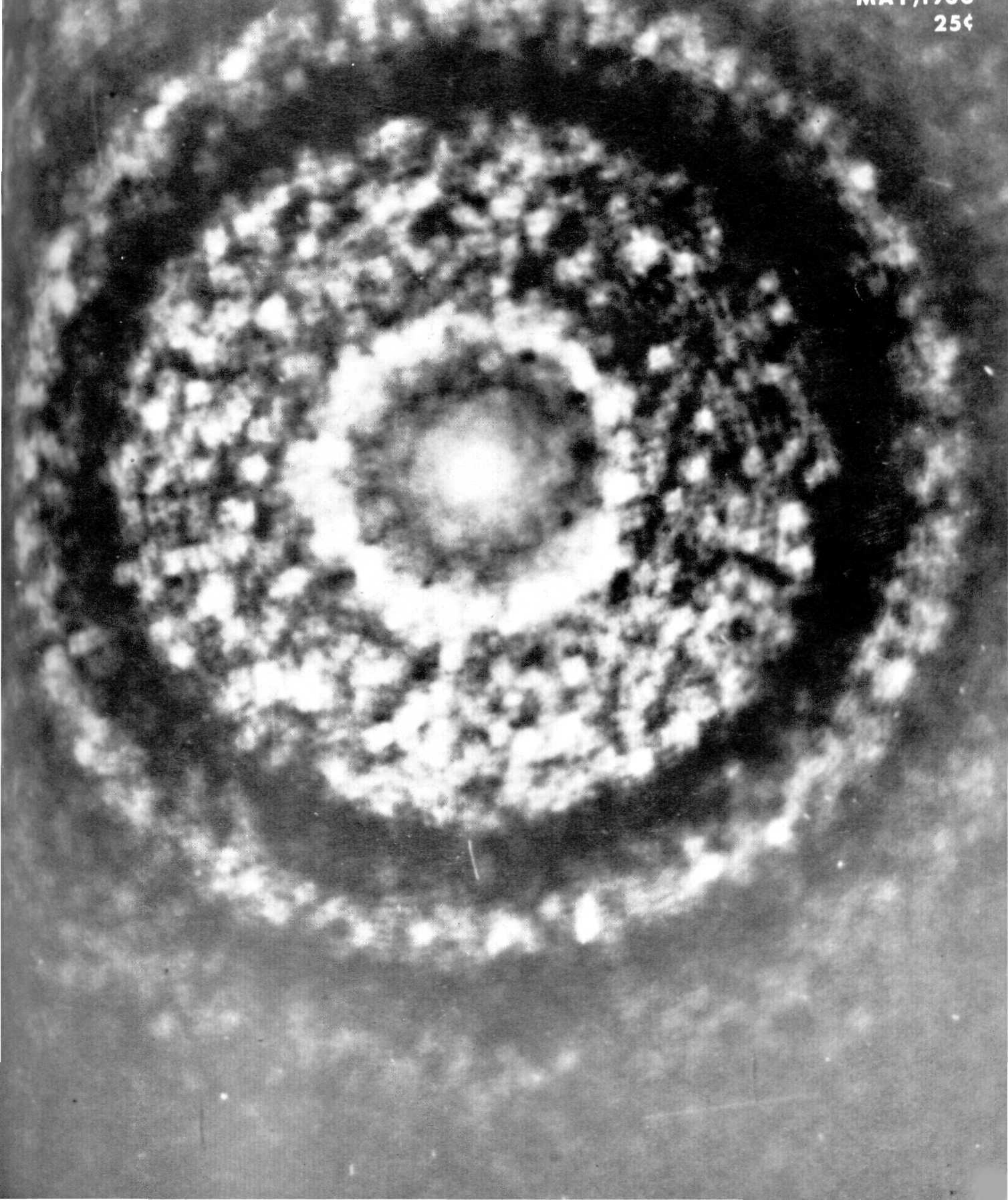
SPARTAN ENGINEER

MAY, 1966

25¢



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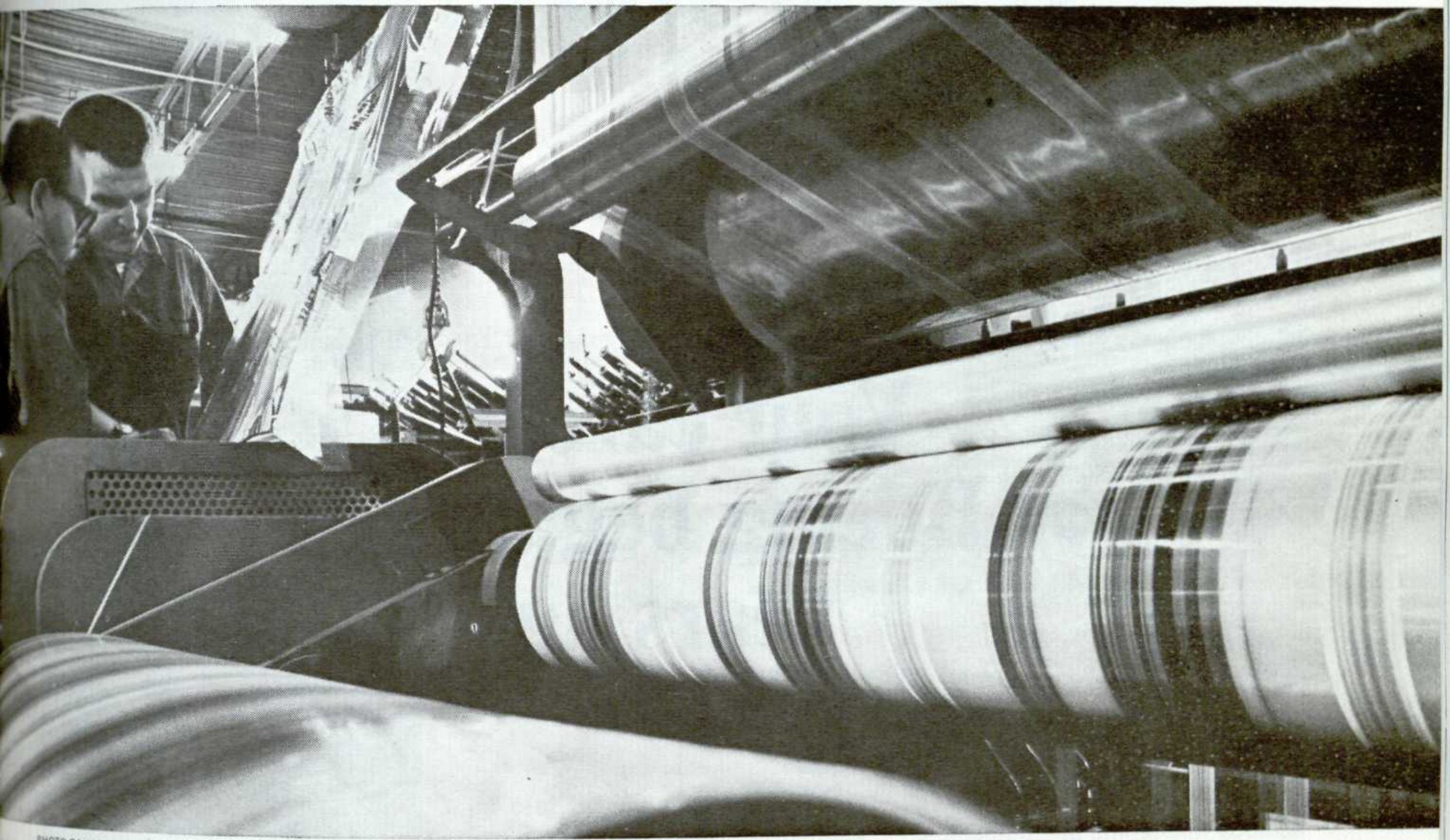

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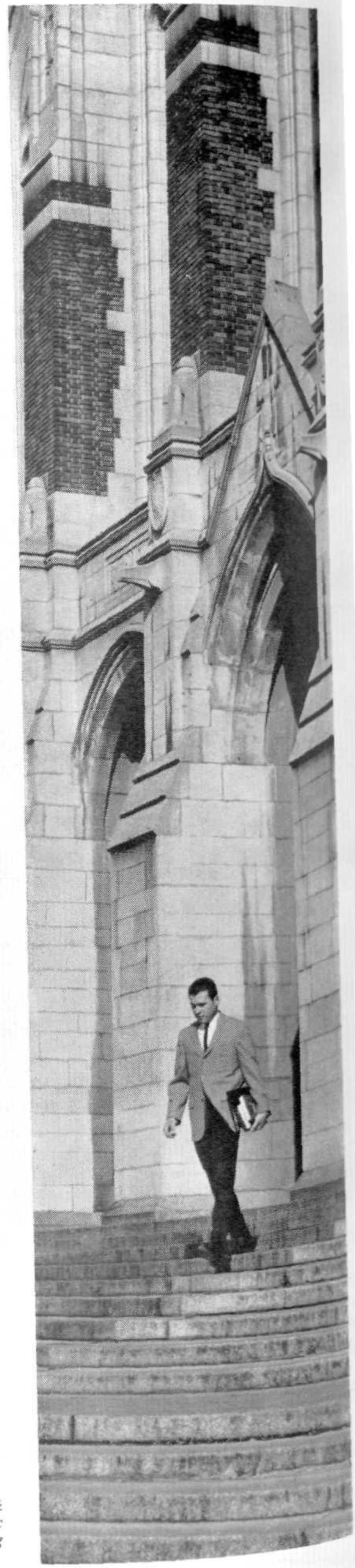
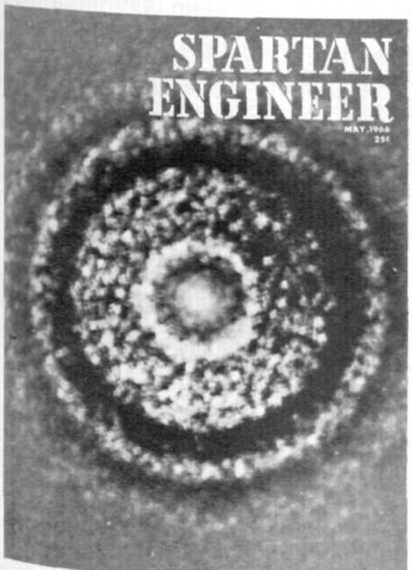


SPARTAN engineer

VOLUME 19 NUMBER 4 MAY,1966



Cover shows diffraction pattern produced by shining laser light through a reduced photo negative. This pattern is representative of an amorphous or random structure.

