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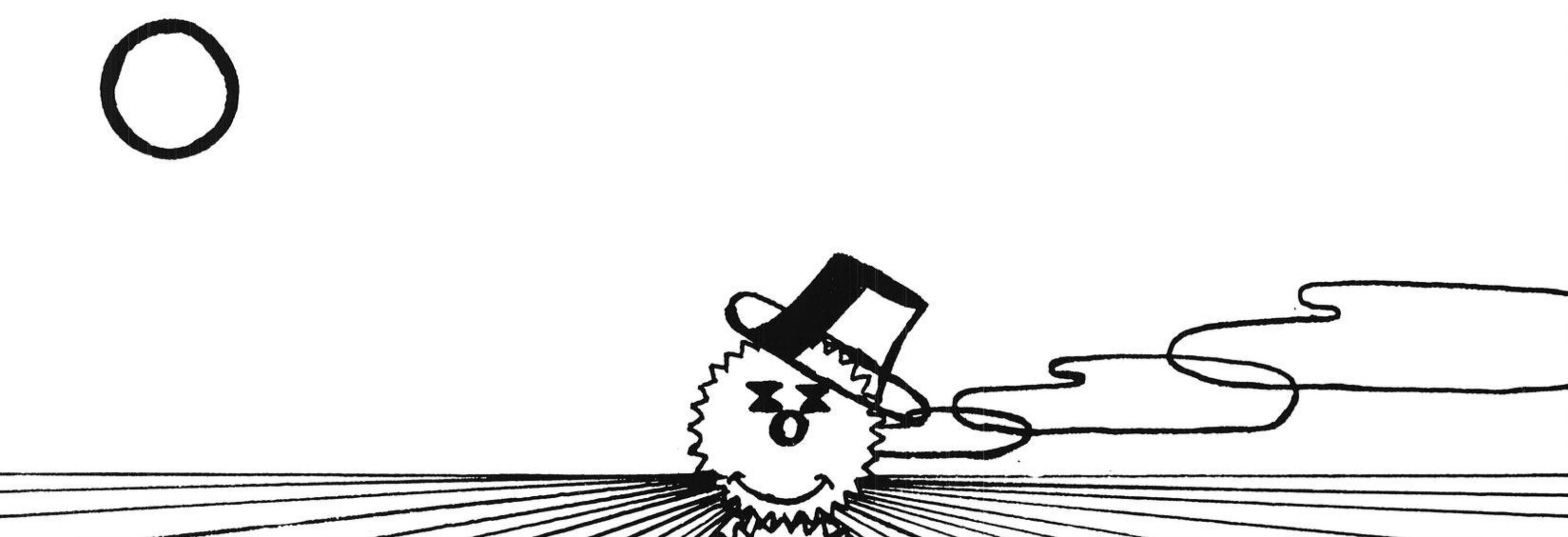
DECEMBER
1958

The Wisconsin engineer

25¢



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Wanted: Inquiring Minds

TEAMMATES—Young engineer Warren Conner—B.S.M.E. 1956—teams up with Armand J. Bilitzke of GM Engineering Staff's Transmission Development Group to test blade-shape models for torque converters. Mr. Bilitzke helped design flow table which is unique to the automotive industry.

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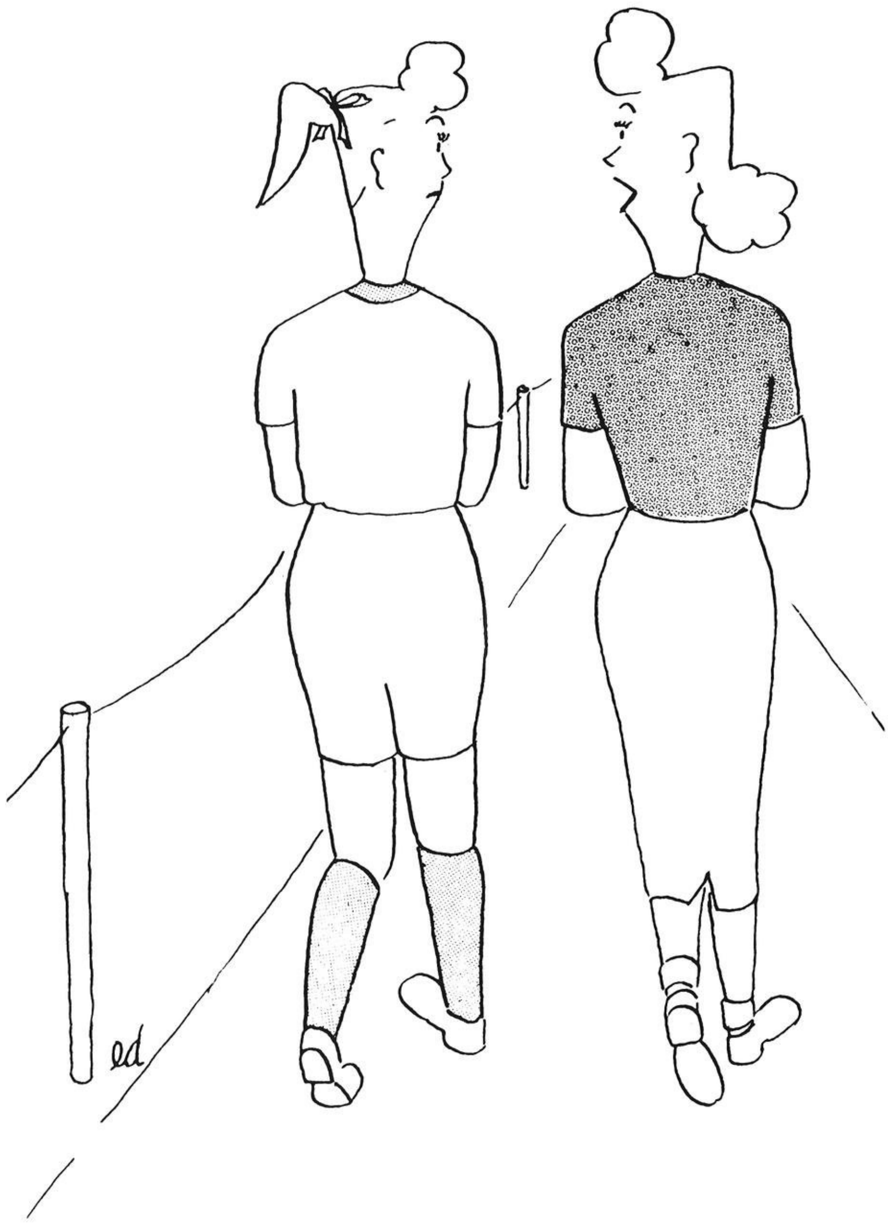

"No, but, if you want to live dangerously, I think I can fix you up with an engineer.

Volume 63 DECEMBER 1958 Number 3

WISCONSIN ENGINEER

The Student Engineer's Magazine

FOUNDED 1896

Features

Departments

Cover

Calvin Kreunen, an industrial design sophomore, illustrates this month's cover with an engineers snow man. For the story on gear production, see page 10.

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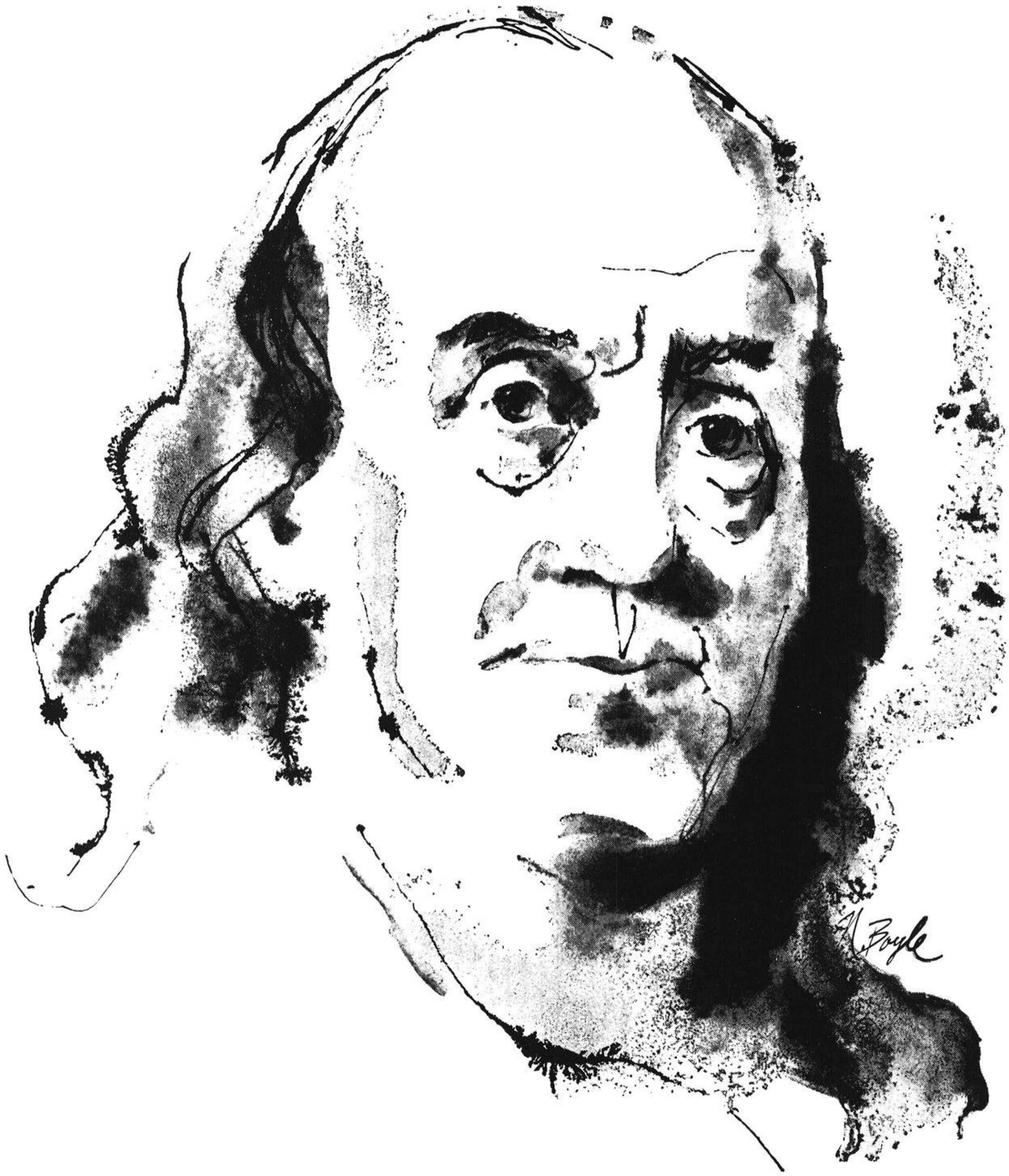
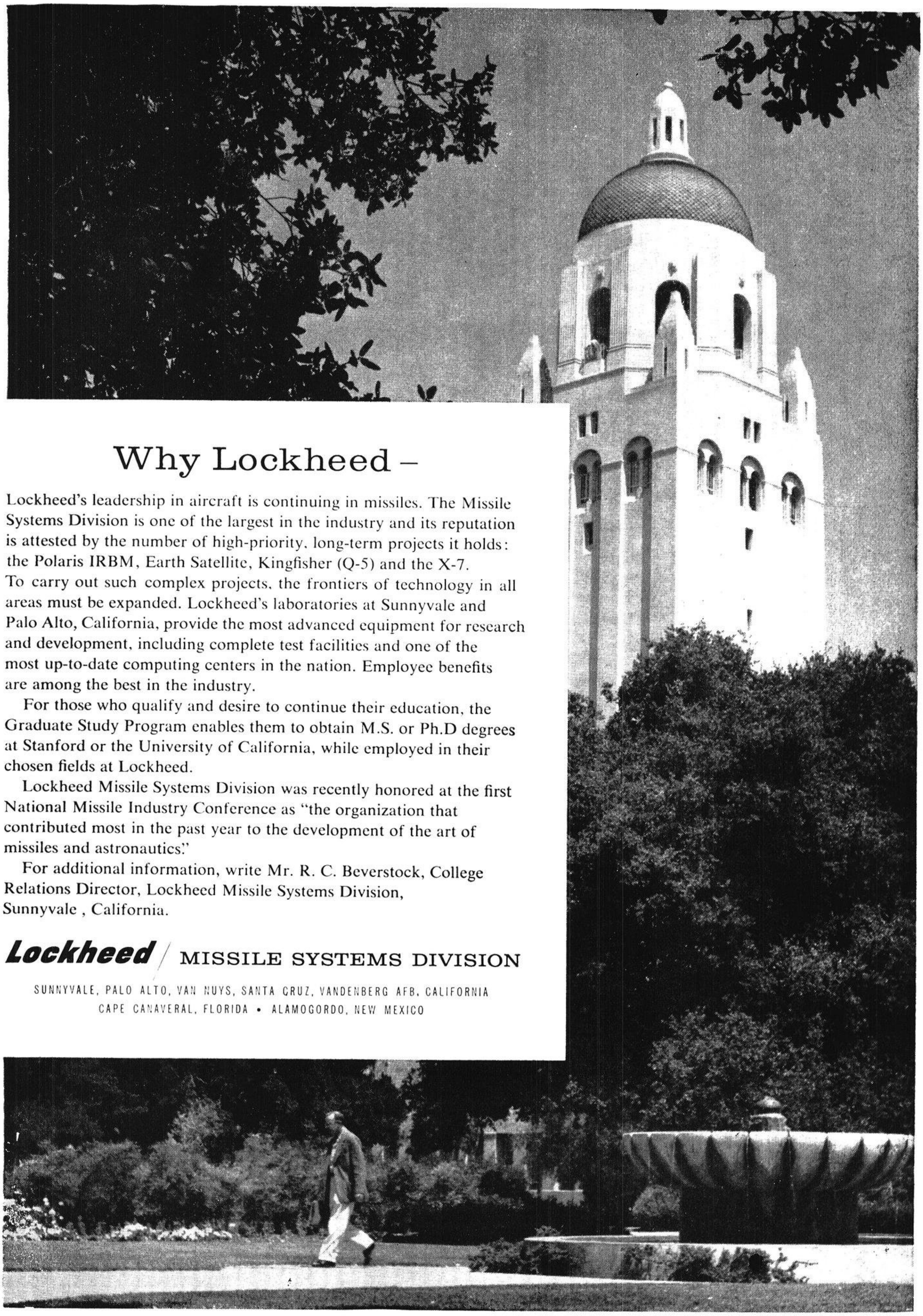
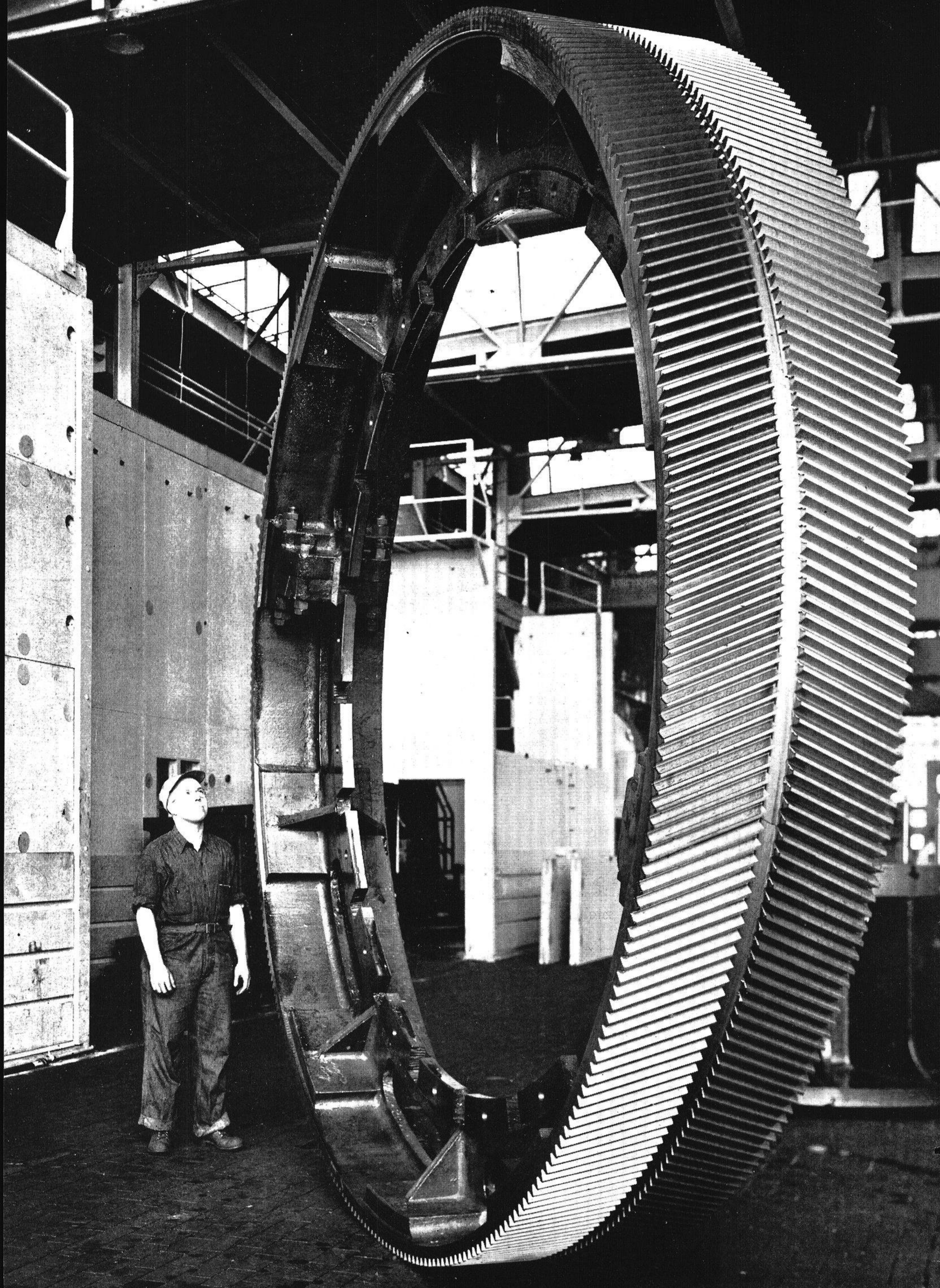






Rambling WITH THE EDITOR

This is the festive season!! For many it is a time when highballs tip higher, when the control over diet and drink is abandoned temporarily—a time to "forget our cares." For others it is a vacation, a time to loaf and to sleep late. Others, of the more foolish set, use this time to study for finals or to catch up on their reading or problem work. But regardless of the activity, this still is the one time of the year when people are heard singing Christmas carols, when more thought and display are given in reverence to a "King of Kings and Lord of Lords." Yes, it is a time when even hard-boiled engineers are maybe a little less hard-boiled, a little more reflective instead of scientific in their thinking.

Maybe this is the time to repeat the question that is asked often. "Is our nation really a Christian nation?" This is being asked not only by ministers but by statesmen, businessmen, engineers, scientists—I dare say by anyone who is genuinely interested in the motivations of its citizenry.

Is there something wrong when our fellow engineering graduates are heard to exclaim? "Why, I can't be successful as an engineer if I am Religious. Why, I'd never get ahead if I went along with the Church." Is there a feeling that one has to be dishonest, without conscience, inconsiderate of others, or a wild entertainer to be successful as a leader in industry or business?

On the other hand, leaders of industry are realizing more and more a need to provide not only for the economic and athletic needs but for the psychological and Spiritual needs of their employees as well. Companies like Western Electric, Caterpillar, LeTourneau, and Kodak now have full time or part time guidance counselors with either psychological or religious backgrounds on their staffs for the employees' benefit.

Many recruiters and interviewers who are presently coming to the Wisconsin campus list "A Religious Faith" as a desirable attribute for a young man entering the field of engineers. Seniors, in their Professional Orientation class, have heard two or three speakers express this point of view. Mr. William H. Younger, Eastern Sales Manager for the Square D Company, told this class on November 20: "One of the things I look for in a young engineer for a possible position as a salesman with our company is a Religious Faith." He said he didn't care what kind of Faith it was, whether it be Catholic, Protestant, Jewish, Hindu, or Islam, but, for an engineer today who must face frustration and seemingly unsolvable problems, there needs to be some kind of a trust in a power greater than his own to give him an inner security to fall back on.

Ethics and Fairness, a part of all world Religions, is just as necessary in industrial relations as they are in community or church groups.

In a day when the future of our nation may very well rest in the hands and the wisdom of our Doctors, Scientists, and Engineers, it is almost imperative that these men have a deep sense of commitment about their work but basically, and prior to that, about themselves, so that they do have that inner strength to rely upon when faced with uncertainties of nature and science. At any rate, regardless of how we choose to conduct our own lives, we can not help but respect the fellow who "sticks to his guns" about his convictions even when in the minority, socially, or when he is confronted with this erroneous stereotype of what he, as an engineer, is expected to be.

This giant double-helical gear is an example of what may be produced in modern day gear production. See page 10 for article.

Gears and Their Production

by Dennis Rufe

A presentation of types of gears, their production, and their applications

GEARS are a very important part of industry today. They are used in almost every application where power must be changed from one form to another. It is just in the last 75 years that gear production has become a science. Seventy-five years ago, gears were produced by the "try it and see" method, but with the modern requirements for machinery, gears must be produced with a great deal more accuracy. This greater accuracy caused gear production to become much more complicated and caused drastic changes in the gear production machinery. This article will go through the major points of the modern machines for producing gears and the finishing operations connected with this production.

In the following material, the various types of gears are described along with the method of production. The mathematics of gears will be included where it is needed in order to explain the processes. The various methods of finishing gear teeth will be included wherever they apply. The last part of the article will give the application of the several types of gears and examples of where they are used.

Types and Production of Gears

The spur gear is the simplest of the various types of gears. It is a gear which has all its teeth straight and parallel with the axis. Although the spur gear is not used a great deal today, it will serve as a good comparison to the other types of gears and may be used to explain the fundamentals of the cutting process. Spur gears are cut by a process called hobbing. A hob, which is the gear cutter, is in the form of a thread with grooves running along the axis. This leaves a series of teeth which are ground to form relief angles and then sharpened. The teeth on a hob are the shape of a rack tooth and form a gear tooth profile of an involute curve.

Hobs are classified according to their diametral pitch, pressure angle, and type of thread. The diametral pitch is the ratio of the number of teeth on a gear to its diameter.

$$P_d = \frac{N_g}{D_g}$$

The P_d is usually a whole number except for the lower ratios which may be in ½ increments. The pressure angle is the angle that the line of force on a tooth develops with the tangent to the pitch circle. The base circle is an imaginary circle that the involute profile of the teeth is formed from. The use of an involute curve for gear teeth has the important feature of being able to maintain a constant speed ratio with a change of the center to center distance between two gears.

The three main pressure angles in use are 14½°, 20°, and 25°. The 20° pressure angle can be full depth or stub. The stub 20° pressure angle is a modification of the full depth and has a shorter tooth. The shorter tooth is used because it will eliminate the interference that sometimes occurs when there is a large number of teeth on the gear and a small number on the pinion. A hob may have a right or left hand thread. Since it is similar to a screw, it can be made with either hand.

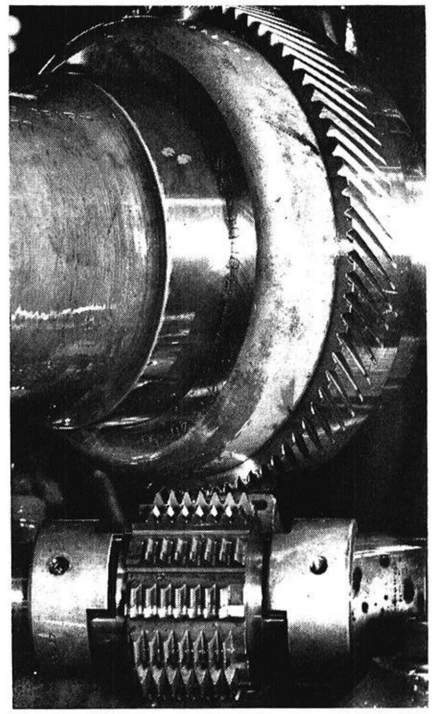
In the cutting process, the hob and gear are both rotated under power and are rolled together. The gear moves a slight amount as each tooth in the hob comes around. Each tooth cuts a small amount off of a portion of the tooth of the gear. This process is called "generating" and is faster and more accurate than the use of a formed milling cutter, the former method of gear cutting.

On most hobbing machines, there are two gear boxes—the indexing and the differential. By changing the gear ratios, the correct speed between the hob and work piece may be obtained. The hob is set at the required depth of tooth and is fed across the face of the work piece, thus cutting the gear in one pass. On larger gears, many feet in diameter, the hob is run across the face twice. The first cut is the rough cut and is for removing most of the material. The second cut is the finishing cut and is set at a high speed and feed in order to clean up the teeth and size them exactly. A third cut may be taken if the size is not within limits. For gears that require very accurate profiles, there may be as many as four or five cuts with a check after each one. The teeth are checked by means of a gear caliper on which the size of the addendum is set and then the width of the tooth at the pitch line is read off of the venier scale, which is accurate to the thousands.

Helical Gears

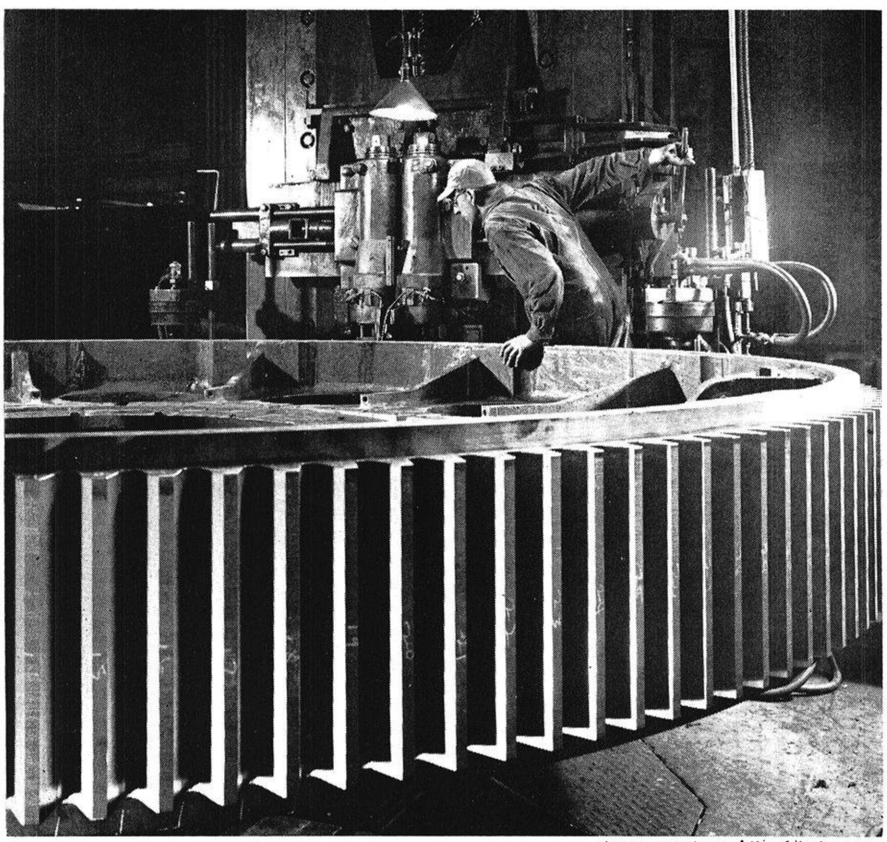
Helical gears are very similar to spur gears except for one important feature. Helical gears have their teeth cut on an angle with the axis of the gear. Because of the helix angle, one gear will transfer a load to another gear with a smoother action. The tip of one tooth will be engaged by the time another tooth leaves the mesh, whereas in the spur gear, the change of load is sudden and results in noisy operation. The helical gears have the bad point of producing end thrust. End thrust is the force along the axis of the gear and increases as the helix angle increases. This end thrust is an important consideration in designing the bearing for a gear box which has helical gears. Helical gears can be either right or left hand and their hand is determined as you would determine the hand of a screw. A right hand helical gear must mesh with a left hand pinion or vice versa. This same principle is used in the cutting of helical gears. If the gear is to be right hand, the hob must be a left hand hob.

In setting up for the cutting, the axis of the hob is set at an angle with the axis of the piece, equal to the helix angle minus the natural angle on the hob. The hob is then traversed across the work piece. In general, the larger the diameter of the gear, the smaller the diametral pitch will be. A smaller diametral pitch will have larger teeth and therefore will carry more load. The hobs vary in size as the diametral pitch, with the large pitch hob weighing only a few pounds and the small pitch hob requiring a crane to lift it. After several pieces are cut on one part of the hob, it is shifted and another sharp portion is used. Helical gears are used more than any other gear and have replaced spur gears in many applications.



—Photo courtesy Falk

Hobbing a helical gear.



—Photo courtesy Allis-Chalmers

Cutting teeth on spur gear for comper mill. Gear has 170 teeth with a 16 inch face and pitch diameter of 170 inches.

Double Helical or Herring-bone Gears

Double helical gears are exactly as the name implies. They are gears that have two sets of helical teeth on the face, one of which is right hand and the other a left hand. The advantages of the double helical gears is that the thrust from one helical will balance the equal and opposite thrust of the other one. The groove in the middle is a relatively new feature and is needed for draining the oil, which had the tendency to build up in the pocket of the old design. This oil was trapped when

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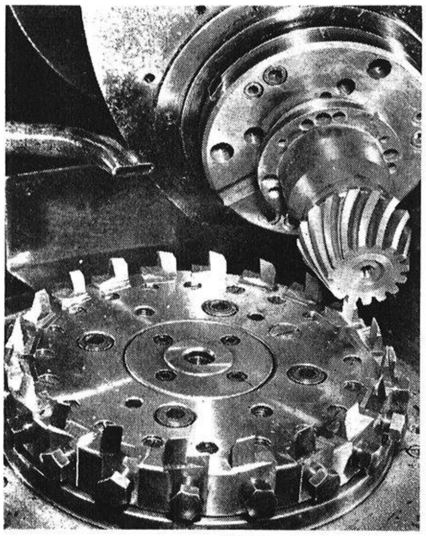

—Photo courtesy Falk

Cutting a bevel gear.

the teeth came together and built up dangerous pressures. The end thrust of the two helicals on the herringbone gear cancel each other and make the design of the bearings easier. The herringbone gear must be aligned accurately so that each helical will carry an equal amount of the load.

Double helical gears may be hobbed, but they are usually cut by a process called shaping. The shaper tool looks similar to a spur gear except that the teeth are relieved and sharpened on one end. In principle, the shaper cutting is very similar to hobbing and is also a type of "generating". The actual process, however, is quite different. If a spur gear were to be cut, the work piece would rotate with the shaper, as in a set of gears, and the shaper would also move across the face of the gear in order to cut it. In the double helical gear, the shapers are set in pairs and move in the same way as in cutting spurs except that they are twisted to follow the helix angle.

