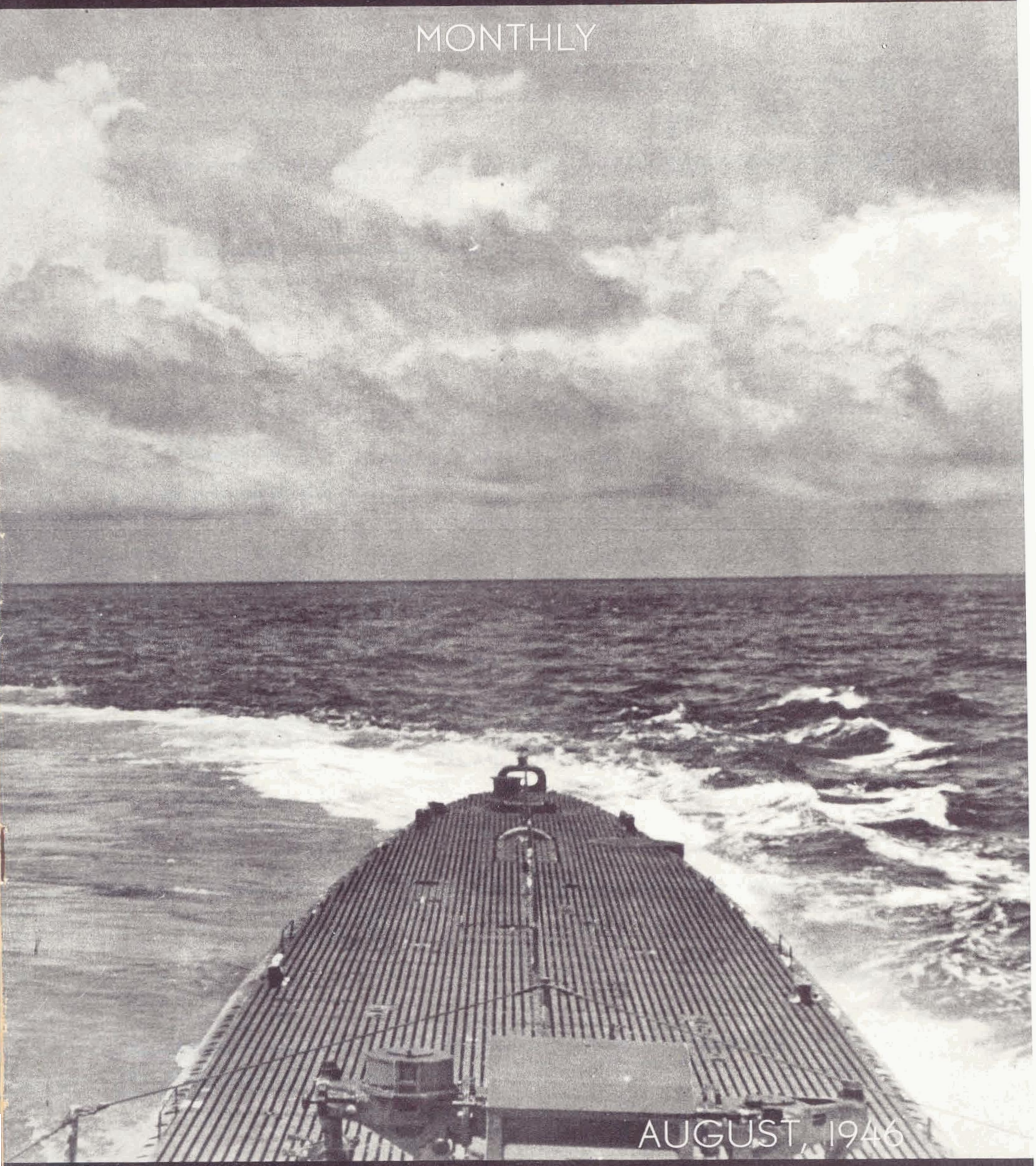
ENGINEERING AND SCIENCE

MONTHLY



AUGUST, 1946

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BY-LINES

HARRISON W. SIGWORTH

Lt. (j.g.) Harrison Sigworth, U.S.N.R. received his B. S. degree at the California Institute of Technology and in September 1943 joined the Navy. Having been chosen for submarine duty, he was assigned to a training submarine for three months, submarine school in New London, Conn., and then a short tour of duty on the submarine Cachalot. He saw the construction and commissioning of the submarine Loggerhead at Manitowoc, Wisconsin, participated in shakedown and training on Lake Michigan, and rode the boat down the Mississippi 1800 miles to tidewater. Lt. Sigworth made two war patrols on the Loggerhead in the South China Sea and Java Sea. At war's end the Loggerhead returned to the States for decommissioning.

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CARROL M. BEESON

Carrol M. Beeson received his A. B. degree in 1935 from U. C. L. A., and his Ph.D. degree in chemistry in 1939 from California Institute of Technology. Since September, 1938, Dr. Beeson has been employed by the General Petroleum Corporation. From 1940 on, he has been in charge of the Production Research Division of the Laboratories Department. He is National Vice-Chairman of the A. P. I. subcommittee on Core Analysis and Well Logging. A study group organized by him on the west coast has recently become affiliated with the A. I. M. E. as the subcommittee on Laboratory Methods of Production Research, of which he is Chairman.

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COVER CAPTION:

The submarine LOGGERHEAD makes a high speed turn in the South China Sea.

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ENGINEERING AND SCIENCE

Monthly

The Truth Shall Make You Free

CONTENTS FOR AUGUST, 1946

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ENGINEERING AND SCIENCE
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Vol. IX, No. 8 August, 1946

Why an Alumni Association

By ALLAN L. LAWS

AN ALUMNI Association, if it is to live, grow, and prosper, and be other than a name, must fulfill some function which is not fulfilled by any other organization or by any other means at the disposal of us qualified to belong. It should not provide merely a means of making inspection trips or of periodically meeting other alumni in the immediate vicinity for dinner and listening to a speaker. The Institute is now 25 years old, and its predecessor, Throop, dates back to the turn of the century. Most graduates, therefore, have reached the age where they belong to service clubs, professional societies, trade associations, or other groups which can adequately satisfy the need for meeting with others engaged in the same kind of work or with others of similar background or interests.

Why then an Association? Inasmuch as a qualification for membership is that a member at sometime in his life must have been a student on the Tech campus, perhaps to answer our question we should review the years when we were Tech students. Those years were among the most impressionable of our entire lives. We were led during that time to appreciate the works of the great, both dead and living; we were taught to think clearly; we founded friendships which will last during our lifetime; and we were admonished that "The Truth shall make you free." President Hyde of Bowdoin College gave a broader expression to this thought as follows: "To be at home in all lands and all ages; to count nature a familiar acquaintance and art an intimate friend; to gain a standard for the appreciation of other men's work and the criticism of one's own: to carry the keys of the world's library in one's pocket, and feel its resources behind one in whatever task he undertakes; to make hosts of friends among the men of one's own age who are to be leaders in all walks of life; to lose one's self in generous enthusiasms and cooperate with others for common ends; to learn manners from students who are gentlemen, and to form character under professors who are Christians—these are the returns of a college for the best four years of one's life."

As the years have passed, we who are Tech Alumni have become increasingly conscious of the influence that Tech has had on our lives, and with that realization comes a feeling of attachment and desire to maintain some connection with the Institute and with our former fellow students. This feeling of attachment is hard to define and place. It must be found in the realm of subtle feeling. It is as hard to define as is the feeling of a daughter or a son for his family or a soldier for his country. In many respects the emotions are similar.

Our Alumni Association satisfies this urge to remain a part of an institution which has had on us such a great influence by providing a connecting link with the Institute and a means of associating with other alumni. Associated with that desire for closeness is the hope that in some way we can repay a portion of the obligation that we owe our college. Again an association offers the desired medium in one very concrete manner by assisting the Institute in maintaining a Placement Service. This Placement Service is a real obligation, for the Institute, having given the graduate a degree and so approved him as an alumnus, turns over to the alumni from that time on a large share of the responsibility for that new graduate. Dr. Millikan expressed the close relationship between the Institute and the alumni in his Introduction to **Engineering and Science** when he said, "The alumni are by far the best representatives of the Institute's ideals, training and accomplishments, and through their contacts can exercise a vital influence on the future place of C.I.T. in American life. Reciprocally the prestige of the Institute is an invaluable asset to every alumnus."

To those who live too far from Pasadena and Los Angeles to attend meetings and renew acquaintances both with former friends and with once familiar surroundings, the Association magazine, **Engineering and Science,** serves as a tie. It conveys to our distant alumni news of other graduates and the policies and "pulse" of the Institute itself.

We can now answer our question of "Why an Alumni Association?" by saying that such an association provides the only means for fulfilling a deep-seated need of the alumnus for retaining a connection with both his alma mater and his former associates, and it offers the alumnus a vehicle for discharging in part his obligation to his college.

Modern United States Submarines

By HARRISON W. SIGWORTH

OF JAPAN'S combined naval and merchant tonnage sunk during the war, United States submarines sank 70 per cent, representing nearly five million tons. Undoubtedly fine fire control devices and superior radar accounted for much of this success, but these ingenious devices would have been useless had there not been a vehicle to carry them, undetected, within shooting distance of the enemy. It was also necessary that this vehicle be capable of bringing them home despite the efforts of enemy anti-submarine vessels, planes, and shore batteries; for submarine personnel and their effective apparatus were never considered expendable.

Such a submarine was developed in our Navy in 1939. Later models incorporated changes dictated by experience in the war, but essentially these "Fleet" type submarines were the same—big (over 300 feet long), fast, quick diving, deep diving, of long range. They were produced in such numbers after 1940 that a fleet was evolved, capable of whittling incessantly at the Japs from start to finish of the war.

How these boats dive and surface, how they propel themselves, stay at sea for months, and come back, meanwhile keeping a crew safe and in a good state of morale, are items of especial interest.

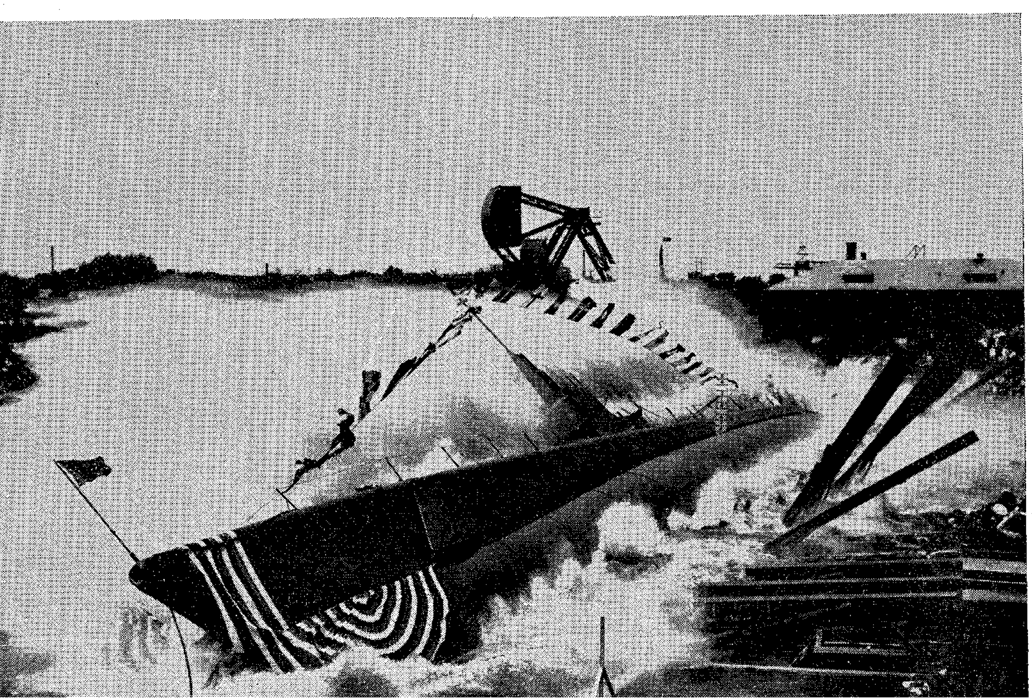
DIVING AND SURFACING

In the study of submersibles it is necessary to be acquainted with four types of buoyancy: neutral, positive, negative, and reserve. Neutral buoyancy is the state in which a submerged object displaces exactly its own weight. An object which floats has positive buoyancy. An object which sinks has negative buoyancy. Reserve buoyancy is the amount of weight a floating body must take on in order to submerge. In the case of a submarine, it equals the weight of water which must be flooded into the boat's tanks in order that it may dive with neutral buoyancy.