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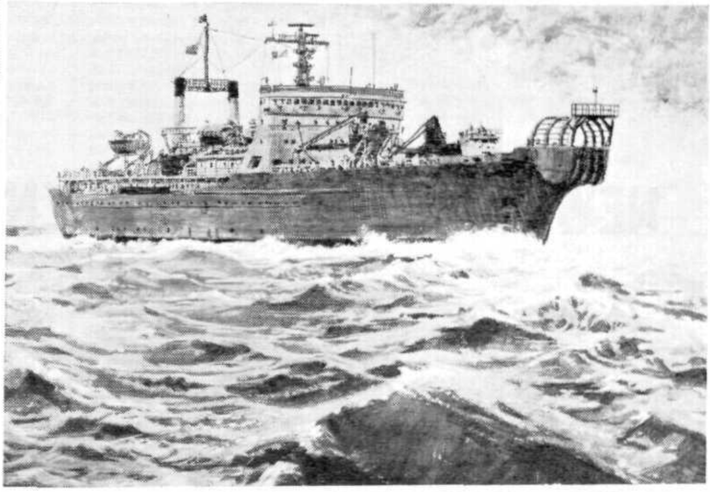

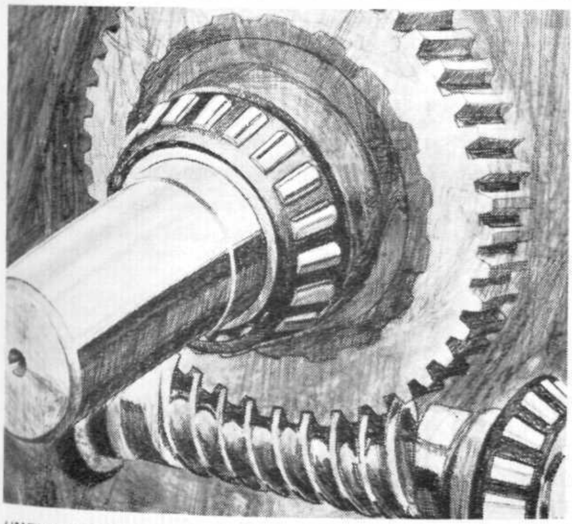

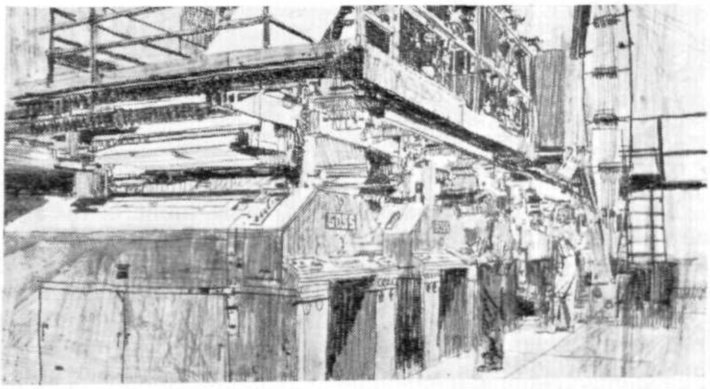

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NEW PROGRAM IN THE ENGINEERING SCIENCES

AT MICHIGAN STATE UNIVERSITY

Educational programs in the new Engineering Sciences such as Computer Science, Systems Science or Materials Science will be provided through a new curriculum pattern for the Bachelor of Science degree just established by the College of Engineering, Michigan State University. The new pattern permits the individual student to select study areas not previously brought together in the curriculums of the professional engineering fields, and will also allow easy combination of the new fields with supporting studies from other engineering areas or in business management, medicine, the social sciences, or the physical sciences. It is anticipated that additional major areas in the Engineering Sciences will be developed.

The new MSU program calls for normal academic loads of 15 credits per term, adding to 180 quarter credits (120 semester hours) for the four-year B.S. degree. The student will undertake a core program comprising 47 percent of the total in basic mathematics, chemistry, physics, introductory computer programming, and general education courses in the MSU University College. This core area will occupy most of the first two years of study, and will not require the student's decision on a major career area until he can form a mature judgment. This plan also makes entrance into the program easy for students transferring into engineering education from liberal arts or community colleges at the Junior year.

Late in the second year, the student will work with his advisor to develop his individual program. This program will assure capability in a major engineering area; the major will require a minimum of 42 quarter credits, comprising 23 percent of the curriculum.

The student's choice of major study area will be broadened by the addition of minor programs in two academic fields, each chosen to complement and support the major area; these minors will require a minimum of 40 credits, or 22 percent of the total time. Only one minor may be selected from an engineering field, but when suitable both minors may be taken in areas of work outside of the College of Engineering. Possible minor areas might include the Engineering Sciences, or be chosen from mathematics, statistics, physics, chemistry, business, medicine, or the social or biological sciences.

Additional credits (about 8 percent of the total) are available for further development of the program in any area.

This new curriculum pattern, combined with the MSU engineering plan which permits engineers to carry normal credit loads, will provide a College of Engineering student at Michigan State University with opportunity for selection of a study program suited to modern needs of business and industry, and which will also provide supporting proficiencies in physical or social sciences, business, medicine, or other appropriate areas as well.

This new curriculum pattern is immediately available for students reaching Junior standing. For those students preferring to major in the professional engineering fields, the College will continue to offer curriculums in Agricultural Engineering, Chemical Engineering, Civil Engineering, Electrical Engineering, Mechanical Engineering, and Metallurgy. Graduate work is available in these fields and in the new fields, as well.

April 21, 1966

LAY THAT SLIDE RULE DOWN,

OR

"Using The Gears Between the Ears!"

PART FOUR

FUN WITH APPROXIMATIONS ,

OR

"Near Misses Are Too"

The Circle Function, π: The ratio of the circumference of a circle to its diameter, , is clearly defined in mathematics as being a transcendental number. By being transcendental it is meant that the number may not be expressed exactly by any finite succession of integers expressing a decimal fraction. Fortunately, however, may be approximated by any of several infinite series arrays. One of the simplest of these insofar as appearances are concerned is due to Leibniz, simultaneous inventor of the calculus with Newton,

$$\pi = 4\left[\frac{1}{1} - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} = \dots \frac{(-1)^n}{(2n-1)}\right]$$

This series has the unpleasant feature of converging very slowly upon the ultimate value of . It is apparent from FUN WITH RECIPROCALS that after as many as 10,000 terms the series continues to fluctuate exasperatingly in the fifth decimal place. Moreover, there is very little additional accuracy to be gained in adding 1/19,999 and then subtracting 1/20,001. The net adjustment to the approximation of π by the inclusion of these two terms is precisely 2/399,999,999 or approximately 0.000000005! You can see, therefore, that this particular infinite series is working on the ninth decimal place while trying to effect an improvement in the accuracy of the fifth decimal place. Fortunately, other series have been developed that result in a much more rapid convergence upon the value of π.

Early history records values of 3, $\sqrt{10}$, and 3 1/3 as being used for this ratio. In our earliest encounters with π we were taught to express it simply as 22/7, or 3 1/7. It is interesting to apply a technique from FUN WITH RECIPROCALS for extracting the square root of 10. By methods explained therein, $\sqrt{10} \doteq 3\ 1/7$. There is historical evidence to indicate that $\sqrt{10}$ and 3 1/7 were once thought to be synonymous and, moreover, both were thought to represent the circle function exactly.

Other interesting algebraic numbers that were once thought to represent π include $(4/3)^4$, $(7/4)^2$, and 113/355. Note the sequence of integers in the last example. A large book was once written with no greater thesis than that $\pi = (4/3)4 = 256/81 = 3.16$.

The invention of the decimal system in the fifteenth century made it possible to express π to any desired number of places without seeking a particularly clever combination of fractions for the purpose. In fact, one of the earliest recorded uses of the decimal fraction was by a little known Arabian mathematician in expressing π to 17 decimal places, the first 13 of which were correct.

Common practice today in reasonably sophisticated circles is to use the decimal fraction, 3.1416, as being a logical and practical mathematical equivalent for π. Nevertheless, this latter-day approximation probably adds unreasonably to the labor involved in a great many simple problems. The difference between 22/7 or 3.1429 and 3.1416 is observed to be less than 13 parts in 31,400, or less than 1 part in 2,400. To draw an analogy, the indiscretion in using 22/7 rather than 3.1416 for π is similar to flattering a young lady attired in a bathing suit by estimating the critical dimensions as being a well-rounded 36-26-36 rather than being a scientific prude and insisting upon 35.985 - 25.990 - 35.985 inches, respectively. Moreover,

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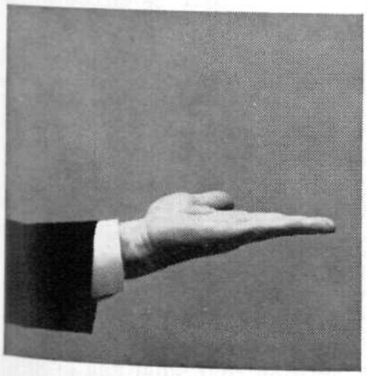
The Rain in Maine is Plainly

$$D = \frac{SNR}{SNR_o} = \frac{t/T_{SYS}}{t_o/T_{SYS_o}} = t_x \frac{T_{SYS_o}}{T_{SYS}} = \frac{\Delta - 1}{\Delta_o - 1}^{*}$$



Attention to detail is an old Bell System habit. Or maybe you call it thoroughness. Or follow-through.

Anyway, we attended to an interesting detail recently—the effect of rain on the microwave link between a communications satellite and our pioneer ground station antenna at Andover, Maine.

If we could but measure the rain's effect, we could improve the design of satellite ground stations. The question was how.

Well, you often have to take your laboratory tools where you find them, and in this case we found ours in Cassiopeia A, a strong and stable radio star that is always visible from Andover. We measured the noise power from Cassiopeia A during dry periods, and then measured the reduction during rainy periods. The result could be expressed as a formula and employed accurately in designing future ground stations.

The initial success of our Telstar® satellites proved the feasibility of communicating via space.

But it also opened the door—or the heavens—to a whole new technology which we are now busily exploring in every detail.

In space, on land or beneath the sea—wherever we operate—we go into things thoroughly.

Sometimes we know when <u>not</u> to come in out of the rain.

