Wisconsin engineer. Volume 76, Number 3 December 1971

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

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VOLUME 76, NUMBER 3 35 CENTS DECEMBER, 1971

wisconsin engineer

Albert Einstein:

"The concern for man and his destiny must always be the chief interest of all technical effort. Never forget it among your diagrams and equations."

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wisconsin engineer

MEMBER OF ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman: DANIEL L. GRIFFEN, JR., Iowa State University, Ames, Iowa.
Publishers Representatives: LITTEL-MURRAY-BARNHILL, INC., 2906 Lincoln Building, 60 East 42nd St., New York, N.Y. 10017.

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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 monthly from October to May inclusive 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. 308 Mechanical Engineering Bldg., Madison, Wis. 53706. Office Phone (608) 262-3494.

The U.W. Merger

A Perspective by Mary Stein

"The real problems of merging of the University of Wisconsin have not been realized", speculates W. Robert Marshall, Dean of the College of Engineering.

"I think we're going to see a 'tip of the iceberg' effect before long."

Funding, keeping of alumnae foundations and faculty roles, maintaining liaison and sharing of facilities were the five major areas where Marshall felt future ramifications are possible.

Since the University of Wisconsin merger is at the Board of Regents level there have been no merging of funds or programs, or interchange of faculty.

Marshall, with this in mind, said, "the only thing we can do is speculate with the few concrete details we have."

First Marshall indicated that in any large educational system today, a major problem is funding. He commented on the use of cost per credit in education. "On various campuses around the state this is a complex criterion," he said.

"For example, the Madison Engineering Campus appears to show quite high cost per credit figures. However, in no other place in the state system can you make a comparison with these cost figure —in terms of facilities and faculty alone."

He would like to see the citizens of Wisconsin learn to understand the complexities of University funding. "People use numbers without interpreting them," he said.

He pointed out that less than half of the University of Wisconsin budget comes from tax dollars. Tuition, federal aid, grants from private and industrial organizations, and other non-tax sources provide over 50 per cent of University funding.

Secondly, many disputes could arise from the diluting of funds provided by the Wisconsin Alumni Research Foundation. WARF, was established in 1927-28 to support research on the Madison campus. Later this was extended to other Center campuses.

The University received much financial support from bequests and endowments. Many legal questions could arise as to whether individual's earlier wills and bequests would allow funds to be distributed to campuses other than Madison.

Marshall questioned what other campuses' responsibilities were in developing alumni programs of their own.

Thirdly, whether faculty will want to stay in the University of Wisconsin system could depend upon the fluidity of the merger. "Resources that built this campus might have to be redistributed," he said.

Marshall cited the example of certain faculty members who were not teaching a specified load each semester. He said it is conceivable that they could be asked to be mobile, teaching at different campuses every semester.

"The faculty would not be happy with such an arrangement. It all depends on what a professor's new obligations would be," said Marshall.

Little change has been noticed in Bascom Hall after the University of Wisconsin was merged with the Wisconsin State Universities.

Fourthly, while engineering degrees are offered at three campuses in the merged University system, the College of Engineering at Madison offers the greatest number of different degree programs. Because of this broader career choice, Marshall said that many students start their education on other campuses in the system with the intention of completing their engineering degree requirements at the Madison campus.

"Long before merger effects went through, we had a program to maintain liaison between state institutions. Each year, an Engineering Education Improvement Committee meets to keep a 'two-way street' open between Madison's Engineering College and other state universities," said Marshall.

Marshall considers this committee an "informal kind of merger." All interactions of this type involve no exchange of equipment.

Assistant to the Dean, Richard Hosman, explained that it was the job of this committee to be informed in changes at all institutions. "Accurately advising students so that they may complete and/or transfer their degree credits successfully has been the goal of this committee," said Hosman.

The future of the EEIC is hanging in limbo at this moment. Hosman is confident that the committee and the Council of Higher Education will recommend to the Board of Regents that their liaison should be continued as a part of a merged system.

Lastly, sharing of facilities in the Engineering College is not anticipated to be that great of a problem. Madison has shared its nuclear reactor with other groups and institutions. Marshall pointed out that this was in cooperation with a national effort to limit the building of university reactors because of the tremendous costs.

Marshall indicated that the nuclear reactor was only one facility. "Now that there's a merger, does that mean that any campus should have access to any facility?", asked Marshall.

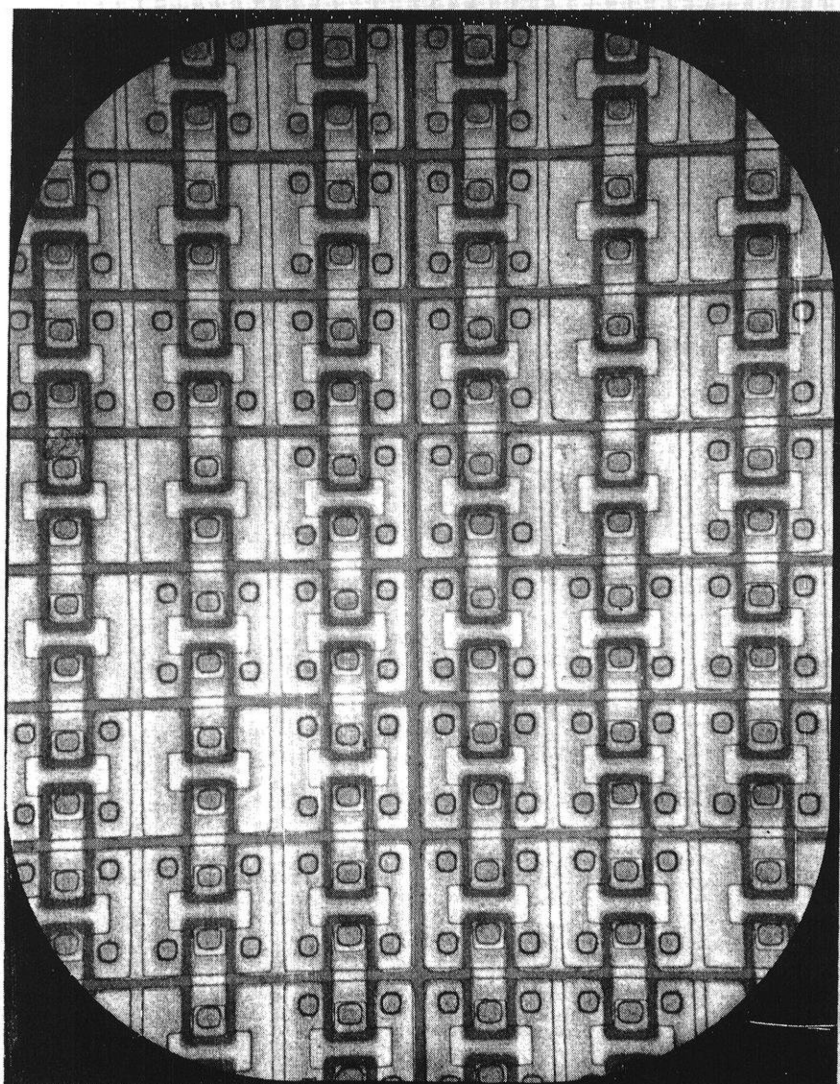
"One can easily point to the problems we are dealing with as falling primarily into the context of the Madison campus," he said.

If there is a continuing resistance to the support of education, Marshall questions "are the people satisfied?" He offers the possibility that the state might have to develop an entirely new system.

Marshall is generally optimistic for he believes "one cannot be too pessimistic or one won't be very happy."

"The people of Wisconsin, in educational crises have come out with good sense and good solutions. I hope that the merger can be worked out in the interest of as many people as possible. The people of the state will examine the situation. If they feel the merger detrimental, they will ask the legislature to reexamine the whole proposal," concluded Marshall.

We keep the news fit to read.



Integrated Circuits

by Tom Abbott

EE-4

We wish to personally thank Professor Guckel and Larry Hall for taking time from their busy schedule to provide us with the pictures and helpful suggestions.

Despite the popular distrust of technology, our society today would not survive without the technical level we now enjoy. Modern communication, transportation, healthcare . . . , all these diversified areas could not function at there present level of efficiency without integrated circuits. These integrated cirucits are the building blocks of almost every current electrical system whether it be a computer, or a large scale communication network. The future use for integrated circuits promises to be even more varied, including use of IC's in micro-wave systems, and increased progress in IC production techniques. We at the University of Wisconsin are fortunate in having an integrated circuits laboratory on campus that has made significant progress in the production of integrated circuits. This facility, headed by Professor H. Guckel of the Electrical Engineering Department, is set up to design integrated semiconductor devices for both University and industrial applications.

The word integrated refers to the fact that this type of circuit combines the previously separated technical areas of materials, devices, and circuits into a single discipline. This union of disciplines had a marked effect upon the electronics industry. As transistors had removed much of the need for bulky, unreliable vacuum tubes, integrated circuits removed the need for discrete components, and also eliminated or simplified the connections needed in electrical configurations. Integrated circuits, such as the kind frequently being made here at Wisconsin consist of passive elements (i.e. resistors and capacitors) placed on top of a substrate by thin-film or diffusion techniques. The substrate contains the transitors that have already been diffused into the substrate by a series of chemical treatments. An example of this type of circuit is given later in the discussion.

