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VOLUME 78, NUMBER 5

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wisconsin engineer

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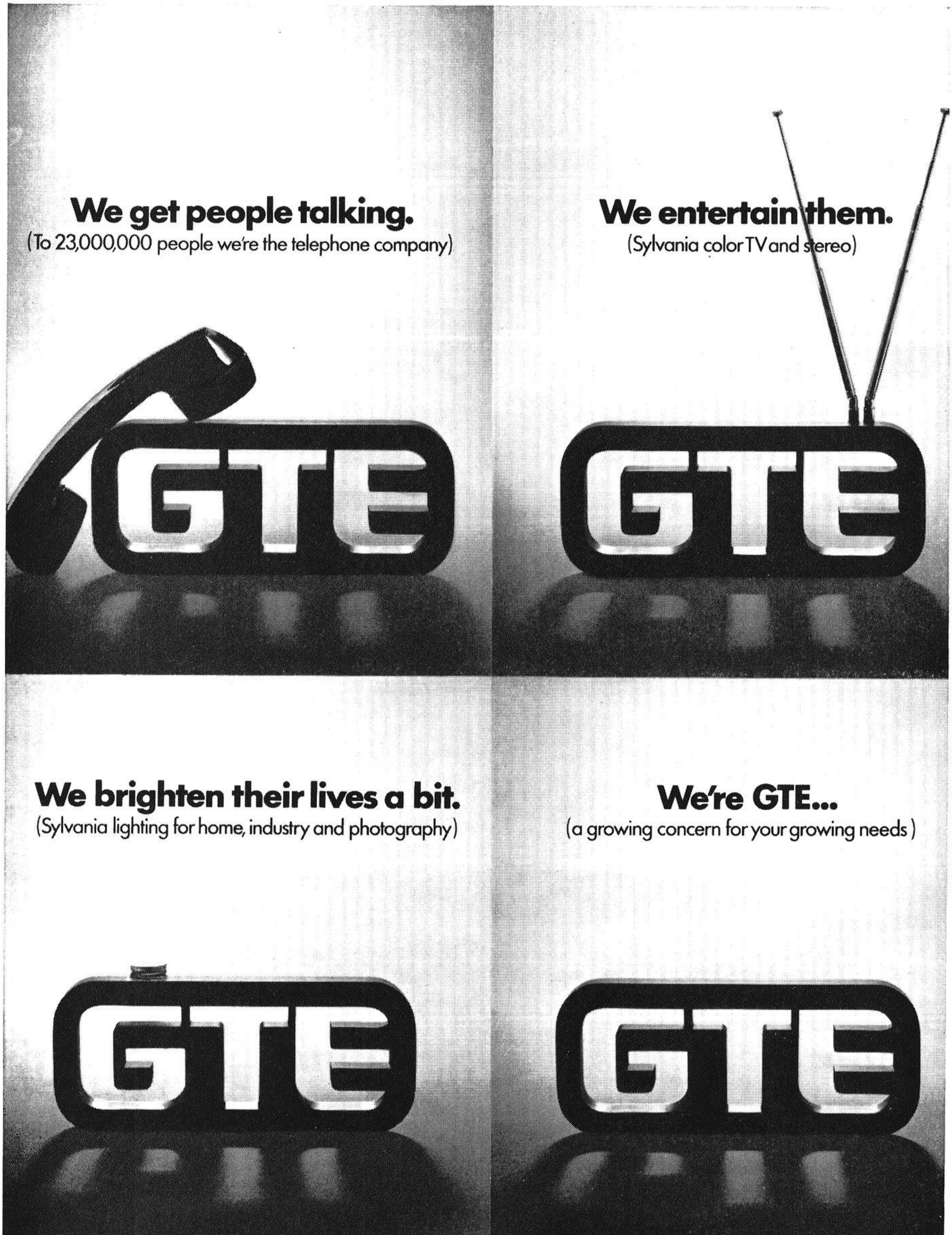

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"If we have a mild winter, we'll have a crisis. If we have a normal winter, it will be a disaster. More than that, and we'll have to coin a new word."

Stanley York
Director of Wisconsin Emergency
Energy Assistance Office

wisconsin engineer

PUBLISHED BY THE ENGINEERING STUDENTS of the UNIVERSITY OF WISCONSIN

CONTENTS

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Fuel Shortage Viewed As Real Crisis

Dean Robert A. Ratner

Because I recently had the opportunity to moderate a panel discussion on the current fuel shortage heard over WHA on the University Roundtable, I was asked to make some comments about the fuel situation. This was another instance of a person becoming an "instant expert" by virtue of the news media. Actually, I am no expert on fuel and the real experts were the panel members of the Roundtable: Professor Cameron in the Department of Geology, Professors Weiss and Cicchetti in the Department of Economics and Mr. Alston from the Governor's Office. So, speaking as a layman on the subject of fuel supply as a result of my participation with the experts in the Roundtable discussion, I am convinced that: there is indeed a fuel crisis in the United States; and that it is a real crisis and not a fabricated or contrived one for some political or economic gain.

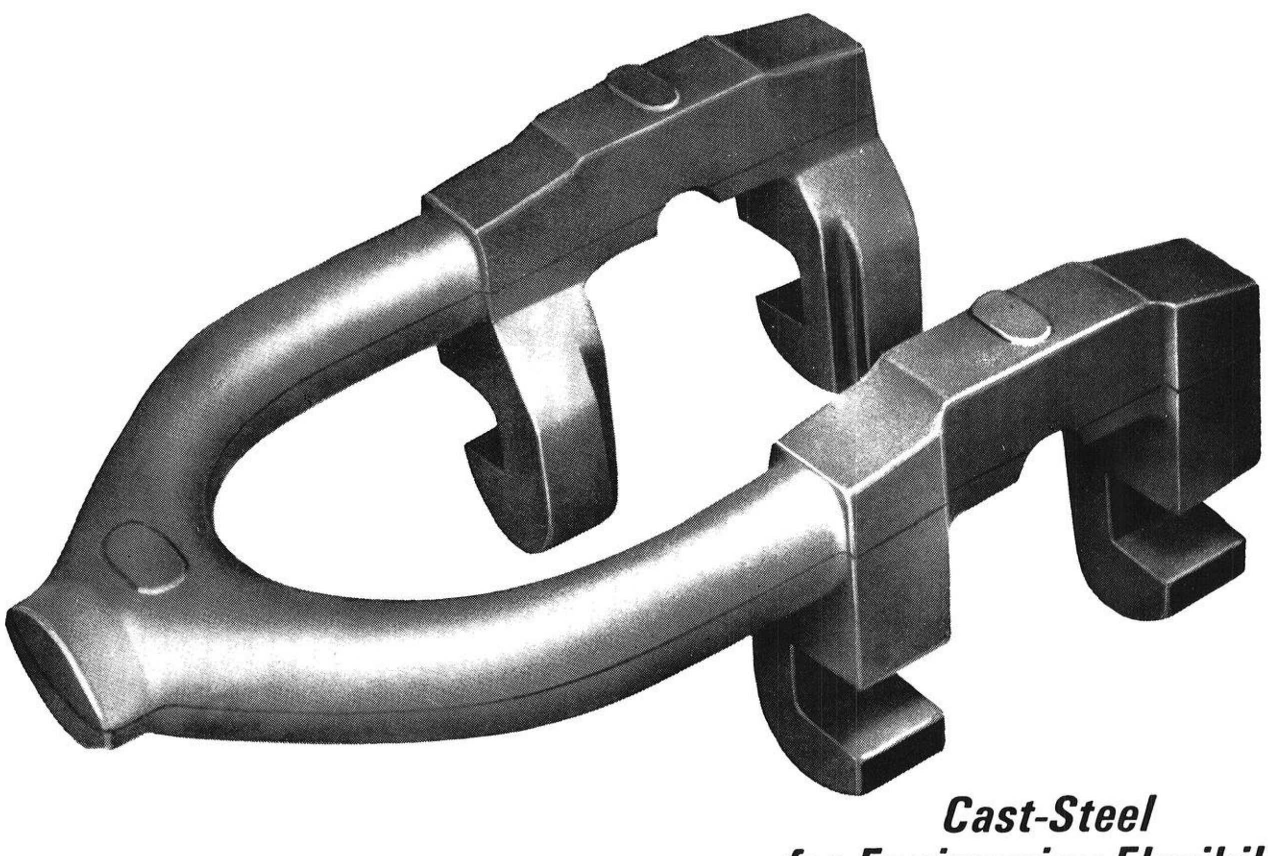
If you can accept the foregoing comment as a basic premise then you will not be misled by what I consider to be Red-Herring type articles that may appear in the press from time to time about U.S. shipping oil overseas or to the effect that there really isn't a shortage. If the Arab-Israeli war had not erupted and if we would have a mild winter, we might have squeaked through this year with no one being noticeably affected. But the oil embargo by Arab countries to the United States and to European countries that gave aid to Israel seems to have created a sufficient shortage so that we will all be touched by it.

