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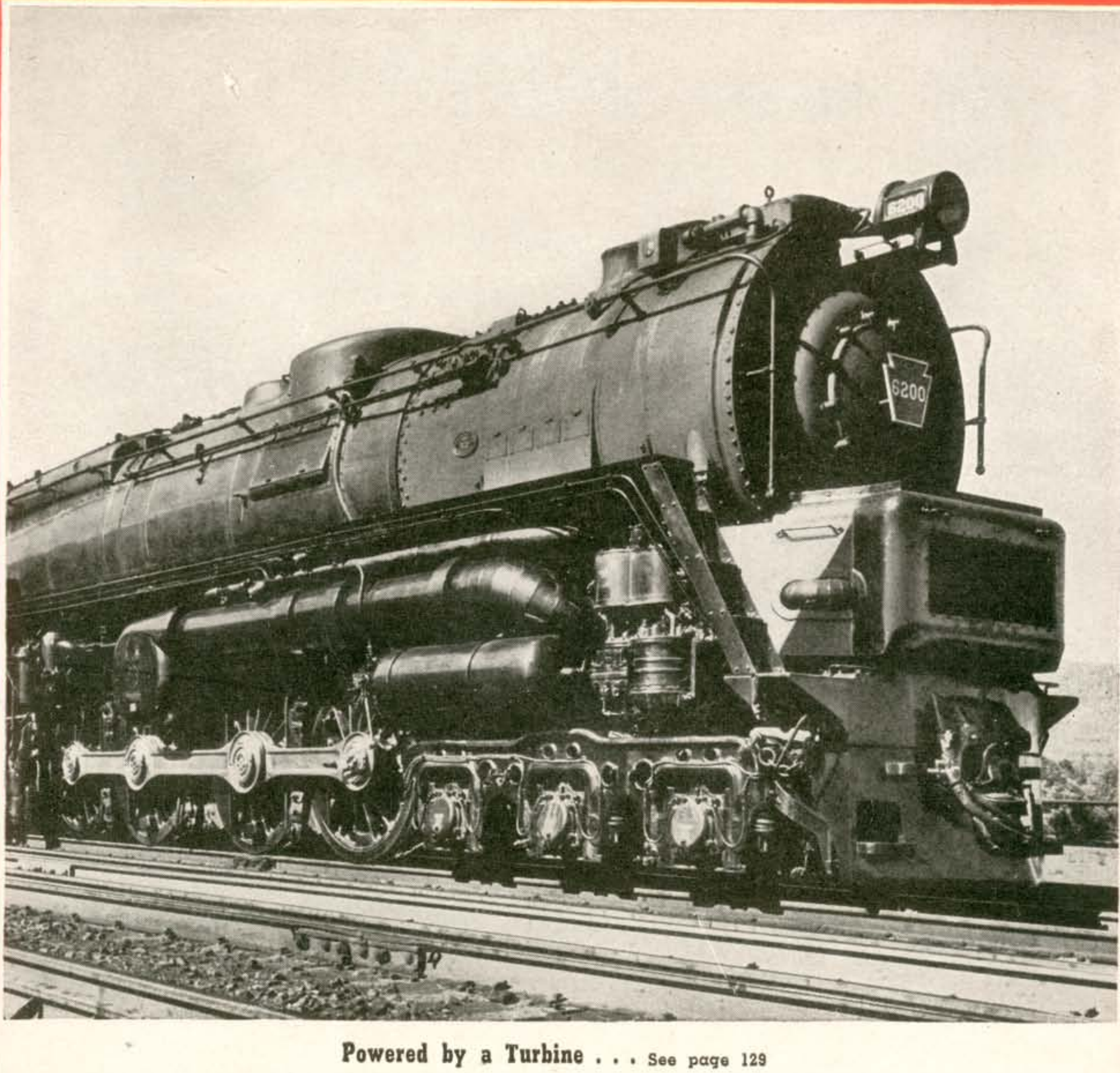
Scientific American

★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



Powered by a Turbine . . . See page 129

The Story of

AMERICAN RAILROADS

Anniversary Issue No. 3

Previews of the Industrial Horizon

By A. P. Peck

RAILROADS AT WORK

As Scientific American salutes 100 years of railroad progress with the present number, the railroads themselves are gallantly carrying a war-time burden that has been made doubly difficult by the continuing reduction in the ability of other forms of transportation to operate at normal capacity. Accustomed as the public has become to other forms of surface and air transportation, it has had to fall back more and more on the rails that were so largely responsible for opening the frontiers of this great nation.

Although the operations of the railroads are confined to their rights-of-way, and they lack much of the flexibility of highway transportation, they handled almost three quarters of the nation's inter-city freight during 1943, plus a large percentage of other transportation requirements brought about by the war. With such a record, the future of the railroads seems assured. Those who would point to the air and to the highways as the future transportation thoroughfares that will carry all passengers and freight would do well to pause and reconsider many of the factors that have made the railroads great.

No longer does the stigma of "the public be damned" dominate the operations of the railroads. Such an attitude died with the passing of adolesence—it is a concomitant of growing pains—and has been replaced with the realization that the public must be served. If the reader still doubts, the articles in this issue of Scientific American should do much to dispel the surrounding mists. Industrial co-operation with the railroads, plus the plans of the roads themselves, point up the place of the railroads in the American way of life.

WHO WILL PAY THE FREIGHT?

Without going too deeply into the mire of taxation, subsidies, and so on, it should be noted here that the railroads must be given an even break with other means of transportation. They have paved the way. They have proved their value over more than a century. They can be equally valuable in the strenuous post-war years to come. But they have two strikes against them, strikes that can well vitiate the technological developments which the railroads have initiated and nutured, unless something is done about the umpiring of the ball game. We can do no better in summarizing this sector of the railroad horizon than to quote Gustav Metzman, president of the New York Central System:

"If our government-owned transport plant—our superhighways, our waterways, and our airways—were made really self-supporting, then these developments could be made free from appropriations and from politics. If this were done, private investment in railways could live alongside of government investment in highways, waterways, airports, and airways."

TOMORROW'S HOMES

Everyone knows, apparently, that a big building boom is due just over the horizon. Figures have been quoted frequently on this page, the latest of them being that an estimated 12 million new homes and apartment units will be built in the first ten post-war years. This is a figure that indicates that only Big Business can turn the trick, can throw into the field the resources necessary to provide such capacity of construction. And this naturally brings up the question of pre-fabrication of home units.

Are the American people going to look forward with any degree of anticipation to vast areas built up with homes of identical appearance? Is John Q. Public going to be satisfied with a domicile that looks just like his neighbors', for as far as the eye can see? It is hardly necessary here to record the negative answer.

But Big Business made possible the millions of pre-war automobiles which brought Mr. Public a freedom of movement that he had never known before. It brought him refrigerators, radios, oil burners, and other modern comforts. And it will bring him the benefits of prefabrication without the possible detriments of pernicious uniformity. Our bets for the future of prefabrication go on kitchens, bathrooms, wall units, heating systems, and the like, which can be economically worked into individualistic designs that will make the home of tomorrow a completely livable place, with the distinctiveness that is a requisite of human nature.

RADIANT HEATING

While on the subject of homes, radiant heating should be given a passing nod. This system, in which the heating pipes are concealed in the walls or floors and there are no radiators in the commonly accepted sense of the word, is going to get a big play in tomorrow's homes. Houses equipped with this system are kept uniformly comfortable with thermostat settings of 60 to 62 degrees and the response to sudden temperature changes is remarkably rapid. Put this method of home heating down as one of the brightest spots on the home's post-war horizon.

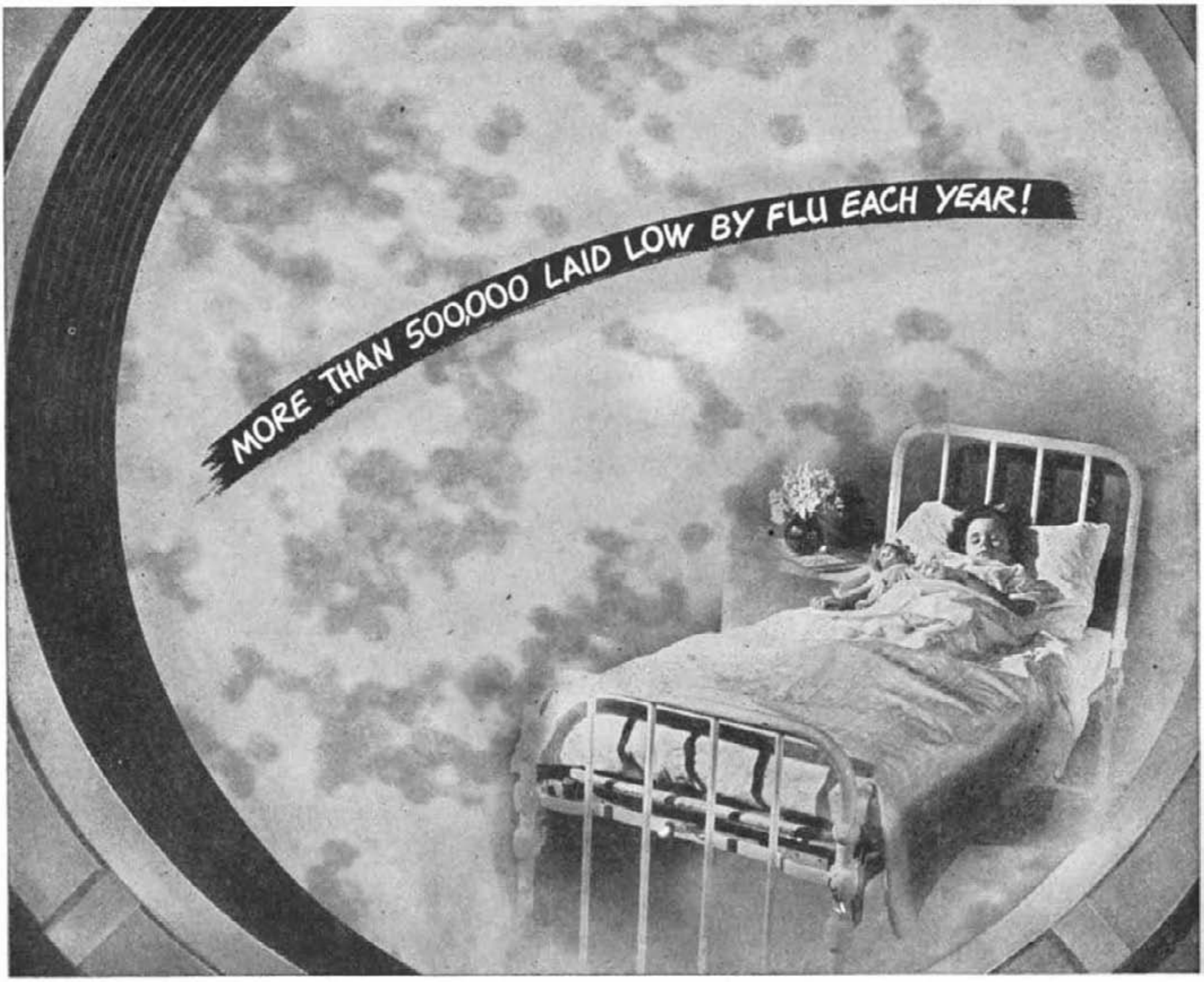
SYNTHETIC COATED METALS

A process of coating metals with synthetic latex is going to make a strong bid for acceptance in days to come. Originally adopted to eliminate the effects of abrasion and rust as well as acid and alkali corrosion, it also provides a cushioned and non-slip surface for hard metal bases. Thus far, applications have been to filter-press plates, airplane and automobile steering wheels, submarine and other naval equipment, airplane cooling systems, and so on through bolts and nuts and a hundred and one other items.

Through a process developed by United States Rubber Company, synthetic latex—neoprene, buna S, and others—is coated on metal without the use of molds or dies. This method of coating and insulating metal has added advantages wherever the possibility of static electricity sparks would cause explosion, fire, or shock.

FOR FUTURE REFERENCE

A recent survey by the Society of Automotive Engineers shows that popular demand will require that the automotive industry provide more headroom; improved ventilation; more and better gadgets in the form of radios, heaters, clocks, and the like; sound-proofing; more and better vision; narrower fenders; less chromium trim; more durable upholstery; but none of these at the expense of room and comfort for passengers and driver. . . Flying buses or taxicabs, carrying passengers on flights of 10 to 20 miles or more, are no longer in the dream stage, according to a spokesman of Lockheed. . . Says the Better Vision Institute, proposals for highway speeds of 75 miles an hour will increase the work of the "grim reaper" because millions of automobile drivers do not have eyes that can function rapidly enough to drive safely at such speed. . . Tortional vibration in Diesel engines, caused by high compression pressures, are well on the way toward being licked.



to destroy 'em you have to see 'em

Microscopes are gunsights in Medicine's battle on bacteria.

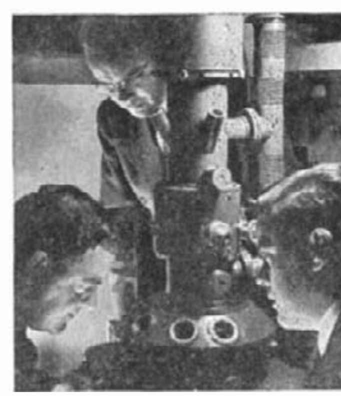
Optical microscopes, however, were not powerful enough to "draw an accurate bead" on the deadly virus that caused influenza.

But today, medical men have seen what no optical microscope could bring into focus—the infinitesimal influenza virus that previously had lain craftily camouflaged among larger cells.

This revelation came about through the Electron Microscope, developed by scientists at RCA Laboratories. And now, having been seen, influenza may be forced to unconditional surrender, saving the lives of thousands each year.

Here is but one facet of the genius shown by scientists behind RCA research . . . the "ever-onward" research that saves lives or creates a better radio with equal skill . . . the "there-when-you-need-it" research that gave super-secret equipment to the United Nations . . . the "way-ahead" research that goes into everything made by RCA.

When you buy an RCA radio or phonograph or television set or any RCA product, you get a great satisfaction . . . enjoy a unique pride of ownership in knowing that you possess the very finest instrument of its kind that science has yet achieved.



They see what human eyes have never seen before!

Drs. Arthur Vance and James Hillier, scientists at RCA Laboratories, with Mr. E. W. Engstrom, Research Director (standing), examine the RCA Electron Microscope that has useful magnification up to 100,000 diameters, revealing unseen new worlds to the eyes of man.

RADIO CORPORATION of AMERICA

PIONEERS IN PROGRESS

RCA

50 Years Ago in . . . SCIENTIFIC AMERICAN

(Condensed from Issues of March, 1895)

RAIL SPEED — "The first famous record of engine 999 was made May 9, 1893, hauling 362,000 pounds of cars and passengers, the engine and tender weighing 204,000 pounds, the total weight of train being 283 short tons. This train ran on that trip 69 miles in 68 minutes, and during this part of the run made 5 miles in 3½ minutes, or at the rate of 85.7 miles an hour on a descending grade of about 20 feet per mile. During the same run one mile was made in 35 seconds, or at the rate of 102.8 miles an hour. The speed was taken between miles posts with a stop watch by the conductor of the train."

MILLSTONES — "Rock emery forms, as would be expected, one of the hardest, strongest and most cutting and durable millstones. Rock emery millstones are also but a trifle more expensive than the best French buhrs, which is a point in their favor. Rock emery millstones not only displace the French buhr, but also the expensive iron mills recently introduced, which cost from three to five times as much as rock emery mills, and do less work and of an inferior quality."

EUCALYPTUS — "The eucalyptus tree promises to become in time almost as useful to California as the bamboo is to Japan and China. . . It has the advantage of requiring little or no attention and of growing with astonishing rapidity. . . The wood brings a good price when sold for fuel and it is generally acknowledged to have, besides, many valuable medicinal qualities. The eucalyptus is also extensively used to form a windbreak about Californian gardens and orchards."

ARGON — "Thursday, January 31, was an eventful day in the history of the Royal Society. . . Lord Rayleigh startled the world by announcing the discovery of a new constituent of the atmosphere. . . The new gas is called 'argon'; and, so far as is at present known, it stands entirely unrelated to any other substance in nature. . . Its solubility in water is 2½ times as great as that of nitrogen. Examined by the spectroscope, it shows that it has two distinct spectra like nitrogen itself; but while the nitrogen spectra are of different characters, those of 'argon' are of the same type."

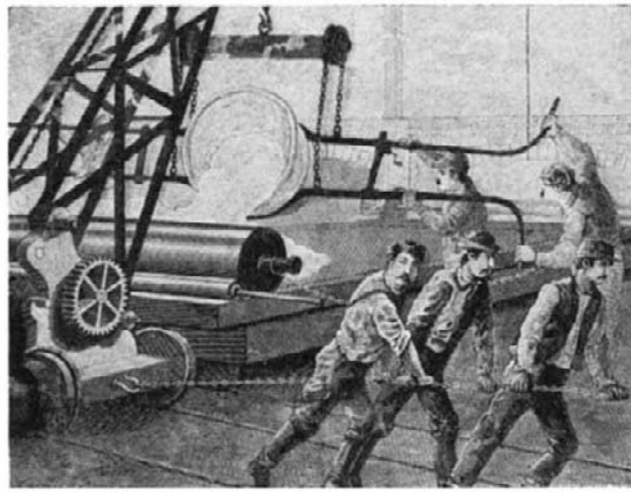
GAGE — "Both pointers of a gage indicating pressure and and temperature are designed to move in unison as long as the boiler is working under normal conditions, the heat indicator hand traveling faster than the pressure gage hand when an abnormal increase of heat takes place in the boiler, an alarm being at the same time sounded."

TESLA — "The attention of the scientific world first centered upon Tesla in 1887 through his invention of the rotating magnetic field for the economic transmission of power. It is believed that Mr. Tesla's experiments were made with a view to saving at least one-third of the energy now wasted in electric lighting. . . He is at present controlling electrical engineer of the Niagara Falls Power Company."

GASOLINE — "The word gasoline suggests danger in the minds of many. It is nevertheless a fact that fewer accidents occur with gasoline engines than with steam power. The very fact that insurance rates are considerably less where gasoline engines are used is evidence that they are less dangerous. It has been but a few years since this type of engine was built in small sizes only, and were not intended to drive machinery of any great magnitude. At the present time, however, they are built in sizes considerably larger than 100 horse power."

SYNTHETIC CHEMISTRY — "A strange conflict is going on just now between nature and science. The field of battle is in the chemical laboratory. Chemistry is making advances along new lines, and products are being obtained by artifice which hitherto have only been known as those of nature. This is the field of synthetic chemistry. Whereas, until recently, chemists have occupied themselves almost wholly with the processes of analysis—that is to say, the taking of things apart—now they are trying to put elements together so as to imitate natural compounds."

PLATE GLASS — "The manufacture of plate glass has attained great development in recent times. It is a striking fact that a material so easily manipulated as glass in the molten state only yields its finest product, plate glass, to the operations



of slow mechanical grinding and polishing. . . The Pittsburgh Plate Glass Company . . . stands as a representative American manufacturer of plate glass, its works being among the largest in the world. . . The material for the plate must be of the utmost purity. . . The first operation after the glass is melted is the rolling. The rolling table is shown in our illustration. It has an iron bed and two rollers are arranged to traverse its surface. The thickness of the glass is regulated by strips of iron which run along the edges of the table, on which strips the rollers rest. The table is mounted on wheels, so that it can be drawn on tracks from one part of the glasshouse to another. A movable crane is shown, which lifts and transports the pots of melted glass."

STEAM SHOVEL — "The primary object of the steam shovel is to supersede hand labor in shoveling; but with the advent of the steam shovel came increased and multiplied opportunities for its use, and it is now doing work which by hand labor would have been impossible."

BALLOON FLIGHT — "A remarkable balloon voyage was made in Germany a few weeks ago by Dr. A. Benson, during which the balloon reached a height of 31,496 feet, or nearly six miles. The balloon was equipped with various instruments for making observations, and much of interest was observed concerning atmospheric physics."

COAL — "Coal is now the great source of power. A ton of coal represents eight or ten thousand man power hours, and perhaps over one thousand horse power hours. It can be produced for so small a price that in the regions of its production it is the smallest element in the expense of power production."

MACHINE GUN USE — "At a recent meeting in London of the Maxim-Nordenfelt Guns and Ammunition Company the chairman, Admiral Sir Edmund Commerell, said their 0.303 Maxim gun had cut down a tree seventeen inches in diameter in one minute. . . This indicates that perhaps the machine gun could be used in felling forest trees in place of saws and axes. While the gun appears to be efficacious on seventeen inch trees, probably it would be stuck if directed against some of the larger trees, such as those of Washington, where a diameter of six feet is not uncommon."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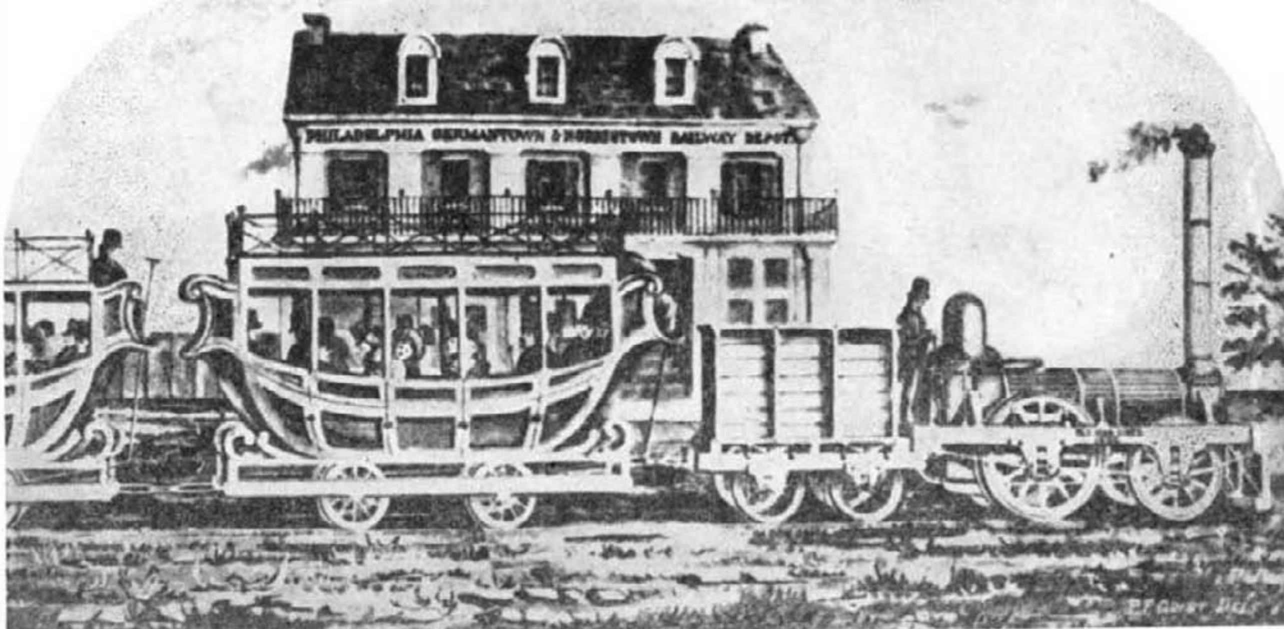


"Old Ironsides" heads the first railroad train in Pennsylvania. First trip made November 23, 1832

On The Railroad Frontier

From the Wood-Burning Engines of a Century Ago to the Streamliners of Today, the Railroads have Served All Industry in Many Ways. Here is the Compact Story of Railroad Progress

By C. B. PECK

At the time they were first projected in America, railways had been in service in England for about 150 years. The simple wood rails had been replaced with various patterns of cast-iron rails and, in the decade after 1820, rolled wrought-iron rails were rapidly taking the lead.

The English track gage was 4 feet, 8½ inches. This gage prevailed on the early American railroads, although there were exceptions to it. A notable one was the New York & Erie Railroad, which was originally built from Piermont, New York, to Dunkirk, on Lake Erie, with a 6-foot gage. For many years the American railway system has standardized on the 4-foot, 8½-inch gage with the exception of a few isolated narrow-gage lines.

In the United States of the early 1800's there was a scarcity of iron, while timber was plentiful and cheap. Nicholas Wood, in his "Practical Treatise on Rail Roads" (London, 1838), described American track structure as consisting of wood rails, laid in parallel trenches filled with broken stone or gravel on white oak cross-ties, also laid in ballast-filled trenches. On the top of the wood rail was spiked an iron plate, cut diagonally at the ends. Other early tracks in the United States were laid with continuous granite sills, instead of the wood rails and cross-ties. The flat iron rails were attached to the tops of the stone sills. The wood track proved much faster and cheaper to build and so became the preferred construction despite its supposed inferior durability.

When Robert L. Stevens, president and chief engineer of the Camden & Amboy Railroad and Transportation Company, went to England in 1830 to buy the locomotive "John Bull," he whittled out a section of a rail which would not need chairs to support it. This section had an enlarged head and a wide flat base.

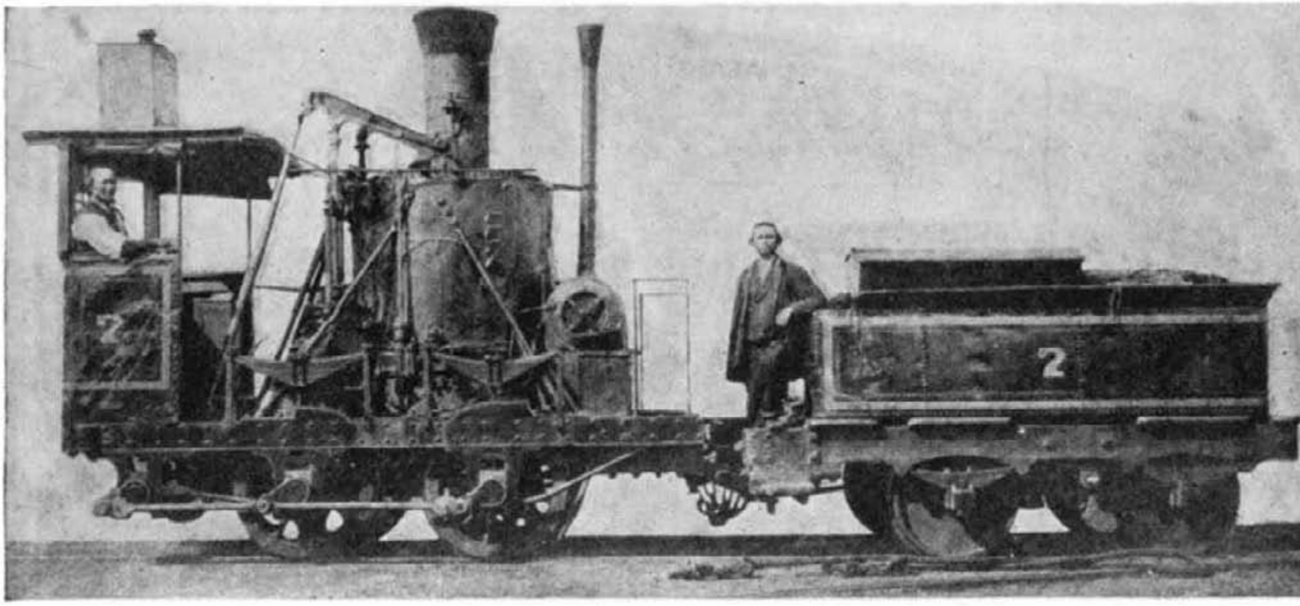
Because such iron rails were expensive and difficult to secure, the strap rail was widely used until the middle 1850's, despite its unreliability in service. The spikes had a way of working out, particularly at the ends which, occasionally, would be caught by a wheel and the rail peeled up in a "snakehead" which was driven through the car floor, placing the lives of the passengers in jeopardy.

The first iron rail to be rolled in America was the Evans U-section. It was rolled at Frostburg, Maryland, in 1844, and was laid on the Baltimore & Ohio Railroad.

In 1845 T-rails were first rolled in the United States at the Montour Rolling Mill, built at Danville, Pennsylvania, to roll rails exclusively. Thereafter, facilities for producing wrought-iron rails multiplied rapidly.

STEEL RAILS—In 1865 the first steel rails were rolled in America at the Chicago Rolling Mill, since then a part of the property of the United States Steel Corporation. The first commercial order, rolled two years later, marked the beginning of the Bessemer era.

Steel rails continued to be rolled in the squat form characteristic of the wrought-iron rail for nearly half a century, despite the fact that within 10 years this form was known



A member of the "Atlantic" family of locomotives on the B & O. It was originally built without cab

to lack adequate stiffness. A long period of tinkering with the section, without improving its fundamental weakness, began in 1874.

A notable exception to this course of events was the rail developed by Dr. P. H. Dudley of the New York Central & Hudson River Railroad in 1883. This had a high section with a relatively thin head and thick base, and weighed 80 pounds per yard. It demonstrated marked superiority over the customary sections, both as to stiffness and wear, but the prevailing engineering opinion of the period was too deeply entrenched to be changed at once.

It was not until 1933 that the need for stiffness was officially recognized by the American Railway Engineering Association. The 112-pound and 131-pound sections adopted in that year have since superseded all of the earlier sections for rail over 100 pounds per yard.

The 131-pound section is designed for axle loads of 80,000 pounds operating at speeds up to 80 miles per hour. Already the Pennsylvania Railroad has designed and is laying rail of high section weighing 152 pounds per yard for axle loads up to 100,000 pounds operating at 100 miles per hour.

Bessemer steel had demonstrated as early as 1900 its inability to stand up under increasing wheel loads and heavy traffic volume, and thereafter was rapidly superseded by open-hearth rail.

In 1911 arose the acute problem of transverse fissures—hidden deffects in the rail which resulted all too frequently in rail failures. After years of controversy between the railroads and the steel industry as to who was responsible, both groups finally pooled their interests and in 1931 began a joint investigation. Out of this came both a diagnosis and a successful remedy.*

Angle bars, bolts, tie plates, spikes, and rail anchors have all been changed by much the same kind of evolution as rail, both as to design and metallurgy. And what has happened to the cross-tie is even more spectacular. The white oak ties of the last century, if available today, would have a life of not over four to eight years. Today, the softer woods, after they have been creosoted or subjected to impregnation with other chemicals, are good for 20 to 25 years.

These developments have contributed to making present-day track highly stable as to line and surface and increasingly reliable as to its need for maintenance.

SIGNALING AND COMMUNICATION—The first 20 years of railway operation in America were without communications other than those provided by the trains themselves. As most of the railways were single tracked, the establishment of effective rules for the safe movement of trains, without undue delay to traffic, was a serious problem. One rule was that the "ruling train" had the right of one hour against opposing trains of the same class. A ruling train which had lost its hour was permitted, after waiting another 10 minutes, to proceed 20 minutes behind a flagman on foot, a tedious procedure limited in its scope by the endurance of the members of the crew.

In the fall of 1851 Charles Minot, superintendent of the New York & Erie Railroad, made the first use of the telegraph to issue orders for the movement of trains, saving an hour or more of delay which would have been incurred under the then current operating rules. The use of the telegraph to transmit train orders was thereafter regular practice on the Erie. Several years elapsed, however, before other railroads began to adopt it.

The semaphore signal was used very early on American railways. The early signals of this type were operated on a "time-interval" system. The signal was set at the "stop" indication for five minutes following the departure of a train and then cleared.

BLOCK SIGNALS—In 1863 Ashbel Welsh, general president and chief engineer of the New Jersey Canal & Railroad Companies (now part of the main line of the Pennsylvania Railroad), installed a system of block signals for controlling the movement of trains. Unlike the time-interval system, the purpose of this block system was to maintain a minimum space interval between trains moving in the same direction. The signal was an oil lamp set in front of a polished white reflector, enclosed in a box which normally concealed the light of the lamp. If, when a train approached, the section of line ahead (the "block") was clear, the lamp was lifted by means of a lever and rope, which was operated from within the station. In its upper position the light of the lamp by night or the white reflector by day showed through a glass window in the box. This was the "safety" aspect. When no light or the black interior of the box was displayed at a station, the train was required to stop. This signal was later improved by fixing the position of the lamp behind the window and drawing a red flannel curtain over the window when a train stop was required. The blocks are said not to have exceeded six miles in length.

Following the leasing of the New Jersey Canal & Railroad Companies' line by the Pennsylvania Railroad in 1871, this system of signals was extended to Pittsburgh. Before 1890 similar block signal systems were in operation on four more railroads: the West Shore, the Erie, the New York Central & Hudson River, and the Chicago, Burlington & Quincy. On parts of their lines the Erie and the New York Central & Hudson River installed a system of electrically controlled manual block signals in which electro-magnets automatically locked the signal lever against movement to the clear indication as long as the track ahead was occupied.

The early installations on all these roads were on double-track lines which were signaled for operation of each track in one direction. The first installation of block signals to a

*See Scientific American for January, 1944, page 17.

single-track line to receive prominent attention was on the Canadian Pacific in 1884.

The first installation of the automatic block signal system, which has since superseded the controlled manual system, was in 1871, when Thomas S. Hall signaled 16 miles of the Eastern Railroad (now part of the Boston & Maine Railroad). Hall employed a track instrument in the nature of a treadle which, depressed by passing wheels, closed an electric circuit in a wire carried on poles at the roadside.

TRACK CIRCUITS—This system, with its open roadside circuit, was soon superseded by the closed track circuit, comprising the two rails, one for each side of the circuit, insulated in block-section lengths. The rails were connected to the two terminals of an electric battery at one end of the block section and to a relay at the opposite end. Normally, the relay was energized, but when a train entered the section at the relay end, the wheels and axles shunted out most of the current. This de-energized the relay and caused the signal to display the "stop" aspect until the train had passed out of that block. The closed-rail track circuit was developed by Dr. William Robinson and installed on the Philadelphia & Erie (now part of the Pennsylvania Railroad) at Kinzua, Pennsylvania, in 1872. It has since been recognized as the only safe means whereby a train may retain control of a signal while occupying the section of track protected by the signal. In 1877 the first signals controlled by more than one track circuit were installed by Dr. Robinson.

More recent developments in signaling are the replacement of the semaphore blades by lights which give the indications both day and night. There are color signals which have separate lights and lenses for each color indication, and others in which the color aspect of a single light and lens is changed by a movable spectacle within the case. And there are position lights, yellow in color, and arranged in rows of three to give angular position aspects similar to those of the semaphore blade.

Power for operation of track circuits and for moving the signal arms was long obtained from primary batteries. They are being superseded by purchased power. To reduce the power consumption, track circuits and relays are arranged for "approach lighting." This arrangement permits the signal lights to remain unlit until a train enters the block in front of the signal and to go out again as soon as the train has left the block beyond the signal.

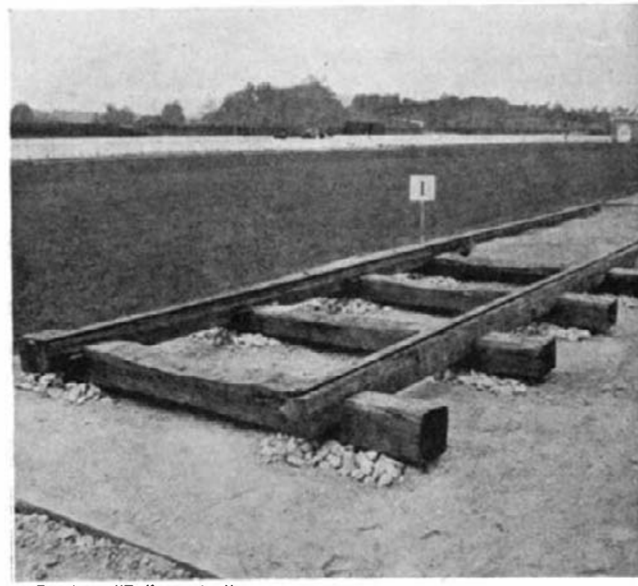
Each forward step in communications has increased the capacity of the line at the same time that it has made the movement of trains safer. The first major improvement supplemented the operation of trains by timetable and rules with the telegraphic train order. The block signal system, in turn, supplemented and simplified the application of train orders. Each step reduced the interference with train movement.

The first complete system for directing train movements over an operating division by signal indication without train orders was placed in service on the Missouri Pacifiic in 1925, using controlled manual block for controlling train movements. The CTC (centralized traffic control) system, was first installed on the New York Central in 1927. It places the signals and switches over a considerable territory under the remote control of an operator directed by the despatcher. No communications with the train are required other than signal indications.

