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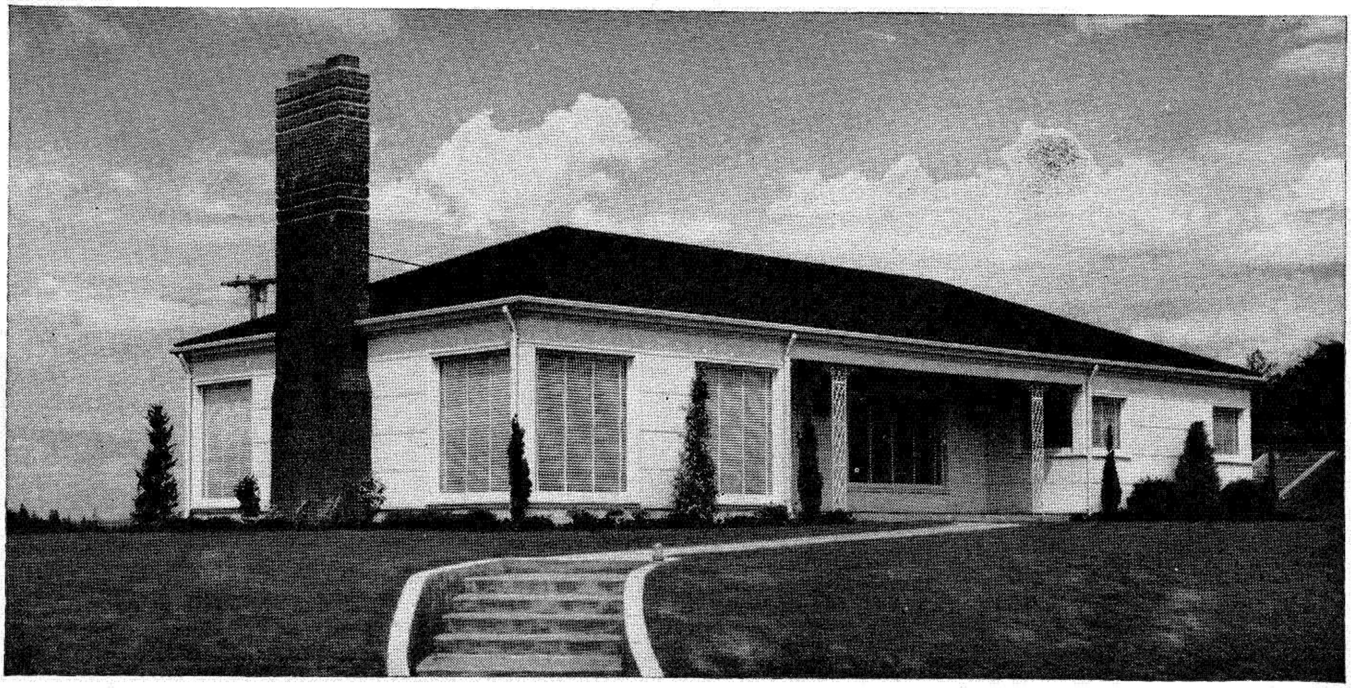

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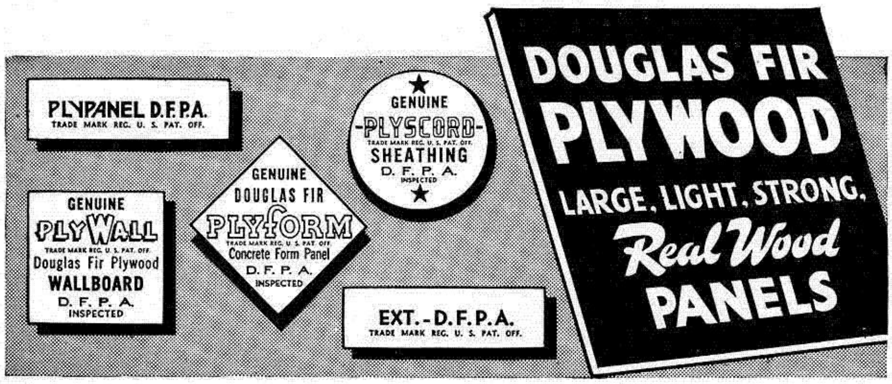

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BY-LINES

WILLIAM V. HOUSTON

Dr. William V. Houston has recently been appointed president of Rice Institute at Houston, Texas. He succeeds Dr. Edgar Odell Lovett, president of Rice Institute since its organization in 1908. Dr. Lovett will continue to serve as president emeritus. Dr. Houston has been on the faculty of California Institute of Technology since 1925, where his work in the field of physics is recognized nationally. At present he is professor of physics, and chairman of the Department of Physics, Mathematics and Electrical Engineering at C.I.T.

• • •

CLARK GOODMAN

Dr. Goodman received his B.S. degree in chemical engineering from the California Institute of Technology in 1932 and a Ph.D in physics at Massachusetts Institute of Technology in 1940. He became associated with Union Oil Company as research chemist in 1932, and in 1933 was employed by Kelco Company as sales engineer. Since 1934, Dr. Goodman has been on the faculty of Massachusetts Institute of Technology and now holds the position of assistant professor in the physics department.

• • •

STANLEY E. SOHLER

Mr. Sohler received his B.S. degree in mechanical engineering from California Institute of Technology in 1941. After graduation he was employed by North American Aviation, Inc., as scheduler, in 1943 being appointed head of manufacturing coordination department. In November, 1945, he became associated with Menasco Manufacturing Company as production control manager.

Caption for Cover Illustration:

Huge ladles in the Westinghouse Trafford foundry pouring the 167,000 pound base for a land station turbine being built at the Company's Steam Division.

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ENGINEERING AND SCIENCE

Monthly

The Truth Shall Make You Free

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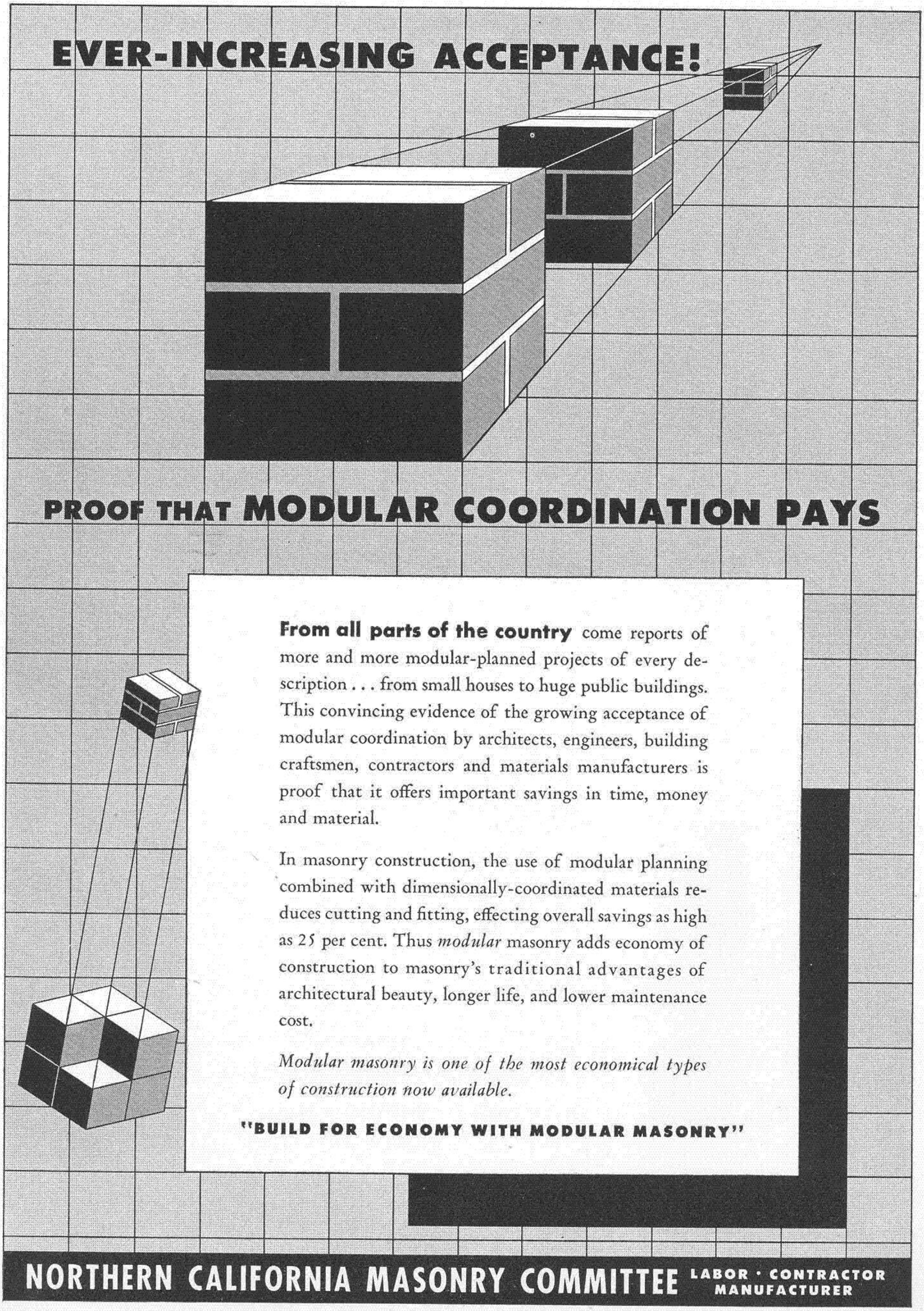
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From all parts of the country come reports of more and more modular-planned projects of every description . . . from small houses to huge public buildings. This convincing evidence of the growing acceptance of modular coordination by architects, engineers, building craftsmen, contractors and materials manufacturers is proof that it offers important savings in time, money and material.
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ENGINEERING AND SCIENCE
Monthly

Vol. IX, No. 1 January, 1946

Trends of Research in Physics

By W. V. HOUSTON

PHYSICS is a very broad subject. It includes the basic knowledge and techniques of practically all branches of engineering and technology, and, in the minds of many people, includes the whole of these subjects. Nevertheless, the *actively* pursued lines of research in physics cover only a small part of this field and change from time to time. In a sense, this is because physicists share with other people the desire to be in style, the desire to be doing something that other people think is of importance and about which they can talk. In another sense, however, this change of emphasis in research stems directly from the fact that progress is being made, that some subjects are becoming well understood, and that it is necessary to look in other directions for new worlds to conquer.

HISTORICAL CHANGES

It is interesting to note some of the historical changes during the past 100 years. At about the middle of the 19th century a great deal of attention was directed to thermodynamics. The law of the conservation of energy and the laws concerning entropy were formulated and checked experimentally by various outstanding physicists as well as by many others whose names are less well known to us. After this first rapid development in the field, there remained a great deal of detailed work, but most of the underlying developments came during a rather short time.

At a slightly later period in the 19th century, possibly from about 1865 to the end of the century, a good deal of attention was directed to electromagnetic phenomena. It was during this period that Maxwell formulated his electromagnetic equations and that Hertz established experimentally the existence of electromagnetic radiation. Out of this has grown all of the tremendous electrical and communications industry, but it is not now a major field of research in physics. Activity along these lines at the present time is usually called engineering, and consists in the applications of Maxwell's equations to various specific situations.

With the beginning of the 20th century, physicists began to turn their attention towards the atomic and electronic constitution of matter. There grew out of this the establishment of the existence of electrons and the measurement of their properties. During the first 15 years of the 20th century this was regarded as an important field for research in physics, but as it became applied to more and more practical uses it became a branch of engineering almost of its own, and during the last few years the term "electronics" has become familiar to almost every person.

The discovery of X-rays and the discovery of radioactivity stimulated research in these directions at about the same time. X-rays have now become a tool in many branches of engineering and of medicine, but the X-rays themselves are rarely a direct object of research in physics.

Starting about 1910, however, attention became directed to the properties of the atoms, and using X-rays spectroscopic and electronic techniques, and every other available tool, scientists fell avidly on the problem of analyzing and understanding the properties of the atoms. In this connection, there developed the quantum mechanics, but since about 1930 it has been felt that problems associated with the external structure of atoms are essentially solved. Out of this has grown again a great many engineering and industrial applications. In particular, the study of spectroscopy, which was originally one of the more esoteric branches of physics, has become a standard means of quality control in many factories.

PRESENT FIELD

At the present time, there are roughly two kinds of things that physicists attempt to do.

On the one hand, there still remains a great deal to be done in understanding the way in which the atoms build up solid pieces of matter. The difficulty seems to be largely a matter of complication. It is believed that if one had the proper mathematical techniques, the properties of solid matter could be described accurately and quantitatively in terms of the properties of the individual atoms. Nevertheless, this has not been conclusively demonstrated, and even if it were true, there still remains the problem of finding the proper techniques.

In one sense, this study of the properties of matter is regarded by many physicists as uninteresting; it is a kind of mopping-up process after the major advances

(Continued on Page 16)

PETROLEUM vs. PLUTONIUM*

By CLARK GOODMAN

INTRODUCTION

THE familiar saying "a little knowledge is a dangerous thing" is particularly apropos in the case of atomic energy. Following President Truman's announcement of the bombing of Hiroshima on August 6, 1945, the air was filled with radio reports. Virtually every newspaper and magazine in the country followed with feature articles on atomic power. These are continuing and, in addition, we are being exposed to a plague of books on the subject. In the sweep of publicity, the facts have often been ignored or hidden beneath a flood of over-enthusiastic extrapolation and speculation.

