Research the Key to Railroads’ Progress

Progress in the art of railroad transportation, throughout the development of the industry, has been inspired by the fruits of research.

To railroad men, research means the organized, scientific endeavor constantly to invent better equipment, facilities and methods of operation and to improve those already in use. Railroads conduct research, individually, as separate companies; collectively, through the Association of American Railroads; and cooperatively, with equipment manufacturing companies in all fields.

Research is animated by constructive imagination, enterprise and vision. Railroad managements never rest content with facilities and methods merely because they work; not even because they work well. Management feels that its obligation is to find something, whenever possible, that works still better—to keep the art in constant progress, so as to increase continu-

Measuring the horizontal effect on track of speed of locomotives.
ously the utility, convenience, attractiveness, economy and safety of railroad service.

Through research, the railroads have kept in the van of technological progress. Not only have they constantly engaged in original work of their own, but they have also, with unfailing diligence, followed the development of every branch of science and engineering for discoveries and advances adaptable to railroad use.

For the last 70 years, the Pennsylvania Railroad has conducted research and testing work through a specialized department devoted entirely to these activities. It was organized in 1874, with a physical laboratory. A chemical laboratory was added the following year. The work and facilities have steadily expanded and are now of extensive proportions in all fields of physical, mechanical and chemical experimentation and exploration bearing upon the advancement of the industry.

The present Test Department is housed in a modern structure, which, with auxiliary buildings, covers 50,000 square feet of floor space at Altoona, Pa., the site of the Pennsylvania Railroad's principal locomotive and car works. The facilities embrace a

*These testing devices, installed in the track at Claymont, Del., played a major part in developing the Pennsylvania's famous GG-1 type high speed electric passenger and freight locomotives.*
number of large physical and chemical laboratories, completely equipped for railroad research and testing, while in an adjacent building is the Locomotive Test Plant, the only one of its kind in America. Several other buildings house special test apparatus.

The work of the Test Department is divided about equally between two related fields. One is pure and applied research and the other, material testing, inspection and control. Research aims to acquire and apply new knowledge respecting railroad equipment, other facilities, materials and operating practices. Tests and inspections insure that materials and equipment purchased conform to standards and specifications which are constantly being improved in the light of increasing knowledge gained by research and experimentation.

The Test Department employs 275 men and costs nearly $1,500,000 a year to operate. The staff includes 62 holders of college degrees. These graduates consist of 33 in chemistry, 15 in mechanical engineering, eight in electrical engineering, five in forestry and one in civil engineering.

Most of the research and test work is done at Altoona, though some highly important and far-reaching original research has been carried out on the railroad under conditions of actual operation. The material inspection work is chiefly done at the points of production.

Fields of research constantly under exploration by the technical
Constant improvement of the coal-burning steam locomotive has been one of the most important factors in Pennsylvania Railroad progress. Multiple-cylinder engines of new types, together with improved designs of direct turbine transmission, are included among some interesting recent developments.

Staff, in the physical and chemical laboratories of the Test Department, include the following:

Improvement of steel rails and detection and elimination of causes of defects; tests and analyses of oils and other lubricants, paints and preservatives; chemical and bacteriological examination of water to ascertain suitability for drinking purposes and locomotive boiler use; heat treatment of steel and other metals; study of destructive electrolysis and its prevention; functioning and improvement of electrical apparatus; investigation of the causes of electrical troubles; analysis of plain-carbon and alloy steels to determine carbon content and guard against harmful impurities; studies of coal and other fuels to determine power producing and other qualities; studies of the strength of materials, including tensile strength, resistance to crushing, etc.; tests of the properties of car springs; tests of different types of brake shoes; development of specifications for various apparatus and materials used by the railroad.

Test Department chemists check the various processes in the brass and iron foundries and the grease and oil mixing plant in the Altoona Works, with resulting important economies in the use of materials and improvement in the products.

Because bituminous coal is the world's most economical fuel, and is abundant and of high quality in Pennsylvania Railroad territory, this railroad has naturally, throughout its history, been
deeply concerned with the development and constant improvement of the steam locomotive, which is its standard source of motive power, except in the eastern seaboard territory where, owing to the great density and other peculiarities of the traffic, electrification became desirable.

In addition to the many highly advanced types of steam locomotives now in regular use on the Pennsylvania, the railroad, as a result of its continuous research, is now building a more modern type of direct-drive steam turbine locomotive of greatly increased power. Construction has also been begun, at the Altoona Works, on an initial order of new-type multi-cylinder steam freight locomotives which have been designed with sufficient horsepower to make better time hauling heavy freight trains.

In the Locomotive Test Plant, the engine under study runs with its own wheels resting on revolving drums, equipped with braking devices, capable of simulating the resistance of trains of various weights. A dynamometer (literally “force-measurer”) machine, measures the tractive force, or “pulling power,” produced by the locomotive when it is running at different speeds and hauling trains of different weights.

