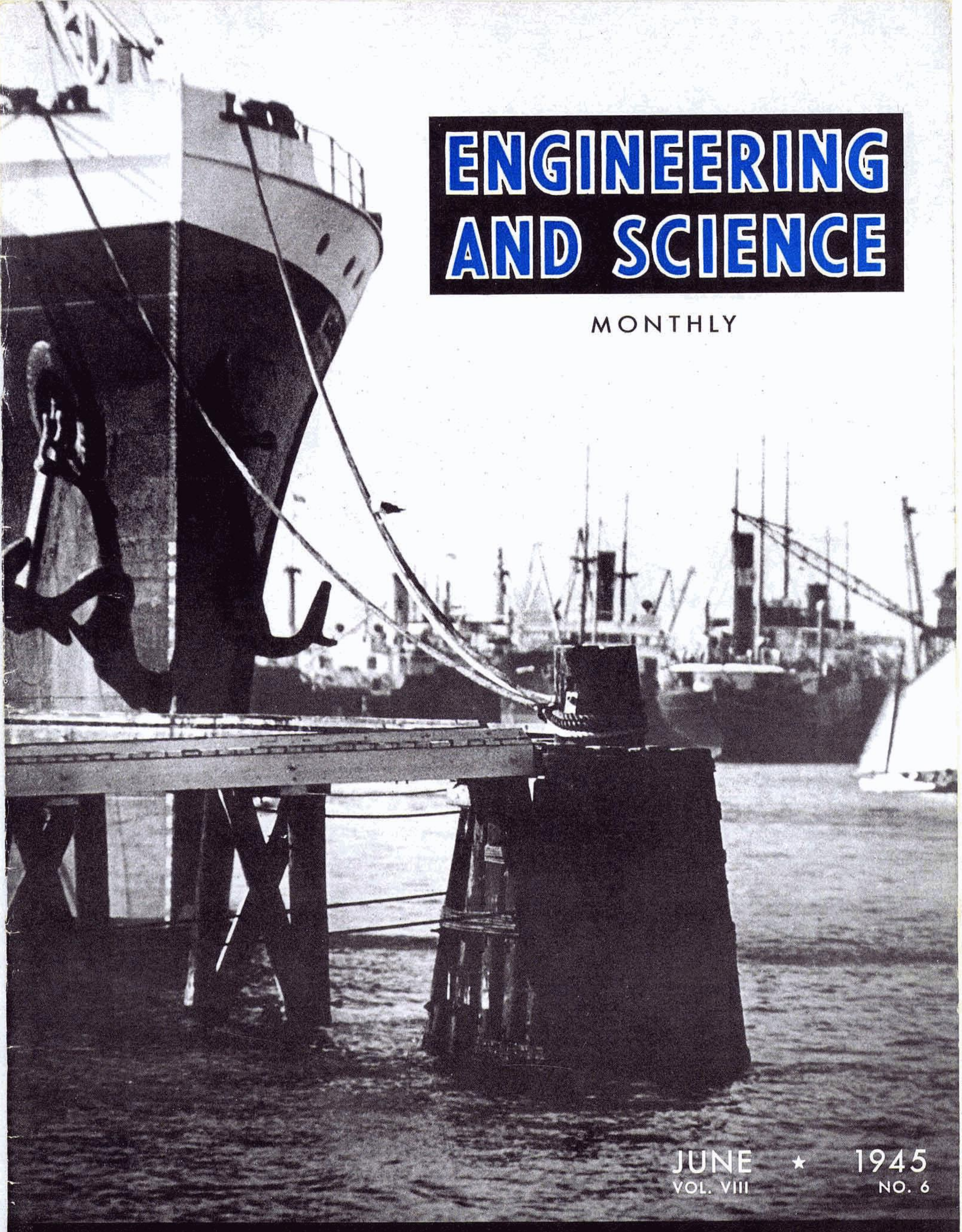
ENGINEERING AND SCIENCE

MONTHLY



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BY-LINES

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ENGINEERING AND SCIENCE Monthly

The Truth Shall Make You Free

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ENGINEERING AND SCIENCE MONTHLY

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ENGINEERING AND SCIENCE
Monthly

Vol. VIII, No. 6 June, 1945

Integration of Power Systems

By J. M. GAYLORD

POWER engineers are talking a great deal these days about "integration." They do not refer to the mathematical operation of the college classroom, but rather to the practical procedure of operating two or more power systems as a unit, the purpose being to utilize more fully the installed generating and transmitting facilities, to minimize spinning reserve, and to save fuel.

In the days of free enterprise each power tycoon was a rugged individualist who wanted to stand on his own feet. His system was complete, self-sustaining and independent. It had enough generating equipment to supply the load and ample spinning reserve to meet emergencies. Interconnections with other systems were considered as troublesome complications to be tolerated only if you were sure you were getting the best of the bargain. In private power companies an additional generator was a welcome means of increasing operating capital, and in government and municipal plants the taxpayer footed the bill. Why interconnect and give up some of your independence when you could buy all the generators you needed?

The public knew so little about the power business that it did not complain too strenuously as long as there was a surplus of everything, but the war made radical changes in our thinking. Tremendous new demands for war purposes developed rapidly as the defense program took form and the upward trend of the load was greatly accelerated. The production of aluminum and magnesium particularly added large power demands with large energy requirements because of high load factors.

Ordinarily such increases in loads would have been met by the construction of new generating plants, but materials were in great demand for the production of war equipment and could not be spared for less urgent purposes. The vital importance of power in the war program was fully appreciated from the first, and the Office of War Utilities took control of the situation to assure an ample supply for essential uses. Fortunately for the country, many of the engineers of that organization were practical power men, borrowed from the industry. Requests for additional equipment were passed on by engineers qualified by long experience to determine the necessity of the proposed extensions. The engineers of the utilities, as well as those in the Government service, knew perfectly well that operating economies could be effected by cooperation and interchange between systems, and the impetus of a national emergency promptly overcame the long-standing resistance to integrated operation.

INTEGRATION IN THE PACIFIC SOUTHWEST

To the credit of the electric utilities the response to the Government's suggestion was immediate, sincere and effective. Practical cooperation was accomplished through such organizations as the Pacific Southwest Power Interchange Committee, which was formed in the Spring of 1943, and consists of engineers representing the principal power organizations of California, Nevada, and Arizona. The committee presents a typical cross-section of the power supply business and demonstrates that engineers representing all schools of thought as to ownership and control of utilities can work together harmoniously and effectively for the general good of the community.

The committee is self-governing under the general direction of the Office of War Utilities, and meets monthly to consider current problems affecting power supply. Estimates of the power requirements and resources for a year or more in the future are prepared and a monthly summary is made of actual results compared with the estimates. Rainfall affecting hydroelectric plants is reported for all watersheds, and the use of fuel oil and gas is carefully watched and reported. Overhaul schedules, outages of generating equipment, major load changes and all other matters affecting the general situation as to power supply and demand are discussed and recommendations made for new facilities when no other means of supply can be found. Interconnection and interchange facilities are matters of first importance in the work of the committee.

The results of integration have been gratifying. No power user has lacked a supply sufficient for all essential purposes. Capacities of transmission facilities have been stretched beyond generally accepted limits; spinning

(Continued on Page 13)

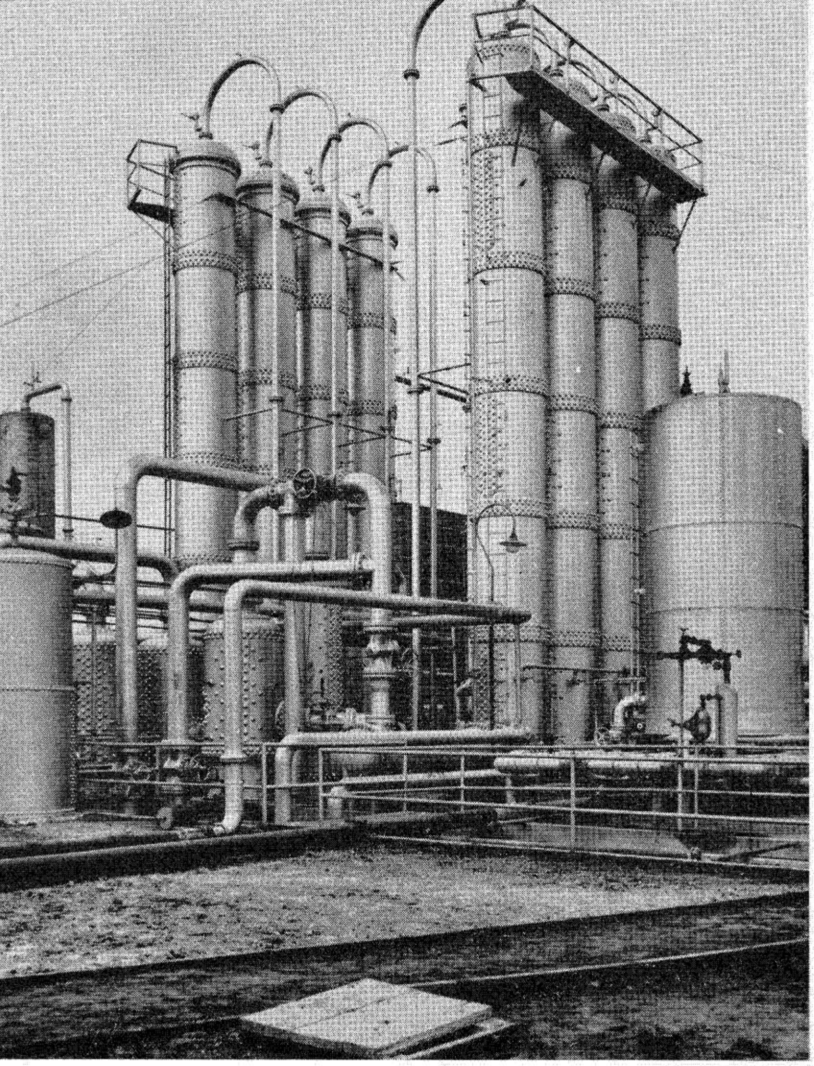


FIG. 1—Showing typical high-pressure absorber installation.

Production of NATURAL GASOLINE

By ROBERT B. BOWMAN

NATURAL gasoline is in the peculiar position of being at the same time a raw material and a finished product. It is seldom heard of in retail transactions involving petroleum products, because it is usually first blended with other fractions to produce motor and aviation fuels, in which it finds its principal outlet. In this case it may be considered a raw material. However, it is usually produced to such stringent specifications that little if any further processing is necessary after it leaves the natural gasoline plant. In this sense it may be considered a finished product.

The importance of natural gasoline is evident from the fact that in California the production of this material in recent years has amounted to about one-fifth the net production of refinery gasoline. The ratio in the United States has been smaller, but still it averaged one gallon of natural to about ten gallons of net refinery gasoline prior to the war and has now reached one gallon in six as a result of the increased demand for the volatile natural gasoline fractions in aviation fuel.

SOURCE OF NATURAL GASOLINE

Natural gasoline is extracted from "wet" gas, which is usually produced simultaneously with crude oil. Wet gas is separated from the oil by stages in field traps and tanks, whence it is collected and delivered to natural gasoline plants. The gas is called "wet" not in the sense in which the word is customarily used, but because it contains gasoline fractions in an amount sufficient to justify recovering them.

In contrast is "dry" gas, which is the natural gas distributed by public utilities for domestic and industrial fuel purposes. Either it has had the gasoline extracted from it, or it was originally produced without an appreciable amount of gasoline in it. Dry gas is often obtained from gas wells which produce no oil, such as those in the Rio Vista, Buttonwillow and other fields in California.

The predominant constituent of dry gas from wells is methane. Also present in dry gases discharged from natural gasoline plants are ethane, propane and some butane. Propane, isobutane and normal butane are intermediate between dry gas and natural gasoline and are becoming increasingly important as raw materials for various products. Originally they were disposed of principally as liquefied petroleum gases, but isobutane has become so much more valuable as a raw material in aviation gasoline that it has been virtually eliminated from this service. By direct combination with butylenes produced in refinery operations, isobutane yields a product high in isooctane content that is one of the principal base stocks for aviation fuels. Much normal butane is converted to isobutane to increase this source material. Also normal butane is dehydrogenated to butadiene, an important ingredient in synthetic rubber manufacture. Natural gasoline is composed principally of isopentane and heavier hydrocarbons, with varying amounts of normal butane depending upon specifications. A small amount of isobutane is usually present because of the difficulty of entirely eliminating this constituent. At the present time natural gasoline plants are generally operated to recover substantially all of the isobutane and heavier fractions from the inlet gas.

Table I is a compilation of compositions of typical wet gases, dry gases, liquefied petroleum gases and natural gasolines. This table serves to indicate the distribution of the various hydrocarbons in these materials. All hydrocarbons heavier than butane are grouped as pentanes (+). This is because an attempt is made always to extract all of these constituents and include them in natural gasoline. Information on the actual amounts of each one present is in general of little importance.

It will be noted that in the case of wet gases, compositions are reported both in terms of vapor per cent and "Gal./m.c.f." The latter expression is of particular significance. It represents the number of gallons of a constituent in 1000 standard cubic feet of gas. The latter quantity, abbreviated to m.c.f., is the unit customarily used in measuring gas volumes.

