ENGINEERING AND SCIENCE

MONTHLY

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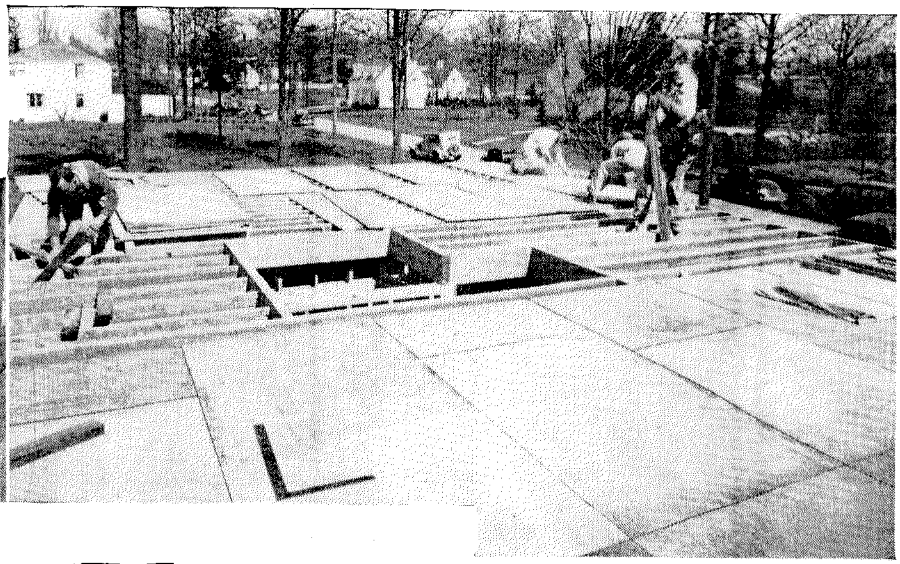

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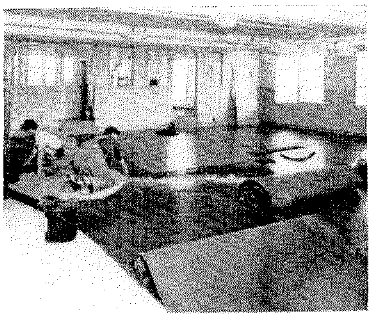

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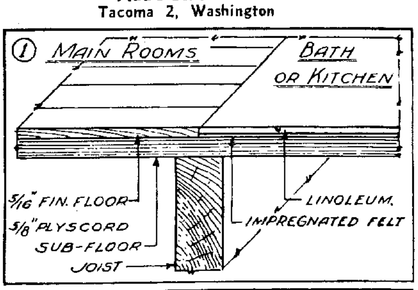

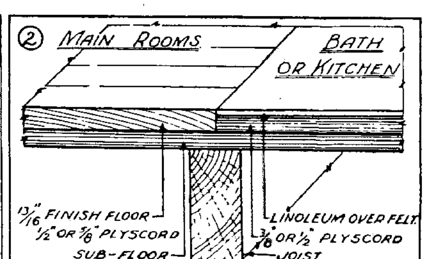

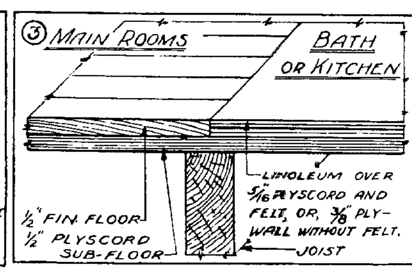

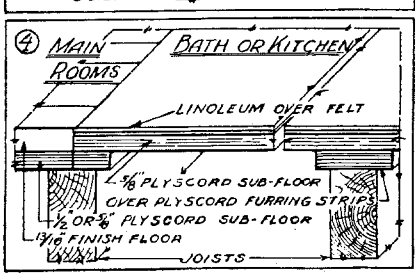

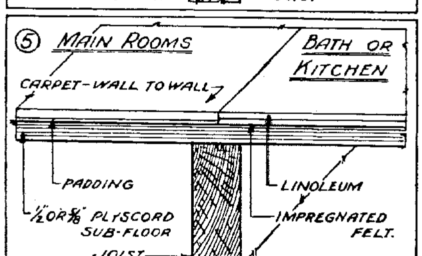

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BY-LINES

ROBERT T. KNAPP

Dr. Knapp received his Ph.D. degree from Caltech in 1929. He came to Caltech as an instructor in 1922, became assistant professor in 1930, and since 1936 has been associate professor of hydraulic engineering. Since 1935 he has been the cooperative agent for the Soil Conservation Service Cooperative Laboratory on the Caltech campus.

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VITO A. VANONI

Dr. Vanoni received his B.S. degree in 1926, his M.S. degree in 1932, and his Ph.D. in 1940 from the California Institute of Technology. Since 1935 he has been research project supervisor for the Cooperative Laboratory of the Soil Conservation Service located on the campus.

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HERBERT S. INGHAM

Mr. Ingham, vice president and chief engineer of the Metallizing Engineering Company, Inc., of Long Island City, N.Y., has been in charge of the Development and Manufacturing Departments of that company since 1937. He received his B.S. degree in mechanical engineering from Caltech in 1931. He has worked for Sterling Electric Motors, Inc., and the Harder and Ingham Machine Company.

. . .

CHESTER STOCK

Dr. Stock, Professor of Paleontology at the Institute since 1926, has guided the progress of paleontological research in the western states and Mexico, and has contributed to the study of early man in America. Dr. Stock has made important fossil discoveries in the California Coast Ranges, and has conducted important field studies under a John Simon Guggenheim Memorial Foundation fellowship.

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ROBERT A. MILLIKAN

Dr. Millikan, Chairman of the Executive Council of the California Institute of Technology, and Director of the Norman Bridge Laboratory of Physics, has contributed extensively to advancements in the field of physics. He was awarded the Nobel Prize in Physics of the Swedish Royal Academy of Science in 1923.

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The Truth Shall Make You Free

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ENGINEERING AND SCIENCE
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The Cooperative Hydraulics Laboratory

By ROBERT T. KNAPP

LABORATORY OBJECTIVE

The basic objective of the Cooperative Hydraulics Laboratory* is to investigate soil conservation problems involving hydraulics and to develop practical applications for field use. The major difference between normal and soil conservation hydraulics is that the former deals with clear water; whereas, the latter problems are complicated by sediment and debris. Therefore, much of the Laboratory's work has dealt with the interaction between flowing fluids and entrained sediment.

LABORATORY HISTORY

The Cooperative Hydraulics Laboratory was established in the spring of 1935. The concept of the Laboratory originated with Dr. W. C. Lowdermilk, then associate chief of the Soil Conservation Service in charge of research. As the name indicates, it is a joint activity of the Soil Conservation Service and the Institute. The laboratory staff members are SCS employees but they also are ranked as members of the Institute research staff. The Institute is represented directly through faculty members who are appointed "cooperative agents" by the Soil Conservation Service. These men participate in the formulation and direction of the research program of the Laboratory. Professor Theodore von Karman serves in this capacity on the wind-erosion aspects of the work and the writer on the hydraulic phases.

In its first years, the Laboratory was connected primarily with a single branch of the research organization of the Soil Conservation Service. Its scope has gradually broadened until now, under Dr. M. L. Nichols, chief of research, it has become a general hydraulics laboratory for the Soil Conservation Service Research Division as a whole.

The Laboratory was built in 1936. It was designed by the staff under Dr. V. A. Vanoni, who has been the Project Supervisor since the beginning. At first the Laboratory concentrated its activities on intensive studies of general soil conservation problems to secure sufficient knowledge to attack field problems. Intimate contact has always been maintained with the rapidly changing field problems of this young and fast-growing Service, and for the last few years much of its effort has gone to the solution of specific field problems. These studies have been in parallel with and complement the Laboratory's fundamental investigations. It is considered very important that the fundamental studies of sediment transportation be continued because much more knowledge will be required than is now available to meet the many difficult and complicated field problems.

EDITOR'S NOTE: In this issue of ENGINEERING AND SCIENCE is begun a series of two articles describing some of the work carried on at California Institute of Technology by the Soil Conservation Service and the application of the investigation. Drs. Vito A. Vanoni and Hans Albert Einstein have presented correlated material; Dr. Vanoni's article appearing in this issue; Dr. Einstein's to be published in August. To clarify the purpose and to outline the activities of the Soil Conservation Laboratory at California Institute of Technology, Dr. Robert T. Knapp has prepared these introductory remarks.

*Operated jointly by the U. S. Department of Agriculture Soil Conservation Service and California Institute of Technology.

LABORATORY ACTIVITIES

Among the first activities of the Laboratory was Vanoni's study of suspended load transportation. This, supplemented with investigations by H. Rouse, N. A. Christiansen, and E. R. Van Driest, and with observations from many field trips, formed the beginning of a good understanding of soil erosion mechanics.

Two other early activities were the studies of density currents as transporting agents for sediment by H. S. Bell and R. T. Knapp and wind erosion by F. Malina in consultation with Professor von Karman. Note that all have the same theme—the transportation of sediment by flowing fluids, which is, and probably always will be, the chief interest of this Laboratory.

The first field problem was the development of a standard design for a drop structure or small dam for use in controlling gully erosion. This was undertaken for the California-Nevada Region of the Soil Conservation Service. The resulting design has been adopted as standard by many operations regions of the Service. This was the first of a series of energy dissipation structures that have been studied. In addition, flow meters, samplers, and similar instrumental equipment have been developed.

During the first field study a practice originated which proved so successful that it became a fixed laboratory policy. It requested that a field engineer, acquainted with the problem, be detailed to work with the Laboratory. This practice has two principal benefits: the field representative brings to the Laboratory accurate knowledge of the problem details and takes back to the field

(Continued on Page 14)

FIG. 1. Concrete channel in orange grove near Pasadena. The channel had adequate capacity to carry the water flow but it could not carry the extremely heavy sediment flow.

SEDIMENT TRANSPORTATION RESEARCH

at California Institute of Technology

By VITO A. VANONI

WHEN the Soil Conservation Service (SCS) was established in 1935 as a bureau of the United States Department of Agriculture, the need for research in soil erosion control was recognized and projects were established to study the basic problems involved. Among the projects established was the one at the California Institute of Technology, which was assigned to the study of the basic hydraulics and mechanics of soil conservation problems. One of the most important research problems undertaken by the project was the study of sediment transportation. The data and results reported below were obtained in this study.

CONSERVATION OF FARM LAND

The SCS is concerned primarily with conserving moisture and controlling erosion on agricultural lands. In general, these objectives are accomplished by (1) encouraging the rainfall to percolate into the soil so as to be available for crop use, and (2) controlling the part of the rain that cannot be absorbed in such a manner that a minimum amount of valuable soil is carried away by the flow. It is easy to see that these two objectives are compatible since the more water is stored in the soil, the less is the flow available to transport soil from the land. Much of the effort of the Soil Conservation Service has gone into finding practical methods of attaining these objectives so that the soil can be protected while, at the same time, yielding a return to the farmer that will enable him to operate profitably. This has been done by modifying tillage practices, installing systems of flood channels, and, in some cases, by actually planting different crops or even by discontinuing farming, on critical pieces of land. The widely used practice of farming on the contour or across the slope instead of up and down the slope has its main value in encouraging infiltration by providing small depressions which can store rainfall, thus giving the water more time to percolate into the soil. The practice of terracing merely provides a drainage system by which the runoff can be discharged from the land without causing serious erosion. Terraces are shallow ditches placed on a relatively flat grade which carry the runoff flow to a terrace outlet channel which conducts the flow down the slope and finally into a stream. Drainage networks, including terraces or other channels as well as the main rivers, involve handling of sediment-laden waters. The control of systems of this kind is as much a problem of sediment transportation as it is one of handling water. As a matter of fact, the handling of clear water alone can be accomplished without difficulty by established methods, but the problem of passing the sediment load is still unsolved. *Fig. 1* illustrates the failure of a concrete storm channel in an orange grove near Pasadena. The channel was adequate to handle the water runoff, but it could not discharge the extremely heavy sediment load and, therefore, was filled with sediment. The storm waters then flooded the orange grove depositing coarse material that must be removed if permanent damage to the trees is to be avoided. Damage due to sedimentation as illustrated in the figure is less spectacular than erosion damage but it can be very destructive. Very often the sediment that is deposited where it is not wanted has been removed from where it is needed and damage is done to both the giver and the receiver.

Fig. 2 shows a large gully in southern California and illustrates another type of erosion that must be combated. In this particular case if the gully is allowed to continue uncontrolled, it will ultimately widen and deepen further and destroy valuable land. In order to determine the best type of control measure to apply, it is necessary to be able to predict just how the gully would react to various treatments. The objective of sediment transportation studies is to obtain knowledge that can be applied to this type of control problem. When it is possible to determine in advance how a particular stream will act, *e.g.*, whether it will deepen, widen, or fill up under given conditions of treatment, then it will be a relatively simple matter to determine the best course of treatment to follow. Sedimentation damage, as illustrated in *Fig. 1* and damage due to stream bank erosion occur with practically every major storm. Much of it can probably be avoided by the development and use of more effective and more reliable stream control methods. It is expected that new basic knowledge of sediment transportation will contribute materially to these developments.

SUSPENDED LOADS

Sediment transportation has been studied experimentally by many investigators. However, practically all of this work has dealt with the so-called bed load or the coarse material which is transported near the bed of the stream and very little work has been devoted to the so-called suspended load that is carried in suspension in the body of the flow. For this reason the early studies at the SCS Laboratory were devoted to the problems of suspended load and the material reported here will concern itself with this phase of transportation. Actually there is no sharp boundary line between bed and suspended load and the two types of transportation are closely related. In general, they occur simultaneously, although during low flows when little material is being transported, the material in suspension may be extremely small.