The tests conducted in this plant make it possible to determine the performance and efficiency of a locomotive under all conditions of practical operation. The knowledge so acquired has inspired many notable improvements in basic features of locomotive design and construction, including

In the Pennsylvania's Locomotive Test Plant, locomotives are constantly studied to effect improvements. This multi-cylinder passenger engine is of the new T-1 type, equipped with two pairs of driving wheels and two cylinders on each side. The streamlining has been removed.
boiler proportions, relative size of grate, size of superheater, draught arrangements, steam flow to cylinders, expansion of steam in cylinders and action of cylinder valves. The tests also yield comprehensive data on fuel and water consumption.

The most important research conducted by the Test Department out on the railroad has been a series of track, locomotive and bridge tests made in recent years at Claymont, Del., and Elkton, Md.

The Claymont tests were to determine the extent and causes of the stresses produced in the track by the operation of electric engines at higher speeds. They solved the mystery, among others, why certain designs of locomotives, running beyond certain speeds, tended to throw track out of line at curves. This knowledge, and other observations, led to the design, and subsequent extensive improvement, of the famous GG-1 type high-speed electric locomotive, used by the Pennsylvania in its fast electrified passenger and freight service.

The first Elkton tests were research into the stresses produced on bridges by speed of electric and steam locomotives. The results demolished beliefs long held as to the highest speeds which could be allowed without risk of harm to the bridge structures. Speed limits in effect for years were raised, and as bridges are frequent in the electrified area, this was an important help in making possible the great improvement of schedules.

The second series of tests at Elkton were conducted with steam locomotives running at high speeds, and developed valuable in-
formation concerning the forces exerted on the rails by the driving wheel counterbalances, and the stresses produced in the locomotives themselves.

In connection with these forms of research, it was necessary to invent an entirely new stress-measuring device, the "electrical strain gauge." Track stresses had previously been measured by the "Brinell test," which is still valuable and measures accurately the horizontal stresses in the track, but does not show which wheels cause them or the stresses developed in the locomotive. The "electrical strain gauge" measures both vertical and horizontal forces in the rail and also records the action of each wheel.

Both the Claymont and Elkton tests were entirely new ventures into fields of original railroad research, and have provided motive power and track maintenance engineers with a wealth of illuminating new knowledge having the greatest utility in refining and improving railroad service.

Many highly specialized products of pure and applied research are in wide use on the Pennsylvania Railroad.

The field of electronics has produced the "cab signal," which reproduces inside the engine cab the indications of the external signals, rendering accurate observance of the signals entirely independent of outside visibility.

The same field of science has also produced, though still in experimental form, an electronic "train telephone," permitting communication between the ends of moving trains, between trains, and between trains and wayside towers. This is being tried out on the Belvidere-Delaware branch, extending 67 miles northward from Trenton, N. J., and with promising results, looking toward increased efficiency of operation.

**Durability and effectiveness of brake shoes are tested by forcing them with various pressures against a revolving car wheel.**
Steel analysis is conducted to check conformity to specifications, determine carbon content, and guard against the presence of other substances in undesirable quantities. A steel sample is here being withdrawn from an electric furnace.

Centralized traffic control, first installed on the Pennsylvania in 1930, makes it possible to govern the movements of distant trains by signals and switches controlled by an operator at a central point, who has before his eyes a diagram of the trackage, with the positions of the trains shown by miniature lights.

Air conditioning is, of course, a product of research, and by far its most practically important and widely appreciated application has been on railroad passenger equipment.

Non-shatter glass for coach windows; improved car illumination; insulation of roofs and sides of cars against heat, cold, and noise; production of rail free from hidden defects; development of types and weights of rail which give greater stability, strength and riding comfort; scientific checking of the condition of rail under use; invention of types of "non-harmonic" car springs, which dampen oscillations and make cars run more smoothly; improvements of many kinds in automatic signals, beside the "signal in the cab"—these and many other forward steps have been the direct product of systematic and continuous research.

Though deeply indebted in the past to the Morse telegraph, the Pennsylvania Railroad has now nearly discontinued its use. Improved telephone apparatus has almost entirely superseded the Morse key for train dispatching.

Supplementing the railroad’s highly developed and very exten-
sive private telephone system of over 22,000 instruments, is a system-wide “teletypewriter” installation, by which messages written on typewriter keyboards are electrically reproduced at distant points, through switchboards like those used in telephony. By this means, in addition to instantaneous transmission of railroad messages, consignees are informed as to the movement of freight, and passengers at large stations are advised as to the arriving times of trains and the locations in them of the various types of railroad-owned and Pullman cars. The Pennsylvania is the only railroad using the switchboard principle to interconnect teletypewriter instruments.

“Facsimile equipment,” which electrically reproduces any written message at distant points, is being tried out in five areas on the railroad to determine its suitability for handling train orders. The indications so far are favorable.