HISTORICAL DEVELOPMENT

Natural gas first became of economic importance in the years 1880-1890. In transporting gases in pipelines from oil fields it was noticed that a volatile liquid col-

TABLE I—TYPICAL COMPOSITIONS OF NATURAL GASES, LIQUEFIED GASES AND NATURAL GASOLINES

WET GASES FROM KETTLEMAN HILLS

Type of Gas	High Pressure Gas		Low Pressure Gas		Tank Vapors	
Component	Vapor %	Gal./m.c.f.	Vapor %	Gal./m.c.f.	Vapor %	Gal./m.c.f.
Methane	75.57		69.57		19.83	
Ethane	10.87		11.46		14.95	
Propane	7.38	2.02	8.88	2.45	26.98	7.37
Isobutane	1.09	0.35	1.58	0.51	6.26	2.03
N-Butane	2.74	0.86	4.02	1.26	17.04	5.36
Pentanes(+)	2.35	0.91	4.49	1.72	14.94	5.79
	100.00		100.00		100.00	

DRY GASES

Source	Discharge Gas from Kettleman Hills Natural Gasoline Plants		Well Gas from Buttonwillow Gas Field	Well Gas from McDonald Island Field
Component	Vapor %	Gal./m.c.f.	Vapor %	Vapor %
Carbon dioxide	0.05		0.5	0.04
Nitrogen	....		....	3.46
Methane	87.75		99.3	96.50
Ethane	8.33		0.2	....
Propane	3.65	1.00	....	....
Isobutane	0.15	0.05	....	....
N-Butane	0.05	0.02	....	....
Pentanes(+)	0.02	0.01	....	....
	100.00		100.00	100.00

LIQUEFIED GASES

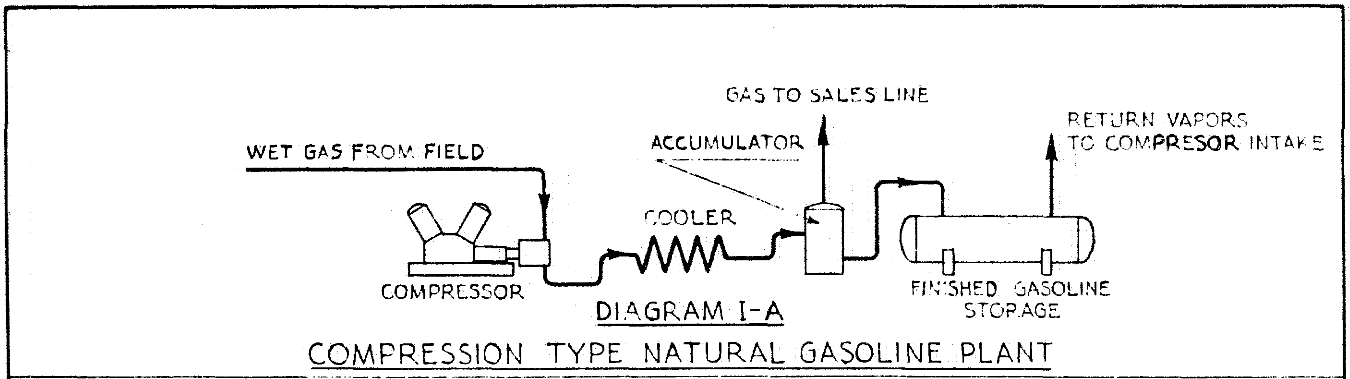
Name	Commercial Propane	Commercial Butane (Winter Grade)	Commercial Butane (Summer Grade)
Component			
Ethane	2.5 liq. %	2.5 liq. %	2.0 liq. %
Propane	97.0	45.0	30.0
Isobutane	0.5	1.0	1.0
N-Butane	....	51.5	67.0
	100.00	100.00	100.00

NATURAL GASOLINES

Source	Kettleman Hills		Southern California	
Reid Vapor Press.	16 lbs.	24 lbs.	16 lbs.	24 lbs.
Component				
Isobutane	0.8 liq. %	2.0 liq. %	1.0 liq. %	2.5 liq. %
N-Butane	11.7	33.5	14.0	30.7
Pentanes(+)	87.5	64.5	85.0	66.8
	100.0	100.0	100.0	100.0

lected at low places in the lines, particularly if cooling due to low atmospheric temperatures had occurred. At that time, which was prior to the development of the automobile, light liquid hydrocarbons such as what is now called natural gasoline had no commercial value. In fact, even in refineries gasoline fractions were discarded from crude oil because kerosene was the lightest product for which there was a ready market. The volatile liquid separating from natural gas was therefore first recognized as a nuisance because it not only was valueless, but caused restrictions in the flow of gas through the lines and created a fire hazard when it was drained off.

About the beginning of the present century, gasoline began to assume value because of the birth of the automobile industry. More of this material was saved in the refineries and some attention was given to the liquid which separated from wet gases. As early as 1904, gasoline became of sufficient importance to justify considering means for extracting from natural gas more of the volatile liquid fractions than were separating from natural causes in gas lines.



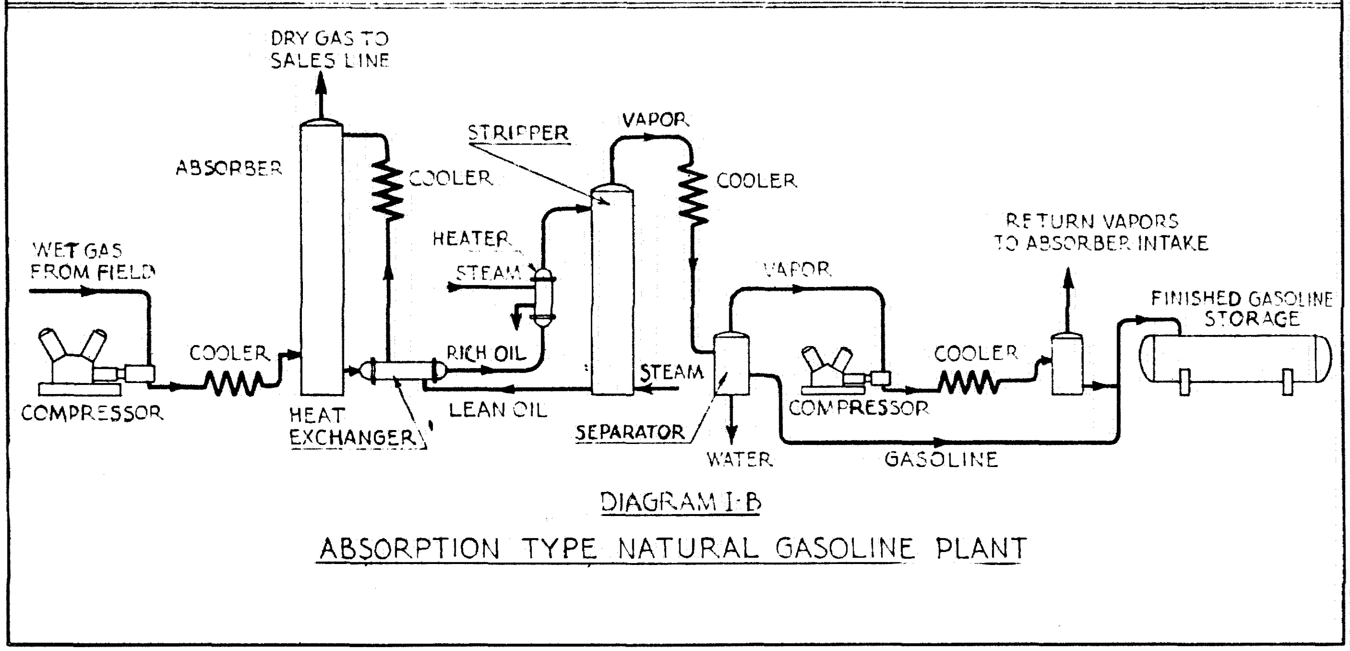


DIAGRAM I-A (Above)—Flow chart of a typical compression type natural gasoline plant. DIAGRAM I-B (Below)—Flow chart of absorption-type natural gasoline plant.

A. COMPRESSION METHOD OF EXTRACTION

It is a fundamental principle that condensation is induced either by a decrease in temperature or by an increase in pressure below the range where the retrograde phenomena occur. Therefore, the first method tried in attempting to obtain more gasoline fractions was to compress the gas and cool it, then separate the condensed liquid in an accumulator. *Diagram I-A* is a simplified flow sheet for a natural gasoline plant of the so-called compression type. The liquid from the accumulator was drawn off into tanks and the uncondensed portion of the gas was delivered to fuel lines. When high pressures were used, a large quantity of ethane and propane was retained in the liquid and an exceedingly volatile or "wild" gasoline was obtained. It was partially stabilized by withdrawing vapors from the tanks and returning them to the intake to the compressor. In passing again through the process of compression and cooling, some of the lightest components of the vapors failed to condense and were rejected into the fuel lines.

The principal weakness of the compression process was its inefficiency. Excessively high pressures or very low temperatures were required to recover substantially all of the pentanes and heavier fractions which could be included in finished gasoline. Also, the quality of the product was poor because it contained a large amount of the hydrocarbons such as methane, ethane and propane, which are not properly designated as natural gasoline. In spite of these weaknesses, however, and in the absence of a well-developed better process, the number of compression-type natural gasoline plants rapidly grew, until in 1912 there were 250, in 1916 there were 550, and in 1921 there were 865. Nevertheless, since 1921 the number has declined and the compression process has given way almost completely to the oil absorption process.

B. OIL ABSORPTION PROCESS

The oil absorption process consists basically of bringing wet gas in contact with an oil, whereupon the oil absorbs the gasoline from the gas. The action of the oil may be pictured as that of a sponge drawing into itself the gasoline fractions. After contacting the gas, the oil is heated and contacted with steam to drive off the absorbed fractions, which are then condensed as natural gasoline.

Diagram I-B is a simplified flow sheet of a natural gasoline plant of the oil absorption type. The individual items of equipment are discussed more fully later. The principal features of the process are as follows:

Wet gas from the field is first compressed and then cooled before it is introduced into the absorber. It then passes upwards counter-currently to a descending stream of oil, and out at the top into fuel lines.

The oil possesses the important property of preferentially absorbing the heaviest hydrocarbons from the gas. This so-called "selective" feature is an advantage of the oil absorption method over the compression method of extracting natural gasoline. The separation between heavy and light fractions in an absorber is, however, by no means a sharp one. When enough oil is circulated to absorb all the hydrocarbons which are desired in finished gasoline, some of the lighter ones are also extracted, but the separation is much sharper than when compression and cooling alone are employed.

The contacted sponge, or "rich" oil as it is called, leaves the absorber at the bottom and is heated before it passes into a stripper. Here steam is introduced to act as a carrier to remove the gasoline fractions from the oil. The "lean" or stripped sponge leaves the bottom of the stripper and is cooled before being circulated again into the absorber.

The steam and gasoline fractions are carried overhead from the stripper and are then cooled. The steam condenses and is drawn off as water from the bottom of the separator. The heaviest gasoline fractions also condense and form a liquid layer on top of the water in the separator, whence they are drawn off to the storage tank. The uncondensed vapors are then subjected to a step similar to the compression type of natural gasoline plant. They are first compressed and cooled, then the condensed portion is conducted to the storage tank, and the portion still in the vapor form is recycled to the absorber to recover any residual gasoline fractions.

A comparison of *Diagrams I-A and I-B* will indicate that compression still plays an important role in the oil absorption process. However, the use of oil makes possible the recovery of substantially all the gasoline from wet gas at ordinary temperatures and reasonable operating pressures. The efficiency and economy of the oil absorption process have made it the predominant method of operation now employed in the natural gasoline industry.

C. OTHER METHODS OF EXTRACTION

In addition to the compression and oil absorption processes, two other methods of extracting natural gasoline have received consideration; namely, (1) charcoal absorption and (2) refrigeration. Neither method has been extensively employed in the past, but future developments could bring either or both of them into prominence.

TYPICAL PRESENT-DAY PLANT

Diagram II is a flow sheet of a modern gasoline plant such as is operated at Kettleman Hills. Basically, this flow sheet is similar to *Diagram I-B*. Among the principal elements are the absorber, the stripper, the separator, and the vapor compressor, all of which appear in *Diagram I-B*. The only additional major feature is the rectifier or stabilizer in which specifications of the final product are controlled. However, the stabilizer is a single unit only when all the recovered hydrocarbons

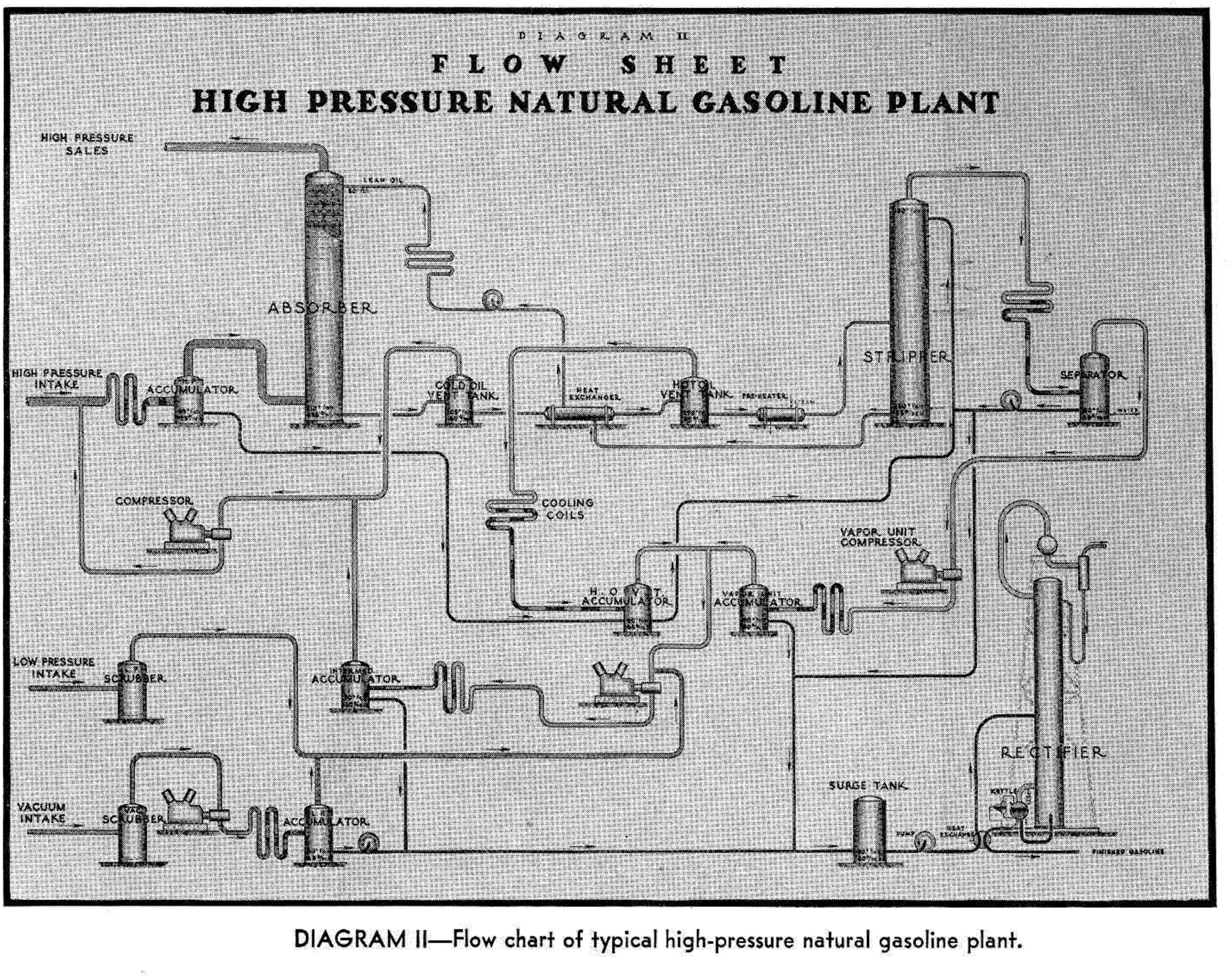
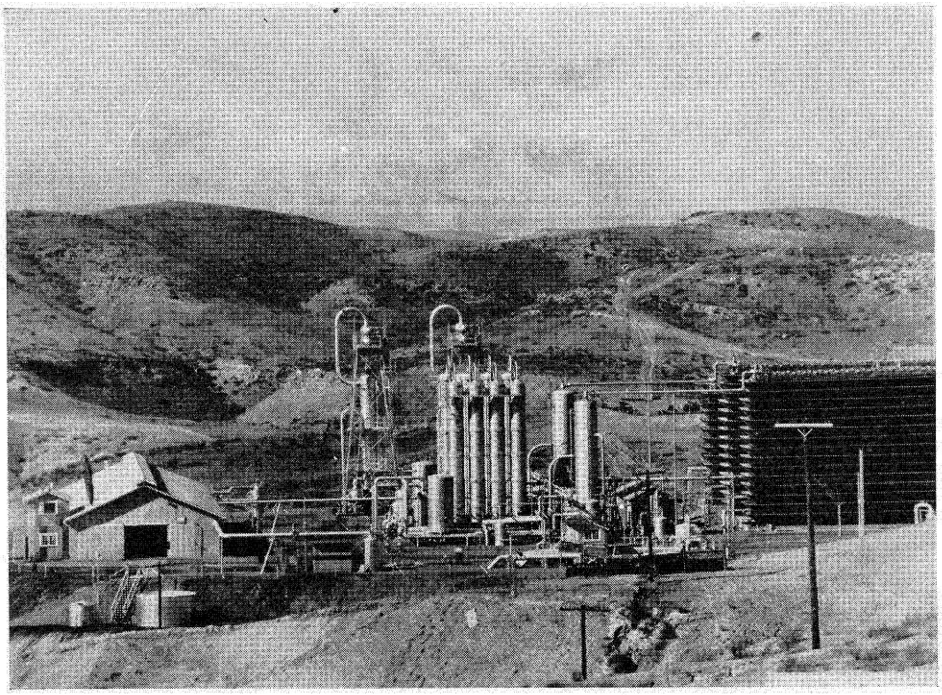


