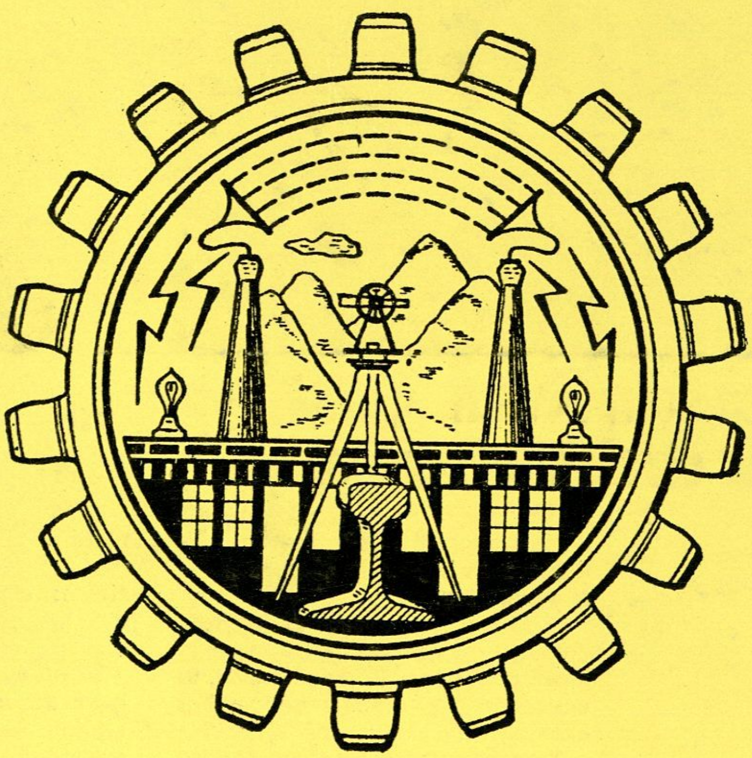
THE COLORADO ENGINEERS MAGAZINE



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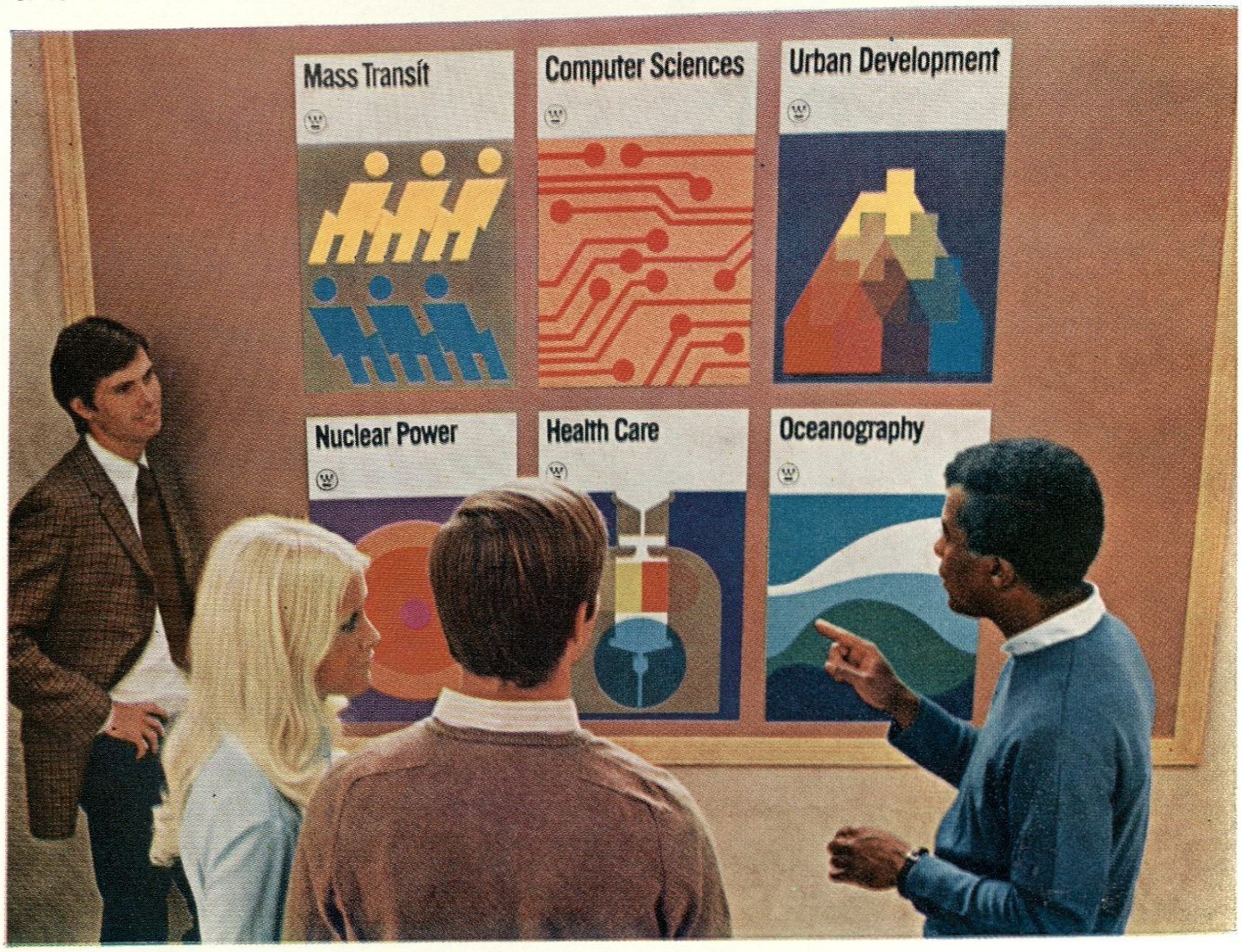
MARCH, 1970

If you want to engineer a better world...



a great place to start is with one of the most diversified companies in the world.