Research is by no means confined to the technical or scientific field. It extends to the field of economics and of convenience. Research has produced many specialized types of freight cars to meet the particular need of shippers. An example is the covered hopper car, in which materials needing protection from the weather, like cement, can be shipped in bulk, without cost or delay to the shipper for packaging or bagging. Refrigerated freight containers give small shippers the advantages of the refrigerator car. Research has produced for passengers more comfortable types of coach seats and more attractive and economical Pullman sleeping car accommodations.

The beautiful streamlined exteriors of the new types of passenger cars and locomotives may be described as the results of research into the fields of applied art and esthetics.

Small, but important, this device was invented by the Test Department. It checks the performance of fusible plugs, installed in locomotive boilers as safeguards. If the temperature rises too far, the plug melts, empties water on the fire, relieves pressure, and gives a signal.
This gigantic mechanism scoops up, cleans and replaces stone ballast as it moves along. Its operation eliminates dust and produces a stable, smooth roadbed, with resulting greatly increased comfort of travel.

Since the outbreak of the present war, a grateful nation has acclaimed the performance of America’s railroads.

Not only are they carrying the war load that naturally would have come to the rails; they are also moving the immense volume of traffic which has been forced off the highways by fuel, vehicle and tire shortages, together with nearly all the freight formerly carried between domestic ports by sea.

Simultaneously, they are continuing to meet the essentials of civilian service—one of the few major industries able to carry the war load and also care for civilian needs.

Basically, this has been because the war emergency found the railroads in a high state of readiness. That, in turn, was due to the fact that they had been rapidly and extensively putting into practical application the fruits of research, invention and technological progress. From the panic year 1929 to the outbreak of war in Europe in 1939—the most difficult and discouraging period in all economic history—the railroads, with faith in themselves and the country, had been aggressively progressing the largest program in their annals, of improvements and betterments to facilities and refinements of service.

These programs were far advanced when war brought them temporarily to a halt. To this circumstance, in great degree, has been due the ability of the railroads to take on the war load and meet civilian requirements as well.
Considering the Pennsylvania as typical of the American railroads as a whole, it is significant that in the ten pre-war years, 1929 to 1938, this railroad spent on improvements, betterments and additions to its facilities and equipment $674,222,000.

In five war years, 1939 to 1943, it similarly expended $304,110,000.

Altogether, during the depression and war years combined, nearly a billion dollars have gone into improvements and betterments on this one American railroad.

In addition, since the outbreak of the war, other very large outlays have had to be made to cope with special operating problems and difficulties created by the war emergency.

From 1929 to 1938, the Pennsylvania Railroad placed in service 32,072 new freight cars and 297 new locomotives. During the five war years, it installed 14,003 new freight cars and 195 new locomotives.

Combining the pre-war decade and the five years of war, this railroad, since 1929, has placed in service a total of 46,075 new freight cars and 492 new locomotives, besides 161 extra-large capacity locomotive tenders built separately.

During the same period, 275,022 freight cars were completely overhauled and refitted; 8,472 cars were improved and modified, largely at time of complete overhaul, to increase capacity and utility, and 7,258 containers were built to handle bulk shipments in less than carload lots. In the passenger train service, 758 units of equipment were either installed entirely new or remodelled to substantially new conditions, with interiors modernized and in many cases exteriors streamlined.
Utilizing electronic principles, a “train telephone” system is now being tried out on the Pennsylvania Railroad, permitting communication between the ends of moving trains, between trains, and between trains and wayside towers. The transmission paths are confined to railroad property. No questions as to assignment of radio wave lengths arise.

In 1938, a year before the outbreak of the present war in Europe, the Pennsylvania Railroad completed the electrification of its eastern seaboard lines between New York, Philadelphia, Baltimore, Washington and Harrisburg. This has been of inestimable value in increasing the traffic-handling capacity of the most heavily used, and probably most strategically important, railroad trackage in the country.

In the same year, also, the Pennsylvania streamlined its through east and west trains, introducing air-conditioned equipment of the most ultra-modern types. Schedules were stepped up and greatly improved over the entire System.

The outbreak of the war in 1939 found air-conditioning spreading rapidly on nearly all railroads. Today, military and civilian passengers receive the comfort of 1,167 air-conditioned cars owned by this railroad, beside 728 air-conditioned Pullmans assigned to its service.

Air-conditioning, streamlining, the introduction of new luxuries and beauties in car interiors and appointments, were, of course, all interrupted by the war. They will be resumed as soon as materials and trained hands are again available, and railroad progress will be pushed into new and untouched fields of advancement as they are opened up by research, invention and the progress of science and engineering.

To make good this pledge, the railroads ask nothing for the future but constructive treatment from the Government, equality in competition with other agencies of service and the opportunity to sustain credit and attract capital through adequate earning power.