DIAGRAM II—Flow chart of typical high-pressure natural gasoline plant.



AT LEFT:
FIG. 2—Typical high-pressure natural gasoline plant located at Kettleman Hills, Calif.

are delivered from the plant as a mixture to be further separated at a refinery. In many cases batteries of rectifiers are located in the field, and propane, isobutane, normal butane, and natural gasoline are produced separately. The miscellaneous accumulators, coolers, vent tanks, etc., are all essential, but they play relatively minor roles in the process and are shown only for the purpose of completeness.

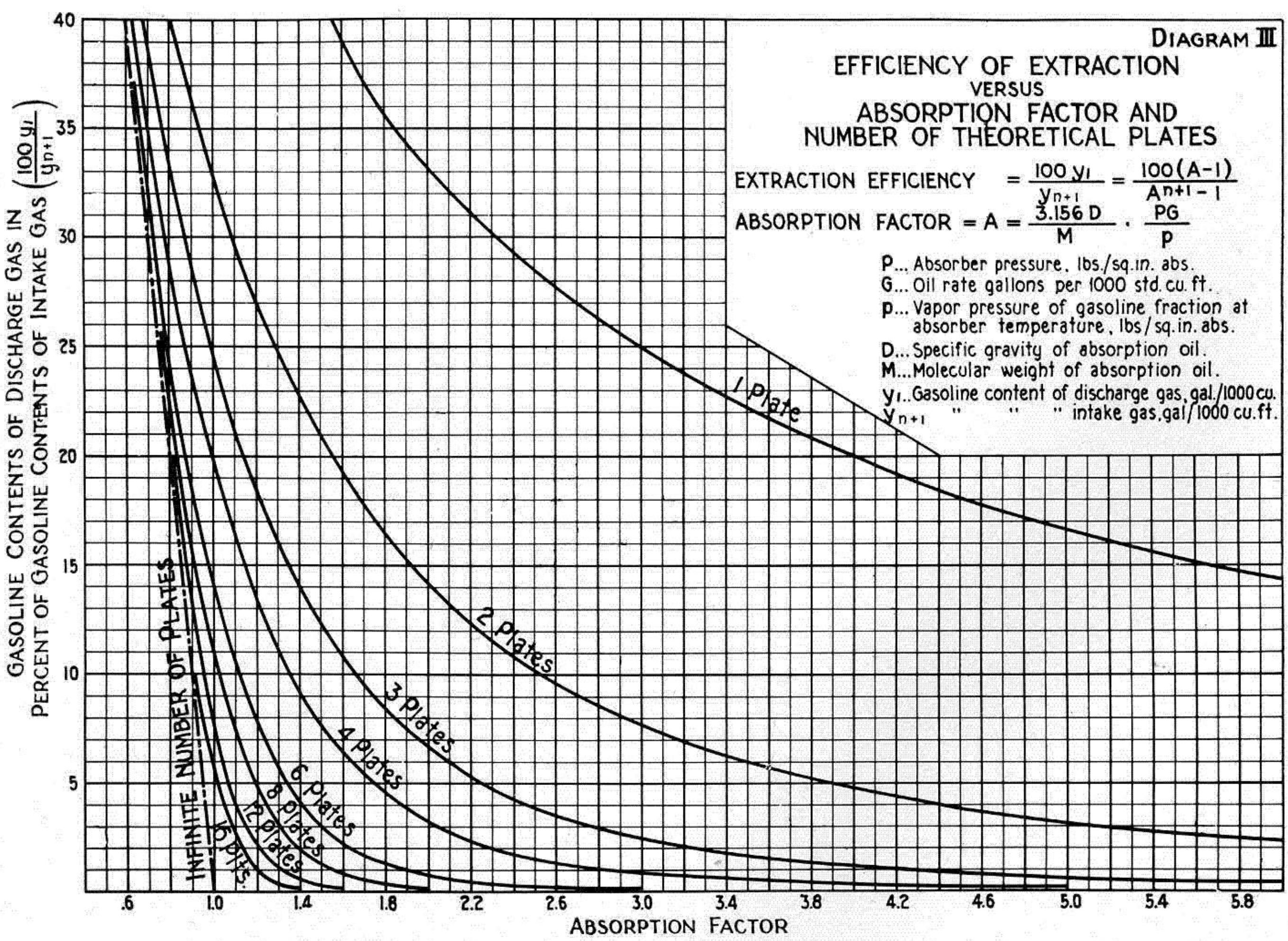


DIAGRAM III—Showing correlation between the absorption factor, the number of theoretical plates in an absorber, and the efficiency of extraction.

TABLE II—PRODUCTION OF NATURAL AND REFINERY GASOLINE
(All Figures in Gallons per Day)

YEAR	NATURAL GASOLINE		REFINERY GASOLINE*	
	UNITED STATES	TOTAL CALIFORNIA	UNITED STATES	TOTAL CALIFORNIA
1911	20,345	**	**	**
1912	33,008	2,844	**	**
1913	65,921	9,482	**	**
1914	116,858	20,770	**	**
1915	179,082	35,164	**	**
1916	282,767	46,883	5,625,354	845,628
1917	596,943	78,953	7,809,690	1,059,786
1918	774,070	88,408	9,781,632	1,190,154
1919	963,110	110,647	10,843,476	1,144,710
1920	1,051,213	131,716	13,340,292	1,356,390
1921	1,232,697	159,507	14,119,350	1,411,662
1922	1,385,481	183,890	16,992,402	1,899,996
1923	2,236,236	474,874	20,701,170	3,515,568
1924	2,551,533	635,462	24,480,036	3,665,928
1925	3,088,959	830,630	29,871,912	4,885,020
1926	3,734,493	1,042,099	34,489,938	5,760,426
1927	4,496,284	1,364,438	38,012,310	6,917,358
1928	4,956,377	1,595,932	43,255,968	7,651,350
1929	6,119,693	2,302,260	50,063,790	10,668,672
1930	6,056,148	2,273,186	49,737,324	9,671,634
1931	5,018,953	1,863,943	49,653,198	8,084,790
1932	4,163,388	1,507,915	45,055,122	7,545,048
1933	3,890,041	1,355,992	46,210,458	7,256,466
1934	4,206,465	1,387,047	47,975,760	7,088,088
1935	4,525,989	1,464,723	52,683,204	7,976,682
1936	4,908,033	1,621,355	57,919,176	8,853,600
1937	5,659,000	1,709,299	64,339,506	9,275,616
1938	5,908,422	1,810,658	63,960,834	8,977,584
1939	5,943,000	1,663,663	68,572,182	9,216,564
1940	6,340,000	1,601,079	68,540,220	8,945,412
1941	9,304,000	1,588,000	77,224,000	9,941,000
1942	9,588,000	1,494,000	67,542,000	9,951,000
1943	10,423,000	1,598,000	68,169,000	10,638,000

* Includes straight run gasoline, cracked gasoline and natural gasoline blended.
** Information incomplete.

A. THE ABSORBER

High pressures and low temperatures are favorable to absorption because they make possible the complete extraction of the desirable gasoline fraction at relatively low rates of oil circulation. The operating pressure employed depends upon the pressure at which gas is available from the wells and the pressure at which it must be delivered to fuel lines after gasoline has been extracted from it. A pressure of 35 pounds per square inch ahead is approximately the minimum at which an absorption plant can be economically installed and operated. If wet gas is produced at a lower pressure in the field, general practice is to compress it to at least 35 pounds per square inch ahead of the absorption step. If gas is available in the field at a pressure above 35 pounds per square inch, or if delivery to fuel lines at higher pressures is required, the absorption step is conducted at the greater of these two pressures. At Kettleman Hills, conditions are such that absorber operating pressure is maintained at about 425 pounds per square inch. Some gas is available in the field at this pressure, but most of the field gas, all crude oil tank vapors and vapors originating within the plant require compression ahead of the absorption step.

An absorber is a vertical cylindrical column such as those illustrated in *Figure 1.* This picture shows a group of eight units arranged in two rows of four each. In the early days of the absorption process, the columns were filled with wooden grids, wire coils or sometimes even baling wire to promote intimate contact between oil and gas. At the present time, bubble plates or trays are used almost exclusively for this purpose.

The use of bubble plates makes possible the absorption of gasoline fractions at low oil rates. At the same time the selectivity of the process is improved; that is, less of the undesirable fractions is absorbed by the oil while the desirable fractions are being recovered. Absorbers generally contain from 16 to 24 bubble plates.

B. THE STRIPPER

Stripping is the reverse of absorption. High pressure and low temperature are favorable to absorption, but low pressure and high temperature are favorable to stripping. Also, steam is admitted into the bottom of the stripper to act as a carrier in removing absorbed fractions from the oil. Thus in an absorber, gasoline fractions are removed from a wet gas by contacting the gas with a "lean" sponge under conditions of high pressure and low temperature, while in a stripper, gasoline fractions are removed from a "rich" sponge by contacting it with a dry gas (steam) under conditions of low pressure and high temperature.

The rich sponge leaving the absorber, after first being vented by reducing its pressure to remove a portion of the undesirable fractions which are unavoidably picked up in the absorber, is heated before it is introduced into the stripper. The first step in the heating is by transfer from hot lean oil returning to the absorber from the bottom of the stripper. The rich oil is again vented, then heated by indirect contact with steam in a preheater.

Rich oil is introduced about midway between top and bottom of the stripper. Steam and stripped vapors pass upwards through the column, and the oil passes downwards over bubble trays. The steam and vapors pass overhead from the column, then through cooling coils into a separator. Here, as was shown previously, the steam is removed as water, and a portion of the gasoline fractions is condensed. Some of these gasoline fractions are returned as reflux to the top of the stripper to wash back any of the light fractions of the oil itself which might tend to be carried overhead by the steam. The remaining gasoline fractions from the separator are conducted to the rectifier, which is described later.

In *Diagram II*, some of the stripper reflux is shown to be supplied by condensed material originating elsewhere in the plant. Any liquid is suitable which is similar in composition to the separator gasoline. Use of material already condensed elsewhere in the plant reduces the load on the stripper vapor condensing system.

The most favorable stripper operating pressure is of the order of 25 pounds per square inch gauge. At this pressure it is usually impossible to condense all the absorbed fractions that have been removed from the oil. The uncondensed portion is therefore subjected to compression and cooling in the plant vapor system.

C. PLANT VAPOR SYSTEM

The uncondensed vapors from the separator are first compressed to a pressure of about 80 pounds per square inch gauge and are then cooled to remove additional gasoline fractions, which are in turn delivered to the rectifier. Even at this pressure some of the gasoline fractions fail to condense. The remaining vapors are therefore subjected to additional compression and cooling and are finally conducted into the absorber. In some cases a separate absorption step operated at low pressure is employed for processing uncondensed separator vapors. This procedure is called reabsorption.

D. THE RECTIFIER

It has been mentioned that the absorption process, while representing an improvement over the compression process for extracting natural gasoline, is still unable to pick up all of the desirable hydrocarbons without at the same time recovering a portion of those not desirable in finished gasoline. It is the function of a rectifier to make the required separation. The nature of the rectifier installation depends upon a number of factors, such as the type of facilities available for transporting finished products, the demand for liquefied petroleum gases in the vicinity of the plant, etc. Where a pipeline outlet to a refinery is available, often the composite final product is shipped as a whole and separation into individual products such as propane, isobutane, normal butane, and natural gasoline is made in the refinery that receives the mixture. In this case the rectifier installation at the natural gasoline plant comprises only one fractionating unit with the simple function of removing methane, ethane, and excess propane from the mixture. When, for example, liquefied gases are produced locally or flexibility in the disposal of finished products is desired, a series of fractionating columns is employed to make the separation.

