Wisconsin engineer. Volume 79, Number 3 December 1974/January 1975

Madison, Wisconsin: Wisconsin Engineering Journal Association, [s.d.]

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wisconsin engineer

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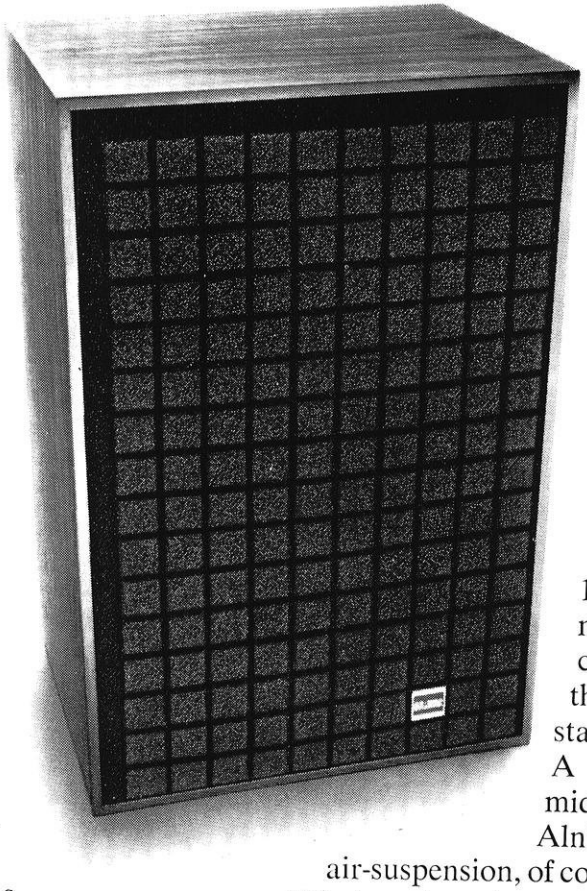

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Like everything else today, even the image of Santa Claus (see our front cover) has changed. But he's still his smiling, jolly old self, (though he has lost some weight.) Both S. Clause and the Engineer Staff wish our readers "Happy Holidays," and a safe return to school in January!

wisconsin engineer

PUBLISHED BY THE ENGINEERING STUDENTS of the UNIVERSITY OF WISCONSIN

CONTENTS

Member of Engineering College Magazines Associated

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Second Class Postage Paid at Madison, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized Oct. 21, 1918.

Published six times a year, Oct., Nov., Dec-Jan., Mar., Apr., by the Wisconsin Engineering Journal Assn., Subscriptions: one year —$2.00; two years—$3.75; three years—$5.25; four years—$6.50. Single copies are 35 cents per copy. 276 Mechanical Engineering Bldg., Madison, Wis. 53706. Office Phone (608) 262-3494.

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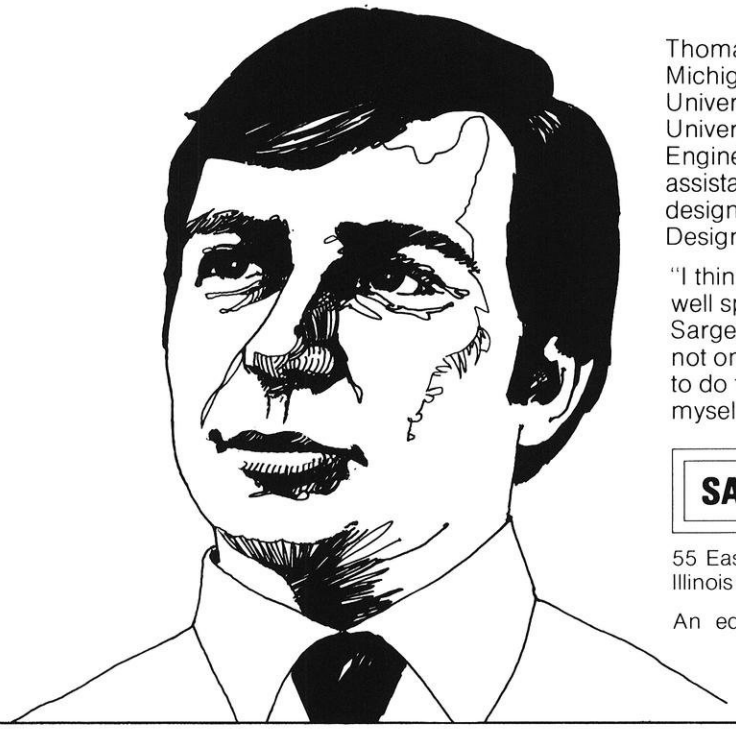

Thomas G. Longlais, B.S., 1969, Michigan Technological University; M.S., 1972, University of Wisconsin, Civil Engineering. Presently, assistant chief structural design engineer, Structural Design and Drafting Division.

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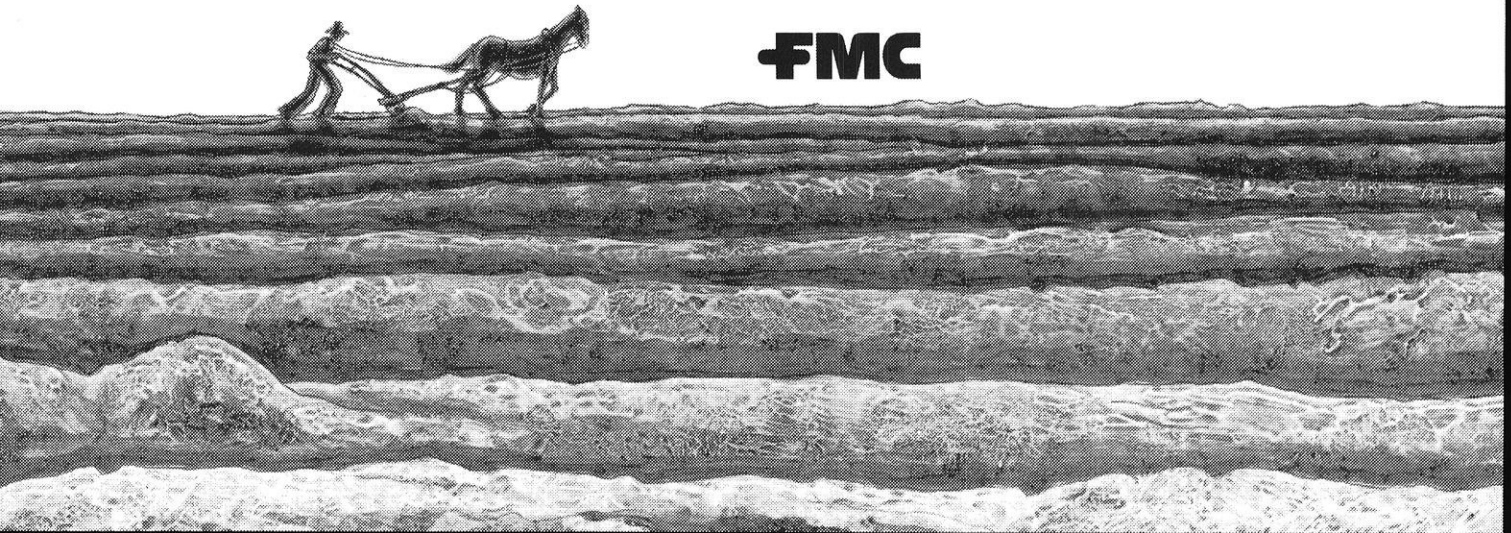

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wisconsin engineer

Vol. 79 No. 3

DON'T DRINK THE WATER:

It May Be Hazardous To Your Health

In ancient times the individual's daily water requirements for all purposes may have averaged three to five gallons. In today's industrialized world, however, as much as 70 gallons of water per capita are needed every day. In this article the WISCONSIN ENGINEER looks at the quality of those 70 gallons that Americans cook with, wash with, bathe in, and drink each day.

by Don Johnson
of the Engineer Staff

In 1969, three carcinogenic chemicals, known to cause cancer in animal experiments, were found in New Orleans drinking water after it had passed through the city's largest water - treatment plant. The plant supplies more than 110 million gallons of water a day to 600,000 people. This might explain the results of a survey from a quarter of a century ago that showed New Orleans to have the third - highest rate for kidney cancers and the sixth-highest rate for cancer of the bladder and urinary tract among 163 metropolitan areas.

