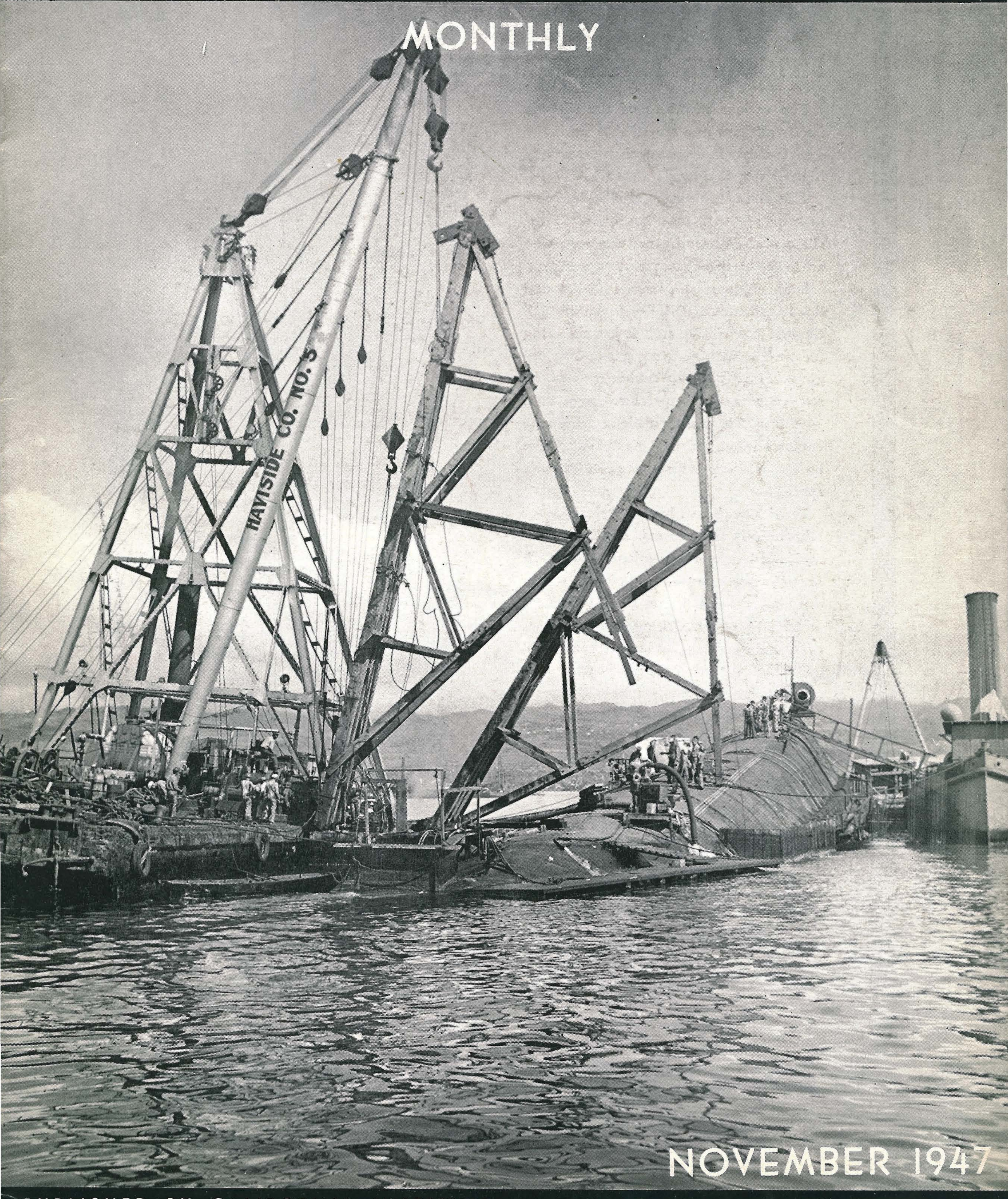
ENGINEERING AND SCIENCE

MONTHLY



NOVEMBER 1947

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SILICONES HAVE EVEN TEMPERS

The various members of the silicone family all have one remarkable similarity—their sturdy resistance against either very high or very low temperatures.

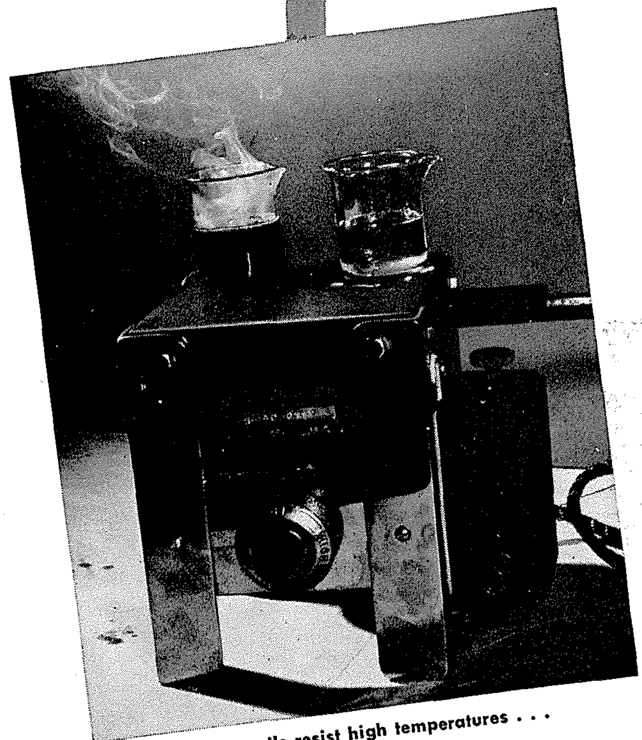
This ability to remain unruffled in tropic heat or antarctic cold has endeared the silicones to all scientists and engineers who are losing sleep over temperature problems.

Flight engineers, for example, have found that the silicone rubber developed through General Electric research is just the thing for gaskets in high-flying gas-turbine engines. Since silicone rubber retains its resiliency over a temperature range from −55 to 520 F, gaskets made of it keep the engine's joints safe and tight against the heat of scalding gases or the cold of outer space.

Plastics engineers have a preference for silicone oils and greases. Applied to hot molds at temperatures up to 575 F (ordinary oils break down long before reaching this temperature), these silicones keep the molded piece from sticking, and thus reduce breakage, save money, and speed production.

In case the names have puzzled you, *silicones* are the compounds made with *silicon.* Silicon is our second-most-common element, and an ingredient of glass and sandy beaches. It's only in the last few years that scientists have begun to realize what silicon can do.

Silicones are one of the many problems occupying the minds of General Electric scientists and engineers. General Electric employs 6,000 engineers and 900 chemists, physicists, and mathematicians—the largest technical staff outside of American colleges and the U.S. Government. This staff is behind every product General Electric makes.



Silicone oils resist high temperatures . . .

. . . won't clog at low

GENERAL ELECTRIC

BY-LINES

LEE A. DUBRIDGE

Dr. Lee A. DuBridge, president of the California Institute, graduated from Cornell College, Iowa, in 1922, and continued his studies in physics at the University of Wisconsin, where he received his Ph.D. degree in 1926. From 1926 to 1928 he did physics research at C.I.T. as a Fellow of the National Research Council. In 1928 he went to Washington University in St. Louis as assistant professor of physics. In 1934 Dr. DuBridge was called to the University of Rochester as Harris Professor of Physics and Department chairman. From 1940 to 1945 DuBridge served as director of M.I.T.'s Radiation Laboratory. Shortly after his return to Rochester, he was appointed to the presidency of the California Institute.

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LEE P. MORRIS

Lee P. Morris graduated from Tech in 1934, with a B.S. in mechanical engineering. As an undergraduate he was active in athletics, being a three-year letterman in football and two in track. He entered the employ of the Standard Oil Co. of Calif., El Segundo Refinery, after graduation, and remained there until May 1941 when he entered the Navy as an ensign. Morris served the first two years of the War at Pearl Harbor engaged in ship salvage. After completing the last two of his five Navy years at Terminal Island, Calif., engaged in ship repair work, Morris, a commander, was discharged and returned to El Segundo. He is now general foreman of Standard's Catalytic Section. Having the Naval Reserve as avocation, Morris is commanding officer of the Bureau of Ships' Los Angeles Reserve Component.

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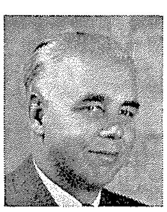
HOWARD LEWIS



Howard Lewis entered C. I. T. in 1918. In 1923 he received the B. S. from Tech, although he was already working for his M.E. degree at Cornell, which he received in 1924. After a year of teaching physics at Riverside High School, he spent six years with Howard Hughes in several engineering and managerial capacities. Later Mr. Lewis, with Glen M. Larson, formed the Lewis-Larson Co., a firm which specializes in supplying engineering services for small businesses.

ENGINEERING AND SCIENCE
Monthly
The Truth Shall Make You Free

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ENGINEERING AND SCIENCE MONTHLY

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Index to Advertisers

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ENGINEERING AND SCIENCE MONTHLY is published monthly, October through July, by the Alumni Association, California Institute of Technology, Inc., 1201 East California Street, Pasadena 4, California. Annual subscription $3.50, single copies 35 cents. Entered as second class matter at the Post Office at Pasadena, California, on September 6, 1939, under the act of March 3, 1879.

With the Editor--

IN pondering the problems of making E & S better serve its readers, many methods come to mind, but invariably we conclude that we'll have to have more advertisers before we can pay for these intended improvements. Then we get to thinking about how our present advertisers have made it possible to publish our present high-quality magazine. If we are alone we say a silent "thanks" to our advertisers. If others are nearby they get a brief harangue on how our advertisers deserve our support. We wonder if members fully realize that the advertisers make the present E & S possible and that patronage of our advertisers by members makes advertising in E & S worthwhile.

We know of several ways to make the magazine more helpful and enjoyable; for one thing we could include more Alumni and more Institute news, for another we could have more articles on accomplishments of researchers at the Institute, further we could include short biographical sketches of outstanding alumni and faculty members and there are other things which readers have said they would appreciate. We want to do these things for you—and we will if you will do enough of these three things: 1) patronize your advertisers, 2) tell them you buy from them because of their ad in E & S, and 3) encourage non-advertisers to advertise in E & S.

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We know that our advertisers get results from advertising with us and we could recite a few examples. We should like to know of more instances, however, because actual cases help us in selling additional space. So another way for you to help is to notify Bunnelle, our Business Manager, or ye editor of all instances wherein the presence of an advertisement in E & S has resulted in a sale by the advertiser. A few alumni have helped greatly by selling advertising space to business acquaintences. We can use a great deal more of that kind of help. We hereby promise to send advertising rate cards and contract forms promptly to any who request them.

●

COVER CAPTION

Setting righting bents or "A" frames preparatory to righting the U.S.S. OKLAHOMA after Pearl Harbor. Twenty-one of these 40-ft-high frames were used to effect large turning moments. Pull from winches on shore was transmitted to the hull through back stays and thrust brackets welded to the hull. These frames were used in rolling the ship from her position on the bottom of 151° 30′ from vertical to 68° from vertical. By the time the OKLAHOMA reached this position, all force had been assumed by the back stays, frame heads pulled free, and the righting bents were removed.

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The Future of Atomic Energy

By LEE A. DUBRIDGE

ON a July day in 1945 the newspapers of Albuquerque, New Mexico, reported that local residents had seen an early morning flash of light and had felt earth tremors due to a mysterious explosion. It was suggested that an Army munitions dump near Alamogordo had blown up, but no further news appeared.

A few hundred observers scattered through the hillsides around a New Mexico valley, however, had witnessed the birth of a new era. Three weeks later when two Japanese cities felt in succession the devastating effects of similar blasts the whole world knew that a new era had come.

As these blasts brought to an abrupt end the most devastating war in history, men all over the world knew that another war must never occur if civilization were to survive. Fifty years of scientific exploration in the field of atomic physics had culminated in a stupendous achievement which placed the world at the crossroads in the field of international relations.

It is not my purpose here to speak of the military application of atomic energy—about the atomic bomb itself or the problems of international control which it has raised. I am going to discuss the possible peacetime uses of atomic energy. But I want to make it clear at the outset that all the peacetime uses we can now foresee—valuable as they may be—are as nothing compared to the terrible military significance. If it were necessary for the world to forego forever all peacetime uses of nuclear energy in order to insure that it would never again be used in war, the world would be getting a tremendous bargain. Fortunately, I do not believe that this will be necessary. International control of atomic weapons **can** be achieved without sacrificing all of its peacetime benefits.

It is worth while, therefore, to examine just what these peacetime benefits may be and in what ways they may benefit our lives.

Even this is a large order for a brief discussion, for the peacetime uses of this great discovery are many and varied—and are to a large extent still unpredictable.

For example, one of the great fields of usefulness of atomic energy might be called its indirect uses—the production of radiations and radioactive materials for scientific and medical purposes. No one can possibly predict what great new discoveries these new tools for research will make possible. Some great new additions to our knowledge are already in sight—others will appear in wholly unexpected areas as the years go by. The radioactive by-products of atomic piles are now available for research purposes to scientists in this country and abroad. A whole new realm of scientific exploration is opening up.

But I shall not discuss these indirect uses of atomic energy. Let us consider only the direct non-military use of atomic energy itself. Here is a great new source of power which man can now control for his own use. How big a source is it? How soon can it come into use? How cheap will it be? Where and how can it be effectively used? How soon, in short, will it put the coal and oil and gas companies out of business?

Our answers to these questions must of course be based on our **present** knowledge. There is no use speculating about what radically new discoveries in science may bring. Let us examine these questions on the basis of what is now known—assuming only the normal processes of engineering development and improvement in techniques.

First, let us review a few facts.*

As is well known, a certain type of uranium atom (U-235) can be split in two, and this process releases a relatively large amount of energy. This splitting can

* **All of the information used in this paper has been previously published. Some will be found in Millikan's book THE ELECTRON (1947 edition, Chap. XVI). The rest is in the Smyth Report or in the reports of the technical committee of the U. N. Atomic Energy Commission.**

be made to occur spontaneously, at a controlled rate, in a so-called chain-reacting pile, or reactor. The energy is then recoverable in the form of heat.

