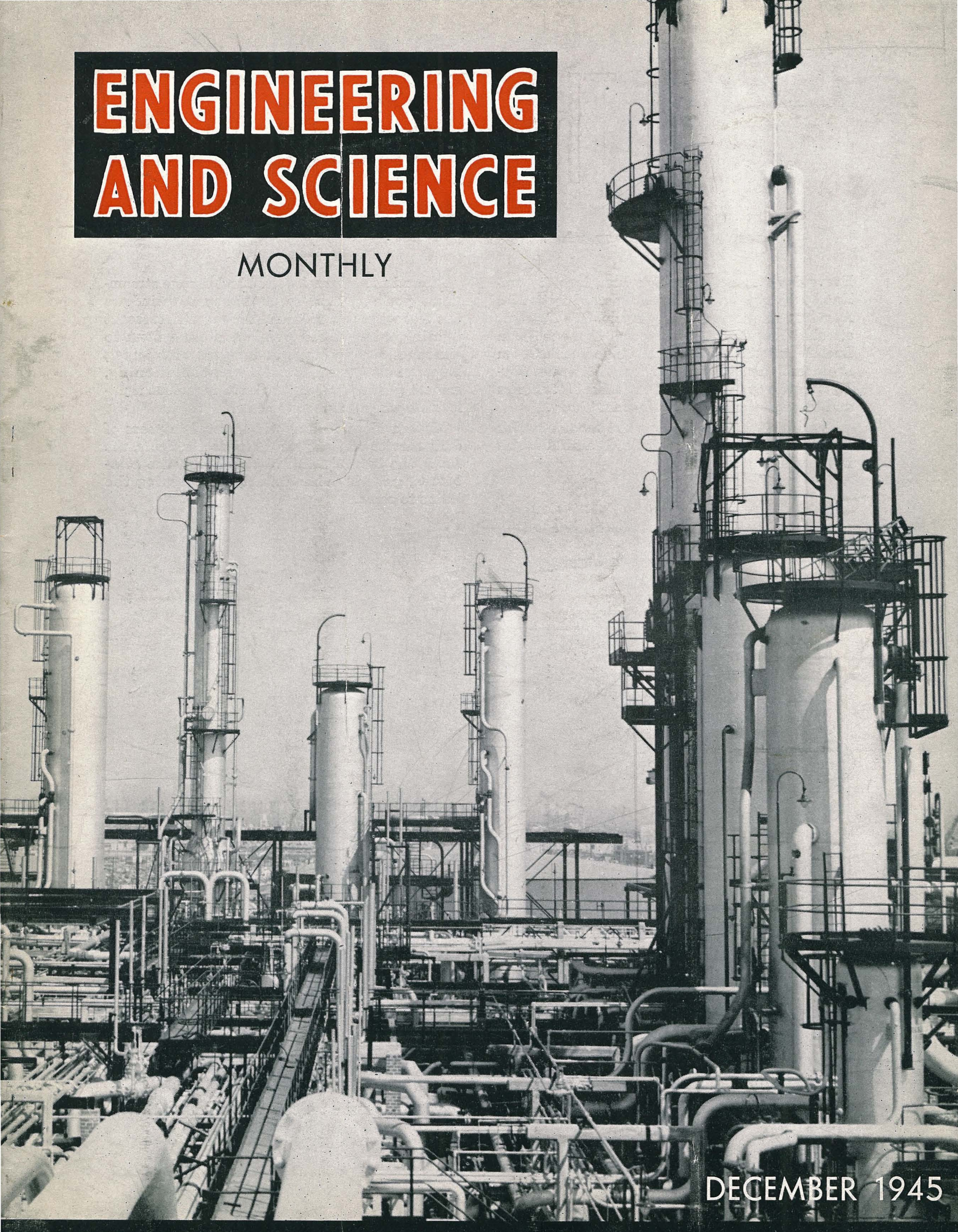
ENGINEERING AND SCIENCE

MONTHLY



DECEMBER 1945

PUBLISHED BY CALIFORNIA INSTITUTE OF TECHNOLOGY ALUMNI ASSOCIATION

today . . . The Daylights

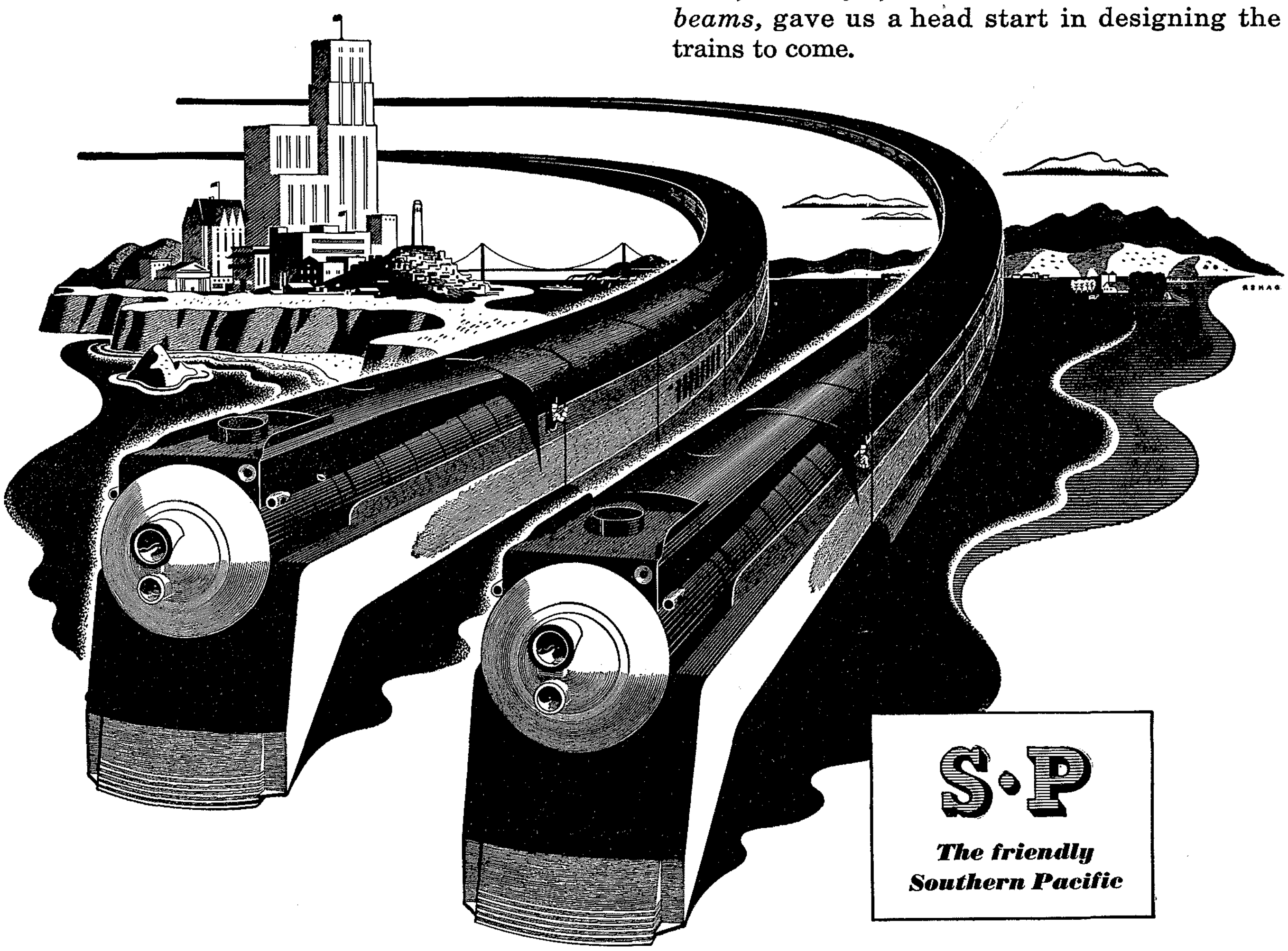
pacemakers for trains to come

Every day Southern Pacific's luxurious streamlined *Daylights* join San Francisco with Los Angeles in a glorious daylight trip. One *Daylight* streaks along the California coast, over the Santa Lucia Mountains and along the blue Pacific Ocean shore for more than a hundred miles. Another *Daylight* travels over the rugged Tehachapi Mountains and through the great San Joaquin Valley.

The *Daylights* are among the most popular trains in America and the most beautiful trains in the world.

Aboard these luxurious red and orange streamliners you enjoy enormous "showcase" windows five feet wide, soft foam rubber seats, fluorescent lighting, a low-voiced public address system to announce station stops and points of interest, baggage elevators, complete air-conditioning, smooth gliding motion thanks to ingenious tightlock couplings between the cars.

Modern ideas such as these, tested in years of daily service on Southern Pacific's *Daylights,* the *Lark,* the *City of San Francisco* and the *Sunbeams,* gave us a head start in designing the trains to come.



tomorrow . . . *Southern Pacific is planning more streamliners, and 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."*

BY-LINES

ENGINEERING AND SCIENCE *Monthly*

The Truth Shall Make You Free

J. FRANK DURYEA

J. Frank Duryea was born on an Illinois farm. Being mechanical minded, he went to Springfield, Mass., where he produced his first gasoline-propelled vehicle and gained eminence with his famous Stevens-Duryea automobile. Mr. Duryea is now retired and lives in New England.

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ROBERT BOWMAN

Robert Bowman received the degree of Bachelor of Science in physics and chemistry in 1926 from the California Institute of Technology. After graduation, he became associated with Standard Oil Co. of California and has been with parent and affiliated companies ever since. Mr. Bowman is now research associate with the California Research Corp., in which capacity he is staff specialist on crude oils, natural gas, natural gasoline, and liquefied petroleum gases.

• • •

EARNEST C. WATSON

Professor Watson received his Ph.B. degree from Lafayette College, Easton, Pa., in 1914, and was associated with the University of Chicago in the physics department prior to coming to the California Institute of Technology in 1919. Professor Watson is now professor of physics at the Institute.

Caption for Cover Illustration: A view of the Union Oil Company of California's refinery illustrates the engineering genius and technical skill which have made possible the high standards of modern petroleum products.

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CONTENTS FOR DECEMBER, 1945

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ENGINEERING AND SCIENCE
Monthly

Vol. VIII, No. 12 December, 1945

The Month in Focus

By LINUS PAULING

PROPOSED FEDERAL AID TO RESEARCH IN SCIENCE AND MEDICINE

THE great contributions to the war effort made by scientists during the past five years have made the public aware that the welfare of the nation depends upon adequate support of research in science and medicine. Moreover, we are beginning the postwar period with a great deficit—not only a deficit of trained scientific personnel, resulting from the interruption of the education of the 165,000 men who, except for the war, would have received scientific or engineering degrees during the war years, and were prevented from receiving these degrees, but also a deficit in the body of fundamental scientific knowledge. The contributions made by scientists during the war years were very largely based on fundamental discoveries made before the war. Further progress in industrial development and in medicine will be possible only if proper support is provided for basic scientific research.

NECESSITY FOR AID

It has been clear that the sources of funds drawn upon in the past for support of basic scientific research will not be adequate in the immediate future. Franklin Delano Roosevelt on November 17, 1944, sent to Dr. Vannevar Bush, director of the Office of Scientific Research and Development, a letter in which he said, "The information, the techniques, and the research experience developed by the Office of Scientific Research and Development and by the thousands of scientists in the universities and in private industry, should be used in the days of peace ahead for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living," and in which he asks for recommendations about the part that the federal government could play in fostering scientific and medical research for the good of the people.

The reply to this request was made by Dr. Bush in a report, "Science: The Endless Frontier," sent to President Truman on July 19, 1945. This report was prepared with the aid of four advisory committees, dealing respectively with medical research, research in the natural sciences, the discovery and development of scientific talent in American youth, and the publication of information about the contributions to scientific knowledge which have been made during our war effort.

As a member of the Medical Advisory Committee, I had an opportunity to see how great an effort has been made to find a way of providing the needed federal aid to research in science and medicine without invoking the evils such as political influence and mediocrity of performance which may characterize government activities. It is my opinion that the recommendations made by Dr. Bush are sound, and that the nation will benefit greatly if they are followed.

PLANS

These recommendations have been embodied essentially in a bill, S. 1285, which was introduced by Senator Warren G. Magnuson. This bill and an alternative bill, S. 1297, introduced by Senator Harley M. Kilgore, are now under consideration by the Senate Committee on Commerce and the Senate Committee on Military Affairs. The bills have been discussed by many members of the staffs of the California Institute of Technology, the Mount Wilson Observatory, and the Huntington Library at an informal weekly seminar on world affairs which is now being held under the chairmanship of Professor Earnest C. Watson, and a statement about the opinion of this group has been formulated and sent to the members of the two Senate committees and to the senators and representatives from California. This statement is presented below. In addition, a national committee of 43 members, the "Committee Supporting the Bush Report," has sent to President Truman a letter in which closely similar recommendations are made; this committee includes four members of the staff of the California Institute of Technology, Professor Carl D. Anderson, Professor Carl Niemann, Professor G. W. Beadle, the new chairman of the Division of Biology of the Institute, and myself.

I recommend that you read the Bush report, in order to obtain a sound basis for an opinion as to the possibilities of future progress in research in science and medicine and of the need for support from the federal

(Continued on Page 15)

America's First Gasoline Automobile

By J. FRANK DURYEA*

THE decade of the '80's may be considered as that in which, for the first time, all the knowledge and things necessary to the construction of a gasoline automobile were present in this country. Oil wells, first drilled in 1858, were furnishing the derivatives kerosene and gasoline. A few gas engines came into use, operating on the Otto four-stroke cycle. Gas producers were in use, making from gasoline a gas suitable for these engines. Ball bearings and rubber tires became common on bicycles. Friction clutches, belts, chains, and gears for transmitting power were well known. Differential gearing had been used on tricycles. The self-propelled trolley car came into use, and experiments were made with steam road vehicles like the one shown in *Fig. 1*.