"This difference suggests that an environmental factor may be responsible for the higher incidence in New Orleans" notes Dr. Lucia J. Dunham of the National Cancer Institute. "Contamination of the drinking water is an obvious potential source for such a factor."

In the days when man had nothing more to fear from his water than bacterial infection, the problems of adequate treatment were simpler, although primitive. But even then, treatment was never preventive, but rather curative—nothing was done unless people began dying; or the water developed a foul odor, a strange taste, and an ugly tint.

EPIDEMICS OF typhoid, cholera, dysentery, and other waterborne bacterial infections, caused deaths traceable to drinking water. This forced the establishment of community water supplies between the Civil War and World War I. These water systems did prevent yesterday's health hazards. But today, many of these overage and substandard facilities are still in use.

Writing in a **Consumer Reports** series on drinking water standards, Dr. Robert H. Harris, of the Environmental Defense Fund, and science writer Edward M. Brecher, report: "Water supply systems are primitive, and they are typically staffed by people trained in an outmoded tradition or not trained at all. As the level of pollution has risen in our sources of raw water, the techniques employed to make that polluted water safe for

human consumption have become less and less adequate. Instead of gearing up to meet today's environmental challenges, most community water systems remain geared to preventing bacterial epidemics alone."

"Poor quality water is due as much to untrained personnel as it is to inadequate standards."

Evidence for these generalizations come from three studies of the last five years:

- In 1969, the U.S. Public Health Service (PHS) published the "Community Water Supply Study," a survey of 969 water systems, serving 18 million people.
- The Water Supply Division of the U.S. Environmental Protection Agency (EPA) has conducted a series of similar studies since 1969 in seven states.
- The Comptroller General of the United States submitted a report to Congress in November 1973, covering 446 water systems in six states. It is commonly referred to as the General Accounting Office (GAO) report.

The findings of these reports indicate that concern for long-term control of lake, stream, river, and coastal water pollution has inadvertently distracted attention from a more immediate part of the pollution problem—maintaining the quality of piped water that 160 million Americans are drinking, cooking with, and bathing in right now.

OFTEN, THE PROBLEM arises from local authorities who flaunt the recommendations of the federal government. The PHS Drinking Water Standards, first published in 1914 and most recently revised in 1962, suggests bacteriological tests on two samples per month for systems serving 2000 people or less, rising to 500 samples per month for systems serving five million people.

No federal law, however, requires a water system to conform to these standards. In the Community Water Supply Study, 85 per cent of the 969 water systems surveyed failed to collect and test the prescribed minimum number of samples. Among the systems serving populations greater than 100,000 people, 64 per cent fell short of the suggested number of samples.

Not only do many communities fail to test their water but many do little to prevent potentially harmful levels of bacteria. The tests recommended by the PHS are designed to identify coliform bacteria—types of bacteria found in feces and soil. A moderate count is permitted. In the EPA studies, these standards were not met by one-third of the water systems in some states, and the GAO review found that 81 out of 446 community water systems did not meet the PHS coliform standards in two or more months during 1972.

This lack of vigilance is beginning to take its toll. Few large waterborne disease outbreaks occur any more, but the number of single incidents seems to be increasing: from one case of sickness annually per 100,000 persons in the period from 1946 through 1960, to two cases annually per 100,000 in the period from 1961 through 1970. It appears these antiquated systems with their apathetic personnel are beginning to fail their original purpose.

MANDATORY LIMITS ON hazardous metals have also been set by the PHS—and largely ignored. Among those pollutants are: lead, chromium, mercury, arsenic, barium, cadmium, selenium, and silver. Many of these metals and chemicals could be present in some 40,000 community water systems around the country. Of those systems surveyed by the PHS in 1969, 90 per cent had not tested for a single metal contaminent on the mandatory list during the previous year. Not much improvement had taken place by the time of the 1973 GAO report, which found that 79 out of 446 systems had **never** been tested for chemical and metal content.

The spector of unsafe drinking water becomes even more frightening when one realizes that even the federal standards that are not being met in the first place are frequently ignored and are not adequate in the first place. The PHS sanctions 10 coliforms per liter of water. In contrast the World Health Organization recommends a coliform standard that is 20 times stricter, and Maryland's standards for **sewage** discharged into certain bodies of water permit only **one coliform** per liter of water. This says in effect that it is illegal to dump into a Maryland river what the PHS deems fit to drink.

Not only do many bacteria slip past treatment, but so do viruses. The PHS Drinking Water Standards set no virus limits. Harris

Unsafe Soft Water

According to the U.S. Department of the Interior, water delivered from Wisconsin's public supplies is ranked with nine other states as being the "hardest" water, containing more than 180 parts per million (ppm) of calcium carbonate. As a result, most Wisconsin residents use water that is softened by the ion-exchange process of home water softeners, in which sodium is substituted for calcium and magnesium.

Soft water, however, may not necessarily be "good". Some English health authorities believe there's a link between the absence of certain minerals in soft water and cardiovascular disease. They point to studies showing that towns with soft water (averaging 32 ppm of hardness salts) have a cardiovascular death rate 50 per cent higher than towns with very hard water (averaging 290 ppm of hardness salts.) Increased sodium content, which has been linked to hypertension and cardiovascular disease, may be one of the causes. Soft water is also often corrosive. According to Dr. Henry Schroeder of the Dartmouth Medical School, corrosive water dissolves heavy metals from some pipes through which it flows. He suspects these heavy metals, notably cadmium, contribute to the cardiovascular death rate.

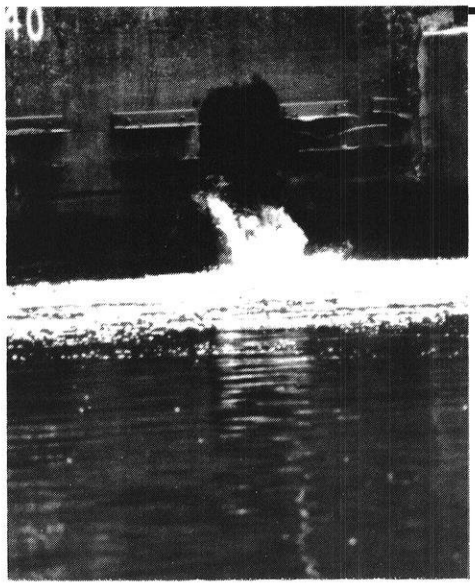
and Brecher note, "No routine tests for waterborne viruses have been developed, and none is required or even recommended by a Federal agency or state government.