When one **pound** of U-235 is consumed in this way the heat produced is equal to that produced by the burning of about 1500 **tons** of coal. Since the entire annual coal consumption of the United States is about 600 million tons, we see that the same amount of heat could be produced by only 200 tons of U-235.

If this heat could be converted by a steam engine into electrical power at 10 per cent overall efficiency, one pound of U-235 would deliver 125 kilowatts for a year. A 100,000 kilowatt generator then would use less than one-half ton of U-235 fuel per year, though the same plant would use 800,000 tons of coal per year. All the electrical power used in the whole country could be produced by consuming about 100 tons of U-235 per year.

This will illustrate, I think, the enormous concentration of energy in atomic nuclei which can be released by the fission process in a chain reaction. A new source of energy of tremendous potentialities indeed!

I said a **new** source of energy. So it is! For as far as we know the energy released by the **fission** of heavy **nuclei** has never before been tapped on a significant scale. However, nuclear energy itself is not a new thing. Nuclear energy released by another process is not only the oldest but is the primary source of energy of the universe. When very light elements, such as hydrogen, unite to form heavier ones, such as helium, great quantities of energy also are released. This process is now known to be the source of energy in the sun and all the stars. Unfortunately—or fortunately maybe—there is in sight no method for causing this type of nuclear process to take place on earth. We are limited for the present to the fission process in heavy atoms.

Now a new source of energy on earth is a tremendously significant thing in itself. Nevertheless it is well to remind ourselves that man is not yet approaching the end of his previously known energy stores. It is estimated, for example, that the known coal deposits will last at the present rate of consumption for another 4000 years. Gas and oil stores may not last that long—but new fields are being found every year.

And then there is one source of energy we have not yet begun to tap except in a small way—namely, sunlight itself. We use waterfalls and windmills, of course, and we grow trees and other plants usable for fuel. Even coal and oil are really only trapped sunlight. But if we could really use all the sunlight falling on a single piece of land 30 miles square it would be equivalent to the entire coal consumption of the United States. Here truly is a staggering and inexhaustible source of energy which we will certainly some day learn to use more effectively than we now do. At the present time, however, we do not know how to use it economically.

But to return to nuclear energy, let us ask a few practical questions. How much uranium is there in sight? What are the problems of using nuclear energy economically? How soon will nuclear power plants become available?

As to the supply of uranium, the picture is not bright. Before the war uranium was mined for various industrial uses, but especially because of its radium content. The annual production of raw uranium was only about 1000 tons a year—with known reserves totaling only 30,000 tons. But natural uranium contains only .7 per cent of the precious U-235; hence, 1000 tons of natural uranium contains only 7 tons of U-235. Seven tons a year is equivalent in heat value to 21 million tons of coal—but that is only 1/30 of our annual coal consumption. Thus if all the U-235 being mined in the world were used in this country for industrial purposes it would add only 3 per cent to the effective annual coal supply. And that assumes no other country uses any. As a matter of fact, very little uranium is actually mined in the United States, it comes mostly from Canada and the Belgian Congo. (If these had not been friendly countries there would have been no atomic bomb!)

And we also assumed that all the 7 tons of U-235 could be used for power—and none diverted to military weapons. This is hardly a reasonable assumption in the world in which we **live.**

So until great new deposits of uranium are discovered, or until economical methods for treating very low grade ores are developed, we had better not abandon our coal mines or oil fields!

Actually the picture is not quite so dark. For we know that if U-235 is consumed in a pile containing raw uranium, some of the abundant isotope, U-238, is converted by neutron bombardment into plutonium—and this is an even better fissionable material than U-235. So while we are getting power from U-235 we are also making plutonium. We can then use the plutonium and get more power—and at the same time make more plutonium. In principle, then we could, step by step, convert all of our natural uranium into plutonium. This at once multiplies our stock of fissionable material by 140, for U-238 is 140 times as abundant as U-235. And if we could use our whole 1000 tons a year of uranium, instead of only 7 tons of U-235, we would have an energy equivalent of 3 billion tons of coal a year, which is 50 per cent more than the production of the entire world before the war. And though only 30 years' supply is now in sight, new sources will surely be found and low grade deposits will be worked.

But here again we must be careful! Using all our uranium rather than only U-235 is a **possibility**—but it has not yet been proved to be practical. Certainly many years of work will be needed before we can be accomplishing this conversion into plutonium on a large scale—and many years more will be required to build up the stocks of plutonium. I am inclined to believe that 30 to 50 years will elapse before uranium can possibly become a **major** source of power, comparable, say, with present production of electrical energy.* And even this assumes that military requirements for plutonium will not take the whole output for the next few years, as they are likely to do. Furthermore, by the time uranium is likely to be a large-scale source of power our power needs will have multiplied so greatly that we will still need full-scale production of coal, oil and other existing fuels.

Does this mean that nuclear fuel is of no importance to us at all? Certainly not!

There are scores of important applications where a few thousand or a few million kilowatts of power from uranium will be of enormous importance.

Think, for example, of ship propulsion.

Once a nuclear-powered engine has been installed on a great ship, only a few pounds of additional fuel will be required to keep it running for a year. This would seem to be one of the most promising applications —especially for naval vessels—and still more especially for submarines. Think of a fleet that could stay at sea almost indefinitely without refueling!

Let me emphasize that even this application is not yet here. A nuclear pile operating at a temperature high enough to operate steam or gas turbines has not yet been built or even designed. Probably, however, a few years would be sufficient to solve the engineering problems, so that if this project could command the manpower, the money and the uranium, one might expect a few ships, say 3 or 4, to be powered in this way in the next 10 years.

Another application has been suggested by my colleague, Dr. Pauling. A nuclear heat engine generating at 50,000 to 100,000 kilowatts, with suitable compressors and heat exchangers, could distill a million gallons a day of sea water for Southern California. For industrial and agricultural purposes this would be much better water than we now get from the Colorado River.

Think also of other places in the mountains or desert —near sources of raw materials—where industrial processing plants might well be located, except for the prohibitive coasts of bringing in coal. Think also of countries such as England where the equivalent of only a few million tons of coal would be a critical addition to a desperately short supply. And you will think of many other places where nuclear power could be a great boon—primarily because of the very small weight of fuel required.

What about costs?

Here there are two unfortunate factors. First, at present, nuclear power plants are rather expensive investments. According to a report of the U. N. Atomic Energy Commission, a plant to produce 100,000 kilowatts of power might easily cost 25 million dollars. Thus interest and depreciation costs are going to be very high.

Second, however, uranium 235 or plutonium are exceedingly expensive fuels. Raw uranium, before the war, cost only about $2.00 a pound. But one must separate out, in part at least, the U-235, and this is extremely expensive. Think of the enormous plants at Oak Ridge devoted to this purpose!

Including both plant investment and fuel costs (and neglecting vast development costs) uranium power will certainly cost much more than power from coal. Hence, the first applications must be those where low weight of fuel is more important than high costs. Engineering development can certainly bring these costs down. But it is hard to see how uranium power can ever be very cheap.

Finally, one must not minimize the magnitude of the engineering problems which remain to be solved before even **one** power-producing pile is in operation. It is true that several reactors were built during the war for experimental purposes and for the production of plutonium. It is also true that some of these reactors produce a very large amount of heat. But they were purposely designed to operate at very low temperatures and hence this heat—while it might supply running hot water to a sizable city—cannot be efficiently converted into electric power. The main engineering problem ahead is the design of a reactor to operate at a high temperature so that one can obtain a reasonable thermodynamic efficiency. This will some day be done, but the design and engineering problems are staggering. For example, many materials that we would like to use to construct the reactor would absorb so many neutrons that they would stop the chain reaction. Structural problems, thermal problems, fantastically difficult chemical problems, problems of shielding and safety appear in a staggering array. It will be many, many years before they can be solved.

Does this all present a pretty confusing picture? Unfortunately, that is the way things are—and even the picture I have presented is over-simplified. But one thing seems clear. An over-enthusiastic press—and some over-enthusiastic scientists—have created the impression that the **large scale** use of **cheap** nuclear fuel is just around the corner. The sober fact is that uranium 235, while it may be a concentrated, is not either an **abundant** nor a **cheap** source of power. If we use only U-235 there is not enough of it in the world to be very interesting. We must therefore convert U-238 to plutonium, but this is a very slow and costly process. And in any case, engineering development takes time.

The public expects great things of atomic energy and all its peacetime possibilities. And it should! But we must expect these developments to come slowly. Each step will come as a result of strenuous efforts in research, development and engineering. It took 200 years to bring the steam engine to its present stage of development! Things move faster now and only a few decades may be required for a comparable development in nuclear power.

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* **J. R. Oppenheimer, in a report to the United Nations Atomic Energy Commission, is a bit more vague. He said "decades will elapse . . . ."**

This paper was given at the 54th Annual Convention of the Pacific Coast Gas Association at San Diego on September 24.

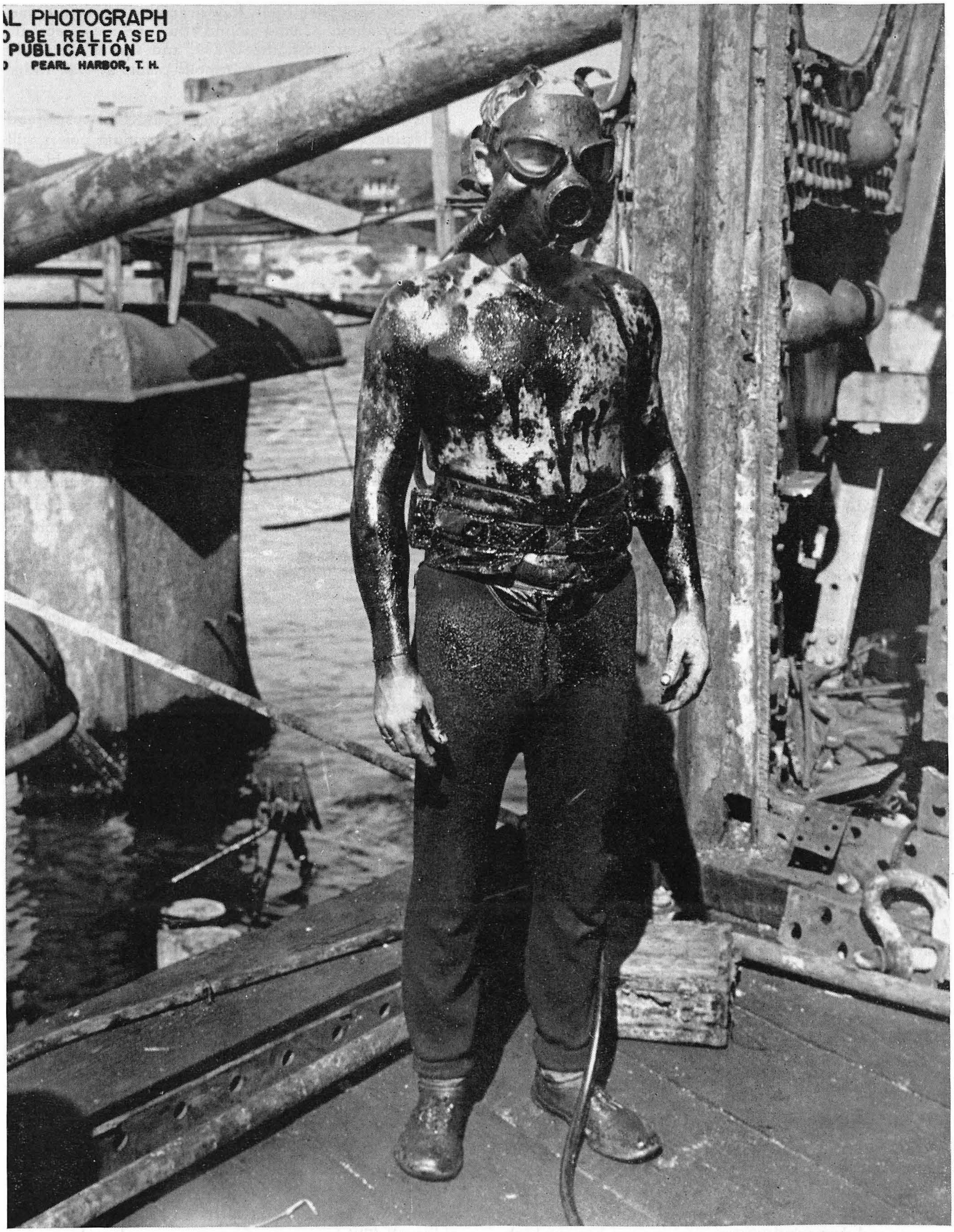


Fig. 1 A closeup of the diving dress worn for work in unwatered compartments, which were sometimes under air pressure, and in shallow water diving (less than 35 ft) where simple, relatively non-hazardous work was required.

SALVAGE OF THE *OKLAHOMA* at Pearl Harbor

By LEE P. MORRIS

BEFORE launching into a report of the salvage of the battleship **Oklahoma**, it is desirable to give some review of the events leading up to December 7, 1941. Subsequent information indicates the facility with which the Japanese attacking force accomplished its moves.

The Pearl Harbor attack was planned originally by the Japanese as the initial step of their Pacific campaign. Admiral Isoruku, then Commander-in-Chief, Combined Fleet, supposedly originated the plan early in 1941. The task force assigned to strike Pearl Harbor rendezvoused, starting November 14, 1941, at Hitokappu Bay in the northern Kurile Islands. The force finally assembled consisted of 2 battleships, 6 carriers, 3 cruisers, approximately 20 destroyers, 5 submarines, including midgets which were carried by mother submarines, and a normal complement of auxiliaries. On November 25 the Commander-in-Chief, Combined Fleet, issued the order for the assembled force to proceed to a predetermined location for refueling. The force departed at 6 a.m., November 26, Japan time, and set an indirect northern course for the next rendezvous, 200 miles north of Oahu. On December 6, when the force was still 800 miles north of Oahu, it received the long awaited code message, "Climb Mount Niitaka," to proceed with the attack. Thus far the force had gone undetected. Luck stayed with it, and on December 7, at 6 a.m., the Japanese began launching their airplanes. The last of the striking force of 361 airplanes departed about an hour later. The United States Navy was to suffer its worst defeat in history.