Material is held in suspension in a flow by turbulence. The turbulence or eddy motion is associated with velocity of the water, for when a sample is taken from a muddy stream, the turbulence soon dies out and the sediment finally settles leaving clear water. Since turbulence is so important to the problem, it seems appropriate to discuss it further.

TURBULENCE

Turbulence is the term applied to the irregular motion of a fluid normally observed in flows of water and other fluids. This motion is caused by a confused mass of eddies of different size that whirl with no particular pattern or system and move about in the flow. When the flow velocity is extremely low, the turbulence will be absent and the water particles will move along smooth, regular paths. Flows of this kind, which are known as laminar or streamline flows, occur so rarely in practice that they are of little interest and importance. *Fig. 3* shows the spread of globules which have been injected into a turbulent flow by the small tube shown at the left. The globules have the same specific gravity as the water so they indicate precisely the motion of the water particles. It can be seen from the figure that the motion is rather irregular and that as the globules proceed down stream, they tend to spread. In this particular case, the flow is from left to right in a flume 10 inches deep and 10 inches wide and the average velocity is 1.2 feet per second. The same kind of picture taken at a lower velocity would not be appreciably different. When the flow velocity is decreased, the cross components of velocity caused by the turbulence which spreads the globules become smaller, but the globules also move forward at a smaller velocity so that the resulting pattern does not change in appearance.

Figs. 4a and 4b show a mixture of fine sand and water being injected into flows having average velocities of 0.5 and 1.2 feet per second, respectively. It will be seen that the turbulence tends to spread the sand as it did the globules. However, in the flow with the lower velocity the entire jet of sand is settling, indicating that this particular flow cannot support material of this size. The sand in this experiement had an average diameter of 0.10 *mm* and individual grains had a settling velocity in still water of about 0.8 *cm* per second. In *Fig. 4b* where the velocity was increased, the jet of sand became practically horizontal, indicating that the flow at the higher velocity could transport material of this size, or, in other words, that the turbulence was of sufficient intensity to keep the sand in suspension. By increasing the size of the sand injected into the stream of *Fig. 4b* which is flowing at a velocity of 1.25 feet per second, the jet could again be made to settle to the bottom as in *Fig. 4a*, because the turbulence would not be sufficiently intense to counteract the greater settling velocity of the coarser sediment.

Turbulence originates at the bottom and sides of a channel due to friction and spreads into the body of the flow. As a whirling eddy in a turbulent flow moves away from a point, other eddies move in to take its place so that there is actually no resultant flow due to this action,

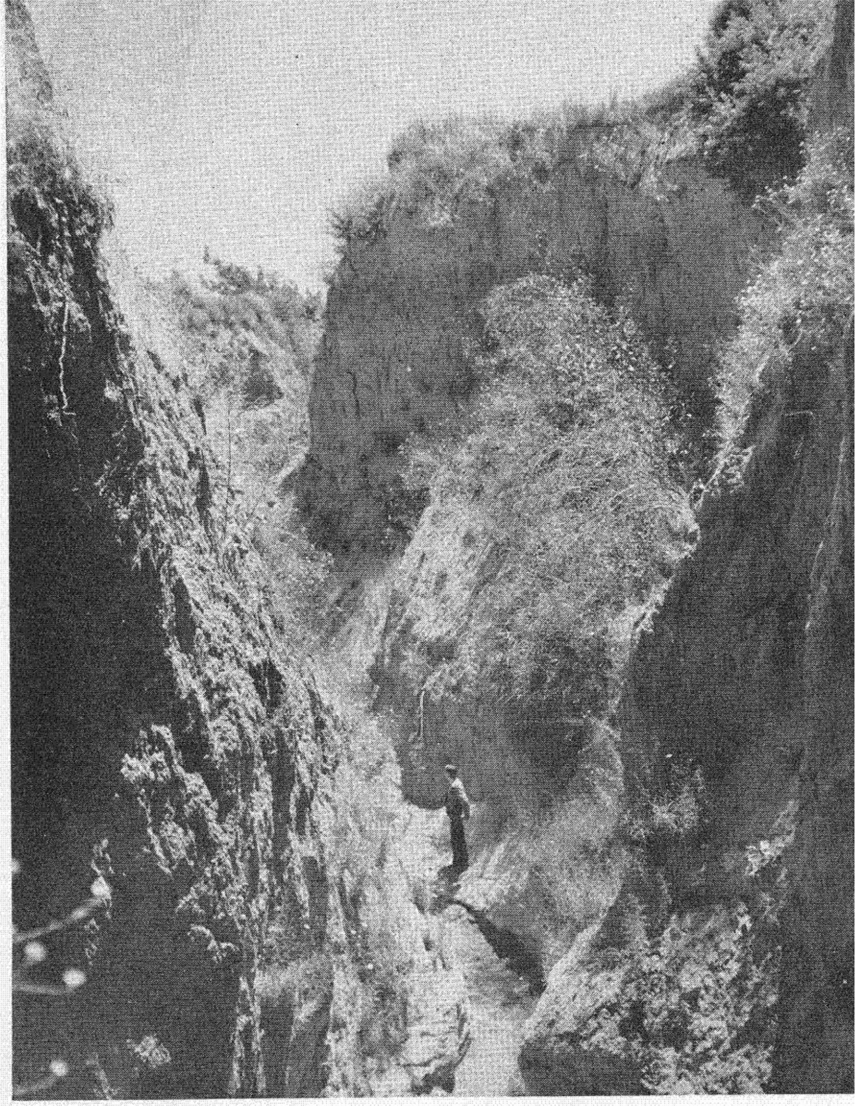
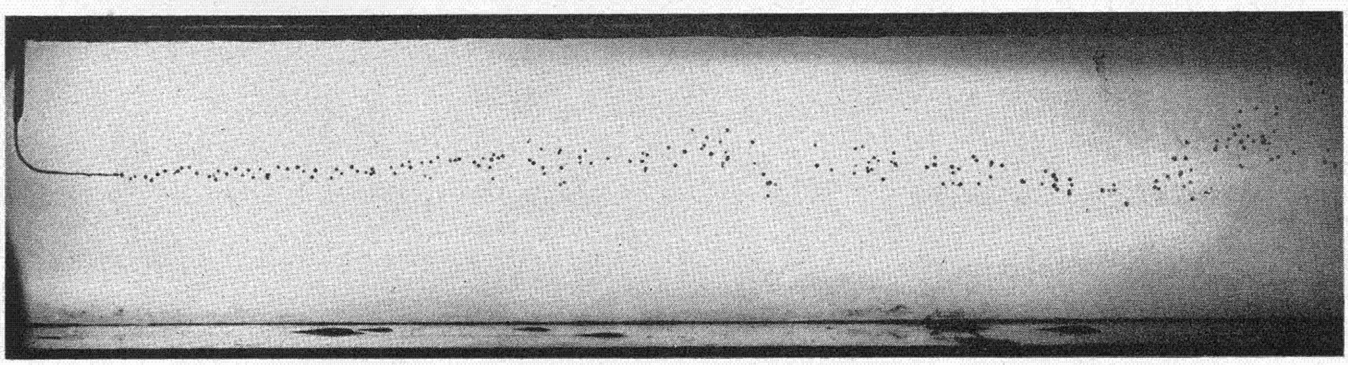
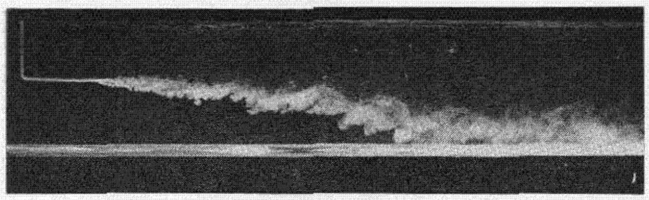


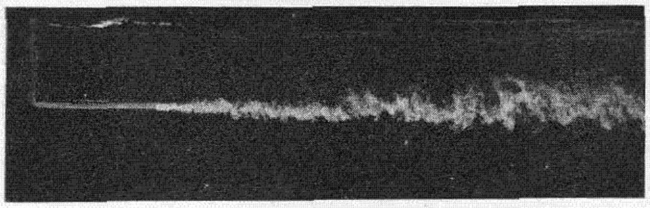
FIG. 2. A large gully in southern California.

FIG. 3. Globules in turbulent flow showing the erratic paths followed by water particles.





(a) Vel. 0.50 feet per second.



(b) Vel. 1.25 feet per second.

FIG. 4. Jets of 0.10 mm. sand in turbulent flow.

but merely an exchange between adjacent positions. In spreading, the turbulence actually transports fluid from the walls into the stream by means of interchanging fluid between adjacent levels. Any substance that is in the fluid masses thus moved will also be moved. It is in this manner, for instance, that the sand in *Fig. 4* was spread and kept in suspension. One important action of the turbulence is to transmit the friction from the walls of the channel to all filaments of the flow. Friction retards the water near the walls. Then when this retarded water is moved to a zone of higher velocity by the turbulence, it will be accelerated to the velocity of its new location and because of the acceleration it will exert a retarding force. By this process the friction force is finally transmitted from the walls and the bed to all parts of the cross section and a velocity profile is established, with the lowest velocity near the walls and the highest velocity in the interior.

SEDIMENT DISTRIBUTION RELATIONS

The rate of upward movement of sediment by the turbulence is given by $-\varepsilon\frac{dC}{dy}$ where ε is an exchange coefficient and C is the concentration of sediment at the distance y, from the channel bottom. The rate of settling of material under the action of gravity, is given by wC, where w is the settling velocity of the sediment in still water. By equating these two quantities, we obtain the differential equation for distribution of sediment over the depth which is

$$wC+\varepsilon\frac{dC}{dy}=0 \quad \text{.......... (1)}$$

This equation can be solved for channels where the width is great compared to the depth by introducing an equation for ε in terms of y which is obtained from velocity distribution equations. On this basis the solution becomes

$$\frac{C}{C_a}=\left[\frac{d-y}{y}\times\frac{a}{d-a}\right]^z \quad \text{.......... (2)}$$

where C_a is the sediment concentration at a reference level a distance a from the bottom and d is the depth of the flow. The exponent is given by

$$z=\frac{w}{k\sqrt{gdS}} \quad \text{.......... (3)}$$

where g is the acceleration of gravity, S is the slope of the channel and k is a constant having a value of about 0.4. It is to be noted that equation (2) gives the concentration as a fraction of the concentration at some reference level and does not give an absolute value. No theoretical expression has been developed for the absolute concentration. The exponent z is a ratio which, in a way, expresses the relative coarseness of a sediment in relation to the ability of the stream to transport it. It is seen that the larger is w, that is, the coarser is the sediment, the larger is z. On the other hand, for a given velocity, z can be decreased by increasing either the slope S, or the depth, or both. This merely means, that when the sediment with the settling velocity, w, is placed in a steeper channel with a deeper flow, it will be carried much easier and will appear finer to the larger and faster flowing stream.

EXPERIMENTAL CHECKS

To check equation (2), experiments were made in a flume 33 inches wide and 60 feet long in which the depth and velocity of the flow could be varied independently.

FIG. 5. View of SCS Laboratory showing flume used in sediment transportation experiments.

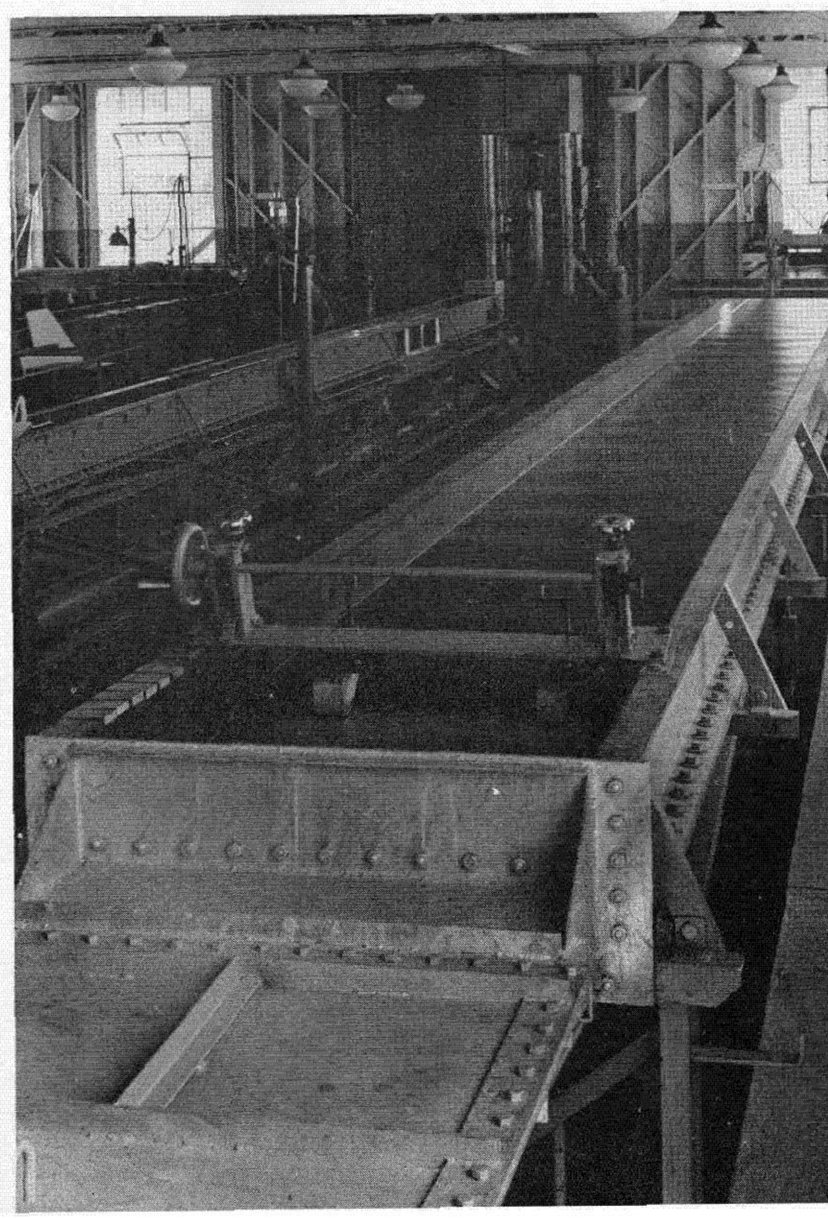


Fig. 5 is a general view of this flume from the inlet end. The water discharging from the end of the flume is pumped back to the inlet end along with the sediment so that the water is in motion all the time, and the sediment is thus prevented from settling in the system. The distribution of sediment over the depth and cross section was determined from samples siphoned from the flume. The head on the siphon is adjusted until the velocity into the sampling tube in the flume is the same as the stream velocity at the sampling point. In this manner a filament of the flow is removed without disturbance and a good sample of the suspended material is obtained.