It seems particularly timely that an accurate evaluation be made of the present and future competition to petroleum of this new source of energy.

FUNDAMENTAL PRINCIPLES

The study of atomic energy constitutes part of the general field of nuclear physics. The first step in the understanding of atomic energy is a definition of the specialized words and symbols used.

Fig. 1 is only one of the various possible systematic arrangements of the elements that occur in nature, or have recently been produced. The elements are arranged in order of increasing atomic number, indicated by the figure immediately below the symbol of each element. Nuclear physicists think of the atomic number Z as the number of positively charged particles, called protons, contained in the core or nucleas of an atom of a given element.

A second important number in the periodic table is the atomic weight, listed just above the chemical symbol. The symbol A will be used for atomic weight. On this scale the lightest and simplest of elements, hydrogen, has an atomic weight of 1.0080. As $Z = 1$, hydrogen must contain only one proton in its nucleus. The single electron that swirls about this nucleus has a weight of only about 0.0005 units. Thus hydrogen nuclei are the charged particles, protons, that constitute building blocks in all nuclei, and the relative weight of each of these elementary particles before incorporation in such nuclei is 1.0075, *i.e.*, slightly greater than 1.

*Abstract of paper presented at General Session of the American Petroleum Institute, Chicago, Illinois, November 15, 1945.

0	I	II
1.0087 n neutron 0	1.0080 H 1	4.003 He 2

0	I	II	III	IV	V	VI	VII	VIII
4.003 He 2	6.940 Li 3	9.02 Be 4	10.82 B 5	12.010 C 6	14.008 N 7	16.000 O 8	19.00 F 9	20.183 Ne 10
20.183 Ne 10	22.997 Na 11	24.32 Mg 12	26.97 Al 13	28.06 Si 14	30.98 P 15	32.06 S 16	35.457 Cl 17	39.944 A 18

0	I a	II a	III a	IV a	V a	VI a	VII a	VIII a			I b	II b	III b	IV b	V b	VI b	VII b	VIII b
39.944 A 18	39.096 K 19	40.08 Ca 20	45.10 Sc 21	47.90 Ti 22	50.95 V 23	52.01 Cr 24	54.93 Mn 25	55.85 Fe 26	58.94 Co 27	58.69 Ni 28	63.57 Cu 29	65.38 Zn 30	69.72 Ga 31	72.60 Ge 32	74.91 As 33	78.96 Se 34	79.916 Br 35	83.7 Kr 36
83.7 Kr 36	85.48 Rb 37	87.63 Sr 38	88.92 Y 39	91.22 Zr 40	92.91 Cb 41	95.95 Mo 42	43	101.7 Ru 44	102.91 Rh 45	106.7 Pd 46	107.88 Ag 47	112.41 Cd 48	114.76 In 49	118.70 Sn 50	121.76 Sb 51	127.61 Te 52	126.92 I 53	131.3 Xe 54
131.3 Xe 54	132.91 Cs 55	137.36 Ba 56	138.9 * La 57	178.6 Hf 72	180.88 Ta 73	183.92 W 74	186.31 Re 75	190.2 Os 76	193.1 Ir 77	195.23 Pt 78	197.2 Au 79	200.6 Hg 80	204.39 Tl 81	207.21 Pb 82	209.0 Bi 83	(210) Po 84	85	222 Rn 86
222 Rn 86	87	226.05 Ra 88	(227) Ac 89	232.12 Th 90	231 Pa 91	238.07 U 92	(239) Np 93	(239) Pu 94										
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

140.13 Ce 58	140.92 Pr 59	144.27 Nd 60	Il 61	150.43 Sm 62	152.0 Eu 63	156.9 Gd 64	159.2 Tb 65	162.46 Dy 66	164.94 Ho 67	167.2 Er 68	169.4 Tm 69	173.04 Yb 70	174.99 Lu 71	*Rare Earth Elements

1945

Fig. 1

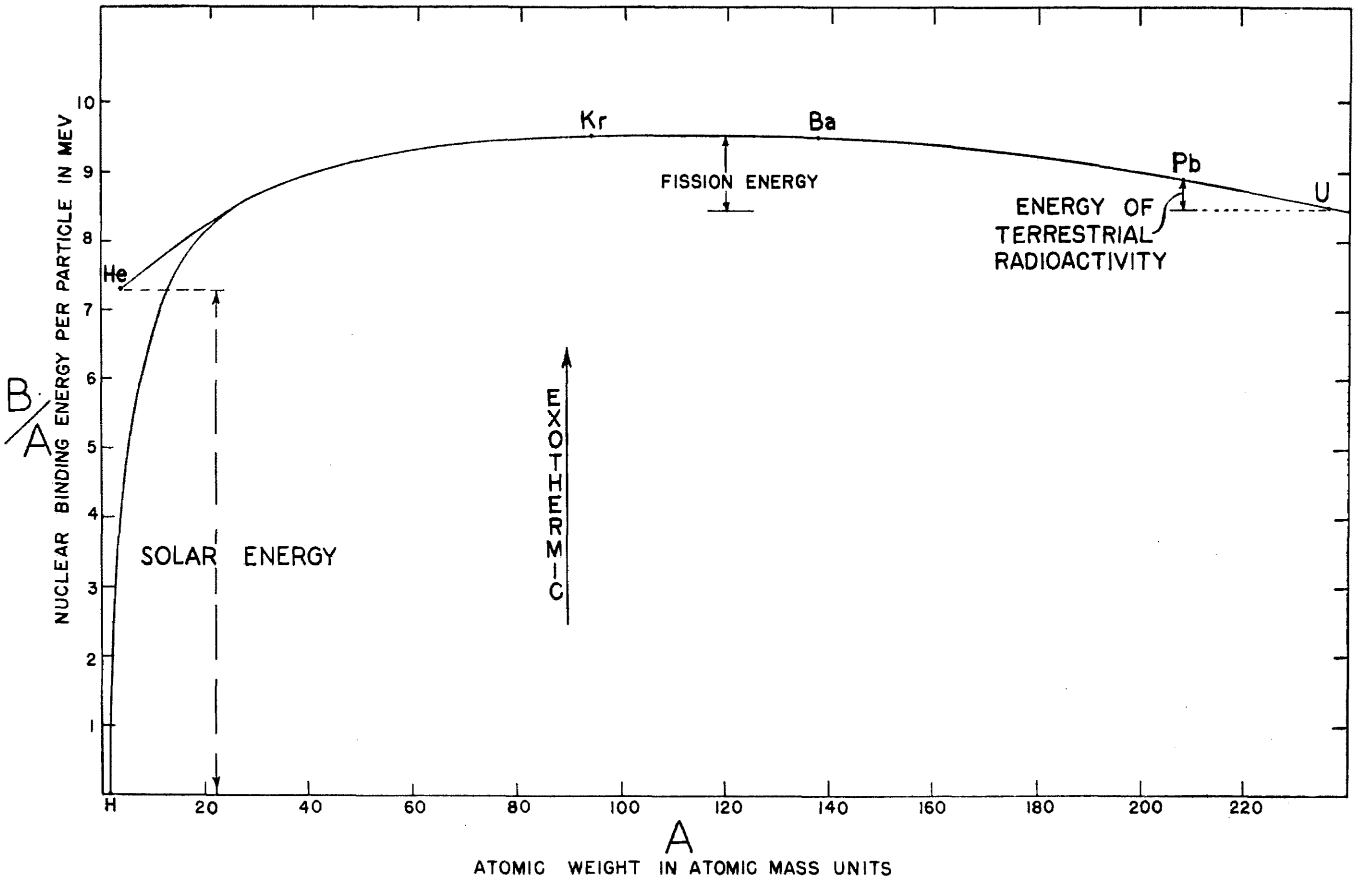


Fig. 2

The interlocking particles that bind the protons together, and prevent their flying apart by electrostatic repulsion, are electrically neutral, and for this reason are called neutrons. They have an atomic number zero and, relative to oxygen, a weight of 1.0087. All nuclei are considered to be made up of neutrons and protons only. However, for a given element, *i.e.*, a given *Z*, the number of neutrons present may vary somewhat. This variation, of course, results in different weights for the individual atoms of the element, even though they all have the same number of protons. The name "isotope" is given to such modifications of the same element. Even hydrogen is not simple. Common hydrogen, referred to above, has a single proton in its nucleus, but there is a rare form of hydrogen that has both a proton and a neutron in its nucleus. For obvious reasons, this is called heavy hydrogen (or deuterium), and water containing an unusually high proportion of this hydrogen is called heavy water. As we shall have occasion to note later, uranium consists of three isotopes, a common form with 92 protons and 146 neutrons known as

$$U^{238}$$

a rare variety with 92 protons and 143 neutrons known as

$$U^{235},$$

and a very rare form with 92 protons and 142 neutrons known alternately as

$$U^{234}$$

or UII. Naturally, with so many different isotopes present in various abundances, the average weight of a given element would not be expected to be a simple multiple of the weights of the constituent particles, the proton and the neutron. However, there is an additional explanation for the observed values of the atomic weights. *The weight of an aggregation of neutrons and protons is always less than the sum of the weights of the separate particles.* For example, the weight of two protons and two neutrons is $2 \times 1.0075 + 2 \times 1.0087 = 4.0324$, whereas the weight of helium (less two electrons) is seen from *Fig. 1* to be 4.0029. This decrease of about 0.03 weight units takes place when the four constitutent particles coalesce to form the helium nucleus. The nuclear reaction that expresses this fact can be written symbolically as:

$$2\,{}_1H^{1.0075} + 2\,{}_0n^{1.0087} \longrightarrow {}_2He^{4.0029} + 0.03 \text{ atomic-weight unit} \qquad (1)$$

Two fundamental axioms in physics require that the sum of the subscripts (charges) on the left must equal the sum on the right, and the sum of the weights on the left must equal the sum on the right. The coefficients in front of the symbols must, of course, be included in these considerations. In the foregoing equation, "0.03 atomic-weight unit" must appear on the right to balance the weight on the left.

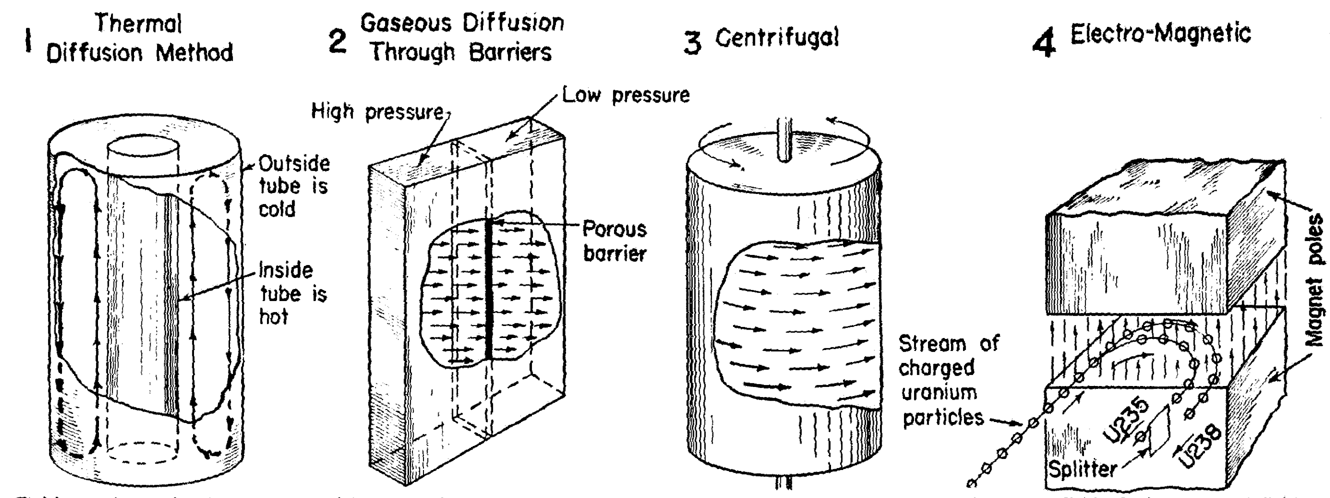
THE SOURCES OF ATOMIC ENERGY

Einstein postulated, and ample experimental evidence has since proved, that weight (or, more exactly, mass) and energy are equivalent and related by the simple expression:

$$\textit{Energy} = \textit{constant} \times \textit{mass} \qquad (2)$$

The proportionality constant in this relationship is so large that the production of a pound of helium from hydrogen + neutrons would liberate 29×10^{10} B.t.u. of heat energy. Alternately it would require the expenditure of this prodigious amount of energy to break one pound of helium into hydrogen and neutrons; *i.e.*, the helium nuclei are bound together with this amount of energy.

The formation of helium from elementary particles



Fluid uranium circulates, tends to concentrate lighter U235 at top.

Lighter U235 gas passes more readily through barrier.

When mixture of gasified U235 and U238 is spun rapidly, lighter U235 tends toward center

In strong field of giant magnet lighter U235 particles are deflected more than U238. Half way round, splitter separates two streams.