AUTOMATIC CONTROL—Another development associated with signaling is automatic train control, the purpose of which is to insure safe operation in the event of a failure in alertness of the engineman. This involves a form of communication between the locomotive and roadway. The first system involved a track ramp contacting a shoe on the locomotive. Another system of the intermittent type operates inductively and involves no physical contact. The continuous system employs an alternating current passing through the rails which results in an electric field around each rail. Coils on the locomotive are affected by this field. In all of these devices, signal indications are translated into the action called for, which is put into effect automatically in case the engineman fails to do so.

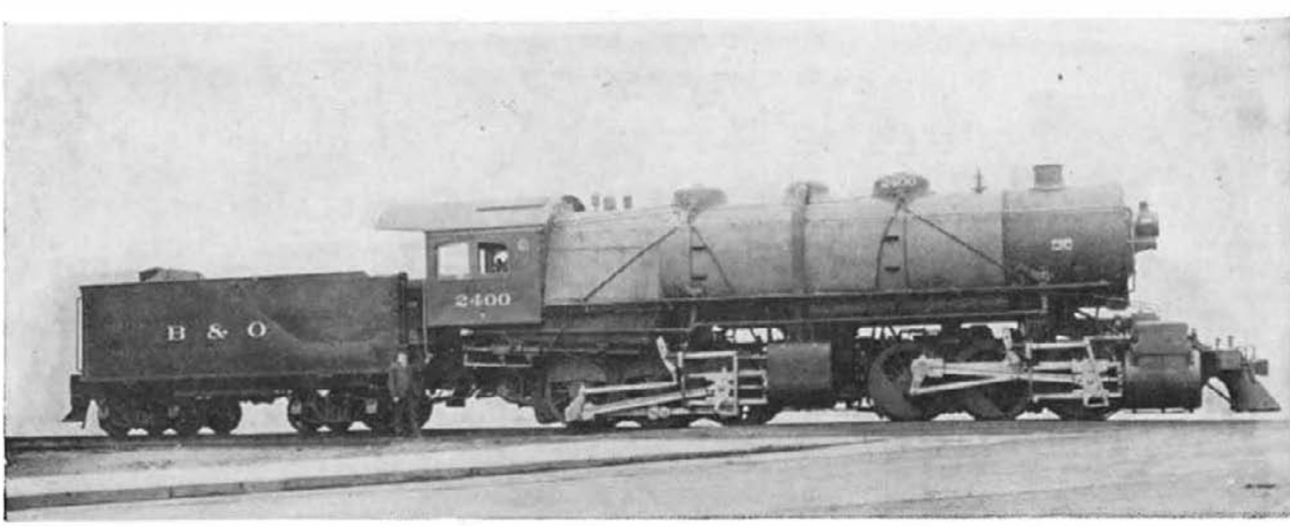
Accessory to the continuous train-control system is the continuously controlled cab-signal system. A substantial body of informed opinion considers the continuous cab signal more useful as a safety device than the train-control system itself.

The first interlocking plant in America was imported from England and installed on the line of the United New Jersey Canal & Railroad Companies at Trenton, New Jersey, in



Courtesy "Railway Age"

A section of the first B & O track built in 1829-30. Iron plates, cut diagonally, were spiked to wood rails



The first Mallet articulated compound locomotive in America. Built in 1904

1870. This comprised mechanical locking of manually operated switches and signals.

Two other systems have since largely superseded the mechanical system. Electric interlocking, in which the switches and signals are both operated by electric motors, was invented by John B. Taylor and the first installation in the United States was made in 1899. Electro-pneumatic interlocking is the invention of George Westinghouse. In this system the source of power for the movement of switches and signals is compressed air controlled by electrically operated solenoid valves.

THE STEAM LOCOMOTIVE—The track structures of the early American railway were much lighter than those in England and the curves were of shorter radii. The four locomotives ordered in England by Horatio Allen for the Delaware & Hudson Canal & Banking Company in 1828 were too heavy for the road and only one of them, the "Stourbridge Lion," was ever set up. It was the first locomotive to run on rails in America, but its trial demonstrated its impracticability.

The West Point Foundry in New York City had set up the Stourbridge Lion in 1829 and thereafter became a builder of locomotives. The "Best Friend," credited with being the first American-built locomotive to be placed in regular service, and another locomotive, were built in 1830 for the Charleston & Hamburg Railway. The "DeWitt Clinton," for the Hudson & Mohawk, was built a year later.

Peter Cooper's "Tom Thumb" contributed nothing to the technical development of the locomotive, but it encouraged the directors of the Baltimore & Ohio to continue their search for a suitable steam locomotive. The "York" (3½ tons) built by Davis & Gartner of York, Pennsylvania, met the terms of a prize contest and was followed by the "Atlantic" (6½ tons) and a whole series of "grasshoppers" with upright boilers and gear drives.

None of these locomotives was influenced by the results of the Rainhill Trials held by the Liverpool & Manchester in October, 1829. The first American locomotives to include the features which caused George Stephenson's "Rocket" to succeed in that famous event were built by Matthias Baldwin and William Norris in Philadelphia in 1832. Baldwin's "Old Ironsides" followed closely the characteristics of Stephenson's "Planet" class. Unlike the latter, however, it had outside cylinders and rods, instead of the inside cylinders driving on cranked axles favored by the British for their superior lateral stability.

Other locomotive builders established during the 1830's were Eastwick & Harrison, Philadelphia; The Locks & Canals Company of Lowell, Massachusetts; Rogers, Ketchum & Grosvenor of Paterson New Jersey; and Isaac Hinckley of Boston. The Paterson firm was a builder of textile machinery until Thomas Rogers, the active member, was induced to manufacture springs, wheels, and axles for the Charleston & Hamburg by Horatio Allen, its chief engineer. This preceded by several years the building of the "Sandusky" for the Mad River & Lake Erie in 1837.

ENGINE TYPES—Succeeding Phineas Davis of Davis & Gartner, Ross Winans became the leader in building locomotives for the Baltimore & Ohio. He is famous for two types. The "Mud Digger" had eight coupled wheels driven by gearing from a jack shaft. In 1850 he developed the "Camel" type, another eight-coupled locomotive noted for its unusual firebox for burning bituminous coal. Neither type has survived.

One of the most important of the early inventions for locomotives was the four-wheel swivel engine truck invented by John B. Jervis, another name made famous by its association with the Delaware & Hudson Canal & Banking Company, who was, in 1831, chief engineer of the Mohawk & Hudson. It adapted the locomotive to the weak track structure and sharp curves of America.

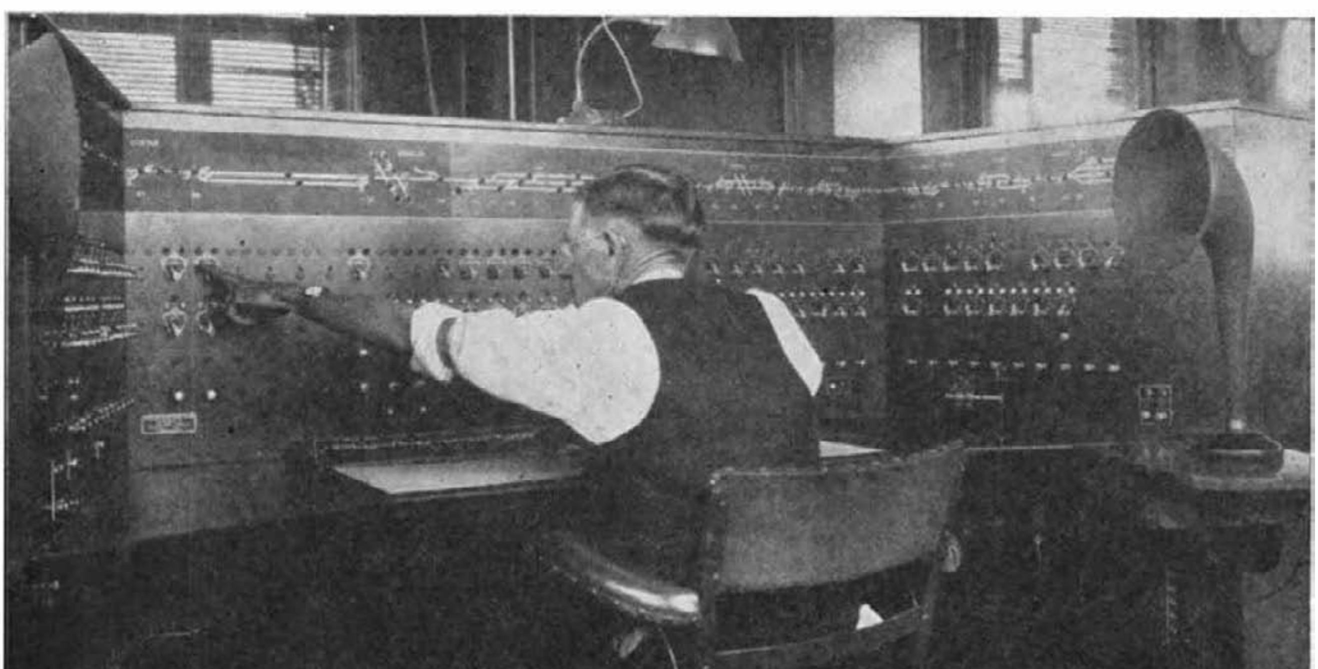
Henry R. Campbell, chief engineer of the Philadelphia, Germantown & Norristown, patented an eight-wheel locomotive with a four-wheel engine truck and four connected drivers and Eastwick & Harrison built such a locomotive in 1837. The driving axles were carried in an equalizing frame separate from the main locomotive frame; equalizing beams between the springs of the two axles were soon substituted for the separate frame construction. This method of adapting the locomotive wheels to the irregularities of track surface has since been a feature of American locomotive construction.

Matthias Baldwin invented the ground metallic steam-pipe joint by which he replaced the canvas and red-lead gaskets of the early British locomotives. This permitted him to boost steam pressures from 60 pounds per square inch to 120 pounds.

Thomas Rogers designed a driving-wheel center with a U-section rim. He is credited with the first effort at counterbalancing the weights on the crank pin of the Sandusky. He substituted the link valve motion for the prevailing hook motion in 1839.

By 1855 more than 40 separate plants were engaged in building locomotives. The major characteristics of American practice were so well established that from that time on there was less difference in the products of the various plants than there were between successive locomotives of the same builder during the 1830's and early 40's.

Since 1860 a great variety of wheel arrangements has been developed and there has been a steady increase in locomotive weights and capacities. At the outset the trend was toward



By control of track switches and signal indications, the operator controls train movements without train orders

more tractive capacity at slow speeds and relatively little attention was paid to the development of sustained high tractive force at high speeds. Following World War I, the demand for faster movement without sacrificing weight of train changed the trend toward increased horsepower capacity. This has led to four- and, in a few cases, six-wheel trailer trucks to carry the additional boiler weight required.

The use of double-expansion cylinders was inaugurated in 1889. By 1900 compounding had reached its peak and rapidly receded. The economy effected was largely a reduction in condensation losses. With the advent of the superheater, condensation losses were practically eliminated in single-expansion cylinders.

SUPERHEAT—The practical development of the locomotive superheater in America began when the Locomotive Superheater Company was organized in 1910. It acquired several American and foreign patents and proceeded with the engineering development of the fire-tube superheater. A high percentage of all steam road locomotives are now equipped with superheaters which effect economies in fuel consumption of about 25 percent and reduce water consumption by about 30 percent.

A closed-type feedwater heater, the feature of which is a high rate of heat transfer, was patented by Luther B. Lovekin and made available for service in 1916. Two years later an open-type feedwater heater was adapted from a marine heater by T. C. McBride. These have subsequently been supplemented by the exhaust-steam injector and few road locomotives in through service are now without some form of feedwater heating. From 10 to 13 percent of the heat in the fuel is reclaimed by the feedwater heater. About 12 percent of the exhaust steam which is condensed by the heater passes into the tank or boiler and increases the effective capacity of the tender.

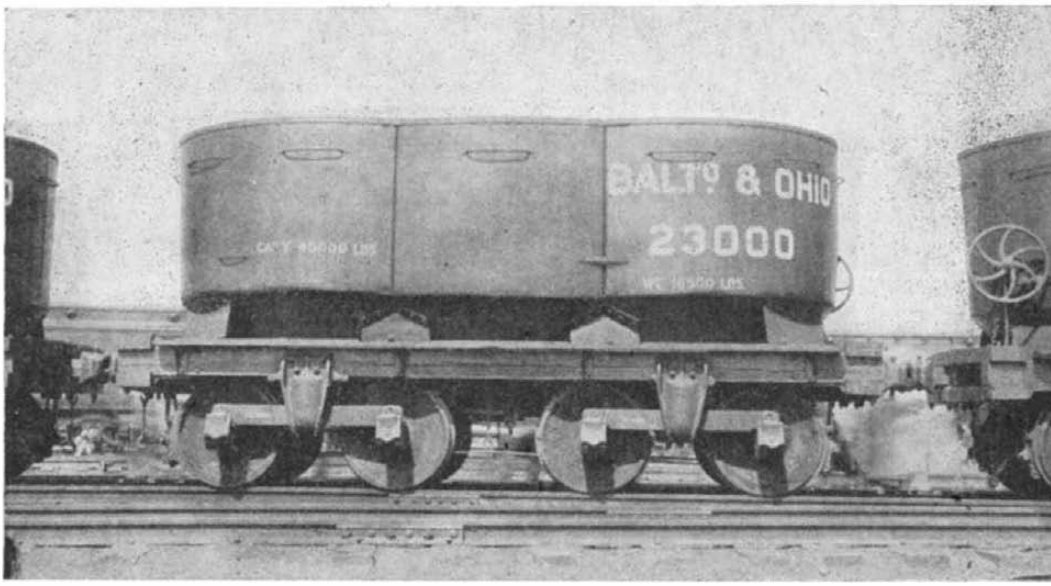
With the development of the wide firebox and increasing grate areas the fireman began to limit the capacity of the steam locomotive about 1900. Grates much in excess of 45 to 50 square feet in area were beyond the capacity of a single fireman. In 1909 an overfeed stoker was developed by Clement F. Street, and several other stokers came out at about that time. The Standard stoker, the type which is most widely used at present, was first installed in 1913.

Stokers have been applied on locomotives with over 180 square feet of grate area which are capable of delivering coal to the firebox at the rate of 20 tons an hour.

In 1918 an appliance known as the Nicholson Thermic Syphon was first installed in the firebox of a Chicago, Milwaukee & St. Paul locomotive. This device replaces the arch tubes by which the sectional brick arch is supported and provides a thin triangular water space which opens through a long slot in the crown sheet (the sheet directly over the fire) and tapers down to a pipe-like connection to the throat sheet (front firebox sheet immediately below the boiler barrel) just above the grate. This device stimulates a rapid backward circulation along the bottom of the boiler shell. It is credited with an increase in evaporation and has proved effective in preventing dangerous overheating of crown sheets under some low-water conditions.

A circulator, several of which are placed transversely in the firebox, has since been developed for somewhat the same purpose. This device draws its water through the side sheets of the firebox and delivers water and steam through an opening in the center of the crown sheet.

In 1918 an auxiliary steam engine was applied to the trailer of a Pacific type locomotive on the New York Central to increase traction at starting and slow speeds. This device, known as the Locomotive Booster, was patented by Howard L. Ingersoll, assistant to the president of the railroad. It drives the trailer axle and its controls are interlocked with the locomotive throttle.



A three-hopper iron coal car equipped with Winan's four-wheel trucks. Iron cars of two intersecting cylinders were first built for the B & O about 1860

Large steel castings are characteristics of the modern steam locomotive. First was the water-bottom tender frame which comprises the entire tender underframe and the bottom of the water tank, to which the outside tank sheets are attached either by riveting or welding. This was followed by the locomotive bed casting which incorporates in a single piece of cast steel the entire frame system of the locomotive from the front bumper to the rear end, including the steam chests, cylinders, and saddle on which the smokebox is supported. Harry M. Pflager, senior vice-president of the General Steel Castings Corporation, is credited with the development of these large and intricate castings.

LUBRICATION—One of the great changes which has taken place in the steam locomotive during the last 25 years is the replacement of the long-spout oil can as a source of lubrication for most of the running gear and motion work. Today, the entire chassis is provided either with force-feed oil lubrication, hard-grease lubrication, or Alemite lubrication, which will permit the locomotive to run between terminals without attention.

A factor in increasing the utilization of the steam locomotive and permitting relatively long runs without stops is the large tender. Twenty-five years ago few tenders were built with water capacities of more than 10,000 gallons and coal capacities of more than 15 tons. Today, locomotives are running with 25,000 gallons of water and 30 tons of coal. On one railroad where water is scooped en route the coal pit has a capacity of 43 tons.

ELECTRIFICATION—The principal factors impelling the installation of heavy electric traction are: (1) Special operating conditions, such as may be encountered on heavy grades, in tunnels, and in densely populated districts where smoke and gases from steam locomotives are a serious nuisance; (2) the need for more intensive road facilities where the saturation point is being reached on densely trafficked lines under steam operation and (3), associated with the other two, considerations of operating economy.

The first heavy electric traction was used to operate trains through tunnels without the handicap of combustion gases from steam locomotives. Such applications were in the Mt. Royal tunnel of the Baltimore & Ohio (1895), the St. Clair tunnel of the Grand Trunk (now the Canadian National) (1908), and the Hoosic tunnel of the Boston & Maine (1911). Later applications included the Michigan Central tunnel under the Detroit River and that of the Canadian National under Mount Royal at Montreal, Quebec.

The electrification of the New York Central in connection with the Grand Central Terminal development went into service in 1906 and that of the New York, New Haven & Hartford a year later.

The Pennsylvania New York terminal development and the Long Island followed in 1910. Various mileages have since been electrified on the Butte, Anaconda & Pacific; the Chicago, Milwaukee, St. Paul & Pacific; the Norfolk & Western; the Virginian; the Staten Island lines of the Baltimore & Ohio; the Illinois Central; the Great Northern; the Reading; the Delaware, Lackawanna & Western; and the New York Central West Side lines in New York City. With the completion of the Pennsylvania electrification from New York to Washington, D. C., and Harrisburg, Pennsylvania, route mileage of electrified line now totals about 2300.

INTERNAL COMBUSTION—In 1899 a gasoline-engine-driven coach was placed in trial service on the Pennsylvania Railroad and the Cleveland, Cincinnati, Chicago & St. Louis Railway by the Jewett Car Company, Jewett, Ohio. In 1904 the McKeen mechanical-transmission car was brought out and in 1905 a gas-electric system was developed by the General Electric Company. These engines operated at relatively slow crank-shaft speed and the engines and electric generators were heavy.

In 1921 began an attempt to adapt the motor-truck chassis and engine with a gear-shift transmission for rail operation by fitting it with a light coach body. This was soon outgrown by the demand for larger and more powerful cars. By 1928 most of the cars built weighed from 100,000 to 150,000 pounds, with power plants ranging from 250 to over 400 horsepower.

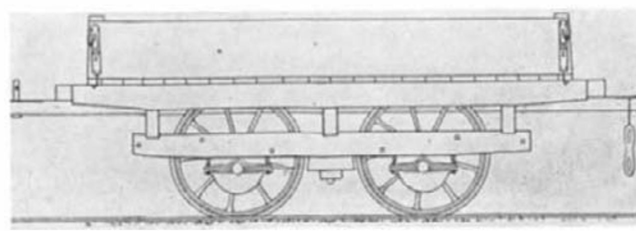
In 1924 a Diesel-electric locomotive developing 300 horsepower and weighing 60 tons was built by Ingersoll-Rand and General Electric. This locomotive demonstrated the practicability of a low-capacity power plant, the entire horsepower of which, via the electric transmission, can be developed at any speed of the locomotive for switching service. The first locomotive of this type entered regular service in 1925 on the Central Railroad of New Jersey.

In 1928 a two-unit 2660 horsepower Diesel-electric locomotive was built for the Canadian National by the Westinghouse Electric & Manufacturing Company. This locomotive was designed for determining the utility of the Diesel in road service.

The next important step in the adaptation of internal-combustion power plants to railroad traction purposes came with the development of streamlined light-weight articulated trains. Except for the first aluminum-alloy train for the Union Pacific, all these early trains, built for that railway and the Chicago, Burlington & Quincy during and subsequent to 1934, were driven by Electro-Motive Diesel-electric power plants. At the outset these were installed at the front end of the head revenue car. But the length and size of the power plant of each successive train increased and it was not long before the power plant and auxiliary equipment fully occupied first one, then two, and finally three vehicles. Thus, the rail-motor-car power plant evolved into a full-fledged passenger locomotive.

In 1941 the Electro-Motive Division of the General Motors Corporation built a four-cab 5400 horsepower freight locomotive for the Atchison, Topeka & Santa Fe Railway. These locomotives have since been installed on several other railroads.

FREIGHT CARS—Ross Winans' first interest in railroads was as a market for horses. When he came to Baltimore in 1828, railway cars were carried on two axles, without springs, and the wheels still turned loosely on the axles. He interested himself in improving rolling stock to increase the hauling capacity of the horse. His first invention, in 1828,



An early B & O four-wheel freight car

was to fix the wheels on the axle and to put bearings on the ends of the axle outside the wheels. By 1834 he had developed a freight car carried on two four-wheel trucks. It was not adopted rapidly; four-wheel cars were still being built in the 1880's.

By 1832 the need of springs was apparent. The chief engineer of the Baltimore & Ohio wrote in his report of that year that "springs would be viewed as an indispensable appendage to all cars when steam shall be the power used in transit."

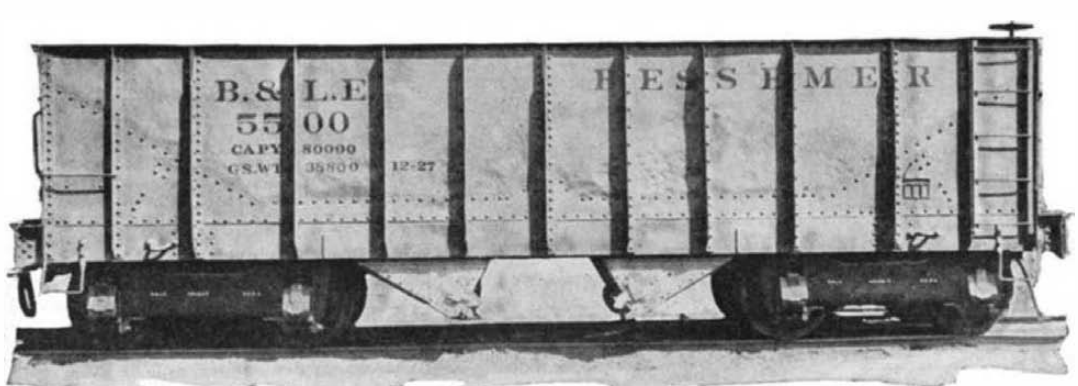
Iron was used very early in the construction of car bodies. The Philadelphia & Reading ordered 1000 new iron coal cars to be delivered in 1846. Iron hopper cars, gondola cars, and box cars were being built for the Baltimore & Ohio in the early 1860's.

In 1857 an eastern railroad is said to have had 30 box cars fitted with double sides, roofs, and floors, with the intervening spaces packed with sawdust. This, so far as is known, was the first step in the evolution of the refrigerator car.

After 1900 steel rapidly superseded wood as the principal material of construction both of freight and passenger cars. Six flat cars were built by the Carnegie Steel Company in 1894. Two years later the Keystone Bridge Company built two steel hopper cars of 100,000 pounds capacity each. These were placed in service on the Pittsburgh, Bessemer & Lake Erie, now the Bessemer & Lake Erie.

During the past 25 years the wood cars of relatively weak construction have gradually disappeared and the railways entered World War II with an inventory of freight cars of adequate and relatively uniform strength.

The use of high-tensile steels and light-weight metals as the materials of construction both for freight and pas-

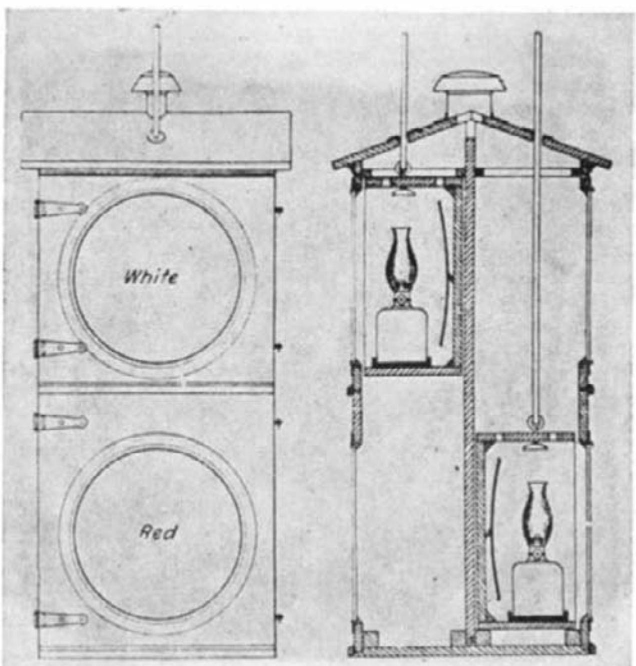


The first steel hopper car, built in 1896, from a photograph taken in 1928

senger cars began in 1934. The materials used are stainless steel, low-alloy high-tensile steels, and strong alloys of aluminum. Both the stainless and high-tensile steels possess high-tensile qualities and resistance to corrosion which permit the development of sufficient strength with lighter metal sections. The saving of weight in the aluminum construction results from the light weight of the metal which is used in relatively bulky sections.

In 1934 and 1935, the Baltimore & Ohio Railroad built one experimental hopper car of stainless steel, one of aluminum alloy, and several of low-alloy high-tensile steel. Since then, some 50,000 freight cars of various types have been built of the low-alloy high-tensile steel. A few additional cars of aluminum alloy have also been built. So far, however, stainless steel has been too expensive to be attractive for freight-car construction.

PASSENGER CARS—Probably the most comfortable of the early coaches were those in which the old Concord stage bodies were adapted to the rail by the use of flanged wheels. Others were simple boxes, some of them mounted on the axles without springs and with the simplest of benches for the accommodation of passengers. Coaches built with platforms and end doors, some with essentially the same seating arrangement that has since become universal in American practice, were adopted at an early date by the Baltimore & Ohio, not, however, without strong opposition



A modified form of the first (1863) block signal system in America. The oil lamps were raised or lowered

on the ground that the center aisle would become one elongated spittoon. This type became well established during the 1840's.

A spring draft gear, patented by P. Alverson, was in service in railway carriages on the Hartford & New Haven Railroad in 1839. Several types of patented four-wheel trucks appeared during the early 40's and before the end of that decade rubber springs were coming into use.

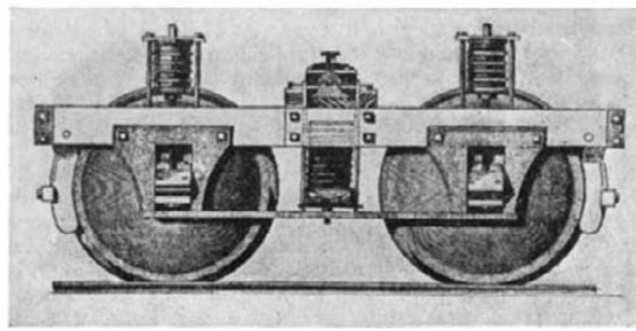
The first use of iron for the complete construction of passenger-car bodies was made under a patent granted to Dr. B. J. LaMothe in 1854. Several of these cars, designed to seat 60 persons, were built in a tin shop at Paterson, New Jersey. Its destruction by fire at the beginning of the Civil War put an end to the enterprise.

Seats with reversible backs were in use during the 50's and this decade was marked by other significant improvements in the comfort of travel. In 1852 a patent was granted to W. L. Boss for a reclining car seat. When the back of this seat was adjusted to the reclining position, a support for the feet and legs of its occupant moved forward from under the seat. The back was fitted with a pillow or cushion for the head.

Sleeping-car service of a kind is said to have been inaugurated on the Cumberland Valley Railroad between Harrisburg and Chambersburg in 1836. Seven years later, on the New York & Erie, cars with seats placed back to back were in service in which berths could be made up at night by the use of the seat cushions.

In 1858 George M. Pullman refitted two coaches for the Chicago & Alton with sleeping-car sections, a linen locker, and two washrooms. Following the incorporation of the Pullman Palace Car Company in 1867, the first "hotel car" was placed in service on the Great Western of Canada, now the Canadian National, and the development of dining-car service had begun.

STEEL FOR SAFETY—The railroads which first purchased steel coaches, shortly after 1900, made much of the increased safety afforded by this type of construction, because of its increased strength and stiffness in case of derailments or other accidents. The public thus came to associate safety



An early car truck using metal and rubber springs

with steel construction, a fact which helped to hasten the retirement of wooden coaches.

The wooden coach, near the peak of its development, weighed about 900 pounds per passenger seat. Coaches of carbon-steel construction weighed from 1400 to 1700 pounds per passenger seat. Ultimately, it became evident that weight alone was no assurance of adequate strength; that each pound added to a fast-moving structure, such as a passenger car, carried the seeds of its own destruction in the form of the energy of its motion.

The use of aluminum in passenger-car construction began in 1933 when the Pullman Company and the Pullman Car & Manufacturing Company jointly designed and built one sleeping car and one coach.

In the following year stainless steel was applied in a high-speed articulated motor train built by the Edward G. Budd Manufacturing Company for the Chicago, Burlington & Quincy, and aluminum alloy in a similar train for the Union Pacific, built by the Pullman Car & Manufacturing Company. Since that time a large number of light-weight passenger cars have been built in many of which the low-alloy high-tensile steels have been employed as the material of construction. Weight reductions approximate one third.

AIR BRAKES—George Westinghouse's first patent covered a straight-air brake system. This was issued in 1869. He was granted a patent on an automatic system in 1872. It took 15 years for the superiority of the automatic air brake to be clearly established.

The system of differential pressure control of compressed air invented by Mr. Westinghouse has proved to be a remarkably flexible medium. As cars increased in weight, and trains in length and speed, shocks caused by the running in and out of slack between cars became progressively more severe. Successive adaptations of the original operating principle have kept the brake abreast of the needs of the times in this respect.

The next step in freight brakes will be the load-compensating brake by which the present inequalities of retarding force in relation to gross car weight will be ironed out. This is ready to meet the needs of faster freight trains of light-weight cars.

Likewise, until the H.S.C. (high-speed control) passenger brake was brought out to meet the needs of the streamline trains for operation on schedules calling for running at top speeds over 100 miles an hour, the all-pneumatic brake met the requirements. Because of the value of split seconds in stopping these fast trains, the new passenger brake incorporates electric control of application and release.

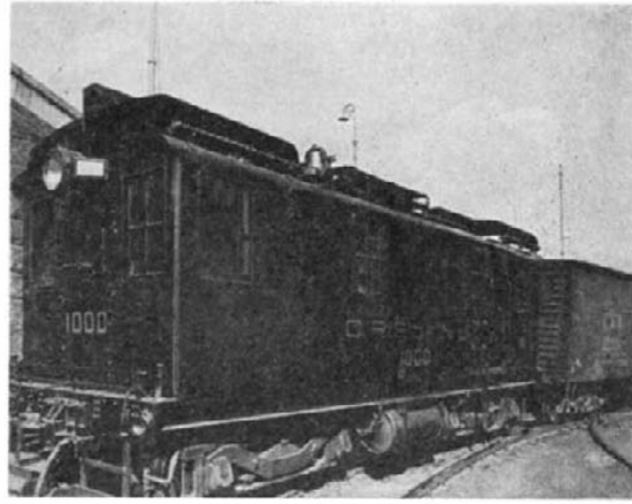
COUPLERS AND DRAFT GEARS—Among the developments which have been of great significance in keeping rolling stock in step with the constantly growing needs of the service are automatic couplers and draft gears. The first standard form of coupler was the link and pin type which prevailed for many years. Because of the appalling number of casualties among trainmen from accidents in coupling cars, the Master Car Builders' Association took up the problem of developing some form of interchangeable coupler. As a result, the Janney vertical plane type of coupler was developed in 1887 as the standard form for freight cars.

Prior to this, the Miller hook type of coupler, more recently in use on street cars, had been introduced and was used extensively on railway passenger cars. The Janney type rapidly superseded it in passenger service. At first standardized for interchangeability of cars alone, it has since been subjected to a vast amount of development work resulting in a complete standardization of details revised from time to time to meet the changing conditions of service.

The draft gear, by which the buffing and pulling shocks on railway rolling stock are cushioned, long consisted of coil springs. The first patent for a friction draft gear in which the coil spring is supplemented by friction elements to dissipate a considerable portion of the energy taken up by the gear was issued to George Westinghouse in October, 1888. An early service installation of the Westinghouse device was made on Pennsylvania Railroad rolling stock in 1896. It was not until after the turn of the century, however, that the friction gear began to make headway.

Since 1934 all draft gears, before they may be offered in interchange, must have been certified by the Association of American Railroads as meeting specifications of limiting draft-gear characteristics worked out by the Association. This has brought uniformity of performance out of what for many years was an extremely chaotic situation.

ROLLER BEARINGS—Development work on the adaptation of roller bearings to the passenger-car truck began on the Chicago, Milwaukee, St. Paul & Pacific in 1924 and was participated in by Hyatt Roller Bearing Company, SKF

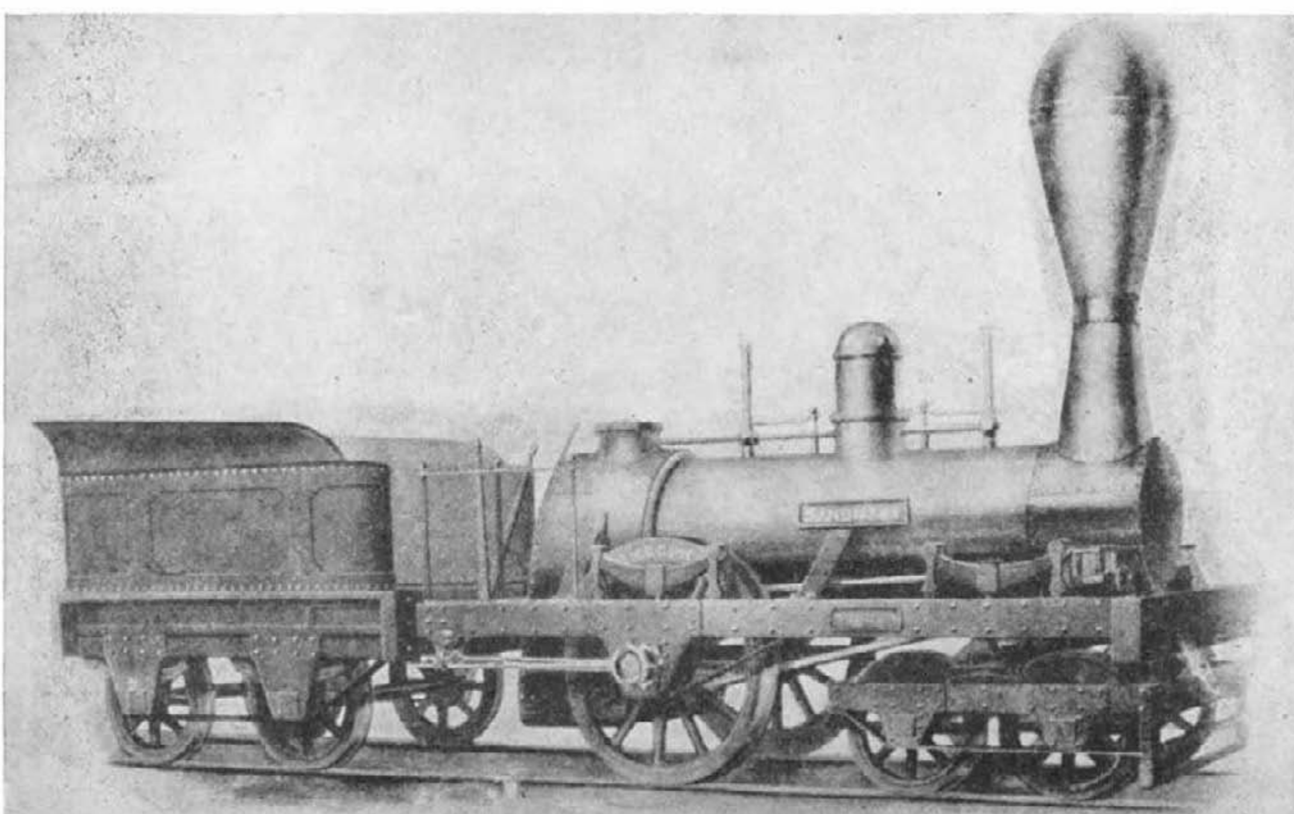


Diesel-electric switching locomotive, 1925

Industries, Inc., and Timken Roller Bearing Company. This railroad made its first installation in 1927 and the use of roller bearings on passenger cars developed rapidly thereafter.