Fig. 6 shows two typical sediment distribution curves obtained from measurements in the center of the flume. The relative sediment concentration is plotted on the horizontal scale against the elevation of the sampling point as a fraction of the distance between the reference level and the water surface. The solid lines have been fitted to the experimental points by selecting a value of the exponent, z, in the theoretical sediment distribution equation that gives the best fit. It will be noted that these curves fit the experimental points very well. In general, it was found that the exponent z, that gave the best fit of the data, did not agree with those calculated according to equation (3). The curves at the right of *Fig. 6* are for 0.10 *mm* sand, the solid curve being the one that fits the data and the dotted curve, the one given by theory as expressed by equation (2) with the exponent according to equation (3). It is seen that the theoretical curve deviates an appreciable amount from the experimental curve. The solid curve at the left of the figure fits data obtained from measurements with 0.16 *mm* sand. For this particular size of material the theoretical and experimental curves are identical and were found to be so in all experiments. It is the opinion of the writer that this agreement is a coincidence and that it is not to be taken as an indication of the complete validity of the theory. The fact that the theory fits the data as it does is truly remarkable and there is no reason why good use should not be made of it even in its present state. Deviations between the theory and experiment are thought to be due to errors introduced by the assumption that the exchange coefficient

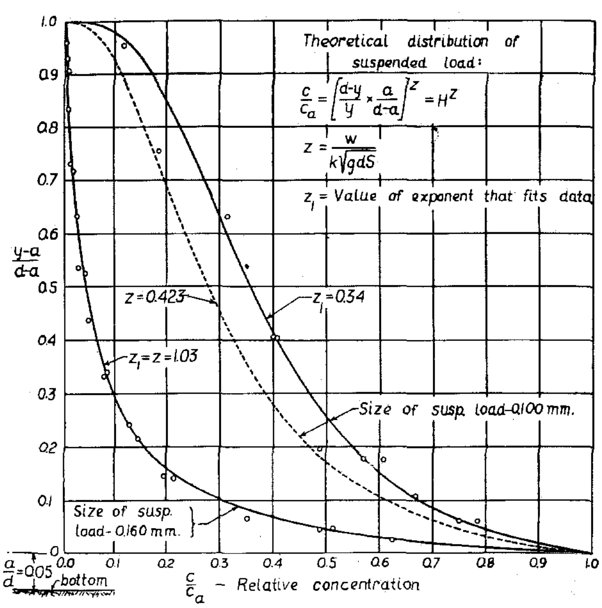


FIG. 6. Graph of experimental and theoretical sediment distribution at center of flume.

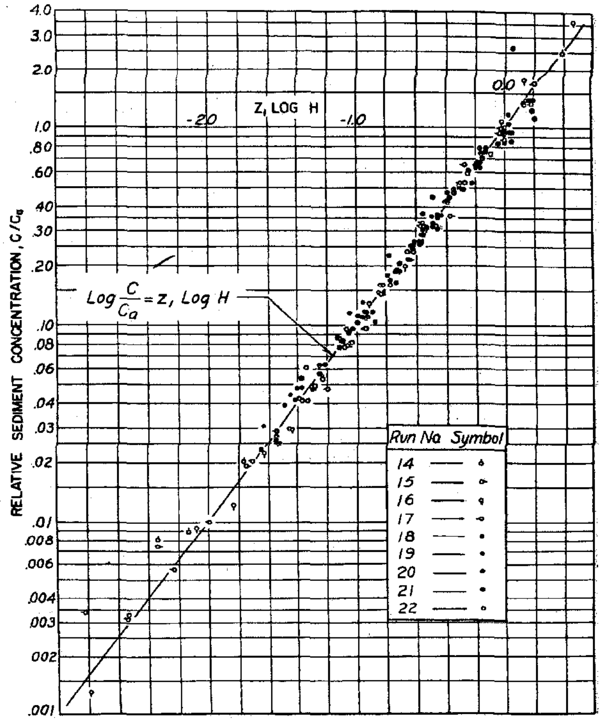


FIG. 7. Graph showing comparison of measured and calculated sediment distribution at center of flume.

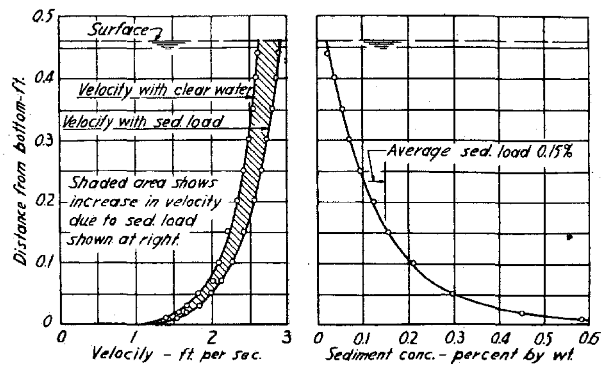


FIG. 8. Velocity and sediment distribution profiles at center of flume.

ε obtained from the velocity distribution equations can be applied to sediment distribution. It will be noted from *Fig. 6* that the distribution of the finer material is much more uniform than for the coarser material. It will also be noted that the smaller the value of z the more uniform is the distribution of material in the stream.

In *Fig. 7*, the relative concentration $\frac{C}{C_a}$ has been plotted on a logarithmic scale against the quantity zLog H, where H is the quantity:

$$\frac{(d-y)a}{y(d-a)}$$

Data plotted in this manner for nine runs made with different size sediment and flow depths and velocities fall very closely to a straight line and indicate again that the experimental results can be represented by a curve which follows equation (2). The fact that the data fall

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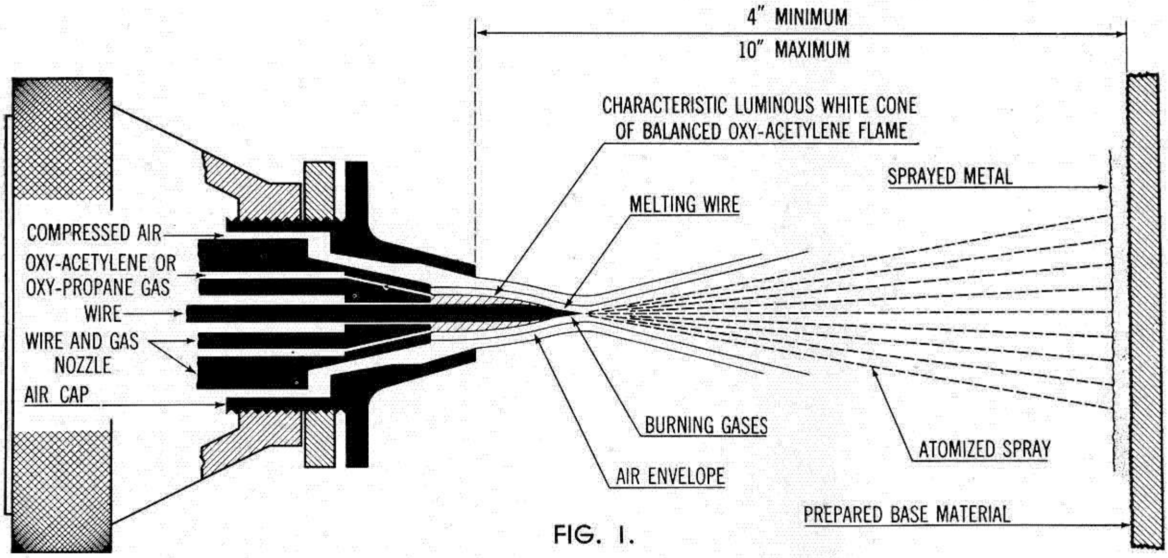


FIG. 1.

THE METALLIZING PROCESS

By HERBERT S. INGHAM

THE metallizing process has reached its maturity as an established industry. Fortunately, there was a long period of industrial development before the present war, so that well-established metallizing methods were available for the tooling up period in industry's war effort. Now, in the second phase of the war, metallizing is particularly active in maintaining the tools of war.

The metallizing process was invented by Schoop before the last war, and introduced into this country about 1920. In the last 24 years, it has become so interwoven with our national industrial life that it deserves the attention of engineers in almost every field. This is particularly true at the present time, as it gives to the engineering profession a new tool and a new material for the construction of postwar products.

The metallizing gun is being used today predominantly as a maintenance tool for repair and rebuilding of machinery. It is also being used to a greater extent than ever in the manufacture of new products, particularly as a means of producing new corrosion resistant materials. There are so many uses already developed for metallizing in the production of new products, that the handwriting on the wall of postwar activity is quite evident.

DESCRIPTION OF THE PROCESS

Metallizing is the process of melting metal and propelling it in finely divided form against an object to be coated. A number of different types of equipment have been developed to perform this process. According to the equipment used, the metal may be supplied in the form of either wire or powder, and may be melted by either an electric arc or any oxy-acetylene flame. The most practical metallizing guns today use metal supplied in the form of wire and utilize a flame for melting the metal. The flame is usually an oxy-acetylene flame, but other gases may be used in place of acetylene, such as propane, hydrogen, coal gas, etc.

Metallizing guns of this type consist of two major parts. The body of the gun constitutes the wire feeding mechanism which conveys the wire to the melting zone. The power is supplied by a high-speed air turbine which drives the wire feed rolls through a train of gears. The most modern equipment of this type has a variable speed governor built into the housing with the turbine. This type of equipment will provide a speed regulation of closer than five per cent from no load to full load over a wire speed range of from two and one-half to 12 and one-half feet per minute.

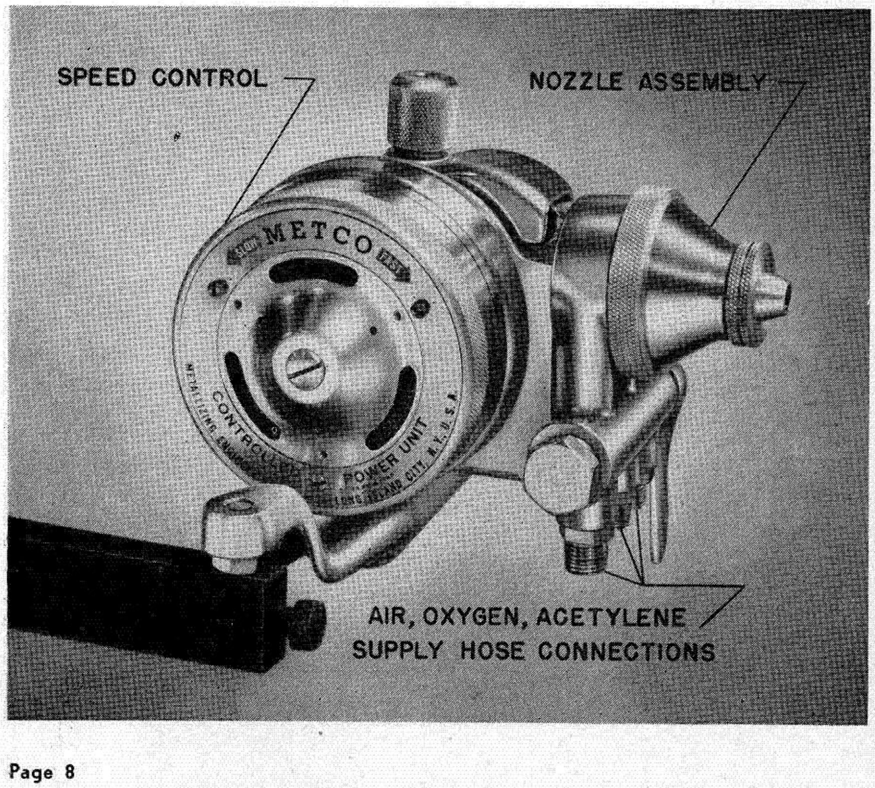


FIG. 2. Production type metallizing gun.

The melting and atomizing of the metal takes place in front of the nozzles, which are mounted on the gas head. *Fig. 1* shows the nozzle and air cap construction in cross-section. The wire is fed through the central hole of the wire nozzle. The combustible gas mixture emerges from a series of holes around the wire, producing a cone of hot, relatively inert, gases extending beyond the tip of the wire. Compressed air emerges from the space between the wire nozzle and the air cap, compressing the hot gases onto the wire tip at a high velocity so as to finely divide the molten metal and propel it from the gun.