* * *

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*The definitions and derivation, plus further information on satellite transmission degradation due to rainfall, may be found in the Bell System Technical Journal, Vol. XLIV, No. 7, Sept., 1965, p. 1528, which is available in most scientific and engineering libraries.

Bell System
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CONTINUED FROM PAGE 8
a beauty contest judge is neither ethical nor discrete if he pursues the determination of the fundamental dimensions to such a high degree of precision.

It may be that you are all but offended by the previous illustration. Then consider an example that offers an opportunity to cancel a seven from the numerator where π is a multiplier. Problems of this kind beg of use of 22/7 as a substitute for π. For instance, the circumference of a pipe or duct with a seven-inch outside diameter is quite obviously 22 inches; well not exactly, but 21.99 inches. The latter dimension might be significant in very precise work, but it would seldom affect the outcome of ordinary measurements since the actual circumference of the seven-inch pipe or duct will vary with the temperature, the internal pressure, the degree of concentricity, and the external finish.

When precision requires that 3.1416 be used for π, we happen to be blessed with a very fortunate combination of integers. That particular sequence of five digits contains no less than seven prime factors:

$$(2x2x2)x3x7x11x17 = 31{,}416 = 10{,}000\pi$$

These several prime factors, in turn, lead to an imposing array of over 60 integer divisors with zero remainder. Some of these divisors appear below:

Table I. Partial List of Exact Divisors of 31,416, or $10{,}000\pi$

2	3	4	6	7	8	11	12
14	17	21	22	24	28	33	34
42	46	51	56	66	68	77	84
88	102	119	132	136	154	168	187

The product of the last two divisors appearing in the table above is expressed: 168 x 187 = 31,416. Other factors of 31,416, some 30 in all, may be found by dividing the near equivalent of $10{,}000\pi$ by each of the remaining values reported above.

Many of the 60 possible exact divisors of 31,416 are commonly arrayed against π across the line of division in problems from mathematics, physics, and courses in engineering. For instance, the brake horsepower equations,

$$BHP = \frac{PLAN^1}{33{,}000} \text{ and } BHP = \frac{2\pi NT}{33{,}000}$$

contain many common factors in both the denominator and the numerator. In general, the length of stroke is L inches, the cylinder bore is D inches, the brake mean effective pressure is P pounds per square inch, and the number of power strokes per minute is one-half the revolutions per minute for the four-stroke cycle in the typical internal combustion engine, or $N^1 = N/2$. The former equation given above may be reduced to very much simpler terms for the brake horsepower per engine cylinder

$$BHP/cyl = \frac{PLAN^1}{33{,}000} = \frac{PL\pi D^2N}{33{,}000(4)2}$$

$$= \frac{31{,}416PLD^2N}{10{,}000(33{,}000)4(2)}$$

But we note from TABLE I, above that 33, 4, and 2, all, are factors of 31,416. Therefore the expression at right above reduces to the simpler form:

$$BHP/cyl = \frac{1.19PLD^2N}{100{,}000}$$

where the three significant figures, 119 = 31,416 divided by 33 x 4 x 2. The number 100,000 in the denominator merely serves to locate the decimal place properly.

The right-hand equation above may be reduced to

$$BHP = \frac{19.04NT}{100{,}000}$$

where N is measured in revolutions per minute and the torque, T, is expressed in pound-feet.

Such devices are convenient in developing brake horsepower relationships for a given engine where additional design variables are known and may be worked into the constants expressed above.

Combining the two equations,

$$BHP/cyl = \frac{19.04NT/cyl}{100{,}000} = \frac{1.19PLD^2N}{100{,}000}$$

The pound-feet of brake torque per cylinder may be expressed in terms of the brake mean effective pressure and the engine dimensions for any four-stroke, single-acting engine by solving for the torque, T, in the pair of expressions above:

$$T/cyl = \frac{1.19PLD^2N}{100{,}000} \times \frac{100{,}000}{19.04N} = \frac{PLD^2}{16} \text{ pound-feet}$$

The preceding is an exact expression, where 1.19/19.04 is precisely 1/16. The same result could have been obtained by cancelling π from the two original BHP equations and reducing each of them to the simpler form in terms of a single numerical constant as we have done above. However, a typical group of student engineers given the task of deriving the desired constants will introduce a standard deviation in their answers of at least three per cent and stand fast in their opinion that what has evolved is simply an unavoidable slide rule error.

Trigonometric Functions: We would like to recall the statement of a fundamental trigonometric proof:

$\sin\theta = \theta = \tan\theta$ as θ approaches zero, providing the angle is expressed in radian measure.

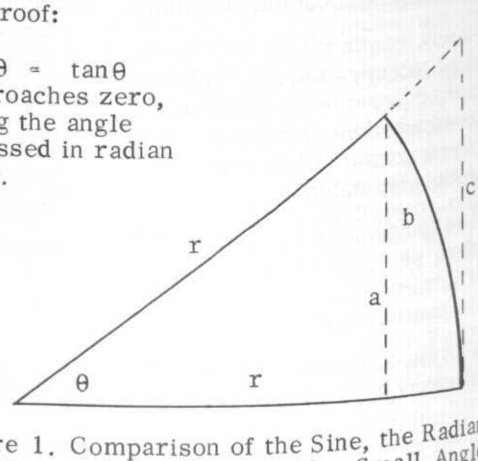

Figure 1. Comparison of the Sine, the Radian Measure, and the Tangent of a Small Angle

$$\sin\theta = a/r \; ; \; \theta = b/r \; ; \; \tan\theta = c/r$$

where $a = b = c$, as θ approaches zero.

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Or, interpreting the same information into the more conventional form of angular measurement in degrees:

$$180 \text{ degrees} = \pi \text{ radians}$$

$$1 \text{ degree} = \frac{3.1416}{180} \text{ radians} = \frac{1}{57.3} \text{ radians}$$

$$1 \text{ degree} = 0.01745 \text{ radians}$$

The decimal equivalent of an angle of one degree, when expressed in radian measure, agrees very closely with both the sine and the tangent of one degree as reported in five-place tables of trigonometric functions. Within certain limits, therefore, we may determine either $\sin\theta$ or $\tan\theta$ where θ is a small angle measured in degrees, by finding the product:

$$\sin\theta \cong 0.01745 \text{ , and } \tan\theta \cong 0.01745\theta$$

The method is hardly more than one percent in error if used for either the sine or the tangent of 10 degrees. It is somewhat closer for approximating the sine function than it is for the tangent. It is interesting to note that this approximation serves closely for either the sine or the tangent by yielding an intermediate value that represents either the sine and the tangent sufficiently well through the recommended range of 10 degrees. In fact, there is less than five per cent error if sin 30% is determined by the same approximation formula:

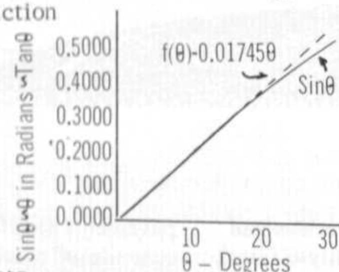

Figure 2. Straight-Line Approximation of Sine and Tangent of Small Angles

$$\sin 30^\circ \cong 30(0.01745) \cong 0.5235$$

We know better of course; sin 30° being exactly 0.5. Yet the example serves to demonstrate the magnitude of the error in this instance. Furthermore, there is no denying the utility of the method in the expression of:

$\sin 10^\circ = 10(0.01745) = 0.1745$ vs 0.1736, or 0.52% error

$\sin 6^\circ = 6(0.01745) = 0.1047$ vs 0.1045, or 0.19% error

$\sin 30' = 1/2(0.01745) = 0.00873$ vs 0.00873,

$\sin 30'' = 0.01745/120 = 0.000145$ vs 0.000145

Applying the method to the tangent of the angles shown above leads to the same approximate solutions with respective errors of 1.03% and 0.38% in the first two instances. There is no apparent error through the three significant figures of the last two examples whether the sine or the tangent function is expressed.

The approximation method is strongly recommended for determination of the sine and tangent for angles smaller than 6° , where the functions range from 0.0000 through approximately 0.1000. Although the sine and tangent of small angles are generally expressed simultaneously by the ST scale on slide rules, the use of this scale remains a hazard it not a mystery to the average slide rule mechanic. Furthermore, there is no provision on most ST scales for reading angles smaller than the angle whose sine is 0.0100. Thus, all angles smaller than 34.4 minutes of arc have to be treated in a special manner on most slide rules. The methods presented above are suitable for such purposes.

We may draw upon any one of several trigonometric identities to speed us along our path of least resistance in determining further useful trigonometric functions of angles.

It would appear we work most often with cosine components which are but slightly skew with respect to the plane of reference or to the line of motion. We may approximate the cosine by application of the above correspondence between radian measure and the sine function for small angles along with the use of a familiar identity:

$$\cos 2\theta = 1 - 2 \sin^2\theta$$

This reduces to a more useful form for examples where $2\theta = x$.

$$\cos x = 1 - 2 \sin^2 x/2$$

If the angle x is small, we may substitute the actual radian measure of the angle for its sine function:

$$\cos x \cong 1 - 2\left(\frac{0.01745x}{2}\right)^2$$

$$\cos x \cong 1 - 0.0015x^2$$

Applying this simple approximation for finding the cosine of various small angles produces excellent results. The error at 20 degrees is 0.032 per cent, the error at 30 degrees is but 0.115 per cent, and the example below shows that the error at 40 degrees is less than one per cent:

$$\cos 40^\circ \cong 1 - 0.00015(40)^2$$
$$\cong 1 - 0.00015(1600)$$
$$\cong 1 - 0.2400$$
$$\cong 0.7600.$$

Whereas $\cos 40^\circ = 0.76604$

The physical interpretation of the method for approximating cosine values is the substitution of the first quadrant segment of a parabola for the actual cosine curve. The parabola crosses the y-axis where y = 1.000 and crosses the x-axis where x = 81.1. The obvious error is that the curve of y = cos x does not intercept the x-axis until x = 90 in degree measure.