"Yet evidence accumulating during the past decade makes it clear that disease-causing viruses do get into community water supplies, that some of those viruses can pass unharmed through today's accepted water-treatment procedures, and that outbreaks of viral disease—notably hepatitis—have indeed been caused by viruses in drinking water." The writers also note that disinfection that is adequate to kill coliform bacteria may not be adequate to kill resistant types of viruses, such as those causing polio and hepatitis.

HARRIS AND BRECHER don't stop there. They charge that the PHS standards are also insufficient protection against bacterial spores, protozoan cysts, and "other potentialy dangerous organisms that can survive current disinfection practices. Like viruses, protozoan cysts and bacterial spores can be much more resistant to disinfection than coliforms are." For example, residents of Essex Center, Vt. were suddenly hit by an outbreak of giardiasis, an intestinal infection caused by a protozoan, although their water met the PHS coliform standards. The EPA is currently involved in revising the water quality standards and is expected to have them finished by the end of 1975.

Many times, though, poor quality water is due as much to untrained personnel as it is to inadequate standards. In the 1969 study it was found that more than 60 per cent of the principal operators of water systems had never even taken a short course in water treatment. Three-quarters of the operators were found deficient in microbiological training and in chemistry.

"The results are sometimes ludicrous," add Harris and Brecher. "The operator in charge of one New England community water supply heard somewhere that activated carbon will remove foul tastes and odors. So, when the water smells bad, he fills a cloth bag with activated carbon powder, ties a rope to it, climbs into a rowboat, and tows the bag back and forth across the town reservoir. This is about as effective as waving a wand over the reservoir."



From New York city 450 million gallons of raw sewage are dumped into the Hudson River every day. Some of it may find its way into drinking water supplies.

Even when water is carefully treated for all possible health endangering pollutants, it may still be contaminated after it leaves the processing plant. **Consumer's Report** notes that contamination can come from the pipes and fixtures through which the water passes: "Lead pipes introduced into our water systems decades ago and never replaced, 'galvanized' pipes coated with zinc (which may contain an appreciable amount of cadmium), joining solders with a high lead or cadmium content, and cement pipes containing asbestos—all can donate hazardous substances to drinking water."

IN ADDITION, WATER can be contaminated after it leaves the treatment plant if the pressure in the distribution systems falls too low, causing backflow. The EPA recommends a minimum of 20 pounds per square inch throughout distribution systems. "The ever-growing complexity of distribution systems, hilly terrain, and tall buildings can make it difficult to maintain adequate pressure," writes Harris and Brecher. "Failure to provide for those conditions, or to plan for future demand, increases the likelihood of backflow problems."

In response to the careless disarray of water treatment many concerned drinkers have tried battling the onslaught of contaminants at the home front. As a result, bottled water and home faucet water filters have found a ready market in communities with substandard community treatment programs. Even these steps provide no assurances of clean water.

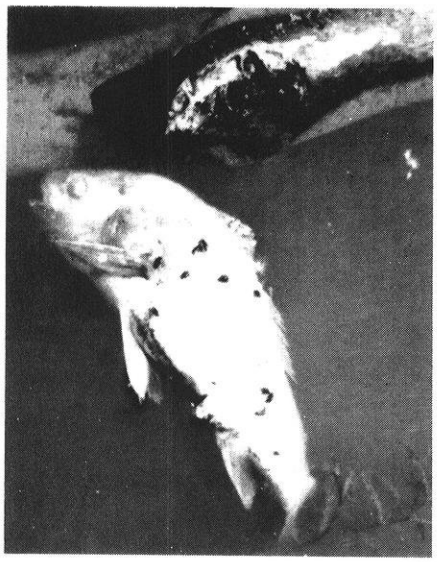
In a survey of 25 out of 500 bottled-water plants in the country, the EPA found that 8 per cent of the samples were contaminated with coliform bacteria. After 25 bottles were left unrefrigerated for a period, four of them showed growth of bacteria in numbers "too numerous to count." All of the bottling plants were guilty of some sanitary deficiencies.

The GAO study in 1973 also found similar deficiencies, and noted that "neither the Federal nor the (five) State agencies included in our review had effective programs for insuring that bottled water was pure, safe, and free of potential health hazards."

ALTHOUGH THE FDA has established new standards for bottled water quality, the standards are deficient, according to Consumers Union.

- •No limits are set on organic compounds or pesticides in water.
- •Water violating standards can still be shipped in interstate commerce if the departure from standards is noted on the label.
- •Water sold in the state where it is bottled is not subject to FDA standards at all.

Installing a home water filter to compensate for bad water may not be much better, and, in fact, is probably worse. A physician in the department of virology and epidemiology of the Baylor College



Chemicals and bacteria in waste water may also filter into drinking water.

of Medicine in Houston told this reporter that the companies manufacturfing such filters would do a greater public service by taking their products off store shelves.

In a study of four popular sinktop water filters, Baylor researchers simulated daily use of the filters and each morning counted the bacteria that multiplied in the water overnight. As the nutrient load increased with time, the bacteria count soared higher. From initial counts of about 100 bacteria per 100 milliliters of water, the bacteria population reached some 7 million per 100 milliliters within a week. One of the researchers concluded: "Illness could result from the first glass of water in the morning."

Consumer's Union replicated the study, using 10 popular models of sinktop water filters. All of the filters were canisters of activated carbon, designed to pick up impurities in the water. No manufacturer made any claims about controlling the level of bacteria, and one cautioned against use with "bacteria or virus infected fluids."

AFTER CONNECTING units to water supplies containing bacteria and allowing them to stand unused during a weekend, researchers found sharp increases in bacterial concentration. Apparently, the bacteria-trapping carbon filters are nothing more than breeding grounds. Consequently, use of home water filters to prevent bacterial infection from community water supplies, may only increase the likelihood of such infection.

Upgrading water quality, then, can only come from improved community supplies. One way to improve water supplies is widespread use of activated carbon, a porous form of carbon that presents an enormous surface area for contaminants to adhere to. A single pound of tiny granules exposes more than four million square feet of surface to which organic molecules can adhere. Recently, procedures for recycling spent carbon have been developed.

Carbon can be "traded in" for a fresh supply, then reactivated and resold for further use. Only about five per cent of it is lost during each cycle, reducing the cost. Since carbon granules filter out suspended particles, besides absorbing organic molecules, beds of activated carbon can be substituted for sand filtration merely by filling the sand beds with carbon granules. "Although carbon is not a universal panacea," says Dr. F. M. Middleton of the EPA, "It does have a high capability for absorbing those organics that are of greatest concern." Besides removing organic pollutants, it can also trap some of the viruses and heavy metals that may be present, writes Dr. Harris.

When it comes to disinfecting the water, chlorine is the traditional choice. But in 1967, when the Pennsylvania Department of Health ordered all community water supplies to be chlorinated, Strasburg, Pa. residents revolted at the thought of chlorinating their fresh spring water. In a legal battle that ensued, the town's attorney hit upon an alternative—ozone, which is used to disinfect water for soft drinks, bottled water, and industrial wastes. Strasbourg's ozone system went into operation on a trial basis in 1972.

HARRIS AND BRECHER describe the process: "The Strasburg ozone is produced at the water- processing site in a self-contained ozone generator, which passes an electric current through ordinary air or oxygen. The current converts oxygen molecules (composed of two oxygen atoms) into ozone molecules (composed of three oxygen atoms). These are then bubbled through the water to ozonate it. The ozone molecules are short-lived. By the time the water reaches consumers, little or no ozone is left."

Professor J. Carrell Morris, Harvard chemist and an authority on chlorine chemistry says there is "no question that ozone exerts a more powerful germicidal action than even free chlorine against all tested forms of microbiological life."