The operation of the individual fractionating or rectifying units is similar and will be illustrated by a description of a single-unit system. In this case the condensed hydrocarbons from the separator and various accumulators are collected in a so-called mixing or surge tank, from which they are pumped through a heat exchanger into the rectifier. The mixture is designated as "raw" product. The rectifier consists essentially of three units, comprising a column, a reflux system, and a kettle or reboiler. The raw product is introduced into the column about midway between top and bottom. When it enters the column, it separates into two parts: a vapor portion which rises towards the top, and a liquid portion which travels downwards. As in the case of absorbers and strippers, there are a number of bubble-cap trays or plates in the column, usually between 24 and 30. These trays are so designed that the liquid and vapor may travel countercurrently to each other and will be brought into intimate contact on each tray. The kettle or reboiler is the source of ascending vapor from the bottom of the column and the reflux system is the source of descending liquid from the top of the column. The contact between vapor and liquid on each tray results in an interchange of the various constituents, the lighter hydrocarbons tending to find their way upwards in the vapor stream and the heavier ones tending to find their way downwards in the liquid stream. The final result is that the product removed from the kettle contains essentially only those fractions which are desired to be retained. At the same time, the undesirable fractions are rejected overhead without carrying any desirable fractions with them.

In the case of a multiple-unit installation a common practice is to make the first unit a depropanizer in which propane and lighter fractions are removed overhead and isobutane and heavier fractions are retained in the bottom product. The second unit is a debutanizer, the feed to which is the bottom product from the first unit. In the second unit all isobutane and as much of the normal butane as is not desired in the finished gasoline are removed overhead and the bottom product is natural gasoline. A third unit processes the overhead material from the first unit and produces commercial propane as a bottom product. A fourth unit processes the butanes mixture from the second unit, separating it into isobutane and normal butane. The principal differences in the units are operating pressures and temperatures and the number of bubble trays in each one. The number of bubble trays is a function of the ease of separation (difference in boiling points) and the efficiency of separation desired. The column making the separation between isobutane and normal butane generally contains about twice as many trays as the others.

E. MODIFICATIONS

The flow sheet represented by *Diagram II* is shown principally as an illustration; many modifications of it are employed. For example, instead of having absorbers operated at only one pressure, two or three pressures may be utilized. If a substantial quantity of gas at low pressure were required locally for fuel purposes, an absorber might be operated at a pressure of the order of 40 pounds per square inch, in which case hot oil vent tank, vapor unit accumulator and low pressure field gases might be processed in it. Again, it might be found expedient to conduct a portion of the absorption step at a pressure of 150 pounds per square inch, in which case the intake gas would comprise cold oil vent tank and intermediate accumulator vapors. A still further modification is to conduct the compression of low pressure and vacuum field gases ahead of the gasoline plant, and deliver all gas to the plant in a single high pressure line.

The hot oil vent tank might be eliminated and a so-called rich oil rectifier be used in its place. In this case, gasoline content of the rejected vapors could be kept low enough to omit further processing. At the same time, light fractions might be eliminated to the extent that the entire remaining gasoline fractions could be condensed and delivered directly to the rectifier without setting up a vapor recycle.

The stripping step may be conducted in two stages instead of one as indicated on *Diagram II*. In many plants the lightest fractions are first removed from the oil in a primary stripper and this step is followed by removal of the heavier fractions in a secondary stripper which is operated at a lower pressure. Variations in the rectifying step have already been discussed.

Figure 2 is a general view of the absorption, stripping and rectification systems at a high pressure natural gasoline plant. It shows the compact arrangement of equipment.

F. COMPRESSORS

As was noted previously, compressors play an important role in the operation of an absorption-type natural gasoline plant. They are employed to boost field gas and vapors to absorber operating pressure and to process plant vapors. At Kettleman Hills, where dry gas must be delivered to sales lines at a pressure of about 425 pounds per square inch, this pressure, as was stated previously, becomes the most favorable absorption pressure. Compressors are required to boost much of the field gas to this final pressure. They are also employed to raise the pressure of gas utilized in producing wells by the gas-lift method. At the present time the total investment in compression facilities at Kettleman Hills far outweighs the value of the actual gasoline extraction equipment represented by the oil circulating and processing systems and the rectifiers.

Compressors have undergone an interesting development. Originally they were steam-driven because the internal combustion engine had not been developed to a sufficient degree of dependability to justify its adoption. Steam-driven units were subject to two major disadvantages. First, they were inefficient and required as fuel a very large quantity of salable gas. In the second place, water with a sufficient degree of purity for boiler operation was frequently not available at places where natural gasoline plants were located. Expensive treating equipment was then required. With the rapid development of the gasoline-driven automobile engines, a parallel improvement in gas-engine driven compression equipment occurred. By 1920, practically all of the steam-driven equipment had been displaced.

The first method of transmitting the power of the engine to the compressor was by means of a belt. Most of the early natural gasoline plants consisted of a row of engines on one side of a wide room and a row of compressors on the other side. The engines were placed well away from the compressors as a safeguard against explosions in the engine rooms. In some cases the engines and compressors were even put in separate rooms, and the belts were run through separate holes in the sidewalls or partitions.

Belted units were bulky and were expensive to maintain. Rapid improvements in gas engines soon greatly reduced the fire hazard, and direct-connected gas-engine driven units were soon recognized as practical and safe. The direct drive is much more efficient than the belted drive and has many less moving parts to keep in repair. Also, it is economical from the standpoint of space requirements, which are often an important consideration in natural gasoline plant design and construction.

The first direct-driven units were horizontal, with the power cylinders in alignment with the compressor cylinders. They were comparatively slow-speed, operating usually at 220 r.p.m. or less, and had high power outputs per cylinder. The result was that immense concrete foundations were required to absorb the large horizontal thrust which was developed.

Early in the 1930's, so-called angle-type units were introduced. These are constructed with vertical power cylinders and horizontal compressor cylinders. The power output per cylinder has been reduced, and the speed and number of cylinders has been increased to provide a high total power output in a compact and efficient unit. A typical unit has a *V*-type arrangement of eight power cylinders. Four compressor cylinders are arranged horizontally and operate from the same crankshaft as the power cylinders. The power output is 300-horsepower per unit. Angle-type equipment can be installed for about two-thirds of the cost of the horizontal units, and is proportionately more economical in maintenance costs and space requirements.

Gas-engine driven compressors are available in units having well over 1,000 horsepower each. However, these are practicable only in service on large dry-gas transmission lines where comparatively steady volumes are handled. For natural gasoline plant service, smaller units possess greater flexibility and can be readily installed or removed to meet changing field conditions.

PLANT CONTROL

The most important basis for control over plant operation is what is known as the Absorption Factor, which was originally developed by Kremser and presented in a paper before the California Natural Gasoline Association in 1930. The original form of the absorption factor equation was as follows:

$$A = 3.156 \frac{D}{M} \quad \frac{PG}{p} \qquad \textit{(Equation 1)}$$

wherein A = absorption factor,
D = specific gravity of sponge,
M = molecular weight of sponge,
P = absorber pressure, pounds per square inch absolute,
G = gallons of sponge per m.c.f. of gas, and
p = vapor pressure in pounds per square inch absolute of constituent for which the factor is computed.

TABLE III—NUMBER OF NATURAL GASOLINE PLANTS IN OPERATION

YEAR	UNITED STATES	TOTAL CALIFORNIA
1911	176	*
1912	250	7
1913	341	14
1914	386	19
1915	414	20
1916	596	26
1917	886	49
1918	1,004	56
1919	1,191	60
1920	1,154	70
1921	1,056	73
1922	917	77
1923	1,067	119
1924	1,096	140
1925	1,081	145
1926	1,102	172
1927	1,119	152
1928	1,078	147
1929	1,087	153
1930	1,035	148
1931	937	136
1932	830	109
1933	779	97
1934	741	92
1935	715	88
1936	700	87
1937	679	90
1938	696	96
1939	652	91
1940	651	88
1941	609	86
1942	606	83
1943	610	83

* Information incomplete.

This equation quantitatively relates the variables in absorber operation. A change which increases the numerical value of the factor increases the efficiency of extraction. The ratio D/M in the equation takes into consideration the nature of the absorbent or sponge stock. Thus an oil which has a high density but low molecular weight is the preferred type of sponge. Other conditions remaining the same, the absorption factor is directly proportionate to the absolute operating pressure or to the oil rate. The influence of temperature is introduced in the term p. The importance of operating at low temperatures is evident when it is realized how rapidly the vapor pressure of a substance increases with a rise in temperature.

At the present time most natural gasoline plants are operated to recover substantially all the isobutane from intake gas. Thus an isobutane absorption factor is usually the basis for operating control.

Since plant capacity is a function primarily of the ability to circulate sponge stock once the operating pressure has been established, the absorption factor presents a simple means for comparing the sizes of plants that will effect different extents of recovery of light fractions. Before butanes were in demand, natural gasoline plants were operated for substantially complete isopentane recovery. In the normal range of operating temperatures (70°-100° F.) the isopentane absorption factor is about three and one-half times the isobutane factor for a given set of conditions. Thus to extract a given proportion of the available isobutane requires the circulation of about three and one-half times as much oil as to extract the same proportion of the isopentane.

Diagram III, taken from the Kremser paper, is a correlation between the absorption factor, the number of theoretical plates in an absorber and the efficiency of extraction. The importance of having an adequate number of trays is obvious when it is noted how rapidly at a given absorption factor the efficiency of extraction increases as the number of trays is increased. Likewise, it will be noted that a given efficiency of extraction can be maintained with a materially lower absorption factor and attendant plant investment and operating cost if adequate trays are used. It must be emphasized that the number of trays is based on theoretically perfect performance. For actual conditions the efficiency may be much lower. In this case the performance would be based on the line corresponding to the number of theoretical trays times the plate efficiency. Thus the performance of a 24-tray absorber having a plate efficiency of 50 per cent would be represented by the line of *Diagram III* corresponding to 12 theoretical plates. As a matter of interest, it will be noted that 100 per cent extraction would be obtained at a factor of 1.0 in an absorber having an infinite number of trays.

In terms of equilibrium constants, the absorption factor equation becomes:

$$A = \frac{L}{KV} = 3.156 \frac{D}{M} \frac{G}{K} \quad \textit{(Equation 2)}$$

wherein L = mols of liquid sponge,
V = mols of vapor, and
K = equilibrium constant, at absorber pressure and temperature, of the hydrocarbon for which the factor is computed.

The general concept of the absorption factor is extremely helpful in other phases of plant operation. Inverted, the absorp-

(Continued on Page 20)

Power Systems

(Continued from Page 3)

reserve has been practically eliminated in some instances; equipment has been operated at the limit of its capacity, but all essential demands have been supplied and the war program has not been handicapped by shortage of power. Fuel has been conserved and essential materials which otherwise would have gone into new generating and transmission facilities have been saved for urgent military needs.

LOOKING TO THE FUTURE

Hydroelectric power production, particularly in the West, is subject to very great variations between dry and wet years. No two watersheds are equally affected by such variations. Integrated operation of hydro developments on different watersheds tends to equalize the supply and minimize the use of fuel in auxiliary steam plants which are a part of every combined power system. In spite of all economies the war has caused a terrific drain on the fuel supplies of the country and this fact emphasizes the importance of conservation of such natural resources. The community will suffer if the lessons learned under the stress of a national crisis are not carried over to times of peace. Integrated operation which has proved so advantageous under government supervision during wartime should be continued voluntarily.

Plans are being made for extensive new developments of hydroelectric power. There are ardent advocates of immense government-operated power pools and equally ardent advocates of so-called private operation of power systems. Each plan has its advantages and disadvantages. The rivalry between these two schools of thought tests the mettle of the best men in the power business and tends to correct abuses on both sides of the fence. Engineering principles are universal. Engineers are confronted by the same problem, regardless of the political and social ideas of governing bodies, and engineers, regardless of their affiliations, can work together and get results, as has been so fully demonstrated during this war when national emergency has breached the political barriers between so-called public and private enterprise.

Integration of power systems is essential to a broad conservation program, and the successful cooperation effective under stress of war should be continued in times of peace, to the end that the community shall be provided with an adequate and reliable power supply at the lowest possible cost, and with the least possible draft on the irreplaceable national resources of the country.

C. I. T. Men In Service

DECEASED

Allen, Richard	'38	*	U.S.N.R.	Lost at Sea
Ashworth, Thos., Jr.	'41	*	U.S.N.R.	Killed in Plane Crash
Blumenthal, W. D.	'42	Cpl.	U.S.A.	Missing in Action
Brahty, J. H. A.	'32	Lt. Cmdr.	U.S.N.R.	Killed in Plane Crash
Hebel, Francis	'34	Lt. (j.g.)	U.S.N.R.	Killed at Pearl Harbor 1941
Losey, R. M.	'35	*	U.S.A.	Killed in Bombing Raid
Rowell, R. M.	'38	*	U.S.A.	Missing in Action
Schneider, C. J.	'39	*	U.S.M.C.	Killed in Action
Van Fleet, J. R.	'38	*	U.S.N.R.	Killed in Training Flight

The following is a list of men who have received degrees from the California Institute of Technology and who are now in military service. Information regarding additions or changes in rank or address should be addressed to the Alumni Office, California Institute of Technology.