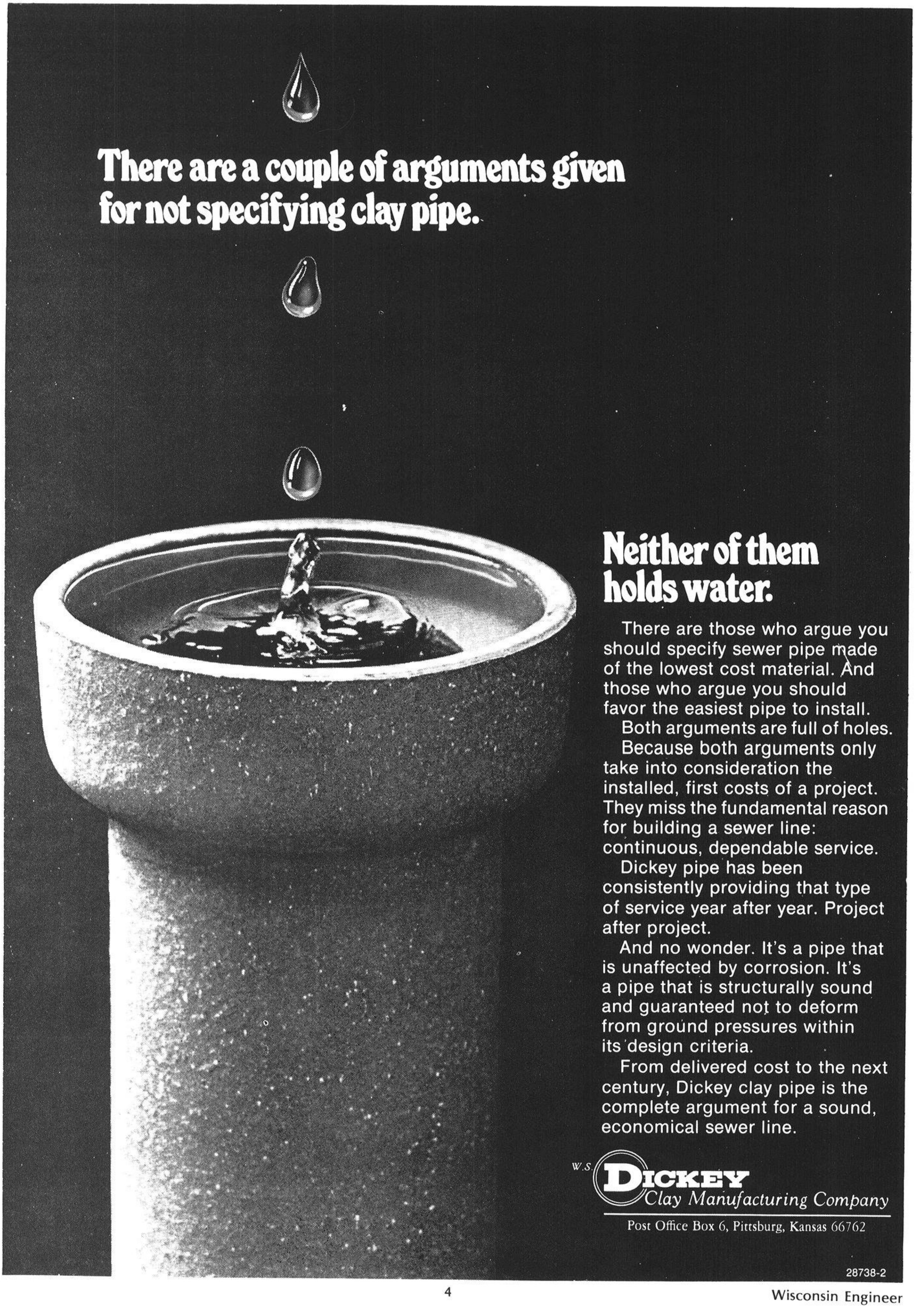
Now I've come, finally, to the initial point of this article and to the request that I would like to make, and that is, I appeal to all Engineering students to conserve energy in every way possible. Some of the measures that you can control might be: Do not burn any more lights than you actually need, turn off all lights when you leave the room, turn down your room thermostats to 68 degrees or 70 degrees during the day and lower at night. If you have a car, decrease your driving speeds and do all of the other things that you know about to increase your m.p.g. There are, no doubt, many other ways that you can think of. I am convinced that the crisis will be minimal if everyone does his best to conserve fuel, and I am hopeful that the University students with the Engineering students leading the way will set an example that all will want to emulate.

In the space that I have left, I want to comment briefly about the Engineering Expositions. As you may know, these are held every two years with the most recent being held last April. Planning for the Exposition to be held in the spring of 1975, will begin with the selection of a chairman for it by Polygon. This selection should be made very shortly. As soon as this person is chosen he, or she, will need chairmen for key committees. If you think that you are equal to the challenge and are interested in telling others about Engineering, as well as helping yourself, step forward, volunteer, be a contributor.

Student projects will be needed as well as student committee workers; so, if you are not interested in working on a committee, start planning a project now for inclusion in the '75 Expo. Perhaps a project on energy conservation would be interesting to you. I am sure that it would be appropriate.

This sounds trite I am sure, and probably "square", but believe me if you make the effort to contribute to Expo in some way either as a member of a committee or as an exhibitor, I feel sure that you will find the experience to be one that will pay off time after time. Thanks for listening and for the opportunity to talk with you. WE




There are a couple of arguments given for not specifying clay pipe.
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Pipeline Faces Final Test

by Pete Scheer

of the Engineer Staff

Engineering design is on trial in its quest to complete a cornerstone of President Nixon's 1980 self-sufficiency goal.