OTHER SOPHISTICATED techniques, such as reverse osmosis and electrodialysis for desalination, developed to remove a wide range of metals and minerals from brakish or ocean water, might be explored for their possible use in treatment of badly polluted water. Obviously, what is needed is more research to find new techniques and study already known ones, such as ozonation, to assure their safety and efficacy. But as Harris and Brecher wrote, "we must not only prepare for the future's problems, but meet today's needs." Impure water is not only threatening wildlife — it is also gurgling out of water faucets across the country.

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"A visit to a new major water treatment plant is an interesting and exciting experience. One finds accurate and well-designed chemical feeders with automatic controls, completely equipped laboratories, ample facilities for material handling, and instrumentation for communication and control, not only throughout the plant but throughout the entire water system. Approaching the treatment units, however, the calendar rolls back 50 years and one is faced with the melancholy fact that water treatment is still an art and not a science. One sees before him the same old mixing basins, flocculators, and sedimentation basins that have served as treatment units for more than five decades. Nature purifies water by settling and filtration and, after all these years, man still continues to do so too." —J.E. Singley and A.P. Black in ***Journal of the American Water Works Association,*** *January 1972.*

Cathy Hamilton is trying to take the bind, chafe, and pull out of your life.

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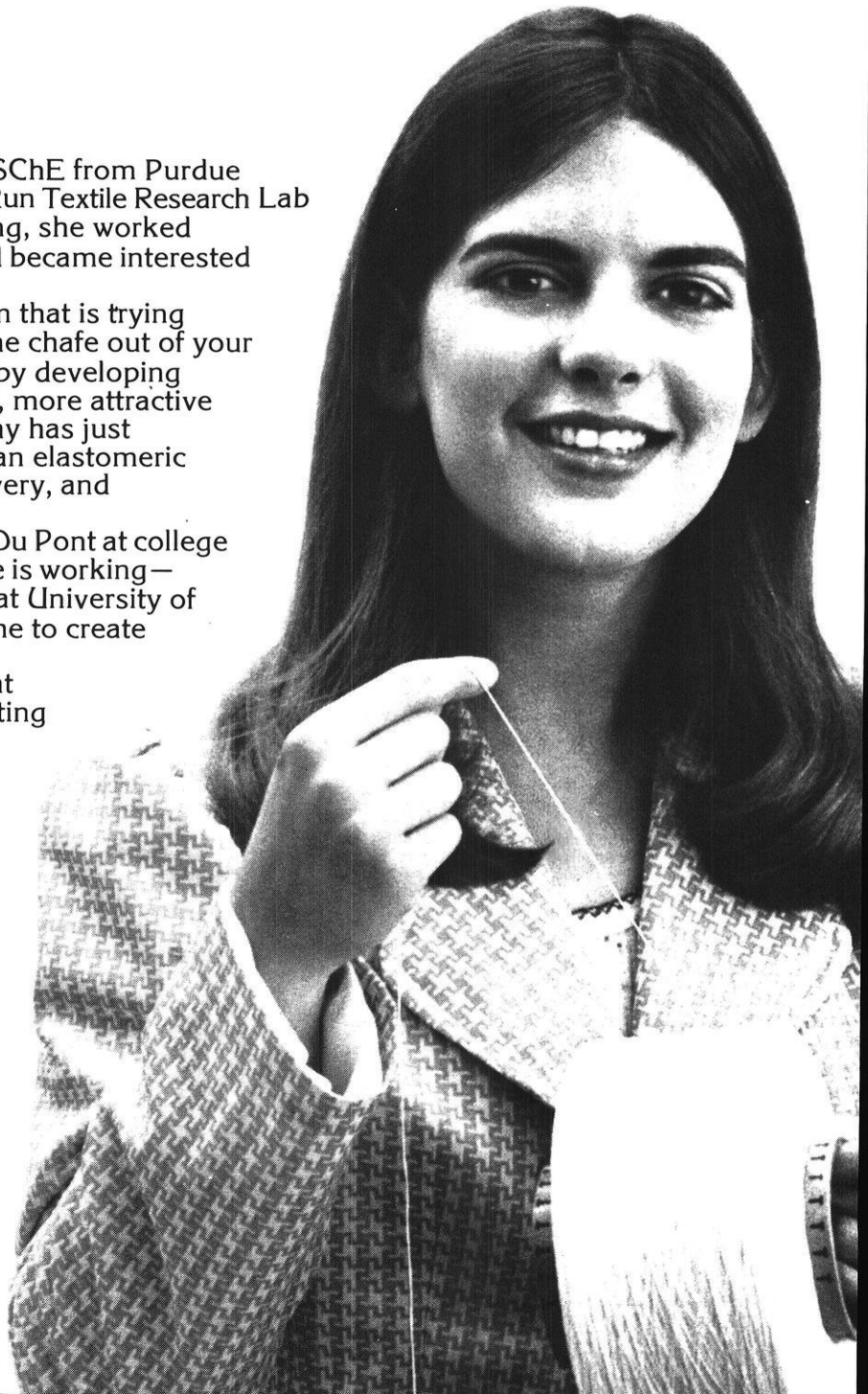