The tanks which are flooded on diving are called main ballast tanks. The drawing on the next page shows one of these in cross section. For the most part they are contained by the outer and inner hulls. In the bottom of the tanks along the keel are many big holes or "flood ports." The only thing which prevents the tanks from flooding through these holes when the boat is on the surface is the small air pressure maintained inside the tank. If the air pressure is vented off through the vent valves in the top of the tanks, the tanks will quickly flood. This, in fact, is the way a submarine is dived.

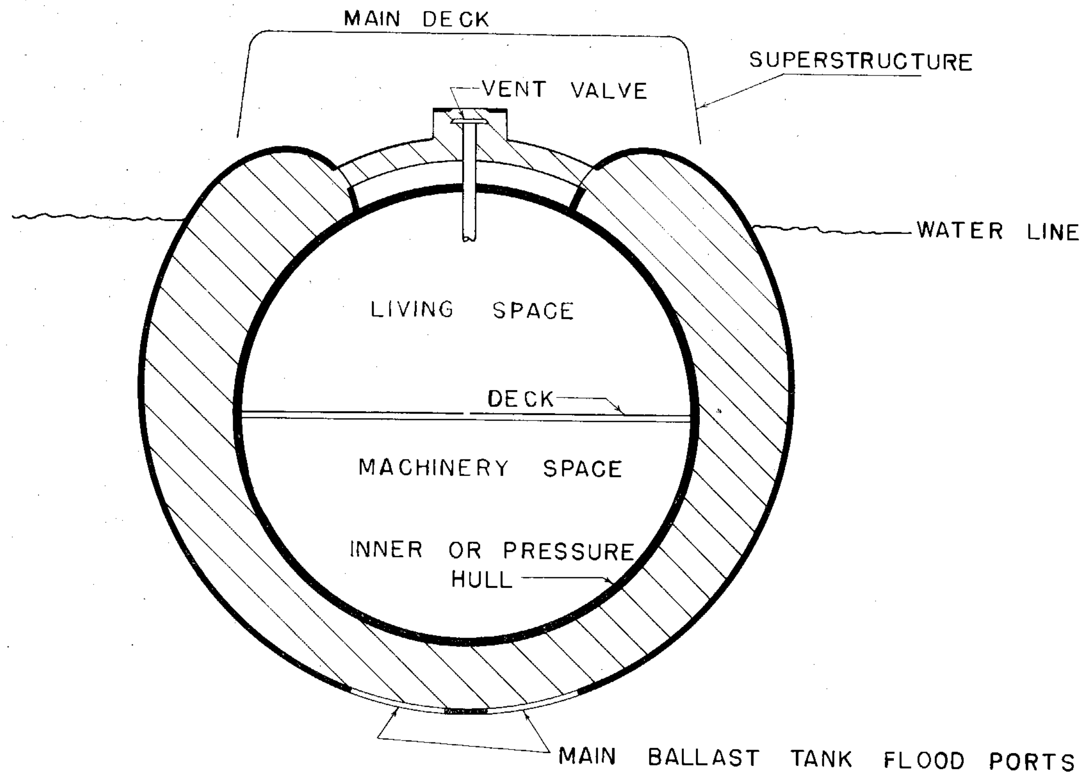
Since the flood ports are merely open holes, it can be seen that when the boat is submerged with the main ballast tanks flooded there is no differential of pressure through the outer hull. Consequently, the outer hull is of light construction. But since the pressure inside the boat is approximately atmospheric, the inner hull withstands full sea pressure. To withstand sea pressure at extreme depths the inner hull is thick and of circular cross section. Frames or braces are spaced longitudinally between the outer and inner hulls. These, being welded to the inner hull, are stressed in tension, with the result of a saving in weight and material.

All talk of diving with neutral buoyancy by flooding the main ballast tanks is predicated upon the fact that the reserve buoyancy must at all times approximate the capacity of the main ballast tanks. Changes in weight are occurring continuously while the boat is under way on the surface. Fuel is being used, water is being distilled and moved from one part of the boat to another, sanitary tanks are being emptied, and perhaps torpedoes and ammunition are being ex-



AT LEFT:

Submarine launching by the Manitowoc Shipbuilding Company, Manitowoc, Wisconsin. This was the only company to launch submarines sidewise.



AT RIGHT:

A typical cross-section of the double hull construction, with main ballast tank flood ports and vent in evidence.

pended. All these weight changes must be compensated for before the boat dives in order to keep the reserve buoyancy approximately equal to the capacity of the main ballast tanks. It is a policy to "compensate" the boat every few hours when under way or after each big change of weight, so that if the boat should dive at any minute, she would have a satisfactory trim.

To surface the boat, using the main ballast tanks, the vent valves are closed and high pressure air is injected at the top of the tanks, forcing water out through the flood ports. Compressed air for this purpose is stored in steel cylinders at several thousand pounds pressure. Enough water is blown out to surface the boat with the main deck awash, but the tanks are not blown dry, because it is highly uneconomical to compress air to such a high pressure and then throttle large volumes down to about 7 or 8 pounds per square inch. For this reason a high capacity, low pressure, Roots type blower is used to blow the tanks dry. The blower is not started until the hatch to the bridge is opened and can take its supply from the atmosphere.

When the boat is at sea, rigged for diving, only the hull valves necessary to the function of propulsion and ventilation are open. At the sounding of the diving alarm, first the hydraulically operated main ballast vents are opened. The boat starts to dive. Second, the engines are shut down and the exhaust valves closed. Propulsion is shifted to the battery. Third, the main air induction valve just aft of the conning tower is closed hydraulically. Fourth, when all personnel are below, the upper conning tower hatch is closed. The pressure hull is then watertight and the boat well on its way down.

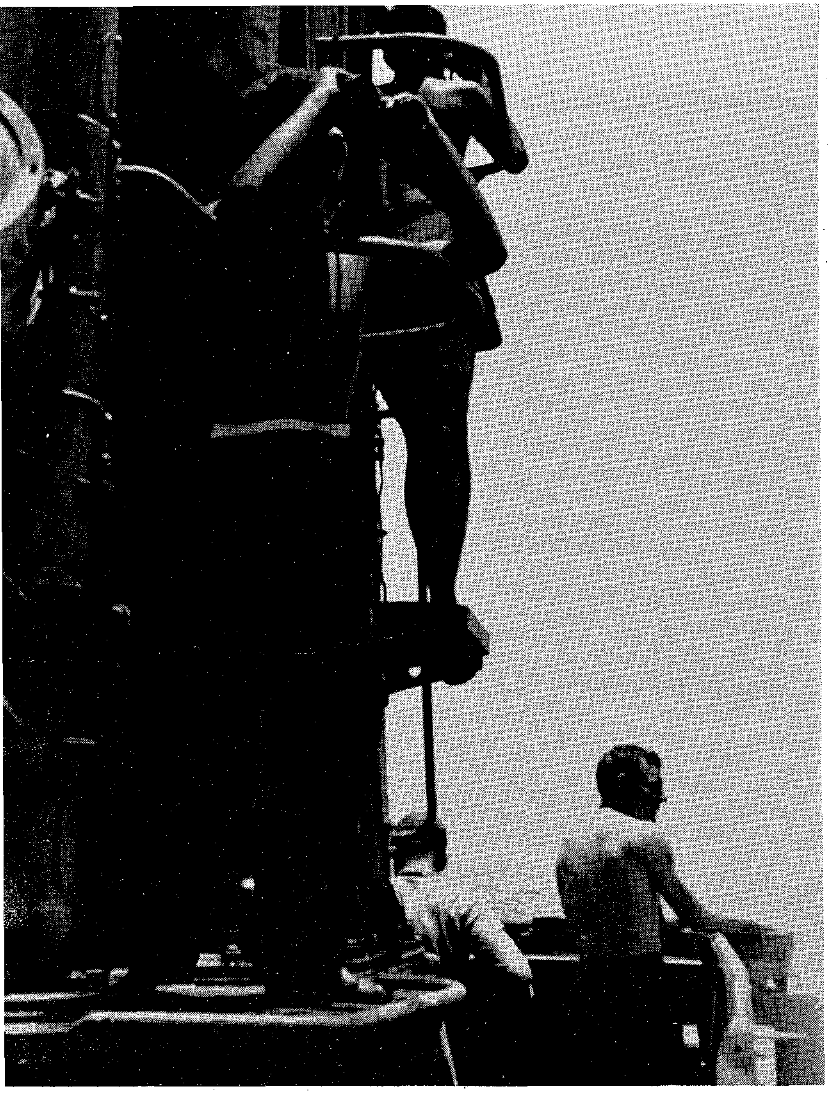
Although an exact figure on diving time is a guarded secret, it is less than a minute. From personal experience on the **Loggerhead** it can be said that the interval from the sounding of the diving alarm to water coming over the bridge is not long. Unless the officer-of-the-deck gets down the hatch on the heels of the lookouts, he is likely to find the hatch closed and himself swimming.

SUBMERGED OPERATION

The achievement of neutral buoyancy is a practical impossibility. It can be approached by pumping water out of the trimming tanks or flooding in; but true neutral buoyancy in which the boat will stay anywhere it is placed below the surface without sinking or broaching is impossible. Depth can be maintained within a foot for hours at a time, however, by propelling the boat through the water and using the diving planes. These are horizontal, tiltable, planing surfaces placed at the bow and stern to control depth and angle of the boat.

When a boat is badly out of trim from damage and taking on water, depth can still be controlled with the planes; but high speed must be used to increase the planing effect. The **Loggerhead** once dived 25,000 pounds heavy in the after end of the boat with the after trimming tank dry. By using a 15 degree up angle and full speed, depth was maintained. In this case advantage was taken of the planing effect of the whole hull by allowing such a large up angle.

There are three variable ballast tanks or trimming tanks: one forward at the bow; one at the center of gravity, called the auxiliary tank; and one aft. These tanks and a pump are interconnected so that trim fore and aft as well as overall can be adjusted. There is no stability fore and aft, submerged, like that from side to side. Thus trim fore and aft must be reckoned with. The tanks are of large enough capacity to compensate for the difference between displacement at the start and at the end of the patrol when a boat has lost stores and torpedoes. It is noteworthy that these boats can be made to operate in fresh water, which necessitates a ballast change of 100,000 pounds.



Lookouts and Officer of the Deck on the Loggerhead keep a sharp watch in a war zone, ready to dive at any instant.

PROPULSION

Fleet submarines have a so-called Diesel-electric drive. On the surface four 1600 horsepower, constant speed, non-reversible, Diesel engines each drive a direct current generator. Two direct current motors are connected to each of two propeller shafts. If one considers the fact that energy for propulsion submerged must be supplied by batteries, this type of drive is seen to be the simplest and most flexible. On diving, the motors can quickly be switched from generators to batteries. On the surface, any combination of generators may be used for propulsion or charging batteries.

Maximum speed, submerged, is 10 knots. On the surface it is about 20 knots. But many factors contribute to varying this latter figure—to name a few, the state of the seas, the draft of the boat, the condition of the bottom (whether clean or not). The best speed ever made by the **Loggerhead** was raised 2 knots one night after an attack on a convoy in a Japanese harbor, when she was chased by four escort vessels in water too shallow for diving.

Generally the engineering plant of the **Loggerhead** performed amazing feats of endurance. Eighteen thousand miles were steamed during one patrol. At one time a run of 2,000 miles was made from the Java Sea to Subic Bay, the Philippines, at full speed virtually all of the way.

SAFETY DEVICES

The development of the United States submarine is largely a story of safety precautions. Every time a boat has an accident or is inadvertently sunk, detailed observations are made and improvements result to avert the danger in a later instance.

The **Squalus** sank on trial runs off Portsmouth, New Hampshire, in 1939 because she dived with the large air induction valve open, allowing a stream of water 36 inches in diameter to flood into the boat. The **Squalus** was later raised, but difficulty was encountered in closing the main induction valve while the **Squalus** lay on the bottom. Now each submarine is fitted with quick closing valves inboard of the main induction, as well as having a special wrench stowed topside for divers to use in closing the valve, should it ever be necessary.

Each compartment is fitted with pipes running from the topside for blowing out water. Each main ballast tank can also be blown by means of fittings on the main deck. Marker buoys which may be released by a sunken boat provide telephone communications with the surface.