Proposed Trans Alaska Pipeline System

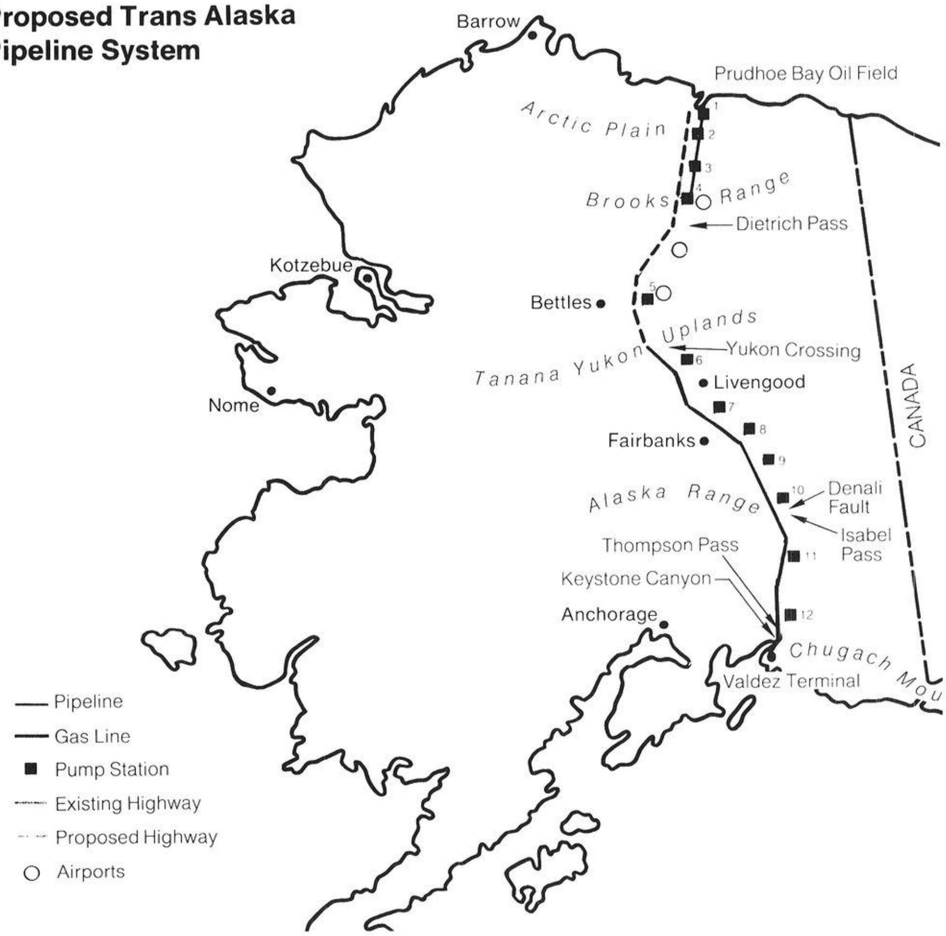


Figure 1: *Route of pipeline.*

In recent months, there have been frequent reports of a fuel shortage. Most Americans, not having had shortages of any kind, dismissed these reports as "rumors", or as stories concocted by the oil industry. But now with talks of fuel oil and gasoline rationing these rumors are becoming reality. The uncertainty of importing oil, especially from the Middle East, has caused renewed interest in retrieving Alaskan oil buried beneath the Alaskan North Slope.

Controversy over the pipeline proposed to carry the oil has kept construction idle for three years. Much has been written and said about the proposed Trans-Alaskan pipeline. Opponents have presented arguments against construction because of the potential ecological disturbance. Advocates have presented a rosey picture of the advantages of processing our own oil and an optimistic opinion of oil spillages in the Alaskan environment.

The sources of reference for the ecological effects of the pipeline presen*t*ed in this article are taken from three volumes of the "Final Environmental Impact Statement for the Proposed Trans-Alaskan Pipeline" as prepared by the Department of the Interior. The information on the pipeline and related construction is taken from the "Project Description of the Trans-Alaskan Pipeline" prepared by the Alyeska Pipeline Service Company. Alyeska is owned by several U.S. oil companies and will be directly responsible for construction and operation of the pipeline.

Figure 1 shows the proposed route, carrying oil from the Prudhoe Bay oil field, across Alaska and terminating at Port Valdez. The complete route will cross 350 rivers and streams and will cover three mountain ranges, as well as running over an active seismic fault.

Pipeline Design. The pipeline itself will be constructed of a low alloy steel, 48 inches in diameter with a nominal wall thickness of .500 inches. The pipe will be joined by welding sections of pipe 30 to 60 feet in length together to make a complete line 789 miles long.

This pipeline was tested at the Structural Research Center at the University of California at Berkeley. A typical section of a thirty-foot pipe was stressed to failure. Bending was stopped when a crack was discovered. The bend was in a welded area but the crack appeared in the base metal and not the weld.

The pipe was designed to meet standards set by the Department of the Interior. These standards include seismic shock that must be withstood by the pipeline in case of an earthquake. The table in Figure 2 lists the design criteria. The five zones of pipeline list a Richter magnitude equivalent to quakes expected to occur every 200 years on the average within these zones. The pipe is expected to deform, but not to leak under these circumstances. Also listed in the table in Figure 2 are the ground acclerations expected with these Richter magnitudes. Ground accelerations equal to half or less of these values will not require any more attention than an examination for leaks.

All sections of the pipe are protectively coated to prevent external corrosion. Above ground piping will be protected by a zinc coating, while buried piping is epoxy-sprayed and cathodically protected. Cathodic protection prevents electro-chemical metal removal from the pipe. Electric current is directed toward the pipe at all places except certain drain sections where cables direct flow to buried anodes which are sacrificially corroded instead of the pipe.

Since oil emerging from Prudhoe Bay will be hot (140-180 degrees F), the pipeline will be insulated to prevent heat transfer to the soil or ambient air and also to keep the pipe temperature above 20 degrees F in order to keep the oil viscous.

Three construction modes will be used in building the pipeline. Wherever possible, a conventional type of underground burial will be used. (See Figure 3). The requirement for this technique is a suitable ground of bedrock or well-drained gravel or soil. Approximately fifty per cent of the pipeline can be built in this conventional mode. In soils where lateral support is not deemed sufficient, anchors will be used to limit bending of the pipe.

In areas with unstable soil or rock conditions, or where permafrost melting would excessively deform the pipe, above ground construction will be used. Approximately forty per cent of the line will be above the ground. Depending on the terrain, the pipe will be supported by either pile bents or gravel berms. (See Figure 3). Construction on gravel berms will be used wherever possible, but will be limited by slope and gravel availability. In elevated construction, pile bents will be spaced fifty to seventy feet apart, with the pipe having a minimum of a two-foot ground clearance. Both elevated structures will be built in a zig-zag fashion to allow expanding and contracting of the pipe without over-stressing. Anchors will be spaced to prevent excessive movement by seismic or thermal forces.

In approximately ten per cent of the line, neither of these conventional modes of construction is possible. Areas with steep slopes and permafrost earth require a special burial construction. This special burial prevents excessive thawing of permafrost and reduces the possibility of losing support for the pipe. In some cases, the thermal insulation described earlier is sufficient, however in colder areas, additional steps must be taken.

One of these methods is to surround the pipe by a frozen liquid, whose melting point is below that of water. The heat lost from inadequate insulation will be absorbed by this liquid and will melt before passing any heat to the surrounding permafrost. The liquid will refreeze each winter, ready for a new cycle. In cases where this method is not sufficient, heat extracting piles that remove heat by convection, or mechanical insulation methods may be used.

In order to control oil flow, a system of 57 block valves and 23 check valves have been included in the pipeline design. Block valves are able to stop oil flow in either direction and are needed to isolate pump stations and terminals from the main line, as well as limit oil spillage in case of a break. The valve locations along the line will be determined by their effectiveness in stopping a possible leak, but in no case will be spaced further than twenty miles apart. Block valves will be located on both sides of the Yukon River crossing and both sides of the Denali Fault. These valves and others significant in controlling spillage, can be remotely or locally closed. The remaining valves can be controlled locally only. The time required for closing a block valve will be approximately four minutes. This is considered an optimum time, due to the increased surge and pressures

Route Segment	Richter Magnitude	Contingency Plan Earthquake Acceleration
Valdez to Willow Lake	8.5	0.5g
Willow Lake to Paxson	7.0	0.15g
Paxson to Donnelly Dome	8.0	0.33g
Donnelly Dome to 67° North	7.5	0.15g
67° North to Prudhoe Bay	5.5	0.10g

Figure 2: *Earthquake Magnitudes.*

caused by valve closure.