Most of the road steam locomotives built in recent years have been fitted with roller bearings on all axle journals—a factor in increasing reliability and reducing machinery maintenance on steam locomotives. Acceptance of roller bearings on driving axle journals was hastened by a demonstration locomotive placed at the service of the railroads by Timken Roller Bearing Company in 1930.

HEATING AND LIGHTING—The evolution of car heating and lighting has tremendously improved the comfort and safety of railway travel. By the early 80's the entire railway world had become aroused to the need of a safer method of heating passenger cars than by stoves. When wrecks occurred, fire from the stoves caused much loss of life which otherwise would have been avoided. The heat distribution was also extremely unsatisfactory. Many schemes for improving both comfort and safety were being tried, among them the



Rogers' Sandusky, 1837, from a model

use of steam from the locomotive. By 1890 this method was clearly in the ascendancy. The development of the modern vapor system removed the final hazard from car heating, which arose from the use of steam under pressure within the cars.

Air conditioning was first installed in a railway passenger-train car by the Pullman Company. An ice-cooled sleeping car began regular operation between Chicago and Los Angeles in September, 1929. This was followed in 1930 by installations in two dining cars, one each on the Baltimore & Ohio and the Atchison, Topeka & Santa Fe. The popularity of these cars was immediate and the spread of air conditioning was rapid.

The change in ventilation associated with the summer cooling aspect of air conditioning has done more to enhance the attractiveness of railway travel than the cooling itself. The universally used suction ventilation system drew great quantities of dust into the car around doors and windows. With the air-conditioning system, the direction of flow is reversed. The outward flow of the air thus seals all openings against the entrance of outdoor dirt.

The systems have also improved the quality of coach heating. Part of the heat is now transferred to the incoming air before it enters the coach space and the regulation of the combination of floor heat and overhead heat by thermostatic control makes possible a much improved adjustment to the needs of varying weather conditions.

The invention of the Pintsch gas lamp in 1867 led to the first major improvement in car lighting. Oil was superseded by gas during the 70's, but the gas held its place unchallenged for only a few years. In the early 80's began experiments with the application of electricity to car lighting, first with storage batteries and then with head-end power units. The Pennsylvania, the Chicago, Milwaukee & St. Paul, and the Baltimore & Ohio were the pioneers in this development. The power required by the carbon-filament lamps, however, was too great to make the system attractive until after 1900, when improvements in the incandescent lamp reduced the demand on batteries and generators, bringing the weight of equipment within practicable limits. From then on the axle-driven generator system come into general use.

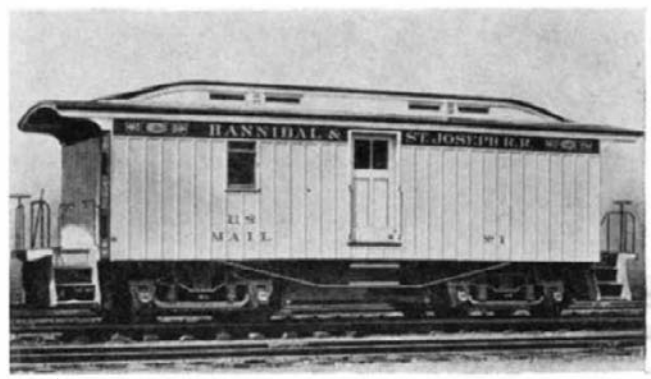
Recent improvements in car lighting, notably the application of fluorescent lamps, have added still further to efficiency. But the addition of other power-using facilities, the largest of which is air conditioning, has stepped up the total auxiliary power demand on the modern de luxe passenger car. Where four-kilowatt lighting generators once were adequate, 20 kilowatt generators are now in use. Some of these are driven from the car axle. Others are being driven independently by propane-gas engines mounted underneath the cars.

THE OUTLOOK—The physical plant of the railroad has by no means attained its ultimate form. Among the changes in track now under trial are welded rails extending several thousand feet without a joint. Further modifications of rail section are also under consideration.

To supplement roadside telephone, telegraph, and signals, wireless communication between the head and rear end of moving trains and between the moving train and the roadside is under development.

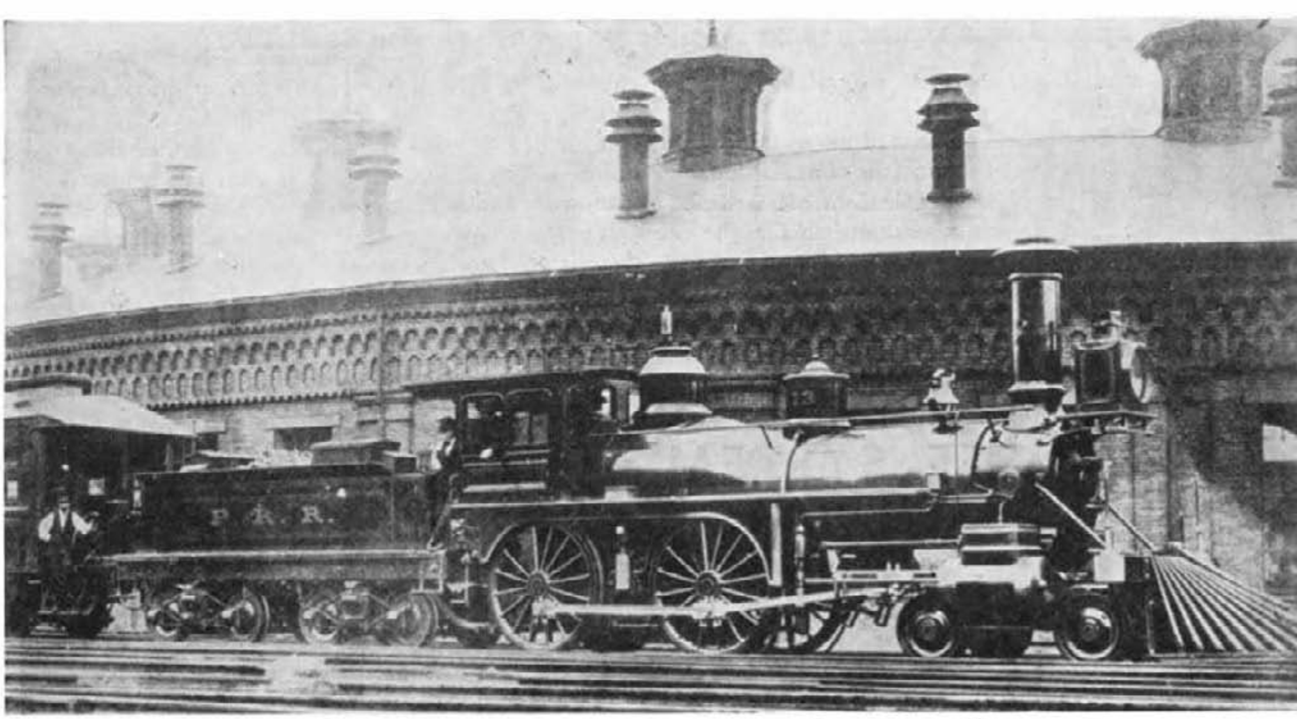
New types of motive power, under discussion for some time, include the steam turbine locomotive, one of which has been built for the Pennsylvania Railroad, and the gas-turbine locomotive. The early trials of poppet valves promise significant improvement in capacity and steam economy of conventional steam locomotives. More than one railroad is anxiously awaiting the opportunity to build all-welded locomotive boilers as soon as war-time restrictions will permit. Roller bearings on the crank pins and in the crossheads of steam locomotives have made a good start. War-time metallurgical advances promise new materials for locomotive boilers, as well as for forged parts.

The car truck, both passenger and freight, is in for a considerable overhauling in the interests of better riding at higher speeds. In passenger service the tightlock coupler is gaining ground and may, in time, replace the present free vertical plane type.



Burlington Route photograph

In 1860 the first railway mail car was placed in service



Compressed air brakes for regular service were first installed by George Westinghouse on this locomotive

Weather-Proof Revolution

Our Armed Forces Needed Containers That Could Withstand Immersion in Salt Water and Pass Unscathed Through the Rough-and-Tumble of Battle. To Meet This Need the Industry Pooled its Knowledge and Trade Secrets. The New Weather-Proof Packaging Will Have Many Uses After the War

THERE IS a revolution coming in the packaging and shipping methods of thousands of products which travel via railroads, steamships, trucks, and airplanes. The change will come because fiber-board containers—both solid and corrugated types—do not have to be kept perfectly dry any more. The V-Board weather-proof fiberboard container has solved the dampness problem, and in a great big way.

Right now, nobody knows more than a tiny fraction of what the possibilities of this container are. It was developed for the emergencies of tossing cartons of war goods into the surf while landing operations were going on under fire, and for stacking goods out in the open on tropical islands for weeks and weeks where the rainfall is more than ten feet a year. And the armed forces are taking as much of this packaging material as can be made.

But shippers and container makers, looking ahead, see the reduction or elimination of troubles which have be-deviled them for years. To understand what they see, it is necessary to look back at the brief history of the V-Board.

The layman sees fiber-board containers in every grocery store, and they all look alike to him. There is, however, many a secret kink and quirk to the making of them, many a formula which is kept locked away in a good strong safe. And these secrets are not the simple bits of lore with which a watchmaker might manipulate tiny metal parts; they are the kinds which apply to huge and slow moving machines, vast tonnages of raw materials, enormous investments of working capital.

For 30 years every large maker of containers tried to solve the weather resistance problem. Naturally, each applied all his secret methods and every bit of knowledge he could gain from the outside The stakes were huge. Getting the right answer would have given leadership of the industry to any company. But no one hit the jack pot.

POOLING KNOWLEDGE—When war needs demanded a weather-proof container, these manufacturers got together to exchange information. They were willing to lay all their facts on a common table and to pool their patents. And the facts proved to be enough. A fiber container could be made which would not be destroyed by 24 hours of immersion.

First came the solid fiber box. Here the hard problem was to seal the edges of the board. Plastics licked that one.

The corrugated box was harder. At every area where the corrugated inner sheet touches the outer or inner wall, glue must be applied. The manufacturers had to find a glue which would continue to hold although the spaces between the corrugations were filled with water and kept that way for 24 hours. By co-operative action they found one.

Production got under way, and everything looked good. But there was trouble to be expected. It would come from those secret methods. The kinks and quirks in use in one plant were bound to turn out more successful weather-proof containers than those in another, and nobody could guess which plant would be the winner.

The industry decided to head that one off. Each plant listed the types of equipment it intended to use, the sizes, operating speeds, inspection methods—everything that would let one plant know what was going on in another. All this was gathered into a book and given to the production executives. Now any plant which was having trouble could look up and see what its competitors were doing.

The product of the whole industry had to come up to the standard set by the military men. There was only one sensible procedure to take. An industry-wide inspecting system was set up. Under this, each manufacturer sent three sample boxes from each order filled—and if the order was larger than one carload, then three from each carload—to a single testing laboratory which served the entire industry.

ABILITY WAS SHARED—The laboratory, in turn, made a monthly tabulated report to the entire industry. Each factory making shipments during that month was identified by a number—a large

Official U. S. Navy Photograph

In war, the ten-thousand-and-one items needed by our armed forces must be packaged to stand rough handling and outdoor storage, as this picture makes clear

company like Robert Gair might have several plants represented and each of these would have a different number, these being scattered through the list and not grouped.

Here the presence of those secret processes began making itself apparent. Some plants were making very good records, in that nearly all their samples were well above standard, while others were not doing so well.

Meetings to discuss these reports were turned into open forums in which the manufacturers who had the worst records discussed their troubles. Very quickly it became clear that many of these problems could not be solved by talk and by reports alone. The personal touch would be needed.

Right here the industry took the step which promises most for the future of the weather-proof container. It made arrangements for men from the successful plants to visit the unsuccessful ones and give personal explanations of how to make those small changes in methods which can make such big differences in results. Secret kinks and quirks, in short, were being taken from plant to plant, and by the very men who knew best how to use them. The industry at last was making an all-out, all-coördinated attack on this decades-old problem. And so successful was this method that failures have been reduced almost to the vanishing point.

Development did not stop there, since many high-powered outfits were interested in the weather-proof container. Big companies like American Cyanamid and Du Pont and National Adhesives were making chemicals for it, and wanted this business to grow.

And there were further possibilities. Full water-resistant protection of the contents of the containers was one of them. The container, as originally developed, is weather-proof only in that it will not disintegrate like an old-fashioned fiber-board container when wet. Water can leak in and get at the contents unless these in turn are protected by being wrapped in heat-sealed bags or by other means.

THE MARINES TAKE OVER—The United States Marine Corps were doing some testing on their own. They developed a plastics-backed adhesive tape. Sealed with this, the weather-proof containers were put on warehouse roofs in Philadelphia and left there through eight months of snow, rain, freezing cold, and broiling sun. The contents remained perfectly dry.

Wanting to give them a real workout, the Marines then soaked these tape-sealed containers in hot salt water at 125 degrees, Fahrenheit. And still the contents remained dry.

Then the leathernecks got rough. They filled 12 of the containers, tied them together with a steel cable, and towed them ten miles down Delaware Bay behind a speed-boat. The contents stayed dry and undamaged, and the Marines decided that they had a container.

The Army used a slower method. Experts were sent all over the world, everywhere that war goods were being delivered. They took colored motion pictures of containers in action. Significant bits of these were shown to the container makers. They showed containers being lowered in slings during rain storms, coming ashore on landing craft, being dredged up several days after having been tossed into the surf, riding over jungle trails after having stood for weeks in tropic rain and sun.

Never in the history of the container business has such a flood of information poured in from so many sources. From inside the industry, from suppliers of chemicals and materials, and from experience records all over the world, the container makers are learning what they can do and what they must do. The experience of decades is being crowded into weeks. And it is being shared by the whole industry. The battle for future business is wide open and every container maker has an equal chance.

WEATHER-PROOFING COSTS MORE—Not everything in prospect for the weather-proof container is bright. The cost may be a stumbling block. In ordinary times an average sized container uses 10 square feet of fiber-board. If the average cost is taken at a nominal $7 a thousand square feet, that means seven cents for the container. The best grade weather-proof container may easily cost five times that, or 35 cents. Used in carload lots, with 7000 to 8000 filled containers in a carload, this would make a big difference to the shipper.

In order to subject V-boxes to the rough treatment and strain they would receive in actual use, this massive tumbling drum was designed and built. In it, loaded cartons receive more strenuous handling than they would in use on the world's war-fronts

Courtesy Container Testing Laboratory

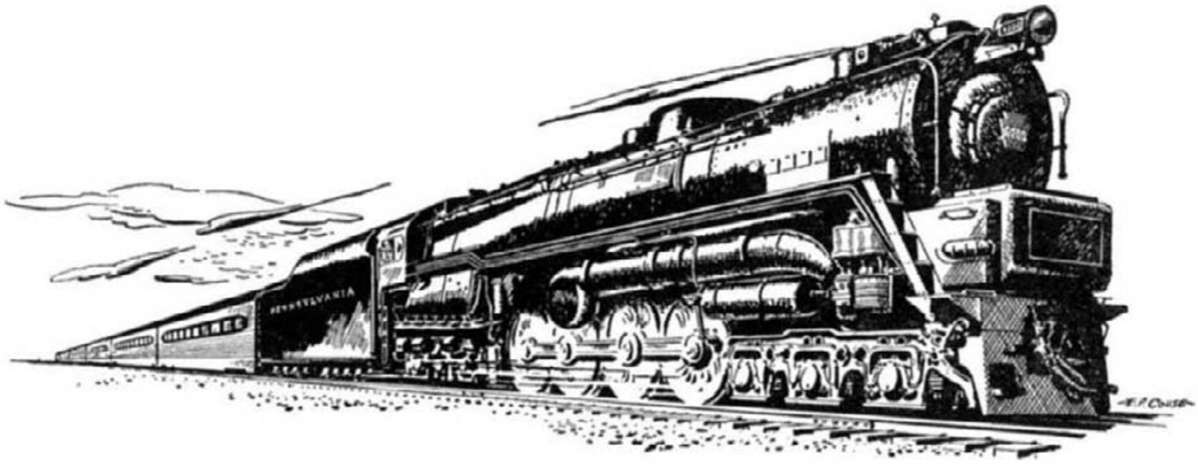
Against this there are mitigations. One of these is superior strength in the same weight. The weather-proof container is more than twice as strong as the ordinary one of the same grade. In many cases the shipper could cut 1½ pounds from the weight of each average sized container. That would mean 12,0000 pounds eliminated from many a carload. Important as this is to rail shippers, it will mean a lot more to trucks, most of all to airplanes. Incidentally, cutting the weight of the container in half will halve the cost disadvantage against it.

Packaging structures will be helped. Many a package is a study in civil engineering, with the contents themselves bracing the box and all sorts of members added to distribute the stresses. Put twice the strength in the outer shell and many a bothersome bit can come out of the inside. This will reduce the overall costs and sometimes may make the weather-proof package the cheaper one.

Stiffness is important. At all ordinary relative humidities, the weather-proof container is a good 4 percent stiffer than the ordinary one, and this means superior ability of filled containers to stand up under handling by lift trucks or when piled in high tiers. But there is more to it than that.

Ordinary containers lose stiffness quite rapidly as the relative humidities of the atmosphere about them increase. It is not wise to store them in such damp places as ordinary refrigerators. But the weather-proof container loses stiffness only slightly and very slowly under damp conditions. Filled or unfilled, it can be stored in refrigerators and in buildings which are much too high in relative humidity for the ordinary ones.

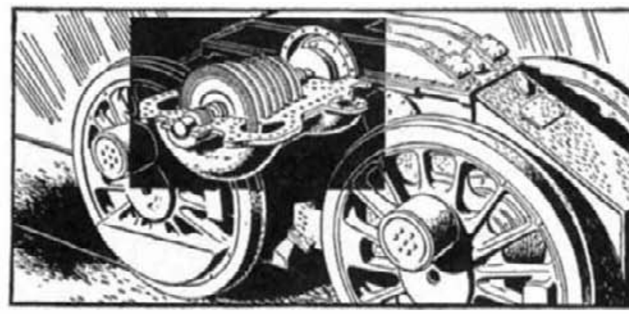
EXPANDING DEMAND EXPECTED—In fact, this retention of strength and stiffness when they are damp is opening to the weather-proof container fields previously closed to the fiber-board container industry. Packaging of fresh meats and of fresh fruits and vegetables are examples. Right now, live lobsters are being shipped from the seacoast to interior points in weather-proof containers carried by airplanes. Farmers can take the weather-proof containers right out into the open fields, pack and seal them full of damp produce, and have that produce reach the market before the dew upon it dries. This opportunity alone can cause the weather-proof container to double the



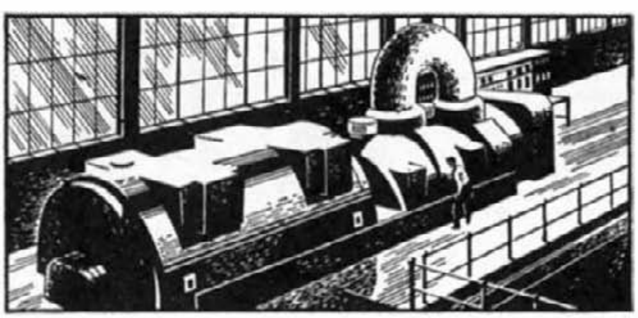
This Newest Locomotive

is Powered Like a Battleship

LONG AGO successfully developed by Westinghouse for ocean vessels, the *steam turbine* has now been harnessed as a brand new type of smooth, efficient motive power for modern railroad locomotives.



THE WESTINGHOUSE steam turbine in the Pennsylvania Railroad's new direct-drive locomotive is *no bigger* than a household electric refrigerator—yet it will haul long passenger trains with ease.



THE POWER-PACKED locomotive turbine is a descendant of giant Westinghouse turbines which generate much of the electricity used today. The great expansion of electric power began with these turbines.

THE VELVETY FLOW of power from this 6,900 horsepower *steam turbine* locomotive will make trains run with extra smoothness and is a major contribution to finer transportation for the future.

THE RAILROADS are developing a dazzling new kind of transportation for the future. The latest and most dramatic improvement is *steam turbine* power, which gives the Iron Horse "new lungs."

To help produce this new locomotive, the Pennsylvania Railroad, a long-time pioneer in transportation improvements, turned to Westinghouse and the Baldwin Locomotive Works. Working as a team, these companies have produced this latest in a great line of steam locomotives—descended from "Old Ironsides," built by Matthias Baldwin in 1832. *Westinghouse Electric & Manufacturing Company, Pittsburgh 30, Pennsylvania.*

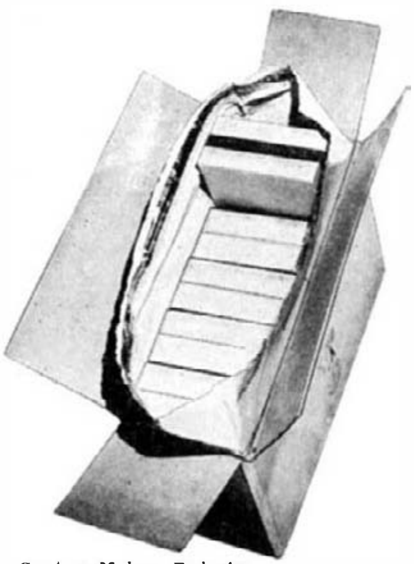
Westinghouse

PLANTS IN 25 CITIES — OFFICES EVERYWHERE

Westinghouse presents:* JOHN CHARLES THOMAS—*Sunday 2:30 pm, EWT, NBC

pre-war sales of the industry and open wide new fields of demand.

Fire damage can be reduced. Anybody who has seen a stack of ordinary cartons turned to a pile of mush by water, with cans or other contents scattered all through it, knows why hose and sprinkler damage is so often



Courtesy Modern Packaging

Vital medical supplies for our armed forces are packaged in V-Board boxes

a separate item on fire insurance policies and the biggest single factor in fire damage. The weather-proof cartons will burn in the flame but they will not dissolve in the water.

Use by exporters will be heavy. Our armed forces are making the weather-proof container known all over the world. Protection of the contents will be important enough in this field, but doubled strength (or the same strength with less weight) will have high value, too. Many an exported box has to be carried inland over the roughest of truck trails, or by airplane to jungle landing fields, or even on the heads of native carriers.

Ability to re-use the container after it is emptied is a major factor in exporting. The extreme strength and durability of the weather-proof container will be a foreign sales asset to any goods packed in it. Right now our soldiers are using these containers as roofs over their fox holes and for many another weather-resisting job. But in peace-time those who get these containers abroad may use them to package other goods, perhaps for shipment back to us.

The whole story is not known yet. Container makers keep on finding out how to reduce production costs, add new qualities, figure out new grades with varying degrees of weather resistance. Not all peace-time packages will need to withstand 24 hours immersion in sea water; there is room for varying degrees of weather proofness at varying prices.

But two things are sure. A problem which has been studied for 30 years has been solved by co-operation of a depth and intensity seldom found in any industry. The resulting weather-proof container is going to solve many a tough problem for post-war shippers.

MAGNESIUM FIRES

Can be Controlled By Sprinkler Systems

Fires in plants where magnesium is machined are dangerous because molten magnesium has the ability to take oxygen from water and thus perpetuate its own combustion.

This hazard has caused many factories to avoid all use of magnesium, while others, as we have noted before, went so far as to specify the kinds of underwear girl operatives might wear, lest a frictional spark from silk panties should reach the machinery and cause the magnesium to ignite.

Recently concluded tests, made jointly by the National Board of Fire Underwriters and the Factory Insurance Association, have shown that magnesium fires can be controlled by sprinklers.

The drops of water from the sprinklers, striking the fire, do cause small explosions during which bits of molten magnesium fly through the air. But these bits are so small and they cool so rapidly that they will not ignite other piles of magnesium chips which are only a few feet distant from the fire. And when enough drops of water have struck the fire it is cooled to the point where it ceases to burn.

Molten magnesium flowing into, or being struck by, solid bodies of water, such as might come from hose streams or be lying on the floor as a result of hose streams, is quite another matter. In this case the magnesium fire will give off enough hot gases and steam to damage or destroy any ordinary building.

Control by sprinklers, then, must bring the sprinklers into action at the earliest practicable minute and must not provide solid bodies of water into which the molten magnesium will flow. But, with careful lay-out and safeguards, the sprinkler system will reduce the magnesium fire hazard to the toleration point for far more machine shops than was believed practicable a year ago.

SET AND SHRINK

Plastics Parts Used In Assemblies

Rivets, grommets, dowels, and pins made of thermosetting plastics are coming into ever widening use as parts assemblers gain greater experience with them.

The basic technique of applying these parts usually includes the application of heat to fit them into the spaces they are to occupy, then permitting them to cool. Under heat, assisted by pressure, the plastics parts flow until they are upset, enlarged, split, bent, or otherwise formed to hold the pieces they are to join. Then, when the heat is removed, the plastics parts not only set themselves permanently to the shapes into which they have been formed, but also shrink and thus tighten the joints.

Enough heat for the flowing and setting often may be had from the friction of spinning rivet heads, spinning grommet ends, or expanding sleeves by the use of friction tools. Other parts are expanded by compressed air and, instead of cooling the air in an after-cooler or inter-cooler attached to the compressor, the air is allowed to retain its heat of compression, this being sufficient to set the plastic.

Applying heat in the process of squeezing rivets is, of course, a common operation which presents no problems.

Not the least of the advantages of these fasteners is that their shrinking action tends to increase the strength of the thin materials which they join by pre-stressing those materials.

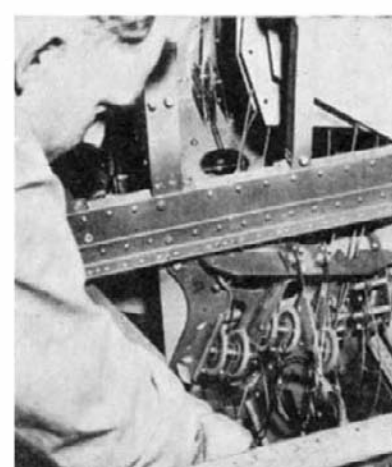
SHEAVES

Have Plastics Faces To Reduce Wear

Wire rope men long have known that the damage done to the rope at the sheave may be the greatest source of rope failure.

In large airplanes the cables are run over sheaves which have contact faces made of Formica. This resilient plastic offers a gentle, cushioning surface to the rope, which tends to reduce inner friction between the wire strands and to prevent wear. Furthermore, the resilient surface has no filing or abrasive action upon the strands of the rope.

Every sheave is mounted on anti-friction bearings which have the lubricant



Resilient plastic facing on sheaves saves wire rope in many industries

so retained that they will withstand years of service without additional lubrication. This minimizes the running friction of the sheave and therefore the frictional resistance to the movements of the rope.

Sheaves of this type will find many post-war applications, especially where small-diameter wire ropes are used as linkage for remote controls.

Plastics Days Ahead

Railroad Modernization Will Offer Many Diverse Applications of Plastics, Some of Which Have Already been Proved in Practice. Lighting Fixtures, Upholstery and Drapery Fabrics, Structural Parts, and Electrical Insulation are a Few of the Possible Uses of these Versatile Materials

MODERNIZATION . . . renovation . . . rebuilding—words to bring tears to the eyes of hard-pressed railroad men. In this war of "movement," domestic rail transportation systems have had to bear a huge burden of bringing raw materials to production plants, moving finished and semi-finished products to points of trans-shipment, transporting troops, moving war workers to and from their jobs and, at one and the same time, keeping civilian economy and morale at a high level.

With production at an all-time high, facilities that would normally be called upon to relieve the railroads have been drastically curtailed or entirely suspended for the duration. Thus there is today no commercial transportation by water between our two coasts. Shortages of tires, gasoline, and new automobiles—with the 35 mile an hour speed limit thrown in to slow things down still further—have combined to reduce the amount of freight and the number of passengers that can be moved by truck and private car.

Swamped with business as a result of these losses in total transportation capacity, railroads felt the pinch from yet another side. The demands of war left little material and even fewer facilities that could be devoted to the construction of new transportation equipment. Thus railroad officials have been forced to put back into service freight and passenger cars they had long marked off as useless, leaving dreams and plans for modernization, renovation, and rebuilding for the days after peace returns.

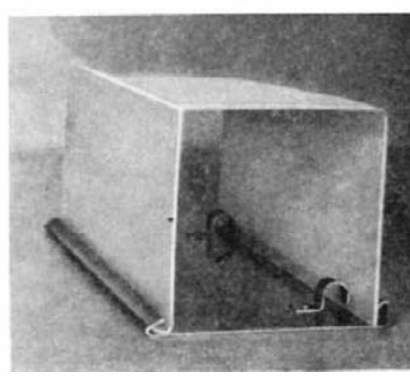
But it is with these dreams and plans of railroad men that plastics is most concerned. For a few years before the war, travelers were given a brief but intriguing glimpse of a new trend in railroad car design based on the premise that rail travel can be made a comfortable and pleasant experience. It is to be expected that these improvements—many of which depend for their success upon the use of various plastics materials—will be further refined when the country returns to peacetime economy and will find acceptance in a large proportion of our future rail cars.

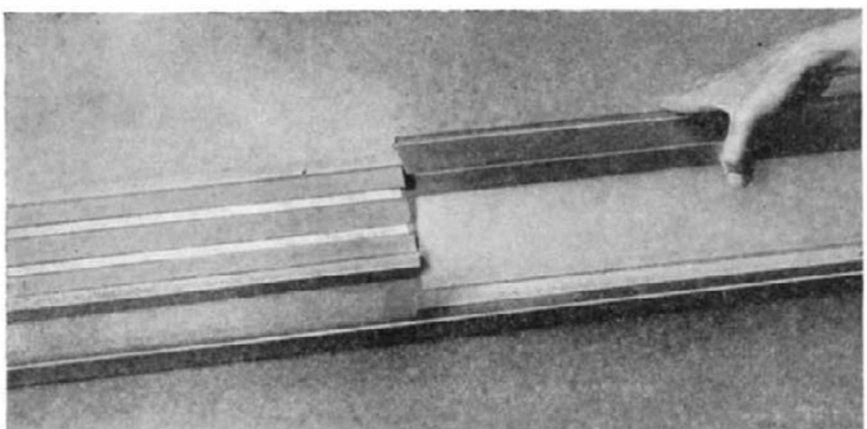
BETTER CAR LIGHTING—An important factor contributing to the luxurious atmosphere in the last passenger cars to be put into pre-war service was proper lighting. Lighting fixtures were designed to provide adequate illumination for comfortable eye-saving reading and to fit into the interior decorations. However, in addition to the usual problems of the lighting engineer—candlepower, shadows, glare—railroad lighting installations must meet certain special requirements.

Below: acrylic resin with appliqued strips of sheet metal is used in this lighting fixture for passenger cars. The resilience of the plastics holds the fixture snugly in place

Right: In this picture, metal applique has been removed to show how the acrylic sheet has been turned along the edge so as to snap into grooves

Courtesy Safety Car Heating & Lighting Co.



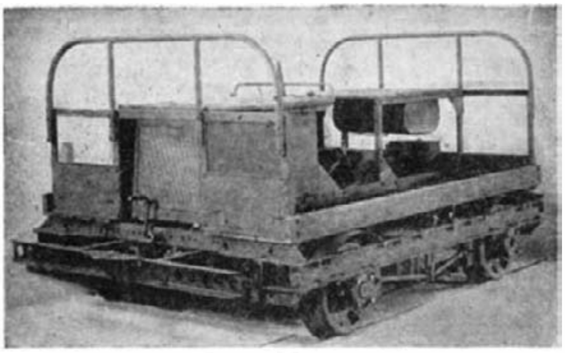


They must, above all, be rugged and dependable so that valuable rolling stock will not be tied up for repeated repairs, and must have a life as long as that expected of the car itself. In addition, the fixtures must be simple and accessible—permitting quick and easy cleaning and maintenance—as well as economical and efficient. Finally, railroad lighting must meet such other requirements as lightness, ease of installation, safety, and freedom from rattling and other annoying noises.

Faced with these requirements, the Safety Car Heating and Lighting Company started working with plastics shades, finally adopting white translucent Plexiglas for their railroad lighting fixtures. The company found this material to be tough and capable of withstanding hard blows and the flexing caused by the weaving motion of the car. It was light in weight, shatter-proof and rattle-proof, and it had proved the permanence of its optical properties and its freedom from dimensional changes in the aircraft field. The only possible disadvantage—the fact that it might soften and deform if the temperature of the fixture exceeded 160 degrees, Fahrenheit—was circumvented by the use of fluorescent lamps.

An ingeniously simple method of mounting, developed by this company, depends for its success on the flexibility of the acrylic resin. The shades are formed to the desired shape, with a slight outward flange along the edges. The piece can be flexed so that the shade may be snapped into two parallel channels. This installation, which permits quick and easy removal of the shields, has proved extremely versatile.

For long troughs running the length of the car, 24- to 48-inch lengths of shade have been used, separated by rigid reinforcing spacers molded from white translucent acrylic resin. Modifications include troughs which zig-zag back and forth across the ceiling of the car and those which run intermittently along the car ceiling, valence, or side wall.



Fitted between the wheels and axles of this handcar, sleeves molded of phenolic prevent it from activating the electric signal system
Courtesy Monsanto Chemical Company

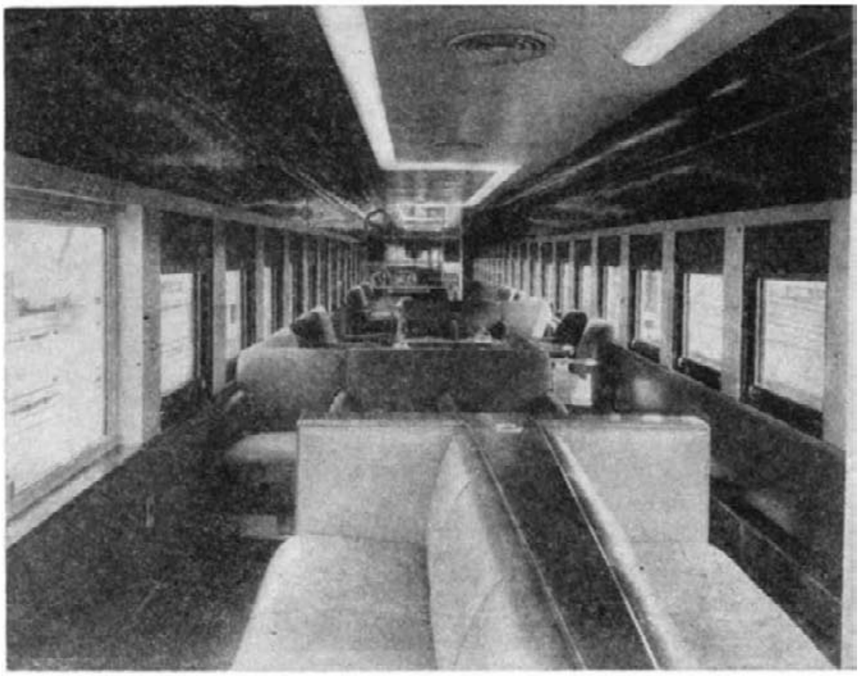
Developments in home lighting during the past year may well have an influence on railroad light fixtures in the post-war period. Finding that a considerable portion of the public look upon fluorescent fixtures as cold and unsympathetic, Morris Sanders, an industrial designer, has developed several lighting fixtures composed of tough extruded Lumarith strips interlaced, crimped, and pleated to form an infinite variety of interesting and distinctive designs. For example, one fixture uses extruded plastics strips in the form of louvers, held in place by metal rods which are covered with plastic tubing to render them almost invisible. In another design, a corrugated sheet of cellulose acetate, 3/32-inch or less in thickness, rests on glass rods slipped through molded acetate rings.