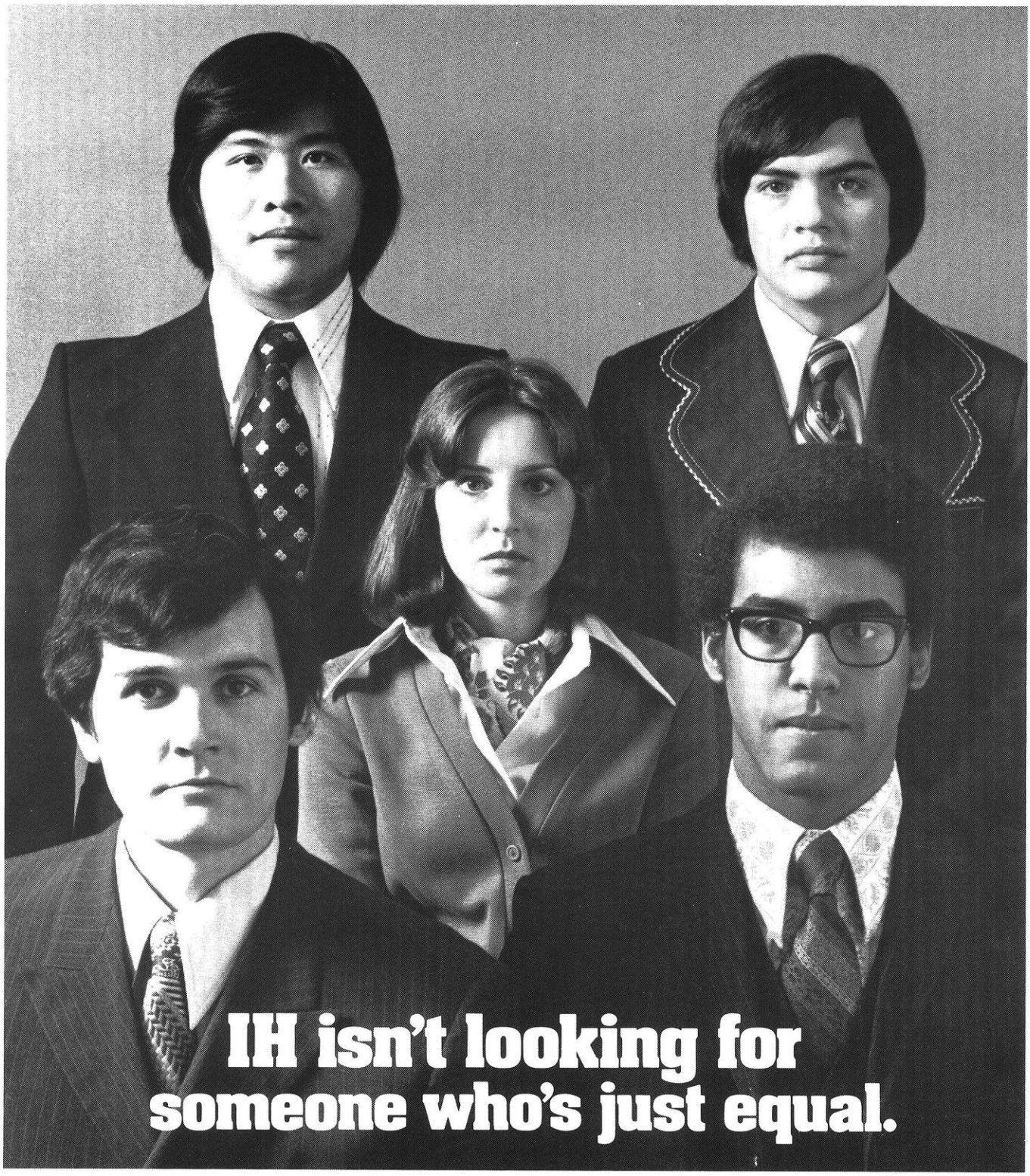

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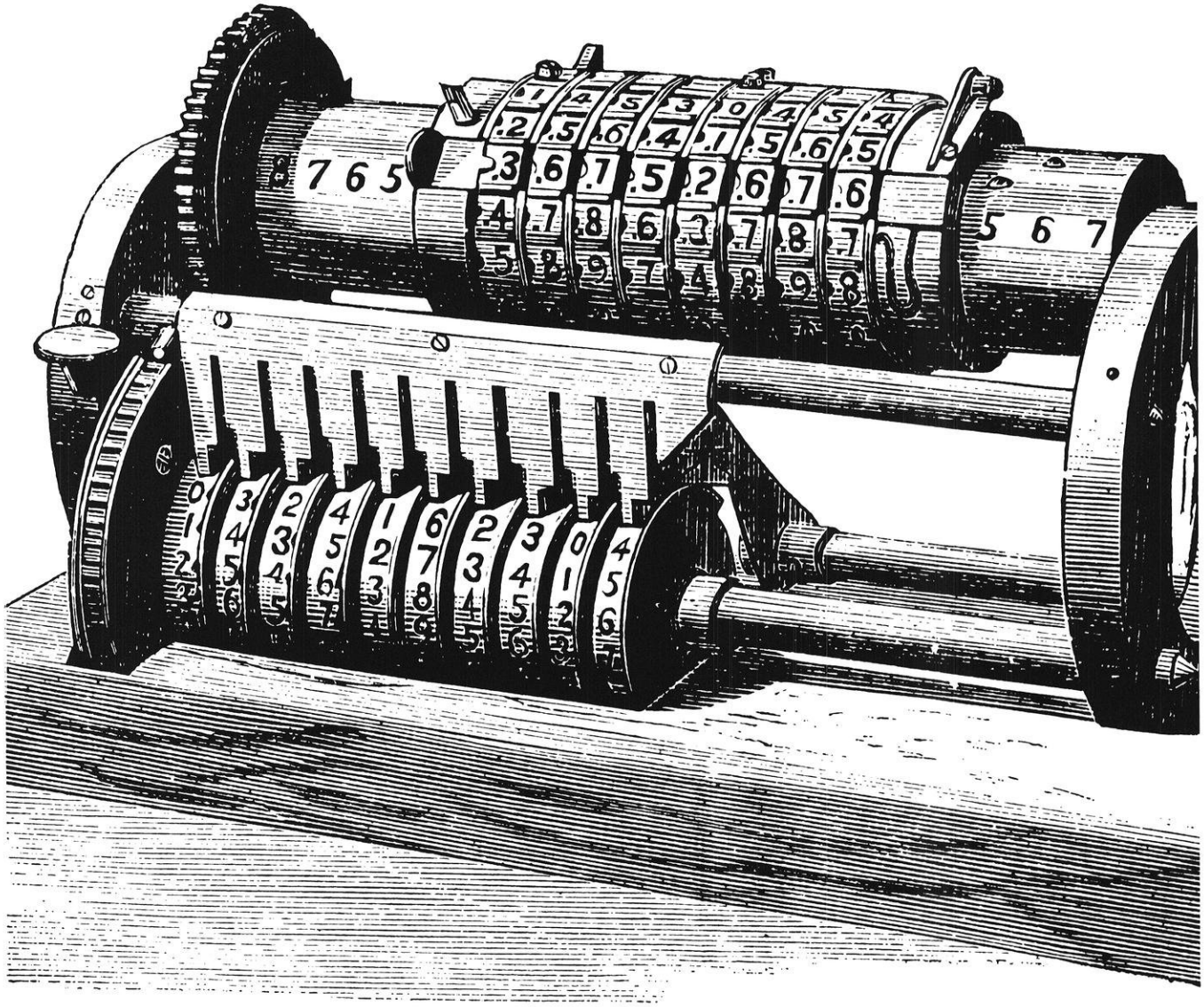

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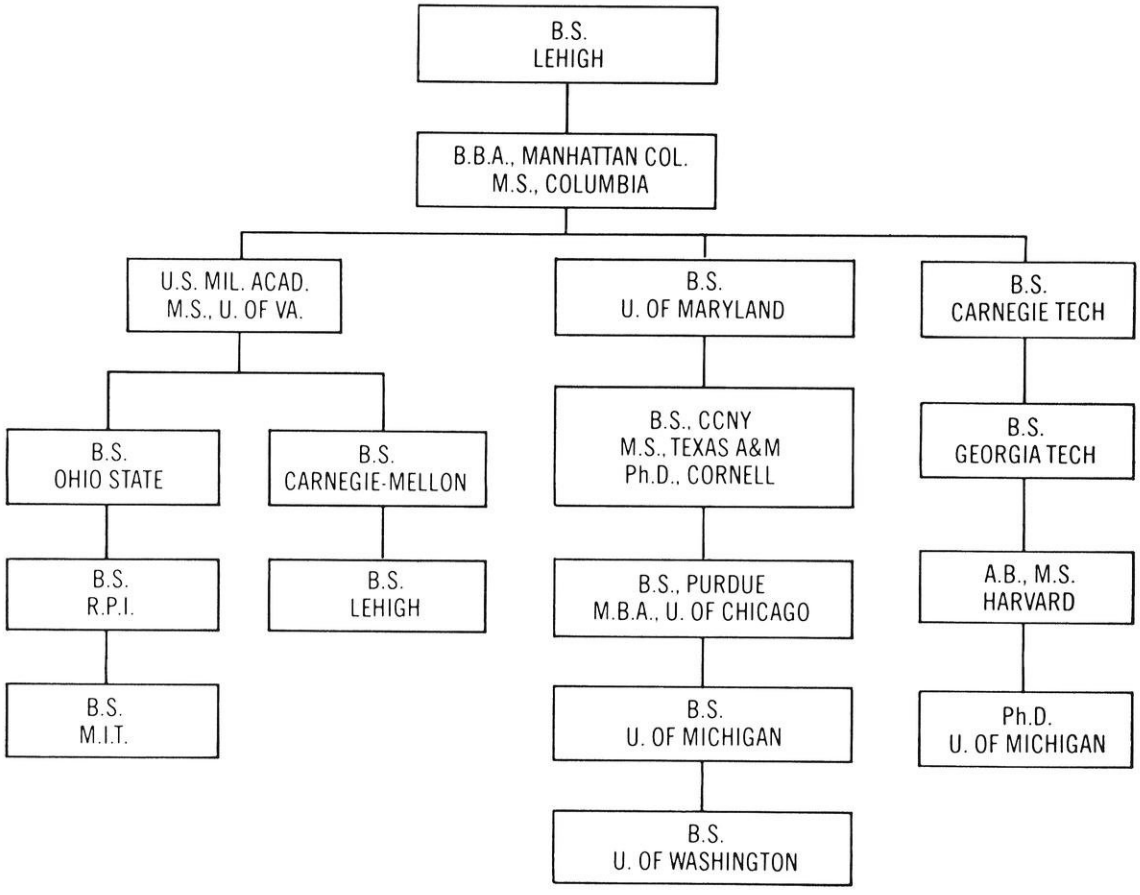