The check valves control flow only in one direction, are self-actuating by reverse oil flow, and have no external controls. These will be placed on slopes and other locations to limit back drainage in case of a break.

Twelve pump stations will be required when the system is operating at line capacity of two million barrels per day. Each pump station will have an area of approximately fifty acres, containing pumps driven by gas turbines, a tank farm, and buildings to house personnel. Eight of the twelve stations will have facilities to produce turbine fuel from the crude oil in the pipe.

The control of these pump stations is located in an operational control center (OCC) at the Valdez terminal. All information, such as line pressures, flow rates, temperatures, quantity of oil in the tanks, and valve positioning, is continually sent to the OCC via microwave telecommunications. At the OCC, two computors receive data and display it on two control panels. The system is designed so that in case of the failure of one component, the other can take over. From the data received, the computor can sense any abnormal conditions or leaks, power failures, or fires at pump stations, and appropriate action can be taken. In case of an emergency or a communication breakdown, pump stations have the ability to control pumps and valves independently of the Valdez OCC.

Leak detection of the line is carried out by computor and line status is displayed and updated every ten seconds. Four methods will be used in leak detection: pressure deviation, flow deviation, flow balance deviation, and line volume balance.

An alarm is sounded when a pressure deviation greater than fifteen pounds per square inch is detected by the computor between a pump station and normal line pressures. Similarly, flow deviation between pump and line values greater than one per cent of total line capacity will sound an alarm. Flow balance deviation is detected when the flow rate leaving one station differs by more than one per cent from the flow rate entering the next station.

The fourth method is the most sensitive. Line volume balance detection essentially compares how much oil enters the pipe to how much leaves, and how much is stored in or along the line. Initial line operations will have oil volume balance checked every 2000 barrels, with cumulative imbalance updated every 2000 barrels. This method is expected to detect leaks much less than one per cent of the line flow.

Another method of detecting small leaks is under consideration. The use of a "pig" which would travel with the oil and detect leaks by the hiss of escaping oil could perhaps detect leaks as small as five barrels per hour. In addition, aerial and ground surveillance will be scheduled once a week over the entire line to visually detect leaks.

Road and Airfield Construction. Road access is necessary for construction and maintenance of the pipeline. An existing highway runs parallel to the pipe route south of the Yukon River, so only access roads would be built here. A roadway would have to be constructed north of the Yukon to Prudhoe Bay (approximately 360 miles). The proposed road is a two-lane gravel road 28 feet wide. The road will be built according to standards set by the American Association of State Highway Officials.

Three permanent and four temporary airfields are planned. The three permanent fields will have 5000-foot runways and will be used to support construction and maintenance of the pipeline. Of the four temporary fields, two will have 5000-foot runways, and two will have 3000-foot runways. The temporary fields will be revegetated after construction is completed.

Tanker Facility at Port Valdez. The southern terminal of the Trans-Alaskan pipeline is the ice-free port of Valdez located on a natural deepwater bay in the Prince William Sound. The bay is 12 miles long by two and one half miles wide with a water depth of over 750 feet. It is here that the oil piped in from Prudhoe Bay would be transferred to tankers and shipped to refineries on the West Coast. The tanker terminal covers an area of about 900 acres. Built on bedrock 200-450 feet above mean sea level, the terminal will have excellent resistance to earthquake tremors.

The facility will consist of a tank farm, a ballast treatment unit, fire protection station and control buildings. The tank farm will hold seven pairs of tanks, each pair having a common level and surrounded by a concrete dike to contain any spill. Each tank is 250 feet in diameter, 62 feet high, and holds 510,000 barrels of oil. All tanks have gauges and alarms to prevent over-filling. The con-

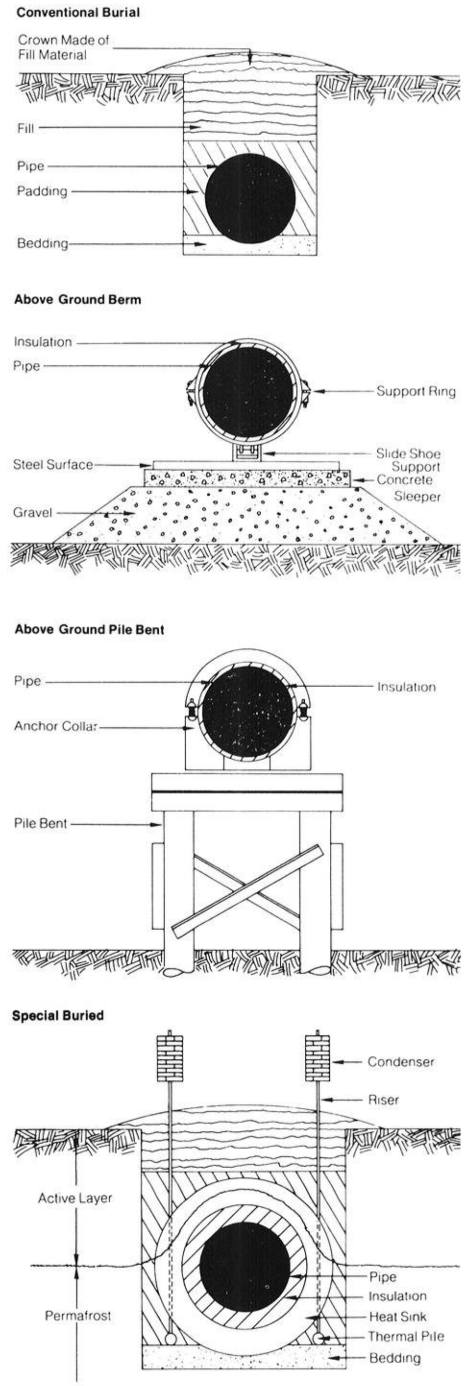


Figure 3: *Pipe Supports*

taining dikes will enclose a volume of 110 per cent of the capacity of the two tanks plus an additional two feet to accomodate any water or ice that accumulates within the dike. The dikes will be constructed of rock with an impervious concrete core at least eighteen inches thick. Both dikes and tanks will be designed to withstand earthquakes.

The Valdez facility carries ballast tanks and a ballast treatment unit. Ballast is water taken on by a tanker to fill its empty tanks to retain stability at sea. This seawater is mixed with oil and the usual procedure is to jettison this mixture directly into the sea. The ballast tanks and treatment unit is included in the terminal design to minimize this oil pollution. Ballast water is allowed to stand for a minimum of six hours in a storage tank after which the oil will be skimmed off the surface. This oil will be treated and piped to the crude oil tanks. Following skimming, the ballast will be chemically treated and an estimated ten parts of oil per million of water will be dispersed through jet orifices into Valdez Harbor. An estimated 300,000 barrels of treated water will be discharged into the harbor per day.

Fire prevention for the terminal is provided by a central pumping system. Three pumps delivering 15,000 gallons per minute at 445 psi, are activated automatically by a pressure drop or fire alarm signal from any ship berth or the tank farm. Additionally, a foam system is ready at the ship berths and tank farm to coat the area with a water-foam solution. Steel towers at the loading dock will hold the foam and water nozzles. The placement of these towers is such that any point on the loading dock area will be covered by at least two water streams and two foam streams.

Water will be delivered to the tank farm such that each pair will have full coverage and keep reserve pressure of 125 psi in all hydrants.