Shaping will do any job that a hob will do, but is not as efficient as hobbing. In shaping the double helical gears, the time required depends upon the diametral pitch and the diameter. In general, as the diameter of the work increases, the speed of rotation will be slower and the length of time for cutting will be longer. Obviously, as the gear rotates once, the cutter cuts all of the teeth. For a five or six pitch gear, the cutter would be fed in four times and then a reading or the size of the teeth would be taken with a gear calipers and the finish cut set. The cut is fed in slowly as the machine continues running.

Shaping is the only method by which internal gears may be cut. The same principle applies to the internal gear cutting as to any other type. The cutter is rotated around the inside of the internal gear and moves across the teeth to do the cutting.

Bevel Gears

Gears which are used to connect non-parallel shafts, which may be intersecting or non-intersecting, are called bevel gears. The teeth on bevel gears are at an angle with the axis of the gear. The most common type of bevel gear has the teeth straight with the axis of the gear. The pitch line of this type of gear is not parallel with the axis, as in a spur gear, but intersects the axis at an angle which is called the pitch angle. These gears are classified according to the diametral pitch.

In order to have a smoother engagement of teeth, the straight teeth were changed to a spiral form. The spiral bevel gear will give quieter operation and faster speeds. They do the same thing for straight bevel gears that helical gears do for spur gears.

Spiral bevel gears are cut on a special machine manufactured by The Gleason Works. The Gleason machine has a rotary cutter into which the gear blank is fed. The cutter cuts one tooth at a time, and then the blank is automatically moved out and indexed to the next tooth. The gear blank is twisted as it is moved into the rotary cutter and this produces the spiral.

After cutting, a gear and pinion are selected and are lapped together under power so that there is a fast wearing on the gears. This will remove or cancel the errors in this set. The set must also be checked for bearing. The gear and pinion are lapped and the wear takes place at point of bearing. By this technique the bearing is brought down to the smaller portion of the teeth as the gear and pinion wear. The bearing must be down on the small part of the teeth because when the gears transmit power the teeth will deflect and the bearing will creep up to the thicker part of the teeth. Because the gears were lapped together they are match marked and may only be used together. The set is then heat treated. The heat treating tends to straighten out the spiral teeth and this throws the bearing off. This is partially taken care of by having the bearing very low on the first lap, but after heat treatment the gears must be relapped to bring the bearing down again. This time the bearing is

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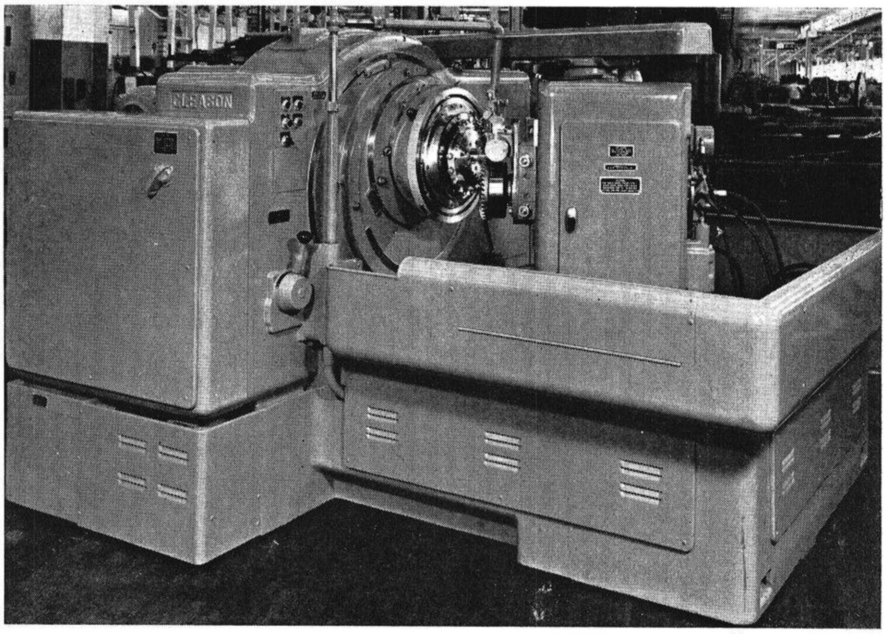
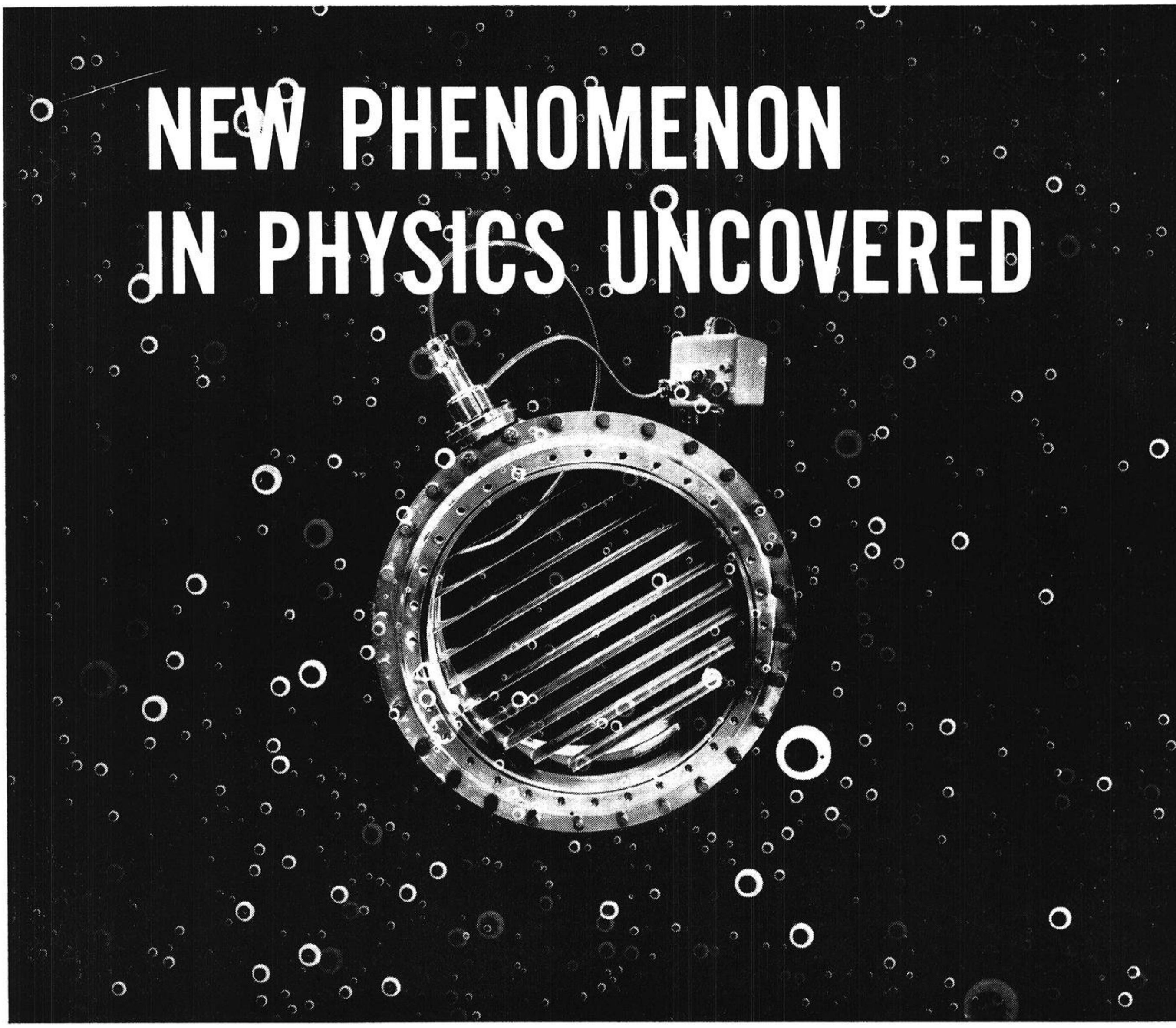


—Photo courtesy Gleason Works

A hypoid generator is a completely automatic high speed machine that cuts spiral, bevel, and hypoid gears up to 18 inches in diameter.



Investigation in detecting cavitation, or forming of vapor bubbles in liquid flow, led AiResearch engineers to the discovery of an important new phenomenon . . . *that flow of bubbles in liquids generates a magnetic field.* This discovery, among other things, helps solve critical flow problems in missile and industrial fields. The AiResearch cavitation detector pictured picks up these tell-tale signals as the liquid passes through the grid, pinpointing the cause of trouble.

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Electronic Distance Measurements

by Jon C. Gilbertson

Highly accurate surveying is now possible in a small fraction of time required by conventional methods.

DISTANCES measured by electronic means are based on the velocity of light or of radio waves. The distance is determined by measuring the time it takes for a wave to leave the sending unit, reflect off a distant station or receiving unit, and then return to the sending unit. Corrections for temperature, pressure, and humidity, must be applied to the measured distance to obtain a correct value.

Electronic methods are used to measure both vertical and horizontal distances. The horizontal distances are obtained with much greater accuracy than the vertical distances.

We can divide the horizontal-distance-measuring instruments into three groups; long, intermediate, and short range instruments. Each group consists of separate instruments, which are used for special purposes.

In the long range group, we have Loran, Decca, Lorac, Raydist, and the Electronic Position Indicator. All their measurements are made with both long and short radio waves. Some of these instruments measure distances up to 500 miles with an accuracy of 100 yards. Instruments in the long range class are used mainly in positioning a ship, while the ship is taking soundings of the ocean bottom.

In the intermediate range group, we have Shoran, Hiran, and the British Oboe. This group of instruments base their measurements on the short, "line of sight", radio waves. There must be no obstructions when determining distances with short wave instruments, so measurements are made from an airplane, flying over the line joining two stations between which the distance is to be determined. Distances up to 300 miles can be measured with an accuracy of 6 feet. Intermediate range instruments are used in setting up nets of triangles, in which all the sides, but no angles, are measured. The angles can be computed from the known sides. This method is called radar trilateration, and appears to be the inverse of triangulation.

The short range instruments consist of the Geodimeter, Tellurometer, Moran, and the Electronic Distance Meter. The Geodimeter and Electronic Distance Meter are based on light waves and the Tellurometer and Moran are based on short radio waves. These instruments are all operated from the ground and must have an unobstructed path to determine distances. Their maximum range is 40 to 50 miles with an error of less than 2 inches. They are used in baseline measurements and in traversing. These instruments are becoming popular because of their speed and accuracy.

Vertical distances are measured in much the same way as horizontal distances, but in this case the earth is the reflecting station. Radar waves are sent out from an airplane, flying a horizontal path above the earth's surface. The waves are then reflected from the earth and returned to the airplane. The accuracy of this system is reduced because the earth absorbs and slows the reflection of the waves as they strike. Elevations can be determined to the nearest 10 ft. in some instances.

Measuring distance by electronic methods is a new procedure and has only been used since 1950, for any practical surveying work. Many people, including surveyors, have not even heard of electronic distance measurements. The purpose of this article is to familiarize the reader with the methods, theory, and instruments used in making measurements electronically.

As is frequently the case, electronic surveying is a useful by-product of war. The demand for an instrument which would enable a bomber to locate its target even when obscured by clouds or darkness, was responsible for the preliminary development of Shoran, Oboe, and similar devices. Surveyors had long dreamed of utilizing radio waves in this manner but the cost of development was too great. The geodetic engineer and the photogrammetrist immediately seized upon these tools of war and by design modifications and skillful techniques, secured accuracies for greater than the original design accuracy. Shoran was used with astounding accuracy for bombing in Korea and its improved quality is a direct result of the studies of the geodetic engineer. Had the geodesist been able to secure funds for his electronic distance measuring research decades ago, all of his studies would have been of untold value to the military.

Until the last decade, few people believed that accurate surveys would ever be made where speed and time would be used to measure distances. Yet, within that short period of time, electronic surveying has emerged as a reality and as aid and even a competitor to the established surveying techniques. In surveying by electronic methods we utilize the speed of light or of radio waves.

The basic principle on which the various wave measurement systems depend, is, that the time required for electromagnetic wave energy to travel from one point to a distant station and then return to the sending station after reflection is a function of the distance between the stations. If the interval of time between emission and reception of a radio signal is very carefully measured and the velocity of the radio wave is known, the distance is directly provided by the product of the velocity and one-half of the round-trip time interval.

The main problem in surveying with different wave bands is obtaining timing devices which can measure the time interval accurately. We know that the velocity of light or radio waves is approximately 186,000 mi/sec, and therefore a clock must be accurate to 1/186,000 of a second to measure a distance to the nearest mile. The accuracy must be much better than this or it would be senseless to use these methods. Actually, distances up to 500 miles are now being measured to the nearest 10 ft. This means that there must be a timing accuracy of about 1/100,000,000 of a second. In short wave instruments, distances measured up to 10 miles have an accuracy of about 1 part in 300,000 or about two inches.

There are actually about three different wave bands now in use: one is light, the second is a high frequency band whose wave lengths vary from about ½ to about 100 feet, and the third is a band lying just above the broadcast band where the waves are over a mile and a half long. The instruments in the latter band have certain great advantages, but also some disadvantages. Since the first two travel through the air in almost a straight line, it is necessary to be able to "see" between points over which the distances are being measured. This reduces the measured lengths to "line of sight". The long waves of the third group have the property of spreading out or diffusing and thus bending closely around the earth for great distances. These waves can be received for hundreds of miles, far beyond the line of sight. The amount of power is the important factor in obtaining long range.

A disadvantage to the long waves is that when they are following the curvature of the earth they are propagated at different rates depending upon the terrain over which they are passing. In much the same manner that a stream of water flows more slowly over porous sand which absorbs part of the water, than it does over rock or hard clay. For instance, they travel faster over a good conducting surface like sea water, than they do over dry sand or rocky terrain. These effects are very hard to correct for, so by using the shorter "line of sight" wave lengths we can obtain much greater accuracy.

Other problems also arise when radio and light waves are used in surveying. For instance, light and radio waves travel at constant speed only in a vacuum. Our measurements are not made in a vacuum, but in air, which reduces the propagation rate, especially as the

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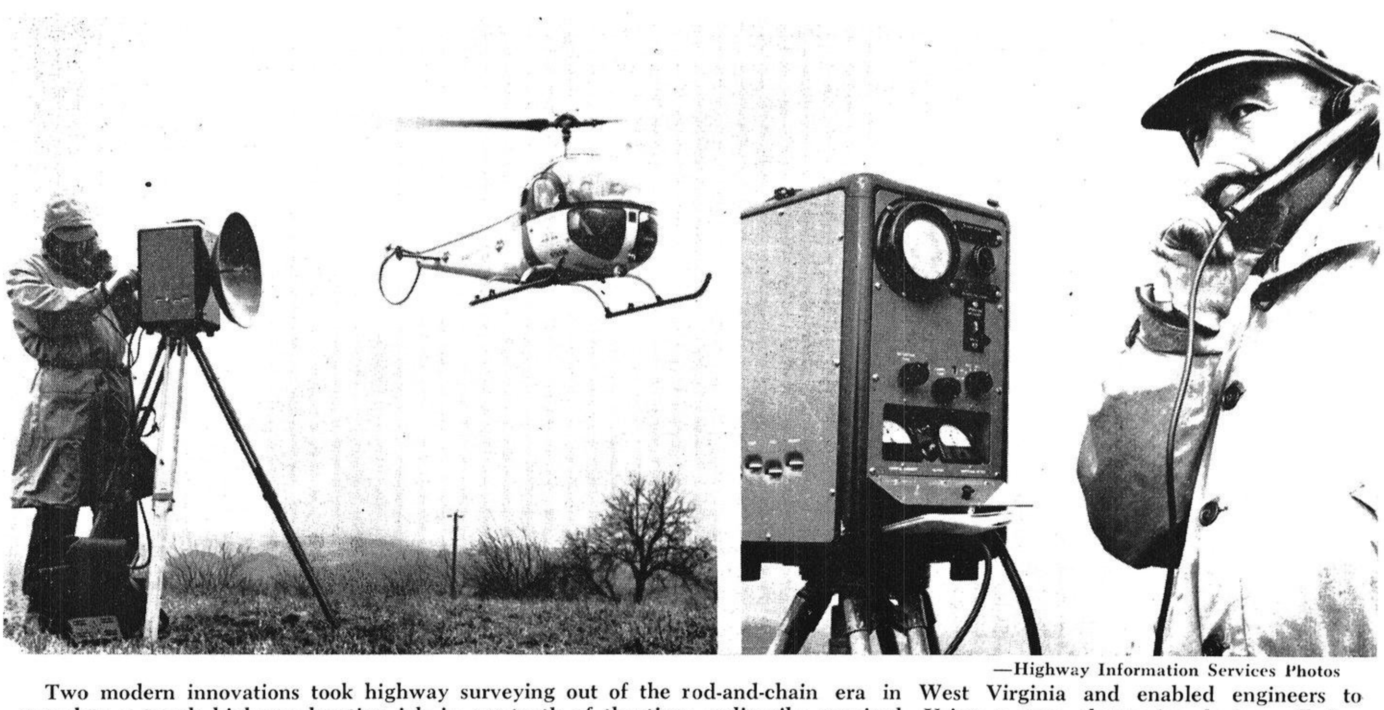
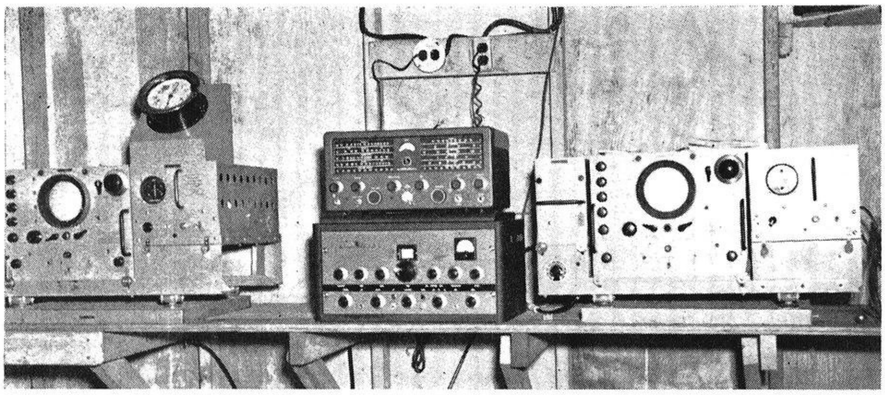


—Highway Information Services Photos

Two modern innovations took highway surveying out of the rod-and-chain era in West Virginia and enabled engineers to complete a tough highway location job in one-tenth of the time ordinarily required. Using a new electronics device called a Tellurometer to measure distances and a Bell helicopter to ferry crew members from point to point, they slashed weeks off the preliminary engineering operation.



—U. S. Coast & Geodetic Survey Photos

A typical duplex ground installaiton for E.P.I. equipment with communications equipment in the center.

air becomes more dense and more moist. It took much research to find out exactly how much the velocity changed with different conditions of temperature and humidity from its value in a vacuum. The temperature and humidity of the air must be measured, and by the use of formulas developed by experimentation, the corrections are obtained.

Various electronic distance measurement systems have been devised since World War II. These systems can be broken down into three main groups; long, intermediate, and short range instruments. The long and intermediate range instruments are based on radio waves and are used primarily in radiolocation and setting up trilateration networks. The short range instruments use both light and radio waves for determining distances. They are used in running traverses, along with the transit and in measuring triangulation baselines.

A description of the most important instruments in each of the range groups will be given in the following sections.

Long Range Instruments

Many long range instruments have been developed and are in use at present. These are generally of two classes: a) those using long waves, and b) those using short waves. As examples of these, we have Loran, Decca, Lorac, Raydist, and the Electronic Position Indicator. Extensive use is made of these long range instruments in hydrographic surveying where lesser accuracy of the long waves can be tolerated. They are very convenient for positioning a ship or boat while soundings of the ocean bottom are being made and they enable us to chart the bottom with great facility. Some of these instruments are capable of measuring distances of 500 miles with an accuracy of 100 yards.

Since the long range instruments work basically as the intermediate range instruments do, and are used mainly in the offshore areas for locating ships, long range units will not be discussed further here.

Intermediate Range Instruments

Included in the intermediate range group is Shoran, British Oboe, and Hiran. These methods are all used in building networks, similar to triangulation, but in electronic surveying called trilateration. The Shoran system of trilateration is the most widely used, so only this system will be described. British Oboe and Hiran are both similar to Shoran but are not used as much at the present time.

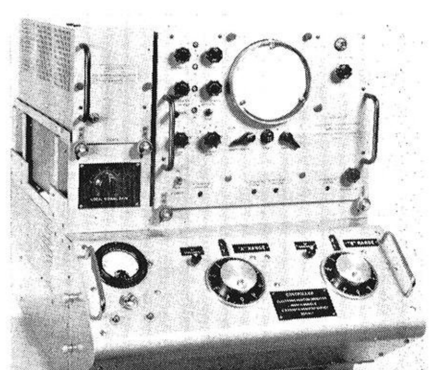
When the triangle sides in a proposed triangulation system approach lengths over which it is impossible to conduct visual observations, it becomes necessary to employ an electronic surveying procedure. Radar has been utilized with considerable success in the measurement of great distances. Its application to the determination of the lengths of triangle sides which are very long, from 300 to 600 miles, has led to the use of the term radar trilateration. This method of extending horizontal control depends primarily upon the electronic determination of the lengths of the triangle sides and not upon measured horizontal measured horizontal angles as with conventional triangulation.

The angles which are needed for transporting azimuths through the trilateration scheme are computed from the known triangle sides. Hence, trilateration appears to be the inverse of triangulation. Angular measurement by electronic methods has been attempted, but the results obtained can not be considered equivalent to those obtained by optical measurement with a theodolite.

In measurements made by Shoran, we use only the high frequency waves of 200 megacycles or greater. These short-wave radio waves are propagated along the "line of sight" so there can be no obstruction between the transmitter and receiver. In order to eliminate the obstructions and measure long distances, the sending station is the instantaneous position of an airplane situated at a high altitude.

The results of a test performed in Florida in 1950, are given in Table 1. In this test, a total of fifteen distances were measured by Shoran, and the results were compared with the distances obtained from conventional first-order triangulation. The distances varied in length from approximately 40 to 320 miles. The maximum discrepancy with a surveyed distance was approximately one in 40,000; the average discrepancy was 0.0012 mile, or about 6 feet.

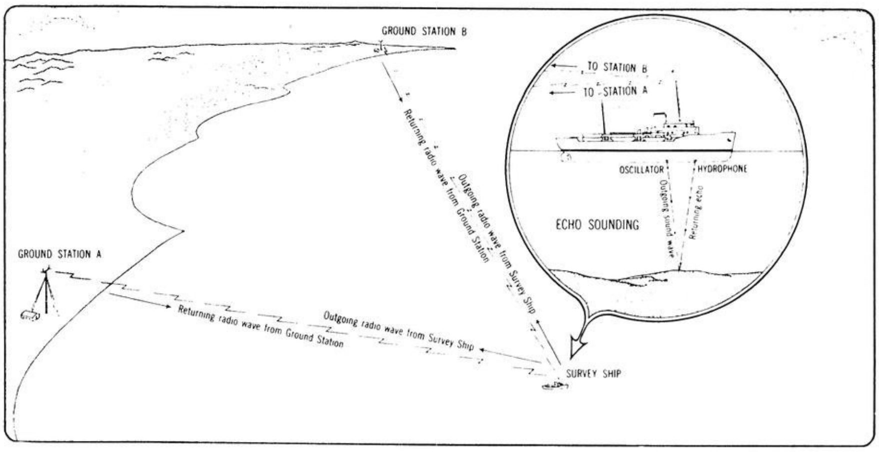
One of the most convincing results of this project was the discovery of a local surveying error at Key West, Florida. In that instance, five Shoran measurements were made to this station from other Shoran stations, the shortest



The E.P.I. control unit developed by the U. S. Coast Geodetic survey.

measurement being approximately 96 miles and the longest, 320 miles (Table 1). On the basis of a computation which used the Shoran-measured distances, it was predicted that a local surveying error of 35.4 ft having an azimuth of 39¾° was present. Several months later, triangulation by the Coast and Geodetic Survey, United States Department of Commerce, revealed that the error actually was 36.4 ft in an azimuth of 37°.

A second convincing proof of the accuracy of Shoran lies in the fact that measurements made by this method have been accepted by physicists as a new and accurate determination of c, the velocity of light. From the beginning of research (1944), indications were found that the statistical value for c of 299,776 km/sec, determined by R. T. Birge in 1941, was too low. Two values of c, (299,792.4 and 299,794.2 km/sec) were obtained from Shoran measurements in Florida. Other measurements of the velocity of light are given in Table 2.



—U. S. Coast & Geodetic Survey Drawing

Hydrographic survey using electronic position indication.

TABLE 2—VELOCITY OF LIGHT, IN KILOMETERS PER SECOND

Investigator	Year	Method	Velocity of light in kilometers per sec.
C. I. Aslakson	1949	Shoran	299,792.4 ±2.4
W. W. Hanson and K. Bol	1950	Cavity resonator	299,789.3 ±1.2
L. Essen	1950	Cavity resonator	299,792.5 ±4.5
C. I. Aslakson	1950	Shoran	299,794.2 ±1.4
E. Bergstrand	1951	Geodimeter	299,793.1 ±0.3
K. D. Froome	1952	Microwave interferometer	299,792.6 ±0.7
J. W. M. DuMond and E. R. Cohen	1952	Statistical	299,792.9 ±0.8

The advantages of the Shoran method of electronic surveying can be listed as follows:

1. Geodetic accuracy can be obtained over distances as great as 500 miles.

2. Errors are a function of time and therefore do not increase perceptibly with an increase in distance.

3. Aerial photography can be controlled by Shoran distances, permitting accurate mapping of all areas within the Shoran ground stations.

4. Navigational devices, utilizing the Shoran distance readings, permit flight-line navigation of great accuracy.

5. Shoran photographic techniques permit the establishment of control points of low accuracy without anyone touching the ground.

6. Vertical control of various degrees of accuracy are possible by Shoran-photographic-radio-altimeter methods.

The largest electronic surveying project ever attempted was made for the purpose of accurately locating tracking stations for guided missile research. But as frequently happens in wartime research, we find an important peacetime application. As a result of this survey in the West Indies we are correcting our maps of this entire area and errors of many miles have been discovered.

Extensive use is being made of Shoran-controlled photography by the United States and Canada. Two distances to each of two Shoran stations are recorded simultaneously with the exposure of the picture. Several methods of photographic analysis have been developed to utilize these distances in controlling the compilation of maps. It has been concluded that 1:500,000 maps can be produced in this manner without other horizontal ground control. The efficiency of a combined Shoran and geodetic-photogrammetric operation is therefore obvious. Geodetic measurements can be made under conditions such as darkness, fog, or extensive cloud coverage, which prevent photography. Therefore the higher priority can be allotted to photography and the combined

(Continued on page 44)

TABLE 1—SHORAN RESULTS IN FLORIDA TEST

(1) Lines	(2) *Geodetic distance in miles	(3) Adjusted shoran distance in miles	(4) Col. 2 minus Col. 3 in miles	(5) Proportional discrepancy, in parts per million
2-6	40.6131	40.6123	+0.0008	19.7
3-4	96.7171	96.7147	+0.0024	24.8
5-6	100.3098	100.3105	−0.0007	7.0
1-5	118.9953	118.9951	+0.0002	1.7
1-6	133.0113	113.0122	−0.0009	6.8
2-3	134.9698	134.9685	+0.0013	9.6
2-5	139.1225	139.1250	−0.0025	18.0
3-6	145.8427	145.8420	+0.0007	4.8
1-2	145.8884	145.8913	−0.0029	19.9
4-6	190.5047	190.5060	−0.0013	6.8
2-4	199.1914	199.1912	+0.0002	1.0
3-5	226.9903	226.9893	+0.0010	4.4
4-5	235.5264	235.5241	+0.0023	9.8
1-3	277.0569	277.0572	−0.0003	1.1
1-4	320.1519	320.1521	−0.0002	0.6
		Average	0.00118	9.1

*Results of first-order triangulation.

Thin Arched Dollar Savers

by Alan W. Mess, ae'59

By using the solid walls of gorges to absorb much of the water pressures, engineers have found that savings in tons of concrete can be made by using thin arch construction. Here, the author discusses the sites, foundation requirements, and designs of this type of dam construction.

DAMS are structures made of various materials such as masonry, earth, and steel. They are designed to obstruct, control, or divert the natural stream flow. Among the most common types of dams are gravity, buttress, earthfill, arch, and combinations of any of these. The first of these uses the mass principle, that is the force of gravity upon its mass determines is stability. Fig. 1 is an example of a gravity dam. Examination of this figure indicates much mass is needed. In other words, a large volume of concrete will be needed. To get around this expensive procedure engineers have designed another type of dam, the thin arch dam. The arch dam uses its arch action to resist the water force. It is arched upstream with the water pressure transmitted through the arch into the sides of the forge.

Site

The location of the site for the abutments will be rather restricted. Besides good solid walls in the gorge, there are many other considerations. The length of the dam should be small in proportion to its height; therefore the gorge should be narrow. Also, the walls of the gorge should have some natural type of abutment, not just parallel sides. That is, the gorge should have convergent contours. This can be seen in Fig. 2.

These factors deal directly with the physical properties of the valley sides. There are many related factors which should be considered in the site selection. A few of these are:

1. Transportation facilities to the site.
2. Silt accumulation and probable life of the dam.
3. Location of source of construction materials.
4. Land required for the dam and basin.
5. Legal aspects of water use in the specific areas.
6. Adequate site foundation.