During his training every submariner is required to make an ascent from a depth of 100 ft., using the oxygen-charged Momsen Lung. These "lungs" are effective in aiding escape to depths of 300 ft. So at least a fighting chance is provided the crew of a boat in peacetime, if they are fortunate enough to find themselves sunk in shallow water.

Hydrogen generated when the batteries are being charged has always been a menace. Five per cent in air will make an explosion sufficient to kill everyone in a battery compartment. Consequently, by forced ventilation through the top of each battery cell, the concentration is maintained below three per cent, even when charging is going on.

More than any other ship, a submarine is in danger from collision. On the surface the reserve buoyancy is only 20 per cent of the displacement, while in the case of most surface craft, it is normally 100 per cent. A submarine's pressure hull is virtually below the surface at all times. Only the conning tower and superstructure emerge on surfacing; thus the puncturing of the pressure hull means almost certain disaster. The only cure for this danger is prevention. The submarine service is outstanding for giving every officer, including the youngest, ample opportunity to handle the ship in all operations, surfaced and submerged. By this policy the safety of the boat is never jeopardized by inexperienced ship handlers.

There are submarines which have made 5000 dives without a serious accident. They develop a diving procedure which is full of precautions yet runs like clockwork. Of the 46 boats which failed to return from patrol during the war, some had been bombed, some torpedoed, but undoubtedly some had fatal accidents. That is inevitable in a machine which dives as a matter of routine.

LIVING CONDITIONS

It has been said that the storage battery, the Diesel engine and the tin can made submarine warfare possible. But it would be best to add that air conditioning and fresh frozen foods are what made the submarine livable. No surface craft can pretend to boast the atmospheric comfort enjoyed in a submarine. Whether the boat is surfaced or submerged, the controlled ventilation, combined with small room volume, allows excellent air conditioning. In patrols four degrees in latitude from the equator submarine crews are no less comfortable than at 40 degrees from the equator. On the **Loggerhead,** fresh meat twice a day was the rule. Special ice cream machines ran continuously, turning out ice cream for every meal, if desired. Fancy dishes such as shrimp and lobster were carried. Bread, cakes, and pies were baked regularly, for food was recognized as a major morale factor. The average patrol run was 60 days; and after he has looked at the same 79 faces and the same eight rooms and the same ocean for months, meals become important in a man's life.

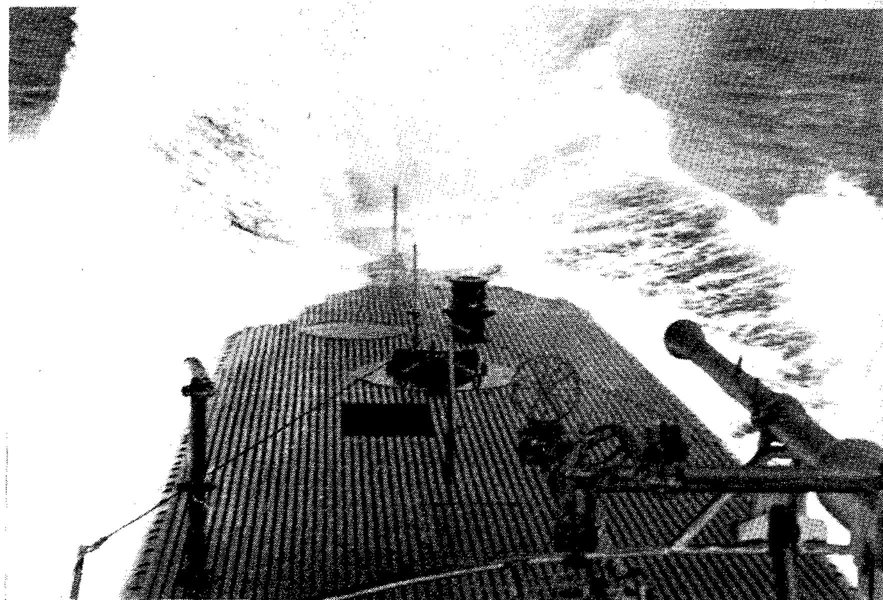
Quarters were cramped. Forty men sleep in a compartment 18 ft. by 30 ft. with semicircular overhead. Stowage of food, personal effects, and spare parts is an ever-present problem. On more than one boat passage ways were paved with stores in boxes of uniform height. It is generally known that torpedoes are bunkmates with many a submariner, but so are valves piping, chain fall and motor-generator sets.

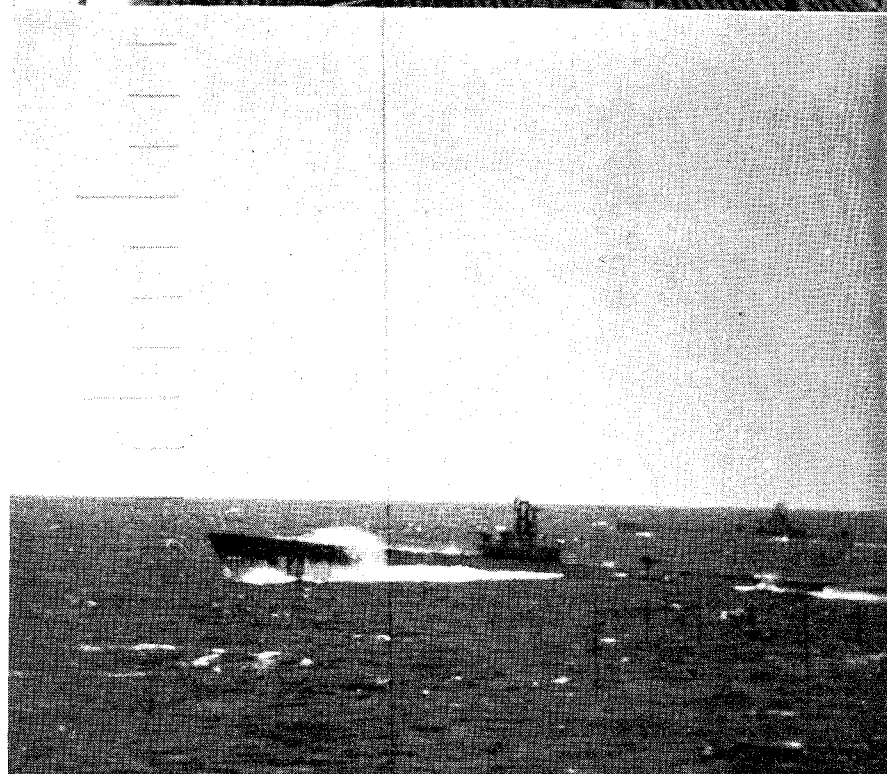
Cleanliness is important; much effort is expended to keep the boats clean. The new boats have a beautiful interior which may be likened to a fine new Pullman car, despite the predominance of piping and valves in the motif. Nor was nine million dollars spent for machinery only. Broadcast radios, record players, and record libraries come with the boat.

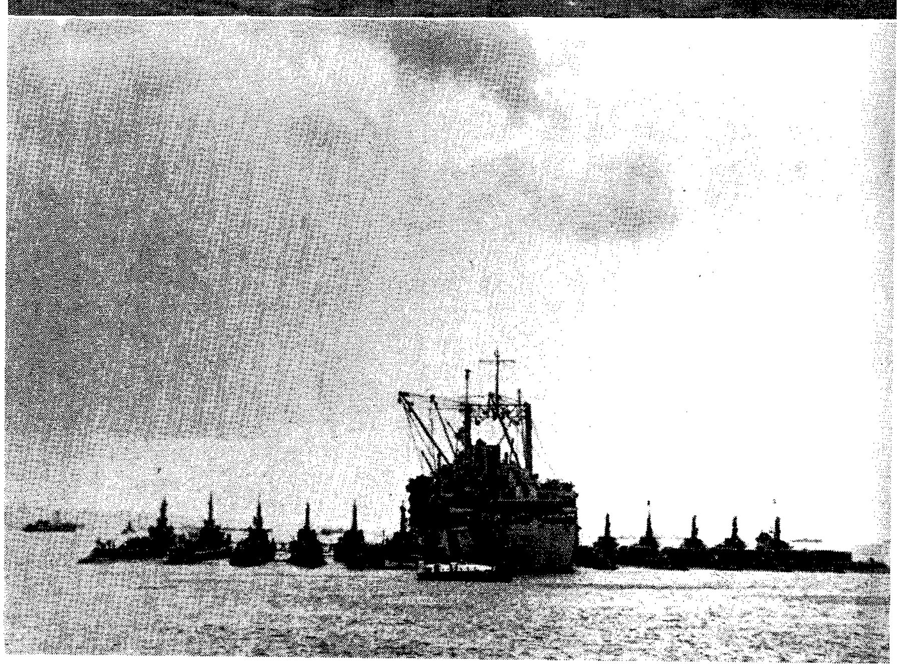
An interesting oddity is that mice or rats are unknown on an operating submarine. Perhaps the reason is the Diesel odor, or maybe the body odor (six days between showers), or the old theory of rats leaving a sinking ship. In any event, they, along with bacteria in general, pay little attention to submarines. Cases of colds, influenza, catarrhal fever clear up after a few days at sea and never reappear.*

*Another biological curiosity is the recognized predominance of girls born to the wives of submariners. In one year, to the families of one submarine squadron 20 children were born. Of these, 18 were girls.

(Continued on page 12)







AT RIGHT:

UPPER: U. S. S. Loggerhead (SS374) taking green water over the bow in the Indian Ocean. CENTER: A modern submarine surfacing. Taken through the Loggerhead's periscope. LOWER: Submarines alongside tender in Subic Bay, Philippines.

PETROLEUM-PRODUCTION RESEARCH

By CARROL M. BEESON

PRODUCTION research is a broad field in which so many valuable principles have been established that no attempt will be made in this place to cover the subject or to enumerate the outstanding contributions. An article of the present kind may more properly mention items that are likely to be of general interest, and at the same time indicate the scope of the field. In addition, the attempt should be made to point out the many existing opportunities for further improvement through research.

FLOW OF OIL, WATER, AND GAS THROUGH SAND

Much of the progress that has been made may be ascribed to the application of a few of the principles governing the simultaneous flow of oil, water, and gas through porous media. At present, few operators would allow the pressure to be exhausted unnecessarily from an oil formation, because they realize that the total production would suffer. Nearly everyone is now aware that maximum production ordinarily is obtained by operating the entire reservoir so as to allow water to enter the sand as rapidly as oil is removed, thereby minimizing the evolution of gas from the oil. Evolution of gas occurs when the pressure drops below the bubble point, and the resulting gas bubbles may interfere seriously with the flow of oil through the tiny sand pores. Furthermore, the restrictions are even greater in the proper handling of condensate fields, in which a reduction in pressure may give rise to retrograde condensation, with possibly irremediable loss of valuable hydrocarbons.

It was necessary to obtain a mass of data, both in the laboratory and in the field, in order to begin to understand reservoir mechanics, and a great deal still remains to be done. In fact, acquiring a thorough knowledge of multi-phase flow through porous media is such a major undertaking that many hope it will soon be made a cooperative effort by the entire industry.

VOLUMETRIC AND PHASE BEHAVIOR OF HYDROCARBONS

Research Project 37 of the American Petroleum Institute, which has been carried forward at the California Institute of Technology, may be cited as an outstanding example of the progress that can be made by properly directed cooperative effort. Professors Lacey and Sage and co-workers, in the investigations of "The Fundamentals of Hydrocarbon Behavior", have gathered an enormous number of excellent volumetric and phase data. Their work has become a manual for the pressure-volume-temperature relations of hydrocarbons, and has guided the design of equipment for such studies. In addition, their research in retrograde condensation has led to a better understanding of condensate fields and has aided in the design of equipment for processing the fluids from those fields.

EFFECT OF DRILLING FLUIDS ON SUBSEQUENT PRODUCTION

A particularly attractive part of production research is the study of the effect of drilling fluids on production. The possibilities in this direction are readily apparent, for a drilling fluid of some kind is present in the hole from the time the well is spudded until it is completed, and doubtless some of it remains long afterward. During most of the drilling operations, the pressure of the mud exceeds that of the fluids in the formation, and hence part of the mud may be forced into an oil sand. After the well has been completed, some of the mud remains plastered on the face of the well bore and some is left in the hole.

As a consequence, drilling fluids have ample opportunity to influence oil-well productivity. The part that enters the sand may reduce the permeability of the critical region near the well bore, and the part that remains in the well may restrict flow through it. Thus, either of these factors may seriously decrease the productivity of the well.