Modern guns of this type spray any metal at high capacity and run in production, giving good continuous service. Many such guns, equipped with the governor speed control, are in operation today on automatic machines operating 24 hours per day. These guns will melt some steels at rates as high as 12 pounds per hour, and zinc at approximately 30 pounds per hour.

Fig. 2 illustrates a production type metallizing gun. A complete installation for metallizing must include, in addition to the gun, air compression equipment, suitable air cleaning and regulating equipment, accurate oxygen and gas regulators, and suitable wire handling equipment for coiled metal wire.

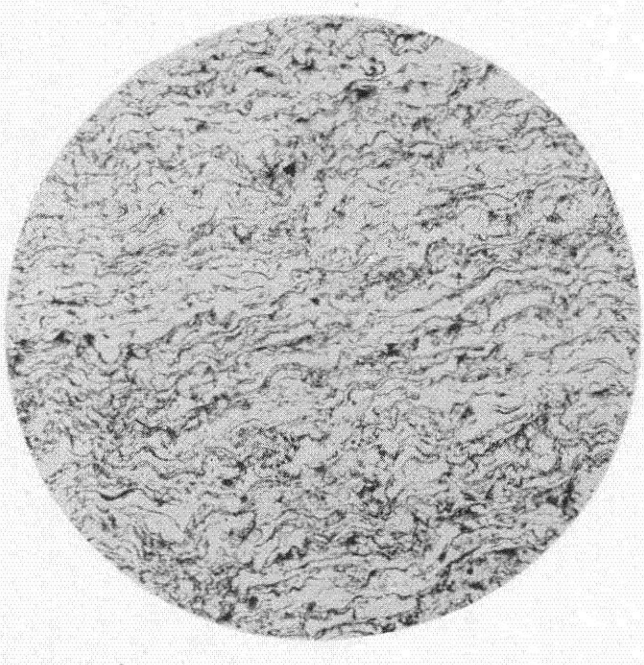


FIG. 3. Photomicrograph of normal spraymetal (100X).

STRUCTURE OF SPRAYMETAL

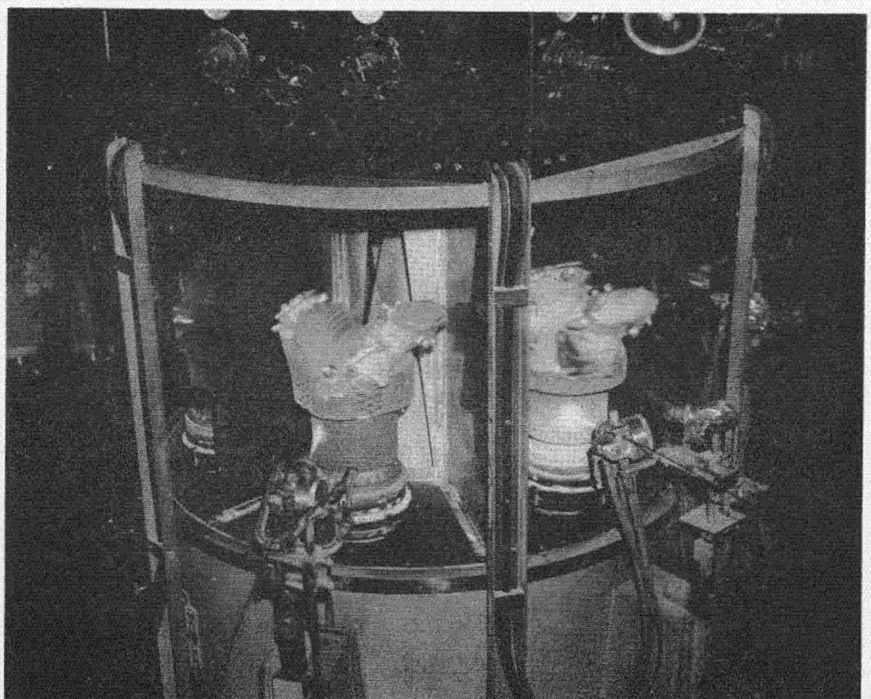
Spraymetal is the metal produced as the result of the metal spraying operation. It is chemically and physically different from the original wire sprayed. Considerable emphasis is required on this point, as spraymetal is a new engineering material. A good many mistakes in the past have been due to the misconception that spraymetal will have physical characteristics corresponding to the metal sprayed. This has led to the specification of wire analysis, for instance, which would have been suitable in the original state, but which, when sprayed, produced a spraymetal that proved unsuitable. Conversely, many of the desirable characteristics of spraymetal that do not exist in the original metal in wire form have been overlooked.

The conditions under which the metal is sprayed with modern equipment are subject to complete control. Therefore, spraymetal can be controlled and standardized. Entirely different structures can be obtained, using the same wire under different or abnormal spraying conditions.

The structure of normal spraymetal results from spraying under normal conditions such as would be normally obtained in a manufacturing or repair shop. This normal spraying, for instance, is thought of as a cold process because the work sprayed does not normally become appreciably heated. Also, for instance, normal spraying uses air as an atomizing medium. Therefore, normal spraying is the practical operation as it is carried out in the present practice of the process industrially. There are some theoretical refinements which can produce far different results in the laboratory, but which, at the present time, defeat the general purpose and utility in commercial metallizing.

AT RIGHT:

FIG. 4 Automatic metallizing machine for aircraft engine cylinders.



Normal spraymetal has a structure made up of a great many layers of small scale-like particles which overlap and interlock with each other. These scales generally are parallel to the surface sprayed, although they are very irregular. A typical spraymetal structure is shown in *Fig. 3*. This is a photomicrograph, at a magnification of 100X, of a cross-section of stainless steel syraymetal polished and etched. The structure is dependent for its strength largely upon a mechanical interlock of the particles, but in addition to the mechanical interlock, there is a certain amount of localized fusing or welding between particles.

The physical properties of spraymetal follow the same general pattern as the physical properties of the wire

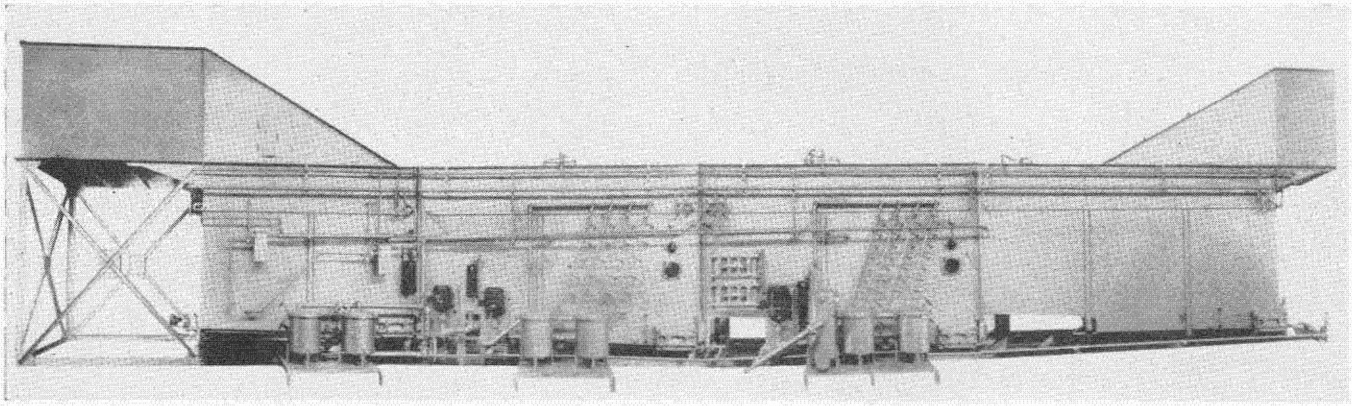


FIG. 5. Vapor spray-type degreaser metallized for corrosion resistance.

sprayed but certain general changes take place. The tensile strength and elongation are considerably reduced. The hardness of such soft metals as tin and babbitt increases considerably. The hardness of steels corresponds roughly to the hardness that would be produced in the same steel by rapid quenching. This hardness results in the spraying operation without requiring a separate treatment. However, as the structure is porous, ordinary hardness testing methods will indicate lower hardnesses. The actual hardness of the particles can be checked either by wear tests or by the micro-hardness testing method. As the structure is somewhat porous, the density is reduced by about 10 per cent. All normal sprayed metal has a certain oxide content. This oxide content tends to increase the brittleness, increase the hardness, and in some cases, as in sprayed aluminum, to increase the corrosion resistance.

It is, therefore, evident that the properties of each spraymetal must be evaluated in terms of its particular use. For instance, coatings for corrosion resistance generally are improved by their oxide content, but being porous, metals which are anodic to the base metal generally are used. For withstanding wear on a machine element, the porosity of the spraymetal structure becomes very important because of the ability of spraymetal to absorb oil. There are special uses for spraymetal, as in the manufacture of electrolytic condensers, where the peculiar porous structure is particularly important since it is responsible for the very large total area of effective condenser surface.

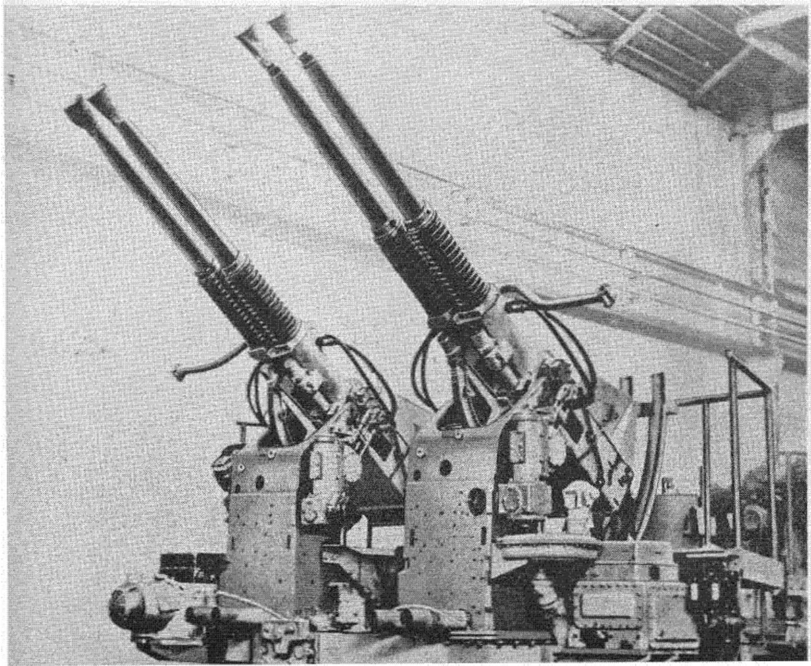
Abnormal spraymetal structures are too varied and not sufficiently important for much discussion here. The gas, oxygen and air pressures, the air cap adjustment and wire speed adjustment affect the resulting spraymetal. These factors are not too critical for average shop practice. One very interesting factor that affects the structure of spraymetal is the mechanical method by which it is formed. In this respect, it differs from all other metals. The structure will vary considerably, for instance, if the metal is sprayed from the gun at a work piece at too oblique an angle. By spraying very nearly parallel to the surface being coated, a very rough and porous structure can be produced. This is due to what is known as the shadow effect. The first particles striking form shadows behind them, which result in large open pores. As in all new materials and processes, an understanding of such fundamentals helps in the application.

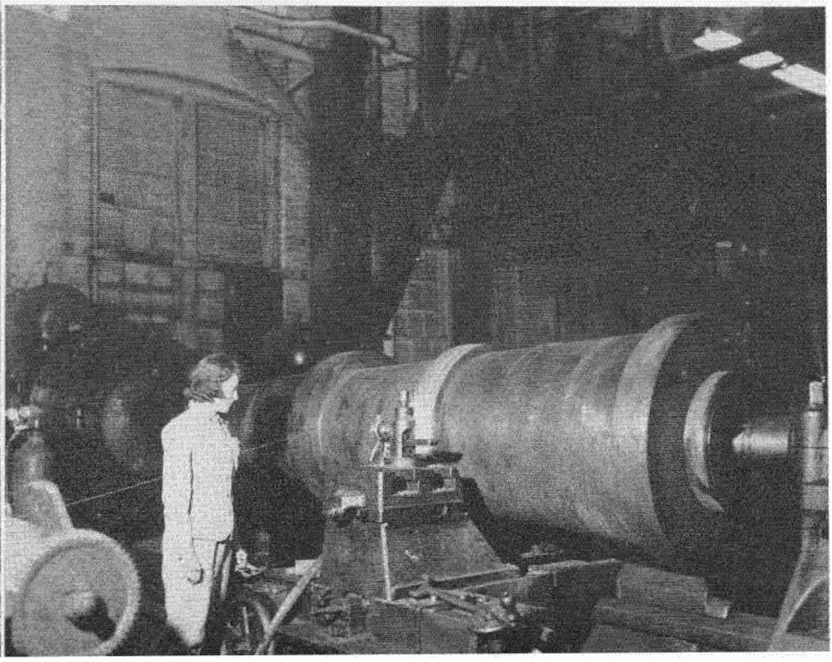
Spraymetal is sometimes heat-treated after application to the base metal. This is quite a common practice in the application of heat corrosion resistant coatings. Where the coatings are heat-treated, the resulting spraymetal structures are changed very considerably. In some cases the coatings alloy with the base or with other coatings, and in some cases the general scale-like structure disappears entirely, leaving coatings that have the pores isolated so that the coatings themselves are impervious to gases.