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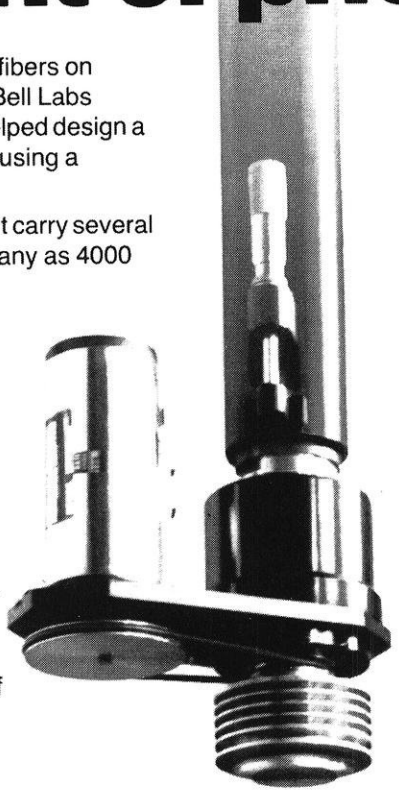
Ray Jaeger wants to make light of phone calls...

by sending them through tiny glass fibers on beams of light pulses. To this end, Bell Labs ceramic scientist Ray Jaeger has helped design a new system to make such fibers — using a powerful carbon dioxide laser.

In the future, one hair-thin fiber might carry several phone calls within big cities or as many as 4000 long-distance calls. But many problems must still be solved. Ray tackled one of them — the problem of today's glass fibers, which contain impurities that absorb and weaken light beams. One impurity source is the conventional heaters used to melt glass rods that are drawn into fibers.

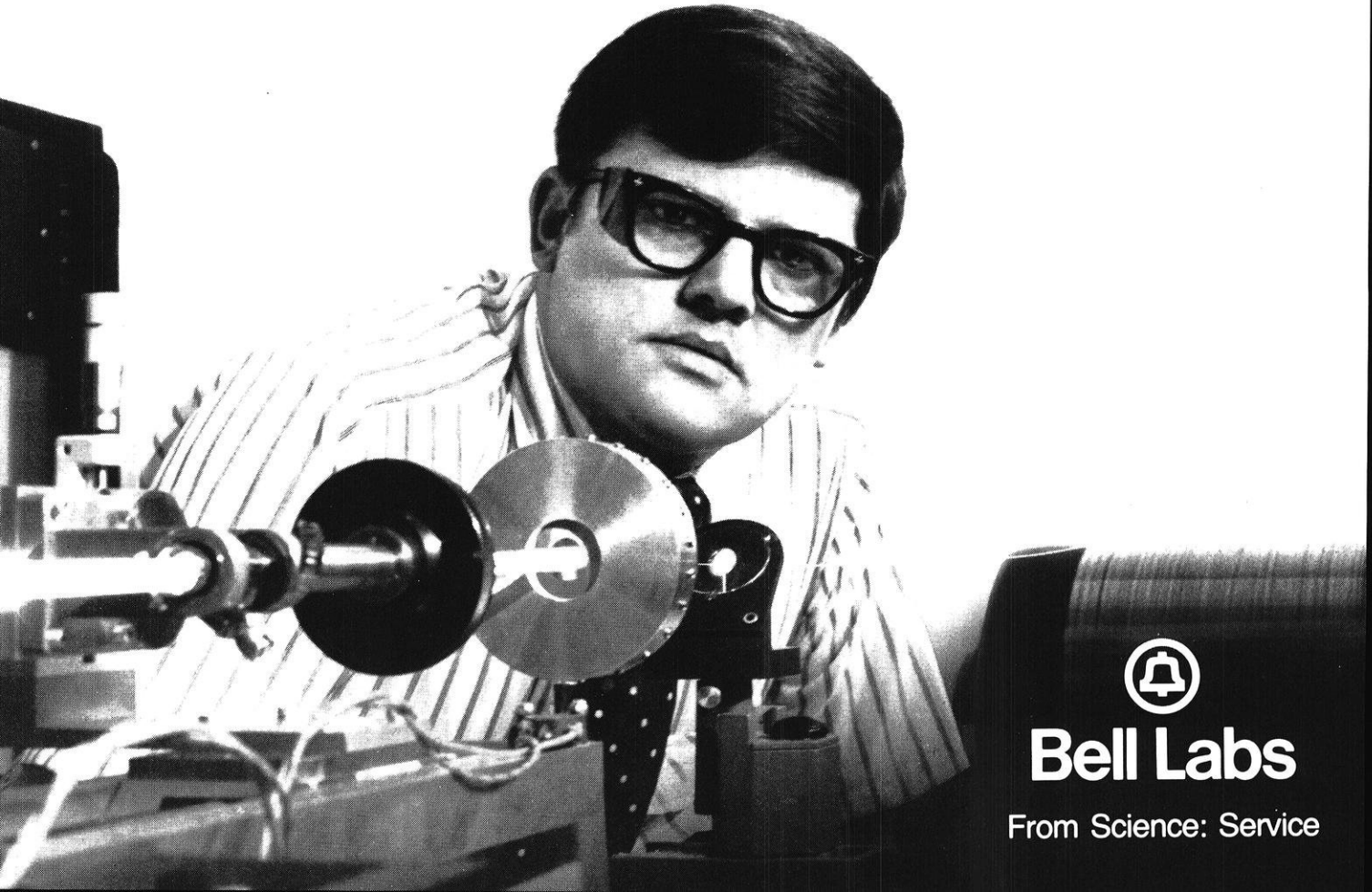
Ray had to find a "clean" heat source that also would be precisely controllable, to assure uniform diameter throughout a mile-long fiber. Using his broad knowledge of ceramic materials — he's a 1967 ceramic science Ph.D. from Rutgers — Ray studied many heat sources. But he finally explored a new approach: melt the glass rod with a carbon dioxide laser.



To make fibers, Ray had to devise a way of focusing the laser beam uniformly around the rod's circumference. He solved this major problem with a rotating lens and reflectors, to form a doughnut of radiation around the rod. Now Western Electric engineers are studying variations of such a laser system to develop the most practical manufacturing procedure.

To make optical communications useful, other Bell Labs scientists are working on ways of splicing glass fibers. And on better, cheaper, longer-lasting light sources and efficient ways of getting calls on and off light beams.