In the progress toward a solution of this important problem, many obstacles were encountered. For example, the sustained flow of liquids through porous media gave rise to plugging by bacteria and by traces of impurities that ordinarily cause little concern. Successful methods have been devised for treating liquids to remove impurities and to prevent bacterial growth. Again, natural sandstone cores are much less inert to water than might be supposed. This fact led to the discovery [1*] of the hydrational effects of clay-like materials contained in oil sands on the West Coast. It also required additional experiments conducted with more inert porous media, such as sintered Pyrex-glass filters.

It is probably apparent that the problem required separation of the variables. The portion of the mud remaining in the well bore presents a somewhat different problem from the portion penetrating the formation. The latter, in turn, may be separated into plugging by solids and by liquids. Finally, the liquids may give rise to globule resistance, to hydrational effects, or to precipitation of solids. By study of these variables separately, much gratifying progress has already been made.

ESTIMATION OF INTERSTITIAL WATER

Another interesting line of research has lain in developing a laboratory method of estimating the water content of oil formations. There is an acute need for this information as an aid in estimating oil reserves, since it is now widely accepted that oil sands are generally wet with what is termed interstitial water, the oil being held in the remaining pore space.

By the time a core taken in a conventional manner has reached the surface, it has been exposed to flushing by the drilling fluid and to depletion by the decrease in pressume from that of the formation to that of atmospheric. Accordingly, the residual con-

*References are given at the end of the article.

tents of oil, water, and gas give little hint as to the interstitial contents of the sand prior to coring.

A knowledge of the interstitial-water content, along with the porosity, would permit estimations of oil reserves in most virgin formations, as the pressure is usually at or above the bubble point and little free gas is present. Considerable expense is involved in the special technique and equipment required to measure the extent of infiltration or to prohibit it, and to prevent pressure depletion of the core while being brought to the surface. As a consequence, a great deal of work has been done [2-3-4] to develop a laboratory method that may be applied to the estimation of interstitial water through the use of cleaned core samples.

In brief, the technique involves making capillary contact between a water-saturated core and a water-saturated porcelain plate with an air-entrance pressure in excess of the highest pressure to be applied during the run. A predetermined pressure of air may be applied to all surfaces of the sample except the part making contact with the porcelain plate. Thus, water may be forced out of the core and through the plate by a constant pressure of air which may permeate all parts of the core without entering the plate. Water is forced out of the sample through the application of increasing pressures, until the pressure is observed to have little further effect.

An analogous method has been developed which involves removing the water by centrifugal force instead of by gas pressure. In either case, the water which is relatively difficult to remove from the core sample is considered as an approximation to the water content of the portion of an oil formation above the zone of transition from underlying water to oil. Both methods are based upon experiments performed earlier by soil technologists.

CORE ANALYSIS

Those interested in increasing oil-well productivity may spend considerable time in improving the methods used in analyzing samples cored from subsurface formations.

The most immediate use of core-analysis data lies in distinguishing oil sands from water sands. Especially when coupled with measurements of permeability, this knowledge aids greatly in the proper development of the drilling and completion program. By comparison of production data with those obtained from core analyses, the core oil-water ratio has been found [5] to be a fairly good empirical criterion for differentiating oil and water sands.

Various methods of determining oil-water ratios have been devised, all involving either distillation or extraction of the contents of the core. The information ordinarily is extended to include the proportion of the pore space occupied by oil or water, which involves the measurement of porosity.

The porosity, or percentage of the bulk volume which is void, may be obtained in a number of ways, and probably most of them have been tried at one time or another by the industry. The main problem involved is pertinent to core analysis as a whole, that of developing a method which is very rapid and yields results with deviations of 1 or 2 per cent. This is due to the need for fairly accurate results on a large number of cores rather than very accurate results on a few.

The determination of permeabiliy is probably more interesting from a fundamental standpoint than any other measurement common to core analysis. Of course, the property that is desired is the permeability of an oil formation to the reservoir fluids. Doubtless, water and oil are both present, and gas as well when the pressure drops below the bubble point. As indicated earlier, multi-phase flow is not thoroughly understood and the measurements are very time-consuming. Consequently, routine determinations of permeability generally have been restricted to the use of air with cleaned and dried core samples.

A recent investigation[1] has indicated the advisability of measuring single-phase permeability after the core solids have had the opportunity to hydrate in the presence of natural or artificial formation water. Oil sands on the West Coast contain varying amounts of hydratable material, and, when cleaned cores are resaturated with formation water, the permeability is often drastically reduced below the single-phase permeability measured with air. The effect of hydration may be emphasized by noting that the development of a satisfactory method of determining permeability to water required preventing disintegration of the core sample during measurement. This was finally accomplished by protecting each end of the sample with a firm pack of realtively permeable sand washed free of hydratable material. Apparently, the protecting sand usually prevents the movement of the outer layers of core solids, so that disintegration does not get a chance to begin.

Aside from the interest that has been aroused recently concerning the importance of determining permeabilities with formation waters, the measurement of permeability in the absence of hydrational effects has occasioned numerous fundamental discussions.

FUNDAMENTAL DISCUSSIONS OF PERMEABILITY

It has been known [6] for many years that slip at the wall affects the rate of flow of gases through capillary tubes; i.e., the gas molecules close to the walls of the tube have velocity components along the direction of flow. As a consequence, the quantity of gas flowing through a capillary is greater than would be predicted from Poiseuille's law for viscous flow, by the amount of superimposed plug-like flow. The correction for slip has been shown to be inversely proportional to the radius of the tube and directly proportional to the mean free path of the molecules. Hence, the correction increases with decreasing radii and with decreasing mean pressure.

Klinkenberg[7] was the first to call attention to the fact that the correction for slip was appreciable in the flow of gases through many oil-formation samples at the near-atmospheric pressures used for laboratory measurements. His data showed that determinations with the less permeable oil-producing formations often yield permeabilities 25 per cent or more above the values obtained by extrapolation to infinite mean pressure. In further agreement with theory, the values obtained with increasing mean pressures were found to approach sufficiently closely those measured with liquids free from electro-endosmotic effects.

The pores in oil formations have bulges, constrictions, and crevices, and their shapes are far from that of a cylindrical capillary. Nevertheless, it may be of interest that a capillary with a uniform radius of 0.0001 cm would have a correction for the slip of air at atmospheric pressure of about 25 per cent. Furthermore, other methods of estimating the effective pore diameter of such samples yield similar results, with values ranging up to 0.001 cm for the more permeable oil sands.

The principles involved in measuring permeability, as presented[7] to the industry in 1941, did not rest unchallenged for long. In 1943, Grunberg and Nissan[8] adduced evidence that the permeability to a gas depends not only upon the mean pressure, but also upon the pressure drop through the porous material. In fact, dimensional analysis and experimental data indicated that permeability is a function of each of these variables divided by the product of the gas density times the square of the linear velocity, as well as a function of the Reynolds number even in the viscous region. A similar study of permeability to liquids caused the authors to arrive at the conclusion that "the effective cross-section under viscous flow was different for different liquids, due to differences in surface energy and consequently differences in thickness of adsorbed layers". Experimental data supported the results of dimensional analysis which signified that the permeability is a function of "the ratio of resistance due to kinematic viscosity to that due to surface-energy effects".

Activities during the war have delayed experiments designed to test the accuracy of these deductions. A good deal hinges upon the results, especially in the proper operation of gas or condensate fields. The large differences between maximum and minimum values of permeability to a gas, which Grunberg and Nissan found to depend upon the Reynolds number in the viscous region, apparently apply to conditions prevailing in many reservoirs. There seems less likelihood of immediate application of the knowledge to improving methods of producing oil, since permeability to a liquid appears less subject to change.

WATER AND OIL

The relation of water to the production of oil has been of interest since the inception of the petroleum industry. At the turn of the century, oil producers in Pennsylvania and New York noticed substantial increases in oil production when water leaked through corroded casings of old wells into producing formations. As early as 1880, Carll[9] had recognized that when oil is produced, something has to reoccupy the vacated space, and that water might be the best flushing agent. Nevertheless, systematic water flooding was not legalized until 1919 in New York and 1921 in Pennsylvania. The delay undoubtedly was due to the fact that the haphazard use of water can do as much toward diminishing the production of oil as systematic flooding can do toward increasing it. Accordingly, the many examples of resulting damage caused the practice to be viewed with skepticism until much had been learned concerning the relations between oil, water, gas, and reservoir solids.

The gradual accumulation of knowledge related to the volumetric and phase behavior of hydrocarbons and to multi-phase flow through porous media slowly shed light upon the problem. In addition, information was needed concerning the wetting characteristics of reservoir solids.

Research Project 27, sponsored by the American Petroleum Institute, got under way during 1939 with Professor Bartell of the University of Michigan directing the study of the "Function of Water in the Production of Oil from Reservoirs".

The investigations have brought to light a large number of surface-energy relations between silica or limestone and various pure hydrocarbon constituents of petroleum. Laboratory methods developed in the project have been used throughout the industry with success.

The possibility that the solids in some reservoirs may be wet with water while the solids in others are wet with oil, or that wetting characteristics may be reversed in the same reservoir, has occasioned much discussion. A complete understanding of the situation will require wetting tests with reservoir solids and fluids at pertinent temperatures and pressures. This is a difficult undertaking, but doubtless the results would help in raising the percentage of oil recovered.

OTHER PRODUCTION RESEARCH

Space permits only the enumeration of a few other fields of production research. These include developing the following: liners which allow entrance of oil without sand, cementing materials and placement techniques effective in drilling and completion operations, and usable drilling fluids causing little or no damage to subsequent producton. In addition, there is the ever present need for improving the methods of research.

Recently, there has been organized on the West Coast the Study Group on Laboratory Methods of Production Research. The group has just become affiliated with the American Institute of Mining and Metallurgical Engineers as a subcommittee which is expected to develop a wide representation throughout the industry. The interchange of ideas through discussions, correspondence and reports should aid greatly in solving many perplexing problems.

Much has already been accomplished through research in this field, both by competitive and cooperative efforts. Only two research projects of the American Petroleum Institute have been included in the present discussion, but many others have contributed to the general knowledge. Furthermore, it would be difficult to overestimate the progress that has been made through the continual interchange of ideas which has taken place in the various committees and publications sponsored by the Institute. Likewise, the American Institute of Mining and Metallurgical Engineers has stimulated a large share of the research activity, through discussions and publications. Despite past progress, much still remains to be done, but there can be little doubt of the end result, provided a wise balance between competition and cooperation continues to prevail throughout the industry.

[1]N. Johnston and C. M. Beeson, **Water Permeability of Reservoir Sands.** Trans. Am. Inst. Mining and Met. Engrs. **160**, 43 (1945)

[2]M. C. Leverett, **Capillary Behavior in Porous Solids.** Trans. Am. Inst. Mining and Met. Engrs. **142**, 152 (1941)

[3]G. L. Hassler, E. Brunner, and T. H. Deahl, **The Role of Capillarity in Oil Production.** Ibid. **155**, 155 (1944)

[4]J. J. McCullough, F. W. Albaugh, and P. H. Jones, **Determination of the Interstitial-Water Content of Oil and Gas Sand by Laboratory Tests of Core Samples.** Am. Petrol. Inst. Drilling and Production Practice 180 (1944)

[5]C. M. Beeson and N. Johnston, **Core Analysis Based on Vacuum Distillation,** Am. Inst. Mining and Met. Engrs. Petroleum Technology, March, 1946, T.P. 2017

[6]International Critical Tables Vol. V, pages 1 and 2 (1928)

[7]L. J. Klinkenberg, **The Permeability of Porous Media to Liquids and Gases.** Am. Petrol. Inst. Drilling and Production Practice 200 (1941)

[8]L. Grunberg and A. H. Nissan, **The Permeability of Porous Solids to Gases and Liquids.** J. Inst. Petrol. **29** (236), 193 (1943)

[9]J. F. Carll, **The Geology of the Oil Regions of Warren, Venango, Clarion, and Butler Counties.** Penn. 2nd Geol. Survey Rept. III 263 (1880)

Reproduction of Prints, Drawings, and Paintings of Interest in the History of Science and Engineering

9. Three Prophetic Aeronautical Prints

By E. C. WATSON

ATTENTION has been called recently to a number of interesting predictions concerning the invention, use and misuse of aircraft.[1] Such predictions are really not particularly surprising if written in the nineteenth century because, as a result of the lighter-than-air developments which took place during the last two decades of the eighteenth century, almost all of the uses—and misuses—to which airplanes have been put during the twentieth century were seriously suggested and even tried with balloons, and many of these suggestions and trials not only were recorded but were given widespread publicity by the numerous prints and caricatures which appeared during that period.