EUROPEAN DEVELOPMENTS

Given initiative and these conditions, the appearance of the automobile in America could not be long delayed. However, conditions in Germany were even more favorable, for there, in 1876, Dr. N. A. Otto had constructed the first four-cycle gas engine, and in the next seven or eight years machines of this type had begun to attract much attention there. Knowledge of these engines no doubt spurred Gottlieb Daimler and Carl Benz to action, for Daimler started work at Cannstatt in 1884, and Benz at Mannheim in 1885.

Daimler's first engine had a single vertical cylinder (see *Fig. 2*), but he soon started building two-cylinder engines, of a narrow "V" type, using hot tube ignition and a tank type carburetor. These engines were operated at a high speed for that time, but since both pistons were connected to the same crank pin, there was considerable vibration. They were not throttled to obtain variable speed, but were held to approximately constant speed by governor control of the exhaust valve action, working on the well-known "hit-and-miss" principle, whereby the engine received either a full charge or nothing.

*Based on a talk before the Horseless Carriage Club of Los Angeles.

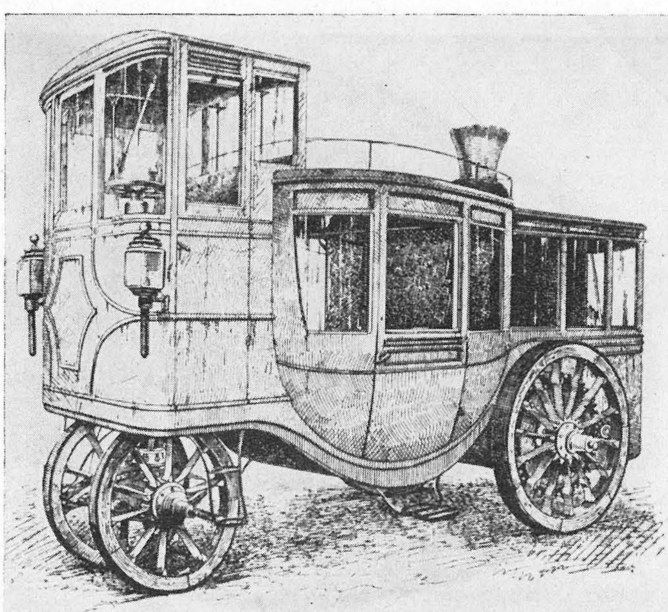


FIG. 1. The steam carriage of Charles Randolph of Glasgow, built in 1872. It weighed four and one-half tons ready for the road, and was probably the first entirely enclosed road vehicle. Note wheel steering and rear engine.

Daimler, in 1885, built a motor bicycle (see *Fig. 3)* and later one or more quadricycles. I have no information as to the number built, but one of these quadricycles was shown at the Columbian Exhibition in Chicago during 1893. It had no front axle, but the front wheels were steered by bicycle-type front forks. This was the first gasoline-engined vehicle shown in America, but if my impression of it was correct, there was little about it to inspire in one a desire to possess it. However, this may also be said of the first Duryea, now in the National Museum, which is shown in *Fig. 4*.

Among those who contributed to the development of the automobile, Carl Benz deserves a high place. In the years following 1885 he built some very satisfactory vehicles (see *Fig. 5*). His first United States patent was issued in June, 1888, and showed a single front wheel for steering, a single-cylinder horizontal engine with vertical crankshaft, and belt and pulley transmission to a jackshaft, from which sprockets and chains drove each rear wheel of the vehicle. Here Benz early disclosed the progress he was making.

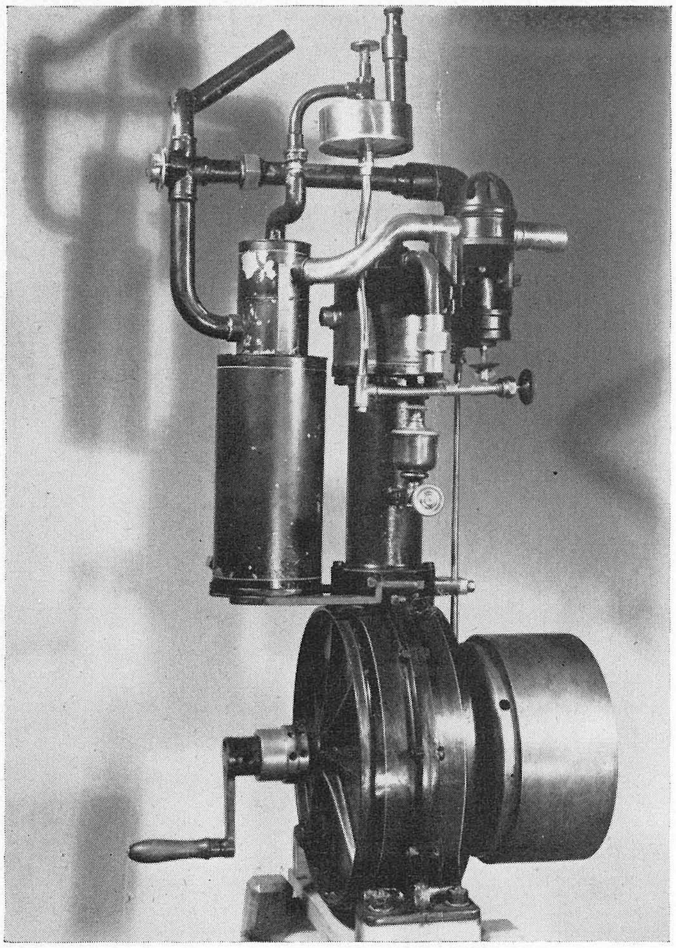
In 1889, the *Scientific American* published an illustration of a later Benz car. This was a four-wheeled vehicle with Akerman steering knuckles and was, I believe, substantially as far advanced in design as were the three Benz cars that took part in the *Times-Herald* Race at Chicago in 1895. Therefore, I would say of this 1889 Benz that it was probably the first really desirable and usable gasoline-engined car in Europe, just as the car which I designed in 1894 and drove to win the Chicago race in 1895 was the first really usable car built in America (see *Fig. 6*).

Charles Duryea and I were together in 1889 at Rockaway, New Jersey, and, as we always read the *Scientific American*, I am sure that we saw the illustration above mentioned, for I have always said that we knew something of the work of Benz before we ever started work on the first Duryea car.

EARLY DURYEA DEVELOPMENT

The Duryeas were Illinois farm boys, used to all kinds of farm machinery with belt, chain, and gear drives. Our imagination had been fired by the power and speed of the railway locomotive. During the '80's we had seen steam threshing-machine engines, drawing their heavy grain separators from farm to farm. We had become engine-minded, and as early as 1883, at the age of 14, I had made crude plans of a belt-driven steam vehicle.

In 1888, after graduating from high school, I joined Charles at Washington, D. C., and took up machine work, while Charles was building a model of his Sylph bicycle (shown in *Fig. 7*). That summer we took our first ride



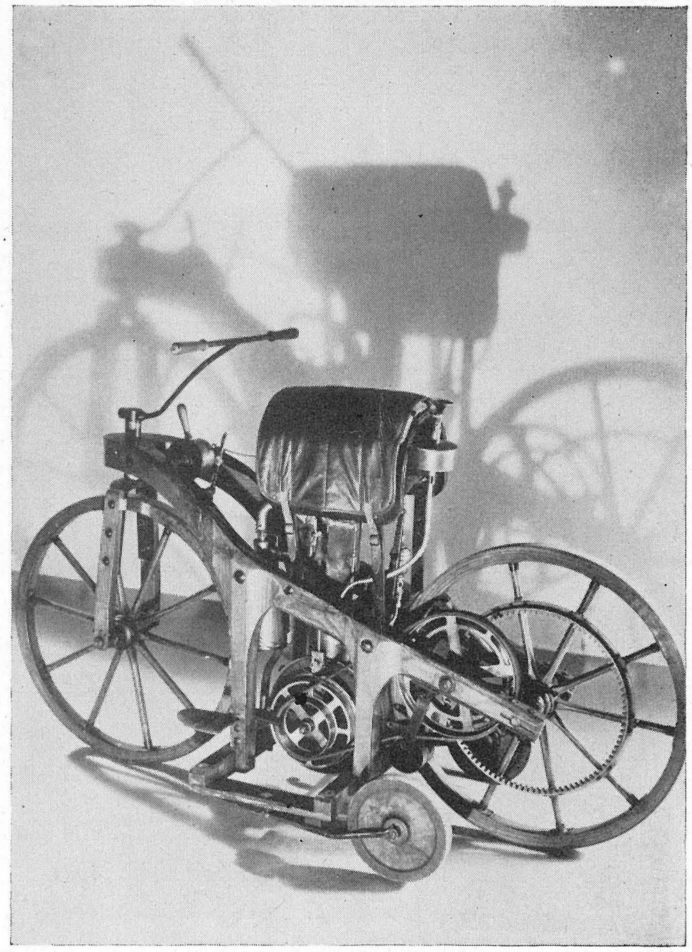


FIG. 2 (at left). Daimler's first single-cylinder vehicle engine, 1885. FIG. 3 (at right). Daimler's first vehicle, the first motor bicycle ever constructed (1885). It employed the second single engine, which he built as shown in FIG. 2.

together in a trolley car, and agreed that an engine-driven vehicle would be equally practical on the road. After a year at Washington we went to Rockaway, New Jersey, where Charles was having his bicycle made, and I engaged in tool work. Here, as at Washington, we regularly read the *Scientific American* and scanned the pages of the *Monthly Patent Office Gazette* for anything of interest.

After a year and a half at Rockaway, Charles moved his bicycle work to the Ames Manufacturing Company at Chicopee, Massachusetts, and I soon followed, again taking up tool-making and mechanical drawing. At Chicopee we spent much of our spare time in discussion of mechanical matters of interest to both of us and, in the summer of 1891, because, I believe, of some further reference to the work of Daimler or Benz, we started reading books on gas engines with the idea of building a motor vehicle.

It was not until the late fall or early winter of 1891 that Charles took the steps that led to our starting work on the first Duryea car, for at this time he came to me and announced that he had just the engine and transmission that we needed for the vehicle we had talked of building. He then described a free piston engine, as suggested to him by C. E. Hawley, and an unusual form of friction transmission which I think was probably never used before or since. I at once contended that both these ideas were highly experimental and their use questionable, but Charles went ahead and had Ames Company draftsmen make illustrative sketches of the idea, as applied to a democrat spring wagon. The only working drawings made were for a part of the friction transmission and a part of the body of the engine. These drawings were made in the winter of 1891 and '92 but it was not until March, 1892, that Charles met Erwin F. Markham and arranged for a conference at which Mr. Markham agreed to put up one thousand dollars to build the first car.

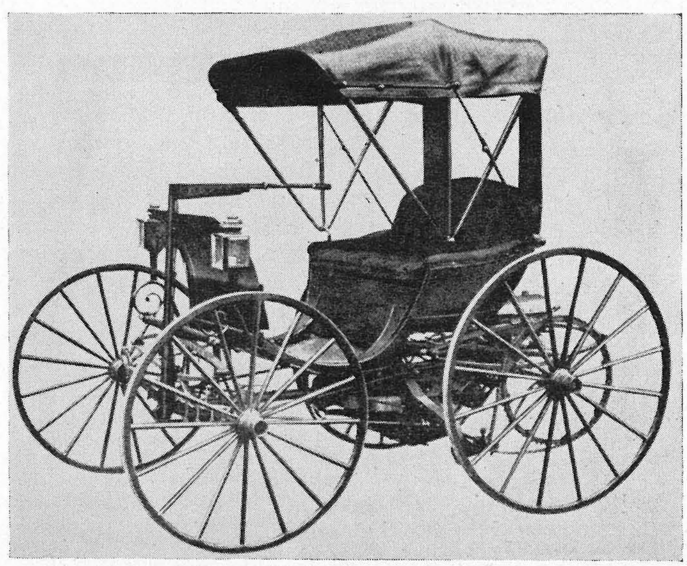


FIG. 4. The first Duryea, with the second engine. This car may be seen at the Smithsonian Institute.

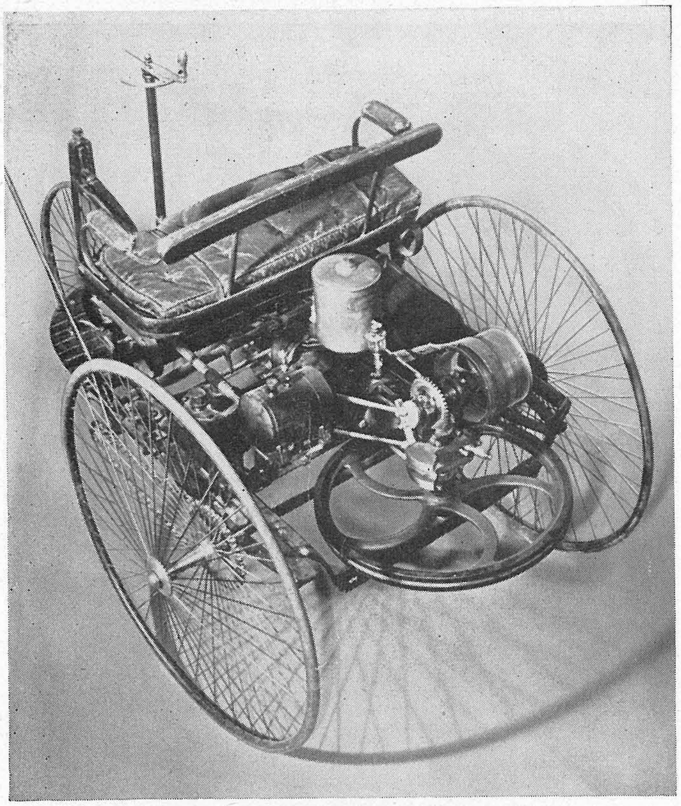


FIG. 5. Benz's first car, a three-wheel, single-cylinder tricycle with belt transmission adapted from lathe practice. This drive was retained until 1902.