Several qualities distinguish integrated semiconductor circuits from the conventional discrete component circuits. Miniaturization is initially the most impressive achievement. Present computers are a vivid example of the usefulness of microcircuits. If a computer such as the IBM 360, had been built with discrete components, it would be several stories high. The integrated circuit described later in this article is 80 mils by 80 mils (1 mil 1/1,000 of an inch; the diameter is a human hair is equal to about 3 mils).

More impressive than miniaturization, however, is the fact that integrated circuits are cheaper and more reliable than their discrete circuit equivalents. The actual process of producing integrated circuits is tedious and expensive, but hundreds of IC's of the same kind be produced using the same procedure. Thus, electrical components can be mass produced, leading to a reduction in the cost of the product to consumers. The reliability achieved by integrated circuits also minimizes maintenance costs. When an electrical failure takes place with integrated circuit components, pinpointing the failure is usually a quick procedure. The opposite is true for discrete component circuits. Testing and maintenance of these circuits is costly in terms of tying up people and equipment. Integrated circuits are also cheaper in terms of performing electrical operations with less power consumption than equivalent large scale circuits. Examples of such low power electrical functions are seen in the form of on-off circuits for computer and timing applications, and linear amplification. This latter example is well known to college students who have stereo equipment.

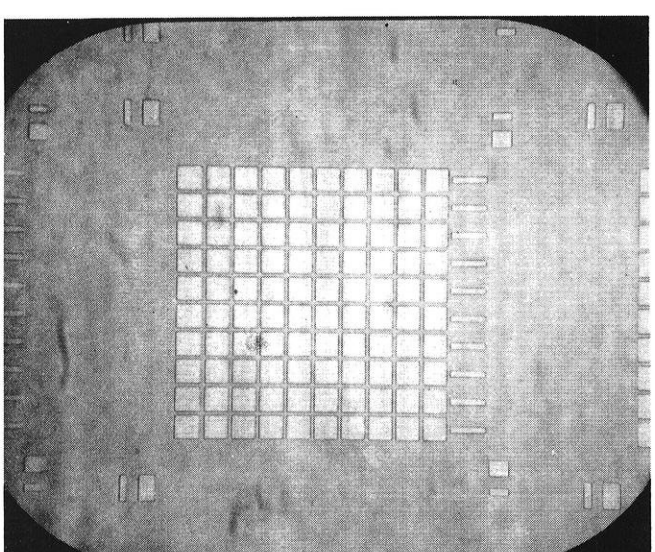


Figure 1. Photograph of individual chip after openings for the diffusion of the base have been opened.

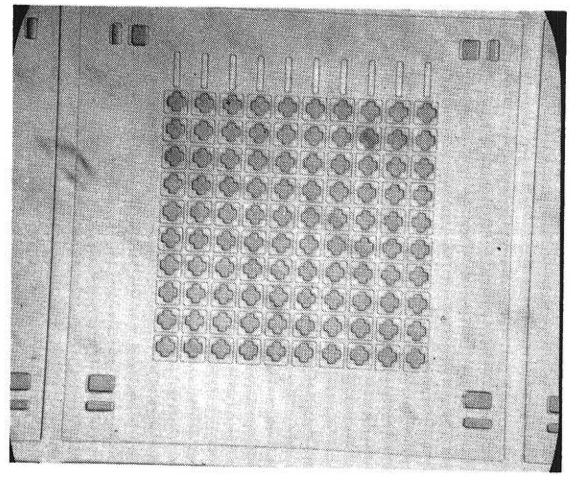


Figure 2. Photograph of individual chip after base has been diffused and openings for the emitter diffusion have been etched.

After noting a few of the many advantages to integrated circuits, disadvantages cannot be ignored. The cost of initial developing in terms of accuracies needed and the tightly controlled environment in which fabrication must take place. The IC lab here is kept at a constant temperature and personnel working in the lab must wear dust-free garments. There are also limitations to the type of circuits that can be put into integrated circuit form. For this reason, the engineers designing and constructing integrated semiconductor circuits must have a knowledge of circuit theory, and be able to communicate with the designers of theoretical circuits, to let them know what can and cannot be done.

When discussing the highly controlled environment in which semiconductor devices must be built, an interesting example comes to mind (the source of this information was an EE T.A. of mine who has since received his degree). A well known electronics firm out west had completed a batch of FET's (field effect transistors). After running tests, they discovered a major portion of the devices didn't meet specifications. They checked the bad FET's carefully, but couldn't come up with an explanation for their failure. Finally some bright person remembered that one of the last steps in the production of the FET's was making metallic connections to the device inputs. The majority employees doing this work were women and many of these women wore nylon undergarments that gave there body (besides a better shape) a static charge. When they perfomed this final assembly step, they gave up some of the static charge to the device through their hands, making the FET inoperable. Such a problem sounds quite bizarre and humorous but is not uncommon in semiconductor device production. Thus, special controls and precautions must be inforced as part of quality control.

To really have an appreciation of what goes into IC production, a qualitative step-by-step description of how 25,600 transistors are put into a silicon wafer that is 1.5 inches in diameter will now be given. The silicon wafer is the main structure upon which the integrated circuit is built. Its atoms in different parts of the wafer can be given a surplus or storage of atomic particles (electrons or protons) by heating the wafer in the presence of certain gases. This process, called "doping," can be isolated to specific locations on the wafer by covering those areas that you do not want doped with a chemically protective layer. Thus each "chip" or individual circuit on the wafer is covered by this layer. In figure 1, we see a chip with the protective layer on top. Holes have been etched in the layer to permit the diffusion of the transistor bases into the wafer. The precise process of etching is past the scope of this discussion, but it is possible to construct accurate patterns for etching through photographic methods. First, a full-scale drawing of the etching pattern is made and photographed. The picture of this pattern is then reduced to 1/250 its original size by a two-step photographic process. This pattern is then layed on top of the wafer during the inital steps of the etching process.

Thus by chemically covering and uncovering portions of the silicon wafer, n-p-n transistors are diffused into the wafer. Figure 2 shows an individual chip with openings etched for the emitters of the transistors. Figure 3 shows the total circuit except for the input and output leads. Thus, each chip contains ten rows and ten columns of transistors and resistors (i.e. 100 transistors per chip). The transistors are connected by a metal film. These metal contacts can be clearly seen in figure 4, which is an enlargement of figure 3.

After metallurgy is completed, the individual chips are cut from the wafer using a "string" (straight-wire) saw. Input and output leads are connected to the desired locations on the chip, and the integrated circuit is ready for packaging in an appropriate protective container, such as a TO-5 "can." The actual chip is 80 mils by 80 mils in size (1 mil 1/1,000 inches). In this particular example each chip is an encoder, taking the electrical equivalent of a decimal number and converting it to a binary number.

This device is just one example of the work involved in producing IC's. One has to keep in mind the fact that once a process such as this has been perfected, mass production of integrated semiconductor devices can be achieved, thus reducing cost per device. This reduced cost, combined with the previously mentioned reliability factor, gives integrated circuit semiconductors the position of importance they have attained in the electronics industry.

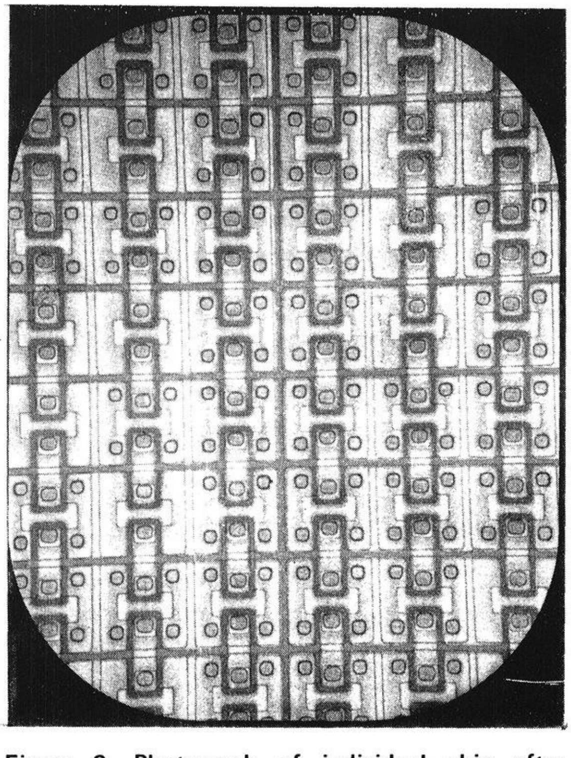


Figure 3. Photograph of individual chip after resistors have been diffused and metallurgical contacts completed.

