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ELEMENTARY HEAT PROBLEMS

By Angus Sinclair.

THE burning of fuel and the boiling of water into steam are the fundamental processes by which the dormant forces of nature are converted into the power that performs the heavy labor that carries the burden of mankind. To keep a fire hot so that it will cause a kettle to boil seems a simple operation, yet every one who has to pay the bills for kitchen fuel knows that to produce the same result some firemen of this most simple kind of furnace burn more fuel than others. When we find the fire grate or stove developed to the furnace of a larger boiler or the firebox of a heavy locomotive, the difference of the fuel used by a good and a poor fireman becomes a very serious matter. We know of no line where the power of knowledge is likely to effect so much saving for steam users and of the fuel treasures that have been laid up for the use of man as in the spread of information relating to the laws of combustion.

The burning of fuel being a chemical operation, the subject can not be properly understood without some insight into the science of chemistry as it relates to combustion. To those whom the word science frightens, it may be well to mention that science is merely accurate knowledge. Those who have no inclination to follow the best way of doing things, generally have contempt for everything of a scientific nature. Knowledge and the sense to apply it make a strong combination and produce the man of ability. Science or knowledge does not, however, always bring wisdom. There is truth in Pope's lines on the Seven Sciences:

> Good sense, which only is the gift of
> Heaven,
> And though no science, fairly worth
> the seven.

It is much better to have an engineer or fireman with good sense and no science, than one with much science and no sense. But the man having both is certain to be of greatest value to an employer and to himself.

In treating of combustion and steam making I will frequently have to refer to the laws of nature. Everything in nature is guided by a mysterious power which controls and regulates its formation, growth or action. For want of a better description this power is called the laws of nature. When a seed is put into the ground it produces a plant after its kind; when steel is poured into a mould the molten metal will cool into a very hard substance; when molten lead is treated in the same way the product will be a soft casting. If a piece of wood or coal is raised to a certain high temperature in the presence of air it will burn. If the gases hydrogen and oxygen come together at a high temperature 212 deg. Fahr. it will become water. If the water in turn is subjected to cold greater than 32 deg. Fahr. it will become ice. All these changes come about in obedience to the laws controling the different substances. We know nothing of how the laws of nature were established and we are ignorant of how the power is applied that enforces them; but the human mind can conceive of nothing more absolute than their action. From the daily rising of the sun and the regular movements of other heavenly orbs, to the more familiar sight of how a seed produces its own leaf and how the frozen raindrop forms a crystal of a certain shape, all are illustrations of the exactness of the immutable power that rules the universe.

Everybody is familiar with the sensation of heat, but how the sensation is produced is not popularly understood. A fire burns and it gives forth heat, the sun's rays are warm to the touch, the hand of a vigorous man feels warm, and the turnings that fall from a lathe tool making a deep cut are hot enough to burn the fingers. These are all different manifestations of heat. How are they produced?

The question is as old as scientific speculation. Few subjects have received more attention from philosophers. Up to the beginning of the present century heat was supposed to be of a kind of a subtle fluid which had no weight and was capable of insinuating itself into the inmost recesses of all visible matter. This fluid was supposed to have taken up its favorite residence in all kinds of fuel and was resting in a semi-sleeping condition, awaiting the kindling spark to bring it into intense action.

Experiments were made by Davy, in the last year of the last century, which led to a thorough scientific investigation of the subject by the ablest philosophers of modern times. By rubbing together pieces of ice, Davy demonstrated that heat could be produced by friction. Others proved the case even more conclusively. The discoveries subsequently made have led to the establishment of what is known as the dynamic theory of heat. This theory holds that heat is a form of energy, and that it is caused by intensely rapid vibratory motion of the molecules forming the heated substance. According to this theory, heat, light, electricity and chemical action are all merely different manifestations of matter in motion.

Heat is measured by what is called the thermal unit or heat unit. After a long series of experiments conducted with extraordinary care and exactness, Dr. Joule, a famous English physicist, discovered that the amount of heat required to increase the temperature of one pound of water one degree Fahr. represented energy sufficient to lift a weight of 772 pounds one foot. This is known as the heat unit, and is used in reckoning the value of fuel and for many other purposes relating to heat and steam. Later investigations proved the heat unit to be 778 foot-pounds.

The energy of heat is estimated by its power of doing work. In physical science the term work means the overcoming of resistance of any kind. All operations performed by animals or machines requiring the exertion of power is classed as work. Heat may be transformed with work and work changed into heat. The science relating to the conversion of heat into mechanical action is called thermo-dynamics, and its first law says: "When heat is transformed into mechanical energy or mechanical energy into heat, the quantity of heat equals the mechanical energy." This is a scientific law that every one studing steam engineering ought to commit to memory.