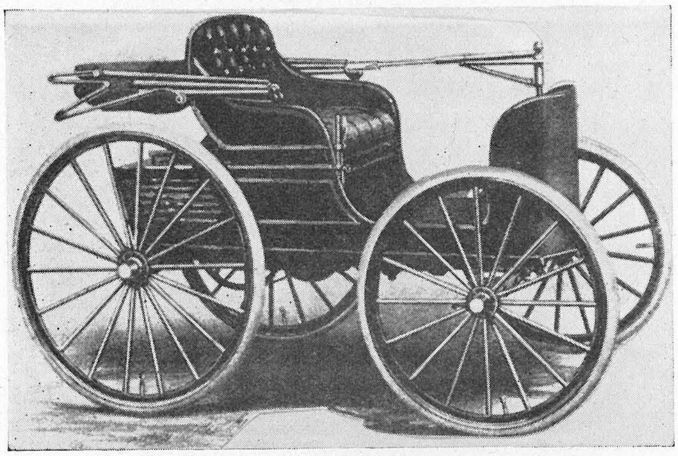


FIG. 6. The Duryea "Chicago car," winner of the first race in America, Thanksgiving Day, 1895.

As I was the more competent mechanic of the two, it had been understood that if a start was made I should have charge of the work, and I went with Charles to see Mr. Markham and later to locate a suitable workshop. Following this, a secondhand phaeton was bought, into which the parts would be fitted. Starting early in April, 1892, construction proceeded through the summer, for it was a new line of work and I had much designing and drafting to do.

With perhaps the most difficult parts of the car, such as carburetor, hot tube ignition, and a method of controlling the engine and transmission yet to be designed, Charles moved to Peoria, Illinois, leaving me full responsibility for carrying on the work and, in return, assuring me of a share in the project. Thus, although disappointed that I had not been included at first, I now became one of the partners. Illness contracted in October stopped all work until January 1, 1893.

Having designed and built for the engine hot tube ignition and a crude spray carburetor, I attempted to start the free piston engine, only to find that it would not give regular power impulses. Our backer, Mr. Markham, threatened to withdraw, and to forestall this action, I eliminated the free piston feature of the engine by pinning the two pistons together, and hastily constructed a little device on the side of the engine to cause the exhaust valve to function properly. I have a model of this little contrivance at Madison, Connecticut.

This crude makeshift engine was now operative, but had very little power and could not be used with the phaeton body set in place over it without first the addition of a special hand starter and some method of remote control for the engine. But with these things added, it would still be a makeshift and the engine was therefore never completed far enough to enable us to use it to drive the car on the road, for Mr. Markham and I decided to discard it.

A NEW DESIGN

I then designed and built a new engine with a cast water jacket, hand starting device, timer gears to operate the exhaust valve, electric ignition, a spray carburetor, a muffler, and finally, a governor—to avoid the necessity of remote control for the engine. The Bowden wire method of remote control was not then known. None of the above features had been used in the first engine except my spray carburetor.

Since the working parts had been supported by a rigid framework connecting front and rear axles, I arranged to support this framework at a single point on the front axle, thus providing a three-point support for the engine and transmission and avoiding distortion due to uneven roads.

This first Duryea car was first driven on the road on September 21 or 22, 1893, as shown in the *Springfield Evening Union* of September 22, 1893. The engine gave no trouble, but because of its friction transmission the car was barely operative, and I was never able to give a demonstration to a possible investor. Charles's engine had been a failure, and now his second principal feature—the friction transmission—was also a failure.

After a few weeks of testing, Mr. Markham decided to quit. Refusing to accept this action as final, I designed a new transmission of gears and friction clutches, and confidently offered to build it on my own time if Mr. Markham would meet material and shop expense. He accepted, and I built and installed this transmission in the car. The *Springfield Union* of January 19, 1894, describes my first trip with this successful transmission. This car, with my engine and transmission, is the Duryea car now in the National Museum at Washington, D. C.

With the first car nearing completion, I started, about

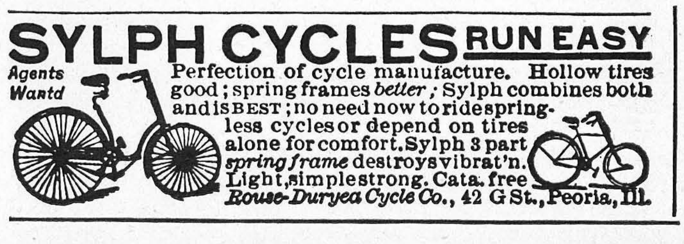
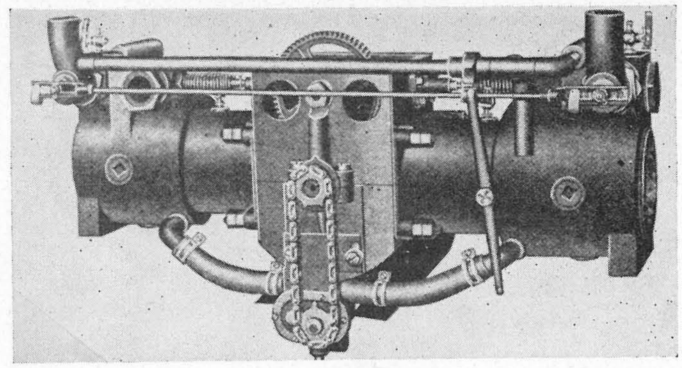


FIG. 7. Advertisements for Charles E. Duryea's "Sylph" cycles appeared in various popular magazines during the latter part of 1892 and in 1893.



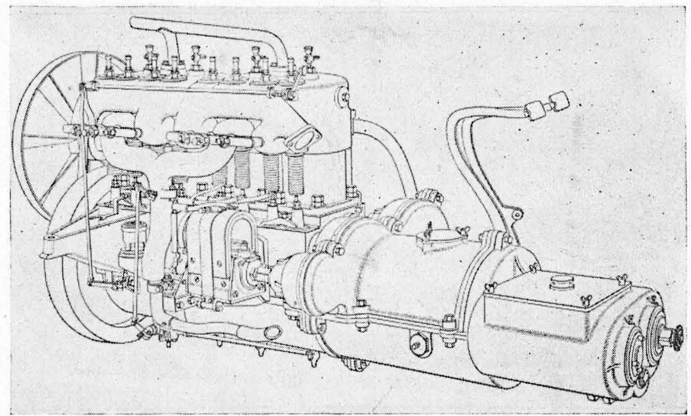


FIG. 8 (at left). The third Duryea (1896). FIG. 9 (upper right). The two-cylinder engine of the 1903 Stevens-Duryea. FIG. 10 (lower right). The four-cylinder unit power plant of the 1905 Stevens-Duryea.

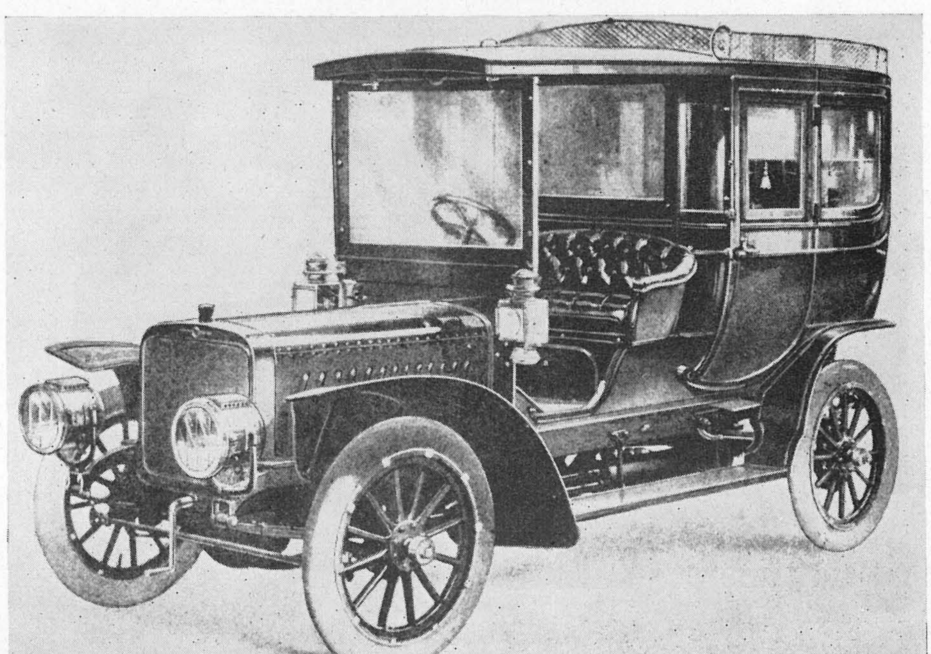
January 1, 1894, to design a second car. Mr. Markham was unable to finance the work further and, as I had been without salary for a month and a half, it was necessary that I quickly find new capital. Borrowing to live, and working earnestly, I had, in March, completed plans for the new car. These plans showed a piano-box side bar buggy, with a two-cylinder, two-cycle motor, and my transmission of gears and friction clutches, all well concealed in the body. A live rear axle with ball bearings, and wheels with all-metal hubs, were shown; also ball bearings for the transmission shafts.

With these plans in hand I was able, late in March, 1894, to induce Henry W. Clapp to agree to finance construction of the car, and work was started in April. This car was operative early in December, 1894, and was repeatedly driven rapidly around the empty top floor of the factory building. The motor was a trifle irregular because of faulty electric ignition, but, believing the motor faulty, I converted it from two-cycle to four-cycle in January and February, 1895. The irregularity continued and was traced to a weak spark, and promptly corrected.

The car was painted and, with wheels equipped with cushion tires, was placed on the road late in March,

AT RIGHT:

FIG. 11. The first six-cylinder Stevens-Duryea, 1905.



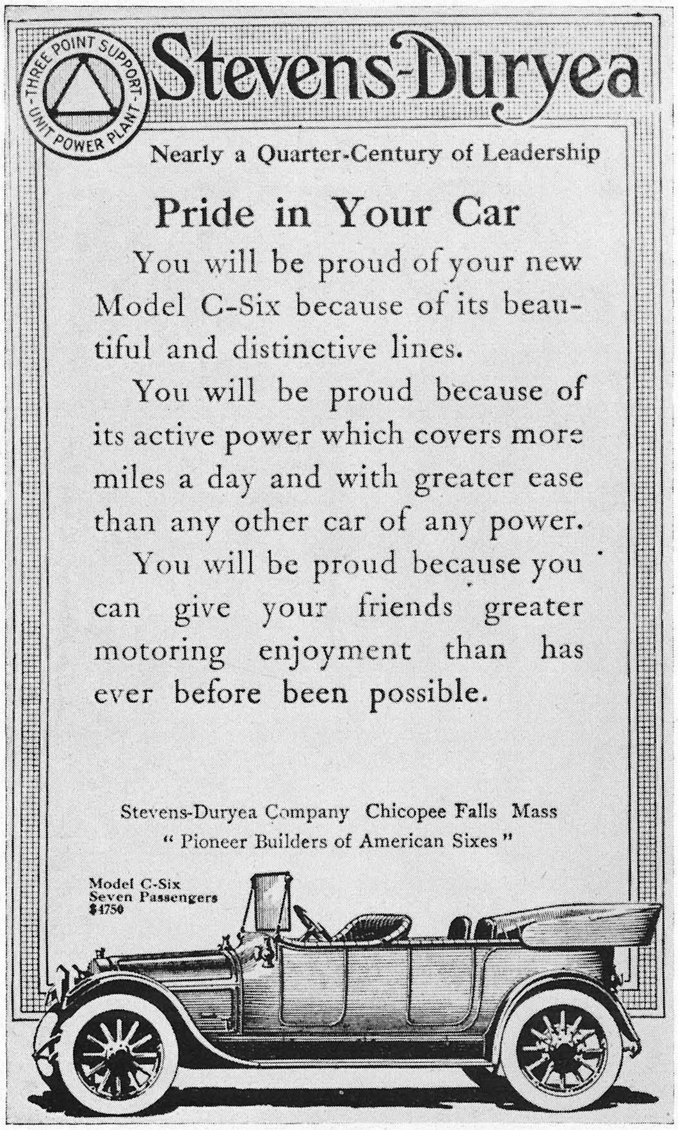


FIG. 12. A 1913 model, Stevens-Duryea. It was equipped with an air starter to which the engine responded immediately.

1895. From this time it was in use nearly every day of the spring and summer, giving demonstrations to build up the interest necessary to enable us to organize a company.

After many demonstrations with the car had been given throughout the summer, the Duryea Motor Wagon Company was organized at Springfield, Massachusetts, in September, 1895, with George H. Hewitt president and T. W. Leete treasurer. In recognition of my work of designing and building the car, I was made a director and employed as chief engineer in charge of design and production.

Driving this car for the Duryea Motor Wagon Company, I won America's first race, sponsored by the Chicago *Times-Herald,* and run on Thanksgiving Day, November 28, 1895. The course was from Chicago to Evanston and return; the distance, 54 miles. Much snow fell the day before the race and, of nearly 80 entries, only six appeared at the start. Two of these were electrics and three were foreign Benz cars; the Duryea was the only American gasoline car in the race.