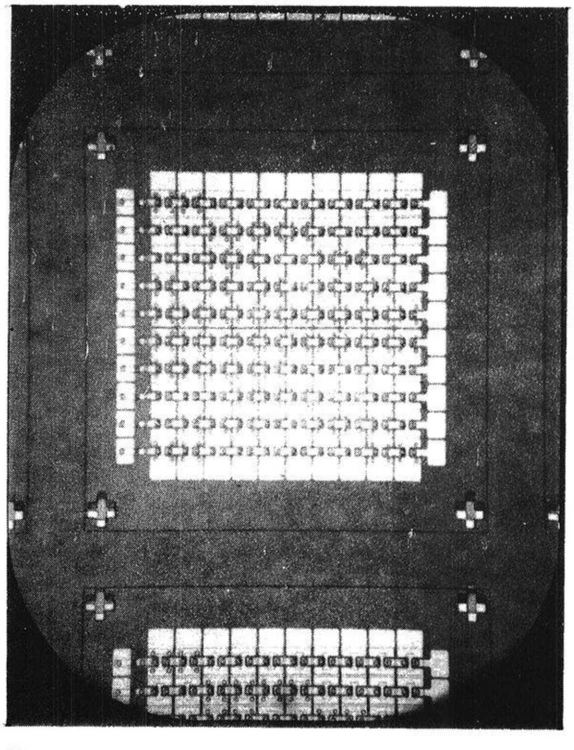


Figure 4. Close-up picture of figure 3, showing metallurgical contacts and openings for external contacts.

Pollution Legislation and the Economy

Automobiles are treated differently than other sources of pollution, says University of Wisconsin--Madison engineer Phillip S. Myers, and this may be costing consumers extra money.

Prof. Myers believes it is unrealistic for legislation to set standards based on existing technology for some industries and then require autos to meet standards that present technology can reach only with high fuel consumption or other expense. The result costs more money for the same quality air as could be achieved with fair distribution of standards.

The problem, as Myers sees it, is created because the people making decisions on pollution control do not have complete information and are influenced by other considerations.

"Politics is not a completely rational process," asserts Myers. "Many factors unrelated to the problem affect final decisions."

He thinks professional societies, relatively free of political and economic pressures, should furnish information that would provide pollution control "to the greatest degree feasible using maximum technological capabilities." Then the public or its representatives could enact legislation setting the required standards. Myers says this method also would be the best from an economical standpoint.

"Economy is important," notes Myers. "Judgmental errors involving as little as five per cent too much expense can cost consumers billions of dollars per year."

He insists that curing pollution is not going to be cheap no matter how the decisions are made. But he warns: "If the cure is not economically sound, there will be consumer backlash." Myers fears that backlash may hinder efforts to provide the pollution protection that will be badly needed in the future.

For adequate pollution control, Myers suggests that scientists be employed to analyze the problem to find its magnitude and sources. Then, in light of existing technology, engineers should set standards on a total cost basis. For instance, instead of arbitrarily saying that industries should reduce a given pollutant by 50 per cent and auto makers should reduce the same pollutant by 98 per cent, cost curves for each polluter should be examined. Then, the combination of methods and costs that are most effective and least expensive should be used.

Heavy emphasis on solving auto pollution problems is justified, Myers says, because increasing numbers of automobiles will soon negate the environmental protection provided by present and proposed control technology. Myers notes that rational economical control must be planned now since it takes at least seven years to get a control device from the drawing board into enough cars to do any good.

Best Bike Protection

A big, case-hardened alloy steel chain with a lock to match is the surest protection against bicycle thieves, a study by a Stanford University engineering student indicates.

Alarmed that $16,000 worth of bicycles were reported stolen on the Stanford campus the first four months of this year, John O. Dierking of Bisbee, Ariz., embarked on a "do-it-yourself" investigation to determine the best devices for foiling thieves.

He solicited the cooperation of local bicycle shop owners who provided a variety of chains and cables for testing as well as some funds for needed equipment. After 100 hours on the project Dierking's conclusions showed:

1. A case-hardened welded alloy steel chain 7/16 inches in diameter was rated "most secure." It could not be cut even by a 24-inch bolt cutter.
2. Almost equally strong were 1/4 inch chains of case-hardened welded alloy steel. One sample withstood the 24-inch cutter, another did not, but defeated an 18-inch cutter.
3. One-quarter inch case-hardened steel chains did almost as well as their bigger relatives and would provide a high degree of protection at less cost than the heavier chains.
4. Five types of woven wire cables or cable locks were rated less secure than the chains and were not recommended for use on expensive bicycles. All could be easily cut with 18-inch bolt cutters or, with more effort, even wire cutters would also cut through the cables. The locks on several could be knocked off easily with a hammer blow, Dierking's tests showed.

In a comment on the study the National Association of Chain Manufacturers recommended that the security chain be wrapped around the bicycle frame, not just through a wheel, and that it be placed as high off the ground as possible, to prevent would-be thieves from putting one leg of a bolt cutter on the ground and standing on the other, thus magnifying the cutting force.

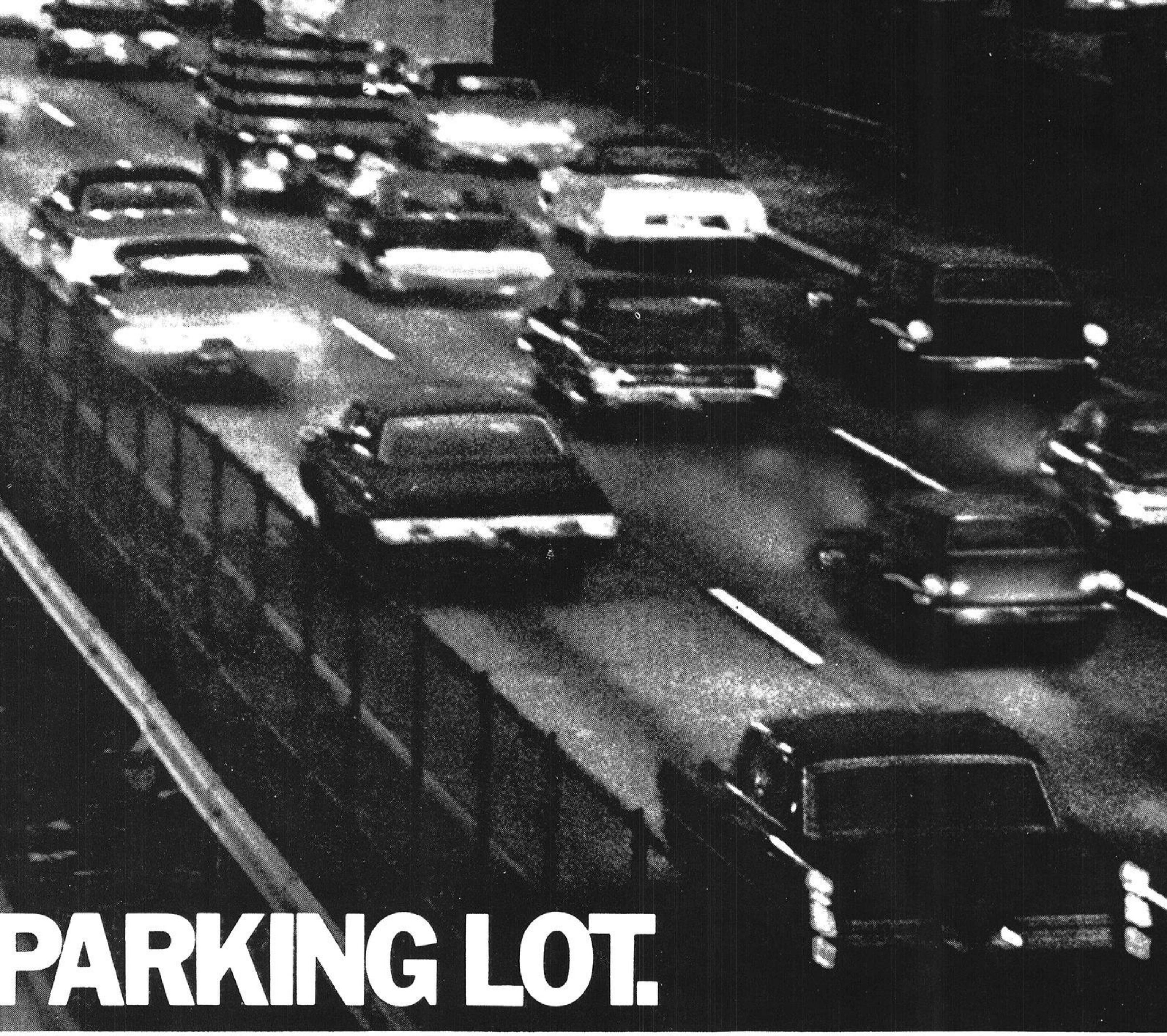
Soon 90-mph commuter trains will put a little more rush back in everybody's rush hour. And nickel's helping make it happen.

At last, true high-speed rail service is on the way. In mass transportation systems from New York to San Francisco.

And, by taking some of the pressure off our clogged highways, it promises to make life easier for motorists as well as rail passengers.

The progress of the Long Island Railroad is typical. Every week now, it replaces six or eight of its old cars with gleaming "Metropolitan" cars. About the middle of next year, after its entire new fleet of 620 cars has been put in service, it will start cutting commuting times throughout its system.

