more wealthy state governments are also large contributors. Industry, conservationists and generous foundations contribute—but not enough.

Overlapping function problems

While money can salve many of the ills from pollution, other remedies are also needed. Since most of our rivers, lakes, and estuaries form political boundary lines, they fall prey to being nobody's problem and everybody's problem at the same time. For example, the border between New Jersey and New York weaves an arbitrary, but legally defined, path down the middle of New York Harbor. Each state's legal jurisdiction extends to the middle of the Hudson River. Therefore, by definition, each can ignore or pass the buck on 50% of every problem affecting the harbor. There also are county governments, city governments and even private organizations with their own piece of responsibility for the river and harbor, and so any action involves coordination between state, county, and municipal-government agencies.

In order to correct this problem, a number of super-agencies have been created to work across government boundary lines. The Interstate Sanitation Commission—one of the earliest water pollution monitoring agencies—is typical. It monitors and has legal authority in matters of sanitation concerning the waters of the New York metropolitan area belonging to the states of New York, New Jersey, and Connecticut.

Not satisfied to have just *one* good coordinating agency, several others have been added: The New York Port of Authority, various river basin commissions and quasi-governmental organizations such as Turnpike or Power Authorities. Although they all do a good job, they are not coordinated, and sometimes apply redundant solutions or other times leave gaps. Besides overlap by political boundaries, there is functional overlap or loopholes. New York Harbor again is a typical example. The Army Corps of Engineers has legal responsibility for maintaining navigation within the channels. The Coast Guard, on the other hand, is charged with maintaining aids to navigation such as the buoys and lights, etc. used for staying within the channel that the Corps of Engineers dredges. To further complicate the issue, the Public Health Service is mainly interested in disease causing properties, while the U.S. Park Service and the Bureau of Outdoor Recreation is concerned with the recreational use of this body of water.

Topping everything, the Fish and Wildlife Service is concerned with the animal and fish life in the area; the Coast and Geodetic Service and Geological Survey is interested in geology and current flow, the tides, and the Federal Water Pollution Control Administration is concerned with pollution. This latter agency is perhaps one of the best examples of an agency empowered to do a job crossing various functional boundary lines. They can examine and take action in all situations of water pollution in cooperation with other federal jurisdictions. This amalgamation of snippets has resulted in some rather unusual situations. The Army Corps of Engineers was taken to court recently, by a party claiming that the Corps could not legally refuse to grant a permit for dredging unless the refusal was based on navigational reasons. In effect, the Corps could not reject the application based on the belief that the dredging would be harmful to wildlife or perhaps create a health hazard, because the only legal objection they could make was on navigational grounds.

Water pollution has many aspects but is merely a small part of a larger problem. By thinking ahead a few years, there still is an opportunity to plan for optimum use of our natural resources for the majority of the country. We are a nation of disposers. We take a natural resource, mine it, use it, and throw it away or dilute it to the environment. This practice will have to stop if we are to fully utilize the natural gifts that we have. It is necessary to reuse more of the material now being discarded. This will eliminate two problems. It will minimize pollution and it will help solve waste disposal.

Water and our other natural resources have been abused. It is up to modern science and technology to provide for their preservation.

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CONTINENTAL WATER POLLUTION

As one country's waters go, So go the waters of the continent

IN BRIEF: *The lakes and the rivers of the Continent were formerly sparkling blue, crystal-clear havens for fish that would tempt a royal palate. But alas, through eutrophication—and other forms of encroachment—the lakes of Europe are dying, its rivers have become polluted torrents containing chemicals, garbage and worse. A dedicated group of professionals, seeking to forestall the eventual uselessness of the continental water resource for human purposes, conducted a survey of the scientific and technical aspects of water pollution control on the Continent.*

The basic aim in any water resource management effort is to maintain an adequate supply of potable water that meets modern standards of chemical and biological purity. In this regard, the processes of disposal and recovery of domestic sewage, industrial effluents, and conservation of the water supply all enter into consideration. In Europe, this kind of control encounters the following stumbling blocks:

1. On the Continent, all major waterways are shared between two or more countries—and international cooperation is more political than practical.
2. Capital demands for efficient effluent-treatment installations are greater than the willingness of the communities to supply them.
3. Because of insufficient specialized knowledge, local laws and regulations are so impractical that they are often ignored altogether.

The abstraction of water from public sources is, of course, governed by legislation in all countries. The amount that must be returned—and particularly the quality of this return—is not always controlled. Great anomalies, as in industry standards along the Rhine (fixed by Rhine authorities), arise; and cannot in practice be enforced. Moreover, the standards are virtually meaningless since some of the major cities along the river discharge their effluents directly into the Rhine without any pretreatment.

In principle, European waters are divided into the following categories: (1) potable water; (2) water supporting fish; and (3) water suitable for navigation only. Unfortunately, some European countries recognize a fourth and unofficial category: "Waters that will be in another country by the time they are analyzed."

Although each country maintains differing standards, the standard for potable water on the Continent is uniform and is supplied by the United Kingdom at a biochemical oxygen demand (BOD) of 20 ppm and 30 ppm suspended solids.

Passing the buck

Most authorities in Europe agree that the treatment of effluents can be classified into three stages.

The first stage involves sedimentation, and is usually followed by filtration through anthracite or sand. The second stage takes in biological treatment, always followed by some sort of filtration. And the third stage involves chemical precipitation, absorption and filtration—often referred to as the "polishing stage." Eventually, all effluents in Europe will have to be subjected to three-stage treatments. At present, realization of this ideal is still a long way off—especially since plants in Germany and Switzerland still discharge about 60% untreated domestic effluents directly into lakes and waterways used for swimming and drinking water.

Water purification and recovery of water for return into rivers and public systems are the biggest problems for European industry. Present thinking is that industry should meet standards prescribed by local authorities and then return its effluent to public sewers instead of discharging effluents into rivers and waterways that precludes effective control. The European water problem has been the subject of Continental conferences and experimentation for many years. There is little doubt, in all countries involved, that a need exists for cleaning the rivers, the lakes, inland waterways, etc. But there *is* doubt as to *who* should bear the burden of the costs of these anti-pollution measures.

For example, there has been a five-nation "International Commission for the Protection of the Rhine against Pollution" for the past 13 years. But up to the present, this commission has merely set a standard for purity de-

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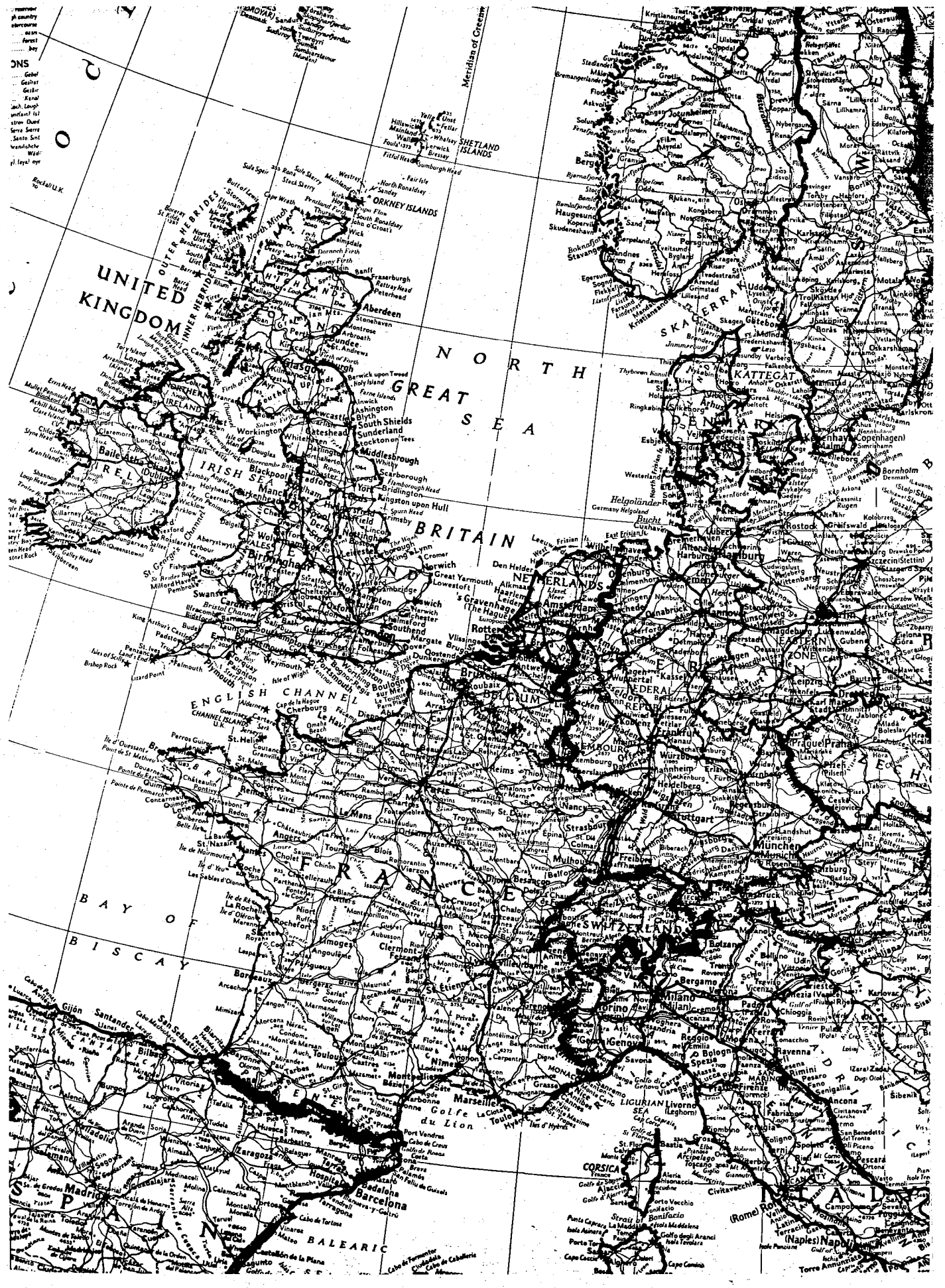

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sirable for the control of industrial and domestic effluents. It has yet no power to enforce this, or any other measure it promulgates.

Tradition

In Europe, the traditional method of sewage disposal is the "sewer farm." Here the effluents are spread over large tracts of land. As the liquid filters through the soil, it is biologically cleaned by the soil bacteria. Obviously, this is hygienically unsafe and impractical where the population is dense and land is at a premium. And so, the trend has been toward using more modern processes involving filters coupled with the use of anaerobic bacteria.

The most popular of the modern methods is the activated sludge process. This does not require the use of massive filter beds. In essence, the supernatant liquor from the primary settlement tanks is passed along to aeration tanks, where the matter is mixed with returned activating sludge from the final settling tanks. The air is adjusted so that (in theory) at no time does the concentration of dissolved oxygen fall below the range of 1-2ppm. From the outlet ends of the aeration tanks, the mixed liquor is then passed on to a final settlement tank or tanks, where the sludge is separated from the supernatant liquor, which is then discharged as the final effluent, while much of the settled sludge is returned to the aeration tanks.

Meanwhile, research is proceeding on the substitution of biological oxidation processes by chemical means employing catalysts. This type of oxidation would open European chemical markets even further. The future possibilities for water management and equipment expansion in Europe are represented in the following table:

The European Market for Plant & Equipment for Water Management
(Million $)

	1968	*1976*
Great Britain	200	350
Germany	250	400
France	180	250
Belgium	20	60
Holland	20	60
Switzerland	50	50
Scandinavia	15	40
Italy	15	40
Total	750	1250

Where the money goes

On a national level it is foreseen that West Germany will have to spend at least $2.3 billion for effluent control over the next decade. Austria has budgeted anti-pollution water defenses at more than $800 million for the next decade.

Chemical Wants for European Water Management
(Million $)

	Communal		*Industrial*	
	1968	*1976*	*1968*	*1976*
Great Britain	17.0	18.5	55.0	80.0
W. Germany	12.0	18.0	40.0	85.0
France	9.0	15.0	23.0	30.0
Holland	3.0	3.5	7.0	12.0
Belgium	2.0	2.5	5.0	10.0
Italy	4.5	8.0	10.0	15.5
Switzerland	2.0	3.5	9.0	15.0
Scandinavia	0.5	1.0	1.0	2.5
Total	50.0	70.0	150.0	250.0

The most important additives and processing chemical aids to be used in industrial waste management are (not necessarily in order of allocation):

- Chelating agents, to prevent metallic sludge;
- Deflocculants, or dispersing agents to prevent sludge;
- Antifoamants;
- Water softeners to prevent scale-deposition;
- Algaecides to prevent slime formation;
- Biocides to prevent brackish water and as sterilants;
- Corrosion inhibitors;
- Flocculants and coagulants to aid precipitation and filtration;
- Neutralizing amines;
- Filter aids and diatomaceous earths;
- Absorbents and activated carbon.

For sewage treatment and effluent water recovery the following are needed:

- Filter aids:
- Coagulants and flocculants;
- Alumina;
- Chalk and calcium hydroxide;
- Ferric Chrolide;
- Gypsum;
- Bentonite and diatomaceous earths;
- Activated carbon;
- Polyelectrolytes, mainly cationic;
- Algaecides;
- Sterilants;
- Chlorine;
- Plastic filter packing.

And in order to assure and to maintain an adequate supply of potable water the following are employed:

- Polyelectrolytes and flocculants;
- Chlorine dioxide;
- Chlorine;
- Filter aids.

In addition to these, sodium-calcium phosphates are in broad popular use to prevent scale formation in boilers. Sodium hexametaphosphate for domestic water softening comes in the same category. Its use is very wide-

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spread in Europe. But some countries are clamping down on the cause of these chemicals to prevent potential causes of eutrophication in their lakes. A special note is necessary about polyelectrolytes because not only are these the last arrivals on the pollution control scene, but they also offer the maximum potential sales to chemical manufacturers. Polyelectrolytes include a large number of chemicals of natural or synthetic origin. The natural ones are alginates and modified starches. Both have advantages in freedom from toxic monomers and easy toxicological assessment. Their disadvantages are mainly that large quantities are necessary. Of the synthetic ones, particularly the partly hydrolyzed acrylamides, only very small quantities are necesesary to achieve flocculation.

Flocculation is the result of hydrolysis, in which a flocculent precipitate of metal hydroxide is formed that contains both colloids and organic substances. These solids become mechanically trapped or are absorbed. A large number of salts can be added to the water for this purpose, including a mixture of aluminum sulphate and sodium aluminate, sodium silicate, magnesium sulphate, lime or lye. The primary aim of this procedure is to control the pH value of the water since the properties of the floc (its settling velocity and ease of filtration) depends, of course, on its acidity. To precipitate aluminum hydroxide (formed from aluminum sulphate), the optimum pH value of the water ranges from 5.5 to 7. For ferric hydroxide (formed from ferric chloride) the optimum values are between 5.5 and 6, and 8 and 9. The flocculant precipitate can then be removed either by settling or by filtration.

Efficacy of the hydrolysis process is a function of increased solubility, molecular weight, and available electric charges. The molecular weight of the polyelectrolytes, particularly the polyacrylamide type, is between 1×10^6 and 7×10^6. Usually about 30% of the amide groups are hydrolyzed. In acid or neutral medium these resins are cationic, but under alkaline conditions they are strongly anionic. Non-ionic polyelectrolytes are usually modified polyvinyl alcohol or copolymers, cationic polyelectrolytes are usually polyamines.

The exact type of polyelectrolyte and the concentration required has to be found empirically as the sludge itself is rarely of constant composition. The most important synthetic polyelectrolytes used in coagulation of flocculation are cationic. All are used usually at very low level with alum, iron salts, or lime to speed up flocculation and give higher filtration speed. They differ among each other in charge and charge rate and requirement of type and amount of charge depend on the nature of the floc required or the nature of the colloids to be flocculated.

Where the money's at

The market in Europe for processing aids and chemicals in water management is clearly divided into such bulk materials as alumina, chalk, ferric chloride, etc. and polyelectrolytes, sterilizing agents, algaecides and other fine chemicals. Into this latter category fall the high-priced chemicals which require specialized technical service know-how and long-term selling efforts. The chemicals are not highly price-conscious, or their sale sensitive to price-cutting. There would appear, therefore, to be no obstacle in selling imported materials. The only real obstacle which must be considered in certain countries with a highly developed national sense is the fact that water management of communal supplies cannot be left dependent on supplies from foreign sources. This obstacle can be overcome by arranging for local manufacture after the introductory effort. Enquiries made directly at all levels of technical and commercial authorities in various European countries have shown that American companies (with American experience to impart and willing and able to cooperate with local laboratories) suffer no handicap and that their materials are throughout highly regarded. British companies are also welcome in Europe as they too are likely to have a greater experience over a longer period of time than any other European country.

Direct introduction from one country to another is possible only in the initial stages, as any company wishing to introduce its products must have a local organization giving service on the spot. In this regard, European companies could make likely acquisitions for aggressive, growth-minded, American firms. Prospects include Fleugers SA, in France; Chemische Fabrik Stockhausen, in Germany, and Chemische Fabrik Uetikon, in Switzerland.

Opportunities are divided into the major ones arising from installations presently in the early stages of planning, and those arising from installations now operating, but requiring improvements in performance. Opportunities for competing with materials already successfully introduced are virtually nonexistent; changes would involve working time and effort at present available nowhere in this field. Be mindful that even in narrow localities or defined industries, new problems arise all the time through changes in the nature and quantities of water effluents and requirements. ■

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Frequency measurements mean a safe launch for Saturn. A pinpoint re-entry for Apollo. A man's life in Boston.