Of the six starters, but two finished, and these were the Duryea, driven by me, with Arthur W. White of Toronto, Ontario, as umpire, and a Benz, driven by Oscar Mueller of Decatur, Illinois, with umpire Charles B. King of Detroit. After a trying day, the Duryea finished ahead of the Benz, by an hour and 35 minutes, winning first prize of two thousand dollars. The Benz was driven across the finish line by umpire Charles B. King after the driver had fainted from exhaustion due to pushing the car through the drifted snow. Charles B. King was the first to build a car in Detroit, and later built the King automobile.

SIGNIFICANT FEATURES OF DESIGN

Since the "Chicago winner" was the first really desirable and usable American car, I shall now list some of its more important features, and I may say that I was the first to use these features in an American automobile:

1. An engine with electric ignition.
2. A pump to circulate water for cooling the engine.
3. A spray carburetor for the engine, with constant gasoline level.
4. A pump to supply gasoline for the carburetor.
5. A transmission having three speeds and reverse, in which power was transmitted through toothed gears by setting a friction clutch.
6. Ball bearings for the transmission shafts.
7. A rear axle having differential gears and rotating axle shafts to drive the rear wheels of the car.
8. Ball bearings for the rear axle shafts.
9. Concealed mechanism.
10. Pneumatic tires—built to my specifications by Hartford Rubber Works.

All of these features are to be found in the automobile of today. None of them were to be found in Charles Duryea's partly completed plans for the first Duryea car. However, following Charles's departure for Peoria, Illinois, I designed for the first car a spray carburetor, electric ignition, and a gear and friction clutch transmission.

I may say further that the Benz cars imported from Germany in 1895 contained but three of these 10 features, namely, electric ignition, ball bearings on a transmission shaft, and partly concealed mechanism.

The "Chicago winner" was the second Duryea car, but after formation of the Duryea Motor Wagon Company, I designed a third car, which is shown in *Fig. 8.* Thirteen cars of this design were finished and the greater part sold during 1896. Driving one of these, I won America's second race on Decoration Day, May 30, 1896. This race was sponsored by the *Cosmopolitan Magazine,* and was from New York to Irvington on the Hudson and return, a distance of 52 miles. Another of these cars was loaned to Barnum and Bailey, and for a time was shown daily in their ring and street parades.

After making some changes in still another of these 1896 machines, I took it to London and on November 14, 1896, drove it in the London-to-Brighton Liberty Day Run, which celebrated the repeal of the English four-miles-per-hour law. Mr. Herbert Thrupp of Thrupp and Maberly, noted London carriage-makers, rode with me, and I have his affidavit that we were first to arrive in Brighton.

Late in 1896 I made for the Duryea Company the fourth Duryea car design. In this I used an electric generator, for ignition without batteries, and a float-feed carburetor. These features are shown in my patents for which application was made on November 7, 1896, and June 14, 1897. I believe that these are also "firsts."

(Continued on Page 14)

Testing and Metering in Natural Gasoline Operations

By ROBERT B. BOWMAN

THE article on "Production of Natural Gasoline" that appeared in the June, 1945, issue of *Engineering and Science* covered in detail the process of recovering light liquefiable hydrocarbons from natural gas. From a review of the article it will be obvious that the process must be carefully controlled in order to obtain the maximum yield of products of satisfactory quality as economically as possible. This control is exercised through testing and metering the various liquid and vapor streams encountered in the process. The following discussion of the procedures involved is intended to supplement the original article.

TESTING

Both periodic and incidental tests are required to supply a basis for controlling the quality of finished products and the efficiency of extraction. Periodic tests are made principally on wet and dry gases and on finished products. Incidental tests are made also on absorption oil, engine lubricating oil, and water used in the various cooling systems. The present discussion will be limited to those tests which are made periodically.

WET GAS

Wet gases are tested principally for their gasoline content and specific gravity.

1. GASOLINE CONTENT

When a new oil field is discovered, gasoline content tests are made to determine whether the anticipated yield of gasoline from the available quantity of wet gas is sufficiently large to justify an investment in extraction equipment. After a plant is installed, tests on wet gas serve primarily as a means of allocating finished gasoline to the various properties from which gas is delivered to the plant.

The field testing procedure adopted as standard in California is called the charcoal adsorption test. A small stream of gas is passed through a tube of charcoal (usually a three-quarter-inch pipe about 30 inches long) under controlled conditions. The charcoal is then taken to the laboratory, where it is distilled and the adsorbed fractions are recovered. The distillation is conducted with the receiver held at a pressure of 30 pounds per square inch gauge and a temperature of 32°-34° F. The amount of condensate obtained under these conditions is proportionate to the isobutane and heavier fractions in the gas. This condensate is then weathered under controlled conditions to give a product of approximately 20 pounds Reid vapor pressure, which represents an average natural gasoline. The volumes of condensate obtained and the volume of gas passed through the charcoal are then related to obtain yields in terms of gallons per 1,000 standard cubic feet or "G/M," as this quantity is usually abbreviated. By the application of appropriate factors, these results are converted into corresponding yields of isobutane, normal butane, and "pentanes and heavier."

For more exact results, fractional analysis is employed. This method is of sufficient importance to be discussed in more detail later. Other methods for determining enrichments of wet gases are the freezing test, the oil absorption test, and the compression test. These, however, have in general yielded to the charcoal adsorption method, principally as the result of its greater selectivity. This feature would make the charcoal method an attractive plant process if the disadvantage of discontinuity could be overcome.

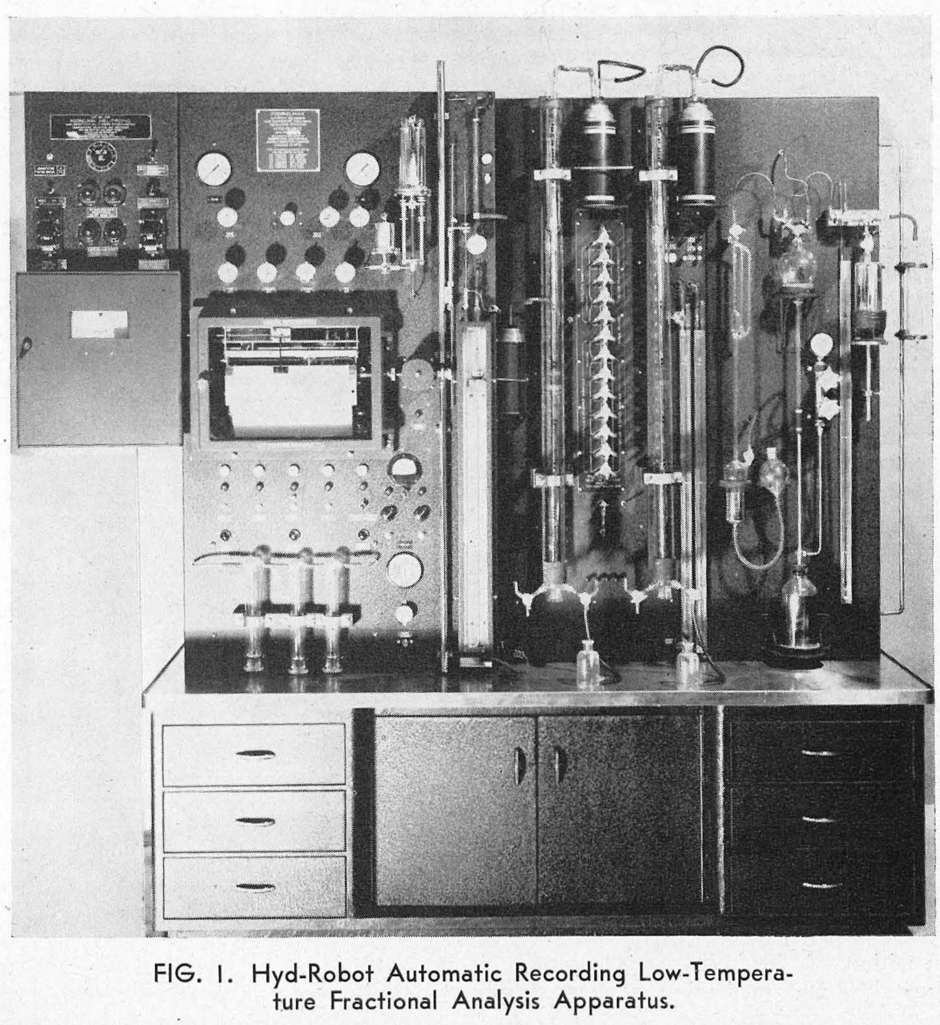


FIG. 1. Hyd-Robot Automatic Recording Low-Temperature Fractional Analysis Apparatus.

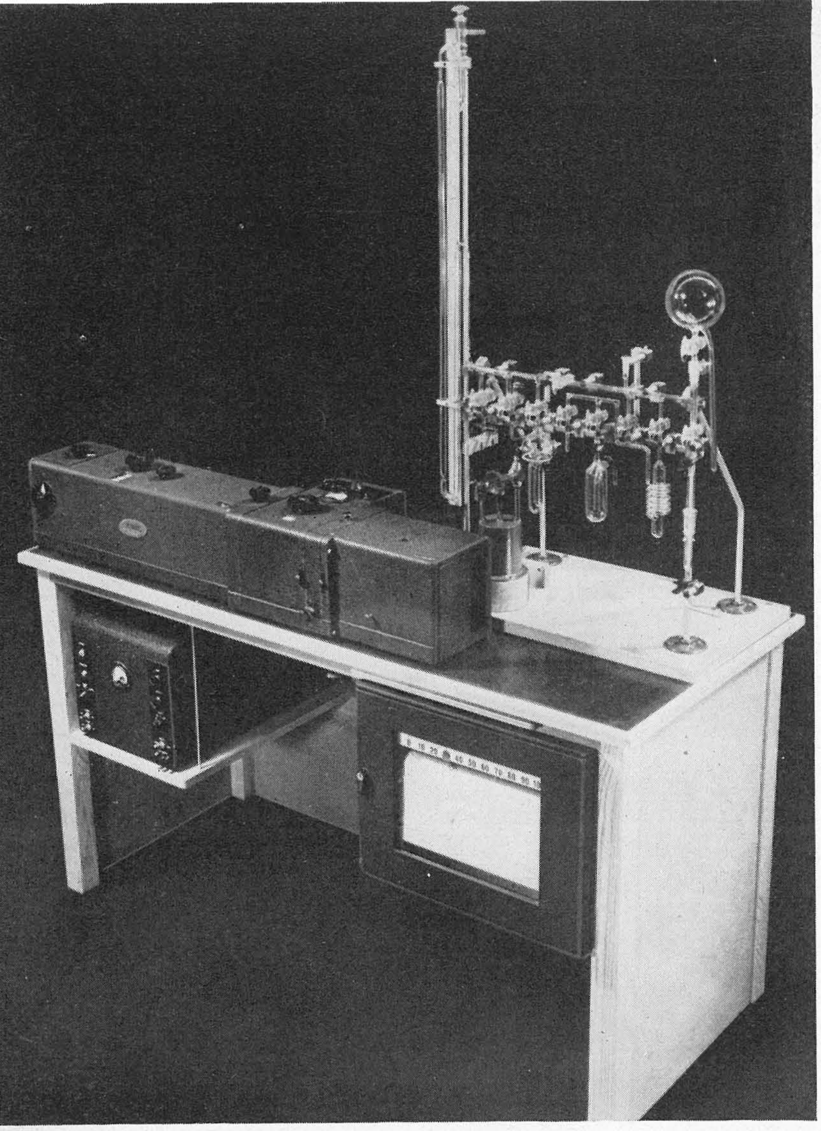


FIG. 2. Beckman infrared spectrophotometer.

2. SPECIFIC GRAVITY

As is discussed later, volume of natural gas is generally measured by orifice meter. The specific gravity of the gas must be known in order to compute the volume recorded by this type of meter. Two methods are commonly employed for determining specific gravity. These are the use of a so-called Schilling's bottle and of an Edwards gas balance.

A Schilling's bottle is a means for discharging a small quantity of gas through a small circular orifice under fixed conditions. A gas having a low specific gravity will pass through at a faster rate than one having a higher specific gravity. The time taken by air to pass through the opening is first measured. Then an equal volume of gas is passed through and the time required is noted. The specific gravity of the gas is the square of the ratio of the "gas time" to the "air time."

The Edwards balance depends upon the principle that the buoyancy or lifting power of a fluid (*i.e.*, either a vapor or a liquid) is directly proportionate to the density of the fluid. A gas with a high density will float a light body more readily than will a gas with a low density. The density of a gas is proportionate to its absolute pressure. It is therefore possible by controlling the pressure on a gas to control its specific gravity.

An Edwards balance is a small evacuated metal bulb mounted on a small metal beam. The beam is pivoted near the center on a knife-edge support. The end opposite the bulb is a pointer which serves to indicate the position of the bulb. This assembly is mounted in a metal container having a glass window opposite the pointer. Gas is introduced into the outer shell and the pressure is increased until the bulb is floated by the gas. A gas having a low specific gravity will require a higher pressure to float the bulb than will a gas of higher specific gravity. The ratio of the pressure of air required to float the bulb to the pressure of gas required to support it in the same position is the specific gravity of the gas.

DRY GAS

The most important tests made on plant discharge gases are likewise those of specific gravity and gasoline content. Specific gravity determinations are made for application in metering the volumes of gas disposed of to sales lines, plant and lease fuel systems, etc. The test procedure is identical with that for wet gases. Gasoline content tests are made to determine the efficiency of gasoline extraction. The low gasoline contents of plant discharge gases make necessary the application of a different procedure from that used in testing wet gases which have much higher gasoline contents.