UPHOLSTERY FABRICS—During the past few months, subway riders and commuters to and from some of our larger cities have been playing guinea pig in tests to determine the wearing qualities of various synthetic and coated fabrics. These riders plucked and pushed at the brightly colored seat covers, anxious to learn for themselves just how these synthetic textiles feel and wear.

Designs for the interiors of tavern lounge cars, parlor cars, observation lounge cars, and dining cars, as developed by Edward G. Budd Manufacturing Company, indicate that synthetic textiles will have wide application on our nation's railroads when new and redesigned cars can be produced once more. Interiors thus far worked out by this company suggest the use of these materials as window drapes as well as for coverings on dining chairs, divans, and club chairs.

STRUCTURAL PLASTICS—During the past year or so, the use of plastics as structural materials has aroused intense interest and active speculation among engineers and builders as well as among the members of the plastics industry itself. In England this development is being given its first railroading tests by the Southern Railway Company. This railroad has put into service the first of 10 luggage vans—the baggage cars of the United States—whose sides, ends, and roof are built of reinforced laminated plastics panels.

The panels of these railroad vans are given increased strength by the use of steel wires and cotton, interwoven on a power loom. This construction, in which, for example, 24 high-tensile steel wires and cotton threads to the inch are woven in both the warp and the weft, has made it possible for Reinforced Plastics Inc. to overcome one of the principal drawbacks to most laminates—their brittleness. The material—woven so as to be interlocking—can be varied to meet requirements by the selection and arrangement of the steel wires.



Plexiglas shades used on zigzag ceiling lights in a lounge car

Although this steel-cotton material is very strong, it lacks the stiffness needed for rolling stock work when used alone. Consequently, after being taken from the loom, the fabric is passed through an impregnating machine where it absorbs sufficient phenolic resin to achieve the necessary rigidity. From the bath the material is removed to the drying oven, then to the cutter where it is divided into sheets of the desired size. At this stage in the process the reinforced material is placed in a press between sheets of ordinary impregnated material and subjected for about 75 minutes to a pressure of approximately one ton to the square inch.

Tests carried out on this material show it to have an ultimate tensile strength, both longitudinally and transversely, of over 24,000 pounds per square inch, and a bolt hole tensile of 21,900 pounds per square inch. The comparatively light weight of the fabric is evidenced by a specific gravity for one-ply steel wire-cotton embedded in laminated paper or fabric of 1.65 as against 7.83 for steel. Another advantage of this laminate is a high impact strength.

In the case of the first experimental luggage van, these characteristics of the reinforced material have meant a lighter car with greater cubic capacity. Compared with a steel panelled luggage van, the test car using the new laminate for its sides, ends, and roof affords a net reduction in tare weight of 5600 pounds. But at the same time this new van has a capacity of 1848 cubic feet as compared with 1808 cubic feet for the standard model.

With the adoption of this reinforced plastics laminate in the panelling of the luggage van went a thorough redesign of the entire car. It was thought advisable, in view of the characteristics of the material, to rebuild the carriage of the van completely in a way that would protect the body from shock. The most convenient method of accomplishing this was to separate the body from the main frame of the van and introduce a spring cushioning device which would allow the body to move longitudinally a few inches and then return to its normal position. With the body thus cushioned and protected from buffing or draw stresses, it could be considerably lightened without danger to baggage.

FREIGHT CARS—In the United States, the Great Northern Railway Company is in the process of constructing, of plywood and light-weight metals, 1000

standard freight cars, 40 feet in length, and weighing approximately 50 tons. While the cost of producing these cars is almost the same as for conventional box cars, a saving in weight of two tons is effected. The phenolic resin adhesives used in the manufacture of the exterior-type plywood is set under pressures of from 175 to 200 pounds per square inch, at temperatures that range from 260 and 285 degrees, Fahrenheit. In the case of most standard panels, the press time is 5½ to 8½ minutes.

Used for both the inside and outside of these box cars, the panels are riveted at horizontal points to lumber stiffeners. The thin metal strips that cover the vertical joints between the outside panels are bolted through to the lumber studding. On the interior walls the panels are installed horizontally, with thinner panels employed for the ceiling.

Even further down the scale in railroading, plastics find their uses. In many railway motor cars produced by Fairmont Railway Motors, Inc., molded Resinox parts serve as a medium of electrical insulation between wheels and axles. On most railroads, signal systems are tripped when an electrical contact is made between the two rails of a track. Maintenance cars, however, are intended to be manhandled off the track when a train approaches and should at no time activate the signal system. They must, therefore, be insulated to prevent contact between the rails; and the best place to provide such insulation is between the wheel mounting and the axle.

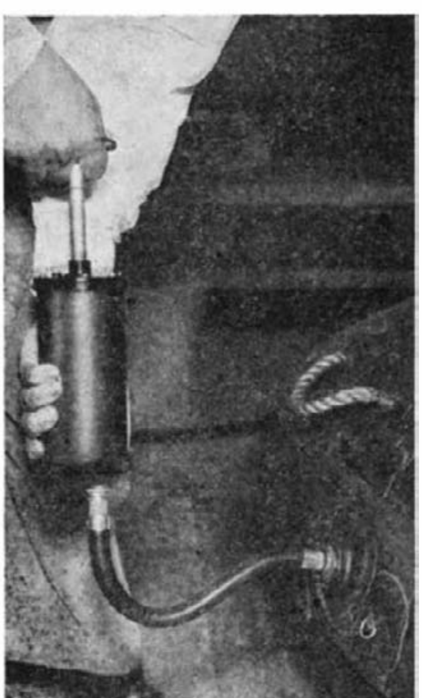
Since wheels on lighter hand-cars are pressed on the axle and held there by a threaded nut, the desired insulation is provided by a phenolic sleeve, molded by Northwest Plastics Inc., which fits between the wheel hub and the axle. In heavier cars, however, the wheels are each bolted by eight bolts to a flange on the bearing. To provide insulation in this instance, a matching flange of high-impact cord-filled phenolic, molded by the same company, is inserted between the wheel hub and the mounting plate to prevent metal-to-metal contact. Each bolt is fitted with a vulcanized fiber bushing.

These applications of plastics to railroading give but a hint of the many and diverse applications that will be found for these materials when present plans move from the drawing board to the road.

PLASTICS PUMPS

Aid War-Time Safety, Pave Way for Peace-Time Uses

THE HAND-OPERATED pumps which are standard equipment on Army and Navy life rafts for use in case of failure or loss of the cylinder of CO_2 gas normally used to inflate these rubber boats, should have many peace-time functions.



Emergency hand pumps for inflating life rafts make good use of plastics

Pre-war pumps of this type had metal cylinders which tended to corrode to such an extent that the plungers stuck in the barrel or were extremely difficult to operate. Also, the sheet metal tubing dented easily and, once dented, was of no further use. These disadvantages have been ended by using plastics for the barrel, end caps, and inner support of the flexible tubing in the Peters and Russell pumps.

The phenolic resin impregnated paper barrel, instead of denting under a blow will, at most, crack. In such contingency, a hand clamped over the crack is sufficient to maintain pressure within the tube. Regardless of the extremes of weather in which the pumps are used, neither the phenolic end caps, the laminated plastic barrel, nor the Tenite II (cellulose acetate butyrate) flexible coil inside the tubing will corrode when subject to salt water and bad weather.

PLASTICS HANGARS

Provide Protection for Aircraft Mechanics

TO INSURE that necessary maintenance work on our Navy airplanes goes on despite vagaries of weather, the United States Navy supplies portable vinyl-chloride acetate impregnated canvas-covered hangars to its many outposts. Whether the field is in the Far North or close to the Equator, the canvas covering offers full protection. The material is not only processed against the ravages of fire, mildew, and rotting but given treatment which keeps it flexible at 40 degrees below zero. Furthermore, when work is finished at one field, the canvas can be easily rolled up and moved forward to the next advanced base.

Although the original hangars were constructed for servicing only one plane at a time, the units now in use are large enough for a two-motored plane to be serviced at one end while a four-motored plane is being repaired at the other. The design is such that planes are placed half in and half out of the hangar, with special canvas socks slipped over the motors and fuselages and laced to the canvas end pieces to seal the openings.

Vinylite-impregnated canvas over a steel frame makes a portable hangar

Each hangar consists of a steel arch covered with Vinylite-impregnated canvas. The Textileather Corporation calenders a 0.004-inch film on single-texture duck and then laminates two sheets together with a wet solution. The laminating is not done when the canvas is calendered because inequalities in the cloth might cause a leak, whereas the laminating solution seals in the material to give high hydrostatic resistance when it is added in a second operation. In the next step the two sheets, which are now laminated together, are impregnated with a solution containing a vinyl-resin base which is resistant to fire, water, and mildew. After this processing the completed fabric is dipped in a bath.

Drying time is about two minutes in an oven that is maintained at a temperature of 275 degrees, Fahrenheit. From start to finish the entire treatment of a given batch of canvas requires little more than 8 hours—a speed that makes it possible for the company to turn out 12,500 yards of 36-inch material in one day.

Since speed in erection is of great importance, the canvas is divided into easily handled sections by Newcastle Products Company and its subcontractors—the fabricators of the hangars. Thus, a total of 21 panels are employed to cover the front, back, and roof of the hangar. A variety of light-weight canvas socks are necessary to provide a tight seal around the openings in the canvas end curtain where a plane's motor and fuselage project into the hangar. These socks are square, slit at the bottom, and equipped with draw strings for tightening the canvas around the nacelle. The sides of the sock lace to the grommet strip on the inside of the curtain. The steel frame is built by International Derrick and Equipment Division, International-Stacey Corporation, and Milwaukee Iron Works.

Planes and Trains

In Designing the Modern Streamlined, Lightweight Train, the Railroads Sought Assistance from Ae.onautical Engineers, and this Successful Example of Working Together by the Two Industries Points the Way to A Future Integration of their Services for the Good of the Public

THERE are two contrasting aspects in the relationship between aviation and the railroads. One, technological and non-controversial, covers the many advances in railroad equipment which owe their origin to aeronautical science. The other, economic, political, and bitterly controversial, is concerned with the participation of the railroads, direct or indirect, in air transportation.

In this article the technological advances can be discussed unhesitatingly with pleasure and pride. In considering the possible role of the railroads in air transportation, however, it is wiser to do nothing more than state possibilities and set forth the arguments of both sides. The right decisions must come from public opinion and Congress, and will be years in the making.

In discussing what the railroads have drawn from aeronautics there are two main lines of advance to consider: The first is the reduction of air resistance of the train; the second the reduction of its weight.

STREAMLINING SAVES POWER—Only 20 years ago, air resistance was considered by railroad mechanical engineers to be a minor matter. So great was the misunderstanding of air resistance that at one time it was lumped with ground friction resistance. Hence, the forms of locomotives as well as passenger and freight cars remained almost ideally suited for creating air disturbances. This was no handicap in suburban traffic where passenger trains operate at low speeds. But at speeds of 60 to 70 miles an hour, the power expended in overcoming air resistance accounts for at least one half the power exercised by the locomotive.

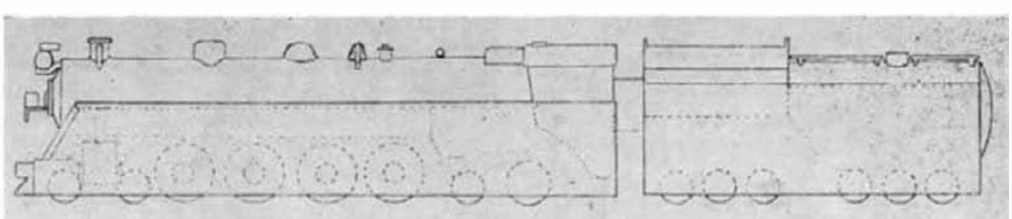
Skilled design can cut this resistance to approximately one half the amount encountered by the un-streamlined locomotive and train. We stress the word "approximately" because so much depends upon the design, condition, and length of the train, as well as additional factors. Hence no generalized statement can be made in spite of innumerable tests and voluminous writings on the subject. Whether the power saving be one half or less than one half, streamlining is evidently fully worthwhile. Not only do our streamlined trains have an enormous advertising value, since they spell to the public a great advance in railroad equipment, but they actually do provide savings in power and, hence, in fuel.

Aeronautical science's second contribution to the railroads has been in aiding better structural design of rolling stock so as to reduce weight. When an aircraft engineer of our acquaintance was first requisitioned by a railroad equipment company to assist in the design of a streamlined train, he asked for examples of stress analyses and load factors, and was greatly surprised to learn that they were not available. Locomotives and trains had become structurally strong through tradition, experience, and the brutal addition of weight.

No attempt had ever been made to utilize light alloys or high-strength steel alloys. Because the engineers who pioneered in the design of streamlined railroad equipment were, on the whole, familiar or made themselves familiar with aircraft practice, they departed from the traditional path and did several things. They made bold use of the light aluminum alloys without which modern aviation would hardly have been possible. Or, alternatively, they made use of the stainless steels of very high tensile strength, and reinforced them skilfully against local buckling by appropriate corrugation.

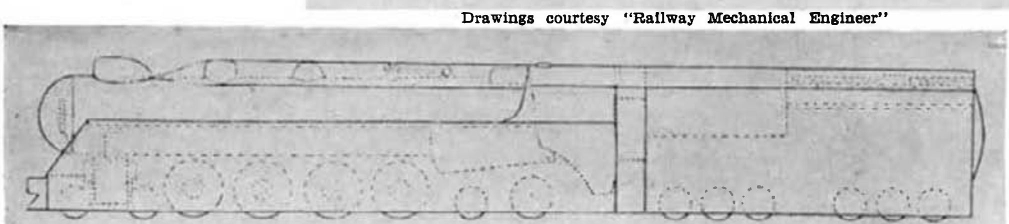
Then, when it came to the actual task of design, they worked out a theory of shock loads. In addition, they investigated the conditions under which a railroad train would encounter the most severe loads. They discovered the points of application of such loads and their directions, and designed extremely refined structures accordingly.

By following aircraft practice, the weight of car equipment has been reduced by nearly 50 percent. One authority states that the 750 tons represented by the heavy conventional cars in an eight-car train can be reduced to 400 tons, approximately. Such a saving would reflect itself in the cost of motive power with consequent effect on fixed charges, fuel costs, and the like. While the railroads so far have not been able to take full advantage of these weight-reducing elements except in their most expensive trains, there is little doubt that in post-war



The first step in streamlining locomotives was to shield the lower part with sheet metal. The dots show the parts that were masked to cut down air resistance

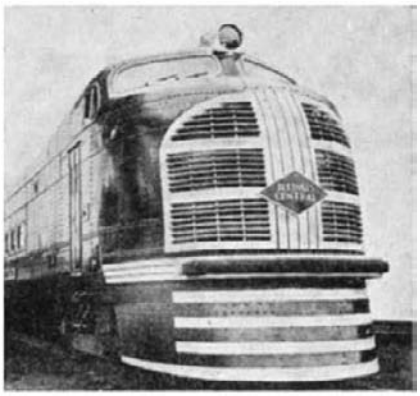
Drawings courtesy "Railway Mechanical Engineer"



This drawing indicates how streamlining was carried to further lengths by shielding the front end and the upper part of the boiler so as to provide unimpeded airflow

trains the process of weight reduction will be accelerated and become more general.

REDUCING VIBRATION—Another important way in which aeronautics has influenced the railroads is in the study of vibration. In aircraft work from the earliest days, it became apparent that the isolation of engine vibration from the rest of the airframe was a vital matter. Rubber engine mountings were found indispensable. The study of flutter of aircraft wings was seen to be an absolute preliminary to safety. Moreover, it was discovered that the reduction of vibration was a



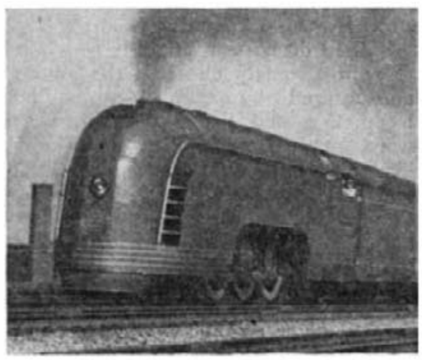
subtle business and not merely a matter of adding weight. There have been cases of locomotives experiencing failures because of vibration, and weight, added as a remedy, caused the vibration troubles to increase enormously.

Aviation taught American engineers that vibration was a subject to be treated with all the resources of applied mathematics and applied mechanics. Our modern streamlined trains with their remarkable smooth-running qualities are evidence of the fact that in vibration, also, railroad equipment designers owe much to their aviation confreres.

SHALL RAILROADS FLY?—In the early days of flight, neither railroads nor steamship operators, with few exceptions, showed much interest in aviation. Today, many surface carriers are keenly interested. Steamship companies, railroads, bus lines, and truck operators have filed applications with the Civil Aeronautics Board for certificates of public convenience and necessity authorizing air operations. But existing airlines are, in general, hostile. The Department of Justice has expressed its interest through formal intervention, and the issue has recently been discussed in Congressional Committees and on the floor of Congress.

What is the nature of this conflict? The Civil Aeronautics Act, passed in 1938, has been regarded by Congress as well as the Civil Aeronautics Board and the aeronautical industries as having been planned to prevent control of air carriers by surface carriers such as railroads and steamship lines. Perhaps the best way to define such views is to quote from testimony before the House Interstate and Foreign Committee by L. Welch Pogue, chairman of the C. A. B.: "The Act (now law) of 1938 provides that consolidations, mergers, and acquisitions of control involving air carriers are unlawful unless it is found that they will not be inconsistent with the public interest . . . it was the intention of Congress to carefully restrict the participation of surface carriers in the air transport field. The requirement was construed to mean that aircraft must be used in a manner which would be auxiliary supplemental (subordinate) to the surface transportation of the acquiring company." Here is something as clear and definite as the testimony of a public official before a Congressional Committee can be. The question today is whether this view shall continue or legislation should be enacted to give railroads and steamships a freer, stronger hand in air-transport operation.

THE CASE FOR THE RAILROADS—There are many persuasive arguments in favor of such participation. The first is the avoidance of duplication in per-



Three examples of differently powered streamlined engines. Upper left: An Illinois Central Diesel-electric locomotive. Above: A streamlined steam locomotive on the New York Central. Right: A steam-electric engine of the Union Pacific line

sonnel and other facilities. There are many ways in which surface carrier facilities, intangible assets, and personnel can contribute to air-transportation service without a proportionate increase in investment and expense. It is argued also that if a single company were permitted to operate both rail and air, the most economical and sound division of traffic would become possible. Again, it is said that air cargo could be carried much more cheaply if all the facilities of surface transportation were coördinated with air equipment, and that similarly, economy could be gained in the carrying of passengers. Certainly, in war-time, air-surface coördination works splendidly and there are many arguments in favor of the idea that coördination in peace-time would be equally efficient.

THE CASE AGAINST—Airlines' spokesmen who oppose the entry of the railroads into the field of aviation say that the projected "integrated transportation companies" would be huge transportation monopolies. The railroads, they argue, had every opportunity to develop air transportation for nearly 15 years and they failed to grasp the opportunity. They point out that the development of air transport was left to independently-owned and financed airlines who went forward despite obstacles and in the face of great financial loss.

"Now, however, the surface interests have moved in," says one of these spokesmen, Captain Eddie Rickenbacker, president of Eastern Air Lines. "They want to reap the harvest and dole out its fruits to the American public in the manner which will best protect their vested interests in their ground facilities. . . For air transportation to come under the control of the powerfully financed surface carriers with their interlocking relationships and their vested loyalties in their railroads and steamships would doom free enterprise in air transportation."

It is possible that Rickenbacker may state his case too strongly. It is perfectly true, however, that heavy pressure is being exercised by railroad, steamship, truck, and bus interests to break down the legislative barriers guarding the airways against invasion.

COMPETITION NEEDED—There is also one argument which Rickenbacker did not use, which nevertheless deserves to go down in the record. There are benefits to be derived from the very existence of different and competing types of transportation. Such rivalry, of

course, if pushed to extremes, with passenger fares and cargo tariffs completely unregulated, would make competition ruinous to both airlines and railroads. But the C.A.B. and the Interstate Commerce Commission have a great deal to say regarding rates and know fully what evils unrestricted competition may bring.

On the other hand, it can be said that it is precisely the competition of the airlines which has stimulated progress on the railroads. It is the one and a half hour schedule by air between New York and Washington which has indirectly led to the four-hour Congressional Limited of the Pennsylvania Railroad. It is the tremendous speed of the transport plane which is fostering the growth of the streamlined train. It is the enterprise and friendly attitude of the airlines towards the travelling public that is fostering a similar outlook by the railroads.

Another argument against railroad operation of the airlines belongs in the field of psychology. The railroads could, to a large extent, supplant lack of experience in air operation by hiring the best talent available, and by drawing on the personnel of the airlines or the Air Transport Command. But the railroad man quite rightly loves his industry. He loves the locomotive and the whole world of railroad operation which is so fascinating and varied.

A decade or more would perhaps be necessary before railroad men had the same loving understanding of aviation work. It would be misinterpreting human nature to think that railroad men at the top could operate airlines with the same flexibility and enthusiasm which young aviation executives like Juan Trippe, C. R. Smith, and many others have shown for their own chosen form of transportation.

AIR-RAIL CO-OPERATION NEEDED—Whatever the outcome of the argument before public opinion and Congress may be, there is one thing which must not be forgotten. The two great methods of transport can co-operate in many ways, whatever the status of legislation may be now or may become in the future.

The desirability of such co-operation was recognized very early in France, Great Britain, Germany, and, to some extent, in the United States. Thus, Major Martin Wronsky, Director of the German Lufthansa, revealed that in 1928 an agreement was signed between the Deutsche Lufthansa and the German railroads whereby offices for the receipt of air cargo were established in every railroad station, and the railroads become responsible for delivery of cargo to the nearest airport.

In 1928, or soon thereafter, Lufthansa and the railroads also had arrangements (similar to our own) whereby railroads took care of air passengers stranded by bad weather.

Major Wronsky further advocated in 1935 the coördination of railroad timetables and airline schedules. In some cases fast ground expresses were eliminated in Germany because the air gave a completely satisfactory alternative service. Combination rail and air tickets were issued, with as much justification as combination tickets are issued for all American railroads.

Similar views were expressed by Raoul Doutry, Director General of the French Chemins de Fer de l'Etat.

Methods of American coördination between railroads and airlines will suggest themselves to almost anyone who travels or ships goods. Travelers should be able to buy at one place tickets for all airlines as well as all railroads and bus lines. Likewise, business should be able to ship by air to points from which railroad or other surface transportation will carry on. Common sense will dictate other co-operational possibilities.

Whatever may be the contents of new legislation, it is clear that the airlines are too strongly established to be dominated by the railroads. On the other hand, it can be expected that the railroads will ultimately seek the maximum coördination with the air lines, whether this is encouraged by legislation or not.

A solution to the problem will be achieved. It is one of the great blessings of American life that no one-sided, authoritarian power is allowed to dominate a situation. Hence the public can anticipate, sooner or later, a reasonable adjustment and friendly relationship between the two great industries.

• • •

PRODUCE BY AIR

Fruits and Vegetables Are Potential Air Cargo

THE WAR has given birth to a new concept of cargo-carrying capacity of the airplane, and there is no doubt that in the post-war period the airplane will be responsible for a great deal of traffic. The problem is to determine in what directions air cargo should be sought, what equipment will be needed to carry air cargo most efficiently, and to what level costs per ton mile must be reduced so that the airplane can, in addition to having much higher speed, compete with other forms of transportation on more favorable terms as regards cost.

Colonel Edward S. Evans of Detroit has generously made possible a study of "Air-Cargo Potential in Fresh Fruits and Vegetables," conducted by Professor A. Larsen at Wayne University and presented in a scholarly and well documented pamphlet. Professor Larsen has made it the purpose of his monograph to secure basic information from numerous sources such as the Department of Agriculture, Department of Commerce, railroads, trucking companies, terminal produce handlers, and so on. At 15 cents a ton-mile, he concludes, the fruits and vegetables carried by air would be insignificant in volume. At three cents a ton-mile fully 25 percent of the gross traffic in fresh produce, or upwards of 4 billion ton-miles per year, would be carried by air. Of course, three cents a ton-mile is a very optimistic figure, and ten cents a ton-mile would be much more likely. But even at ten cents a ton-mile, there is evidently a great potential market. The more fragile and expensive fruits would come first—strawberries and peaches for example. Then would come cantaloupes, cherries, plums, and so on. At very low rates even the lowly lettuce and tomato might become air travelers.

Non-perishable farm products are not likely to be airborne for many years to come. From air traffic there will come many benefits, such as fresher fruits, with less chance of damage, savings in stock carried, in rentals, in interest, and the like.

AIRPLANE LOADER

Has Self-Contained Power Plant

A COMPLETELY portable and mechanized unit for loading and unloading air cargo has been put into use by American Airlines. A conveyor belt is mounted on a gasoline-powered tractor which keeps a continuous stream of baggage, express, and mail moving from truck to plane as fast as cargo handlers inside the plane can stow it away. The conveyor can be adjusted to the height of the forward cabin of the Douglas DC-3 or the post-war DC-4.

Both the operating and the elevating mechanisms are hydraulically operated. At the lower end of the conveyor belt is a platform to receive cargo coming down the conveyor, from which it may be placed on the low-level panel trucks on which passengers' baggage is carried, or on the regular mail and express delivery trucks.

When the much larger transports such as the DC-4's or DC-6's come into service, the conveyor will put the passengers themselves on board, and even now they are used as escalators for the captain and crew of the DC-3. The credit for the actual construction of this equipment is due to the Lyon-Raymond Corporation.

Adjustable for height, the conveyor belt is powered by a tractor engine

Electronics In Railroading

Increased Safety is the Goal of Many Uses, Direct and Indirect, of Electronics by the Railways. Flaw Detection in Rails, Materials Testing, Signal Systems, and Communications All Involve the Busy Electron

By JOHN MARKUS
Associate Editor, *Electronics*

DESPITE the pressure of war-time operations the American railroads have been continuing their constant search for new devices to improve operation. Faced with post-war competition from motor trucks, airlines, pipelines, and passenger cars, the railroads are taking a keen interest in electronic equipment, not only for signaling and communication, but also for testing materials used in the manufacture of rolling stock and equipment.

One of the lesser known electronic instruments used by the railroads is the Sperry rail flaw detector. This instrument, developed by Dr. Elmer Sperry in 1927, has found wide application since that time. During 1943, 17 fissure detector cars were operated by Sperry Rail Service and traveled from coast to coast and as far north as Hudson Bay. Besides the rail-testing electronic equipment, each car contains a cook's galley, shower bath, and sleeping quarters for the crew of five.

The cars are self-propelled by gas-electric drive and move over the tracks at a speed of from six to nine miles an hour, stopping each time a defect is found. Usually working from dawn to dusk, they cover about 30 miles in a 12-hour day.

As the car moves, an operator keeps a constant check on the condition of the rails by watching a recording tape. Defective portions of a rail show up as irregularities on this tape when the search unit attached to the car passes over them. The electronic equipment actuates the recorder to cause a distorted line to appear on the tape. Defective sections are sprayed with white paint for identification and are then further examined by hand-testing as a follow-up operation.

Investigation of 142,000 miles of rail with the electronic equipment during 1942 resulted in removal of nearly 100,000 defective rails. About 160,000 miles of rail were tested during 1943.

MATERIALS TESTING — Widespread use of electronic testing and examination of ferrous and nonferrous raw materials in the metallurgical industries means further application of electronic instruments to promote the safety of railroad travel. Already the cyclograph, the electron microscope, the spectrophotometer, and the mass spectrometer have been rather widely applied to the raw materials that go into the making of railroad engines and cars. Although ear-marked now for war products, such electronic devices will be increasingly used in the post-war period.

A boon to heavily laden passengers is seen in the recently demonstrated electronic door opener for sleeping cars. In a car now riding the rails of the Canadian Pacific, doors open automatically when the handle is touched, not turned. The mere contact sets electronic circuits in operation, actuating the door-opening mechanism for entry or exit.

Radio enables the engineer of this Baltimore and Ohio switching engine to receive his orders. The antenna of the receiver-transmitter is seen on the cab roof over the headlight

SIGNALS SYSTEMS — One of the most pressing problems confronting railroads for many years has been that of block protection. By means of an electric signal system, each rail route is divided into blocks or sections of track which no two passenger trains may occupy at the same time. Thus no train may enter a block already occupied and collision is prevented. The signals on this system are manually operated and are susceptible to human error. To remedy this, an automatic block system was developed about 70 years ago. Today, of a total of 160,000 miles of track for passenger trains in this country, about 140,000 miles have automatic or non-automatic block signals while 8000 miles are equipped with automatic train-stop or train-control devices.

In 1922, the application of radio communication to railroad service received careful study by a committee of the Association of American Railroads while at the same time a number of individual railroads conducted research to study operation under varying conditions of service. Even than it was anticipated that short-range sets would meet the emergency requirements caused by floods, storms, and so on, for marooned trains and for use by train crews and construction crews. Automatic train control and signaling were also predicted.

RADIO SYSTEMS—About a dozen different types of electronic devices have been tried by the railroads. These fall into three general classifications; carrier telephone systems using the rails as conductors; induction radio systems using side-of-track wires; and radio systems through the ether. By 1928 each of these methods had been tried by at least one railroad with considerable success.

In that year, a report on radio equipment used on a freight train of the Chesapeake & Ohio stated that a saving of two or three tons of coal per trip was noticed for a particular engine because of shortened trips. Considerable saving of time also resulted when trouble developed en route, since the crew could be directed to the fault and have it repaired before a man could walk the full length of the train. By notifying the engine crew when flagmen had been called in, speedup of operation resulted, as well as elimination of the chance that the flagman might be left behind, a not infrequent occurrence. Handling of trains in dense fogs and snowstorms that prevented the use of hand signals was expedited as well.

When radio was first applied to rail-

Chemistry Serves The Railroads

Important Contributions Have Been Made to the Great Forward Strides in Speed and Comfort by the Railroads in the Last Ten Years. Chemistry Has Helped in the Achievement of Lighter Rolling Stock, Lessening of Boiler Scale, More Efficient Lubrication, Better Fuels, and Air Conditioning

CHEMISTRY is inescapable. Even in the conservative atmosphere of America's great railroad systems, products of chemical research and of chemical industry are constantly utilized. In fact, an important part in the continuing railroad revolution can be traced to applications of chemistry to the problem of faster, cheaper rail transportation.

That these chemical aspects are not obtrusive comes from the innate conservatism of railroading and from the consequent gradual adoption and adaptation of the many improvements which differentiate today's trains from those of a decade and more ago.

Changes cannot happen quickly on the railroads, since the processes of evolution operate slowly through the immense size and intricate ramifications of the systems. During the early years of the present century, necessity made safety the guiding thought, slogan, and credo of American railroads. Everything any railroad man does must first be considered in its effect on safety before action is taken.

This reaction has been so carefully cultivated over such a long period that the entire railroad world is built up around the thought of safety. Thus any change must be carefully studied and analyzed in order to make completely sure that it produces no reduction in the factor of safety.

Also contributing to railroad conservatism is the necessity that all rolling stock on all railroads be completely interchangeable between one and the others. Freight once loaded into a car must reach its destination even on a different road without needing to be reloaded into another car because of some difference of habit between the carriers involved. In the same way the design and construction of roads and rights of way must conform even down to minor details to rigid standards established to insure safe interchangeability of equipment.

Thus it is that newer modes of transportation, by highway and by air, have advanced swiftly, compared with the slow progress of the railroad revolution. But it is a revolution in spite of appearances. The changes basic to the revolution are increased speed of trains, increased power of locomotives needed to move heavier trains faster, and increased comfort of passengers.

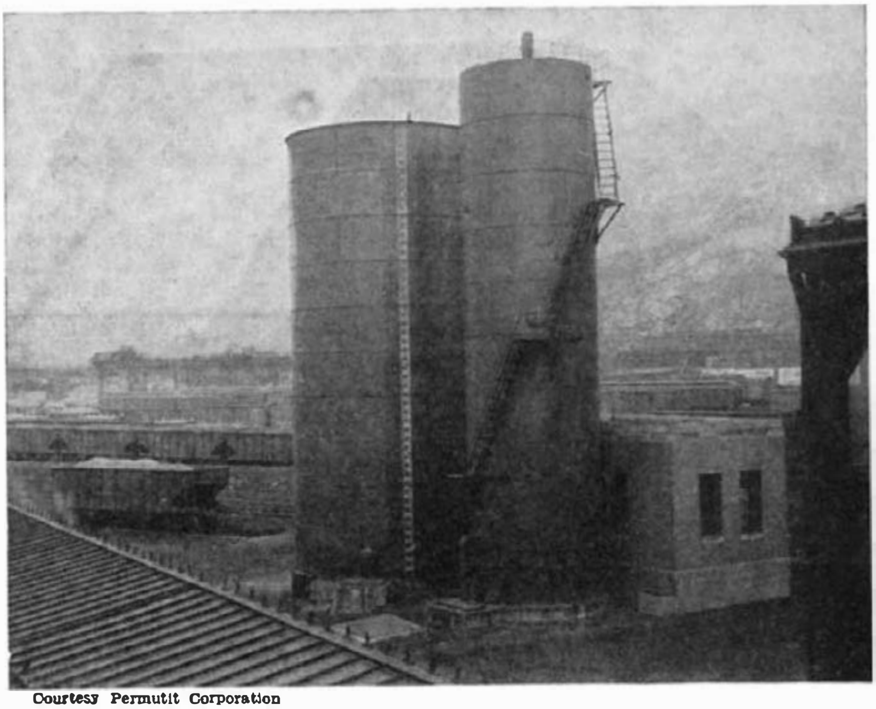
It seems strange to discuss these points at a time when the railroads are staggering under the load of war-time traffic and when none of their services even approaches normal. However, the present situation, with its high rate of obsolescence and the difficulty of replacing old equipment, is laying a foundation for much more rapid improvement in the future.

The obvious railroad problem is to raise the overall efficiency of transportation, its only salable product. This means, first of all, faster trains. And greater speed can be attained in two ways: by increasing power of, or by lightening loads on, locomotives.

COAL AND STEAM STILL RULE—Railroad prime movers are now largely, and probably will continue to be, coal fired steam locomotives, in spite of their already very close approach to maximum economical size. The reasons for the railroads' preoccupation with steam locomotives are readily understood on the basis of their conservatism, and the fact that each of the important systems was planned to include access to a coal field of its own, with the additional fact of the cheapness of this form of power. Thus, in spite of the immense amount of attention lately given both Diesel and electric locomotives, these newer types supply what yet amounts to only a small fraction of the power consumed on our railroads.

Obviously, then, any increase in the efficiency and power of the railroads must be realized by improving the efficiency of steam locomotives. Yet this must be accomplished within the limitations of cross-section imposed by tunnels, bridges, and other structures on the rights of way; within the lengths permitted by the minimum radius of curvature of the track; and within the weight limits that can be safely carried by bridges and trestles.

When these limitations are considered, greatly increased power seems quite impossible to realize except by raising steam pressures; and that in turn meets structural limitations inherent in the peculiar form of the locomotive



Courtesy Permutit Corporation

By chemical means this Permutit Spaulding Precipitator treats water for the prevention of locomotive boiler scale. Its capacity is 400 gallons a minute

boiler and the necessity for so many strengthening staybolts as to decrease circulation. Actually, the power output of today's locomotives has been increased by more than 50 percent over those of World War I by the very important expedient of increasing their efficiency.

The steps by which this has been accomplished have involved mechanical changes in the structure and moving parts of the locomotive. These changes were made possible principally because alloy steels of high strength permitted lightening moving parts. Important among them were redesign of the running gear to increase its efficiency; lightening connecting rods by making them of alloy steels to reduce inertia loads; and improvements in wheel design to balance rotating loads more accurately at higher speeds. Basically these improvements have depended on the appropriate use of the increasingly valuable alloy steels and cast irons available through combined chemical and metallurgical development.

LOSING WEIGHT — The use of high-strength alloys, both those containing large percentages of alloying elements available before Pearl Harbor and the efficient low percentage emergency alloys of the war period, is giving railway mechanical engineers a new and important group of materials. The availability of these metals has led to an entire reconsideration of the design problems of cars as well.

The old conception of a car, whether for passengers or freight, was a simple platform with a superstructure to protect passengers or lading from the weather. The entire strength of the structure was embodied in a central beam of great strength but also of great weight.