When the Japanese attacked, 86 vessels, including 8 battleships, 7 cruisers, 28 destroyers and 5 submarines, plus the usual complement of small craft, were

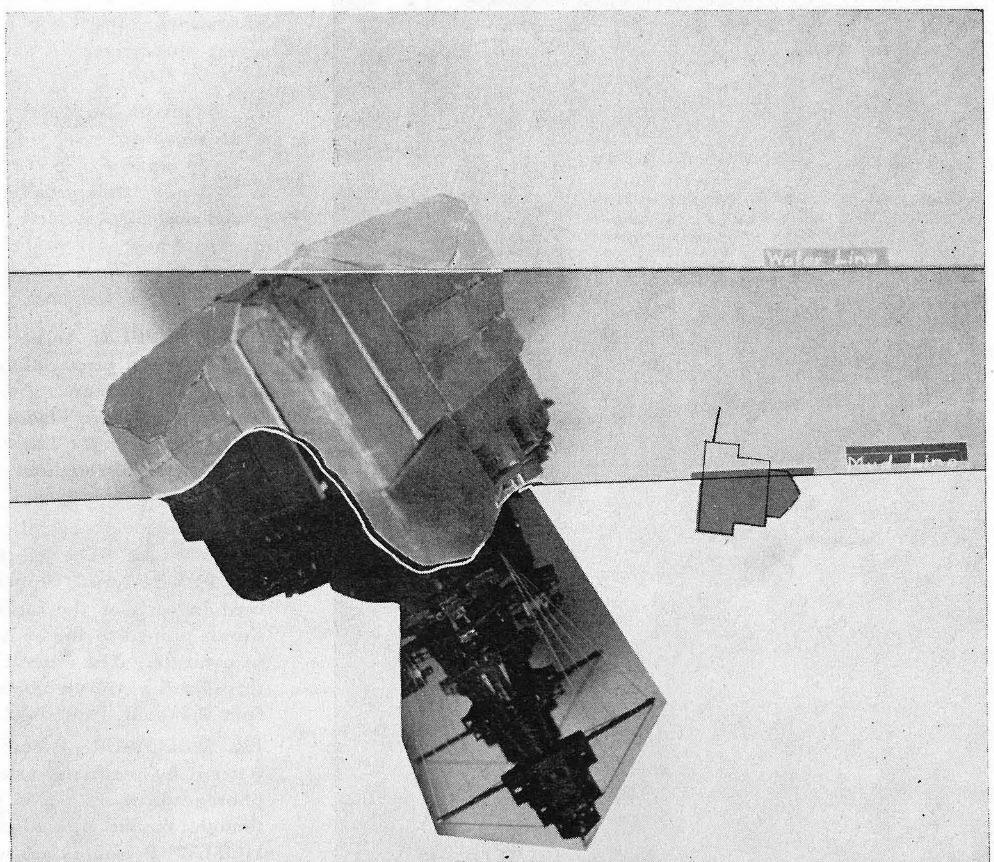
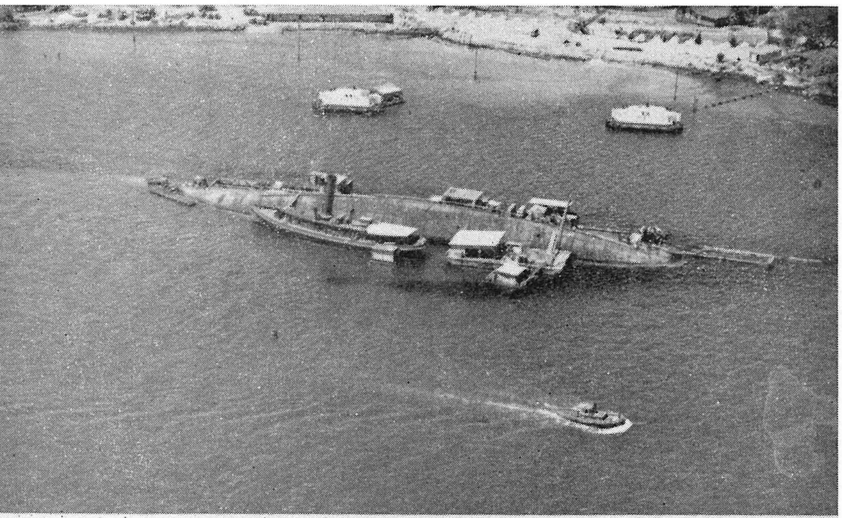


Fig. 2 Cardboard model of the OKLAHOMA placed to show the position of the ship before righting. The S-shaped mud line was caused by a mud bank formed when the forward section of the ship became embedded in soft mud before it capsized.



based in the harbor. It is of interest that, contrary to public opinion, the Japanese task force learned December 6 from its espionage service that no aircraft carriers were moored at Pearl Harbor. This absence of carriers was a piece of luck for which we were later exceedingly thankful. When the onslaught subsided, nearly every ship bore scars. One of the worst damaged, the **Oklahoma**, was salvaged by one of the most complex operations in history.

The **Oklahoma** was, at the time of the attack, located outboard of the battleship **Maryland**, which was moored alongside Ford Island. She was struck on the port side by four or five topedoes, which caused the ship to capsize quickly to port and come to rest on the bottom at an angle of 151° 30′ from upright. Only the starboard bilge showed above water. See Fig. 3. With the ship in this position, about 30 men were rescued through holes cut in the bottom during the 24-hour period following the attack.

RIGHTING OPERATIONS

Two steps were required in the salvage operations on the **Oklahoma**. Before the second step of refloating

Fig. 3 UPPER: An aerial view, showing the various facilities used in initial preparations for salvage, including diver's floats and air compressors. Accessible fuel oil, the starboard propeller, and the three blades of the port propeller were removed prior to righting. The tug shown was used as a tender and headquarters throughout most of the operation.

Fig. 4 CENTER: Winches and righting tackles, looking north showing central control station, and midship and after position stations. The block assemblies are reeved with 1 in. 6 x 19 wire rope. Approximately 9500 ft of 1 in. rope was used in each of the tackle assemblies. The inner blocks are shown pinned to the ends of steel beams which were anchored in concrete. The outer blocks are each to be attached to two three-in. 6 x 37 wire rope lines which will be extended to "A" frames mounted on the bottom of the ship.

Fig. 5 LOWER: Recovering equipment from a turret, unwatered by pumping, after removal of guns and slides. This photograph was taken in the #2 turret of the ARIZONA, although similar operations were performed on the OKLAHOMA. Personnel are wearing the shallow-water diving dress shown in Fig. 1.

could commence, righting had to be carried out. The **Oklahoma** capsized in a position parallel to the shore. Righting operations involved the use of 21 five hp DC motor-driven winches, each of which, through two 17-part tackles, applied an approximately horizontal force transverse to the ship. To effect large turning moments, pendants extending from the outer blocks were secured to the tips of 21 40-ft-high "A" frames mounted on the above-water portion of the starboard bilge. See Figs. 8 and 10. The frames transmitted the pull exerted by the winches through compression members to thrust brackets mounted along the centerline or port docking keel of the bottom (Fig. 9), and wire rope back stays transmitted the pull to the starboard blister, which had previously been reinforced to prevent buckling of its transverse members (Fig. 18). Figs. 4 and 7 give an idea of the winches and righting tackle on shore. Preparatory to righting, the following steps were taken to assist the operation:

1. Oil in accessible fuel oil tanks was removed. Also some machinery in the above-water portion inside the ship, the starboard propeller, and three blades of the port propeller were removed.

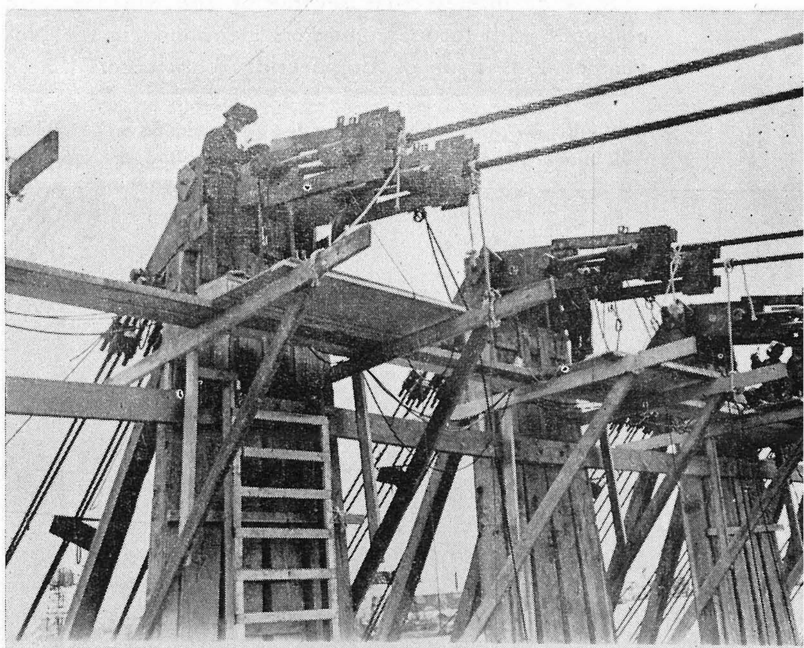
2. Air pressure was applied inside the hull to lighten the vessel and aid in righting. To prevent a complete and rapid loss of air in the event of a serious leak during righting, the air was compressed in seven separate sections which were rendered watertight by opening and closing hatches and doors inside the hull as required. This work was accomplished by divers. Fig. 12 is an air lock for access to and from a watertight section. Final sealing of each section was done by men wearing shallow-water diving masks.

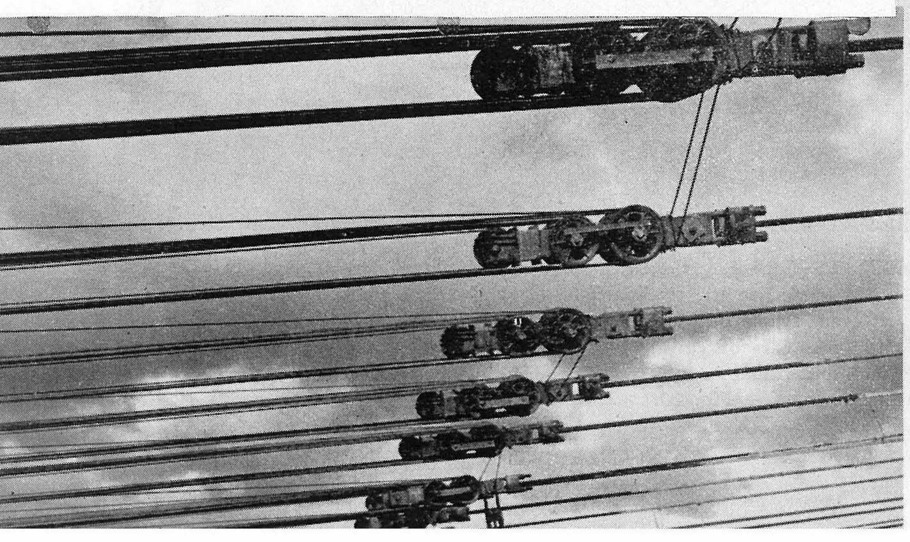
3. Because mud in the path of the rolling ship was particularly prevalent inshore of the forward end, 4500 cubic yards of coral were deposited in the way of the bow to provide at better bed.

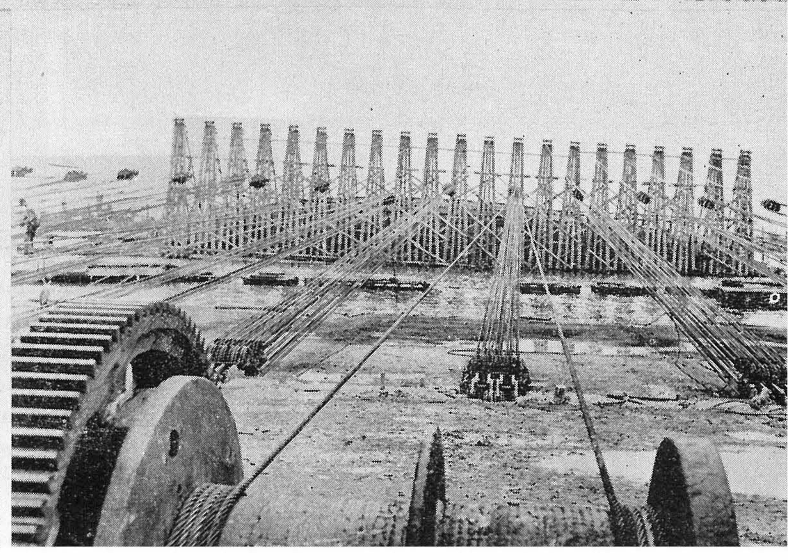
Fig. 6 LOWER LEFT: Outer or moving blocks composed of eight 28 in. diameter sheaves, eight 24 in. diameter sheaves, and one 20 in. diameter sheave. The small sheave served to equalize the tension on each pair of load lines extending from an individual winch. All tackle was especially designed for the job.

Fig. 7 UPPER RIGHT: "A" frame head fittings, fabricated from heavy steel plate. Of welded construction, these were bolted to steel plate extensions on the "A" frames and pinned to allow rotation in a lateral plane.

Fig. 8 LOWER RIGHT: View from Ford Island of the OKLAHOMA in 140° position. The three photographs in this group were all taken in March 1943. In this phase of salvage operations, righting was frequently interrupted to re-rig the tackles or because of rigging failures. Reasons for re-rigging included: Avoidance of too many layers of wire rope on winch drums; shifting tackle from "A" frames to the ship's structure. Failures occurred in the structure of "A" frame head fittings and in wire rope slings used to transmit the pull to various hull structures after "A" frames were removed.