Fig. 3

symbolized above does not take place on the earth, because it requires very high temperatures. However, this reaction is believed to account for the tremendous thermal productivity of the sun, and takes place in six steps involving carbon and nitrogen as nuclear catalysts. A graphical representation of the relative binding energies of all known nuclei is given in *Fig. 2.* The binding energy per nuclear particle B/A is plotted against the atomic weight A for all known nuclei from hydrogen, $A = 1$, to heavy nuclei of $A = 240$. As we have already seen, the binding energy of helium nuclei is much greater than that of hydrogen nuclei and neutrons separately. Hence the B/A for helium lies well above that of hydrogen. The significance of the curve now becomes evident. Transformations which result in changes from a lower portion of the curve to an upper portion are exothermic, and vice versa. However, there is one important difference between the changes at low values of A as compared to those at high values. Certain heavy nuclei can be made to split into two or more fragments of medium atomic weight A at ordinary temperatures (0-200° C.). This process is known as nuclear fission, and the energy released by such a change has been designated as the fission energy in *Fig. 2.* Pound for pound, or on the basis of the number of nuclear particles involved, the fission of heavy nuclei generates about one-seventh as much energy as the formation of helium from hydrogen in the sun. It is small wonder that this process constitutes a potent source of energy.

Apparently, there is a minimal change in binding energy below which fission does not occur. Although nearly all of the heavy elements have been tested, fission apparently is appreciable only in those elements above about 210 in atomic weight. Of these elements, only uranium and thorium occur in appreciable quantities in terrestrial materials. Their presence indicates that uranium and thorium must be relatively stable, otherwise they would have long since disappeared during the two to four billion years since this planet was formed.

RADIOACTIVITY

Uranium and thorium are not completely stable, but undergo spontaneous transformations that result in elements of lower atomic weights. Radioactivity is the term used to describe these changes. In *Fig. 2* the small shift from $A = 238$ to $A = 206$ for the uranium series, and from $A = 232$ to $A = 208$ for the thorium series, releases sufficient energy to account for all the internal-heat flux of the earth.

The emission of an alpha ray ($2He^4$) by radioactive decay is similar to nuclear fission in that both processes result in the splitting of a nucleus into two parts, forming two new nuclei. However, these related phenomena differ in a number of important respects.

NUCLEAR FISSION

In the first place, radioactive decay is spontaneous, and not susceptible to any control. On the other hand, to produce fissions it is necessary to strike the nucleus with a particle or with radiation. There are a number of such *nuclear detonators*, but neutrons are by far the most effective. The absence of electric charge ($Z = 0$) enables these particles to penetrate easily; whereas protons, deuterons, and alphas—being positively charged—are strongly repelled by the large electrostatic fields of heavy nuclei.

The probability of a neutron-producing fission in a uranium or thorium nucleus is dependent upon a number of factors, not the least in importance being the velocity of the neutron. In fact, the less abundant isotope[1]

$${}_{92}U^{235}$$

is very infrequently split by other than relatively slowly moving neutrons, the probability of fission being inversely proportional to the velocity of the neutrons. On the other hand, *thorium* nuclei

$$({}_{90}Th^{232} \text{ only}) \text{ and } {}_{92}U^{238}$$

nuclei undergo fission under neutron bombardment only when the neutrons have high energies, called "fast neutrons." With slow and intermediate-velocity neutrons the following transformations occur:

$${}_{90}Th^{232} + {}_0n^1 \text{ (slow)} \longrightarrow {}_{90}Th^{233} + \gamma \qquad (3)$$

$${}_{92}U^{238} + {}_0n^1 \text{ (slow and intermediate)} \longrightarrow {}_{92}U^{239} + \gamma \qquad (4)$$

The product nuclei do not undergo fission, but are less stable that the original nuclei, being beta-radioactive with half-lives of 26 minutes and 23 minutes, repectively.

The action of fast neutrons on

$${}_{90}Th^{232} \text{ and } {}_{92}U^{238}$$

and of slow neutrons on

$${}_{92}U^{235},$$

results in fission into two slightly unequal nuclei. The process is highly exothermic and considerably more complex than any of the foregoing reactions. One possible sequence for

$${}_{92}U^{235}$$

will serve to illustrate the nature of the changes involved:

$${}_{92}U^{235} + {}_{0}n^{1}\ (\text{slow}) \longrightarrow {}_{92}U^{236} \longrightarrow {}_{56}Ba + {}_{36}Kr + 2{}_{0}n^{1} + \text{HEAT} \qquad (5)$$

This reaction occurs almost instantaneously and hence is explosive in character. The fission products,

$${}_{56}Ba \text{ and } {}_{36}Kr,$$

fly apart with tremendous velocities. Because these nuclei contain too many neutrons to be stable,[2] several beta-disintegrations and possibly a neutron-decay are necessary before stable nuclei are formed. These secondary changes occur relatively slowly, and are accompanied by the evolution of about one-fourth as much heat as the fission reaction.

[1]Uranium is composed of 0.7 per cent

$${}_{92}U^{235}$$

and 99.3 per cent

$${}_{92}U^{238}$$

PROPERTIES OF PLUTONIUM

In the preceding section it was mentioned that slow- and intermediate-velocity neutrons on

$${}_{92}U^{238}$$

produce a beta-radioactive isotope,

$${}_{92}U^{239}.$$

The decay of this substance results in the formation of a new element of atomic number 93, called neptunium

$$({}_{93}Np^{239}).$$

Neptunium, in turn, emits another beta particle, becoming plutonium[3]

$$({}_{94}Pu^{239}),$$

which emits an alpha particle, thus decaying to

$${}_{92}U^{235}$$

but so slowly that in effect it is a stable element.

Plutonium is fissionable with slow neutrons, and hence

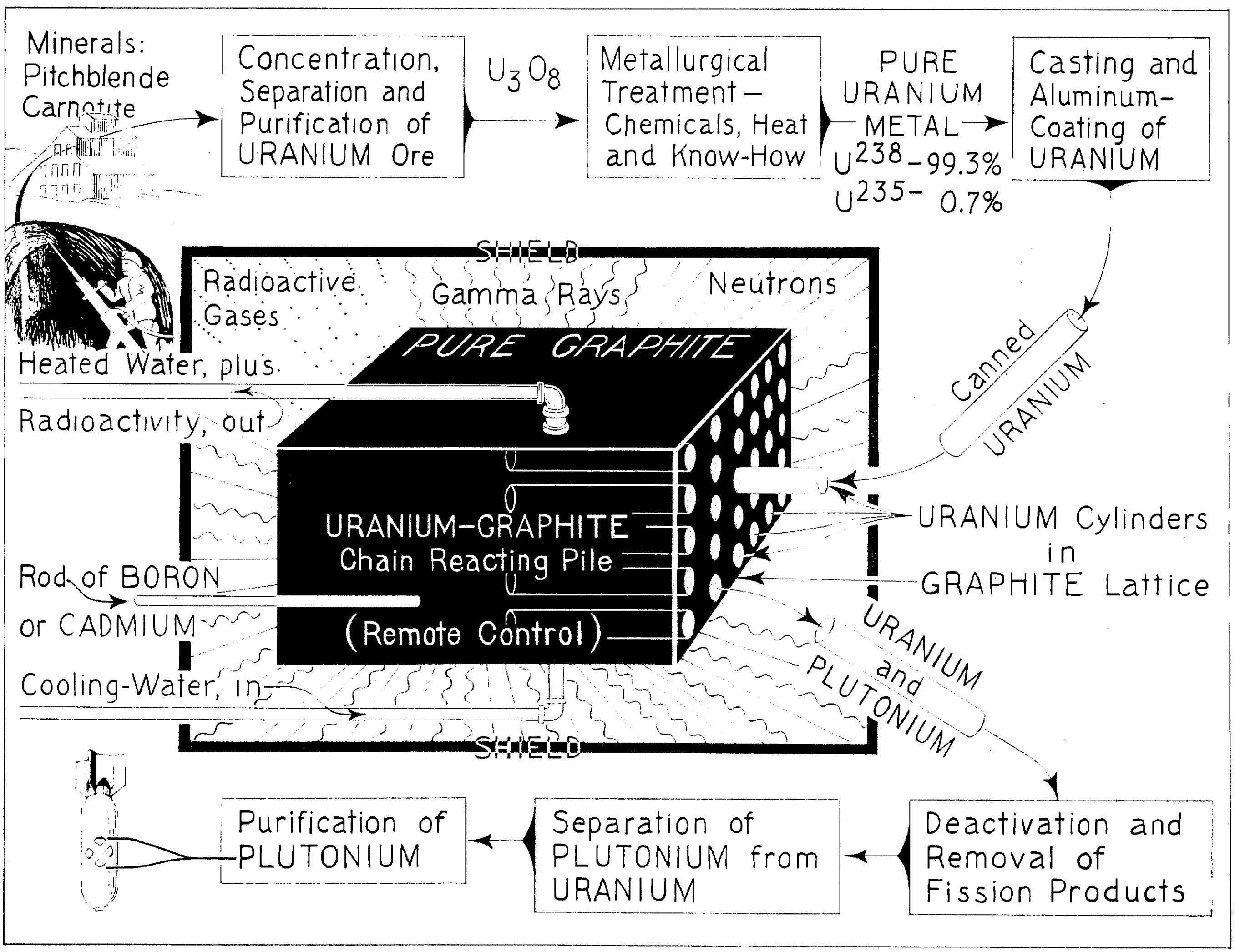


Fig. 4

is equivalent to

$$U^{235}$$

in this regard. However, plutonium is sufficiently different from its progenitor.

$$U^{238}$$

that it can be separated from uranium by chemical methods. The importance of this fact is made clear in a subsequent section.

SOURCES OF NEUTRONS

Thus far nothing has been said concerning the sources of neutrons. These uncharged nuclear particles are produced either by fissions or by the collision of nuclei t high velocities. There is a small neutron component in cosmic radiation, but much greater intensities are produced by bombarding certain light elements (for example, beryllium) with alpha particles, deuterons, or protons. Radon or radium mixed with beryllium provides a compact source of neutrons. It was by means of neutrons from such sources that fission was initially produced and studied. Deuterons or protons accelerated to a high velocity in a cyclotron can produce even more intense sources of neutrons.

However, enormously greater intensities are required to release significant amounts of atomic energy. As indicated in Equation (5), neutrons are released by the fission process itself. Under proper conditions, these secondary neutrons produce further fissions which release more neutrons to produce still more fissions, and so on. If the number of these self-induced fissions exceeds even by a minute amount the number produced by the initial neutrons, this avalanche-like reaction results. The propagation of the reaction is extraordinarily rapid. For this reason, unless carefully controlled, such reactions are violently explosive. The critical condition under which a self-sustained chain reaction occurs constitutes the crux of atomic energy as known today.

CRITICAL SIZE

In the official U. S. government publication, the now famous Smyth report,[4] this condition is summarized as follows: "The question of whether a chain reaction does or does not go depends on the result of a competition among four processes:

"(1) Escape of neutrons.
"(2) Non-fission capture of neutrons.
"(3) Non-fission capture by impurities.
"(4) Fission capture.

If the loss of neutrons by the first three processes is less than the surplus produced by the fourth, the chain reaction occurs; otherwise, it does not."

Two methods can be used to limit the escape of neutrons. The first is to enlarge the amount of active material to the point where the bulk of the neutrons produced is captured within the mass of the fissionable material itself. This procedure establishes a critical size above which the chain reaction takes place.[5] The second method of decreasing the loss of neutrons by escape is the use of a reflector surrounding the material. Heavy elements serve as reflectors of fast neutrons, for the relatively light neutron bounces off a heavy nucleus with very little change in speed. If reflection with a substantial decrease in velocity is desired, light-weight elements, called "moderators," are used.

The loss of neutrons by non-fission capture is equally important in determining the critical size. Certain elements, such as boron and cadmium, are very accessible to neutrons and behave like neutron sponges, because they so readily "soak up" neutrons. Most elements possess this characteristic to a considerably smaller degree. For example, nitrogen, iron, nickel, and vanadium have moderate capture cross-sections; whereas beryllium, magnesium, carbon, aluminum, zinc, tin, bismuth, and lead have very small capture cross-sections for neutrons. In establishing the critical size for the chain reaction, it is necessary that even minute traces of cadmium and boron be eliminated and that only traces of the medium cross-section elements be present. All essential structural materials must contain only elements with small capture cross-sections.

Because uranium and thorium ores are inevitably associated with elements of large or medium cross-section, a self-sustained reaction is impossible, regardless of the size of the ore deposit. In addition, because of the large proportion of

$$U^{238}$$

in ordinary uranium, the non-fission capture of neutrons by

$$U^{238}$$

predominates over the fission capture by

$$U^{238} \text{ and } U^{235},$$

even in a very large mass of this material. Hence, not only are uranium ores stable to fission, but even pure uranium metal does not undergo spontaneous fission in bulk. An important exception to this conclusion is discussed in the following section.

PRODUCTION OF FISSIONABLE MATERIALS

In the foregoing, thorium has been included with uranium as a source material. Because of the susceptibility of

$$U^{235}$$

to slow neutrons and the possibility of producing plutonium from

$$U^{238}$$

the major effort of the Manhattan project centered on the direct or indirect use of uranium. No information has been released concerning chain reactions of thorium. Hence, this element will not be considered further, although thorium certainly constitutes a potential source of atomic energy.

---

[2]The heaviest stable isotopes of these two elements are

$$_{56}Ba^{138} \text{ and } _{36}Kr^{86}.$$

[3]Neptunium (half-life 2.3 days) and plutonium (half-life about 20,000 years) do not occur in nature in any appreciable quantity. They lie beyond uranium in the periodic table (*Fig. 1*) and hence have been named for the planets Neptune and Pluto, which lie beyond the planet Uranus.

[4]H. D. Smyth, *A General Account of the Development of Methods of Using Atomic Energy for Military Purposes under the Auspices of the United States Government 1940-1945*, written at the request of Major General L. R. Groves, U. S. Army. Publication authorized as of August, 1945. Available from Princeton University Press, Princeton, N. J.