A procedure now employed quite extensively is known as the "B-W Test." This is an abbreviation of "butane absorption and weathering test." A measured quantity of the gas to be tested is bubbled through a liquefied petroleum gas mixture in a special apparatus maintained at a low temperature (usually about −44° F.) by being immersed in a bath of boiling propane. The liquefied gas mixture is principally butane. At the low temperature used in the test, the butane acts as an absorbent for any pentanes (+) fractions that may be present in the gas. After a few cubic feet of gas have been bubbled through the absorbent, the gas flow is stopped, and the temperature of the absorbent is allowed to rise slowly to +35° F. During the course of the rise in temperature most of the absorbent weathers or evaporates. The temperature at which 90 per cent has evaporated is noted, as is the volume of liquid remaining at 35° F. Each different combination of these two readings corresponds to a particular quantity of pentanes (+) material in the mixture at the end of the absorption step. The concentration of pentanes (+) fractions in the original gas sample can then be computed.

More recently, following the trend towards complete recovery of butanes, the principle of the weathering test has been extended to the determination of isobutane (+) contents by absorption in a propane solvent.

FINISHED PRODUCTS

Vapor pressure and composition are the most important characteristics of finished products from natural gasoline plants. Vapor pressures are determined by standardized procedures in which equilibrium is established between a liquid and its own vapor under fixed conditions, and the pressure is simply read from a gauge connected to the vapor space of the container. Correlations can be made in many cases between vapor pressure and composition, with the result that a vapor pressure determination alone is adequate for some purposes.

Compositions are determined by fractional analysis, spectrometry, or weathering tests. The first two procedures are discussed in detail below. Weathering tests are applied principally in the case of propane, isobutane, normal butane, or mixtures of them. A small sample of the stock to be tested is allowed to evaporate under controlled conditions, and composition is estimated from correlations between volumes and temperatures observed during the evaporation. Tests of this type are decidedly attractive in many ways. They are simple and inexpensive and can be run directly at the processing equipment by a non-technical operator. Their low cost is conducive to frequent testing, and the ability to obtain results promptly without the delay of transporting samples to a laboratory facilitates maintaining close control over plant processes that influence quality of products.

FRACTIONAL ANALYSIS

This method is so called because it is employed in analyzing liquid or gaseous hydrocarbon mixtures in terms of the individual constituents or fractions, such as methane, ethane, propane, etc., which are present. It is the only procedure capable of accomplishing this objective by physically separating the individual components. As is explained below, spectrometry gives results in terms of the individual components, but no actual separation is made. The expense involved in conducting a fractional analysis (usually $5 to $25, depending upon the nature of the sample) prohibits routine use of the method. It is applied principally in (1) standardizing and interpreting results of the empirical test methods which have been briefly reviewed above, and (2) special investigations requiring a higher degree of accuracy or a wider range of results than could be supplied by empirical methods.

Basically, the procedure is similar to the rectification step in the plant process. A small glass apparatus is used, comprising a kettle, a column, and a reflux condenser. However, operation is at atmospheric pressure or under a vacuum, in contrast to the high pressures employed in plant equipment. The sample is first introduced into the kettle, where it is completely liquefied. This is accomplished by having the kettle immersed in a suitable cooling bath. If methane is present in an appreciable quantity in the sample, liquid nitrogen which boils at −320° F. is used in the bath. For more stable materials, a bath of liquefied propane that boils at −44° F. is often adequate.

Boiling is next allowed to commence in the kettle, and refluxing starts when the top of the column is cooled. In a short time the material at the top of the column is the lightest hydrocarbon, in a high degree of purity, which was originally present in the sample. The temperature in the top of the column will then be the boiling point of the lightest hydrocarbon present. Some of this fraction is next withdrawn as vapor into an evacuated flask. Withdrawal is slowly continued until there is a tendency for the temperature in the top of the column to rise, which indicates that the amount of the lightest hydrocarbon has been nearly depleted and the next heavier hydrocarbon is starting to arrive at the top of the column.

The withdrawal is then reduced to a very slow rate, and when there is an abrupt rise in temperature, it is discontinued. The amount of material withdrawn up to this point represents the amount of the lightest fraction originally present in the sample. Withdrawal is then commenced at the higher temperature until another rise in temperature begins, after which the process described above is repeated.

If natural gas (either wet or dry) or liquefied petroleum gas samples are involved, the usual procedure is to remove each fraction overhead as vapor. If the sample is natural gasoline, the normal butane and lighter fractions, and sometimes the isopentane and normal pentane, are taken overhead as vapor, but the composite heavier fractions are retained in the kettle and measured as liquid. Factors are available for converting vapor volumes of the individual fractions to equivalent liquid volumes, and vice versa. When the volumes of the individual fractions have been determined, they are converted to a uniform basis. The sum is the amount of sample originally present. The percentage of each fraction can then readily be computed.

In a modern laboratory fractionation apparatus, a large portion of the operation is automatic and one operator is able to conduct a number of analyses simultaneously. *Fig. 1* is a picture of a widely used type of equipment known as the Podbielniak Hyd-Robot Automatic Recording Low-Temperature Fractional Analysis Apparatus. It is a two-column unit, and preparations can be made for running a second sample while the analysis of one sample is in progress. Not visible in the picture are the measuring flasks into which the individual vapor fractions are withdrawn from the top of the column for measurement. It is interesting to note that the columns themselves, which were the principal features of the original manually operated type of equipment, represent only a comparatively minor portion of the assembly of potentiometers, relays, and other controls that are required to make the operation substantially automatic.

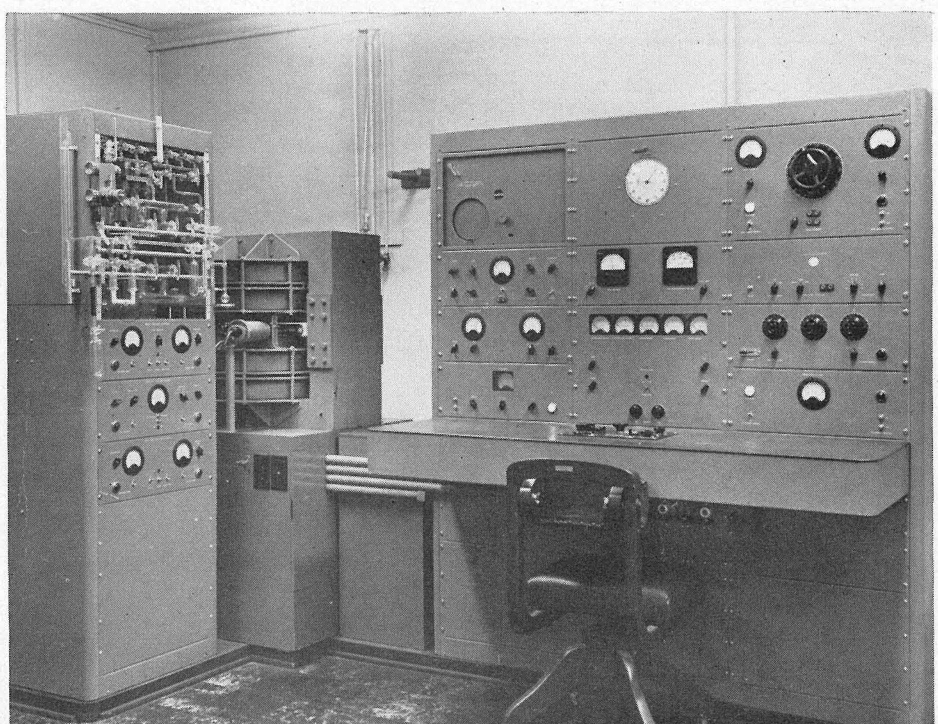


FIG. 3. Typical Consolidated Mass Spectrometer Installation.

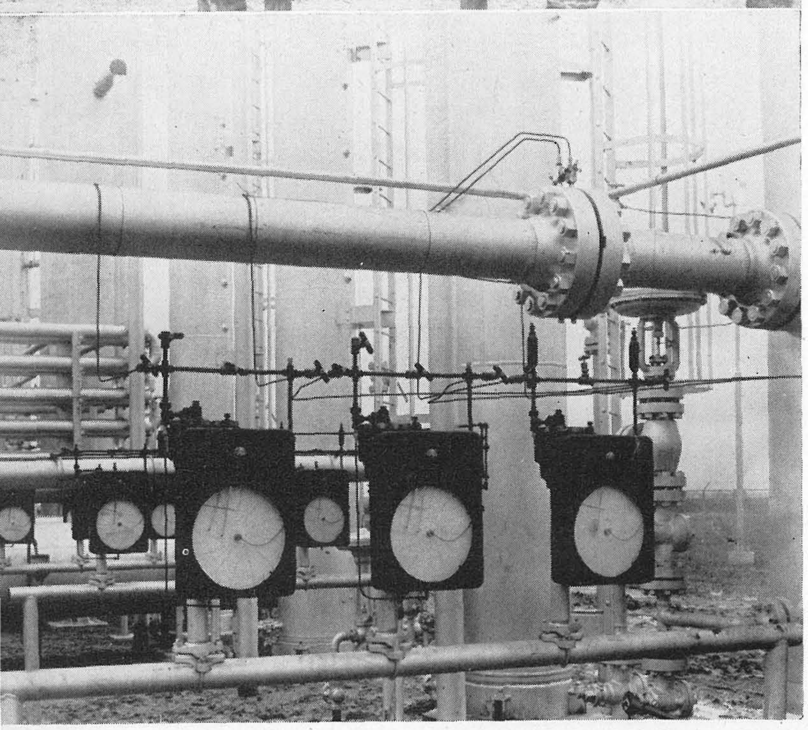


FIG. 4 (at top). Multiple orifice meter installation on gas lines from gas-oil separators for individual wells. FIG. 5 (at bottom). Orifice meters in a natural gasoline plant.

SPECTROMETRY

The most modern developments in equipment for analyzing gases and liquids of the types encountered in natural gasoline operations occurred during the war. These are infrared spectrometry and mass spectrometry.

Infrared spectrometry is based upon the principle that changes in vibrational energy that are constantly occurring within molecules give rise to absorption of radiation in the infrared range. A small sample of the hydrocarbon mixture to be analyzed is subjected to infrared radiation of a fixed series of wave-lengths and fixed intensity. Part of the energy is absorbed by the sample and the residual energy is measured. In this manner an energy absorption spectrum is obtained. The amount of absorption is specific for each atomic pattern and from the spectrum of a mixture the components can be identified and their concentrations computed.

Fig. 2 is a photograph of a Beckman infrared spectrophotometer of the type employed for analyzing hydrocarbon mixtures. The spectrometer itself is in the case. Below it are the amplifier and recorder for indicating the absorption pattern. To the rear is the system for handling the sample preparatory to introducing it into the infrared light path.

At the present time infrared spectrometry is employed principally in analyzing comparatively narrow ranges of fractions, such as mixtures of isobutane and normal butane or of butanes and butylenes encountered in refinery operations. Undoubtedly its use will be extended to cover other mixtures, but mass spectrometry appears to offer greater promise in analyzing all of the types of mixtures encountered in natural gasoline operations.

In mass spectrometry* the sample to be analyzed is bombarded by a stream of electrons which break down the molecules into electrically charged fragments. These charged fragments or ions are then drawn through a combination of electrical and magnetic fields in such manner that the ones of different weights can be segregated and their relative abundance can be determined. A definite pattern, called a mass spectrum, exists for each type of molecule when it is bombarded by a stream of electrons of specific energy. From the mass spectrum of a mixture the presence of the individual components can be identified and their amounts determined. At the present time it is possible to analyze a mixture containing all the paraffin hydrocarbons from methane through pentane, and rapid progress is being made in extending this range. However, despite the ability of a mass spectrometer to analyze in a single operation for a wider range of constituents than an infrared spectrometer, the latter instrument possesses the advantage of being able to distinguish between stereoisomers of the *cis* and *trans* type. Thus both types of instruments will probably find their most suitable ranges of applicability and will supplement rather than compete with each other in the general field of hydrocarbon analysis.

Fig. 3 is a view of a Consolidated Mass Spectrometer of the type employed in making routine hydrocarbon analyses. At the left is the assembly for conditioning the sample and introducing it into the ionizing chamber. The ionizing chamber and the electrostatic and electromagnetic fields are shown at the left center. At the right is the control panel for obtaining and recording the so-called mass spectrum.

The principal advantage of spectrometry as compared with fractional distillation lies in the speed with which the spectrum can be obtained and results computed. One hour or less is required to determine the composition of a sample that would require several hours for analysis by fractional distillation. On the other hand, spectrometric equipment is much more expensive to install, and in order to take full advantage of the time-saving feature a high load-factor with respect to number of tests must be maintained. Accordingly it is unlikely that spectrometry will supersede fractional distillation, except in comparatively large central laboratories where a large number of analyses are made.

METERING NATURAL GAS

The measurement of gas volumes occupies an important place in the natural gasoline industry. Both the volume and gasoline content of wet gas delivered from each individual lease must be known in order that the proper allocation of finished gasoline may be made. Also, a similar allocation of dry gas must be made, for which purpose it is necessary to measure the volumes of gas delivered to the various outlets, such as sales lines, field fuel lines, etc.

*See *Engineering and Science*, October, 1945.