Although today's communications systems are more than adequate, someday there will be a need for the added versatility and capacity of optical systems. And the Bell System will be ready because of Ray and others like him.



Bell Labs

From Science: Service

A "shocking" tale —

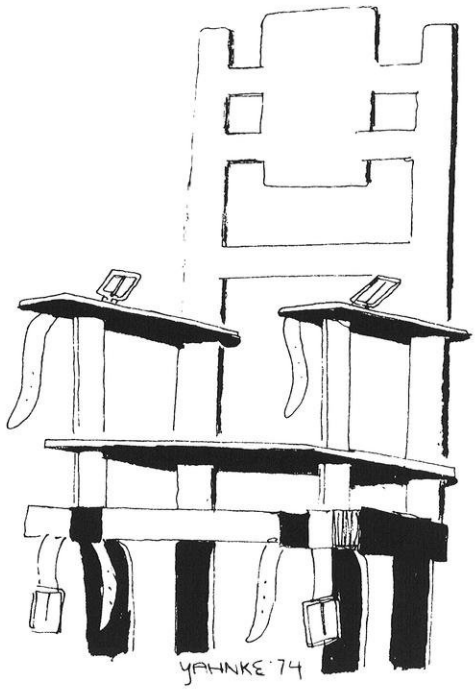
The first electrocution

By Theodore Bernstein
University of Wisconsin
Condensed by
Daniel K. Zeitlow
of the Engineer Staff

In a sense it all began in Buffalo, N.Y., when William Kemmler murdered his 29-year-old mistress, Tillie Ziegler with a hatchet on March 29, 1889, thus reserving for himself a place in electrical history. He was to become the first man legally executed by electricity.

Earlier in 1886, David B. Hill, governor of New York, appointed a commission to find a form of execution "more humane than hanging." In several hangings prior to that date, the condemned persons died gruesomely by strangulation when the drop from the scaffold failed to break the neck and sever the spinal cord. Therefore a commission was appointed to obtain an efficient alternative to the rope.

All forms of execution were studied including the favorites of Europe, but none of the previous methods seemed much better than hanging. However, it had been noted that several people had been fatalities of commercial electricity and therefore after several experiences with animals the commission recommended electrocution as an acceptable alternative.



The first legal electrocution was fraught with controversy which flared between Edison and Westinghouse.

THUS ON JUNE 4, 1888, Governor Hill signed into law a bill to substitute electrocution for hanging in the State of New York as of January 1, 1889. And later on March 1, 1889, Governor Hill signed a bill authorizing the Superintendent of State Prisons, General Austin Lathrop, to obtain "an electrical apparatus suitable for the infliction of the punishment of death — together with the necessary machinery and appliances for the execution of convicted criminals as provided by said Code."

After a four day trial on the charge of first degree murder, William Kemmler was found guilty by jury. Judge Henry A. Childs had no alternative but to pass the sentence of death by electrocution.

At this time Thomas A. Edison and George Westinghouse were having a titanic struggle over what type of current should be used in the power industry. Now that Kemmler was to be executed by electricity it only pumped more energy into the controversy.

AFTER EDISON INVENTED his incandescent lamp in 1879, he developed a distribution system for electric power by using "continuous," or direct, current. Many such DC distribution systems were installed in the 1880's. Since direct current must be generated at the voltage at which it is used, this system required low-voltage high-current distribution lines. Because of the high current, the power loss in long distribution lines was also high and required that the power stations be located near their loads.

Westinghouse, however, began the promotion of AC systems in the late 1880s. (Alternating-current transmission developed later than DC distribution because it had to "wait" for the development of suitable transformers and motors.) The voltage level for alternating current can be readily and efficiently changed by transformers so that the alternating current can be generated at one voltage, raised in voltage for transmission at high voltage and low current, and distributed to consumers at safer lower voltages. Edison and Westinghouse were engaged in an economic battle over whether AC or DC systems would be used.

Edison objected to the use of AC systems. He felt that alternating current was more hazardous to human life because people could be killed by it at voltages of 200 volts whereas direct current at that voltage level was relatively safe.

FURTHER, IN THE LATE 1880s, Harold P. Brown, a New York "electrician" (the term then used for electrical engineer), mounted a campaign to prove that AC was dangerous. He advocated state laws limiting AC to 200 volts and DC to 500 volts for safety. His book, *The Comparitive Danger to Life of the Alternating and Continuous Electrical Currents*, published in 1889, described experiments on animals that proved that AC tended to be more lethal than DC.

Earlier in 1886, David B. Hill, governor of New York, appointed a commission to find a form of execution "more humane than hanging."

He also compiled a list of human deaths caused by AC; in fact, Brown was one of the leading advocates of the new electrocution law. He proposed to obtain AC generators (Westinghouse manufactured them, of course) to be used for executions at Auburn, Sing Sing, and Clinton prisons.

The battle lines were now drawn. Although Edison objected to capital punishment, he felt that if a sure, swift death were desired, the dangerous AC would be preferable. But Westinghouse opposed legal electrocution because he felt it would conflict against his promotion of alternating current.

Physicians favoring the electrocution law felt that, with sufficient voltage, death would be quick and relatively painless. Opposing physicians, however, insisted that not enough was known about electricity — or the human body — to be sure of a painless, burnfree death. There was also the question of the wide variations of the electrical resistance in human bodies — variations that would make it almost impossible to establish what value of voltage would always produce death.

HUNDREDS OF EXPERIMENTS were made with a Wheatstone bridge to prove that the body resistance between two limbs was about 1000 ohms. The Westinghouse faction (against electrocution in general and against use of AC for the job, in particular) argued that Wheatstone bridge measurements of resistance would not be meaningful for a nonlinear resistor such as the human body.

A point made time and again was that people had survived — or had been resuscitated — after being struck by lightning; therefore, since the power of electricity at the time was so much less than lightning, death produced by electricity could not be ensured.

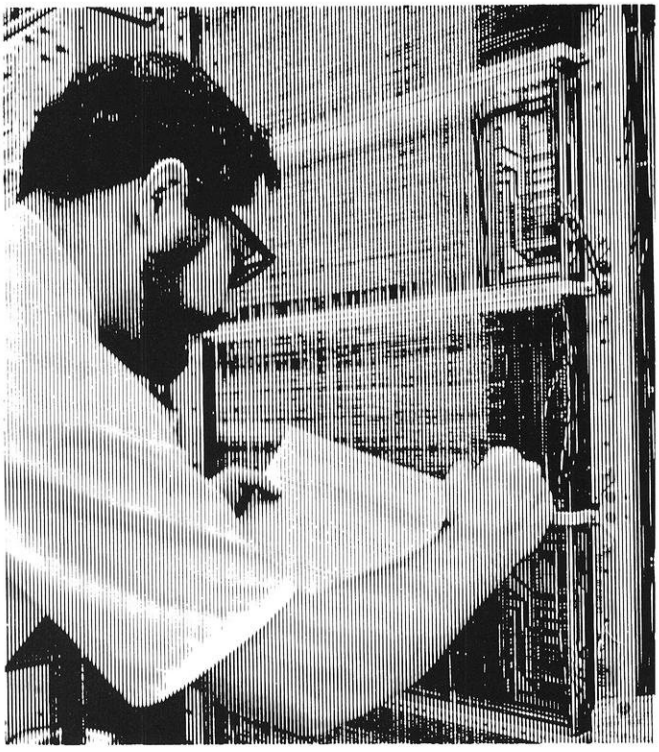
Kemmler appealed the conviction on cruel and unusual punishment. His defense council, Bourke Cockran, tried to disprove Brown's results and prove that it was impossible to determine what level of current would kill in every instance