Shaking the life out of a Saturn V.

Imagine a vibrating platform like the one you stand on for a foot massage. Except this one's 50 feet by 50 feet. And on it stands a rocket over five stories tall. Yet this vibrating platform can shake the life out of a Saturn V launch vehicle. Some massage!

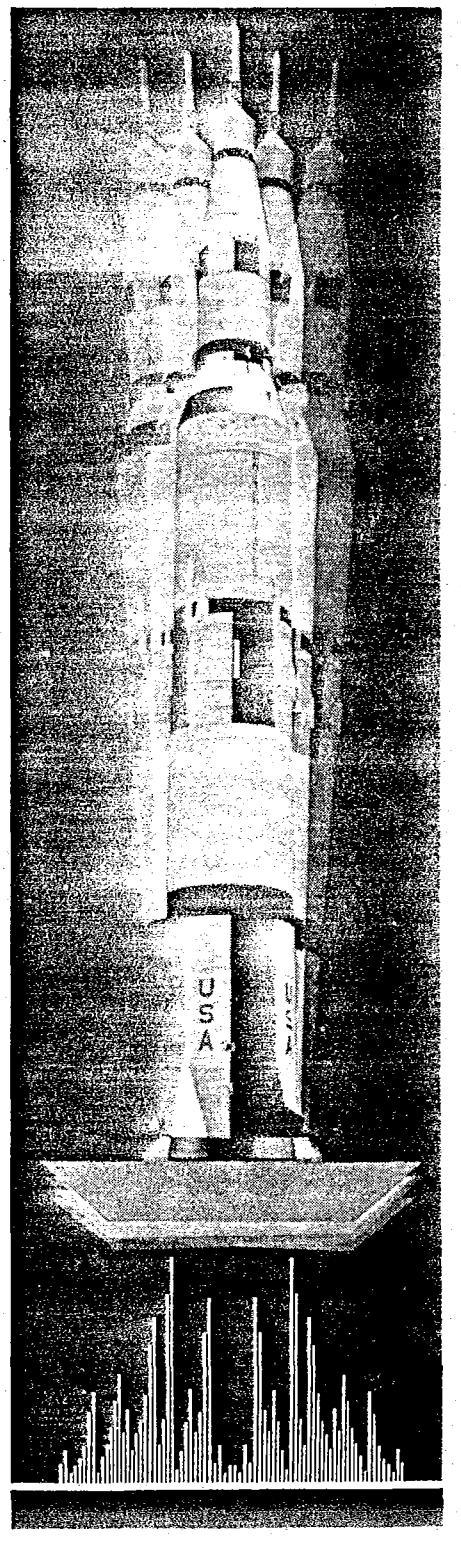
What the engineers would like to know are the critical vibration frequencies that could destroy a rocket at launch or in flight. Hewlett-Packard has just the instrument to make sense out of all the shakes and rattles.

With this same instrument, electronics engineers can perform more detailed circuit analyses, doctors can look closer at EKG and EEG signals, architects can probe building structures, physicists can dig deeper into nuclear magnetic resonance, and astronomers can minutely scan the noisy universe.

In the case of Saturn, the HP 5450A Fourier Analyzer can perform in seconds a complete vibration analysis, resolving all the component frequencies to display on a scope the power spectrum indicating any dangerous resonance. At the push of a button, it will convert the power spectral density function to the correlation function—using Fourier transforms.

The HP Fourier Analyzer can perform as a Power Spectrum Analyzer, a Correlator, an Averager, a Digital Filter, or you can select from a keyboard any combination of these functions. Using digital techniques and Fast Fourier Transform Algorithm you get the speed and versatility to perform Time Series Analysis up to 25 kHz. Since a straightforward keyboard is used for programming you don't have to be a digital computer expert. However, as a side benefit you do have the full computing power of a standard HP Model 2115A Computer whenever you call for it from the keyboard. System price is approximately $50,000, depending on options.

The full 5450A story, far more intriguing than just massaging Saturn V, is yours for the asking. Simply write for the 5450A Data Sheet and mention your application.



Apollo, journey into time and space—and back.

Apollo re-entry and splashdown precision is no happy accident; it stems from astronaut practice and skill—and, in part, HP dedication to microseconds of time.

Microseconds might seem irrelevant in week-long, million-mile space flights. But such precision timing is critical to mission success. It helps tracking-radars detect minute increments of Doppler shift caused by spacecraft movement—even at lunar distances—so as to determine the vehicle's speed precisely and to plot its position within feet. NASA's worldwide computer network, 15 land stations and 3 ships, depends on meticulously synchronized data exchange necessary for correlating the trajectory calculations. In the event of engine malfunction, behind the Moon or in deep space for example, such information would be vital in getting the astronauts safely back to Earth.

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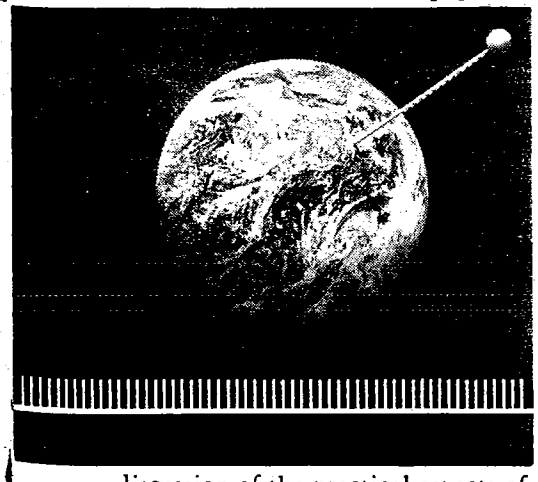
NASA's timing system was completely updated before Apollo 8 and played a vital role in the lunar orbit and subsequent Apollo experiments. Tracking stations in California, Spain and Australia were each equipped with a new primary frequency standard—the HP Precision Frequency Source (E02-5061A), keyed to an HP cesium clock. These primary references and their slaved rubidium and quartz standards were synchronized with a portable HP atomic clock that was flown on a pre-launch round-the-world trip.

If minute details—in time—govern your time- or frequency-dependent studies, write for HP Application Note 52, "Frequency and Time Standards," a 100-page



discussion of the practical aspects of their applications.

Hearts shouldn't lose their tempo undetected.

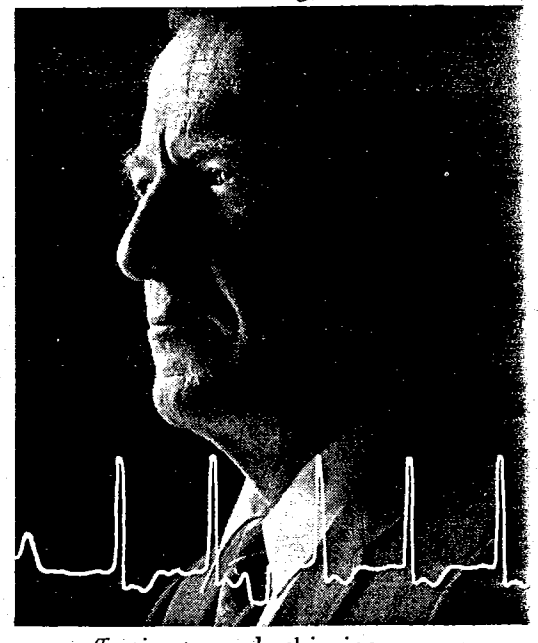
The chances of complete recovery for patients who have suffered a common type of heart attack called myocardial infarction are generally good. But complications after this trauma can greatly complicate the physician's job, to say nothing of threatening his patient's life. Some 40% of all fatalities in the hospital due to myocardial infarction are caused by arrhythmias—electrical disturbances within the heart causing irregularities in the beat such as speed-ups, pauses or double-beats.

Doctors know arrhythmias can often be successfully prevented by medication, but the usual coronary instrument alerts the doctor only when a serious arrhythmia is in process. Again, doctors know that major arrhythmias—the potentially fatal ones—are almost always preceded by less dangerous ones. The problem is to detect these small irregularities.

Since monitoring for medicine is part of Hewlett-Packard's business, we've been searching for a means to help doctors detect smaller arrhythmias, to give them a head start on treating major ones. The new 7822A Arrhythmia Monitor is such a means. When inserted into a patient monitoring system, it measures a pattern of heart signals that the physician establishes as "normal" for a particular patient. Characteristics of this "normal" pattern are stored in the instrument's memory, and each subsequent beat is compared to it instantaneously.

Beats which are abnormal as compared with this stored "normal" are classed as ectopic or out-of-place. The number of these beats occurring in a given time period is numbered and recorded so that the doctor can assess the success of drug treatment. Any excessive ectopic activity will trigger alarms to indicate a more serious condition.

This "extra ounce" of prevention can make monitoring even



more effective toward achieving a complete recovery from myocardial infarction. If you would like a definitive description of this new instrument, drop us a note asking for publication No. 7822A. We'll also send you our pamphlet, "How Patients are Helped by Intensive Care Monitoring."

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SOLID WASTE TREATMENT

Garbage and industrial waste?
In America, we spread it;
in Japan they compact it
And innovators may yet convert refuse into money

by Alex Hershaft

IN BRIEF: *A number of current waste disposal methods produce an intolerable burden of land, water, and air pollution, to the point where sanitation authorities are now convinced that only major technological breakthroughs can save the national solid waste disposal effort from utter collapse within a decade. These breakthroughs are not likely to come, however, until the public demands that a small fraction of the funding allocated to the design of a product be devoted to providing a means for its proper disposal. Here is a concise—but comprehensive—overview of the problems in solid waste disposal and some sensible alternatives to meet them successfully.*

■ Solid waste disposal has been a pollution problem ever since man began to live communally. A sign outside ancient Rome warned citizens to carry their refuse beyond the city limits or risk a fine. In the Middle Ages the custom of dumping garbage into the street was responsible for breeding rats, insects, and other carriers of disease. Although the situation has improved considerably since then, Americans, who produce solid waste at a rate reflecting an advanced twentieth century economy, still dispose of it by nineteenth century techniques.

"Solid waste" covers a very broad category of undesirable substances generated in the course of producing, processing, or consuming useful products. Table 1 presents a classification, description, and distribution of solid waste in the United States.

Agricultural wastes represent the largest contribution, with about two billion tons a year. These consist primarily of animal manure (85 percent) and, to a lesser extent, of animal carcasses, crop residues, and logging debris. The two billion tons of sediment, mostly soil and mineral particles, that are annually washed down from farm lands into the nation's streams are not included in this figure. Until recently, manure was composted and plowed back into the soil as fertilizer, but today, commercial fertilizers are considered more cost-effective. Manure and other agricultural wastes are now generally disposed of by open burning, which contributes, of course, to the air pollution burden. Some crop residues are converted into pulp or used in the manufacture of such products as insulating board.

Mining and mineral processing wastes, amounting to 1.5 billion tons a year, include both the earthen overburden removed to uncover the mineral resource and gangue, i.e., impurities associated with the ore. Mining wastes are usually stored near the mines, to the great distress of conservationists. Increasing pressure from this source will gradually compel mining companies to landscape each area after finishing their operations.

Heart of the matter

Although wastes produced in the process of exploiting the earth's natural resources constitute 95 percent of all solid waste, the crux of the solid waste problem is the pressing need to dispose of the growing burden of garbage, rubbish, ashes, and municipal wastes (know collectively as refuse), in the face of dwindling dumping space abutting major population centers. The reason for this apparent paradox is that most agricultural and mining wastes accumulate in sparsely populated areas where their potential nuisance value is more readily ignored. But, in the light of the rapidly expanding population, this will obviously not always be the case.

The proliferation of refuse is partly attributable to population growth, but also to the consumer's increasing purchasing power and a concomitant distaste for secondhand articles. The chief culprit here is the packaging industry, which contributes about 35 million tons to the nation's annual refuse burden. This includes countless cartons and paper wrappers (63 percent by weight), roughly 25 billion glass bottles and jars (20 percent), some 50 billion metal cans (16 percent), and numerous

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TABLE 1
Classification of U. S. Solid Waste

	Category	Description	Composition	(%)	Prod. Rate (10^6 tons/yr.)
refuse	garbage	animal and vegetable kitchen waste		15	
refuse	rubbish and ashes	dry household, commercial, and industrial waste; combustion residue	paper	28	
refuse			yard waste	14	
refuse			metal & glass	10	170
refuse			other	10	
refuse	municipal waste	street sweepings and construction waste		23	
refuse	scrap metal	automobiles, major appliances, and machinery			20
refuse	mining	overburden and gangue			1500
refuse	agricultural	animal carcasses, manure, crop residues, logging debris			2000

plastic containers (1 percent). The "disposables" industry (producers of goods designed to be discarded after one or a few uses) is rapidly becoming another major contributor. Its products range from paper cups and paper clothing to disposable furniture and even temporary housing units.

The growth of American refuse that must be collected and disposed of each year is summarized in Table 2. But, the total production of refuse is estimated at twice the amount shown.

Managing refuse

Unlike gaseous and liquid wastes, solid waste undergoes very little degradation and dispersion by natural processes. Accordingly, solid waste management requires several additional steps before disposal to the environment. The major stages are listed below and diagrammed in some detail in Figure 1:

- sorting and storage on premises
- collection
- processing (compaction)
- disposal (including transportation).



The optimal sequence and the correct method to be applied in each case are determined by a number of factors, including the composition of refuse; the availability of storage space and collection equipment; the economics of salvage, labor and transportation costs; the proximity to disposal sites; and the environmental considerations. Thus the selection of an optimal refuse handling procedure for a given facility, community, or region represents a formidable challenge in systems analysis.

The average cost of refuse management in the nation is expected to rise from the current level of $3.7 billion, or $21 per ton, to nearly $6 billion, or $27 per ton by 1980. Labor accounts for around 70 percent of these totals. On the national scale, this expenditure outranks that of any other community service except education, welfare, and road construction.

A recent survey by the United States Public Health Service revealed that an additional $750 million a year would be needed for the next five years to develop and implement a satisfactory solid waste management plan. Nearly 75 percent of this amount would be for improving collection systems, 6 percent for increasing incinerator capacity, and 20 percent for upgrading land disposal operations—including the conversion of open dumps to sanitary landfills.

The mechanics—and costs

Refuse in the United States is presorted only to the extent required by the operation of the sink waste disposer units and the separate collection of bulky or saleable items (e.g., discarded furniture and appliances, returnable bottles, and newspapers). But subsequent additional sorting may be necessary in preparation for processing.

In most communities, refuse is collected at curbside by custom-designed closed vehicles

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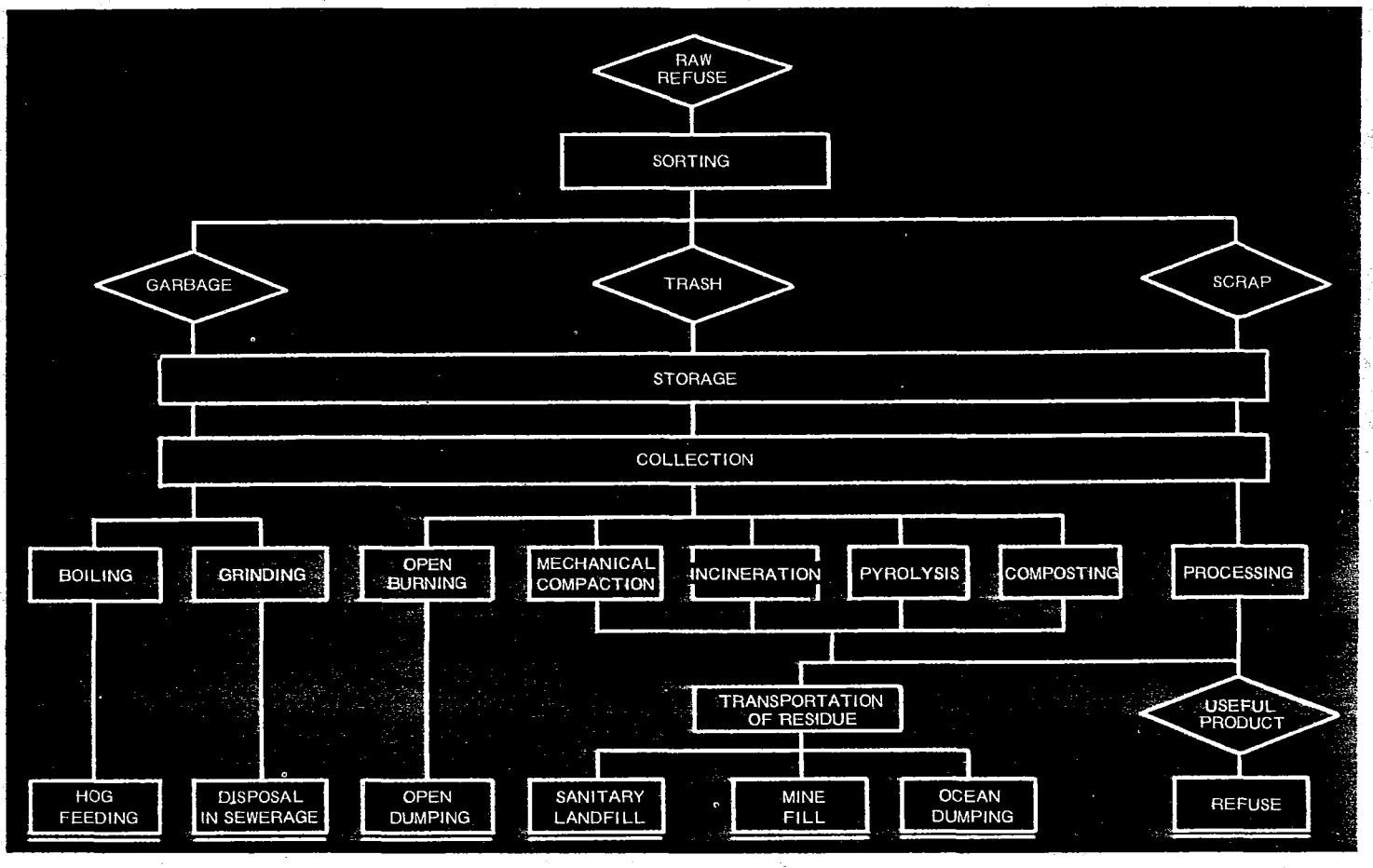

equipped with a compaction mechanism that maximizes load capacity. Some commercial facilities store refuse in receptacles that mate with the collection vehicle to achieve a more efficient transfer. A recent innovation is a refuse-compacting container that is picked up and emptied at the dump by a special lift truck. There is a continuing need for lighter collection vehicles—ones that would not exceed legal weight limits when fully loaded—and for a means of keeping the refuse in a compacted state when it is dumped.