If an iron rod set on an anvil is struck several sharp blows with a hammer it is made hot. The mechanical energy represented by the descending hammer is converted into heat. If any ordinary drop-hammer is employed the amount of heat generated is the same quantity that would be required to raise the hammer to the point from which it fell.

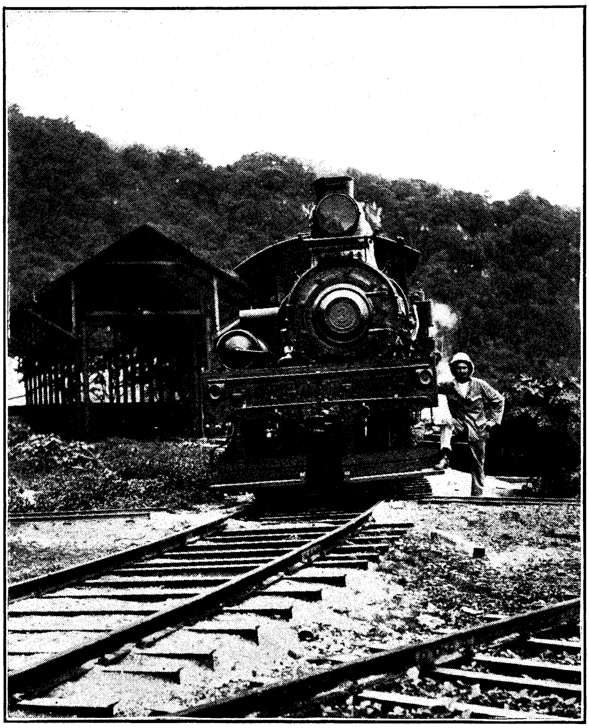
Work is measured by foot-pounds, or the amount of labor represented by the raising of one pound one foot high. The work done by machinery and engines is generally estimated by the horse power, which is equivalent to the raising of 33,000 pounds one foot in one minute. It does not matter in what direction the power may be applied. It may be 330 pounds raised 100 feet in one minute or the height and distance may vary to any extent so long as the unit is 33,000 of weight by pounds and feet performed in one minute. The weight may be pulled or pushed horizontally, or moved at any angle from the perpendicular and the result will be the same so long as the pull or pressure represents 33,000 pounds with the distance in feet traversed in one minute.

When the demand of a growing business required that James Watt, the famous engine improver, devise some method of measuring the power of steam engines, he thought of several plans, but finally decided that horse power

(continued on page 8)

The Shay Geared Locomotive

THE Geared Locomotive is especially designed for heavy hauling on steep grades, sharp curves and uneven tracks, and the ideal geared locomotive should be efficient, durable and economical. The general principles underlying the construction of the Shay Geared Locomotive, the subject of this sketch, was conceived by a Michigan Lumberman in 1873. It was a success from the very first, but of course the many years of experience the builders have had in building this locomotive, linked with the long experience of one of the most complete Engineering Corps of technical trained engineers in the country, has added to it the most modern improvements so that today the Shay is the only geared locomotive recognized to be standard the world over. It is superior in every point which goes to make up an ideal geared locomotive—it is so constructed that it will perform the greatest amount of work—thus superior in durability. By reason of the excellent design, large deep firebox, large extended wagon top boilers, three cylinders, etc., the Shay shows great economy in operation and maintenance.



Seventy-ton Shay Locomotive at plant of Christmas Island Phosphate Co., Christmas Island.

The builders of the Shay Locomotive find the following requirements are necessary in a COMPLETE GEARED LOCOMOTIVE.

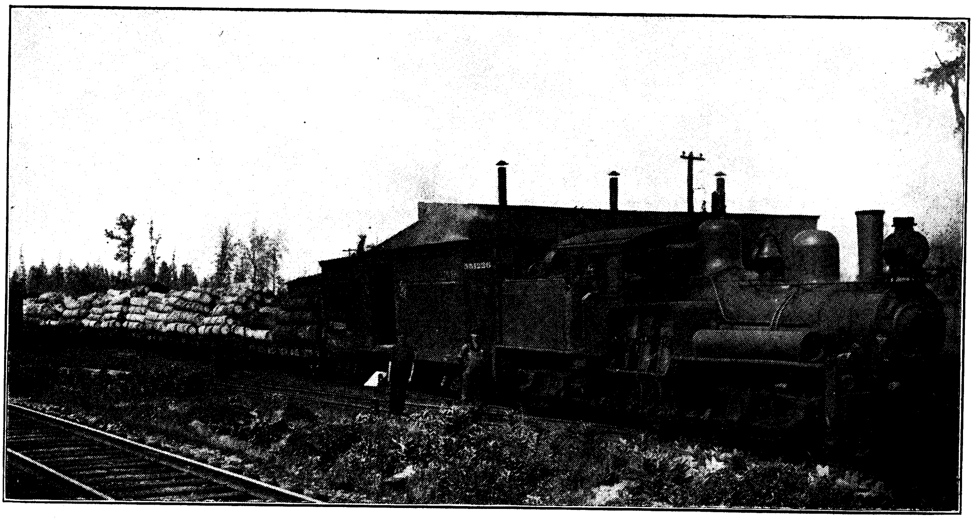
1st—SIMPLICITY. As practically all geared locomotives are operated in some remote place a great distance from the base of supplies, the wearing parts should be as simple as possible so as to be easily replaced if broken, also understood by ordinary mechanic and engineer. All cylinders, gears and shafts should be on outside of engine so the engineer can have easy access to these parts for adjustment and oiling.