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Transportation: Our computerized transit systems can operate on a 90-second schedule, and meet the transportation needs of many cities.

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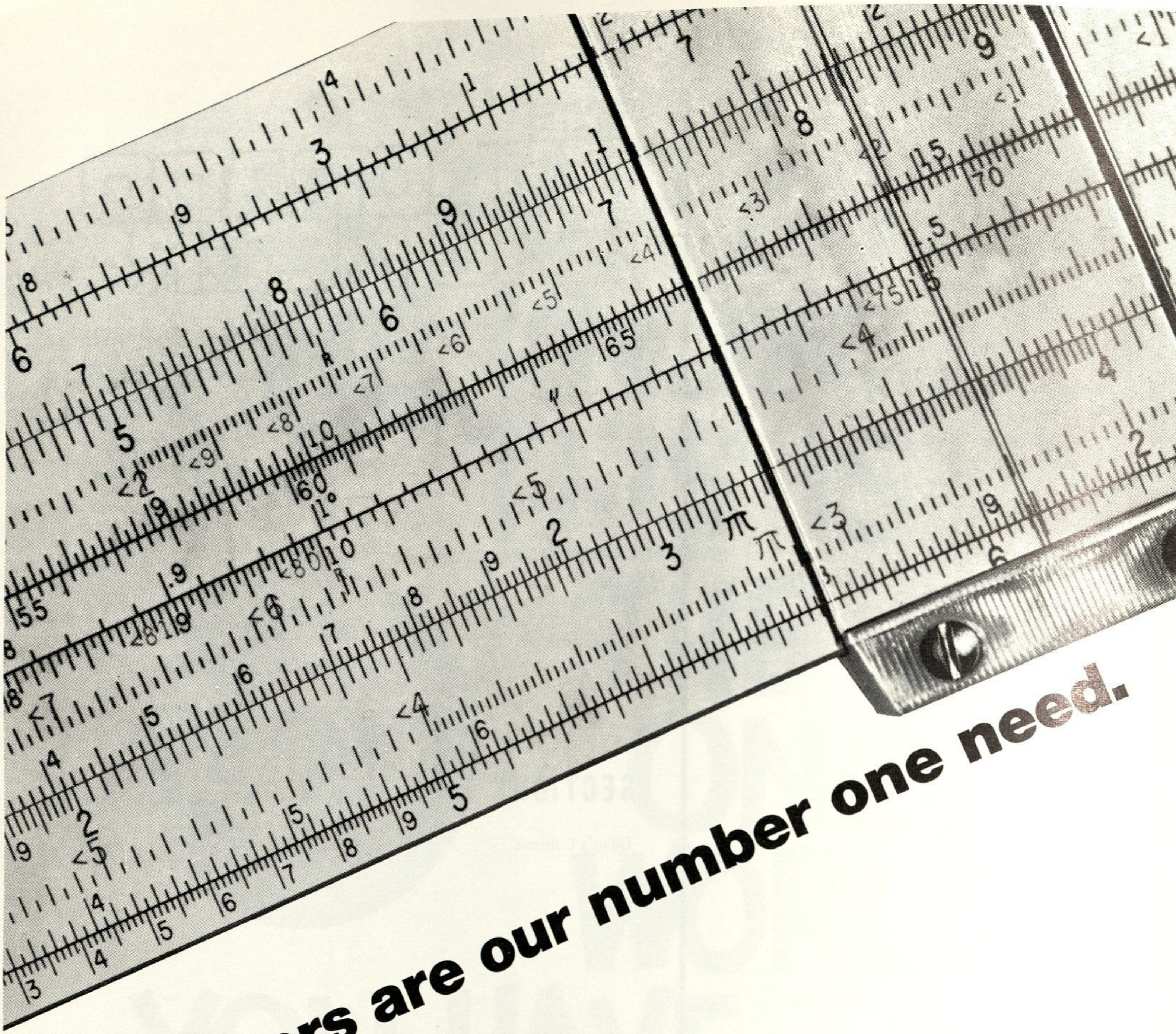
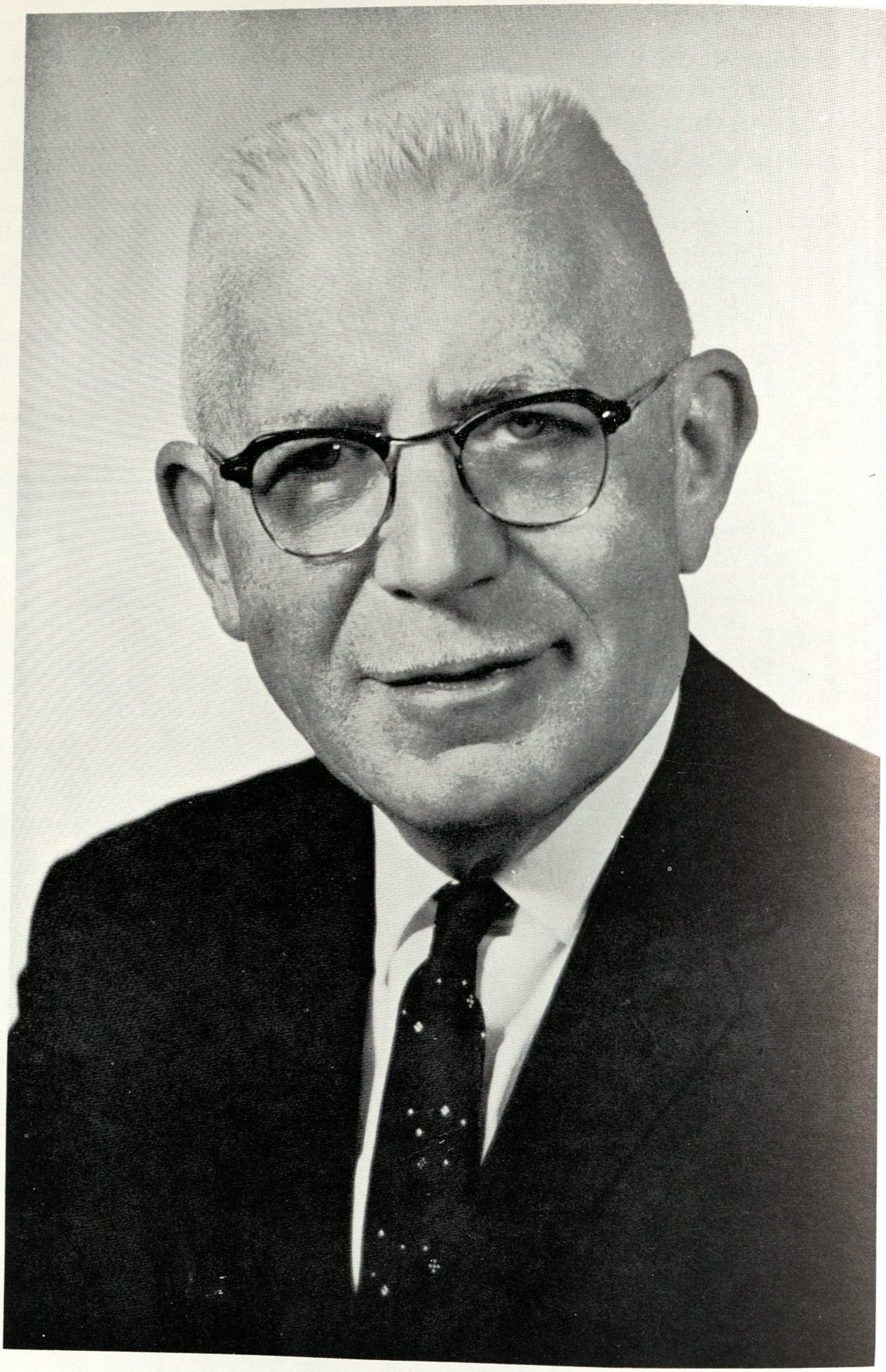