NATURE OF BOND OF COATINGS

Spraymetal is bonded to the base on which it is sprayed

AT LEFT: FIG. 6. "Bofors Twin" Navy gun which uses metallized cast iron for gear shroud in place of bronze. AT RIGHT: FIG. 7. Salvaging a 60,000-pound chill mold with 50 pounds of spraymetal.





either by mechanical adhesion or by alloying or both. Mechanical adhesion is used for the vast majority of commercial applications. The base metal to be sprayed usually is first prepared by mechanical roughening. The roughness produced must be of a type that has a great many overhanging edges and keyways so as to provide anchorage for the spraymetal. Grit blasting with angular steel grit or with aluminum oxide abrasives is commonly used. Articles such as soft steel shafting may be satisfactorily roughened by tearing a broken thread on the surface in machining. For the strongest bond on machine elements, a method of grooving and treating with a rotary tool has been developed. The tool roughens and spreads the lands between the grooves so that after the metal is sprayed it is locked into the machine element by a true dovetail type of joint.

A new method for bonding sprayed metal has recently been developed. This is a patented method known as the "fuse-bond process." It is suitable for preparing hardened smooth surfaces as well as soft surfaces prior to metallizing. A low-voltage, high-amperage source of current is connected to the work piece and to an air-cooled electrode holder which holds about six nickel-alloy electrodes. The electrodes are stroked or brushed across the work piece and the current which flows produces sufficient heat to form a foam or froth of electrode metal fused to the base metal. Viewed with suitable magnification, the deposit appears like frozen soap bubbles or lava. This surface produces a great many craters and interlocks for the sprayed metal so that a uniformly strong bond results.

The use of alloying between the coating and the base for bonding is, at present, restricted commercially almost entirely to coatings for heat corrosion resistance. In this application the grit blasting method is used to obtain sufficient bond for the coating to adhere before heat-treatment.

USE FOR CORROSION RESISTANCE

One of the primary uses for metallizing is to prevent corrosion. As the coatings are generally porous, aluminum, cadmium or zinc usually is used for protecting iron or steel, as these metals are anodic to iron. Occasionally metals such as lead or tin, which are cathodic to iron, are used. In such cases, it is necessary that the coatings either be sufficiently thick that they are impervious to the penetration of liquids, or be made non-porous by other treatment. Lead may be made non-porous by wire brushing between coatings. Other metals may be made non-porous

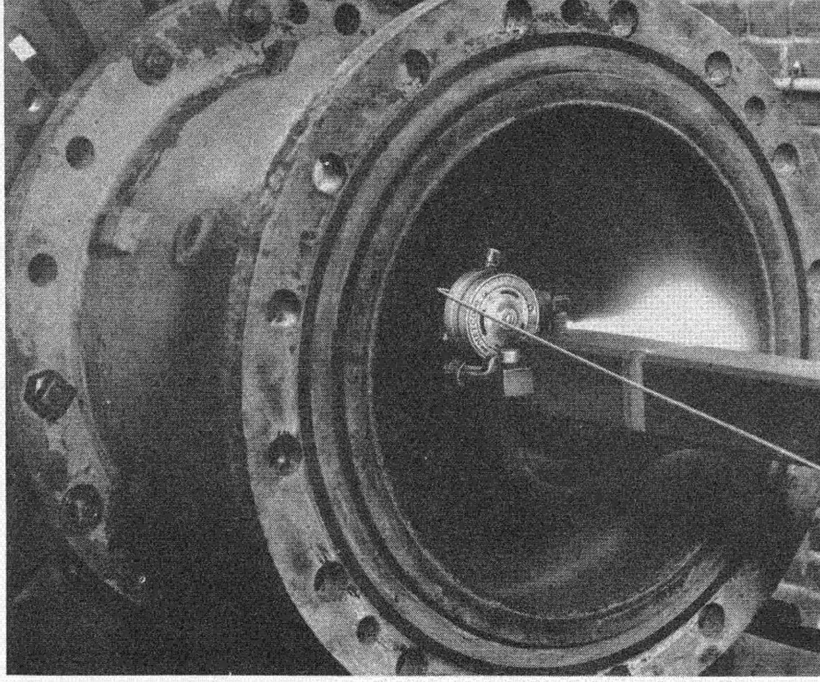


FIG. 8. Rebuilding the bore of a steam cylinder.

in some cases by the application of lacquers or other finishes.

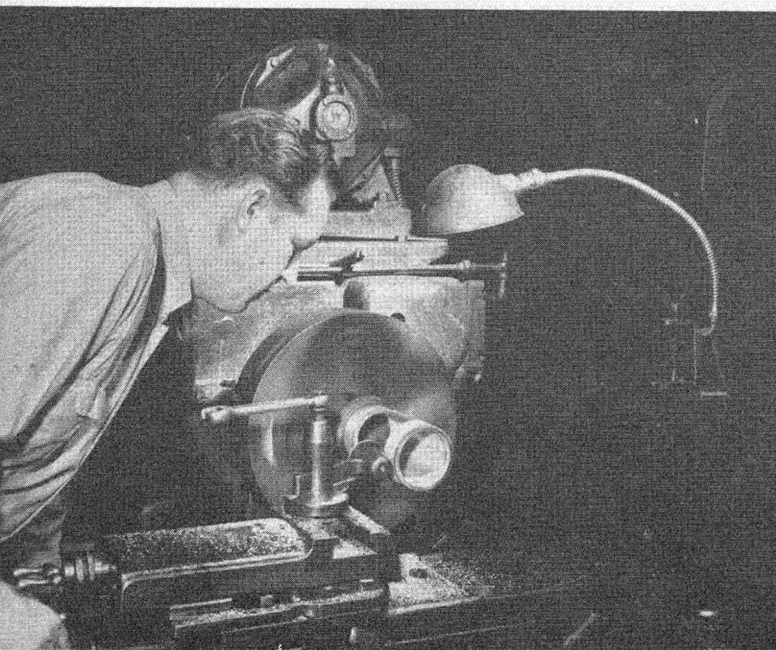
There has been a great increase in the use of metallizing as an undercoat for paint or other organic finishes. Zinc or aluminum is commonly used for this application, and these metals form an excellent base for paint.

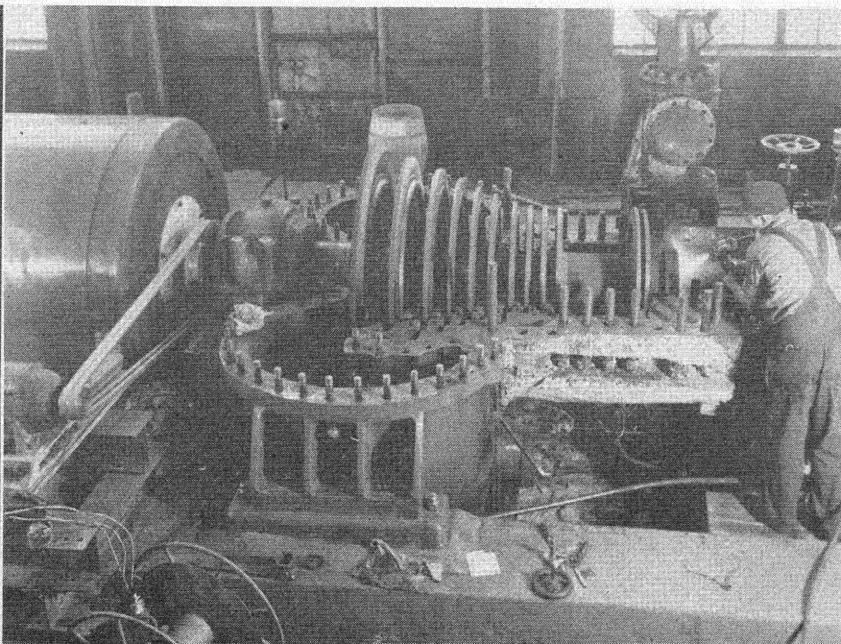
The requirements of the war program have vastly increased the use of metallizing to prevent heat corrosion. A series of new coatings known as "metcolized" coatings has been developed for this purpose. These new processes involve the use of aluminum in combination with nickel-chromium alloys. They have made possible the use in industry of mild steel melting and heat-treating vessels in place of nickel and chrome alloy vessels.

Typical uses of metallizing for corrosion resistance are illustrated in *Figs. 4 to 6*. *Fig. 4* shows an air-cooled aircraft engine cylinder being sprayed with aluminum. This work is done on many automatic machines which employ seven metallizing guns per machine. *Fig. 5* shows a 90-foot long vapor spray type degreaser which has been metallized for corrosion resistance. It is used in an automotive plant where the shop conveyor travels right through the degreaser. *Fig. 6* shows the mighty Bofors Quad. The cast iron gear shroud for the Bofors Twin, formerly made of bronze, is protected against corrosion with sprayed zinc.

(Continued on Page 15)

AT LEFT: FIG. 9. Machine preparation of an armature bearing prior to metallizing. AT RIGHT: FIG. 10. Turbine shaft being built up to size without being removed from the turbine housing.





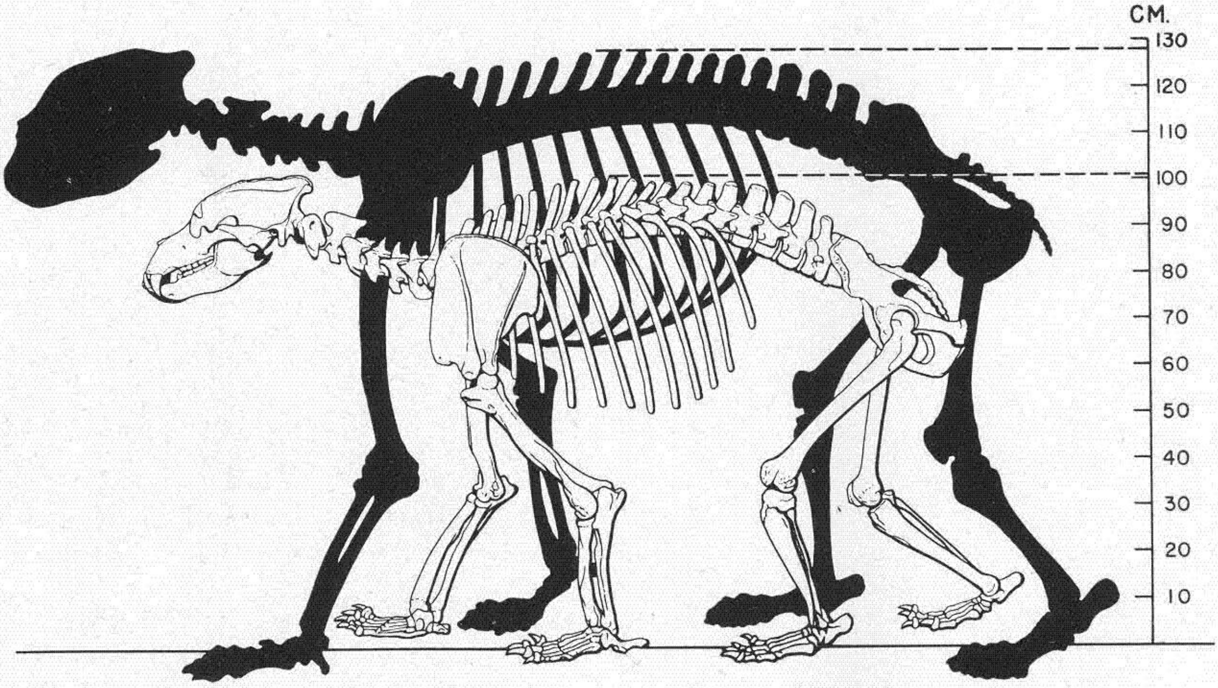


FIG. 1. Skeleton of recently extinct Californian grizzly (Ursus horribilis) in outline and of the Pleistocene short-faced bear (Tremarctotherium californicus) in silhouette, showing difference in size. Outline of the grizzly specimen after a photograph by Gardet, an illustration of a mounted skeleton rarely seen. Outline of the tremarctothere based on a specimen from Rancho La Brea.

CALIFORNIA BEARS

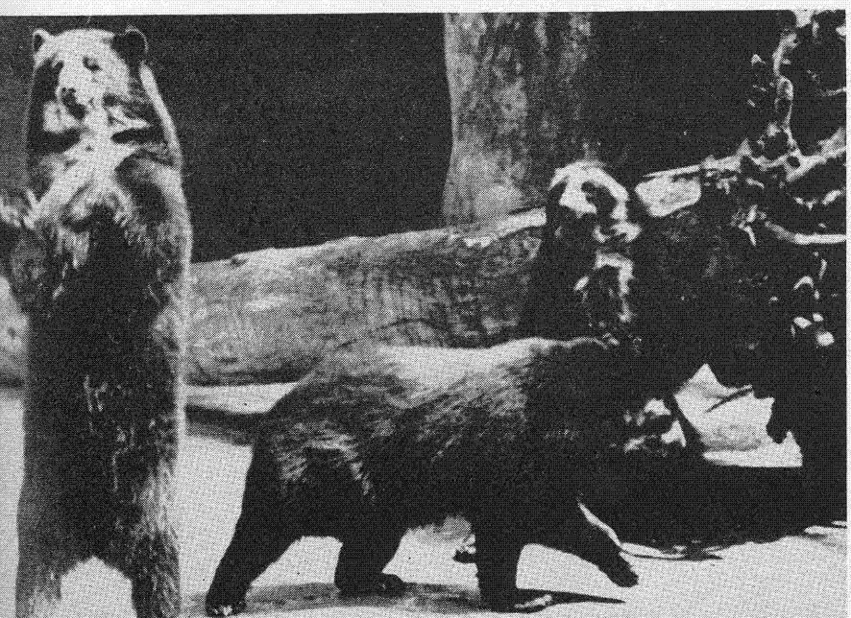
PRESENT AND PAST

By CHESTER STOCK

BEARS are among the most interesting animals of the wildlife of California. Today, most people know the black bear, its characteristic appearance and some of its habits, since it is commonly seen in frequented places like Yosemite and Sequoia National Parks. While it is the largest of our fur-bearing mammals, overestimates of its weight and size are commonly made. An individual of average size weighs between 200 and 300 pounds although instances are known where a black bear of large size weighs almost 500 pounds. These animals stand from 30 to 36 inches at the shoulder. The black bears at present and during the historic past are known to have ranged in the northern coast ranges, north of San Francisco, into Siskiyou County, and southward throughout the length of the Sierra Nevada. The southern end of their distribution extended from the Tehachapi Mountains into the eastern portions of Ventura and Santa Barbara Counties.