2nd—WORKMANSHIP, MATERIAL AND DESIGN. The geared locomotive by reason of severe service which it is called upon to perform should be constructed of strictly first-class material—the workmanship should also be first class, and the design such as to insure continuous service with least trouble, day in and day out, year in and year out, and no attempt made to obtain ornamental polish, outside of good clean and substantial finish.

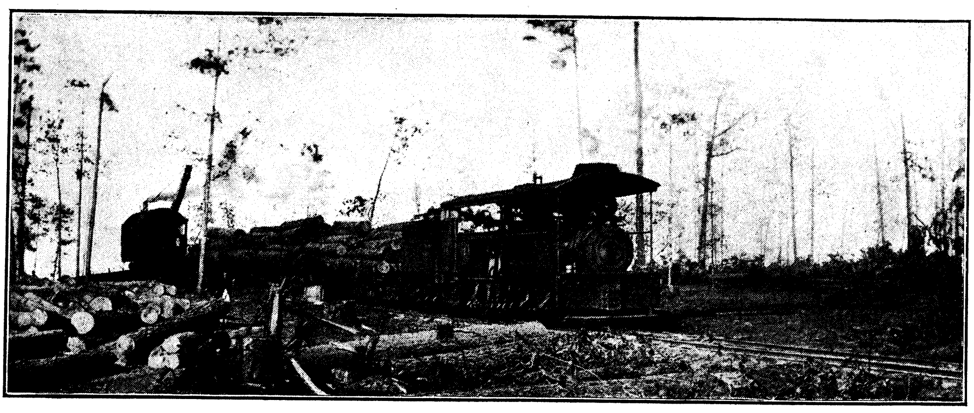
3rd—GREAT FLEXIBILITY. A geared locomotive should be of such design and construction to avoid a tendency to leave the rails on sharp curves and uneven tracks; should have such flexibility in trucks to avoid loss of power from flange wear and furthermore the vibration should be reduced to a minimum which can only be accomplished by a perfectly balanced three cylinder locomotive.

4th—HEAVY TYPE OF CONSTRUCTION. The trucks should be constructed entirely of iron,

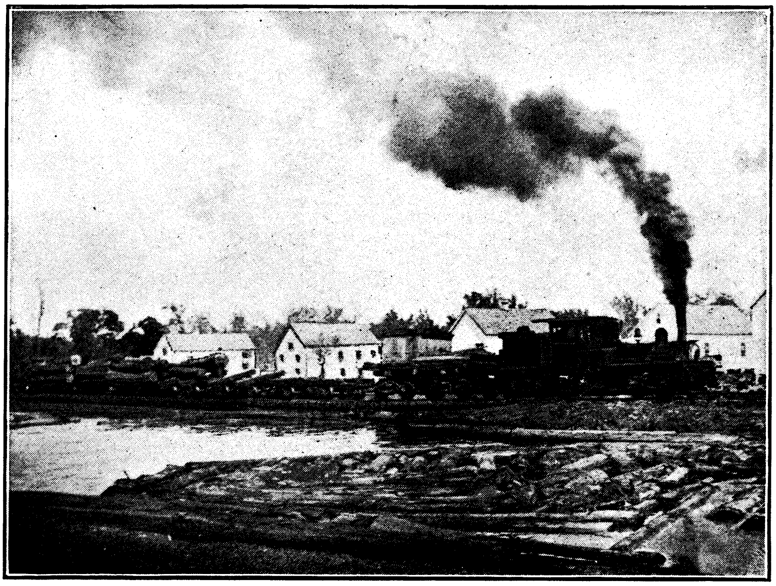
Logging Train in Woods Great Southern Lumber Co., Bogulsa, La.—70-ton Shay Locomotive.



Logging Railroad Cobbs & Mitchell, Boyne Falls, Mich.—42-ton Shay Locomotive.