TABLE 2
Growth in U. S. Refuse Production

	1950	*1960*	*1970*	*1980*
total, 10^6 tons/year	100	135	180	230
per capita, lb./yr.	1300	1500	1700	1900

The cost of refuse collection varies from $5 to $25 per ton, depending on route structure, number of required stops, and location of containers. Since this item represents 70 to 80 percent of the total refuse-handling budget, simplification of collection procedure can yield considerable savings. Conversely, a cumbersome collection problem can lead to dramatic consequences. For example, the average cost of disposing of an item discarded along the highway has been estimated at 32¢!

Among the more advanced collection concepts are automated curbside pickups and household waste grinders. The former would allow the driver of a collection truck to pick up refuse at curbside without leaving his cab—sharply reducing the high cost of labor. The waste grinder, patterned after the garbage disposer unit in the modern kitchen sink, would dispatch all refuse to a central treatment plant via the city's sewer system.

The treatment

Refuse is processed primarily to reduce its bulk, and, consequently, also reduce collection, storage, transportation, and disposal costs. In some cases, processing also serves to convert refuse into a useful product. The most common processes are:

- mechanical compaction and comminution
- open burning
- incineration
- pyrolysis
- composting.

The function and the status of each are concisely summarized in Table 3.

Light compaction of refuse begins in collection vehicles, where its density is increased from 5-15 lbs/ft^3 to 20-30 lbs/ft^3. Heavy presses used in conjunction with long-distance hauling of refuse can exert pressures on the

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order of 2500 psi to achieve densities of 70-80 lbs/ft^3. Unsolved technical questions in this area include the pressure-volume relationship of various types of refuse and the effects of moisture on the compressibility of refuse and on the retention of high densities upon relaxation of pressure (for Japanese innovations in this respect see picture essay *Compact Garbage*).

Comminution (reduction of the size of individual refuse fragments) can take the form of cutting, shredding, grinding, or milling—and is generally performed in preparation for one of the following processes.

Burning in the open is the cheapest—and most widely used (over 45 percent of all waste disposal)—method of reducing the bulk of refuse. It is also the least desirable from the sanitary and aesthetic viewpoint. The smoke and the stench contribute appreciably to the local air pollution problem, while incompletely burned organic waste putrefies, attracting rats and flies. For these reasons, open burning has been banned in six states, and other states are likely to follow suit. Incineration, eliminating most drawbacks of open burning, is gradually replacing the latter practice in a number of communities, both in this country and abroad.

Confined combustion

A typical incinerator consists of a furnace, where the refuse is first ignited; a secondary combustion chamber, where higher temperatures prevail to ensure complete burning; and flues to convey the exhaust gases to the stack and then to the atmosphere. The flues of modern incinerators are equipped with pollution control devices to minimize the amount of pollutants discharged into the atmosphere. About 10 to 20 percent of the original volume of refuse remains as ash, which must subsequently be disposed of.

Several technical needs remain to be met. Outstanding among these are more effective methods of supporting the refuse and supplying sufficient oxygen during incineration (including the use of a fluid bed suspension), a means of curbing corrosion of equipment by hydrogen chloride produced through combustion of chlorine-based plastics, and more efficient pollution control devices. The principal obstacle to widespread use of incinerators is their high initial cost, amounting from $3000 to $10,000 per ton of rated capacity. Incinerators equipped with adequate pollution control safeguards are therefore generally not economically feasible for communities with a population under 100,000. Operating costs vary from $3 to $8 per ton of raw refuse, depending on the scale and efficiency of the operation and on the use made of the principal by-products of incineration: heat and residual ash.

Although the calorific value of refuse is relatively high (3,600-5,500 Btu/lb compared to 7,800 Btu/lb for coal), efforts to utilize it in the United States are complicated by inadequate knowledge of the thermodynamics and the chemistry of incineration processes, the relatively low cost of fossil fuels, and insufficient control over the rate of heat generation. Residual ash, currently produced at the rate of 20 million tons a year, has potential applications as an abrasive, a soil conditioner, and a filler for construction materials. New York is designing two mammoth $50 million incinerators in the South Bronx and on the site of the former Brooklyn Navy Yard. These facilities will convert daily 7,000 tons of waste, to be brought by barge from several collection points, into 1,500 tons of choice fill material. A combine of three waste-processing firms is

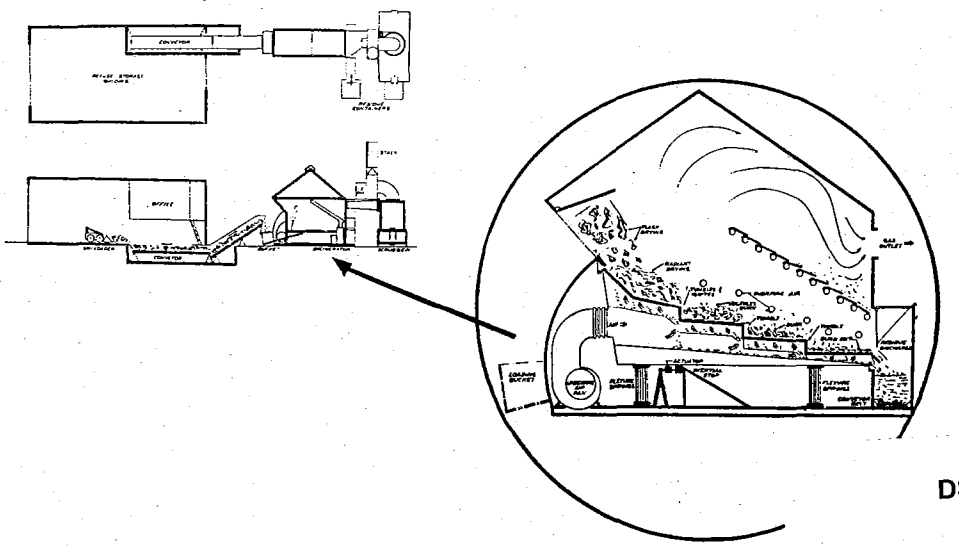

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TABLE 3
Common Solid Waste Disposal Methods

Method	*Description*	*Direct Cost* *A*	*B*	*Status*
mechanical compaction	compression of refuse to reduce its volume by a factor of 3-15			used extensively to reduce collection and hauling costs
burning and dumping in the open	dumping and burning of refuse in the city dump	minimal		accounts for 45 percent of waste disposal, but use is decreasing
incineration	burning of refuse in a furnace under controlled conditions	3,000-10,000	3-8	fairly well accepted in large communities
pyrolysis	chemical conversion of organic fraction to useful products	5,000-10,000	3-10	introduction contingent on salability of products
composting	conversion of organic fraction to harmless products by microbial activity	4,000-10,000	3-10	introduction contingent on salability of products
sanitary landfill	burial of refuse or processed residue under 1-2 feet of soil	1,000-2,000	1-2	accounts for 45 percent of waste disposal, especially in communities with access to land expanses
mine fill	hauling of refuse to and burial in abandoned mines		4-6	being introduced in large communities with access to abandoned mines
ocean dumping	dumping of refuse from barges in open ocean			largely discontinued except for a few coastal cities
hog feeding	feeding of garbage to hogs	not relevant		largely discontinued as a consequence of sterilization requirement
waste disposer	grinding of garbage in sink unit and disposal in sewers	not relevant		fairly popular in communities with sewer systems
salvage	processing and re-use of waste	highly variable		ancient, with a growing impact

A—capital investment (excluding cost of land), in $ per ton of rated daily capacity
B—operating cost, in $ per ton of unprocessed refuse

constructing a $5 million incineration plant in Houston that will handle over 100,000 tons of solid refuse a year. The plant will generate about 1000 tons of residual ash a year and 100,000 pounds per hour of low-pressure steam, which its operators plan to sell.

Pyrolysis (destructive distillation), a time-tested process for recovering charcoal, methanol, acetic acid, and turpentine from lumber waste, is now being considered for processing refuse. After glass, metal, and other inorganic components are removed, the resultant refuse is ground and heated at 1200-1500°F in the absence of air to drive out moisture and to convert the solid residue to char, ligneous acids and alcohols, and gases (hydrogen, methane, carbon monoxide, and carbon dioxide). The volume reduction produced is in excess of 50 percent.

The pyrolysis ploy

The capital investment for a pyrolysis plant is roughly equivalent to that for an incinerator. Operating costs are slightly higher, but they may be offset by the resale value of pyrolysis products. And incineration of some of these products can provide the energy required to sustain the process. One pyrolysis plant using the Lantz converter system is currently operated by the Ford Motor Company, and another by the city of Houston at a projected cost of $3 per ton.

Composting is a method of reducing the bulk of refuse through controlled aerobic decay. As in the case of pyrolysis, about a quarter of all refuse is unsuitable for composting and must be removed manually or by magnetic separators. The remaining fraction is ground and mixed with sewage sludge, to increase the moisture content to 50 to 60 percent, then digested and cured. Biological activity in the digestion stage converts some 40 percent of organic solids to carbon dioxide and water. The process is accelerated by periodically wetting and aerating the refuse for several days in a mechanical digestion unit, or for 6 to 7 weeks in open windrows (outdoor heaps). After curing, which reduces moisture content to 25 percent, the resulting compost can be used as a soil conditioner.

The economics of composting closely depend on the marketability of the product. For this reason, this process is more widely accepted in Europe and Japan than in the United States, where synthetic soil conditioners are more readily available. The National Waste Conversion Corporation has developed a prototype mechanized composting system. A demonstration composting plant is operated jointly by the U.S. Public Health Service and the Tennessee Valley Authority at Johnson City, Tennessee. Of the other 15 plants built in this country, seven are still functioning, with varying degrees of success.

The disposition ploy

The ultimate disposal of refuse (processed or not) usually takes place on land. Disposal in waterways has been banned nearly everywhere, while dumping in the sea is pretty much restricted to certain types of waste, such as fly ash, sewage sludge, chemicals and radio-

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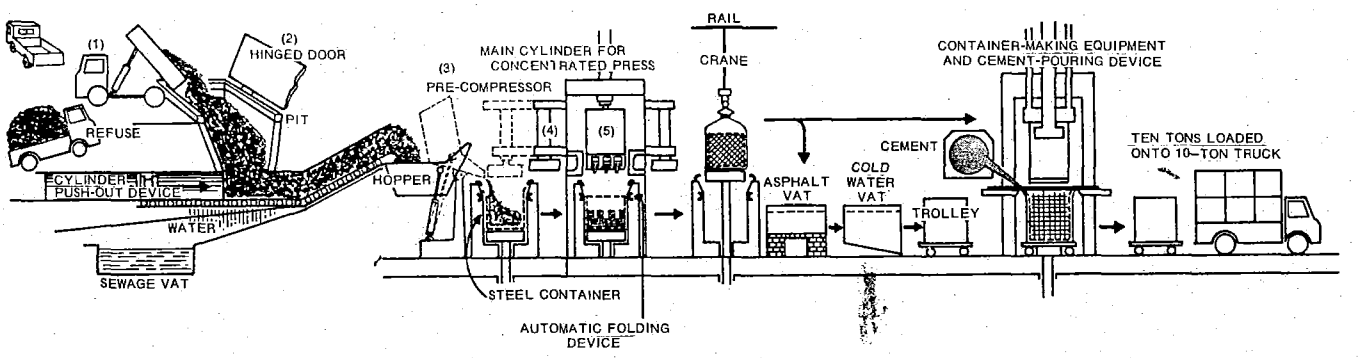
COMPACT GARBAGE

A novel method of processing garbage into useful materials is being employed in Japan. This brainchild of Kunitoshi Tezuka, President of Tezuka Kosan Company Ltd., is expected to change the disposition of waste and refuse from an ever-increasing municipal burden and expense into a profitable—and businesslike—brand new industry. As Alex Hershaft explains in his very fine article on solid waste disposal, the trouble with compacting garbage lies in the failure to eliminate bacteria from the compressed residue. The Tezuka system, illustrated here, handles this problem quite neatly.

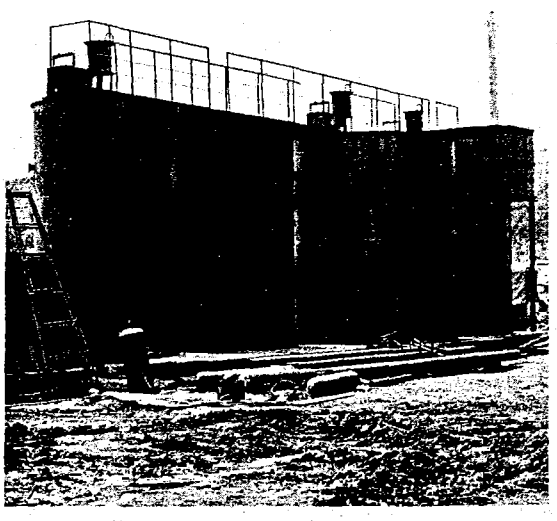
Working on the same principle as the press used in compacting scrap automobiles, the method used in Japan almost completely dehydrates garbage under intense pressure. The product of this compaction is almost as hard as rock. After it has been baled in chicken wire, or covered with thin sheet steel, the compacted garbage becomes biologically inert when the baled blocks are dipped in asphalt, concrete or vinyl. The resulting blocks can be formed into any desired shape, and can be made to interlock if desired. They then can be effectively used in construction of houses, dikes, and for flood prevention and shoreline protection. The end product also can be effectively used for land fill, since there is little chance of the encased garbage inside the blocks ever contributing to pollution. One of the best aspects of this process, of course, is that the costly work of sorting garbage and refuse is completely eliminated. The following photos and drawings illustrate the process as it is now being used in Japan.

DIAGRAM OF REFUSE PROCESSING SYSTEM



The system is roughly divided into three sections: (A) Automatic refuse intake and pressing; (B) Waste liquid disposal; and (C) Coating. In particular:

1. Garbage truck dumps refuse into pit through hinged door.
2. Door is closed—cuts off bad smells.
3. A specified amount of refuse is pre-pressed by a pushout device (cylinder) to squeeze out liquid, which drains into the sewage tank through a pipe.
4. Pre-pressed refuse is placed in a revolving hopper which transfers it to smaller containers in which boxes made of chicken wire or iron sheeting have been placed.
5. Containers move under the main press.
6. Then the covered block is removed by crane and dipped into the asphalt vat or, in the case of cement coating, placed in the cement-pouring device.



Waste liquid squeezed out of refuse in the pre-pressing process is disposed through the following devices:

1. Waste liquid tank
2. Settling tank
3. Addition of diluting water
4. Aeration tank
5. Setting tank
   a. Returning sludge is taken back into the aeration tank.
   b. Residue sludge goes into sludge storage tank.
6. Sterilization by chlorine
7. Outlet

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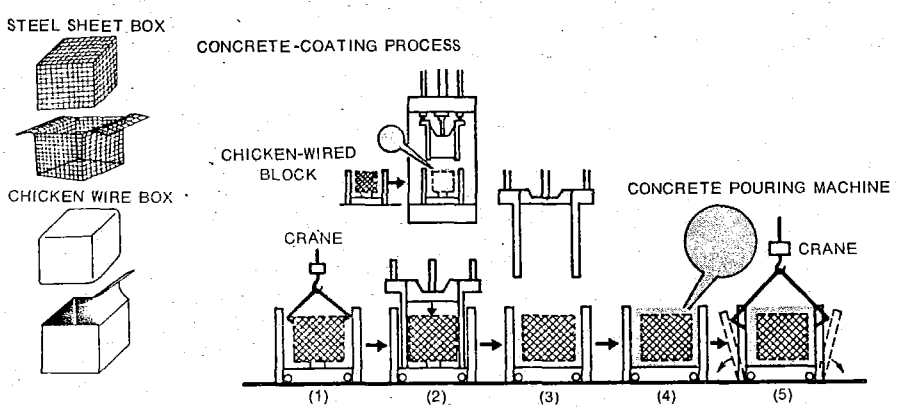
Chicken wire box or iron sheeting box is placed in the container of the main press before refuse is thrown in.

Pressure is applied with the main cylinder and concentrated pressure with a number of small cylinders. This process is repeated several times.

The surface compression for making garbage rocklike is 100 kg/sq.cm to 210 kg/sq.cm in the concentrative compression system. The resultant volume of "garbage rock" is 1/7 to 1/10 of the original volume and has a specific gravity ranging from 1.4 to 1.7.

The solid block is then covered with chicken wire by the folding device fixed above the container.