The prints reproduced in this article are three examples from many that might have been chosen to illustrate the military uses of aircraft which were suggested about 1800. Except for the fact that balloons are depicted instead of airplanes, they might almost represent battle scenes of the war just ended.

The first suggestion of the possible military use of aircraft was made in 1670 by the Jesuit, FRANCESCO LANA (1631-1687), in connection with his proposal of the first lighter-than-air machine based upon a sound scientific principle.[2]

LANA did not attempt to construct the proposed aerial ship for the following reason:

> God would not suffer such an invention to take effect, by reason of the disturbance it would cause to the civil government of men. For who sees that no City can be secure against attack, since our Ship may at any time be placed directly over it, and descending down may discharge Souldiers; that the same it would happen to private Houses, and Ships on the Sea: for our Ship descending out of the air to the Sails of Sea-Ships . . . it may over-set them, kill their men, burn their Ships by artificial Fire-works and Fire-balls. And this they may do not only to ships but to great Buildings, Castles, Cities, with such security that they which cast these things down from a height out of Gun-shot, cannot on the other side be offended by those from below.[3]

This is a truly remarkable prediction and one that was completely realized during World War II. That

[1]See, for example, M. F. Ashley Montagu's note in Science 98, 431 (1943).

[2]F. Lana, **Prodromo overo Saggio di alcune Inventioni Nuove premesso all'Arte Maestra** (Brescia, 1670).

[3]Translation by Robert Hooke, **Philosophical collections** (London, 1679), No. 1, p. 18.

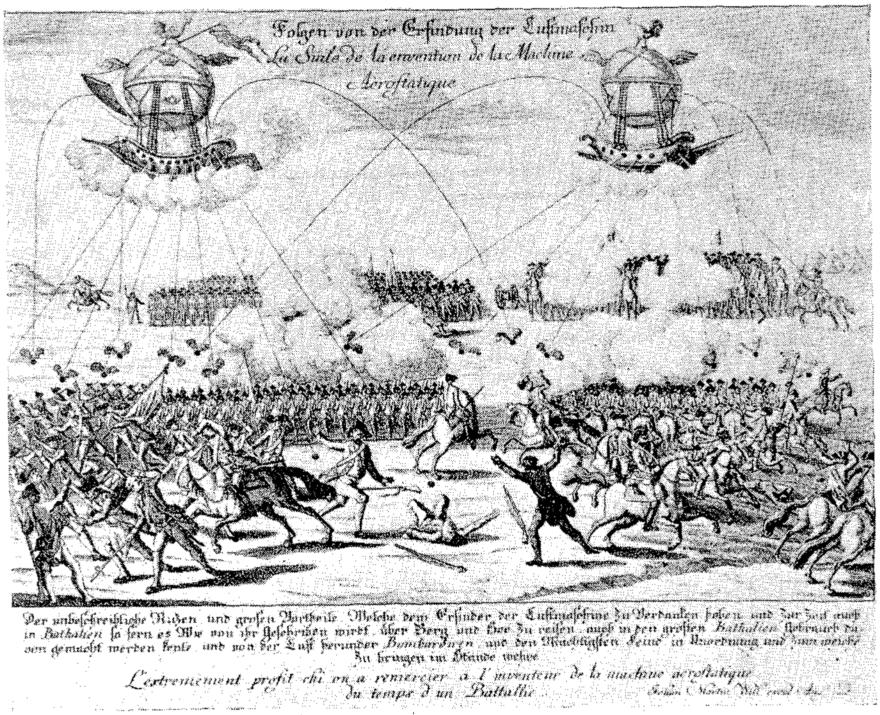


Plate 1. A German caricature showing two military balloons strafing troop concentrations. *(Circa 1804)*

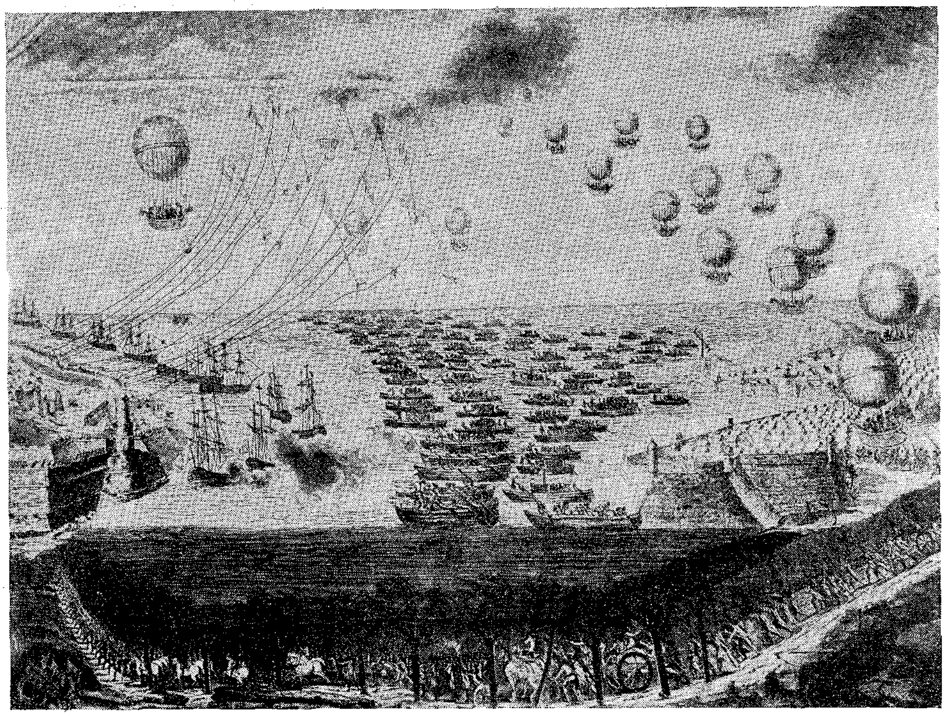
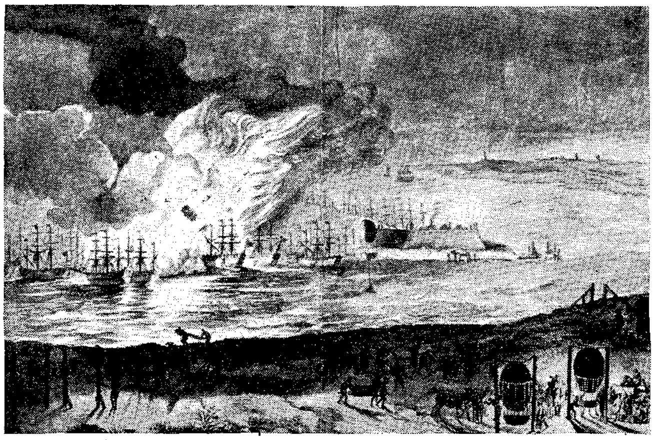


Plate 2. A Napoleonic project for attacking England. *(Circa 1803)*

the possibilities envisioned by LANA and achieved by modern war planes were also considered very seriously nearly 150 years ago is clear from the three prints here reproduced.



The bombing and strafing of troop concentrations by airplanes has now become standard practice. Plate 1 is a reproduction of a German caricature of about 1804 showing two armies, one of which is put to flight by the artillery of two aircraft.

During the Napoleonic Wars several schemes for attacking England from the air were proposed. Plate 2 shows the French forces attacking in balloons, in barges and through a channel tunnel. Actually from May 1803 until August 1805, NAPOLEON had an army of approximately 130,000 men encamped at Boulogne while more than 2000 flat-bottomed boats and barges, designed to land men and equipment on the beaches at Dover, were constructed and assembled. The project was abandoned only shortly before the Battle of Trafalgar.

Plate 3 is an early (**circa** 1803) suggestion of a bombing attack from the air on the British Fleet.

Plate 3. (left) A Napoleonic project for destroying the British fleet. *(Circa 1803)*

Modern United States Submarines

(Continued from page 7)

But the finest part of submarining during the war was the two-weeks rest periods after each run. For two weeks a man lived ashore in a hotel while the repair crews took over the boat. He got caught up on the sleep, fresh milk, oranges, eggs, and horseback riding that he had missed at sea. Or if he spent a refit in Australia, he could lose sleep and have a fine enough time to require two months of sea duty for recuperation. The important thing was the complete change in living routine, environment, and the lifting of all responsibility.

Fifty-two United States submarines were lost during the war—less than the number lost by any Axis nation or by Great Britain. The Germans lost 700. The Japanese lost over 100 out of an original 140. The damage to the enemy by the submarine force of this country in proportion to losses was tremendous, any way one looks at it. In terms of tonnage, the Japanese paid 100,000 of theirs for every 1500 of ours. In terms of lives lost, every American accounted for about 70 Japanese. At war's end there were 240 submarines in the United States Navy. There can be no doubt of the effectiveness of this weapon, considering the small size of the submarine force in terms of what it did.

The future of the submarine looks even brighter. Faster submerged speeds, faster, smaller and longer range torpedoes, and its innate ability to hide from radar may well leave the submarine the only truly **naval** weapon of the future. In any event, the modern American submarine has proved itself a fine foundation on which to build a future submarine navy.

Aid To War-Stricken Scientific Libraries

By FRITZ ZWICKY*

THE WORLD of today is in a state of disorder which is in conspicuous contrast to the avowed purposes of man. It is not intended in this article to analyze the reasons for this sad state of affairs. It may merely be stated as a personal opinion that the teachings of science, of education, and of religion seem to have become lost in an elaborate system of hypocrisy in which there is little relation between words and actions. Assuming that a deeper analysis will bear out this view, some simple directives suggest themselves for the purpose of making actions measure up to professed convictions. These directives, which concern both the community and the individual, obviously constitute a vast problem, the solution of which might profitably be attempted in a series of successive approximations. These approximations should be considered as limited and flexible temporary objectives.

One of the objectives which in particular is of interest to men of science concerns itself with the establishment of closer international and national scientific human relations. On the basis of the views expressed above, it is mostly actions which are lacking, rather than words. It does not appear difficult to name many fields of action which may strengthen mutual confidence and thus pave the way to peace.

*Professor of Astrophysics, C.I.T.

For instance, an analysis of the needs of war-stricken countries in matters scientific and technical shows the necessity for the following primary prerequisites:

The collection and the free delivery of

a) Scientific journals and books.

b) Elementary and advanced scientific instruments.

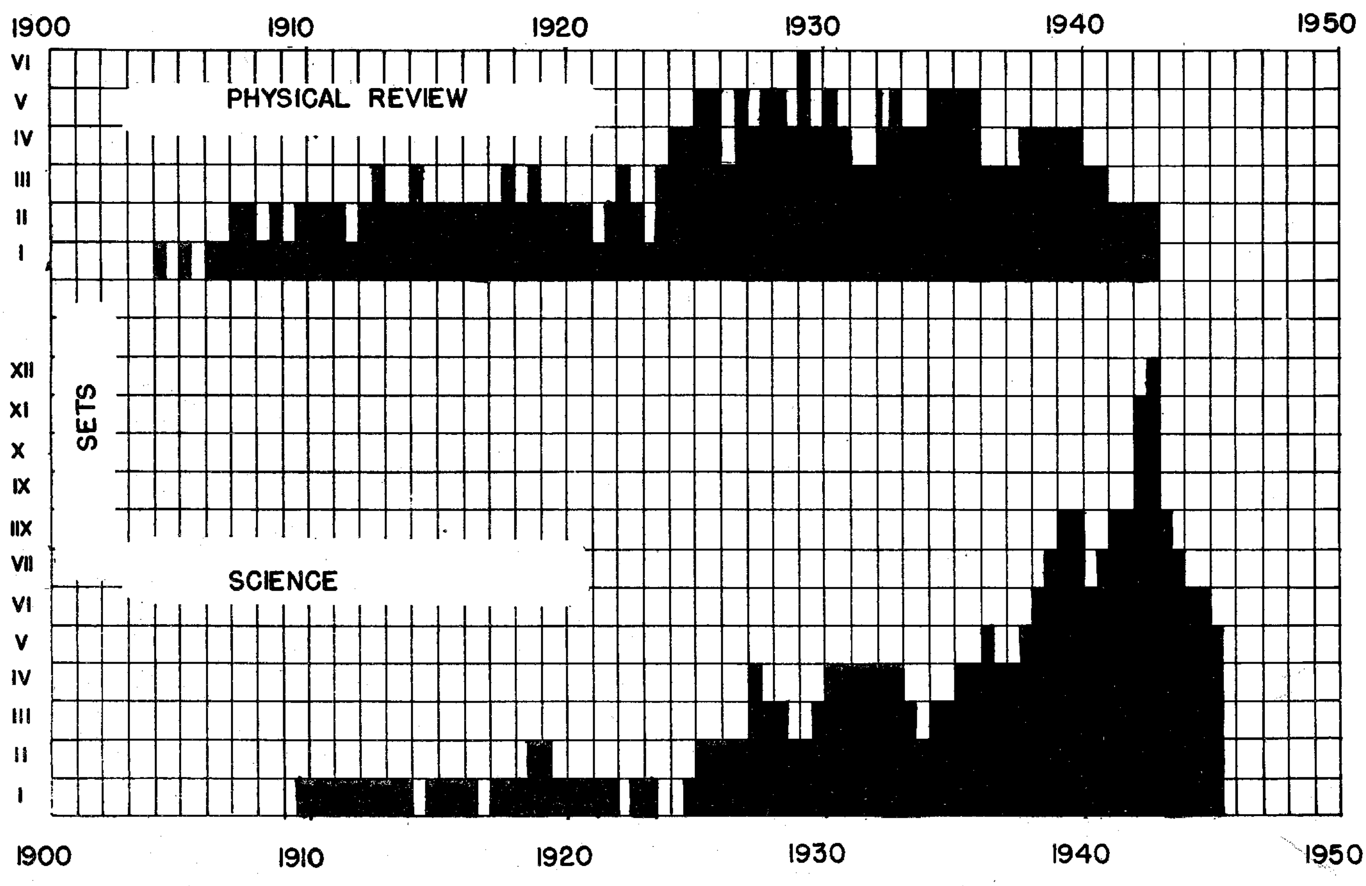
c) Small work shop tools.