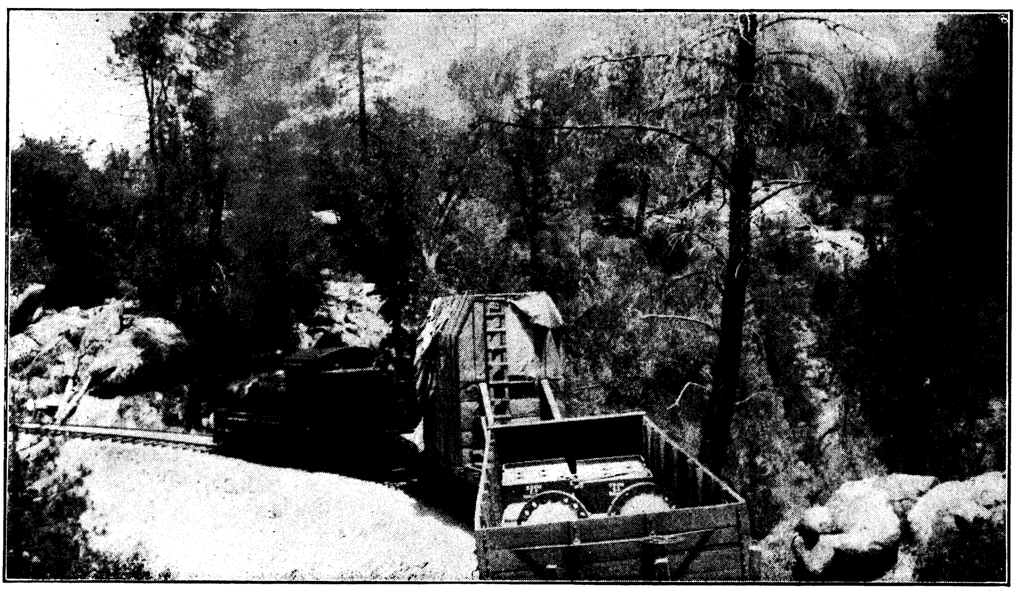
View of Logging Railroad of Eastman, Gardiner & Co., Laurel, Miss.



Twenty-four Ton Shay in use by Morley Cypress Co., Morley, La.

steel and bronze, and should be of heavy type to stand the severe shocks which are common to conditions on ordinary railroads where heavy grades, sharp curves and uneven track are prevalent. All bearings should be made of phosphor bronze, accurately machined and fitted; should be easily replaced and be readily adjustable for wear.

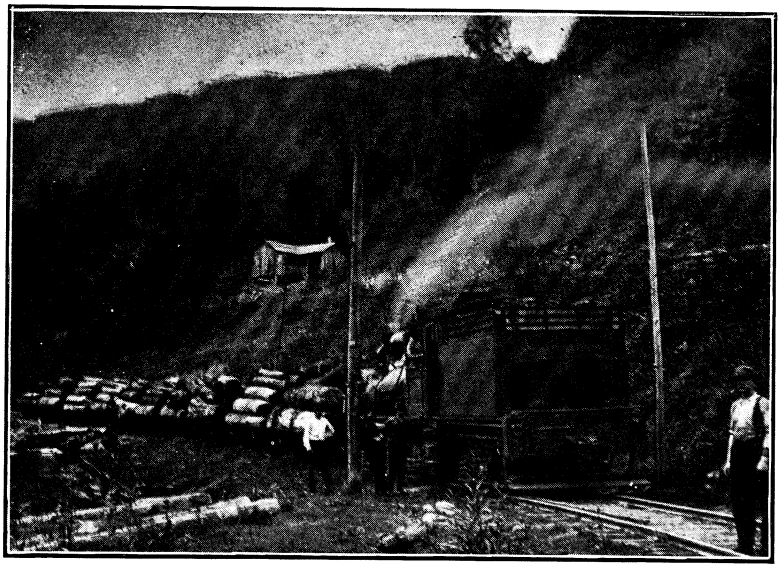
5th—ELIMINATION OF WEARING PARTS. The least possible number of gears should be used. They should have extra large wearing surfaces and contain sufficient metal to give ample strength after being worn to stand the most severe shocks without breakage. Cylinders, or engines as they are sometimes called, should be located so they are easily inspected



Shay Locomotive, 60-ton three truck on Big Creek Hydroelectric Project in California.