(1) BUNDLE GOES INTO FRAMEWORK
(2) OPERATION TO DETERMINE THE THICKNESS OF CONCRETE
(3) POURING CONCRETE
(4) DYING
(5) REMOVAL

The process is designed to compress and solidify garbage into blocks, using a powerful oil-hydraulic press. The blocks are then dipped in asphalt, concrete or vinyl and can be used in construction or reclamation work. The processing capacity of the plant depends on size.



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active residues. The more common disposal processes are described briefly in Table 3.

The most frequent method of disposal on land is still dumping in the open, a step typically associated with burning in the open and characterized by many of the latter's deleterious effects. Around major population centers, open dumping is rapidly being replaced by sanitary landfill, which currently accounts for nearly the same fraction of waste disposal (45 percent).

In the sanitary landfill process, refuse is discharged into a specially dug trench or natural cavity, compacted by bulldozers, and covered with about 6-18 inches of dirt as a sanitary precaution. The refuse then undergoes anaerobic decay, causing reduction in volume and consequent settling of the filled area. This method is widely used by communities adjacent to large expanses of land. It is particularly advantageous when the filling serves to reclaim otherwise useless land or to build up topographic features for recreational and scenic purposes. The location of a landfill site should be chosen with care to avoid pollution of nearby water supplies by seepage or runoff from the accumulated refuse.

A variation of the landfill approach, holding considerable promise for communities within economic hauling distance of abandoned mines, calls for hauling refuse by special trains for disposal in such mines. The Penn-Central Railroad has been negotiating with a group of New England cities for the collection and disposal of their solid wastes at about $6 per ton. The Eastern Land Reclamation Company has already signed a contract of this kind with the city of Philadelphia.

Sanitary alternatives

Dumping of solid waste into the sea from barges has been largely discontinued because much of the material never exceeds the density of sea water (64 lbs/ft^3). This is required for sinking, and eventually the sewage is washed up on shore. The Dillingham Corporation is exploring the concept of pumping refuse down to 1000 foot depths, where the water pressure is sufficient to compress the material to the density required.

The disposal of garbage, or kitchen waste produced during the preparation and consumption of food, requires an additional note. In many modern homes connected to a sewer line, garbage is ground up in sink waste disposer units and dispatched to a central treatment plant, along with sanitary waste. Feeding of household garbage to hogs practically ceased with the passage of state laws in the late 1950's requiring its prior sterilization. Some hotels and restaurants still find the practice worthwhile.

It appears that the intermediate-term solution to the solid waste disposal problem will consist of sanitary landfill for communities within economical hauling distance of large land areas or abandoned mines and a compost-salvage operation for other large communities.

The salvage "thing"

Salvage (processing and re-using waste materials) is applied primarily to industrial and commercial waste, but not to municipal refuse—in view of its highly heterogeneous character and the inherent sorting problem. Most junked automobiles, approximately 20 percent of waste paper, and smaller fractions of discarded glass and metal containers are now salvaged. A number of experimental projects are aimed at enlarging salvage possibilities.

A common technique for salvaging seemingly useless materials is to incorporate them as filler in construction components. Fly ash (produced by power plants at a rate approaching 20 million tons per year) and cinders have been employed to good advantage in the manufacture of bricks and blocks as well as in laying roadway pavement. The Korblock Corporation, under contract to the U. S. Bureau of Mines, has developed a building block consisting of a compressed scrap metal core encased in concrete. The blocks are lighter, have superior insulating characteristics, and compare in strength with conventional masonry products. Japanese engineers have found a similar use for raw refuse. The material is first compressed at 3000 psi to reduce its volume by about 75 percent and to destroy decay-causing microorganisms. The blocks are then sheathed in iron to impart greater structural strength and to permit joining for construction purposes (see picture story).

Most industrial and commercial scrap can be reprocessed and re-used, provided it is of sufficiently high grade and that its price is competitive with that of the corresponding raw materials. This is particularly true of paper, glass, and metal, but not of plastic materials, because their polymerization is not reversible.

Salvage of the nearly 40 million discarded automobiles defacing the nation's countryside falls in a special category. Their first stop is the junkyard, where they may remain for several years, until most of their usable parts are sold. At this stage, they are shipped either to the dump or to a salvage plant, according to the economics of the situation. At the salvage

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TABLE 4
Federal Funding of Solid Waste Management in Thousands of Dollars

Agency and Activity	FY 1967 Author.	FY 1968 Appropr.	FY 1969 Request	FY 1969 Author. (est.)	FY 1970 Author. (est.)
Public Health Service	14,000	15,602	17,534	15,300	15,200
Grants					
demonstration		5,000	5,546		
research		2,515	2,515		
planning		2,000	2,000	10,100	9,600
training		490	490		
Direct Operations**		5,597	6,983	5,200	5,600
Bureau of Mines	4,000	3,367		317	—

plant the cars are stripped of their engines and transmissions, then flattened and shredded. The ferrous chunks are picked out by magnetic separators and fed into a steel furnace. A Japanese process slated for introduction in this country heats the auto bodies in a giant furnace at 900°C to burn off nonmetallic components and then sequentially melts out lead, aluminum, and copper, as their particular melting points are reached. The remaining hulk,—with about a 97 percent iron content—is compressed into a bale and used as blast furnace feed.

A major obstacle of the reclamation of scrapped auto bodies (largely responsible for the current glut) has been the advent of the basic oxygen steel-making process, which requires a smaller and higher quality scrap charge than did the traditional open hearth furnace. This problem is being attacked through development of new uses for scrap and new processes for upgrading its quality to render it competitive with raw materials.

The legislative effort

The first federal legislation in this area was the Solid Waste Disposal Act of 1965, which authorized a three-year national research and development program designed to improve solid waste disposal technology and provided for grants to states and interstate agencies for survey, planning, and demonstration activities. The U.S. Public Health Service (Offices of Solid Waste) was charged with implementing the act primarily in the area of municipal and industrial wastes, while the Bureau of Mines was assigned responsibility for the solid waste problems associated with mining operations. Their spending ceilings over the three-year period were set at $60.2 and $32.3 million, respectively. The Solid Waste Disposal Act of 1968 extended these programs through FY 1969, but the solid waste effort of the Bureau of Mines is being phased out and merged in the Bureau's Conservation and Development of Mineral Resources program. Current and projected distribution of federal funding in this area is presented in Table 4.

Solid waste legislation on the state level is also relatively recent. New York pioneered in this area with the 1963 Sanitary Code requiring replacement of open burning by sanitary landfill. Although New York City has used this method to good advantage in reclaiming vast lowland areas, nearly half the upstate population still disposes of refuse in open dumps.

The programs

The burden of advancing solid waste management technology is being shouldered both by government and private industry. Some recent projects have been sponsored by federal agencies.

Industry can contribute substantially to the solution of the nation's solid waste management problem by making ease of disposal a product design consideration. As a result of federal "encouragement", packaging manufacturers have established a council charged with coordinating this effort throughout the industry; and smaller groups, such as the Glass Container Manufacturers' Institute (GCMI), have promptly followed suit.

The program of the GCMI Environmental Pollution Control Department is illustrative of this type of effort. Its objectives call for salvage and re-use of glass scrap in conventional glass making, development of new uses for glass scrap, and development of ways to include glass in conventional waste disposal processes. The more advanced concepts include a glass container that shatters into harmless granules when it is struck with sufficient impact and one that dissolves in water on removal of a protective coating.

The ultimate goal of waste disposal technology is, of course, the complete re-use of all waste materials. The major challenges in the endeavor are the design of rapid, highly selective, and economical sorting devices and the development of cost-effective conversion processes. This concept of a "total disposal system" is perfectly valid in principle, and its feasibility has already been demonstrated to some extent in a number of projects.

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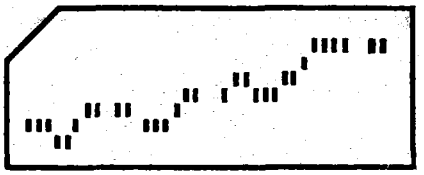

the PREDICTOR

POLLUTION IS A DIRTY WORD

by John F. Ferraro and Robert A. Lerman

■ Correcting an unfavorable radio or TV choice from the air waves is accomplished simply by turning a knob; but, cleaning up the air itself is more difficult, since individual sources of pollution are often difficult to recognize, let alone turn off. To bring our environment back to some kind of reasonable order calls for restraint on the part of the citizenry, as well as industry leaders, to stop pollution at the source; and, it is the process of curtailing avoidable emanations that has given birth to the field of pollution control. There are opportunities for investing in the right pollution control device company.

In the time it takes to read this article, more than 11,000 tons of pollutants will have found their way into the atmospheric sewer of air we depend upon for life itself. To legislate against ignorance has always been difficult; but through the Clean Air Act passed by Congress in 1963, an industry is in creation in which aggressive technological planners and practitioners are being given a chance to mass-market the concepts of unfouled environments and balanced ecologies. And, hopefully, much of the healthful conditions previously dissipated will be recovered. In addition, two years ago, Congress passed the Air Quality Act which was a big step in the direction of Federal pressure to clean up pollution. And last February, the Department of Health, Education and Welfare published in the Federal Register the national criteria and control techniques that will implement the Air Quality Act. This doesn't mean, of course, that the problem is solved, and we can all sit back and just wait for results. It does mean that the Federal government is beginning to put some teeth into its laws, giving visionary industrial leaders support for their pollution control programs, and giving hesitant business leaders a choice of spending the money on pollution control equipment, or receiving fines.

The public, government, and industry have finally accepted the fact that we cannot continue to destroy the environment in which we live. The pollution control industry, which had scarcely a name a decade ago, is fast coming into its own.

The Federal government has been hesitant to set a price tag on what it will cost to rid the nation of pollution. Outside the government, there are as many predictions as experts on the subject. One says it will take twenty years and cost $212 billion; another reports the job will require 33 years and $275 billion. And estimates reaching $300 billion are bandied about. Right now, the cost of cleaning up the nation's air and water is running at $10 billion a year, and it seems a reasonable conclusion that the cost for clean air and water will be reckoned in hundreds of billions of dollars.

Investment perspective

From an investing viewpoint, it is evident, therefore, that pollution control is a growth industry of towering potential. Outlays for pollution control have increased markedly within the past few years, and they are likely to climb even more sharply in the future if standards of air and water purity that are being established now are to be met. Within the next decade, outlays for pollution control could reach staggering sums, and the overall pollution control market is currently developing into one of the most rapidly growing, dynamic segments of our economy. Growth of the pollution control field, of course, has highly favorable implications for investors in the industry. The sheer bulk of money to be spent in this endeavor assures that many factors and companies in the industry will grow, and grow rapidly. Selecting stocks for participation in the industry, however, is, as always, a matter of judgement.

Essential to growth in any industry or company is sound, aggressive, and effective management—management capable of operating a business efficiently, recognizing where potential lies, and directing efforts to areas which are most likely to be rewarding. While many of these measures of management are intangibles and cannot be recorded with any degree of preciseness, we have completed a survey of representative companies in this field, and have presented in Table I a list of 20 such issues, with various statistics intended to reflect, at least in part, current and recent

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the PREDICTOR'S computer print-out* of Pollution-Control stocks

REPRESENTATIVE POLLUTION - CONTROL STOCKS

SECURITY	SYM	EX	REC PRICE	POL FIELD	EARNINGS PER SHARE 1965	1966	1967	1968	LATEST 12MO	P/E	PCENT YIELD	PRICE 65-9 HIGH	LOW
AMER AIR FILT	AAF	NY	30	AIR	1.46	1.72	1.63	1.51	1.55	19	2.6	45	15
AQUA-CHEM INC	AQM	NY	.46	WATER	.58	.64	1.00	1.11	1.23	37	.0	50	10
BECKMAN INST	BEC	NY	56	AIR	1.40	1.44	1.81	1.23	.93	60	.9	82	35
BETZ LABS		OTC	57	WATER	.79	.90	1.02	1.20	1.30	44	.8	60	10
BUFFALO FORGE	BFC	NY	35	AIR	1.82	1.93	2.40	2.30	2.52	13	2.8	39	14
CRANE CO	CR	NY	51	WATER	3.08	4.45	4.05	3.29	3.22	15	3.1	61	22
CULLIGAN	CUL	NY	23	WATER	.60	.65	.74	.80	.87	26	1.2	32	9
DOW CHEMICAL	DOW	NY	78	A/WAT	3.58	4.06	4.41	4.51	4.48	17	3.0	92	54
JOY MANUFACT	JOY	NY	34	AIR	2.97	3.09	2.36	2.01	2.41	13	4.1	50	22
LUBRIZOIL	LZ	NY	53	AIR	1.00	1.14	1.26	1.67	1.69	31	1.1	64	10
MARLEY CO	MY	AM	37	WATER	1.03	1.50	1.71	1.44	1.39	26	1.0	63	6
NALCO CHEM	NLC	NY	57	WATER	.83	1.01	1.06	1.33	1.16	15	5.1	65	16
OGDEN CORP	OG	NY	32	AIR	1.67	2.08	2.34	1.90	2.01	15	2.5	52	11
RESEARCH-COTT	RC	AM	41	A/WAT	.13	.28	.46	.64	.67	61	.1	56	5
SLICK CORP	SLI	AM	16	A/WAT	.53	.91	1.36	.91	.58	27	1.9	37	4
SYBRON CORP	SYB	NY	33	WATER	1.15	1.36	1.45	1.35	1.37	24	1.7	45	17
UNIVERSAL OIL	UOP	NY	36	AIR	1.56	1.81	1.91	1.97	1.79	20	2.1	52	20
WESTINGHOUSE	WX	NY	64	WATER	2.88	3.16	3.21	3.49	3.42	18	2.7	79	40
WHEELABRATOR	WHL	AM	32	AIR	2.15	2.44	2.45	2.40	2.49	13	2.1	46	13
ZURN INDUST	ZRN	NY	32	A/WAT	.36	.47	1.01	.72	.72	37	1.0	46	2

* the contents herein is from an actual photograph of the Predictor's report without alteration

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efforts of management to participate in this rapidly growing industry. Using a computer to evaluate these companies, based on various technical and fundamental factors, we have presented the computer printout as an aid to your investment decision-making process.

Some of the larger chemical factors, such as Dow Chemical, will, of course, play a big role in the pollution control industry; other industrial giants, like Westinghouse, are spending great sums of money to establish a foothold in the emerging pollution control industry. Because of the size and diversity of these companies, pollution control will play only a modest role in their total picture and the impact in terms of dollars and cents benefit to investors is likely to be relatively insignificant. But there are currently smaller, budding industry factors which are making pollution control their most important—or sole—business. So from the broad cross-section of securities representing the field now, we offer commentary on three factors still in their incipient growth stages which appear to have substantial potential for further progress. Each of these companies will, in our opinion, match or exceed the growth expected for the pollution control industry. And it is in these situations that we believe investors seeking above-average gains, and willing to assume the risks inherent in such a venture, should concentrate their investment capital.

Research-Cottrell is the largest company in the world devoted exclusively to solving the problem of pollution. Coverage of the field ranges from water and air purification to such complex problems as thermal pollution—wherein waste water entering a stream must be altered in temperature to avoid upsetting the ecological balance. Revenues have climbed from $11.1 million in 1965 to $40.8 million in 1968; and in the same time period, per share earnings have increased from 13 cents to 64 cents. First quarter earnings in 1969 show continuing growth, with per share earnings up 33 per cent over the same period last year. The computer currently pegs RC's price-earnings ratio at a high 61—which is the sort of multiple that horrifies conventional analysts. But to call the stock overpriced is to say it is wrong to place a premium on demonstrated growth and anticipated earnings; and if this is an acceptable criticism, IBM has been too high for at least twenty years. With backlog currently at a record $69 million—up from $41 million a year earlier—it appears that Research-Cottrell's forthcoming earnings statements will make extraordinarily good reading, and it seems only a matter of time before earnings justify the currently lofty P/E. The company's stated objective is to be the leading factor in total pollution control, and their management, experience, and demonstrated capability make them well-situated to achieve this objective.

Two other situations we would like to offer capsule commentaries on are *Slick Corporation* and *Zurn Industries*. Slick obtained its name from an earlier air cargo business but is no longer in that field except through its investment holdings in Airlift International. What makes Slick so interesting is that investors still appraise it at an air cargo P/E multiple, when in reality the company is quietly becoming an increasingly important factor in the air and water pollution field. Slick moved into pollution control by virtue of capabilities developed in its Pulverizing Machinery division. Other pulverizing processes kick up a storm, which is how Slick got into the dust-control business. Expansion of this concept led to the acquisition of Airtron—a maker and marketer of air pollution control devices. Last year's merger with Drew Chemical added an extensive line of water treatment chemicals; and Slick's participation in the rapidly growing air and water pollution control industry represents more than 20 per cent of sales and 50 per cent of earnings. Furthermore, this percentage is expected to increase, since the company's long-term objective is to concentrate expansion in these product areas. We believe Slick's entry into pollution control activities will lead to a sharp reappraisal as investors become more aware of this participation. It is possible that earnings could double or triple over the next few years as potentials inherent in the company's position are realized, and we believe the stock is worth serious consideration by longer-range investors.