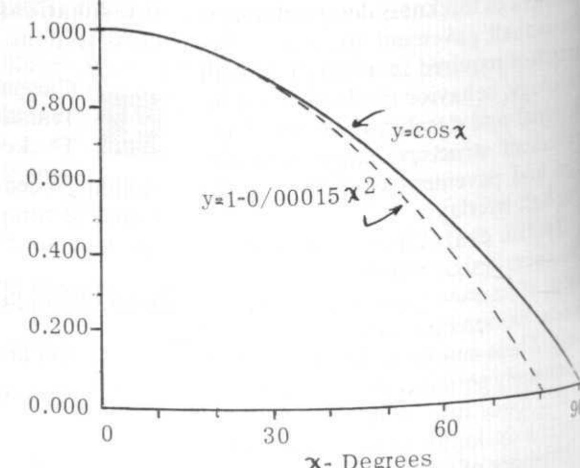

Figure 3. Comparison of Actual Cosine Curve and Its Substitute

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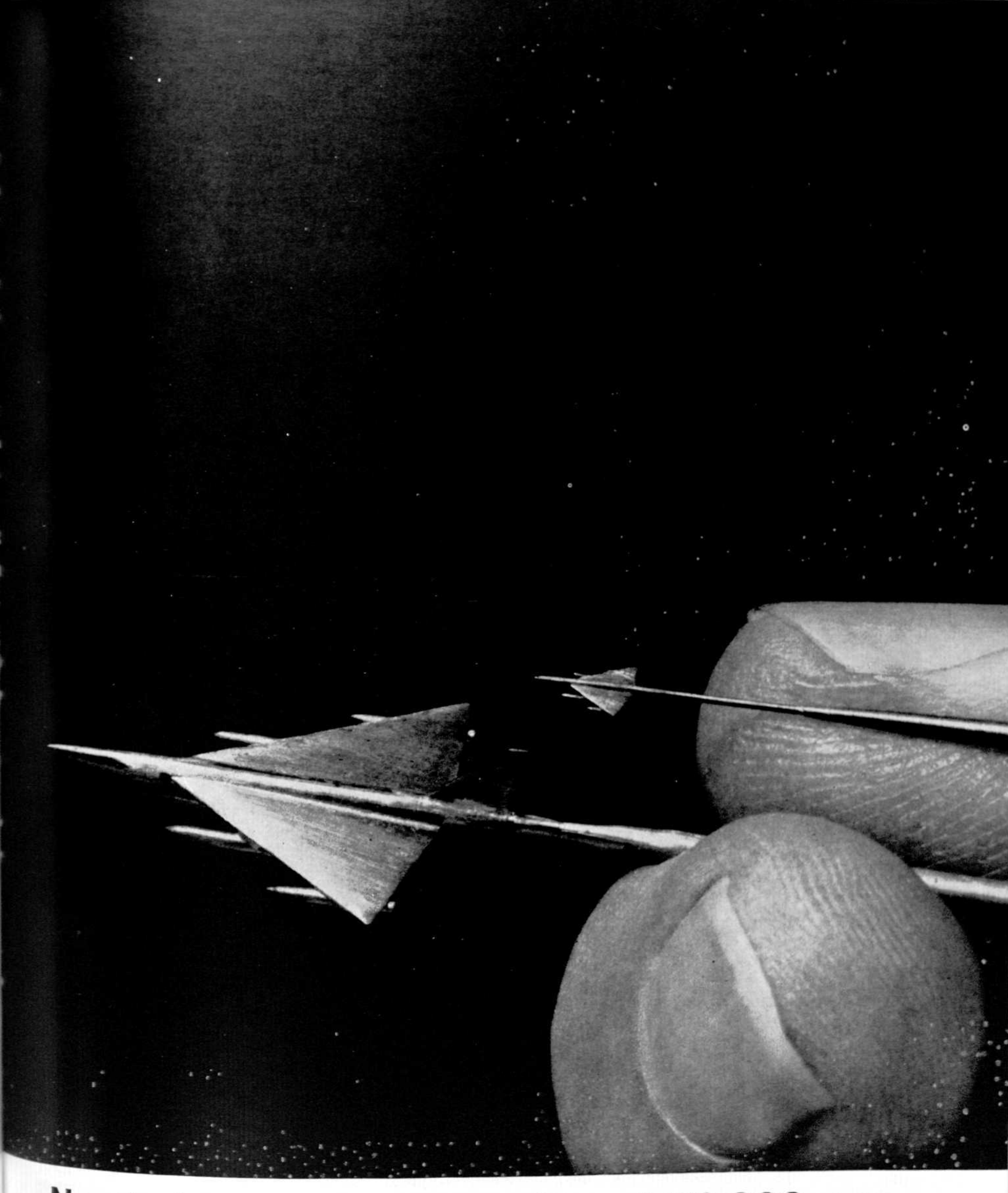

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Cosines of angles, say between 0° and 30°, by the foregoing approximation are also practical sine values for the angles between 90° and 60°. A similar statement may be made about the earlier sine function development where cosines of angles between 80° and 90° may be found by evaluating the sine over the recommended ten-degree range.

Strangely, these approximations are about the only practical tool for expressing the functions of extremely small angles such as are encountered in the most exacting of sciences, astronomy. Thus the sine or tangent and the cosine of one second of arc become 0.000004848137 and 0.999999999988, respectively.

The sun and the moon alternately dominate the appearance of the heavens. The full moon and the sun each subtend approximately 30 minutes of arc. This may be classed as a small angle suitable to these approximations as we have seen above. On the other hand, the apparent positions of even the closest stars as viewed from opposite sides of the earth's orbit -- at six months' intervals -- change in the approximate magnitude of one second of arc due to this parallax. We therefore see that a science as precise as astronomy is forced to use the approximation methods we have derived above.

Another useful application of these approximation methods is the elimination of sine and cosine functions from a great many emprical equations where the range of angles are appropriately limited.

Trade-offs. Defense industries practice and, for all of that matter, the very art of engineering design consists of a technique called trade-offs. Examples of trade-offs are compromises between weight and reliability for space vehicles, between efficiency and cost for electric motors, between style and utility for automobiles, between comfort and wear for clothes, etc. Economists speak of a law of diminishing returns. This rule applies generally to a single objective, which very often yields less and less incremental return as one pursues the objective with greater and greater investment of time, material, effort or money. Sophisticated techniques in the handling of trade-offs require that one deal with two or more returns or yields simultaneously and arrive at the optimum expenditure in terms of the ratio of input to yield. Thus we see life is made up of a succession of trade-offs in which judgment, common sense, tradition or social pressure enter into the decisions one makes. Needless to say, whether defense industry, ordinary engineering design, or the conduct of one's personal life, the ability to handle trade-offs with wisdom and dispatch has a great influence upon the satisfactions one derives from life.

Now we propose to apply the basic idea of making trade-offs as an aid to mental computation. Assume the following problem examples:

a) $\frac{120}{95} = \underline{\qquad\qquad}$ b) $\frac{17.9}{2.10} = \underline{\qquad\qquad}$

c) $18.44\pi = \underline{\qquad\qquad}$

Each of the problems contains two known parts and an unknown answer. The technique to be introduced here is that of trading increments between the two parts so that, while the basic problem remains unchanged, an approximate answer becomes apparent by inspection.

In Example a), above, we increase each term by 5 per cent:

$$\text{a)}\quad \frac{120}{95} = \frac{120}{95}\frac{(+5\%)}{(+5\%)} \cong \frac{126}{100}$$

$$\cong \underline{\underline{1.26}} \text{ (estimated) vs } \underline{\underline{1.26315}} \text{ (actual).}$$

In the second example, we decrease each term by 5 per cent

$$\text{b)}\quad \frac{17.9}{2.10} = \frac{17.9\ (-5\%)}{2.10\ (-5\%)} \cong \frac{17}{2}$$

$$\approx \underline{\underline{8.5}} \text{ (estimated) vs } \underline{\underline{8.524}} \text{ (actual).}$$

In the third example, we chose to increase one term by 5 per cent and decrease the other term by the same fraction

$$\text{c)}\quad 18.44\pi = (18.44)\ (+5\%)\ (\pi)\ (-5\%)$$
$$\cong [18.44 + 0.922]\ [3.1416 - 0.1416]$$
$$\cong [19.36]\ [3] = \underline{\underline{58}} \text{ (estimated) vs } \underline{\underline{57.93}} \text{ (actual).}$$

The basic principal illustrated above is that a given factor in a problem can be changed to any nearby round number by introducing an incremental increase or decrease of a few per cent. Then a compensating mental adjustment must be made in some other factor of the problem to restore the fundamental mathematical relationship. The nature and amount of the change to be effected must be learned by experience. In general, it makes more sense to "convert" the denominator to an integer as in examples a) and b) above rather than to round off a numerator. The amount of the change should be kept as small as possible for reasons of simplicity as well as for purposes of minimizing the error that enters the problem by virtue of the small inaccuracies of number and of method that are introduced by these techniques.

The following examples are intended to show how a given number can be modified by approximation methods to yield an equivalent round number.

Given 144; add 6 units or about 2% to yield 150.

Given 1728; deduct 28 units or about 1 1/2% to yield 1700;

or 1728; add 72 units or about 4% to yield 1800.

Given 3413; deduct 80 units or about 2 1/2% to yield 3333;

or 3413; add 187 units or about 5 1/2% to yield 3600.

Given 2545; deduct 45 units or about 2% to yield 2500.