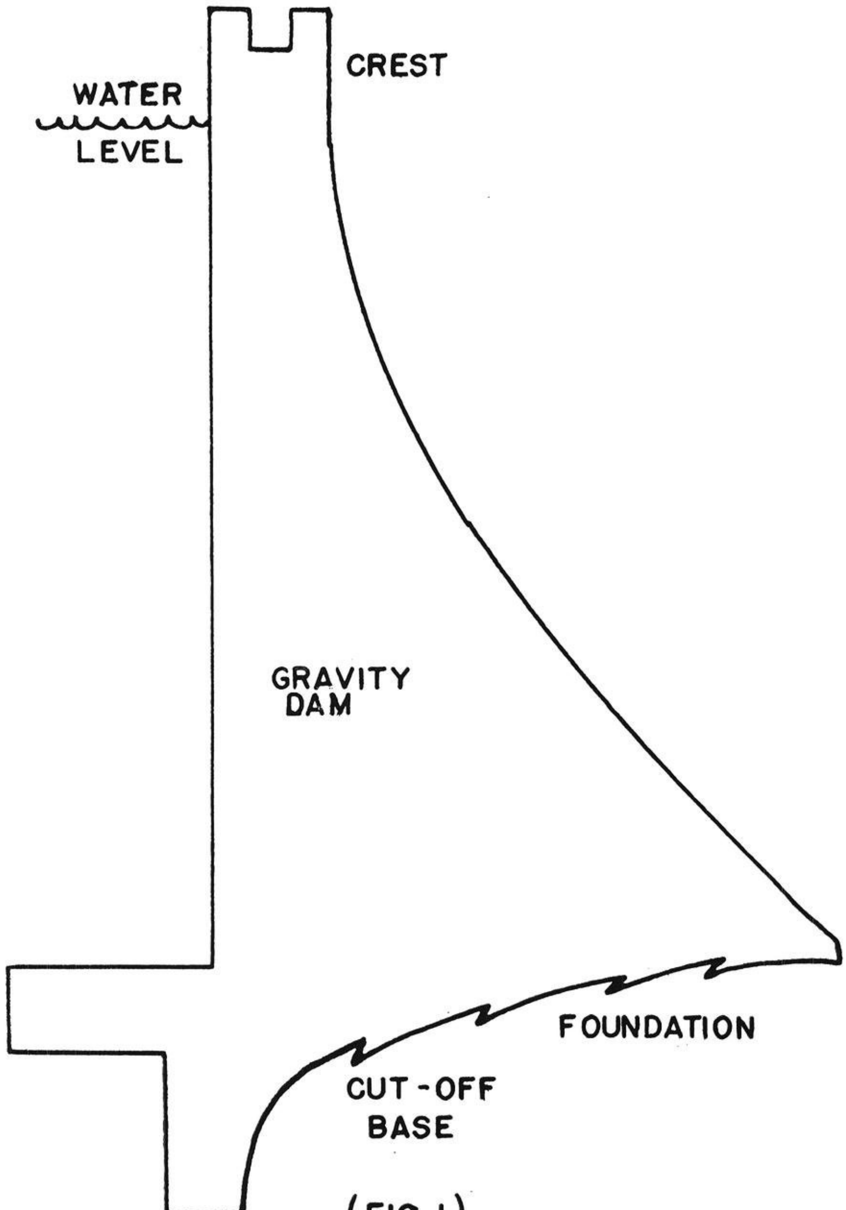
Foundation

The site foundation factor should be thoroughly examined since the usual cause of failure of dams is defective foundations. The foundation may fail through:

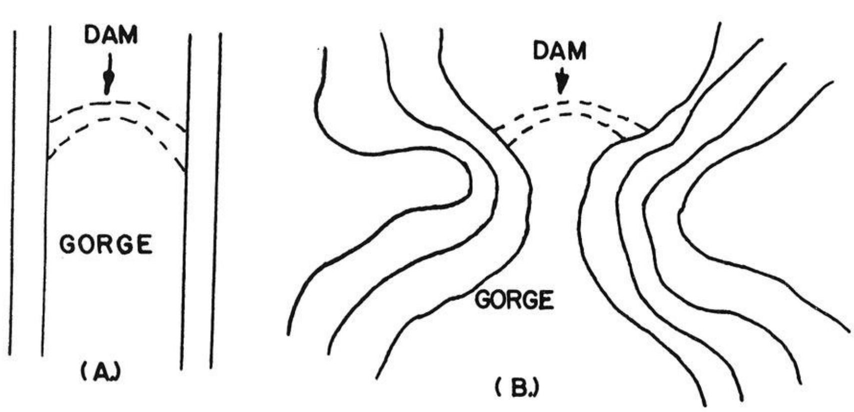
1. Crushing.
2. Sliding.
3. Piping.
4. Scouring.
5. Uplift.

To prevent crushing the selected foundation should have sufficient bearing power to resist the dead weight of the dam. Sliding occurs when the coefficient of friction between the dam and the foundation is exceeded. This is not a great problem in arch dams. According to Hanna and Kennedy "The factor of safety of a gravity dam against sliding may be only a little over one, and is seldom over two, whereas that of a well designed arch dam made of good concrete is four or five or more."

Therefore to prevent sliding and to aid in the prevention of crush-



(FIG 1.)



(FIG. 2)

ing the crevices should be excavated to a solid bottom and all loose material should be removed. The face of the foundation should be roughened and then scrubbed with water. After scrubbing application of a coating of neat cement makes a good bonding agent. Along with this coating all test boring holes must be filled with grout of neat cement under pressure. Besides bonding, the cement also acts as a sealing agent for the seams found in the face.

This latter fact aids in the reduction of hydrostatic uplift pressure. If this pressure were large it could cause an increase in the overturning moment, or could decrease the coefficient of friction. Another aid in uplift pressure reduction would be a cut off trench excavated on the upstream side of the dam. Actually overturning is almost never a problem in the design and construction of an arch dam; but it is, like sliding, a major factor in gravity dams.

Another factor which should be watched is piping since the flow of water with an erosive velocity in a concentrated stream will tend to wear the foundation and leave the dam unsupported. The correct selection of the site will eliminate this problem or else diminish it to the point of no further consideration. Scouring can be a problem, since arch dams are designed with over topping spillways.

The force of the water at the base of the dam may wear the foundation and weaken it enough to fail for reasons (1), (2), and (3). The best prevention of this is the construction of a downstream apron in the area where the water will tend to scour. Fig. 3 has an example of an apron. Uplift was already mentioned in connection with sliding and needs no further statement here.

In gravity dams, factors (1), (2), (3), and (5) are causes for some concern but in the arch dam these four causes, although they should be considered in each particular case, are not of great importance.

The reason for the de-emphasization of these factors is based upon the theory of the arch struc-

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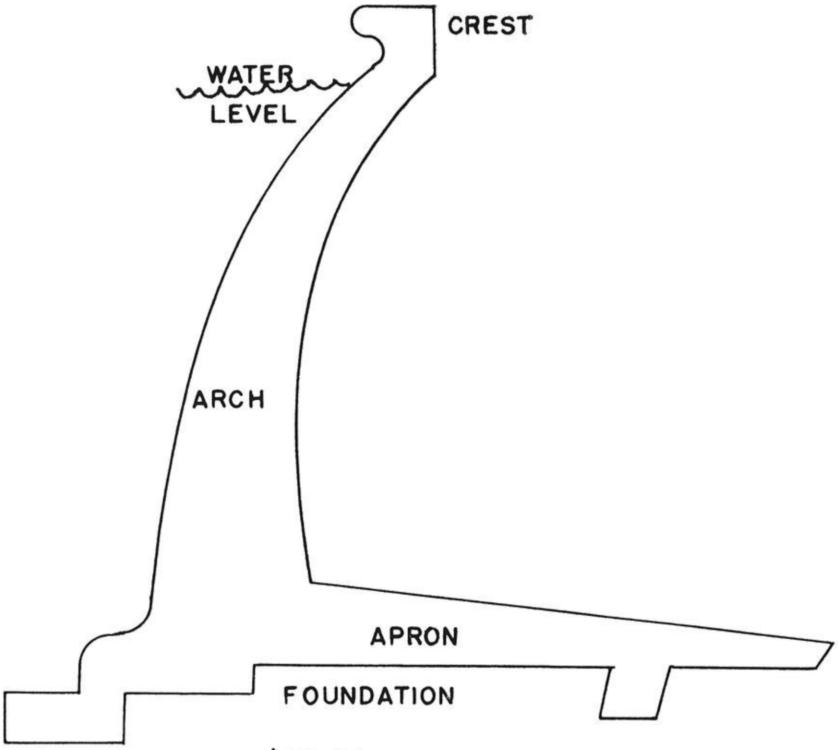


(FIG, 3)

ture. The arch dam is designed as a series of horizontal rings, each supposedly independent of the neighboring rings and each having a constant radial hydrostatic pressure. The water load is carried by these rings into the abutments, not into the foundation. Since an actual dam does not follow this theory exactly, some pressure does reach the foundation and the stated causes of foundation failure must be considered. Note Fig. 4.

Overtopping Effects

The effect of overtopping is only a slight increase in stresses all of which are directly proportional to the applied pressure. The reason for this insensitivity is again found in the theory of carrying water load. In fact the use of the crest as an overflow often is possible and useful.

The first dimension to be selected will be the central angle because of several reasons; two of these are: (1) To ensure the structure will act as an arch (2) To ensure economic use of material. The former would indicate the use of a large angle, but since the angle determines the surface area and the volume of the dam other considerations must be made.

To reduce the volume of the dam the surface area of each individual arch element must be made as small as possible, consonant with low stresses. The following calculations indicate the correct or most economical central angle to use would be 133° 34′.

(1) Surface formula: $S = 2\phi\ re$ (see fig. 5)

(2) Using $e = \frac{w_z h r}{\epsilon}$;

$\frac{l}{2} = r \sin \phi$; $P = w_z h$

(3) Substitute in (1) $S = \frac{P l^2}{2\epsilon} \cdot \frac{\phi}{\sin^2 \phi}$

(4) For the minimum surface set $\frac{ds}{d\phi} = 0$

(5) Therefore: $\tan \phi = 2\phi$

(6) i.e. $\phi = 66° 47'$; $2\phi = 133° 34'$

Water pressure increases with depth; therefore the deeper the dam the smaller the radius, while the thickness will increase and the central angle will decrease. Thus there are long thin upper rings and short thick lower rings, the latter having a small central angle. The heavy lower rings often act as beams or wedges.

If we assume the dam to be a true cylinder, not to have thin upper rings nor heavy lower rings, and not to be restrained at the bottom; we can use a cylinder formula.

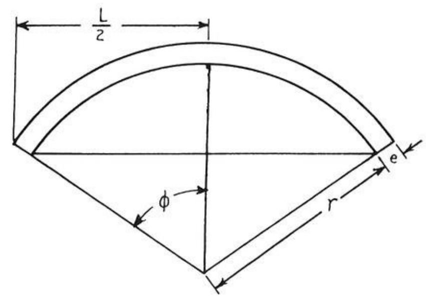
Cylinder formula: $\epsilon = \frac{e}{w_z h r_e}$

Where:

ϵ = Unit compressive stress in lbs. per cubic foot.
w_z = Weight of water in lbs. per cubic foot.
h = Depth of water at any elevation in feet.
r_e = Radius of the extrados in feet.
e = Thickness of the arch in feet.

This method of analysis negects several important factors:

1. The influence of fixed abutments.
   a. Differential bending stresses in the arch.
   b. Constant distance between the abutments.
2. The fact that all dimensions of an unrestrained elastic cylinder reduce under external load.



(FIG.4)

3. The shearing resistance between successive arch laminas which interfere with independent action.
4. The force of gravity on, and the beam action of the vertical elements of the dam; which causes a cantilever action and prevent the use of the dam as a true arch.
5. The design would produce a dam of uneconomical proportions.

(Continued on page 41)

The Building of Tomorrow—Today

by Don Roeber, me'60

The wonders of aluminum construction are now exemplified in this Virginia garden office building.

A NEW multi-million dollar office building—an aluminum showcase in a Virginia garden setting was formally opened this fall as the new home of Reynolds Metals Company.

Designed by Skidmore, Owings and Merrill of New York, the building contains 1,235,000 pounds of aluminum, used in many ways for economy, efficiency or beauty.

The project exemplifies the nearly unlimited use of aluminum and the part it will play in future construction. Aluminum uses include the world's largest system of automatic sun louvers, movable office partitions, acoustical and light-diffusing ceilings, a new line of aluminum office furniture, aluminum yarn draperies and carpeting, and most of the hardware. From the exterior, almost everything that can be seen is either aluminum or glass. Aluminum has been used only where appropriate. All aluminum items used are available today to any builder.

The square-shaped, four-level structure is capable of housing 1,000 employees, contains 293,673 square feet of usable floor space and dominates 160 acres of rolling Virginia countryside.

Through the glass walls—tinted gray to resist glare—employees can look out on a 253-foot reflecting pool bordered by willow oaks, terraces abloom with flowers, or a classical courtyard with its 40-foot magnolia tree and leaping fountain. The building cost $11.5 million, excluding land and land improvements.

A system of 880 giant color-anodized aluminum sun louvers, each 14 feet high and 22 inches wide, shield the eastern and western faces of the building from heat and glare and reduce air conditioning load. The louvers are geared to an astronomical clock which will anticipate the movements of the sun through the year 2100 A.D. Other exterior uses of aluminum include the vertical mullions, black anodized spandrels between floors, column casements, the entrance canopy, door frames and other trim.

The first level contains a 208-foot lobby, the personnel department, corporate officials' offices, executive dining room and a large meeting room. The floor of the lobby and exterior terraces was paved with more than 225,000 bricks, identical with those originally used in Colonial Williamsburg. Office space on the second and third levels is laid out on a precise 5′2″ module so that the movable Hauserman aluminum wall partitions can be rearranged to meet changing space requirements of company departments.

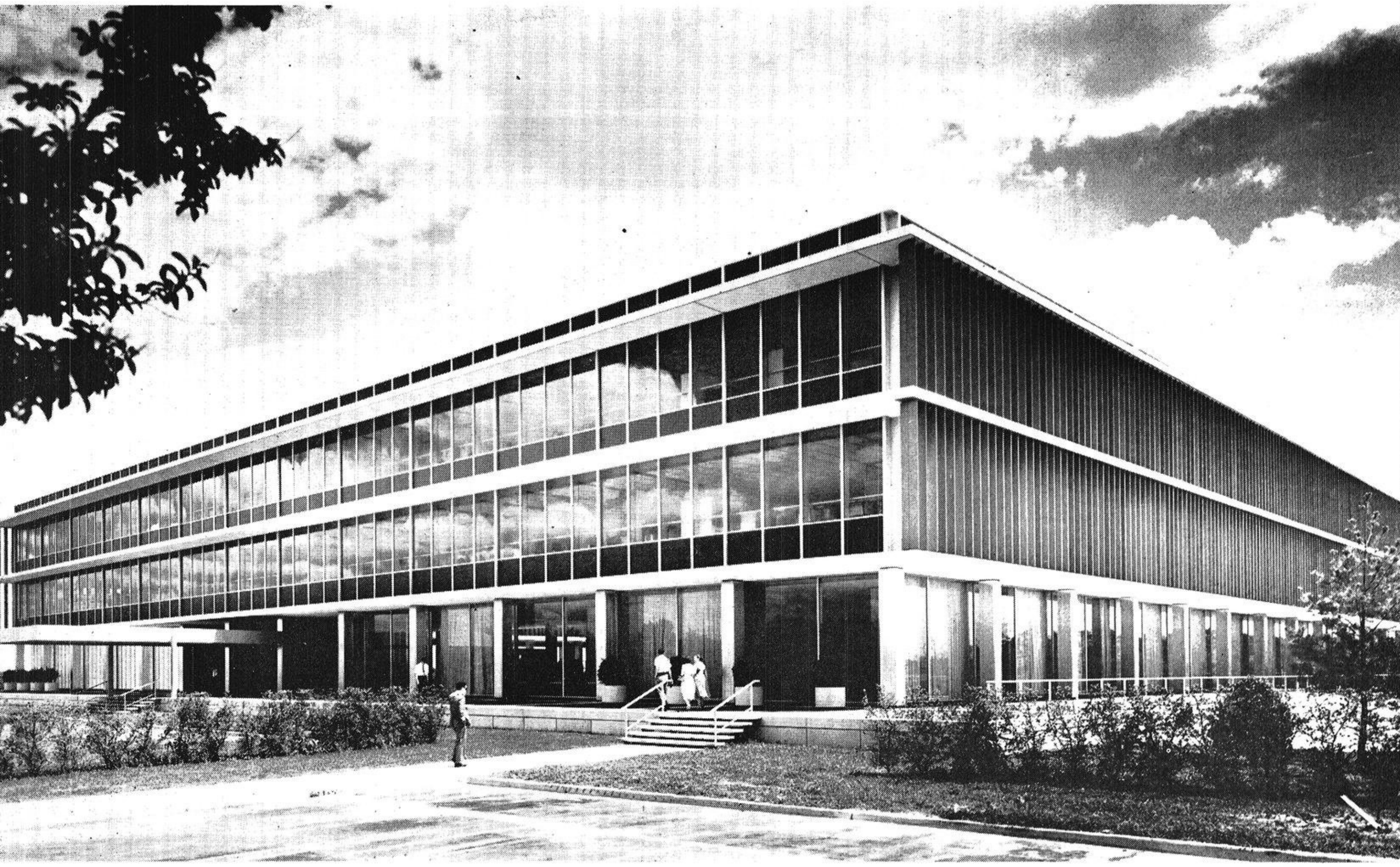
Ceilings utilize a record 92,000 square feet of Hexcel aluminum honeycomb panels which stretch out overhead like a canopy of delicate lace. The honeycomb serves as a diffuser for the fluorescent lights, and through it flows filtered air, cooled in summer and heated in winter, and music by Muzak.

Climate inside the sealed building is centrally monitored and controlled from a push-button Supervisory DataCenter, the first large control panel designed in aluminum. Here an attendant can modify temperatures throughout the building in response to employee desires and control operation of steam and hot water boilers, chillers and fans.

The cafeteria and sandwich bar can accommodate up to 2,000 persons during lunch hours each day. Special equipment includes water faucets operated by electric eyes, a Radar Range and food trays made of sparkling aluminum yarn encased in fiberglass. Adjacent to the cafeteria is a spacious employee lounge which opens onto a resort-like terrace with lounge chairs and sun shades.

The meeting room seats 100 in comfortable arm chairs. It is equipped with Cinemascope and Stereophonic Sound facilities and an aluminum saw-tooth ceiling for virtually perfect acoustics. The ceiling section above the platform is raised by electric motors for motion picture showings and lowered to project voices of human speakers. The suite of executive offices is connected with motorized aluminum sliding doors, operated by push buttons. These offices and other first level rooms feature panels of cherry wood and are adorned with original paintings by Picasso, Le Corbusier and other modern masters.

The employee medical center, staffed by a full-time physician, nurse and technician, has complete X-ray equipment. There are also a library, barber shop, four special



—Courtesy Renolds Metals

The new Reynolds Metals Company General Office Building, Richmond, Va., which contains 1,235,000 pounds of aluminum, is a showcase of the light metal's many uses in modern architecture. Glass walls are shielded by the world's largest system of automatic sun louvers, made of aluminum. The building cost $11.5 million, excluding land and land improvements.

dining rooms, two completely equipped kitchens, a health center and solarium, and special duplicating, mail, communications and other service rooms. The landscaping project, one of the largest in Virginia history and second in size only to Colonial Williamsburg, involved planting more than 4,000 trees and shrubs and 10,000 flowers, plus installation of an aluminum irrigation system.

Sun Louvers and Their Operation

The previously mentioned adjustable aluminum sun louver system which shades the eastern and western faces of the building is the largest sun louver installation in the world (total area: 21,355 square feet).

The system is operated by two 7.5 h.p. motors and two 5 h.p. motors and is governed by a complex control system made and installed by Lemlar Manufacturing Co., Gardena, Calif. There are a total of 880 louvers. Gray on the outside and blue on the inside, they are 14 feet tall, 22 inches wide and have a cross section resembling a flat diamond three inches thick at the center. All louvers were made by Reynolds Metals Company.

The popular conception of sun louvers is that they eliminate the glare of direct sunlight. But this is only a part of the story. The most important function of the louvers is "preventive air-conditioning", stopping solar heat *outside* the building so it won't have to be "pumped out" by the cooling system. The end result is that air conditioning costs are reduced enough to write off a large portion of the louver cost.

The louvers change position several times during the day. Their rotation is only slightly in advance of the sun's movement so that minimum restrictions are placed on view and entering daylight. The proper timing and amount of adjustment was determined through a study of daily and seasonal movements of the sun by Lemlar.

Seasonal changes in sun angles require periodic corrections in the daily program of louver movements. These corrections are made automatically by a master clock so that the louver operation is automatic the year around. Barring power failure, this master clock will keep the control system properly adjusted until about 2100 A.D.

The control system also provides for cloudy weather. Reduced light intensity from cloud overcast will cause photoelectric units to countermand (after three-minute time lag) the program control of the

(Continued on next page)

louvers and turn them perpendicular to the building to admit maximum light. Return of clear sunlight lets the program control system take over and the louvers automatically move to their proper time-positions.

Supervisory Datacenter

Building engineers have fingertip control over heating and air conditioning in the mammoth new office building.

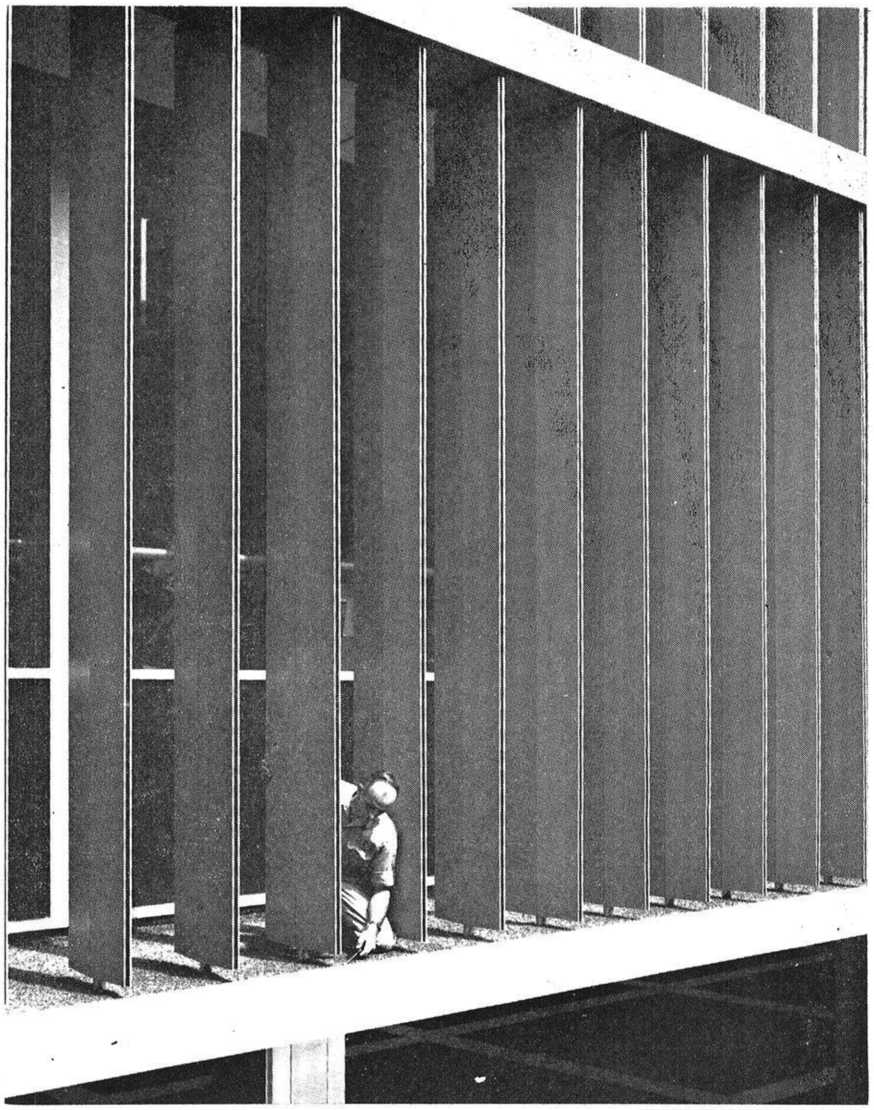
This supervision is achieved through a "Supervisory DataCenter" developed by Minneapolis-Honeywell Regulator Company. The custom-built panel, the world's first giant control board built of aluminum, applies the same concept of one-location control which is widely used in industrial processing operations.

The dial-studded 32-foot-long DataCenter panel allows a single building engineer to:

1. Continuously check and log temperatures and other data from all parts of the building.
2. Adjust remotely-located equipment and control devices.
3. Start and stop heating and air conditioning equipment.
4. Instantly make basic adjustments in temperatures in any area of the building.
5. Supervise flow in the fire alarm sprinkler lines, providing instant warning of fire or failure in sprinkler equipment.

Schematic layouts of various equipment systems are shown on the portions of the panel governing those systems, with control instruments located in the appropriate part of the layout. This greatly simplifies the control operation. A system of indicating lights also shows whether the various pieces of equipment are functioning properly.

The Supervisory DataCenter gives the operating engineer a simple means of efficiently coordinating the highly complex mechanical functions of the heating and air conditioning system. Without such a control center, the same supervision of heating and air conditioning would require a crew of eight maintenance men taking temperatures and making adjustments in various parts of the building.



—Courtesy Reynolds Metals

A total of 880 giant aluminum louvers like these (each is 14 feet high and 22 inches wide) move automatically with sun to protect eastern and western faces of the new aluminum and glass general office building against heat and glare. They are controlled by a master clock which will anticipate movements of sun through 2100 A. D. A solar eye takes over on cloudy days to open louvers for maximum light.

Usage of Aluminum

General

The building was designed as a showcase of practical aluminum usage in monumental buildings. A total of 1,235,800 pounds of the light metal were used in constructing and furnishing the building.

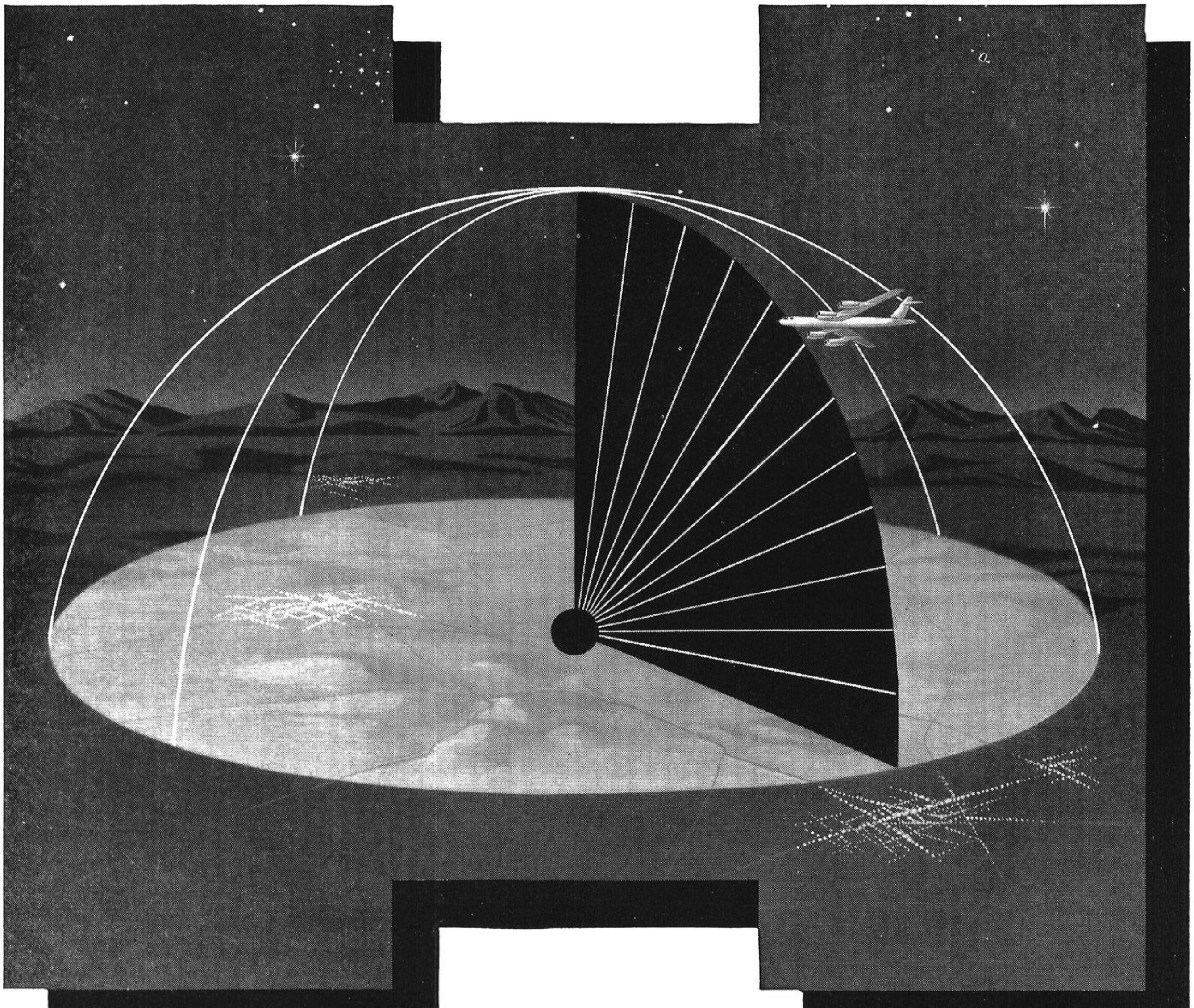
Aluminum was not used for its own sake. Extensive use is also made of other materials. Aluminum is used where, in the professional judgment of the architects, it provides an important functional or aesthetic advantage. All of the metal's versatile qualities are demonstrated in one form or another—its beauty, light weight, colorability, immunity to rust and corrosion, easy maintenance, heat reflectivity and conductivity, electrical conductivity, and ease of fabrication.

The fact that aluminum can be extruded into countless shapes was of prime importance. Many of the shapes and forms which aluminum takes in the building would be either impossible or too costly to fabricate from other metals.

The use of aluminum made possible an "integrity of design" concept whereby the basic architectural themes could be sustained, expanded and varied throughout exterior and interior, the aesthetics of one melting and blending into the aesthetics of the other.

(Continued on page 40)

MAKING UMBRELLAS



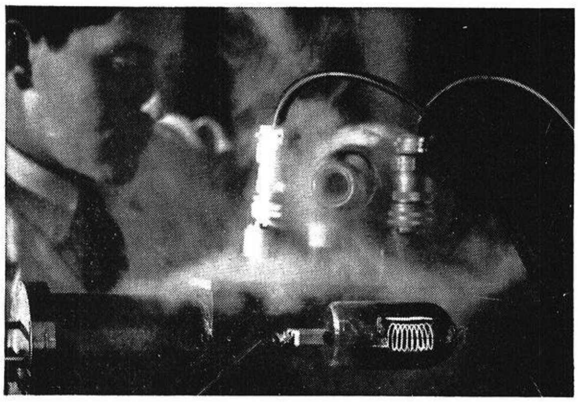
THAT NEVER LEAK

To achieve umbrella-like radar protection, Hughes engineers have developed systems which position radar beams in space by electronic, rather than mechanical means. These unique three-dimensional radar systems are digitally programmed to instantaneously detect high speed enemy aircraft, even at low altitude.

Another Hughes system using radar information is the Hughes Electronic Armament System. This system pilots high-speed jet interceptors from take-off to touch down... and through all stages of the intercept. Both radar and infra-red guidance systems direct today's most sophisticated air-to-air guided missile—the Hughes Falcon.

Advanced new projects are under way in all areas of Hughes. Presently under study are Space Vehicles, Ballistic Missiles, Nuclear Electronics, Advanced Airborne Systems, AICBM, and Subsurface Electronics . . . just to name a few. Hughes Products, the commercial activity of Hughes, has developed an electronic control system which automates a complete and integrated line of machine tools. Also under way at Hughes Products is the development of revolutionary new semiconductor devices.

The highly advanced and diversified nature of Hughes projects—in the air, on the ground, and for industry—provides an ideal environment for the graduating or experienced engineer.