Both the frame and skin of the new Metropolitans are nickel stainless steel. The nickel's in there for several reasons. It makes the steel easier to weld and form, and adds toughness to insure car safety. It also helps arm the car against grime and corrosion. Maintenance can take place at the wash siding, instead of the paint shop.



And, because of the remarkable strength-to-weight atio of nickel stainless, each new car is about 3,000 ounds *lighter* than if it had been built with ordinary eel. Which means quicker acceleration and braking, lus savings in power costs estimated at $2,700,000 for ne fleet over a 35-year lifespan.

Just as our metal is a helper, one that improves the erformance of other metals, so International Nickel is helper.

We assist dozens of different industries all over the orld in the use of metals. We offer technical information. nd the benefit of our experience. Often, Inco metallur-ists are actually able to anticipate alloys that will be eeded in the future, and to set about creating them.

This kind of helpfulness, we figure, will encourage ur customers to keep coming back to us.

And that helps all around.

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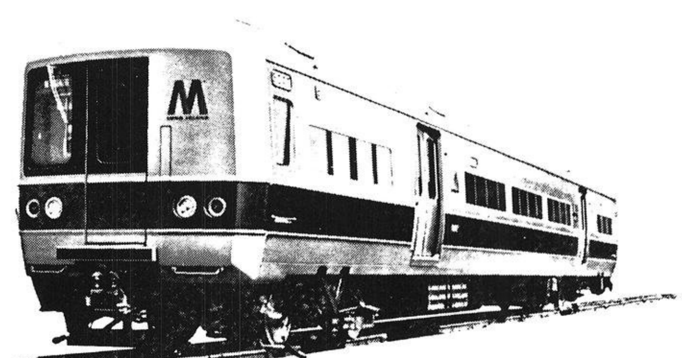


New "Metropolitan" car of nickel stainless steel.

INTERNATIONAL NICKEL HELPS

The HAWK and the BADGERS

by Carol Ward

Coach Johnson (THE HAWK)

With the Badger football season a part of history, many a University of Wisconsin sports fan now directs his enthusiasm to the ice arena.

Ice hockey has emerged on the University of Wisconsin campus as one of the most popular spectator sports. Ticket sales soared this year, with all student season tickets sold before the first game.

The *Wisconsin Engineer* recognizes the popularity of this sport, and wishes to feature the hockey team in this issue. In addition to the history of the Badger pucksters, an interview with Badger coach Bob Johnson and Michigan Tech coach John MacInnes reveals their predictions for the Western College Hockey Association (WCHA), as well as some insight into the upcoming games between Tech and Wisconsin.

The Wisconsin Athletic Department re-instituted hockey as an inter-collegiate sport in March of 1962 after an absence of 28 years. John Riley coached the team from then until 1965, when Bob Johnson took over the helm. Riley managed to compile a 34-23-3 record during his three season career.

Johnson, now in his sixth season, has amassed a 102-54-3 record. The 1969-70 season was his best. That winter the Badgers finished third in the National Collegiate Athletic Association. It was their first year as a WCHA team, and they were the only team who has ever finished out of the cellar during their first year of membership. Wisconsin ended up fourth in the WCHA that season.

Seven out of the last eight years, Wisconsin has won more than 60% of their games. Last season was the fourth consecutive season that Wisconsin won more than 20 games.

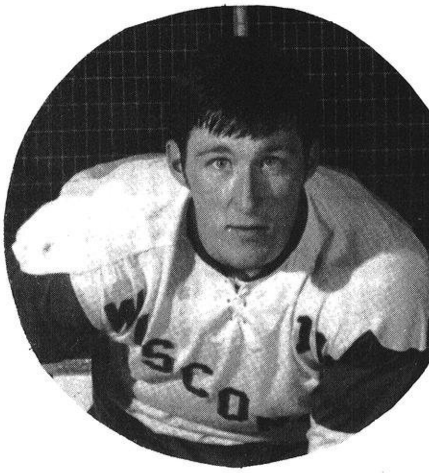
Attendance has grown substantially from the first season when a total of 8,937 fans attended Badger Hockey games. That was an average of 596. Last year approximately 107,000 supported the Badger skaters, for an average of 6800. This year is expected to be "better than ever," by Wisconsin coach Johnson.

The Badgers have had one All-American. He was junior John Jagger, a defenseman. Jagger won the honor during the 1969-70 season.

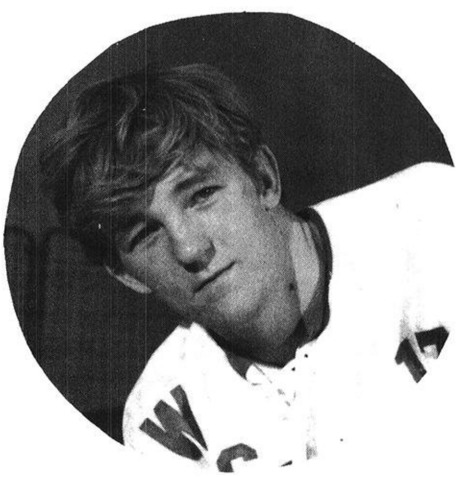
The upcoming series between Wisconsin and Michigan Tech will be played in the Dane County Memorial Coliseum on Friday, December 17 and Saturday, December 18 at 7:30. As one avid fan proclaimed: "The series between Tech and Wisconsin is always a big one, and this year it will be bigger than ever."

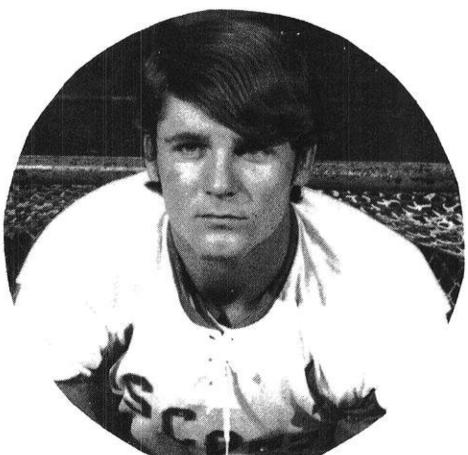
Michigan Tech, a top-rated team, was called "the finest in the league," by coach Johnson. Johnson plans to give Tech a good fight, however, and Tech expects strong competition from the Badgers. Neither Johnson, nor Tech coach John MacInnes would speculate as to who would win the series.

Because the series consists of only two games, it's important for both teams. An eight point value is assigned to each series, and generally four games make up one series. The victor of each game in the Wisconsin-Tech series will receive four points. If



"THE BADGERS" – Top left: co-captain Jim Young. Top right: co-captain Jeff Rotsch followed by Junior: Tim Dool, Freshmen: Dean Talafous and Goalie: Dick Perkins.





Wisconsin can accumulate enough points and earn a first division finish, playoffs will be in Madison. Tech of course, wishes to gain the same honor.

Both Wisconsin and Michigan Tech belong to the WCHA, considered to have the strongest competition in the country. "With the addition of Notre Dame," Johnson noted, "we have 10 good teams in our league."

MacInnes predicted that Denver will finish on top of the league, and that from there the remaining teams could rank in any order.

In the Badger lines we will have pucksters Dean Talafous, a freshman, Tim Dool and Norm Cherrey, both juniors. Gary Winchester, a sophomore, senior co-captain Jim Young and Gary Kuklinski and Bill Reay Jr., both seniors. Former wing Phil Uihlein will center the third line, with sophomore Stan Hinkley and senior Pat Lannan as wings.

Senior co-captain Jeff Rotsch, freshman Bob Lundeen and seniors Brian Erickson and Al Folk will be playing defense. Dave Arundel, a sophomore, has played on the Badgers' power play and killed penalties. Freshman Tom Machowski and junior Ernie Blackburn have also played defense.

Sophomore Jim Makey and Freshman Dick Perkins have worked the goalie position, and will probably do so in the future.

Wisconsin's hockey team has faced some tough competition this season, and has looked good. The *Wisconsin Engineer* predicts a good showing against Michigan Tech, and urges all alumni and students to turn out for "an exciting display of talent on ice."

Rheology:

Funny Fluid Fenomena

by Jim Guenther Chem E-4

The first time I met this word was in Transport Phenomena, a junior level chemical engineering course. It immediately caught my eye and drew me in like the spider drew the fly, while the unique nature of the subject entraped my mind and left me helpless to resist its temptations.

The subject, as defined technically, is the science dealing with deformation and flow of matter. In a more practical sense, Rheology is the study of non-Newtonian fluids in an attempt to construct equations which can describe their unusual flow properties. Finally, my favorite definition of Rheology is the study of "funny fluid fenomena."

Non-Newtonian materials consist of many different substances, including pastes, slurries, liquid crystals, soap solutions, and even rubber and polymers. Each class has its own peculiar properties which make it different from all of the rest and especially from Newtonian fluids, which behave very predictably. Because of the widespread applications in the polymer industry, more is known about the Rheology of polymers than about most of the other materials, so this article will deal mainly with macromolecular substances.

To demonstrate the weird behavior of these "funny fluids" a few enlightening experiments will be discussed. They will point up the fact that non-Newtonian fluids not only exhibit different quantitative behavior, but in some cases, completely opposite qualitative results occur.