Zurn, like above-reviewed Research-Cottrell, carries a high price earnings multiple of 37—which can be frightening to the growth investor wondering how many times earnings he should pay for a share of stock in this emerging industry. It may be worth remembering in this regard that in 1956, when earnings of the pre, pre-split Polaroid were approaching $1 for the first time, sales were only $34 million and the P/E multiple registered 30, and then moved to above 50 the following year. The $40 shares of those days are now worth more than $900; and while you shouldn't expect to find a Polaroid every year, recognize that you'll never own one unless you are willing to pay a premium for that kind of growth. The pollution control industry is going to cost you—directly or indirectly—a lot of money during your lifetime; you might as well try to share in the growth. ■

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TAINTED RADIATION



by Karl Z. Morgan

Radiation's evil is properly feared but the wrong sources are suspected

IN BRIEF: *The atom bombs that exploded over Hiroshima and Nagasaki kindled a lasting fear of atomic radiation among the world's population. While people now quickly react to possible nuclear power plant construction in their neighborhood, they generally fail to recognize more lethal emanations such as those from diagnostic X-ray units. In factories, switches and condensers, operated in a vacuum, can also be powerful radiation sources. And, in the homes, color TVs and radar ranges may daub detrimental dosages.*

■ The specter of man-made radiation poisoning and mutating hordes of people has become an intransigent thing for many people. Cries of complaint echo the blasts from atmospheric atomic bomb tests. Citizens group together to battle atomic power plant construction in their communities. Yet, background radiation from cosmic rays—and particulate matter thrown out by the sun—pour through our bodies at an annual rate 50 times that ever achieved by radiation from atomic bomb testing. And, more radiation is thrown up into our skies in one year's burning of coal (radon) than is released from an atomic thermal reactor operated for 50 years. These examples, of course represent oversimplifications. Various parts of the body and many animals, plants, and insects are also centers of concentration for particular radioactive sources, thus increasing hazards. So atomic bomb fallout (containing radioactive iodine), tends to settle in the thyroid—and can be particularly harmful. Yet man-made radiation is not to be generally ignored as a hazard. Rather, human concern and vigil has been misdirected.

Where it's at

Ionizing radiation includes both particulate types (alpha and beta particles) and wavelike radiations (X-rays). Of all possible

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man-made radiation, fully 94% is attributable to medical and dental X-ray equipment. But any time a device operates in a vacuum at high voltage, or there is radioactive material present, the possibility arises that radiation may be emitted. Thus there is a host of insidious sources that pass attention, generally unrecognized. In terms of biological consequences, it doesn't matter whether a radioisotope is produced in a nuclear reactor or a high voltage accelerator, or is of natural origin. Exposure from X-ray or beta (electron) particles in terms of rem units produces equal damage. A rad is the absorption of 100 ergs per gram of body tissue and the rem is the rad times a biological effectiveness factor. An exposure to X-rays in these units is the same whether generated by a medical X-ray machine, a color television set, or a high-voltage vacuum switch. In fact, the exposure is the same whether from an X-ray source or a cobalt-60 gamma-ray source, provided the energy distributions are equivalent.

Each day, through X-rays, thousands of Americans blithely permit themselves to absorb ionizing radiation doses, often exceeding ten times that needed for diagnostic purposes. While no definite figures are available, many health physicists suspect that this superfluous radiation accounts for somewhere between 3,500 and 36,000 deaths, in the form of mutations, leukemia, thyroid cancer, bone cancer and general life-expectancy foreshortening. This may seem a small price to pay considering the benefits of radiation diagnostics. But, even these fatalities could all but be eliminated with extra care.

A survey by the U. S. Public Health Service indicates that 105 million radiographic examinations were taken in 1964. In addition there were 53.6 million dental, 10.5 million fluoroscopic and 3.4 million therapeutic examinations. Also, the use of such medical applications for X-rays is doubling every 13 years or less.

Studies also indicate that exposure is cumulative—effect growing linearly with built-up dosage—and there is no threshold below which effects are totally absent. It has been estimated that the average man loses nearly a month of his life to diagnostic radiation and in extreme cases of exposure, many months may be "burned" away.

Killing a future

Perhaps the most serious consequences of diagnostic medical X-rays result from exposing pregnant women, causing fetal damage, and exposing the reproductive organs, responsible for genetic damage to offspring yet to be conceived. While many doctors are aware of the possible consequences of X-raying expectant mothers, some persist in routine pelvimetry or even using fluoroscopy as a general diagnostic tool. Exposure at any time during pregnancy can be harmful, but the most crucial time is from the second through the eleventh week of gestation. It is a statistical fact that mortality from leukemia among children whose mothers had undergone X-ray diagnosis during the fetal period is 40% higher than among comparable groups not so exposed. Moreover, fetal exposure can produce dwarfed heads (microcephaly), mental retardation, skeletal and genital abnormality, cataracts, leukemia and cancer—especially of the nervous system—among other maladies. Adult gonad exposure may produce mongolism in the offspring, or if the parents are more fortunate, a miscarriage. Additionally, small mutations involving reduced mentality, poor physique or general malaise may result.

An interesting sidelight to the promiscuous use of X-rays for examinations is that blacks are being exposed to as much as 50% more radiation than other races. Many technicians falsely believe that a black's bones are generally denser and harder and that their skin is less pervious to radiation than a white's. Actually, it might be best if technologists and radiologists were "color-blind".

I × KV = X-ray

There is an abundance of commercial, industrial, medical research and consumer product devices operating in the voltage range of 10 to 200 kv. A high electrical potential applied across a partial vacuum produces an electron current between the electrodes. Upon striking material such as tungsten, iron or copper with a high atomic number, these electrons, accelerated by the high voltage are slowed, producing penetrating electromagnetic radiation—called X-rays, if the voltage equivalent is above 10 kv. Some of these devices—diffraction analyzers and electron microscopes—have been recognized as potentially dangerous X-ray sources for many years, but even today such equipment, in universities and industry, leads to many cases of over-exposure due to improper supervision and the failure of some operators to recognize the conditions whereby X-rays may leak from these devices. For example, the eyes of a researcher may be inadvertently exposed, leading to radiation-induced cataracts. The industrial radiographic X-ray machine has assumed some notoriety because it is, at times, used without proper sup

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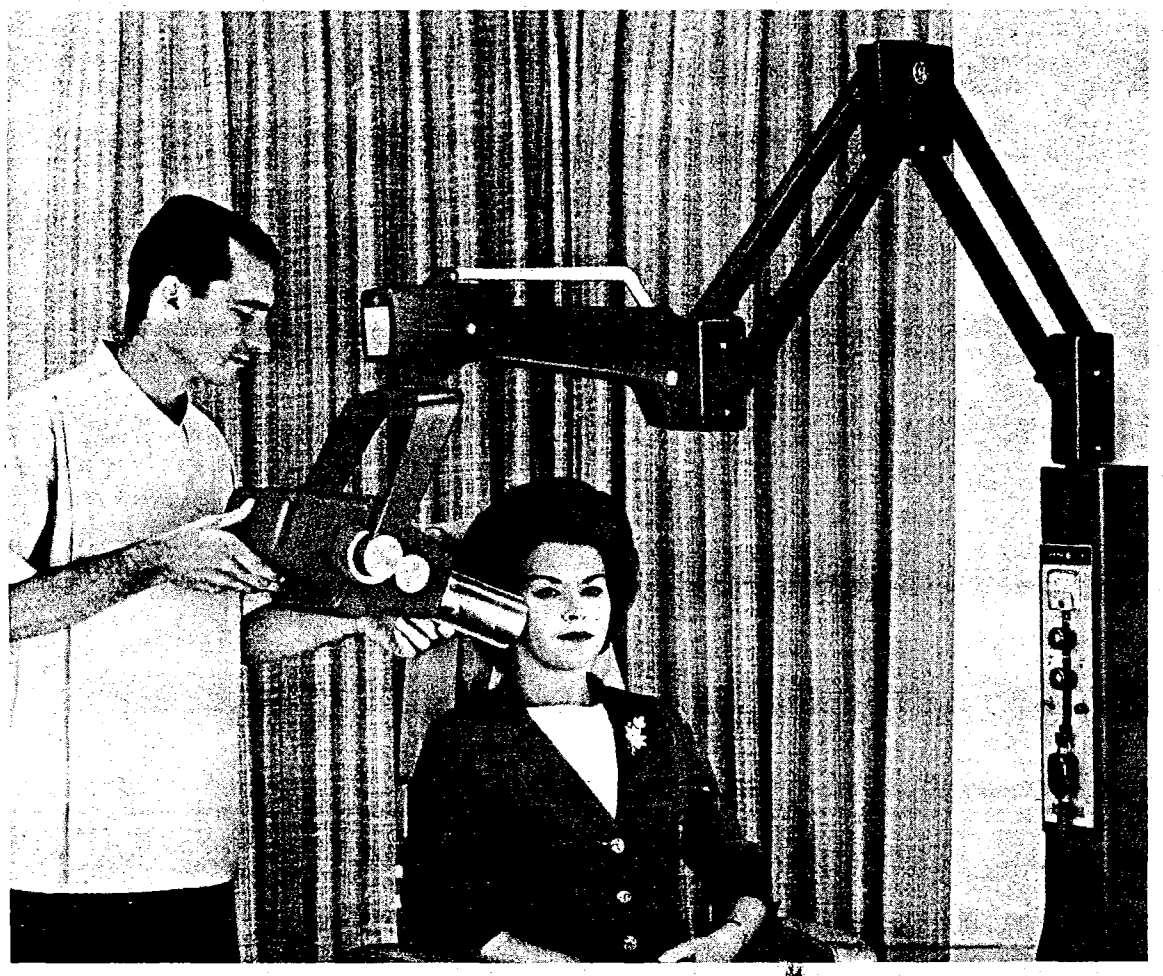

X-rays are the most common cause of radiation contamination

ervision. Not only the operator, but also other workers nearby have been unnecessarily exposed.

Devices such as the high-voltage vacuum switch or the high-voltage vacuum condenser were only recently unveiled as potentially dangerous X-ray sources. Although some vacuum switches, several feet away, produced X-ray fields hundreds of times the maximum permissible levels for occupational exposure, no warnings or indications of shielding requirement are given in their accompanying literature. In fact, no mention is made that the switches might produce X-rays.

Tainted color

Perhaps the most widely publicized electronic unit that can produce X-ray exposure is color television. The facts are still apparently buried in half-truths created by worrywarts on the one side and manufacturers—with a vested interest—on the other. The National Council on Radiation (NCRP) standard of 0.5 millirads per hour at 5 cm. from any readily accessible location on the set is conservative for unnecessary radiation sources. Even such a conservatively permissible radiation figure may, however, produce some 70 genetic deaths per year assuming that 14 million color television sets in the U. S. are operated at the maximum limit set by the NCRP and that these sets are viewed on the average of 20 hours per week each by two persons at a distance of eight feet. Actually, many TV sets emit radiations *in excess* of the NCRP standard. A survey conducted last year indicated that 6% of 1124 sets surveyed exceed the NCRP recommendation and two sets overpowered the test meter, indicating at least 25 times the permissible dosage. The survey also indicated that brand names were not free from fault, and that all sets operating above 31 kv exceeded the NCRP standard.

The bomb scare

Most people first heard of nuclear energy and nuclear radiation when the Hiroshima and Nagasaki bombings were announced. Today everyone is aware of the tremendous damage that can be caused by a nuclear detonation.

Perhaps for this reason people have developed an inordinate fear of nuclear power and exposure to its ionizing radiation. Yet, because of the efforts of research and applied health

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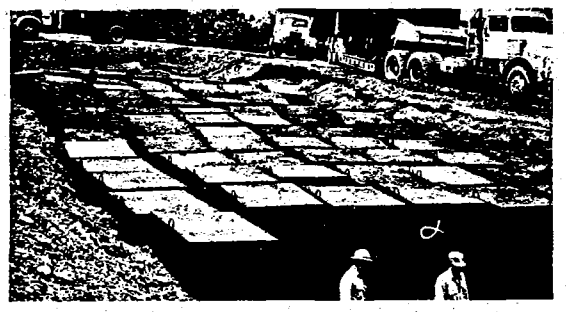

Disposing of radioactive material

physicists, the nuclear energy industry is one of the safest of all modern industries. Radiation from the nuclear power industry contributes a very small percent of the average population dose from man-made ionizing radiation sources—less than 0.3%.

Most nuclear reactors built so far are classified as thermal reactors, and use uranium containing natural mixtures at ^{238}U, and ^{235}U capable of undergoing fission by thermal neutrons. The fuel used in some of these reactors has been enriched artificially by adding a few percent at ^{235}U. In the years immediately ahead, breeder reactors making more ^{239}Pu and/or ^{233}U than the ^{235}U they burn, will replace burner-reactors now operating. The next round of power reactors will be fast neutron breeders (0.5-2 Mev) also producing more ^{239}Pu from ^{238}U than the ^{235}U they consume. These reactors will be followed 10 to 15 years later by thermal breeders that produce ^{233}U from ^{232}Th and operate as most present-day burner-reactors in the thermal or low energy neutron region.

Certainly there's risk

These same nuclear reactors, it is true, introduce risk to the community. But this risk will be far less than latter-day chemical pollutants from the coal and gas-burning power plants and industrial operations. The current fear of nuclear power is not now justified. Of course, it is true that dangerous nuclear reactors could be built. But every reasonable precaution is taken in building a nuclear reactor—and especially a power reactor—to minimize the possibility of any type of accident. There are many independently operating safety devices, so that with a failure of the human element, the possibility of a so-called maximum credible accident is exceedingly small.

In the maximum credible accident, 90 percent of the small number (<5000) of fatalities would be caused by radiation exposure from the radioactive cloud that moved into a nearby populated area. Of course, these estimates are speculative, because in this nuclear age there has been only one commercial reactor accident resulting in serious environmental contamination. However, there was not, nor has there been, any direct evidence of damage to the surrounding population. But there have been two experimental nuclear reactors that have resulted in fatalities. One person was killed in a reactor accident near Belgrade, Yugoslavia on October 15, 1958; and there were three fatalities at the experimental reactor in Idaho Falls, Idaho on January 3, 1961. Yet the risks of having an accident from such experimental reactors are probably many orders of magnitude greater than the risks of an accident from a large power generating reactor.

Hot wastes

Perhaps of greater significance is the radioactive waste and environmental contamination that would be associated with a large chemical plant reprocessing the spent fuel from a number of nuclear power plants. These must certainly be located in areas relatively isolated. Careful planning must be done to see that the large quantities of fission products (radionuclides) are properly stored and permanently disposed of in a manner to completely remove them from man's environment.

It is estimated that the large chemical reprocessing plants by the year 2000 will have discharged into the earth's atmosphere a total of 3,200 megacuries of ^{85}Kr and 96 megacuries of ^{3}H. The dose to the world population from the ^{3}H will be negligible but that from ^{85}Kr will have reached 2 mrags per year to each member of the population. Although this is only 2% of the natural background dose, it is a significant increase if radiation damage relates monotonically to the dose. As a consequence, methods of removing and storing ^{85}Kr are now under serious discussion.

Considerable progress has been made in the development of methods to mix cement and clay with liquid radioactive waste and pump the mixture into deep wells where—in the proper geological formation—it spreads through the rock strata, hardening into thin layers. Another promising method appears to be to reduce the waste to a solid, and store the solid in abandoned salt mines.

Peaceful purposes penalized

Project Ploughshare (atomic blasting) and some of its commercial derivatives have created a stir among population segments, especially among those in the vicinity of the experiments. For example, it is hoped that this atomic blasting will speed the flow of gas

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within the earth and make oil production from shale fields economically feasible. The fear is, however, that gas and oil so produced will be dangerously radioactive. While a small fraction of the initial outcroppings would contain radioactive krypton, it would be in amounts less than the carbon monoxide produced by burning the gas—and should pose no problem.

Some radioisotopes such as strontium-90 and cesium-137 beta emitters, common in fallout debris from atmospheric testing of nuclear weapons, are a particular concern when taken into the body. Strontium-90 deposits in the bone, increasing the risk of bone tumors and leukemia. Cesium-137, on the other hand, deposits rather uniformly throughout the body, increasing the chances of various forms of malignancies and genetic damage to descendants. These two radioisotopes are also produced in nuclear reactors.

Another common reactor and weapons-produced beta-emitting radionuclide causing concern is iodine-131. If liberated to the environment, much of it settles onto the grass. Then cows eating this contaminated grass pass much of it on to their milk where, if consumed by a child, it concentrates largely in the thyroid, increasing the risk of cancer there.

Unnatural natural risks

In addition to man-made radioisotopes, isotopes also occur naturally in our environment such as radium-226, polonium-210, thorium-232 and uranium-238. Usually, these do not represent a problem unless man tampers with or concentrates them. For example, radium-226 was a serious problem during the decade following World War I—especially among the radium dial painters who tipped the brushes with their lips. In doing this they ingested minute quantities, and while only a few millionths of a gram deposited in their skeletons, bone cancer was an invariable outcome.

Most underground uranium mines have operated for years with radon and its daughter products (produced by a natural radioactive decay of uranium-238) at ten to 100 times the air concentration recommended. As a consequence 89 radium miners have reputedly died from lung cancer.

Quantities of fission products will be made into radiation sources to be used in radiography, small power plants, static eliminators, etc. These must also be carefully monitored for, in time, they may represent one of the principal radiation risks of the industry.

Radioisotope sources such as strontium-90, cobalt-60, cesium-137 and radium-226 can be destructive from either without or within. Used in devices they may be, initially, relatively safe, but if tampered with or otherwise damaged—so that the source begins to leak—they can present a serious contamination problem. Most of the sources containing reactor-produced radionuclides are under surveillance of the Atomic Energy Commission or, in some cases, under state control. However, accelerator-produced sources and sources of natural origin are, in most cases, either under very limited control or under, no control.