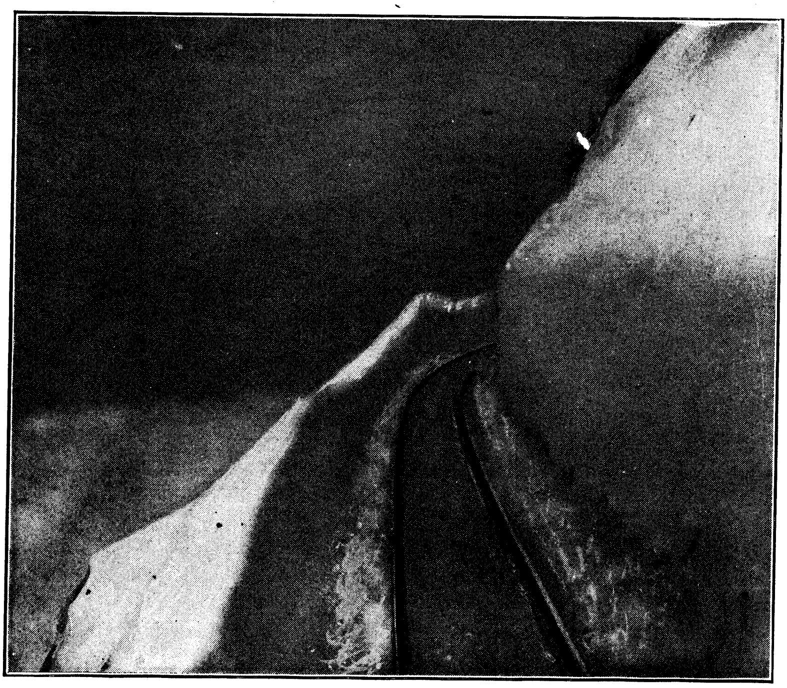
and cared for. Cylinders should be properly proportioned so that the angularity of the rods is not too great, eliminating wear on pistons and other parts.

6th—AMPLE BOILER CAPACITY. The boiler should be large for given weight of locomotive, so that it is not necessary to force it to get the amount of steam required for severe duty. The firebox should be large and deep to give large firebox volume so that all fuel gases will be consumed, before passing out through flues, giving the maximum economy in fuel.



View Logging Railroad Pidgeon River Lumber Co., Crestmont. N. C. 50-ton Shay Locomotive Pulling Train.

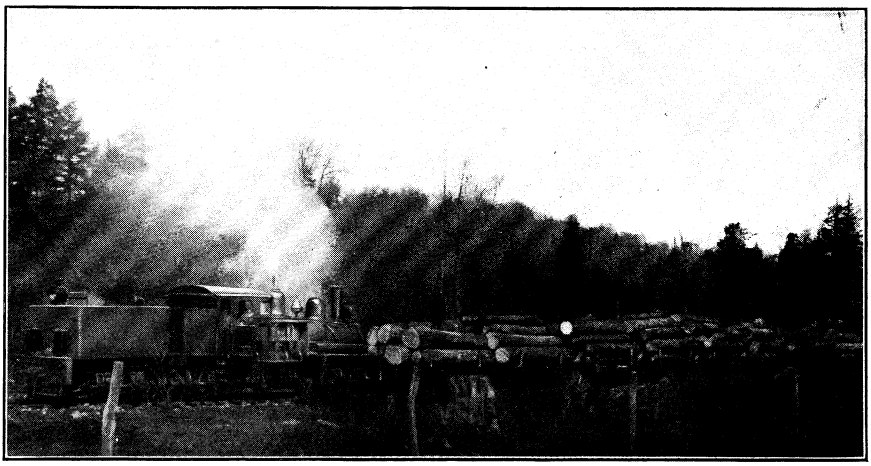
The above points of superiority are embodied in the Shay Geared Locomotive, and the fact that seventy-five per cent of all geared locomotives built to date are of the Shay type, it can be readily understood that manufacturing lumbermen in all parts of the world where the saw milling industry is carried on extensively, are large users of the Shay Locomotive.



View Taken from Back End of Moving Train Pulled by 42-ton Shay Locomotive Passing the Steepest Mountain Side, Grade on Railroad 7½%, Uintah Railway, Mack, Colorado.

The Shay Geared Locomotive is better adapted for service on logging roads because it is constructed especially for spur tracks, steep grades, sharp curves, light rail and uneven temporary track. While many logging roads of today are built with the heavier rail and well ballasted, yet the largest percentage of logging railroad mileage is made up of the more or less temporary track.

The illustrations shown will give the readers an idea of the class of work being performed by the Shay. The Lima Locomotive Corporation, builders of this type of locomotive, have hundreds of such il-



Legging Railroad, Babcock Lumber Co., Ashtola, Pa.—70-ton Shay Locomotive.

lustrations which will prove beyond a doubt to the most skepitcal mind that no other locomotive on the market has attained the same degree of supremacy for such work, as the Shay.