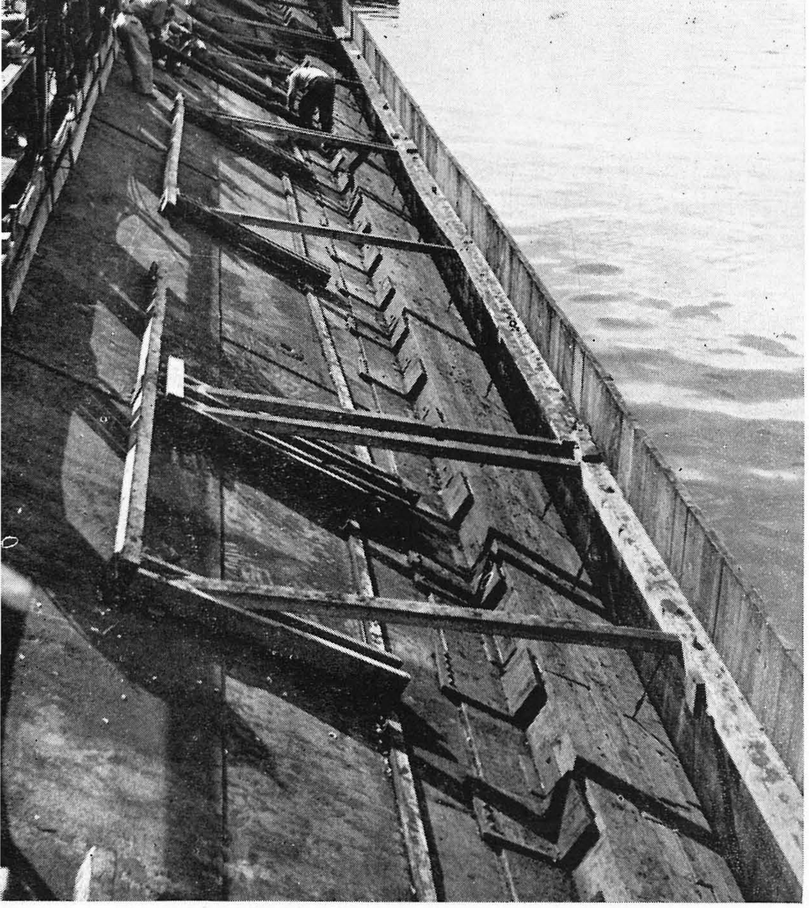


Fig. 9 Thrust brackets welded to the bottom along the centerline. Each bracket absorbed the force transmitted by individual compression members, of which there were four for each "A" frame. The cofferdam on the right holds water back during high tide.

It is of interest that several of the winches were equipped with torque converters mentioned in the November 1945 issue of **Engineering & Science.** These winches exert maximum pull at zero speed. In 100 days the vessel was rolled over to a final port angle of 2° 10′. See Fig. 16. The total actual pulling time was 73 hours, an average of a little more than 2° per hour. During the 100-day period, most of the time not spent in actual pulling was spent in removing by water jets the mud bank built up inboard as the vessel rolled toward the shore, in inspecting damage as the topside portions of the vessel were exposed, and in rerigging the pulling tackle to the ship's structure. The "A" frames were removed after the vessel had rolled to a 68° position. See Fig. 13. Most of the facilities used to right the **Okla-**

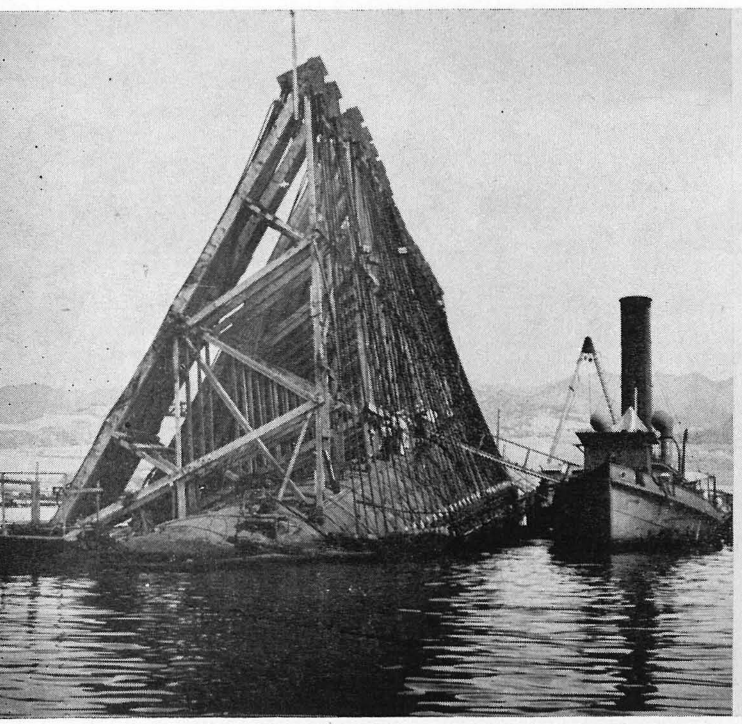


Fig. 10 "A" frames mounted on the ship's bottom. After the OKLAHOMA was rotated to a 68° position from the vertical, the frames were removed and the direct pull was assumed by the back stays. This photograph was taken in February 1943.

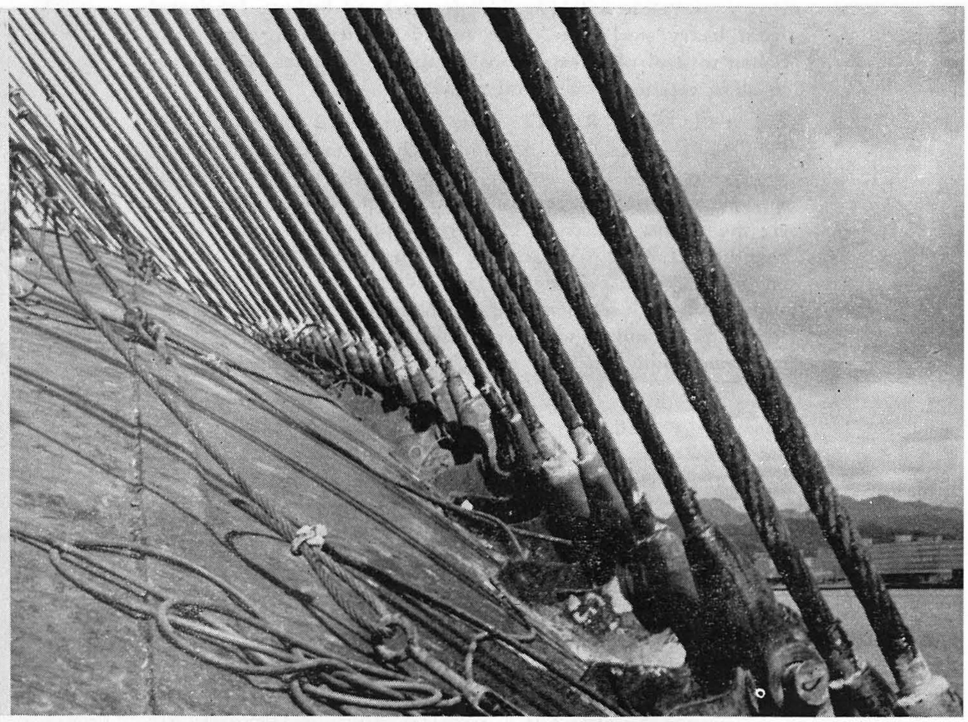


Fig. 11 Back stay detail. The back stay attachments consisted of pads welded to the starboard blister. The attachments were spaced at every frame of the hull to correspond to the individual compression members of each "A" frame. There were two back stays for each individual compression member. This photograph was taken a month after Fig. 10.

Fig. 12 Airlock for access to and from one section of the main air bubble. The bubble, designed to lighten the ship, was divided into seven sections which extended from stem to stern. It was effective from the bottom to the second deck, originally about 25 ft below the water level. Each air lock while being used was manned by a crew supervised by an officer diver.

homa were later moved to the other side of Ford Island, where they were reused to right the **Utah.**

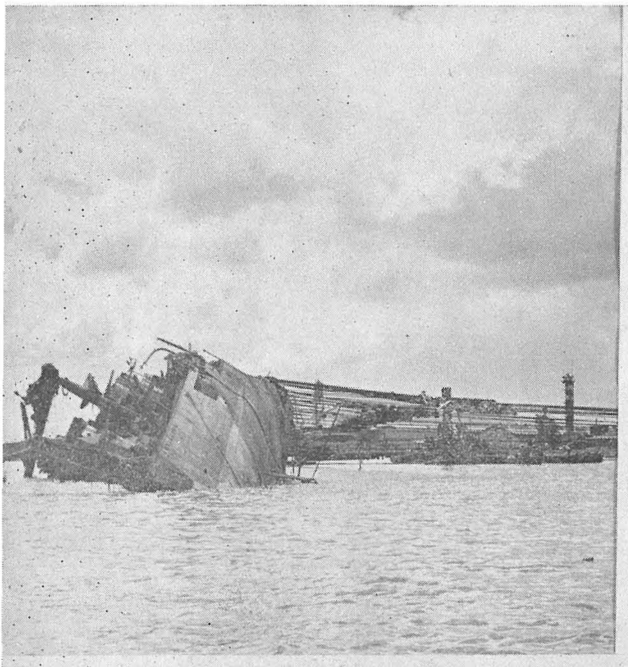
REFLOATING OPERATIONS

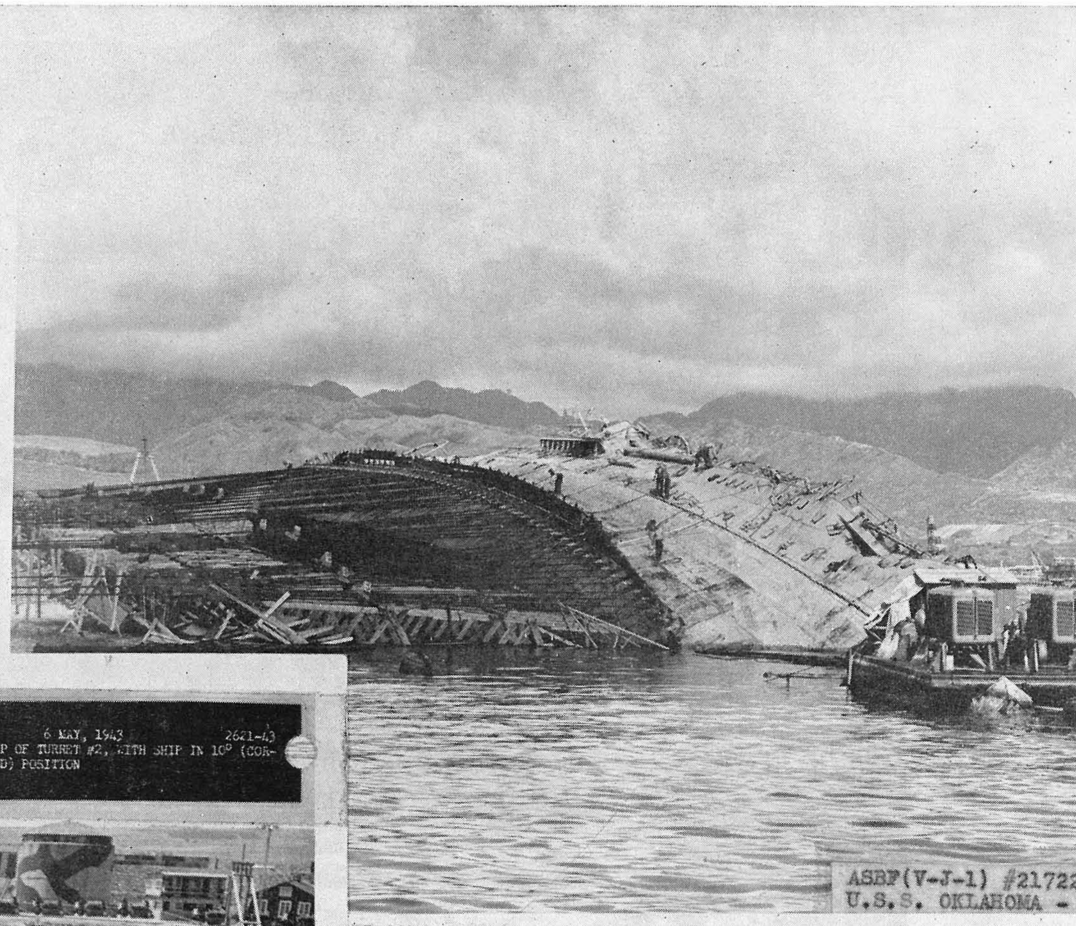
Refloating operations were commenced by installing four independent patches, the largest of which consisted of five sections and was 130 ft long by 57 ft high. This patch, one section of which is shown in Fig. 20, was of wood construction heavily reinforced by external steel trusses. The external structure served to reinforce the patch, which consisted of 4-in. thick siding sealed with packing materials. The sections were secured to the sides by means of hook bolts installed in holes burned by divers through the damaged shell of the ship. The patches were sealed by means of concrete poured into forms along the bottom and up both ends.

A fence type cofferdam was also installed around the main deck aft. Refloating was accomplished with the aid of numerous electric- and Diesel-driven deep-well and portable submersible pumps. See Fig. 21. In order to have sufficient pumps to keep the vessel afloat during the trip from the berth to drydock, some of the electric pumps were driven by Diesel generators. The rest of the power requirements during refloating were supplied from shore. Views of the vessel in drydock before and after removal of the patches are shown in Figs. 23 and 24.