Research on the Maser (Microwave Amplification by Simulated Emission of Radiation) is directed towards applications of a portable, airborne Maser for missiles and aircraft.

A laboratory for learning, Field Engineering at Hughes provides over-all systems experience in both guided missiles and advanced airborne electronics systems.

Members of our staff will conduct

CAMPUS INTERVIEWS

on April 16. For interview appointment or informational literature consult your College Placement Director.

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HUGHES

HUGHES AIRCRAFT COMPANY
Culver City, El Segundo,
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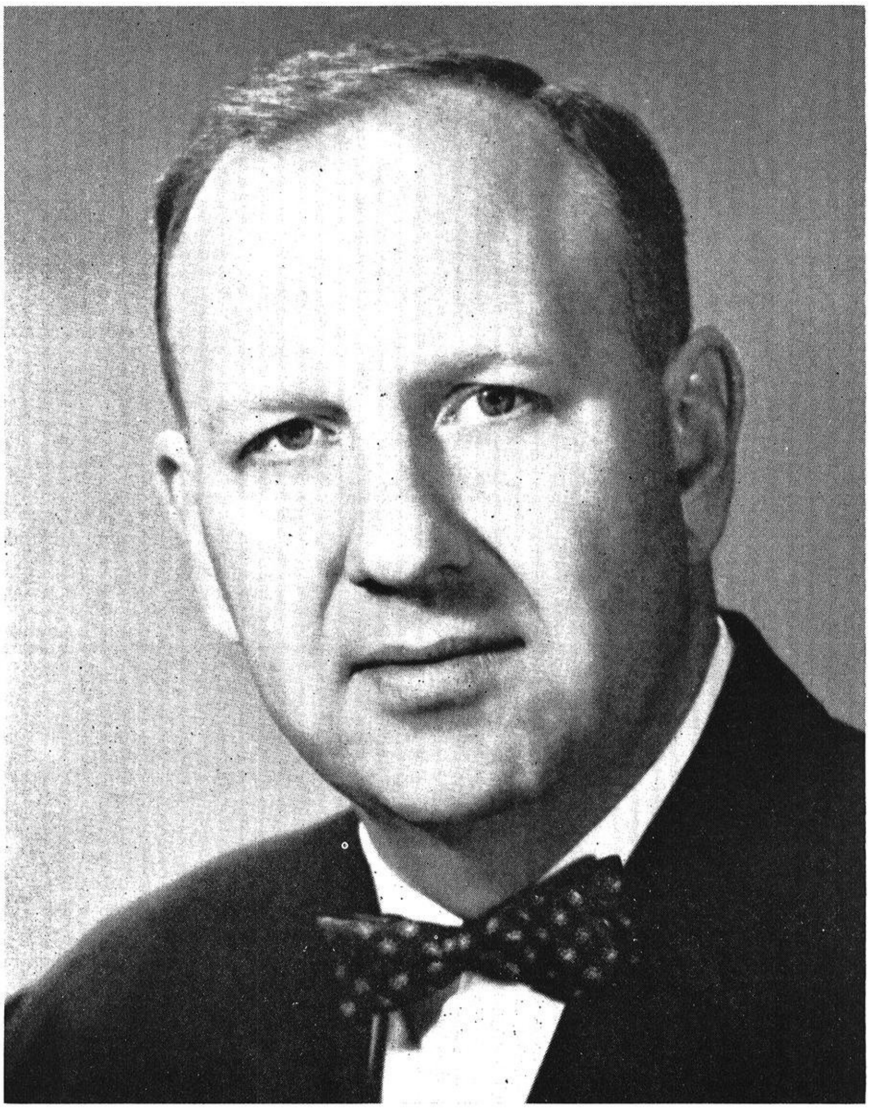
Tucson, Arizona

Meet the Presidents



Carl W. Giesler, Wisconsin Valley Chapter.

Carl W. Giesler, President of the Wisconsin Valley Chaper, WSPE, was born in Green Bay, Wisconsin, on Nov. 20, 1922. After graduating from East Green Bay High in 1941 he studied at Moravian College, Princeton University, and graduated from the University of Wisconsin in 1948 with a B.S. in Electrical Engineering.

The above schooling was interrupted for over three years while Giesler served in the United States Army. Most of this time was spent in Europe with the 424th Combat Team of the 106th Infantry Division.

Since graduating from the U. of W. he has been continuously employed by the Wisconsin Public Service Corp. in its Steam Plant Department. Starting out as Assistant Efficiency Engineer at the Pulliam Plant in Green Bay, Carl moved through the jobs of Efficiency Engineer and Results Engineer at that plant. In 1954 his company built the first unit of a new central station near Wausau, Wis., and he was appointed Assistant Superintendent of the new Weston Plant at that time. He serves in that capacity today.

Mr. Giesler has been active in both Civic and Church Affairs. He is serving his second year as Public Relations Chairman for WSPE, is president of "The Men of St. Therese Church", 1st vice-president of the Rothschild Lions Club, immediate past president of: the Rothschild Civic Association, the St. Therese PTA, and the St. Therese Holy Name. He is an engineer member of the Consolidated School District Building Committee and a three year committee member for the Cub Scouts. He has been active on Community Chest, American Red Cross, and Polio Drives. He served as a member of the board of directors of the Brown County Chapter of the American Red Cross and secretary of the Green Bay Engineers Club before coming to Rothschild to make his home.

Meet the Presidents

Charles A. Nagle, Milwaukee Chapter.

Because Charles A. Nagle, President of the Milwaukee Chapter of the W.S.P.E., has not changed company affiliation in the past eight years, it may be safe to assume that his 'wandering impulses' have finally came to rest. Culminating an extremely wide field of engineering and contracting experience extending over the past 39 years (and 15 different positions), Mr. Nagle now heads the firm of Charles Nagle and Associates, Milwaukee consulting engineering company. The office is engaged in design and supervision of construction of industrial, commercial, and public buildings.

The varied range of Mr. Nagle's background has found him working in many parts of the middle west, and into Canada. Positions he has held include superintendent of construction; instructor of engineering; design superintendent for buildings, sewage treatment plants, highway bridges and other public works; Chief of Squad of Engineer Examiners for the Public Works Administration; Village Manager; Defense Construction Project Manager; and Partner in consulting firms. One of the largest projects was responsibility for the construction of the Blue Grass Ordnance Depot in Richmond, Kentucky during 1942–43 where Mr. Nagle headed a force of 3000 men.

St. Louis, Missouri was the birthplace of Mr. Nagle on November 8, 1897. He graduated in 1919 from the University of Illinois with a B.S. degree in Civil Engineering (Structural Option). Mr. Nagle is licensed in Wisconsin as a Professional Engineer and in Illinois as a Structural Engineer.

Active in the American Society of Civil Engineers for 33 years, the Engineers Society of Milwaukee for 10 years, and the W.S.P.E. for 12 years, Mr. Nagle was chairman of the critical Interprofessional Committee of the W.S.P.E. from 1953 to 1958. He has been Vice-president and Board Member of the City Club of Milwaukee, Treasurer of the Kiwanis Club of Milwaukee, and member of the M.A.C. and Tripoli Shrine. Other civic activities were Boy Scout leader for 20 years and for the past five years "Camp Construction Consultant" for the Milwaukee area Girl Scouts.

Wisconsin Society of Professional Engineers

by Darell Meyer ee'61

HIGHLIGHTS OF NSPE BOARD OF DIRECTORS MEETING

Dire predictions and rumors concerning the so-called engineering shortage are a disservice to the nation and the engineering profession because they are not based on sound analysis.

Misguided neutrality on the part of industrial management regarding the unionization of engineers could result in a complete breakdown of the concept of professionalism in industry.

These positions and others taken by the NSPE Board of Directors at the fall meeting in San Francisco, October 23–25, represent actions by the group on a broad front.

The Board issued a plea to the nation to stop "adding fuel to the shortage fire." The officials called upon all communications media to "weigh carefully the facts, and soberly analyze those facts, before starting a new wave of publicity to the effect that the nation faces a severe engineering manpower shortage."

The National Society directors urged that all those who intend to speak or publish articles on the subject of engineering manpower first consider the following four points:

1. Engineering school enrollments are at an all-time high and are continuing to increase without artificial stimulation.
2. Action which may force-feed students into engineering curricula without adequate assistance to the overburdened engineering schools can only harm the cause of engineering education.
3. The current engineering need in industry and advanced technology is one based on qualitative, rather than quantitative factors. The serious technological problems facing the nation cannot be resolved by merely adding to the number of engineers.
4. Greater utilization of existing engineering manpower is recognized by all serious students of our manpower problems as a first priority item.

After Board action on a unionization report, Dr. Clark A. Dunn, Society president, Stillwater, Oklahoma, said in an interview that the "neutral attitude taken by management in some firms when faced with an election among engineering employees on the question of union representation is actually an abdication of management's responsibility in preserving the distinction between professional and nonprofessional services."

Dr. Dunn pointed out that "such an abdication of management responsibility has led to a situation in the aircraft and other industries here on the West Coast in which many young engineers have never heard an expression of support concerning professionalism from their employers."

ENGINEERS' CREED

As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare.

I PLEDGE

To give the utmost of performance, to participate in none but honest enterprise, to live and work according to the laws of and the highest standards of professional conduct. To place service before profit, the honor and standing of the profession before personal advantage, and the public welfare above all other considerations. In humility and with need for Divine Guidance, I make this pledge.

TAX ENGINEERS SOUGHT BY REVENUE SERVICE

Uncle Sam has come up with a new "branch of engineering"—tax engineer! The Internal Revenue Service says that tax collection is an emerging field for engineers and it has undertaken to explain why in a pamphlet called "Engineer Tax Men." Those interested may obtain a copy of the pamphlet by writing to the Assistant Commissioner (Technical) Att: T:S:E, Internal Revenue Service, Washington 25, D. C.

The pamphlet points out that most taxpayers think of taxes in terms of blood, sweat and tears, little realizing that engineer revenue agents are part of the team required to make the system work. Many tax cases involve "engineering issues," the IRS says, such as various aspects of depreciation, depletion, industrial management, valuation, etc.

INDUSTRY LAGS IN PROFESSIONALISM

A survey of recent graduates who are associate members of the American Society of Mechanical Engineers disclose serious deficiencies in industry's programs to promote professionalism among engineers, particularly in the small companies. Only 40% of the respondents to the ASME Junior Forum said their company encourages participation in professional activities. In the large companies, 75% said they were being treated as a professional engineer, but only 33% replied in the affirmative among small companies. On salary, 80% in the large companies said their compensation is in line with their worth, but only 40% in the small companies were satisfied.

Advancement Prospects Rated High

In other categories of interest: 75% said their transition from college to industry was handled well; 60% in small companies said their initial traning was adequate, but only 33% in the large companies thought favorably of their initial training and 75% felt there is room for advancement in their present job; and 75% said their company encouraged advanced education.

Type of Work Most Influential

The survey was conducted among engineers who have been employed in industry for two to three years. The group placed in order the following factors which influenced them in the selection of their jobs: type of work, location, salary. In seeking their next job, they said, the factors would be the same except opportunity for advancement replaced location, which fell to fourth place.

NOVEMBER MEETING OF THE SOUTH WEST CHAPTER OF WSPE

November 5, 1958

The November meeting was held at the Cuba Club, Madison, on November 5, 1958.

Following the dinner, Mr. Charles E. Carlson, Madison, was presented his Professional Engineer Certificate of Registration. Engineer-in-Training certificates were presented to the following men: James P. Doering, Arnold Zimmerman, Roger Sackett, David Tredwell, and Poul Winskell, all of Madison, Fredrick Fuchs, Janesville, and J. M. Essex, Bowling Green, Ohio.

Mr. Ralph Culbertson, Wisconsin State Engineer, led the recipients in pledging the Engineer's Creed, after which he presented to each engineer, his certificate.

Professor James Villemonte, of the University of Wisconsin, was the speaker for the evening. His discussion concerned the Technical Aid Assistance Program to underdeveloped countries, particularly India. Professor Villemonte has spent approximately four years assisting India in its program of establishing graduate engineering courses and laboratory facilities. His discussion was accompanied by slides and moving pictures of engineering projects in India.

ENGINEERING EXAMINATIONS

The Wisconsin Registration Board of Architects and Professional Engineers have announced the dates of their next Engineering Examinations as January 26 and 27, 1959. To be eligible for those examinations, application must be on file in the Board's office on or before December 1, 1958. Application forms and information may be obtained at or by writing to the Board's office, 1140 State Office Building, Madison, Wisconsin.

Examinations will be conducted January 26, 1959, at Madison and Milwaukee Wisconsin, for those desiring Certification as an Engineer-in-Training. To qualify for certification as an Engineer-in-Training the applicant must in addition to passing the one-day, 8 hour, examination on the fundamentals of engineering have a record of 4 years of satisfactory engineering experience. All of the required 4 years of experience may have been gained by formal education.

Examinations will be conducted January 26–27, 1959, at Madison, Wisconsin, for those desiring registration as a Professional Engineer. Holders of certification as an Engineer-in-Training in Wisconsin will be required to appear for examination only on January 27, 1959, while those who are not holders of such certification will be required to appear on both January 26 and 27, 1959. The examination on January 26, 1959, will be on the fundamentals of engineering. The examination on January 27, 1959, covers in the forenoon a field of engineering and in the afternoon a sub-field of the field selected by the applicant for the forenoon's examination. The applicant must choose a field and sub-field which has been established or approved by the Board. Fields and sub-fields for each have been established by the Board as follows:

1. Chemical with the established sub-fields of Chemical Plant, Gas, Sanitary and others to be approved by the Board.
2. Civil with the established sub-fields of Highway, Hydraulics, Municipal, Sanitary, Structural.

(*Continued on page 50*)

ENGINE EARS

by Tom Corth, ee'60

Welding Codes Institute A Success

WELDING codes, both ASME and ASA codes got the lion's share of the credit here for the dramatic reduction in boiler explosions and the resulting reduction in fatalities and injuries.

"A boiler explosion today is an extremely rare occurrence," Elmer C. Korten, assistant chief engineer, The Hartford Steam Boiler Inspection and Insurance Company, told the assembly at a University of Wisconsin Engineering Institute in mid-October.

Korten was speaking to nearly a hundred contractors, engineers and architects who gathered to hear how ASME and ASA codes governing pressure-pipe and pressure-vessel welding were administered.

"There were 10,051 boiler explosions, 15,634 injuries and 10,884 deaths due to explosions in the years from 1867 to 1908," said Korten as he recalled the almost phenomenal drop in accidents in present times.

The two codes cover separate areas with ASME designed to cover the boiler and equipment up to the pressure valve and ASA to govern primarily welding of pressure-piping beyond that point.

Prof. Robert S. Green, executive director of the Engineering experiment station at Ohio State University and a consultant for the National Pipe Welding Bureau, told the group of continuing efforts to acquaint architects, engineers and contractors with the code requirements.

"The necessity of getting widespread acquaintance with the codes among these people is especially important because they are the ones who need to make plans for meeting the codes," he maintained.

Green outlined what he called a quite simple procedure for meeting the codes: 1. responsibility for seeing that the correct procedures are used in welding and fabrication; 2. responsibility for the qualifications of welders employed, and; 3. continuing supervision in the field.

"These steps combined with final inspection can insure quality work," he concluded.

In a thumbnail sketch of the NCPWB (National Certified Pipe Welding Bureau) he indicated that it was organized to develop standard welding procedure and to produce qualified welders, thus making it easier for contractors to comply with state and federal codes.

An interesting and ingenious mobile laboratory used by William Lilly, consulting and welding supervisor of the certified welding bureau division in Chicago was a highlight of the second day's program. The laboratory is used to test welders for certification which will enable them to weld on pressure equipment. It is transported in a large truck and station wagon.

The idea of a mobile laboratory was developed by Lilly when difficulties in maintaining and financing a central lab became nearly insurmountable.

"I tried using the welding facilities of another contractor," he said, "but that, too, wasn't very satisfactory. It was then that the idea came to me that it might be better to go to the job or to the shop and let the welder be tested under normal instead of laboratory conditions and with his own equipment."

Lilly maintains that there are several advantages to this procedure. The welder is familiar with his tools and he is not under more than normal pressure.

"I am better able to see the use being made of the equipment," he remarked. "I can also give spot advice or correct wrong procedure through opportunities which might otherwise not arise."

In elaborating on his position as a consultant and inspector for the bureau he maintained that his function is to help the man do a better job. "It is not enough just to test a man to see if he can meet specifications. We also try to help him so that he can do the job and do it better," he concluded.

A.S.M.E. NEWS

The speaker at the last meeting, introduced by vice president Sally Trieloff, was Mr. James Albrecht, sales engineer of Detroit Diesel Division of General Motors. Mr. Albrecht spoke on "Sales Engineering", adding to his talk with a film on diesel engines.

Bob Olson, president, announced to the 160 members attending the meeting that the national A.S.M.E. is sponsoring several speech and paper contests. Also, a joint meeting with the senior A.S.M.E. was held on December 11.

NEWS FROM KAPPA ETA KAPPA

The Delta chapter of Kappa Eta Kappa has started the fall season off with a bang. Parties were given after the home football games, with an all out effort going into the homecoming weekend. After the homecoming game a supper of ham and turkey plus all the trimmings was served, followed by refreshments and entertainment for the rest of the evening. Included in the entertainment was dancing, hi-fi recordings, a song fest, and television.

An alumni banquet was held in Milwaukee during November. The Delta chapter was well represented both by alumni and invited actives.

Looking on toward winter, the house has undergone a slight face lifting program. The porch and roof were repaired and reconditioned while the entire outside was repainted.

The K H K display case, located in the main entrance of the Electrical Engineering building, has been attracting much attention lately. Satterfield's, of Madison, donated the use of a transmitter and receiver and various other instruments and equipment. Also a computer digital timing device has been loaned to the display. This timing device was connected to a "read-out" combination which gave numerical values in lights on the face of the instrument. This was connected to a frequency oscillator which had a capacitor arrangement through one terminal. The oscillations of the machine were varied by the body acting as one plate of a capacitor. This change in frequency was recorded in lights on the "read-out". The same equipment, with slight modifications and additions, will be used for a continual temperature recording on the "read out".

Kappa Eta Kappa has about ten licensed hams and three novices. Early last spring they started building a small transmitter. They now have it connected to a dipole on the roof of the house. The receiver is a Halicrafter S X 38, which has a comparably short range. This setup, although limited, has given the group very much enjoyment. With increasing interest in the group, plans are being made for a new 300 watt all band transmitter. Eventually the transmitter will be placed in a case for use with attached side band transmitters, with additional space being left for a voice control unit. Thus, reports Gene Pezon and Bob Schlorf, the transmitter will be in three separate parts, a modulator, transmitter and power supply. Bill Steil, another member of the group, is to donate a receiver. These boys have big plans for the future and for future members of KHK.

Kappa Eta Kappa is proud to announce the new pledges of the fall semester. They are as follows: James Smedema, Rodger Peterson, Donald Bendis, Myron North, Don Laughlin, Rodney Littlefield, and Carlos Matos. Vice president and pledge master, Dick Frosk, reports the pledge class is very active. They planned a big party for November 22, and furnished entertainment themselves.

On the tenth of November the members saw a film lecture on SAGE. A representative from IBM was there, and the showing was open to the public.

TRIANGLE FRATERNITY

After a successful fall social program, the men of Triangle are now looking forward to the annual Christmas Party and the vacation which follows shortly after.

Homecoming weekend saw Triangle busy with house decorations and welcoming Triangle alumni. A buffet luncheon following the Wisconsin–Northwestern football game highlighted the afternoon while a homecoming party was held in the evening.

On occasion, faculty members have been invited over for dinner

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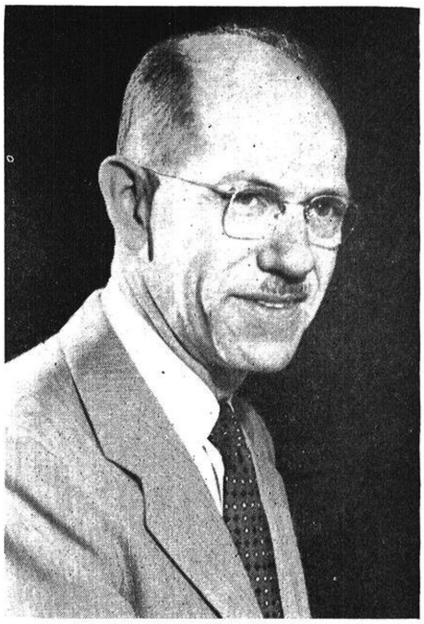


DEAN WENDT APPOINTED TO POST

Dean Kurt F. Wendt of the University of Wisconsin's College of Engineering has been appointed a member of the National Research Council.

The appointment was made by Detlev W. Bronk, president of the National Academy of Sciences, on the nomination of the academy's division of engineering and industrial research.

Dean Wendt will represent the American Society for Engineering Education in the division of engineering and industrial research on the council. Wendt's appointment is for 1958–61.

Wendt has served as dean of the UW College of Engineering since 1953. He graduated from the UW in 1927 and has taught in its engineering college since that time. He is professor of mechanics, and in 1948 he was named associate director of the Wisconsin Engineering Experiment Station. He became director of the station in 1953 when he was named dean of the college.

Dean Wendt is chairman of the nation's Engineering College Research Council and vice president of the American Society for Engineering Education. Recently he was elected president of the national Association of NROTC Colleges made up of 53 major American colleges and universities throughout the nation which operate the naval ROTC training program in conjunction with the U.S. Navy.

in the hope that better understanding between students and instructors will result.

Triangle has been holding rushing smokers for prospective pledges and interested students. Watch the Triangle bulletin board in the Mechanical Engineering Building for the dates of these smokers.

CIVIL SERVICE STUDENT TRAINING PROGRAM

The United States Civil Service Commission has announced a new Student Trainee examination for use in selecting college students and high school graduates for work-study programs in various Federal agencies. The training programs are in the scientific, technical, agricultural, accounting, and statistical fields. Some positions are located in Washington, D. C., and the nearby area, only. Others will be filled throughout the country. Trainees will be paid at the rate of $3,255 to $3,755 per year during the periods in which they are employed.

Students must be enrolled in, or accepted for enrollment in, a curriculum in college leading to a bachelor's degree in one of the fields included in this training program. A written test will be given.

To be more specific, opportunities open to college students and high school seniors and graduates are in the fields of architecture, chemistry, engineering, mathematics, metallurgy, meteorology, oceanography, and physics. In addition these fields are open to college students only: cartography, accounting, agricultural economics, biological and plant sciences, entomology, home economics, plant pest control, soil science (research), and statistics.

Student Trainees will be paid according to the level of their scholastic progress. They will generally receive no salary while attending college and will pay their own expenses incident to college attendance.

The training programs will consist of two parts, on-the-job training and regular scholastic training in an accredited college or university. Three variations of the program, depending on the field of study, may be as follows:

1. Students may be employed part time in a Federal agency while in school attendance, or
2. They may alternate their employment and school attendance, or
3. They may be employed during the summer vacation period and attend college during the entire scholastic year.

While on the job, student trainees will work under and assist professional personnel engaged in research or other professional work. The work will be pertinent to the field of the trainee, and the difficulty and responsibility will vary with the grade level of the position.

Further information and application forms are available at many post offices throughout the country, and at the United States Civil Service Commission, Washington 25, D.C. Applications will be accepted until April 2, 1959.

$50,000 MACHINE DESIGN AWARDS

The James F. Lincoln Arc Welding Foundation of Cleveland, Ohio, is offering 54 awards totaling $50,000 for papers describing the use and advantages of arc welding in the design and construction of machines or machine components. Top award to the author or authors of the best paper is $10,000. Papers may describe how a machine is improved or reduced in cost through the redesign of a casting to a weldment, the redesign of an existing weldment, or the design of a new weldment. Weldments used in practically every type of industrial machinery are eligible. The competition is open to all persons in the United States or its possessions. The Rules booklet is available from The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Dr. E. E. Dreese, Chairman of the Foundation, states that the purpose of the new competition is to stimulate and encourage industrial and economic progress through the development of machinery that is more efficient in operation and lower in cost. The efficient application of the advantages of welded steel design, Dreese states, will accelerate this progress. THE END

Gear Production

(Continued from page 12)

placed exactly where it must be for proper operation.

There are many types of bevel gears used for special applications. Some of the types that may be used for special conditions are:

1. Hypoid Gears: This is a gear where the shafts are offset. It is used in automobile rear axles in order to lower the center of gravity of cars.
2. Angular Gears: These are gears which intersect at an angle of other than 90°.
3. Miter Gears: These types of gears have a velocity ratio of one and their shafts intersect at right angles.

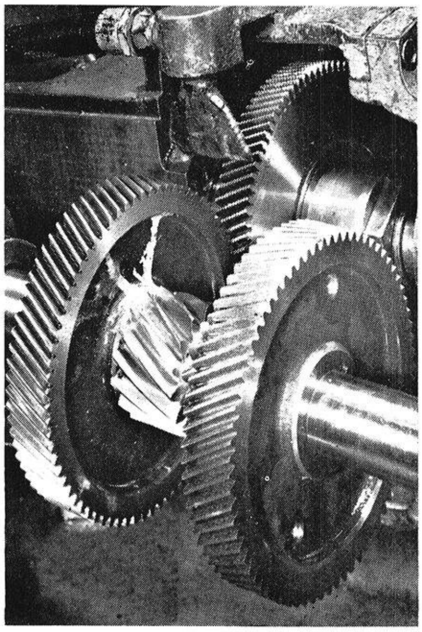
The Finishing of Gears

There are two main types of gear finishing. One is lapping, which was mentioned above, and the other is shaving. Both of these machine processes are used to quickly wear the gear teeth in order to remove any cutting marks or errors and make the teeth smooth for good operation.

In the shaving process, the gear is rotated at high speeds with the shaver, similar to the way in which two gears would mesh. The shaver is on a power shaft and drives the gear. The shaver has sharp razor like projections which extend around the teeth. If the gear is a right hand helical gear, the shaver must have a left hand helix. A shaver is selected that has a helix angle different than the gear and the two are forced together in the machine. Because the helix angles are different the shaver will remove small amounts of material from the profile of the gear because of the razor like teeth on the shaver.

Crown shaving is where the thickness of the gear teeth are a slight amount smaller on the ends. There is only a difference of a few thousands between the ends and the center. Because of the crown, the teeth will bear only in the middle of the gear, even though there may be slight misalignments in the gear's assembly. This crown will eventually wear off but by the time it does the gears will be a near perfect mesh. Crowned gears are produced by rocking the table that holds the work while the cutter head remains stationary. This process is sometimes reversed in some machines.

In taper shaving the teeth are shaved smaller on one end. This process is a correction measure and is used where the gears have a tendency to burnish. The process consists of setting the table at an angle to the horizontal. This will make the shaver take a greater amount of material off of one end.



—Photo courtesy Falk

Shaving a helical gear.

Lapping is the other major way of finishing gears. It has a priority on the finishing of larger gears which are too large to shave. Lapping is a slow process, taking days for the larger gears, but it does not require a machine operator once it is set up. It is a simple process but one that is very necessary.

Usually the two gears which are to run together in application are lapped together. The gear which is to carry the power in application is powered and drives its mating gear. The two gears mesh together and lapping compound is applied to the teeth. The compound is applied automatically by a pump and nozzle arrangement. The teeth of the gears wear rapidly and form a pair of quiet running gears. The principals of shaving and lapping is the same, but the process is quite different.

When only one gear is to be lapped a tool is used called a "dummy lap". A dummy lap is a gear that is made for lapping only. It is made of cast iron and the teeth are cut for a special gear, since large gears are usually one shot jobs. When the dummy lap is of no further use it is stored and a record kept of its location. When another job comes up it may be modified or used as it is for the new job.

Applications

In most cases, the smaller diameter gears are installed in a case that includes all the gears necessary for a given reduction or increase of speed. There are many variations of the setups of gear boxes. Power may be transmitted from the horizontal plane to the vertical plane or at right angles in the horizontal plane. In the common speed reducer or increaser, the power is delivered on one side and the output shaft comes out of the other side.

In the right angle drive, two bevel gears are used to change the direction of the drive and then helicals are used for the reducing or increasing of the speed. The vertical drive is a similar setup except that the bevel gears transmit the power up a vertical shaft at the end of the chain of meshes. The simple motor reducer or increaser does not contain any bevel gears. It has meshes of helical gears and, depending upon the ratio of the input to the output, may have from one to four meshes.

Other special applications include large gears for ships and mining. These large gears are the ones referred to in the first part of the report. These gears, of course, require very large machines to cut them and therefore the demand for places to cut them is great. Because of the large size of the gears, any change in temperature during cutting will deflect the gear and produce errors of high magnitude. For this reason the machines are inclosed in sheds and the sheds are air conditioned. The gear cutting industry is one of the few industries where such care must be taken in the machining of large pieces.

THE END

SCIENCE HIGHLIGHTS

by Jim Mueller me'59

AIR CONDITIONING TEST ROOM

A room simulating weather extremes and interior heat loads for demonstrating central air conditioning systems in virtually any new or existing multistory building to owners, architects, consultants or development engineers, is announced by Carrier Corporation.

Industry representatives who have witnessed the versatile new environmental room, report it's the "most completely flexible facility of its kind."

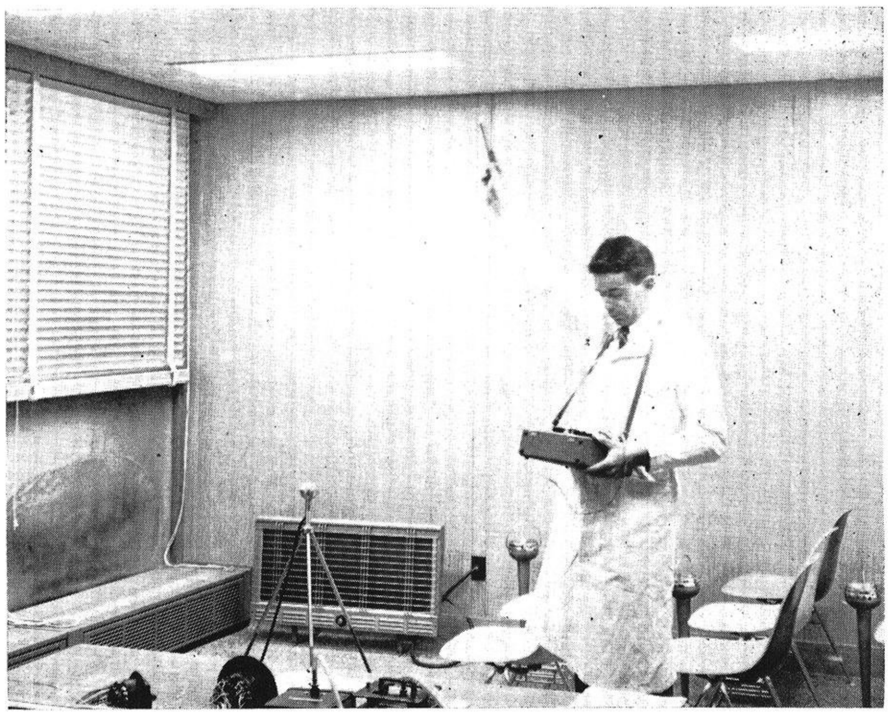
Occupants of a building still on the drawing boards can learn what working in their future office will be like. They will actually see the air conditioning unit counteract freezing cold and feel it quickly remove scorching heat.