The necessity for reducing weight of cars as part of the program for greater speed led to consideration of the entire frame of the car as the strength member rather than merely its underframe. Engineers redesigned cars as tubes housing the lading rather than as platforms upon which loads rested.

Further economies of weight were effected by the substitution of welding for the heavier method of riveting steel structures together. These and other less obvious changes, largely based upon the use of light, strong alloys instead of the older low carbon steels, have made substantial savings in car weights.

In freight box cars this saving has amounted to about five tons per car without sacrificing load capacity or safety. That means an increase of 10 to 20 percent in the capacity of a train for pay load, or a corresponding economy of cost. Clearly this has been an important factor in enabling the railroads to carry their staggering war-time loads today and will be vital in their future services.

These changes and improvements in locomotive and freight equipment are far less apparent, but far more revolutionary, than the introduction of streamlining, air conditioning, and what may be called good housekeeping, into passenger trains. Using light metals—aluminum and its alloys—as well as alloy steels, car builders have completely discarded old designs and have built new cars of wonderful lightness and comfort. Speed is attained without the sacrifice of safety. In fact, safety is increased by lowered centers of gravity. Furthermore, a distinct economy of operation is gained as compared with the heavy cars of old design.

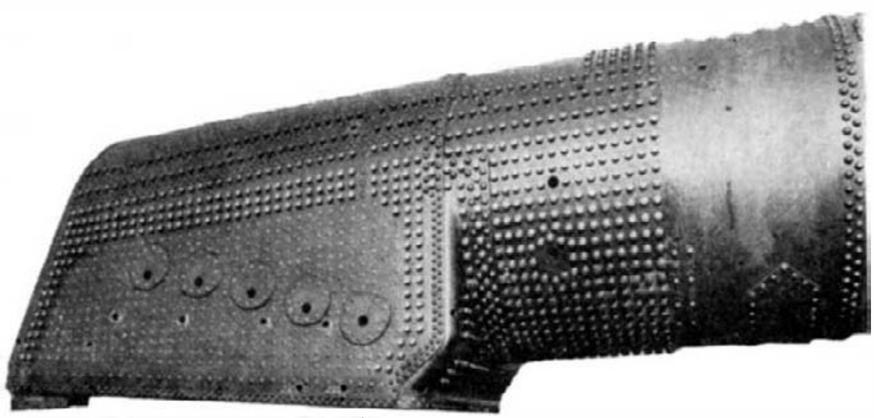
CHEMISTRY HELPED—These basic improvements rest upon vital chemical advances. The production of the elements (chromium, nickel, vanadium, molybdenum, and others essential in alloys) from their ores involves chemical processes of great nicety. The effective utilization of these metals in alloys employs the latest and best in metallurgical science. The light metals —aluminum, magnesium, and their alloys—are also products of chemical industry given special emphasis by war demands, and are already serving useful purposes on the railroads largely in sharp competition with alloy steels in reducing the weight of rolling stock. Their post-war roles in railroad transportation seem likely to be highly important in this country as they were in pre-war years abroad.

Few developments in recent years have been so useful in railroad work as that of welding techniques. Gas, electric, and thermit welding have each served valuable purposes in building and repair of railroad equipment. Welding has been particularly useful in reducing the weights of structures below those obtained with riveting, yet without sacrificing strength. Each of the standard methods of welding in their modern forms uses products of chemical industry essential in attaining superior results as compared with older techniques. In this, as in other fields, the great magnitude of railroad demand supplies a sharp goad to the development of methods and products needed.

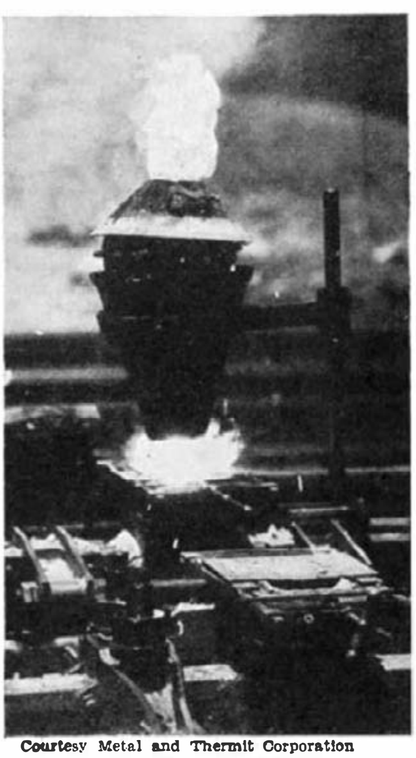
SAVING THE SURFACE—Protection of the huge tonnages of steel and iron used in railroad equipment from the ravages of corrosion is a gigantic undertaking. Supplying of materials for this purpose alone supports an industry itself. Conditions for atmospheric corrosion encountered on railroads are particularly severe because of the presence of both cinders and sulfur dioxide in the smoke from locomotives burning soft coal.

Thus, both in magnitude and severity, this corrosion problem is exceptional and hence has stimulated the most important developments so far realized in this field. Furthermore, both architectural and engineering finishes are involved, so that the results of developments undertaken primarily by, and for the benefit of, the railroads actually serve everyone. Not only have chemists employed by the railroads engaged in this important endeavor, but those of coating manufacturers and of the chemical industry itself, supplier of the needed raw materials, have co-operated actively in the joint effort.

Similarly huge is the problem of supplying water to the boilers of thousands of steam locomotives traversing all parts of the country. The crux of the matter lies in wide variations in the character of water available even over relatively short distances. But that would be no problem, and was none of any magnitude, so long as boilers



Courtesy Vanadium Corporation of America
Manganese-vanadium firebox plates are used on this type of locomotive boiler



Courtesy Metal and Thermit Corporation
Thermit welding of railroad tracks

were operated well below their maximum capacities.

However, the whole completion of water supply changes, when, as now, the entire capacity of all motive power must be fully employed. This means that even slight variations in composition of water beyond recognized limits must be corrected to save steaming capacity that would be reduced by scale; to reduce corrosion and caustic embrittlement that constantly threaten boiler steel; and to minimize cleaning and blowdown needed to keep boilers free from sediment and objectionable concentrations of dissolved salts.

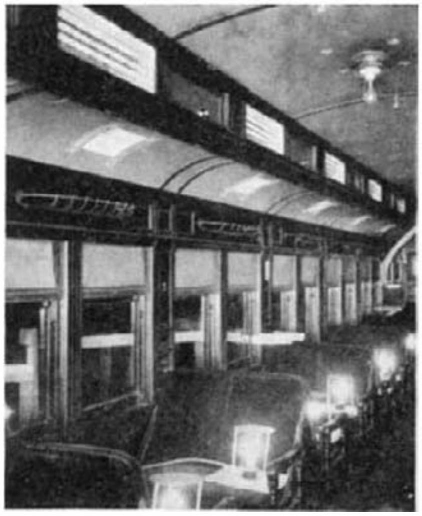
Water treatment is essentially a chemical process employing chemical products, and is necessarily carried out under chemical control to insure optimum results. While much of the technique of water treatment has been developed for other purposes, the variety of waters encountered on the railroads has stimulated a vast amount of research in this field, both by the carriers and by those who supply them.

OILING THE WHEELS—Railroad lubrication has assumed new aspects with the greatly increased speed of trains today. The adoption of improvements in all equipment—of more efficient bearings, of Diesel and electric power, and of higher temperatures and pressures employed in modern steam engines—has changed the lubrication problem significantly. New types of oils and greases must necessarily be employed following changes in the surfaces to be lubricated and their conditions of operation. Here, too, experience in other fields has had to be supplemented by developments carried through the final stages to fit lubricants precisely to their new roles in rail transportation. In this case, as in others, overall developments have greatly increased the loads on lubricants.

Air conditioning of passenger cars and refrigeration of freight cars owe much to chemical industry. These two closely related functions obviously will provide greater and greater service in the future. Clearly, the public wants both in very much their present forms, so far as results are concerned. However, the future seems sure to witness modifications of these two techniques to bring them closer together.

Air conditioning of freight space will serve the same purpose as refrigeration in the preservation of many perishable foodstuffs and will actually do it better. And few are able to differentiate between refrigeration and what passes for air conditioning of today's passenger cars. Chemical industry and chemical engineering research have already provided answers to these problems well in advance of present practice. They are now waiting for the railroads to put them to use.

CHEAPER FUELS—The problem of efficient use of fuel on the railroads is still a major one. Clearly, steam locomotives fired by coal will continue, probably for a minimum of many decades, to supply most railroad motive power for reasons already mentioned. Efforts to burn powdered coal



In its early research on the design of air conditioning systems for the railroads, the Carrier Corporation used an actual coach in which lights simulated the heat of the passengers

in locomotives have failed of full success, but have demonstrated that improved efficiencies are possible.

Oil firing has been accepted as approaching the ideal where oil is available on a reasonably competitive basis with coal. This points the way to a satisfactory solution: use of an oil-coal mixture of the type of the so-called "colloidal fuel," already successfully burned in marine boilers. Atomizing such a mixture of finely pulverized coal in oil gives a flame with the characteristics of oil flames yet actually burning principally cheaper coal.

Thus in the operation of American railroads at the increased efficiencies required to meet modern competition with other means of transport, one finds chemistry and chemical industry supplying vital materials and techniques. Some of these services were already serving other industries and were available for immediate adaptation to railroad needs. Others have been developed by the railroads themselves or at their instigation by others. Obviously, future progress in transportation by rail will more and more employ chemical developments.

STARCH LACQUER

Has Resistance to Heat, Weather, and Solvents

ALLYL STARCH, a chemical derivative of starch made by its reaction with allyl chloride or bromide, has been shown to have valuable properties as a constituent of varnish and lacquer coatings. The freshly prepared compound is readily soluble in most paint and varnish solvents, but when the solution is applied to a surface and dried, the resulting coating cures to an insoluble state either by contact with the air or, better, by the application of heat.

The final coating is hard, transparent, and extremely resistant to weather and to solvents. It is also resistant to heat and will withstand 400 degrees, Fahrenheit. The development, now in the pilot-plant stage, is being conducted by the Department of Agriculture as an industrial outlet for farm products.

DICHLOROSTYRENE

Shows Promise in Synthetic Rubber

SYNTHETIC resins made by polymerization of dichlorostyrene instead of styrene possess both better electrical insulating properties and higher resistance to heat. The dichloro compound is also showing promise in synthetic rubber where it is polymerized with butadiene in a way similar to styrene. The new synthetic rubber is now undergoing exhaustive tests, particularly in heavy truck tires, where its heat resistance is important.

Dichlorostyrene itself is highly active and readily polymerizes to resins resembling the polystyrenes in most of their properties, particularly chemical resistance, solubility, and appearance. The point of heat distortion of the dichloro resin is 240 to 265 degrees, Fahrenheit, compared with 165 to 190 for polystyrene.

WELDING PLASTICS

By Using Hot Inert Gas

A NEW method of "flame" welding of plastics is described in recent reports from England. The torch heats an inert gas—nitrogen—to the proper temperature to soften the resin and then directs the stream of hot gas at the point to be softened for the weld. The problem of control of temperature has caused some concern but has been solved best by the skill of the worker rather than by intricate control devices. Results are reported to be excellent when an inert gas is used instead of flame or products of combustion directly.

PROTECTING CANS

By Dipping Them in Simple Alkaline Solution

THIS global war has imposed a severe and extraordinary burden on the tin coating of cans. Failure of the protecting coating has been frequent.

A new method of improving the effectiveness of the tin layer, made even thinner by war, consists of dipping the filled and completely processed cans into a hot alkaline solution. No satisfactory explanation of the remarkable effect of this simple, quick treatment has yet been found.

But the explanation is probably less important at the moment than the fact that cans so treated resist corrosion in humid, hot atmospheres substantially longer than untreated cans. The new protective method entails neither the complications nor the expense of lacquering, and it lends itself to mechanical application in the cannery.

Metals Make Railroads

The Railroads are Planning Now to Utilize the Far-Reaching Advances Made by Metals During the War in Higher-Speed, Lighter-Weight Rolling Stock for Both Passenger and Freight. With this Equipment They Will Meet Peace-Time Competition of the Airplane, Truck, and Bus

THE HISTORY of the railroad industry has been underwritten by the progress of the metal industries. The steel rail made possible the great expansion in railroad activity in the middle of the last century. Boiler plate made from open hearth steel provided the urgently needed solution to the problem of larger plates for the bigger locomotives being built. Steel axles permitted heavier loads.

To an even greater extent, however, are the futures of these two groups of industries interwoven, for the post-war period will be a critical one for the railroads. Informed engineering opinion among railroaders is virtually unanimous that only through extensive and thorough-going use of new high-strength or lightweight materials in the enormous car-building program projected can the railroads out-distance the expected competition from bus, truck, and airplane.

Plans are already underway for broad re-design embodying the most modern materials for lightweight construction. We may confidently predict many startling developments of this nature from the railroad industry in the early post-war years.

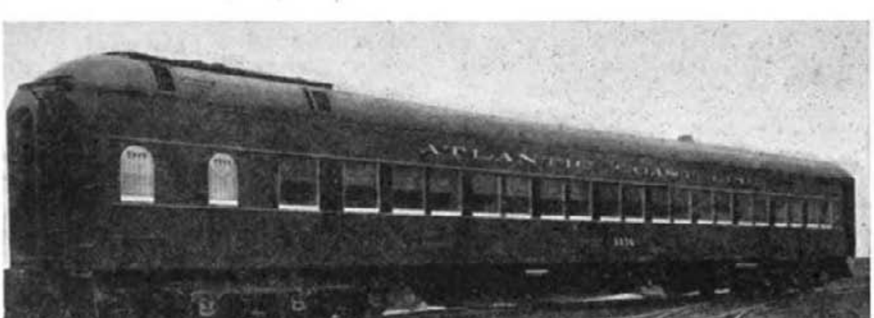
In its simplest terms, lightweight construction can mean either higher speed, less power consumption, or greater pay-load to the railroad. Any or all of these factors make railway transportation more competitive or more economical. The lightweight construction may be accomplished by using lightweight materials (such as aluminum alloys, magnesium alloys or plywood) or high-strength materials (for example, alloy steels, stainless steels or heat-treated carbon steels) and by employing fabricating methods like welding that are ideally adapted to this type of construction.

METALLURGY HELPS STREAMLINING—From the standpoint of the public, the most spectacular application of the lightweight development in the railroads has been in passenger cars—particularly in some of the streamlined high-speed trains. Here the goal has been a combination of speed, comfort, and beauty with adequate safety. The materials used were chiefly aluminum alloys, stainless steel, and low-alloy, high-strength steels. The last are a group of steels containing fractional percentages of chromium, phosphorous, copper, nickel, molybdenum, or others, with good mechanical properties, weldability and corrosion resistance. They are only slightly more expensive than plain carbon steels.

Originally lightweight passenger car construction was based on aluminum alloy (pioneered by Pullman-Standard) or on stainless steel (pioneered by Budd). The development of the much cheaper low-alloy steels provided a third and welcome medium that was put to use by practically all car builders in some form.

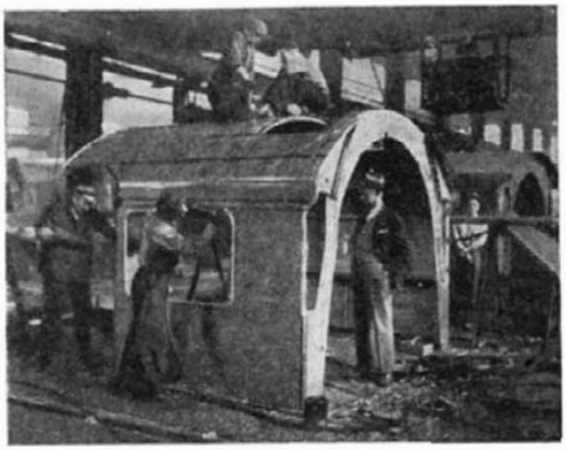
At the beginning of the war, when construction of passenger cars was discontinued, four structural types were being built—(1) all-aluminum-alloy, of riveted girder type side construction, lighter by several thousand pounds than any other, but more costly; (2) stainless steel, of truss-frame construction with spot-welded connections, and with the outside sheets functioning as covers rather than strength members; (3) low-alloy steel truss-frame, of all-welded construction, with sides covered with corrugated stainless steel, and weighing about the same as all-stainless cars of equivalent strength; and (4) welded-girder constructed throughout of low-alloy, high-strength steel, weighing only a trifle more than the truss-type car but less expensive.

Right: Car-ends of low-alloy steel are being cold-flanged
Courtesy Inland Steel Company



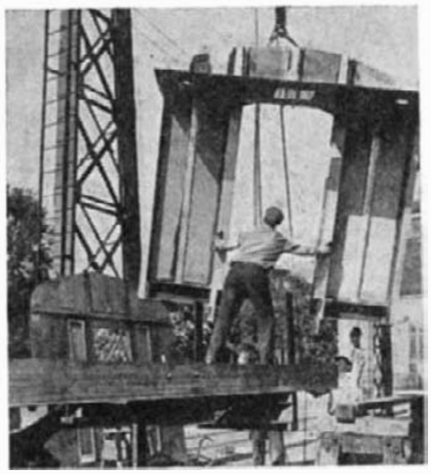
Below: Low-alloy steel made by the Bethlehem Steel Company was used in building this lightweight day coach

LIGHTWEIGHT TRAINS POPULAR—At the present time there are some 120 lightweight streamlined passenger trains and hundreds of additional lightweight cars in use. A comprehensive and detailed analysis of their performance has shown that before the war they were distinctly profitable investments for the railroads and that during the war period, with all trains presumably loaded to



Left: Cabs of aluminum alloy being fabricated for use on high-speed steam locomotives
Courtesy Aluminum Company of America

Below: Workmen lowering into place the end section of an aluminum alloy railroad car



their doors, the lightweight trains show larger proportionate increases in traffic handled than the standard trains.

For this reason virtually every railroad plans to add streamlined lightweight trains to its lines, a survey made by a leading railway business magazine recently revealed. Railway executives' comments ran something like this: "The railways realize their present passenger equipment is outmoded and are planning to replace it with modern lightweight equipment just as soon as possible after the war". . . "The improved metallurgy coming out of this war will insure light weight with the utmost in comfort. . . I look for a tremendous improvement in the speeds with which railway trains are operated." . . . "We are so thoroughly convinced that comfort and speed are so important that at the end of the war we will proceed as rapidly as we can to replace all of our conventional equipment with modern cars."

The big question now is: "Which materials will participate most heavily in this enormous car-building program?" From 1935 through 1939 some 1458 passenger cars were built, of which 63 percent were of low-alloy steel, 20 percent of stainless, 11 percent of aluminum, and only 6 percent of conventional design using ordinary carbon steel. This may foreshadow the future trend.

However, weight is not the sole factor, although it is obviously the prime mover. The so-called "steel" coaches (they embodied considerable wood) of 1906 weighed 110,000 pounds. A typical all-steel coach of the late twenties weighed 130,500 pounds, but was longer and carried many more specialties. Modern de luxe cars weigh less than 120,000 pounds, despite a startling increase in the weight of specialties over the last 25 years. If the modern cars were to have specialties similar to those of 1906, we would find typical low-alloy steel cars weighing 113,000 pounds, aluminum-alloy cars weighing 105,000 pounds, and stainless-steel cars somewhere between.

This is a remarkable weight-saving accomplishment in car bodies, especially in view of an increase of some 10 feet in the length of typical cars of today over those of 1906. On the other hand, it also points a stern finger at one outstanding direction in which passenger car design can still be radically improved: the lightening in weight of the specialty items, which are following a trend opposite to that of the car bodies.

METALS WILL COMPETE—Only time will tell which of these three types of materials is best and cheapest for passenger car structures. The war has had the most pronounced effect on aluminum by enormously increasing its production capacity and by spreading the know-how of handling the material on a much broader scale than ever before. For extreme light weight and highest speed, aluminum cars are still the most popular.

Stainless-steel cars, on the other hand, have the most eye-appeal and their strength-weight ratios in the cold-rolled condition are outstanding. Furthermore, they require no painting or other protection. The low-alloy steel cars, finally, have good all-round properties, are the cheapest of this group and can be used as-rolled—that is, they do not require heat treatment as do the aluminum alloys nor must they be fabricated in the difficult cold-worked condition as must the stainless steels.

Magnesium alloys are generally admitted, even by their manufacturers, to have little possibility of early use in the structural members of railway cars. They can and will be used, however, for many non-structural applications, especially to lighten the weight of specialties.

Of course all this ignores the possibility of new magnesium alloys with radically different properties than those now on the market, but none are as yet evident. At the same time, the aluminum industry *has* produced something which the railroad industry has yet to place in commercial use—new, super-strength aluminum alloys and clad materials with vastly improved strength-weight ratios—while a new low-alloy steel containing molybdenum (Aldecor) has just been announced.

IMPROVING FREIGHT CARS—But what about the more prosaic freight car? Here the competition is narrowed to exclude the expensive stainless steels from all but the most specialized consideration. It is stretched, however, to include copper-bearing open-hearth steel and steel castings (liquid-quenched and otherwise) as well as aluminum and low-alloy steel for lightweight construction. The choice is of considerable economic importance to the railroads. Every reduction in weight of one ton represents an operating saving of $15 per year to a road. Hence, a typical reduction of 10,000 pounds in a single car means $75 per year. In terms of increased payload, a reduction of three tons per car is reported to result in 5 to 7 percent greater payload regularly.

The popular material to date seems to be open-hearth steel containing a small amount of copper. The low-alloy steels are nevertheless currently receiving extremely favorable attention from designers and prospective purchasers of post-war freight cars, because for many applications their cost is so much less than for a car of the same weight made of aluminum. Actually, in nature and cost, they are much closer to the ordinary open-hearth steels than to the aluminum alloys, yet their weight-saving possibilities are substantial. Many alert car builders consider them a more economical solution to the lightweight problem than the copper-bearing steel mentioned earlier.

The seriousness with which the railroad industry regards this matter is well indicated by the recent order placed by the Missouri Pacific Railroad for 25 aluminum alloy 70-ton hopper cars to be made by American Car and Foundry Company—said to be the first order of its kind ever placed. The entire bodies will be of aluminum alloy with the center sills and bolsters of steel. The cars, when empty, will weigh about 38,000 pounds each, contrasted with an average weight of 50,100 pounds for the conventional steel 70-ton hopper car, or about six tons less for the locomotive to pull. They will have 240 cubic feet greater carrying capacity. The railroad intends to study closely the performance of these cars to determine whether their higher cost is sufficiently counterbalanced by the resulting improvement in net operating revenue from them.

CHEAPER METALS SUGGESTED—Two other means of achieving weight saving in freight car construction without adopting highly expensive materials have recently been suggested by outstanding metallurgists. One is that the railroads attempt to utilize quenched-and-tempered plain carbon or low-alloy hardenable steels for structural members, based on the experience of the automotive and aircraft industries

To avoid transverse fissures in steel rails, careful control of temperatures is required while the stock is rolled

that "heat treatment is the cheapest practice metallurgy has to offer for increasing the strength of steel without too great a sacrifice of ductility."

The other suggestion was that the railroads determine for how many important applications they might not profitably forego their present practice of specifying a more expensive, completely deoxidized, fine-grained, non-aging steel, and (where no corrosive service is involved) use instead a semi-killed steel with just enough carbon and the cheaper alloys to raise the strength to the proper level and still keep the steel cheap.

By regulating the rolling mill practice, it is often possible to secure improved structures to meet the requirements. Not yet tried by the railroads, this approach has been highly successful in other applications, in one of which it has been in regular large-scale use for several years.

BETTER LOCOMOTIVES—In the case of the locomotive, side and drive rods are under continual study to reduce their weight or increase their ability to resist stress. Here again the answer would seem to lie in the heat treatment of the parts to get the most benefit from their alloy content. New high temperature alloys have improved the performance of locomotive boiler systems, which in the post-war period will therefore operate at higher temperatures and pressures than formerly.

In this respect a most significant development is the emergence of the gas turbine as a potentially important railway prime mover. Engineers are agreed that the gas turbine will certainly become of interest as a locomotive drive when alloys of sufficient heat resistance to match the temperatures required for most efficient operation become generally available.

Many other materials find important and changing use in our heavily loaded railroad systems. Copper and its alloys serve to the extent of more than a billion pounds in permanent use, primarily in the conductor wires for electrical railways, signal systems, headlights, and so on. In addition, they are important constituents of railway train air-conditioning systems which are expected to be universally installed in post-war trains. Brasses and bronzes, lead, tin, and their alloys are widely used for bearings, while all types of solders and brazing alloys find substantial application in locomotive construction and in the assembly of general electrical systems as well as decorative items and other specialties.

Steel castings are among the most important of railway car materials, being used for bolsters, side frames, couplers, and so on. Axles have received a great deal of attention lately. A general effort is underway to reduce their weight by various means, among them heat treatment and the development of a hot-pierced, hollow steel axle. As to wheels, chilled iron wheels have been traditional for freight cars, but steel wheels are receiving increased application as the speed of freight traffic increases.

The best possible closing for this article is provided by S. L. Hoyt and H. W. Gillett of Battelle Memorial Institute, who said in a recent paper before the American Society of Mechanical Engineers: "It seems clear that we have entered a new era, that of high speed traffic. . . A corollary of high speed is low weight. . . Recourse must be had to new materials which are either inherently stronger or which have a more favorable strength-weight ratio than the old. Insofar as high speeds affect fabrication or construction, the outstanding feature of recent years has been the swing to welding to save weight and increase the joint efficiency. . . It is the hope of all that the new materials and the new methods of shaping, joining, and fabrication will provide needed answers to many railroad problems."

The most progressive railroad men are certain that they will!

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HIGH-SPEED MILLING

With Carbide Tools and Negative Rake Angles

New machining developments of recent years have been as spectacular in their production and cost benefits as the new and increasingly used practice of milling steel at very high speeds with carbide tools and negative rake angles. Higher production, better finish, and lowered heat-distortion are the outstanding advantages—in some instances production increases of several hundred percent over ordinary milling practice using tool steel cutters have been recorded.

Originally a West Coast aircraft industry development, the practice is spreading fast to alert shops throughout the country. The accompanying illustration shows graphically the difference between conventional milling and negative rake angle practice.

Actually, the inner edge of the cutter is ahead of the outer edge. The action has been likened by a North American Aviation engineer to a stroke of the hand in the sand. If the forward stroke is by the finger tips of the hand (positive rake) they dig into the sand; but if the forward stroke is accomplished by the heel of the hand (negative rake) the bite into the sand is a drag, the line of force flowing back through the wrist and arm to be absorbed by the shoulder joint.

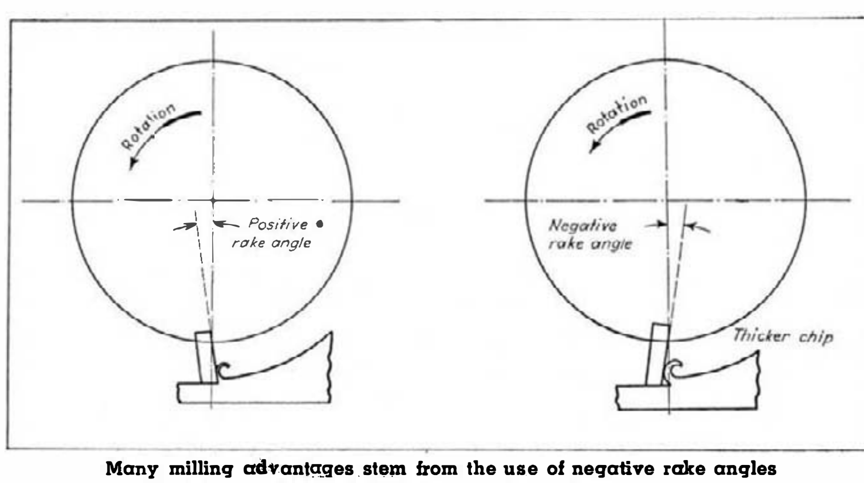
ELECTROGALVANIZING

Provides Protective Zinc Coatings on Steel

A NOTABLE trend in the applications of metals and metal coatings is the growing interest in and use of electrogalvanizing as a method of producing relatively thin but adequately protective zinc coatings on steel.

Using the same electrolytic lines that have revolutionized production of tin plate, there are now 26 units in the United States capable of turning out electrolytic zinc-coated sheets. High purity zinc is being deposited on continuous strip up to 38 inches in width, at a speed of 160 feet per minute, in coating weights up to 0.2 ounces of zinc on both sides, per square foot of strip

This development offers many possibilities in the expansion of the use of pre-plated metals, and the automotive industry is giving serious consideration to the possible use of such zinc-coated steel for body stock. Consideration is also being given to the use of small stampings made from zinc-coated steel, where the protection of zinc is carried over to the cut, unplated edges through galvanic action.



Many milling advantages stem from the use of negative rake angles

Wheels Of Worth

In the Mutual Working Relations of Railway Car Wheels Rolling on Steel Rails There are Some Interesting Applications of Fundamental Science. An Abbreviated Consideration of the Effects of Heavy Stresses and Strains on Both Wheels and Rails. How Much Wheel Area Touches the Rail?

By L. K. SILLCOX
First Vice President, The New York Air Brake Company

OF THE WHOLE SUBJECT of railroading, perhaps the least likely phase to hold the public attention is that of the relationship of wheels and rails. Though romance favors "The Iron Horse"; though the public taste leans toward more luxurious lounge and bar cars; and though safety in the form of refined signal and communication systems meets a proper public insistence, down under the comfortable train on which you ride there is something basic to all these—the homely, commonplace, but all-important wheel-and-track combination.

In the accompanying article the author has condensed some of the fundamental meat of a wheel-and-track science about whose extent not all of us are very conscious. Have you ever wondered how the wheels of a railway car withstand the rampant stresses to which they are heavily subjected? How the rails resist the action of the wheels? What mechanical considerations surround so apparently simple a question as how a train stays on the track? After reading this article you will be likely to watch and study the wheels you see rolling on rails, and will be made more conscious of how the railroads maintain their splendid safety and service.

The author of this article is the author of a book, "Mastering Momentum," a study of railway equipment and its operation.

—The Editor

ORIGINALLY railway car wheels were made of wood and were run on wooden rails. As at present, a flange on the side of the rim served to guide the wheel but, later, flanges were placed on the rail in order that wagon wheels could be operated on them. Eventually the flanged wheel was found to be the more satisfactory, and the guiding action was returned to the wheel.

The wooden wheel was discarded about 1767, and many designs were experimented with before the present types were universally agreed upon. These are the chilled-iron wheel, the cast-steel design, and those of wrought-steel, both single and multiple-wear.

In 1789 the process of chilling iron was developed, but the first chilled-iron wheels did not appear until about 1816; and by 1867 this wheel design had been quite generally accepted for freight car use.

By 1865 steel was becoming important as a metal in wheel design, steel tired wheels being installed under passenger cars in this country and under both freight and passenger cars in England.

The next development in the evolution of the car wheel was the one-piece wrought-steel type, experiments beginning in 1900 and the first major installation being made in 1906. This design is very similar to that known as the multiple-wear steel wheel of today, in which the tread is thick enough to permit turning down after wear; although in some instances the present-day wheel is heat treated by quenching and tempering to harden the tread and flange, thereby reducing the rate of wear. The wrought-steel wheel is initially formed into rough shape by forging under a press with the plate part of the wheel straight. In a further operation the plate part is coned or dished by pressing into its final form.

About 1926 the one-wear wrought-steel wheel, with a reduced plate and web thickness, was introduced. The only other difference from the multiple-wear design was a reduction of the tread thickness, making it impossible to restore normal contour by turning down. Prior to this innovation, in 1903, cast-steel wheels had been introduced into service on a test basis, the first installation in this country being in 1911. This wheel is cast in a mold fitted with metal chillers around its outer circumference. It is heat treated after it is cast.

A relatively recent addition to wheel design is the spun-steel design. In the manufacture of this wheel a special steel is poured into a mold revolving at high speed. Subsequently it is heat treated also.

WHEEL AND RAIL DEFECTS—In load support and in guiding along the rails, wheels and rails receive identical stresses. A wheel and a rail have much in common, even as to form. Each has a substantial contacting mass to receive traction abrasion. In the wheel, the rim is supported by a broad area, the hub, and similarly in the rail, the head is supported by a broad area, the rail base. The hub and rim of the wheel are connected by a relatively light member, and so are the head and base of the rail. The contacting areas are termed the wheel tread and the rail running surface.

Wheel tread defects also have their counterparts in defects in the running surface of rails. Wheel rims and rail heads fail by local distress, or loss of metal, and by transverse breakage. The breakage of rail webs from lateral stress sometimes occurs corresponding with the collapse of plates of wheels under torsion from heavy traction couples, oft-repeated and quickly applied and reversed.

The sliding of a wheel without rotation has an effect upon the tread that is very similar to the effect upon the rail of slippage of traction wheels without forward motion. In the first case, a single point in the wheel periphery engages a rail running surface which constantly presents a new contact. In the other case, when traction wheels slip, a single point on the rail is acted upon by a renewing wheel contact. In either case, energy dissipation is concentrated over an extremely limited area of one surface, high temperature results, structure of the metal is affected, and a loss of metal may occur beyond the abrasive effect. Reactions upon wheels may be equalled by reactions on the rails upon which they bear, but they are vastly more repetitive on the wheels.

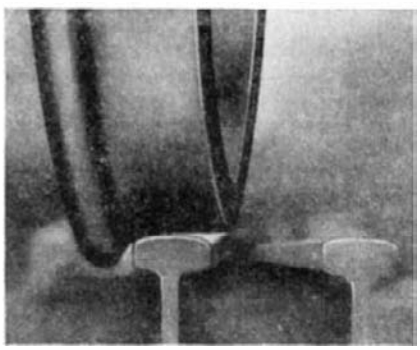
SHELLED WHEELS, RAIL BURNS—In so far as failures of wheels under load are concerned, two effects are predominant. In the first, vertical pressures between wheel and rail introduce shearing stresses which frequently approach allowable working loads for the materials ordinarily employed—even when subjected to the most favorable operating conditions. Tensile and shearing resistance of carbon steel decreases materially at elevated temperatures and there are two factors, met in normal railway operation, which create sufficiently high local temperatures to weaken appreciably the resistance of the material. Their effects are obvious. When a non-rotating wheel slides, a temperature of 800 degrees, Fahrenheit, or more, is momentarily developed at one point in the tread of the wheel and the strength of the material may be reduced as much as 40 percent. Should the ultimate resistance be exceeded under these conditions, a section of the metal breaks away and may be dislodged long after the overheating and stressing occur, or evidence of them is removed. When wheel metal is lost in this manner the visible defect is termed a "shelled" spot. A rail "burn," which has the same appearance as a shelled spot in a wheel tread, results from identical conditions—a railway wheel, rotating for an appreciable time but bearing upon one point on the rail, weakens the metal, produces fracture along natural slip planes, and the metal subsequently separates.

In the second effect of loaded wheel failure, high tread temperatures, extending completely around the periphery of a railway wheel, may result from prolonged braking at high pressure and speed. Under these conditions, as with soft wheel treads, shelling is aggravated, and wheel metal is reduced to a state where flow occurs—a pressing of the metal away from the bearing zone until it projects beyond the edge of the wheel rim. This has proved very troublesome where interference with closely fitting parts of the brake mechanism has been experienced. Ordinarily, only loads exceeding 25,000 pounds per wheel produce this defect, and the greatest difficulty is experienced with locomotive tenders because wheel loadings in other services are usually not excessive.

WHEEL LOADING—The pressure with which cast-iron brake shoes must be applied to wheel treads to produce a given braking rate increases somewhat faster than in direct proportion with the total weight supported. Very high speed operation demands still higher brake shoe pressures and extends both the time and distance over which this pressure must be sustained. Despite a somewhat variable coefficient of brake-shoe friction, the pressure is a direct measure of the energy input, represented by heat, which wheels and brake shoes must receive during braking. In this way, weight again must take indirect responsibility for wheel damage — in some cases evidenced by characteristic shelling when loading is extremely heavy, and at other times by thermal checking under more moderate bearing pressures.