IN MEMORY OF DEAN HUTCHINSON

The staff of the *Colorado Engineer* wishes to express its regret at the death on January 13 of Charles A. Hutchinson. By now everyone in the university community has read at least one notice of his death and of his long career as a professional man, teacher, and administrator. His achievements and many honors have been fittingly described elsewhere; we feel it is not too late, however, to record here our respect and a sense of loss for the man and what he eminently represented.

Upon Mr. Hutchinson's retirement in 1966, Dean Peters said:

> The rapport he has developed with his students and the inspiration he has been to them through his teachings is attested by the constant references made to the great influence his teaching has had on their lives by his former students.

Mr. Hutchinson was happiest as a teacher. That same day he remarked, *"I've done what I've wanted to do–teach."* That he would gladly teach is, it seems to us, the most just cause to honor a man of Mr. Hutchinson's bright and varied achievements. It seems to us that his long tenure as a teacher must be the grandest achievement, that his fifty-two years of affecting the minds and lives of his students is a responsibility given to very few men, and that Mr. Hutchinson filled his role and that responsibility with high distinction. In doing so he has recorded his own place of distinction beyond the customary praise and naming of his achievements.

Attention Bra Engineers!!

Bra-Design Contest In Engineering Schools Set by Garment Makers

Sponsor Says Bust 'Properties' Present 'Unusual' Challenge For Technological Students

By a Wall Street Journal *Staff Reporter*

June 12, 1968

NEW YORK – A contest to apply complex engineering principles of stress and load to improve brassiere design was announced by Lovable Co.

The national competition, open to engineering school students, is billed as the first of its kind in the country. It carries prizes of $500, $350 and $150, with matching grants to the winners' schools. Entries, which close Oct. 31, become the property of Lovable, a women's undergarment maker with sales of $60 million a year.

"Considering the complex structure of the garment, we feel that the application of engineering concepts may well make a significant contribution to improvements in design," said Arthur Garson, chairman of Loveable.

Mr. Garson said schools that have agreed to distribute application forms include Harvard University, Columbia University School of Engineering, City College of New York, Purdue University, and Carnegie Institute of Technology.

The Massachusetts Institute of Technology, Mr. Garson said, declined to distribute the forms, explaining such a contest "isn't for us."

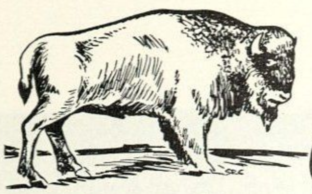
A press release says entrants will be required to submit "supportive engineering-design calculations, which may range from slide-rule computations to elaborate studies employing digital computer methods."