d) Some scientific and technical test equipment, such as wind tunnels and testing machines, derived from Germany and Japan.

e) Chemicals and other working materials.

f) Aid in instruction.

A common supposition is that activities of this kind require for their successful realization large organizations and considerable funds. This supposition is, however, not necessarily correct. In fact, both democratic life within a national and international cooperation are badly in need of **more initiative on the part of every individual as such.** In order to test the practicability of this idea I have made an attempt, during the past few years, to tackle first the easiest of the tasks listed above; namely, the collection of scentific journals and books without recourse to any funds except for a few dollars for wrapping paper, a card index, and some expenses for driving a car



for the purpose of collecting the material. This attempt has so far netted a very fine collection of some ten thousand complete volumes of scientific journals and books. This collection contains the **Physical Review**, the **Astrophysical Journal**, the **Journal of the American Chemical Society**, the **Proceedings of the National Academy of Sciences, Science**, the **Scientific Monthly, Fortune, Life**, and many other journals too numerous to mention. To give some idea of the extent of the collection, I refer to the two graphs for the **Physical Review** and **Science**. The distribution over the years from 1900 to 1946 is shown, each shaded rectangle representing one complete volume or set of volumes for the year indicated on the abscissa. In the case of the **Physical Review**, one shaded rectangle may correspond to as many as four volumes (year of 1932). This amounts to a total of 230 volumes of the **Physical Review** and to 221 volumes of the **Scientific Monthly**. In addition, a great number of single issues is at hand, which, as new material comes in, rapidly contributes toward the accumulation of more complete volumes.

Most of the material was freely contributed by many of my colleagues at the California Institute of Technology and the Mt. Wilson Observatory, to whom sincere thanks are due for their generosity. A small fraction of the collection has been obtained from various sources, both private and institutional, in Pasadena, Los Angeles, and surrounding communities.

The material, after being solicited and hauled in, is sorted, registered, packed, and stored away in some of the basements of the California Institute. This work requires very concentrated effort of considerable extent. Many friends have lent a big hand in this job, and have perhaps contributed more toward the cause of true international understanding than many of the persons who are in the limelight of radio and press on international matters. To these friends is addressed a passage in a letter received from the Chinese Minister of Education, Dr. Chu Chia-hua, in which he says "Your friendly movement, I am convinced, will be deep-rooted in the heart of the Chinese intellectual circles."

Although it would take more than this article to mention by name all of those who have helped, thanks are particularly due to Mr. Ernest W. Rosischon and to Professor Hardin Craig, who have spent much time and effort as vice-chairmen of the committee. A number of ladies from the Huntington Library and some of our students have worked long and hard on the collection. Initial effective assistance was given me by Mrs. F. B. Badgley and Mr. Paul K. Richter of Pasadena, to whom deep gratitude is due for their unselfish efforts. Thanks are due to the authorities of the California Institute of Technology for the working and storage space which they have generously provided.

It is hoped that the collection can be sufficiently rounded off by 1947 and then shipped to the most needy. To whom? The choice should not be difficult. China, in its long fight for the cause of freedom, has suffered very extensive damage which must be repaired. There is Poland, which threw itself first against the Nazi tide, and there is Greece. In the darkest hour of the war when France was beaten, England at its lowest strength, and the Soviet Union, in partnership with Hitler, had invaded the Baltic States, Poland and Finland, and the United States still was isolationist, Greece, with no hope, preferred to fight to the end, rather than surrender. And there are more if we still have anything left to give.

Two important conclusions can be drawn from the results of the project sketched in this article.

1) It has clearly been demonstrated that enough men and women of good will can be found to make any project of genuine international character a success provided that such a project is pushed with determination. Availability of money is not a prerequisite to success. Neither is it necessary to create any large organization.

2) Through efforts of the type described, the ties of confidence between men and women of different nations and races can be strengthened to a degree superior to the effects which can be achieved by mere speech making, legislation and other methods of theorizing.

It is therefore suggested that many people, including scientists, might profitably abandon some of their high-sounding, but often empty efforts at international cooperation and use their imagination to bring about such cooperation through individual projects of a more constructive nature.

C. I. T. NEWS

LAST UNDERGRADUATE C. I. T. SUMMER SESSION NOW IN PROGRESS

THE C.I.T. Summer Session, now halfway through its course, marks the end of year-round undergraduate courses. Of the almost 800 students enrolled, one-half are undergraduates taking second semester work at all levels. The second largest group is the graduate students, comprising 30 per cent of those enrolled at the Institute. Refresher courses in mathematics and physics have attracted 12 per cent of the students here this summer, most of them preparing for the examinations for admission to upper classes. These are non-credit courses, given on the freshman and sophomore college levels. The others are classified as special CE, ME, and Ae students, taking work also of a refresher type.

The fall semester, with registration scheduled for October 4 to 7, will see the return of the three term system, discontinued when the Navy V-12 courses dominated the undergraduate enrollment from July, 1943 until June, 1946.

ARMED FORCES PERSONNEL TAKING GRADUATE WORK

FOUR GROUPS of military and naval personnel will be stationed at C.I.T. taking work leading to M.S. and professional degrees at the start of the fall semester in October. Already here are three army groups made up of air force, ground and service forces, and engineer corps officers. These men, captains, majors, and lieutenant colonels, have technical backgrounds, two-thirds of them being graduates of the United States Military Academy. Present army policy indicates that possibly a few men will be selected upon completion of their course for further instruction and research leading to the Ph.D. degree.

A 12-month course in civil engineering is in store for the 14 engineer corps officers. Now taking refresher work in mathematics, concrete, and structures, these men will enter regular graduate sections in October.

The other officers are reviewing mathematics and basic engineering preparatory to work in jet propulsion and mechanical engineering in the fall. A group of naval offiers, 10 air force officers, and three officers from the ground and service forces will commence a one-year course leading to the degree of Jet Propulsion Engineer.

Largest in numbers are the ground and service forces men taking two years for the degree of M.S. in Mechanical Engineering. Being given a technical background for the army's guided missile program, these men will also be prepared for further work in jet propulsion.

These officers, selected for Institute training on a basis of their interest and capabilities, are mainly regular army men, but include a few reservists on extended duty. They are grouped under the Army Liaison Office in Pasadena, commanded by Colonel B. S. Mesick.

WESLEY L. HERSHEY IS NEW Y.M.C.A. EXECUTIVE SECRETARY

WESLEY L. Hershey, the new executive secretary of the C.I.T.—Y.M.C.A., began his work at the Institute August 1, heading the department which had been under the direction of a student-faculty committee since Paul Ackerman left in July 1945.

Mr. Hershey, who will carry on the "Y" work of an enlarged student body, took his B.A. degree at the University of California in 1938, and was assistant secretary of the Student Y.M.C.A. on the Berkeley campus until 1940. From 1940 until 1943 he served in a similar capacity for the student association at Cornell University. This spring he took his B.D. degree at the Yale Divinity School. Mr. Hershey was chosen for the position here from a large number of applicants on the basis of recommendations from his co-workers on previous posts.

Coming from the staff of the Y.M.C.A. in Hartford, Connecticut, the new secretary brings his wife and two children. En route he attended a camp counselors' study group in Colorado.

With a full-time executive secretary at the Institute for the first time since the beginning of the war, the C.I.T. "Y" organization will be able to once again give full-time service to the functions of counseling, emergency student loans, freshman camp sponsorship, book exchange, and lost and found service.

1946 FROSH CAMP

THE 1946 freshman camp promises to be the first major venture of its kind since 1942. To be at Camp Radford, owned by the City of Los Angeles, and situated in the San Bernardino Mountains 35 miles east of Redlands, the camp's services to entering frosh are being planned on the basis of an analytical recollection of pre-war camping groups.

A wider faculty participation and more small informal "bull sessions" will be the keynote of the camp. The full-sized class of 160 men will be housed in eight-man cabins, each group including a faculty member or an upper-classman.

Athletic facilities at Radford are reported excellent, and besides intramural competition, a faculty team is expected to be formed to stand the class of '50 at touch football, baseball, or any other sport.

The program will start Friday, October 4, with registration in the morning. The frosh will leave for camp that afternoon, returning Sunday. After a day or two to recuperate, the freshmen will attend a tea dance Monday afternoon during registration of upperclassmen.

New this year is compulsory attendance, which may draw wails from married freshmen. The camp is planned, however, to be an integral part of the registration procedure and must not be missed.

The camp represents a cooperative venture of the Institute, the Y.M.C.A., and the Beavers, honorary organization of student leaders, which is devoting this summer to camp planning.

C. I. T. VETERANS HOUSING

TEMPORARY relief for C.I.T. student housing to accommodate the influx of veterans was assured in the middle of July when the Federal Public Housing Authority awarded Shoemaker and Evans of Los Angeles a contract to transport 56 housing units from Port Orchard, Washington for use as dormitories. These units, consisting of two rooms and a bath, will be erected on the Institute's experimental farm south of Arcadia. C.I.T. will level and subdivide two of the farm's ten acres, and bring in public utilities. Installation will be done by Harvey and Rose, Monrovia, who expect to complete the job by September 18.

The installation will be temporary: for the duration of the emergency plus two years, with renewal possible if a need for housing can be shown at the end of that time. Obligations to remove the structures will rest with the Institute after the contract terminates.

At this stage transportation to and from the Institute must be provided by the veterans who will occupy the housing project. Furnishings will be provided out of government stores as far as possible, with the Institute furnishing the remainder. The contract provides that each unit will come equipped with heating and cooking facilities and an ice box.

Eligibility of occupants has not been definitely decided. The Government requires that this be a veterans' housing project, and C.I.T. will probably set the tract aside for married couples with preference given to those with children.

CRAIG GOES TO RICE

HARDIN Craig, Jr., assistant professor of history, who has been at the Institute since 1937, has accepted an appointment as associate professor of history at Rice Institute, Houston, Texas. Very active on the C.I.T. campus, Dr. Craig was Throop Club advisor, secretary of student-faculty relations, chairman of the student social affairs committee, chairman of the Y.M.C.A. advisory board, and served for a time as Assistant Dean of Freshmen. His acceptance of the Rice Institute appointment leaves a place at C.I.T. that will be difficult to fill.

Portrait of a C.I.T. Graduate

MAGAZINE editors are eternally consumed with a curiosity about their readers, and rightly so; for the success of any publication rests on its ability to adequately service the particular group to which the magazine is directed. The editors of **Engineering and Science,** for instance, need to know a great deal more about its readers than the fact that you are all C.I.T. graduates (important as that is, in itself). We are interested in your home life, your hobbies, your professional interests and activities, your sphere of influence, and of course the level of your income, which, let us say, will some day have a relative influence on your preference for butter or margarine.