Temperature of air in the room, its velocity, sound level and distribution pattern at any point, as well as effects of radiation, can also be noted.

Design theories for new air handling apparatus can be proven under typical conditions saving hundreds of manhours. It can also be used to check architectural plans and interior motifs, eliminating expensive construction changes after the building has been completed.

For example, a prominent Chicago consulting firm tested various air conditioning systems with a novel ceiling it was planning for a new skyscraper. Data collected in one day's experimentation provided essential information for designing the building around the year-round system.

The room can be made the exact size of standard spaces in a commercial structure, hotel or hospital. The ceiling is adjustable and the outside wall can be changed for glass ratios occupying 20 to 80 per cent of total area, which includes virtually all buildings.



Three different outlets for five of the most commonly used central air conditioning systems for multistory buildings are demonstrated in this flexible testing room. Engineer is checking velocity of the air from the overhead diffuser.

External conditions ranging between zero and 120° F. can be created to demonstrate downdraft, plus gains and losses due to radiation. The effect of venetian blinds or drapes can also be shown.

Air velocity of better than 100 feet per minute has been recorded sweeping down the room's single thickness glass wall when outside temperature is zero and 75° F. is maintained inside. The degree with which different systems are able to neutralize this "waterfall effect" is easily one of the "most dramatic" demonstrations made in the room.

For the finale, the air flow pattern provided by one of the air conditioning systems is vividly outlined by use of a fireworks smoke bomb.

The room permits comparison of the six most popular central systems: high velocity, induction; high or low pressure ceiling diffusion; high or low pressure side wall discharge and double duct. Radiant panel sections are also installed above the hung ceiling.

By means of an intercommunication system and large picture window, in one wall of the test module, large groups can follow the scientific demonstrations.

NEW DETECTOR FOR INFRARED "SEEING"

Scientists have developed a new ultra-sensitive detector that can respond to less than one-twentieth of a billionth of a watt of infrared (heat) radiation.

The function of an infrared detector is to convert invisible infrared radiation into electrical signals that can be amplified and seen. It is the most critical component of a complete infrared system.

Such systems are assuming ever-increasing importance in a variety of scientific and military tasks. They are used for guiding missiles to a desired target, for detecting missiles and fast-flying aircraft, for making "heat pictures" of the ground in the complete absence of light, for studying the radiation from stars and other celestial bodies, and for a variety of similar purposes.

Because of its high sensitivity, fast response, and ability to "see" a wide frequency of infrared radiation, the new detector developed in the Westinghouse Research Laboratories will add considerably to the performance of such infrared systems.

Every object above the absolute zero temperature of outer space emits infrared radiation. It is generated inside the molecules of a material as a result of their own thermal motion. The higher the temperature, the faster the molecules move, and the more energetic and shorter in wavelength is the infrared emitted by a body.

Infrared lies in a band of wavelengths between those of visible light and microwave radar. For this reason, infrared behaves sometimes like light and sometimes like radar waves. Its practical applications serve many of the same functions as radar. Like light, it is reflected and refracted by mirrors and lenses, and the devices used to detect it resemble those useful for detecting visible light rays.

The new infrared detector is a type known as a "photoconductor detector." A photoconductor is a solid material that changes its ability to conduct electricity when radiations such as infrared or visible light strike its surface. As a result, changes in the intensity of infrared radiation reaching the photoconductor are converted into changes in the amount of electric current flowing through it.

Scientists report that the photoconductor in the new detector is composed of germanium, the same basic semiconductor material from which most transistors are made. The germanium, however, is made sensitive to infrared by "doping" it, or adding an impurity, gold. It is this new photoconducting material that gives the device its superior characteristics.

In addition to its sensitivity, a major advantage of this gold-doped germanium detector over other varieties is its response to the longer wave lengths of infrared. Longer wavelengths, corresponding to lower temperatures, are the most difficult to detect. Yet these often are the very wavelengths we want to "see."

One has little difficulty, for example, in observing a red-hot object with a fairly insensitive infrared detector. Such an object will have a temperature in the neighborhood of 1500 degrees and emits most of its infrared radiation near the comparatively short wavelength of three microns, or 100 millionths of an inch. It is an entirely different matter, however, to detect the same body when it is, say, at the temperature of the human body, 98.6 degrees. Its peak infrared radiation has tripled to a wavelength of about nine microns, while the total emitted energy has fallen to less than one-hundredth of its previous value.

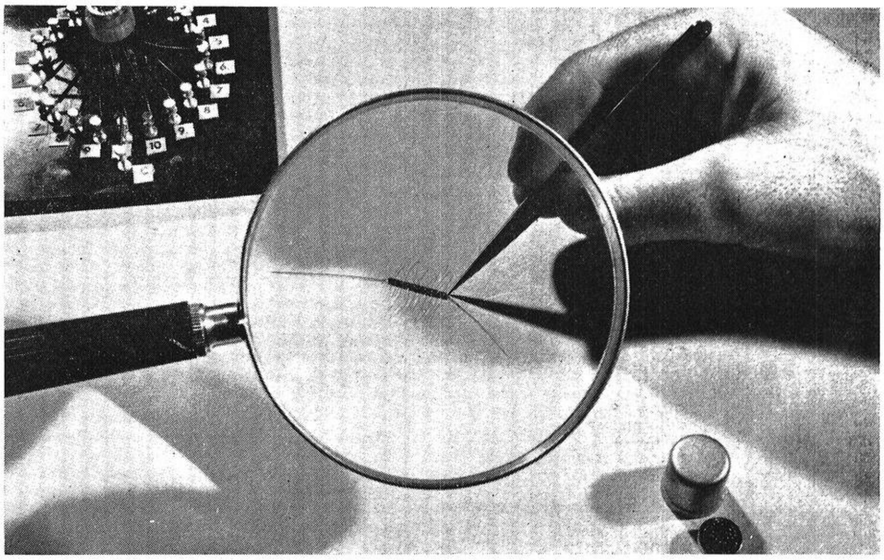
The problem, then, was to devise a detector that responds to these feeble, long-wavelength radiations, has good sensitivity through the range of infrared frequencies, and reacts rapidly enough to be useful in practical situations.

The new detector is highly sensitive to infrared up to a wavelength of 10 microns, which corresponds roughly to the peak radiation at room temperature. At the same

(Continued on next page)

ENTIRE ELECTRONIC CIRCUIT IN A SINGLE UNIT

A "significant break-through" in research, aimed at developing a new class of ultra-miniature "integrated" electronic devices combining many different functions in a few small components, has been announced by the Radio Corporation of America. An experimental shift register transistor's operation in the laboratory has shown feasibility of integrating active and passive elements of a circuit. The laboratory device, only ½-inch long and 4/1000-inch thick, is expected, with further development, to perform functions that now require a circuit arrangement of twenty transistors, forty resistors, and twenty capacitors.



Under the magnifying glass in the center is an experimental shift register transistor. Object in upper left is a testing unit for the device while in the lower right are capsule elements used in testing.

time, it is about 10 times faster than any previously measured photoconductor detector.

The combined speed and sensitivity of the detector means that it can detect tiny and rapid fluctuations in the temperature of an object, even at body temperature and below. Therefore, the detector is potentially very useful in medical research, astronomy, exact scientific experimentation and industrial control.

The new detector is so fast in its response that special laboratory apparatus had to be developed in order to test its speed. The apparatus, a mechanical light chopper, breaks infrared into pulses only a few billionths of a second long. The pulses, reflected to the surface of a detector, show its "time constant" to be two-tenths of a millionth of a second.

Since the sensitivity and frequency response of a photoconductive infrared detector is increased by operating it at low temperatures, the new detector is cooled to a temperature of 320 degrees below zero Fahrenheit by surrounding it with liquid nitrogen in a special container.

Operator obtains final surface density (or surface moisture) reading on the construction site. Total time elapsed for entire operation: three minutes.

GAUGES FOR "ON SITE" ANALYSIS OF MATERIALS

Probes developed by Nuclear-Chicago Corporation permit rapid determination of moisture content and density on the surface level. These new probes provide highly accurate moisture and density measurements directly on the surface of the material eliminating the necessity of removing, weighing, or destroying a sample of the material for testing. The results obtained with these devices are in many cases far more accurate and reproducible than those gained with the conventional "non-nuclear" methods, and no field laboratory, scales, or drying ovens are ever needed. One non-technical person can perform tests and successfully arrive at precise moisture and density determinations in as little as two minutes with this completely portable field system.

The surface probes are ideally suited for compaction studies, control of earth fills and embankments, tillage and cultivation studies, etc. Results with the Surface Density Probe are accurate within 2 lbs/ft^3 wet density. The Surface Moisture Probe provides results reproducible within $\frac{1}{2}$ lb./ft^3 moisture content. The surface probes can be used on sand, clay, granular materials, asphalt, concrete, etc. On general construction projects such as road building, air fields, etc., the d/M-Gauge Surface Probes assure higher quality controls, more accurate adherence to job specifications, and greater personnel and equipment utility. They also may be used in research to assist equipment manufacturers in designing more efficient equipment to better meet the demands of the expanding building and highway construction programs.

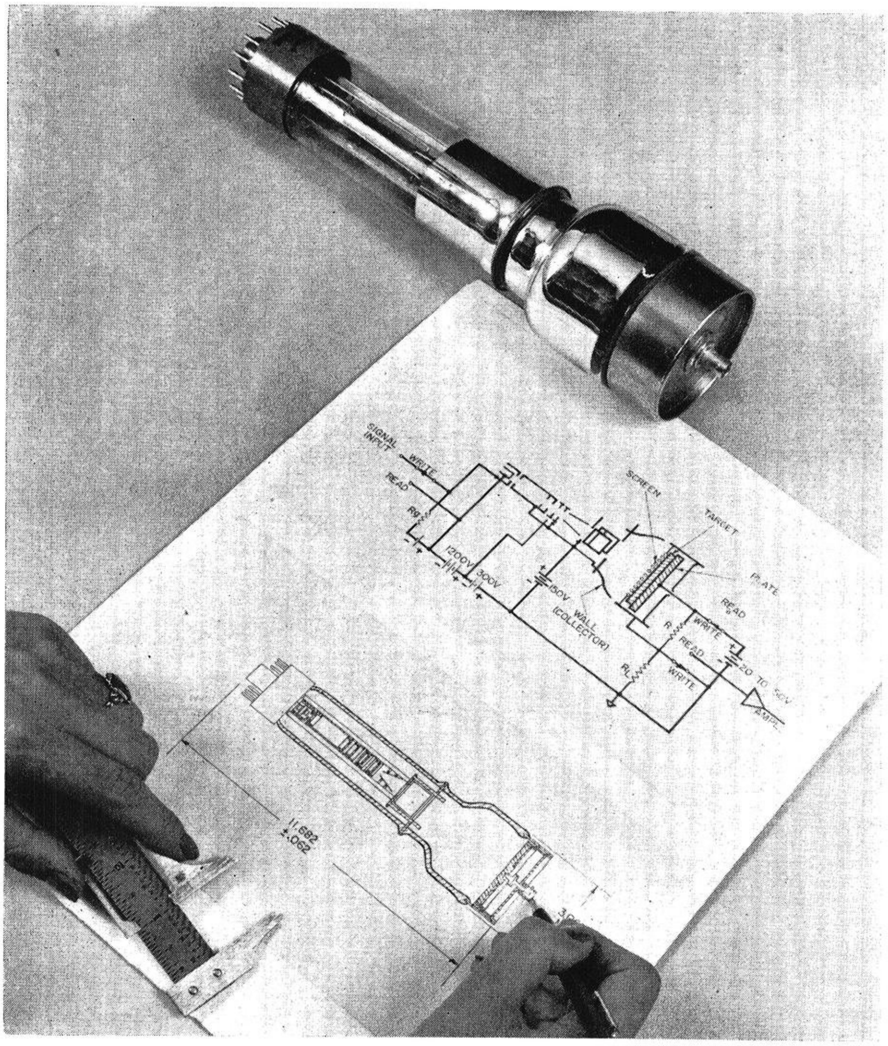
Surface measurements are performed by placing the Surface Moisture Probe, containing a fast neutron source, or Surface Density Probe, containing a gamma-ray source, on a relatively smooth portion of the surface. The radioactivity is scattered with varying degrees when placed in contact with materials of different density or moisture content. Measurement of the "scatter" with the Portable Scaler results in a number corresponding to the material's moisture content or density. A special calibration curve of the "scatter-count" vs. density or moisture content is furnished with each probe. Since both units are completely portable and measurements are performed in a minimum of time, many measurements can be made in a given area providing more dependable controls than can be gained through other slower methods.

NEW COMPUTER STORAGE TUBE

A new three-inch storage tube (WL–7225), used for storing information in computers, is now available from the Westinghouse Electric Corporation.

The tube receives information in the form of electrical impulses, stores it, and when signalled to do so, reads back electrically the accumulated information.

Special features of the WL–7225 are: extreme ruggedness; 2.6 inch diameter of useful target; increased



This computer storage tube receives and sends information in the form of electrical impulses.

resolution; electron gun beam focusing to a fine spot; convenient coaxial connector for the output terminations making possible a compact mounting not previously attainable.

One method of writing with the tube involves holding the screen at a fixed potential and applying a fixed positive charging potential of from 20 to 50 volts to the plate. The signal to be written is applied to the electron gun control grid, usually clamped to the cutoff, while the beam is scanned across the target in the desired pattern.

Reading the stored pattern is accomplished by first returning the screen and plate to the same potential. Those parts of the target upon which the writing beam did not land then return to equilibrium potential, while the portions written upon are negative with respect to the equilibrium potential by the potential difference to which they are discharged. Both screen and plate are now returned to ground through a load impedance, and the scanning electron beam, held at a fixed beam current, returns the target surface to equilibrium.

Due to the electron beam returning all parts of the target to equilibrium during reading, erasure occurs simultaneously with the reading cycle.

Challenge For Photographic Scientists

The study of space is the new challenge for photographic scientists—simply because space is there and man's insatiable curiosity will drive him to explore it.

And much of the information about outer space will be obtained by photography. Just as the camera has been the astronomer's indispensable tool, so it will be the primary tool of the space scientist.

Taking man's first exploration of the moon as an example, it is a safe prediction that rockets in orbit around the moon will be the first successful instruments for relatively close-up study of the moon's surfaces, including the far, hidden side.

How will the orbiting rockets give us the information they are sent to gather, since there is no likelihood of a directly produced, sharply detailed television image because of the high resolution required.

But photography practically guarantees a satisfactory solution, with a rocket carrying automatic cameras with telephoto lenses and automatic processing equipment. Add the TV system needed to scan the finished film minutely and transmit the image back to earth and you have a capable instrument for doing the job.

Scientists are finding out what difficulties might be caused by cosmic rays or other radiation in such space-photography.

Only recently somewhere in outer space, Explorer IV was dutifully sending back impulses which add to our knowledge of these matters.

The current plans are to study the spectra of Mars from a high-flying balloon. From 100,000 feet above the earth it is hoped that much can be learned about the atmosphere of Mars and especially about its water content.

Surely, these efforts foretell the day when men will visit this provocative neighbor of ours. For just as surely as this indomitable creature (man) has moved out of the cave to his present estate, he will set foot on other worlds. You and I may not live to see his triumph, but we'd better get busy with our preliminary assignments all the same. Keep in mind all the celestial reconnoitering by photography that must be done in advance.

Photography has varied uses in the study of the sun, in nuclear physics, and in electronic computing systems.

In computers all the functions of photography; the recording of information, the storage of information, and the retrieval of information are brought into play in a way to stagger the imagination.

(Continued on page 50)

Future Building

(Continued from page 24)

Furnishings and Textiles

More than 63,200 pounds of aluminum were used for executive furniture, and desks, chairs and accessories throughout the building. In addition, aluminum yarns are woven into draperies, carpeting and upholstery in the executive offices and dining rooms.

Desks and Chairs

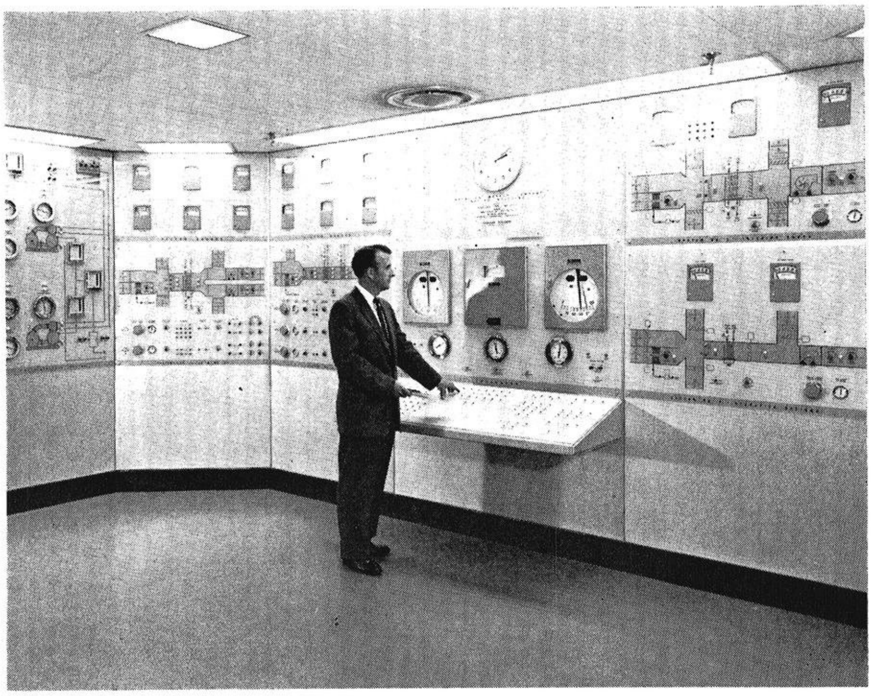
Desks for the executive offices on the first level, the receptionists desk in the main lobby and certain other first level desks were designed by Skidmore, Owings & Merrill and made by several leading manufacturers. All of the desks and chairs other than those in top executive offices are a completely new line designed and manufactured in aluminum by General Fireproofing Company of Youngstown, Ohio.

The new line, termed "Italic Styling," was designed to complement the architectural motif of the new building. This furniture was the first production run of the new line, which now has been introduced to the office furniture trade.

Italic Styling represents one of the most extensive functional and decorative applications of aluminum for office furniture. Aluminum is used for desk legs, back and side panels and for drawer fronts. Chairs and other matching accessories also make broad use of the light metal.

For pleasing textured surface treatments, two different aluminum mill products are used. A rolled-rib pattern alternates ribs of smooth surfaces with recessed ribs of fine textured lines, creating a rich textural effect. The other mill product used has a striated surface with a relief grain effect.

Both of these aluminum textures are produced in four soft anodized colors (bronze gold, antique gold, ebony and natural). Of special interest is the combination of these basic colors with each other to provide 20 different possible anodized color combinations. This is the first two-tone anodizing on a production line basis in the office furniture industry. The technique demonstrates the color versatility of aluminum for attractive interior applications.



Building engineers have finger-tip control over heating and air-conditioning. A single engineer can continuously check and log temperatures and other data from all parts of the building, adjust remotely located equipment and control devices, start and stop heating and air-conditioning equipment, instantly make basic adjustments in temperatures in any area of building, and supervise flow of fire alarm sprinkler lines.

Draperies

Drapes in executive offices and dining rooms were made from approximately 2,700 yds. of silk and Reynolds aluminum yarn which were woven in Bangkok, Siam, employing a restrained but rich tone-on-tone technique. Thirteen different colors were used.

Casement drapes, on the second and third levels were made of 1,865 yds. of white linen with aluminum yarn.

Carpeting

The 3,000 sq. yds. of jet black carpeting were of hand-woven wool and Reynolds aluminum yarns which were made in Puerto Rico.

Nearly 2,000 yds. of aluminum yarn upholstery fabrics, in 20 different colors, were used for furniture in the executive offices, cafeteria lounge and other spaces.

Cafeteria Trays

Cafeteria trays are of molded fiberglass, with woven nylon and silver Reymet aluminum yarn fabric sandwiched between the fiberglass.

Desk Accessories

Specially designed aluminum desk accessories, including calendar stands, telephone index stands, in and out baskets and waste baskets are used throughout the building.

Landscaping

The general landscaping for the building site is entirely modern, and was suggested by the contemporary design of the building itself.

For example, the squares of grass in the courtyard, the rectangular reflecting pool and flower beds on the terraces carry out the clean, angular motif of the architecture.

At the same time, however, trees, flowers and shrubbery are representative of the South and reminiscent of a traditional Virginia garden.

The landscaping contract was one of the largest in the history of Virginia. It ranks second in size only to Colonial Williamsburg.

The Magnolia Grandiflora (Southern Magnolia) in the courtyard is 40 ft. high and was transplanted from a site about three miles away. The transplanting operation took a week to complete.

THE END

Thin Arch Dams

(Continued from page 20)

6. Also the dam would likely be subjected to higher and different stresses than assumed in calculations.

To counteract these reasons, multiply the cylinder formula by a ratio of the maximum compressive arch stress obtained by the elastic method, to the arch stress obtained from $\epsilon = \frac{w_z h r_e}{e}$. i.e. by the cylinder method. This ratio was developed by Professor William Cain for fixed arches and includes the influence of shear.

Design—Trial Load

The U.S. Bureau of Reclamation has developed a systematic method of analysis applicable to any valley, known as the trial load method. In this, the dam must be considered as consisting of two inter-penetrating structural systems; one of these is a series of vertical cantilevers and the other a series of arches. The water pressure load is divided by repeated trial between these two systems until the displacements of both are same at a number of selected points. This method is based on the following assumptions:

1. Uniform elasticity of foundation and abutments.
2. Uniform homogeneity and elasticity of the concrete.
3. Fixation of the dam to the abutments and the foundations.
4. Action of the structure as a monolith along with the arch action starting when the reservoir begins to fill. This can be done by grouting the vertical construction joints before applying water load.
5. Stress well below the limit of elasticity of the material for the dam, base, and abutments.
6. Independent action by the cantilevers of their neighbors.
7. Carrying of all vertical loads by cantilevers.

The Stevenson Creek Test Dam, a constant radius thin arch structure 60 feet high was built solely for research. Under rigid controls testing was carried on. The main results were as follows:

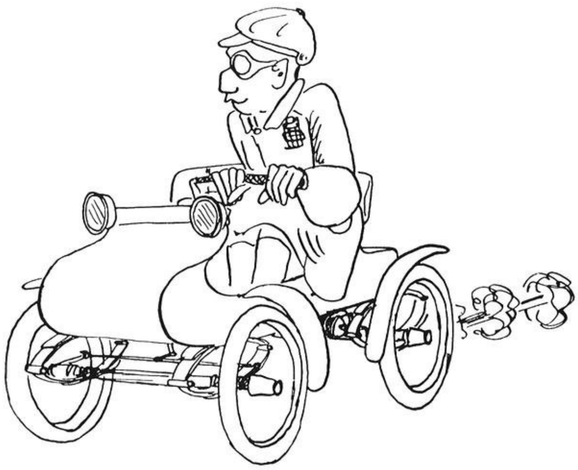
1. Concrete temperature changes affect structural movements, crack formations, stress, magnitude, and distribution.
2. Chemical heat generated during the curing process must be dissipated before the grouting of contraction joints or filling of radial slots.
3. Even in dams of thin arch type appreciable portions of horizontal water loads are carried by cantilever action.
4. Since the thin arch dam has tension stresses in the cantilever elements near the foundations, horizontal cracks may develop along the upstream face.
5. Allowance for rock deformations, twist action, and tangential shear effects; estimation of movement of arch dams can be done satisfactorily by the use of the elastic formula.
6. Final design should not be based upon uniformity of water loads.
7. The trial load method of analyzing arch and cantilever action in curved concrete dams furnishes a satisfactory basis for any type or size of arch dam.

The result of the Stevenson test dam and the faulty assumptions in the cylinder theory of dam construction seem to indicate that the latter should be used for a quick preparative design but the final design should be done in scale by the trial load method.

History

The first arch dams were Spanish, named Elche, and Almanze, built in the 16th century. In 1612 the Italians built Pontalto dam, which by the way was heightened many times and is still in use. The Shoshane dam built in 1910 was the first high dam with a height of 328 feet above its foundations. Boulder dam in Colorado is a mixed type dam using the best of both the gravity and the arch dams. It is 722 feet high and is the highest dam in the world.

THE END



THE ENGINEER OF YESTERYEAR

by John Nichols ee'60

THE THREE PHASE ELECTRIC MOTOR
January, 1897

SEVEN years ago the three-phase motor was simply an interesting scientific curiosity. It is still a novel sight to see an armature which has no visible connection, in fact, no mechanical connection to any motive power, running as if by magic. However, that revolving mass of iron and copper is more wonderful now, as it can do work equal to that of an engine larger than itself. In the last five years the three-phase motor has been developed to such an extent that it takes equal practical rank with its older brother, the direct current motor, and promises, with the aid of long distance transmission, to leave it far behind.

THE COTTON GIN
January, 1897

One of the greatest inventions the world has ever seen is the cotton gin. It is great, more on account of the economic effect resulting from its introduction than from a mechanical standpoint. There are a great many farming machines, wonderful to look at, that operate as though endowed with life, but they have been developed by a gradual process and improvement had to be added to the crude originals to make them the perfect mechanisms of today. Not so with the cotton gin, however. Born of the genius of Whitney, it stands today practically the same as in childhood.

IGNITION OF INTERNAL COMBUSTION ENGINES
April, 1897

The first ignition of the internal combustion engine was accomplished through use of flame. However a large number of difficulties with the flame method led to a great deal of experimentation with ignition by incandescent metals. Clerk developed a slide valve which has a small port filled with a grating made of platinum plates. This valve was first moved out and the grating heated to incandescense by a jet of gas-flame. The valve was then run in till the grating covered a port leading from the cylinder to a small cavity in the valve cover. The compressed gases in the cylinder were ignited upon rushing through the hot grating, and their combustion kept up the temperature of the grating. This worked very well until from any cause the engine missed an explosion. Then the grating would become too cool to ignite the charge and the engine would stop.

Drake first used a thimble shaped piece of metal in a cavity in the back of the cylinder and heated it by a blow-pipe flame directed into the interior of the thimble. The ignition took place when the piston uncovered a port communicating with this cavity containing this hot piece of metal. These pieces of metal soon became brittle and weak from the intense heat. Atkinson finally overcame this difficulty by using wrought iron tubes closed at one end and the other end opening into the cylinder. This tube with some modifications has been the method used most extensively in this country. In a great many of the engines the tube is left constantly open to the cylinder and the proportions so designed that the compression will force the fresh gases up the tube to the heated part and thus give ignition at the proper time. It is generally found, however, that in these engines the point of ignition varies a great deal and the explosion very often comes far from the beginning of the stroke. Some manufacturers have endeavored to overcome this difficulty by using a timing valve which gives communication between the cylinder and the tube only at the proper time for ignition. This does away with premature explosions, but does not prevent their being late at times, and it is found that the tubes give out more quickly than they do when they are in constant communication with the cylinder.

Under ordinary conditions the tubes will not last for more than thirty hours, and in order to secure the best running, they should be renewed more often as the metal usually thickens up with the heat and chokes the tube before it finally gives out. The hot tube furnishes a fairly reliable method of ignition except as to time, but there is the constant trouble and expense of renewing the tubes and in some cases it is dangerous to have the external flame necessary to heat the tube. It is also evident that this method cannot be used in a portable engine or in one which is so situated as to be exposed to draughts of air.

ELECTRIC IGNITION

Electric ignition has lately been developed so as to overcome a great many of the difficulties mentioned in connection with the other methods. All of the early experimenters used the spark from the secondary of an induction coil, which was made to pass between two electrodes, generally of platinum, in the back part of the cylinder. Sometimes the electrodes were in the cylinder itself and the spark was made to pass only at the time of ignition. This did away with all timing valves, but it was found that occasionally the interrupter on the induction coil would not start immediately upon making connection in the primary circuit and this would cause either late firing or missed explosions. To remedy this evil, some makers placed the electrodes in a small side cavity of the cylinder, which was placed in communication with it only at the proper time for ignition, and allowed the spark to play continuously between the electrodes. This necessitated the use of a timing valve and in all these early electrical methods the electrodes were found to be difficult to keep in order. The platinum points would become dirty or damp and the spark would not pass. These facts, together with the trouble and expense of keeping up batteries, were serious drawbacks to the use of electric ignition.

THE ELECTROLYTIC DECOMPOSITION OF SODIUM CHLORIDE

July, 1897

The enormous quantities of bleaching powder which are consumed yearly in various industries and for various purposes has been the incentive for the numerous applications for patents on various forms of apparatus for decomposing sodium chloride by electrolysis, their object being to produce a substitute for bleaching powder at a lessened cost.

It has long been known that by electrolysing a sodium chloride solution that the result was a liquid which possessed excellent bleaching properties. The primary elements liberated are sodium and chlorine, but these immediately recombine and form sodium hypochlorite (Na Cl O).

The principle commercial apparatus for the production of electrolytic hypochlorite is one developed by Hermite, a Frenchman. His apparatus has been tried experimentally at Worthing, England, for the disinfection of the sewage of that town, and tests at this plant have shown it capable of doing much toward the solution of the sewage problem.

His apparatus consists of a galvanized iron tank in which the decompostion takes place. The anodes are made by mounting platinum gauze in an ebonite frame, these anodes being fastened to a copper bar by a leaden lug. Between each pair of anodes is a zinc cathode. The cathodes are discs mounted on a revolving shaft, each being provided with a scraper which cleans it as it revolves.

Hermites's process is a continuous one. The electrolyte enters the tank through a well perforated pipe which runs along the bottom of the tank and after passing up between the electrodes it overflows into a trough which surrounds the top of the tank. From here it is conducted away for use. Sea water is used for the electrolyte where available.