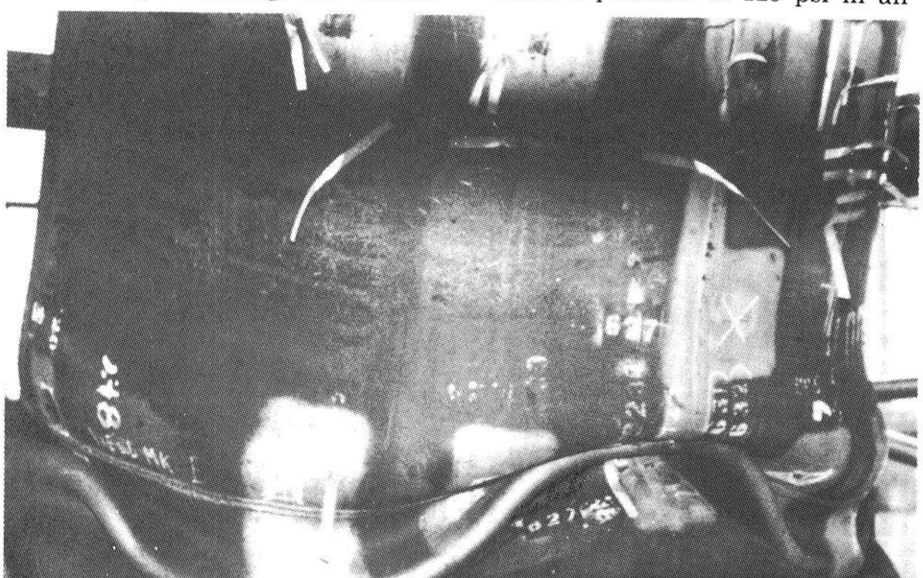


Figure 4: *A representative specimen of the pipe is shown at the point where the first crack formed. Wall thickness of the pipe is 0.462 inches. The initial wrinkle was formed with an internal pressure of 25 pounds per square inch, an axial force of 1.92 million pounds and a lateral or bending load of 750,000 pounds. At this time the 31.5-foot long specimen had a bending deflection of 1.2 inches at mid-length. Bending was continued, with the internal pressure increased to 932 pounds per square inch and the axial force increased to 2.55 million pounds. The first crack formed when the pipe had deflected 33 inches as shown. A girth weld was tested and is shown in the wrinkled section. A welding flaw was also purposefully introduced. The crack is located in parent pipe metal in the heavily wrinkled section.*

The tankers transporting the oil will all be U.S. flag ships varying from 50,000 to 250,000 deadweight tons (DWT). The estimated number of tankers required will be 41, 33 of which will be specifically built for Alyeska at a total cost of about one billion dollars.

Ecological Impact. It is difficult to accurately predict the full range of effects that the pipeline construction will produce. Studies done by Alyeska, the University of Alaska, and many other organizations and individuals have attempted to fully understand the impact of the pipeline construction on Alaskan ecology. These have been collected in a three-volume Environmental Impact Statement, put out by the U.S. Department of the Interior. Exerpts from this and an Alyeska environmental impact publication will be used to discuss some of the possible consequences of pipeline construction and oil spills.

Construction will result in the removal of the vegetative covering of the affected areas. Permafrost regions depend on this covering to remain frozen; removal of such vegetation will result in thawing, and subsequent erosion of the landscape. After construction, Alyeska plans to reseed and plant grasses and shrubbery to replace the native material. These are expected to stabilize the permafrost and allow native vegetation to recover. Due to the short growing season, this may take 5 to 7 years.

Increased erosion of the land along the pipeline route is expected. Increased siltation of streams and rivers is not believed to be detrimental to fish in these waters. However, increased silt in clear, spawning waters are likely to reduce fish reproduction. According to the impact statement, erosion is not expected to be excessive if proper controls are exercised during and after construction.

Construction materials will be obtained from the vicinity of the pipeline route. Sand, gravel, and rock needed for roads, pipe berms, pump stations, and trench backfill, will be collected from 54 quarries and 234 borrow sites. The borrow sites include glacial moraines, sand dunes, river flood plains, terrace sediments and river bars of streams laden heavily with sand and gravel. Quarry sites will be found in surface bedrock usually on ridge tops. Estimated material requirements for the entire pipeline is approximately 67.5 million cubic yards.

The effects of a pipeline on migratory herds, such as caribou, are not fully understood. It has been found that such animals do not hesitate to cross man-made structures such as roadways and airports. What is not known is how the animals will cross a pipeline as a herd. Experiments done by Alyeska have shown that a group of caribou when faced with a simulated pipe complete with over and under passes have split; some of the animals crossing while others following it to the end of the two-mile test section, then crossing over. The ground elevations of the pipe on pile bents ranges from two to eight feet. Such clearances are sufficient for all animals wishing to cross the pipeline. Some sections allow small animals to cross while blocking a larger one. This may separate the young calves from the caribou herd, leading to increased mortality among the young. It is probable that the herds will be diverted from their natural migratory paths resulting in disruption of traditional habits and movements. Sections of pipe supported by gravel berms are crossable only by ramps. Animals will either cross or change migratory habits. A danger to hooved animals crossing buried pipe is the backfill which may not freeze over readily. This muck or ice mud may entrap animals as has been previously discovered in similar situations in Sweden.

Of major concern is the probability of an oil spill. Alyeska does not expect great quantities to be lost because of their extensive prevention measures. Estimates have been made of the total volume of oil that would be spilled between the time of separation of the pipe and completed valve closure based on a ten minute duration. It is to be noted that these values are only for a complete rupture of the line which is not expected even during earthquake ground accelerations. Further, the highest spill volumes are found in areas of the lowest seismic activity such as the North slope. The valving was positioned with respect to seismic rupture probability and hence spill volumes vary inversely with the probability of oil spillage.

Maximum Potential Amount of Drainage (Barrels) Following Shutdown.

			Miles of Pipeline	Percent of Pipeline
0	—	5,000	115.0	14.6
5,000	—	10,000	139.4	17.6
10,000	—	15,000	137.0	17.4
15,000	—	20,000	118.3	15.0
20,000	—	25,000	95.5	12.1
25,000	—	30,000	70.2	8.9
30,000	—	35,000	47.2	6.0
35,000	—	40,000	32.2	4.1
40,000	—	45,000	22.4	2.8
45,000	—	50,000	11.8	1.5
			789.0	100

Figure 5: *Distribution of leakage after pipe failure.*

Oil spills along the pipeline would kill vegetation in the vicinity. The exact acreage of land so affected is determined by the amount of oil, temperature and slope of land.

Oil in streams and rivers could (1) interfere with the respiratory tract of fish, (2) coat and destroy algae and plankton, (3) settle to bottom and interfere with spawning, and (4) deoxygenate water sufficiently to kill fish. Oil in streams can be spread downstream and eventually be washed to the sea.

Water pollution in Port Valdez is expected from the treated ballast water and normal crude oil spills into the harbor. 300,000 barrels of treated water containing less than 10 parts of oil per million parts of water will be introduced to the harbor each day. This is equivalent to 4-8 barrels of oil per day. It must be pointed out that such treated water is likely to contain water soluble elements which are up to three times as toxic as the crude oil with which it is mixed. Comparing toxicity then, 5 barrels of oil in effluent from ballast is equivalent to about 15 barrels of crude. Again it is difficult to estimate the results of such practices because of the many variables involved.

Alyeska has estimated .037 ppm of oil in the harbor resulting from 10 barrels spilled per day. Tidal actions are still being studied and conclusions are not available as yet. Significant spills in this area and in the Prince William Sound can affect large amounts of marine life, especially salmon which spawn in this area.