In the first experiment, two liquids have apparently the same viscosity as measured by a falling ball viscometer. When placed in a vertical tube, open at both ends, the polymer fluid drains faster than the Newtonian fluid. (see figure 1) In other words, the polymer viscosity is dependent upon the shear rate. For an engineer this means that the flow rate of non-Newtonian fluid through a pipe is not a linear function of pressure consequently solving piping problems becomes much more difficult. (see figure 2) This is an effect which cannot be overlooked, since the viscosity can vary by a factor as large as a thousand from the Newtonian prediction.

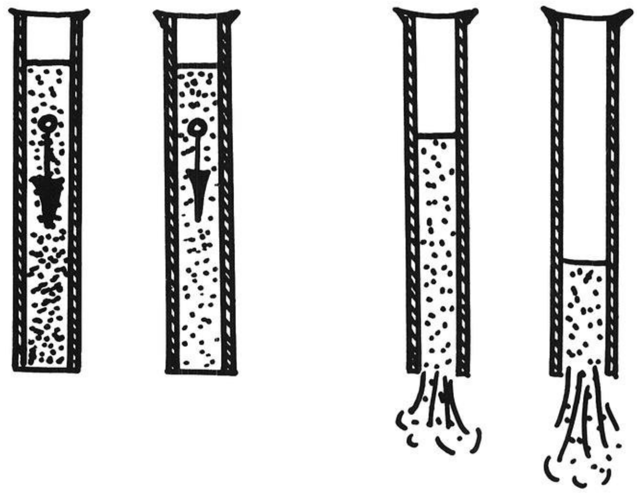


Figure 1 showing equal viscosity at low shear rates for a Newtonian fluid (N) and a Polymer (P). At high shear rates the polymer exhibits shear thinning and has a lower viscosity.

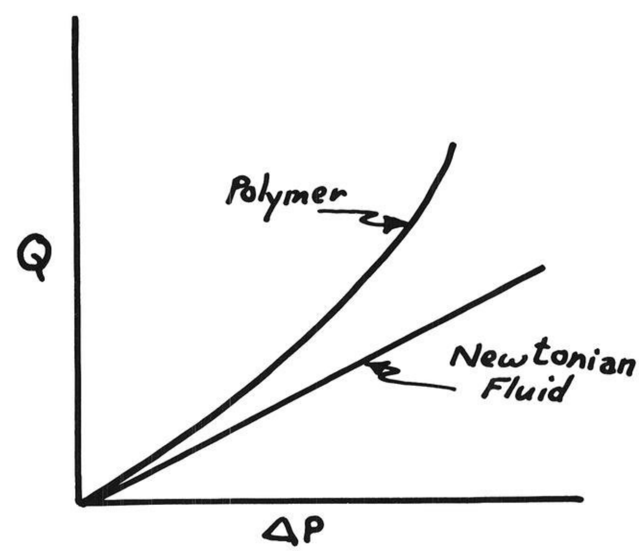
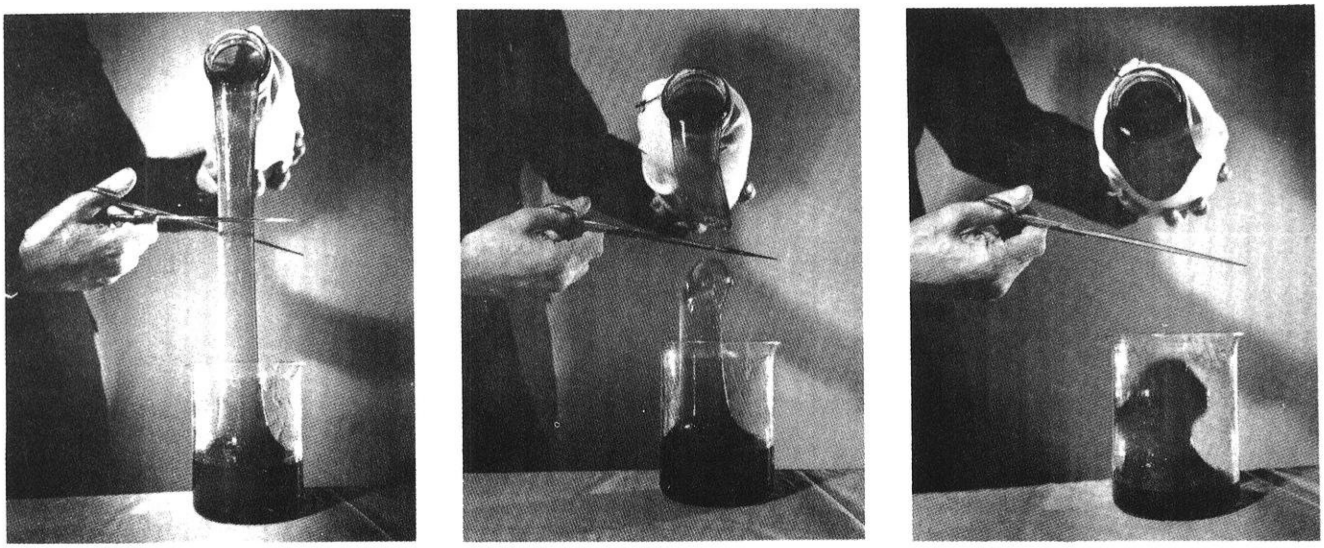


Figure 2 is a plot of the volume flow rate (Q) versus the applied pressure difference (P) for flow in a pipe. Notice how the polymer flow rate is a nonlinear function of applied force.



A three photo sequence showing an unusual property of macromolecular liquids. The liquid is being poured like a normal fluid on the left. A scissors cuts the stream as shown in the center picture. The liquid "jumps" back into its container in the right hand photo.

A second unusual phenomenon exhibited by macromolecular fluids is called the rod climbing effect or "Weissenberg Effect."It demonstrates the totally opposite behavior of a polymer under the same flow conditions as a Newtonian fluid. (see figure 3) A rotating rod is placed in a beaker of each material.

This induces a circular flow of the fluid in each beaker. The surface of the Newtonian liquid forms a vortex because of the centrifugal force which throws the fluid toward the outside of the container. The polymer, on the other hand, builds up near the rod and climbs right up. It is clear from this result that another force, larger than the centrifugal force, is acting on the fluid. This additional force has been termed a "normal force" by Rheologists. It causes us to re-evaluate our methods for solving macromolecular flow problems and our methods of design for mixers and stirrers where baggles should now be located on the stirring rod instead of on the outer rim of the container.

A third flow property peculiar to non-Newtonian fluids is that of recoil. The experiment done to show this effect consists of taking a tube of fluid that is initially at rest, and imposing a pressure differential. This causes the fluid to flow and attain a curved velocity profile, as shown in figure 4. Then, the pressure difference is instantaneously removed and the fluid behavior noted. The Newtonian fluid stops, "in its tracks," as soon as the force is stopped, while our polymer tries to return to its original unsheared position by creeping backwards after the driving force is removed. One of the explanations offered for this unusual behavior of macromolecular materials is that they are a hybrid between Newtonian liquids and Hookean (elastic) solids. The recoil effect is an example of the elastic response of these fluids.

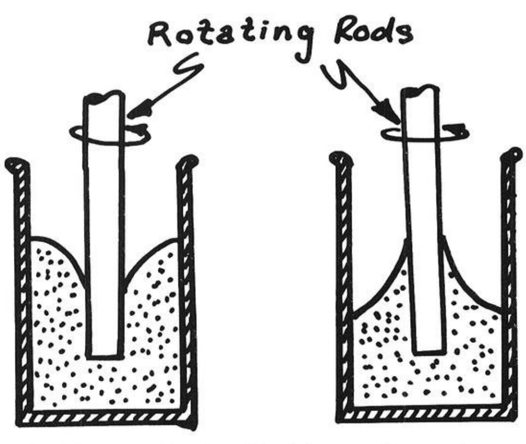


Figure 3. Macromolecular liquids are drawn toward the rotating rod by normal forces which overcome the centrifugal force. Newtonian fluids don't have these normal forces acting on them, so they move toward the outside, forming a vortex.