DIVING OPERATIONS

No article on ship salvage is complete without mentioning the hazardous work performed by divers. At Pearl Harbor their numerous tasks included interior and exterior inspections, closing and opening doors and hatches, installing and sealing patches and cofferdams, and removing wreckage and salvable equipment. The Pearl Harbor divers are all the more to be respected when it is realized that they operated inside capsized vessels, wearing deep-sea diving dresses weighing 185 lbs, and working for many hours several hundred feet from access openings. All of this was done in total darkness, underwater lamps being of no use because of the excessively murky water. All in all, about 6000 individual dives were made, during salvage operations at Pearl Harbor, averaging approximately four hours per dive. In all of the salvage work undertaken at Pearl Harbor there was only one Navy casualty, and that was not on the **Oklahoma** operations. A diver on the **Utah** after working several hours, suddenly had an air supply





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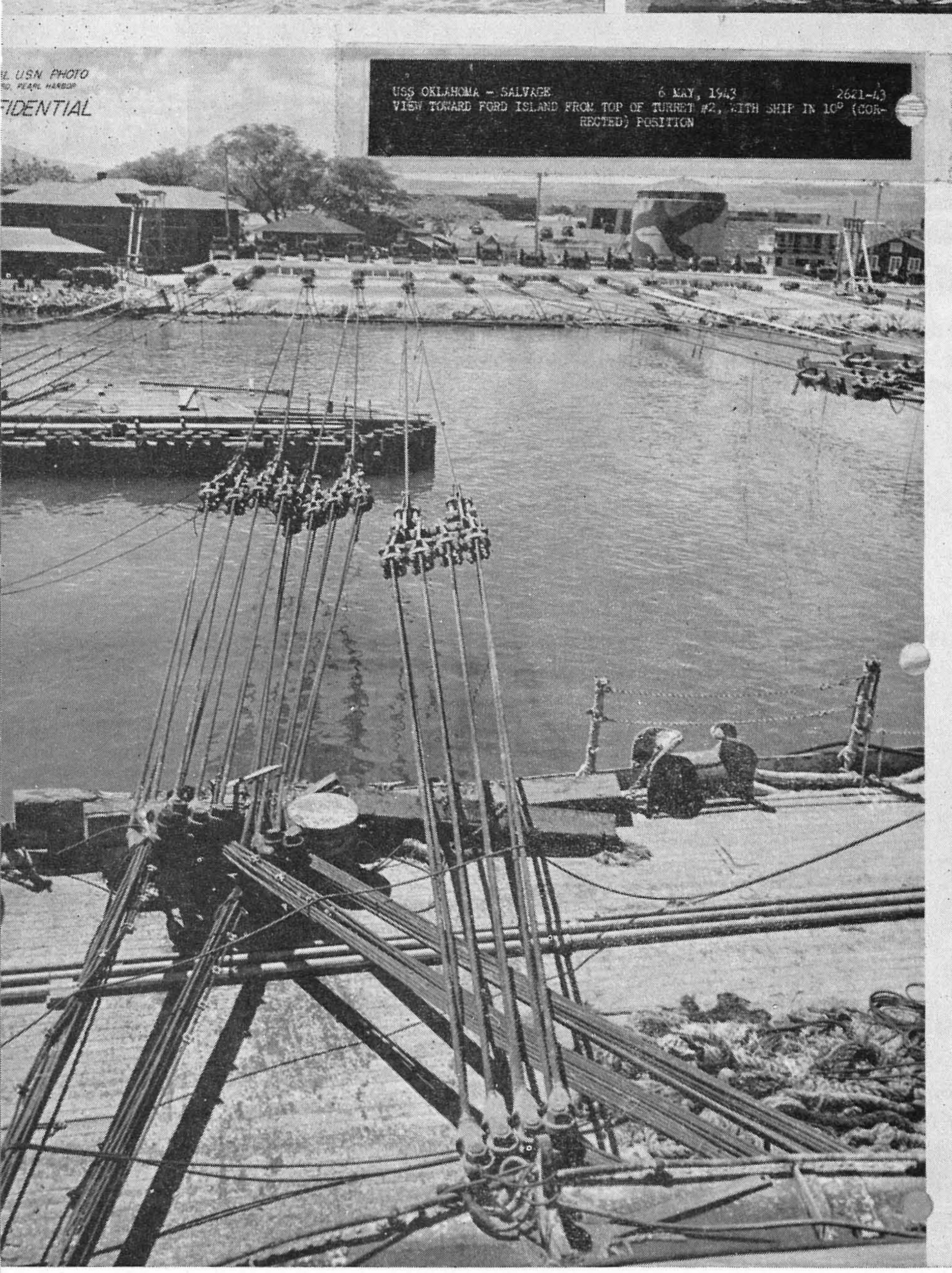


USN PHOTO
FIDENTIAL
USS OKLAHOMA - SALVAGE 6 MAY, 1943 2621-43
VIEW TOWARD FORD ISLAND FROM TOP OF TURRET #2, WITH SHIP IN 10° (CORRECTED) POSITION

NASPH #119147 - 8 June, 1943.
U.S.S. OKLAHOMA - Salvage.
Aerial view from stbd bow in 2°-

Fig. 17 Adjusting a discharge hose from a submersible pump in 14 in. magazine spaces during refloating operations. None of the 14 in. ammunition was removed because of the dangers and difficulties in handling.

failure and lost consciousness from lack of oxygen. He died by drowning, water entering through the helmet exhaust check valve after he fell to a prone position. Many men trained at Pearl Harbor developed into seasoned divers and proved invaluable in subsequent Navy salvage operations throughout the world.

CONCLUSION

Today little evidence remains at Pearl Harbor of the salvage work which required two years to accomplish.

Fig. 13 UPPER LEFT: The OKLAHOMA late in March 1943. Seen from astern with ship in about 68° position.

Fig. 14 UPPER RIGHT: Looking aft at about the same period as Fig. 13. The ship had been rolled 39° in 19 hours the day previously, the longest roll made at one time. Compressors in the foreground were used to assist in maintaining the air bubble mentioned in Fig. 12.

Fig. 15—LOWER LEFT: Detail of righting tackles. Nos. 3, 4 and 5 tackles in the foreground are connected through wire rope slings to No. 2 turret structure. The special shackle fittings were formerly used to secure the backstays to the attachment pads on the starboard blister. The fittings in the middle of the picture were formerly part of the "A" frame head fittings. Although it may appear differently, the deck bitts shown did not serve as righting tackle attachments. In the background, the outer or moving blocks are nearing the stationary blocks. Positions were "corrected" regularly at shore observation stations by means of transit and distance measuring wires.

Fig. 16 LOWER RIGHT: June 1943. This is the final position to which the vessel was pulled by righting tackles. At this position the total pull required to hold the ship was nearly 8500 tons. The two large barges are each carrying cranes and miscellaneous salvage material. Outboard of the forward barge is a smaller barge loaded mainly with deepwell pump pipe, and outboard of the small barge is a floating derrick. The small floats are mainly divers' floats or are carrying compressors. The salvage tender is moored to the forward key.

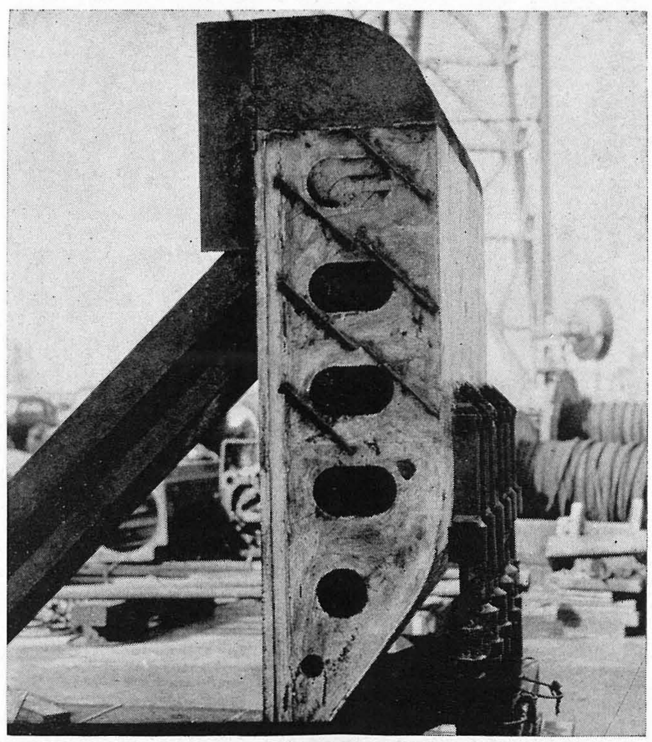
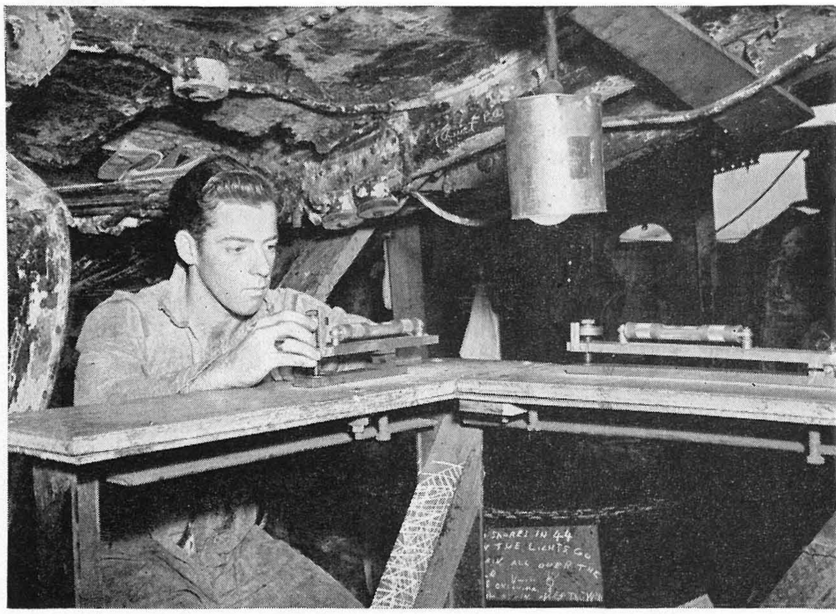


Fig. 18 One-fifth scale blister model. To determine the stresses to be induced in the starboard blister from the backstay connections, a model was designed to simulate the conditions. Hydraulic jacks were used to represent forces applied by the back stays. Premature buckling of the transverse members in the blister indicated diagonal stiffening would be required. This model has been reinforced by welding bars onto the transverse members and withstood the test. The OKLAHOMA starboard blister was similarly reinforced.

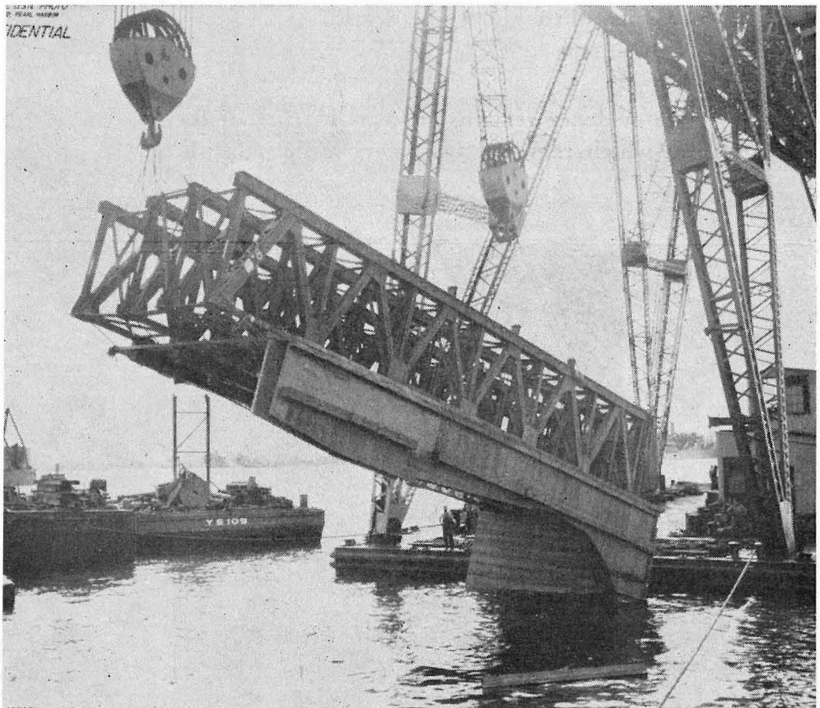
Fig. 19 RIGHT: Clinometer and trim indicator used to determine list and trim respectively during refloating operations. These instruments were set up on the center line, approximately amidships. The clinometer indicated the list to the nearest minute, and the trim indicator was sensitive to the point where it served as a check on draft readings at bow and stern. These instruments, along with other references, were observed at regular intervals.



The **Oklahoma,** after being drydocked December 28, 1943, was later purchased by the Moore Drydock Co. of Oakland, California, for scrapping. On May 17, 1947, while under tow, the **Oklahoma** sank 540 miles out of Pearl Harbor with no one on board. Two other heavy casualties remain at Pearl Harbor. The battleship **Utah** is righted but has not been refloated, and the sunken hull of the battleship **Arizona** remains in an upright position.

ACKNOWLEDGMENT

The author is particularly grateful to Captain F. H. Whitaker, USN, who kindly furnished prints of the pictures ap-