THERMAL CHECKS—A thermal check is a hairline crack extending across the wheel tread and is the result of a difference in the rate of expansion between a very thin surface layer and the underlying metal. Exposed to abrasion by the brake shoe, which reaches local temperatures as high as 2500 degrees, Fahrenheit, in extreme cases, a thin ribbon of wheel tread metal receives tremendous local energy (heat) accumulations at so rapid a rate that a high temperature difference is set up between the tread and the body of the rim. The resulting difference in expansion, together with the change in physical structure of the surface metal, results in these tread cracks. A zone develops which encourages and, at the same time, is highly susceptible to stress concentration. High local stress, fatigue conditions, and impact effects combine to increase the crack and if it is permitted to extend it may cause a complete fracture of the wheel, extending from the defect on the tread all the way to the hub. This is a reason for the substitution of a steel-tired wheel for the all-steel design in extreme cold climates. Here, while the wheel tread temperature is elevated during braking to a degree comparable to that experienced in warmer territories, the hub remains much cooler, with a resulting intolerable temperature gradient for solid wheels.

The service of railway car wheels has become progressively more exacting without corresponding study being accorded to the capacity of wheels and rails to withstand the requirements of the service and difficulties to be met. Yet, because of many practical and structural limitations, it has not been possible for railways to compensate by employing larger wheels or enlarging the running contact with the rail by adopting broader rail heads. There are instances where a greater number of wheels could be applied to advantage, relieving the demands per individual wheel, reducing wheel maintenance cost, improving equipment utilization, and affording insurance against service failure, but such an expedient increases initial cost and adds to weight.



The bearing is at a theoretical point, enlarged by metal yielding

In most cases, railways have preferred to suffer necessary maintenance expense, and to depend upon rigid inspection for security from accident. The records show their service to be outstandingly safe but with a cost penalty suffered in many instances, an element that is being improved as materials research progresses.

LATERAL LOADING — Thrust loads—which in railway terminology means the side pressure exerted by the wheel flange upon the rail head—are inescapable but must, in the interest of comfort and safety, be maintained below certain specified maxima. The magnitude of thrust loading at wheel flanges is judged only by lateral impacts transmitted to car bodies and recognized in resulting riding qualities. Inasmuch as the flange guides the trucks along the rail "highway," excessive flange wear is sometimes taken to be a measure of that service performed, but more often it is an indication of questionable equipment maintenance. Lateral loads on railway wheels introduce definite and severe bending moments within the wheels. These are relieved by yielding lateral restraint through swing hanger and spring devices, but they reach high values. The fact that wrought-steel railway wheels have been successfully continued in services many times more severe than those in which they were heretofore required to operate, yet still have offered a high degree of security against service failure, is indicative of the measure of safe performance which was originally incorporated in the design.

MATERIAL SELECTION—Not far in the past the heaviest wheel loading generally practiced, plus the most severe heating effects experienced in braking, did not tax the capacity of wheel and brakeshoe materials or involve the railways in unusual maintenance expense. As long as this was true, there was little incentive seriously to investigate the possibilities of alloy substitutes for wheel materials or the potential advantages to be secured by carefully controlled heat treating. All this has changed. Molybdenum is now an ingredient in many railway car wheels used in exacting service; and the low carbon wheel, resistant to the origin of thermal cracks, is being made more suitable by precise heat treatment, carefully carried out.

INTERNAL EFFECTS — Under vertical loading, intense shearing stresses are delivered simultaneously to wheel rim and rail-head metal in contact, subjecting them to crushing strains, compacting the material, cold working the structure, and altering their physical properties. A chilled-iron or wrought-steel wheel of standard tread contour bears upon a new rail head surface, or one worn in the customary manner, over a limited area of contact. This is illustrated in an accompanying photograph in which a portion of the wheel is shown on a rail section. Although the contact area theoretically is a point, that degree of perfection is never attained in practice. As the wheel tread becomes worn, its contour, starting with the standard taper of 1 part in 20, becomes more nearly cylindrical; in which case the point of contact is in fact not a point, but a line.

The wearing of the rail head also has its effect in developing this condition. Add to the effect of wear, the strains arising from wheel loading, and the actual point of contact becomes an area, its size being governed by the physical characteristics of the contacting metals and the loading imposed. In the case of a 33-inch diameter wheel, bearing upon a new 100-pound rail, the initial contact area under 30,000 pounds load will be approximately circular in shape with a diameter of 5/8 inch. The measured area under this condition is approximately 0.30 square inch — a unit loading equivalent of 100,000 pounds per square inch. Surface wheel metal compresses under such conditions, and vertical flow within the metal has been measured at a depth of 3/8 inch. The separation of wheel tread metal is im-

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THE HALLICRAFTERS COMPANY, MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT, CHICAGO 16, U. S. A.

minent and the shelling out of the wheel surface is to be expected under such circumstances.

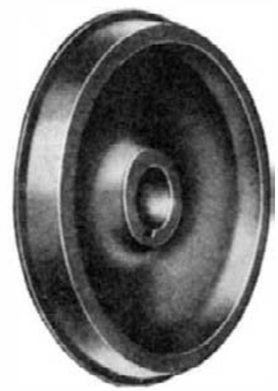
At the same time, flow in the rail head occurs. At 25,000 pounds wheel load, some compression with actual deformation occurs at a depth of 1/4 inch. At 15,000 and 20,000 pounds wheel loads, no deformation can be measured at 1/4 inch depth but, whatever the load may be within the range of common installations, a ribbon of surface metal is affected and repeated use under light load prepares both rail and wheel by cold rolling to receive heavier loading without damage. Just as a stiff rail distributes an individual wheel load over a distance embracing a number of ties, rather than transmitting the whole pressure to the tie or ties immediately below the point of wheel-rail contact, so, in the rail, the effect of the cold-rolled surface is similarly to distribute the load throughout the rail head. The rail deformation previously referred to in connection with the wheel does not exist in a rail which has a cold-rolled and consequently hardened surface, in a degree comparable to a more yielding surface. Hence, loading stresses are distributed over a longer section of rail head. A similar effect must be obtained in the tread of a wrought-steel wheel if the initial loading can be lightened, permitting the tread surface to roll to a suitable finish without overstressing the metal before applying the highest load that it will be required to sustain.

WHEEL-RAIL CONTACT AREA — As the diameter of a wheel is increased for a given wheel loading, the area of wheel-rail contact increases, and unit loading is decreased. In any case, the area of contact increases with service as both wheel tread and rail head contours adjust themselves to the average condition. Moreover, contact areas increase proportionately with the magnitude of the load, indenting both supporting surfaces and tending toward the automatic accommodation of whatever stress may be applied. It has been found that the load supported by locomotive driving wheels of 79-inch diameter is distributed over the measured area of contact with surprising uniformity. These are wrought-steel tires. On the other hand, the load carried by new 33-inch chilled-iron wheels is sharply concentrated at the center of contact. The distinction relates to the size of the two wheels under consideration, and not to the material of which they are composed.

While initial contact areas are of substantially circular configuration, the areas gradually assume elliptic formations with continued wear of wheel and rail. Actual intensity of maximum pressure in the rail head is greater beneath 33-inch, chilled-iron car wheels with customary loading than beneath the heavily loaded driving wheels of 63-inch diameter and over. In either case it can be shown that, because of vertical pressures alone, and with selection of unit wheel loads of the order commonly used, excessive stresses frequently are experienced. By virtue of the nature and direction of this type of loading, it is received and its reactions are set up without danger in any but most extreme cases, and without involving sufficiently great maintenance expense to demand correction.

Were forces of like order delivered laterally, operation would be unsafe, since guiding along the rails would be seriously affected by excessive flange pressure against the rail head. Furthermore, this force would have a tendency to loosen the rail from its fastenings and, in extreme instances, the rail could be overturned.

LATERAL STRESS IN RAILS — Lateral stresses in rails, delivered at the rail head and loading the rail section at a distance above its supporting ties equal to rail height, arise from the position of the wheel on the rail head, as determined by wear of the contacting areas; from the lateral sliding of wheels on rails permitted by the necessary clearance between rail and flange; from the inclined installation (canting) of rails practiced by some railways to secure more liberal wheel-rail contact area when new wheel treads are given an initial taper; and from the guiding of wheel flanges on curves. The gradual super-elevation of the outer rail on straight track approaching curves establishes a type of lateral loading identical with that resulting from a canted rail. The amount of super-elevation of the outer rail on curves is established for a single speed and, if the actual operating speed is either higher or lower than the ideal, a similar lateral loading will result. If the speed is too low the reaction is against the inner rail and, if too high, against the outer rail.



The wheel, an invention on which our modern civilization is based

WHEEL TREAD TAPER — The standard taper of 1 in 20 to which car wheels are formed introduces a lateral component of negligible amount which presses each rail in an outward direction. Since this component and actual flange pressure cannot occur simultaneously, the effect of tread taper upon rail stresses need not be considered. Tread taper is furnished to provide a centering tendency of the wheels on the rails. To be most effective, a much steeper taper would be required and this in turn would increase lateral pressure proportionately — a condition which, though undesirable, would be evidence that the centering function was being served.

When the matter of unbalanced wheels is treated, the natural reaction is to think of the locomotive drivers but, surprisingly, road tests conducted for the purpose of checking the magnitude of rail stress arising from driving wheel unbalance have disclosed that even higher dynamic blows may be struck by the wheels of heavily loaded tenders and freight cars. Not only is the rail stress increased markedly, but there is a tendency for the wheels to run hot. Furthermore, a rail surface condition, termed rail corrugation, may result from the intensified rail pressures induced by the passage of unbalanced wheels at high speeds. The result is a noisy rail which is sometimes referred to as "roaring" or "washboard" track. The rail, its fastenings, and supporting structure are damaged, as is the equipment which moves over it. There are various minor causes for corrugation, but there is one basic condition which must be initiated if the phenomenon is to develop: synchronized vibration with an accompanying overstressing of the rail metal. Both rolling stock and track structure have definite periods of frequency of vibration, and if those frequencies synchronize, corrugation will result. Add to that the increased stress caused by unbalance and the condition is aggravated.

SIGHT AND SOUND—In the past, when car inspectors with hammers came out and tapped wheels on passing trains during terminal stops, their ability to discover defective wheels and axles, as well as wheels loose on axles, became truly remarkable after experience. They depended entirely on the sound emitted. The more recent change from the "sound" to the "visual" method of inspecting railway wheels and axles brings into clear distinction the differences in the technique involved to reach a similar goal.

The later system did away with the reassuring sound of the inspector's effort and substituted one where sight and silence alone are depended upon. Elaborate means have been worked out to make this system work by employing depressed pits fitted with mirrors (no doubt a forerunner of an "electric eye" technique) where trained men with the most expert vision are stationed to discover defects in passing trains. The skill and the alertness of the crews assigned to this work are demonstrated every day by subsequent inspection of the units of equipment they have thus marked out for repairs and which might otherwise have caused a bad wreck.

However, the method of tapping wheels, or inspection by sound rather than vision, is still followed by some of our more northerly situated railways. The cold climate creates a higher heat gradient, or difference in temperature between parts of the wheel, and thus increases the chance that wheel defects may develop. Also, the presence of snow and ice make visual inspection less reliable. Therefore the greatest precautions must be practiced in order to safeguard properly the equipment and its integrity of movement.

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in LENSES & PRISMS

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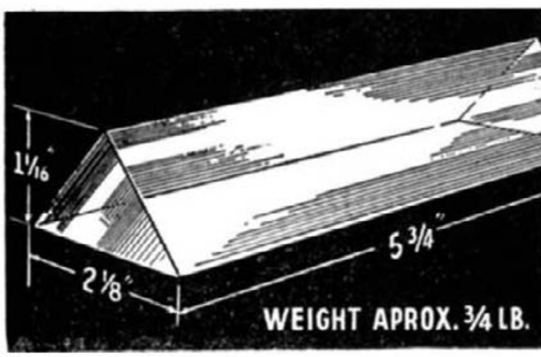
3. We are making a special effort to bring our items to the attention of all Schools, Colleges, Amateurs.



TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

You can use these Prisms to make Periscopes to see over the heads of crowds, fish under water, high or low gauges, inspection of machinery without climbing, for examination of hot metals without danger to eye or camera, etc. Also excellent for experiments, class-room demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious cutomers have used these Prisms to make camera stereo attachment, photometer cube, range finder, etc.

Normally, these Prisms would retail from about $24 to $30 each.

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6017-S	12	80	Cemented	50¢
6018-S	15	41	Uncemented	40¢
6019-S	15	41	Cemented	60¢
6020-S	18	49	Uncemented	50¢
6021-S	18	49	Cemented	60¢
6022-S	25	95	Uncemented	50¢
6023-S	25	95	Cemented	75¢
6033-S	37	51	Uncemented	70¢
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FREE Cement and Directions included with all uncemented Sets.

USES: — Use these lenses for making projecting lenses, low power microscope objectives, corrected magnifiers, substitute enlarging lenses, eye-piece lenses, macrophotography, gadgets, optical instruments, etc., etc., etc.

RIFLESCOPE LENS SET #2000-S .... $11.00 Postpaid
5 achromats matched by manufacturer. Cemented, ready for construction of fine 3½ power 'scope which would retail up to $50.00. A rare opportunity! Full instructions included.

COMPLETE SET OF MOUNTED PERISCOPE COMPONENTS
Consists of two fine Periscope mirrors mounted in metal and plastic for building a Periscope. Used for top and bottom extremities. Only plywood body frame is required to finish this exceptional unit. First surface mirror is well protected by glass windows. Set weighs 2¾ lbs. Overall length of mount 6⅛ inches, width 2⅛ inches.
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1⅝ inches wide, 2⅝ inches long. Weight 3½ ounces. Very limited quantity.
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The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

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KELLNER EYE-PIECE LENSES with F.L. of 27.5 mms. Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. These are excellent for all sorts of telescopes.
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Size 9 mm. x 17 mm. . . . another war bargain. Normal prices would be 20 to 40 times above quotation. At this exceptionally low price, you should purchase a few of these, even though you have no immediate need for them. Such a bargain will not be available long.

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Luxury On Rails

In the Coming Post-War Scramble for Passenger Business, the Railroads Will Have Much to Offer. Pullmans Will Feature Private Rooms More Than Before, and New, Low-Priced Three-Tier Sleepers Will be Introduced. Moving Pictures and Dance Music Will Entertain Travelers

By HARRY E. SCHADEN

IN THE early 1930's the railroads of America were jolted into wakefulness by the growing competition of the auto, the bus, and the airplane. To hold their own, they introduced air-conditioned, streamlined, smooth-rolling trains which made travel by rail a pleasure even for coach passengers.

Now the railroads are ready for another period of advances. On their behalf, the nation's carbuilders have in preparation a series of innovations that will make their passengers comfortable both day and night, whether they are on a coast-to-coast journey or a short ride into the suburbs.

All the improvements planned are a legacy of years of drawing-board work and laboratory experimentation. Neither railroad executives nor equipment manufacturers are given to radical changes that may be founded on whimsy. When one considers that the average modern lightweight passenger car costs $80,000, it is easy to understand why engineers do not toy with car designs as a milliner does with hat styles.

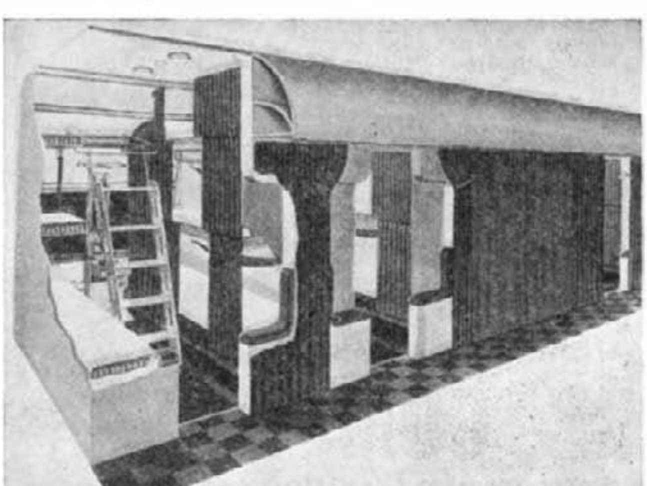
In order to get a down-to-earth view of what the railroads want in the way of improvements, Pullman-Standard Car Manufacturing Company made an intensive survey more than a year ago. The company interviewed executives of 71 railroads owning 92 percent of the nation's passenger cars. The survey showed that the railroads, regarded by many as ultra-conservative, had gone modern-minded to an astonishing degree. Most of the officials interviewed said they wanted more color in trains, newer and faster streamliners, more recreational facilities, improved baggage handling systems, better lighting, and bigger and better washrooms. In brief, they asked for modern trains.

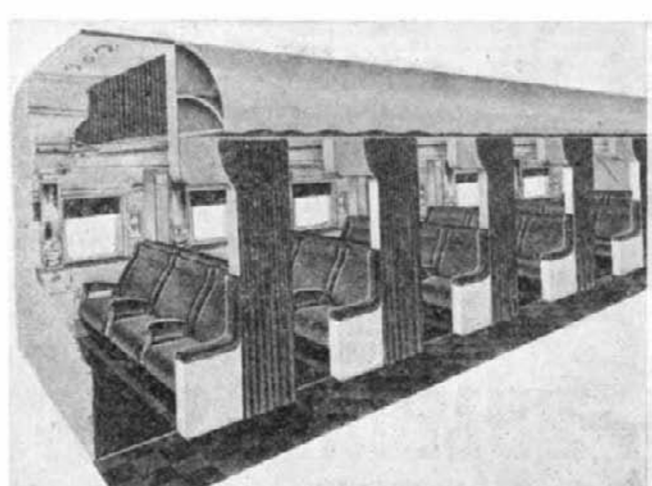
Above: Solid comfort in the three-tier sleeper the railroads plan to introduce for lower-income travelers. Lower right: During the day the new sleeper will be divided into seats set three in a row across the car. Lower left: At night the car will be made up so that each triple tier of berths will divide into a section

Some carbuilders already had anticipated this trend and had plans for these kinds of improvements on their drawing boards before the beginning of World War II. One of the most interesting of the new developments is progress in private room design. In recent years there has been a marked trend in this direction as passengers became acquainted with the extra comfort that private rooms afford at little added cost.

TWO-STORY PULLMANS—Even the cost margin is reduced to a narrower point in the new duplex roomette car, which is expected to become one of the most popular accommodations. Engineers, by using an ingenious staggering principle of design, have put 24 private rooms into the same space which earlier contained only 18 roomettes of conventional design. The rooms are arranged on each side of a center aisle, with the lower room at aisle level and the upper one reached by two steps.

The duplex roomette is an achievement in space conservation. Within its walls it contains most of the functional fixtures of a bedroom, living room, and dressing room. Each roomette has individual control of heat, light, and air conditioning, complete toilet facilities, electric shaving outlet, a large mirror, vacuum bottle for drinking water, and





a bed that is six feet, five inches long.

The bed in the lower room, when not in use, slides under the floor of the upper room. The upper room bed is a fold-in-the-wall type which may be operated easily by the passenger. Beds are made up before the train leaves the station and the traveler can retire at any time without summoning the porter.

A CHEAPER SLEEPER—Comfort of the lower budget traveler is just as important to railroads as that of the man

In this new day and night coach, leg rests pull out of the seat ahead to give a full-length sleeping surface

who has unlimited funds. So this problem has been solved by designing a new car called the three-tier sleeper. Of entirely new design, it has more than 40 berths, compared with 28 in the average old type car. In the daytime it is an attractive coach. Seats are all on one side, somewhat in the European fashion. At night, the car is converted into a sleeper, with each triple tier of berths forming a section. Each section has its own lavatory facilities with additional washrooms at each end of the car.

That takes care of the situation for the traveler who desires a berth. But engineers have also kept in mind the day and night comfort of the passenger who takes cross-country trips in a coach type car.

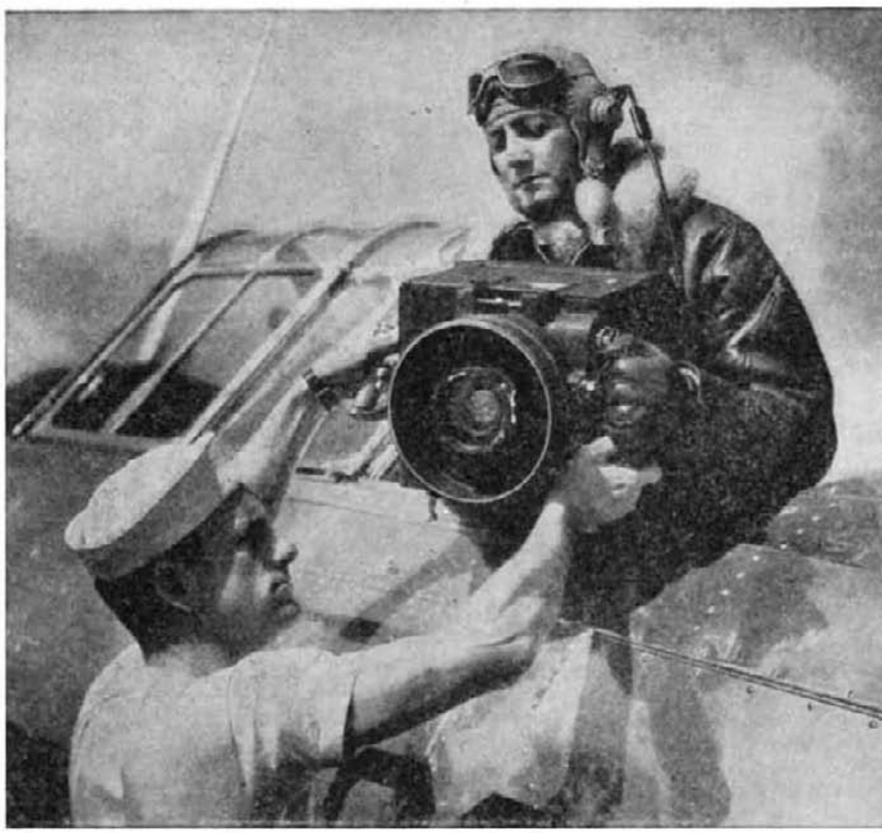
One of the principal objections to coach travel in the past was that it afforded doubtful comfort at night. Passengers did not rest well because they were unable to get their feet up level with their bodies; hence their ankles and legs were likely to swell. To eliminate this discomfort, Pullman-Standard engineers designed a leg rest that pulls out of the seat ahead. It fits snugly against the seat and the occupant can recline as though he were on a chaise longe. Semi-privacy is afforded by window draperies which may be converted at night into curtains separating each pair of seats. Spot-type lights enable a passenger to read without disturbing other persons.

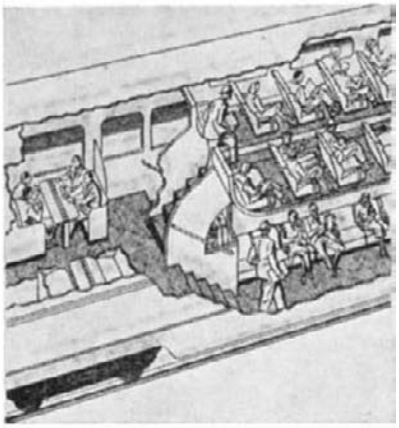
THREE-DECKER COACHES—Trains of tomorrow will include another innovation—the three-decker coach. Again engineering skill has shown its hand in the utilization of every cranny of space. The car is built on three levels so that it can carry 112 passengers instead of the 70 to 76 in the usual car. It has two washrooms at each end, plus provisions for air conditioning. As a favor to bridge players, the car has two card nooks, complete with tables. Luggage compartments take care of baggage that heretofore has cluttered up aisles.

When the engineers turned their attention to the dining car, again they had comfort and efficiency in mind. The problem posed in this instance was how to eliminate congestion in the aisles and at tables and reduce noise and confusion. Most of this was achieved by rearranging the seating plan.

It was learned that, by placing the tables diagonally, service was accelerated and interruptions caused by arrivals and departures reduced to a minimum. The arrangement permits waiters to step between tables when serving, eliminating congestion in the aisle. Other innovations include vibrationless tables, spot-ray illumination, linen storage at each table and intercar telephone communication. Shelves along the wall hold water bottles, creamers, and sugar bowls.

FUN FOR TRAVELERS—In the belief that a passenger's holiday should begin the moment he steps on a train, a recreation-lounge car has been designed. In the middle is a bar, a powder room, and a small compartment housing a motion picture projector which flashes newsreels and short subjects on the rear





The roomy interior arrangements of the new three-decker commuter coach

of a screen facing the back half of the car. Chairs and divans arranged on each side of the car by day, swing on pivots into the aisle at night and face the screen, so that this section of the car becomes a small movie theater.

At the other end of the car, facing the bar, padded seats fold up against the wall at night, leaving space for a dance floor as large as that of an average night club. A phonograph record player in the movie projection room provides music.

These improvements probably will be the most effective sales argument the railroads will have in making their bid for future business, but new "hidden" mechanical devices also will do much to add to riding comfort. For example, one car manufacturer has developed a new kind of truck to provide a cushioned ride and a new hot-box alarm to increase safety. Other developments include a new high speed, electrically activated brake and a new lock coupler, both of which will reduce jerking and jolting when a train starts.

When will these new devices be put in use? Carbuilders today are concerned primarily with the job of producing their share of war materials and rail equipment essential to victory. Many factors must be weighed in determining when they will get the green light for their new products.

The important point is, however, that when the time does arrive for railroads to begin replacing their worn-out equipment, manufacturers will be prepared to open the throttle and start production of cars with improvements which they know will give the railroads a fair start in the coming battle for transportation business. And it all means that the public will get the best bargains it has ever had in travel comfort.

RADIOSONDE

Advances Knowledge of The Upper Air

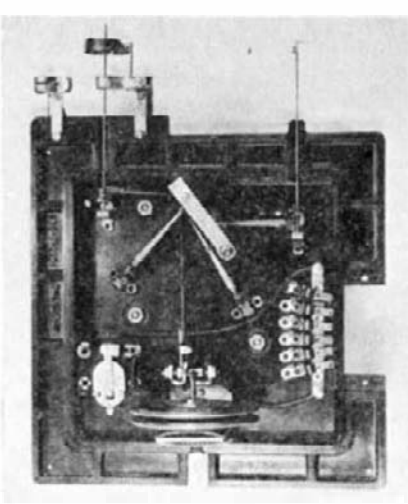
THE TECHNIQUE for exploring the upper atmosphere has been advanced greatly by the Chronometric Radiosonde Meteorograph of Simmonds Aerocessories. The unit comprises a "shoebox" which goes up by balloon and descends by parachute for safety. An alternative and perhaps more striking name for the new device is "The Weather Broadcaster." The average limit of ascension is between 50,000 and 60,000 feet, the range of flight may be many miles, and the length of flight from one to three hours. When the balloon breaks, the flight instrument floats to earth suspended from its 'chute, and bears a note offering a nominal reward for its return. The number of radiosondes returned depends upon the location of the flight and the ruggedness of the territory in which the landing is made.

The Chronometric Radiosonde Meteorograph contains three weather "feelers" sensitive to changes in temperature, humidity, and atmospheric pressure. A simple alarm clock mechanism keeps a recording helix continuously revolving. The radiosonde also carries a miniature high-frequency radio transmitting set consisting of a single tube and an ordinary meteorological battery. The whole is carried aloft by a five-foot latex balloon.

A bi-metallic thermometer is used to register temperature changes; changes in humidity are registered by the hygrometer which consists of a single human hair; a two-stack aneroid capsule registers changes in atmospheric pressure.

There are five styli—three movable according to changes in temperature, humidity, and pressure. The three weather styli move up and down the helix as they are moved by the hygrometer, the thermometer, and the aneroid capsule. Signals are made by electric contacts of the styli with a spiral wire on the helix. The timing of the signals from the three movable styli is measured in reference to those from the two stationary styli, or so-called reference styli. The instrument is completed by the transmitter which sends signals to the recorder on the ground.

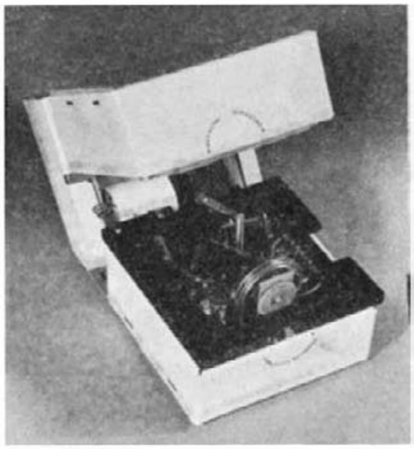
A recorded chart comes out of the



Interior of the new radiosonde, showing the hygrometer unit at the top

recording apparatus where it is spread over a drum, around which is wound a raised wire corresponding exactly with the helix in the meteorograph aloft. The paper passes under a sheet of carbon paper and a steel bar. This bar is tripped every time a signal is received. Since the drum in the recorder on the ground and the contact apparatus in the meteorograph in the air are both revolving at the same rate of four times a minute, and since their helixes correspond, the movements of the styli in the meteorograph are recorded on this paper. These recordings contain complete records of temperature, humidity, and pressure changes. The instrument is carefully checked before use, in a flight chamber simulating conditions of flight up to 70,000 feet.

Hundreds of launchings like these can be made from strategic points throughout the country, and the assembling of records helps in giving



Recording helix of the radiosonde is under the flat arm in center of photo

a highly accurate forecast of weather conditions. The radiosonde is undoubtedly a far superior device for weather forecasting than kites, passenger balloons, or high-flying airplanes.

While the radiosonde is not new and the first experimental launchings were made at Harvard University as early as 1935, its latest form as illustrated is vastly improved. Its use for military purposes is obvious. Its possibilities in civil aviation and in other types of weather forecasting are equally valuable and all the advances made in weather forecasting in war-time will sooner or later serve in peace-time.—*A.K.*

DIE-LESS DUPLICATING

Permits Economical Forming Of Small Metal Parts

THE PREPARATION of dies for forming small metal parts has always been an expensive and time-consuming task for manufacturers. This is all the more true when dies are used for short production runs or for making parts for experimental purposes. The war, with its acute shortages of skilled workers, especially die makers, and intensely accelerated production schedules, has made more acute than ever before this problem of dies used for duplicating small parts.

A solution to this problem has been found by many manufacturers whose products require small metal parts. They dispense with the need for dies by using a number of hand-operated duplicating tools which are capable of quickly and accurately forming metal into intricate shapes and outlines.

This system of die-less duplicating, named Di-Acro, employs shears, brakes, and benders as its basic units. Women or ordinary unskilled male labor can easily be trained to operate them with a high degree of proficiency. These tools are adaptable to production-line work where they can be used to obtain a continuous daily output in large volume. They are also extremely useful in test rooms and engineering departments for building experimental models and testing materials for stress and fracture.

The Di-Acro shear is a precision tool for a wide range of work too light for the floor type foot-operated instrument and too heavy for the hand-operated scissor type shear.

The bender is a precision bending unit. In addition to forming a wide variety of metal pieces, eliminating the need for special blanking or forming dies, it can be used to create shapes and outlines impossible to obtain on regular production dies.

These tools, used in conjunction with the brake in a continuous integrated production process, permit the speedier and more economical production of small metal parts. Now used widely in war production, it is expected that they will find a growing place in the manufacture of civilian goods when the nation returns to a peace-time economy.

ROCKET FLIGHTS

Seen by Expert on The Post-War Horizon

"TRANSATLANTIC rockets are unlikely in this war, but rocket planes making flights from London to Paris will materialize in the not too distant future," according to Alfred Africano, former President of the American Rocket Society, and now engaged in confidential war research as Assistant to the Director of Research, Allegany Ballistics Laboratory, in an address delivered before a meeting of the Metropolitan Section of The American Society of Mechanical Engineers. Explaining why transatlantic rockets were unlikely now, Mr. Africano said the speed required to propel them would necessitate the use of 26 pounds of fuel for every pound of final weight in the rocket, "obviously impractical to build."

"To get the 3000 mile effective range," he said, "and assuming the 4000 mile vacuum range, the required velocity is shown to be almost five miles per second, or the speed that a body needs to keep flying in a circular path around the earth as a satellite at the 500-mile level."

As for the three-step rocket in which fuel tanks are thrown off as fuel supply is exhausted, proposed in 1911 by Dr. Andre Bing of Belgium, this also is impractical, Mr. Africano believes. "The weight ratio increases as a power of the number of steps," he said, "so that the three-to-one ratio would require about 2500 tons initial weight to send just one ton over the Atlantic. Even a war could not justify a 5,000,000-pound projectile at a cost of anywhere from ten to a hundred million dollars just to deliver one ton of TNT in a enemy country. It is also impractical, because even if the energy requirement can be met, the initial damage to the surrounding countryside at the launching stage from the burning of 100,000 pounds of fuel a second for only a five times gravity acceleration might be a hundred times greater than that inflicted by the one ton of explosive delivered in the enemy country."

In discussing the rocket plane, Mr. Africano said: "The maximum range equation I have derived for the rocket plane shows the range to be proportional to the square of the jet gas velocity, as expected, as this is a measure of the available horsepower of the jet. The range is also linearly proportional with the velocity ratio. Thus, for current practical value of the constants, the range might be only 157 miles at a low speed such as 670 miles an hour, 314 miles at double that speed, and so on, up to a maximum of 1400 miles when the rocket plane speed equals the jet gas speed of 5400 miles per hour. The crusing level for this high speed would be at 30 miles altitude."

Summing up the practical possibilities of the rocket plane, Mr. Africano concluded: "While military applications of jet propulsion engines are now possible, as everyone knows, the subject is still in its infancy as far as commercial and peace-time applications are concerned. With adequate support of research and development after the war it is my sincere conviction that the rocket flights to London and Paris we have so long just talked about will finally materialize, and not in the too distant future."

MICROWAVES

Useful for Television And Other Applications

NATION-WIDE television hook-ups through microwave radio stations 20 to 100 miles apart all over the country were predicted as an immediate possibility as soon as the war is over by Dr. George B. Hoadley, in charge of the instructional microwave laboratory at the Polytechnic Institute of Brooklyn, at a recent meeting of the New York Electrical Society.

While the principles on which national television networks could be achieved have long been recognized by scientists, Dr. Hoadley explained, it took the war to bring about the developments which will hold down the microwaves to the defined and limited beam necessary to operate station links. These links will be placed across the country at 20- to 100-mile intervals and in parallel bands 150 to 200 miles apart, much as the several transcontinental railroads now span the country, making it possible for any event of national interest to be televised into homes throughout the country.

The advantage of microwave links is the fact that communication can be achieved with relatively less transmitter power than would be required for broadcast service; however, microwave boosters still are necessary to link television stations because the range of the short waves they utilize is bounded by the optical horizon.

Release by the military of information and the imagination of American industrial designers will be the two determining factors in the uses to which microwaves will be put in the post-war era, Dr. Hoadley pointed out. Possible applications, he said, may be to increase the availability of radio-telephone communication, now threatened by interference between existing stations. It will be necessary to go to higher and higher frequencies and to evolve new schemes to get around this interference. Another use will be for spanning water gaps by telephone companies to eliminate costly and delicate sunken cables. In fact, Dr. Hoadley added, a microwave relay station can be set up at any point where it will eliminate costly construction and maintenance in carrying through telephone poles and wires.

FOOT-REST SEAT

Foreshadows Greater Comfort In Railroad Coaches

SOME of the passengers on one of the Seaboard Airline Railroad trains these days are experiencing a new comfort in coach seating accommodations. Four experimental seats with foot and leg rests have been installed for tests and travelers' reactions.

The new seat, designed by the Edward G. Budd Manufacturing Company, is patterned along the lines of the steamer chair, but is actually even more utilitarian. The central arm rest has been doubled in width as contrasted to the standard dividing arm rest, which is usually half the width of the outside arm despite the fact that two passengers have to use it.

The foot rest, in one position, is similar to a hassock. When swung on its pivot against the seat occupied by the passenger, it supports the feet and legs and enables the traveler to enjoy complete relaxation. The seat and foot rest occupy 52½ inches of space. They also enable a traveler to sleep on his side or to curl up in the seat and still have support for the knees and legs.

More comfort in the railway coach

Each leg rest contains a pocket into which can be placed for safety and convenience a woman's large pocketbook, shoes, or small packages.

PREFORMED PLASTICS

Has Tensile Strength Equal to Steel's

SUCCESSFUL development of a "missing link" in the family of plastics—a tough high-strength material easily formed into complex shapes—has been accomplished by Westinghouse, according to Dr. A. Allan Bates, manager of the Chemical and Metallurgical Department.