The air quality in Port Valdez is not expected to change signficantly after construction of the tanker facility. All exhaust emissions and oil vapors will be within standards set by National Primary Air Quality control and Alaskan state air pollution guidelines.

Only a small portion if the impact statement was summarized here. Overall it is recognized that a Trans-Alaskan pipeline will change the land and water characteristics of the area to some degree. Estimates of this degree are difficult to make because of the number of variables and because this will be the first long pipeline in so cold a region. Many conditions encountered are unique and will only be fully understod after construction of the pipeline.

After years of debate in Congress over the Alaskan Pipeline issue, it has taken a major energy crisis to come to a conclusion. On November 16, 1973, President Nixon signed the bill authorizing the construction of the oil line from Prudhoe Bay to Valdez Harbor. While it is no longer a national issue, it will remain a public concern — throughout its construction and in subsequent years. The engineering design must be put to trial and the consequences evaluated. WE

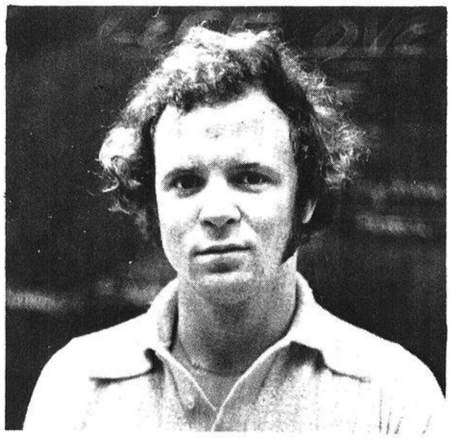
The Calculating Revolution

by Rick Giesler
of the Engineer Staff

If you are enrolled in the school of engineering or plan to in the near future, along with your books, pencils and paper, you will probably need an electronic calculator. Electronic calculators are the hottest selling item in the electronics field today.

The start of this industrial success may be traced back about two years ago. Before then, most calculators were mechanical and consequently slow, noisy, and awkward to carry. With the beginning of electronic calculators came increased speed, less noise and greater accuracy.

The basic "heart" of the calculator is one circuit called metal-oxide silicon large-scale integration (MOSLSI). The MOSLSI performs the entire computational function and may represent as many as 8000 discrete transistors. Along with this circuit are needed devices to supply power, generate clock pulses for the timing circuit and provide for input and output.



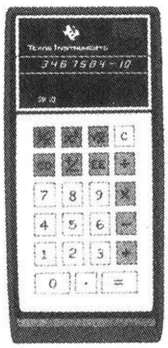
Rick Giesler

While the computational circuitry are always being improved, so are the designs. New light-emitting diode displays made it possible for small sizes with excellent readibility. Power supplies are adapted for AC or battery operation. Physical improvements included new plastics for lighter, stronger cases.

The three most common calculators around campus are The Data Math, Texas Instrument SR-10 and Hewlett Packard-35.

The Data-Math, a product of Texas Instruments, offers the simple functions of addition, subtraction, multiplication and division, as well as a single constant memory. It features operation from an AC wall socket or from it's internal batteries, eight digit display, and a floating decimal. A constant may be stored for use in repetive calculations.

The Texas Instrument SR-10 is larger than the Data-Math. It can do everything the Data-Math can do except store a constant. In addition the SR-10 features exponen-



Texas Instrument SR-10

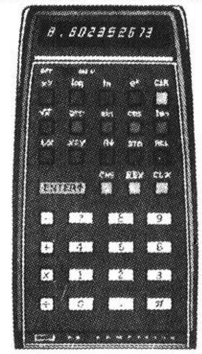
tials from 10^{-99} to 10^{99}, along with square root, square, and inverse keys.

The Hewlett Packard HP-35 is a 35-key, pocket-sized scientific and engineering calculator. It performs logarithmic, trigonometric, and mathematical functions with a single keystroke. The HP-35 has special keys for π inverse function, and features a four stack memory. You may also raise a number to any power.

The price one pays to perform these electronic wonders depends on the size of the wonder. A basic pocket calculator such as the Data-Math sells today for about $70 although a year ago the price was $125. The price of the SR-10 has dropped from $160 to $99 today. The HP-35 has dropped from $395 to today's present price of $295.

The prognosis for the calculator industry in the foreseeable future will be nothing short of excellent. Forecasted sales are 1.2 million units. Gross sales this year alone totaled $350 million with a potential market four to five times that amount in a few years. Further price decreases made possible by better designs and manufacturing techniques are inevitable. Competition is also growing at an accelerating rate and each price decrease seems to uncover another new market.

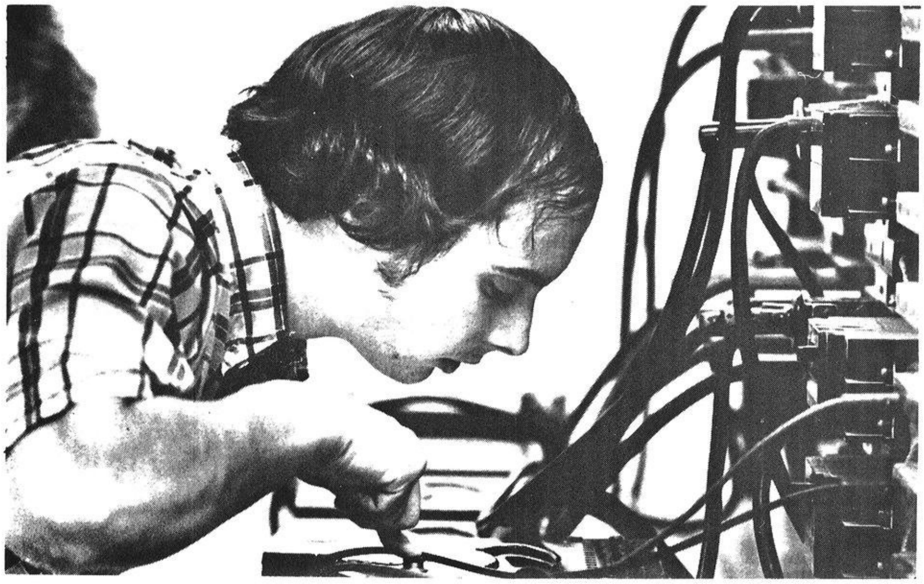
Calculators are permissable in most engineering courses taught at the University, although a few professors refuse to give up the slide-rule. There is no rule on the use of calculators for exams presently, although there has been much controversy over the issue. Some people feel those that do not have calculators are at a disadvan-



Hewlett Packard HP-35

tage at exam time, even though most exams are designed with "easy" or "workable" figures, or just "set up" problems. It has been estimated that over 30 percent of a sophomore electrical engineering class use calculators.