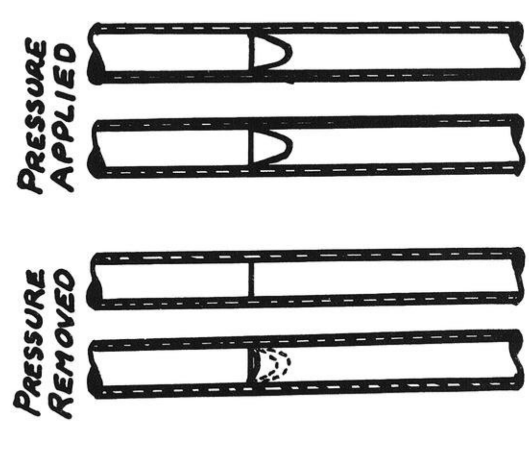
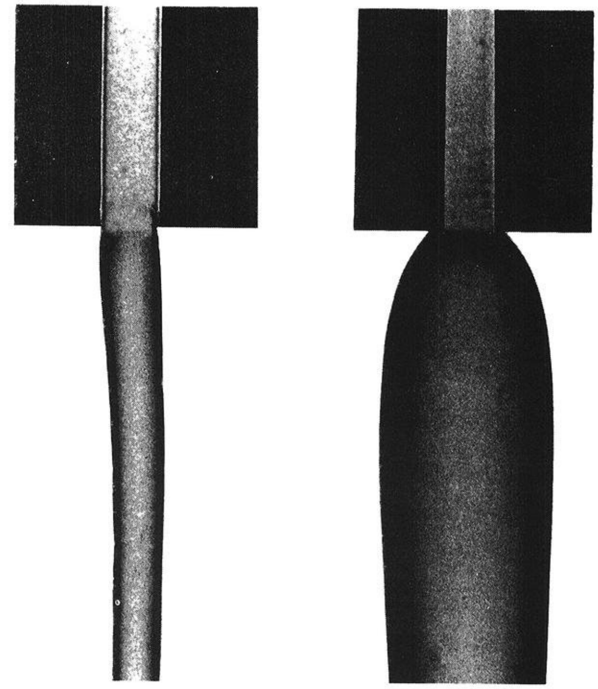


Figure 4. Both Newtonian and polymer fluids have similar velocity profiles when flowing, but the polymer "recoils" when the stress is relaxed while the Newtonian fluid does not.



An example of "die swell." The polymer, on the right, expands greatly when it is extruded.

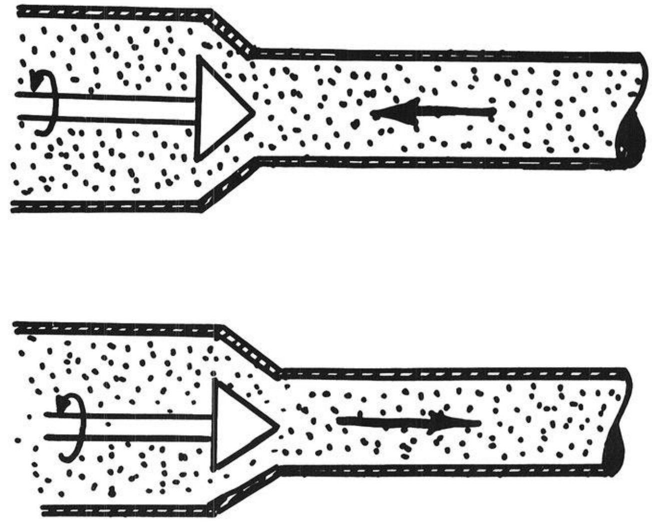
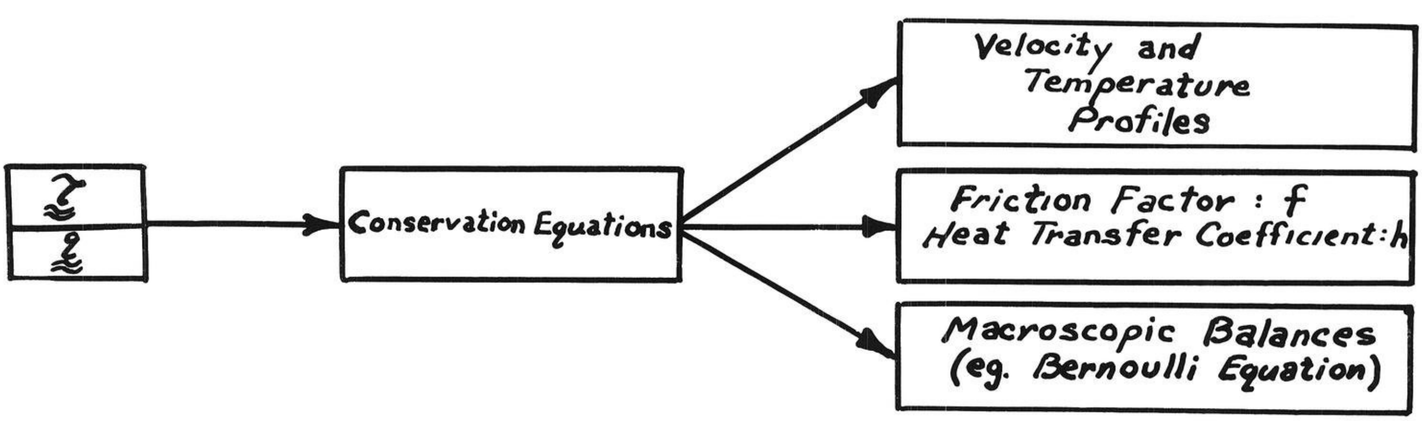


Figure 5. The rotating cone pump, producing flow in opposite directions depending upon the type of fluid it is pumping.

Extrusion is an important engineering unit operation. In this process a material in a semi-liquid state is drawn through a die where its shape is changed or made smaller. Because of the widespread use in the fiber and clothing industry, and in the coating of wires; the flow properties of the polymers, as they pass through the die, must be known. As you can see in the photograph a Newtonian fluid shows no unusual flow characteristics when going through the orifice. A macromolecular fluid, on the other hand, exhibits an increase in size of up to five or six times its original size. This can be critical where there are close tolerances in the diameter of a fiber or the thickness of the coating on a wire. This effect, like many of the other unusual ones polymers show, is not fully understood and is currently being researched.

The final and most important demonstration is that of the rotating cone pump (or centrifugal pump). This pump has a rotating cone or disk which imparts a force to the fluid through the shear stress at the surface. For the Newtonian fluid this creates a pressure differential with a high pressure area located on the outer rim of the rotating cone. Therefore the fluid is forced to flow from right to left in the diagram as shown. In the case of a non-Newtonian fluid an extra force is present. It is a normal force in the direction of the primary flow – in this instance it acts in the direction of the rotation. The normal force tightens a ring of fluid around the cone much like the band around a barrel pulls the boards toward the center. Because the direction of flow for a non-Newtonian fluid is in the opposite direction as that of its Newtonian counterpart, these "normal forces" must be much stronger than the centrifugal forces opposing them. Therefore, they cannot be overlooked in any engineering design.

FIGURE 6



As I'm sure you can see from the experiments discussed previously, non–Newtonian fluids present problems to the engineer unsolvable by normal hydrodynamic equations. These include:

NEWTONS LAW OF VISCOSITY

$$\tau_{yx} = -\mu \frac{dv_x}{dy}$$

FOURIERS LAW OF HEAT CONDUCTION

$$q = -K\nabla T$$

CONSERVATION OF MASS EQUATION

$$\frac{\partial \rho}{\partial t} = -(\nabla \cdot \rho \vec{v})$$

CONSERVATION OF MOMENTUM EQUATION

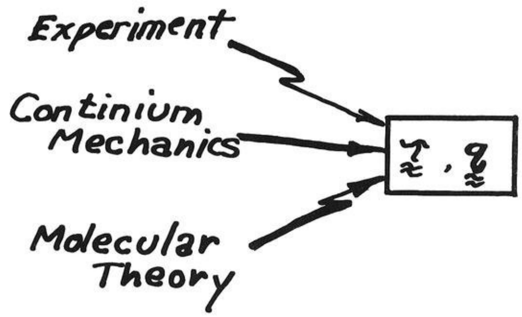
$$\frac{\partial}{\partial t}\rho\vec{v} = -[\nabla \cdot \rho \vec{v}\vec{v}] - \nabla p - [\nabla \cdot \vec{\tau}] + \rho g$$

CONSERVATION OF MECHANICAL ENERGY

$$\frac{\partial}{\partial t}\left(\frac{1}{2}\rho v^2\right) = -\left(\nabla \cdot \frac{1}{2}\rho v^2 \vec{v}\right) - (\nabla \cdot p\vec{v}) - (-\nabla \cdot \vec{v})p - (\nabla \cdot [\tau \cdot \vec{v}]) - (-\tau : \nabla \vec{v}) + \rho(\vec{v} \cdot g)$$

Very simply, the approach to fluid dynamic problems (see figure 7) involves finding an expression for the shear stress and the heat flux. Then substituting this result into the conservation equations and solving for velocity and temperature profiles, deriving expressions for the friction factor (f) and heat transfer coefficient (h), or integrating and arriving at the macroscopic balances (eg. Bernoulli equation). The problem occurs when we attempt to find a relation for the shear stress and the energy flux, because neither is a simple known function for non-Newtonian fluids.

There are three approaches taken to find values for the shear stress and the heat flux – experiment, continuum mechanics, and molecular theory.



Experimental work in this field is extremely difficult to perform because polymer solutions do not act the same as other fluids and therefore their responses to normal testing equipment will be different. So, each experiment must be designed individually, taking into account all of the irregularities of polymers. University of Wisconsin chemists John D. Ferry and John L. Schrag have done quite a bit of experimentation in the study of polymer mechanical and optical properties and their relation to chemical structure and molecular motion.

Continuum mechanics has yielded some important results for engineers; one of which is the Ericksen equation(see figure 9).Included as its first term is the "generalized Newtonian fluid" equation, which is the simplest and most widely used equation for flows of this type.