After a time, you will be able to recognize trade-offs among numbers in a great many problems. For example, 45 parts in 2545 corresponds, more or less, with 63 parts in 3413, with 31 parts in 1728, with 3 parts in 144,

CONTINUED TO PAGE 26

LATE NEWS for 1966 ENGINEERING GRADUATES

Miss Engineer

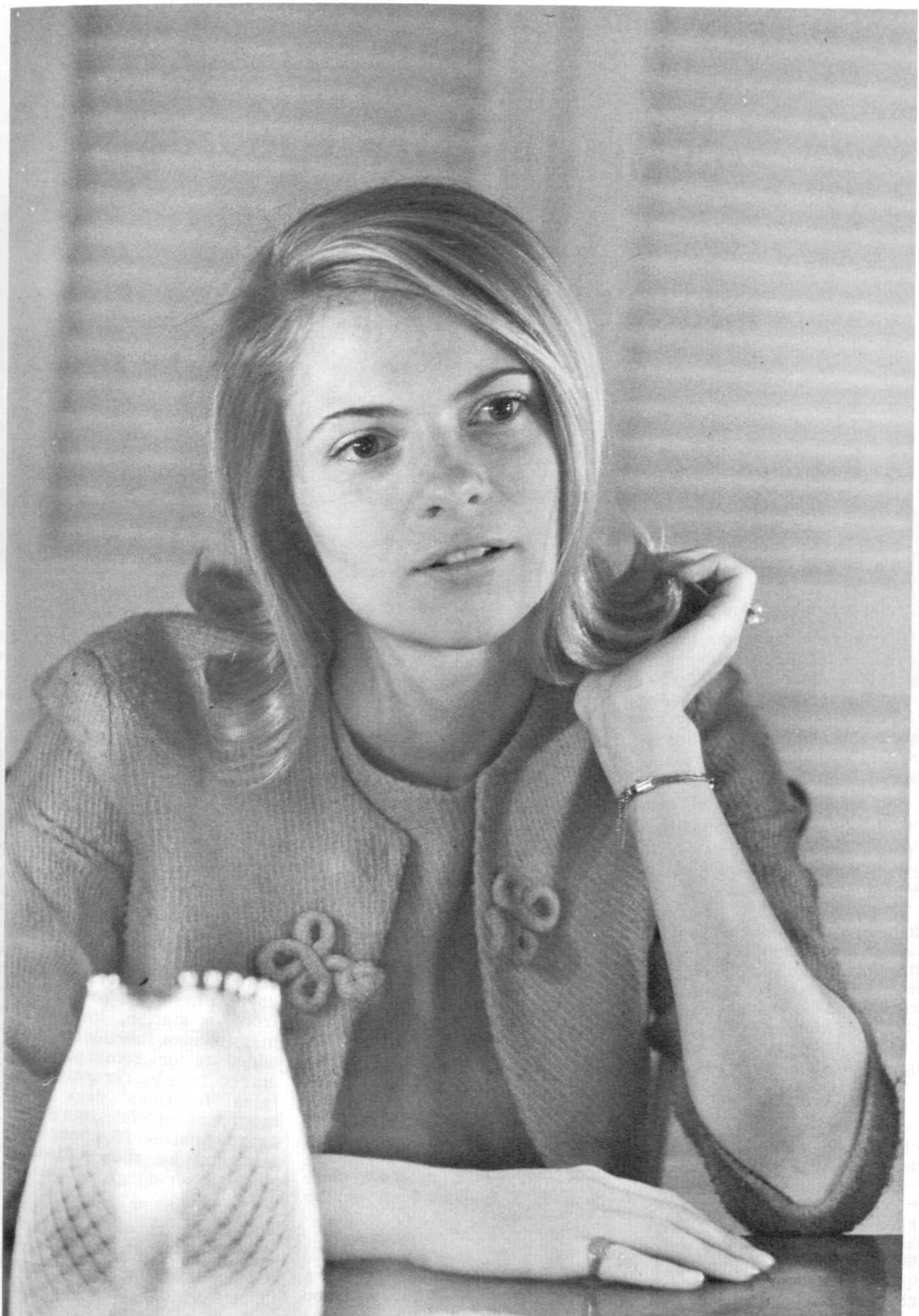
CAROLYN
CANDLER

1966

1965 Engineering

Ball Queen

Photos by;
Dave Laura



COMPUTER PREVENTIVE MAINTENANCE SCHEDULING

by Gary A. Pniewski

ABSTRACT

Computer programming for preventive maintenance scheduling is the most operational method of complete scheduling available. It has been wholly accepted and utilized at the Michigan Gas Storage Freedom Compressor Station.

PREVENTIVE MAINTENANCE SCHEDULING

Preventive maintenance scheduling can be improved through the use of a computer. It is an economical, quick and accurate method of scheduling all maintenance functions with very little work involved. A flexible, low input program can easily be written.

IMPORTANCE OF GOOD SCHEDULING. The actual savings will be hard to calculate, but the uniformity of preventive maintenance man-hours and the distribution of oil, grease and replacement parts throughout the year will emphasize the importance of good scheduling. The reduction in shut down time, because of improved machine care, will improve total production, thus adding to the importance of complete preventive maintenance scheduling. Engine or machine life should be improved because of a decrease in missed maintenance functions. All in all, good care of machinery through preventive maintenance will lead to increased profits. Also, good scheduling will give the preventive maintenance crews more confidence in the work they perform. Good scheduling helps to show the interest management places upon its machinery, thus acknowledging to the maintenance crews that their work is not in vain.

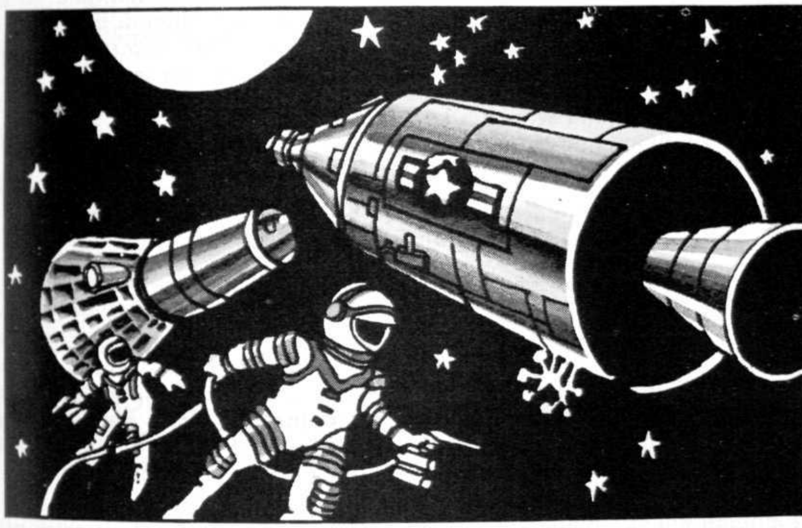
COMPUTER USAGE. Consumers Power Company has developed such a computer program for their compressor stations. It is presently being used at Michigan Gas Storage's Freedom Compressor Station. At this station there are 291 preventive maintenance functions to be performed at specific intervals. Some of these necessary functions depend on calendar date while others depend on engine running hours, i.e., some maintenance operations are performed every few months, while others are performed after a specific number of hours run by an engine.

The program has been written such that it is completely flexible for compressor station use. The input depends on calendar date and engine running hours, although it could relate to any of many variables, such as: (rpm) X(time), percentage of running time, (load or horsepower) X (time), etc. Thus, the input can easily be adapted to any form deemed necessary with very little deviation in the actual program. Also, the number of maintenance functions, which are stored on tape, can be easily increased, decreased or changed completely. If, for instance, an engine is added to or removed from a station, its preventive maintenance functions are easily added to or removed from the stored tape by rerunning the original functions' deck with the incorporated changes. A cost of approximately \$5.30 per week is incurred as the station takes weekly advantage of this program.

This computer program can also be used for future preventive maintenance planning. Its input can be up-dated (six months,

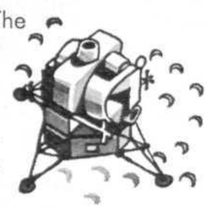
CONTINUED ON PAGE 22

Here are 7 knotty problems facing the Air Force: can you help us solve one?

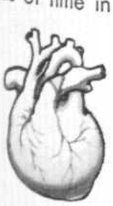


1. Repairs in space. If something goes wrong with a vehicle in orbit, how can it be fixed? Answers must be found, if large-scale space operations are to become a reality. For this and other assignments Air Force scientists and engineers will be called on to answer in the next few years, we need the best brains available.

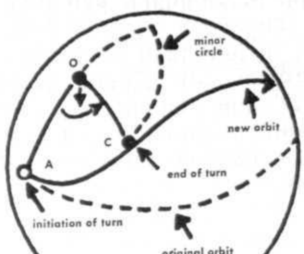
2. Lunar landing. The exact composition of the lunar surface, as well as structural and propulsion characteristics of the space vehicle, enter into this problem. Important study remains to be done—and, as an Air Force officer, you could be the one to do it!



3. Life-support biology. The filling of metabolic needs over very extended periods of time in space is one of the most fascinating subjects that Air Force scientists are investigating. The results promise to have vital ramifications for our life on earth, as well as in outer space.

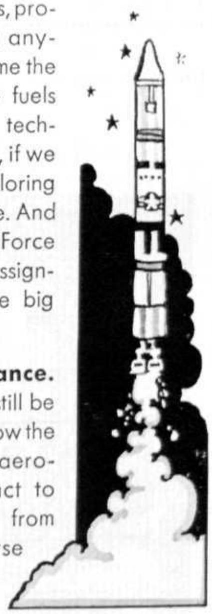


4. Space orientation. The orbital problems of a spacecraft, including its ability to maneuver over selected points on the earth, are of vital importance to the military utilization of space. There are plenty of assignments for young Air Force physicists in this area.

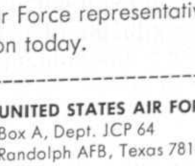


5. Synergetic plane changing. The ability of a spacecraft to change altitude can also be crucial to space operations. Where but in the Air Force could Sc.B.'s get the chance to work on such fascinating projects right at the start of their careers?

6. Space propulsion. As our space flights cover greater and greater distances, propulsion—more than anything else—will become the limiting factor. New fuels and new propulsion techniques must be found, if we are to keep on exploring the mysteries of space. And it may well be an Air Force scientist on his first assignment who makes the big breakthrough!



7. Pilot performance. Important tests must still be made to determine how the pilots of manned aerospacecraft will react to long periods away from the earth. Of course not every new Air Force officer becomes involved in research and development right away. But where the most exciting advances are taking place, young Air Force scientists, administrators, pilots, and engineers are on the scene.



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CONTINUED FROM PAGE 20

one year, etc.), by estimating the number of engine hours run over the desired time span, so as to see what preventive maintenace operations will have to be performed during this period. Major overhauls are included among the preventive maintenance functions, therfore, advance notice of six months or a year can help considerably to alleviate many maintenance planning problems. If an engine is due for an overhaul during this time, arrangements can be made well enough in advance so as to lessen pumping problems during the actual overhauling operations.

This program has been operational at the Freedom Compressor Station for four months and everyone, presently, has only the highest regards for it. It has accomplished everything it set out to do: ease of handling, low cost, speed, accuracy and also scheduling only 5-15 functions per week. The scheduling of only 5-15 preventive maintenance functions per week allows them to be performed on schedule without falling behind.

Each week the engine hours are phoned into the Jackson, Michigan, office. Here they are put on computer cards and the program is run. The output sheet which describes the preventive maintenance functions to be performed is mailed to the station. The station usually receives the output sheet two days after phoning in the engines' hours. This 48 hour delay is small in comparison to the maintenance function intervals.