Stockholders in Railways of the United States

The Bureau of Railway Economics, Washington, D. C., has prepared a bulletin showing data as to the number of stockholders and average amount of stock per stockholder, in railways of the United States, June 30, 1914. Returns of the railways to the Interstate Commerce Commision were used in preparing the figures, and the roads are divided into three classes, following the practice of the commision. Class I roads are those having annual operating revenues of $1,000,000 or over, class II roads of less than $1,000,000 and not less than $100,000, and class III roads of less than $100,000. The compilation shows, for the United States, as a whole, a total of 1287 roads, which have 622,284 stockholders and outstanding capital stock of $8,685,764,125. The average amount of stock per stockholder, par value, is $13,958. These figures comprise 837 operating roads, and 450 non-operating roads, for the former of which there are 539,438 stockholders, and $7,351,202,529 capital stock outstanding, and $13,628 stock per stockholder, par value; while for non-operating roads there are 82,846 stockholders, $1,334,561,596 capital stock, and $16,109 stock per stockholder. The data for the respective classes of operating roads are as follows: for 171 class I roads, 520,918 stockholders, $6,774, 840,346 capital stock outstanding and $13,006 stock per stockholder, par value. For 271 class II roads, 10,040 stockholders, $441,579,609 stock outstanding and $43,982 stock per stockholder. For 395 class III roads, 8480 stockholders, $134,782,574 stock outstanding and $15,894 stock per stockholder.—*Railway Review.*

Vessel Losses During the War

A record of merchant vessels of all classes destroyed from Aug. 1, 1914, to June 30, 1915 compiled by the Journal of Commerce, Liverpool, shows a total of 511, with a gross tonnage of 915,547 (approximate). Naturally the greatest proportion of the total loss has fallen on Great Britain. This amounts to 170 steamships of 577,986 gross tons, and 157 trawlers, smacks and sailing vessels, of 31,948 tons, a total of 327 vessels of 609,934 tons. Other vessels owned by the allied nations destroyed during the same period are: France, 24 vessels of 42,233 tons; Russia, 17 vessels of 16,024 tons, and Italy, 2 vessels of 3,826 tons. Of the enemies' vessels 34 German vessels of approximately 102,062 tons, 4 Austrian vessels of 5,691 tons, and 9 Turkish vessels have been destroyed. These figures are only of vessels actually destroyed, and do not include the numbers and tonnage of vessels which have been interned in neutral countries, of which the greater number are German. Taking the last figures available of the total merchant tonnage of the various countries of the world, the loss of tonnage by Great Britain shows approximately 4½%, and of Germany approximately 3%. — *Canadian Railway and Marine World.*

(continued from page 2)

would be the most comprehensive. Nearly everybody knew in a loose way something about the load a horse would haul, so Watt proceeded to find out with exactness the hauling capacity of the horses in his neighborhood. Experiment proved that an ordinary horse would put a strain of about 220 lbs. upon the traces of a wagon and travel at the rate of 100 ft. per minute. That was the equivalent of raising 22,000 lbs. one foot per minute, and was in its day known as the actual horse power. Business was very dull in steam engine building at the time this investigation was made, so Watt and his associates, in order to stimulate business, began offering to sell engines with horse power reckoned at 33,000 lbs. raised one foot per minute. Of course, engine purchasers readily accepted this inducement, but it proved like many other cases of breaking prices, much more easy to reduce than to restore. So in the course of time the standard horse power of all nations became 33,000 foot-pounds.

It is a common thing to find a locomotive that is capable of exerting a pull of 16,500 lbs. of the draw-bar when running at a low rate of speed. An engine keeping up this pull at a speed of ten miles an hour exerts 440 horse power.

In connection with elementary mechanical questions an interesting problem for railroad men to solve is the foot-pounds of energy in a moving train and the heat units represented by the conversion of mechanical energy into heat when the train is suddenly stopped. When the losses from friction and air resistances are eliminated, it takes exactly the same amount of energy to stop the train that it takes to force it into speed. Suppose a train of one engine and seven sleeping cars, the whole weighing 600 tons, is running sixty miles an hour, required the energy of the moving mass and the heat unit represented by its conversion into heat? The problem is stated algebraically, $\frac{w \times V^2}{2g}$, in which w is the weight of the train, multiplied by V^2, the square of the velocity, and divided by 2 g, twice 3.16 the velocity, which a falling body acquires at the end of one second. The weight of the train is 120,000 lbs., the speed 88 ft. per second, so we have the problem arithmetically:

$1{,}200{,}000 \times 88 \times 88 \div 64.32 = 144{,}477{,}600$ foot pounds.

That is the energy of the train regarded as a moving body like a huge shot. But something else has to be considered. Each wheel in the train has revolving momentum in itself similar to the inertia of a revolving fly-wheel, and this course of energy has to be calculated because it tends to keep the train in motion and is an important portion of the momentum to be overcome in the stopping of a train.