(Continued on Page 15)

REPRODUCTIONS OF PRINTS, DRAWINGS AND PAINTINGS
of Interest in the History of Science and Engineering

6. George Stephenson and the First Public Railway

By E. C. WATSON

THE most famous of all the early locomotive builders was George Stephenson (1781-1848). "Although he cannot be described as the inventor of the locomotive, he certainly did more towards its improvement during the crucial period than any other man and, by concurrent construction of suitable railways, did much to establish its practical utility."[1]

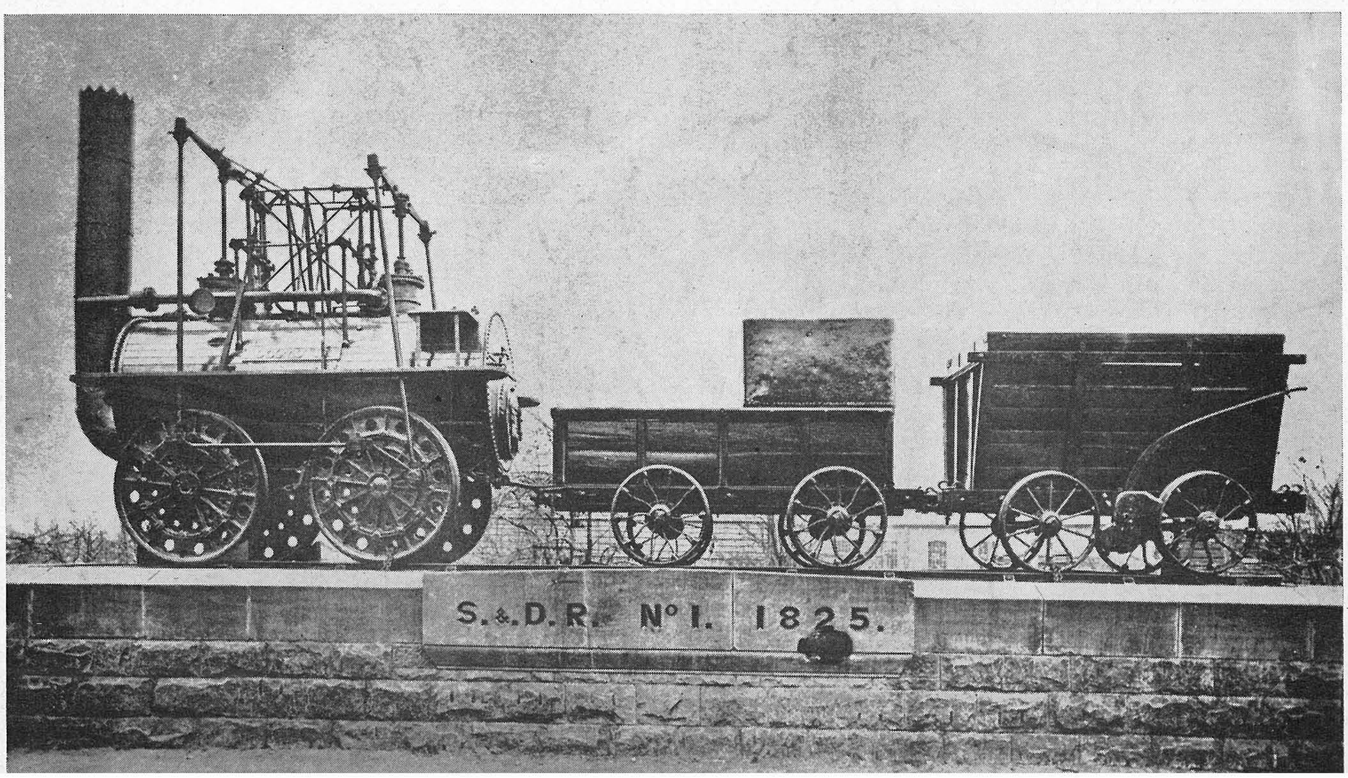
Since a number of accounts[2] of Stephenson's life and work are available, one will not be attempted here. Suffice it to say that, having had his interest in steam traction aroused by the success of Blenkinsop and Hedley at Wylam, in 1814 he built a locomotive for the tramway between the Killingworth Colliery, where he had been appointed enginewright in 1812, and the shipping port nine miles away. This locomotive, which was modelled after that of Blenkinsop, was the first to run by adhesion on iron edge-rails. Between 1814 and 1822, moreover, he made a number of improvements in this engine, and several of the improved types were built and used successfully. In 1823, having succeeded in impressing the advantages of steam traction on Edward Pease, the promoter of a railway from Darlington to Stockton to transport the coal wealth of Durham County to North Sea ports, he was appointed engineer of the railway, with permission to carry out his own plans. The success of the Stockton and Darlington

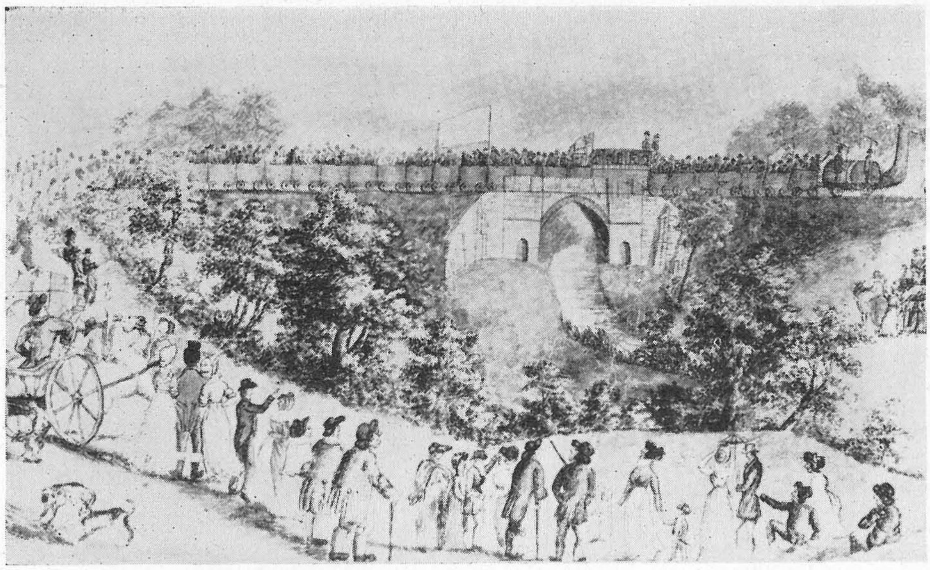
1. *Handbook of the Science Museum, Land Transport III. Railway Locomotives and Rolling Stock. Part I—Historical Review* (H. M. Stationery Office, London, 1931), p. 11.

2. Samuel Smiles, *Story of the Life of George Stephenson* (London, 1857; new ed., 1873); Samuel Smiles, *Lives of the Engineers,* Vol. III. *George and Robert Stephenson* (London, 1868; new ed. 1904); C. Matschoss, *Great Engineers* (London, 1939), pp. 171-189; R. H. Thurston, *A History of the Growth of the Steam-Engine* (Ithaca, 1939), pp. 183-204; J. S. Jeans, *Jubilee Memorial of the Railway System. A History of the Stockton and Darlington Railway* (London, 1875), pp. 219-230.

FIG. 1. George Stephenson (1781-1848).

FIG. 2. The first locomotive used on a public railway.





AT LEFT:

FIG. 3. Inauguration of the first public railway, September 27, 1825.

Railway led to his employment in the construction of the Liverpool and Manchester Railway, the first great line and the one which established the railway system as truly successful. In 1823, also anticipating a demand for engines, he and his son Robert, with the backing of Pease, opened in Newcastle the first locomotive works in the world. "This establishment was the chief seat of practical locomotive development for the ensuing twenty years, and a training ground for locomotive engineers."[3]

The Stockton and Darlington Railroad was the first public steam railway in the world. At the opening, on September 27, 1825, a train of 34 vehicles, making a gross load of about 80 tons, was drawn by one engine driven by Stephenson with a signalman on horseback in advance. The train moved off at the rate of from 10 to 12 miles per hour and attained a speed of 15 miles per hour on favorable parts of the line. The locomotive, appropriately called "Locomotion," was built by the Stephensons at Newcastle. It weighed about seven tons, developed about 10 horsepower, and hauled a load of from 60 to 70 tons at an average speed of five miles per hour.

Fig. 1 reproduces a full-length portrait of Stephenson by John Lucas. It is taken from the well-known engraving by T. S. Atkinson. The section of the Liverpool and Manchester Railroad across Chat Moss, a bog some 12 square miles in extent, is shown in the background.

Fig. 2 shows the "Locomotion" mounted on a pedestal in front of the Darlington North Road Railway Station, where it was placed with suitable ceremonies in June, 1857.

Fig. 3 is reproduced from a drawing by Dobbin in the Science Museum, London. It portrays the opening of the Stockton and Darlington Railway. As Jeans wrote 50 years later, many curious recollections of the opening ceremony were preserved by those who were present. "One can scarcely even now meet with a man or woman of advanced years between Auckland and Darlington, both inclusive, who did not assist in the opening celebration. It was commonly reported at the time, and has since been handed down as a reminiscence of the event, that the whole of the inhabitants turned out to witness the advent of the 'iron horse,' save and except two old ladies whose infirmities or prejudices, or both combined, prevented them from rendering so marked a need of homage to the new era. Great excitement prevailed among the spectators as the engine came in sight. Excitement in many minds took the form of disappointment when it was found that the locomotive was not built after the fashion of a veritable four-footed quadruped, some of the older folks expecting to see the strange phenomenon of an automatical semblance of a horse stalking along on four legs. But everybody admitted that the performance of old 'Locomotion' was wonderful in its way, and vigorous cheering greeted its approach."[4]

3. *Handbook of the Science Museum*, loc. cit.
4. J. S. Jeans, *Jubilee Memorial of the Railway System* (London, 1875), pp. 71-72.

America's First Gasoline Automobile

(Continued from Page 8)

I took this car to London in June, 1897, and there became acquainted with the Honorable C. S. Rolls, later of the famous Rolls-Royce car. Mr. Rolls frequently rode with me, both as passenger and driver, and in July, 1897, wrote an article for the English magazine *Automotor*, in which he praised the flexibility of the engine and stated that the car was free from most of the objectionable features of other makes.

LATER DEVELOPMENTS

With manufacture started in 1901 at the J. Stevens Arms and Tool Company in Chicopee Falls, Massachusetts, the first Stevens-Duryeas had a two-cylinder engine, shown in *Fig. 9*, and three-speed transmission, located in the body beneath the driver's seat. These cars were profitably sold for three years, but, seeing the growing influence of foreign design, in 1903 I designed a four-cylinder motor, placed forward under a hood with a shaft drive to a bevel gear in the rear axle. For the engine I designed a multiple-disk, dry-plate clutch, and arranged to bolt the engine crankcase, clutch housing, and transmission housing together as a unit. This we called the "unit power plant" and a diagram of it appears in *Fig. 10*. The car was finished in 1904 and shown at the New York show in January, 1905. A year later a company now prominent in the industry exhibited at the New York show an exact copy of the chassis of this Stevens-Duryea car, and later the unit power plant, with multiple-disk, dry-plate clutch, became substantially standard for the industry.

A six-cylinder car, shown in *Fig. 11*, was added to the Stevens-Duryea line in 1906 and after that sixes became the company's principal product. These cars were a source of very satisfactory profits to stockholders, but they were all high-priced cars, ranging from $2,500 for the four-cylinder car of 1905 to $6,500 for certain later models. A seven-passenger, six-cylinder model appears in *Fig. 12.*

By 1915, it had become clear to me that mass production methods would eventually spell the doom of the high-priced car. I was in ill health at the time, and, having received an excellent offer from the Westinghouse Company for our plants in Chicopee Falls and Springfield, I accepted the offer and retired. This move I have never regretted.

Testing and Metering in Natural Gasoline Operations

(Continued from Page 12)

The equipment now almost universally employed for measuring gas volumes is the orifice meter. Its operation is based upon the principle that the rate of flow of fluid is a function of the pressure drop caused by the presence of a suddenly restricted opening or orifice of known size inserted in the line.

For every combination of pipe size, orifice size, flowing pressure, and temperature and specific gravity of gas, a given differential pressure across the orifice corresponds to a definite rate of flow of gas through the line. Tables are available for relating these quantities.

Of the factors named above, pipe size of course remains constant. The size of orifice may be varied at will simply by removing one orifice plate and inserting another. The specific gravity of the gas from a particular source is usually so nearly uniform or changes at such slow rate that periodic determinations of this property are adequate. Temperature is either taken daily at a time representing average conditions, or, where large volumes of gas are involved, it may be recorded continuously. Continuous records of both line pressure and differential pressure are usually made on clock-operated charts attached to the orifice meter. These charts are usually changed daily.

The charts are sent in to a field office, where the pressures indicated on them are averaged. From carefully kept records of the other conditions existing at each meter, the corresponding volumes of gas are computed with the aid of the tables mentioned above.

Fig. 4 is a photograph of a number of orifice meters installed on gas lines from gas-oil separators in which fluid from individual wells is separated into wet gas and crude oil streams ahead of the natural gasoline plant. *Fig. 5* is a picture of a number of orifice meters located inside a natural gasoline plant to measure streams entering or leaving processing equipment.

METERING LIQUIDS

Orifice meters are applicable to the measurement of liquid flow as well as gas flow and are widely employed for this purpose in natural gasoline operations. Typical locations are on lean oil streams to absorbers, feed and reflux streams to fractionating columns, etc.

On the other hand, orifice meters are less reliable in determining rates of flow of volatile liquids than in measuring the flow of gases and vapors. Accordingly, while they have been widely used for operating control purposes, they have been considered unsuitable for measuring volumes of finished stocks produced at natural gasoline plants. For this service, positive displacement meters of the general type used in domestic water and gas service are often employed. The use of meters on finished product streams makes possible the observation of rate of production without the necessity of accumulating large quantities of highly flammable liquids in gauging and shipping tanks in the plant area where boilers and gas engines might present an ignition hazard.

As has been the case with most industries, there has been tremendous technological progress in the last 25 years in the natural gasoline industry and the related liquefied petroleum gas industry, which actually developed from infancy to maturity during that period. Improvements in metering and testing methods have contributed effectively to that progress.

The Month in Focus

(Continued from Page 3)

government. This report can be obtained from the Government Printing Office for 30 cents.

November 13, 1945

To the Members of the
Senate Committee on Commerce
and the
Senate Committee on Military Affairs

Gentlemen:

We have a feeling of deep concern regarding the pending legislation on federal aid to science. We share the belief of the sponsors of this legislation that expansion of our scientific work can yield returns of great benefit to the nation.