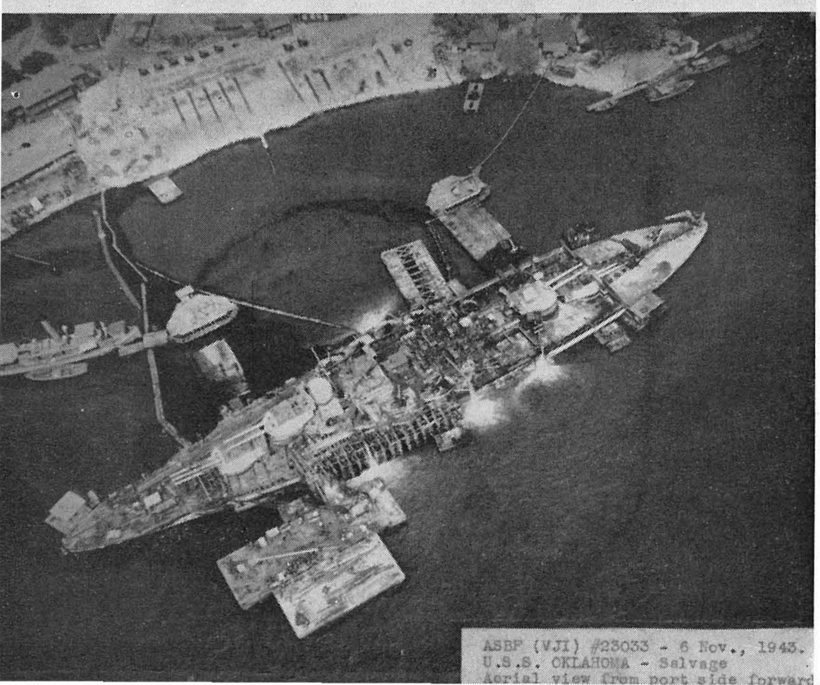
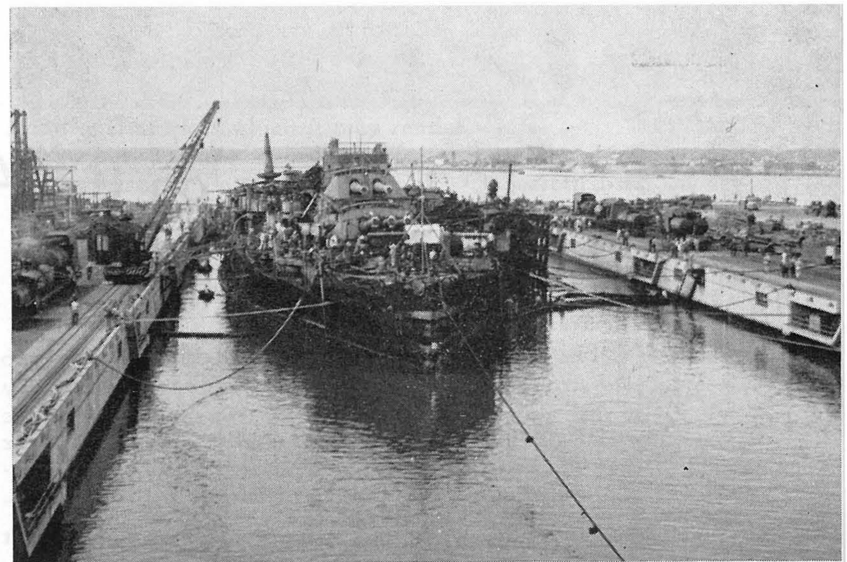
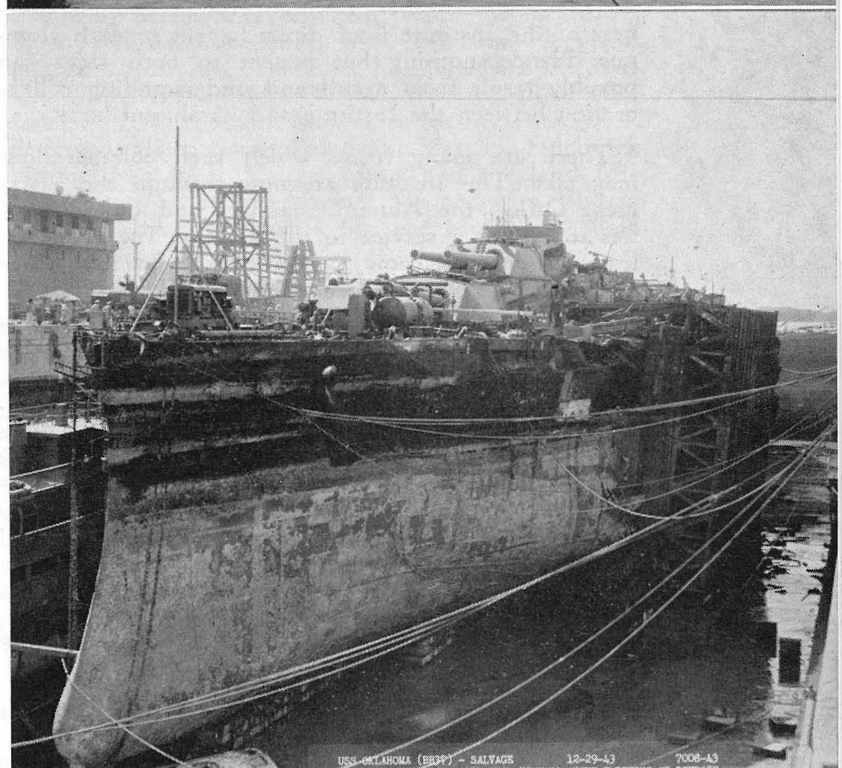


Fig. 20 UPPER: Forward section of the main five-section cofferdam patch. Preparatory to taking the measurements required for the design of the patches, considerable wreckage had to be removed from the port side by divers. Measurements were made by means of vertical and horizontal battens.

Fig 21 LOWER: Aerial view from port side of the OKLAHOMA after refloating. The largest volume of water handled by deep well pumps used was at the start of refloating operations. Volume was then equivalent to that handled by approximately 16 10-in. pumps against a 50 ft head. Pumping was continuous. Nine righting tackles are still attached to the ship but were removed after this picture was taken. To restrict movement of the floated vessel, small barges were placed between th ship and quays and the vessel anchored. Guns were placed in a state of preservation, and fire, fresh water, and ventilation systems installed. Diving proceeded continuously during daylight hours.

Fig. 22 UPPER RIGHT: View from ahead in drydock.
Fig. 23 CENTER: A few hours later, December 29, 1943. Drydock blocks were set in accordance with the OKLAHOMA'S docking plan with some modification. In order that the patch projecting below the ship's bottom would clear the harbor bottom and drydock blocks, the vessel was given a 3° list to starboard. This was done by flooding the starboard blister and wing tanks and attaching pontoons to the main patch on the port side.





pearing in this article and most of the data regarding salvage of the OKLAHOMA. Captain Whitaker had full charge of the salvage of the OKLAHOMA.

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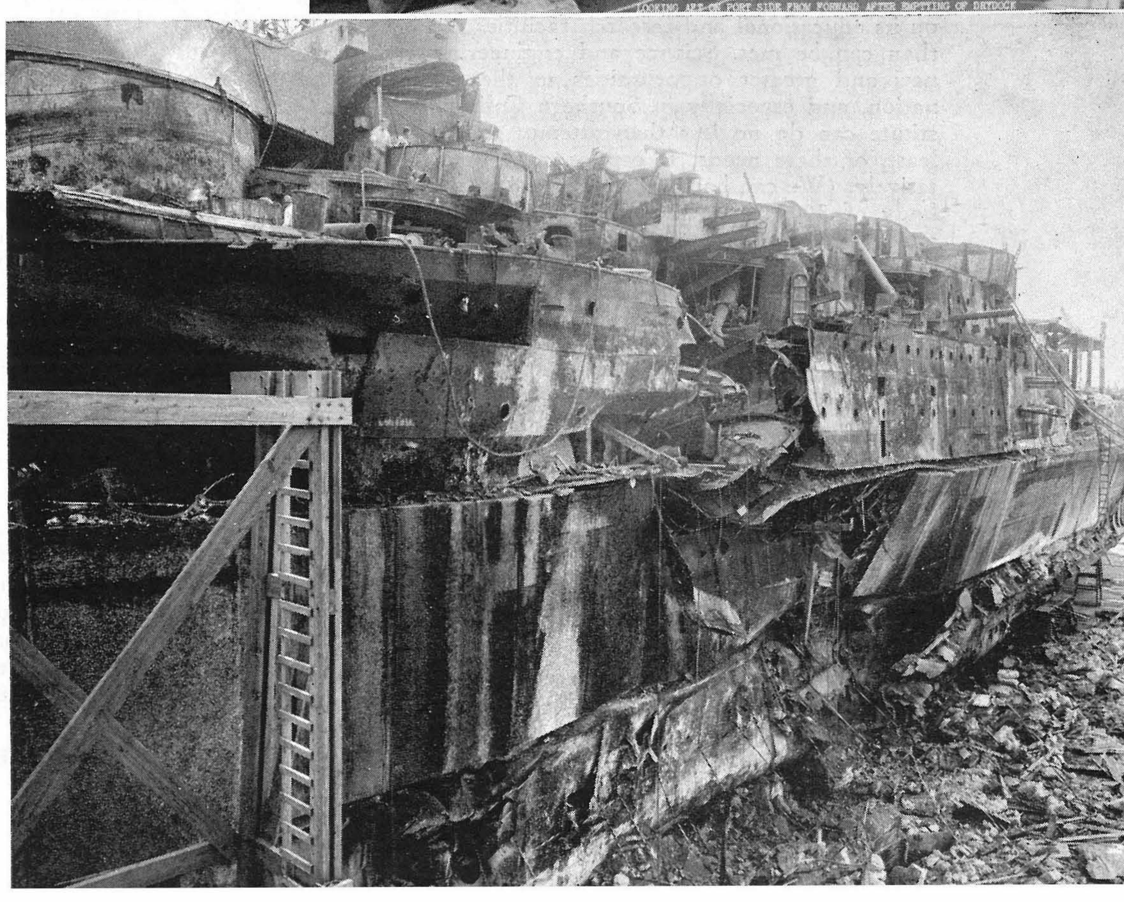

Fig. 24 Port side looking aft after removal of patches. These were removed by cutting the various supporting members. One of the important features in designing the patches was to insure against their premature collapse after the supporting forces of buoyancy and hydraulic pressure were removed when the ship was no longer water borne.

Views on the ALUMNI FUND

By LEE A. DUBRIDGE

THE California Institute of Technology is no stronger than its alumni. It deserves to exist only if its alumni are serving the community and the nation in an important way—and if it is also clear that what the alumni gained while students at the Institute made an important contribution to their careers.

Conversely, while the Alumni are reflecting credit on the Institute, the growing prestige and effectiveness of the Institute is of direct benefit to each alumnus. Hence, nothing but benefit to both sides can possibly result from a full and understanding collaboration between the Institute and its alumni body.

There are many forms which such collaborations may take. The Institute attempts through the Placement Office, the Alumni Seminars and other activities to render a service to the alumni. The Administration would welcome suggestions as to how these services may be extended and improved.

A number of alumni groups have recently arranged to render a very valuable assistance to the Institute's Director of Admissions in handling the problems relating to examination and selection of entering students. The enormity of this problem and the terrible responsibility involved are seen in the fact that this spring about 1100 students completed applications for admission to CalTech this fall. Seven hundred ninety were allowed to take entrance exams, about 400 did well enough to warrant an interview—and 180 were admitted. Are we sure we selected the **best** 180? Can we improve our system of administering examinations, gathering all revelant information about each student? The need for alumni help is obvious!

This problem is but one illustration of the way in which the Institute is entering a new era in its development. Its prestige is world-wide, the demands on its educational and research facilities are far greater than can be met. Science and engineering are facing new and greater opportunities in the world, in the nation, and especially in Southern California. The Institute can do no less than attempt to meet some, at least, of these needs. It cannot meet them all quantitatively. (We can hardly contemplate an undergraduate body of 3000 even if it were desirable!) But it can attempt to do the finest possible job, qualitatively. To do this, its facilities and staff must be kept at the highest level. A new, and substantially higher, faculty-salary scale now going into effect will insure our ability to attract and retain the best men. But our physical plant is not yet complete, our income for education and research is still inadequate.

It would be natural at this time to turn to our rapidly growing alumni body for aid. We would probably have done so—if the Alumni Association had not beat us to it! The Alumni Fund is **your** idea. It is a great one, and will be warmly welcomed by alumni, students, faculty, trustees and administration. It can help make CIT a finer place. Toward that end we shall work together.

This view by Dr. DuBridge is reprinted from the June 1947 issue of ENGINEERING & SCIENCE.

By HOWARD LEWIS

OUR Association exists to help us maintain old friendships and make new friends, to help us advance professionally, and to enable us, the chief beneficiaries of the Institute, to help the Institute provide similar opportunities for younger men.

Our assistance to the Institute can, and should, take several forms. We can assist materially in disseminating factual information about the Institute to the general public, to student advisers and administrators in high schools, and to potential supporters of the Institute. We can assist in the selection of candidates for admission to the Institute, particularly in areas relatively remote from Pasadena. Many of us can participate directly in seminars or student technical society meetings, to the great advantage of ourselves, the students, and the Institute. We can, to a limited extent, guide and counsel the students who are following us.

All of these activities require time, thought, and effort of individual alumni who are willing to help for the satisfaction of helping. Alumni are participating now in these efforts and they will doubtless continue to do so in increasing numbers.

We can also assist the Institute with direct gifts of funds for general or specific purposes. No general appeal for such assistance from the alumni has ever been made by either the Association or the Institute, but many alumni have expressed a desire to help and have asked why no effort was made to acquaint them with needs and why no provision was made for soliciting such gifts.

The establishment of a CalTech Alumni Fund was announced in **Engineering & Science** for June and at the annual meeting of the Association this year. While the fund is still very, very young and no canvass of members has yet been made, over $1600 has been collected and deposited to the credit of the Fund. Disbursements from this fund can be made only with the approval of both the Institute Board of Trustees and the Alumni Association Board of Directors.

No specific allocation of funds has as yet been made. All of the alumni so far consulted hope to see the Fund instrumental in providing or helping to provide a gymnasium and other recreational facilities for the use of students, faculty, and alumni. With the acquisition of Tournament Park assured, plans for such facilities are being developed. When those plans are completed and when we, as alumni, have indicated the extent to which we are willing and able to contribute to their fulfillment, it will be possible to determine what specific part of the plan the alumni will undertake.

A canvass of all CalTech alumni is being started now. The Association and the Institute are asking for your help now. Don't miss this opportunity to show your appeciation of the generosity of those who made your CalTech training possible. Our strength is in numbers; 4000 small contributions can make a large total. Let's do what we can to make CalTech stronger and better.

C. I. T. NEWS

SERVICE LEAGUE TO HELP STUDENTS

THE health and welfare of CalTech students and their families will receive greater attention this year than has ever been possible in the past through the cooperative effort of a newly formed California Institute of Technology Service League and the Institute.

Organization of the new Service League, comprising parents of students, members of the faculty and their wives, graduates' wives, associates, and other interested persons, both men and women, was begun last spring. Assisted by Dean Franklin Thomas, representing the Institute, a small interested group met with Institute officials to lay the ground work for the organization and determine the type of program needed. Out of this meeting came a policy-forming committee composed of Mrs. William S. McCay, Mrs. Harold C. Whittlesey (deceased)*, Mrs. Samuel B. Morris, Mrs. H. S. Simons, Mrs. C. W. Six, Mrs. Morgan Ward, Mrs. Ray Gerhart, Mrs. William S. Long, Mrs. P. K. Walp, and Mrs. R. W. Sorensen.

A four-objective program was outlined. First objective was determined to be that of providing for convalescent care of students. This was given top priority. Second is need for a welfare program among married students with assistance in housing and similar problems. The third objective is that of assisting wives and children of married students and the fourth objective that of giving financial aid to worthy students.

Realization of the first objective, that of providing for convalescent care of students, is already well underway and sometime in December a new CalTech Health Center will be in operation on the campus. This is being established in one of four temporary buildings obtained from the government and now being erected on the campus. The Health Center building will have six beds, 24-hour nursing service, a full time physician, Dr. E. D. Kremers, student health director. Meals will be prepared in student house kitchens.