Calculators are replacing the slide rule at a fantastic rate. Before long, slide rules may become a collectors item. WE



From

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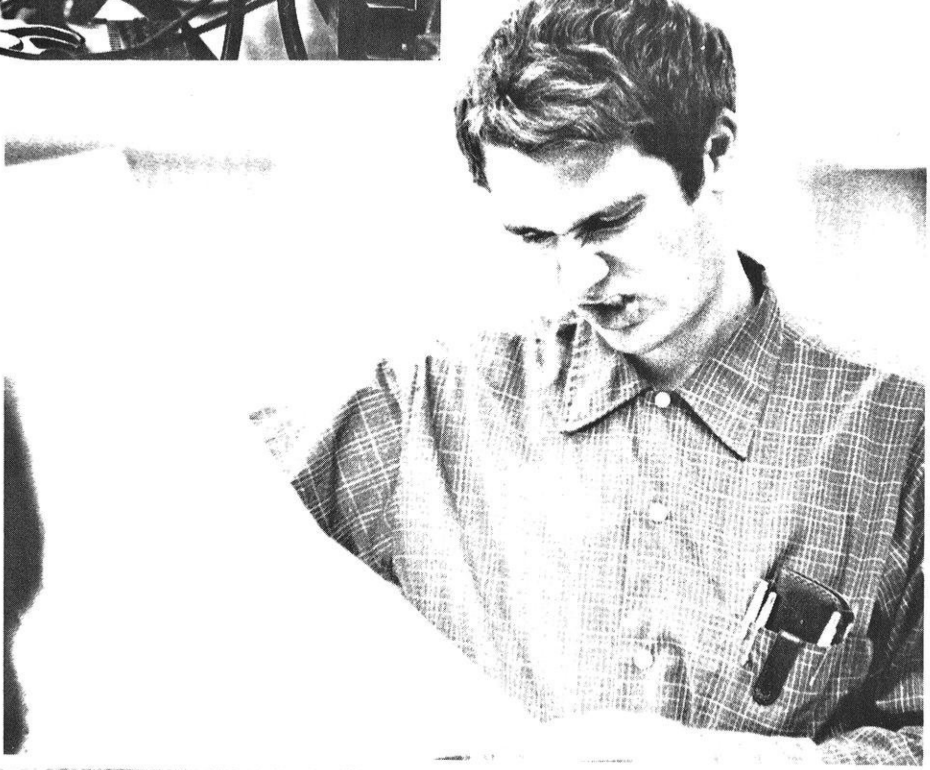


Drowning the Oceans in Oil

by Don Johnson
of the Engineer Staff

Perhaps the most recent discovery about the extent of pollution is that the oceans, which cover three-fourths of the surface of this planet, are also in trouble. Consequently, pollution and imminent self-destruction seem to be closing in from all sides — from above in the air; from within from dumps, streams and lakes; and from around us, in the "boundless" sea.

During a voyage in a small boat from Africa to Central America, Thor Hyderdahl, Norwegian author-explorer and former skipper of the "Kon Tiki", was shocked by the extent of pollution. In a report to the Norwegian Mission at the United Nations, he said "Large surface areas in mid-ocean as well as near the continental shores on both sides (of the Atlantic) were visibly polluted by human activity." He explained that jetsam appeared hundreds of miles from land, and almost every day, plastic bottles, squeeze tubes, and other forms of industrial civilization floated by.

Dr. Max Blumer of the Woods Hole Oceanographic Institution told *National Geographic,* "Man puts at least three million tons of oil a year into the oceans. The yearly total may run as high as ten million tons, which doesn't include tanker wrecks or production accidents."

Attention, then, must also be given to the less spectatcular but more persistent, more pervasive problems of deliberate and negligent oil spoils. Two million tons of oil each year come from tankers flushing out tanks at sea, only because local laws prevent them from doing so in port. Recently, the U.S. Coast Guard estimated that the nation may be experiencing a spillage of pollution materials to U.S. waters approaching 10,000 incidents annually, with oil leading all other categories by a ratio of three to one. Oil can be discharged from ships during the following operations:

- Cargo transfer and handling.
- Deballasting the vessel.
- Cleaning oil tanks.
- Pumping bilge waters (which usually contain waste oils).

Another source of pollution is pipelines. The U.S. is laced by about 200,000 miles of pipelines, which, in 1965, carried more than one billion tons of oil and other hazardous substances. Offshore mining, also a major oil pollution source, contributes to pollution of offshore waters through the following operations.:

- Blowouts of wells.
- Dumping of oil-based drilling muds and oil-soaked cuttings.
- Losses of oil in production, shortage, and transportation.
- Rupture of pipelines by storms and the dragging of ships anchors.

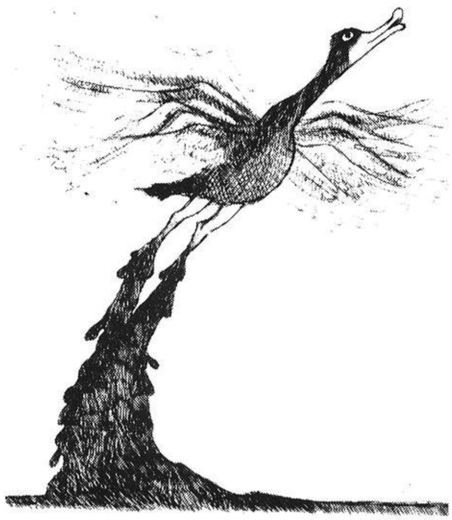
Immediate clean-up of a spill is a primary concern. But toxic elements dissolve and remain diluted with a poisonous effect.

On the average, clean-up costs for massive spills are approximately \$1 to \$3 per gallon, depending on whether it is an inland or offshore ocean spill. Some data reports that the direct costs for oil clean-up range from \$1700-4100 for small (1000 gallons) harbor spills, from \$64,000-115,000 for medium (100,000 gallons) offshore spill, and from \$4.5-8.5 million for a large (10 million gallons or 30,-000 tons) offshore spill.

Those figures, though, only include the cost of cleaning-up. In a report to the President, prepared by the Secretaries of Interior and Transportation, it was noted that the effect of a major pollution episode on any particular recreation region is not difficult to estimate. For example, a serious spill along the Long Island shore during summer months could mean 20 million people-visits-people times visits-would be lost. Assuming an economic loss of \$1.50 per lost visit, the immediate loss could be \$30 million. A serious spill in the Los Angeles region could cause the loss of 34 million people-visits, costing in the vacinity of \$51 million. The report is quick to point out that these costs do not include the economic or ecological damage to wildlife resources and the eco-system.

This touches on the immediate problem of what specific measures can be taken in the event of a critical oil spill to keep the damage to a minimum. William E. Lehr, Chief of Pollution Prevention Projects of the U.S. Coast Guard, wrote in *Technology Review,* "No matter where it is, the steps to be taken in response to any oil spill are similar. They include securing the source of leakage, containing and concentrating the oil that has been released, harvesting the spilled material, disposing of the recovered liquids, and restoring contaminated areas."

Several measures have been used, or proposed, to handle the critical problem of cleaning-up an oil slick. Shoreline spills are frequently cleaned up by using the oil floating on the surface of the water, and then raking it onto the shore. Another, less controllable means, is to set fire to the surface oil and burn it off. Less familiar



methods include the use of chemicals to disperse the oil, and the use of microbes to make it "disappear" by "devouring" it. Lehr explains that a prototype of a fence-type barrier has been developed. Buoyancy is furnished by air-inflated horizontal tubes 36 in. long by 14 in. diameter, spaced every 66 in. along the barrier. Tests in March, 1972, indicate that the barrier can survive 40 m.p.h. winds and 10-knot currents, and contain oil in 20 m.p.h. winds and five-foot seas.

According to Blumer a large oil spill is an emergency and should be treated as quickly as possible. Toxic elements dissolve quickly into the sea water. Removing the oil from the water is the best method. Pumping it into another ship or into an air-dropped "bladder", which is similar to a large, flexible, plastic tank, is highly recommended. Dr. Blumer offered burning as another alternative if pumping was impossible.

The immediate impact of an oil spill is a primary concern, but when the slick may be cleaned up, there are still the long term effects. Blumer reports that "toxic elements dissolve quickly into the sea water" and remain diluted with a poisonous effect that persists long after the oil had been either soaked up, pumped out, or dispersed away. He explains that, while detergents and dispersents may get the problem out of sight, they do it by sinking the oil down into the marine environment where it can do more harm. This narrows the most effective clean-up to complete removal.

What must be concentrated on, though, is not what to do about the problem, but what to do about the cause. The United States consumes far more oil than it produces, making the need for the oil industry great. Almost 4 billion barrels of petroleum and natural gas liquids are used annually in the U.S. By 1980, the figure is expected to reach 6.5 billion barrels.