An airplane tail fillet made of new light but strong preformed plastics

"Heretofore, plastics have been roughly divided into two classes," Dr. Bates says: "those that could be molded into shapes easily, but had little strength, and those with great strength but little moldability. This new plastics has both strength and formability to a degree never before achieved in a single plastics material."

Called "preformed plastics" because it is shaped roughly to finished form before it is finally molded by heat and pressure, the new material weighs only half as much as the aluminum alloys used in airplane construction, Dr. Bates states. It is so strong that a one-inch-square bar can stand a pull of 16,000 pounds, equivalent to the tensile strength of structural steel.

"After the war," the Westinghouse scientist says, "this plastics will be available for use in hundreds of new products now made of wood or metal—radio and refrigerator cabinets, automobile doors, dashboards and other body parts, luggage, cameras, furniture, typewriter frames, filing cabinets, and many other articles."

Millions of tiny wood fibers, the same kind of cellulose fibers as in ordinary wrapping paper, give the new material its strength, he explains. Under heat and pressure these fibers are tightly locked together with a varnish-like resin to give the finished material its steel-like strength.

Dr. Bates is shown in the accompanying photograph with one of the first experimental pieces made by the preformed process—a gracefully-curved airplane tail fillet which resembles a giant man's spat. He says that bullet-shaped covers for airplane propeller hubs have also been made experimentally.

BOX CAR

Has Complete Aluminum Exterior

THE FIRST American railway experimental box-car having a complete aluminum exterior has been designed by Great Northern Railway and Aluminum Company of America engineers. It is equipped so that it can be used for high-speed express service on passenger trains.

Another "first" for the new car is use of a reflective material for monograms and lettering on the aluminum exterior. By using this, words, numbers, and monograms on the sides appear as though internally illuminated and are readable when lights shine on them at night.

The reflective material is "Scotchlite," made by the Minnesota Mining and Manufacturing Company. It consists of millions of small glass spheres coated in a synthetic resin for protection against weather and water. The material, in sheetform, is applied to the side of the car by means of a water-proof synthetic resin adhesive. The tiny glass spheres return the light toward the source of the beams shining on them.

Parts of the new car which use high-strength aluminum alloy are outside sheathing, roof, corrugated ends, doors, floor protective doorway plates, "W" corner posts, running boards, brake step, and other parts. Roof, ends, side sheets, and doors are assembled with aluminum alloy rivets.

The car weighs 43,500 pounds. Saving in weight due to use of the aluminum is 4057 pounds. Aluminum in the car weighs 3722 pounds.

TWISTED DRILLS

Are Demonstrating Many Advantages Over Conventional Types

MANY tons of critical, high-speed steel have been saved during the war emergency by the widespread use of twisted drills in thousands of American factories and machine shops.

A workable method for making twisted drills was developed at the Rouge plant of the Ford Motor Company after salvage experts took steps to reduce the 50 percent waste of expensive, high-speed steel bar stock that accompanies the manufacture of conventional drills.

The first twisted drills were made at the Rouge plant some years ago. Advantages of the shankless twisted drills are many, with ease of manufacture and low cost among the most important. Conventional drills are machined from solid bar stock, an operation that consumes time besides producing waste, while twisted drills are made from roll-forged stock of predetermined dimensions and then hot-twisted to the desired spiral. The spiral is produced by roll-forging and twisting, instead of cutting on a milling machine as in the regular drill.

In addition, twisted drills are stronger than the conventional type. There are three reasons for this: the web, or center section of the drill, is of uniform thickness; the twisted drill has better physical properties, since the grain lines in the metal are not cut at spaced intervals, but curve with the spirals like the twisted fibers in a rope; the neck of the shankless drill is toughened by heat-treatment so that it will "give" slightly, thereby cushioning the shock of sudden torsional strains.

On numerous jobs the twisted drill can produce more holes because of its superior strength; in addition, it is less easily broken and has a higher scrap recovery value. More important, when a twisted drill wears to its shortest usable length, it can be butt welded to another short drill and, after the weld is ground and polished, restored to use. Salvage experts frequently weld three or more short drills into a single drill. This salvaging operation is peculiar to these drills. Conventional drills with milled flutes cannot be butt welded properly due to their tapered web.

Twisted drill manufacturing technique is relatively simple. The stock used is purchased in the form of round rods. These are heated to a high temperature, then placed in a form rolling machine. This produces a straight section, resembling the shape of a finished drill without a spiral, sufficiently oversize to permit finishing to size later on.

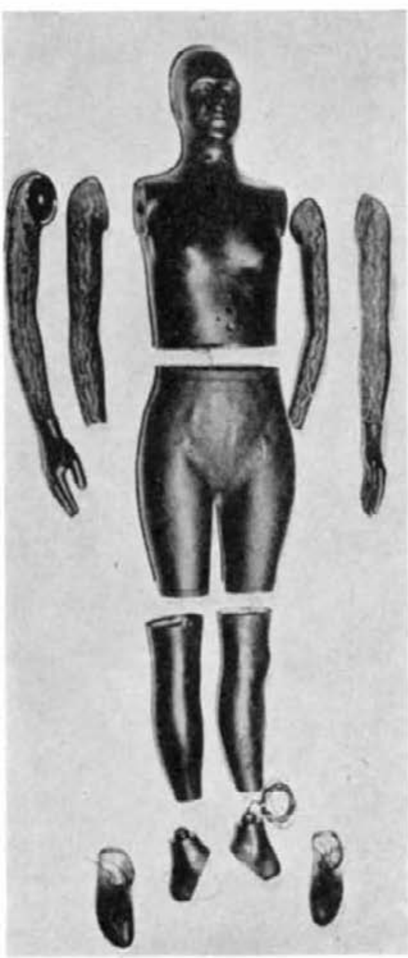
The drill, still red-hot, then goes to the twisting machine. Here the proper spiral or "lead" is produced. Next the long, twisted shaft goes to the cut-off machine for cutting into whatever lengths are desired. The drill is then rough-pointed, heat-treated, tempered, and straightened. It is sandblasted, to remove any remaining scale or roughness, the flutes hand-polished, and it is then placed on a centerless grinder for finishing to a specified diameter.

To complete the operation, the drill then goes to a finish point grinder, where a cutting edge is ground and the point shaped, following which it is inspected for flaws and workmanship and the size etched on the driven end.

COPPER MAN

Replaces Humans in Cold-Room Tests

A LIFE-SIZE "copper man" which reproduces the temperature response of the human circulatory system has been developed as a test machine for electrically warmed flying suits and other similar equipment at the Bridgeport, Connecticut, plant of the General Electric Company. There he will spend a lot of time in the cold room in subzero temperatures. In time he will also contribute to the development of the new automatic blanket which General Electric has scheduled for manufacture after the war.



Parts of the "copper man," which reproduces human body temperatures for laboratory research on clothing

Only by "cut and try" methods and by testing which involved people sitting for long hours in a cold room at as low as —60 degrees, Fahrenheit, were the garments developed that have made high-altitude bombing possible. In this work with electrically warmed clothing and blankets for fliers and their implements, cold chamber testing is so vital that it was deemed highly desirable to develop a mechanical device that would simulate the reactions of the human body. Hence the full-size copper man which duplicates almost exactly the human temperature system and provides the perfect scientific answer to the problem of testing electrically warmed flying suits, gloves, shoes, and blankets at low temperatures without inflicting suffering and danger on human beings.

General Electric's copper man is 5 feet 10½ inches tall and has a copper "skin" 1/16 inch thick. A complicated system of electric wires is connected with separate areas of the copper head, torso, hands, and feet.

It is necessary for the human body to generate sufficient heat with which to keep warm. The temperature of the different parts varies considerably. For example, the face and hands, which are normally more exposed, may vary over a wide range of temperature without harm or discomfort, whereas the torso must be kept at a relatively uniform temperature.

The value of the copper man is that he has been so wired and circuited that he practically reproduces the varied heat of different parts and members of the body. His body has been divided into 15 areas, the amount of energy to each area being subject to individual control. His temperature can be made to vary from sub-normal to above normal.

The copper man represents many refinements over similar devices previously used for low-pressure, high-altitude testing. He has two main tricks. First, by maintaining a desired temperature equivalent to the human body, the results can be determined for any kind of garments worn by him under any atmospheric conditions by measuring the energy input together with the surrounding temperature. Thus it is possible to tell what clothing is adequate under given atmospheric conditions. Second, the controls can be set so that the energy is equivalent to that of normal metabolism less exhaled heat. In this case, the copper man represents man at rest and it can be determined how much clothing to put on to keep him warm.

Recognizing the importance of developing better hand and foot protection, the Aero-Medical Laboratory at Wright Field had General Electric make four separate hands and four separate feet and remote control equipment for them. With these it should be possible to determine precisely the proper distribution of heat applied to various parts of the body and the amount of heat necessary with various outer clothing and surrounding temperatures.

NYLON INSULATION

Applied to Wire At High Speed

A NEW nylon compound offers a tough abrasion-resistant substance for sheathing cables or for the manufacture of tubing. Among its advantages as a coating for wire are heat-resistance and its imperviousness to attack by practically all solvents. Ignited by a free flame, the nylon ceases to burn when the flame is removed and is therefore self-extinguishing.

Du Pont laboratories have extruded nylon jackets seven mils in thickness

Adjusting one of the controls on the "copper man"

at rates of over 1000 feet per minute, according to Dr. J. W. Shackleton of the company's plastics department. "A tube of nylon is extruded and laid snugly over the wire, the wall thickness being controlled primarily by the wire speed. Nylon has been proposed as a sealing compound to fill the interstices between individual wires in a multi-strand cable and for use as a barrier layer between materials in the cable which might contaminate each other."

MAGNESIUM WINGS

Point Way Toward Post-War Flight Economies

AIRPLANE wings fabricated entirely of magnesium have been in flight for more than a year on navy training planes, it was revealed recently by J. C. Mathes, of The Dow Chemical Company, speaking before a meeting of the American Society of Mechanical Engineers.

"While the use of magnesium alloys in aircraft has increased during the war to the extent that the average fighting plane now utilizes approximately half a ton of this light metal, the use of all-magnesium structures represents a new departure in aircraft design," Mr. Mathes said. "I am convinced that our success with these wings foreshadows all-magnesium airplanes in the very near future." Since magnesium is one third lighter than aluminum, such planes would be notably lighter than present types, a factor which would do much in making air transportation more economical. "If we can save a few hundred pounds in plane weight we can carry that many more pounds of pay load with no increase in operating costs," Mr. Mathes said. "The saving of a single pound has been estimated as worth $100 a year on a commercial plane."

MATERIALS TESTING

Must Take Into Account All Stresses to be Met

METALS and materials get tired just like human beings. They wear out in much the same way. In a way, they "get diseases," although not as humans do. For some years industry has been trying to find out how much certain materials can stand by using complicated testing machines.

Up to the present most materials testing has been static testing—that is, a bar of steel would be tested as it was, regardless of what modifications might later be made in its shape or size. Industry has found these tests useful, but not good enough. Therefore, dynamic testing came into wide use.

Dynamic testing is simply testing metals or other materials in actual use. For instance, to test bridge strains, models can be made which can be subjected to vibration up to the point of actual collapse. This work will show what happens under actual stress. Or —and this is something automobile manufacturers constantly seek—vibratory tests can be made on an actual automobile to test parts until they fail, to show whether certain parts will give satisfactory life expectancy.

In an automobile, as scientists point out, it is not necessary that a rod or a gear last forever. The car itself will not. But it is important to be sure that any given part will last as long as the car itself—or close to it—allowing for normal wear and tear and sometimes excessive stresses or impacts.

While static tests can test materials separately, the real conclusions can be found only by dynamic testing. These apply not alone to cars and bridges, but to railroads, locomotives, busses, and almost anything used in commerce or in the home—even to sweepers, electric irons, gas stoves, or toasters.

Higher speeds in present-day machinery and transportation have amplified the importance of dynamic forces as a factor in design. Studies made in England by Aitchison showed that 95 percent of the failures in automobile parts were caused by dynamic forces. Hardly any machine part failures investigated by Ross of Sweden could be attributed to static forces alone: 80 percent were caused by repeated stress, and the remaining 20 percent involved impact. A complete knowledge of the behavior of materials as well as structural shapes and assemblies under dynamic forces is thus an acknowledged necessity in modern engineering.

Machinery for making such tests of materials ranges from strain gages, no larger than a postage stamp, to four million pound monsters. Intimately connected with the design and construction of such a wide variety of equipment is the Baldwin Locomotive Works, reported to be the manufacturers of more testing machinery than any other company in the United States.

STAINLESS STEEL SHOT

Used to Clean Castings of Similar Metal

WHERE cleaning and finishing of ferrous metal castings is performed by means of blasting with steel balls or shot, the repeated impacts of the steel pellets against the castings result in a fine deposit of steel dust being worn away from the pellets and deposited on the casting surface.

This, of course, makes no difference in carbon or low alloy steel and iron castings, but obviously when a surface layer of ordinary steel is deposited on stainless steel, it renders the surface subject to corrosive attack, thus destroying the primary property of the stainless alloy—its corrosion resistance.

The Cooper Alloy Foundry Company, producers of corrosion- and heat-resistant alloy castings, when confronted with this trouble, promptly developed a remedy by using shot, punchings, or filings of stainless chromium-nickel steel for blasting and tumbling castings of similar compositions.

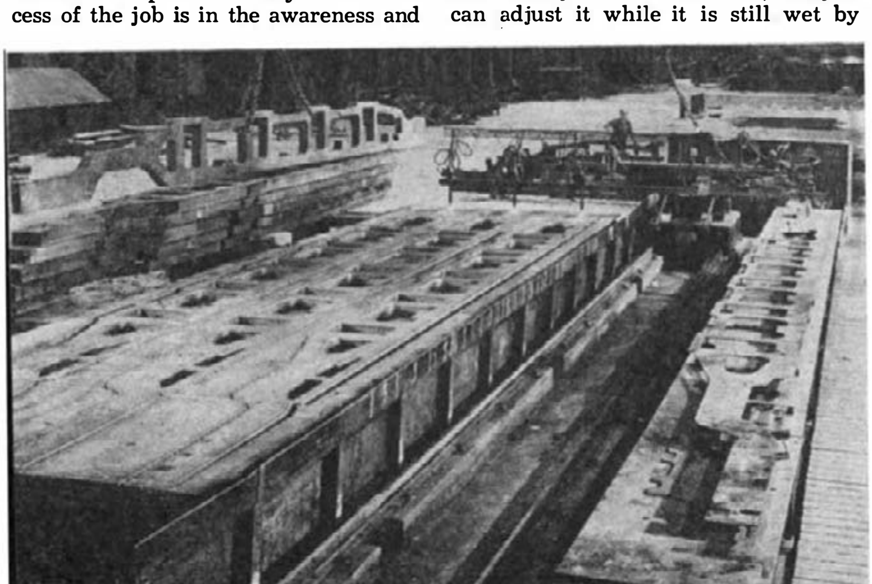
These stainless pellets perform their primary duty as efficiently as ordinary steel; yet the deposit which wears off and deposits on the casting is homogeneous with the casting material itself, and hence equally resistant to corrosion. —*Nickel Steel Topics.*

MULTIPLE FLAME-CUTTING

Takes on New Job in Steel Plant

THAT MULTIPLE flame-cutting is making notable strides into new fields is evidenced by the simultaneous production of three heavy frames of intricate design from a single 40-foot hot rolled Lukens steel plate. The key to the success of the job is in the awareness and intelligent appraisal of factors which affect adversely the accuracy of such flame-cutting and in the application of counter-measures to eliminate such factors.

The feat is being performed daily at By-Products Steel Corporation's plant, where three sizes of these frames are cut from five-inch thick carbon steel plate which has a tensile strength of 75,000 pounds per square inch. Hundreds of such frames are being produced for railway locomotives, most of which will be used as lands are freed in Europe, to restore transportation facilities destroyed by the Nazis or in bombing raids.



Flame cutters in action, with template at the right

CUT-OUTS

Are Readily Applied to Any Surface in the Home

READY-PASTED cut-outs, a new and colorful type of decoration for plain and painted surfaces, are the latest industrial offerings to amateur home decorators. These cut-outs are velvety-soft and blend richly against the surfaces on which they are used, giving a hand-colored, craftsmanlike effect, rather than the hard, enameled look which some other types of decorations give. The blended colors used are harmonious, yet sharp and brilliant. This color harmony is the product of skilful designing and painstaking printing, and result in colors that will blend with almost any interior color scheme.

Fadeproof and washable, these cut-outs need only be dipped in water and then applied to the surface to be decorated. Each one comes on a sheet scored all around, ready to be "popped out" of the background. The pieces are small and easy to handle, and no special equipment is needed—just a basin of water and a soft, clean cloth. You first press the design out of its perforated paper background, then pin it in place in order to judge the effect. Remove the pins and dip the piece in water to moisten the adhesive on the back, and press it against the surface you are decorating, patting it with a cloth. It will not dry for a few minutes, and you can adjust it while it is still wet by

Only a few of the many possible applications of ready-pasted cut-outs

sliding it to adjust the position. Your own imagination can be your guide as to placement, although suggested uses as well as detailed instructions are included with each cut-out.

If you should want to remove one of the cut-outs and change the pattern in accordance with a change in your decorating scheme, the cut-out can be removed by soaking thoroughly and peeling it off. Or if you are using a cut-out on a surface which will receive much wear, a quick coating with shellac or clear lacquer will assure special durability and washability.

ARTIFICIAL EYES

Have Improved Qualities When Made of Plastics

A NEW all-plastics artificial eye which rivals a human eye in color and appearance, can be dropped without breaking, won't corrode like glass, and can be re-shaped, if necessary, to provide an exact fit, has been announced by the American Optical Company.

First of its kind to be made commercially, the new synthetic eye is molded from acrylic resin, one of the newer plastics, and production has already been inaugurated. "Prior to the war," the company says, "millions of glass eyes had to be imported from Germany to fill American needs. However, development of the new plastics eye ends the reliance of the United States on foreign sources for artificial eyes."

The new plastics eye, it is claimed, is unique for two reasons. First, it is made entirely of non-irritating plastic materials and, second, its iris is reproduced by a photographic print. Both of these improvements are new in respect to commercially-made eyes and give the eye its radically new properties.

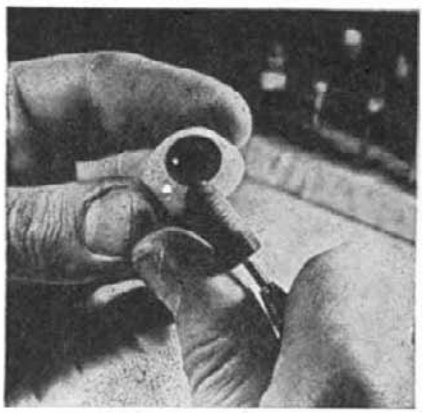
The new plastics eye is said to be more lifelike than a glass eye. For example, the photographic reproduction of the iris is realistic, the black dot of the pupil being located naturally, deep in the eye, instead of close to the surface as in glass eyes.

If dropped, fragile glass eyes may

shatter or chip, and if subjected to sudden temperature changes they may explode in eye sockets. Their average life is from six months to two years while the new eye, because of its plastics composition, is practically unbreakable and will last many years.

Once a glass eye has been made, it cannot be altered. The new plastics eye, however, can be re-shaped by grinding to fit the eye socket comfortably, and it does not have to be removed at night, thus helping to maintain the shape of the eye socket.

Non-irritating to the socket's tissues, the plastics material of the eye resists color fading, corrosive action of eye socket secretions, and changes in temperature. It also reflects less light than a glass eye, and is therefore less glassy in appearance.



Glass eyes cannot be altered after they are made; new plastic eyes can be ground to fit if necessary

The plastics eye is made in three parts. First, the sclera, or white portion of the eye, is molded from a translucent plastics. Then a round recess is cut into it for the iris. Next, the iris button, which contains a photographic reproduction of a real iris, properly colored, is made and inserted into the scleral recess.

In the final operation the sclera and iris button are put into a mold and an overlay of transparent plastics is added. Under the process the three pieces fuse and the finished product is a one-piece all-plastics eye.

WATER-PROOF MAP PAPER

Retains Writing Qualities After Soaking and Washing

PAPER that does not disintegrate when wet is one of the products developed under the stimulus of war needs that will become an accepted convenience of everyday life in the future. At present it has many military uses, one of the latest being for maps.

Developed by the Army Map Service, co-operating with paper manufacturers and the National Bureau of Standards, for use under rigorous combat conditions, the new map paper has greater strength than paper used formerly for this purpose. It retains its durability after being soaked with water and oil and after being trampled in the mud, and later washed with soap and water.

Even when soaking wet, the paper has satisfactory writing and erasing qualities. In addition, it has excellent printing qualities and meets all the requirements of map paper.

The current requirement of more than 10,000,000 pounds a month is being turned out by mills all over the country. Pulps from eastern spruce, southern pine, western hemlock, and the jack pine of the Great Lakes are being used with equal success.

FLOATING REFRIGERATOR

Can Supply 53 Tons Of Refrigeration Daily

THE first all-concrete refrigerated cargo carrier, a floating ice-box which is supplying United States troops with fresh food, is now in action somewhere in the South Pacific.

Engineered and equipped by the York Corporation with a unique cold-storage system for fresh meat and produce, the new refrigerated barge is one of three such vessels to be built for the United States Army in the yards of the Concrete Ship Constructors. More than 1000 tons of fresh meat, fruits, ice, and ice cream were carried on her maiden voyage.

At sea, the floating refrigerators will perform the same job for the Army as mobile land commissaries, supplying food for fighting men and ice for emergency treatment of wounded. The ships will be camouflaged and moved into position during attack on main islands. Until the island is secure and permanent refrigeration installed, they will maintain a supply line of provisions between sea and shore. After initial operations are completed, they will be towed to the next scene of attack.

First barge of its type ever built, the new vessel is 265 feet long with a 48-foot beam. The concrete walls of the hull are five inches thick. Reported refrigerated storage capacity amounts to 122,000 feet and includes a plant capable of turning out 500 gallons of ice cream a day. Another plant produces 5 tons of ice daily. All together the ship produces 53 tons of refrigeration every 24 hours.

New Products

MARKERS

Devices which can be used to print or mark boxes, crates, cases, and so on, either in a continuous strip or with single impressions, have recently been placed on the market by Adolph Gottscho, Inc.

These Rolamarker units are available in sizes that will print information to users or manufacturers' identification

Boxes and crates marked quickly

from two inches to ten inches wide. They can be applied to asbestos, cloth, cheese, composition board, plastics, and similar materials.

The Rolamarker for single impressions is equipped with a return mechanism so that after the imprint is made and the unit is removed from the surface being marked, the die drum automatically will return to the starting position.

Permanent dies or interchangeable type may be used in these markers. They are all automatically inked by rollers.

TAX CHART

A simplified withholding tax chart designed to help office managers and accountants to make, easily and accurately, payroll deductions under the tax law effective January 1, has been prepared

For figuring payroll deductions

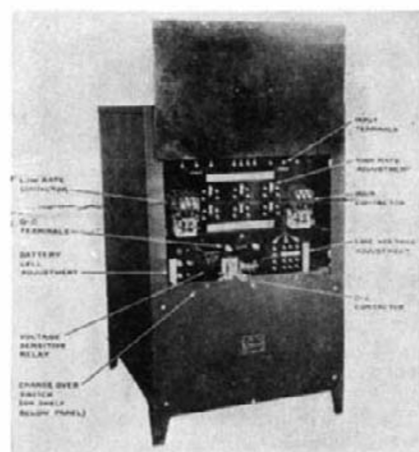
by Delbridge Calculating Systems, Inc.

It is published in four editions covering weekly, bi-weekly, semi-monthly, and monthly payroll periods. In addition, each of the four charts shows daily and miscellaneous deductions for periods from one to six days inclusive. No multiplication or addition is required in using these charts.

BATTERY CHARGER

Production of a new large-capacity automatic copper-oxide battery charger, for charging electric truck batteries, is announced by General Electric's appliance and merchandise department.

This combination charger has simplified controls and a D.C. contactor. It is capable of charging 30 nickel-alkaline



Charges electric truck batteries

or 24 lead-acid battery cells. It is designed specifically for applications where both lead-acid and nickel-alkaline batteries are employed.

The charger takes up little room and can be installed anywhere in the operating territory of the trucks that three-phase A.C. power is available.

The internal control panel of the new charger is clearly laid out to enable even an inexperienced operator to make adjustments. Name plates show the method for changing the charging rate, the one-step operation of line voltage adjustment, and the battery-cell adjustment.

The D.C. contactor prevents batteries from discharging back through the charger after the A.C. input has been turned off or fails. The charger automatically shuts off when the charge is completed. When desired it can be shut off manually before the charge is completed.

SAFETY SURFACE

Designed for use in any plant or factory where floors may become wet and dangerously slippery, a new floor brick incorporates an abrasive baked into the surface. This new floor surface material, known as Empire Emri Tread Floor Brick, is made with a clay base and is fired at high and carefully controlled temperatures. It is impervious to water and is not subject to attack by acids or alkalis, except at a very slow rate.

The surface of the brick is given a non-slip surface by the abrasive, thus not only reducing the danger of falling but giving workmen a foothold which makes it unnecessary to shorten steps or brace themselves, as has to be done on slippery surfaces.

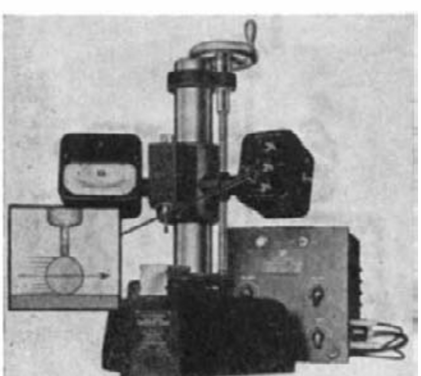
LUBRICANT

A NEW lubricant is being manufactured for all types of internal combustion engines such as steam and gas engines, turbines, air compressors, truck engines, vacuum pumps, and so on. When added to any type of lubricating oil, it produces a "super-lubricant," will not settle out or segregate, and cannot be extracted by any filter.

Bearing the trade name Gibraltar Oil Concentrate, the new product is said to prevent formation of hard carbon on valves and rings when used in air compressors and internal combustion engines. It gives better spreading or wetting action to the lubricant treated and actually penetrates the pores of the metal, according to its manufacturer. Cylinder walls become saturated with oil and, when the walls heat up, the oil exudes from the pores of the metal, giving instant lubrication.

ELECTRONIC GAGE

AN electronic gage is now available which permits inspection of dimensions having very small tolerance limits, at low cost with inexperienced operators. In this Foote-Pierson instrument, gaging is performed electronically and is not accomplished through the use of low-frequency magnetic fields nor does



Unskilled help can read the dial

it depend on the position of make and break electrical contacts. Variations in the position of the mechanical contact point are magnified sensitively, accurately, and conveniently by means of the electronic circuit. The gage is provided with both indicator dial and with limit lights.

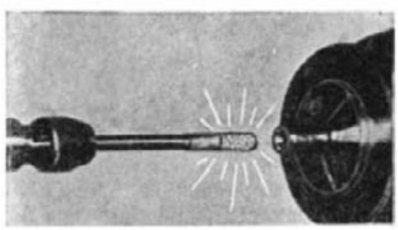
The indicator dial may be used when it is desired to determine how much the dimension varies from the specified tolerance and for selecting workpieces according to their dimensional variations. The indicator dial is also used when setting the gage. The limit lights provide an extremely rapid means of inspection. Any one of the three lights tells instantly the status of the dimension: green means acceptable, red oversize, and yellow undersize. Only one mechanical means for setting to within plus or minus .003 inches is required, since the wide range electrical zero adjustment covers the full scale of plus or minus .003 inches, easily permitting a final zero setting even on the most sensitive scale.

One master only is required and this master need not be to the exact dimensions specified. As long as the gage block or master is within the range of the indicator scale being used, the gage can be set exactly to the specified workpiece dimension.

The gage is set by means of simple radio type knobs; approximate location of the sensitive contact point is obtained manually by means of the lead screw which lowers or raises the gaging head. The gaging head can also be swung 180 degrees in either direction by rotating the column.

DIAMOND BURS

SPECIALLY graded diamond dust, from 80 to 500 grit, impregnated in a special alloy metal bond, makes the Oscap diamond bur a low-cost means of super-



Cuts with diamonds

finishing cutting edges, form tools, drawing or press dies, as well as of internal or external lapping of small holes and gages. It can be used on high-speed steel and high temperature alloys such as stellite, rexalloy, or the hardest grades of cemented carbides.

The diamond bur has a supercharge of diamonds below the regular .050 depth of impregnation, resulting in long cutting life because it will continue to cut after its regular cutting surface is worn away. When the outer cutting surface is worn away, the lower layer of diamonds comes into cutting range.

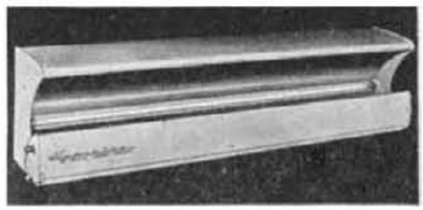
PLASTICS COATERS

TWO SMALL plastics coaters are now available for melting and maintaining ethyl cellulose and other plastics protective coatings in which parts and tools are dipped. The new models were designed for use by manufacturers of small parts or tools for coating prior to shipment, or for shops that want to protect their own precision cutting tools and gages while in storage prior to use.

Manufactured by the Youngstown Miller Company, each coater has a pump arrangement which provides constant level in the dip tank and continual removal of surface film and bubbles caused by dipping. In addition, oil jackets the sides and bottom of each tank. Oil and plastics are thermostatically controlled so that the electric heaters are shut off when either reaches its ceiling temperature.

AIR STERILIZER

The most recent model "Hygeaire" unit for air sterilization employs a General Electric germicidal tube to project intensified ultra-violet rays across living or working areas above



Kills air-borne germs

eye level. A scientifically designed reflector provides both optimum intensity and diffusion of the rays that are lethal to air-borne bacteria. The unit may be recessed into the wall, or suspended from the wall or ceiling.

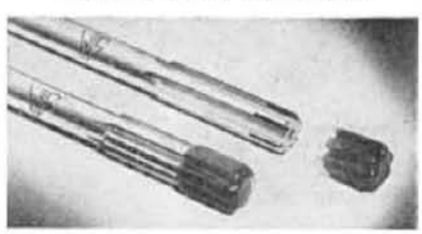
Because more than 85 percent of the ultra-violet energy output of this new unit is of the germicidal wavelength (2537 Angstroms) it will assist industry in combating absenteeism caused by cross infection in offices and plants. The unit is made by American Sterilizer Company.

PARTS PROTECTION

New methods for the protection of precision machined parts and sensitive surfaces are appearing in industry.

Thread protectors and dust caps for the protection of threaded and machined parts have been put on the market by Precision Paper Tube Company. They are made of spiral-wound fiber, kraft paper, or cellulose acetate,

Protection for delicate surfaces



Sharp edges are kept sharp

under heat-treated compression. They are designed and constructed for durability in protecting fittings and exposed openings and ends from moisture, rust, dirt, or damage in packing or shipping.

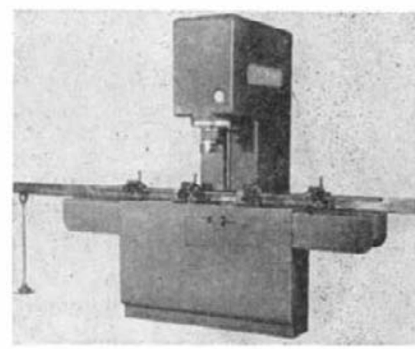
These protectors are shaped to the article to be safeguarded—cylindrical, square, rectangular or tapered, crimped, flared, or perforated—with tolerances as close as ±.003". The name of the part and number, as well as the name of manufacturer can be printed on the protector.

Another example of protection is being practiced by the Wendt-Sonis Company in the safeguarding of carbide tipped tools in transit, stock-room, or tool-room bin by applying a strong plastics coating to each tool immediately after final inspection at the plant.

This hard and durable covering remains in place until inspected by the purchaser and then it can be slipped back over the tool tip to achieve permanent protection in the tool bin. Although the covering is air-and-moisture proof after initial application, it will not leave any gummy residue on the working surfaces when removed from the tip.

STRAIGHTENING PRESSES

A line of hydraulically operated and accurately controllable presses has been designed for straightening both finished and rough work. The presses incorporate many of the construction and operating features which have contributed to the successful operation of Colonial



Pressure is registered on gage

Broach Company's other machines and assembly presses.

The machines are of reinforced welded steel construction with built-in motor and with a direct-acting hydraulic cylinder built into the head of the machine. Sensitive control is provided through light-pressure hand control and foot pedals. A pressure gage mounted on the head of the machine in front of the operator indicates the exact pressure being applied to the workpiece.

Straightening fixtures are equipped with either center or roller-type work supports according to whether finished or rough work (such as forgings, upset shafts, and so on) is to be straightened. These supports are mounted on a long guide rail which is particularly useful when long shafts are to be straightened, because they will prevent possible sagging of the work beyond the work anvils.

DRAWING COMPOUND

A dry drawing and annealing compound applied as a waxy, aqueous emulsion, is announced by the Plasteel Corporation, and has been used with success in the deep drawing of brass and steel. The compound is applied in varying strengths in either drum or spray type mechanical washing machine at an operating temperature of 175 to 185 degrees, Fahrenheit.

The coating contains sufficient annealing compound to prevent the formation of hard mill scale during anneal, but does produce a thin, porous, protective scale that is easily removed in subsequent pickling, leaving a clean, scale-free piece.

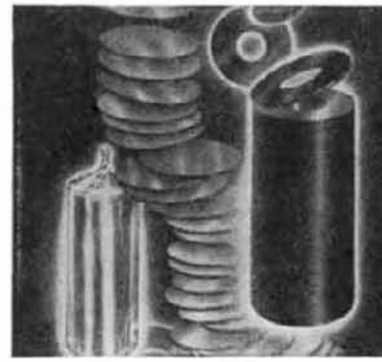
The pieces can be drawn as they come from the washing machine without the use of a coolant or added lubricant. This gives a final product that is smooth and clean.

EXPLOSION-PROOF MOTOR

A NEW explosion-proof electric motor is totally enclosed in a bronze casting with removable screw cover and adapted for conduit mounting. It can be supplied in various shaft speeds, voltages, and frequency. Said to be explosion proof by its manufacturer, the Warren Telechron Company, the new motor was developed primarily for use in connection with automatic controls used in industrial processes where atmospheres contain explosive vapors.

RHEOSTATS

MANY types and sizes of continuously adjustable carbon rheostats formed of carbon disk piles are being manufactured by the Stackpole Carbon Company. Simply by changing the pressure applied to these piles, every possible resistance value within their range is made available without opening the electrical circuits in which they are connected. The pressure to vary the resistance to the most critical adjustment may be applied electrically, mechanically, centrifugally, or hydrauli-



Pressure changes the resistance

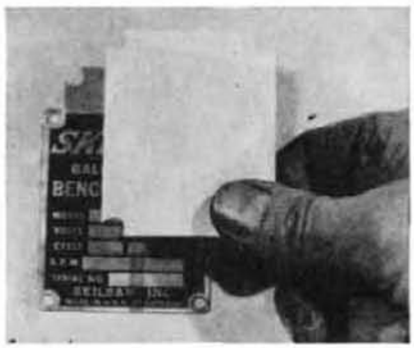
cally. Uses range from both generator and line voltage regulator applications to speed control through governed field current on motors. Many other projects incorporating the carbon pile resistor are now in the development stage.

METAL DEGREASER

A METAL degreaser and cleaner containing a finger-print and body-acid neutralizer is being manufactured by the Colonial Alloys Company. Even the most carefully cleaned and handled work going through the various routing and shop operations prior to final finishing, picks up finger-marks, most of which are acidic. It is this acid which, if not quickly neutralized, oxidizes the metal surfaces long before the finishing operation is reached. Too often the finish is blamed, when the trouble really centers on proper cleaning and neutralization of the metal surfaces.

MASKING STICKERS

AN EFFICIENT method of masking name and instruction plates, now being widely used in war plants, has been developed under the trade name of Kum-Kleen masking stickers. They are available die-cut to the exact specifications of the manufacturer. The name

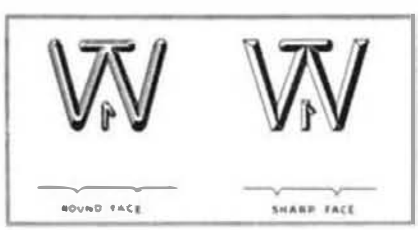


These masking stickers protect name plates during the finishing process

plate is attached to the product on the production line, covered with the masking sticker and the product then painted or finished. These masking stickers, in addition to being die-cut, are applied without moistening, stick to any smooth surface, are not affected by heat or cold and easily peel off without leaving a trace.