The tread of the wheel has the same velocity as the train. This is called the angular velocity of the wheel. If all the weight of a wheel were at the circumference it would be easy calculating the momentum. But as the weight extends from the center of the axle, where movement is imperceptible, to the tread, where the velocity is the greatest, the energy of rotation has to be estimated from a point called the center of gyration. To find this point with exactness is a complex problem, but it is near enough for practical purposes to assume that the center of gyration of a car wheel is at a distance of one-fifth of its radius from the circumference. The angular velocity of the wheels of our train is, therefore, four-fifths of the speed of the train.

Our whole train has about the following wheel and axle weights:

	Lbs.
7 Sleepers, 42 wheels, 21 axles, total weight	37,800
12 Small wheels of engine, 6 axles, total weight	19,200
4 Driving wheels of engine, 2 axles, total weight	6,000
Total	63,000

The velocity of our train was 88 ft. per second. We have now 4/5 of 63,000 pounds to be calculated in the same way as the energy of the train was figured out. The problem is $63{,}000 \times 4/5 \times 88 \times 88 \div 64.32 = 6{,}040{,}000$ foot-pounds. This sum added to the energy of the moving train previously found, makes a grand total of 150,517,600 foot-pounds. This sum divided by 778, the number of foot-pounds in a unit of heat, gives 193,467 heat units, into which the mechanical energy of the train will be converted in stopping.—*Railway & Locomotive Engineering.*

Effectiveness of Wood Preservatives.

Washington, D. C.—The effectiveness, in checking the growth of fungi, of a number of preparations used for preserving wood has recently been tested by the United States Department of Agriculture and the results published in a professional paper, Bulletin No. 227. The investigators found that in general the common molds among the fungi were more resistant to poisons than the true wood destroying fungi, and that even among the latter group the different species showed a great difference in susceptibility.

The tests were made by the Petri-dish method and the results with eighteen wood preservatives used in connection with Fomes annosus and Fomes pinicola are given in the following table. The quantities mentioned are sufficient to stop growth in a cubic foot of culture medium.

For Fomes Annosus.

		Pounds
Coal-tar creosote:		
Fraction II		0.14
Sodium fluorid		.16
Cresol calcium	0.09	.18
Coal-tar creosote:		
Fraction I		.19
Fraction III		.20
Zinc chlorid		.31
Coal-tar creosote, Grade C		.34
Water-gas tar distillate (Sp. Gr. 0.995)		.41
Wood creotote		.41
Hardwood tar		.78
Coal-tar creosote:		
Fraction IV		2.06
S. P. F. carbolineum		2.8
Avenarius carbolineum		3.27
Coal-tar creosote:		
Fraction V		20.59
Copperized Oil		25
United Gas Improvement Co., 1.07 oil	Over	25
None Such Special	Over	25
Sapwood antiseptic	Over	25

For Fomes Pinicola.

		Pounds
Coal-tar creosote:		
Fraction III		0.08
Fraction IV		.08
Fraction II		.09
Sodium fluorid		.09
Wood creosote		.13
Coal-tar creosote:		
Grade C		.14
Fraction I		.14
Avenarious carbolinium		.19
Zinc chlorid		.47
Hardwood tar		.47
Coal-tar creosote, Fraction V		4.87
Copperized oil	Over	25
United Gas Improvement Co., 1.07 oil	Over	25
None-Such Special	Over	25

—*The St. Louis Lumbermen.*

Big Crops will be Record Breakers.

Washington, D. C.,—Three billion bushels of corn, one and a half bushels of oats, and a billion bushels of wheat, are in prospect for this year's American harvest. Record crops of rye, white and sweet potatoes, tobacco, rice and hay also are predicted for the prosperous farmers, who have planted 310,546,000 acres or 10,000,000 acres more than last year, to their principal products.

The wheat crop, the largest ever grown in any country, will be worth more than $1,000,000,000, while the corn crop's value may reach $2,500,000,000. Estimates of the principal crops, announced today by the department of agriculture, based on conditions of August 1, show that all crops will be greater than last year. Interest centered on wheat and corn. Both showed improvement over July conditions, though excessive rains and clod in the central states interfered with threshing. Oats also suffered in those states, but in other sections the improvement more than offsets this.

Corn prospects increased almost 100,000,000 bushels with the principal gains having been Illinois, 30,000,000 bushels, Kansas 24,000,000 bushels, Nebraska 15,000,000 bushels, Iowa 14,000,000,000 bushels and Texas 10,000,000.