Membership in the Service League has now increased to more than 60 mothers and fathers of students, members of the faculty and their wives, and friends of the Institute. Letters to parents of students and many others are being sent out by the Service League explaining its objectives and seeking new charter members. Charter membership dues are $2.00. Checks should be payable to the CalTech Service League and mailed to Box 51, 1201 E. California Street, Pasadena 4, California.

As word of the organization has spread, so too has interest in it. A result has been the offer of Dr. Belle D. Poole, formerly pediatrician on the staff of the Children's Hospital in Los Angeles and now supervisor for Southern California District of the State Maternal and Child Hygiene Department, to personally conduct a Well Baby clinic one afternoon each week at the Health Center for children of married students. The Health Department of the City of Pasadena is also cooperating in this program.

Committees have been appointed to begin work on other objectives of the Service League and to study additional services which it may render.

Members to date include the following: Mrs. J. G. Bailey, Mrs. A. Perry Banta, Mrs. E. C. Barrett, Mrs. Henry Borsook, Mrs. R. C. Burt, Mrs. L. A. DuBridge, Mr. and Mrs. Ray Gerhart, Col. and Mrs. E. C. Goldsworthy, Mrs. F. Grose, Mrs. Beno Gutenberg, Mrs. W. L. Hershey, Mrs. F. W. Hinrichs, Mrs. J. S. Johnson, Mrs. L. W. Jones, Mrs. R. R. Martel, Mrs. W. S. McCay, Mrs. J. O. Rasmussen, Mr. and Mrs. C. W. Six, Mrs. M. W. Smith, Mrs. R. W. Sorensen, Mrs. J. E. W. Sterling, Mrs. A. H. Sturtevant, Dean and Mrs. Franklin Thomas, Mrs. Morgan Ward, Mrs. Archibald Young, Mrs. G. I. Billheimer, Mrs. Thomas Fleming, Mrs. H. Holt, Mrs. W. C. Jackson, Mrs. Seeley Mudd, Mrs. W. B. Munro, Mrs. Harold Washburn, all of Pasadena; Mrs. G. W. Beadle, San Gabriel; Mrs. L. M. Powell, Glendale; Mrs. Albert Eschner, Santa Monica; Mrs. O. R. Bulkley, Alhambra; Mrs. Thurlow Heggland, Mrs. S. Y. Johnson, Mrs. E. D. Kremers, Mrs. E. Kruse, Mrs. Foster Strong, Mrs. W. W. Webster, all of Altadena; Mrs. N. Hibbard, Mrs. A. B. McCay, Mrs. W. K. Patterson, all of South Pasadena; Mrs. H. Hitchcock, Mr. and Mrs. H. R. Simons, Mrs. Thad Vreeland, Miss Ann Patton, all of San Marino; Mr. and Mrs. William S. Long, Mrs. S. B. Morris, Mr. and Mrs. P. K. Walp, Mrs. William Godshall, Mrs. J. R. Page, all of Los Angeles; and Mrs. Frank Jewett, Brentwood, Short Hills, New Jersey. Honorary membership, Mr. Harold C. Whittlesey.

* Mrs. Whittlesey, one of the original and most active organizers of the Service League, passed away May 1 following a heart attack. Mr. Whittlesey, who has also been most interested in the organization, was subsequently extended an honorary membership and recently made a gift of $100 to the League to help carry on the work his wife had started.

PALOMAR MIRROR NEARS COMPLETION

EARLY IN OCTOBER, work on the 200-inch telescope mirror for the Palomar Mountain Observatory was completed. Dr. Max Mason, chairman of the Observatory Council, stated that: "Our last tests show that we have reached the goal toward which we have worked from the beginning—a parabolic (concave) surface accurate to within two millionths of an inch."

Never before has so large a piece of glass been polished to such accuracy. It has been not only painstaking but nerve-wracking work. The closer CalTech astronomers approached their goal the slower the work became, for it progressively called for more and more testing and less and less polishing. A mistake could have set back completion of the mirror for months.

As the goal was approached, Dr. John A. Anderson, who has been in charge of this challenging optical work from the beginning, Dr. Ira S. Bowen, director of the Mt. Wilson Observatory, who will also be director at Palomar Mountain, and other members of the Observatory Council met more and more frequently to watch and discuss progress of the final polishing. New testing methods confirmed the accuracy of previous ones. They assured Anderson and his colleagues that the readings they were getting were as accurate as man can obtain with today's instruments. The final test will come when the telescope is completed and in operation.

November will probably see the mirror's transfer to the observatory atop San Diego County's Palomar Mountain, 130 miles southeast of Pasadena. The mirror, mounted in the cell in which it will ultimately be placed in the telescope, will be packed in a huge insulated wooden box. It will be moved to the observatory by truck and trailer over a route specially designated by state and county highway departments. On portions of the route it will be necessary to set up road blocks and there will be a highway patrol escort for the entire route. The mirror, cell and box will weigh approximately 37 tons.

WM. HOWARD CLAPP SERIOUSLY ILL

ON A TRIP to the East, via San Francisco, Professor Emeritus Wm. Howard Clapp suffered a slight stroke. Returning in late September to his son's home in Vista, near San Diego, Professor Clapp suffered a relapse, and was taken to the Oceanside Hospital. At press time Clapp is resting comfortably at his son's home.

REGISTRATION REMAINS LARGE

REGISTRATION FOR the fall term closed late in September with 1320 students, 52 less than last year, enrolled. The freshman class totals 176 students from 23 states and 11 foreign countries. Following a Tuesday registration, freshmen embarked for Camp Radford in the San Bernardino Mountains, returning Friday after 1144 upperclassmen and graduate students completed registration.

Named to the freshman honor section were 20 students, representing three foreign countries, four states and the territory of Puerto Rico. Students from outside the United States are: Kwok-Ying Chong, Perak, Malaya; Uri Retter, Jerusalem, Palestine; Edwin E. Matzner, Cairo, Egypt; and S. E. Rodriquez-Gelpi, San Juan, Puerto Rico.

FOOTBALL 1947

STARTING EARLY, with a September game scheduled against California Polytechnic at San Luis Obispo, the Beavers are expecting results from the foundation laid last year. Included in the 1947 squad are 16 lettermen, eight of whom were in the 1946 starting lineup and three others who were regulars on the 1945 team but were not in school last year.

Coach Mason Anderson, in his second year at the Institute, will be assisted by Pete Mehringer, who will coach the line, also for the second time.

All schools in the Southern California Conference report a large turnout this year, with more returning lettermen than usual. To discount universal high hopes for a successful season, Redlands, the 1946 champion, and Whittier, the runner-up, appear to be every bit as strong as last year. Pomona and Occidental also expect big things from their 1947 teams.

October 24	**Occidental**	**at Rose Bowl**
November 1	**Pomona**	**at Rose Bowl**
November 15	***Redlands**	**at Redlands**
November 22	**Pepperdine**	**at Inglewood**

*** This game will start at 2 p.m. All other games will start at 8 p.m.**

SAN DIEGO MAN ADDED TO COACHING STAFF

TO PROVIDE additional coaching personnel, the Institute has appointed Edward T. Preisler as freshman coach in football and basketball and varsity coach in baseball. Preisler, who graduated from San Diego State in 1941, was an outstanding athlete at the Aztec school, having made letters three years each in football, basketball and baseball.

Preisler comes to CalTech from Colton, where he coached junior varsity sports. After his graduation in 1941 he coached and taught at Carlsbad Union High School, leaving there to enter the Navy in 1943. While in the Navy as a gunnery officer in the armed guard he helped organize various leagues and tournaments while ashore in Nova Scotia, France and Italy. He also played on and helped manage the Navy Separation Center baseball and basketball teams at Terminal Island.

In his first assignment, Preisler started freshman football practice on September 29, the first day of school. With an enrollment of 175 in the freshman class, the football material follows the normal CalTech pattern. Only 25 men have had any high school football experience, and perhaps only one-third of these have played on a major high school team. However, frosh material in basketball appears more experienced.

Only four games are included on the 1947 freshman schedule. The opening game with Whittier frosh was played at Tournament Park October 18. Remaining games: Occidental, on October 24; Pomona, November 1; and Pepperdine, November 22; will be played as preliminaries to the varsity games with those schools.

Coach Preisler will be assisted by Neville Long, graduate student, who played on the 1945 and 1946 teams.

TECH MEN FIGURE IN YALE'S SHEFFIELD CENTENNIAL

CHAIRMEN OF Biology and Chemistry Divisions, George Beadle and Linus Pauling, gave two of four Silliman Lectures at the October Centennial Celebration of Yale University's Sheffield Scientific School. Dr. Beadle spoke on "Genes and Biological Enigmas," and Dr. Pauling discussed "Chemical Achievement and Hope for the Future."

Following the Silliman Lectures, Yale University conferred honorary Sc.D. degrees upon Drs. Beadle and Pauling.

Before returning to the Tech campus, Dr. Beadle met with the Atomic Energy Advisory Committee, of which he is a member, in Washington, D. C.

LARGEST PEACETIME FACULTY

THE CALIFORNIA Institute has the largest peacetime faculty in its history this year, following the announcement of 75 new appointments for 1947-48. Appointments range from full professors to research fellows, and have been made in every department of the Institute. Among new professors are such outstanding men in their fields as Dr. H. P. Robertson, theoretical physics, who came here from Princeton; Dr. J. G. Kirkwood, theoretical chemistry, from Cornell University; Dr. Max Delbrück, biology, from Vanderbilt University; Dr. Hunter Mead, philosophy, from San Diego State College; and Dr. R. P. Sharp, geology, from the University of Minnesota; as well as many others who will greatly strengthen Tech's teaching and research staffs.

FELLOWSHIP WINNER PICKS CALTECH

DR. JOSEPH LEIN, Hill zoology instructor at Syracuse University, New York, has been appointed to one of the fellowships established this year for the first time, by Merck and Co., Rahway, N. J., manufacturing chemists. It was awarded by the National Research Council in Washington. Dr. Lein, who received his doctor's degree at Princeton, has elected to work on a research project on the relation of enzyme systems to the biochemical aspects of evolution, at the California Institute.

ALUMNI NEWS

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The San Francisco Chapter meets weekly for lunch at the Fraternity Club, 345 Bush Street, on Mondays.

RICHARD W. SHOEMAKER '03 CONSULTING IN TWO FIELDS

RICHARD W. SHOEMAKER '03 has recently established an office in Oakland for the purpose of doing consulting work in the fields of radiant heating and electrical engineering. Mr. Shoemaker has been consulting engineer for Chase Brass & Copper Co., Inc., of Waterbury, Connecticut, and the Kennecott Wire & Cable Co., of Providence, Rhode Island for the past 13 years.

In addition, Mr. Shoemaker has been appointed consulting engineer for the Oakdale Irrigation District in connection with irrigation and power developments on the Stanislaus River, involving the construction of dams and hydroelectric plants approximating 50,000 kw.

While with the Chase Brass & Copper Co., Mr. Shoemaker wrote the "Chase Electrical Handbook" and directed studies on radiant heating which resulted in the publication of the "Chase Radiant Heating Manual."

Prior to his work with the Chase Company, Mr. Shoemaker was engineer for the Turlock and Modesto Irrigation Districts during the building of the Don Pedro Dam, and also acted in a similar capacity for the Merced and Imperial Irrigation Districts in their power developments.

DIRECTORY DELINQUENTS

THE DIRECTORY COMMITTEE acknowledges the cooperative spirit of alumni in filling out and returning forms for the forthcoming Directory. While not all of the information asked for will be used in the Directory, it will be of great service to the Institute and to the Association in any further listings.

However the Alumni Office is still short quite a number of questionnaires. In order that the Directory be published within a reasonable length of time, a deadline of November 15 has been set.

A. F. Dufresne '38, chairman of the Directory Committee, requests that any alumni who have misplaced their Directory Questionnaires send a letter marked "*For Directory*" including name, class, address, degrees, giving dates and schools from which they were received, present occupation, and employer to the Alumni Office. Any other pertinent data concerning recent activities will be helpful for classification.

So many changes, not only of occupation, but also of address took place during the war years that some men are still listed as "lost" with the Alumni Office. Any men having alumni neighbors suspected of being lost to the Office are requested to show them this copy of *Engineering & Science* and ask them to mail Directory Data--including correct mailing address--in at once.

Remember the deadline

November 15

Fill out your questionnaire tonight!

With the Board

SITTING with the Board of Directors around the table in the Athenaeum, discussing the increasingly complex affairs of the alumni group, one is deeply impressed with the amount of business involved in running the Association. A few years ago nine or ten meetings per year lasting two or three hours each sufficed to handle Association affairs, but as the Association has grown its activities have become more complex and more numerous. When Chuck Varney became President in 1945 he stated that the meetings were getting a little long and he would try to shorten them. Al Laws tried again in 1946 and 1947, but he achieved an opposite record; one meeting lasted five hours and finally was adjourned considerably after midnight. Mort Jacobs at his first meeting in 1947 announced that the closing hour henceforth would be 11 p.m., and then that very meeting, expected to last till 9 p.m., ran till nearly midnight. Adjournment then was made possible only by scheduling a special meeting for a few days later.

Newcomers to the Board meetings have been impressed by the willingness of each director to take on a job; to arrange a dinner meeting, to obtain a speaker, to arrange a seminar, to make a study of alumni records. These men obviously are accustomed to getting things done, their information on any subject is comprehensive; by the time a proposition has survived 15 or 20 minutes' discussion the decision made is a sound one. Sometimes it is necessary to obtain further information; in that case a report is made at the following meeting and the decision is usually made at that time.

Take the case of the Alumni Directory: At the August meeting where this was discussed the Directory Chairman, A. F. DuFresne, stated that he was ready to go ahead and asked how much money was to be allocated. It was pointed out that the budget had not yet been approved, so his allocation could not be stated. Alternative plans and recommendations were requested for the September meeting. Then at the September meeting Jim Bradburn, director in charge of the Directory, presented alternatives and cost estimates and asked for information on how many copies would be needed and for concurrence of the Board on a finance plan. This was given and on page 21 you will find an announcement about the Directory.