While use of live models as design aids isn't covered by contest rules, Mr. Garson said, "Presumably, the application of scientific principles will have to be checked out on live models after the plans are drawn."

Mr. Garson says "the properties of the bust are unusual and unlike those of most engineering materials." As a result, he says, designing a strapless bra or one for an unusually large bust size "is a great engineering feat in itself."

Instructions accompanying the contest's application forms state that although engineering innovation is desired, designs must conform to elemental requirements of "function, styling, comfort, and safety."

"The factors of safety," the directions explain, "are based upon uncertainties in the stress distribution, uncertainties in material properties, as well as the static or moving nature of the load."



Chips

Seeing the sight of New York City via the Fifth Avenue bus, a very prim young lady was scandalized to hear an obviously newly immigrated man saying to an attentive companion:

"Emma coma first, I coma next, two assa coma together, I coma again, two assa coma together again, I coma one-a-more, pee-pee twice, then I coma for the lasta time."

The young lady was crimesonfaced when he finished, and then, noticing a policeman seated nearby, she whispered to him, "Aren't you going to arrest that terrible old man?"

The policeman stared at her, and said, "What? For spelling Mississippi?"

Then there was the Aero and his new bride going to Colorado Springs for their honeymoon. The Aero put his hand on his bride's knee.

"Honey, now that we're married you can go further," she said sweetly.

So he went to Pueblo.

The ME. and his date had been sitting in the swing in the moonlight alone. No word broke the silence for more than a half an hour until –

"Suppose you had money," she said, "what would you do?" He threw out his chest, in all the glory of his manhood.

"I'd do some travelling."

He felt her warm, young hand slide into his. When he looked she was gone.

In his hand was a nickel.

It was a delightful spring day and four high school girls skipped morning classes to go for a drive. After lunch, they reported to a teacher that their car had had a flat tire on the way to school that morning.

To their relief, she smiled understandingly and said: "Girls, you missed a test this morning. Please take seats apart from one another and get out your notebooks."

When the girls were settled and waiting expectantly, the teacher continued, "No talking. Now write the answer to this question: 'Which tire was flat ?' "


CAVU*

Where Have All The Chem E's Gone

DEAN MAX S. PETERS

In the Fall of 1968, the AIChE conducted a survey of chemical engineering departments to obtain information on graduate student enrollments and possible effects of the draft regulations. The results of this survey gave a sound basis for considerable concern about the developing changes in the enrollments in chemical engineering graduate programs, showing a startling drop of 23 per cent from the Fall of 1967 to the Fall of 1968 for new male students entering chemical engineering graduate school who were United States Citizens. Other disconcerting trends were also indicated by this 1968 survey, and a definite recommendation was made to obtain additional data in the Fall of 1969 to see what the continuing effects would be on chemical engineering graduate school enrollments due to the draft situation.

To obtain the additional continuing data and permit a resonable extended analysis, questionnaires on the graduate student enrollments in chemical engineering were sent to the chairmen of all chemical engineering departments in the United States, asking for data on the Fall 1969 graduate enrollments and a repeat of data from the same schools for the Fall 1968 enrollments. Of the 125 questionnaires sent out, 80 usable ones were returned. The information presented in the following is based on the returns in 1969, along with results of calculations to permit extrapolation of data from 1967 through 1969 to give a three-year picture. In those few calculations where the 1968 survey results did not agree with the data given for 1968 in the 1969 survey, the 1969 data were used.

In interpreting the data in Table 2, changes are presented on a percentage basis for full-time male U.S. citizens, full-time foreign students, and totals for all chemical engineering graduate students. The changes from the Fall of 1968 to the Fall of 1969 are very disturbing when one notes the very large percentage change of 17%, 37%, and 16% decrease respectively for first-year students, second-year students, and advanced students who are male U.S. citizens. This group, of course, represents our major future output of graduate degree holders in chemical engineering in the United States, and the situation that has developed this Fall on all three levels of graduate work is one about which we should have great concern.

The entire column under changes from Fall of 1968 to the Fall of 1969 on the graduate level in chemical engineering, as shown in Table 2, should cause every chemical engineering educator and every person in industry who is interested in hiring chemical engineers in the future to take careful notice and express sincere concern. It is also clear, by examining the column giving per cent changes for the Fall of 1967 to the Fall of 1968 in Table 2, that the effects we are now seeing for the Fall of 1969 were predicted by the results obtained in the Fall of 1968. Table 2 definitely confirms the reservations and concern we expressed in the Fall of 1968. However, we find we are now in an extrememly serious situation of a *major* drop in chemical engineering graduate enrollments, and it is necessary for us to face up to the problems which will be forthcoming in the near future as a result.

The seriousness of the situation is pictured graphically in Figure 1 where a series of bar charts is presented showing what has happened during the past three years. The basis for this bar chart is a total of 100 full-time graduate students in chemical engineering in the Fall of 1967. The first series of bar charts shows the decrease in the total number of students from 1967 to 1969. However, the second series of bar charts is the most distressing of the figures presented in that this particular emphasis on the great percentage reduction in full-time male U.S. citizens who are first-year students. These numbers, of course,

TABLE 2

AIChE

TABLES OF DATA FOR INTERPRETATION OF DRAFT EFFECTS

CHEMICAL ENGINEERING GRADUATE STUDENT ENROLLMENT QUESTIONNAIRE

Fall, 1969

(80 schools responding of 125 questionnaires sent)