Name	Class	Rank	Service	Location
Abbey, E. K.	'41	Lt.	U.S.N.R.	Overseas
Ackerman, J. B.	'38	Colonel	U.S.A.	*
Adams, P. L.	'44	*	U.S.N.R.	*
Ahuja, V. B.	'41	Lt.	Army of Mexico	Mexico
Albach, W. H.	'37	Lt.	U.S.N.R.	*
Alsaker, A. K.	'38	Lt. (j.g.)	U.S.N.R.	*
Allen, J. R.	'42	*	U.S.N.R.	*
Allen, P. H., Jr.	'42	Ensign	U.S.N.R.	*
Allingham, R. E.	'44	Ensign	U.S.N.R.	*
Allyne, A. B.	'26	Major	U.S.A.	Maryland
Altmaier, R. D.	'42	Ensign	U.S.N.R.	Washington, D.C.
Anderson, D. W.	'32	Lt. Cmdr.	U.S.N.R.	New York, N. Y.
Anderson, Keith	'40	Pvt.	U.S.A.	Overseas
Anderson, M. M.	'31	*	U.S.N.R.	Nevada
Anderson, R. E.	'42	Lt.	U.S.N.R.	Anacostia, D.C.
Andrews, R. A.	'42	*	U.S.A.	*
Antonenko, B. P.	'39	*	U.S.A.	Chanute Field, Ill.
Arnold, D. R.	'43	Lt. (j.g.)	U.S.N.R.	Mare Island, Calif.
Arnold, H. A.	'39	Lt.	U.S.N.R.	Massachusetts
Arnold, J. K.	'41	Capt.	U.S.A.	Hawaii
Arnold, M. W.	'37	Capt.	U.S.A.	Washington, D.C.
Ashley, C. L.	'26	Lt.	U.S.N.R.	*
Atchison, E. M.	'44	*	U.S.N.R.	*
Atherton, T. L.	'25	Capt.	U.S.M.C.	Overseas
Atkins, E. R., Jr.	'43	Lt. (j.g.)	U.S.N.R.	Overseas
Atkinson, T. G.	'42	Lt. (j.g.)	U.S.N.R.	Overseas
Axtman, Grice	'41	Ensign	U.S.N.R.	Washington, D.C.
Bacon, J. W., Jr.	'43	Lt.	U.S.A.	*
Bair, W. P.	'44	Ensign	U.S.N.R.	*
Baird, R. C.	'42	Major	U.S.A.	*
Baker, J. R.	'38	Ensign	U.S.N.R.	*
Ballard, W. O. B.	'44	*	U.S.N.R.	*
Banta, A. P.	'28	Major	U.S.A.	Overseas
Barfield, H. P.	'44	Lt.	U.S.A.	*
Barnes, D. P.	'30	Lt. Col.	U.S.A.	Overseas
Barnes, F. A.	'44	Ensign	U.S.N.R.	New York
Barnes, O. H.	'26	*	U.S.A.	Overseas
Baronowski, J. J.	'44	Lt. Cmdr.	U.S.N.	*
Bartlett, E. R., Jr.	'42	Lt. (j.g.)	U.S.N.R.	*
Bashor, R. H.	'43	Lt. (j.g.)	U.S.N.R.	Overseas
Baskin, A. C.	'37	Lt.	U.S.N.	*
Bassett, J. V.	'41	*	U.S.A.	*
Bassler, E. W.	'44	Ensign	U.S.N.R.	*
Bauer, F. K.	'42	Cpl.	U.S.A.	*
Baxter, A. N.	'45	*	U.S.N.R.	*
Beakley, W. M.	'35	Lt.	U.S.N.	*
Beanfield. B. F.	'39	Lt.	U.S.N.R.	Philadelphia, Pa.
Beardsley, G. F.	'39	*	U.S.N.	New York
Beauchamp, E. E.	'44	Ensign	U.S.N.R.	*
Beckstead, M. W.	'43	Ensign	U.S.N.R.	*
Beek, B. B.	'44	Ensign	U.S.N.R.	*
Beers, K. H.	'42	Ensign	U.S.N.R.	Overseas
Behrens, F. A., Jr.	'44	Ensign	U.S.N.R.	Overseas
Bell, A. E.	'42	*	U.S.N.R.	*
Bell, W. E.	'44	*	U.S.N.R.	*
Benjamin, D. G.	'44	Ensign	U.S.N.R.	*
Benson, G. L., Jr.	'44	*	U.S.N.R.	*
Belzer, T. R.	'37	Lt. Col.	U.S.M.C.	Overseas
Benioff, Ben	'22	Lt. Col.	U.S.A.	Salt Late City, Utah
Bennett, G. G.	'44	Ensign	U.S.N.R.	*
Bennett, R. L.	'44	Ensign	U.S.N.R.	Washington, D.C.
Benton, Robert	'43	S 1/c	U.S.N.R.	California
Berbower, R. F.	'45	*	U.S.N.R.	*
Bergh, P. S.	'42	*	U.S.N.R.	*
Bergren, W. R.	'32	Capt.	U.S.A.	Overseas
Berry, F. A., Jr.	'37	Lt.	U.S.N.	*

*Information lacking.

Name	Class	Rank	Service	Location
Berry, W. L.	'29	Lt. Col.	U.S.A.	New York
Best, Chas. W.	'36	*	U.S.A.	Utah
Bewley, J. W.	'43	Ensign	U.S.N.R.	Florida
Biddison, C. M.	'40	Ensign	U.S.N.R.	Florida
Biglow, J. O.	'40	Lt.	U.S.N.R.	Overseas
Bilicke, A. C.	'27	Lt. Col.	U.S.A.	Overseas
Billman, G. W.	'41	Lt. (j.g.)	U.S.N.R.	Overseas
Biot, Maurice A.	'32	Lt.	U.S.N.R.	Washington
Blayney, J. A.	'43	Lt.	U.S.A.	Grand Island, Nebr.
Blue, J. H.	'37	Major	U.S.M.C.	New York
Bogert, R. C.	'44	Capt.	U.S.A.	Ohio
Bolen, T. M.	'37	Lt.	U.S.A.	*
Bolster, C. M.	'36	Cmdr.	U.S.N.	Washington, D.C.
Bond, W. H.	'44	*	U.S.N.R.	*
Bonell, J. A.	'38	Lt.	U.S.A.	*
Booth, F. O., Jr.	'44	Ensign	U.S.N.R.	*
Boothe, R. H.	'36	Lt.	U.S.N.R.	Overseas
Borden, J. R.	'44	2nd Lt.	U.S.A.	*
Bower, M. M.	'27	Major	U.S.A.	Washington, D.C.
Bowler, Gordon E.	'32	Lt.	U.S.N.	*
Boyd, James	'27	Colonel	U.S.A.	*
Bracken, G. R.	'43	*	U.S.N.R.	*
Bradburn, J. R.	'32	Major	U.S.A.	New York
Brice, R. T.	'37	Major	U.S.A.	Overseas
Bridgland, E. P.	'43	Flt. Lt.	R.C.A.F.	Canada
Broadwell, J. E.	'44	*	U.S.A.	*
Brodie, R. P.	'44	*	U.S.N.R.	Rhode Island
Brose, F. M.	'40	2nd Lt.	U.S.A.	Douglas, Ariz.
Browder, E. M., Jr.	'37	Major	U.S.A.	Canal Zone
Brown, E. I.	'43	*	U.S.A.	*
Brown, F. W.	'40	Lt.	U.S.N.R.	Overseas
Brown, G. H., Jr.	'43	*	U.S.N.R.	*
Brown, K. G., Jr.	'44	*	U.S.N.R.	*
Brown, Sheldon W.	'42	Cmdr.	U.S.N.	Bethesda, Md.
Brown, Wayne H.	'43	Lt. (j.g.)	U.S.N.R.	*
Brown, W. A.	'41	*	U.S.A.	*
Browne, J. J.	'39	Lt. (j.g.)	U.S.N.R.	*
Bruce, S. C.	'41	*	U.S.A.	Randolph Field, Texas
Brunner, M. C.	'25	Colonel	U.S.A.	Fort Belvoir, Va.

Name	Class	Rank	Service	Location
Brydorf, Robert	'44	Ensign	U.S.N.R.	Los Angeles, Calif.
Buchanan, J. W.	'43	2nd Lt.	U.S.A.	South Carolina
Buchanan, R. A.	'44	Ensign	U.S.N.R.	*
Budney, Geo. S.	'45	*	U.S.N.R.	*
Buetall, T. D.	'43	S 1/c	U.S.N.R.	Treasure Island, Calif.
Buller, J. S.	'44	*	U.S.N.R.	*
Bungay, R. H.	'30	Major	U.S.A.	*
Bunker, E. R., Jr.	'43	*	U.S.A.	*
Burch, J. E.	'44	Ensign	U.S.N.R.	*
Burke, M. F.	'28	Lt.	U.S.A.	Washington
Burke, W. G.	'44	Ensign	U.S.N.R.	*
Burleigh, R.	'40	*	U.S.N.R.	*
Bussard, W. A.	'44	Ensign	U.S.N.R.	Florida
Cabral, H. J.	'44	Ensign	U.S.N.R.	Florida
Caldwell, N. H.	'41	*	U.S.A.	*
Callaway, W. F.	'42	Lt.	U.S.N.R.	Overseas
Campbell, D. C.	'41	Lt.	U.S.N.R.	Washington, D.C.
Campbell, R. S.	'37	Lt.	U.S.N.R.	Overseas
Capra, Frank R.	'18	Lt. Col.	U.S.A.	*
Carberry, D. E.	'30	Lt. Cmdr.	U.S.N.R.	San Francisco, Calif.
Carlmark, C. W.	'41	*	U.S.A.	*
Carlton, Jos.	'39	Lt.	U.S.A.	Texas
Carr, E. A.	'42	Lt.	U.S.N.R.	Massachusetts
Carstarphen, C. F.	'39	Lt.	U.S.N.R.	Overseas
Carter, C. L.	'43	Lt.	U.S.A.	*
Carter, T. A., Jr.	'44	*	U.S.N.R.	*
Casserly, F. G.	'41	Capt.	U.S.M.C.	South Carolina
Chadwick, J. H., Jr.	'44	*	U.S.N.R.	*
Chambers, L. S.	'44	Cmdr.	U.S.N.	Alabama
Chang, Howard	'44	PFC	U.S.A.	Minnesota
Chastain, J. A.	'42	Lt. (j.g.)	U.S.N.R.	Mare Island, Calif.
Chilberg, G. L.	'28	Lt.	U.S.A.	New Jersey
Christianson, W. L.	'43	*	U.S.N.R.	*
Clapp, G. W.	'26	Lt. (j.g.)	U.S.N.R.	Corpus Christi, Texas
Clark, Robert J.	'42	*	U.S.N.R.	*
Clendenen, F. B.	'44	*	U.S.N.R.	Rhode Island
Clingan, F. M.	'42	Lt.	U.S.N.R.	Overseas
Coates, L. D.	'39	Lt.	U.S.N.R.	*
Cobb, C. L.	'41	S 1/c	U.S.N.R.	*
Coda, L. R.	'44	*	U.S.N.R.	Texas
Cogen, W. M.	'31	Capt.	U.S.A.	Overseas
Cohn, G. L.	'42	Lt.	U.S.A.	Overseas
Collings, W. T.	'44	Ensign	U.S.N.R.	Rhode Island
Combs, T. C.	'27	Colonel	U.S.A.	Overseas
Cooley, R. A.	'42	Lt. Cmdr.	U.S.N.R.	Pasadena, Calif.
Copeland, G. B.	'44	Ensign	U.S.N.R.	*
Cowden, W. L.	'44	Ensign	U.S.N.R.	*
Craig, Carroll	'34	Lt.	U.S.N.R.	Arlington, Va.
Craig, P. H.	'33	Lt.	U.S.N.R.	Overseas
Crawford, E. G.	'33	Lt. Cmdr.	U.S.N.R.	*
Creal, Albert	'36	Lt. Col.	U.S.A.	Arlington, Va.
Creveling, Robert	'27	Capt.	U.S.A.	Dayton Field, Ohio
Cummings, C. I.	'44	2nd Lt.	U.S.A.	Cambridge, Mass.
Daams, Gerit	'40	Capt.	U.S.A.	Pasadena, Calif.
Dall, G. R.	'42	Lt.	U.S.A.	Overseas
Dameson, L. G.	'44	*	U.S.N.R.	*
Dana, I. R., Jr.	'44	Ensign	U.S.N.R.	Rhode Island
Dane, P. H.	'34	Lt. Col.	U.S.A.	Dayton Field, Ohio
Darling, M. D.	'27	Major	U.S.A.	Texas
Davis, J. S.	'45	*	U.S.N.R.	*
Davis, Stewart	'42	*	U.S.N.R.	Maryland
Davis, W. R.	'44	*	U.S.N.R.	*
Dazey, M. H.	'43	Lt. (j.g.)	U.S.N.R.	Overseas
Debevoise, J. M.	'44	Lt.	U.S.A.	*
DeCamp, L. S.	'30	Lt. Cmdr.	U.S.N.R.	*
DeRemer, K. R.	'44	Ensign	U.S.N.R.	Boston, Mass.
Desmond, J. M.	'34	Lt.	U.S.A.	Fort Monroe, Va.
Dessel, F. W., Jr.	'40	Lt. (j.g.)	U.S.N.R.	Overseas
Dethlefsen, D. G.	'44	Midshp.	U.S.N.R.	New York
Detmers, Fred	'33	2nd Lt.	U.S.A.	*
DeVoe, J. J.	'22	Major	U.S.A.	Fort Monmouth, N. J.
Dewdney, H. S.	'43	*	Canadian Army	
Dickey, W. L.	'31	Lt. Cmdr.	U.S.N.	San Francisco, Calif.
Dilworth, J. A.	'41	*	U.S.A.	*
Dixon, B. A., Jr.	'38	Ensign	U.S.N.R.	Washington, D.C.
Dixon, H. H.	'44	Flt. Officer	R.C.A.F.	Canada
Dobbins, W. E.	'41	Capt.	U.S.A.	Overseas