GENERAL PROGRAM DESCRIPTION. With this program, scheduled maintenace of equipment is maintained. At specific intervals (usually weekly) the hours which each engine has run during the interval and the current date is fed into the program on data cards; one card per engine plus a current date card. The program checks each of the numerous maintenance functions, which are stored on tapes, to see if any is due to be performed. The program does this by adding up the total engine hours run since the last time the function was performed and comparing it to the frequency of the function. If the total hours are less than the frequency number (ex: 3500 hrs. in less than a 4400hrs. frequency for sleeve clearance check) the computer just stores the information, but if the total hours exceed the frequency, a maintenance request is printed out on the output sheet. The output sheet contains the machine number and description, the maintenance description, lubricant (if any), frequency, hours last scheduled and total engine hours (if related to hours and not date). The date frequency functions are such things as: change oil in lake water pump, check oil in air compressor, service air cleaner for auxiliary generator, etc. I hope this illustrates the fact that this program can schedule all the preventive maintenance for the complete plant or station very easily.

On any computer run, the engine hours for any individual engine function can be changed on the tape. This is done with signal card telling how many function engine hours are to be changed and then a card which designates the numerical location from the first engine function and the new engine hours for the numerical location. This program also contains many error messages which are printed on the output sheet at the appropriate time.

The adaptation of this program to any preventive maintenance industrial use is easily foreseen. It can be used anywhere equipment is run at changing intervals, thus making it a very feasible program for use in almost any industrial situation.

Any additional information regarding this computer program of preventive maintenance scheduling can be obtained from Consumers Power Company, Gas Production and Transmission Department, Jackson, Michigan.

APPENDIX A

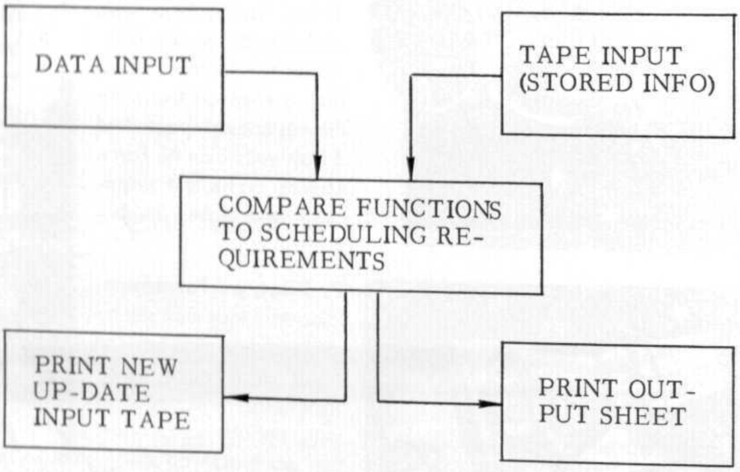


Fig. 1. The Simplicity of Computer Preventive Maintenance Scheduling.

APPENDIX B

GENERAL COST BREAKDOWN

(APPROXIMATION)

Receive data for input (by phone)	$ .10
Technician's wages a). Phones and mails output to the station b). Punches data cards c). General coordinator	2.00
Computer; at $100/hr.	2.25
Computer set-up	.75
Mailing to station	.20
	$5.30

Table I — Cost Distribution for Weekly Use.

A NEW APPROACH TO STUDENT EMPLOYEES

by Thomas G. Corneil

College students are becoming less interested in working for our colleges and universities which is causing serious problems for university departments which employ students. The Distribution Services Division of the Instructional Media Center at Michigan State University has formulated a new policy concerning student employees which has proved very successful.

If university departments are to continue to give top quality service, a new and positive approach to student employees must be found.

With seldom exception, departments in our universities and colleges which employ students as part-time employees are being confronted with a serious problem; the inability to attract enough students to fill necessary job openings. University food service and residence halls maintenance are constantly hampered by this problem.

Another field which had a similar problem was the department of audio-visual instruction. The Distribution Services Division of the Instructional Media Center at Michigan State University employs approximately 60 students for the purpose of operating audio-visual equipment and providing classroom assistance to instructors on the campus. Three years ago, this same organization employed only 45 students for this same purpose. In this same three year period, service requests doubled. As a result, five requests a day had to be refused due to a lack of students to take the assignments.

Today the Distribution Services Division has all but solved this problem. This was accomplished by making the job of the student employee more attractive which in turn has caused more students to seek employment at this organization.

By giving a higher starting wage to new employees the attraction to this organization became greater. Regular raises and merit wage increases to deserving students are also given. The starting wage now paid is higher than wages paid by other departments which also have no policy of giving raises to student employes. Students have also been given the opportunity to hold supervisory positions. Students are permitted to work as their class schedule allows and are never asked to miss a class period to accept an assignment.

The student employee is encouraged to use his own initiative and judgement when the need arises. This has given the student a feeling of greater independence while on an assignment.

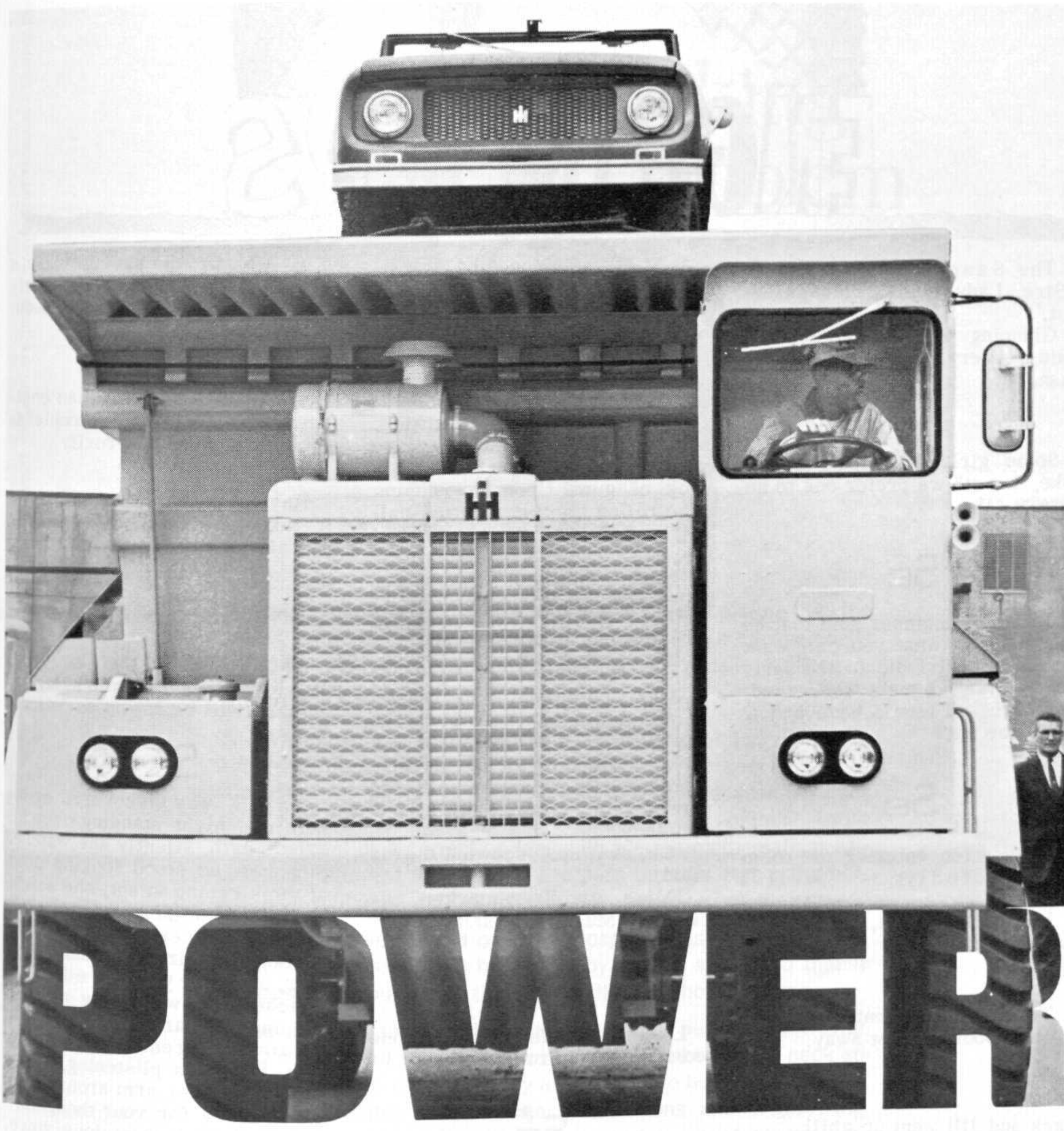
As a result of this policy, student employees are staying with the organization longer periods of time and their operating efficiency has greatly increased. A study of these student employees was recently completed and the results are very encouraging. The great majority of these students are completely satisfied with wages, working conditions, and working hours, and feel that the organization is doing an excellent job. The need to recruit new students to replace those lost through normal turnover and to increase the number of employees when requests increase has been cut back considerably. Most new employees come to the Center seeking employment after talking to a present employee.

Many students seek employment at the Distribution Services Division because of the excellent working conditions. Students come here from other departments within the university strictly because of these working conditions. The job of the student employee is a great challenge. Seldom are two assignments carried out under similar conditions. The student must use his own judgement and be able to work for people under all conditions. Seldom is this opportunity found in other university departments.

In connection with the study made of student employees a random sample of the student body was also studied. A great number of students said that they would rather use a loan or scholarship than to hold a part-time job while in college. With the increased availability of these loans and scholarships more students are going to use them in preference to a job. This is evidence that those students who are employed at the Distribution Services Division are there because they enjoy their work and as a result, are dedicated employees to this organization.

This organization has found a workable solution to its problem in developing a new policy concerning student employees. The need to recruit new students has dropped to a minimum and the quality of the work of the student employee has greatly increased. Today this organization handles twice the number of service requests that it did three years ago with only a small increase in the number of student employees.

In view of what has been done by the Distribution Services Division of the Instructional Media Center at Michigan State University it would seem advisable for other university departments to follow suit. This organization is proof that such a policy will work.