Sources such as plutonium-239, hydrogen-3, or carbon-14 are contentious only as internal sources because of their short range radiation in tissue. But for this very reason they may deliver radiation to the most radio-sensitive tissue in the body. Radioisotopes existing as a gas, dust, liquid or other contaminant may be inhaled, digested or fused after contact with the skin. Most of the larger and more dangerous isotope sources are found under adequate health physics supervision and control. But there are many cases of improper handling. Perhaps the most dramatic case occurred in 1962 in Mexico, when four persons died as a result of a cobalt-60 radiographic source left in their home accidentally.

In summation

The danger today from large powerful sources to large segments of the population is remote. But thousands of people are potential users of radioisotopes, though usually in relatively small quantities. These applications can lead to serious exposure of large numbers of people. Radium-226 or polonium-210 have created some serious exposure risks.

Radioisotopes are used in a number of small devices (1) to measure thickness (gauges), (2) as electrostatic charge eliminators, (3) as a weak source (watch dials, instrument dials, emergency lights), (4) as electron sources (certain instruments and radio tubes). Care must be taken to see that these sources are not used in certain devices such as foods and children's toys and to assure that when they are used, they do not flake and become a population risk as they deteriorate.

We entered the nuclear age in 1945, and it is to be expected that in the years to come, man will make increasingly greater use of the vast source of power that nuclear energy has made available. Besides power plants, radiation will actually help to purify our environment—e.g., it will sterilize our foods for the purposes of preservation. While we must maintain a vigil against radiation pollution, the fact is, that radiation, in general, will provide more benefits than liabilities. ■

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Three books were chosen to complement this special issue of Science and Technology. Two are *Air Pollution Instrumentation* ($4.75, published) and *Environmental Pollution Instrumentation* (shortly to come off the presses). Both are Instrument Society of America publications and both are collections of talks or papers. The third book (perhaps more properly, pamphlet) is entitled *Air-Pollution-Monitoring Instrumentation*, published by NASA.

While perusing Air Instrumentation my strongest thought was that "a lot of stuff is being printed these days." Here is a printed transcription of several air pollution instrumentation sessions held during the 20th Annual ISA Conference—talks, panelist discussions, questions, answers and all. We're not even spared the salutary remarks in the first third of the book that is Session I.

Session I represents snippits of panelist and audience remarks. In all fairness, there's some good information—such as the use of laser radar to track stack emissions—if the reader has the fortitude to wade through the "informal" presentation.

The remaining two-thirds of the book is shared equally by Sessions II and III: two papers are covered in each. One paper (with more authors than information) relates "round-robin" testing from automotive exhausts. Conclusion: success! Another paper about simulating actual engine operation under laboratory conditions using programmed control conceivably will be of interest to a select few in the automobile industry who want to duplicate such a setup.

Perhaps of broader purview is a paper giving the requirements for an air analysis laboratory. It's quite short, but this is not in its favor—not even for this book.

The last paper in *Air Pollution Instrumentation*—and perhaps the best thing in the book—describes the use of azo-dyes for detecting nitrous oxides. The information is both detailed and explicit.

Environmental Pollution Instrumentation, by comparison, stands up fairly well. It contains papers on methods for measuring environmental pollution plus one anomaly on noise pollution.

Nearly all the papers resemble conventional industrial engineering reports, although they all apparently have been edited into respectable reading form.

Most of the articles detail techniques for existing equipment. Among some of the more interesting articles are: "Instrumentation for New Jersey's Vehicle Emission Testing" which gives a rundown of devices useful for detecting and measuring CO, CO_2 paraffinic compounds and other hydrocarbons by flame, spectrometer, ultraviolet analyzer and chromatograph devices, among other means. Virtues and limitations of the equipment are given.

"Instrumentation for Monitoring Air Pollutants" may not be quite as thorough as the above paper, but it does succeed in acquainting the reader about the merits of most of the equipment in the field.

"Methods for Measuring the Concentration of Radioisotopes in Water" is useful for making the appropriate equipment choice based on the material being measured and the sensitivity required.

Two papers (one on remote chemical sensing and another on sound pollution) have broader appeal than the rest. But while these two—and especially the latter—have some very interesting facts to convey, they don't take the book out of a very specialized sphere. Nevertheless it may be a worthwhile investment for those in the field.

But, the best investment of all is the Government Printing Office's 40¢ book. True, NASA SP-5072 is more by way of an introduction to the equipment involved in monitoring air pollution, but it represents thorough and competent reporting.

The work has three chapters. The first two, "Current State of the Art" and NASA's contributions, are of equal length. Most of the instruments covered in *Environmental Pollution Instrumentation* are discussed here, though admittedly, in cursory fashion. One nice note: equipment cost ranges are given. The NASA contributions are more detailed, and, for the most part, represent refinements of current state of the art equipment. In this respect, the work is valuable both to the novice interested in a description of equipment and to the specialist who wants to improve what he already has. Apparently, though NASA made equipment modifications with space applications in mind, the modified equipment is equally useful for other applications such as industrial hygiene.

The professional reader will also appreciate the extensive reference and bibliography. ■

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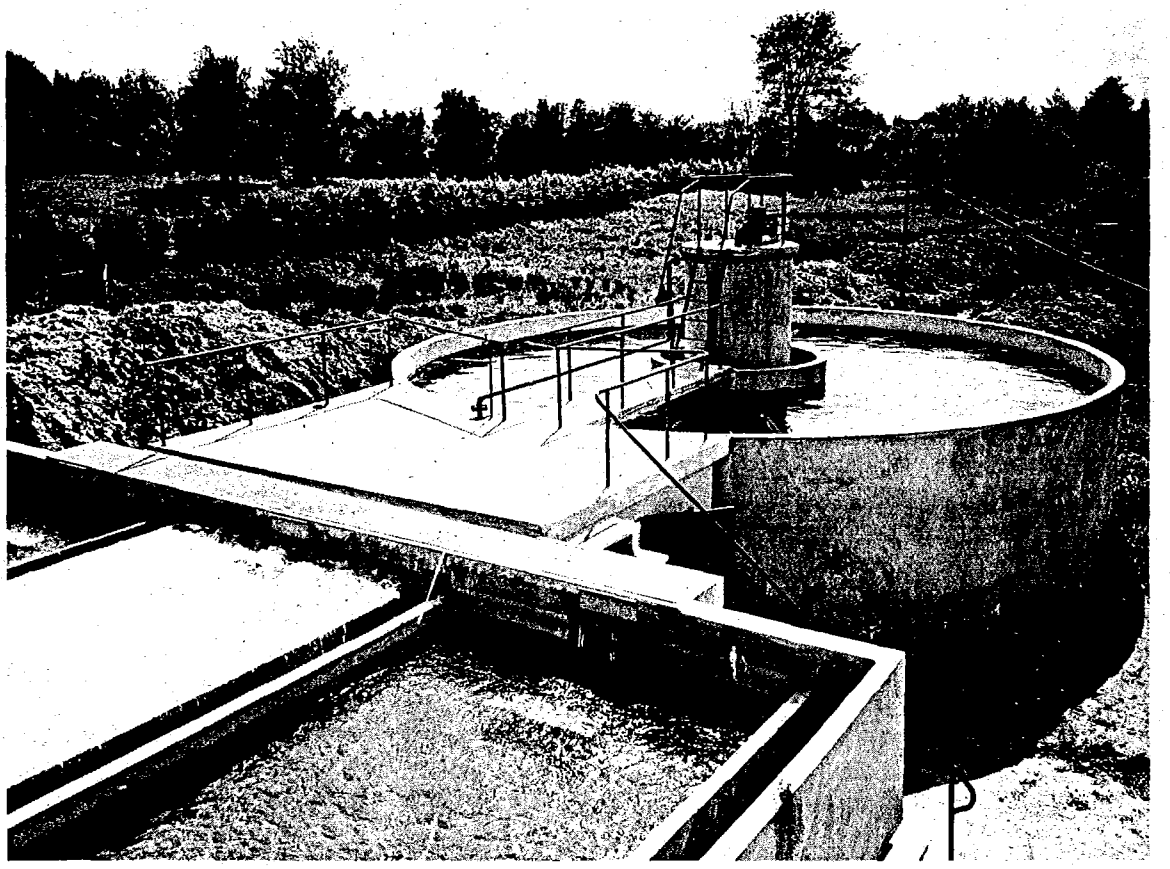
WASHING WATER



The sparkle is gone, life within ebbs and the blight goes on

by Joseph H. Neale

IN BRIEF: *There are three ways to rid water of the solids and the solutes it captures through use by industry and public consumer. One is physical; another is chemical; and the third is biochemical. Here is a rundown of alternatives available within each of the processes—what makes them work (when applicable) and how they compare. Of course, there's always the problem of disposing of the pollutants removed. Major methods for tackling this problem are noted.*

The treatment—and disposal—of liquid pollutants pose a major problem. Accordingly, liquid pollutants are divided into three classes: (1) floating material; (2) suspended matter; and (3) dissolved impurities. There is a further distinction between organic and inorganic pollutants.

The specific treatment for a given waste depends, of course, on the kind and amount of pollutants, the assimilation by the water resource involved, whether or not the material removed, or the resulting purified liquid can be re-used or sold, and the requirements of the regulatory agencies. Unfortunately, existing legislation is often vague and rather general.

Treatment of liquid waste is best described in processes rather than in details of equipment. Moreover, it is difficult to present equipment cost ranges per unit of flow since, in most installations, the cost depends primarily upon size, while the flow handled by any equipment unit of a given size varies widely with the job to be done. The processes are listed categorically in Table 1. In practice, one or more of the listed processes will be required for effective control of the liquid

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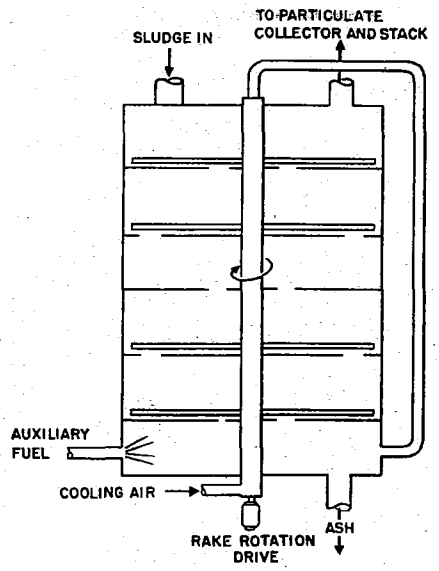

waste, but not necessarily in the precise order presented. Most liquid waste treatment involves screening, sedimentation, flocculation, flotation, and/or filtration. In addition, chemical additives may be used in the processes to abet the mechanics of the aforegoing methods. A brief description of the currently employed treatment of liquid wastes follows:

Screening employs coarse, bar screens or racks to remove large floating material: These are generally cleaned manually or fitted with rake-like equipment for cleaning off collected material. Mechanically-cleaned screening equipment of finer mesh usually follows. This equipment removes solids, mechanically reduces particle size, and returns the "comminuted' solids to the water source.

Sedimentation is the simple process of separating discrete solids by gravity in a basin or tank. Solids collect at the bottom as sludge, while the liquid is collected and removed at the top. The tank needs no mechanical equipment if its bottom can be steeply sloped, or if it can be emptied for sludge removal periodically. But an economical, continuous operation requires a bottomscraper. This simple process is often not adequate for clarification but constitutes an important preliminary step. Gravity separation, in the reverse of sedimentation, is also used for removal of oil, scum and other matter with specific gravity less than the liquid. The material floats and is removed by skimmers or other mechanical means. The most common equipment is the API separator (basically a concrete tank designed to recommendations of the American Petroleum Institute).

Flocculation decomposes oils, greases, or other pollutants present in stable emulsion by heat, allowing gravity separation. Floc may also be formed to trap or coat particles and settle with them if they are in colloidal suspension, or just too small or of too low density to settle out by gravity at a useful rate. Thirdly, chemical additives react with dissolved pollutants, creating a precipitate which may or may not have floc properties.

Chemicals added to react with dissolved constituents will vary widely according to the constituents. Common floc-forming agents are alum, ferric chloride, copperas and various organic polyelectrolytes. More additives may be used to improve the characteristics of floc; to make small pieces of floc coagulate into larger pieces, or weight floc to make it settle faster. Activated silica, glue, clay and various organics are typical. It is often necessary to select floc-forming agents and aids to suit the pH of the liquid, or to make further chemical additions to tailor the pH to the requiremnts of the floc formation.

In the clarifier, floc settles, while liquid flows up and out of a vertical tank, or across and out near the top of a horizontal tank. Mixing of the liquid and reagents may take place in a separate tank, or occur in a separate section of a combination clarifier. The latter saves space, but there are design limitations. Thorough mixing must take place, but destruction of the floc must be avoided. In some designs, there is a blanket of sludge, floc and/or precipitate and collected material is maintained through which polluted liquid must flow. This is very effective, but careful design and operation is required to avoid disruption of the blanket.

A portion of sludge can be returned to the clarifier for improved action in removal of suspended matter and conservation of chemical requirements.

Flotation may be used to remove materials that will not settle rapidly or settle at all. Gravity may do it, or the material can be acquired by air bubbles either blown in at the tank bottom, or produced by pulling a vacuum above the liquid surface. Emulsion-breaking chemicals may be added.

Filtration may be used instead of the screening and gravity methods just described, or may constitute secondary treatment following screening and/or treatment in a clarifier.

Thin or extremely fine-pore filter media are not practical, except for very low flow rates and very low solids content. Most waste treatment filtration utilizes deep beds of media such as coal, gravel and sand, usually in combination. Coagulants may be added. Filtration may be simply the blocking or trapping of particles unable to pass through the interstices between the media surfaces, or may involve adsorption.

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When the filter bed becomes clogged, it is backwashed by forcing water, or water and air through in a direction opposite to that of the polluted liquid flow. Filtration is thus a batch process, and if the flow of polluted liquid is continuous, two or more filters will be needed for service to continue while backwashing is going on.

Since filtered water is generally used for washing and becomes polluted again, it is desirable to minimize the amount of water required. This is why compressed air may be used, especially with media coarser than sand, to lift the media particles and make them accessible to efficient washing.

Continuous filtration is possible, using a moving filter medium which may be externally cleaned and returned to the filter. Or, the filter medium may be an additive such as asbestos, which forms a layer on a permanent substrate that continuously moves through, out of, and back into the liquid. While it is out of the liquid, the outer layer of the coat is stripped off and discarded with its accumulation of pollutants.

Activated carbon can be used as a filtration medium and will absorb certain pollutants. This is important for removal of organic pollutants not subject to biological treatment. The carbon is cleaned by removal from the filter, draining and incineration of the collected material at about 1600°F. Control of oxidation results in a preferential action which burns off all the organics, but only a small percentage of the carbon.

Biochemical treatment

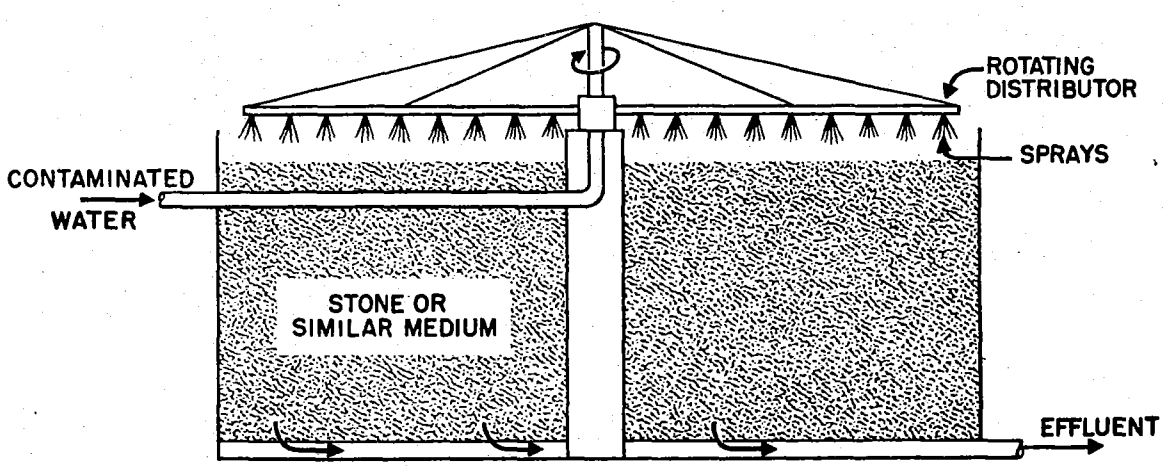
Many industrial wastes can be treated by biological means widely used for sewage disposal. The process is highly effective on material suspended or in solution. The basic action is attack by bacteria, resulting in production of CO_2 and water with inorganic by-products—producing a sludge. While sewage usually contains all the necessary nutrients, in industrial processes it may be necessary to add forms of such elements as magnesium, nitrogen, calcium and phosphorous. Poisonous elements and compounds must be avoided.

For aerobic biological processes, addition of oxygen is necessary. Therefore the polluted liquid is aerated. This may be done in tanks with air blown in to cause stirring, with mechanical stirring and air diffusion, or by agitation of the liquid surface with impellers.

Sludge is collected in a secondary clarifier and settles, while a highly-clarified liquid low in BOD (biochemical oxygen demand) flows out. Most of the sludge is returned to the aeration tank to seed incoming waste liquid with bacteria. In many modern systems, all the incoming waste is mixed with all the sludge. This permits treating more waste in a system of given size and achieves very high BOD reduction.

Another type of system, suitable for low and moderate loading, achieves aeration and clarification in one tank. Aeration is required for an extended period. But high BOD reduction can be achieved with little or no pretreatment, except screening out or comminuting large floating solids.