CALIFORNIAN GRIZZLY

In contrast to the black bear, the Californian grizzly is less well known, and apparently became extinct in the



AT LEFT:

FIG. 2. Three individuals of the spectacle bear (Tremarctos ornatus) from Guayaquil, Ecuador. Note small size of animals. Courtesy of the Zoological Society of San Diego.

state some 20 years ago. The so-called Sunland bear, killed in the lower part of Tujunga Canyon in 1916, was the last grizzly on record to be found in southern California. The grizzly bears were the most striking wild animals in early California history. They were much more widely distributed over the state than the black bear, for their range extended from the Mexican border to Oregon. Almost the only areas not inhabited by them were the arid or desert sections along the eastern border and in the southeastern portion of the state. The Californian grizzly was a distinctly larger animal than the black bear. As in the instance of the latter, estimates of its weight were often on the liberal side. A grizzly in poor condition, shot in the vicinity of Pasadena in the winter of 1879-80, weighed about 500 pounds. It is probable that an average weight for these bears was 800 pounds, with some weighing distinctly more. When it died, Old Monarch, a grizzly kept in captivity for many years in Golden Gate Park, San Francisco, weighed, according to reports, 1127 pounds. It had a shoulder height of 48 inches.

Their wide range made them well known not only to the native Mexican occupants of the region when it still belonged to Mexico, but likewise to those Americans who came west as adventurers, explorers, miners and settlers in the days of '49 and before and after. The subsequent history of the grizzlies in the state is a sad one to relate. Relentlessly hunted and trapped by man, their numbers gradually became depleted until this group of bears reached the vanishing point about 1924. Curious though it may seem, little information of scientific value was recorded about the grizzly when it was still alive. Even in its heyday, authentic facts concerning the natural history of this animal were of the most meager sort, since the statements of trappers and hunters were principally concerned with its spoor, the formidable character of the bear, its ferocity, and the dangers of the hunt. Today, therefore, our knowledge of the Californian grizzly is gleaned from stray notes and accounts and from a relatively sparse collection of skulls and still fewer skins.*

To the paleontologist this episode in the wildlife history of California has special significance, for it demonstrates in striking manner how animals come to disappear from the living world in a relatively short span of time, due to the introduction of some new factor, even though the original life expectancy was considerable. The change in the mammalian life that has taken place in the Californian region with the passing of the Ice Age or Pleistocene epoch and the coming of Recent time is precisely of this sort, although the direct cause of extinction was apparently not always man, and on occasion may have been due to some physical rather than biological factor.

A comparison of the assemblages of mammals exhumed from the Pleistocene asphalt deposits of Rancho La Brea and McKittrick with that living in California today emphasizes the paucity of the present fauna. The difference displayed by our existing life results largely from the disappearance or extinction of many of the characteristic types of Pleistocene mammals. To less extent is this due to the appearance of new specific types. Thus, while black bears and grizzlies were present in the Californian region during the Ice Age, and the former at least is definitely known to be specifically different from the black bear of today, the most striking feature of an earlier history of the bear group is the existence in California during the Glacial Period of an extinct short-faced bear unrelated to the black bear and grizzly. In contrast to the disappearance of the grizzly in California, the extinction of the short-faced bear cannot, as yet, be ascribed to the advent of man in the late Ice Age or early Recent time.

*An excellent summary of the available information concerning the Californian grizzly is found in Grinnell, Dixon, and Linsdale: *Fur-Bearing Mammals of California,* University of California Press, 1937.

FIG. 3. Spectacle bear (Tremarctos ornatus) from Guayaquil, Ecuador. Note color pattern on face and chest. Courtesy of the Zoological Society of San Diego

SHORT-FACED BEAR

The *tremarctothere* or short-faced bear takes its common name from the fact that the snout is not long and slender as in the grizzly and black bear, but the face is blunter. The animal grew to very large size, and its stature exceeds that of the grizzly. In this respect, it resembles the giant brown or Kadiak bears that today inhabit Alaska. The difference in size between the *tremarctothere* and the Californian grizzly is well shown by a comparison of their skeletons *(Fig. 1)*. Male individuals of this bear must have weighed at least 1500 pounds and probably exceeded that figure.

When the remains of these creatures were first found in 1879 in Pleistocene cave deposits of northern California, the animal was called a cave bear, but short-faced bear is a more appropriate name. These animals are now known to have had a very wide distribution on the North American continent during the Ice Age, for their fossil remains are found from the Yukon to the Mexican plateau. They were unquestionably the most formidable carnivores of the American Ice Age, holding their own by size and strength. Close relatives occur also in the Pleistocene of South America. It is apparent from their structural characteristics that they were more carnivorous mammals than either the black bear or the grizzly.

Perhaps the most interesting fact concerns their relationship to living bears. It is now apparent that the short-faced bears are not nearly related to the living bears of North America, but have closest kinship with the diminutive spectacle bear of South America. The latter animal is found in the Andes from Colombia south to Chile. It is not often seen in zoological gardens in North America, although several living animals are the property of the Zoological Society of San Diego *(Fig. 2)*. The spectacle bear takes its name from the color pattern on the face, more particularly the marking about the eyes *(Fig. 3)*. In contrast to the black bear, the spectacle bear is a smaller animal, standing about 22 inches tall at the shoulders and weighing less than 100 pounds. Thus, in the lineage of the *tremarctothere* it may be said that not only did the occupants of what was once a great estate give way to a smaller breed, but also their territory became much more restricted in area.

The history of the short-faced bears can be traced back still farther in geologic time. Some of the evidence of their more ancient existence is furnished by fossil teeth and jaw fragments that have been collected in the Mt. Eden formation, Riverside County. These strata accumulated during the Pliocene, or the epoch immediately preceding the Pleistocene. The earliest record of the group leads back into the Miocene epoch, for in the famous Barstow deposits of the Mojave Desert are found curious animals showing relationship to the *tremarctothere* and to the dogs. *Hemicyon*, or half dog, as this carnivore is appropriately called, is a connecting link suggesting the derivation of this group of bears from one branch of the great and diversified family of dogs during the middle of the Age of Mammals.

Hydraulics Laboratory

(Continued from Page 3)

a thorough understanding of the advantages and limitations of the Laboratory solution.

PRESENT ACTIVITIES

Because of the war, work on basic research projects has been reduced in order to concentrate on problems of more immediate assistance to the war effort. Wind erosion studies have been discontinued and density current and sediment transportation studies retarded.

During 1943, hydraulic model studies of six large spillways were made by the Laboratory. The first four studies were for existing structures which had proved unsatisfactory and unsafe in operation because their designs were based on faulty hydraulic assumptions. One of these structures is in Oklahoma, one in Louisiana, and two in Texas. By means of the model studies, simple and economical methods of reconstruction were developed for these Southern structures, which will provide them with adequate hydraulic design for the spillways and their stilling basins. Incidentally, the damage loss, plus the cost of reconstructing these four large structures, will exceed the cost of operating this Laboratory for several decades. The other two spillway studies were for structures to be located in Utah and California. In both of these cases the designs were submitted in advance of actual construction, thus giving the Laboratory an opportunity to make constructive suggestions.

During 1943, a standard design for baffle type energy dissipators for pipe outlets was developed as a sequel to the standardized drop structure design. The development of such standardized designs is an effective Laboratory activity because the results apply to innumerable structures instead of to one. Another recent development in this category is a flow meter for pipe line irrigation outlets.

An interesting new density current development arose through the Southern California Edison Company. The company observed that in the spring at their Shaver Lake reservoir the cold heavy snow water entering from the stream would flow underneath the warmer, light water of the lake without mixing with it. Valuable field measurements have already been secured and the investigation is being continued this spring.

The sediment transportation studies have been accelerated by the addition of H. A. Einstein to the staff. He has been studying this particular problem for several years at one of the Soil Conservation Service research stations in the East.

At the request of the Navy, this Laboratory and the Hydraulics Structures Laboratory are studying an important problem of the Los Angeles Harbor. Although this project consumes most of the energies of both staffs, the effort seems justified since it appears that the study is assisting the Navy in more satisfactory operation of this important base.

Sediment Transportation

(Continued from Page 7)

on a straight line must not be taken as evidence that the theory is in complete agreement with experiment since as mentioned previously, the exponent z was determined so that the curve would fit the experimental data.

Fig. 8 shows velocity profile curves on the center of the flume for two flows of the same depth, one with clear water and the other with a suspended load of 0.15 per cent by weight, distributed according to the curve at the right of the figure. The shaded area between the velocity curves represents the increase in velocity due to the presence of the sediment. It will be seen that this increase is almost 10 per cent. The effect of the sediment is to reduce the apparent friction resistance of the channel. This results from a modification of the turbulence by the suspended sediment. The turbulence must support the sediment against the action of gravity which causes it to settle. This requires energy which must be supplied by the turbulence thus reducing its intensity. Since the turbulence also transmits the resistance of the channel to the entire cross section of the flow, when its intensity is reduced it is less effective in transferring this resistance and a higher velocity is necessary to establish equilibrium conditions.

The action of sediment in increasing the velocity of flow was observed in all laboratory tests; however, the concentrations used in the laboratory were rather low so there is no evidence available on the variation of this effect with extremely high sediment loads. The action of sediment in reducing the intensity of turbulence indicates that the maximum load that a stream can carry is determined by some kind of equilibrium between the supporting power of the turbulence and the settling tendency of the sediment.

SUMMARY

The experimental work on the transportation of suspended sediment described briefly in this paper has shown that the theoretical relationships which were based on analysis of turbulent flow give approximate results for the distribution of sediment. They have also clarified the inter-action of the sediment and the turbulence and suggested the mechanism by which the maximum load that a stream can carry is determined. Further experimental work and research on the subject is needed and promises to yield results that are necessary to enable engineers to handle sediment-laden flows.

Metallizing

(Continued from Page 11)

USES FOR MACHINE ELEMENT WORK

The largest single use for metallizing today is for machine element work. This includes maintenance and repair and also includes salvage of mis-machined parts. The metal to be sprayed in each case is selected for the physical properties of the spraymetal which will be produced. Because of the excellent wearing qualities of the spraymetal, it is used most extensively on bearing surfaces. The machine element is first prepared, usually by some form of roughening, and then sprayed to a larger size than the finished size. Spraymetal may then be machined or ground.

Typical uses of metallizing for this type of work are illustrated in *Figs. 7 to 10.* In Fig. 7 is shown the salvaging of a 60,000-pound chill mold with 50 pounds of spraymetal. In *Fig. 8* a steam cylinder is being metallized with iron to restore the bore to its original size. In *Fig. 9* an armature bearing is being prepared for metallizing. After this preparation, spraymetal will be applied, and then finished to size. Many scrap piles are being redeemed in this manner. *Fig. 10* shows how metallizing is being used to make repairs on the job without complete dismantling. The steam turbine shaft is being built up to size at the packing area where it was badly pitted. A portable grinder was installed on a bracket for the final finishing of the journal.

USE FOR NEW PRODUCTS

Spraymetal as a new material offers many new possibilities because of its various and unusual properties. It will be used much more extensively in the future for corrosion resistance on newly manufactured articles. Its recent rapid expansion in the field of tumbling barrel coating of small articles indicates this trend. Its use for inlay of such metals as stainless steel on shaft sections has increased rapidly in recent years. It is being used, for instance, on turbine shafts in several standard makes of steam turbines at the packing ring section. Metallizing will be used very extensively in the future on newly manufactured articles for bearing surfaces, such as crank shafts, because of its superior wear qualities and oil retention feature. Metallizing is being used extensively for the manufacture of carbon brushes and resistors to provide a means of soldering to the carbon. It is being used for the manufacture of electrolytic condensers, the condenser plate being manufactured from cloth tape on automatic metallizing machines. Glass is metallized with copper in production to permit soldering to the glass for sealing purposes, as on gas meter windows. Glass reflectors are being manufactured with reflecting surfaces of sprayed aluminum.

FUTURE OF METALLIZING

The future of the metallizing process lies in two obvious directions. One is the further technical development of the process itself, and the other is the expansion in uses of the process. It is only natural that today the development of the process is ahead of the uses. This is always the case with a relatively new development. Specific applications have brought about the development of metallizing equipment and processes, and this same equipment with the same processes is suitable and available for many other uses that have yet to be found.

It is probably safe to predict, therefore, that the most immediate postwar trend will be the vast expansion of the uses of the present process, while the technical development continues for use in future years.

The biggest increase in use probably will be for bearing surfaces. Another big expansion in use will be for corrosion resistance, particularly on small products produced by production methods, as by tumbling barrel spraying. Metallizing structures such as metal window sash and metal furniture, as an undercoat for paint, will, no doubt, increase very rapidly. The biggest future uses, however, are doubtless among those that have yet to be discovered. New applications are increasing rapidly as the engineering profession appreciates more and more that spraymetal is truly a material with a future.

STATESMANSHIP

By ROBERT A. MILLIKAN*

A YEAR ago a group of some 400 men, quite similar to this group, had completed training in meteorology in U.C.L.A. and C.I.T., just as you now have done, and were then assembled to receive their commissions in the Air Corps.