THINK POWER Think diesel power to drive a truck as big as a house. Think power for the fun of it, to carry just two people and their camping gear. Think gas turbine power. Think marine power. Think rockets and missiles, and farm equipment and earthmovers. Think about a career with International Harvester. Our 4,000 engineers and technicians are thinking power for every purpose from rocket thrust combustion chambers to gas turbine tractors and trucks. We're the world's largest producer of heavy-duty trucks, a major producer of farm and construction equipment—and we're doing very nicely in steel. Gas turbines and aerospace equipment also are important parts of our POWER complex. At IH, POWER is a 2-billion-dollar-a-year plus business, with research and engineering one of our biggest budget items. We need engineers! We especially need mechanical, industrial, agricultural, metallurgical, general and civil engineers. If you're an engineering graduate who is intrigued by POWER and its unlimited applications, you should find yourself right at home with us.

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The Saxon flunky reported, "Sire, Lady Godiva rides without."

Glancing outside, his master said, "Very tactfully put, my man."

Some girls just can't take a joke, but others prefer one to no date at all.

The civil engineer said that he didn't know what you call what he and his girl did in the park, but so far as he's concerned, baseball and tennis have had it — from now on.

Mother (on entering the room unexpectedly) — "Well I never..."

Daughter — "Oh, Mother, you must have!"

Two old maids went for a tramp in the woods. He got away.

Jack and Jill went up a hill
Upon a moonlight ride;
When Jack came back,
One eye was black,
His pal, you see, had lied.

A M.E. was speeding across the M.S.U. campus when he was stopped by a Kampus Kop.

"Let's see your license," mumbled the K.K.

The M.E. said nothing.

"What's your name?"

Still without a reply, the M.E. casually reached inside the glove compartment, and pulled out a stick of gum. Upon unwrapping it he rolled the tinfoil into a ball and handed it to the bewildered K.K.

"Here," he said, "this silver bullet should explain who I am."

After a shipwreck a parrot and an old maid found themselves the only survivors. They floated on the raft together for two days in absolute silence, until finally the parrot said, "Bawk, how's your old fanny?"

"Oh, shut up," scowled the old maid.

"Mine, too," remarked the parrot. "Must be the salt water."

Love — the delusion that one woman differs from another.

On the tombstone of an atheist: "All dressed up and no place to go."

No doubt the saying "come across" was originated shortly after the invention of twin beds.

We hear some freshman engineers think that a neckerchief is the president of a sorority.

Anyone can play bridge, but it takes a cannibal to throw up a really good hand.

The leader of the new White Muslim movement, now being organized will be known as Talcum X.

An I.E. was discovered by his wife one night standing over his baby's crib. Silently she watched him. As he stood looking down at the sleeping infant, she saw in his face a mixture of emotions that she had never seen before — rapture, admiration, doubt, despair, ecstacy, incredulity. Touched and wondering alike at his unusual parental attitude and the conflicting emotions, his wife, with her eyes glistening, arose and slipped her arm around him.

"A penny for your thoughts," she said in a tremulous voice.

He blurted them out: "For the life of me, I don't see how anybody can make a crib like that for $3.49!"

CONTINUED FROM PAGE 16

with 4.5 parts in 231, with 0.0056 parts in 3.1416, etc. The point here is to be decisive, self-assured, and accurate as you can be without becoming unduly concerned about the third and fourth significant figures.

In the final analysis trade-offs, as we have applied them, are analogous to the process of factoring identical terms from a given common fraction. We recognize 4/8 as being 1/2 or 0.500 by virtue of having cancelled the common factor of 4 from each term. We could arrive at the same result by increasing each term by 25 per cent to yield 4/8 = 5/10 = 0.500.

Madison, Wisconsin
May 5, 1964

* * * *

Professor Paul J. Grogan, Chairman
Department of Engineering
University Extension Division
The University of Wisconsin

STRENGTH

One of the outstanding properties of Malleable Iron Castings

One of the first considerations in designing a metal part is its strength to perform a given function.

In most instances, the second question is always how to provide the necessary strength . . . at the lowest possible finished cost. On both counts, Malleable iron castings offer exceptional advantages. Here is why:

Malleable castings are available in two general types (ferritic and pearlitic) and in 9 ASTM grades that range in tensile strength from 50,000 to 100,000 PSI. Tensile strength figures represent the load at which materials fail. Yield strength and fatigue strength are among the more important engineering yardsticks.

Yield strength represents the point at which materials exceed the elastic limit. Fatigue strength is the greatest stress which can be sustained when the load is applied repeatedly. As indicated by the table below, Malleable has an advantage over steel in fatigue strength and yield strength when grades of identical tensile strength are compared.

	TENSILE	YIELD	FATIGUE
1020 Steel	75,000 PSI	48,000 PSI	34,000 PSI
50007 Pearlitic Malleable Iron	75,000 PSI	50,000 PSI	37,000 PSI

Strength and Cost — Malleable iron has been described as providing more strengh per dollar than any other metal. There are many factors which contribute to this reputation. Malleable can be cast close to finish shape, thereby reducing or eliminating machining operations. What machining must be done can be accomplished quickly because Malleable iron is the most easily machined of all ferrous metals of comparable hardness.

This is a pearlitic Malleable iron universal joint yoke for an automobile. Subjected to repeated torque as the car reverses, speeds up and slows down, these high strength parts have an enviable record for reliability and service. One automaker reports no warranty claims on this part for the past seven years!

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MALLEABLE FOUNDERS SOCIETY

Reprint from DUPONT MAGAZINE, March - April 1966

"Detaclad" explosion-bonded clad metals make a jingling debut in dimes and quarters as the Treasury Department institutes a

Big Change in Small Change

The nostalgic crowd that wistfully regards the products of the Sixties—be they automobiles, houses or washing machines—and laments with plaintive sighs that "they don't make 'em the way they used to" can now apply the assessment to a trio of U.S. coins.

Last November, Federal Reserve and member banks received shipments of 263 million freshly minted quarters. The coins stirred commentary. "They look just a little different," said some, eyeing the reddish-brown tint that circles the coin's milled edge. "Sound different, too," remarked others, noting the quarter's slightly off-key clunk rather than clink against a metal desk top. Reason for the differences: The shipment was the initial distribution of composite or clad coinage — "sandwich quarters" as some are phrasing the new coins—and, in point of fact, they're not making them the way they used to.

In the first major alteration in the metallic content of subsidiary coin since 1792, Congress enacted legislation last summer removing silver from dimes and quarters and cutting its content in the half-dollar from 90 to 40 per cent. Silverless substitutes in the 10- and 25-cent denominations consist of a pure copper core bonded between face layers of 75-25 per cent copper-nickel alloy. The new four-bit piece, likewise, is a "sandwich" coin—facings of 80-20 per cent silver and copper on a core of 79-21 per cent copper and silver.

(The metallurgical recipe for the silver dollar remains unchanged; an academic point, since Mint presses haven't punched out the cartwheel since 1935.)

The Treasury Department's distribution timetable calls for 3.5 billion of the new composite coins to be in circulation by June 30, 1966. During fiscal year 1966-1967, output may be raised to seven billion; and within three years it will be possible, though perhaps not necessary, to meet total subsidiary coinage needs with silverless coins.

Why the extraction of silver? "Because there's a worldwide shortage of the precious metal," answers Miss Eva Adams, Director of the United States Mint. "Over the last decade, consumption of silver in the free world has steadily outpaced production. Between 1960 and 1964, for example, consumption rose nearly 190 per cent; production was up only 3.5 per cent."

During that period industrial consumption of silver—most notably in the photography, electronics and flatware industries—increased by more than 60 million ounces. But the biggest drain by far on supply is the increasing U.S. coin production.

In 1960 the Treasury used 46 million ounces of silver in the minting of new coins. By 1964 that figure had rocketed to 203 million ounces as they stepped up operations to meet the coin shortage.

The shortage, Miss Adams comments, was not a problem of an insufficient supply of coin but the unavailability of the coin in existence. Coin movements are seasonal. The demand for coins begins to build in the fall, peaks in the Christmas season, and "flowback" (coin returned to Federal Reserve banks and branches by commercial banks and others) starts in January. However, flowback in 1964 was seriously subnormal.

Reasons cited for the scarcity of free-flowing coins included the voracious appetites of coin-fed machines, speculative hoarding in expectation of a price rise in silver, "holdback" by businessmen in fear of a lack of coin to meet their own needs, and the swelling ranks of coin collectors, now estimated to number 8-10 million. The solution to the problem, maintained the Treasury, was to beef up coin production—flood the country with coin and thus negate the fear and profit motives causing the shortage.

That brought coinmakers face-to-face with the dwindling silver supply. "It presented," says Miss Adams, "the choice of depriving coin of silver or depriving the economy of enough coins to keep it functioning properly." The Treasury recommended the former and Congress concurred.

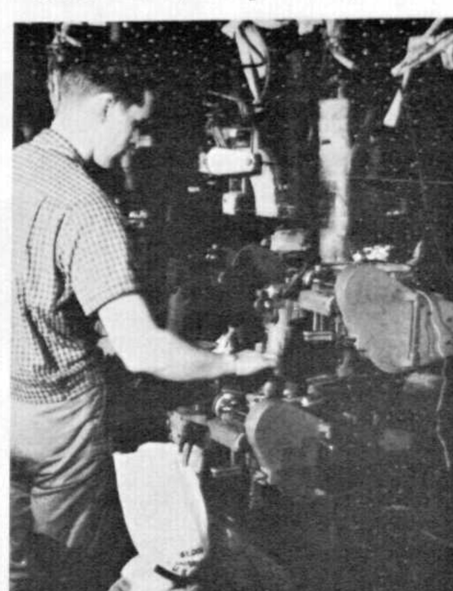
The decision to mint a cladded coin rather than a single metal or alloy piece, such as the present minor coins (pennies and nickels), was necessitated by the requirements of the vending machine. Explains the U.S. Mint Director: "Only a composite type of coin could be engineered to duplicate the electrical properties of the former 90 per cent silver coins. And these properties had to be preserved to forestall the need of retooling the nation's coin-operated machines.

(There are roughly 12 million such machines and devices in the U.S.—from pay telephones to toll highway hoppers to dispensers of candy, cigarettes, cosmetics and countless other items. Half of these machines, at least, have sophisticated sensing devices and the process of revamping them would take three years to complete.)

In its 174-year history the Mint has traditionally produced its own coin, from ingot to end. But with the new coinage system, private industry has been contracted to provide—temporarily at least—laminated strip from which the "sandwich" coins will be stamped. Du Pont, for one, is supplying the Philadelphia Mint with a two-metal laminate in the form of "Detaclad" explosion-bonded clad metals.