[5]The critical sizes for various materials are military secrets. Prior to the war it was estimated that a sphere of

$$U^{235}$$

six inches in diameter might be sufficient to sustain a chain reaction. This amount of

$$U^{235}$$

would weigh about 100 pounds. The Smyth report implies that somewhat less than 100 kilograms is necessary.

A large part of the efforts of the project was devoted to the difficult task of separating the isotopes of uranium.

U^{238} and U^{235}

are essentially identical in chemical properties; hence, they are separable only by processes depending on the small (1.3 per cent) difference in atomic weight.

Four large-scale physical methods have been used to produce

U^{235}

for atomic bombs (see *Fig. 3*). Several other methods offer promise, but have not progressed beyond the laboratory stage.

While these developments in the separation of uranium isotopes were taking place, another compartment of the Manhattan project was studying methods of producing plutonium. A most ingenious process was evolved which not only yields large amounts of this fissionable material, but appears as the most likely industrial source of atomic energy. It is in the production and utilization of plutonium that petroleum may find an atomic competitor.

The major steps involved in the production of plutonium are shown schematically in *Fig. 4*. The crude source material is pitchblende, carnotite, or some other uranium mineral. After mining and milling, the ore is concentrated and treated chemically to obtain the pure oxide, U_3O_8. The next step requires the preparation of essentially spectroscopically pure uranium metal. This very exacting metallurgical work requires considerable know-how, as do all of the other specialized techniques which have been so expeditiously developed under the Manhattan project. The metal, of course, contains the same proportion of isotopes as the original ore: viz., 99.3 per cent

U^{238}

and 0.7 per cent

U^{235}.

It is cast into bars, and is coated with a thin impervious layer of very pure aluminum to protect the uranium from direct contact with the cooling water. This "canned" uranium is then placed in a lattice structure made of highly purified graphite. The size of this so-called pile is very precisely determined. It contains just slightly more uranium than the critical amount required to maintain a chain reaction. A simplified explanation of the operation of the pile is as follows:

> When the pile has been assembled to the proper size, it is triggered by stray neutrons from cosmic radiation. These produce a few fissions of either
>
> U^{235} or U^{238},
>
> depending on whether these initiating neutrons are slow or fast. The secondary neutrons resulting from the fissions are fast and, hence, cannot produce additional fissions in
>
> U^{235}
>
> although they may cause fissions in
>
> U^{238}.
>
> The most probable result, however, is that these secondary neutrons will be slowed down by collisions to intermediate velocities before producing such fissions. Because of the predominance of
>
> U^{238}
>
> most of these neutrons are captured to form
>
> U^{239}.
>
> However, by having pure carbon in the form of graphite alternating with the uranium, many of the secondary neutrons are slowed down to thermal velocities. Because the capture of neutrons by
>
> U^{235}
>
> increases inversely with the velocity of the neutrons, the probability of producing fissions in
>
> U^{235}
>
> is greatly increased by the use of the graphite moderator. In this way a self-sustained chain reaction is produced.

Of course, a large amount of cooling must be provided in order to limit the rise in temperature. Special pipes, made of elements with small capture cross-sections, provide channels for the cooling water. The magnitude of this cooling problem can be appreciated from the fact that an appreciable rise in temperature of the Columbia River takes place when one of the piles is operating at the Hanford plant in Washington. The production of a pound of plutonium per day releases energy in the form of heat at the rate of about 1,000,000 kilowatts.

The pile and its products are intensely radioactive and hence extremely dangerous to personnel. For this reason the operation of the pile and chemical treatment of the uranium, after removal from the pile, must be carried on by remote control within air-tight shields several feet in thickness. Following removal of the fission products, the relatively small amount of plutonium is separated from the bulk of the parent uranium, after which the plutonium is purified. This material is then ready for incorporation in an atomic bomb.

UTILIZATION OF ATOMIC ENERGY

The purpose of the present discussion is to consider the possible effects of atomic energy on the petroleum industry, not on military strategy. The fission reaction releases about 32 billion B.t.u. per pound of

U^{235}

or plutonium, and the radioactive decay of the fission products releases an additional eight billion B.t.u. This energy is more than a million times the heat of combustion of a good grade of coal (14,000 B.t.u. per pound) or of 100-octane gasoline (22,000 B.t.u. per pound). Yet the enormous amount of heat produced in the present piles is wasted. By means of heat exchangers, it probably would be relatively simple to use some of this energy for household or other low-temperature heating. In order to utilize such heat for industrial purposes, it would be necessary to operate the pile at temperatures comparable to those of modern steam power plants. Apparently, the problems involved in this transition are very large.

However, if developments in this field are allowed to flourish unhampered by military restrictions and government controls, it seems probable that these problems can be solved in a reasonably short time, and that atomic energy will be available for industrial purposes within the next decade. The question will then be: Can atomic power compete with petroleum, coal, and water power on an economic basis? Too many unknowns are involved to allow other than speculation, but in all likelihood the answer will not be clearcut.

Inasmuch as coal is generally used as fuel for large installations, it would appear that natural uranium piles may compete with coal, particularly in the generation of electric power. The piles could be located near the populated areas, but sufficiently remote to prevent radiation hazards. The heat released would be used to produce steam to drive turbo-electric generators. This electric power would actually be a by-product from the production of plutonium and radioactive fission materials and the treatment of substances by radiation. Some of the heat from these large piles also might be used to operate thermal or diffusion plants for separating

U^{235}

from uranium.

The natural uranium and graphite piles, which may compete with coal, are far too bulky to be used in units for mobile power. By using uranium that has been enriched in

U^{235}

or to which plutonium has been added, the size of the pile can be considerably reduced. The use of heavy water (deuterium oxide) as a moderator in place of graphite also allows substantial reduction in size.

With the decrease in size of power units, the competition with petroleum would probably begin in replacing fuel oil in large transports and naval vessels. Full speed ahead would be achieved by pulling out the cadmium "throttle." A distinct advantage for naval vessels would be that "refueling" would be infrequent. An additional consideration would be that the atomic fuel is noninflammable. Shielding would be a major problem, and would add considerably to the weight and size of the units. Such applications of atomic energy might be entirely ruled out on this basis alone.

Pure

U^{235}

and plutonium in excess of the critical sizes can be assembled—provided cadmium, boron, or some other neutron absorber is preesnt in sufficient amount to prevent the chain reaction. If the absorber were gradually removed until the critical point is reached, a controlled release of energy from a very compact source might be possible. However, with pure

U^{235}

or plutonium, this procedure would be extremely sensitive—a slight movement of the absorber might result in a violent explosion. For this reason, compact units will probably use a mixture of

U^{235} and U^{238}

containing not more than about 20 per cent of the lighter isotope and some moderator in order to obtain a safe degree of controllability. Even more problems than arise with the larger units must be solved before diminutive atomic engines will be possible. For military purposes such engines might supply the power for guided missiles or robot planes. In order to compete seriously with diesel oil and gasoline, atomic engines must be adaptable to trains, trucks, planes, and automobiles. For these purposes the shielding problem would be most acute. The compactness gained in using atomic fuel might be more than offset by the large amount of shielding required. Of course, all of these considerations have been limited to the source of atomic energy now known; *i.e.*, to nuclear fission of heavy elements. It will be recalled that the consolidation of light elements into medium-weight elements releases comparable amounts of energy. Although such nuclear syntheses have never been accomplished on a large scale, they have been achieved in minute amounts in the laboratory. If future research extends the range of available atomic energy to include the light elements, many of the foregoing limitations may be removed. In addition, these light elements would probably be far more plentiful than the relatively scarce fissionable elements, uranium and thorium.

Within the bounds of available information, it would appear that petroleum and coal will probably continue for at least another generation as the primary sources of energy for transportation and heating. Water power and coal will probably generate most of the electricity during the next fifty years. Although atomic energy may gradually enter as a competitor, its most extensive applications will probably be in new fields of human endeavor. Industrial processes at extremely high temperatures, ultra-high-speed transportation, the production of radioactive materials for industrial and medical purposes, as well as for some scientific investigations, the manufacture of rare elements by transmutation, and the treatment of materials by radiation, are among the more likely specialized uses of fission energy in addition to the continued production of atomic explosives.

For some time the more conservative members of the petroleum industry have been concerned about what the world would use for fuel when the petroleum and coal reserves were exhausted. Prior to 1935 new discoveries more than offset the increased consumption of petroleum. During the past 10 years the discovery rate has rapidly declined while production has soared. Although there will be a postwar respite, this trend is likely to continue for some time. However, the petroleum industry now has somewhat less occasion to regret the expenditure of a large part of the earth's supply of chemical energy. By the time this source is exhausted there should be plenty of atomic energy available.

Although this change seems inevitable, it will certainly not be rapid. Few of us will live to drive atomic automobiles or fly jet planes powered by nuclear energy. When this time arrives, there will still be a petroleum industry, but it may have changed rather remarkably in character. Instead of petroleum being primarily used for fuel, it will be the raw material for all kinds of organic substances. The refinery of the future will be more of a chemical factory than a producer of fuel.

To Establish Firm in Brazil

FOLLOWING his resignation as vice-president and director of Northrop Aircraft, Inc., Theodore C. Coleman of the class of 1926, left with his family in November for Brazil, where he will establish his own company to be devoted to distribution and maintenance of aircraft and other U. S.-manufactured products in South America.

A resident of Pasadena since 1922, when he entered Caltech, Mr. Coleman has been prominent in business and civic affairs in southern California for 20 years. Prior to his joining the Northrop Company shortly after its formation, he was vice-president and partner of the old southern California banking firm of Banks, Huntley & Co.

Mr. Coleman spent two months last summer in South America on a business trip, and heard news of V-J Day by shortwave while in the interior of Brazil. He will live in Sao Paulo with Mrs. Coleman and their two children.

OPERATING CONTROL TECHNIQUES

By S. E. SOHLER

THE meaning of operating controls in the aircraft industry is best expressed by their three basic principles:

1. The operating plan of action must consider all limiting factors and be possible of attainment as a total program as well as for individual projects.
2. The operating plans, including policy instructions where applicable, must be transmitted to concerned personnel throughout the organization in adequate detail.
3. Progress information must be available with sufficient speed, coverage, and competent evaluation to provide a basis for intelligent action at all levels of supervision.

The true test of manufacturing management's ability is the devising and revising of operating control techniques to meet changing conditions effectively and efficiently.

Because of space limitations, no attempt will be made in this article to cover the many phases of operating controls involved in a major aircraft plant. However, two typical control problems encountered at the California Division of North American Aviation, Inc., during the war will be described, along with the operating control techniques which were developed at that time and which have been used to advantage on similar problems since.

The philosophy behind the development of these techniques is expressed by the following motto, which occupies a prominent place in the office of one of the foremost aircraft executives: "It may not always be the best policy to adopt the course that is the best technically, but those responsible for policy can never form right judgment without knowledge of what is right technically."

This type of approach is especially cogent in the aircraft industry, where the complex problems involved, combined with the so-called "human element" in the many people concerned, make complete dependence on theory and statistics impractical, and make operations without them almost an impossibility.

TOOLING

A. Problem

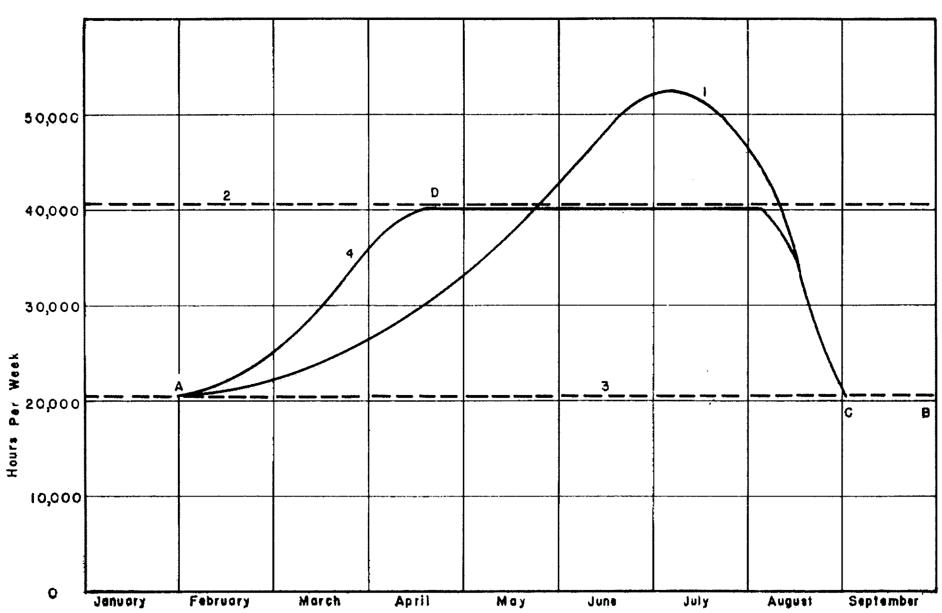
The problem of tool loading was a chronic headache even during the pre-war period, when contracts were small and comparatively little tooling was justified. Whenever the tool shops appeared to be overloaded, the problem was usually overcome during a comparatively short period by working overtime and Saturdays, or even hiring a few additional tool-makers temporarily. However, wartime conditions made some form of control necessary for several reasons:

1. Contracts were much larger and, therefore, much more elaborate tooling was justified. Most of this elaborate tooling had to be completed for the first ship, unless there was adopted the very expensive alternative of building temporary tooling for the first ship and replacing with permanent tooling later.
2. As tooling departments were already working 50 to 60 hours per week and tool-makers were very scarce, any overload condition could not be appreciably alleviated by additional overtime or additional hiring.
3. Many more production workers were dependent upon the tools to be made than ever before, especially because of the inexperience of production department labor available. In view of the labor shortage, idleness of productive labor resulting from lack of tooling could not be tolerated.