At that time I chose to address them not in their capacity as soldiers, but rather as citizens of the United States. I shall do the same again to you today, for while we hope that it will be only for a very short time that you will be doing your duty as officers in the United States Army, for the next half century you will be playing a vital role, I hope, in what I expect to be the most critical peacetime period in the history of the world—a period in which we Americans have it in our power largely to determine whether mankind can find a substitute for war and therefore can usher in for the world a period of lasting peace.

That issue will depend, first, upon our will to peace, and, second, upon the kind of statesmanship developed in the United States. That statesmanship will be but a composite of the statesmanship of you voting citizens of this country. You men who are before me today can be vital factors in the determination of the quality of that statesmanship. Your service along side British and other Allied troops will open your own eyes to international situations and to the stupendous need now and in the future of international cooperation, and in particular Anglo-American cooperation.

Let me first try to give you as clear and full an idea as I can of what I mean by statesmanship. Walter Lippmann is generally considered America's foremost political analyst and commentator. According to a recent, and I think a dependable, poll his syndicated column extends its educating influence at its every appearance over some three million American citizens.

One of his recent most penetrating observations was to the effect that the real progressives, the constructive men who alone deserve to be called forward-looking liberals, are in general not found either on the extreme left, which presumes to call itself liberal, or the extreme right, though even Hitler calls himself a democrat, Nazi meaning "National Socialist." Progress actually finds its source and gains its strength in the main not from the left or the right, but from the center.

This is no new discovery. The Greek philosophers knew it when they coined the phrase "the golden mean." The wise men of Rome expressed their approval in the slogan *"Ne Nimium."*

The reason why neither radicals nor reactionaries—extremists on either the left wing or the right—in general are not effective progressive leaders is quite clear. It is because these two groups are very much alike in the

*Address June 5, 1944, at the exercises commissioning Aviation Cadets in Meteorology from the Army Air Forces Base Units at the California Institute of Technology and the University of California at Los Angeles.

characteristic that destroys their effectiveness, namely, they are both in the main emotionalists rather than careful analysts. They are men who are guided primarily by their feelings and their preconceptions rather than by well considered intelligent judgments.

On the other hand, the man who is an effective leader in human progress, the man who possesses that great and rare quality which we call statesmanship, is of necessity a rationalist—a man capable of analyzing and appraising the whole situation, seeing what it is possible to *do* under existing circumstances, and with the use of actually existing forces. Of course he ought to have, and in general he does have, far-reaching ideals, but he must also have sufficient analytical power and sufficient wisdom not to destroy his own influence by butting his head against a wall for an unattainable ideal. He must have sufficient wisdom to avoid setting back all reform through creating so many antagonisms as to produce disorder instead of ordered progress. He must be able to see the merits of both sides of a controversy. He must be able to negotiate, to persuade, to find a solution that promotes the real, long-range interests of all parties. He must educate his public to an understanding of its long-range interests, and to a willingness to set its sights, not upon its immediate interests, but upon the long-range goals.

After this war the American people as a whole will confront the necessity of developing vastly more of that sort of statesmanship than we have developed in the past or have been under the necessity of developing. In our isolated position it is not surprising that our record has been in no way comparable in the matter of statesmanship with that of the British. Britain's Statute of Westminster of 1931, for example, is nothing less than a milestone in human history. The American Revolution is called such a milestone because it created for the first time free, representative government outside of England, where it had been developing for the preceding five centuries. But the Statute of Westminster was a greater milestone in the progress of mankind toward a rational, beneficent world order, for it was what created "The British Commonwealth of Nations" as it is today, unquestionably the nearest approach to an actually working world organization of free peoples that has yet been achieved.

Through the voluntary extension of complete local self-government to all the constituent members of the Commonwealth (and India, too, was years ago offered dominion status, like all the rest, as soon as she would organize herself to use it) the British have exhibited a profound statesmanship altogether unique in history. The Statute of Westminster is the first example of the relinquishment of centralized power in place of its seizure. It is a greater step than the American Revolution because it represents the discovery of the mechanism of social revolution without a cannon shot, the inception of reasoned progress without the spilling of a single drop of blood.

Within the British Commonwealth is found the cleanest civil service, the greatest freedom from political corruption (this is the great historic destroyer of democracies, and the chief menace to the future of our country) that exists or ever has existed anywhere on earth. That clean political civil service, that freedom from political corruption, the key to which is local self-government such as the constituent members of the British Commonwealth possess, is the *sine qua non* for the preservation of a free representative society such as we often speak of incorrectly as democracy, for no pure democracy ever succeeded anywhere on earth. So-called democracies, better called republics, have always been destroyed either by internal corruption or by external aggression. To prevent the latter some kind of federation or union of peace-loving communities or states for their common defense against bandit nations bent on world conquest is an obvious necessity, and of this the British Commonwealth of Nations has been thus far the best example, combining the maximum freedom of the parts with adequate ties for defense against external aggression. In the century from 1814 to 1914 it was the British fleet in the main that not only protected the parts of the entire empire, but also served as world policeman and protected small independent countries like Holland, Belgium, and many others. Indeed, it is probable that without the protection of that fleet, free representative governments, including our own, could not have developed all over the world as they did.

But after this war, in view of our resources and our power, we in the United States must of necessity become as internationally minded as the British and we must clearly do our share of world policing. I also hope that all peacefully disposed nations will contribute to that policing job in proportion to their strength. But it cannot possibly work unless the three great powers that have now the policing strength can somehow learn to cooperate with one another. Never has there been a world situation in which it was so clearly to the long-range interests of all of these three powers to create a machinery for insuring between them a period of lasting peace.

Let no man be misled by the shallow talk so much in vogue just now that a nation seeks and should seek only its own interests. If the makers of that statement mean to assert that a nation can only consider its immediate interests it is a stupendous falsehood which if believed in and followed will inevitably bring ruin to any people that practices it. For ignoring the interests of all other nations inevitably arouses not only the hate of all mankind but it forces the whole world to combine and attack any nation that follows that practice just as it is now attacking Hitler, and no nation on earth is strong enough alone to withstand such attack.

A nation that is possessed of any wisdom and any statesmanship at all will and should seek its long-range interests it is true, but it will also know that the greatest interest and the greatest asset any nation can have is the good will, the confidence, the respect, and the friendship of other nations. Any trade or any international conduct that does not in the long run and on the average profit all the parties involved is simply international banditry and that is precisely what we are fighting this war to put an end to. In other words, we American citizens as a whole have got to learn the statesmanship of international cooperation if we want to live during the next 50 years in a decent world.

Let me repeat, I hope that all nations can contribute in proportion to their strength to put down international banditry, but fortunately it is at this moment both to the immediate and also to the long-range interest of the three strongest nations, Britain, Russia, and the United States, to exert their joint power to destroy that Nazi, that wild-beast type of ideology, and inaugurate a period of lasting peace. Because of this conjunction of interests there never has been in history a moment so favorable for this effort. Britain's present situation and the last 100 years of British history constitute the assurance that she will do her part. Will Russia and the United States do theirs? If either one of us refuses and threatens to start out alone on a program of world conquest the other two, with the assistance of the smaller Allies, must be powerful enough to make the project hopeless.

Is, then, such international cooperation in the interests of a lasting peace a possibility? I answer, if Britain and the United States with their history and their relationships cannot learn to cooperate, then certainly nobody can, and the project is a hopeless one. Therefore, the future of the world today reduces to just one thing, namely, the possibility of Anglo-American cooperation. The alternative is ever recurring world wars, and the end certainly of Western European and American civilization. I think the answer is in the hands of the citizens of the United States whom you young men will be in position to do much to educate and to lead.

JUNE COMMENCEMENTS

ALTHOUGH the next regular Commencement will be held at the end of October, June brought two special Commencements for graduates of courses arranged primarily to meet war needs and schedules out of phase with the normal academic calendar. The first of these Commencements was held Saturday, June 3, at 10 A.M. in Tournament Park. That day's group of graduates had completed the three-term course in meteorology which was set up several years ago primarily to supply trained meteorologists for the Army. (For the last two or three rounds of the course Navy personnel has also been enrolled in it, and a few civilians). The June 3 graduates comprised officers of the U. S. Naval Reserve, aviation cadets of the U. S. Army Air Forces, and civilians, including several students from Latin American countries who had attended the Institute on U. S. Weather Bureau fellowships. The Certificate in Meteorology was awarded to 11 Navy officers, 131 cadets, and three civilians. The degree of Master of Science was conferred upon 35 Navy officers, nine cadets and one cilivian (and, *in absentia*, on five Army officers).

Rabbi Edgar F. Magnin, whose son, Cadet Henry D. Magnin, was one of the graduates, served as Commencement chaplain. The Commencement address was delivered by Dr. Max Mason, member of the Institute's Executive Council; Dr. Robert A. Millikan awarded certificates and degrees; and brief addresses were made to the graduates on behalf of the Navy and Army by Rear Admiral Ralston S. Holmes, U.S.N. (Ret.), Navy Department Liaison Officer, N.D.R.C., and Major Philip E. Daugherty, A.U.S., Judge Advocate, Headquarters, Los Angeles Civilian Schools Area, Army Air Forces Western Technical Training Command.

On the following Monday afternoon, June 5, commissioning exercises were held in Tournament Park for the Institute group of cadets and a group from the University of California who had just completed a similar course in meteorology. Major General John F. Curry, Commanding General, Western Technical Training Command, flew west from his headquarters in Denver to take part in the ceremonies. In a colorful ceremony the 260 cadets were reviewed by General Curry and a group of guests consisting of high-ranking Army and Navy officers and representatives of the Institute and U.C.L.A., who reviewed the meteorology training program, and Lieutenant Colonel Oscar Heinlein, who spoke on behalf of the Weather Wing, to which the cadets are assigned after commissioning. Lieutenant Colonel Franklin Rose, commanding officer of both the Institute and U.C.L.A. units, presented awards to outstanding students. After the commissioning oath was administered, General Curry presented the cadets with their commissions as second lieutenants in the Army of the United States. The program closed with the presentation of Awards of Merit to the Institute and U.C.L.A. for their part in the meteorology training program, and to Pomona College for its conduct of a pre-meteorology course.

These exercises marked the termination of the Army's meteorology training. The meteorology course will continue to be given at the Institute, but after July 1 it will be scheduled on a semester basis and while it will be open to civilians, the students will be principally Navy men who are enlisted in the V-12 College Training Program.

The second June Commencement was held on the morning of the 30th in the Lounge of Dabney Hall. The principal group of graduates were the Army and Navy officers who entered the Institute November 1, 1943, to take the regular two-semester graduate course in aeronautics. Some received the degree of Master of Science in Aeronautics; others, who had completed at least a year of graduate work before being assigned to the Institute, received the professional degree of Aeronautical Engineer. Another group of graduates, composed of members of the Senior class who normally would graduate in October, were granted their degrees at this time because of imminent induction into the armed forces. Dr. Robert A. Millikan delivered the Commencement address on June 30.

COMMISSION WON BY HANCHETT

HOLLIS K. Hanchett, '43, was graduated as a second lieutenant recently from the Army Air Forces Training Command School at Yale University. During the graduation ceremony his mother, a second lieutenant in the Wacs, had the distinction of pinning the bars on her son.

Lieutenant Hollis Hanchett is now stationed at Boeing Aircraft School for B-29 Engineers at Seattle, Washington, and his mother is stationed at Fort Douglas, Utah, where she is performing administrative duties in the Tank and Automotive Section of the Ordnance Division.

Wac Lieutenant Ilda L. Hanchett won the National Women's Archery championship in 1932, and Lieutenant Hollis Hanchett won the junior archery title three years later. About a year ago mother and son gave up one of the world's most ancient weapons in favor of more effective firing equipment aimed at Axis targets.

PERSONALS

1922

LIEUTENANT COLONEL DOUGLAS C. MACKENZIE, resident engineer of the Marietta Air Assembly Plant in Marietta, Ga., has been visiting friends in Pasadena while on leave. Colonel Mackenzie has been area engineer at Marietta, directing the designing and construction of Camp Stewart, which is one of the largest cantonments in the south.

1924

HOWARD W. GOODHUE is with the U. S. District Engineers Office in Seattle under a War Service appointment, working on studies for a new report on the comprehensive development of the Columbia River and its tributaries.

1928

JOHN W. THATCHER has been engaged in confidential work for the U. S. Navy for the past two years, while employed by the Western Electric Company. His work has taken him all over the east coast, to Guantanamo, Cuba, and San Juan, Porto Rico. At present he is senior engineer at the naval base located at Terminal Island, Calif.

MAJOR F. GUNNAR GRAMATKY, operations officer for the 27th Engineer Combat Battalion, is at present in service somewhere in the Pacific, and at the last report was entitled to wear a bronze cluster on his Asiatic-Pacific ribbon.

1929

KARL A. GANNSLE transferred from the Southern California Telephone Company to the department of operation and engineering of the American Telephone and Telegraph Company in New York City, where he is concerned in step by step and cross bar switching systems. He was recently in Los Angeles on business.

1931

LAWRENCE KINSLER was recently promoted to the rank of lieutenant commander, U.S.N.R. He has been teaching physics at the U.S. Naval Academy, Annapolis, Md., for the past three years.

EDWIN KYUKENDALL is now working for the Truesdale Laboratories, Los Angeles.

LOUIE W. MOSLEY is employed as a structures engineer at the Fletcher Aviation Corporation, Pasadena.

ROBERT H. GRIFFIN and Mrs. Griffin have adopted a baby girl, Geraldine Grace. Mr. Griffin is employed by the U.S.E.D. in Canada.