The molecular theory of macromolecules is much too difficult to approach from a theoretical direction because of the many different positions molecules can be in. Therefore, simplified models have been developed which help to reduce the problem to a mathemcatically tractable one.

For dilute polymer solutions, professor R.B. Bird, from the Chemical Engineering department, has been using a model consisting of a number of "beads" joined by various connectors such as rigid rods or Hookean springs. (see figure 7 for a sketch) These long chains of beads and connectors are considered to be surrounded by a Newtonian solvent. This model is then used to calculate various viscoelastic properties for different flow conditions, which are compared to actual experimental results. In this way the models are continually revised to yield a better understanding of polymer flows.

For very concentrated solutions and polymer melts, the network theory has been developed. The molecules in this case are considered as tangled chains with secondary chemical bonds holding them together in a matrix form. (see figure 8)

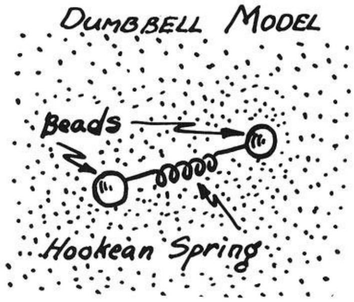


Figure 7. Two beads are connected by an ideal Hookean spring and suspended in a Newtonian solvent. This model is used to develop equations which describe the unusual flow properties of polymers.

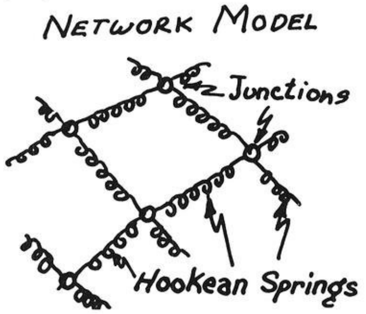


Figure 8. This model is made up of many junctions which are connected by Hookean springs. This is intuitively how one might think that rubber or polymer melts might be constructed.

Professor Arthur S. Lodge, of the Engineering Mechanics department, has developed this theory into a useful scientific tool as well as heading the interdisciplinary Rheology Research Center on campus. Professor Lodge has also recently received the Bingham Award for excellence in the field.

Closely akin to the matrix model of Lodge is the work currently being done by Millard W. Johnson, also of the Engineering Mechanics department. He is developing a mathematical model for nonwoven fabrics, such as paper linens or disposable hospital clothing. This model will relate the fiber structure to properties such as strength and softness.

As one might expect, from the number of different disciplines represented in the Rheology Research Center, some friendly rivalries have developed. Over the years, the engineering faction has acquired the name, Randall Street Rheological Society, better known as the RSRS. Not to be outdone, though, the chemists dubbed themselves the Johnson Street Jiggling Society or JSJS, because their work is done mainly with small amplitude oscillations of polymeric materials. When the new chemistry building was erected and the street address changed to University Avenue, the chemists couldn't resist the challenge to come up with a new title – the University Avenue Undulating Association (UAUA).

It is evident that the Rheologists at the University of Wisconsin have a lot of fun, but they have also done much to increase our knowledge of this intriguing subject.

CAMPUS COMMENTS

AIChE

Professor R. R. Hughes, of the Chemical Engineering department, will be the featured speaker at the December eighth meeting to be held at the Union South. He will speak on AIChE's response to changing conditions, including news from the national convention held in San Francisco the preceeding week.

ASCE

On Friday, December 3, 1971 ASCE will tour the facilities of the Forest Products Laboratory. The tour will include the lab's pilot plant on wood fiber recycling. Also during the month of December there will be a Christmas Party for all ASCE members in room 120 of the Union South on Friday, December 10.

AIIE

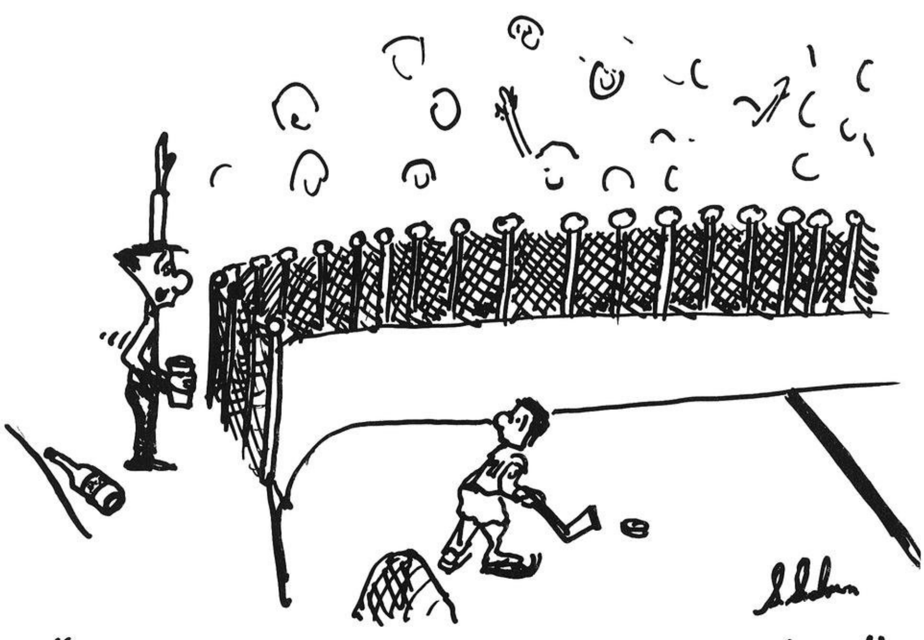
The month of December usually signifies celebration, and this year is no exception for the Industrial Engineers. In place of the business meeting this month, a Christmas party is being held on Saturday, December 11. Faculty, staff, and students are all being invited for an evening with cocktails and dancing. It will be an excellent opportunity to meet the other people in the department in an informal setting.

THETA TAU

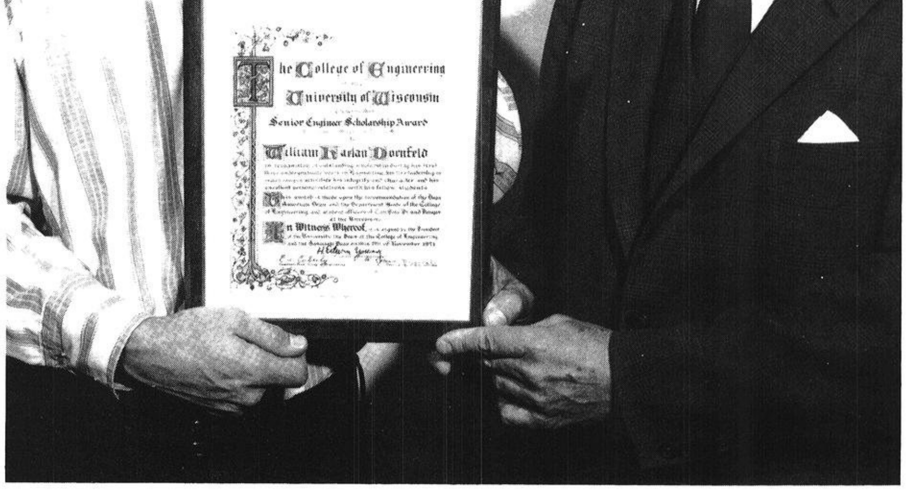
Theta Tau will have a light schedule in December. A plant trip to the United Aircraft Service Facilities at O'Hare Field in Chicago will take place on Friday, December 10, at noon. Anyone outside of our organization is welcome to attend at our expense. Just call 256-6725 or 257-7206 for reservations.

An enlightening presentation by Prof. Moll of the M&ME Department on product liability highlighted our professional development program for November. According to Prof. Moll, shoddy products are inexcusable; however, even the best quality control play will fail to isolate every inferior product. In sports, completion of our undefeated season in football earned our jocks another league championship.

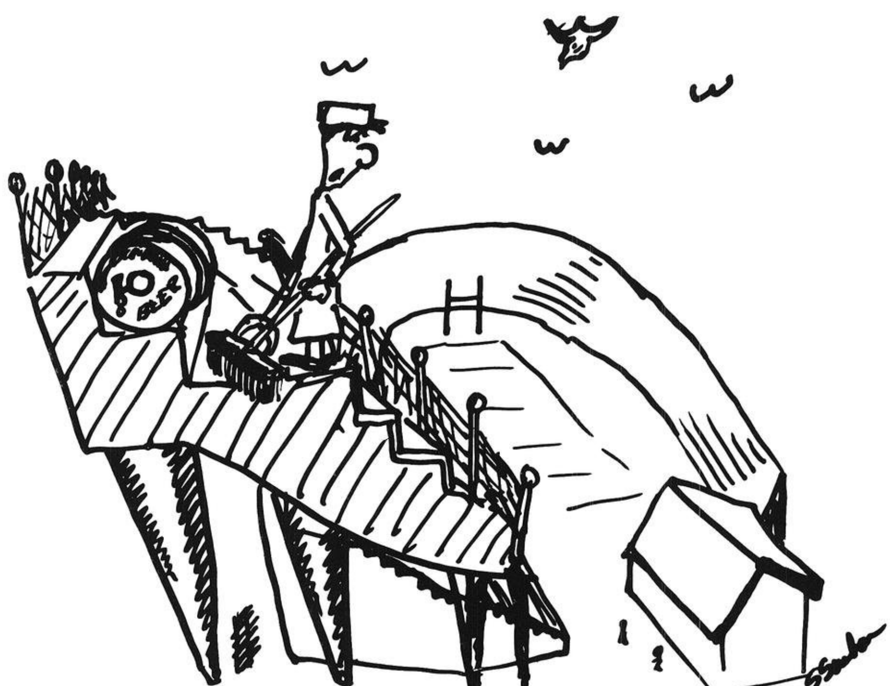
Our final function of the month was a trip to Minneapolis to support the Badgers in their final game of the season and to visit our brothers of the Minnesota Chapter of Theta Tau. A party at their house ended the day.