An analysis of past experience showed that the tooling shortages usually become critical during the last 30 to 60 days prior to completion of the first ship. The reason for this became apparent when the total of tooling hours required for the basic tooling on the first ship was plotted against a time scale, with the distribution of these hours based on the assumption that all tools were

AT RIGHT:

FIG. I
Tooling load chart.



Part Number	Tool Number	Tool Name	Date Order Issued	Acct.	Shown are total accumulative hours expended 3-1	3-8	3-15	3-22	3-29	4-5	4-12	4-19	4-26	5-3	5-10	Total Hrs. Est.	Adjust Hours Est.
175-24678	87491	MP	2-7	8321	53	75	126	—153	—178							175	200
175-28671-1	88421	ADJ	1-3	8321	30	46C										50	
175-34878	88215	ADJ	1-20	8351	0	10	30	37C								35	
175-58764-1	87465	TWJ	2-10	8321	40	58	80C									85	
175-48226	181681	DP	8-18	8311	6	13	22C									18	
175-24004	181683	DJ	8-20	8311	0	0	0	25	50C							50	
175-24409	182606	DJ	8-22	8311	20	23	23	46	—80							88	
175-22410	182610	DJ	8-23	8311	0	0	25	50	—50							100	
175-22409	182608	DJ	8-22	8311	10	35	65	75	—90							100	
175-24410	182609	DJ	8-23	8311	0	0	0	50	—80							130	
175-21601	183184	DJ	10-8	8321	0	0	0	12	25C							25	
175-23403-3&4	183231	DJ	10-2	8321	15	20	25	50	—50							60	
175-22316-3	181895	DP	8-21	8311	0	0	10	20	30							60	
175-34557-3	183118	D&RJ	10-2	8321	10	20	25	30	40C							40	
175-31813	183156	DJ	10-21	8333	3	6	10	15	20C							20	
175-22505-6	181631	DJ	8-23	8554	0	0	0	0	0							10	
175-22405	181361	DP	8-20	8331	0	0	10	12	14							16	
175-33589	183105	PF	10-1	8321	2	10	12	15	18							23	
175-16106	181632	MF	10-21	8311	0	0	10	20	45							50	
175-56006	182908	DJ	8-31	8311	0	15	35	65	75							75	
175-33589	181633	DJ	8-31	8331	10	15	15	25	30							45	
175-52753	182620	DF	9-26	8331	0	0	0	10	10							30	
175-33104-1-2	183626	ApDJ	10-2	8331	0	0	2	8	10							60	
175-52753	181718	DJ	9-6	8321	0	0	0	0	0							40	
175-52466	181715	DJ	10-2	8321	0	5	5	5	5							30	

Dept. 14 — Group No. 2 Singleton — WEEKLY TOOLING COMPARISON SCHEDULE North American Aviation, Inc. — Contract NA-175 — Note: Heading on vertical column denotes due date of tool.

Fig. 2

to be constructed just in time to meet the true required **completion date** of the tool as needed to support the **"in-work" date** of the part or assembly involved. (See *Fig. 1*, Curve 1.) Curve 2 in the illustration indicates the total anticipated tooling capacity over the period considered. Curve 3 indicates the portion of that capacity already allocated to other projects. In actual practice these two lines would normally vary during such a period, but they have been shown as fixed values for the purpose of simplifying this example. Point *A* indicates the date on which sufficient engineering information was available to enable tooling hours to be started. Point *B* indicates the tentative date set for completion of the airplane, and Point *C* indicates the date by which the basic tooling for the airplanes had to be completed in order to support that completion date. From this graph it was immediately apparent that tooling shortages during the 30 to 60 days prior to airplane completion were inevitable if all tools were started just in time to meet the completion date, as there just wasn't enough capacity available during that period to expend the hours required. The control problem then became one of devising a means of insuring that enough tooling hours were expended early in the project to complete all basic tooling by the required time. The other alternative, increasing and decreasing of the capacity to conform to the load represented by Curve 1, was impossible under conditions of wartime labor shortage.

B. Solution

The first step was to redistribute the total basic tooling hours required over the period between Point *A* and Point *C* in such a way that the load would not exceed the available net capacity. (See *Fig. 1*, Curve 4.) Such a plan required that the expenditure of tooling hours reach a maximum by the date indicated by Point *D*, and a check was made of the engineering release schedule to determine whether or not sufficient engineering information would be available for the tooling departments to support such a plan. If not, the completion date of the airplane was set back, or the tooling policy was revised to call for less permanent tooling for the first ship. This investigation and planning satisfied the principle of making sure that the total plan of action (including all other commitments), as well as the plan for the specific project, was physically possible.

Satisfaction of the second principle of operating controls (transmission of the plan) presented additional problems of technique. Two possibilities were available:

1. Rescheduling of sufficient tools from their true due dates to earlier due dates, such that the distribution of the hours load per schedule corresponded to Curve 4.
2. Leaving the true due date on each tool, and through some other device insuring that the tool departments expended hours on this project in accordance with Curve 4.

The first possibility had several inherent **disadvantages:**

- (a) Giving specific tools due dates appreciably earlier than their true dates tended to lessen the shop's confidence in the dependability of schedule dates, especially if tooling supervision were on occasion chastised for missing due dates on rescheduled tools which it could individually prove weren't really needed for six or eight weeks.
- (b) There was a possibility that the engineering department would not meet its own release dates on those specific parts for which specific tools had been rescheduled earlier.

Therefore, it was decided that the due date to be used on individual tools would in every case be the true due date as actually required by the master schedule for the first ship. In this way, confidence of the individual tool-maker in the schedule was not impaired, and a behind-schedule tool obtained priority treatment for reasons that were provably valid. The plan of action for the project, when issued to tooling supervision, included a curve similar to Curve 4, along with an explanation of the need for the expenditure of hours in accordance with that curve. This device also made unnecessary the risk of out-guessing engineering, as tooling departments merely expended hours on whatever information was available early, so long as the total expenditure conformed to Curve 4.

In addition to the due date on the tool order it was found advisable to prepare a so-called weekly comparison schedule (*Fig. 2*) which kept a summary of current tool orders by due date in front of all levels of supervision, along with the estimated hours required for the construction of the tool, and the actual cumulative hours expended on each tool to date. This type of schedule was for the purpose of satisfying the first and second principles at the same time, with a minimum of clerical effort.

The third principle of operating controls was also satisfied in this case by a weekly comparison between Curve 4 and the actual weekly hours' expenditure during the early phases of the project, along with an analysis of the reasons for any deviation. This was subsequently supported by the weekly comparison schedule noted above, during the latter phases of the project, when individual tools became due.

PLANT CONVERSION

A. Problem

Early in 1944 the Army indicated a desire for increased quantities of P-51's, which were currently in production at the California Division at 10 per day. However, in view of the manpower shortage it was agreed that an increase could be accomplished only by discontinuing the production of B-25's, which were currently running at five per day, but which were also being produced in appreciable quantities at North American's Kansas City plant. Thus, it became management's problem to plan and execute an orderly and efficient conversion of the California Division plant from B-25's plus P-51's to full P-51 production, starting with the following basic factors:

1. A total of approximately 10,000 direct workers was employed, with 6,000 working on the P-51 and 4,000 on the B-25.
2. Employees were quitting at the rate of 200 to 300 per month and new hires were not quite able to keep pace with this turnover rate.
3. The B-25 project occupied the larger of the two final assembly high-bay areas, and the P-51 had to be moved into this area before production rates could be appreciably increased. Also, supporting P-51 major assembly departments had to be relocated or expanded, or both, to provide the additional capacity necessary.
4. Duplicate tooling would be required on most major assembly jigs and on some subassembly jigs. This problem included the determination of which assemblies would need any duplicates, how many would be needed, and when they would be required, as well as the finding of tooling capacity to construct them.

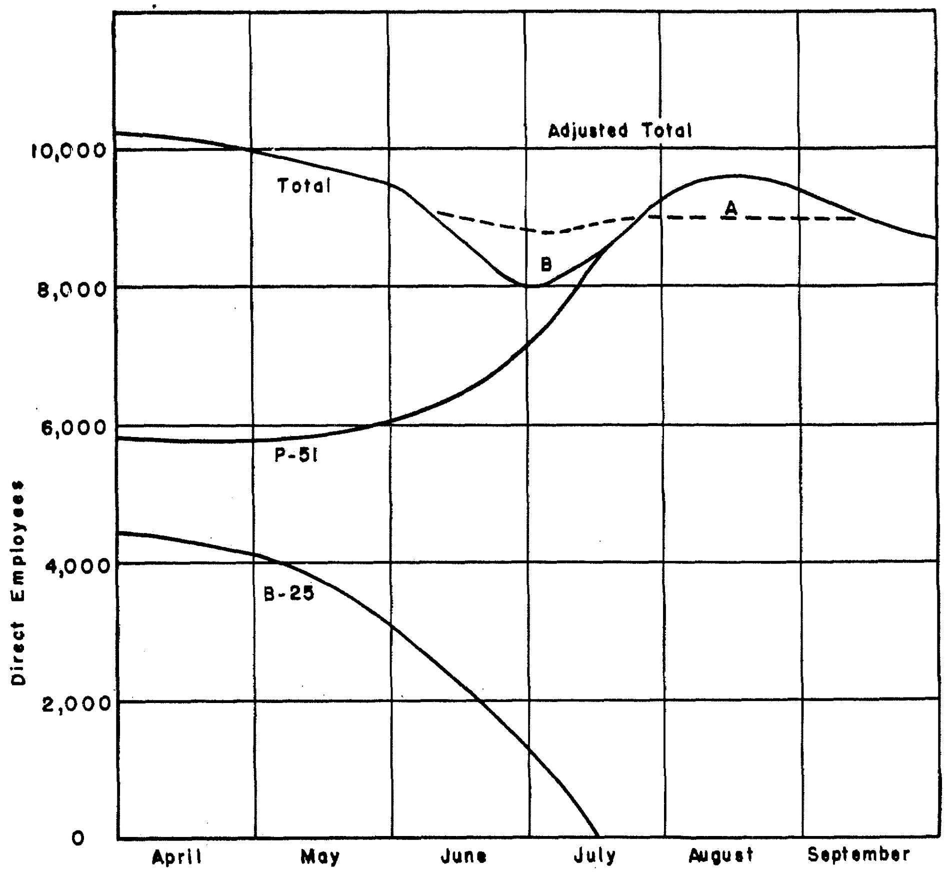
A preliminary survey indicated that it would take approximately three weeks to convert the B-25 area to accommodate the P-51 project. In other words, for a three weeks' period hundreds of employees working on the B-25 would be available, but the P-51 production rate could not sufficiently increase in its existing area to use all the capacity thereby made available. Any attempt to lay off these employees for this period and subsequently rehire them was out of the question, in view of the already high turnover rate and the difficulty of obtaining new employees. On the other hand, merely allowing these employees to stand around during that period would be very bad on morale, to say nothing of the wasted effort involved.

B. Solution

The satisfaction of the first principle of operating controls required considerable investigation and analysis because of the many factors involved. The first step was to reexamine the conversion plans, which, in the preliminary survey, were estimated to require three weeks in the critical final assembly departments. By specifying the maximum prefabrication of conveyor line structure and equipment, and by planning that the actual construction work in the B-25 area take place station by station immediately following the last airplane as it went down the line, the planned final assembly conversion time was cut to 10 days.

An analysis of the operations in the P-51 final assembly area was made, showing that by "supercharging" or over-manning each station with some of the personnel released from the B-25 final assembly, a temporary production rate of 14 per day could be obtained while the P-51 project was still located in its original area. Also, production rates above 14 per day were planned for the P-51 as soon as possible after the scheduled relocation into the larger area. On the basis of the production schedules arrived at in the manner described above, a total direct labor load was computed for the period involved in the conversion. (*Fig. 3*, solid lines). This total labor load for the factory assumed normal distribution of hours' expenditure prior to airplane completion; i.e., it assumed that hours would be expended on parts and assemblies as actually required by the next assembly or by the final line and with normal minimum storage time allowed. In anticipation that some net loss of personnel would be inevitable as a result of this conversion, the maximum P-51 scheduled rates were set at a level which would not require a peak load in excess of 9,500 direct employees, the most optimistic figure possible under the circumstances, as normal turnover rates would easily bring about this reduction during the two months that no new hires would be taken on. The gradual decrease of employee requirements beyond the peak of 9,500 was a recognition of the hours per unit improvement that would be experienced after the maximum production rate (20 per day) had been attained.