Table 2-A - Changes in Full-Time Male U.S. Citizens

			Per cent change	
	Fall 1968	Fall 1969	Fall '68 to Fall '69	Fall '67 to Fall '68 (*)
1st-year students	476	395	-17%	-23%
2nd-year students	447	282	-37%	- 3%
Advanced students	743	622	-16%	+15%

Table 2-B - Changes in Full-Time Foreign Students

			Per cent change	
	Fall 1968	Fall 1969	Fall '68 to Fall '69	Fall '67 to Fall '68 (*)
1st-year students	385 (44%)	337 (45%)	-12%	+12%
2nd-year students	255 (36%)	275 (49%)	+ 8%	+ 6%
Advanced students	262 (26%)	289 (32%)	+10%	+20%

Table 2-C - Changes in Totals for all Ch.E. Graduate Students

			Per cent change	
	Fall 1968	Fall 1969	Fall '68 to Fall '69	Fall '6. to Fall '68 (*)
Full-time U.S. citizens	1671	1315	-21%	-4 to -10%
Full-time foreign stud.	902 (35%)	901 (41%)	0	+12%
Total full-time stud.	2573	2216	-14%	- 5%
Part-time students	983	817	-17%	~0 to +16%

(*) The Fall, 1967, to Fall, 1968, data are from the AIChE Graduate Enrollment survey made in the Fall of 1968 with 75 schools responding. See Chem. Eng. Progr., 65, No. 1, p.15 (1969).

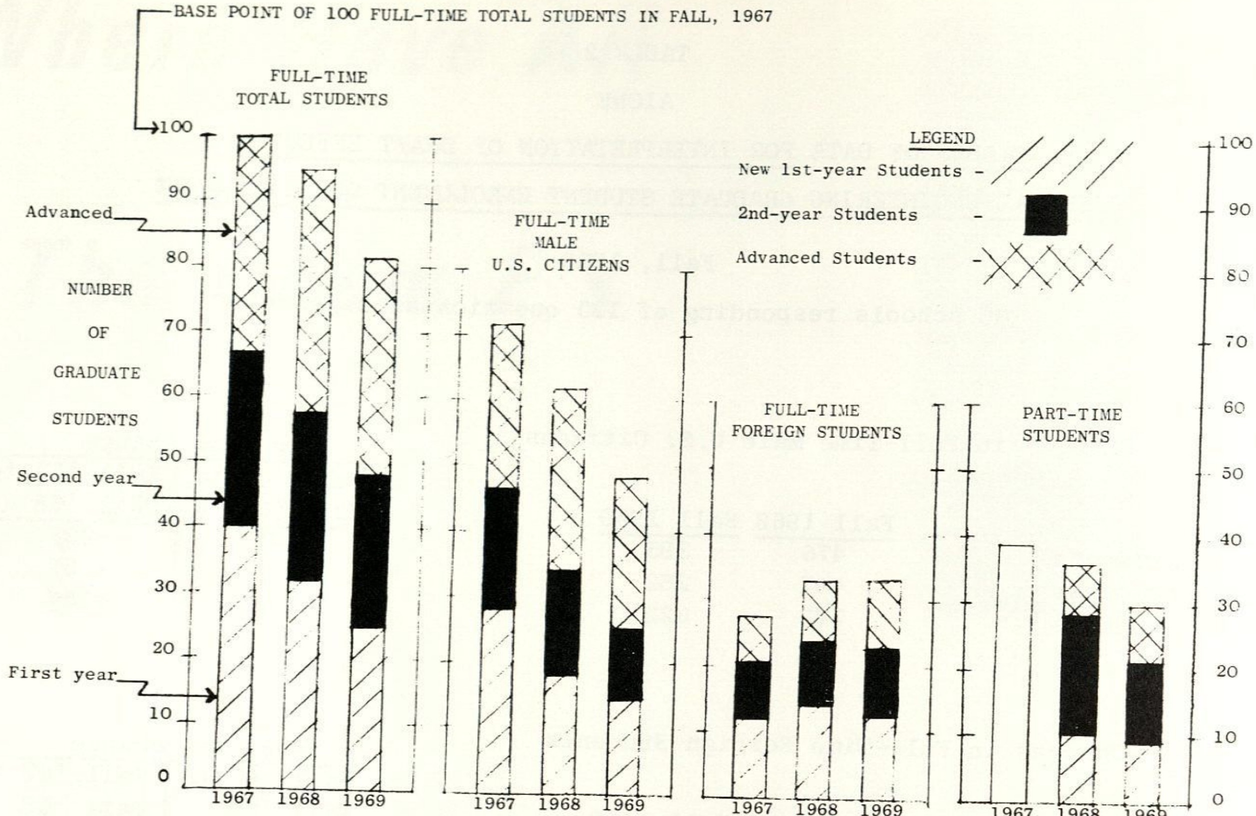


FIGURE 1. Bar Charts Showing Distribution of Chemical Engineering Graduate Students for 1967, 1968, and 1969 Using as a Starting Basis 100 Full-Time Total Graduate Students in Fall, 1967. Based on AIChE surveys of Chemical Engineering Departments in Fall, 1968 (75 schools) and Fall, 1969 (80 schools).

represent the future for our graduate program, and it is very shocking to note that, in the Fall of 1967, about 28 out of every 100 full-time graduate students in chemical engineering were full-time male U.S. citizens in the first year of graduate work, while this number, on the same basis of 100 original full-time graduate students in the Fall of 1967, had been cut approximately in half by the Fall of 1969.