Name	Class	Rank	Service	Location
Dodge, W. O., Jr.	'44	2nd Lt.	U.S.A.	Fort Monmouth, N. J.
Doll, R. E.	'44	Lt. Cmdr.	U.S.N.R.	*
Donsback, W. R.	'44	*	U.S.N.R.	*
Doolittle, R. G.	'40	Lt.	U.S.N.R.	Anacostia, D.C.
Douglas, Perry	'29	Lt.	U.S.N.R.	*
Drake, J. A.	'42	2nd Lt.	U.S.A.	McCook, Nebr.
DuFresne, A. F.	'38	*	U.S.A.	Overseas
Dunbar, O. C.	'35	Major	U.S.A.	Overseas
Dunn, Allen W.	'29	Lt. Col.	U.S.A.	Overseas
Dunn, S. A.	'43	*	U.S.N.R.	*
Durfee, P. T.	'28	Lt. Col.	U.S.A.	Alaska
Durrenberger, R. W.	'41	*	U.S.A.	*
Duval, Richard H.	'28	Lt.	U.S.N.R.	*
Earl, J. B., II	'44	*	U.S.N.R.	*
Easley, S. J.	'41	*	U.S.A.	Sacramento, Calif.
Edelman, L. B.	'43	Ensign	U.S.N.R.	Annapolis, Md.
Edwards, G. L.	'41	Lt. (j.g.)	U.S.N.R.	Overseas
Edwards, J. S.	'37	2nd Lt.	U.S.M.C.	Quantico, Va.
Edwards, M. W.	'26	Lt.	U.S.A.	*
Elliott, T. D.	'42	Lt. (j.g.)	U.S.N.R.	Overseas
Ellis, A. T.	'43	*	U.S.A.	*
Ellison, W. J., Jr.	'37	Lt. Col.	U.S.A.	Overseas
Elmer, D. A.	'43	Lt. (j.g.)	U.S.N.R.	Mare Island, Calif.
Ellsworth, R. E.	'41	Major	U.S.A.	*
Ely, F. B.	'44	Lt.	U.S.N.R.	*
Ely, R. L.	'44	Lt.	U.S.A.	Wright Field, Ohio
Engelder, A. E.	'35	Capt.	U.S.A.	California
Engelder, P. O.	'39	Major	U.S.M.C.	Overseas
Estrada, N. S.	'44	Lt. (j.g.)	U.S.N.R.	*
Eusey, M. V., Jr.	'41	Lt. (j.g.)	U.S.N.R.	Overseas
Evans, B. G.	'23	Capt.	U.S.M.C.	Florida
Evans, Thos.	'30	Lt. Col.	U.S.A.	Washington, D.C.
Everett, W. S.	'34	Lt.	U.S.N.R.	San Francisco, Calif.
Fenzi, W. E.	'37	Ensign	U.S.N.R.	Rhode Island
Field, A. J.	'44	*	U.S.N.R.	*
Fischer, C. F.	'40	Lt. Cmdr.	U.S.N.R.	Maryland
Fisher, E. K.	'44	Ensign	U.S.N.R.	Massachusetts
Flavell, E. W.	'43	2nd Lt.	U.S.A.	Florida
Fleck, F. A.	'42	2nd Lt.	U.S.A.	Long Beach, Calif.
Fleisher, E. P.	'43	*	U.S.N.R.	*
Fleming, M. K., Jr.	'36	Lt.	U.S.N.R.	Washington, D.C.
Fleming, R. E.	'40	*	U.S.A.	*
Ford, M. E., Jr.	'44	Midshp.	U.S.N.R.	New York
Forward, R. B.	'38	Lt. Cmdr.	U.S.N.R.	Washington, D.C.
Foster, G. P.	'40	Capt.	U.S.M.C.	Overseas
Frampton, W. R.	'39	*	U.S.N.R.	San Diego, Calif.
Francis, R. M.	'44	Lt.	U.S.N.R.	*
Frank-Jones, Glyn	'41	Lt.	U.S.N.R.	Vancouver, B. C.
Franklin, E. S.	'33	Lt.	U.S.N.R.	Pasadena, Calif.
Franzini, J. B.	'42	Ensign	U.S.N.R.	Overseas
Freeman, J. R., Jr.	'44	*	U.S.N.R.	*
Fuller, W. P., Jr.	'42	*	U.S.N.R.	San Diego, Calif.
Fulton, R. F.	'39	Lt.	U.S.A.	Colorado
Furer, A. B.	'44	Lt. Cmdr.	U.S.N.	Philadelphia, Pa.
Galbreath, A. M.	'44	Ensign	U.S.N.R.	*
Galeski, R. B.	'41	*	U.S.N.R.	*
Gally, S. K.	'41	Lt. (j.g.)	U.S.N.R.	*
Gardner, A. H.	'43	Ensign	U.S.N.R.	*
Gardner, J. H.	'44	*	U.S.N.R.	*
Garland, J. J., Jr.	'44	Ensign	U.S.N.R.	Norfolk, Va.
Garner, H. K.	'43	*	U.S.N.R.	*
Gazin, C. L.	'27	Major	U.S.A.	*
Geitz, Robert	'41	Lt. (j.g.)	U.S.N.R.	Overseas
Gentner, W. E.	'40	Lt.	U.S.N.R.	*
George, J. W.	'37	Sgt.	U.S.A.	Colorado
Gerfen, W. H.	'36	Ensign	U.S.N.R.	Overseas
Geselbracht, W. G.	'38	Capt.	U.S.A.	Missouri
Giacomazzi, W. F.	'43	Lt.	U.S.A.	California
Gibbons, R. M.	'42	Lt. Cmdr.	U.S.N.	Rhode Island
Gillette, Warren	'42	Lt. (j.g.)	U.S.N.R.	Overseas
Gillings, J. W.	'41	Lt.	U.S.A.	*
Gilman, Richard	'44	2nd Lt.	U.S.M.C.	*
Given, F. I.	'42	*	U.S.A.	*
Glassco, R. B.	'40	Ensign	U.S.N.R.	San Diego, Calif.
Goldsmith, E. A.	'44	Ensign	U.S.N.R.	Overseas
Graff, D. B.	'32	Lt.	U.S.A.	*
Graham, H. K.	'43	2nd Lt.	U.S.A.	Texas
Gramatky, F. G.	'28	Major	U.S.A.	New Guinea
Graner, J. B.	'43	Ensign	U.S.N.R.	*
Grasso, C. H.	'44	2nd Lt.	U.S.A.	*
Graul, D. P.	'37	Capt.	U.S.A.	Maryland
Gray, J. B.	'44	Lt.	U.S.N.R.	*
Green, W. M.	'39	Capt.	U.S.A.	Wright Field, Ohio
Greenhalgh, F. M.	'41	Lt. (j.g.)	U.S.N.R.	*
Greenwood, D. T.	'44	*	U.S.N.R.	*
Griffin, R. H.	'31	*	U.S.A.	Minnesota
Griffith, G. D.	'43	Lt. (j.g.)	U.S.N.R.	Texas
Griffiths, J. R.	'39	*	U.S.N.R.	*
Grimes, W. B.	'29	Lt. Col.	U.S.A.	Overseas
Grimm, Lewis	'44	Ensign	U.S.N.R.	*
Grote, A. O.	'43	*	U.S.N.R.	Treasure Island, Calif.
Gruen, Harold	'43	*	U.S.A.	*
Guillou, A. V.	'40	Lt. Col.	U.S.A.	Overseas
Gulick, H. E.	'34	Lt.	U.S.A.	*
Gulley, Wm. F.	'45	*	U.S.N.R.	*
Hacker, W. D., Jr.	'33	Capt.	U.S.A.	New York
Hahs, M. L.	'44	2nd Lt.	U.S.A.	*
Hale, F. S.	'27	Capt.	U.S.A.	Overseas
Hall, A. S.	'44	Ensign	U.S.N.R.	*
Hall, E. A.	'41	*	U.S.A.	*
Hall, E. E.	'43	2nd Lt.	U.S.M.C.	Virginia
Hall, E. S.	'44	*	U.S.N.R.	Washington, D.C.
Hall, Robert F.	'42	Ensign	U.S.N.R.	South Carolina
Hall, W. A.	'42	Lt. (j.g.)	U.S.N.R.	Mare Island, Calif.
Hall, W. L.	'44	*	U.S.N.R.	*
Hallwachs, R. G.	'44	Ensign	U.S.N.R.	*
Halpenny, W. H.	'43	Lt. (j.g.)	U.S.N.R.	Annapolis, Md.
Hamilton, W. R.	'44	*	U.S.N.R.	*
Hanchett, H. K.	'43	*	U.S.A.	*
Hanger, W. M.	'43	*	U.S.N.	California
Hanson, L. A.	'42	Lt. (j.g.)	U.S.N.R.	*
Hardin, P. V.	'43	*	U.S.A.	*
Harney, P. J.	'35	T/S	U.S.A.	*
Harper, T. S.	'37	Lt.	U.S.N.R.	*
Harrell, DeWitt	'44	Lt. Cmdr.	U.S.N.	*
Harris, H. R.	'22	Colonel	U.S.A.	Washington, D.C.
Harrison, Chas. P.	'44	Ensign	U.S.N.R.	*
Harrison, K. J.	'18	Lt. Col.	U.S.A.	Phoenix, Ariz.
Harshberger, J. D.	'34	Lt.	U.S.M.C.	*
Harvey, D. L.	'41	Major	U.S.A.	Illinois
Hasert, C. N.	'44	Lt.	U.S.A.	*
Haymond, C. D.	'43	*	U.S.A.	*
Hayward, R. E.	'38	*	U.S.A.	*
Head, R. M.	'42	Ensign	U.S.N.R.	Washington, D.C.
Heinz, J. A.	'45	*	U.S.N.R.	*
Hendrickson, W. J.	'42	*	U.S.A.	*
Hiatt, J. B.	'41	Lt. (j.g.)	U.S.N.R.	Bremerton, Wash.
Hicks, W. B.	'42	*	U.S.A.	*
Higgins, H. M.	'44	*	U.S.N.R.	*
Hight, C. T.	'41	Capt.	U.S.A.	Overseas
Hill, R. R., Jr.	'44	Ensign	U.S.N.R.	*
Hills, J. D. T.	'39	Lt.	U.S.A.	*
Hines, M. E.	'40	*	U.S.A.	*
Hinton, W. D.	'44	*	U.S.N.R.	*
Hite, J. E., Jr.	'40	Lt.	U.S.N.R.	Overseas
Hoagland, J. C.	'42	*	U.S.N.R.	Annapolis, Md.
Hoch, W. C.	'31	Lt.	U.S.N.R.	Washington, D.C.
Hoff, F. G.	'39	Lt. (j.g.)	U.S.N.R.	Hastings, Nebr.
Holser, W. T.	'42	Lt.	U.S.N.R.	Washington, D.C.
Holzman, Benj.	'31	Lt. Col.	U.S.A.	Washington, D.C.
Honnell, P. M.	'40	Lt. Col.	U.S.A.	West Point, N.Y.
Hooper, D. L.	'34	Lt. Cmdr.	U.S.N.R.	Overseas
Hooper, R. H.	'39	Lt.	U.S.A.	Overseas
Horne, Othneil	'42	Lt.	U.S.A.	Nebraska
Hotchkiss, T. M.	'25	Lt.	U.S.N.R.	California
Howell, W. J.	'40	Lt.	U.S.M.C.	North Carolina
Hubert, D. S., Jr.	'40	Pvt.	U.S.A.	*
Hudson, L. U.	'44	*	U.S.N.R.	*
Hudson, R. A.	'44	*	U.S.N.R.	*
Hudson, T. A.	'44	*	U.S.N.R.	*
Hudson, T. E.	'44	*	U.S.N.R.	*
Huggins, J. G.	'44	*	U.S.N.R.	*
Hughes, L. E., Jr.	'44	Lt. (j.g.)	U.S.N.R.	San Francisco, Calif.
Hughes, W. H.	'44	Ensign	U.S.N.R.	Overseas
Hunt, Carter	'42	Lt.	U.S.N.R.	Overseas
Hurst, S. D.	'44	*	U.S.N.R.	*
Ingersoll, H. V.	'26	*	U.S.A.	Philippine Islands
Ingersoll, W. L.	'41	Ensign	U.S.N.R.	*
Jack, S. S.	'38	Capt.	U.S.M.C.	*
Jackson, A. M., Jr.	'39	Lt.	U.S.N.	*
Jackson, W. C., Jr.	'44	Lt. Cmdr.	U.S.N.	*
Jasper, R. N.	'45	*	U.S.N.	Rhode Island
Johns, R. R.	'43	*	U.S.N.R.	*
Johnsen, E. G.	'43	Lt.	U.S.A.	Overseas
Johnson, K. W.	'43	Ensign	U.S.N.R.	*