It was immediately apparent from this graph that some additional action would be required to avoid the necessity of a layoff or a period of mass idleness. A reexamination of employee turnover experience indicated that termination rates appreciably higher than average could be expected during the conversion to full P-51 production, as the reorganization of departments and the regrouping of personnel were certain to result in many dissatisfied employees who were merely waiting an excuse to quit. Therefore, it was decided that plans were to be based on the assumption that approximately 1,000 direct workers would be lost as a result of the conversion. The tentative final assembly completion schedules mentioned above, which had been based on the physical limitations of the areas involved, were left intact, and it was assumed that the volume of work represented by Area *A*, *Fig. 3*, could be rescheduled to take



AT LEFT:

FIG. 3
P-51 and B-25 labor loads for conversion period.

place earlier, as indicated by Area *B*. The following plans were devised to carry out such a program:

1. The problem was comparatively simple in those detail and functional subassembly departments which had been fabricating both B-25 and P-51 parts. It merely required that sufficient additional P-51 parts be scheduled into those departments immediately behind the end of the B-25 contract, such that the full capacity of the departments would be used. This meant that an appreciable number of P-51 detail and subassemblies would be fabricated prior to actual need, and arrangements were made to provide storage area for these. The schedule was so adjusted that this excess of parts was gradually absorbed during the four to five months after the conversion, by which time all schedules were faired back into line on a normal minimum storage basis.
2. The plans temporarily to "supercharge" the P-51 final assembly lines prior to moving were rechecked and left as described above.
3. In the major assembly departments supplying final assembly, a similar temporary "supercharging" was planned. However, in some major assembly departments, such as those building wings, flaps, control surfaces, etc., it was planned that inefficient "supercharging" would be avoided as much as possible by specifying that the production of spares be temporarily stopped and the 14 per day rate required to support final assembly obtained by temporarily diverting that spare capacity to production parts. It was intended that the behind-concurrency status of spares production resulting from the action described above would be compensated for at a later date by increasing the production rate to a maximum in those departments prior to the time final assembly schedule production rate had reached maximum. This concentration on major assemblies for final assembly actually had to start several weeks prior to the time the final assembly rate went above 10 per day, in order that additional assemblies would be on hand by the date the stationized conveyor lines were moved. This additional supply of major assemblies had to be available to fill the increased number of stations in the new conveyor line layouts. Only by filling these stations immediately after the move, could the excess final assembly personnel be kept busy at the earliest possible moment and the production rates increased quickly thereafter to use up the backlog of stored details and subassemblies.

The plans described above were laid out for each department and a load chart similar to *Fig. 3* prepared for each. When totaled, these charts closely corresponded to the desired total load as expressed in *Fig. 3*, and the plan of action for production departments was approved by management.

4. After all departmental production schedules had been established in the manner described above, the current hours-per-unit reports were consulted to determine those jigs on which one or more duplicates would be required to support 20 per day plus spares, and a chart plotted for each, indicating future production rates, including spares. (See *Fig. 4*). On each of these charts there were plotted the dates on which each duplicate would be required to meet the increased rates, using current unit hours as a basis for this decision. (*Fig. 4, A.*) In the case of major jigs

involving a considerable expenditure of man hours, a careful check of the hours per unit expended on that item during the last several months was made, and if appreciable additional improvement on hours per unit could be anticipated, such a consideration was used in deciding whether or not all of the duplicate jigs would actually be necessary. In a surprisingly large number of cases it was found that some of the additional tooling required on the basis of current hours per unit would not actually be required by the time maximum production rates were scheduled, because of the justifiably expected improvement in unit hours performance which would be obtained by that time. *(Fig. 4, B)*. Individual duplicate tooling requirements determined in the manner described above were then extended into a total man hours load, and this in turn added to the known loads on other projects in the tooling departments. In this particular case, no adjusted hours load curve had to be used, but, if necessary, the control device described in the first section of this article could have been used.

The second principle of operating controls was satisfied as follows:

1. In accordance with normal practice, all detail part work orders had been given in-work and completion schedule day numbers prior to issuance to the shop. The temporary acceleration of P-51 detail fabrication schedules then merely required the adjustment of the conversion chart between schedule day numbers and calendar dates. This revised chart was issued to all stockrooms and control stations handling detail work orders.
2. As all assemblies were already scheduled individually on a weekly comparison schedule form, of the same general type as the tooling comparison form described in the previous section, the specific plans for each assembly department were quickly and accurately expressed to all personnel concerned.
3. Departmental rearrangement plans were plotted on a master chart by industrial engineering, all the timing was checked for proper coordination, and specific detail move notices were issued to cover each area involved.

The third principle of operating controls was satisfied principally by the existing progress reporting mediums, such as work order status in detail departments and weekly progress reports in the assembly departments on the comparison schedule form mentioned above. Tooling progress was followed on the tooling comparison report described above. Additional special follow-up on the conversion work was instituted and closely watched.

As a result of the operating controls described above, the last B-25 was completed on schedule to the minute. On a Saturday and Sunday, nine days after the last B-25 had been completed, the P-51 final assembly department was moved to the converted B-25 area. On Monday, 14 P-51's were completed off the new line, and this rate was increased to 16 per day one week later, as planned. As a result of the manpower controls used during this period, the unit cost of the P-51 rose only two per cent, and that for a period of only two weeks, after which the previous improvement trend continued. The conscientious adherence to the principles of operating controls had paid off a thousandfold in relation to the development and maintenance expense of an organization to provide those controls.

Wins Legion of Merit

COLONEL JAMES BOYD, former professor of mining geology at the Colorado School of Mines, and now United States Director of Industrial Production in Europe, recently was awarded the Legion of Merit for success in initiating and developing materials control and the procurement of metals and minerals for the Armed Services.

Colonel Boyd was a staff assistant to the director of materiel in the headquarters of the Army Service Forces between March, 1942, and April, 1945, during which he "was responsible in large part for the successful operation of the entire system of allocation by the War Production Board of critical raw materials in such manner as to assure a maximum war effort."

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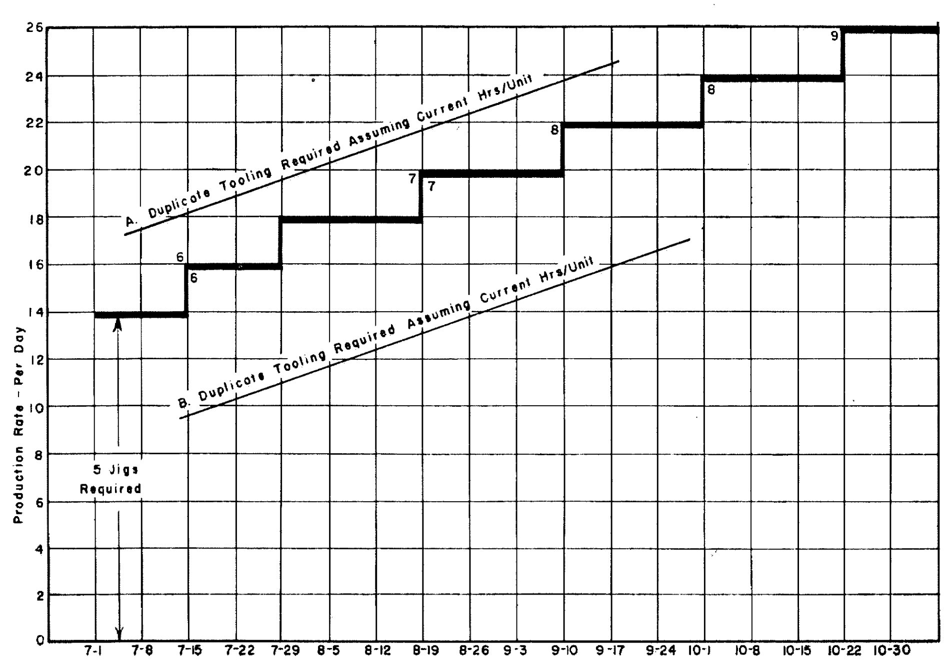
FIG. 4
Typical duplicate tooling survey sheet showing effect of employed hours per unit.



C.I.T. NEWS

December Meeting

THE December 13 Alumni Dinner Meeting. held at the University Club. was a great success. There were 70 members and guests present: the class of '33 being represented by six members—not bad! After a session of elbow bending and the partaking of a most delicious dinner. the meeting was formally opened by President Charles Varney. Vice-President and Program Chairman Al Laws introduced the speaker of the evening. R. G. Kenyon, vice-president of the Southern California Edison Company.

Mr. Kenyon gave a very interesting talk on Labor-Management Relations. He differentiated between labor as a commodity. and the laborer as an individual. Labor as a commodity is priced in accordance with standard economic laws of supply and demand and not according to the buyer's ability to pay. This classification fits very accurately into the picture when used with reference to the depression of 14 years ago and the huge demand for labor during the war years. Labor problems date back as far as 1350 A. D. At that time the great plague took place in England and people died in such large numbers that there was a serious labor shortage for food production.

Mr. Kenyon then went on to give a history of the organization of labor into unions. The earliest known labor union was organized in 1790, but not until 1886. when the Knights of Labor was formed with 700,000 members, did labor unionize into a large organization. However, the Knights of Labor lasted only six years, and not until the American Federation of Labor was started in 1900 were there any strong unions. With the A. F. of L. came the institution of collective bargaining. Mr. Kenyon then described the labor-management relations during the war and at the present time. He ended his talk with the statement that management is not hostile to labor unions as such, but to some of the corollary philosophies which have developed in the movement.

President Varney then asked for further business. and Al Laws gave a short resume of the coming meetings next year.

The meeting was then adjourned.

Affiliates With National Organization

AN organization known as the Association of Pasadena Scientists was formed at the California Institute of Technology in November 1945. Purposes of the Association will be to study the problems associated with the relationship between society and scientific developments, with special emphasis on problems of atomic power; to promote freedom of research. particularly nuclear research; to cooperate with other groups which are working to prevent the destructive use of atomic energy. and to convince the public at large of the necessity for taking action designed to achieve this goal.

At a special meeting of the new organization held December 19. addressed by Dr. J. R. Oppenheimer. former head of the Los Alamos bomb project and by Dr. Linus Pauling. the membership voted to affiliate with the American Federation of Scientists. the national group formed to gather and disseminate information concerning developments in science insofar as they affect world peace and the general welfare.

Membership in the American Federation of Scientists is open to local associations with at least 25 "qualified" members. Qualified individuals (for voting purposes in the Federation) shall be natural scientists, mathematicians. or engineers active in scientific works with a minimum of a bachelor's degree or its equivalent. in science or engineering.

Physics Research

(Continued from Page 3)

have been made. To others, however. who see the value of such things to all engineering applications. as well as to those whose minds are only satisfied when everything is finally in order. this presents a challenging problem. At the present time. work is under way in a great many academic and industrial laboratories on what is roughly designated as the "theory of solids".

On the other hand. the field of research that is now so much in the public eye as to be a possible source of embarrassment to physicists. is that of nuclear physics. In a sense. nuclear physics began with the discovery of radio-activity. Its progress was slow until the early 1920's. when patient and persistent efforts of the physicists in the Cavendish Laboratory at Cambridge began to show results. and the first atomic nucleus was broken down. After that time interest grew at an increasing rate. until the tremendous expenditure of funds during the recent war produced results in the application of nuclear physics to the destruction of people and cities that has brought it to the attention of every thinking person. Most physicists are very unhappy because of the emphasis that has been put upon the destructive possibilities of the results, but many of them believe that by continued research and investigation this new source of energy can be made adaptable to extensive peacetime uses, and to uses that may tend to alleviate some of the causes of war.

NUCLEAR RESEARCH

Most active physics laboratories. both academic and industrial, are now making extensive preparations for nuclear research. It can be done in a variety of ways. but characteristic of most of these methods is the necessity for relatively large installations and equipment. There are those who think that such research should be operated and sponsored by the Government. But the Government has not yet decided to what extent and in what way it may contribute to research of this kind. There are others who think research would be much more fruitful if sponsored entirely by individual groups. In the meantime. active preparations are being made in the Kellogg Radiation Laboratory and the Norman Bridge Laboratory at California Institute of Technology for a resumption of nuclear research at something like the point where it was dropped in 1941. Some of the advances during the war can be turned to advantage. but. in general. it is a laborious process of attempting to recover the ground lost while developing lethal weapons of one kind or another.

Herbert Ingersoll '26

Herbert Ingersoll was killed December 15. 1944. in Subic Bay. when he was a prisoner of the Japs aboard a prison ship which was sunk. Herb was in action on Bataan. His wife has received the Silver Star Citation.

Dr. William Houston to Be Rice President

On March 1, Dr. William V. Houston, professor of physics, and chairman of the Department of Physics, Mathematics and Electrical Engineering at California Institute of Technology, leaves the Institute to become president of Rice Institute at Houston, Texas.

John T. Scott, chairman of the board of trustees of Rice Institute, announced the appointment of Dr. Houston who succeeds Dr. Edgar Odell Lovett, president of Rice Institute since its organization in 1908. Dr. Lovett will continue to serve as president emeritus.

Dr. Houston received his B.A. and B.Sc. from Ohio State University in 1920 and his Ph.D. from the same Institution in 1925. He came to C.I.T. in 1925, and his work at the Institute has won him a national reputation in the field of physics.

Since Rice Institute, like C.I.T., is a school in which the fundamentals of engineering and science are supplemented by a generous study of the humanities, Dr. Houston's career will continue in an educational atmosphere congenial to him. All of the Institute Staff and alumni wish Dr. Houston success and satisfaction in his new duties.

New Associate Dean Appointed

At a meeting of the Board of Trustees of the California Institute of Technology held on December 3, 1945, Foster Strong, assistant professor of Physics was appointed Associate Dean of Freshmen. L. Winchester Jones remains Associate Dean of Upper Classmen, and the title of Franklin Thomas is changed to Dean of Students rather than Dean of Upper Classmen.

Fill in and send to:

News Editor, Engineering and Science Monthly
1201 East California Street, Pasadena 4, Calif.

Name____________________ Class______

Home address____________________

Information about myself (marriage, position, type of work, change of position or location, etc.)