The bar charts in Figure 1 also show that the total number of full-time foreign graduate students has increased only slightly during the past three years and, surprisingly, the total number of part-time students has actually decreased during the past three years. With reference to the number of full-time foreign students, even though the numbers have only increased slightly, the foreign student percentage of the total enrollment has increased significantly and was more than 40% in the Fall of 1969.

Many of the individuals who filled out the questionnaires had comments on the general situation. Almost all of the comments reflected great concern about the decrease in the total number of graduate students, with particular reservations being expressed for the future because of the great problems in getting male U.S. citizens to enter graduate school on a full-time basis. Some of the schools in large cities were not particularly concerned because they were able to increase their part-time student enrollment, but this was not the situation in most of our universities which generally are not located near large industrial centers.

A number of the comments were related to the fact that many potential new graduate students had indicated a strong interest in going on to graduate school but had decided they must enter industry in order to keep from being drafted. There were many comments to the effect

TABLE 1
AIChE QUESTIONNAIRE - FALL, 1969
Summary of Results for
Graduate Enrollment in Chemical Engineering

Number of questionnaires mailed = 125
Number of usable replies from Chemical Engineering Departments = 80

	Fall, 1968		Fall, 1969	
New first-year students	Full-time*	Part-time*	Full-time*	Part-time*
Male U.S. Citizens	476	253	395	215
Female U.S. Citizens	4	4	13	2
Foreign	385	36	337	45
SUB-TOTAL	865	293	745	262
Number in above total receiving financial support through University as scholarship, fellowship, assistantship, etc.:	436	24	395	3
Second-year students				
Male U.S. Citizens	447	272	282	291
Female U.S. Citizens	1	0	3	4
Foreign	255	188	275	26
SUB-TOTAL	703	460	560	321
Number in above total receiving financial support through University as scholarship, fellowship, assistantship, etc.:	443	11	398	15
Advanced students**				
Male U.S. Citizens	743	209	622	205
Female U.S. Citizens	0	3	0	4
Foreign	262	18	289	25
SUB-TOTAL	1005	230	911	234
Number in above total receiving financial support through University as scholarship, fellowship, assistantship, etc.:	703	12	822	23
TOTAL full-time students	2573		2216	
TOTAL part-time students		983		817

Number of graduate degrees granted:	1968-69	1969-70	(estimated)
Master's degree	753	728	
Doctoral degree	303	462	(This estimate is high)

* Full-time means students who are full-time at the University regularly as students. Thus a Fellow or a half-time teaching or research assistant would probably be considered as full-time, while 3/4 or full-time assistants as well as persons in industry taking a course or two per term would be considered as part-time.

** Includes all graduate students not counted as first or second-year students.

TABLE 3

AIChE

CHEMICAL ENGINEERING GRADUATE STUDENT ENROLLMENT SURVEY

Data for Bar Chart Showing Distribution of Chemical Engineering Graduate Students for 1967, 1968, and 1969 Using as a Starting Basis 100 Full-Time Total Graduate Students in Fall, 1967.

	Fall, 1967		Fall, 1968		Fall, 1969	
	Full-time	Part-time	Full-time	Part-time	Full-time	Part-time
New First-year Students						
Male U.S. Citizens	27.9	-	17.6	9.3	14.6	7.9
Female U.S. Citizens	0.4	-	0.1	0.2	0.4	-
Foreign	11.8	-	14.2	1.3	12.5	1.7
	40.1	-	31.9	10.8	27.5	9.6
Second-year Students						
Male U.S. Citizens	18.2	-	16.6	10.1	10.4	10.7
Female U.S. Citizens	0.3	-	-	-	0.1	0.1
Foreign	8.5	-	9.4	6.9	10.2	1.0
	27.0	-	26.0	17.0	20.7	11.8
Advanced Students						
Male U.S. Citizens	25.5	-	27.4	7.7	23.1	7.5
Female U.S. Citizens	0.2	-	-	0.1	-	0.1
Foreign	7.2	-	9.7	0.7	10.7	1.0
	32.9	-	37.1	8.5	33.8	8.6
ALL-YEARS TOTAL	100 (Basis for Table & Chart)	38.4	95	36.3	82	30

that the students from the individual university who were seniors had, to a large degree, considered the graduate school possibilities seriously and then made the decision to enter industry directly and perhaps take graduate school later on a full-time basis or take up graduate work on a part-time basis. The results of the survey for the Fall of 1969 do not show any indication that the students are immediately picking up graduate work on a part-time basis in increased numbers over preceding years.

The overall conclusions on a numerical basis are illustrated visually in Figure 1, while Table 2 summarizes the results on a percentage basis. The large decrease in full-time male U.S. citizens as chemical engineering graduate students on an overall basis and on a first- and second-year basis is very apparent. Because of the nature of this decrease, it is assumed that it can be attributed essentially completely to the effects of the Selective Service regulations. The indication that the Selective Service requirements would be changed did not come soon enough to permit students to change their minds and go on to graduate work instead of going into industry to avoid the draft.

The large decrease in the number of second-year graduate students in chemical engineering supports the fact that, in addition to fewer students entering in the Fall of 1968, many of the students left graduate study either before they received their Master's degreee or after receiving the Master's degree instead of remaining on for further graduate work. This, of course, will cause a serious decrease in the number of Doctor's degree graduates within the next several years. It also represents a reduction in number of available students for advanced students to help as Teaching Associates.