METERS OF TODAY

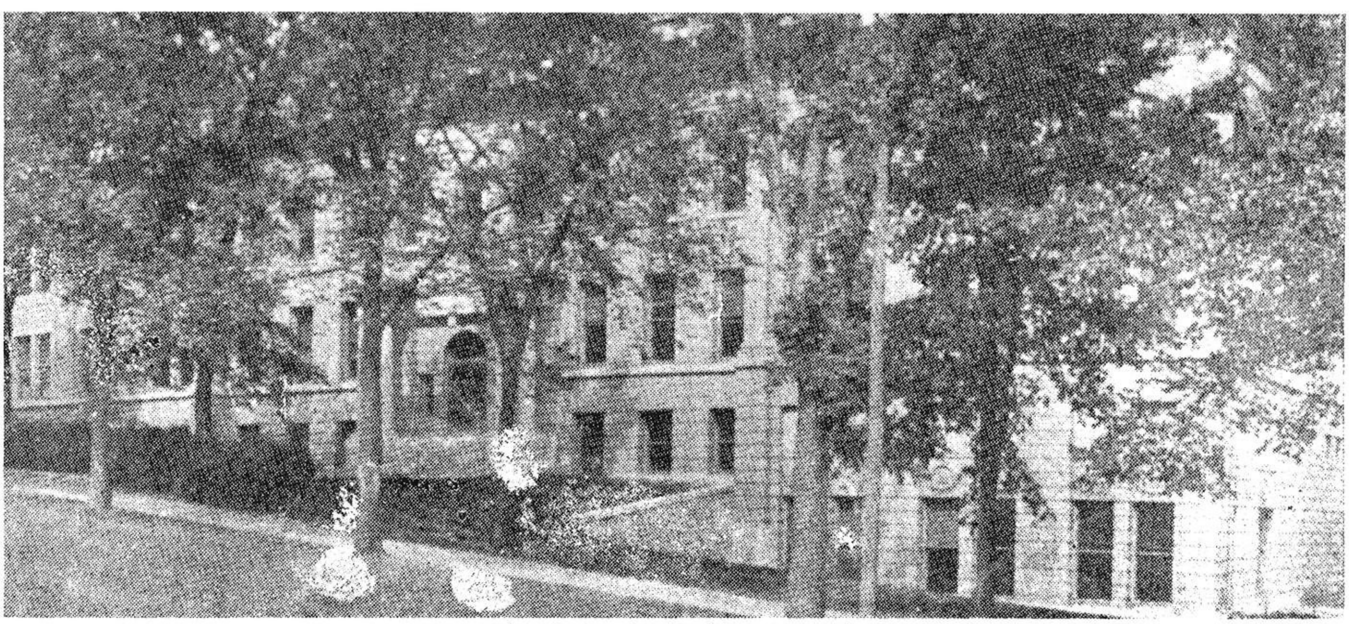
October, 1897

There are three classes of meters —the electrolytic, clock, and motor meters. In the first, the quantity of current is measured by the amount of metal deposited or the quantity of electrode decomposed in an electrolytic cell. The only one of this class which has found much use in America is the Edison chemical meter, which, through exceedingly accurate under proper conditions, has the disadvantage of having no recording device, and like all electolytic meters is likely to freeze unless heat is provided, which entails a loss.

Most of the clock meters consist of two clocks, one of which keeps accurate time, the other being retarded or accelerated by the action of the current on its pendulum. This retardation or acceleration is registered by a differential gear connecting the two clockworks, which, in turn operates a train of gears connected to the dial. The objection of most of these is that the clock must be wound up every month or so, which, if neglected, will cause the meter to run backwards and destroy all former readings.

The most important class comprises those meters which operate on the principle of the electric motor.

THE END



The Engineering Building in 1907.

Measurements

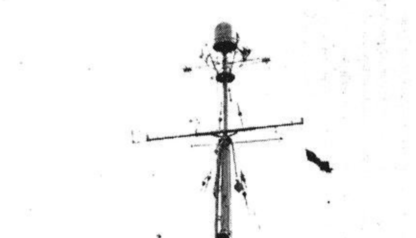
(Continued from page 17)

operation can operate very efficiently, utilizing the non-photographic weather to measure the distances for geodetic control.

Short Range Instruments

In the short range group we have the Geodimeter, Tellurometer, Moran, Electro-Optical system, and Electronic Distance Meter. The maximum effective range of these "line of sight" instruments is approximately 50 miles. The Geodimeter, based on light waves, and the recently developed Tellurometer, based on radio waves, are the most important of the short range group and will be thoroughly described. The other instruments will be described briefly.

The Geodimeter, which derives its name from the words "geodetic", "distance", and "meter", was developed by Dr. Erik Bergstrand, Geodesist of the Swedish Geographic Survey Office. The instrument was designed for the purpose of measuring distances, using the fundamental constant, the velocity of light. Geodimeters for the precise measurement of unknown distances have been in use since 1952. Early measurements with experimental models in the period 1941 to 1952 over very precise distances, some of which were established with light interference devices, resulted in the present, universally accepted, value for the velocity of light.



U.S.C.&G. S. Ship "Explorer," first ship equipped with Shoran for hydro graphic survey.

Measurement of distance with the Geodimeter is carried out indirectly by determining the time interval for red light, of wave length approaching invisible infra-red light, to reach a distant reflector and return to the receiving optics of the same instrument. With the known velocity of light it is then possible to compute the distance. Corrections for temperature, pressure and humidity must be applied to this distance to obtain accurate results.

Each distance is accurately determined in 30 to 60 minutes, and the time saved may reach 50 man-days per measurement compared to taping. In addition, the computation of a geodimeter traverse is far easier than the adjustment of a triangulation net. This ease has been proved both in Europe and in the United States by users of the Geodimeter.

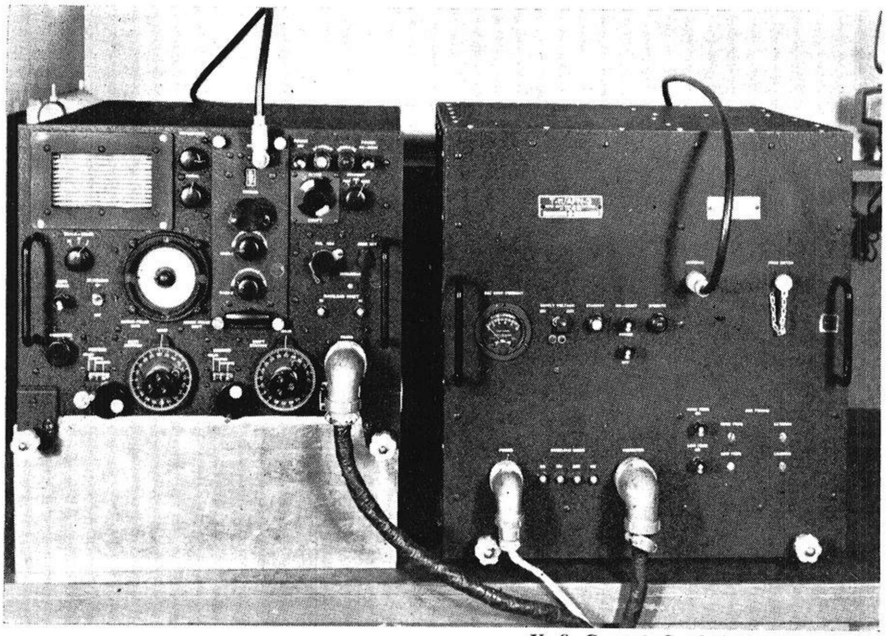
The Geodimeter is composed physically of two sections, the measuring unit weighing 108 pounds and the optical unit weighing 113 pounds. Each unit is packed in a separate, shock absorbing, wooden case. The power for the Geodimeter should be a 115 or 230 volt, 60 cycle alternating current at 140 watts. The instrument is mounted on a sturdy metal tripod with a revolving top plate. The reflector stations are composed of 32 retrodirective prisms mounted on a light metal frame, which return the light rays even if the Geodimeter is pointing a few degrees off line.

The Geodimeter can only be used at night to obtain accurate readings. The procedure is relatively simple. The Geodimeter is mounted on its tripod with the back edge over the station mark, and all optics and associated parts are put in place. The gasoline generator is started and the Geodimeter cord is plugged into it. While the Geodimeter's electronic circuits are warming up, the observer inserts the sighting telescope in the optical line of sight of the instrument and centers on the light being shown at the mirror station. The observer then removes the telescope and swings the lamp assembly into place and instructs the mirror tender, by radio, to replace his signal lamp with the mirror system. After the electronic circuits have been turned on for an hour, and it is sufficiently dark, observations can begin. The Geodimeter is then further lined up optically for best light return. Minor adjustments are made in the optical system for best strength of light return as indicated on the light indicator meter. Temperature, pressure, and humidity readings are taken at both ends of the line and the light intensity is adjusted for proper operation.

Usually 12 observations are taken on two different nights to obtain a length suitable for first order triangulation.

Another short range instrument is the Tellurometer, a name borrowed from the Greek words of "earth" and "measure". It is an electronic system employing radio microwaves, which permit distance measurements either in daylight or darkness, in clear or foggy weather. Lines must be unobstructed by ground, buildings, or heavy woods, but visibility is otherwise immaterial and is not a factor in the accuracy obtained.

The minimum component items of the tellurometer system necessary to determine a distance are a master unit and a remote unit together with a power supply and transformer with each unit. No outside antennas are required. The master and remote units are almost identical in appearance; each is set up on its tripod and centered over a point in a manner similar to that of a transit or theodolite. The power supply is a 6-volt standard automobile battery which is normally adequate for two or three full days of operation. The entire Tellurometer unit at a station, together with its accessories, weighs 85 pounds. This equipment is easily



—U. S. Coast & Geodetic Survey Photo

Ship installation of Shoran equipment.

back-packed as the heaviest single item is the battery weighing about 28 pounds. The Tellurometer is of rugged build and can be carried in a truck over rough roads with less worry than that usually accorded a transit or theodolite. A small spare-parts kit is available with each unit; this kit is generally adequate for at least 1,000 hours of operation.

The carrier wave length of the Tellurometer is approximately 10 cm and this may be varied in the band between 2,900 and 3,200 megacycles. This radio carrier wave is modulated by a lower frequency measuring wave of about 10 megacycles. A two-way communication system is inherent as a built-in feature of the set which permits conversation during the field operation.

In measuring a distance between stations, two men are required, one at the master and one at the remote unit. If the equipment must be back-packed, an additional man at each station is needed. A recorder is an asset at the master unit to expedite the observation, but not essential. The observer at the master unit need not be a trained electronic technician. A capable instrument surveyman will learn to operate the master unit after one full day of training. The remote unit can be satisfactorily operated by a rodman or chainman with 30 minutes of instruction.

For geodetic accuracy, meteorological readings are taken at both stations to determine humidity, temperature and barometic pressure. These corrections to the velocity of propagation are quickly made from tables prepared for that purpose. For 3rd and lower order accuracy, the meteorological readings may be dispensed with and a standard correction applied.

The entire operation at a station, including set-up, computation from time interval to distance, and teardown, varies from 10 to 15 minutes for 3rd order work to 30 minutes for high geodetic accuracy.

The accuracy of the Tellurometer is 3 parts per million plus or minus 2 inches on lines from 500 ft to 30 or 40 miles. This formula will give an accuracy of 1 part in 225,000 on a 30 mile line, 1 part in 30,000 on a 1 mile line, or 1 part in 3,000 on a 500 ft line.

The results of one of the many tests on the Tellurometer will be given here. Before an audience of 100 engineers and scientists, Tellurometer officials demonstrated the equipment by measuring an 8-mile line near Rockville, Maryland, the length of which had previously been determined by both triangulation and the Geodimeter. The Tellurometer distance compared with the other measurements is as follows:

	Meters
Tellurometer distance	12,811.60
Triangulation distance	12,811.79
Geodimeter distance	12,811.66

The comparison between the Tellurometer and triangulation distance was of the order of 1:67,400; between the Tellurometer and Geodimeter distance was 1:213,-500. The Geodimeter distance was considered to be the more nearly correct as the triangulation distance was a computed value in the geodetic network about 50 miles from a measured baseline.

The Tellurometer was designed as a geodetic instrument and can therefore be used for lower-order surveys with a minimum of observations, in the same way that a first-order theodolite will give third-order results with many less repetitions of angle measurements than those required by a surveyor's transit. By use of the Tellurometer we can use the traverse method of surveying instead of triangulation, thus reducing the number of angular observations necessary at each station.

In the footsteps of the Bergstrand Geodimeter has followed another similar type of instrument which can be used on traverse operations for measuring courses ranging from 600 to 6,000 ft. in length. Called the Electronic Distance Meter, this instrument is much smaller and lighter than the Geodimeter and can be supported on the conventional surveying tripod. The reputed accuracy attained is said to approach 1 part in 100,000.

Another electro-optical instrument was developed under the auspices of the United States Engineers Research and Development Board. Again light is used and is reflected from a corner cube mirror target at distances up to several miles. The accuracy of this instrument is not high, being about 1 part in 2,000. However, it serves a very useful purpose in topographic surveys, for in addition to measuring distance, it will also measure angles with topographic accuracy.

The principles of radar can be utilized in the determination of vertical distances also. The procedure has found its major application in economically providing vertical control for relatively small-

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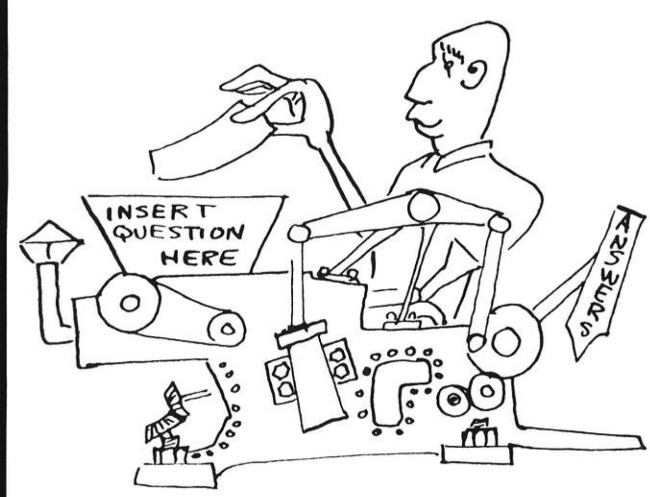
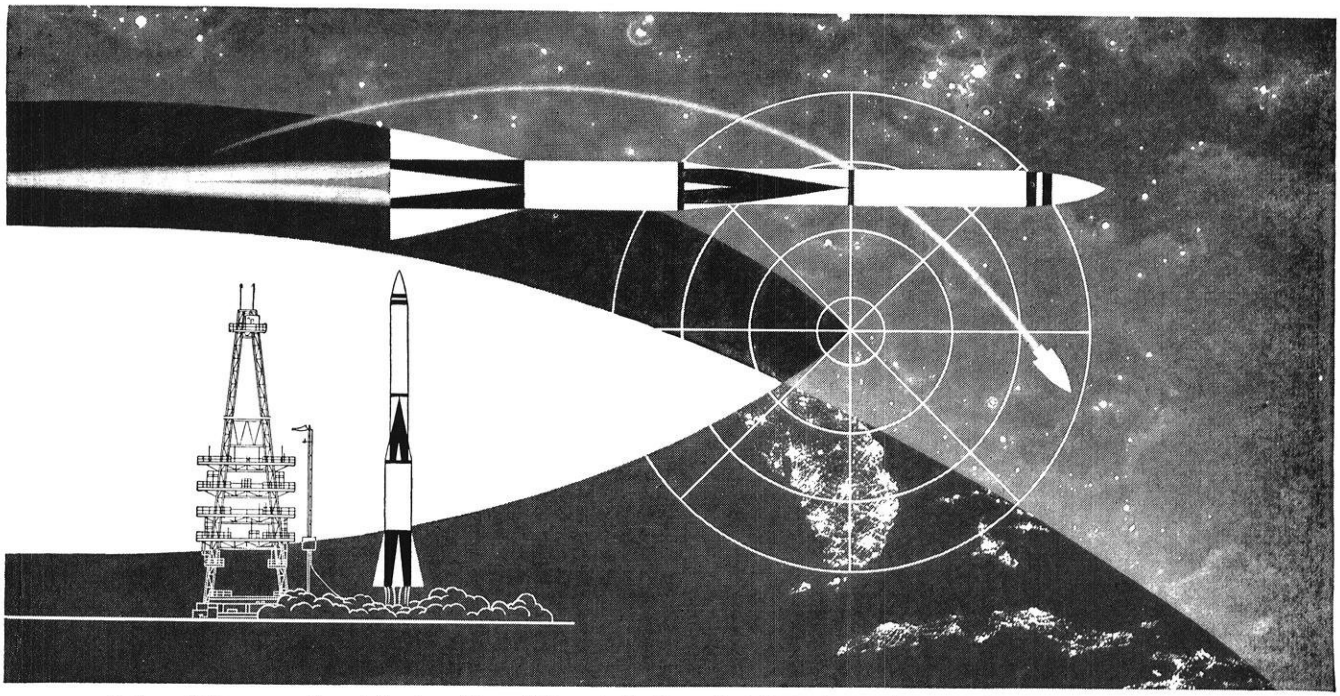


FINAGLE FACTORS

Multiply	*By*	*To Get*
Inches	2.540	centimeters
Inches	10^3	mils
Inches	.03	varas
Inches of mercury	0.03342	atmospheres
Inches of mercury	1.133	feet of water
Inches of mercury	345.3	kg per square meter
Inches of mercury	70.73	pounds per square ft
Inches of mercury	0.4912	pounds per square in.
Inches of water	0.002458	atmospheres
Inches of water	0.07355	inches of mercury
Inches of water	25.40	kg per square meter
Inches of water	0.5781	ounces per square in.
Inches of water	5.204	pounds per square ft
Inches of water	0.03613	pounds per square in.
Joules	9.486×10^{-4}	British thermal units
Joules	10^7	ergs
Joules	0.7376	foot-pounds
Joules	2.390×10^{-4}	kilogram-meters
Joules	0.1020	kilogram-calories
Joules	2.778×10^{-4}	watt-hours
Kilograms	980,665	dynes
Kilograms	10^3	grams
Kilograms	70.93	poundals
Kilograms	2.2046	pounds
Kilograms	1.102×10^{-3}	tons (short)
kilogram-calories	3.968	British thermal units
kilogram-calories	3086	foot-pounds
kilogram-calories	1.558×10^{-3}	horsepower-hours
kilogram-calories	4183	joules
kilogram-calories	426.6	kilogram-meters
kilogram-calories	1.162×10^{-3}	kilowatt-hours
kg-calories per min	51.43	foot-pounds per sec
kg-calories per min	0.09351	horsepower
kg-calories per min	0.06972	kilowatts
kg-cm squared	2.373×10^{-3}	pounds-feet squared
kg-cm squared	0.3417	pounds-inches squared
kilogram-meters	9.302×10^{-3}	British thermal units
kilogram-meters	9.807×10^7	ergs
kilogram-meters	7.233	foot-pounds
kilogram-meters	9.807	joules
kilogram-meters	2.344×10^{-3}	kilogram-calories
kilogram-meters	2.724×10^{-6}	kilowatt-hours
kg per cubic meter	10^{-3}	grams per cubic cm
kg per cubic meter	0.06243	pounds per cubic foot
kg per cubic meter	3.613×10^{-5}	pounds per cubic inch
kg per cubic meter	3.405×10^{-10}	pounds per mil-foot
kg per meter	0.6720	pounds per foot
kg per square meter	9.678×10^{-5}	atmospheres
kg per square meter	98.07	bars
kg per square meter	3.281×10^{-3}	feet of water
kg per square meter	2.896×10^{-3}	inches of mercury
kg per square meter	0.2048	pounds per square ft
kg per square meter	1.422×10^{-3}	pounds per square in.
kg per sq millimeter	10^6	kg per square meter
kilolines	10^3	maxwells
kiloliters	10^3	liters
kilometers	10^5	centimeters
kilometers	3281	feet
kilometers	10^3	meters
kilometers	0.6214	miles
kilometers	1093.6	yards
kilometers per hour	27.78	centimeters per sec
kilometers per hour	54.68	feet per minute
kilometers per hour	0.9113	feet per second
kilometers per hour	0.5396	knots
kilometers per hour	16.67	meters per minute
kilometers per hour	0.6214	miles per hour
km per hour per sec	27.78	cm per sec per sec
km per hour per sec	0.9113	ft per sec per sec
km per hour per sec	0.2778	meters per sec per sec
km per hour per sec	0.6214	miles per hr per sec
kilometers per min	60	kilometers per hour
kilowatts	56.92	Btu per min
kilowatts	4.425×10^4	foot-pounds per min
kilowatts	737.6	foot-pounds per sec
kilowatts	1.341	horsepower
kilowatts	14.34	kg-calories per min
kilowatts	10^3	watts
kilowatt-hours	3415	British thermal units
kilowatt-hours	2.655×10^6	foot-pounds
kilowatt-hours	1.341	horsepower-hours
kilowatt-hours	3.6×10^6	joules
kilowatt-hours	860.5	kilogram-calories

Multiply	*By*	*To Get*
kilowatt-hours	3.67×10^5	kilogram-meters
knots	6080	feet per hr
knots	1.853	kilometers per hr
knots	1.152	miles per hr
knots	2027	yards per hr
Lines per square cm	1	gaus
lines per square inch	0.1550	gaus
links (engineer's)	12	inches
links (surveyor's)	7.92	inches
liters	10^3	cubic centimeters
liters	0.03531	cubic feet
liters	61.02	cubic inches
liters	10^{-3}	cubic meters
liters	1.308×10^{-3}	cubic yards
liters	0.2642	gallons
liters	2.113	pints (liq)
liters	1.057	quarts (liq)
liters per minute	5.855×10^{-4}	cubic feet per second
liters per minute	4.403×10^{-3}	gallons per second
$\log_{10} N$	2.303	$\log_{10} N$
$\log_e N$ or ln N	0.4343	$\log_e N$ or ln N
lumens per sq ft	1	foot-candles
maxwells	10^{-3}	kilolines
megalines	10^6	maxwells
megmhos per cm cube	10^{-3}	abmhos per cm cube
megmhos per cm cube	2.540	megmhos per in. cube
megmhos per cm cube	0.1662	mhos per mil foot
megmhos per inch cube	0.3937	megmhos per cm cube
megohms	10^6	ohms
meters	100	centimeters
meters	3.2808	feet
meters	39.37	inches
meters	10^{-3}	kilometers
meters	10^3	millimeters
meters	1.0936	yards
meter-kilograms	9.807×10^7	centimeter-dynes
meter-kilograms	10^5	centimeter-grams
meter-kilograms	7.233	pound feet
meters per minute	1.667	centimeters per sec
meters per minute	3.281	feet per minute
meters per minute	0.05468	feet per second
meters per minute	0.06	kilometers per hour
meters per minute	0.03728	miles per hour
meters per second	1968	feet per minute
meters per second	3.284	feet per second
meters per second	6.0	kilometers per hour
meters per second	0.06	kilometers per min
meters per second	2.237	miles per hour
meters per second	0.03728	miles per min
meters per sec per sec	3.281	feet per sec per sec
meters per sec per sec	3.6	km per hour per sec
meters per sec per sec	2 237	miles per hr per sec
mhos per mil foot	6.015×10^{-3}	abmhos per cm cube
mhos per mil foot	6.015	megmhos per cm cube
mhos per mil foot	15.28	megmhos per in. cube
microfarads	10^{-15}	abfarads
microfarads	10^{-6}	farads
microfarads	9×10^5	statfarads
micrograms	10^{-6}	grams
microliters	10^{-6}	liters
microhms	10^3	abohms
microhms	10^{-12}	megohms
microhms	10^{-6}	ohms
microhms	$1/9 \times 10^{-17}$	statohms
microhms per cm cube	10^3	abohms per cm cube
microhms per cm cube	0.3937	microhms per in. cube
microhms per cm cube	6.015	ohms per mil foot
microhms per inch cube	2.540	microhms per cm cube
microns	10^{-6}	meters
miles	1.609×10^5	centimeters
miles	5280	feet
miles	1.6093	kilometers
miles	1760	yards
miles	1900.8	varas
miles per hour	44.70	feet per minute
miles per hour	88	centimeters per sec
miles per hour	1.467	feet per second
miles per hour	1.6093	kilometers per hour
miles per hour	0.8684	knots
miles per hour	26.82	meters per minute
miles per hour per sec	44.70	cm per sec per sec

(Continued on page 52)



• An artist's conception of the launching of the missile, its guided flight, its track on a radarscope in its final stage.

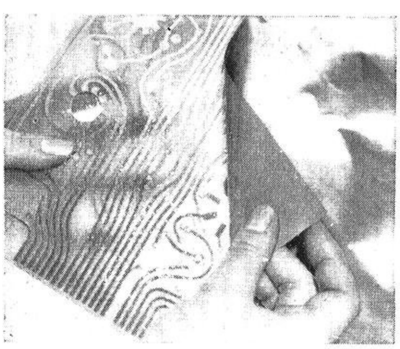
MINIATURIZATION for the MISSILE AGE

Another new design frontier for copper

"The increasing amount of equipment carried on military aircraft . . . has made it necessary for the design engineer to cram more equipment into less space."

"To achieve maximum usefulness from miniaturization, all elements of the system must be reduced to the same order of size. New design techniques, components and production methods have been developed to aid the designer in reaching this goal."
— *Electronics* Magazine

Many of these new design techniques are taking advantage of the properties of a very old material — copper. One of copper's big jobs is conducting electricity in control circuits. Of course, copper is the best commercial conductor, but when miniaturization takes over, many other properties of copper also become important.

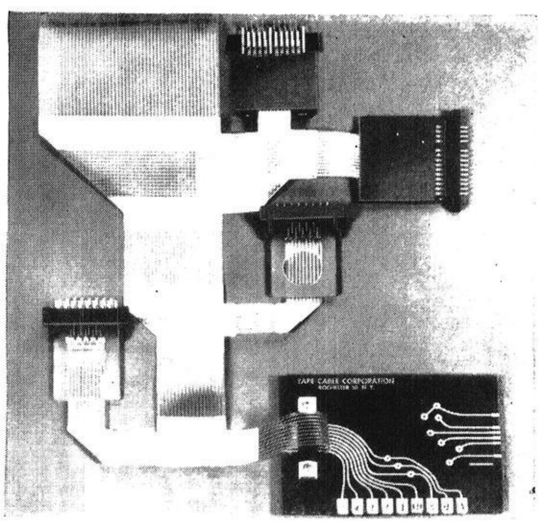


Printed circuit of copper bonded to epoxy glass base, and sheet of the adhesive-backed copper used in its manufacture by Rubber & Asbestos Corp.

In the printed circuits that are the very basis of most subminiature designs, the conductors may start out as a sheet of copper foil. This foil often has to be very thin — yet free of flaws that might cause circuit discontinuities. Here, copper's ductility is vital.

Good joining properties are also important. Some of the tiny connections are resistance welded. (Copper can withstand the temperatures.) Others are soldered. (Easily done with copper and with very little solder metal.)

Complex control circuits can now be wired with flexible Tape Cable. This tape may contain as many as 50 copper conductors, side by side — and weigh only 2½ pounds per 100-ft. roll. The standard size of each of the rectangular conductors in the tape is 0.0015 in. by 0.03 in.



Wiring harness of Tape Cable provides flexible, flat 50-conductor interconnection system.

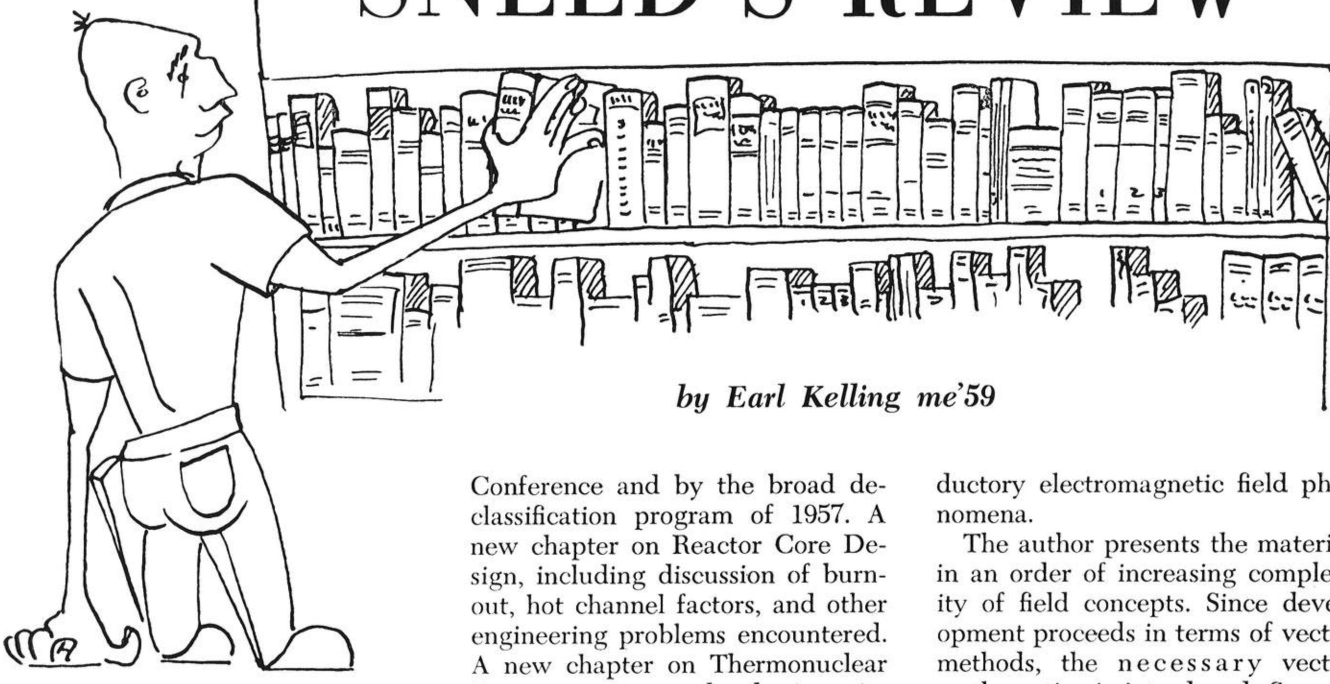
Obviously, with such small cross sections, no deterioration of the conductor is permissible. Yet temperatures, particularly in missile applications, are high. The answer is found in copper which is free of oxygen—eliminating oxidation, scale formation and conductivity losses.

In other high temperature applications, copper's high thermal conductivity can be used to protect more delicate parts from excessive heat. For this reason it is useful in missile nose cones. And, of course, copper's excellent corrosion resistance is often valuable in exposed parts and in tubing.

The field of missiles and rocketry is but another example of a design frontier where the versatility of copper and the copper alloys helps make progress possible.

If you'd like to know more about these metals and their design possibilities, send for "A Guide to Copper and its Alloys." Write The Copper & Brass Research Association, 420 Lexington Avenue, New York 17, New York.

SNEED'S REVIEW



by Earl Kelling me'59

INTRODUCTION TO NUCLEAR ENGINEERING

By Richard Stepenson
McGraw–Hill, $9.50

Here is the first book to bring together the many unique engineering problems encountered in the nuclear energy field. It is intended as an introductory survey of this field for engineers who are taking or who have completed a conventional engineering curriculum. It is assumed that the reader is familiar with the standard engineering operations, and only the unique features of nuclear energy are discussed. Numerous examples and problems are included.

The discussion covers such topics as—

- Nuclear fission
- The nuclear chain reactor
- Radiation shielding
- Reactor materials
- Reactor control
- Separation of stable isotopes
- Chemical processing of radioactive materials
- Remote handling equipment

The author has revised the numerous teaching aids, problems, and exercises on the basis of experience with the first edition. The major changes in this second edition include: Complete revision of the entire book based on the information released in the Geneva Conference and by the broad declassification program of 1957. A new chapter on Reactor Core Design, including discussion of burnout, hot channel factors, and other engineering problems encountered. A new chapter on Thermonuclear Reactions giving the basic principles of this new field of research.