Information about another alumnus

Name____________________ Class______

MISSING ADDRESSES

The residence, business, or military addresses of the following graduates are unknown. If anyone reading this column could supply this information, it would be appreciated if they contact the Alumni Office.—Editor.

Name	Class
Aggeler, William F.	'25
Alexander, Chas. K.	'37
Allen, Robert N.	'16
Anissmoff, Constantin	'26
Applegate, Lindsay M.	'33
Arnold, Lee	'38
Ayars, William F.	'14
Batu, Buhtar	'40
Bauer, Frederick K.	'42
Beakley, Wallace M.	'35
Beichley Francis W.	'40
Bell, Richard W.	'41
Benioff, Ben	'22
Bennett, Foster C.	'37
Benson, Arthur S.	'41
Berry, Frederick A., Jr.	'37
Biddle, Russell L.	'31
Blackman, Roy B.	'98
Bradshaw, Richard R.	'39
Briggs, Thomas H., Jr.	'29
Burns, Martin C.	'39
Byrne, Hugh J. P.	'25
Cabeen, William	'39
Call, Raymond	'15
Campbell, John S.	'26
Carlmark, Carl W.	'41
Carr, John	'24
Chang-Hung-Yuan	'26
Chao, Chung-Yao	'30
Chase, Carl T.	'26
Chawner, Wm. D.	'34
Chen, Shang-Yi	'40
Cheng, Ju-Yung	'37
Chou, P'ei-Yuan	'28
Clark, John D.	'30
Cook, David E.	'34
Cowden, Warren L.	'44
Cox, Charles S.	'44
Cox, Edwin P.	'22
Cox, Raymond E.	'27
Craig, Philip H.	'33
Curci, Harold V.	'44
Davidson, Leonard E.	'00
Davis, Edwin N.	'33
Djanab, Kamal	'38
Dykes, John C.	'37
Eastman, Luther J.	'28
Easton, Anthony	'37
Easton, Robert L.	'39
Ellis, Eugene	'30
Farman, Ivan L.	'26
Fleming, Thos. J.	'22
Foster, Alfred	'26
Fox, Joseph	'21
Fraps, A. W.	'32
Freeman, Hugh B.	'24
Frye, Calvin B.	'31
Fuetsch, Frederic T.	'38
Garrett, James R.	'41
Gates, Clinton E.	'30
Gentner, William E.	'40
Gershzohn, Morris	'38
Gillies, Robert	'22
Gilliland, Ted R.	'27
Go, Chong-Hu	'42
Goering, Kenneth J.	'39
Goodhue, Elbridge A.	'20
Gould, Martin	'41
Graham, Thomas C.	'28
Granger, Wayne E.	'26
Graul, Donald P.	'37
Gray, Boris A.	'24
Green, Wm. Jeffrey	'40
Greenlees, A. Lloyd	'25
Gregory, Carter H.	'31
Gregory, Jackson, Jr.	'32
Gridley, Horace V.	'24
Griest, Raymond H.	'32
Grimm, George, Jr.	'35
Gross, Siegfried T.	'35
Haeff, Andrew V.	'29
Haffner, Bernhard	'40
Hamilton, James H.	'25
Hamway, Daniel S.	'41
Hand, Ross L.	'36
Hanger, Willard M.	'43
Hansen, Raymond J.	'25
Hardwick, Fray	'26
Hartman, Edwin P.	'40
Hastings, Robert C.	'24
Hayward, Russell E.	'38
Head, Alfred B.	'42
Hendry, Noel W.	'39
Herlin, Robert G.	'33
Hetzel, Eustace P.	'40
Hoard, J. L.	'32
Hoch, Winton C.	'31
Holzman, Benjamin	'31
Hughes, Lawrence E., Jr.	'44
Imus, Henry	'30
Jack, Samuel S.	'38
Jackson, Andrew M.	'39
Jennings, Stephen	'38
Jetter, Ulrich	'38
Jones, Winthrop G.	'39
Johnson, Norman S.	'34
Joseph, Paul A.	'35
Kinney, Edward E.	'30
Kleinbach, Hugo	'30
Knudson, Alfred G. Jr.	'44
Koons, Harry M.	'35
Labanauskas, Paul J.	'44
Launer, H. F.	'32
Levy, Henri A.	'35
Lewis, Glenn H.	'36
Lewis, Stanley M.	'11
Lowe, Frank C.	'38
MacKnight, Robt. H.	'39
Magden, John L.	'33
Marsland, John E.	'27
Marston, C. Sargent	'34
Martin, Francis C.	'28
Martin, R. S.	'32
Matthews, Elmo S.	'35
McCullough, James D.	'36
McCutchan, H. C.	'04
McDaniel, Gene W.	'42
McFadden, Wm. C.	'34
McLeish, Chas. W.	'38
McIntosh, James	'41
McNaughton, Duncan A.	'34
Menis, Luigi	'40
Mesenkop, Louis H.	'27
Michal, Edwin B.	'33
Michels, Walter C.	'30
Miller, Eugene C.	'35
Miller, Jos. A.	'41
Miller, Nash H.	'37
Moorman, Thos. S.	'38
Morgan, Stanley C.	'28
Morgenstierne, S. S.	'32
Murdock, DeWolfe O.	'31
Murdock, Keith	'33
Murphy, Jos. N.	'37
Myers, Charles S.	'41
Neal, Wilson H.	'39
Nelson, Julius	'29

Name	Class
Newton, Walter L.	'14
Norquest, Kenneth S.	'39
Nysewander, Cecil W.	'38
Odell, Raymond H.	'37
Ofsthun, Sidney A.	'38
Oiman, Samuel	'29
Orr, James M.	'38
Overhage, Carl	'31
Parker, Percy E.	'26
Parish, Elliott W.	'39
Parry, H. Dean	'37
Peters, Ralph	'41
Peterson, Frank F.	'27
Pierce, John R.	'33
Plank, Dick A.	'33
Portman, Herman G., Jr.	'35
Putt, Donald L.	'38
Ravitz, Sol F.	'31
Reynolds, Roland W.	'27
Rice, Winston H.	'33
Richardson, Omar B.	'30
Ridenour, Louis N., Jr.	'36
Ries, Emil D.	'22
Rinehart, John S.	'37
Robertson, Francis A.	'39
Robertson, Howard P.	'25
Romer, Alfred	'35
Romoli, John A.	'34
Rosencranz, Richard, Jr.	'38
Rumbaugh, L. H.	'32
Rupert, Claud S.	'41
Russell, Richard L.	'33
Russell, Wm. J., Jr.	'43
Sandberg, Edward C.	'29
Saurenman, Dean F.	'33
Schafer, Sidney	'36
Scherb, Ivan V.	'35
Schlecter, Arthur H.	'33

Name	Class
Schoeller, Chas. P.	'32
Schultz, John R.	'37
Schwartz, Jack W.	'35
Scott, Leslie O.	'29
Scott, Percival T. W.	'25
Shappell, Maple D.	'33
Shaw, Thomas N.	'37
Sheppard, Dickson M.	'35
Shores, Von R.	'41
Shuler, Ellis W.	'37
Sinclair, Arthur W.	'05
Skinner, Selby M.	'33
Smith, Alexander	'42
Smith, Bill H.	'36
Smith, Dwight O.	'25
Smith, Joe Nelson	'37
Smith, Warren H.	'33
Snow, Neil	'36
Sokoloff, Vadim M.	'26
Spencer, Norman C.	'41
Steele, Geo. F.	'41
Stephens, Frank B.	'39
Stephenson, Wm. B.	'41
Stern, Benjamin	'36
Stone, George B.	'24
Stone, Wm. W., Jr.	'40
Stone, Wm. S.	'38
Strange, Hubert E.	'36
Streib, John F.	'36
Sunderland, Robt. C.	'34
Sutton, Richard M.	'29
Tarbet, Thomas V.	'32
Tatom, John F.	'39
Taylor, Ralph T.	'18
Thearle, Frederick G.	'27
Thiele, Carl L.	'32
Thomassen, Lars	'28
Tiemann, Cordes F.	'41
Tilker, Paul O.	'38
Tobin, Bernard M.	'40
Towler, John W.	'30
Turner, Francis E.	'28

Name	Class
Tyler, Albert	'29
Uhrig, Leonard F.	'36
Ure, William	'28
Vaile, Robert B., Jr.	'27
Varnes, David J.	'40
Veenhuyzen, Paul N. A.	'42
Von Beroldingen, Linton	'29
Vosseller, A. B.	'34
Walseth, Erling	'37
Warner, Arthur H.	'27
Warren, Harry L.	'24
Wasem, Richard	'40
Webb, Glenn M.	'31
Webb, Robert W.	'32
Welge, Henry	'32
Wells, John C.	'38
Welton, Francis G.	'33
Wenner, Ralph R.	'31
Wenstrom, W. H.	'34
White, Dudley	'30
White, Ernest C.	'25
White, M. P.	'32
Whitfield, Hervey H.	'41
Whittlesey, David W.	'40
Widmer, Robt. H.	'39
Wiget, Clark H.	'37
Wilking, Arnold P.	'33
Wilson, Keith M.	'25
Wingfield, Baker	'28
Winstein, Saul	'38
Wisecarver, Burnett B.	'26
Wiseman, Sam H.	'37
Wolf, Alexander	'33
Wolfe, Samuel	'41
Wolochow, David	'24
Wyckoff, Donald	'44
Yates, Donald N.	'39
Yensen, Trygve D.	'27
Yost, Don M.	'26
Zahorski, Adam T.	'31
Zimmerman, Don Z.	'36

PERSONALS

IT WILL be helpful if readers will send personal items concerning themselves and others to the Alumni Office. Great interest has been shown in these columns, but more information is required. Do not hesitate to send in facts about yourself, such as change of position or location, present job, technical accomplishments, etc. Please help.

—Editor.

1918

CORLISS A. BERCAW, who holds the position of district sales manager for General Motors Corp., electro-motive division, Chicago, Ill., made a business trip to Los Angeles in November in connection with testing a 6,000 h.p. diesel electric locomotive between Salt Lake City and Los Angeles on the Union Pacific.

1925

ALFRED A. NEWTON passed away on November 12 in a Boise, Idaho, hospital of cerebral hemorrhage. Mr. Newton was en route home from Seattle, where he had gone to meet his sister on her return to the states after liberation from a Japanese prison camp. Mr. Newton was very active in civic affairs in the city of Santa Monica, Calif., where he lived and was professionally a civil engineer, holding an executive position with the Aircrafts Products Co. of that city.

NEAL D. SMITH has been appointed city engineer of the City of San Diego and assumed office on the first of December. Mr. Smith was city manager at Ontario, Calif., for six years, resigning to take the San Diego position.

O. S. LARABEE, a lieutenant-colonel in the Army, has been discharged from military service and has returned to the Southern California Telephone Co., chief engineer's department, in equipment engineering.

1926

DOCTOR A. M. BALL, employed by the Hercules Powder Co. of Wilmington, Del., visited the campus during the latter part of November. Dr. Ball has been involved in the development of rocket propellants.

1927

COLONEL TED COMBS returned to the states by plane from Tokyo in November and is now living at Long Beach, Calif. Colonel Combs's last assignment was with the Construction Brigade, Sixth Army.

COMMANDER R. T. ROSS has been separated from the Navy for several weeks. Commander Ross was stationed at Pearl Harbor in charge of personnel work for fleet schools.

1928

EDWIN W. TEMPLIN, formerly with Bell Telephone Laboratories, New York, N. Y., is now employed by the Electrical Research Products Division of Western Electric Co., at Hollywood, Calif.

1929

BEVERLY F. FREDENDALL has joined the organization of Frederick Hart & Co., Inc., of Poughkeepsie and New York City, which makes Hartron and Recordgraph sound recording equipment. Mr. Fredendall was formerly with N. B. C., working both in New York and Chicago.

LESLIE SCOTT is reported on his way home from Berlin, and expected to be back in California by Christmas. Les was a lieutenant-colonel and commanded the 208th Engineer Combat Battalion under the First and Ninth Armies from Cherbourg across France and Germany until they became part of Task Force Berlin.

TOM EVANS has taken over the duties of head of the civil engineering department at Georgia Tech. Tom was a lieutenant-colonel in the U. S. Army Engineers, on duty in the Pentagon Building during the war.

LIEUTENANT-COLONEL WALTER GRIMES, after serving two months in the South Pacific theater, returned in September and is now in San Francisco.

1930

DAVID SHEFFET visited on the campus in October. David is working in the laboratory of Stanolind Oil and Gas Co., as research group supervisor.

1931

LIEUTENANT-COMMANDER FRANK H. FORD visited on the campus early in November while on terminal leave. Frank spent eight months in the Pacific area working in ship repair and battle damage and over a year in the European theater, at which time he was engaged in rebuilding the French fleet. Frank is married and father of a son, Preston, 18 months of age.

C. E. BUFFUM visited the Institute late in November on a vacation trip to southern California. Mr. Buffum is technical group supervisor in the research laboratory of the Stanolind Oil and Gas Co., Tulsa, Okla.

F. W. HUTCHINSON left the University of California a short time ago to accept a position as full professor at Purdue University.

1933

LEWIS H. GOSS has just been appointed city engineer of Brawley, Calif. Lewis was previously employed at the U. S. Engineers' office.

LAWRENCE HALLANGER, who spent some time during the war in the South Pacific theater in the service of Pan American Airways and the Navy as an aerological officer, is now located with Pan American at San Francisco.