Motivated by this curiosity, we seized the opportunity afforded by the recent Alumni Seminar at the Institute to bombard you with a simple and somewhat unscientific questionnaire — unscientific because we can't be sure that our small sample represented by the attendance at the Seminar was typical of the entire alumni group.

In spite of the inadequacy of the questionnaire, we did secure information which provides a basis for some idle speculation. We aren't sure that our summary of your replies proves anything — it probably doesn't. For what the portrait is worth, here is the composite Caltech alumnus as reflected by our **Engineering and Science** questionnaires.

THE COMPOSITE ALUMNUS

Our typical alumnus, Joe, for short, has an income—estimated from our study of the figures—of a bit over $5,000 annually. However, after Joe has been out of C.I.T. for over 10 years, his chances of being above the $5,000-$7,500 per year bracket are 62 in 100. His chances of hitting above the $7,500 level after 10 years are 16 in 100. Not all of those who turned in questionnaires answered this one on income. The tabulation on the 92 per cent who did, looks like this:

ANNUAL INCOME OF C.I.T. ALUMNI ATTENDING 1946 SEMINAR

Annual Income	All Classes	Out of C. I. T. 5 Years or Less	Out of C. I. T. 5 to 10 Years	Out of C. I. T. Over 10 Years
Under $2,500	1.0%	5.6%	———	———
$2,500–$5,000	46.5%	72.2%	48.3%	38.7%
5,000– 7,500	40.5%	22.2%	44.8%	43.6%
7,500–10,000	10.0%	———	3.45%	16.1%
Over $10,000	2.0%	———	3.45%	1.6%

INFLUENCE ON SPECIFICATION AND USE

To our gratification, our notion that Joe is a very influential citizen received rather substantial documentation. Individually, he influences product purchase, specification, and use to the extent of an impressive $101,933 per year. Collectively (if our individual figure is correct) this influence for the graduate body is a staggering $437,292,570 annually. This figure is practically pure speculation, but it's fun to speculate, and here's how we arrived at a conclusion. We asked, "Do you make decisions which influence the use, specification, or purchase, of engineering, scientific, or office equipment or components?" of the 95 per cent who answered this question, 78 per cent replied in the affirmative, and of this number 27 per cent hazarded an estimate in dollars annually. The total amount estimated was $3,058,000, or $101,933 per alumnus estimating. Since C.I.T. has a graduate body of approximately 5,500, of which our sample indicated that 78 per cent influence product, use, etc., and since our average influence was $101,933, we arrive at a total of $437,292,570 annually.

SUPERVISORY STATUS

In addition to exerting influence on product purchase, specification, and use, Joe apparently directs the activities of a substantial number of subordinates. Average per alumnus reporting was 5.3 engineering and scientific personnel, and 80.3 non-technical personnel. Again allowing the free play of arithmetic and imagination, we find that C.I.T. graduates probably supervise the activities of 331,237 workers. Of this number, 21,862 are engineering and scientific personnel, and the remainder clerical, shop, and non-technical workers. As is to be expected, length of time after graduation and number of people supervised has a direct relationship.

This is the summary:

SUPERVISORY STATUS

C. I. T. Graduates	Supervision of Scientific Personnel, Each	Supervision of Other Workers, Each
16 per cent (less than 5 Years)	1.7	1.4
30 per cent (5-10 Years)	4.3	7.5
54 per cent (10 Years and Over)	6.9	144.1

OVER-THE-SHOUDER READER OF E & S

Some of our esteemed contemporaries in the publication field (like **Life** and **Fortune**) quote imposing figures on circulation. Not satisfied with the impressive totals on actual paid circulation, they go on to quote even more stupendous figures on "over-the-shoulder" readership. This makes us wonder about our typical C.I.T. alumnus who receives Engineering and Science. Does he leave his copy on the table in his reception room or on the end table at home? Apparently he does both, for our Engineering and Science survey supplies us with the following answer. Replies indicated that at least five persons other than the subscriber read each copy of the magazine and that of these, one-third are in the homes of alumni and two-thirds are in the offices of alumni.

PREFERENCE ON FREQUENCY OF ISSUE

Of course we wondered how many months out of the year you like to receive your alumni magazine, so we asked, "Would you prefer publication on a twelve-time basis, a nine-time basis, on some other basis, or not at all?" To our surprise, none of you checked the "not at all". There should have been at least one dissenter!

The tabulation of your replies showed:

Favoring	12-time	publication	annually—	79	per cent
"	9- "	"	"	18	" "
"	6- "	"	"	2	" "
"	4- "	"	"	1	" "

Since E & S is currently published on a monthly basis, this may be regarded as a vote of confidence. To a degree, we believe that it may be thus regarded. However, we are inclined to think that there is always a substantial vote for the status quo and it may be that the votes of the 21 per cent who favor publication at a less frequent interval have greater significance that the 79 per cent favoring the state of things as they are. We would like to hear more on this point and are curious to know how you would have answered had the question been rephrased to read: "Would you feel a serious loss if you received your copy of E & S only nine times, instead of twelve times, annually?"

MISCELLANEOUS INFORMATION

For no particular reason, we asked what oil company credit cards you had in your possession, and tried to check your mental reflexes on western railroads. We are at a complete loss to know what your replies indicated—maybe you can tell. But one fact is clear, oil companies regard C.I.T. graduates as good credit risks.

You said that you had the following credit cards (percentage basis):

Associated	6
General Petroleum	12
Richfield	7
Shell	14
Standard	28
Texaco	10
Union	23

The name of the first railroad entering your mind was (percentage basis):

Southern Pacific	41
Santa Fe	36
Union Pacific	20
Other	3

Unfortunately, we believe the score of "The Harvey Girls" had an undue influence on your replies to this question.

SUGGESTIONS ON IMPROVING ENGINEERING AND SCIENCE

In a moment of humility we asked for suggestions on improving the magazine. Suggestions and percentage commenting are listed below:

Less technical articles	10
More technical articles	10
Larger magazine with more articles	14
More alumni news	18
More Wallace Sterling	8
More about C. I. T.	15
* All-out confidence	25

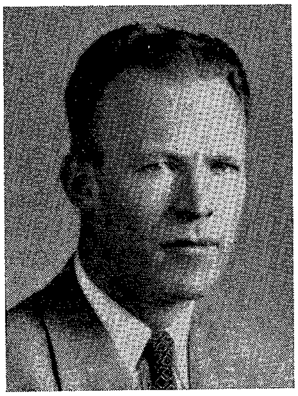
We shall do our best on all of these points. When you feel that we are publishing too many technical articles you can figure that we are attempting to satisfy those who yearn for knowledge. When we publish too few technical articles, it will be because we hope to please those of you whose interests are more general.

Thanks to all of you for answering our somewhat impertinent questions. We enjoyed reading your replies and we believe we succeeded in securing some information which will be helpful to the editors in preparing future issues of **Engineering and Science.** However, our editorial curiosity is never completely assuaged, and on another day we hope you will permit us to delve still deeper into the facts surrounding your existence.

* To the faithful, our most sincere gratitude.

ALUMNI NEWS

RUSSEL J. LOVE HEADS RESEARCH COMMITTEE



RUSSEL J. Love '28 formerly assistant vice president of the Southwest Welding and Manufacturing Company, has moved to New York City to assume his new post as executive secretary of the Pressure Vessel Research Commitee of the Welding Research Council.

The recent appointment has been given in national recognition of his activities and contributions to the development and promotion of pressure vessel welding.

The Pressure Vessel Committee, with headquarters in New York City, is jointly sponsored by the A.W.S., A.S.M.E., A.S.C.E., A.I.E.E., and the A.I.M.M.E., and supported by such companies as Babcock and Wilcox, Bethlehem Steel, A. O. Smith Corporation, Blaw Knox, Socony Vacuum, Timken Roller Bearing, and many other leading industrial organizations.

Russ was born in Los Angeles and educated in Los Angeles public schools. He received his degree in Mechanical Engineering from C.I.T. in 1928. While at the Institute, he was active in the Press Club and the Dramatic Club, of which he was president in his senior year. He was also a member of the Big T staff, the swimming team, and the football team. Pi Alpha Tau, Tau Beta Pi, and Omega Xi Alpha number Russ among their members.

After graduation he was employed by C. F. Braun and Co. from 1928 to 1931 inclusive. In 1932 he entered Southwest Welding and Manufacturing Company, becoming chief engineer of the company in 1936 and assistant vice president in 1944.

He is a member of the American Welding Society and of the California Natural Gasoline Association, and has addressed the local A.W.S. section on several occasions, his most recent presentation being a paper on "X-Rays and Welding" in 1938. In 1941 he presented a paper on "Codes and Specifications" at the Western Metal Congress held in Los Angeles. In 1943 he addressed the California Natural Gas Association on "Welded Refinery Equipment", and in 1943-44 gave a series of talks on "Welding Design" at C.I.T.

Russ has no permanent New York address at present. Until he has solved his personal housing problem, his mail will reach him care of Welding Research Council, 29 West 39th St., New York 18, New York.

SAN FRANCISCO ALUMNI HOLDS SPORTS DAY

THE seventh Annual Sports Day was held at the "Cactus Rock" home of Howard Vesper '22 on May 25. It was a cold and rainy day, but 81 alumni and guests attended. Such a turnout speaks highly of the thoughtful hospitality of Ruth and Howard Vesper.

The usual ball game was short due to a slippery wet field. By 6 P. M. the smell of good food filled the air, and soon everyone was busy eating. The meal finished off with apple pie a-la-mode and plenty of hot coffee.

After supper the officers for the coming year were introduced. Four reels of moving pictures were shown, including an interesting color film on flower growth. A short session of community singing concluded the formal program of the evening.

Bob Bowman '26 again extended an invitation to have the Fourth Annual Swimming Party at his home in Concord. The date is set for Saturday, August 31, and all alumni, wives, and girl friends are urged to come.

The regular Monday luncheons are still held at the Fraternity Club, 345 Bush Street. If any alumni are in San Francisco on Monday noon, be sure to try to attend.

Alumni planning to attend the fourth annual swimming party of the San Francisco chapter should contact Robert P. Jones '35, 1431 Park Boulevard, San Mateo. The party will be held at the home of Bob Bowman '26 on Saturday, August 31. All alumni, wives, and girl friends are invited.

HENRY K. EVANS NOW A DIRECTOR OF THE NATIONAL CONSERVATION BUREAU

HENRY K. Evans '38 has been appointed director of the Traffic Engineering Division of the National Conservation Bureau, accident prevention division of the Assocation of Casualty and Surety Executives.

Hank has been a traffic engineer with the National Conservation Bureau for three years. He recently served as a coordinator of the Third New England Traffic Conference at M.I.T. in Boston.

Prior to his joining the National Conservation Bureau in 1943, he was a traffic engineer with the National Safety Council, special instructor at the Federal Bureau of Investigation's War Emergency Control Schools, project technician for the Works Progress Administration in California and also traffic engineer for the Auto Club of Southern California.

Graduating from C.I.T. in 1938 with a Bachelor of Science degree in Civil Engineering, Hank attended the Yale Bureau of Highway Traffic in 1939. He is vice president of the New York section of the Institute of Traffic Engineers, and a member of the American Society of Civil Engineers and American Society of Safety Engineers.

As director of the Traffic Engineering Division, Evans will be in charge of traffic surveys, traffic engineering publications and accident and traffic engineering research and conferences. He is currently editor of "Traffic Engineering Magazine".

PERSONALS

1923

WALTON E. GILBERT transferred from Shell Oil Company, Los Angeles Office to Asiatic Petroleum Company, New York City. Mr. Gilbert is to select producing and drilling equipment for affiliated foreign Shell organizations, principally, at first, in South America.

1924

VLADIMAR A. KALICHEVSKY, consulting chemical engineer of the Magnolia Petroleum Company, Beaumont, Texas, has been elected chairman of the Texas-Louisiana Gulf Section of the American Chemical Society. Mr. Kalichevsky has authored several books on technical subjects, some of which have been translated into foreign languages, and has contributed numerous articles to scientific publications.

W. L. HOLLADAY has recently become chief engineer of Airtopia Distributors, Inc. of Los Angeles, Calif.

1925

M. B. KARELITZ, after four years at the Radiation Laboratory, Massachusetts Institute of Technology, Cambridge (the last two years as the Group Leader in charge of Mechanical Design of Ground and Ship Microwave Radar) joined the General Precision Laboratory in the East as Senior Staff Member of the Mechanical Group.