The author, Richard M. Stephenson received his Ph.D. from Cornell University in 1946 and taught in the University of Minnesota's Department of Chemical Engineering from 1946–1950. From 1950–1954 he was Senior Design Engineer at the Oak Ridge National Laboratory, and in 1954 he became Associate Professor of Nuclear Engineering at New York University. Professor Stephenson has worked as a research engineer with the General Chemistry Company. At present he is serving as visiting professor at the Vienna Institute of Technology under a Fulbright grant.

INTRODUCTION TO ELECTROMAGNETIC FIELDS

By Samuel Seely
McGraw–Hill Book Company,
308 pages, $8.50

In addition to providing a sound background in electricity and magnetism, this book also serves as the foundation on which to develop later work in field operated devices, such as tranducers and rotating electrical machinery, and the important problems of electromagnetic field theory. The book covers the usual important topics, such as: current flow fields, electrostatics, electromagnetism, and introductory electromagnetic field phenomena.

The author presents the material in an order of increasing complexity of field concepts. Since development proceeds in terms of vector methods, the necessary vector mathematics is introduced. Several features of the book set it apart from others in the field:

1. The development proceeds from considerations of a study of the current flow field, to the static electric field, the static magnetic field, and then dynamic fields. This provides an excellent means for understanding scalar and vector fields.
2. Considerable emphasis is placed on the concept of energy storage in fields and the relationship to forces, and the energy flow concept. This provides the essential background for the study of field operated devices.
3. Many illustrative examples of very important practical applications of the theory are used to show the formulation and the solution of problems.

Professor Seely's introduction of material through field plotting experiments presents the scalar potential field first, and makes clear the relation between the scalar field and the vector field. The introduction of vector mathematics as needed in the development serves to provide the reader with this powerful shorthand mathematical method, and to make him familiar with the form in which all more subsequent advanced books are written and developed.

Measurements

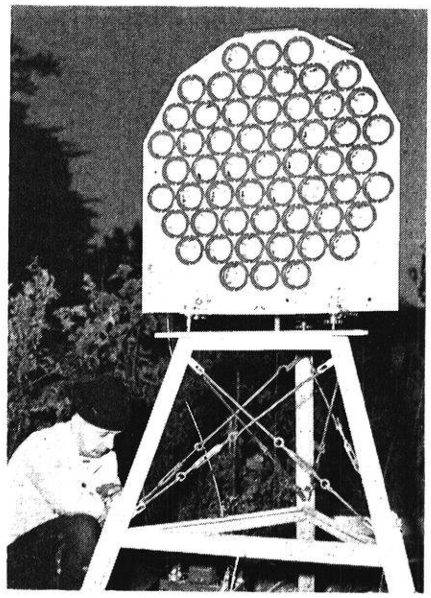
(Continued from page 45)

scale air mapping in mountainous terrain.

The chief item of equipment is the airborne profile recorder. This is a precision radar set which measures the distance from the aircraft to the reflecting earth's surface and immediately records it on a high-speed tape as the airplane travels along a nearly constant-level surface in the atmosphere. The closest approximation to such a reference surface for radar altimetry operations is the isobaric surface or that surface along which the barometric pressure is constant. Since such a surface is not necessarily a level (or constant altitude) surface, but is usually tilted up or down, its elevation is determined at the beginning and end of each flight line by measuring the height of the airplane above a lake or level ground surface of known elevation.

Basically the airborne profile recorder (APR) consists of a parabolic reflector having a beam width of about 1.5°, which is mounted on the underside of the aircraft. The transmitter unit feeds short pulses of radio energy to the reflector which radiates the beam vertically downward to the ground. A portion of such energy is reflected back to the APR which measures the round-trip time and converts it to distance which is automatically recorded to provide a virtual profile of the terrain beneath the plane along the flight line. Since the resulting profile is of little value unless it can be correctly positioned and oriented with respect to various known features of the region, it is necessary to obtain photographic coverage along the flight path. A common way of relating the profile and the aerial photography is to record a tick on the margin of the profile tape at the moment an exposure is made.

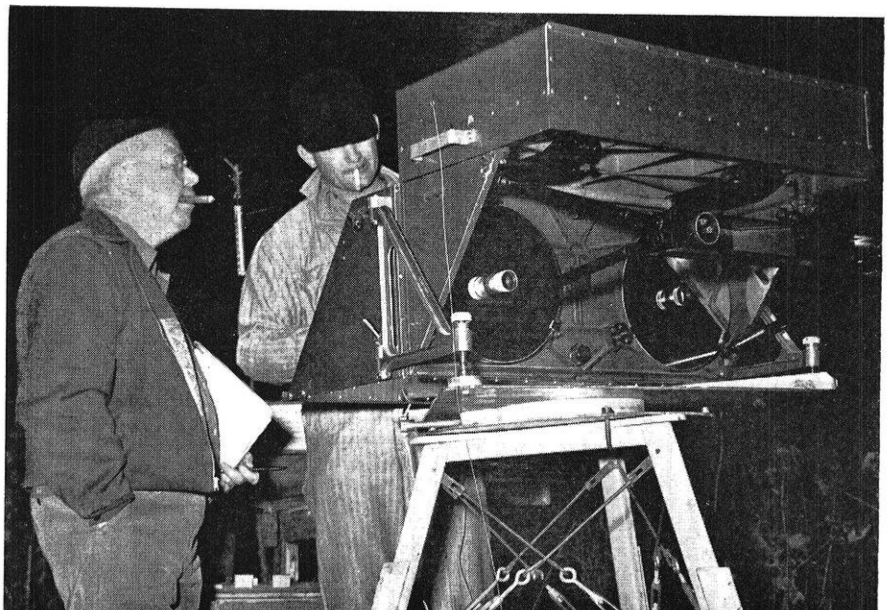
Partly to check the accuracy of the equipment and proposed technique, and also to provide control elevations for the ends of the parallel profiles, control flights were planned by the United States Geological Survey to encircle the area over which the profiles were to be obtained. The control routes were to be flown three or more times. On each flight, elevations were to be determined for designated lakes, river crossings, and flat sections of land. These features were selected so that the elevations of many of them could be checked by ground methods from bench marks that had been established previously not too far away. It was stipulated that the total spread of the three or more elevations determined for any feature should not exceed 20 ft. Of 22 elevations so determined, all satisfied this requirement of having not more than a 20 ft spread, the average spread of readings being 11 ft.



Bank of reflecting prisms used with the Geodimeter.

It was further stipulated that the average of the several elevations determined for each feature should check the ground-survey determinations within a tolerance of $\pm(10 - 2\sqrt{m})$ft, where m is the distance in miles from the nearest check point or from the start of the run. Of 14 elevations so checked, all were well within this limit. The maximum error was ±23 ft at a distance of 114 miles from the check point, where a tolerance of 31 ft was allowed; the absolute average error was less than 10 ft.

"Our research has only begun, yet tremendous strides have been made despite great handicaps. Thus far, many of our instruments have not been designed for surveying but are modified wartime instruments. Much of the research has been accomplished with military personnel. That means a constant turnover of technicians. Continued progress is inevitable and so we see another example of the impact of electronics on our civilization. We can fire 'electronic bullets,' count them as we fire them, and measure distance in that manner. History has proved that development follows good maps. Who can predict what the impact of these new techniques will be during the coming century."[1]



—U. S. Coast & Geodetic Survey Photos

Geodimeter transmitter–receiver unit.

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[1] C. I. Aslakson, "Electronics in Surveying," *A.S.C.E. Proceedings*, Sept. 1953, pp. 284–1 to 284–13.

THE END

Science Highlights

(Continued from page 39)

As of today, the output of electronic computers can be recorded by photography at the rate of 100,000 characters a second, and a rate of 1,000,000 characters a second in the near future is foreseen.

In fact, photography can record faster than the computer can compute, and because it can, photography has made it possible to use the highly expensive computer at full efficiency. The small amount of energy required for photographic recording renders this method faster than the electrostatic and magnophotographic methods of recording.

Speaking of photographic methods of retrieving stored information, the benefits of such systems have scarcely yet been realized.

For example all known medical information could be stored in a single place. The physician, faced with a rare disease, could telephone to this center and, within a matter of minutes, have the precise and most useful information needed out of all medical history for making his diagnosis.

Some still faster films may come from research of simpler processing for black-and-white and for color photography.

It would take a rash man to predict the developments another ten years will bring. We know that the usefulness of photography will be vastly expanded.

SPACE-AGE INSULATING

Difficult space-age insulating problems may be solved by a new white fibrous material, which combines light weight with excellent resistance to heat.

Called fibrous potassium titanate, the new product is composed of a compact mass of crystalline fibers which due to their fineness give it a talc-like feel. Because of the small diameter (less than 1/25,000 of an inch) and high reflectance of the fibers, the new insulating material blocks heat penetration by scattering incoming infrared rays.

The product was developed by the Du Pont Company's Pigments Department based on fundamental research on new forms of inorganic materials by the company's Central Research Department.

Fibrous potassium titanate appears best suited for insulating applications where space and weight are critical. In the 1300° to 2100° F. range, it is about twice as effective on a volume basis as any known insulating material.

As a thermal insulator at high temperatures, fibrous potassium titanate may offer construction advantages for rockets and missiles, aircraft and atomic-powered vehicles. Suggested but as yet untried uses include insulation for missile nose cones and rocket combustion chambers.

Other suggested applications include use for electrical and acoustical insulation, reflective shielding for heating units and ovens, gaskets and packing, filters, fire blankets and protective clothing, high temperature paints or coatings, high temperature cement and caulking, paper filler, and plastic reinforcement.

Blocks, which can be formed into any desired shape while wet, show exceptional dimensional stability upon prolonged exposure to heating. After six days aging at 1900° F., blocks have shown no dimensional change. Fibrous potassium titanate has almost four times the insulating value of commercial firebrick at comparable temperatures with one-twelfth the weight.

One of the unusual advantages of the product is ease of fabrication. Presently available forms include loose fibers, loose fill, blocks of varying densities, mats of various thicknesses, and "lumps." Also available is a trowelable material which, when combined with water, can be spread onto almost any irregular surface like mortar.

THE END

W.S.P.E.

(Continued from page 31)

3. Electrical with the established sub-fields of Communications, Electrical Machinery, Electric Power-Generation and Distribution, Illumination, Industrial Electronics.
4. Mechanical with the established sub-fields of Air conditioning-Heating-Refrigeration, Heat Power and Heat Engines, Industrial, Machine and Tool Design.
5. Metallurgical with the established sub-fields of Metallurgical Research and others.
6. Mining with the sub-fields to be approved by the Board.

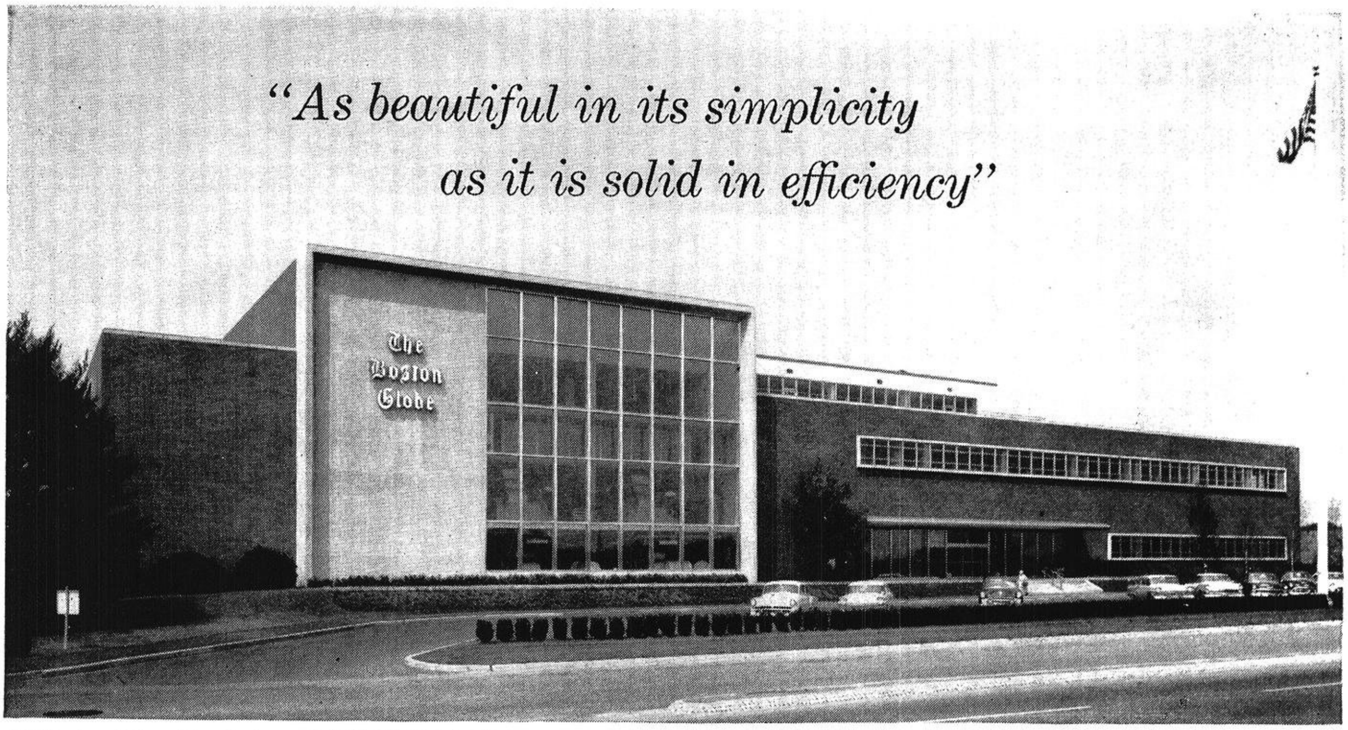
To qualify for registration as a Professional Engineer the applicant must in addition to passing the 2-day examination have a record of 8 years of satisfactory engineering experience, 4 of which may have been gained by formal education.

The next engineering examination after the January 26 and 27, 1959, examination will be conducted by the Board about the middle of June 1959, with April 15, 1959, as the closing date for filing application to enter it.

THE END

APPLICATIONS FOR MEMBER AND AFFILIATE MEMBER—SEPTEMBER 27, 1958

Name and Position	Address	Reg. No.	Sponsor
MILWAUKEE			
John H. Schmidt, PE Senior Project Engineer A. C. Spark Plug	1901 E. Beverly Rd. Milwaukee, Wis.	E-6579	Norbert Sem, PE
Herbert J. Zwarra, PE Transmission Engr. Wis. Telephone Co.	4791 N. Elkhart Ave. Milwaukee 11, Wis.	E-6596	W. C. Lallier, PE
Francis R. Manci Mechanical Engr. Lofte & Fredericksen	11833 W. Gilbert Ave. Milwaukee 13, Wis.	ET-1855	W. C. Dries, ET
Richard A. Pieri Service Engr. General Electric Co.	4855 W. Electric Ave. Milwaukee 1, Wis.	ET-1381	C. E. Matheis, PE
SOUTHWEST			
W. Perry Bentheimer, PE Design Engr.—Elec. Dept. Carl C. Crane, Inc.	2702 Monroe St. Madison 5, Wis.	E-6678	Carl C. Crane, PE
Joseph W. Spradling, PE Product Engineer Carnes Corporation	4316 Hillcrest Dr. Madison 5, Wis.	E-4797	Stanley Nestingen, PE
FOX RIVER VALLEY			
Emil A. Weber, PE President McMullen & Pitz Construction Co.	923 Commercial St. Manitowoc, Wis.	E-486	Charter Member



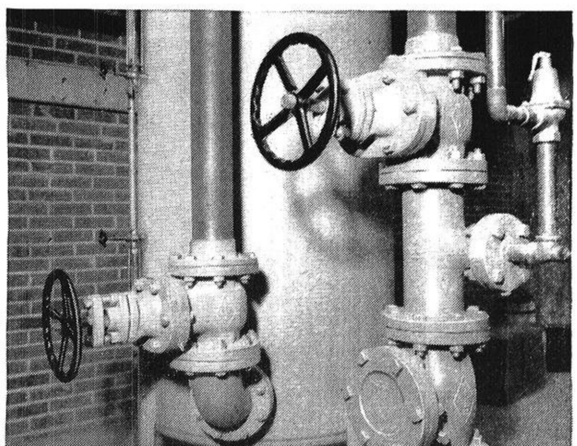
Architect and Consulting Engineer: GANTEAUME & McMULLEN, BOSTON • *General Contractor:* TURNER CONSTRUCTION COMPANY, BOSTON
Heating and Air Conditioning Contractor: THE MERRILL COMPANY, INC., BOSTON • *Plumbing Contractor:* M. AHERN CO., BOSTON

New Boston Globe Building relies on JENKINS VALVES

When the Boston Globe moved into this modern newspaper plant, it *made* news. A showplace for passersby with its battery of 37 presses turning out the news in a "picture window" two stories high, the new $12,000,000 home of the 86-year-old Globe is a model of efficient operation.

Efficiency is seen throughout the building plan. For example, practically all mechanical departments are on the first floor. The stress on efficient, trouble-free operation is equally evident in the equipment specifications which provided for utmost dependability in everything mechanical. To assure complete dependability in the control of water, air, gas, heating and air conditioning lines, Jenkins Valves were chosen.

Because of such confidence, "JENKINS" has been the trusted valve specification of three generations of building men. Yet the valves that have this well-earned confidence *cost you no more*. . . . Jenkins Bros., 100 Park Avenue, New York 17.



These valves on the cooling system for press plates are among 1,402 Jenkins Valves serving the 15-acre Globe building.

Sold Through Leading Distributors Everywhere

JENKINS VALVES

LOOK FOR THE JENKINS DIAMOND
JENKINS® SINCE 1864
Jenkins Bros

FINAGLE FACTORS

(Continued from page 46)

Multiply	*By*	*To Get*
miles per hour per sec	1.467	feet per sec per sec
miles per hour per sec	1.6093	km per hour per sec
miles per hour per sec	0.4470	M per sec per sec
miles per minute	2682	centimeters per sec
miles per minute	88	feet per second
miles per minute	1.6093	kilometers per min
miles per minute	60	miles per hour
milligrams	10^{-3}	grams
millihenries	10^{6}	abhenries
millihenries	10^{-3}	henries
millihenries	$1/9 x 10^{-14}$	stathenries
milliliters	10^{-3}	liters
millimeters	0.1	centimeters
millimeters	0.03937	inches
millimeters	39.37	mils
mils	0.002540	centimeters
mils	10^{-3}	inches
miner's inches	1.5	cubic feet per min
minutes (angle)	$2.909 x 10^{-4}$	radian
minutes (angle)	60	seconds (angle)
months	30.42	days
months	730	hours
months	43.800	minutes
months	$2.628 x 10^{6}$	seconds
myriagrams	10	kilograms
myriameters	10	kilometers
myriawatts	10	kilowatts
Ohms	10^{9}	abohms
Ohms	10^{-6}	megohms
Ohms	10^{6}	microhms
Ohms	$1/9 x 10^{-11}$	statohms
ohms per mil foot	166.2	abohms per cm cube
ohms per mil foot	0.1662	microhms per cm cube
ohms per mil foot	0.06524	microhms per in. cube
ounces	8	drams
ounces	437.5	grains
ounces	28.35	grams
ounces	0.0625	pounds
ounces (fluid)	1.805	cubic inches
ounces (fluid)	0.02957	liters
ounces (troy)	480	grains (troy)
ounces (troy)	31.10	grams
ounces (troy)	20	pennyweights (troy)
ounces (troy)	0.08333	pounds (troy)
ounces per square inch	0.0625	pounds per sq inch
Pennyweights (troy)	24	grains (troy)
Pennyweights (troy)	1.555	grams
Pennyweights (troy)	0.05	ounces (troy)
perches (masonry)	24.75	cubic feet
pints (dry)	33.60	cubic inches
pints (liquid)	28.87	cubic inches
poundals	13,826	dynes
poundals	14.10	grams
poundals	0.03108	pounds
pounds	444,823	dynes
pounds	7000	grains
pounds	453.6	grams
pounds	16	ounces
pounds	32 17	poundals
pounds (troy)	0.8229	pounds (av)
pounds per cubic foot	$1.356 x 10^{7}$	centimeter-dynes
pound-feet	13,825	centimeter-grams
pound-feet	0.1383	meter-kilograms
pound-feet	421.3	kg-cm squared
pounds-feet squared	144	pounds-in. squared
pounds-feet squared	2.926	kg-cm squared
pounds-inches squared	$6.945 x 10^{-3}$	pounds-feet squared
pounds-inches squared	0.01602	cubic feet
pounds of water	27.68	cubic inches
pounds of water	0.1198	gallons
pounds of water	$2.660 x 10^{-4}$	cubic feet per sec
pounds of water per min ..	0.01602	grams per cubic cm
pounds per cubic foot	16 02	kg per cubic meter
pounds per cubic foot	$5.787 x 10^{-4}$	pounds per cubic inch
pounds per cubic foot	$5.456 x 10^{-9}$	pounds per mil foot
pounds per cubic inch	27.68	grams per cubic cm
pounds per cubic inch	$2.768 x 10^{4}$	kg per cubic meter
pounds per cubic inch	1728	pounds per cubic foot
pounds per cubic inch	$9.425 x 10^{-6}$	pounds per mil foot
pounds per foot	1.488	kg per meter
pounds per inch	178.6	gıam per cm
pounds per mil foot	$2.306 x 10^{6}$	grams per cubic cm
pounds per square foot	0.01602	feet of water
pounds per square foot	4.882	kg per square meter

Multiply	*By*	*To Get*
pounds per square foot	$6.944 x 10^{-3}$	pounds per sq inch
pounds per square inch	0 06804	atmospheres
pounds per square inch	2.307	feet of water
pounds per square inch	2.036	inches of mercury
pounds per square inch	703.1	kg per square meter
pounds per square inch	144	pounds per sq foot
Quadrants (angle)	90	degrees
Quadrants (angle)	5400	minutes
Quadrants (angle)	1.571	radians
quarts (dry)	67.20	cubic inches
quarts (liq)	57.75	cubic inches
quintals	100	pounds
quires	25	sheets
Radians	57.30	degrees
Radians	3438	minutes
Radians	0.637	quadrants
radians per second	57.30	degrees per second
radians per second	0.1592	revolutions per second
radians per second	9.549	revolutions per min
radians per sec per sec	573.0	revs per min per min
radians per sec per sec	9.549	revs per min per sec
radians per sec per sec	0.1592	revs per sec per sec
reams	500	sheets
revolutions	360	degrees
revolutions	4	quadrants
revolutions	6.283	radians
revolutions per minute	6	degrees per second
revolutions per minute	0.1047	radians per second
revolutions per minute	0.01667	revolutions per sec
revs per min per min	$1.745 x 10^{-3}$	rads per sec per sec
revs per min per min	0.01667	revs per min per sec
revs per min per min	$2.778 x 10^{-4}$	revs per sec per sec
revolutions per second	360	degrees per second
revolutions per second	6.283	radians per second
revolutions per second	60	revs per min
revs per sec per sec	6.283	rads per sec per sec
revs per sec per sec	3600	revs per min per min
revs per sec per sec	60	revs per min per sec
rods	16.5	feet
Seconds (angle)	$4.848 x 10^{-6}$	radians
spheres (solid angle)	12.57	steradians
spherical right angles	0.25	hemispheres
spherical right angles	0.125	spheres
spherical right angles	1.571	steradians
square centimeters	$1.973 x 10^{5}$	circular mils
square centimeters	$1.076 x 10^{-3}$	square feet
square centimeters	0.1550	square inches
square centimeters	10^{-6}	square meters
square centimeters	100	square millimeters
sq cm (cm sqd)	0.02402	sq inches (inches sqd)
square feet	$2.296 x 10^{-5}$	acıes
square feet	929.0	square centimeters
square feet	144	square inches
square feet	0.09290	square meters
square feet	$3.587 x 10^{-8}$	square miles
square feet	.1296	square varas
square feet	1/9	square yards
sq feet (feed sqd)	$2.074 x 10^{4}$	sq inches (inches sqd)
square inches	$1.273 x 10^{6}$	circular mils
square inches	6.452	square centimeters
square inches	$6.944 x 10^{-3}$	square feet
square inches	10^{6}	square mils
square inches	645.2	square millimeters
sq inches (inches sqd)	41.62	sq cm (cm sqd)
sq inches (inches sqd)	$4.823 x 10^{-5}$	sq ft (feet sqd)
square kilometers	247.1	acres
square kilometers	$10.76 x 10^{6}$	square feet
square kilometers	10^{6}	square meters
square kilometers	0.3861	square miles
square kilometers	$1.196 x 10^{6}$	square yards
square meters	$2.471 x 10^{-4}$	acres
square meters	10.764	square feet
square meters	$3.861 x 10^{-7}$	square miles
square meters	1.196	square yards
square miles	640	acres
square miles	$27.88 x 10^{6}$	square feet
square miles	2.590	square kilometers
square miles	3,613,040.45	square varas
square miles	$3.098 x 10^{6}$	square yards
square millimeters	$1.973 x 10^{3}$	circular mils
square millimeters	0.01	square centimeters
square millimeters	$1.550 x 10^{-3}$	square inches

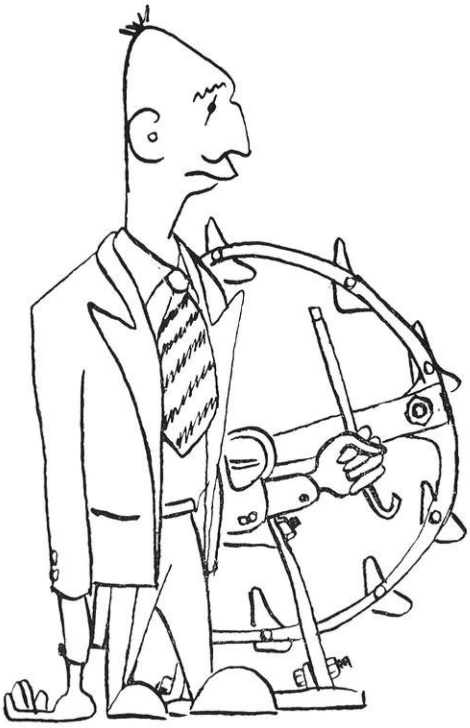
Multiply	By	To Get
square mils	1.273	circular mils
square mils	6.452×10^{-6}	square centimeters
square mils	10^{-6}	square inches
square varas	.0001771	acres
square varas	7.716049	square feet
square varas	.0000002765	square miles
square varas	.857339	square yards
square yards	2.066×10^{-4}	acres
square yards	9	square feet
square yards	0.8361	square meters
square yards	3.228×10^{-7}	square miles
square yards	1.1664	square varas
statamperes	$1/3 \times 10^{-10}$	abamperes
statamperes	$1/3 \times 10^{-9}$	amperes
statcoulombs	$1/3 \times 10^{-10}$	abcoulombs
statcoulombs	$1/3 \times 10^{-9}$	coulombs
statfarads	$1/9 \times 10^{-20}$	abfarads
statfarads	$1/9 \times 10^{-11}$	farads
statfarads	$1/9 \times 10^{-5}$	microfarads
stathenries	9×10^{20}	abhenries
stathenries	9×10^{11}	henries
stathenries	9×10^{14}	millihenries
statohms	9×10^{20}	abohms
statohms	9×10^{5}	megohms
statohms	9×10^{17}	microhms
statohms	9×10^{11}	ohms
statvolts	3×10^{10}	abvolts
statvolts	300	volts
steradians	0.1592	hemispheres
steradians	0.07958	spheres
steradians	0.6366	spherical right angles
steres	10^{3}	liters
Temp (degs C) + 273	1	abs temp (degs C)
Temp (degs C) + 17.8	1.8	temp (degs Fahr)
temp (degs F) + 460	1	abs temp (deg F)
temp (degs F) − 32	5/9	temp (degs Cent)
tons (long)	1016	kilograms
tons (long)	2240	pounds
tons (metric)	10^{3}	kilograms
tons (metric)	2205	pounds
tons (short)	907.2	kilograms
tons (short)	2000	pounds
tons (short) per sq ft	9765	kg per square meter
tons (short) per sq ft	13.89	pounds per sq inch
tons (short) per sq in	1.406×10^{6}	kg per square meter
tons (short) per sq in	2000	pounds per sq inch
Varas	2.777	feet
Varas	33.3333	inches
Varas	.000526	miles
Varas	.9259	yards
volts	10^{8}	abvolts
volts	1/300	statvolts
volts per inch	3.937×10^{7}	abvolts per cm
volts per inch	1.312×10^{-3}	statvolts per cm
Watts	0.05692	Btu per min
Watts	10^{7}	ergs per second
Watts	44.26	foot-pounds per min
Watts	0.7376	foot-pounds per sec
Watts	1.341×10^{-3}	horsepower
Watts	0.01434	kg-calories per min
Watts	10^{-3}	kilowatts
watt-hours	3.415	British thermal units
watt-hours	2655	foot-pounds
watt-hours	1.341×10^{-3}	horsepower-hours
watt-hours	0.8605	kilogram-calories
watt-hours	367.1	kilogram-meters
watt-hours	10^{-3}	kilowatt-hours
webers	10^{8}	maxwells
weeks	168	hours
weeks	10,080	minutes
weeks	604,800	seconds
Yards	91.44	centimeters
Yards	3	feet
Yards	36	inches
Yards	0.9144	meters
Yards	1.08	varas
years (common)	365	days
years (common)	8760	hours
years (leap)	366	days
years (leap)	8784	hours


Prelude to space
The U. S. Air Force's LOCKHEED F-104A STARFIGHTER, fastest production airplane in the world, is one of the current crop of military aircraft whose extreme speeds and operating altitudes typify the problems of projecting man into space and keeping him alive. HAMILTON STANDARD designs and builds the air conditioning, engine fuel control and engine starter equipment for the F-104A and other leading supersonic aircraft. This experience is now being used as the springboard for investigations into the problems of environmental control for human survival in space.
USAF
FG-786
56-786
The refrigeration package shown at the right which Hamilton Standard builds for the F-104A has the capacity to cool a seven to nine room house and weighs only 50 lbs.
If you are interested in sharing in the fascinating work that will help make possible man's new age of flight, contact:
MR. TIMOTHY K. BYE
Engineering Personnel Coordinator
or arrange for an interview with your college recruitment officer.
HAMILTON STANDARD
DIVISION OF UNITED AIRCRAFT CORP.
200 BRADLEY FIELD ROAD
WINDSOR LOCKS, CONNECTICUT

FINAGLE FACTORS

(Continued from page 53)