Kansas showed a loss of 12,000,000 bushels in winter wheat; Oklahoma 6,000,000, Nebraska 4,000,000 and Missouri 3,000,000 while Ohio and Indiana showed an increase of 3,000,000 bushels each.

White potatoes promise to exceed their former record production by 103,000,000 bushels and sweet potatoes by 4,000,000 bushels. Other increases over record crops indicated include, tobacco 28,000,000 pounds, flax 4,200,000 bushels, hay 2,400,000 tons, and rye 1,300,000 bushels. Corn prospects fell 206,000,000 bushels and oats 16,000,000 bushels below the records.

Consider the men whose names mean efficiency, achievement, success. Notice that practically everything they undertake comes out as it should.

The reason is simply that these men have the habit of making good. There is no luck about it. They have acquired a habit.

That habit—the habit of making good—was gained by hard work and the unsparing expenditure of energy.

The successful conduct and development of the railway industry requires the services of thousands of men who are chosen for their fitness for the positions to be filled.

And in proportion to a man's fitness is his career. If a trial proves him to be unfit, he is dropped. If he proves his fitness for a higher post, he gets it in due course.

The opportunities in the railway field are practically without limit. Given a normal brain and the desire and energy to develop it, there is no position to which a man in the ranks may not rise.

It is necessary to the progress of the railway industry that men in the ranks should rise. The industry is not a thing of today alone. Means of transportation will always be in demand, and the man most fit will be the man who will lead in supplying the demand.—*Brill Magazine.*

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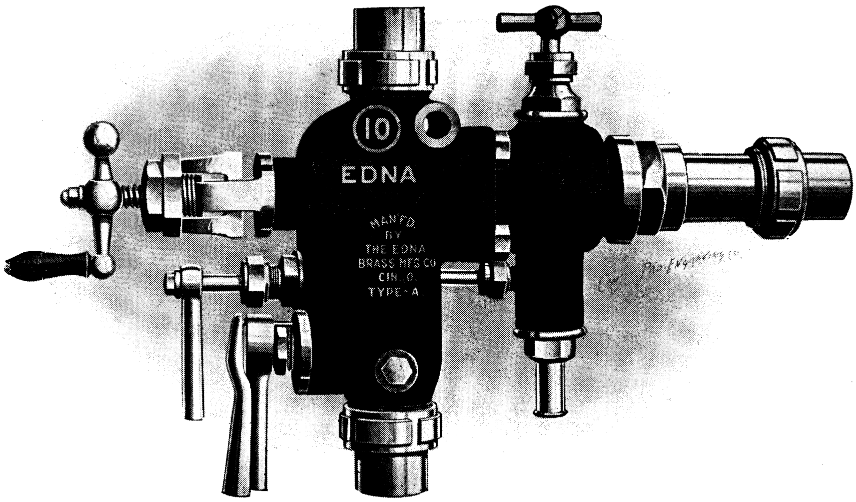

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CATALOG AND PRICES ON APPLICATION

INDEX TO ADVERTISERS AND WHAT THEY HAVE TO SELL

SECOND HAND LOCOMOTIVES

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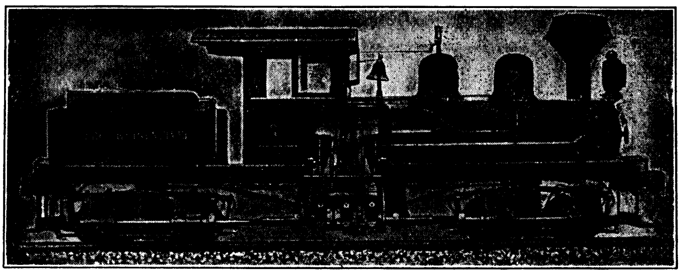
Second Hand
Shay Locomotive

For Sale at a
Bargain

Write
or
Wire for
Full Particulars

Reference No. 137



This Locomotive is built for 56½″ Gauge

PARTIAL LIST OF SECOND-HAND LOCOMOTIVES

	Tonnage	Type	Gauge	Location	Reference No.
1	55	Shay	56½″	New Mexico	0832
1	65	Shay	36 ″	New Mexico	083
1	65	Shay	56½″	New Mexico	0831
1	40	American	56½″	Alabama	134
1	24	Shay	42 ″	Pennsylvania	138
1	24	Shay	36 ″	Pennsylvania	0138
1	30	Shay	56½″	Pennsylvania	139
1	42	Shay	56½″	Louisiana	140
1	50	Shay	56½″	Wisconsin	141
1	45	Shay	56½″	Vermont	142
1	32	Shay	56½″	New Hampshire	143
1	28	Shay	56½″	New Hampshire	144
1	23	Shay	56½″	New Hampshire	146

Write for full information and price on the above Equipment

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