There is also an anaerobic biological action by bacteria that flourish in an environment without dissolved oxygen. The ordinary household septic tank is an example. Anaerobic digestion is used to treat some wastes such as those from meat packing plants, and used to treat the organic sludge resulting from aerobic processes. Anaerobic action also takes place in some aerobic processes below the level of aerobic action.



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The *trickling filter* is simpler than the activated sludge process in complexity of equipment and maintenance of proper operating conditions, and requires little or no power. However, it requires more space than the activated sludge process and is not capable of as high a BOD reduction. It is sensitive to temperature and is less tolerant of poisons such as copper. Such filters are most commonly used for higher flow rates and lower loading than the activated sludge process.

Trickling filters are not filters at all, since no blocking action is used. The rock or other medium, simply serves as a base upon which bacteria can grow and through which the waste liquid trickles. Operated at low rate, with low loading of organic material, BOD reduction of 80-90% can be achieved. Effluent is recirculated only when incoming flow is low, to keep the bed wet.

Operated at high rate, with loading typically ten times that of low-rate filters, large amounts of organics can be stabilized per unit filter volume with a substantial degree of recirculation, but efficiency in BOD reduction drops.

Even simpler than the trickling filter, when suitable space is available, is utilization of the biological process in a shallow pond or lagoon. A lot of land area is required, since the liquid may have to remain in the pond for several days or months for acceptably complete treatment, and a large surface area is required for transfer of sufficient oxygen. However, air may be blown in, or introduced by surface agitation to speed up the process. Then the operation resembles the activated sludge process and may reach as high as 90% BOD removed.

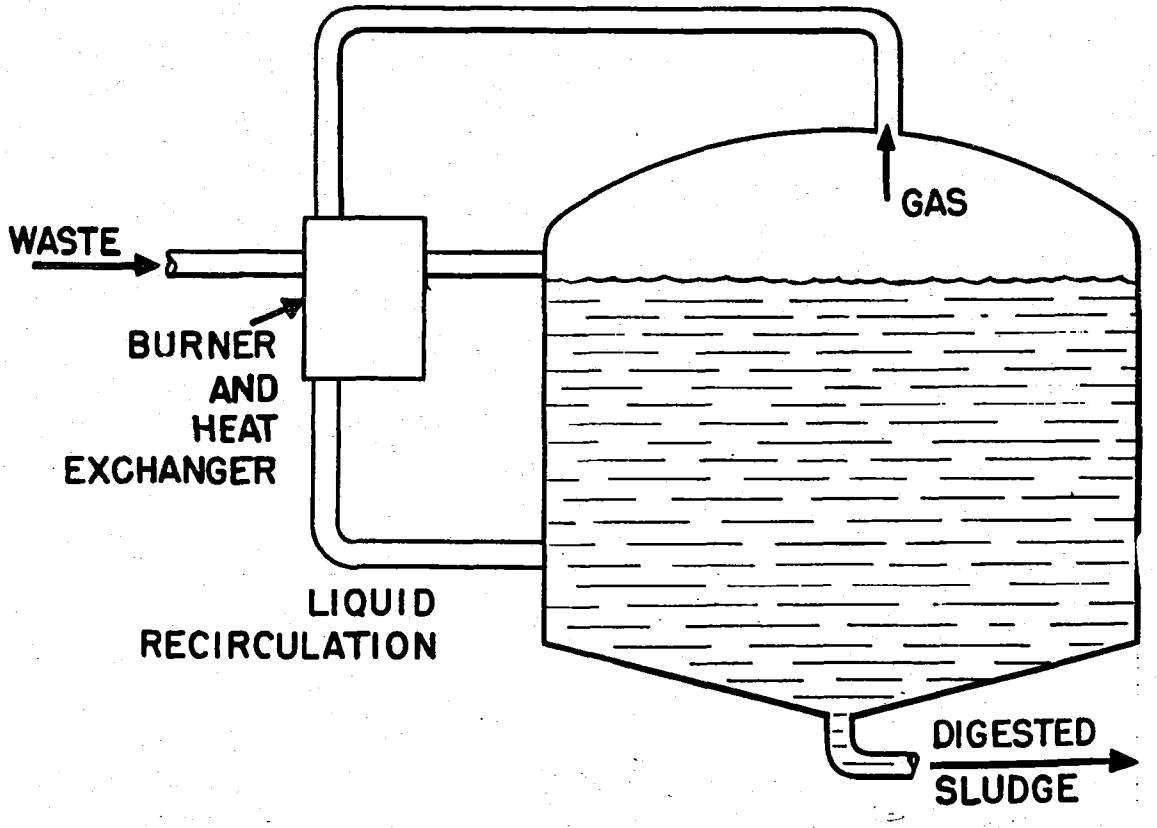
Physio-chemical treatment

Chemicals added to neutralize acids or alkalis, or accomplish special tasks, are frequently part of the additives in processes already described. Or their use may be all the treatment required. Lime, caustic soda and sulfuric acid are typical reagents.

Chromium salts and cyanides are examples of pollutants removed by oxidation, or reduction and precipitation. Chromates are reduced with acidulous sulfur dioxide or sodium bisulfite, or neutral ferrous sulfate, then precipitated with, typically, lime. Cyanides are oxidized by chlorine or ozone or hypochlorites, to cyanates or all the way to CO_2; water and N_2.

Ferrous salts are oxidized to ferric salts and precipitated by coagulants. Sometimes aeration is required to provide sufficient oxygen, and coagulant aids are usually necessary. Manganese is usually oxidized by chemical additives and precipitated.

Adsorption by activated carbon, or specialized adsorbents, has already been mentioned as a valuable tool, especially for polishing the effluent from other processes when necessary. Adsorption is also used for removal of the



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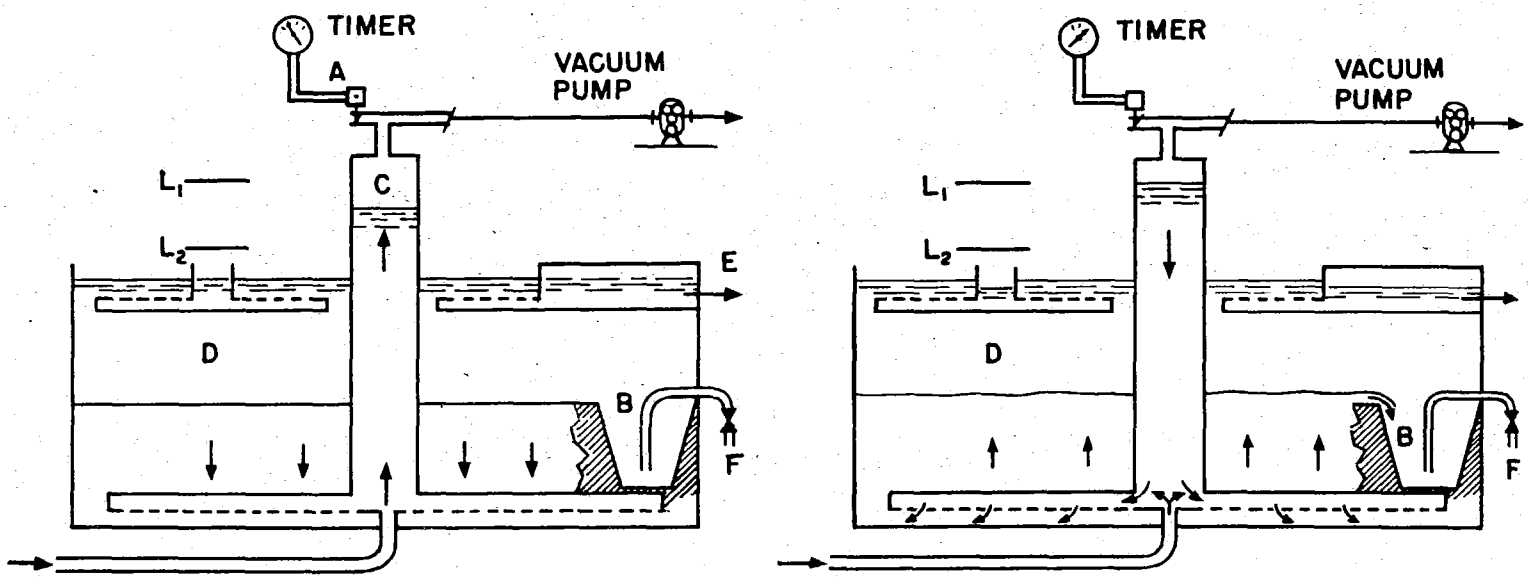

various organics not readily degraded by biological action.

Ion Exchange is utilized principally when the pollutant to be removed is valuable and can be reused, or when the polluted liquid must be softened or completely demineralized for reuse. The process utilizes insoluble media, usually synthetic resins capable of effecting the exchange of cations and/or anions. The operation consists of charging the cation and anion media with suitable ions by exchange with regenerants. Then these ions are exchanged for the unwanted ions in the polluted solution. The regenerant is selected to provide ions such that the resulting compound in the treated liquid is harmless in the concentrations involved, or is readily removed.

The major waste-treatment application of ion exchange is regeneration of chromic acid plating baths. Impurities such as iron and alumnium are removed. Metal ions in rinse waters are first removed by a cation unit. Then the anion unit exchanges hydroxide for chromate anions to produce demineralized water. Chromate is recovered by regenerating the anion exchanger with a caustic. The resulting Na_2CrO_4 in the spent regenerant is converted to chromic acid in the cation exchanger. The spent acid regenerant from the cation unit requires neutralization and possible precipitation of metallic ions before discharge.

A very high degree of pollutant removal can be accomplished by mixed-bed units in which cation and anion resins are combined and mixed in one bed. Their principal disadvantage is that regeneration is complicated and time-consuming compared with dual-bed units. Regeneration first requires separation of the media, done on the basis of their different weight, by flowing water up through the mixed bed. Once the media are on different levels, a separate regenerant for each is flowed through the appropriate layer. The regenerated media are remixed by air to cause stirring.

A comparatively recent development is *continuous ion exchange.* In this process small amounts of resin are periodically removed from the bottom of the exchange column, where the resin first contacts the incoming polluted liquid. The small batch of spent resin is routed through regeneration and rinsing operations, and eventually reaches a hopper above the exchange column. From this hopper, batches of fresh resin are introduced into the exchange column to replace the amounts removed from the bottom. The advantages are reduced capital investment and space requirement, reduced regenerant chemical consump-

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tion, and the possibility of convenient neutralization of spent regenerant through blending of the continuous flow of cation and anion regenerant effluents.

Ion exchange can be selective if the material to be removed is present in a complex solution which fixes on the resin while other ions are not retained. This is used to remove toxic products such as cyanides, copper and chromates, for recovery of precious metals, and in regeneration of metal surface treatment baths. A description of the remaining physio-chemical treatment processes are as follows:

Dialysis involves the transfer of a pollutant from one liquid to another liquid by selective passage through a membrane. The pollutant passes through the membrane at a much higher rate than other constituents of the water from which it is being removed. Since the driving force is concentration of the pollutant, the process is not effective for dilute concentrations of pollutant.

Electrodialysis involves flowing the polluted material between two membranes—each with a flowing medium on its other side in which electrodes are immersed. A flow of current causes pollutant anions to migrate through one membrane toward one electrode, and cations to migrate toward the other electrode through the other membrane. Dissolved solids are thus removed, and the electric driving force reduces the need for the concentration of dissolved pollutants to be high.

Reverse osmosis is a process of preferential passage of water, rather than pollutant, through a membrane, as in dialysis and electrodialysis. The effect is an increase in the concentration of pollutants in the liquid being treated, aiding further treatment.

Distillation and crystallization are both effective methods by which solvents and materials, if discharged, may be separated. These operations are usually considered part of primary processing, rather than pollution control operations. However, evaporation or distillation are methods used for concentration or separation of radioactive waste material. (Ion exchange is also used for this purpose, as are precipitation processes.)

Sludge disposal

The processes described so far remove pollutants from a liquid, usually in the form of a sludge. It remains to dispose of the sludge or other accumulation of pollutant. If simply discharged into a lake or stream, sludge would be as unacceptable as if the pollutants remained in the liquid and were discharged with it. Barging sludge out to sea and dumping it is still done, but has been considered increasingly unacceptable. Some sludge is still piped or trucked after little or no treatment, to remote sites as land fill. This is rapidly becoming unacceptable due to lack of suitable sites, and to prohibitive legislation.

Usually, sludge must be treated to make it relatively unobjectionable and/or to facilitate convenient disposal. This is especially true of organic sludge which putrefies rapidly. Usually sludge is first concentrated by gravity or by air floatation: (1) via a thickener or a gravity tank in which retention time is lengthy; the sludge is slowly agitated while water is freed and rises up for removal; or (2) via a clarification process in which sludge settles. Further dewatering may be done in beds or lagoons if space is available and soil conditions permit. Alternately, centrifuges or filters may be used. Vacuum filtration is most common. Washing of the sludge, to reduce alkalinity, may be necessary. Chemical agents may be added to condition sludge for filtration.

Digestion converts the organic residue in biological process sludge, using anaerobic bacteria in closed vessels. Since the rate of digestion improves with increasing temperature, vessels are insulated and the sludge heated. The process produces gases such as methane, which can be burned to produce most, if not all of the heat input. Dewatering follows digestion.

Drying and Incineration are done in specially designed furnaces which drive off remaining moisture and then burn the sludge if it is combustible. It is usually possible to have the option of burning all the sludge, merely drying all of it, or drying some and burning the rest. Incineration produces particulate pollution in the form of fly ash, usually handled by mechanical collectors or a wet scrubber.

Wet Oxidation is possible if the sludge is sufficiently concentrated to a high BTU content, using flameless combusion under pressure in a reactor at 500-700°F. Hot gases such as CO_2, N_2 and steam may be used to power turbine-driven pumps or compressors.

Dry sludge may be salable as fertilizer soil conditioner, or used as land fill.

As man's population and industry keeps growing, the problem of the disposal of his liquid waste will burgeon, becoming critical as the years pass. To prevent an eventual calamity, researchers in Government, in industry and in academe, are working away, improving the basic processes—and concomitantly seeking new methods to make the biosphere a better place to live in the future. ■

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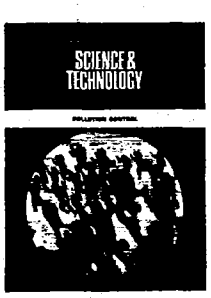

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From: The Publisher

To: ALL READERS AND ADVERTISERS

Subject: THE COMPUTER COMPLEX
September 1969 Special Issue

A latter-day author claims: "Men and women today are ciphers on an IBM card, magnetic bits on computer tape. Hired according to scores on entrance tests, they are ranked, paid, and even fired by machine-printed notices ..." If this is true, it is just the beginning; because the computer is only a basic part of the complex that someday is destined to impart the greatest impact on man's way of life. This complex is broadly classified as a "system."

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Here-- in a single magazine -- is the state-of-the-art being practiced in areas that include bioscience to statistics. Because of the tremendous complexities in electronic systems it is more than obvious that the real rewards in industry and management will come to those executives equipped with an understanding and a vision of innovative applications of the computer and its accoutrements

Prepared by internationally known -- and-- esteemed -- experts in the field, the editorial content of the September SCIENCE & TECHNOLOGY magazine not only will aptly describe the state-of-the-art situation within the computer complex, but it will also emphasize that we are all still men and women -- human beings who unlike punch cards cannot be folded, spindled, or mutilated.

Since the coming computer world will be the bailiwick of the systems men and managers, it is prudent -- indeed educational -- to study the September SCIENCE & TECHNOLOGY magazine. And because of the unique impact our magazine has on the people who count within the science and engineering community it will more than pay companies involved in systems work to display their expertise in our pages.

Publisher

Future Interdisciplinary SCIENCE & TECHNOLOGY Articles

COMPUTER LANGUAGE: *Quick & Dirty Introduction To The Computer,* by Professor R. Hart, Hofstra U. A wonderfully entertaining treatise on sensible methods of teaching the uninitiated the basic language of computer programming.

METALLURGY: *Bubbles in Solids,* by R. Kueh, Oak Ridge National Lab. What happens when gas bubbles form and grow inside solids? Much that is new here about cracks and blisters and malformation in metals.

LUMINESCENCE: *Molecular Flashlights,* by I. Berlman, Physicist, Argonne National Lab. All about the luminescence, the flourescence, and the activity of molecules with respect to their ability to create and to reflect light. Includes a new concept of *sensing* by one of the field's most competent authorities.

EARTHQUAKES: *Isolation of Multistory Structures from Seismic Vibrations,* by the distinguished authority Marc Caspe. The author sets forth pragmatic alternatives so that buildings of the future can better withstand tremors and shocks.

AEROSPACE: *Lunar Hopping Transporters,* by M. Kaplan, Professor of Aerospace Engineering at Penn State. Of moon cars and multi-man rovers, including the lunar pogo stick.

R AND D: *R and D For Sale,* by S. Zeiring, Director of Research, Whittaker Corporation. Dr. Ziering cogently discusses the proliferation of small companies specializing in selected areas of technology and the economic considerations for acquisitions.

PHYSICS: *An Atomic View of Metallic Interface Coalescence,* by H. Rondeau, Sr. Engr. USM Corp, Boston. Here is a dimensional feel for the metallic bond presented as a delightful fantasy.

FORECASTING: *Technological Forecasting,* by William McLoughlin, Assistant Director, Technological Planning, LTV. Here the author reveals the inside story on how large, complex corporations effect their forecasting in order to enable them to sensibly plan for technological expansion.

ASTROPHYSICS: *The Universe,* by R. Wildey, Astrophysicist at the Center for Astrogeology, Interior Department. Dr. Wildey tells about the universe as it *really* is.