COMMANDER HARALD OMSTED, who has returned to the states from being in command of the 94th Construction Battalion, is now on terminal leave. Commander Omsted's executive officer has been Ed Crawford '33, and he was relieved by Commander Perry Boothe '31.

1934

LIEUTENANT-COMMANDER GEORGE W. VAN OSDOL is stationed at San Francisco in the assistant industrial manager's office, the duties of which are radar installation and maintenance and removals. George is the father of a son and daughter, aged five and a half and two and a half respectively.

1935

LIEUTENANT ROBERT P. JONES is home on terminal leave after being stationed 19 months in the Admiralty Islands.

JOHN C. STICK, JR., has been a member of the staff of the division of physical war research at Duke University for the past three years. With the closing of the laboratory, John plans to return to his home in Pasadena.

LIEUTENANT-COMMANDER FREDERICK PEHOUSHEK, having been in service three and one-half years, has been released from service and intends to make his home in California. Commander Pehoushek was attached to the Shangri-la, Task Force 38, which made a carrier raid on Japan near the end of the war.

1936

NEWELL POTTORF is employed in the patent department of Stanolind Oil and Gas Co., in Tulsa. Last June Newell received a degree in law.

RAYMOND F. H. BOOTHE is a designer for Parkinson & Parkinson, of Los Angeles, Calif.

1937

ALAN GROBECKER is working with Gilfillan Bros. as a design engineer. Alan was a lieutenant in the Navy before discharge.

ANTHONY EASTON was married December 3 in New York City to Peggy Hopkins Joyce.

1938

DOCTOR WILLIAM F. NASH, formerly instructor of mechanical engineering at the Institute, is now a metallurgist with Naval Ordnance Research Laboratory in Pasadena.

DONALD HUDSON, assistant professor in mechanical engineering, is now on a leave of absence from the Institute and is employed with Naval Ordnance Research Laboratory in Pasadena.

CAPTAIN CHARLES A. MORSE has been discharged from military service and is working at the Southern California Telephone Co., Los Angeles, Calif.

PRIVATE RALPH W. JONES, JR., has been assigned to Hanford Engineering Works at Pasco, Wash. (Manhattan Engineering District). Until October 1, when he entered service, Ralph was employed with C. I. T. Section 5, Chemical Engineering Department.

1939

LIEUTENANT BARRY DIBBLE is home on terminal leave and intends to locate in southern California. Barry has been at Iwo Jima, Okinawa, and Tinian with Patrol Bombing Squadron 118 and later with the U. S. S. Curtis.

LIEUTENANT-COMMANDER B. F. BEANFIELD has transferred his address from Resident Inspector of Naval Material, Philadelphia, to the same at Brooklyn, N. Y.

ROLAND STONE, who has been working at Inyokern, is now employed by the Superior Honey Co. of Los Angeles.

MAJOR PAUL ENGELDER, who has been in active service with the Marines in the Pacific area since October, 1941, is expecting an early return to civilian status and an opportunity to return to the Institute for graduate work.

1940

ENSIGN CYDNOR BIDDISON is a navigator aboard the store ship "Valentine" (AF-47) which is stopping at eastern ports. Ensign Biddison brought his ship through the typhoon in the Okinawa area without serious damage. They were forced to ride the storm out for two days while waves broke over the flying bridge of the ship. At the end of the year, Ensign Biddison expects to put into San Francisco for another cargo, then return to sea for another six months.

CARL SCHRADER visited the Institute the latter part of November on a business trip to southern California. Carl is employed by the Bureau of Ships, Navy Department, Washington, D. C.

MAJOR GILBERT VAN DYKE returned from Asheville, N. C., Headquarters Weather Service and is now a reserve officer on inactive status. Major Van Dyke was stationed 18 months at Nome, Alaska, a stepping-off point for lend-lease to Russia, and also spent seven months at Edmonton, Alberta, Canada.

MAJOR FRED ODER just completed a course at the Command and General Staff School at Ft. Leavenworth, Kan., and will return to headquarters at Asheville, N. C.

BILL CLEVELAND has been separated from military service and is now attending school at U. C. L. A.

DOCTOR R. C. BRUMFIELD has changed positions from Aerojet Engineering Corp. to a civil service job. He is the father of a baby girl.

CAPTAIN GERALD P. FOSTER, a captain in the Marine Corps, is coming back to the states soon.

1941

ENSIGN STANLEY STROUD is stationed at the U. S. submarine base, New London, Conn.

LIEUTENANT (j. g.) ROGER WALLACE reported to the China Lake pilot plant, Inyokern, Calif., from European duty.

1942

LIEUTENANT PAUL VEENHUYZEN, who since 1942 has been attached to Naval Training School (harbor defense) instructing in underwater detection equipment and radar, is now on terminal leave.

LIEUTENANT EARLE A. CARR has been transferred to Mare Island, Calif., to serve in the electronics division. Lieut. Carr is the father of a baby boy, Wayne, born October 31.

DWAIN BOWEN, who has spent the past three years as research associate at the radiation laboratory at Massachusetts Institute of Technology, has returned to the Institute for graduate work.

ALVIN R. PIATT has opened an office in Long Beach, Calif., in which he will be engaged in product and machine design work.

MAJOR RAYMOND C. BAIRD is on terminal leave until January. Major Baird returned from Iwo Jima where he was in charge of the Army Air Force Weather Service, serving ground, sea, and air forces. Major Baird was at Atsugi Air Base in Japan on the day the surrender was signed, for the purpose of getting Japanese weather interception data.

JOHN MILES resigned his position at Lockheed Aircraft, Inc., to join the staff in the electrical engineering department at U. C. L. A. John Rubel '42 has taken Miles's former position with Lockheed.

1943

LIEUTENANT (j. g.) GLENN R. BRACKEN prior to V-J Day spent 18 months at Vernon, Calif., in engineering duty with naval inspection service, in charge of supervising tests relative to the acceptability of material purchased by the Navy for war materials. Lieut. Bracken served three months on sea duty as an officer of Pacific patrol.

STANLEY SNOWDEN, an instructor in the physics department of the Institute, is the father of a son, Peter, born on November 7.

ALBERT T. ELLIS is a member of the scientific staff, Columbia University, Division of War Research, located in the Empire State Building, New York, N. Y.

1944

ENSIGN LEWIS L. GRIMM and Miss Edith May Barton were married on August 2 at Yorba Linda, Calif.

ENSIGN CHARLES G. ALMQUIST is stationed aboard the "Mighty Midas" in the vicinity of the Philippines. Ensign Almquist reports, "The Philippines is the country of blue waters, green islands, and red sunsets—and temperatures of 100° F. and rain of 20 to 30 inches a month."

ENSIGN WILLIAM T. COLLINGS has been appointed aide to the commanding officer of the Seabee Base at Camp Endicott, R. I.

SECOND LIEUTENANT CLIFFORD CUMMINGS, Signal Corps, spent a 10-day leave at his home in Venice, Calif., late in November. When leave terminated, Clifford was en route to the European Theater Army of Occupation. He was an instructor for four months at Camp Edison, N. J.

LIEUTENANT J. R. BORDEN is an instructor at Camp Edison in Navy navigational type radar for installation on Army type transports.

LIEUTENANT LEROY SANDERS, formerly an instructor at Camp Edison, left in November for Germany to instruct in Signal Corps work.

ENSIGN GEORGE SHOR, communications officer on the U. S. S. Sarita (AKA 39), is engaged in the task of bringing veterans back from Japan and Okinawa areas.

JACK WARREN is now a civilian and is employed by Knudsen Creamery Co., Los Angeles. Jack was an aviation cadet at Tyndall Field, Fla., for four months, taking radar training for P-61's.

ENSIGN THOMAS W. NORSWORTHY is serving as assistant engineer on the destroyer U. S. S. Bache.

ENSIGN JOHN W. MARSHALL transferred from Engineering Division, Bureau of Aeronautics, Washington, D. C., to Ames Aeronautic Laboratory, Moffatt Field, Calif.

ENSIGN R. G. McANLIS, engineering officer on the destroyer U. S. S. Uhlmann, returned to the states early in December. His ship was docked at Seattle for overhaul, after which it will be taken to San Diego for inactive duty.

1945

ENSIGN RICHARD E. SPRINGER, commissioned at Notre Dame Midshipmen's School, left for St. Simons Island to attend tactical radar school for two months, after which he will be assigned sea duty.

ENSIGN HALCYON BALL, commissioned at Columbia Midshipmen's School, visited the Institute the middle of November. Ensign Ball was assigned to a troop ship (AP-126) as a deck officer.

ENSIGN EUGENE BOLSTER, commissioned at Notre Dame, visited at the Institute in November and was to report to San Francisco for assignmnet on a patrol craft for overseas duty.

ENSIGN ROBERT F. SCHMOKER left Ft. Schuyler for Camp Endicott, R. I.

today . . .

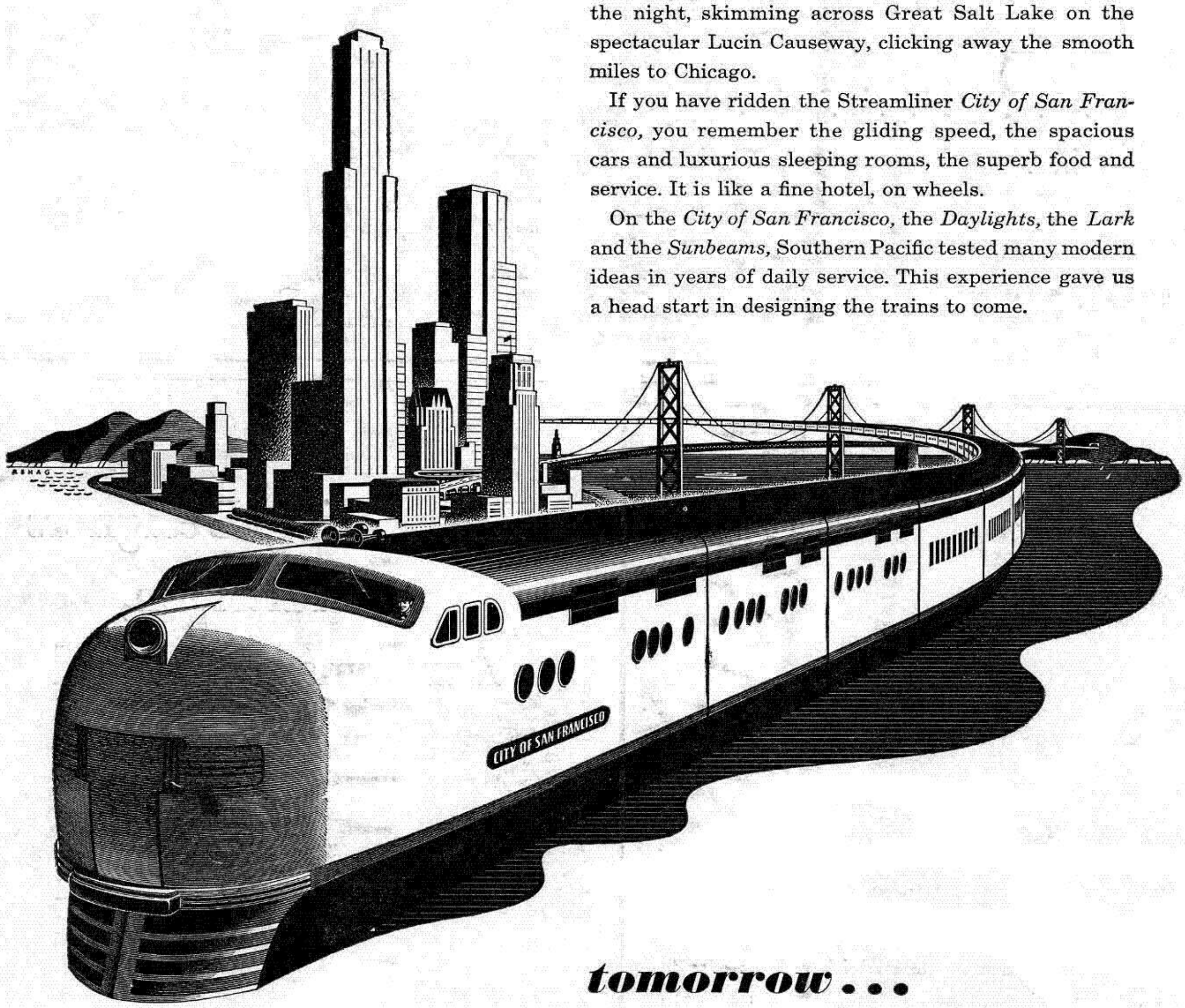
The Streamliner City of San Francisco

pacemaker for trains to come

Every three days a sleek golden yellow streamliner speeds eastward from San Francisco into the dusk, climbing up and over the High Sierra, through Reno in the night, skimming across Great Salt Lake on the spectacular Lucin Causeway, clicking away the smooth miles to Chicago.

If you have ridden the Streamliner *City of San Francisco,* you remember the gliding speed, the spacious cars and luxurious sleeping rooms, the superb food and service. It is like a fine hotel, on wheels.

On the *City of San Francisco,* the *Daylights,* the *Lark* and the *Sunbeams,* Southern Pacific tested many modern ideas in years of daily service. This experience gave us a head start in designing the trains to come.



tomorrow . . .

Southern Pacific is planning more streamliners. We will have them on our four major routes as fast as conditions permit. These new trains will be the finest the world has seen. Watch for the new Southern Pacific streamliners. Then it will be more exciting than ever to "try the train."

S•P ***The friendly Southern Pacific***