The manner in which this aid is administered is vital to the success of any program undertaken. We have studied this matter, and we transmit to you our considered opinion on the two administrative plans which you now have under discussion.

It is our belief that the top authority in the proposed National Research Foundation should rest in a board or commission of scientists and laymen chosen by the President on the basis of interest in and capacity to promote the purposes of the Foundation, and not in a director who would be aided by a board with only advisory duties. The responsibilities of the top authority will be so great and the fields to be covered are so extensive that only a broad and representative board of most able men could effectively assume this responsibility and authority.

We believe that the Foundation can achieve its objectives better by grants to institutions for the support of broad fields of scientific research and scientific education than by contracts for research on specified and closely limited problems.

We believe that the Foundation should not supervise or direct research activities of other government agencies, and should not have the duty of surveying these activities, but should arrange for suitable interchange of information between government agencies and research men carrying on work with the support of the Foundation; and that officers of other government agencies should serve *ex officio* on certain advisory panels of the Foundation, such as Advisory Panel to the Division of National Defense, but that no such *ex officio* members should serve on any board or commission of this Foundation to which authority is delegated.

Recognizing the great need of study of human relationships, we believe that the Foundation should provide suitable support for the social sciences and humanities as well as for the medical and natural sciences, that the social sciences and humanities should be suitably represented in the membership of the board or commission, and that provision should be made for scholarships and fellowships in the social sciences and humanities as well as in the medical and natural sciences.

It is our considered opinion that Bill S. 1285, which was introduced by Senator Warren G. Magnuson and is based on the report, "Science: The Endless Frontier," made to President Truman by Dr. Vannevar Bush, conforms far more closely to the requirements stated above than does Bill S. 1297, which was introduced by Senator Harley M. Kilgore, and we urge that you recommend passage of the Magnuson Bill S. 1285 (Committee Print of October 12, 1945), in order to achieve the maximum benefit from scientific research for all of the people.

Yours very truly,

(This letter was signed by 84 members of the California Institute of Technology Weekly Seminar.)

C. I. T. NEWS

NOVEMBER ALUMNI MEETING

The November meeting of the Alumni Association was held at the Kaiser Steel Plant at Fontana, Calif., on November 15, 1945.

Interest in the plant and in association activities was adequately demonstrated by requests for reservations from 350 C.I.T. alumni in the Los Angeles-Pasadena area.

The meeting, which had been arranged by Donald R. Warren of the Donald R. Warren Company, a Tech alumnus, assembled for dinner in the Kaiser Plant cafeteria. After the dinner, Chuck Varney, president of the Association, introduced M. W. Sahlberg of the Warren Company. Mr. Sahlberg related the story of the construction of the plant, portions of which were designed by the Warren Company. In an amazingly short time what had been raw land became a fully integrated unit capable of transforming the ore from the Vulcan Mine at Kelso, in San Bernardino County, Calif., and from Utah to finished steel products.

Construction started in March, 1943, and nine months later the blast furnace began to deliver the metal which has gone into the hulls of hundreds of ships needed for victory, as well as into countless other war materials. Mr. Sahlberg told of the important part in the structural design and engineering which had been played by Jim Fox, chief engineer of the Warren Company and a C.I.T. graduate of the class of 1936.

The members of the Kaiser Steel Company who were to act as guides and hosts for the inspection tour were then introduced. They were:

Thomas M. Hart, assistant general superintendent
W. A. Vogt, plant engineer
Thaddius Kay, assistant plant engineer
Wright M. Price, material and cost engineer
Franklin C. Frye, special combustion engineer
Nathan Hittelman, project engineer
Warren Hubbard, Sr., project engineer
Lynn Jones, electrical engineer
Harry Riegel, superintendent of utilities

Itinerary of the trip included the coke ovens, capable of processing 1728 tons of coal per day; the blast furnace, with 1200 tons capacity; the five stationary and one tilting type open hearth furnaces, of 185-ton capacity each; and the plate and structural mills and merchant mill. The plate mill is designed to roll plates from three-sixteenths inch to one inch in thickness and up to 92 inches in width. The structural mill—rated at 70 tons per hour—produces *I*-beams, channels, angles, blooms and billets. The merchant mill produces light structural sections, rounds and squares and reinforcing bars. Stops were also made at the power plant, the soaking pits, and the ore and coal storage structures. The trip afforded spectacular views of the tapping of the blast furnace and the unloading of the coke ovens as well as a splendid opportunity to see the scope of the whole process of steel making.

The Alumni Association wishes to express its appreciation to the Kaiser Company and the Donald R. Warren Company for making the trip possible.

SEMINARS REVIEW CURRENT EVENTS

Members of the faculty of C.I.T., of the staffs of the Huntington Library and Mt. Wilson Observatory are meeting in weekly seminars at Caltech to discuss the relations of science and technology to society and government.

Attendants at the seminars, which have been held throughout October and November, have heard reports from Dr. C. C. Lauritsen and Dr. Paul Epstein on the necessity of arriving at a method of control of the atomic bomb, a discussion by Dr. Linus Pauling of two bills before the Congress proposing federal financial aid to science, reports from Professor Horace Gilbert on the effects of concentrated British-U. S. bombing of German industry, and an eye-witness account from Commander J. T. Hayward of the damage done at Nagasaki and Hiroshima by the atomic bomb. At the seminar of November 27, Dr. Edwin F. Gay reported on the work being done in the social sciences and the funds being expended for projects and investigations in the field of the humanities.

Out of these seminars have come two newsworthy documents; first, the open letter to the President of the United States, setting forth the belief of the members of the seminar that control of the atomic bomb and atomic development must be established at any cost on first a national and then on an international basis. The complete text of this letter was carried in the November issue of *Engineering and Science.*

Following the letter on the atomic bomb, and indirectly related to the same subject, a second document, addressed to the members of the Senate committees on commerce and on military affairs, stated the group's majority conclusions on the subject of federal aid to science. This letter appears in connection with Dr. Linus Pauling's editorial in the "Month in Focus." The reports by Professor Gilbert and Commander Hayward on the effects of bombing against Germany and Japan brought to light many startling facts, and as this information is released by the government, *Engineering and Science* will relay reports to its readers.

THOMAS HUNT MORGAN

Dr. Thomas Hunt Morgan, 79, one of the world's foremost authorities on heredity and 1933 Nobel Prize winner, died December 4 at Huntington Memorial Hospital, Pasadena, after a brief illness.

Professor emeritus of biology at the California Institute of Technology, to which he came in 1928 as a leader of research in at least five fields and as president of the National Academy of Sciences, Dr. Morgan won the $40,000 Nobel Prize in medicine for his investigations concerning the eugenic function of the chromosomes.

It was the first time the prize in medicine had been awarded to anyone who was not a physician. The award came as the result of 17 years' study of tiny vinegar flies—known as *Drosophila melanogaster*—which clarified the laws of heredity and of the mutation of species. Among other honors which came to the renowned biologist, who also was president of the American Association for the Advancement of Science in 1929-30, were the award of the Copely Medal by the Royal Society of London, investiture with the Insignia of Academician in the Pontifical Academy of Science in behalf of Pope Pius XI, and the Copernican citation.

Institutions which conferred honorary degrees on Dr. Morgan included Johns Hopkins, Harvard and McGill universities; the universities of California, Edinburgh, Michigan, and Paris, and his own University of Kentucky, from which he graduated in 1886. He won his master's degree there two years later and his Ph.D. at Johns Hopkins in 1890.

The genes which Dr. Morgan studied to evolve the findings which won him world-wide recognition are the guiding units determining formation of characteristics in animal, plant, and human life. Chromosomes are the larger units in which the genes are found. Because the vinegar flies multiply 800 times as fast as man, they afforded Dr. Morgan an opportunity for rapid cross-breeding in the laboratory, where they were subjected to many experiments, including X-ray bombardment. The genes are so small that they are invisible under ordinary magnification but the result of their action was apparent through physical changes in flies to the scientist whom many considered the "20th century Mendel."

Dr. Morgan, who recently retired from the Executive Council of the California Institute of Technology, was also a member of the American Society of Naturalists, the American Society of Zoologists, the Society of Experimental Biology and Medicine, the New York Academy of Sciences, the French Academy of Sciences, and the Royal Society of London.

Under his direction the William G. Kerckhoff Laboratories of Biological Science at Caltech became known as one of the world's most distinguished scientific organizations.

Dr. Morgan leaves his widow, Mrs. Lillian Simpson Morgan, of 1149 San Pasqual Street, Pasadena; a son, Howard K., airline executive of Kansas City; and three daughters, Mrs. Edith S. Whitaker of Palo Alto; Mrs. Lillian V. Sherp of Rochester, N. Y.; and Miss Isabel Merrick Morgan of Baltimore, Md.

DR. J. E. BELL RETIRES

Dr. James Edgar Bell, professor of chemistry at the Institute, retired in June, 1945. For many years chairman of the Freshman Registration Committee, Dr. Bell made a policy of knowing each member of the freshman class. His personal interest in Caltech men made his Sunday evening "at homes" events in which many freshmen participated during their first year at the Institute.

Dr. Bell's activity in recruiting able men for the study of science at C.I.T. was comparable to Bernie Bierman's effort to encourage outstanding football players to enter Minnesota. At every opportunity Dr. Bell appeared before the senior classes of California high schools, and his ability to open to his audience the vistas and challenges of engineering and science undoubtedly marked the turning point in the choice of a career for many a student.

Dr. Bell received his S.B. at the University of Chicago in 1905 and his Ph.D. at the University of Illinois in 1913. He joined the staff of C.I.T. as associate professor of chemistry in 1916 and became professor of chemistry in 1918. He was active in the social life of the C.I.T. faculty and it was his pleasure to see that any new graduate student was made to feel at home at faculty functions.

At present Dr. Bell is teaching chemistry at Rollins College in Florida, where he continues to concentrate on his special interest, the development of men of science.

ATHLETICS

By H. Z. MUSSELMAN,
Director of Physical Education

In the opening Conference basketball game, Caltech nosed out the strong Whittier Poets 30-29 in a thrilling contest. Tech held a 21-17 half-time margin, but the Poets scored two quick baskets in the second half to tie the score. Throughout the half the Engineers never had better than a tie, and with two minutes to go, the Quakers held a three-point advantage. However, quick baskets by Elmore Brolin, guard, and Vincent Nurre, forward, swept the team to victory in the final 30 seconds.

At present, Coach Carl Shy is carrying only 10 men on the squad. The starting line-up consists of Jerry Schneider and Dick Jackson forwards, Paul Saltman center, Stuart Bates (captain) and Elmore Brolin guards. The second-string lines up with Don Root and Vincent

Nurre forwards, Art Bruington center, and Dennis Ahern and Andy Tudor guards. Bates, Schneider and Ahern are lettermen, while Brolin and Nurre played on last year's "B" team. Two freshmen, Saltman and Bruington, are the only civilians on the squad. Several other men, who are being left on the "B" squad to gain game experience, will be brought up in a few weeks.

The team is tall (all the starting men are six feet) but not too fast. However, there is a decided absence of consistent scorers, and the team will sorely miss the threats which featured the Tech teams for the past five years. With scoring at a premium, Coach Shy is stressing tight guarding, and a deliberate and ball-controlling type of game with set plays. This should result in lower scores than Tech teams have been noted for.

Little is known of the strength of the other Conference teams, but all have favorable records in preseason practice games. With all teams decidedly strengthened by the return of many war veterans, the championship race appears to be wide open.

The classy water polo team, coached by Bob Merrick '42, is off to a fine start, with victories over both Inglewood High and U. C. L. A. by identical scores, 10-7. Additional contests will be played within the next few weeks with U. S. C., U. C. L. A., Fullerton J. C., and Whittier High.

COMING SOCIAL EVENTS

The Annual Dinner-Dance will be held at the Oakmont Country Club in Glendale on February 2. Kay Kalie and his band will provide the music for the evening.

Dinner will be at 8:00 P. M.—	$3.80	per couple
Dance will be at 9:30 P. M.—	2.70	per couple
Dinner and Dance—	6.50	per couple

This is also to announce that the date of the June banquet is tentatively set for June 21. Members of the alumni who have some distance to travel may wish to arrange their vacations accordingly.

INDUSTRIAL RELATIONS MEETINGS ANNOUNCED

The Industrial Relations Section of the California Institute of Technology announces the following dinner-discussion meetings for the current season. Attendance at these meetings is limited to representatives of the sponsors of the activities of the Industrial Relations Section and is by invitation.

Date	*Subject*	*Speaker*
Dec. 10, 1945	"The Economic Effects of Labor Policy"	Professor Leo Wolman, Columbia University, National Bureau of Economic Research
Feb. 20, 1946	"Collective Bargaining of Professional Employees"	Professor Waldo E. Fisher, Wharton School of Finance and Commerce, University of Pennsylvania
April 4, 1946	"Executive Practices in the Field of Human Resources"	Lawrence A. Appley, Vice-president, Vick Chemical Company

C.I.T. ENROLLMENT

Military students continue to predominate enrollment at California Institute of Technology, as shown by registration for the current semester which began October 31, 1945.

From a total enrollment of 921, which approximates former peacetime numbers, undergraduate students numbered 619 and postgraduates 254, according to L. W. Jones, registrar.

Of the undergraduates, 125 were Navy V-12 seniors and 241 Navy V-5 freshmen. Civilian student registration showed: freshmen, 137; sophomores, 55; juniors, 29; and seniors, 32.

Included in civilian enrollment were 110 veterans of World War II—undergraduates, 75; graduates, 35.

Among graduate students were 72 army and navy officers assigned to the Institute for special study in aeronautical engineering. Eight naval ordnance officers were also enrolled.