With the proposed changes in the draft regulations, many persons are indicating that the problem will be over and we do not need to worry about the difficulty anymore. I do not feel this is the situation, because we have clearly seen what sort of major problems can evolve from government decisions on Selective Service. These kinds of problems could easily occur again in the future, and we must be prepared with precise data to show what results are forthcoming when certain decisions relative to the draft are made. There will be a decrease in the number of graduate degree holders on both the Master's level and the Ph. D. level produced in chemical engineering in the United States during the next several years, and industry and university must be prepared for this reduction which is a direct result of the draft regulations in the years 1968 and 1969.

The fact that the number of part-time students did not increase with the reduction in total full-time students in graduate school suggests the chemical engineering departments in our country might give some special attention to the developing situation concerning part-time graduate work. Perhaps, the students are deciding to take graduate work in business school on a part-time basis or are switching to some other field because of the feeling that graduate work in chemical engineering, generally, is best accomplished on a full-time basis.

The comparative statistics as shown in Figure 1 clearly indicate where problems can develop in graduate activities as a result of governmental decisions. It is hope that this kind of comparative information will be useful for future evaluations of possible effects on graduate student enrollments.

Mathmanship

In an article published a few years ago, the writer [1] intimated with befitting subtlety that since most concepts of science are relatively simple (once you understand them) any ambitious scientist must, in self protection, prevent his coleagues from discovering that *his* ideas are simple too. So, if he can write his published contributions obscurely and uninterestingly enough no one will attempt to read them but all will instead genuflect in awe before such erudition.

What Is Mathmanship?

Above and beyond the now-familiar recourse of writing in some language that looks like English but isn't, such as Geologese, Biologese, or, perhaps most successful of all, Educationalese[2] is the further refinement of writing everything possible in mathematical symbols. This has but one disadvantage, namely, that some designing skunk equally proficient in this low form of cunning may be able to follow the reasoning and discover its hidden simplicity. Fortunately, however, any such nefarious design can be thwarted by a modification of the well-known art of gamesmanship[3].

The object of this technique which may, by analogy, be termed "Mathmanship" is to place unsuspected obstacles in the way of the pursuer until he is obliged by a series of delays and frustrations to give up the chase and concede his mental inferiority to the author.

The Typographical Trick

One of the more rudimentary practices of mathmanship is to slip in the wrong letter, say a y for a r. Even placing an exponent on the wrong side of the bracket will also do wonders. This subterfuge, while admittedely an infraction of the ground rules, rarely incurs a penalty as it can always be blamed on the printer. In fact the author need not stoop to it himself as any copyist will gladly enter into the spirit of the occasion and cooperate voluntarily. You need only be trusting and not read the proof.

Strategy of the Secret Symbols,

But, if by some mischance, the equations don't get badly garbled, the mathematics is apt to be all too easy to follow, *provided* the reader knows what the letters stand for. Here then is your firm line of defense: at all cost *prevent him from finding out!*

Thus you may state in fine print in a footnote on page 35 that V^{x} is the total volume of a phase and then on page 873 introduce V^{x} out of a clear sky. This, you see, is not actually cheating because after all, or rather before all, you *did* tell what the symbol meant. By Surrepitiously introducing one by one all the letters of the English, Greek and German alphabets right side up and upside down, you can make the reader, when he wants to look up any topic, read the book backward in order to find out what they mean. Some of the most impressive books read about as well as backward as forward, anyway.

But should reading backward become so normal as to be considered straightforward you can always double back on the hounds. For example, introduce μ on page 66 and avoid defining μ until page 866. [1] This will make the whole book required reading.

The Pi-throwing Contest or Humpty-Dumpty Dodge

Although your reader may eventually catch up with you, you can throw him off the scent temporarily by making him *think* he knows what the letters mean. For example every schoolboy knows what π stands for so you can hold him at bay by heaving some entirely different kind of π into the equation. The poor fellow will automatically multiply by 3.1416, then begin wondering how a π got into the act anyhow, and finally discover that all the while π was osmotic pressure. If you are careful not to warn him, this one is good for a delay of about an hour and a half.

This principle, conveniently termed pi-throwing can, of course, be modified to apply to any other letter. Thus you can state perfectly truthfully on page 141 that F if free energy so if Gentle Reader has read another book that used F for *Helmholtz* free energy he will waste a lot of his own free energy trying to reconcile your equations before he thinks to look for the footnote tucked away at the bottom of page 50, dutifully explaining that what you are talking about all the time is *Gibbs* free energy which he always thought was G. Meanwhile you can compound his confusion by using G for something else, such as "any extensive property." F, however, is a particularly happy letter as it can be used not only for any unspecified brand of free energy but also for flourine, force, friction, Faradays, or a function of something or other, thus increasing the degree of randomness, dS. (S, as everyone knows stands for entropy, or maybe sulfur). The context, of course, will make the meaning clear, expecially if you can contrive to use several kinds of F's or S's in the same equation.

For all such switching of letters on the reader you can cite unimpeachable authority by paraphrasing the writing of an eminent mathematician [4]:

> "When I use a letter it means just what I choose it to mean—neither more nor less . . . the question is, which is to be master—that's all."

The Unconsummated Asterisk

Speaking of footnotes (I was, don't you remember?) a subtle ruse is the "unconsummated asterisk" or "ill-starred letter." You can use P* to represent some pressure difference from P, thus tricking the innocent reader into looking at the bottom of the page for a footnote. There isn't any, of course, but by the time he has decided that P must be some registered trademark as in the magazine advertisements he has lost his place and has to start over again. Sometimes, just for variety, you can use instead of an asterisk a heavy round dot or bar over certain letters. In doing so, it is permissible to give the reader enough veiled hints to make him *think* he can figure out the system but do not at any one place explain the general idea of this mystic notation, which must remain a closely guarded secret known only to the initiated. Do not disclose it under pain of expulsion from the fraternity. Let the Baffled Barbarian beat his head against the wall of mystery. It may be bloodied, but if it is unbowed you lose the round.