The final plan to give the Directory to members and to sell it to non-members for $1 per copy was the result of considering aspects of this matter far too numerous to mention here. However, it is interesting to note that the plan adopted represents something of a gamble and that we must sell a goodly number to non-members to finance its publication. If any members would have objected to paying a small price, 25 or 50 cents per copy, they would probably be interested in learning that the smaller risk involved made such a plan so attractive that it was rejected by only a small margin. It was rejected because your Board feels that it has made an implied promise to you to provide a Directory at no cost beyond your dues. And Board members feel that although a risk is involved, we'll be able to sell enough copies to cover expenses.

—H. K. F.

NEWS OF ALUMNI IN JAPAN

DR. ROYAL SORENSEN, in Japan this summer, encountered several Tech alumni. Among them:

Brig. Gen. Ivan Farman '24, in charge of the Tokyo area for the Army's Air Transport Command. His command includes Shanghai, China.

Fred M. Hirano (Morikawa) '25 is engaged in engineering liaison work. He is an electrical engineer with the Japan Electric Generation and Transmission Co., Ltd., Tokyo. During the war he was in charge of a power company in Sendai. Fred was bombed out in Sendai, but his family was situated in a place of safety and his Tokyo home was undamaged. Hirano mentioned shortages of sugar, soap, shoes, salt, and tobacco.

A. Tomizo Suzuki '28 is a civil engineer and liaison officer with Hazama-Gumi and Co., Ltd., constructors, engineers and architects. Tomizo was with the Company during the war. One of the jobs he supervised was the building of bridges in Burma. Tomizo was in charge of a crew of 11, all civilians, all unarmed.

Stranded at war's end, he walked 125 days to the China coast and caught a ship back to Japan. En route the ship hit a mine, but finished its voyage. Tomizo's family was in Hiroshima when that town was bombed in August 1945, but were saved by a hill.

Thomas T. Hiyama '30 is head of the Engineering Department of the Nippon Columbia Co., Ltd., manufacturers of phonograph records, radios, and public address systems. Thomas was in the Indo-Chino area before the war, setting up a factory under license by an English company. On his return home, he found living conditions crowded, as his wife and four children were sharing their house with another family.

ED THAYER '25 PROMINENT IN NEW YORK ADVERTISING WORLD

EDWIN F. Thayer '25 has drifted quite a distance from his engineering background. Now president and publisher of **Tide,** weekly news magazine of the advertising, merchandising and public relations. Thayer has been identified with this field for the past 21 years.

After graduating with a degree in engineering and economics, Thayer became assistant editor of **Electric Railway Journal,** a McGraw-Hill publication. Then followed several years as advertising manager of the Mitten Management properties in Philadelphia, after which he became assistant to the president of the St. Louis Public Service Company, in charge of public and industrial relations.

In 1934 he re-entered publishing activity as western manager for Retail Ledger Publications, making his headquarters in Cleveland. He joined **Advertising Age** and **Industrial Marketing** in 1937, shortly becoming eastern manager for this group of publications. He became publisher of **Tide** in July of 1943.

Thayer, married to former Pasadenan Miss Ruth Hubley, is known as "Mayor Thayer" in New York. Two years ago he was elected a trustee of Ocean Beach, an incorporated village in New York, on Fire Island. This year he was elected mayor. A resort town, Ocean Beach has a population of between 5000 and 6000 in the summer.

PERSONALS

1922

JAY J. De VOE has been appointed chief fire engineer for Founders Fire and Marine Insurance Co. in Los Angeles. Following his graduation from CalTech, De Voe was for many years with the Board of Fire Underwriters of the Pacific and served with the Army Signal Corps during the war as a major.

1924

P. L. MAGILL has been appointed to the staff of the Stanford Research Institute, Stanford University, California, and will direct work in chemistry and chemical engineering. Mr. Magill was formerly with the DuPont Co. at Niagara Falls.

1925

NEAL D. SMITH, who for several years has been city engineer of San Diego, relinquished the duties of that office and became assistant city manager of San Diego.

1926

TED COLEMAN, who has been in Sao Paulo, Brazil since the end of the war is engaged in the distribution of airplanes, representing the Fairchil,d, Luscombe, and Northrop Companies. He is also doing a little general importing.

ROYAL E. FOWLE has been appointed vice-president and manager of the Granite Rock Company in Watsonville, California. Mr. Fowle has been associated with the company for the past 18 years as civil engineer and manager of the Logan, California Quarry Plant.

1927

VAINO A. HOOVER is president of the Hoover Electric Co., Los Angeles, which has commenced manufacture of electric motors and transmission units. Hoover is a three-degree Tech man, having remained with the Electrical Engineering Department through an M.S. in 1928 to the Ph.D. in 1931.

1929

WALTER B. GRIMES is back with the U. S. Engineers as assistant chief of Construction Division. He has been hoping to get a few dams to build, but as yet the construction is mostly war conversions and completing permanent posts.

FIRTH PIERCE is now head of the Instrumentation Section, Underwater Ordnance Division, NOTS, in Pasadena. This summer will complete his sixth year in naval research. Mr. Pierce and his wife have a three year old adopted daughter.

1930

R. I. STIRTON, who has been assisant manager of research, Union Oil Co., Wilmington, Calif., is to become manager of Product Development, Oronite Chemical Company, San Francisco.

1931

JOHN E. GIRARD was married to Miss Lorraine Lucille Arata of St. Louis, Mo. in May. Girard served two and a half years in the navy during the war. He and his bride will live in Los Angeles.

EDWARD S. PEER has recently accepted advancement from his position in the Fundamental Group of The Filtrol Corporation Research Department into the Patent Department. The new position, which demonstrates increasing opportunities within progressive industrial research organizations, entails liaison between the Patent and Research Departments as well as patent work.

HARLAN B. ROBINSON, formerly with A. M. Clifford and Associates, has announced the opening of his own investment counselor service in Pasadena.

1932

ROBERT V. CAREY has taken a position with the Eng-Skell Company of Los Angeles doing design and sales of food-handling machinery and store equipment.

EDWARD P. KEACHIE is now lecturer in Industrial Management at the UCLA College of Business Administration.

1933

PAUL F. HAWLEY has returned to the Stanolind Oil and Gas Company, for whom he formerly worked, as patent supervisor, in charge of the Patent Division of the Research Department of the Company.

J. G. PLEASANTS, formerly manager of technical divisions with Proctor and Gamble Co., Cincinnati, Ohio, is now director of manufacture in charge of all manufacturing and technical activities of P. and G. Dr. Pleasants came to the company in 1933, and has served in the manufacturing end of the business as superintendent at the Port Ivory, N. Y. and Baltimore plants, also as Western Division manufacturing superintendent.

1934

HENRY A. BELLIS, production manager of the Philippine American Drug Co., recently resumed contact with the Association. During the war Bellis was in a concentration camp in the Philippines. He, his wife and three daughters are now living in the Islands.

VERNON NEWTON has accepted a position with General Petroleum in Commercial and Marine Sales Training Division.

1935

GUSTAV EHURENBERG with a partner, has formed a business named Plastic Classics Co. The business is display advertising of metals and plastics, and is located in Charleston, West Vo.

ROBERT S. STANLEY, Bell Aircraft Corporation's chief test pilot, was made vice-president of engineering. With Bell seven years, Mr. Stanley was formerly a Naval aviator. Soon after he joined the Bell organization he was made chief test pilot and in 1944 was named chief engineer.

1937

BRIG. GEN. MILTON W. ARNOLD was recently appointed vice-president of the Air Transport Association in Washington, D. C. General Arnold was wartime assistant chief of staff of the Army Air Transport Command and also commanded a combat wing of the Eighth Air Force in England. He arranged the late President Roosevelt's flight to the Casablanca Conference.

RALPH S. BENTON JR. has a position with Ingersoll Rand Sales, over which he is quite enthusiastic. Benton expects to leave soon for India and will be gone for three years.

1938

RALPH JONES is now in Chicago, Illinois working with Booz, Allen and Hamilton, Management Engineers. Last July he married Miss Edith Malone.

LUPTON A. WILKINSON has been selected by the Stanford Research Institute to serve on a small staff of aircraft industry men to investigate for the Army and Navy the potential of the nation's present and future aircraft industry in responding to a national emergency. The Army and Navy wish to determine what preparedness measures would assure necessary immediate productive capacity in the event of a national emergency. When the investigation terminates, Wilkinson expects to return to his position as supervisor in the field of industrial engineering at Lockheed.

1939

ALBERT P. GREEN is now an engineer in the Sound Department of Warner Brothers Pictures, Inc. in Burbank, Calif.

1940

ROBERT ALCOCK is a proud father of an 8 lb. 1 oz. boy, born in June. Bob's son is named Richard Aguirre.

THEODORE B. SMITH was married to Miss Jean Key Dewey of Pasadena in August. Ted is an instructor in the Meteorology Department at Tech.

HERBERT C. SUMNER was married to Miss Jewel Ahonen in August, in Detroit, Michigan. Herb is working for the Ethyl Corporation.

1941

JAMES T. HARLAN is now research engineer with Shell Development Co., in San Francisco. He has found a number of Tech men in the organization. His family now consists of wife Barbara, two-year old daughter Patricia, and three-months old son, David.

RAY KIDDER, Navy veteran, was married to Miss Marcia Sprague of Shippan Point, Conn. in June.

1942

ALFRED LANDAU married Miss Ruth Anne Burdick of Los Angeles in August.

1943

GLENN R. BRACKEN is studying for a Masters Degree in Business Administration at the Harvard Business School. During the summer months Glenn toured Europe as foreign representative for a Connecticut concern engaged in the production and distribution of a newly developed lathe tool. His trip was planned to establish foreign channels of distribution for the product.

W. E. COLBURN is now employed at C. F. Braun Co., in Alhambra.

EVERETTE C. NEWTON has been commissioned a first lieutenant in the Regular Army and is stationed at Tinker Field, near Midwest City, Okla.

1944

ALAN ANDREW, teaching assistant and former research staff member of the Institute's rocket project, has been named assistant professor of physics at Pomona College for the coming year. Since receiving his M.S. degree in physics, Andrew has been working toward his PhD.

JOHN NELSON is now employed by the Standard Oil Co. of Calif., in San Francisco in the General Engineering Dept.

LEROY SANDERS married Miss Marie Dorothy Rice of Aberdeen, Scotland in June. Sanders served overseas as a radar officer during the war.

JOHN ROBERT UKROPINA was married to Miss Maryann Moran last summer.

WILTON E. VANNIER, former V-12 student, is at the University of California Medical School. After his graduation he hopes to take graduate work in Chemistry at the Institute.

1945

ROY G. KILLIAN is an ensign with the Naval Reserve in Miami, Florida.

DONALD McCLOUD LEINWEBER is now employed as a field engineer by the Fluor Corp. Ltd., engineers and constructors of all types of oil refinery equipment. During the war Leinweber was an ensign in the Naval Reserve, his duties including a tour with Weather Reconnaissance Squadron One (VPW-1) during which time he was an aerological observer on flights into Pacific typhoons. He also participated in Operation Crossroads, the atomic bomb test at Bikini Atoll in July 1946.

DONALD C. TILLMAN and wife are proud parents of Donald Calvin, born June 26 weighing 7 lbs 13½ oz.

ERNEST B. WRIGHT, Ph.D., instructor in physiology at the School of Medicine and Dentistry of the University of Rochester, reports that he is at present working on the effects of certain drugs on neuromuscular and synaptic transmission. Recently he has been instructing in the laboratory as part of the physiology course for the medical students, his job being primarily to demonstrate to and teach the students about excitability, conduction, and bio-electrical phenomena. The students in his class, almost all veterens—average age 27—are the most attentive, studious group he has ever seen. Dr. Wright and his wife, the former Elizabeth Whiting whom he married in 1939, have two daughters, Elizabeth Carolyn, six, and Charlotte Garrigne, one.

1946

JOHN H. BARBER, who attended Tech off and on for seven years, was a member of the Foreign Service Review Course, conducted last summer at the George Washington University in Washington, D. C., for persons planning to take the State Department examination for the U. S. Foreign Service. Barber was a biology undergraduate here from 1937 to 1939, transferring to Stanford where he received his B.A. degree. In 1942 he was back at Tech where he received a certificate in meteorology for an Army training course. In 1946 he completed work for the M.S. in meteorology, and then returned to Stanford for another year of graduate work.

STUART BATES was married to Miss Audrey Jones of Altadena, in August. Mr. and Mrs. Bates are students at Redlands University.

DOUGLAS ELLIS has been appointed a teaching fellow at Northwestern University, beginning in September. In addition to teaching courses in general and experimental psychology at Northwestern, Ellis will work toward his doctor's degree.

FREDERICK C. ESSIG has a new son, Frederick Burt, born on August 25.

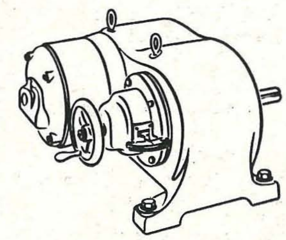
NORMAN R. GREVE married Miss Lola A. Schwartz of Long Beach last January. Norm is employed by Stiles Clements, Architects and Engineers of Los Angeles as a structural designer.

FRANK LANNI is working with Dr. Campbell of the Division of Biology at CalTech as a National Institute of Health Research Fellow. They have completed a chapter on "The Chemistry of Antibodies" for a new book which is being edited by Professor D. M. Greenberg at Berkeley. Dr. Lanni has been spending his time studying serological precipitation and the nature of antibodies. He is using the electron microscope as an aid to the first problem. Frank and his wife, Bruna, have two children, Melissa, five, and Eugene, two.

DAVID B. SHELDON is attending Harvard Medical School. He reports that his children, Spencer, born this February, and his fifteen-month-old daughter, Anne, together with the Medical School, comprise his interests. He was married to Dorothy Anne Hamilton while he was serving in the Army Air Corps.

1947

GEORGE D. SHIPWAY has a daughter, born in July in Pasadena.



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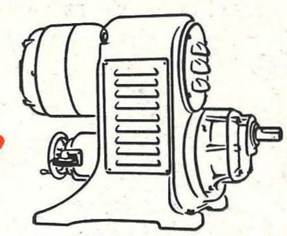

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