Name	Class	Rank	Service	Location
Johnson, L. B.	'44	Ensign	U.S.N.R.	*
Johnson, P. O.	'42	Pvt.	U.S.A.	Ohio
Johnson, R. S.	'44	Ensign	U.S.N.R.	*
Johnson, W. S.	'26	Capt.	U.S.A.	California
Johnston, W. C.	'42	Lt.	U.S.A.	Colorado
Jones, G. A.	'41	Lt.	U.S.N.R.	Overseas
Jones, J. A.	'41	Ensign	U.S.N.R.	Philadelphia, Pa.
Jones, O. K.	'41	Lt. Col.	U.S.A.	Overseas
Jones, P. S.	'36	Ensign	U.S.N.R.	Arizona
Jones, R. P.	'35	Lt.	U.S.N.R.	Overseas
Jones, W. B.	'38	Lt.	U.S.N.R.	Overseas
Jones, W. L.	'43	Lt. (j.g.)	U.S.N.R.	Overseas
Jopson, R. C.	'44	Ensign	U.S.N.R.	New Jersey
Jordon, J. T.	'41	Carp. Mate 1/C	U.S.N.R.	Overseas
Joujon-Roche, J. E.	'28	Major	U.S.A.	North Carolina
Judd, H. C.	'44	Ensign	U.S.N.R.	Overseas
Kafitz, P. H.	'42	Chief Spec.	U.S.N.R.	Washington, D.C.
Kane, R. F.	'43	Cmdr.	U.S.N.	Annapolis, Md.
Karstedt, F. H.	'44	*	U.S.N.R.	*
Keating, D. A.	'44	*	U.S.N.R.	*
Keech, D. W.	'26	Lt.	U.S.A.	San Diego, Calif.
Keller, S. H.	'38	Lt. (j.g.)	U.S.N.R.	Overseas
Kemmer, P. H.	'33	Colonel	U.S.A.	Wright Field, Ohio
Kennedy, E. R.	'33	Major	U.S.A.	Overseas
Kern, J. C., Jr.	'44	Ensign	U.S.N.R.	*
Kerr, J. G.	'44	Ensign	U.S.N.R.	Camp Endicott, R. I.
Kettler, J. R.	'44	*	U.S.A.	Texas
Kidd, R. E.	'35	Lt.	U.S.N.R.	Washington, D.C.
King, J. L.	'40	Capt.	U.S.N.	Pasadena, Calif.
Kingsbury, W. S., Jr.	'26	Major	U.S.A.	Overseas
Kinsler, L. E.	'31	Lt. Cmdr.	U.S.N.	Annapolis, Md.
Klein, D. J.	'43	Ensign	U.S.N.R.	Massachusetts
Kneymeyer, F. H.	'44	Ensign	U.S.N.R.	Florida
Knudsen, R. A. B.	'44	*	U.S.N.R.	*
Knudson, A. G., Jr.	'44	*	U.S.N.R.	*
Kolb, L. L.	'39	Major	U.S.A.	Minnesota
Kott, W. E.	'44	Ensign	U.S.N.R.	Washington, D.C.
Krick, I. P.	'33	Lt. Col.	U.S.A.	Washington, D.C.
Kruse, F. W.	'44	*	U.S.N.R.	*
Kuhns, R. E.	'44	Ensign	U.S.N.R.	Overseas
Laabs, R. F.	'44	*	U.S.N.R.	*
Labory, R. F.	'31	Lt.	U.S.N.R.	Virginia
LaForge, G. R.	'43	S 1/c	U.S.N.R.	California
Lakos, E. A.	'41	Lt.	U.S.N.R.	Virginia
Landau, Alfred	'42	2nd Lt.	U.S.A.	Overseas
Larabee, O. S.	'25	Lt. Col.	U.S.A.	Washington, D.C.
Larson, E. R.	'42	Lt. (j.g.)	U.S.N.R.	Overseas
Larson, L. C.	'22	Capt.	U.S.A.	Los Angeles, Calif.
Larson, W. R.	'40	Capt.	U.S.A.	Tennessee
Lassen, H. A.	'43	Ensign	U.S.N.R.	Overseas
Latter, Richard	'42	Lt.	U.S.N.R.	*
Laue, E. G.	'40	Ensign	U.S.N.R.	*
Lauterback, R. E.	'44	Midshp.	U.S.N.R.	New York
Lawrence, B. E.	'41	Lt. (j.g.)	U.S.N.R.	*
Lawrence, Theo.	'43	Ensign	U.S.N.R.	*
Lawson, W. G.	'39	Lt. (j.g.)	U.S.N.R.	Mare Island, Calif.
Leenerts, L. O.	'44	Ensign	U.S.N.R.	*
Leeper, L. D.	'31	Lt.	U.S.A.	Overseas
Leggett, J. R.	'37	Lt. (j.g.)	U.S.N.R.	Overseas
Lester, R. W.	'44	Ensign	U.S.N.R.	New Jersey
Levet, Melvin	'39	Capt.	U.S.A.	Overseas
Levin, G. B.	'40	*	U.S.A.	*
Levenson, B. D.	'41	Lt.	U.S.A.	Overseas
Lew, H. W.	'31	*	U.S.A.	Florida
Lewis, Chas. F.	'28	Capt.	U.S.A.	Overseas
Lewis, E. B.	'42	*	U.S.A.	*
Liddicoat, R. L.	'44	Ensign	U.S.N.R.	*
Lind, C. F.	'32	Lt.	U.S.N.R.	*
Lind, G. W., Jr.	'42	Ensign	U.S.N.	Tucson, Ariz.
Lester, R. W.	'44	*	U.S.N.R.	New Jersey
Lingle, H. C.	'43	Lt.	U.S.A.	Texas
Llewellyn, F. E.	'38	Lt.	U.S.N.R.	Massachusetts
Loeffler, D. E.	'40	Lt.	U.S.A.	California
Lochhead, R. R.	'44	*	U.S.N.R.	*
Lockwood, W. E., Jr.	'44	*	U.S.N.R.	*
Long, E. L.	'43	Ensign	U.S.N.R.	Overseas
Long, N. S.	'44	Ensign	U.S.N.R.	Overseas
Lovett, B. B. C.	'36	*	U.S.N.R.	*
Low, P. F.	'44	2nd Lt.	U.S.A.	*
Lowe, E. K.	'45	*	U.S.N.R.	*
Lownes, E. D.	'24	Lt. Col.	U.S.A.	Canada
Lynn, L. E.	'29	Lt. Col.	U.S.A.	*
Macartney, E. J.	'43	Ensign	U.S.N.R.	Connecticut
MacDonald, F. E., Jr.	'44	*	U.S.N.R.	*
MacDonald, J. H.	'30	Lt.	U.S.N.R.	Washington, D.C.
MacDonald, Robert	'33	Major	U.S.A.	Overseas
MacKenzie, D. C.	'22	Lt. Col.	U.S.A.	Georgia
MacKnight, R. H.	'39	*	U.S.M.C.	*
MacRostle, Wayne	'42	Lt. (j.g.)	U.S.N.R.	Overseas
Madley, H. H.	'42	Lt. (j.g.)	U.S.N.R.	Utah
Maginnis, Jack	'37	*	U.S.N.	*
Maier, M. P.	'44	Lt.	U.S.A.	*
Maier, O. G.	'36	Col.	U.S.A.	New Jersey
Main, J. H.	'41	*	U.S.N.R.	Pennsylvania
Maloney, F. V.	'36	Lt. (j.g.)	U.S.N.R.	Overseas
Mapel, R. W.	'44	*	U.S.N.R.	*
Marsh, R. E.	'43	*	U.S.N.R.	*
Marshall, J. W.	'44	Ensign	U.S.N.R.	*
Marshall, R. W., Jr.	'44	Ensign	U.S.N.R.	*
Martin, J. S.	'44	*	U.S.N.R.	*
Martinez, Victor	'42	Lt.	Argentine Nav. Com.	Washington, D.C.
Mason, D. M., Jr.	'43	Ensign	U.S.N.R.	New York
Mason, H. S.	'32	Lt.	U.S.A.	California
Mathews, T. E., Jr.	'32	Lt.	U.S.A.	California
Mathewson, A., Jr.	'33	Lt.	U.S.N.R.	Overseas
Matson, Joseph, Jr.	'26	Lt. Col.	U.S.A.	Overseas
Matthew, T. R.	'39	Lt.	U.S.N.R.	Pasco, Wash.
Mattson, D. F.	'43	*	U.S.N.R.	Texas
Mauzy, H. K.	'30	Lt. Cmdr.	U.S.N.R.	Florida
Maxson, J. H.	'27	Major	U.S.A.	Washington, D.C.
Mayer, Adrian	'42	*	U.S.A.	Illinois

Due to lack of space it is impossible to complete the list of Men in Service in the June issue. Names beginning with the letters "Mc" to "Z" will be published in the July issue.

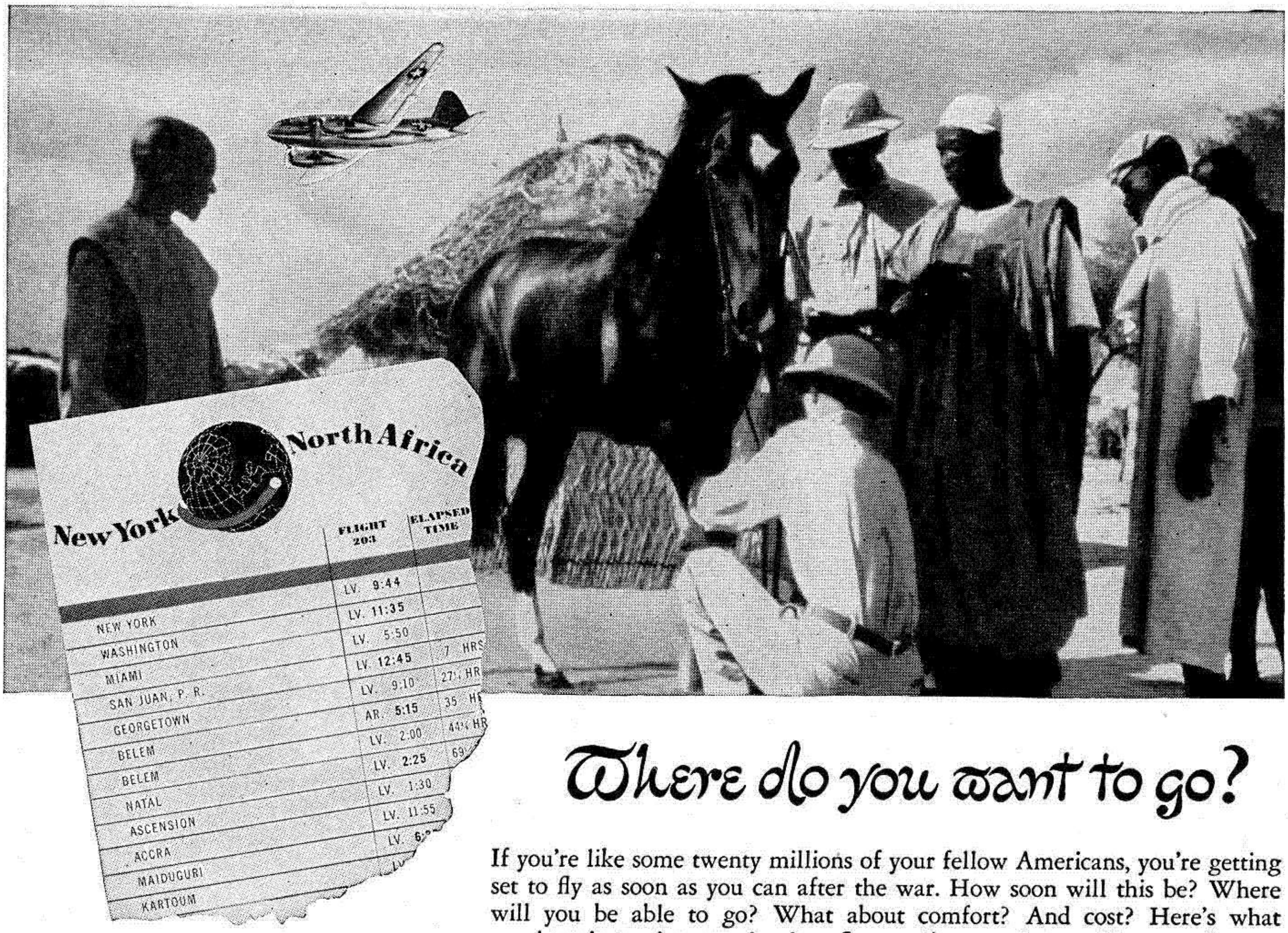
ATHLETICS

By H. Z. MUSSELMAN,
Director of Physical Education

THE month of May, 1945, will bear a prominent place in the athletic history of California Institute of Technology, for it was this month that three sports—baseball, track and swimming brought league championships to the Institute. This together with the tennis tournament victories and the undefeated, untied and unscored-on record of the football team last Fall, makes the 1944-1945 sport season the most outstanding ever recorded at Caltech.

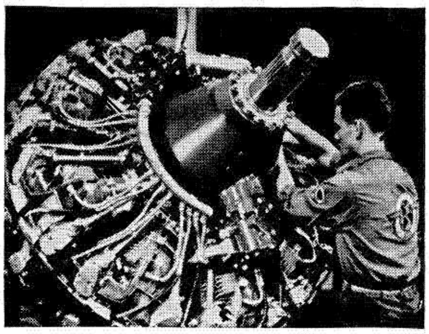
The baseball team won seven out of eight league games, winning two games from each, U.C.L.A., Pepperdine and Occidental, and split the series with U.S.C. The Beavers clinched the title two weeks before the season closed, when an 8-0 victory over U.C.L.A. put the Bruins out of the running. The only defeat registered by the Engineers was at the hands of U.S.C. when the Trojans grabbed a 11-9 mid-season free-hitting affair. Featuring the season were the two victories over U.C.L.A. at the time when the Bruins were fighting it out with Tech for the top spot. In the first engagement, Jack Anderson, starting his first game of the season, pitched and batted his team to a 3-1 victory, while holding his opponents to six hits and striking out nine men. In the return encounter, Anderson again was in fine form, limiting U.C.L.A. to four hits while his team mates pounded out an 8-0 victory. Incidentally, only one other shutout game was recorded in the league this season.

With Anderson and Dick Roettger, two topnotch pitchers, available, many midweek games were played with the record against Junior College and the top Service teams as impressive as the league record. The complete result for the season shows 17 victories and one tie in 22 games played. The team was strong in all departments and all league games were won in a convincing manner. Six men finished the season with a batting average of over .350 in league contests.



Where do you want to go?

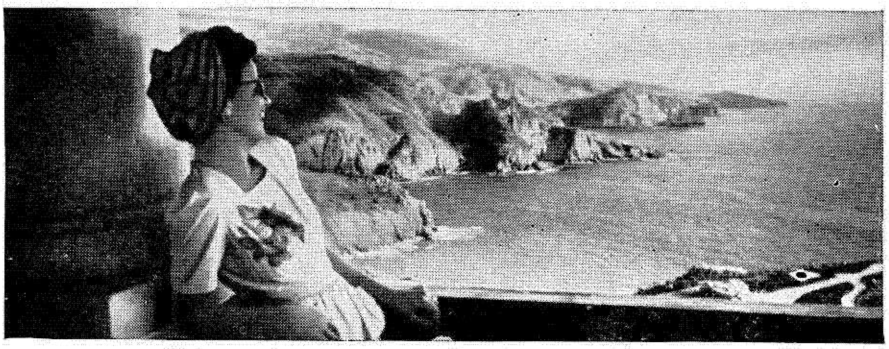
If you're like some twenty millions of your fellow Americans, you're getting set to fly as soon as you can after the war. How soon will this be? Where will you be able to go? What about comfort? And cost? Here's what an American airman who has flown all over the world can tell you:



1. "No place worth seeing will be out of reach . . . The main routes are being flown daily — more than 110,000 miles of them. Key airfields are fully developed — hundreds more are in the making. The finest flying equipment ever designed will be ready for use soon after the war ends.

2. "The peacetime versions of the big twin-engine Curtiss Commando, for instance, will carry 36 to 45 people with all the comforts of a drawing room . . . soft, roomy seats — plenty of space — an attractive powder room — complete dining service—they'll be tops in luxury travel . . .

3. "And as for speed . . . well, when multi-engine transports can cross the country in six hours, you get some idea of the concentration of power in their Wright Cyclone engines — the same dependable engines that power the B-29 Superforts and the giant Martin Mars.



4. "Vacations in Mexico, in Rio, on the Mediterranean, by air, may seem fantastic right now. Yet 27 airlines are already planning to take you to the markets and the playgrounds of the world at a cost well within your reach . . . "

FIRST IN FLIGHT

CURTISS WRIGHT

AIRPLANES • ENGINES • PROPELLERS

[*Aviation offers a bright future for College Engineers: Write Engineering Personnel Bureau, Curtiss-Wright Corporation, Passaic, N. J.*]

The league results:

Caltech	21	Pepperdine	5
Caltech	10	U.S.C.	9
Caltech	13	Occidental	2
Caltech	9	U.S.C.	11
Caltech	3	U.C.L.A.	1
Caltech	13	Pepperdine	3
Caltech	8	U.C.L.A.	0
Caltech	7	Occidental	3

Dr. Floyd Hanes and his sensational track squad produced a season of thrills by winning the conference meet, accounting for victories over U.S.C., U.C.L.A. and California, defeating all comers at the Fresno West Coast Relays and finishing a close second in the Modesto Relays.

Seeking further laurels, Caltech rudely startled the sports world by trouncing U.S.C., U.C.L.A., and California to capture three dual meets in one afternoon in a feature meet at the Coliseum.