The other side of the asterisk gambit is to use a superscript as a key to a *real* footnote. The knowledge-seeker reads that S is – 36.7·[14] calories and thinks "Gee what a whale of a lot of calories" until he reads to the bottom of the page, finds footnote 14 and says "oh."

The "Hence" Gambit

But after all, the most successful device in mathmanship is to leave out one or two pages of calculations and for them substitute the word "hence" followed by a colon. This is guaranteed to hold the reader for a couple of days figuring out how you got hither from hence. Even more effective is to use "obviously" instead of "hence," since no reader is likely to show his ignorance by seeking help in elucidating anything that is obvious. This succeeds not only in frustrating him but also in bringing him down with an inferiority complex, one of the prime desiderata of the art.

These, of course, are only the most common and elementary rules. The writer has in grogress a two-volume work on mathmanship complete with examples and exercises. It will contain so many secret symbols, cryptic codes and hence-gambits that no one (but no one) will be able to read it.

References

1. Vanserg, Nicholas. How to write Geologese, Economic Geology, Vol. 47, pp. 220-223, 1952. 2. Carberry, Josiah. Psychoceramics, p. 1167, Brown University Press, 1945. 3. Potter, Stephen. Theory and Practice of Gamesmanship or the Art of Winning Games without Actually Cheating. London: R. Hart-Davis, 1947. 4. Carroll, Lewis. Complete Works, Modern Library edition p. 214.

* April fool. See what I mean?

[1] All these examples are from published literature. Readers desiring specific references may send a self-addressed stamped envelope. I collect uncanceled stamps.–N. Vanserg

* Reprinted from "American Scientist," Vol. 46, June 1958.

A tightwad went into a gift shop to find an inexpensive birthday present for a friend, but found everything very expensive–except for a vase which had been broken. He purchased it for practically nothing and asked the store to send it. He wanted the friend to think it had been broken in transit.

A week later, he received a thank you note which read, "Many thanks for the vase. It was nice of you to wrap each piece separately."

"I was married twice," explained the CE to a newly graduated EE, "and I'll never marry again. My first wife died after eating poison mushrooms and my second wife died of a fractured skull."

"That's a shame," offered the friend. "How did that happen?"

"She wouldn't eat her mushrooms."

The "COLORADO ENGINEER" has recently come into possession of Santa's list of bad girls.

Equal opportunity employer.

3 flops and 1 wild success from GT&E research.

Let us be the first big corporation in America to admit it:

Sometimes we fall flat on our face.

That may come as a shock to you, but we've found it's a smart way to run our research laboratories.

Rather than saddle our scientists with a "Do It The Way It's Always Been Done" philosophy, we encourage them to stick their necks out—to poke around in places nobody ever poked around before.

Sometimes this philosophy makes millions of dollars for us (see Eureka!).

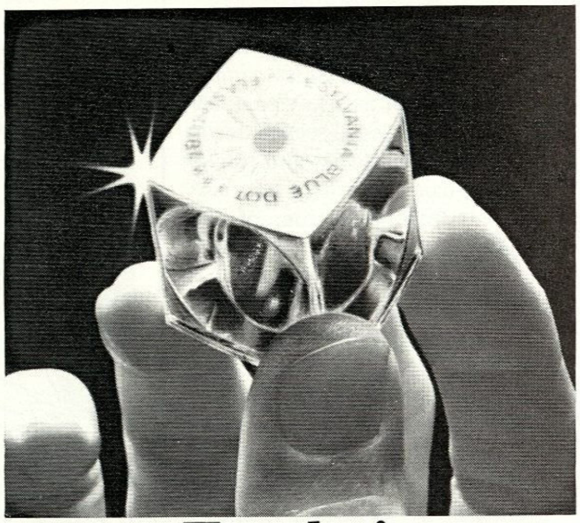
Sometimes it doesn't make us a penny.

Take, for instance

Flop #1: The Wam-O-Scope—a new kind of radar set that was supposed to be 10 times more sensitive than ordinary radar. (This was because we put lots of little electronic parts right inside the radar tube, where nobody ever put them before.) Theoretically, it worked fine. Practically, it didn't work at all. Which brings us to

Flop #2: The Stacked Tube. After years of work, we perfected the world's best radio tube—long lived, practically indestructible. Unfortunately, we built it the same year the transistor was invented, making our tube instantly obsolete. Then there was

Flop #3: The Omegatron—a clever device designed to tell vacuum tube manufacturers precisely how much excess gas they had in their tubes (which, you remember from Physics 1, are supposed to be completely empty). This, however, was more than they wanted to know. They wanted to get rid of the gas, not measure it. So finally, we come to



Eureka!

The Sylvania Flashcube—a little idea that revolutionized the whole camera business. For the first time, people could take flash pictures as fast as they could click the shutter—no more hot bulbs to change, no more missed pictures.

It looks simple. But it took more than 100,000 designs and years of fiddling and testing before we made the first one.

What are we up to now? Everything from electronic switching to total information systems. Which is why we're running this ad.

We need fresh thinking in these areas—new theories, new ideas, new challenges.

After all, we can't go on resting on the same old flops and successes forever.

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