1932

HENRY H. BRUDERLIN, after receiving a medical discharge from the Army as a first lieutenant, has been employed at Douglas Aircraft Co., Inc., for the past two years. He has been acting as assistant director of quality for the entire company, all plants, having resigned from the job of assistant executive engineer of the Santa Monica plant.

P. G. BURMAN has completed five years as engineer in charge of the Fuel Injection Laboratories, American Bosch Corporation, Springfield, Mass. In addition to diesel work, the laboratories are now testing and building gasoline injection equipment for the Army Air Corps. Mr. Burman is married and has two children, Bruce, 5, and Vonla, 3.

1933

GROVER SECORD was killed on Monday, May 29, when his car overturned at a bend on Telegraph Road in Los Angeles. He was employed at the Goodyear Tire and Rubber Company.

DR. JOHN McMORRIS was killed on June 6 in an airplane crash in Massachusetts. He had been a member of Caltech's war research staff for the past two years, and an instructor in chemistry for several years at the Pasadena Junior College. Dr. McMorris was known all over the world for his fingerprint detection method, now in use by more than 1000 police departments. Known as the McMorris method, it employs a specially constructed blowpipe, using iodine smoke to bring out latent prints.

FRED DETMERS is a sergeant in the Signal Corps, engaged in photography, with headquarters in New York. He visited the campus recently while on furlough.

1934

LIEUTENANT COMMANDER J. C. RADFORD, U.S.N.R., is with the Bureau of Ships, Navy Department, Washington, D.C.

LIEUTENANT DONALD R. ROOKE, U.S.N., is with the Bureau of Yards and Docks, Navy Department, Washington, D.C. He was in the South Pacific for two years.

LIEUTENANT (j.g.) CARROLL C. CRAIG, U.S.N.R., is with the Bureau of Ordnance, Navy Department, Washington, D.C.

LIEUTENANT RAY E. KIDD, U.S.N.R., is with the Bureau of Ships, Radar Section, Washington, D.C.

CAPTAIN ALFRED SWITZER, U. S. Army, was recently a patient at the Pasadena Area Station Hospital after having been struck on the head by a golf ball at a nearby golf course. Captain Switzer had worked on the design of the hospital two years ago, but had never been inside the completed hospital before.

DR. W. H. JORDAN is on leave of absence from the University of South Dakota and is now at Arlington, Mass.

1935

WILLIAM F. KEYES has been employed as a chemist in the Industrial Laboratory, Mare Island Navy Yard, since March 17.

NEIL SNOW has received his second lieutenant's commission as a technical officer in Aircraft Maintenance Engineering at the Army Air Forces Training Command School at Yale. He was one of the founders of the Society of Aircraft Industrial Engineers. Before entering the service in January, 1943, he had been industrial engineer for Douglas Aircraft Co., Inc., Vega Aircraft Corporation, and the A.A.F. Materiel Command.

WALLACE JOHNSON is now the general sales manager of Joshua Hendy Iron Works, Sunnyvale, Calif. Before taking this position he had been general manager of the Production Engineering Company of Berkeley, and assistant general manager of the Pomona Pump Division of Joshua Hendy Iron Works.

CAPTAIN ARTHUR E. ENGELDER, U.S.M.C., is the father of a daughter, Barbara Josephine, born January 4 at Douglas, Ariz.

JOHN C. STICK, Jr., left Lane Wells Company in Los Angeles in February to do government research work under N.D.R.C. at Duke University. He was married to Miss Ruth Oncley of Winfield, Kan., on June 18. She is studying for her Master's degree in Dramatic Art at the University of North Carolina.

1936

BRUCE L. HICKS is head of a research section in the fuels and lubricants division of the Aircraft Engine Research Laboratory of the N.A.C.A. in Cleveland, Ohio. He is the father of a son born January 31.

LIEUTENANT COLONEL AL CREAL, U.S.M.C.R., was overseas with the Marines in the Samoan area and Gilbert Islands for two years. He is now on duty with the Marine Corps Radio Headquarters, Washington, D.C.

1937

LIEUTENANT THOMAS S. HARPER, U.S.N.R., is serving as medical officer aboard a gunboat in the Pacific.

ROBERT H. MARSH, formerly research engineer of the Machinery Manufacturing Company, Vernon, Calif., has been appointed chief engineer. After graduating from Caltech, he spent two years on the student engineering course of the Southern California Edison Company, and was then engaged in special engineering investigations and cost studies. Before joining the Machinery Manufacturing Company he was with the Holly Heating and Manufacturing Company of South Pasadena, Calif.

J. RIDGELY LEGGETT, U.S.N.R., is on active duty on a submarine in the Pacific. He has completed naval training at M.I.T. and the officer's submarine school at New London, Conn.

ROBERT P. BRYSON is Party Chief, U.S. Geological Survey, with a party of about 40 men, investigating the bauxite reserves in Arkansas. He was recently promoted from associate geologist to geologist. He was married to Miss Frances Clark of Itasca, Texas, on May 27.

MAJOR T. R. BELZER, U.S.M.C., has been serving in the Southwest Pacific for over a year and a half. He was in the Bougainville Campaign, where he conducted artillery fire successfully on the Japs.

1938

WILLIAM TWISS has moved his business, the Twiss Heat Treating Company, to a new location in Burbank. The new plant includes a metallography laboratory and specialized hardening furnaces.

HERBERT B. ELLIS is with the Rheim Manufacturing Company, Los Angeles, as research engineer.

FRANKLIN H. PAGE, Jr., ex-'38, received a thousand dollar award in April from the board of directors of Solar Aircraft Company, San Diego, for his successful experiments with a vastly improved metal pickling solution. He had spent nearly four years in the laboratory to produce a pickling solution which has reduced the percentage of damageable, critical stainless steel and other war materials to nearly zero. The special award to the San Diego chemist "for meritorious service in speeding up the war effort" was presented by Edmund T. Price, Solar president, at the plant's annual suggestion award assembly.

FRANK B. JEWETT, Jr., is the father of a son, Frank B. Jewett, III, born November 16. Mr. Jewett, Jr., received his M.B.A. degree from the Harvard Business School in 1940 and was on the staff for a year. He then joined the National Research Corporation, where he was production manager and at present is in charge of the vacuum engineering division. His most interesting assignment for that corporation was a trip to Pearl Harbor in June, 1942.

1939

GUSTAV ALBRECHT is a research chemist for the Union Oil Company in Wilmington, Calif. He also teaches courses in X-ray diffraction for the E.S.M.W.T. program at U.S.C.

MAJOR BOB WINCHELL transferred in May to the 26th Weather Region and is now stationed at Orlando, Fla.

MAJOR RICHARD H. HOPPER, who has been in the South Pacific for almost five years, is now in the Dutch East Indies.

DAVID HOLCOMB SCOTT is assistant geologist for the Texas Company, Bakersfield, Calif.

1940

CAPTAIN WALTER R. LARSON is instructing flying at the Smyrna Army Air Field, Tenn.

RALPH G. PAUL is the assistant to the process engineering manager at Douglas Aircraft Co., Inc., in Santa Monica.

JULES F. MAYER is the father of a son, Steven Lewis Mayer, born May 6.

VICTOR WOUK is the father of a son, Jonathan Abraham Wouk, born in New York City on May 19.

1941

ROY M. ACKER has been a layout draftsman in the engineering department of Lockheed for the past two years. The work has involved design of mechanisms and machined parts.

LIEUTENANT (j.g.) BRUCE LAWRENCE, U.S.N.R., returned recently from overseas duty on an aircraft carrier. He was married on March 2 to Miss Beverly Jan Gray of Pasadena.

JOHN T. JORDAN enlisted in the Navy in October, 1942. He is now Carpenter's Mate First Class in the 117th Battalion of the Naval Construction Battalion, somewhere in the Pacific. Before enlisting, he was geologist at the Cactus Mines Company at Mojave, Calif.

WALTER Z. DAVIS, Jr., is the father of a son, Walter Z. Davis, III, born April 25 at Spokane, Wash.

SERGEANT RICHARD SILBERSTEIN is now overseas.

1942

ROBERT N. HALL is the father of a son, Richard, born August 17, 1943.

GEORGE P. SUTTON and Miss Kathleen M. McMullan of Los Angeles were married on June 24. He is employed at the Institute as a mechanical engineer.

CHARLES M. BROWN is the father of a daughter, Kathleen Adair, born April 7.

WILLARD P. FULLER, Jr., is now an apprentice seaman in basic training at the U.S. Naval Training Station at San Diego, Calif. He was formerly mining geologist with Basic Magnesium, Inc., at Gabbs, Nev.

ALBERT D. PAUL, field engineer for General Electric Company, is now in the South Pacific.

ADRIAN MAYER is receiving basic training at Camp Grant, Ill., prior to entrance to Northwestern University Medical School in September under the A.S.T.P. program.

JOHN T. HAYS is employed at the Hercules Powder Company Experiment Station. He was married on August 1, 1943, to Miss Esther Henvis.

1943

AL GROTE and Miss Margaret Wheelan were married in Bakersfield on April 27.

ROBERT L. BENNETT is an ensign in the U.S.N.R., temporarily stationed at Washington, D.C.

ROBERT ROSS DAVIS and Miss Geraldine Spence of Pasadena have announced their engagement and plan to be married on August 26. He is employed by the Consolidated Engineering Corporation in Pasadena.

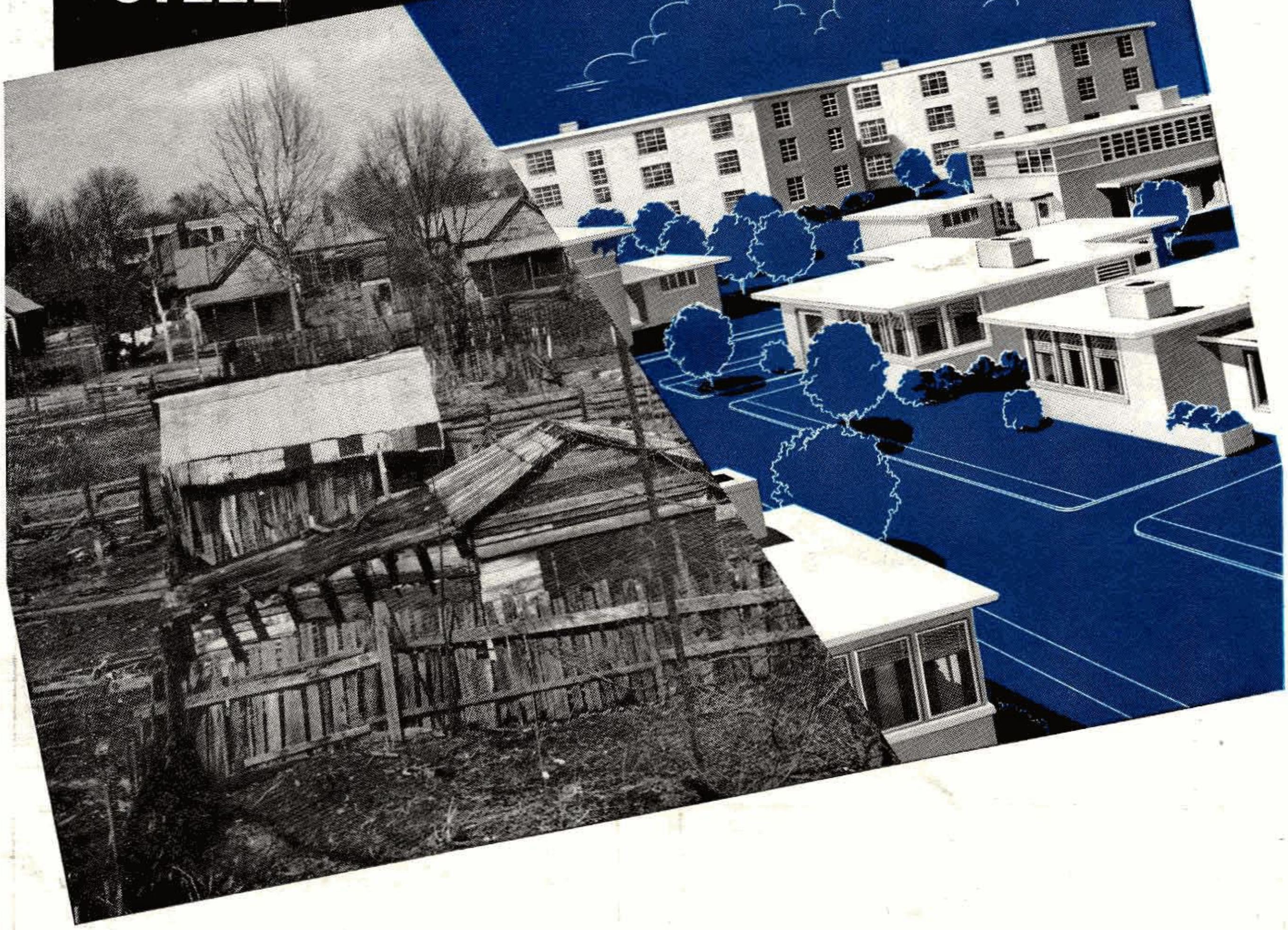
JOHN E. PETERSON, ex-'43, has entered the Army Air Forces Training Command School at Yale University for aviation cadet training in photography. Upon successful completion of this course he will be commissioned a second lieutenant and assigned to active duty with the Air Forces as an officer.

1944

ENSIGN HALE CHAPIN FIELD, U.S.N., and Miss Gingerlee Cordray were married May 6 in Williamsburg, Va.

1943 — Caltech Year Book — 1944

PROJECT IN STEEL



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