Multiply	*By*	*To Get*
Days	24	hours
Days	1440	minutes
Days	86,400	seconds
decigrams	0.1	grams
deciliters	0.1	liters
decimeters	0.1	meters
degrees (angle)	60	minutes
degrees (angle)	0.01745	radians
degrees (angle)	3600	seconds
degrees per second	0.01745	radians per second
degrees per second	0.1667	revolutions per min
degrees per second	0.002778	revolutions per sec
dekagrams	10	grams
dekaliters	10	liters
dekameters	10	meters
drams	1.772	grams
drams	0.0625	ounces
dynes	1.020×10^{-3}	grams
dynes	7.233×10^{-5}	poundals
dynes	2.248×10^{-6}	pounds
dynes per square cm	1	bars
Ergs	9.486×10^{-11}	British thermal units
Ergs	1	dyne-centimeters
Ergs	7.376×10^{-8}	foot-pounds
Ergs	1.020×10^{-3}	gram-centimeters
Ergs	10^{-7}	joules
Ergs	2.390×10^{-11}	kilogram-calories
Ergs	1.020×10^{-8}	kilogram-meters
ergs per second	5.692×10^{-9}	Btu per minute
ergs per second	4.426×10^{-6}	foot-pounds per min
ergs per second	7.376×10^{-8}	foot-pounds per sec
ergs per second	1.341×10^{-10}	horsepower
ergs per second	1.434×10^{-9}	kg-calories per min
ergs per second	10^{-10}	kilowatts
Farads	10^{-9}	abfarads
Farads	10^{6}	microfarads
Farads	9×10^{-11}	statfarads
fathoms	6	feet
feet	30.48	centimeters
feet	12	inches
feet	0.3048	meters
feet	.36	varas
feet	1/3	yards
feet of water	0.02950	atmospheres
feet of water	0.8826	inches of mercury
feet of water	304.8	kg per square meter
feet of water	32.43	pounds per sq ft
feet of water	0.4335	pounds per sq inch
feet per minute	0.5080	centimeters per sec
feet per minute	0.01667	feet per sec
feet per minute	0.01829	kilometers per hour
feet per minute	0.3048	meters per minute
feet per minute	0.01136	miles per hour
feet per second	30.48	centimeters per sec
feet per second	1.097	kilometers per hour
feet per second	18.29	meters per minute
feet per second	0.6818	miles per hour
feet per second	0.01136	miles per minute
feet per 100 feet	1	per cent grade
feet per sec per sec	30.48	cm per sec per sec
feet per sec per sec	1.097	km per hr per sec
feet per sec per sec	0.3048	meters per sec per sec
feet per sec per sec	0.6818	miles per hr per sec
foot-pounds	1.286×10^{-3}	British thermal units
foot-pounds	1.356×10^{7}	ergs
foot-pounds	5.050×10^{-7}	horsepower-hours
foot-pounds	1.356	joules
foot-pounds	3.241×10^{-4}	kilogram-calories
foot-pounds	0.1383	kilogram-meters
foot-pounds	1.286×10^{-3}	kilowatt-hours
foot-pounds per minute	3.766×10^{-7}	Btu per minute
foot-pounds per minute	0.01667	foot-pounds per sec
foot-pounds per minute	3.030×10^{-5}	horsepower
foot-pounds per minute	3.241×10^{4}	kg-calories per minute
foot-pounds per minute	2.260×10^{-5}	kilowatts
foot-pounds per second	7.717×10^{-2}	Btu per minute
foot-pounds per second	1.818×10^{-3}	horsepower
foot-pounds per second	1.945×10^{-2}	kg-calories per min
foot-pounds per second	1.356×10^{-3}	kilowatts
furlongs	40	rods
Gallons	3785	cubic centimeters
Gallons	0.1337	cubic feet
Gallons	231	cubic inches
Gallons	3.785×10^{-3}	cubic meters
Gallons	4.951×10^{-3}	cubic yards
Gallons	3.785	liters
Gallons	8	pints (liq)
Gallons	4	quarts (liq)
gallons per minute	2.228×10^{-3}	cubic feet per second
gallons per minute	0.06308	liters per second
gausses	6.452	lines per square inch
gilberts	0.07958	abampere-turns
gilberts	0.7958	ampere-turns
gilberts per centimeter	2.021	ampere-turns per inch
gills	0.1183	liters
gills	0.25	pints (liq)
grains (troy)	1	grains (av)
grains (troy)	0.06480	grams
grains (troy)	0.04167	pennyweights (troy)
grams	980.7	dynes
grams	15.43	grains (troy)
grams	10^{-3}	kilograms
grams	10^{3}	milligrams
grams	0.03527	ounces
grams	0.03215	ounces (troy)
grams	0.07093	poundals
grams	2.205×10^{-3}	pounds
gram-calories	3.968×10^{-3}	British thermal units
gram-centimeters	$9.302 \times 10^{3-}$	British thermal units
gram-centimeters	980.7	ergs
gram-centimeters	7.233×10^{-5}	foot-pounds
gram-centimeters	9.807×10^{-5}	joules
gram-centimeters	2.344×10^{-8}	kilogram-calories
gram-centimeters	10^{-5}	kilogram-meters
grams per cm	5.600×10^{-3}	pounds per inch
grams per cu cm	62.43	pounds per cubic foot
grams per cu cm	0.03613	pounds per cubic inch
grams per cu cm	3.405×10^{-7}	pounds per mil-foot
Hectares	2.471	acres
Hectares	1.076×10^{5}	square feet
hectograms	100	grams
hectoliters	100	liters
hectometers	100	meters
hectowatts	100	watts
hemispheres (solid angle)	0.5	sphere
hemispheres (solid angle)	4	spherical right angles
hemispheres (solid angle)	6.283	steradians
henries	10^{9}	abhenries
henries	10^{3}	millihenries
henries	$1/9 \times 10^{-11}$	stathenries
horsepower	42.44	Btu per min
horsepower	33,000	foot-pounds per min
horsepower	550	foot-pounds per sec
horsepower	1.014	horsepower (metric)
horsepower	10.70	kg-calories per min
horsepower	0.7457	kilowatts
horsepower	745.7	watts
horsepower (boiler)	33,520	Btu per hour
horsepower (boiler)	9.804	kilowatts
horsepower-hours	2547	British thermal units
horsepower-hours	1.98×10^{6}	foot-pounds
horsepower-hours	2.684×10^{6}	joules
horsepower-hours	641.7	kilogram-calories
horsepower-hours	2.737×10^{5}	kilogram-meters
horsepower-hours	0.7457	kilowatt-hours
hours	60	minutes
hours	3600	seconds



THE FERROUS WHEEL

by Joe Coel

IT'S THE TRUTH . . .

Some girls go in for necking—others go out for it.

Many of the girls you see at college are at the age where their voices are changing—from no to yes.

One thing a girl learns in college is how to refuse a kiss—without being deprived of it.

Being a man is difficult—if only for the reason that we must deal with women.

The hardest thing for a man to remember are the girls he told he would never forget.

A woman looks upon a secret in one of two ways. Either it is not worth keeping, or it is too good to be kept.

* * *

A new AFROTC officer stopped the young man in the neatly fitting uniform entering the Union and asked:

"What's the eighth general order?"

"I don't know," the fellow admitted.

"Have you ever been out to drill?"

"Nope."

"Don't you know enough to say sir, either? What outfit you in?"

"Me? I'm the Pepsi-Cola man."

* * *

Professor: "Jones, can you tell us who built the Sphinx?"

Jones: "I—I did know, sir, but I've forgotten."

Professor: What a calamity! The only man living who knows and he has forgotten."

Chem. E.: "On our date tonight, wear something seductive."

Coed: "What do you mean?"

Chem. E.: "Oh, nothing."

* * *

A group of civilians was touring a battleship when the guide paused before a bronze plate set in the deck and said reverently, "And this is where our gallant captain fell."

"Well, no wonder," said a little old lady, "I nearly tripped over the damn thing myself."

* * *

A sharp rap on the door startled the two lovers.

"Quick, it's my housemother," exclaimed the frightened co-ed. "Jump out the window."

"But we're on the thirteenth floor," the junior ME gasped.

"Jump," cried the co-ed. "This is no time to be superstitious."

* * *

A fire engine went screeching down the street, past a small bar. A very woozy character stumbled out of the bar and started to chase the fire engine. He ran for five blocks, but simply wasn't able to catch up with it, and finally he collapsed against a handy lamp post and shook his fist at the departing engine.

"Okay," he screamed, "keep your damn peanuts!"

* * *

"You've read that passage wrong, Miss Adams—it's 'All men are created equal,' not 'All men are made the same way.' "

The quiet little freshman co-ed from the country was on her first college date, and thrilled beyond words. She didn't want to appear "countrified"; she had put on her prettiest dress, got a sophisticated hair-do, and was all prepared to talk understandingly about music, art, or politics.

Her hero took her to a movie, and then to the favorite college cafe.

"Two beers," he told the waiter.

She, not to be outdone, murmured, "The same for me."

* * *

It seems this salesman had a lot of trouble locating one Colonel Sexhauer in the Pentagon. After a while, he started telephoning various departments. No success. Finally, he tried one last number.

"Hello?" he said eagerly, "Do you have a Sexhauer in your Office?"

"No, sir," said a girl's voice. "We don't even have a coffee break!"

* * *

Two engineering students were taking calculus for the first time and while waiting for the instructor to arrive, they took a quick perusal through the book. One of them came across the integral tables in the back of the book.

"Tell me," he asked his friend, "can you read that?"

"No," replied his friend, "but if I had my flute with me I could play it."

Little Willie was late for school and the teacher inquired as to the cause of his tardiness. "Mamma was ill, Daddy called the doctor, and I had to get my own breakfast," explained Willie.

"Well, you go right home and find out what was wrong with your mother," said the teacher, "it might be contagious, in which case your presence in the room might expose me and the rest of the children."

So Little Willie went home and came back in a little while. "Teacher," he said, "Mamma had a baby and she said to tell you that if you were a good girl you wouldn't get it."

* * *

An ME was very indignant at being arrested. He staggered into the police station and before the captain had an opportunity to say anything he pounded his fist on the desk and said: "What I wanna know is why I've been arrested."

"You were brought in for drinking," answered the captain.

"Well, thass different—thass fine —let's get started."

* * *

"How can you keep eating this dorm food?"

"Oh, it's easy. I just take a tablespoon of Drano three times a day.

* * *

Teacher (warning her children against catching cold): I had a little brother seven years old, and one day he took his new sled out in the snow when it was too cold. He caught pneumonia and three days later he died.

Silence for ten seconds.

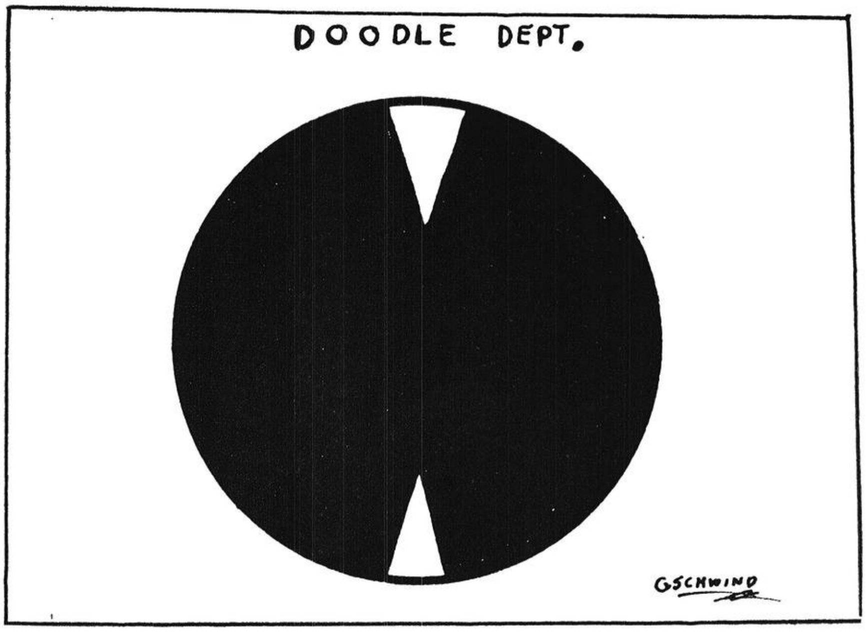
A voice from the rear: Where's his sled?

* * *

One day while we were eating, our waitress asked what we thought of the new uniforms that the girls had been outfitted with. They were black with white trimmings around the neck, the sleeves and the pockets and across the left breast pocket each waitress had her name embroidered in white.

After pirouetting for our benefit she faced us and asked, "Well, how do you like it?"

Jerry, my dinner partner, convulsed the house by staring at her embroidered name and dryly answering, "I like it very much, but tell me, what are you going to name the other one?



Looking at the world through a beer can.

* * *

She was only a photographer's daughter, but she was certainly well developed.

* * *

"Did you see that donkey fall down and break his leg?"

"No, did they blame the driver?"

"No, they said it was the asphalt."

* * *

"Give me a double shot quick, before the trouble starts!"

The bartender did and he drank it.

"Give me another double shot before the trouble starts!"

The bartender did and being puzzled, asked, "Before what trouble starts?"

"It's started now. I haven't any money."

* * *

Ch. E.: "I just bought a skunk."

M. E.: "Where you gonna keep 'im?"

Ch. E.: "Under the bed."

M. E.: "What about the awful smell?"

Ch. E.: "He'll just hafta get used to it like I did."

* * *

"Ah wins."

"What you got?"

"Three aces."

"No you don't. Ah wins."

"What you got?"

"Two eight's and a razor."

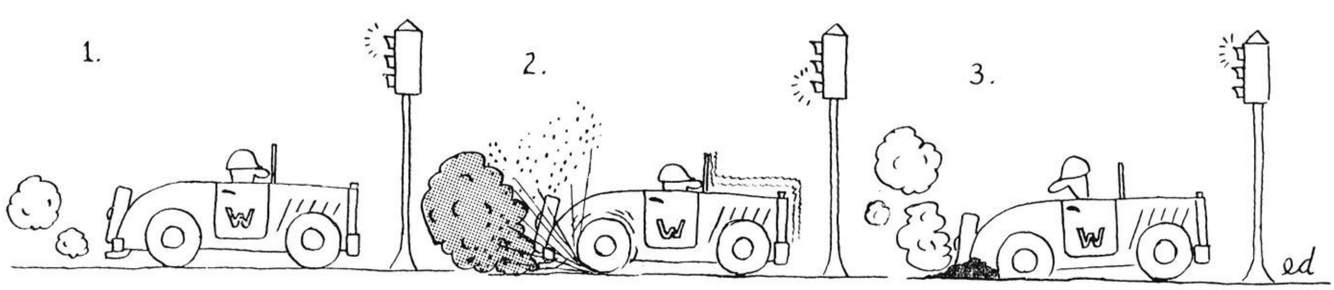
"You sho do. How come you is so lucky?"

* * *

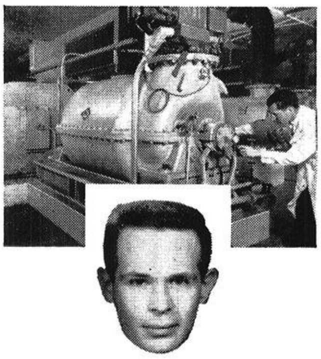
Co-ed: "I had a date with an absent-minded professor last night."

Co-ed No. 2: "How do you know he is absent-minded?"

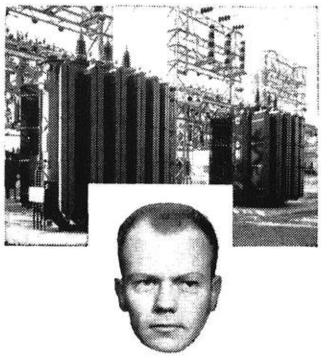
Co-ed: "He gave me a zero on a quiz this morning."



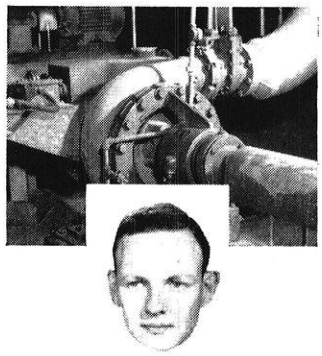
Allis-Chalmers training course has



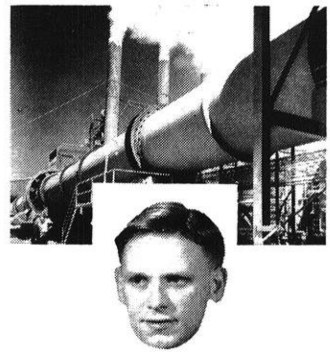
Aeronautical engineer Robert Claude, Parks College of Aero Technology, BS Aero Eng. '50, engineers compressors for wind tunnels.



Application engineering on large power transformers is handled by Michael Waterman, Case Institute of Technology, BSEE, '47.

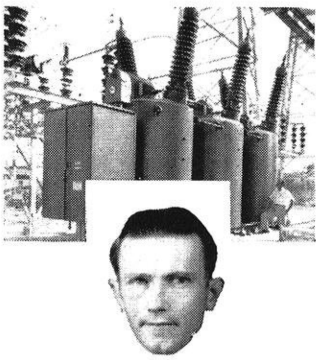


Sale of large centrifugal pumps to a wide range of industries is directed by Howard Godfrey, Oregon State College, ME '48.

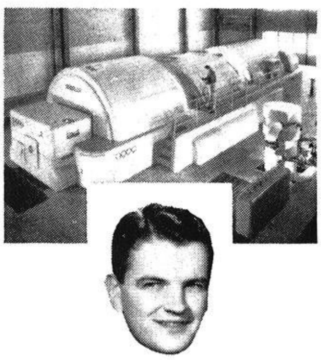


Field sales of America's widest range of industrial equipment is choice of Michael A. Mooney, University College, Dublin, BSE '53.

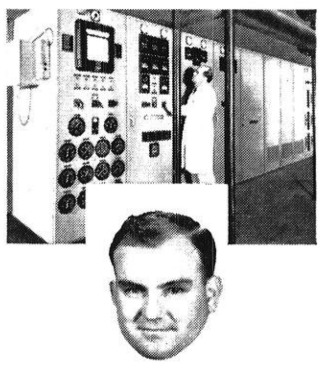
proved excellent springboard to



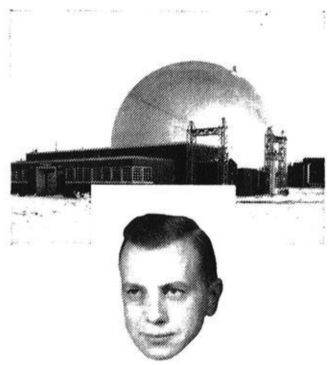
Sales and promotion man Irving Fisk, Clarkson College, EE '52, works with large power circuit breaking equipment.



Sales manager of large steam turbine generator units is interesting specialty of John M. Crawford, Clemson College, BME '49.



Sales engineering of high voltage electrical control is specialty of Ernest Horne, graduate of Alabama Polytechnic Institute, EE '49.



Nuclear engineer Raymond W. Klecker, University of Southern California, EE '49, is supervisor of design of nuclear reactors.

interesting and varied careers

YOU get off to the right start in your career at Allis-Chalmers—even though, at graduation time, you may not know exactly what you want to do.

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The course, incidentally, was started in 1904, and most of the A-C management team are graduates of it.

Your choice includes research, design, manufacturing, application and sales of hundreds of products in practically every industry . . . a wide range of fields from nucleonics to electronics to stress analysis.

Learn more about Allis-Chalmers. Contact the A-C district manager in your area or write Allis-Chalmers, Graduate Training Section, Milwaukee 1, Wisconsin.

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A-5601

So You Think You're SMART!

by Sneedly bs'60

SNEEDLY was very happy to receive the solutions to Novembers thought twisters promptly. The comments sent in were also very much appreciated.

About this time of the year when the days get colder and the nights get longer the approaching holiday season seems to grow in importance to all University of Wisconsin students. (by the way that does include the Engineers). To make this a more enjoyable and profitable season for you Sneedly has decided to add an extra problem this month. The first three problems will still be worth $10 and you do not need the solution of the extra problem in order to win. To those of you who are ready, willing and able to solve the extra problem an additional 10 dollars will be given. However, in order to win on the fourth problem the first three must also be solved. It would indeed be possible for someone to win $20 which would make a very nice Christmas present. So don't delay. He who hesitates is lost!

With the hope that the final 4 weeks of the semester will salvage those descending grades Sneedly wishes all his readers the very best Holiday Season ever. He also sends a very special Greeting to the young lady from Minneapolis who sent him that very nice letter.

Here are this month's problems:

A man has a 12 pint cask filled with moonshine. He wants to give 6 pints to a friend but besides the cask he only has a 7 pint and a 5 pint bottle. How can he get 6 pints into the 7 pint bottle?

* * *

How many minutes is it until 6 o'clock if 50 min. ago it was 4 times as many minutes past 3 o'clock?

* * *

A Civil Engineer staked out his square property with a rail fence seven rails high. Each rail, 8 feet 3 inches long, touches an adjoining rail at centers of support stationed along the perimeter of the field 8 feet 3 inches from center to center. The number of rails in the fence equals the number of acres in the field.

What is the length of his property?

Here is the extra problem worth a saw-buck.

There are 100 people at a barbeque with a supply of 100 Frankfurters. Each man eats 3 Hot Dogs, each woman 2, and each child ½. How many men, women and children were there?

The answers to the problems in the November issue were very easily solved as follows:

1. The Engineer had $8.75 in his pocket when he entered the first store. This answer may be found by setting up one equation with one unknown.
2. The second problem was tricky. However setting up two equations and solving them simultaneously give the answers of 21 and 28 years.
3. The third problem tested the ingenuity of you Engineers. This problem can be solved with the use of modulo theory. However for those of you who have not as yet had Math 115a a trial and error method would have given the answer of 47 lines.

Congratulations, Wayne Spindlu of Noyes Hall, on your correct answers.

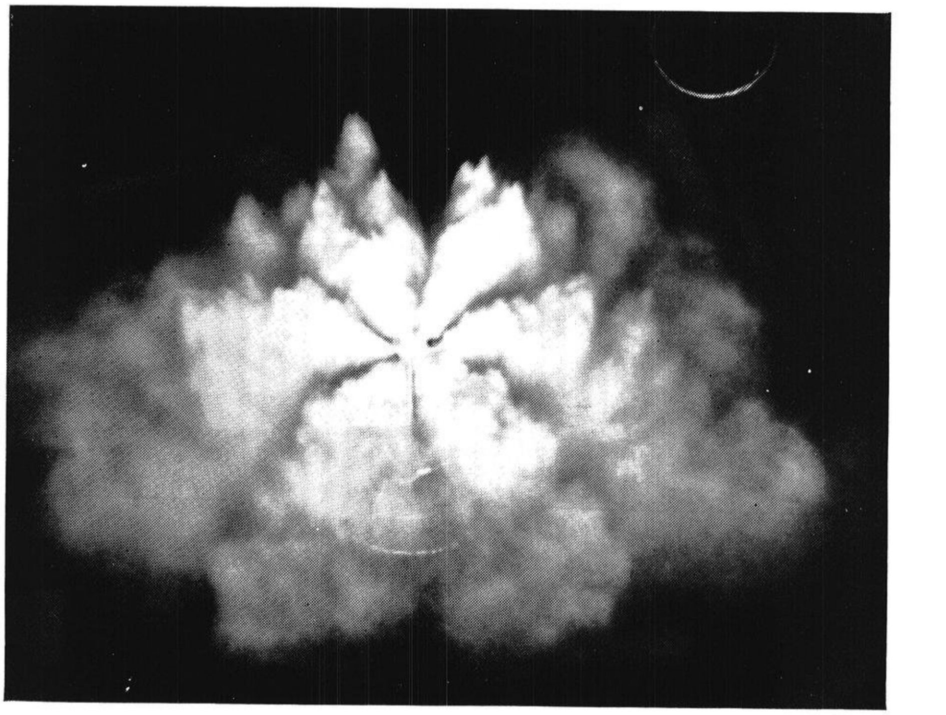
If there are any questions about Sneedley's solutions he will be most happy to explain them in further detail. So send all solutions and other correspondence to

SNEEDLY
c/o The Wisconsin Engineer
Mechanical Engineering Bldg.
Madison, Wisconsin

PHOTOGRAPHY AT WORK
No. 33 in a Kodak Series

The Army's first operational rotor-tip propelled jet helicopter—built by Hiller.

The camera has caught the fuel spray pattern within the rear end of the ram-jet engine even though passing by at about 450 miles per hour.



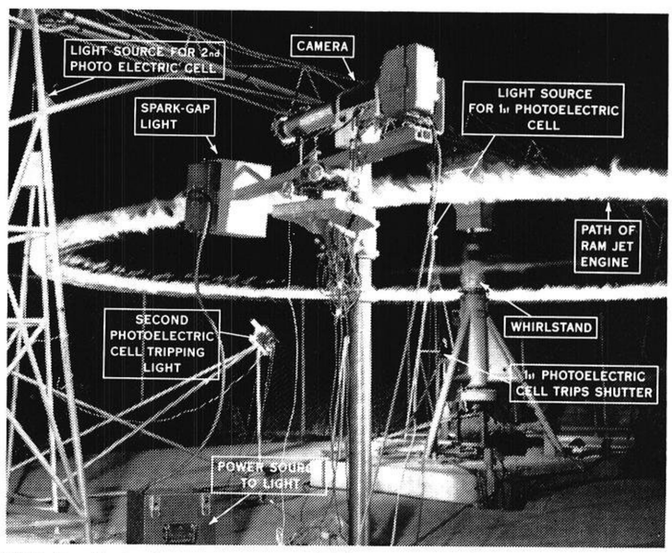
Project: Inspect rotor tip jets for a whirlybird

Hiller Helicopters wanted facts on the fuel spray pattern of a ram-jet engine whirling at speeds up to 700 feet per second. Photography got the job.

When Hiller Helicopters of Palo Alto, Cal.—a pioneer in vertical take-off aircraft—developed a rotor-tip ram-jet engine, they knew the fuel spray would be subject to high air velocity and centrifugal force up to 1200 G's. Would the fuel spray be deflected outward and cause the jet to lose thrust? They wanted to know. So they set up the camera with its fast eye to catch what otherwise couldn't be seen. And they learned the right angle of air intake and nozzle to obtain the greatest power.

Using photography in research is an old story with Hiller—just as familiar as using it for improving public relations. It's an example of the way photography plays many important roles in modern-day industry.

In whatever work you do you will find that photography will play a part in improving products, aiding quality control and increasing sales.



This is all the human eye could have seen of the whirling ram-jet engine as camera takes its picture.

CAREERS WITH KODAK

With photography and photographic processes becoming increasingly important in the business and industry of tomorrow, there are new and challenging opportunities at Kodak in research, engineering, electronics, design and production. If you are looking for such an interesting opportunity, write for information about careers with Kodak. Address: Business and Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

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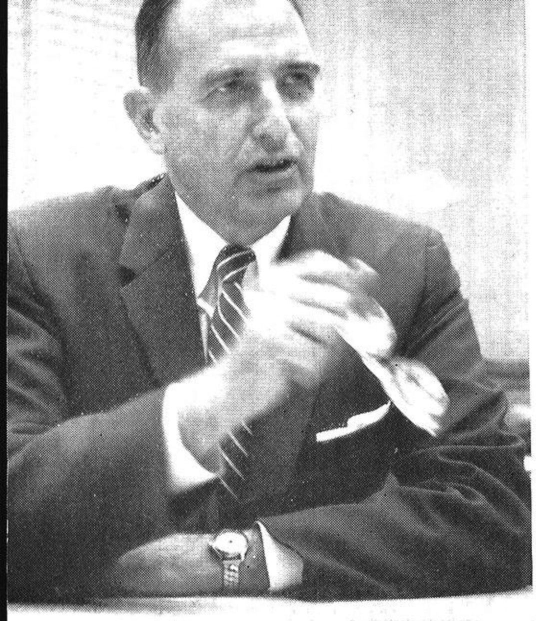

One of a series*

Interview with General Electric's W. Scott Hill Manager—Engineering Recruiting

Qualities I Look For When Recruiting Engineers

Q. Mr. Hill, what can I do to get the most out of my job interviews?

A. You know, we have the same question. I would recommend that you have some information on what the company does and why you believe you have a contribution to make. Looking over company information in your placement office is helpful. Have in mind some of the things you would like to ask and try to anticipate questions that may refer to your specific interests.

Q. What information do you try to get during your interviews?

A. This is where we must fill in between the lines of the personnel forms. I try to find out why particular study programs have been followed, in order to learn basic motivations. I also try to find particular abilities in fields of science, or mathematics, or alternatively in the more practical courses, since these might not be apparent from personnel records. Throughout the interview we try to judge clarity of thinking since this also gives us some indication of ability and ultimate progress. One good way to judge a person, I find, is to ask myself: Would he be easy to work with and would I like to have him as my close associate?

Q. What part do first impressions play in your evaluation of people?

A. I think we all form a first impression when we meet anyone. Therefore, if a generally neat appearance is presented, I think it helps. It would indicate that you considered this important to yourself and had some pride in the way the interviewer might size you up.

Q. With only academic training as a background, how long will it be before I'll be handling responsible work?

A. Not long at all. If a man joins a training program, or is placed directly on an operating job, he gets assignments which let him work up to more responsible jobs. We are hiring people with definite consideration for their potential in either technical work or the management field, but their initial jobs will be important and responsible.

Q. How will the fact that I've had to work hard in my engineering studies, with no time for a lot of outside activities, affect my employment possibilities?

A. You're concerned, I'd guess, with all the talk of the quest for "well-rounded men." We do look for this characteristic, but being president of the student council isn't the only indication of this trait. Through talking with your professors, for example, we can determine who takes the active role in group projects and gets along well with other students in the class. This can be equally important in our judgment.

Q. How important are high scholastic grades in your decision to hire a man?

A. At G.E. we must have men who are technically competent. Your grades give us a pretty good indication of this and are also a measure of the way you have applied yourself. When we find someone whose grades are lower than might be expected from his other characteristics, we look into it to find out if there are circumstances which may have contributed.

Q. What consideration do you give work experience gained prior to graduation?

A. Often a man with summer work experience in his chosen academic field has a much better idea of what he wants to do. This helps us decide where he would be most likely to succeed or where he should start his career. Many students have had to work hard during college or summers, to support themselves. These men obviously have a motivating desire to become engineers that we find highly desirable.

Q. Do you feel that a man must know exactly what he wants to do when he is being interviewed?

A. No, I don't. It is helpful if he has thought enough about his interests to be able to discuss some general directions he is considering. For example, he might know whether he wants product engineering work, or the marketing of technical products, or the engineering associated with manufacturing. On G-E training programs, rotating assignments are designed to help men find out more about their true interests before they make their final choice.

Q. How do military commitments affect your recruiting?

A. Many young men today have military commitments when they graduate. We feel it is to their advantage and ours to accept employment after graduation and then fulfill their obligations. *We have a limited number of copies of a Department of Defense booklet describing, in detail, the many ways in which the latter can be done. Just write to Engineering Personnel, Bldg. 36, 5th Floor, General Electric Company, Schenectady 5, N. Y.* 959-8

*LOOK FOR other interviews discussing: • Advancement in Large Companies • Salary • Personal Development.

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