1927

LT. COL. EDWARD MARION BROWDER, planning engineer in the Department of Operation and Maintenance, Balboa Heights, Panama Canal, visited the campus in June when on military leave. Col. Browder will be released from Service in December. His wife and two sons live at Balboa Heights.

1928

KENNETH M. FENWICK is now assistant district maintenance engineer for the California Division of Highways in Los Angeles, Calif.

1929

WILLIAM H. MOHR, who was promoted to Colonel in the Corps of Engineers while on terminal leave, has returned to the Los Angeles office of the California Division of Highways where he is employed at a Right-of-Way Agent.

LAWRENCE J. GRUNDER, former Lieutenant Colonel who spent four years in the European theatre of operations on petroleum technical matters, is now released from Service.

1931

GEORGE LANGSNER is resident engineer for the California Division of Highways on a 2.1 mile unit of the Terminal Island Freeway now under construction between Long Beach and the U. S. Naval Base on Terminal Island. John Ritter '35 is office assistant on the contract.

1932

A. J. TICKNER left the Naval Ordnance Laboratory in Washington, D. C. and went to the Western Electric Company, Electrical Research Products Division in Hollywood where he is a method engineer.

E. C. KEACHIE is doing management work with the Newbery Electric Corporation of Los Angeles, having been released from his Army assignment with the Corps of Engineers. He and Mrs. Keachie and two sons, Stephen and Douglas are back in the Southland after an absence of ten years.

CARL LIND has been released from the U. S. Navy and is now Assistant Maintenance Engineer on the Sacramento Headquarters Staff of the California Division of Highways.

1933

LT. COMDR. ELMER S. FRANKLIN, after four and a half years with the Navy, has left the Service to take a position with the Kellex Corp., in the capacity of aeronautical engineer. His present assignment is at the Applied Physics Laboratory of Johns Hopkins University, Silver Springs, Md.

BRUCE M. DACK was married the early part of August to Miss Margaret Koeber who was senior librarian in the State Library at Sacramento, Calif.

ROBERT G. MACDONALD who commanded an Engineer Regiment, has just returned from Okinawa with the rank of Lieutenant Colonel. On returning to inactive duty, he became associated with Haddock - Engineers, Ltd. in Los Angeles as an engineer.

ROBERT FLETCHER last January transferred from his position as Officer in Charge, Burbank, Calif. Weather Bureau Forecast Center, to the position of Chief of the Hydrometeorological Section, U. S. Weather Bureau in Washington, D. C. Bob has two sons, Bob Jr. aged 9½ years and John, aged 4½ years.

1934

NORMAN L. HALLANGER visited the campus in the middle of June from San Francisco, where he is employed by Pan American Airways as Assistant Division Meteorologist.

1935

LAURENCE J. STUPPY, M.D., having returned from military service, has announced his partnership with Dr. Henry H. Lissner. Their office is located on Wilshire Blvd. in Los Angeles, Calif.

1937

LT. COL. RICHARD T. BRICE, since release from Service, is now associated with the Otis Elevator Company of New York City.

THOMAS V. DAVIS is now Staff Commander, Joint Task Force One at Kwajalein Island. For the past year and a half, Tom was Assistant Group Head for mechanical components of the atomic bomb. At present, he is in charge of air sample collection at the Bikini bomb test.

WARREN E. FENZI, since release from service, is now Mine Superintendent of the Phelps-Dodge Company of Morenci, Ariz.

1938

FREDERIC H. MOORE, with his wife, visited Southern California in early June. Mr. Moore is employed as a process engineer with the Texas Company at Port Arthur, Texas. As a hobby, Mr. Moore engages in theatrical work, recently directing a three-act play for the Little Theatre of Port Arthur.

HERBERT D. STRONG, after 32 months of Naval aviation maintenance and repair work, completed duty in the Navy as a lieutenant, in April. Herb is now a mechanical engineer with Howard Corbitt Industries, Montrose, Calif.

1939

LT. COL. R. W. WINCHELL has been released from Service after five and one half years of duty and expects to locate in Southern California.

CURTIS M. LEE has been taking an indefinite leave of absence because of health, from his position as assistant chief engineer of the Vortox Mfg. Co. in Claremont, Calif. At present, Mr. Lee is working with his father on his 40-acre citrus-chicken ranch in Ramona, Calif.

1940

GEORGE BARBER is now working in the Power Plant Test and Analysis Group of the Douglas Santa Monica Engineering Department.

1941

GEORGE H. BRAMHALL who is employed by the General Electric Company, is at present working as an engineer, doing mechanical design and development work.

LT. COMDR. JOHN H. MAIN is now on terminal leave, after serving in the Philippines one year and China for four months.

ENS. ROBERT G. COOPER, now on inactive status, spent 20 months in Houston, Texas where he was a petroleum inspector under the Inspector of Naval Materiel.

1942

LT. JOHN F. MCCLAIN, U.S.N.R., is now on inactive status, having been stationed at the San Diego repair base about 18 months. John is the father of John F. McClain III, born on Feb. 25.

WARREN GILLETTE is in medical school at George Washington University, Washington, D. C. Warren announced the birth of a son in June.

1943

LT. (jg) HERBERT LASSEN is now on inactive status after three years of submarine service. Herb is going to work for Standard Oil of California for the summer and plans to enter Massachusetts Institute of Technology in the Fall for graduate work.

LT. EVERETT J. MACARTNEY, U.S.N.R., who served on submarines, Thornback and Carp in the South Pacific for eighteen months, is now on inactive status.

CHUCK MCGEE EM 3/c has been discharged from the Navy and is returning to Stanford for the summer quarter.

LT. (jg) R. H. BASHOR who spent two and one half years on a destroyer mine sweeper in European and Southern Pacific waters, is now on inactive status.

ROBERT M. BENSON, former aviation radio technician in the Navy, has been discharged. Bob was stationed with CASU-6 at Alameda, California for the past nine months.

LT. JOHN W. BEWLEY, U.S.N.R., who was on active duty from June '43 to May of this year, is now on inactive status. John was stationed at CASU-33 at Los Alamitos, California where he was in charge of 50 to 300 men in engineering installation. John has a small daughter, Margaret Ann, 18 months of age.

1944

RICHARD GILMAN who served three and one half years in China and Okinawa is now on inactive status and plans to return to the Institute for further study.

ENS. LE VAL LUND returned from Okinawa recently and is now on inactive status. He expects to enter the Institute next Fall.

ALBERT SPAULDING, a former Lieutenant (jg) is now on inactive status, having been stationed on Guam for one year as a Communications Officer.

MERWYN E. HODGES, radio technician in the Navy, is now back in civilian life and plans to return to the Institute this coming semester.

ENS. STANLEY NEWMAN who has been stationed on a destroyer at Okinawa is now released from duty. Stan is planning to return to the Institute in the Fall. A year ago in April, he was married to Marion Viault of Pasadent.

BOB ALLINGHAM is attending Harvard Business School, having entered in June.

ENS. FRED KARSTEDT, C.E.C. returned from the Philippines where he was stationed the past seven months and is released from active duty. Fred is planning to go to Stanford for his Master's.

1945

HAROLD FORD, former Ensign stationed on the troop transport "George F. Elliott" is now on inactive status. Harold was released from duty when his ship was decommissioned recently at Portsmouth, Va. He plans to return to the Institute in the Fall for graduate work.

ENS. JOHN AUSTIN MORGAN who was stationed on the U.S.S. General Hersey A. P. 148 for six months, is now on inactive status. John was married last Nevember to Miss Kathleen McConaghy and they are now living on Balboa Island.

ENS. MARTIN STEVENSON returned from Midway in June on a PC 1078; the ship heading for the Norfolk Navy Yard to be overhauled. When released from duty, Martin plans to return to school for business administration. Last Fall, Martin was married to Miss Velma Henningsen, a Wave at the Corona Naval Hospital.

ENS. L. E. WILFERTH, after three years of Service is now on inactive status.

on and off The Main Line

AUGUST, 1946

The summer travel season which began when schools let out in June reaches its peak this month.

Civilians and veterans alike have earned a vacation this year, for the war years were very trying for everybody.

Yet in recent months we have heard many people say, "What's the use? It's impossible to get reservations on trains or planes. Busses are crowded. Hotels and resorts are jammed for months ahead. We'll just stay at home this summer and try some other time."

The fact is that *everybody* badly needs a vacation, and a rest. Thousands of families are finding ways to do this, in spite of travel difficulties and congestion. So before you decide it's impossible to take a Victory Vacation this year, the least you can do is *try*.

Many Southern Pacific trains have accommodations available if you simply ask a little in advance.

We are informed that although the best-known hotels and resorts are pretty well sold out for this summer season, many of the smaller, not-so-famous hotels in the larger cities have space for guests.

Another thing: hotel and resort reservations are cancelled every day because of changes in plans. Your favorite spot will be glad to put you on its waiting list and notify you if accommodations become available.

The important thing is—*try*. If you can't get space this summer, shoot at the off-season—late September, October or November. But *get a rest*, this year. You'll need all your strength in the busy months to come.

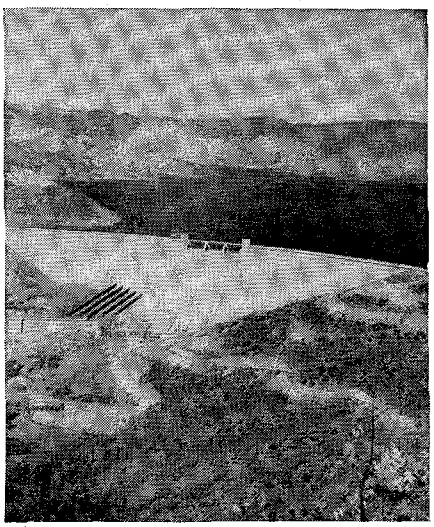
NEW SHASTA DAM TOUR

The West's newest recreational area is Shasta Dam and the 25-mile Shasta Lake it backs up into the Sacramento, McCloud and Pit Rivers.

Shasta Dam itself is the second largest in the world—602 feet high and two city blocks thick at the base. Behind it looms Mt. Shasta.

Daily until November 15th, The Gray Line is operating a tour from Redding to Shasta Dam, including a cruise on Shasta Lake.

Motor coach starts from the S.P. station in Redding at 8:45 a.m., picks up passengers from Redding hotels, and carries them to Shasta Dam. Here you board a brand new diesel-



powered cruiser for the three-hour cruise on Shasta Lake. Returning, the motor coach passes through the picturesque 1849 gold town of Buckeye and gets you back in Redding at 2:15 p.m. Fare for the whole tour is \$6.50 for adults (plus Federal Tax). Half fare for children.

Redding is on the main line of Southern Pacific's Shasta Route between San Francisco and Portland. It is also the gateway to Lassen Volcanic National Park.

Any Southern Pacific agent will gladly make all arrangements for your tour to Shasta Dam, or to Lassen Park.

ANOTHER "DAYLIGHT"

No trains in America are as well-known and as popular as Southern Pacific's red and orange streamlined *Daylights* between northern and southern California.

To the fleet was recently added the *Sacramento Daylight*, operating daily from the state capital to Los Angeles via the San Joaquin Valley.

To bring you up to date, there are now four Southern Pacific *Daylights:*

1. The *Morning Coast Daylight* between San Francisco and Los Angeles via the Coast Line.
2. The *Noon Coast Daylight* between San Francisco and Los Angeles via the Coast Line.
3. The *San Joaquin Daylight* between San Francisco-Oakland and Los Angeles through the San Joaquin Valley.
4. The *Sacramento Daylight* between Sacramento-Stockton and Los Angeles through the San Joaquin Valley.

All of these streamliners have the same high standards of comfort and service. All of them sincerely invite your patronage, but ask that you reserve your seats in advance.

TUNE IN "THE MAIN LINE"

Several years ago Southern Pacific inaugurated a new and different kind of dramatic radio program called *The Main Line*. It is broadcast over the Pacific Coast Network of the Don Lee Mutual Broadcasting System every Wednesday night from 8 to 8:30 p.m.

If you haven't heard it, please tune it in next Wednesday night and let us have your reaction. We'll appreciate it.

A FEW "TRAIN PRIMERS" LEFT

More than 500 people wrote for the free *Train Primer* we offered in this page last June.

This is the little 16-page booklet we printed for the San Francisco World's Fair. It shows you how to tell our locomotives apart, what the signs, signals and whistles mean, etc. We still have a few of these booklets left. If you'd like one, write Room 735, 65 Market St., San Francisco 5, California.

—H. K. Reynolds