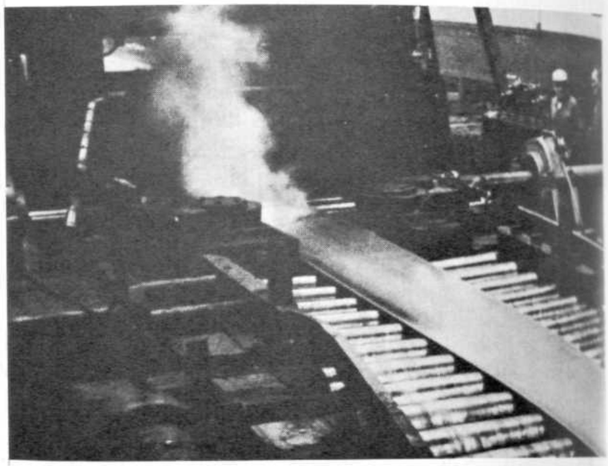
A Blast That Bonds

In commercial production since 1964, "Detaclad" metals are created by the force of precisely controlled explosions which produce metallurgical marriages that are strong, uniform in quality and easily adaptable to conventional fabrication processes. Briefly, the two metals to be joined are placed within a few thousandths of an inch of one another, an explosive is placed on



New clad coins are bagged at the Philadelphia Mint for shipment to Federal Reserve and member banks.

Explosion-bonded clads await furnace-softening prior to hot-rolling.



Hot- and cold-rolling mills flatten five-inch clads to coin thickness.

top, then detonated, and the resulting explosion drives the metals together in a firmly welded bond without any significant change in the properties of the respective metals.

"Thus far the patented process has been most widely applied in producing corrosion-resistant clad plate for the chemical processing industries," points out Dr. Marshall Acken, Du Pont clad products sales manager. " 'Detaclad' metals in a variety of combinations, from stainless steel on copper to titanium on carbon steel, have been used with great success in such things as pressure vessels and heat exchangers."

The measure of success is reflected in an expansion program now under way that will bring a fivefold increase in the company's explosion-bonding facilities at Pompton Lakes, N.J.

The assignment of furnishing composite strip for coins has introduced a new aspect to Du Pont's technology of "bonding with a bang," according to Acken. Says he: "Our commercial work has been largely final gauge cladding; that is, cladding directly at the specified thickness. Under the coin contract, however, we're cladding first, then conversion-rolling the clad to the thickness required for the coins."

The metals used come from the Government's metal stockpile through refiners who cast the pure copper and nickel into properly dimensioned "cakes" of copper and copper-nickel. With its explosion-bonding process, Du Pont produces a cladded composite that's over five inches thick in a layer to core to layer ratio of 1:4:1.

The clad is next reduced by hot-rolling and precision cold-rolling to the thickness of quarters (.054 inch) or dimes (.041 inch). The rolling facilities, identical to those used in producing strip for pennies and nickels, produce coils of composite strip that may yield as many as 5,000 quarters or 12,500 dimes per 100 pounds of strip.

Delivered to the Mint, the coil strip is fed into blanking presses where circles of metal are punched out in coin size. The blanks are annealed, i.e., heat-softened, and run through stamping presses where the coin design is imprinted. The finished coins then pass across reviewing tables where each is examined, front and back, to guard against production misprints that might be coveted by collectors.

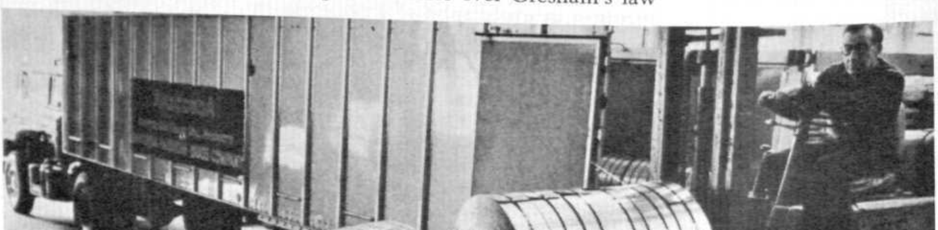
"We're taking every step to see that the new and old coins circulate freely, side by side in the economy," asserts Miss Adams. Further, she doesn't feel that the new coinage is apt to stumble over Gresham's law which hypothesizes that "poor money drives good money out of circulation."

Continues Miss Adams: "There'll soon be billions of both old and new coins in existence, so neither will have the quality of rarity to make them of any numismatic value. What's more, by removing the coinage drain from its silver supply the Treasury can keep the price of the metal well below the $1.38 an ounce price at which it would become profitable for speculators to melt down the old silver coins."

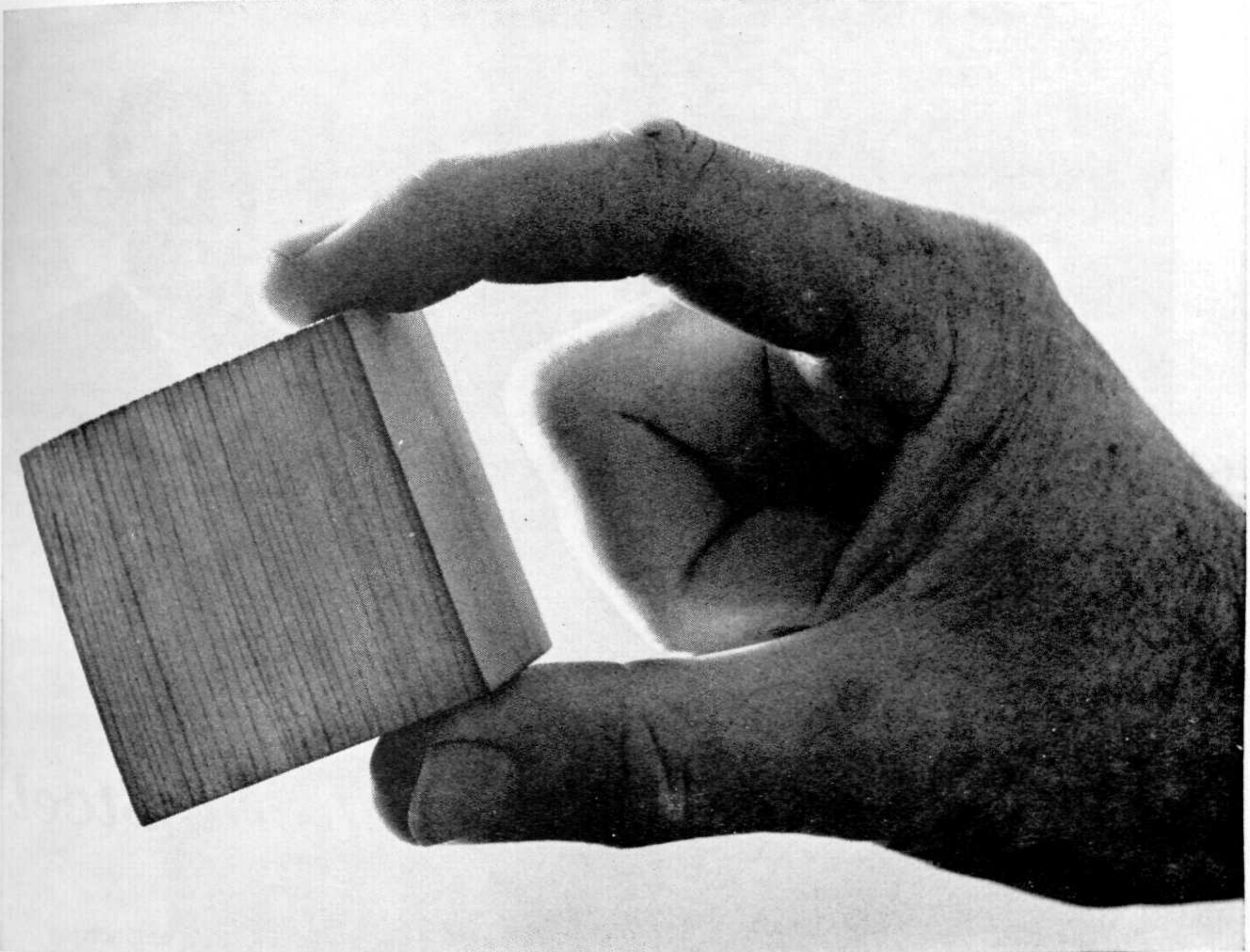
How is the public reacting to the new composite coins? Replies one bank official: "Fortunately, we haven't noted any particular reaction and this is a case where no reaction is a good reaction. Sure, we heard some comments about the appearance and 'ring' of the new coins when they were first issued, but the novelty wore off quickly and now they seem to be circulating without a hitch."

Queried about the new "sandwich" coins, a customer in a supermarket check-out line comments: "I'm not concerned with how they look or feel. The important thing is they'll buy as much as the old coins."

Interjects another shopper, digging forlornly into her purse: "Or as little."



Rolling results in coiled composite strip for the Mint's coin-blanking presses.



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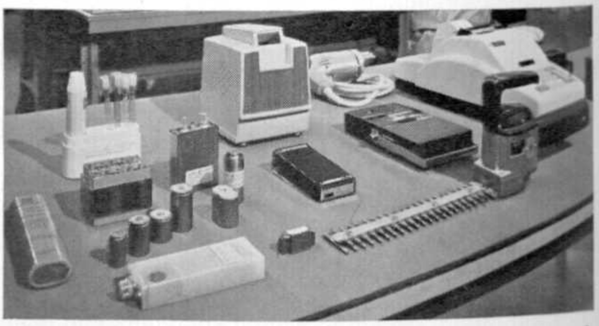
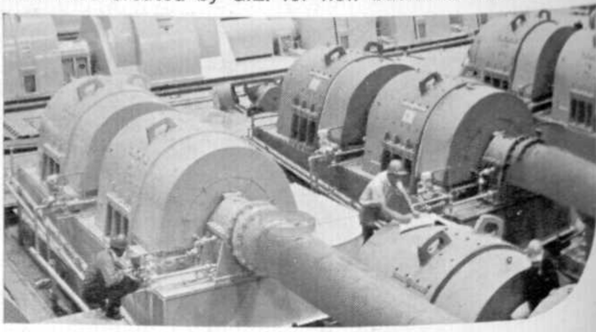


CONSUMER—Nickel-cadmium batteries for cordless products were created by G.E. for new business demands.



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