Caltech	70-1/3	U.S.C.	60-2/3
Caltech	68-2/3	California	62-1/3
Caltech	83-2/3	U.C.L.A.	47-1/3

Winning from three major schools in a decisive manner, several of the Tech spikesters turned in their best performance of the season. Frady was nosed out by Beaman of SC in the 100, but came back strong to annex the 220 in 21.8s. Ken Shauer cracked the Caltech 440 record for the second time this season with a 49.4s win, while Neilsen topped his record with a mark of 12 ft. 6 in. win in the pole vault. The mile relay team of Roger Clapp, Bill Frady, Stuart Bates and Ken Shauer won over California by 10 yards in 3m 22.5s, the best time registered on the coast this season.

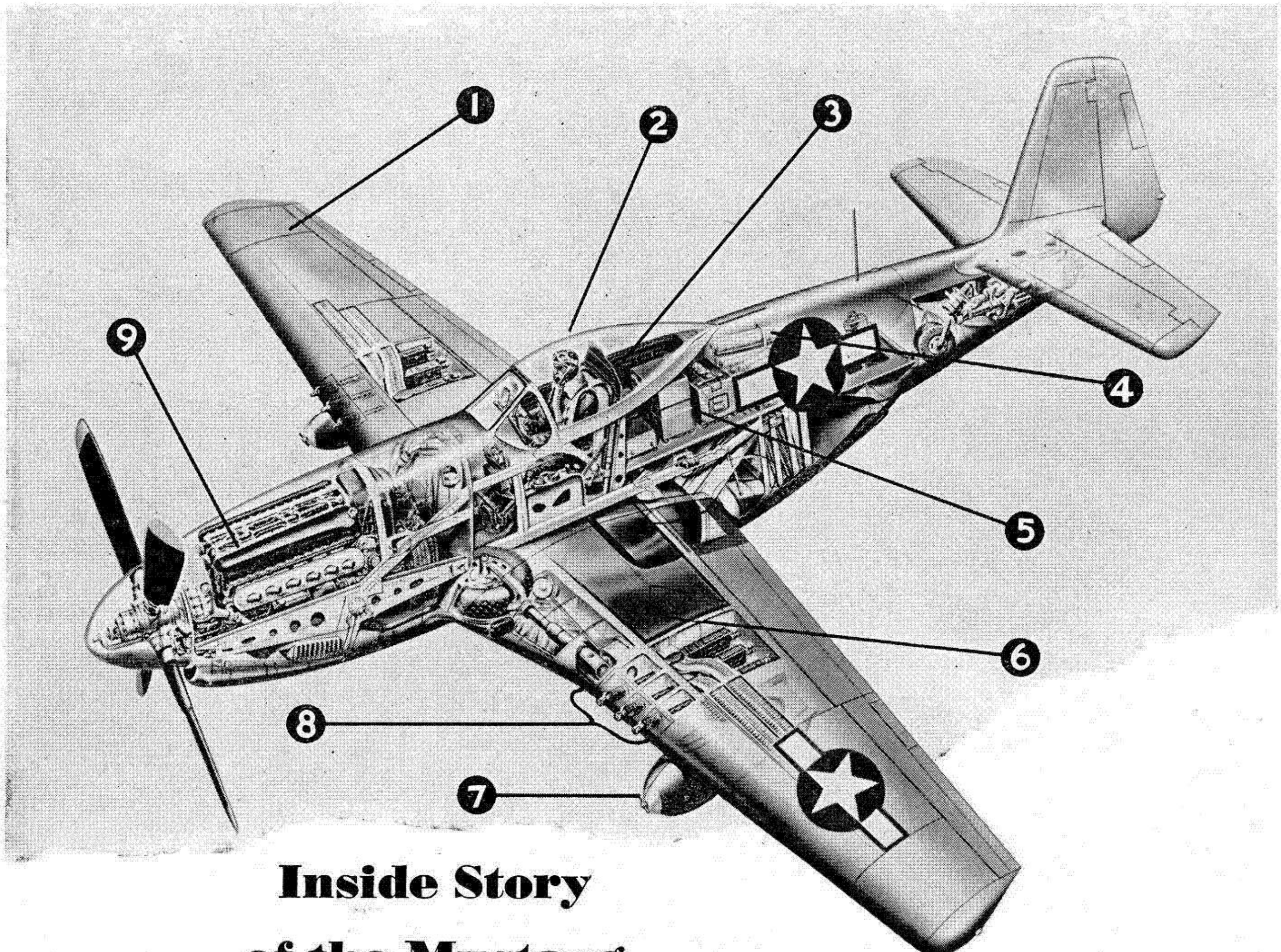
In the competition, first places were evenly divided between Caltech, U.S.C. and California—each school leading the field in five events.

Caltech won its first Fresno Relays open championship, annexing the title through a last minute victory in the mile relay. The Engineers scored 41 points. Olympic Club placed second with 36 points. California nosed the defending champions, U.S.C., for third with 32½ points to 32. U.C.L.A. Bruins registered 25, with various minor teams trailing. The last Tech victory at Fresno was in 1927 when the Engineers won the Class *B* or College title.

Winning five of their six meets over U.S.C., U.C.L.A. and Occidental, Coach Bud Lyndon's swimming team concluded the season with an easy victory over these rivals in the Conference meet. Tech registered 63 points, U.S.C. was a close second with 59 points, while U.C.L.A. and Occidental trailed with 26 and 12 points respectively. Two high scorers for the season were Rex Cherryman, who set a new Caltech record of 1m 50.6s in the 150-yard back stroke and Don Lindsay, diver. Lindsay won his event in all meets, only to be nosed out by a few points by Fenton of U.C.L.A. whom he had defeated twice in dual meets.

After completing a mediocre season, in which the team won four and lost four, the Caltech tennis team came back strong to sweep the championships in the Intercollegiate Tennis Tournament. In the finals Stan Clark defeated his teammate, Jack Cardall, after the latter had scored an upset over Nick Buzolich of Pepperdine. Clark and Cardall also won the doubles championship in defeating the favorites, Burt and Donnell of U.S.C.

The Institute plans to send Clark and Cardall to the N.C.A.A. Intercollegiate Tennis Tournament at Northwestern University, which starts June 25.



Inside Story of the Mustang

Here are nine reasons why the P-51 Mustang is the most efficient, most deadly, most feared American fighter-plane in enemy skies:

1. **REVOLUTIONARY DESIGN**—laminar-flow super-speed wing.
2. **NO BLIND SPOTS**—full vision cockpit enclosure.
3. **ARMOR PLATE**—this bullet-proof seat back protects Mustang pilots.
4. **FIGHTS EIGHT MILES UPSTAIRS**—these tanks provide oxygen for pilot.
5. **TWO-WAY RADIO**—provides close coordination during missions.
6. **SELF-SEALING GAS TANKS**—an important safety factor in combat.
7. **BOMB LOAD**—1000 pounds under each wing.
8. **DEADLY FIREPOWER**—six .50 cal. machine guns, three in each wing.
9. **SPEED—OVER 425 MPH**—1520 HP supercharged engine and automatic, variable pitch propeller.

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Whether you are newly graduated or experienced, North American Aviation invites you to join its engineering staff to assist in the improvement of our present aircraft and the designs to come. Here is an opportunity to grow in a sound, progressive company with a world-wide reputation for building fine aircraft.

Your questions about this essential, war-vital work will be answered by men experienced in aviation and engineering.

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North American Aviation *Sets the Pace*

PLANES THAT MAKE HEADLINES... *the P-51 Mustang fighter (A-36 fighter-bomber), B-25 and PBJ Mitchell bomber, the AT-6 and SNJ Texan combat trainer. North American Aviation, Inc. Member, Aircraft War Production Council, Inc.*

Natural Gasoline

(Continued from Page 12)

tion factor becomes a stripping factor applicable to controlling the operation in which the absorbed fractions are removed from the rich sponge stock. By an appropriate change in units, the equation becomes:

$$S = \frac{1}{A} = \frac{KV}{L} = \frac{KW}{150} \frac{M}{D} \quad \textit{(Equation 3)}$$

wherein S = stripping factor, and
W = pounds of steam per gallon of oil.

A similar approach could be made to the performance of a rectifier or fractionating column. The section of the column above the feed could be considered as an absorber and that below the feed as a stripper. Reflux in the upper section serves as sponge stock, and vapors from the reboiler serve as the stripping medium in the lower section.

STATISTICS

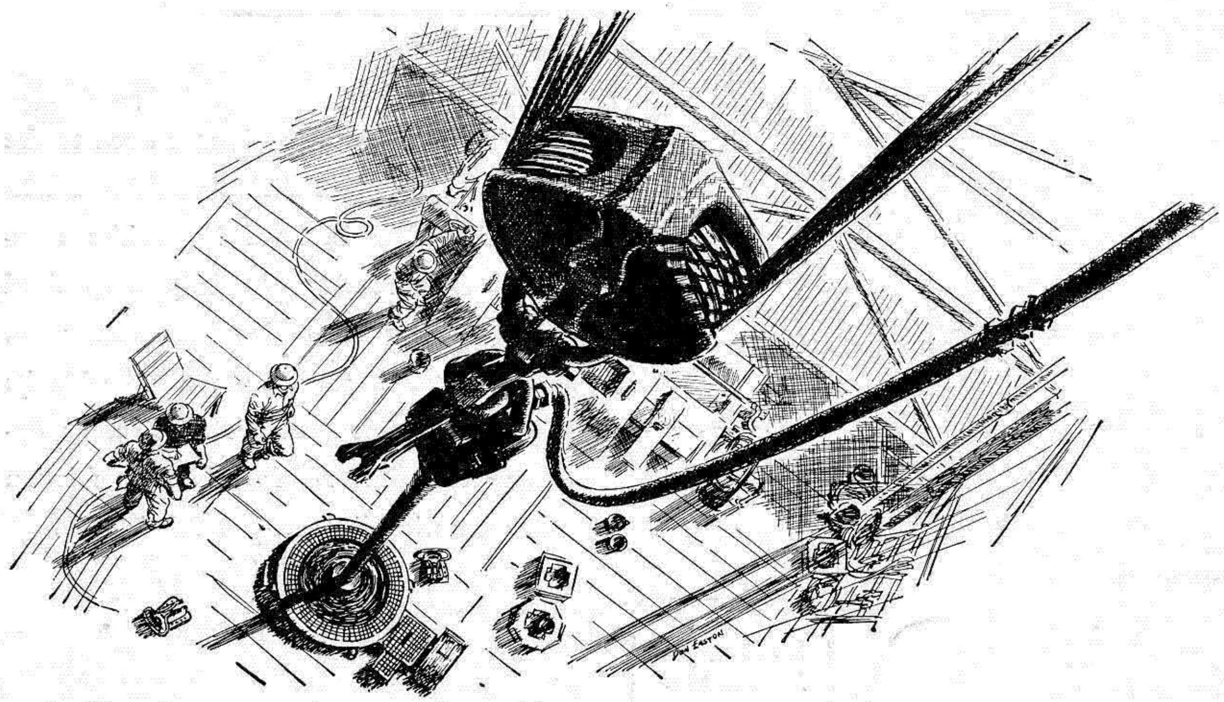
Table II is a summary of the average daily production of natural gasoline and refinery gasoline in California and the United States for the years 1911 to 1943. The figures for refinery gasoline include the natural gasoline which has been blended into the product.

Production of natural gasoline in the United States is now slightly more than 15 per cent of the entire output of refinery gasoline. In California, the ratio is almost the same. Prior to the present war, the ratio in California was appreciably higher than in the United States as a whole. However, in the concerted effort to increase the production of light fractions for use in aviation gasoline it was possible to expand production at a much faster rate elsewhere than in California. California is now the source of about 15 per cent of the total natural gasoline produced in the United States, but in a number of prewar years the percentage was about double that.

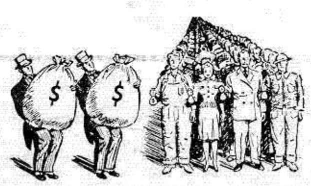
Table III represents the number of natural gasoline plants operated in the United States and in California in the years from 1911 to 1943. The total number in the United States is shown to have increased rapidly from 176 in 1911 to a peak of 1,191 in 1919. From that time until 1930, with the exception of one year, the number stayed in excess of 1,000 but subsequently there has been a decline.

The relatively static position of the number of plants in the 1920's was due to the fact that as fast as new ones were built, there was an elimination of small units which became unprofitable to operate. Also, with the inception of the oil absorption process, there were many cases where a single new plant of this type took the place of several small compression plants. The decline since 1930 has been in a large measure due to construction of jointly-owned plants in new fields which are co-operatively developed by the various oil operators. The result has been a trend towards a smaller number of plants with larger individual capacities. In recent years, approximately one-seventh of the entire number of plants in the United States has been operating in California.

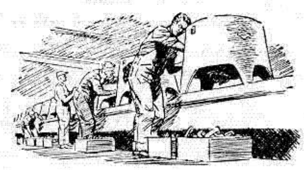
The above statistics are believed to indicate, in turn, the importance of natural gasoline in relation to the entire output of motor and aviation gasoline and the importance of California in the natural gasoline industry of the United States.



$2.10 to drill an oil well?

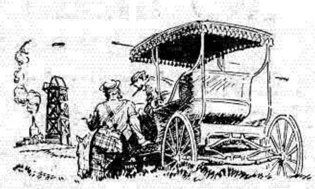


1 Yes—the average oil well, drilled by Union Oil in California, costs $65,888. If you divide that expense between two men, it would cost them $32,944 apiece. But if you divide it among 31,375 people, as we do, the average cost to each person is only $2.10.



2 For Union Oil Company is owned not by one man, or two, but by 31,375 men and women. In this principle of *multiple ownership* you have the secret of America's amazing ability to produce more goods (at lower prices) than any other nation on earth.

3 Before the machine age, when everything from shoes to rifles was made by hand, almost any business could be financed and operated by one man. But with the advent of mass production techniques, many businesses began to require more equipment than any one man could finance.



4 In the early 1890's, for example, you could drill an oil well in the California fields for about $2,500. Today, because we go so much deeper and need such expensive equipment, *it costs almost 26 times as much.* Furthermore, the chances of getting oil in an exploratory well are *only 1 in 12.*

5 Obviously, you can't finance that kind of operation for very long unless you pool the money *of a lot of people.* Now some countries form these pools by government ownership. But in America we do it under legal agreements known as *corporations.* For that way we can preserve the *freedom* of the individual...

6 ... the efficiency of a free economy and that all-important human incentive—*competition.* Apparently those factors are worth preserving. For while our system isn't perfect yet, it has given us the highest standard of living and the greatest capacity for production the human race has ever known.

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