ROUND-FACE STAMPS

HAND stamps with "round-face" rather than sharp-face characters specifically designed for low stress marking of lightweight alloy forgings and castings are now available. Manufactured by New Method Steel Stamps, Inc., they



Round-faced characters on stamps reduce stresses in lightweight alloys

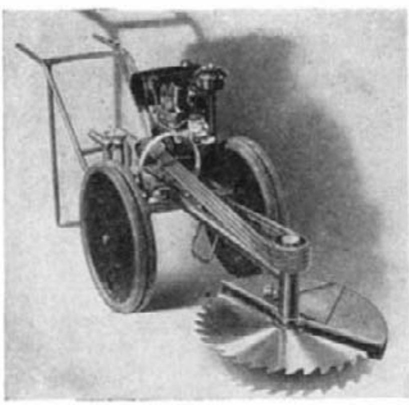
are said to be particularly suitable for marking aluminum and magnesium alloy parts which will be subject to either tensile or torsional stresses in service.

Use of round-face stamps lessens the chances of cracks starting in the forgings or castings marked by them. All characters have been carefully engineered and designed in accordance with S.A.E. aeronautical specifications which call for impressions not deeper than .003 inch and fillets (radius of curve) of not less than .006 inch at all intersecting surfaces of an impression.

Shanks are provided either plain, or knurled for finger and thumb gripping. Every stamp is tempered by automatically controlled heat-treating methods. The upper portion of each shank bears a characteristic "temper color" indicating that the correct degree of hardness for best withstanding of mushrooming has been imparted. The tapered and rounded heads retard peening and dangerous chipping under blows.

TIMBER SAW

A NEW Lowther C-Saw for timber cutting has a constant centered drive which is said to insure belt alinement no matter what the angle. The saw operates with equal smoothness at any angle on or off the ground. Four 112-inch V-belts connect two constant centered drive pulleys. Wheels have needle bearing and heavy-duty industrial type dual pneumatic tires as optional equipment for easy rolling.



V-belts drive the blade

Power comes from a six horsepower air-cooled engine, claimed to be economical of fuel. The frame is tubular welded steel, and the axle is heat-treated steel. A 30-inch blade with extra large teeth and extra deep gullets minimizes file and upkeep. Saw speed is 1150 revolutions per minute.

SYNTHETIC CHLORINATED RUBBER

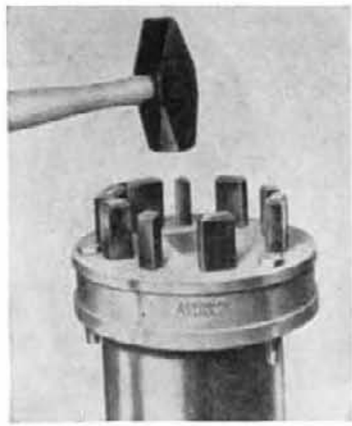
A RECENTLY developed synthetic, called chlorinated isopol, available in metal primer formulations and in powder form, is said to be practically identical to chlorinated rubber in flame resistance, moisture resistance, chemical resistance, solubility, stability, and compatibility with plasticizers.

Among its suggested uses are as a primer for rubber-to-metal adhesion; as an ingredient in adhesives, paints, lacquers, and inks, and as an acid- and an alkali-resistant coating for metal, concrete, and other surfaces. It is also useful for fire-proofing or moisture-proofing fabrics and other materials; for sound and heat insulation qualities; and as a plastics wherever inertness to chemicals and fire-proofness are of importance.

Although the new product is not yet standardized in viscosity range, the Union Bay State Chemical Company has announced that production is sufficient at present to enable sampling and service of reasonably sized orders.

MARKING DIE HOLDER

A NEW style die holder facilitating the marking of all types of ordnance and automotive parts too large to be handled has been announced by Acromark. It is said that the compact self-contained unit holds all marking dies in exact position ready for stamping. The face of each marking die is protected in the holder so that it may be quickly placed in marking position without danger of scratching the work.



A single blow marks the work

Each marking die is properly balanced with the marking arranged so that an impression can be made by a single hammer blow on each die. The dies are supported in such a manner that "bounce" or "chatter" marks are practically eliminated. Individual sections of the marking may be changed as required, making it unnecessary to scrap the entire set-up or die. Markings cannot be placed in a wrong position or inverted after holder is set in place.

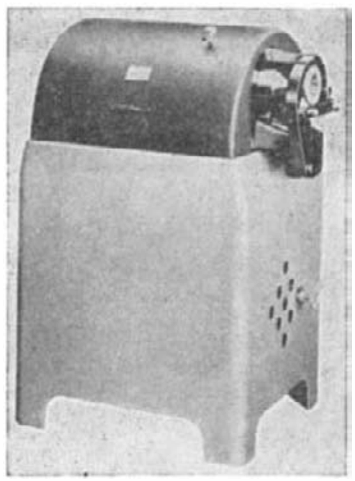
GAS GENERATOR

A NEW model of the generator which produces dry chlorine dioxide gas from chlorine and dry sodium chlorite has been developed by The Mathieson Alkali Works. The chlorite is now contained in a reaction tower within the control unit, in contrast with earlier models which required separate chlorite towers. Removable front and sides make all parts of the unit easily accessible for servicing. The new generator measures five feet in height, two feet in width, and 18 inches in depth.

This equipment is used commercially to generate chlorine dioxide, a gas with two and a half times the oxidizing power of chlorine, for the dry bleaching of starch, wheat flour, high-fat soy flour, and wool grease, and for checking blue mold in citrus fruits. Chlorine dioxide is also used, in solution, in bleaching soap, paper, and textiles, and in removing objectionable tastes and odors from public water supplies.

TUBE FINISHER

A COMPLETELY automatic Leonard Tube Master for squaring, burring, flaring, and beading ferrous and nonferrous tubing, in sizes from ⅛ to 3-inch, outside diameter, is now available. Known as model 3CP, it was developed and



Finishes tubing automatically

perfected as a completely automatic machine at the request of the major aircraft companies. The operator, man or woman, places the tube in position and presses the control button. The machine automatically completes the cycle of squaring and burring, flaring or beading the tubing. Uniformity of finish can be maintained indefinitely to exact predetermined specifications.

POWER BRUSH

A POWER brush for removing burrs, preparing metal surfaces, and for work on rubber parts as well as many other applications, is said to provide industry with a tool capable of increasing production rates at a minimum end-of-service cost and extending the application of fine-wire brushes to work hitherto considered impractical.

A product of the Osborn Manufacturing Company, it is a 12-inch monitor section filled with .005-inch power brush wire and has a one and a quarter-inch arbor hole. It is especially well suited to aluminum, brass, and other ductile metals for removing burrs effectively without damaging adjacent surfaces of the part, according to the company, and will find extensive application on hardened and unhardened steel parts.

Current Bulletin Briefs

Conducted by

K. M. CANAVAN

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

Fluorochemistry is a six-page bulletin, the first of a series, based on fluorescent analysis of various chemicals, liquids, and solids with ultra-violet rays. The theory and utility of fluorescence is fully covered as well as the basic concept of luminescence. Printed in form convenient for filing. The series is available upon request. *Ultra-Violet Products, Inc., 5205 Santa Monica Boulevard, Los Angeles 27, California.—Gratis.*

National Codes for the Prevention of Dust Explosions, 1944, is a 176-page book covering the 15 American Standards Codes, a new code for Explosion and Fire Protection in Plants Producing and Handling Magnesium Powder or Dust, an amended code for starch factories, and a statement of fundamental principles of dust explosion prevention in industrial plants. *National Fire Protection Association, 60 Batterymarch Street, Boston 10, Massachusetts.—Red cloth binding $2.00, brown paper covers $1.00.*

Tomorrow's Production Today by Resistance Welding is a booklet directed at the non-technician, giving brief explanations of each basic type of resistance welding, what resistance welding is doing to speed the war effort, and what its post-war possibilities are. Request Bulletin 101. *Resistance Welder Manufacturers' Association, 505 Arch Street, Philadelphia 6, Pennsylvania.—Gratis.*

Wheelco Thermocouple Data Book and Catalog is a 40-page guide to the proper selection of thermocouples, lead wire, protecting tubes, heads, and insulators. Descriptions, prices, millivolt and temperature conversion tables are given. *Wheelco Instruments Company, Harrison and Peoria Streets, Chicago 7, Illinois.—Gratis.*

Post-war Uses of Explosive Rivets is a manual containing many post-war possibilities for explosive rivets in the automotive and air conditioning industries, in housing and household appliances, and in other fields. *E. I. du Pont de Nemours and Company, Inc., Explosives Department, Wilmington 98, Delaware.—Gratis.*

Consider the Calendar, by Bhola D. Planth, is a 138-page booklet published by the Bureau of Educational Research in Science, Teachers College, Columbia University, and it presents the historical perspective, pertinent facts, and two salient alternative solu-

The Editors Recommend

PROCEDURES IN EXPERIMENTAL PHYSICS — *By John Strong, Ph.D.* A wealth of useful data of a practical kind for the constructor, experimenter, and skilled craftsman. **$6.80**

STEEL SQUARE POCKET BOOK — *By Dwight L. Stoddard.* Practical methods for using the carpenter's steel square for layout work of all kinds. Time-tried methods used by two generations of carpenters and found both rapid and accurate. **$1.00**

A MANUAL OF MECHANICAL MOVEMENTS — *By W. M. Clark.* Presents fundamentals on which all machines are built. 400 illustrations and 160 photographs of models demonstrating mechanical principles supplement the text. **$2.10**

TOOL MAKING — *By C. M. Cole.* Instructions for making and using all kinds, from personal tools to arbor presses, lathes, planers, etc., in different metals. **$3.60**

TECHNIQUE OF PLYWOOD — *By Charles B. Norris.* Technical information on all phases of plywood manufacture and use, compiled for engineers, designers, and users of plywood. Important to many phases of wartime housing and manufacturing problems. **$2.50**

OPTICAL WORKSHOP PRINCIPLES — *By Col. Charles Dévé.* War-time translation of a French work on precision shop optics, with heavy emphasis on actual handiwork. Covers glass, abrasives, cements, mechanical theory of working optical surfaces, surfacing, tests, centering, and so on. **$6.10**

HANDBOOK OF CHEMISTRY AND PHYSICS — A classic reference book recently revised and brought up-to-date to keep pace with recent research. Includes material on all branches of chemistry, physics, and allied sciences. Used in laboratories and by engineers throughout the country. Flexible binding. 2571 pages. **$4.10. Foreign $4.50 postpaid**

ATOMIC ARTILLERY — *By John Kellock Robertson.* Electrons, protons, positrons, photons, neutrons, and cosmic rays, all described for the layman in plain language. Also transmutation of the elements and the manufacture of artificial radioactivity. **$2.35**

EXPERIMENTAL SPECTROSCOPY — *By Ralph A. Sawyer.* Covers theory and types of spectroscopes and spectrographs, mounting and use of gratings, determination of wavelengths, infra-red spectroscopy, spectrochemical analysis, and so on. Somewhat elementary but requires knowledge of physics and some physical optics. **$5.10**

EXPERIMENTAL ELECTRONICS — *By Ralph H. Muller, R. L. Carman, and M. E. Droz.* A solid book of eminently practical information on the characteristics and non-communication applications of electron tubes. The text describes experiments and presents results. For students, radio engineers, communications experts, and the serious general reader. **$4.75**

PRISM AND LENS MAKING — *By F. Twyman.* A wide variety of notes based upon a long lifetime of practical optical shop work. Not a full step-by-step manual but a valuable working aid to the advanced telescope maker and others in optical work. While the text deals ostensibly with professional quantity production, much of it is basically applicable to single-piece work. **$4.60**

PLASTICS — *By J. H. Dubois.* Revised enlarged edition of an important work on the whole general subject of plastics, plus much new material on synthetic rubber, manufacturing processes, and plastics moldings. **$3.85**

Best Sellers In Science

A PRACTICAL COURSE IN HOROLOGY — *By Harold C. Kelly.* Definite, outright, practical instructions on watch making, repair, and adjustment. **$2.85**

SLIDE RULE SIMPLIFIED — *By C. O. Harris.* How to use a slide rule without any of the mystification that often surrounds this important tool of the engineer. Excellent illustrations make everything clear. $3.60 including a slide rule; for book alone. **$2.60**

THE ELECTRON MICROSCOPE — *By Burton and Kohl.* A well-written account of this newest tool of science, with all technicalities explained for complete understanding by average person. **$3.95**

A COURSE IN POWDER METALLURGY — *By Walter. J. Baeza.* A sound view of the overall subject of powder metallurgy which will serve as an excellent guide and reference book. **$3.60**

THE SCIENCE OF WATCHES AND CLOCKS — *By A. L. Rawlings.* Not a book on watch and clock repairing, but one for horologists interested in the science underlying fine timekeepers. **$3.60**

PLASTICS, PROBLEMS AND PROCESSES — *By Mansperger and Pepper.* The whole story of plastics, including a resume of manufacturing processes and a number of thorough-going chapters devoted to plastics uses. **$3.10**

FUNDAMENTALS OF ELECTRICITY — *By a Staff of Electrical Experts.* Although designed to supply men about to enter military service with a foundation for further training, this text will serve a similar purpose for anyone desirous of acquiring such knowledge. **$2.10**

ELECTRONIC PHYSICS — *By Hector, Lein, and Scouton.* A simplified text for those who desire to acquire a sound basis for following the advance of applied electronics. **$3.85**

A LABORATORY MANUAL OF PLASTICS AND SYNTHETIC RESINS — *By G. F. D'Alelio.* How to prepare many of the well-known resins and plastics in the laboratory. Understanding of the text requires a knowledge of organic chemistry. **$2.10**

FUNDAMENTALS OF OPTICAL ENGINEERING —*By Donald H. Jacobs.* This new work starts out at the very beginning, is mainly non-mathematical, and is probably the best suited of all existing books as an introduction to optical design. Author is a physicist at Bureau of Standards. **$5.10**

FUNDAMENTALS OF PERSPECTIVE — *By Theodore DePostels, A.I.A.* A method of showing the order, or sequence, in which lines of a perspective are drawn. Use of colors, numbers, and arrows eliminates much text found in other books on this subject. 20 loose sheets in binder. **$2.60**

MACHINERY'S HANDBOOK — *12th Edition.* "Bible of the mechanical industry," 1815 pages of latest standards, data, and information required daily in the shop and drafting room. **$6.10**

● **The above prices are postpaid in the United States. Add, on foreign orders, 25¢ for postage on each book, except as noted.** ●

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tions relating to calendar change. *Bureau of Publications, Teachers College, Columbia University, 525 West 120 Street, New York, New York.—$1.35.*

FACTS YOU SHOULD KNOW ABOUT REX SPEED PRIME PUMPS is an 18-page catalog based on various models of pumps, their features, specifications, and applications in agriculture, in utility work, in general dewatering use, in oil field and marine field use, and in industry. *Chain Belt Company, 1600 West Bruce Street, Milwaukee 4, Wisconsin.—Gratis.*

SUPERIOR FLUXES FOR WELDING, BRAZING, AND SILVER SOLDERING is an eight-page catalog covering over 20 different fluxes with details on the characteristics of each and a schedule of list prices. The catalog is arranged for easy selection of the proper flux for each application. *Superior Flux Company, 913 Public Square Building, Cleveland, Ohio.—Gratis.*

CATALOG AND HANDBOOK OF BAUER AND BLACK INDUSTRIAL ADHESIVE TAPES is a 21-page loose-leaf brochure listing, on separate pages, each type of industrial tape, a sample, description, and a list of its uses and specifications. *Bauer and Black, Division of The Kendall Company, 2500 South Dearborn Street, Chicago 16, Illinois.—Gratis to requests made on business letterheads.*

METAL QUALITY is a 40-page booklet describing how "hot working" improves quality of metal. Beginning with the ingot, the process is described and illustrated, step by step, through all operations to the finished forging. *Drop Forging Association, 605 Hanna Building, Cleveland, Ohio.—Gratis.*

YOUR FIRE PROTECTION INSURANCE POLICY is a 12-page folder covering the seven basic types of fire extinguishers, their construction specifications, and Underwriters Laboratories classifications, as well as information on the types of fires each extinguisher is designed to combat most effectively. *General Detroit Corporation, 2270 East Jefferson Avenue, Detroit 7, Michigan.—Gratis.*

OCCUPATIONS IN TELEVISION, by John E. Crawford, is a six-page leaflet outlining the training required, methods of entrance, range of salaries, advantages and disadvantages, and postwar prospects of television as a career. Sources of more detailed information are listed. *Occupational Index, Inc., New York University, New York 3, New York.—Single copies 25 cents.*

DIE AND MOLD DUPLICATORS is a 12-page booklet containing data, specifications, a duplicator table, and a tracer head specification sheet for three duplicator models which are used on dies and molds for plastics, rubber, and glass, as well as drop-forging dies, metal patterns, and die-casting dies. Request Bulletin 1319-E. *George Gorton Machine Company, Racine, Wisconsin.—Gratis.*

Our Book Corner

THE BOOK DEPARTMENT of Scientific American is conducted, with the co-operation of the Editors, to make available for you a comprehensive book service. Each month the Editors select and review in these columns new books in a wide range of scientific and technical fields. In addition, they are ready at all times to advise you regarding the best available books on any subject. You are invited to use this service freely. Tell our Book Department what kind of books you want, and you will be furnished with the names of available books, including prices. When inquiring about books, please be specific; remember that we can be of the greatest help only when you tell us just what you are looking for. Books listed in these columns may be ordered from our Book Department. Add 25 cents per book for mailing outside U. S.

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THE AIRCRAFT ANNUAL — 1945

By David C. Cooke

NON-TECHNICAL but technically accurate throughout, this second edition brings its readers completely up to date on details of the aircraft industry and war-time operations. It not only gives a broad view of the whole subject but will serve as an excellent reference book. (288 pages, 7 by 9½ inches, lavishly illustrated.)—$3.10 postpaid.—*A.P.P.*

THE STORY BEHIND GREAT INVENTIONS

By Elizabeth Rider Montgomery

SUITABLE gift for youngsters but not aimed at adults, this is a dramatization in speaking narrative form of the invention of the telephone, phonograph, spinning jenny, lathe, motor, Carborundum, reaper, steamboat, airplane, and a score of others. Your reviewer's boy, 14, says it is a "swell book" but laments the lack of "an invention to make latin and algebra easy." (254 pages, 5¼ by 8 inches, 8 illustrations.)—$2.10 postpaid.—*A.G.I.*

OURSELVES UNBORN

By George W. Corner

EMBRYOLOGIST of world-wide fame here presents three Yale University lectures on human embryology which would interest serious readers, also expectant mothers (and fathers), having scientific curiosity extending beyond the immediately practical; indirectly it would also be of some practical help to these expectants. It is not a manual on prenatal care or a sex book despite its excellent anatomical illustrations. (188 pages, 5½ by 8 inches, 26 ilustrations.)—$3.10 postpaid.—*A.G.I.*

SNOWSHOE COUNTRY

By Florence Page Jaques

DELIGHTFUL and informative is this tale of dog team and snowshoe travels through the great Rainy Lake watershed, in the border country of Minnesota and Canada. The author, as a keen, practiced observer, and her noted artist husband, Francis Lee Jaques, with his characteristic black-and-white drawings, have captured the wild charm of that isolated region and wrapped it around a fund of information on wild life, geography, and geology of the Rainy Lake district. (110 pages, 7½ by 10¼ inches, profusely illustrated with Jaques' drawings.)—$3.10 postpaid.—*A.D.R., IV.*

PORT TERMINAL OPERATION

By Eugene H. Lederer

TRAINING manual for new personnel of piers, export-import houses, steamship lines, stevedoring companies, lighter and tug operators, which covers many aspects of port terminal operation, such as hoisting facilities, paper work, cargo handling, warehousing, administration, stevedoring, stowage, lighterage, towage, and the like. An entirely practical, all-around book. (430 pages, 6 by 9 pages, illustrated.) —$5.10 postpaid.—*A.G.I.*

FUNDAMENTAL PRINCIPLES OF PHYSICAL CHEMISTRY

By Prutton and Maron

NEW college textbook of the special branch of chemistry which deals with the physical properties and structure of matter, laws of chemical interaction and the theories governing them, written by two professors of chemistry at the Case School of Applied Science. Mainly this is a typical text but it emphasizes thermodynamics, with mathematics (calculus), also fulness of treatment. (780 pages, 5½ by 8¼ inches, illustrated.)—$4.60 postpaid.—*A.G.I.*

HELLDIVER SQUADRON

By Robert Olds

A FINE story of Carrier Bombing Squadron 17 with Task Force 58 which, led by Lieut. Comdr. James E. (Moe) Vose, fought the Japanese with Curtiss SB2C Helldivers flying from the deck of the *Essex*. The story is illustrated with sketches of fine pilots, photographs of vivid action, and is exciting throughout, perhaps all the more because of its restrained style. It gives an authentic, graphic idea of the way in which our naval aviation is strafing the Japs on land and sea in the Pacific. At the same time, the book presents a comprehensive, instructive, and reliable account of bombing technique, its accuracy and destructiveness, and its limitations. This is a fascinating book for the general public and for those professionally interested in aviation. (225 pages with illustrations and maps.)—$3.10 postpaid.—*A.K.*

ENOUGH AND TO SPARE

By Kirtley F. Mather

Our planet's important non-renewable natural resources, mainly mineral, are far more extensive than is commonly held, and will last for 1000 to 5000 years, according to the Harvard professor of geology who in this book analyzes and discusses this large subject from several angles including its immediate implications for world organization and planning. Is man then to run through his recently acquired riches within only 5000 years, after living in poverty 500,000 years? Seen against this scale of proportion the reassurances of the cheerful cheerer-upper leave the conservationist a conservationist still. (186 pages, 4½ by 7½ inches, 10 illustrations, map, statistical data, bibliography.)—$2.10 postpaid.—*A.G.I.*

NOAH'S SHOES

By Max Fleischer

Whimsical yarn about a man of today who stocks an ark with all the animals, goes through a great flood and lands on Mt. Ararat, with innumerable sidelights on animal oddities in natural history, all of which the author claims are factual. (160 pages, 5¼ by 8 inches, unillustrated.)—$2.35 postpaid.—*A.G.I.*

FUNDAMENTALS OF ELECTRICITY

By Charles E. Dull and Michael N. Idelson

Compact and to the point is the text of this book aimed at the level of eleventh and twelfth grades in school. It gives a sound basic presentation of the whole subject of electricity, in more comprehensive scope than is found in physics textbooks. (456 pages, 5½ by 7½ inches, thoroughly illustrated with photographs and drawings.)—$1.30 postpaid.—*A.P.P.*

GENERAL METEOROLOGY

By Horace Robert Byers

While this textbook, by the professor of meteorology at the University of Michigan, starts at the beginning, it is less elementary than some others and involves the calculus (a little, not heavily) and college physics. Its coverage includes dynamic and synoptic meteorology, with thermodynamics, air mass analysis, and forecasting technique, as well as the surrounding general aspects of meteorology and the recent advances. Since considerably more advanced treatises exist, this one therefore rates as intermediate and it probably would best suit the reader who prefers something fairly substantial. (645 pages, 5¾ by 8¾ inches, 300 illustrations.)—$5.10 postpaid.—*A.G.I.*

PIONEERING THE HELICOPTER

By C. L. "Les" Morris

One of the nation's most skilful helicopter pilots, and the first to take the new kind of aircraft more than 5000 feet above the earth, tells in lively and simple fashion how the Sikorsky helicopter, to date the most successful, grew from the experimental stage under the guidance of its designer, Igor Sikorsky, until it was capable of sustained vertical flight as well as hovering, and flying backwards and forwards with safety and precision. Mr. Morris was Sikorsky's chief test pilot in the helicopter development and his unpretentious account answers many of the questions the flight-minded layman has been asking about this newest form of aviation. (161 pages, 5½ by 8½ inches and numerous photographs.)—$2.85 postpaid.—*J.C.*

ON YOUR OWN

By Graham and O'Roke

Within the covers of this one small volume are condensed the many-sided field instructions for which you would surrender your whole fortune if suddenly stranded in wild country: how to find emergency food (plants, insects, other animals, anything to support life); how to deal with dangerous animals; how to avoid diseases; how to get out. For lack of this book the Swiss Family Robinson had many troubles. Your soldier or sailor son and his buddies would pore lengthily and perhaps profitably over these practical pages. (150 pages, 5 by 8 inches, 52 illustrations.)—$2.10 postpaid.—*A.G.I.*

THEORY OF GAMES AND ECONOMIC STRATEGY

By Von Neumann and Morgenstern

Mathematicians will grasp the connection between games and economic strategy, which is approximately this: The exposition of the various applications of mathematical theory to games (and if you glance at this book you may get some glimmering of why it may be dangerous to get into a game with a mathematician, also the principles involved in these applications, are used as a springboard for the newer investigation of sociological problems—but *not* as light summer reading except for mathematicians. The authors are respectively professor of mathematics at the Institute for Advanced Study (Einstein), Princeton, N. J., and professor of economics at Princeton University. (625 pages, 6 by 9 inches, 103 figures.)—$10.10 postpaid. —*A.G.I.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IN MAKING achromatic objectives for refractors, an approach from another direction than the more familiar one is described below by Patrick A. Driscoll, 39 Bateau Terrace, Rochester 12, N. Y. While this "testplate method" involves a little more work, it requires no optical flat and avoids other headaches.

Asked to tell about himself, Driscoll says: "In 1930 I stumbled across the telescope making hobby when I was a ship model fanatic, and suffered a direct hit in the superstructure. I have had Carbo in my teeth ever since, having been an 'A.T.M.' (amateur telescope maniac) and made a 5" and two 6" achromats, also eyepieces, prisms, and so on. I am now an experimental lens maker employed by the Eastman Kodak Co., Hawkeye Works. Thus you might call me a sort of amateur professional amateur." His article:

SPECIFICATIONS—The data in Figure 1—the radii, *r*, each *r* being numbered with a subscript, and thickness *t*, similarly numbered—have been very carefully calculated to produce an ideal telescope objective. All tolerances have been worked out to give the greatest permissible leeway, for error in measurements.

Crown component: Bausch and Lomb Optical Co. (Rochester, N. Y.) Light Barium Crown LBC-2, N_d 1.5711, V 57.3, thickness at center 17 mm, diameter

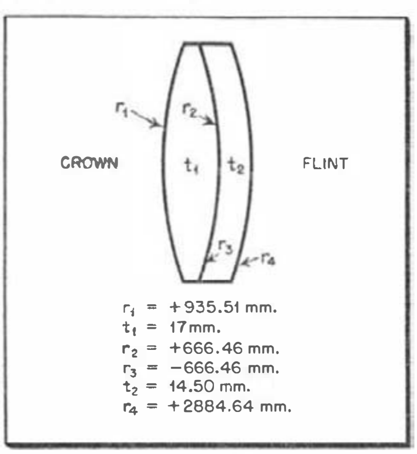

Figure 1: Specifications

4⅞" (thickness of blank 19 mm, diameter 5¼").

Flint component: Bausch and Lomb, Extra Dense Flint EDF-2, N_d 1.6890 V 31.0, diameter 4⅞", thickness at center 14.5 mm (thickness of blank 18.5 mm, diameter 5¼").

Finished diameter, 125 mm; e.f.l., 1480.82 mm (58.30"); focal ratio 11.84.

Hold thickness of each component to plus or minus 1 mm; radii to 1 in the third significant figure (for example, plus 666.46 would be passable at 665.46).

To convert millimeters to inches, divide by 25.4.

METHOD—In place of the method involving regrinding or repolishing the fourth surface to correct variations of curves on the other three, we shall first make concave test plates, or masters, to match the desired curve of each lens surface, controlling them by our familiar old friend the Foucault knife-edge test, and then test our lens surfaces against these test plates by means of Newton's rings and the simple setup described in "A.T.M.," page 244. We shall then be sure that, since the original computations and specifications by which we make the masters are correct; and since we shall make the masters correctly to them; and since we shall make the lens surfaces faithfully to these masters, our achromatic lens itself will be—must be—correct.

Making our test plates will be exactly like making spherical mirrors, but four spheres look like a lot of work. Let's investigate.

Surface 1, the r_1 surface of Figure 1, calls for one test plate.

Surface 2 will be worked against surface 3, tool-and-mirror fashion; surface 3 becomes the test plate for surface 2.

Surface 4 calls for a test plate.

Net extra labor, therefore, two temporary test plate curves—minus the job of making a flat.

For the first of the surfaces—surface 1 (+935.51 mm)—we shall use the crown blank as the tool and work a 5¼" disk of common one-inch plate glass to the corresponding concave radius; roughing, grinding, and fine grinding precisely as in producing a spherical mirror, as described in "A.T.M." To obtain the desired curvature, an arc of radius 935.51 mm is scribed on a thin piece of window glass at least 14" long, using a glass cutter, and this glass is broken apart to make a template ("A.T.M.," pages 310, 344); the best 6" section that shows evenness of break being used. Our tool, when this is done, will be our crown component and will have been completely fine ground to curve on one side.

For the other test plate, the one for surface 3 (—666.46 mm), we use the other side of the crown as the tool and the flint as the "mirror," proceeding as before. The result is the flint fine ground to —666.46 mm and the second surface of the crown similarly fine ground to the corresponding plus curve. This finishes the grinding of the crown; care, of course, having been taken to bring it to the desired thickness—the computations called for 17 mm and we started with 19 mm, a 2-mm leeway for grinding. We also have, as has already been stated, a 1-mm plus or minus tolerance on thickness of either component. This will eliminate elaborate miking devices and automatically chloroform that bugaboo of the amateur optician, the fear of deviating from stated formulas. We would not ruin our reputation in optics nor would we spoil the performance of our objective lens if, on completion, the latter were to come out with a crown curve, for example, of plus 666.00. Any such small percentage of error still will produce a *good* achromat and a pleased maker.

In grinding a lens having a curve on either side it is important that the surfaces be centered with respect to each other; that is, that the optical axes of the respective surfaces be made to coincide longitudinally; otherwise we shall have what is termed a

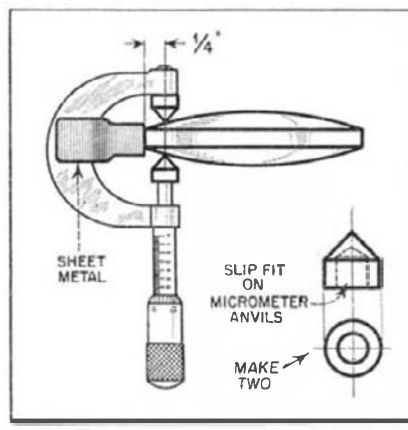

Figure 2: Adapted mike

prismatic lens and this "prism" then could be removed only by centering the lens far below the diameter we want. The 5¼" blanks have enough excess of glass for centering out slight errors in edge thickness but, when grinding the second sides, we should occasionally check the thickness at several points around the circumference. Micrometering is best but measuring with a steel scale will be satisfactory at this stage. The mike shown in Figure 2, with some kind of stop-block attached, will give very accurate readings, but such close readings—an alternative for the most exacting amateur—are unnecessary.

If one side shows thicker than the other, apply more grinding to the thick side. Stop occasionally moving around the lens and make extra strokes on that side.

For the last step in the grinding operations we now take our flint blank, which is already ground to the —666.46 curve (surface 3) and, turning it over and using it as a tool, place the plate glass test plate (which already has the —935.51 curve fine ground on it) flat side down and once again make a concave surface, this time —2884.64. When this concave test plate is finished in its fine grinding, the last side of the flint lens is also finished to +2884.64 so far as grinding is concerned. Care is taken again to bring it to tolerated thickness and to check for prism. Our test plate also is finished, so far as grinding is concerned, since it now has concave curves on both sides. This eliminates a second plate glass blank and gives us something to feel really bad about if we drop it.

The flint lens, having a concave surface on one side—exactly the same curve as the convex surface of the crown—automatically becomes the third test plate surface; the only drawback being that, in placing the flint and crown together for testing purposes, care must be taken not to slide them and scratch the flint lens.

In all stages of the fine grinding on all the surfaces of the test plate and components we have made every effort to fit the lenses tightly to the template.

Because emery, which is graded in mesh sizes, is more consistent in grain size than Carbo, I prefer to do grinding with emeries. Suitable emeries are made by Bausch and Lomb and by the American Optical Co. Since the time lost in washing up and changing during use of very elaborately graduated series of emeries, such as eight sizes, tends to annul the time saved by their use, three sizes only—No. 180, No. 500, and No. 1200—will fully suffice and will produce perfect work.

This will be especially true if the micrometer is used for measuring glass removal and for controlling the old bugaboo, pitted edge. Before grinding is started, a permanent mark—nick with a file or a glass cutter—is made on the edge of the blanks. After the lenses have been brought to fit the template with No. 180, they are miked near this mark and the reading is written down. At least 0.008" of glass thickness must then be removed with No. 500 in order to wipe out all pits left by No. 180. At least 0.004" additional must similarly be removed by No. 1200.

During work on all sizes the familiar trick of inverting and working the tool on top should be made available for helping to arrive at gage fit.

In roughing out with No. 180, a long stroke—almost edge to center—may be used.

If the mark is overshot in the 500 stage, the curve may be brought closely to gage through resort to several alterations of inversion and return. No departure thicker than an average sheet of writing paper should be permitted to creep in at the second and third stages.

In all stages of emery it is most important to spread it evenly. A blob of emery in the center will dig its own hole, and a smear on the edge will turn the edge.

The emery should be watery, not thick. In the 1200 stage it should not be allowed to dry out too much. A wet mixture cuts faster and reduces the likelihood of scratching.

After the 500 stage, and again at the 1200 stage, the edges should be beveled slightly with some 500 and a small piece of glass. To eliminate any chipping of the edge the bevel should be retained throughout the 1200 stage and throughout polishing.

POLISHING—Now, after many tedious hours, we are ready to polish. Let the good worker's rule be: "Never polish one side until the other side is ground." Thereby hangs the tale of no scratching.

The test plate must be polished first, in order to give us a master reference to apply to the crown and flint curves.

In polishing we can once more refer to "A.T.M.," page 85, for procedure; except that, having polished innumerable lenses both by machine and by hand, I wish to make a suggestion that will immensely benefit the amateur, both in polishing time saved and in the figure produced. That is, to make our polisher 6/5 the diameter of the lens, when working with lens on top of the polisher, and 5/6 the diameter of the lens when working with the polisher on top.

In polishing lenses of such long radii, it is not necessary to have a curved polisher base. For a base we can use flat plywood disks, heavily shellacked. Let the thickness of the pitch be approximately ⅜" and, when the pitch is shaped to curve, scratch lines into it to form about ½" squares about 1/16" deep. Lines this close and this shallow will flow in more quickly than a more familiar kind but will give more polishing facets. They will also facilitate the rouge flow, and keep better contact with the lens. Do not try to cut them in an absolutely even pattern; merely scratch them freehand, as they flow in.

The —935.51 curve on the plate glass test plate will be our first polishing surface, and here we can take heart in the fact that neither side of the test plate has to be completely polished out. It is necessary only that we have a fairly good polish on it so that under Foucault's test it will give a reasonably bright reflection. Don't worry about pits but, if you feel that a test plate surface should be perfectly polished, then polish it perfect and accept my commendation on your perseverance.

We set up the Foucault test to find our radius of curvature and in so doing we once more digress from the familiar method, substituting for the opaque knife-edge a piece of thin glass (microscope specimen slide?) frosted on one side, and for the pinhole a ¼" hole covered with coarse wire mesh (window screen), arranging these so that knife-edge and pinhole will move always equidistant from the lens. These are shifted to the point where the image of the pinhole is sharpest on the ground glass. With a steel tape, one end held by our partner (friend wife?), this distance is measured from the center of the test plate. My experience has been that any good steel tape will measure accurately within the tolerance to which we are working. One half millimeter is close enough. If over or under the specification, the test plate curve must be brought within the tolerance by polishing.

Driscoll's instructions will be continued next month but the specified glass is temporarily unavailable: war.

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