THERMODYNAMICS: *Abrasion & Friction,* by Dr. E. Finkin, Chief Tribologist, Colt Industries. Dr. Finkin makes the question of abrasive wear crystal clear—and points up some startling but efficient ways of overcoming it.

STANDARDS: *Fundamental Standards of Measurement,* by Dr. N. Chinmulgund, Varian Senior Scientist, England. Dr. Chinmulgund assesses current standards and suggests workable changes designed to make them more palatable and useful for all nations.

COMPUTERS: *Trajectory Techniques with an Avionic Digital Computer,* by E. Gott, Senior Scientist, North American Rockwell. Dr. Gott examines the various techniques for mechanizing the effect of variable winds on weapon trajectory in a digital computer.

MOTION: *Momentum Conservation,* by Dr. N. Andres, a California scientist. Dr. Andres compares the conservation of momentum against the conservation of energy and comes up with some new slants on the topic.

PHYSICS: *Image* Intensifiers by H. V. Soule, Sr. Member Tech Staff IT&T. Dr. Soule talks authoritatively about low-light-level instruments and the resolution of images they process. Military applications are discussed and explained.

EXPLOSIONS: *Explosions,* by Professor A. K. Oppenheim, U. of Cal. It is the author's object to estimate the direct or indirect influence upon modern civilization of explosive agents for the purpose of war. Extremely timely in an age when nuclear warheads are facing each other across the world.

OCEANOGRAPHY: *Undersea Living,* by H. Rind, Grumman Aircraft. Dr. Rind surveys the possibilities of undersea life support for human beings that may eventually be compelled to live and to work on the ocean floor.

HOLOGRAPHY: *Holographic Storage,* by Arm and King, scientists at the Riverside Research Center, N.Y.C. The learned authors treat the holographic storage of electric signals comprehensively—and at the same time discuss holographic coding and decoding.

BIOSCIENCE: *Polluted Light,* by Dr. R. Wurtman, MIT. Dr. Wurtman makes a case against light pollution and its effect on the pineal gland.

This is merely a representative list with major lead articles in Thraustics, MHD and Transportation scheduled to appear before January 1970.

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INTERNATIONAL SCIENCE AND TECHNOLOGY DIGEST

ATTENTION . . . . REGARDEZ . . . .

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TO DIG DEEPER

SWEET WATER POLLUTION

A comprehensive, reasonably priced introduction to the study of water pollution is *Water and Waste* by J. H. Stephens, (St. Martins, 1967, $3.95). But water pollution is a complex problem and its many facets deserve specific study. Accordingly, for a look at the more insidious aspects of water pollution read "Role of Ground Water Contamination in Water Management," (H. E. Le Grand, *American Water Works Association Journal 59:* 557-65, May '67).

Another type of fresh water pollution from more insidious sources, is covered in "Cattle Feedlot and Runoff; Its Nature and Variation," (J. R. Miner and others, *Water Pollution Control Federation Journal 38:* 1582-91, October '66).

Two special studies of fresh water pollution by chemicals are R. E. Frazier's "Chemicals in Water and Their Significance," (*American Water Works Association Journal, 59:* 575-91, May '67), and "Concentration and Effects of Pesticides in Aquatic Environments," (S. L. Warnick and others, *American Water Works Association Journal 58:* 601-8, May '66).

For concise treatment of manmade (and natural) contamination read, "The Role of Silt in Water Pollution," (R. D. Walker, *American Water Works Association Journal 58:* 1483-8, November '66).

More immediate, and possibly our most pressing pollution problem, is "Water Pollution and the Potable Water Dilemma," (R. Porges, *Water Pollution Control Federation Journal, 39:* 1613-20).

URBANAIR

For a broad view of air pollution, investigate, *Air We Breathe; A Study of Man and His Environment*, edited by Seymour M. Farber and H. L. Wilson, (C. C. Thomas, $14). And Roger A. Meetham's *Atmospheric Pollution, Its Origins and Prevention,* (Pergamon, 3rd ed., $10). A brief but necessary accompaniment to these is "Measurement and Analysis of Air and Water Pollutants," (J. W. Brant, *Heating-Piping 39:* 60-64, December '67).

To get a better perspective on just how serious the situation of urban air pollution can be, the following is valuable: Lewis Herber's *Crisis in Our Cities,* (Prentice-Hall, 1965, $5.95). *Photochemistry of Air Pollution* a topic—only passingly mentioned in this issue and particularly relevant to the problems of urban California—by P. A. Leighton, (Academic Press, 1967, $11), is also suggested reading.

The ways in which air pollution is inflicting damage on the urban organism are described in *Air Pollution and Community Health* by Clarence A. Mills, (Christopher, 1945, $3.75), "Biological Effects of Atmosphere Contaminated by Auto Exhaust," (F. G. Hueter and others, *Archives Environmental Health 11:* 765-9, June '66), and the Royal Society of Medicine's *Medical and Epidemological Aspects of Air Pollution,* (Grune, 1964, paper, $2.50).

Lastly, having found this an interesting subject, you think your children should also learn something about it, introduce them to the illustrated, *Dangerour Air* for grades 6-9 by L. Kavaler, (Day, 1967, $3.95).

TAINTED RADIATION

For more about the hazards of radiation contamination see "Radiation Accidents; the Public's Right to Know," by R. J. Longwood (*American Journal of Public Health 56:* 1943-7, No. 866).

The effects of radiation on living organisms are covered in the following works: G. E. Purdom's "Genetic Effects of Radiation," (Academic Press, 1963 $7), "Actions of Radiations on Living Cells," by Douglas E. Lea, (Cambridge, U. P., 2nd ed., 1955, $7.50), and "Human Effects of Chronic, Low Dose Radiation," (L. A. Sagan, *Archives Environmental Health 13:* 345-50, September '66).

While not mentioned in Science and Technology's article, accelerators have been inflicting injury on scientists for nearly three decades. If you are interested, read "Radiation Hazards of the New Generation of Accelerators," (R. H. Thomas, *Nucleonics 24:* 64+, April '66).

Then for a better understanding of the danger of radiation contamination outside the plant and laboratory, read "Population Exposure to X-Rays," by J. N. Gitlin and P. S. Lawrence, (*Public Health Service Publication No. 1519,* U.S. Government Printing Office, Washington, D.C., 1966).

Since a major share of X-Ray pollution is due to dental examination, take interest in "Radiation Hygiene and Practice in Dentistry, IV," JADA, Vol. 76, p. 363, February 1968, published by the *American Dental Association Council on Dental Materials and Devices and Council on Dental Research.*

Also, very informative and thorough coverage on radiation contamination data can be obtained from the United Nations General Assembly Session's reports by their Scientific Committee on the Effects of Atomic Radiation. These include: "Suppl. 17 (A/3838) General Assembly/ 13th Session, N.Y., 1958, $5.00; "Suppl. 14 (A/5814, General Assembly/ 19th Session, N.Y. 1964, $3.00, and "Suppl. 14 (A/6314, General Assembly/ 21st Session, United Nations, New York, 1966.

SOLID WASTE DISPOSAL

The most authoritative and comprehensive—though unduly wordy and haphazard—treatment of the entire waste management area may be *Waste Management and Control* (National Academy of Sciences-National Research Council Publication 1400, Washington, D. C., 1966, $4.00). Two other "musts" on this level, distinguished by excellent organization and em-

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phasis on local problems, are *California Waste Management Study* (Aerojet-General Corporation Report No. 3056, Azusa, Calif., 1965) and *Waste Management* in the New York Region (Regional Plan Association, New York, N. Y. 1968, $10).

Solutions to the problem of air pollution are presented in, "Basic Air Pollution Control Equipment," (*Safety Maintenance 132:* 38-41, August '66), "Utilities Fight Against Dirty Air; Special Report, (*Electrical World, 168:* 97-112, November 13, 1967) "Control of Gaseous Pollutants" by B. D. Bloomfield, (*Heating-Piping* 40: 195-206, January 8, '68), and D. Williamson's "Pollution Control Equipment; the New Systems," (*Foundry 96:* 86-91, September '68).

If you're interested in specific processes that contribute to atmospheric cleansing, *Atmospheric Diffusion* by Frank Pasquill, (Van Nostrand, 1961, $12.50) is particularly pertinent.

The urgent need for such solutions are made explicit in Ronald J. Ridker's *Economic Cost of Air Pollution*, (Praeger, 1967, $13.50).

SWEETWATER POLLUTION

Some practical and detailed approaches to prevention of lake pollution are introduced in "Protecting the Purity of Our Inland Waters," by G. M. Fair, (*American Society of Chemical Engineering Proceedings 90* (SA 6 no. 4148, 1-11, December '64).

Also recommended reading is "Solution to Estuary Problems and Network Programs," J. V. Leeds and H. H. Bybee, (*American Society of Chemical Engineering and Proceeds 93* (SA 3 no. 5277) 29-36, June '67).

Combatting the wastes of our technology with technology forms the theme of "Computer to Regulate Water Pollution", (*Control Engineering 14:* 20, December '67)

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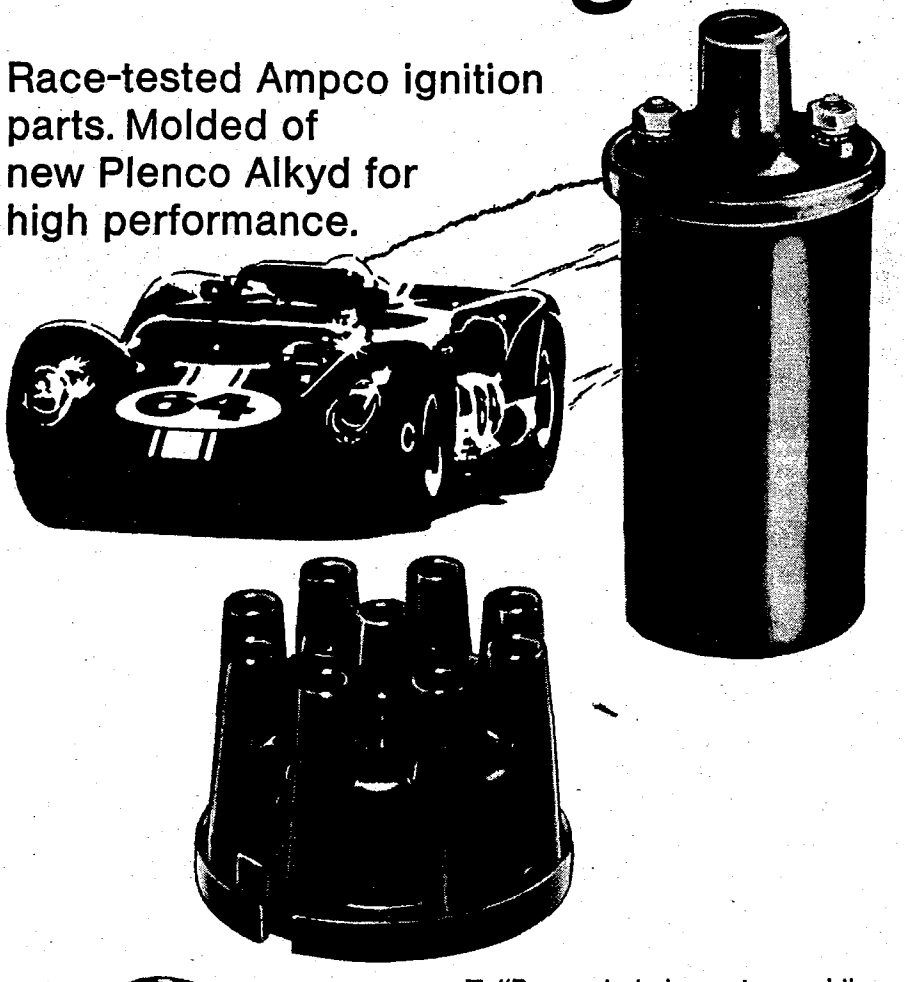

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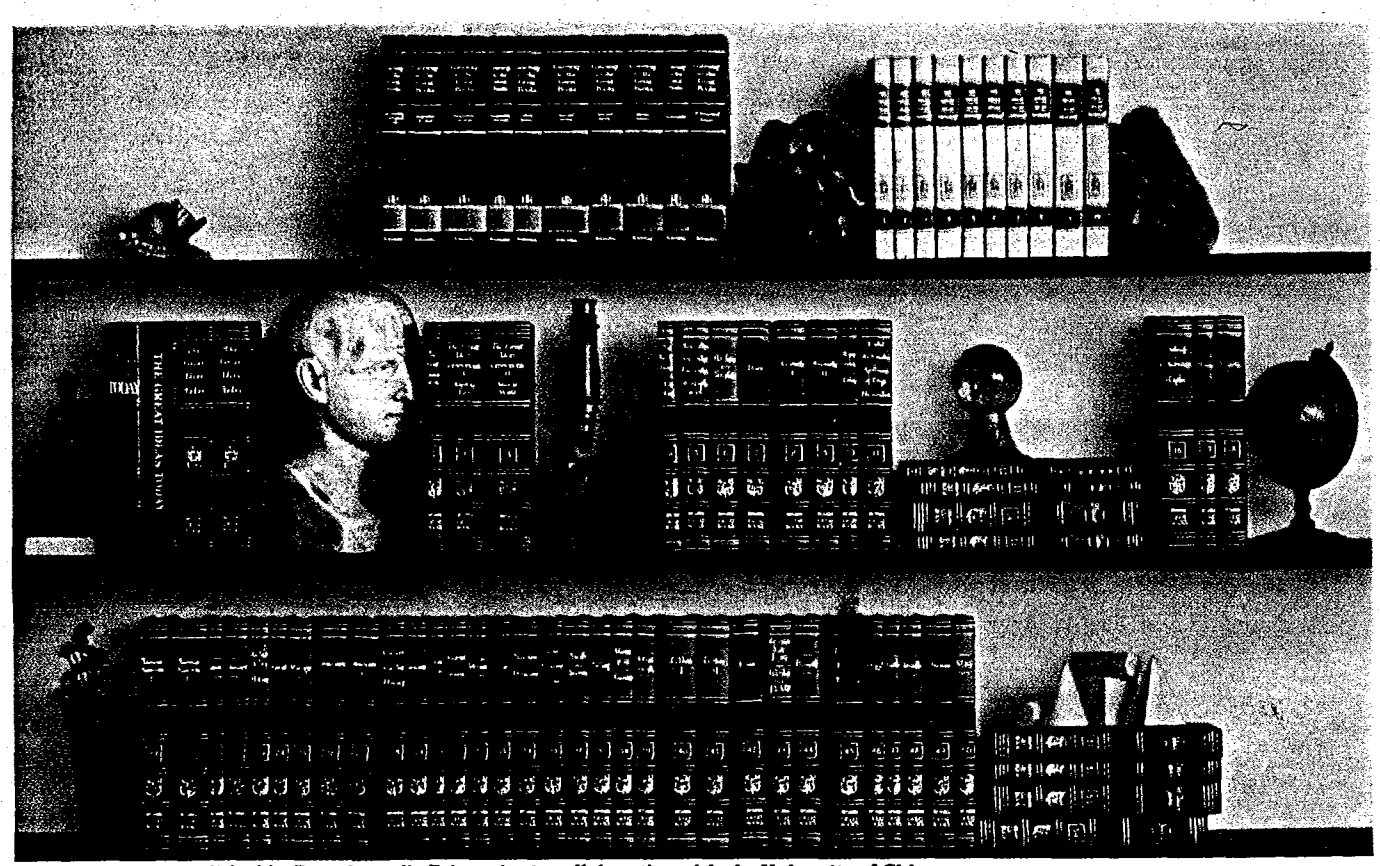

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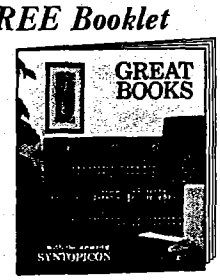

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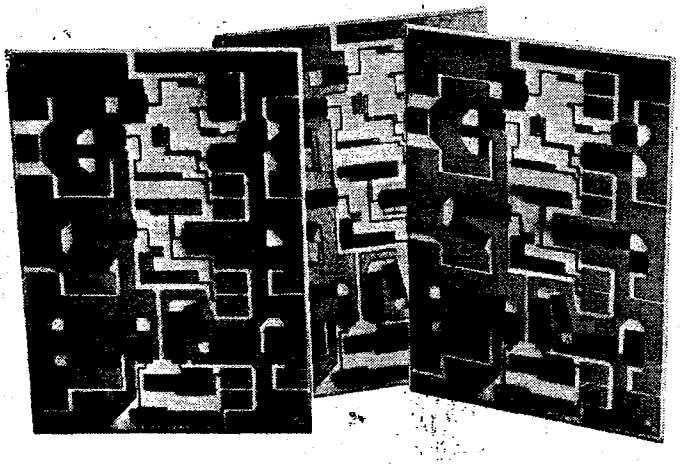

We decided that scoring the plates with a laser might prove effective. A serious challenge in this area involved the control of the laser beam itself. Precise control over the powerful beam—getting it to cut only a fraction of the way through the ceramic plates, for instance (and the *correct* fraction at that)—had not been achieved by any other manufacturer up to that time, to the best of our knowledge.

By using a digital control console to control the laser, we were able to control the pattern it cut with great precision. A pre-punched tape was fed into this console. This, in turn, controlled the path taken by the movable base holding the plate under the beam, while the laser itself remained stationary. This device is faster and more flexible than manual control; since tapes are used instead of dies, the cutting shapes can be changed in seconds.

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We hitched a laser to a computer to make squares out of circles.

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