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.

1922

BRIGADIER-GENERAL HAROLD R. HARRIS was elected vice-president and general manager of American Export Airlines, the name of which is to be legally changed to American Airlines Overseas. General Harris, formerly senior vice-president of Pan-American Grace Airways, has been serving as assistant chief of staff, Air Transport Command. General Harris holds 13 world flying records and was the first flyer in this country to receive the Caterpillar Club's Switlik trophy in saving his life by parachute in emergency.

HAROLD S. OGDEN was named chairman of the American Institute of Electrical Engineers in the Erie section. Mr. Ogden's appointment was made in September.

1927

RALPH M. WATSON was recently appointed assistant to the vice-president in charge of engineering for the Worthington Pump and Machinery Corp. at Harrison, N. J.

LIEUTENANT-COMMANDER WILLIAM W. AULTMAN was, on last reports, in charge of a Seabee battalion on Iwo Jima and, after a short tour of duty in Japan, expected to be returned home to inactive duty.

1928

MAJOR ELLWOOD H. ROSS has returned to his home in Los Angeles after serving 19 months overseas in the European theater. When serving as Assistant G-4 of the Fifth Army, Major Ross was on the joint Army and Navy Planning Staff for the invasion of Italy. When his division was attached to the British Army, Major Ross held the position of American Town Major of Constantine. On his return to the States, he spent one year in the office of the Chief of Engineers, Washington, D. C.

MAJOR F. GUNNER GRAMATKY, with the Corps of Engineers, was returned to inactive status on October 9. His service activity included campaigns in New Guinea and the Philippines. In civilian life he has resumed his activity in engineering construction.

1929

RICHARD G. ROFELTY has been working for the past three years as project engineer for the Guy F. Atkinson Co., building Army bases. Mr. Rofelty spent a short vacation in southern California last month, then entrained for Portland, Ore., where he expects to locate.

DOCTOR PHILIP G. MURDOCH has accepted appointment as professor of chemical engineering at Texas Agriculture and Mechanical College. During the past 12 years Dr. Murdoch has been with the Shell Oil Co., mostly in the New York area.

1930

JACK PRITCHETT, on leave from the U. S. Army Engineers Board, visited the Institute while on a business trip to southern California late in October. Mr. Pritchett was on a mission to Europe for several months, mainly in Germany, to investigate the engine-generator sets used by the German Army.

ARTHUR NOMANN is in charge of the geophysical laboratory of the Superior Oil Co. in South Pasadena, Calif.

1931

COMMANDER PERRY M. BOOTHE, previously in charge of Pontoon Assembly Detachment No. 5, is now in Guam in charge of a large Seabees group.

LIEUTENANT BYRON JOHNSON is stationed at the Naval Auxiliary Air Station at Shelton, Wash.

ADAM T. ZAHORSKI announces the arrival of a son in October.

1932

MAJOR WILLIAM BERGREN, who formerly was assistant conductor and director of the Caltech concert orchestra, has just completed two weeks as guest conductor of the newly revived Manila Symphony Orchestra. Major Bergren, formerly a biologist at Caltech, is now stationed in Manila as the chief nutrition officer for the entire western Pacific area and is in charge of the area's food supply. He saw action in New Guinea and other Pacific battle areas.

EDWARD GRISWOLD has accepted a position with the Burklyn Co., Glendale, Calif.

1933

DAVID WEINSTEIN is in the geophysics department of the Superior Oil Co. at Houston, Tex.

JACK SPARLING is chief structural engineer for J. Gordon Trumbull, Inc., consulting engineers, of Cleveland, Ohio.

LIEUTENANT-COMMANDER PHILIP CRAIG is stationed in the Navy Office, Consolidated Aircraft Co., at San Diego, Calif.

LIEUTENANT ARTHUR MATHEWSON, JR., U.S.N.R., is an assembly and repair officer at the Alameda Air Station.

1934

WARRANT OFFICER (j.g.) DAN MATHEWSON is assistant plant clearance officer for disposition of air force surplus material at the Douglas Aircraft Co. at Long Beach, Calif.

ERNEST R. HOWARD, previously in the engineering department of The H. A. Wilson Co. at Newark, N. J., is now in charge of the Thermometal Sales Department of that firm.

1935

JOHN R. ROSSUM announces the arrival of John R. Rossum, Jr., on October 23.

1936

FRANCIS V. FRAZIER passed away at his home in Los Angeles on October 14. Mr. Frazier is survived by his wife, Betty; two sons, Francis and Richard; and his mother, Mrs. Helen E. Frazier.

THE REVEREND TYLER F. THOMPSON has been released from a Japanese prison camp, where he was interned since February, 1942. At last report, he was still in Singapore but expects to return to the United States soon.

EDGAR W. OLSON and JACK JOHANNESSEN '38 have joined as a partnership in the electrical contracting business.

1938

CAPTAIN ARMAND DU FRESNE is spending terminal leave at his home in southern California and has been returned to reserve status. Captain Du Fresne would like to hear from others of the class of '38. His home address is 1936 Hanscom Drive, South Pasadena, Calif.

GARDNER WILSON has returned to southern California to establish residence.

WILLIAM BRENNER, employed by Westinghouse Electric Corp. at East Pittsburgh, visited his family in southern California late in September.

1939

JAMES S. GASSAWAY has accepted a position with North American Aircraft in Inglewood, Calif.

VOLNEY K. RASMUSSEN, JR., and Miss Janette Heald were married in Pasadena on September 28. Mr. Rasmussen is associated with one of the O. S. R. D. projects. The couple plans to reside in Pasadena.

J. EUGENE STONES is vacationing in southern California from Chickasha, Okla., where he is seismograph party chief for Superior Oil Co.

ALBERT P. GREEN, who is employed at the Naval Research Laboratory, Washington, D. C., in Airborne Radio Division, made a brief business trip to southern California late in October for the purpose of making surveys of air fields for naval radio activities.

LIEUTENANT WILLARD M. SNYDER, U.S.N.R., has arrived home in California and is on terminal leave. Lieutenant Snyder served in the air evacuation and air transportation squadrons in the Guam, Saipan, and Okinawa areas.

1940

DOCTOR EDWARD R. VAN DRIEST announces the arrival of a son, Edward Reginald, Jr. Dr. Van Driest is assistant professor of mechanical engineering at Massachusetts Institute of Technology, Cambridge, Mass.

MAJOR GORDON B. WEIR, U.S.A.F., has returned to the States and is now on terminal leave at his home in Los Angeles. Major Weir served in the Mediterranean Theater for 31 months—Africa, Italy, and France—as base weather officer in the 15th Air Force and was awarded the Bronze Star Medal.

DOCTOR A. M. ZAREM is the father of a new daughter, Janet Ruth, born on August 16.

1941

DALE TURNER is a seismologist at Bakersfield, Calif.

WILLIAM CHAPIN has a position with the Fluor Corp. of Los Angeles. Bill was married the latter part of September and is living in Long Beach, Calif.

1942

LIEUTENANT CARTER HUNT, U.S. N.R., and Miss Shirley Rotermund were united in marriage October 2 at the Post Chapel, Presidio of San Francisco. Lieutenant Hunt was stationed on the U. S. S. Fulton, a submarine tender.

PRIVATE MAYNARD STRADER describes the situation in Japan as he saw it on his arrival from Manila, September 13, as follows: "The one daylight B-29 raid of 600 planes did all the damage in this area. The industrial sections have been levelled to the ground, but most of the schools, office buildings, and stores were not damaged. Streets and bridges are in good condition and the street cars are running. The Japs are cleaning out the buildings which we are to occupy, for which they receive pay and a good lunch. So far there has been no trouble; these Japs are obedient and courteous; however, the Jap soldiers are not allowed in the city.

"In the downtown part of Tokyo are large, modern buildings, most of which are undamaged. There are wide streets, some of which look like the ones in Paris. The Imperial Palace grounds are across the street from the business section. The people seem to welcome the Americans and have had very little enthusiasm for the war, as it meant less food."

LIEUTENANT WARREN GILLETTE, U.S.N.R., having served in submarine service for 29 months, will be discharged within two months. Lieutenant Gillette was in both the Atlantic and Pacific areas, having seen action in the latter.

LIEUTENANT GEORGE MEYER, who has been in submarine service in the Pacific area, has returned to the States. He expected his discharge sometime in November.

1943

WARREN D. EATON has accepted a position with Rheem Manufacturing Co. of Pasadena.

ENSIGN ROBERT M. SHERWIN is stationed in the Pacific area in the boat group of an assault transport, awaiting transfer or demobilization. In 1943, Bob worked as a junior engineer in the general engineering department of Standard Oil of Calif.

LIEUTENANT (j.g.) EVERETT McCARTNEY was at the Institute last month while on leave. Lieutenant McCartney has been in the Pacific theater one year on the submarine U. S. S. Thornback and in the war zone about four months, during which time they participated in patrol off the coast of Japan.

LIEUTENANT (j.g.) HARRISON SIGWORTH was home on leave in October and was married to Miss Mary Sweningsen of Long Beach. Lieutenant Sigworth is assigned to submarine duty on the U. S. S. Loggerhead and served four months in the war zone, including Australia, Hong Kong, and the Java Sea.

1944

ENSIGN BRUNO PILORZ, stationed on the U. S. S. Entemedore, was home on leave recently.

ENSIGN TONY SPAULDING is a communications officer at Guam.

ENSIGN DOUGLAS G. DETHLEFSEN, who was commissioned last March at Columbia, left in October to join the amphibious forces overseas.

ENSIGN JAMES R. FREEMAN is a communications officer on the staff of the Zeilin, a transport, now in the Philippines.

ENSIGN PHILLIP ADAMS is with Amphibious Group No. 7, now in Korea.

ENSIGN FRANK CLENDENNEN is with a Seabees maintenance unit in New Caledonia.

ENSIGN DAVID ROUX JONES and Mrs. Jones announce the birth of their son, David Roux Jones, Jr., on September 1.

1945

ENSIGN JOHN L. STERN stopped at the Institute in October on his way to report to the Commander Service Force, Pacific Fleet, for assignment to duties with Seabees in the South Pacific area.

ENSIGNS CLIVE JACKSON and NORMAN MAGNESAN, having received commissions at Endicott, are on their way to the Pacific area.

D. B. SMITH, W. E. HELLER, R. V. SCHMOKER, R. J. SMITH, A. A. ERKEL, WILLIAM COOK, T. H. YOUNG, LIN BURZELL, DON KENDALL, DON TILLMAN, FRED BRIGGS, and JIM MASON were commissioned on November 8 at Fort Schuyler, N. Y.

C. A. BERGMAN and K. R. BURRELL are at Line Officers' School at Notre Dame.

Ex. '45

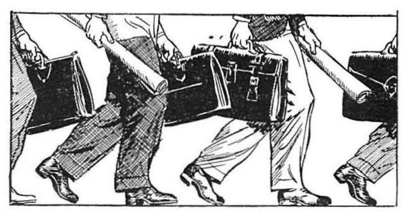
MILTON SWANSON, who is stationed at San Diego in amphibious training, visited the Institute last month.

Ex. '46

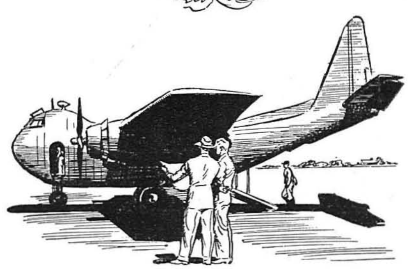
PFC. WILLIAM E. PALMER participated in the first triangular swimming meet ever staged involving three theaters of war, under the sponsorship of the Allied Sports Commission and held in Rome recently. Private Palmer serves in the 370th Medical Battalion of the 70th Infantry Division.

Flying Tigers fly strawberries now

1. 12 Flying Tigers, India-China "hump" pilots and A.V.G. ground crew men came home from the war with an idea. After what they'd learned in China, they thought they could carve out a place for themselves in the air freight business – not as a regularly scheduled line but as contract haulers.

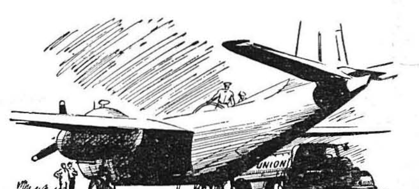


2. They knew they'd need a lot more capital. But that didn't discourage them. They pooled the savings they had, drew up their plans and started beating the bush for backers. Eventually they lined up several Los Angeles businessmen to furnish the additional capital on a 50-50 basis – the veterans to operate the company.



3. With this capital they bought 8 new, twin-engine, Navy-designed "Conestoga" cargo planes from the Surplus Property Board. Then they set up offices at the Long Beach (Cal.) Municipal Airport, named their company the *National Skyway Freight Corp.* and started business August 1, 1945.

4. Today the "Flying Tiger Line" employs 40 men, 38 of them veterans. Its planes, each with a cargo capacity of 10,000 pounds, haul *anything,* from strawberries to penicillin, on a contract basis. They'll pick up freight *any time, anywhere* in the U.S. and deliver it *anywhere* in the world.



5. The company uses Union Oil Aviation Products. But that doesn't seem nearly as important to us as the fact that the boys were able to do what they did. It could hardly have happened under anything but the American "system."

6. Without the *profit incentive* the businessmen would not have put up the capital. Without the hope of gaining *financial independence,* the boys wouldn't have sweated out the problems of starting a business. Altogether, we think it's one of the greatest things that's happened since the war.

UNION OIL COMPANY
OF CALIFORNIA

This series, sponsored by the people of Union Oil Company, is dedicated to a discussion of how and why American business functions. We hope you'll feel free to send in any suggestions or criticisms you have to offer. Write: The President, Union Oil Company, Union Oil Bldg., Los Angeles 14, Calif.

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