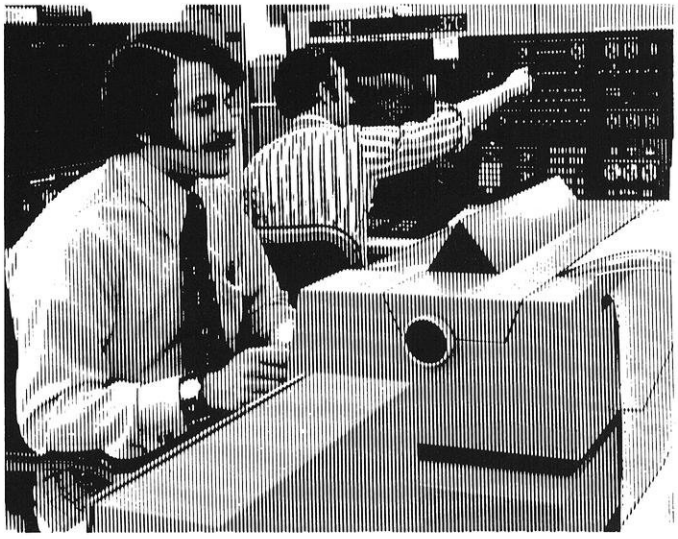
However, the state was successful in its case based on accidental electrocutions, experiments in electrocuting animals, and one member of Governor Hill's commission on execution stated that he had "firm faith in Thomas Edison as an oracle." Kemmler was then sentenced to death by electrocution on August 6, 1890.

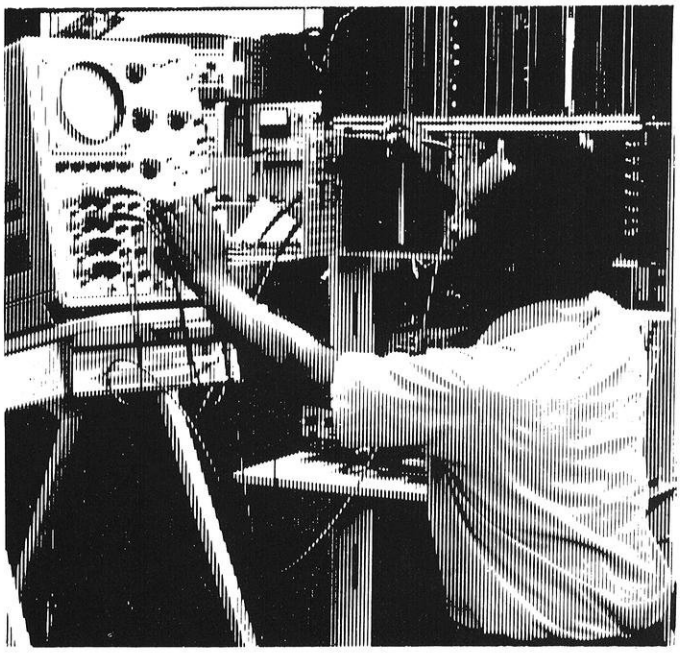
THE UBIQUITOUS HAROLD Brown eventually obtained three Westinghouse generators and additional instruments and installed them at Auburn prison. After which Kemmler was electrocuted.

Looking back, this event must have seemed to spell doom to who ever's system was used for the electrocution. However, the opposite was true. Edison was wrong in opposing AC, because its use was inevitable in the transmission and distribution of electrical energy.

Although AC is more dangerous than DC, it is not so hazardous to restrict its use to below 200 volts. Westinghouse was wrong in insisting that AC was not dangerous, but he was right in promoting its use.







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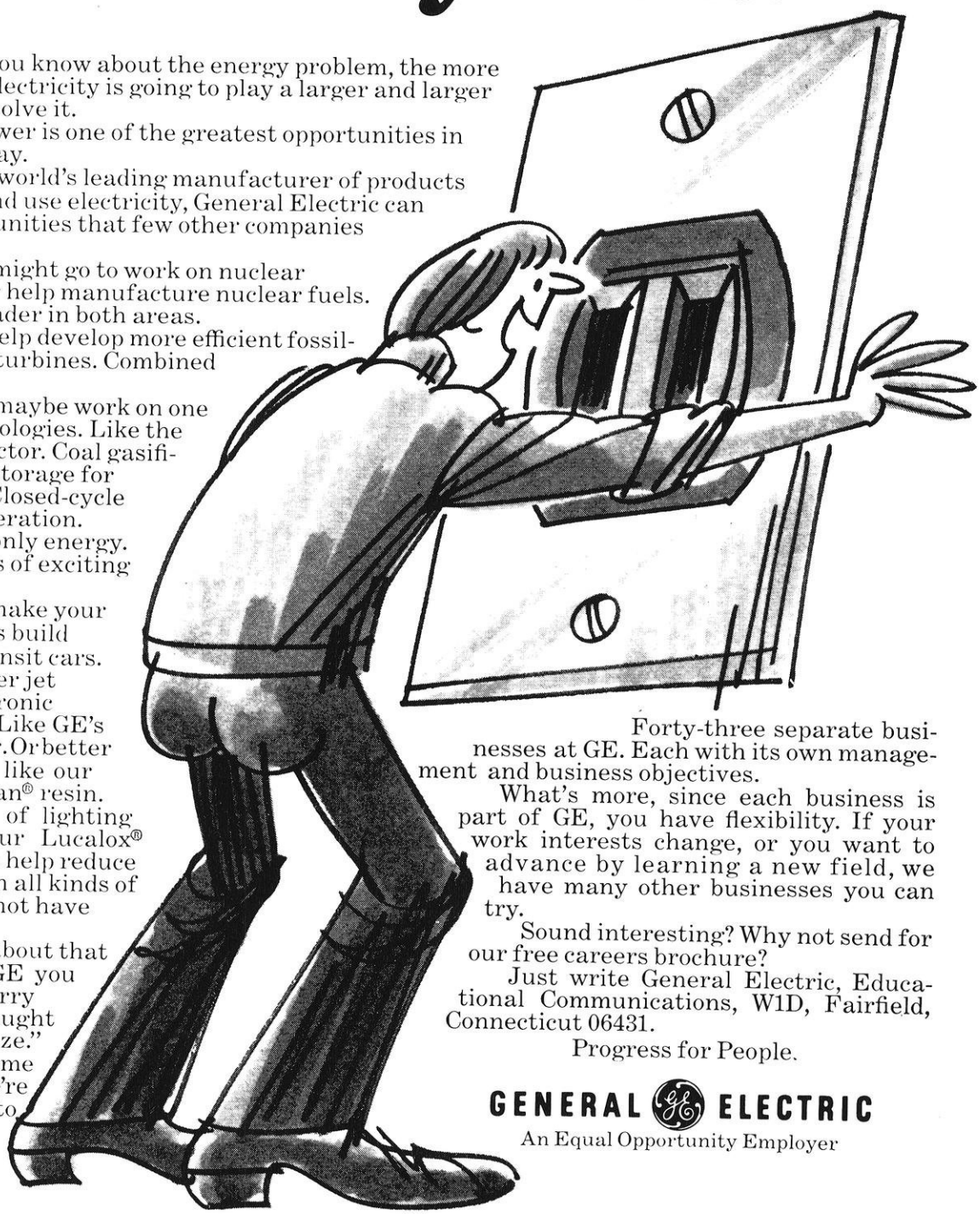

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