"Throw some ice up here buddy..."



A student who has achieved a perfect scholastic record in electrical engineering at the University of Wisconsin in Madison, William H. Dornfeld of Horicon, is the winner of the Hugh and Cynthia Rusch Senior Engineer Scholarship Award for 1971. He received $500 and a certificate from Dean W. Robert Marshall, and Rusch, retired president of Hugh Rusch and Associates Inc., Princeton, N.J. Rusch is a graduate of Wisconsin in electrical engineering in 1923. The award is given annually to a UW student whose grades are in the upper three per cent of his class and who has shown leadership in major campus activities, personal character, and ability to get along with fellow students. Dornfeld is vice chairman of the student chapter of the Institute of Electrical and Electronics Engineers, and is an active member of the American Society of Mechanical Engineers and Tau Beta Pi, honorary society.



" IT'S AMAZING, HOW THEY MUST GET THESE THINGS UP HERE? "

THIS CONCLUDES CHAPTER 1 OF "THE TRIUMPHS OF THE WISCONSIN ENGINEER."

How to call a stereo buff's bluff.

A buff will probably tell you you've got to drop a bundle to get a really great stereo system.

Nonsense.

Stereo is all in the ear. It's how it sounds, not how it costs, that makes a stereo system great.

So next time some buff hands you that old line call his bluff. See if he can figure out how much you paid for your Sylvania matched component stereo system. Just by listening.

Pick your favorite record. Put it on the BSR micro-mini turntable. (If tape's your thing, slip one into the 8-track cartridge playback.)

Then balance the bass and treble on the FM stereo FM/AM tuner and amplifier. And let him have it.

Make sure he digs those round low notes from the two six-inch woofers. And those high sweet ones from the two three-inch tweeters. They're all air-suspension speakers, so they sound as good as standard speakers two sizes larger.

Your buff won't have a chance. He'll stand there, surrounded by sound, completely bluffed. Trying like crazy to figure out how much you laid out for a stereo that sounds that great.

But don't tell him.

After all, you just want to call his bluff. Not destroy his ego.

GTE SYLVANIA

Static

Ode to a Martini Drinker

Sold Cober,
Starkle, Starkle, little twink,
Who the hell you are I think.
I'm not under what you call,
The alchofluence of incohol.
I'm not as drunk as thinkle peep,
I'm just a little slort of sheep.
Tee martoonis make a guy,
Fool so feelish, don't know why.
Really don't know who's me yet,
The drunker I stay, the longer I get.
So just one more to fill my cup,
I've all day sober to Sunday up.

* * * * *

What did the 1604 Datacraft say to the Computer Science 211 student? — — ABORT — —

* * * * *

Hockey is a puck of a game.

* * * * *

The college student, looking bent, weary, and worn out stumbled up to the bar.

"What's the trouble," asked the bartender. "You look really bad."

"It's yoorz," moaned the student. "I've got a bad case of yoorz."

"What's yoorz?" asked the bartender.

"A double scotch," replied the student.

* * * * *

I.E.: "Do you have a french curve I could use?"
Girl: "Does the sun rise; Do birds fly; Do engineers use slide rules?"
I.E.: "Of course."

* * * * *

What did the 1604 Datacraft say to the senior Computer science student? — — ABORT — —

* * * * *

"Did you make it home from the party all right last night?" "Oh, Yea, except that just as I was turning the corner, some drunk stepped on my fingers."

* * * * *

C.E.: "What would you say to me if I stole a kiss?" She: "What would you say to a thief who had a chance at stealing a car and only took the hubcaps?"

"I told the florist I wanted a potted plant not planted pot!"

Did you hear about the Chemistry student who spent two days at the lumber yard looking for his draft board.

* * * * *

Skate, Skate, . . . Whiz . . . Crunch, . . . Skate, Skate

* * * * *

What did the 1604 Datacraft say to the Comp. Sci. Prof. — — ABORT — —

* * * * *

Did you hear about the moran that did Do loops?

* * * * *

Did you hear about the keypunch that duplicated?

* * * * *

What did the 211 Computer Science student, the senior Computer Science student, and the Comp. Sci. Prof, say to the Computer? "Get the puck outta there."

* * * * *

Sieve, Sieve, Sieve . . . . Right on!

* * * * *

You win some, you lose some, and the others bomb out.

The ad shown below has told the public about a Kodak product intended to save people from a life of mental retardation.

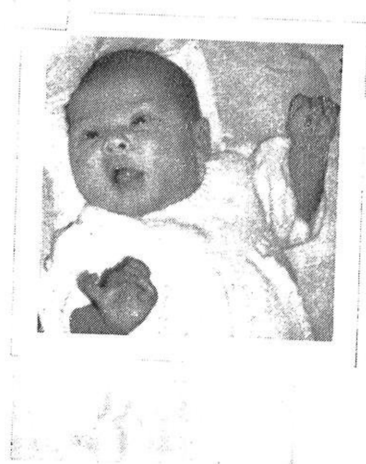
A young Kodak technical guy convinced us we ought to market that product.

Convincing us was not easy.

Nobody who wants to do a little good in the world *ever* has an easy time of it, *any place*.

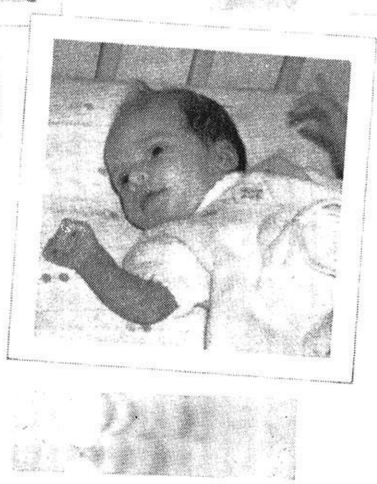
EASTMAN KODAK COMPANY

Kodak



The upper row of crescents in each case is for comparison.

The lower row is from the baby.



Baby pictures

Seen here as strips beneath the familiar kind of baby snapshots is a new kind, made from urine samples donated by these healthy new citizens. (A test of blood plasma is also desirable.) The strips tell about body chemistry. One out of many thousands of such patterns may turn up with a prominent crescent in the lower row at this particular point

▼

Such is the hint that the infant's body is mishandling phenylalanine, a required substance that results from digestion of any natural protein food, like milk. If this continues, the child will probably suffer mental retardation.

Most states already require a test for this condition. If after the first weeks at home babies had an additional blood test with one of these snapshots, chances would increase of detecting other such metabolic defects. Unrecognized and untreated, many of these also lead to retardation and other severe impairments.

Treatment consists of precise regulation of diet.

Kodak, long known for simple snapshots, also makes the material on which these simple non-photographic ones are taken. (Thin-layer chromatograms, they're called.) No camera, only a few plastic accessories.

The physician's time and insight are required only for the infant whose test falls outside the common range of variation—to decide on more detailed confirmation of abnormality and, if confirmed, on remedial measures.

Cute baby pictures are both priceless and remarkably inexpensive. So is this less cute, biochemical kind. Who ought to pay for it is an interesting question in ethics, politics, and economics. Here is one place where industry's ambitions for efficient production may encounter little opposition.

HOW CAN A MICROBE HELP TURN GARBAGE INTO FOOD?

The petri dish at the bottom of the page holds a special strain of thermophilic microbes. What does it have to do with garbage?

The microbes digest cellulose. And cellulose is what nearly two-thirds of all municipal garbage and farm refuse are made of.

So the microbes can digest your garbage. But that's not all they can do. They can convert it into a high-protein substance that livestock will accept as food.

This strain of microbes was first isolated in a General Electric research lab a few years back.

Today, our engineers are working to design a pilot plant to make the waste-conversion process work on a large scale.

It's a technological innovation with a good chance of solving one of the biggest problems facing the country today. But, then, that's hardly surprising. Technology is one of the surest ways of solving social problems.

That's why, at General Electric, we judge innovations more by the impact they'll have on people's lives than by their sheer technical wizardry.

Maybe that's a standard you should apply to the work you'll be doing. Whether or not you ever work at General Electric.

Because, as our engineers will tell you, it's not so much what you do that counts. It's what it means.

GENERAL ELECTRIC