The major efforts in dealing with the oil pollution problem is in its prevention. Two important technical problems are being studied:

•Improvement in the design and construction of vessels.

•Improvement in the navigation of the vessels.

According to "Environmental Science and Technology" magazine, the use of recommended sealanes needs to be expanded to assure the most orderly movement of traffic in U.S. territorial waters and beyond. The magazine also suggests an examination of the feasibility of some form of shore guidance system to promote safe movement of shipping.

Since 1968, the Coast Guard has established sealanes in approaches to major U.S. seaports. Regulations have been developed to require deck spill containment systems, emergency shut-down valves in transfer systems, development and posting of approved instructions for conducting transfer operations, licensing of personnel in charge of transfer operations, and improved equipment tests and inspections.

'Finger-printing' oil may trace the origin of a slick and help determine liability.

Examples of traffic systems seem promising: the stop-and-go traffic signals on the Mississippi River, control of traffic on the St. Marys River between Lakes Huron and Superior, a communications control network on the Chesapeake and Delaware Canal, radar-assisted navigation at the port of Long Beach, Calif., and a combined radar and communications system now in use in the Cape Cod Canal.

A short radar monitoring system, installed in San Francisco Harbor, has been helping ships navigate, since January, 1970. A radar operator maintains information on the position and destination of participating vessels. He also monitors the movements of all other craft in the harbor, and furnishes advice on nearby ships and other navigational hazards.

Although it took great ecological disasters to draw attention to the need for action, the United States congress is making some progress towards tackling the problem. Amending the 44 year old Oil Pollution Act of 1924, the Oil Pollution and Hazardous Substances Control Act of 1968 expands present legislation to cover the following additional points:

•Extends the prohibited area for spills.

•Includes shore facilities for the first time.

•Provides for cleanup.

•Specifies other hazardous substances.

•Makes owners liable for the full cost of cleanup rather than limiting the cost to the salvage value of the vessel.

Discharge of oil is prohibited from vessels in waters within 12 miles of shore, which includes both the three mile territorial and the nine mile bordering zones. For the first time, shore facilities are prohibited from discharging oil into their seaside waters. And also, if owners of a vessel fail to clean up an oil spill caused by that vessel, the Department of Interior would be empowered to do so. The full cost incurred by the Interior would be levied on the vessel's owners. The legislation authorizes a revolving fund in the U.S. Treasury to be used by the Secretary of Interior to carry out clean-up operations.

Another measure hoped to be effective is the Nautical Contingency Plan. The plan provides a mobilization scheme in the event of a major oil spill accident. This scheme would hopefully provide sources of equipment as well as manpower, both of which must be determined in advance of any emergency situation.

Much oil pollution occurs in the middle of the oceans. The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measures taken by the U.S. government affect only the small area of our coastal waters. The oceans will not be protected unless international controls can be adopted. Two important conventions on oil spills and cleanup are the most important recent achievements of the Intergovernmental Maritime Consultative Organizations (IMCO), the specialized agency of the United Nations that provides cooperation in all shipping matters, and involves 68 member governments. The two agreements adopted by IMCO include authority for the:

•Right of coastal states to intervene in oil spill casualties if their shorelines are threatened by the incident.

•Civil liability to both coastal states and owners of shoreline property for oil cleanup.

The significance of these agreements is that they hold ship owners and operators to strict liability and are broader than legislation by Congress, which does not cover third party liability.

In spite of their pragmatism, the cooperation of the oil industry is encouraging. They are now assisting one another on oil spill clean-up. Referred to as cooperatives, an agreement is made in advance by an oil company to help a neighbor who has an oil spill. One year ago there were 23 cooperatives and 27 more in the formative stages. In addition, the industry is developing a voluntary plan for tanker liability. According to L.P. Haxby, chairman of the American Petroleum Institute committee on oil spills cleanup, "More than half of the free world's tanker owners are now enrolled in the plan. Under the plan, participating tankers accept responsibility to reimburse any national government for the costs it incures in cleaning up oil spills they negligently cause." While their ethics are commendable, it's their sly benevolence that is striking, particularly in the face of legal action.

Although legislation gains the cooperation of the involved parties, technical research provides invaluable insight and knowledge on how to handle the problems of oil pollution.

For many years the Coast Guard has conducted routine surveillance overflights of harbors and the coastal high seas. To improve detection the Coast Guard began development of an all-weather, airborne sensor system in 1968 that would not only improve detection and subsequent prosecution, but also provide early warning of unreported spills, their location, quantity, and movement.

The Federal Water Pollution control Administration (FWPCA) has created a laboratory with the purpose of continuous updating of technological advances for prevention, control, restoration, and advice pertinent to oil pollution. Projects include improved methods for cleaning oilsoaked birds, and the improvement of devices such as booms for 'coralling' oil spills so that other than quiet harbor operations can be handled.

One research program, currently funded by FWPCA grants, involves the use of a pneumatic curtain of air to protect bathing beaches from pollution. Theoretically, the circulation pattern of water, caused by the rising bubbles, will set up a barrier for flotsam and oil.

Research is also being sponsored by the individual oil companies themselves to prevent costly oil spills, saving themselves money in the long run. Western Company of Richardson, Texas is investigating techniques for gelling tanker cargoes to prevent oil loss in the event of an accident. The funding is being provided by a special government contract. Other federal contracts have been awarded for the development of oil sensors, beach cleanup, and better mechanical recovery and separation devices.

In the arctic neighborhood, where the oil industry just moved in, large submarine oil tankers have been proposed. These would protect against the hazards of ice and storms. Ecologists hope that this concept will be used. It is feared that an oil tanker wreck in these arctic regions where the cold and ice would prevent the oil from dispersing would prolong and increase the extent of damage.

Another plan which is being studied is "finger painting" oil, a method designed to trace the origin of oil found on the open seas. In this way oil ships that flush out their tanks at sea can be apprehended by authorities so that the captains or owners can be charged with negligence.

Lehr cautions, however, "Spilled oil "ages", its composition being altered through biological decomposition, evaporation of more volatile components, and interchange of some components with water. Thus oil in an older slick can have a significantly different signature from that of its parent." In liability cases, "there may be more than one source for a slick of a particular kind of oil. For example, several vessels may have fueled from a single terminal, and any one of them, as well as the terminal, could be the source."

Technological developments can serve two purposes — to aid prevention of oil spills and to assist the enforcement of legislation against those responsible. All of the research, however, seems ironically reminiscent that "we have met the enemy and he is us."

While many may herald the development of programs and the relative burgeoning of research, experience has yet to prove their adequacy as legislative vaccines.

WE

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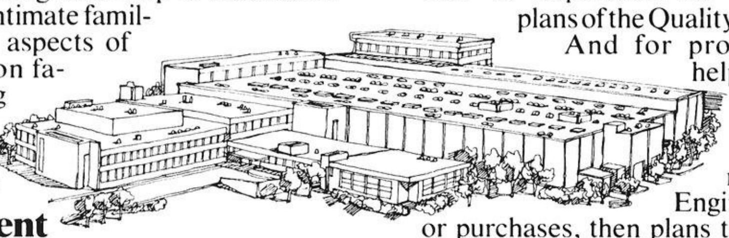

Factory Management

Factory managers supervise a factory's work force, materials and machines. Their job is to meet production schedules while maintaining product-quality standards, plant efficiency and a favorable working environment. To do this, they consult with, and implement the plans of, manufacturing engineers, quality-control engineers and materials experts. They also deal directly with the factory's production workers on a regular basis. Thus, good interpersonal skills and the ability to manage large numbers of people are vital.

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