(Established 1832.)
AMERICAN ENGINEER AND RAILROAD JOURNAL

JUNE, 1904.

CONTENTS.

FOUR-CYLINDER DE GLEHN COMPOUND LOCOMOTIVE

4-4-2-TYPE.

PARIS-ORLEANS RAILWAY OF FRANCE.

WITH AN INSET.

There is now running on the Pennsylvania Railroad a 4-4-2-type, De Glehn compound locomotive, built especially for that road at the Belfort works of the Société Alsacienne de Construction Mechaniques. This locomotive was ordered by the Pennsylvania in order to make an experimental study of the type which has made such remarkable records abroad and has been adopted as standard construction by all the leading railways of France. As large a locomotive of this type as could be obtained was desired and as there was insufficient time before the opening of the St. Louis World's Fair for a special design to be prepared, the locomotive was built from the drawings of the heaviest De Glehn passenger engines, those running on the Paris-Orleans railway.

Through the courtesy of M. Solacroup of the Paris-Orleans railway and M. A. G. De Glehn, of the Société Alsacienne de Construction Mechaniques, general drawings of this engine are presented in this journal. While the illustrations show the Paris-Orleans locomotive, they also indicate the construction, with the exception of a few relatively unimportant details, of the Pennslyvania locomotive. A somewhat smaller design, that of the heaviest passenger locomotive on the Northern Railway of France, is now in service on the Great Western Railway, in England.

This locomotive is unique in representing a continuous and systematic development of the four-cylinder compound on the divided and balanced principle, which Mr. De Glehn began in 1885. It has steadily increased in favor, and is unquestionably the most advanced type of locomotive in use in Europe, yet there is not a single patent on any part of its construction.

Very little that is new can be said about the De Glehn compound at the present time. Articles by Messrs. De Glehn and Herdner, in this journal, in September and December, 1902, and January and December, 1903, clearly state the principles involved. This design was not developed with special reference to fuel economy alone, but this was an incidental advantage sought. The object was to obtain the utmost possible capacity within a limited weight.

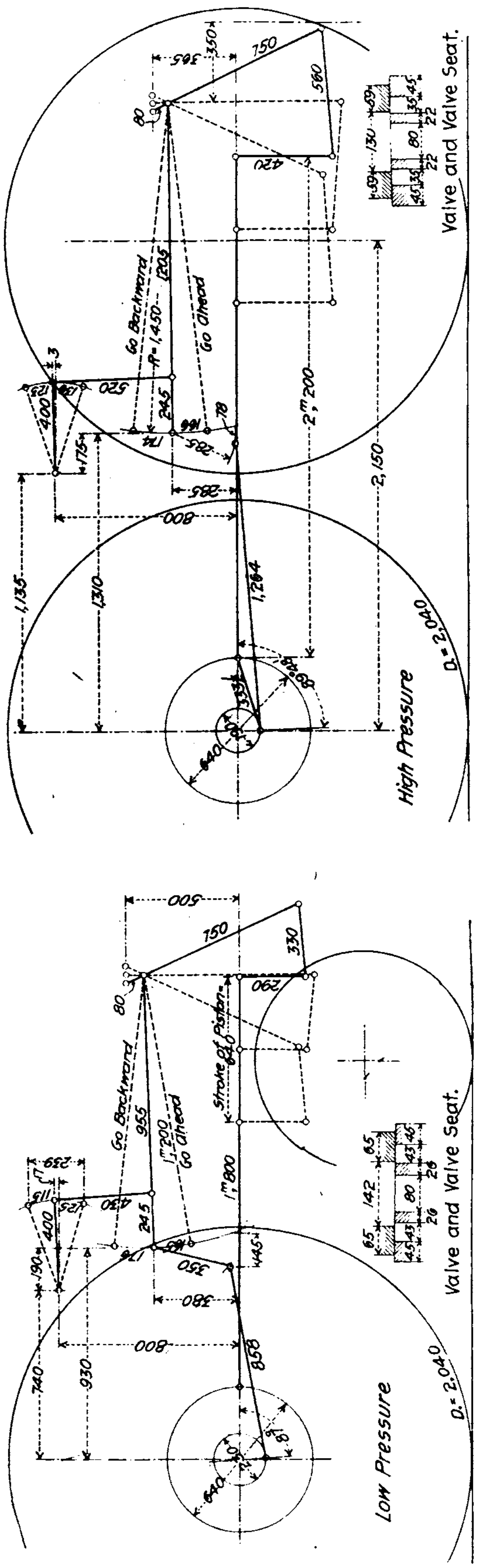
For a locomotive weighing 65 tons, to haul in regular, everyday work, 370 tons behind the tender, a distance of 184 miles, from Paris to Calais, in three hours and ten minutes, with one intermediate stop, and do this on a coal consumption of 38½ pounds per mile, is one result obtained by this system. In this run there is a fifteen-mile hill of one-half of one per cent., and 23 miles of one-third of one per cent. There are four other hills of nearly one per cent., one of which is seven miles long. Under these conditions on the Northern Railway of France, with a locomotive lighter than the one herewith illustrated, a steady speed of fifty-six miles an hour is maintained, on the one-half per cent. grades and 1,500 horse-power sustained. The maximum speed in this run is never allowed to exceed seventy-five miles per hour. It would be difficult for American railroads to match this work with a locomotive of this weight.

Word has just been received that one of the Paris-Orleans engines, which is exactly like the one illustrated, has just indicated 1,900 horse-power, at 70 miles per hour, with 350 tons behind the tender, the drawbar pull at that speed being 7,350 pounds. It must be remembered that this engine weighs only 80 tons. Mr. Sauvage in his recent paper before the Institution of Mechanical Engineers of England stated that one of the Paris-Orleans engines hauled 350 tons (behind the tender) for 200 miles at an average speed of 55 miles per hour, and for 73 miles the average speed was 63 miles per hour. From indicator diagrams the effective power was from 1,200 to 1,800 horse-power, the water consumption being not more than 24 pounds per indicated horse power per hour, as an average from a number of experiments. The boiler evaporated 7.7 pounds of water per pound of coal.

The essential principles of this type are: 1. Four cylinders, the low pressure between the frames and underneath the smoke box, being coupled to the leading crank axle; the high pressure being outside the frames and further back, coupled to the rear driving wheels, thus dividing the stresses of the cylinders upon the axles and the cylinders upon the frames and balancing the reciprocating parts. 2. Each cylinder has its own valve and valve gear, the high and low pressure valves being connected to separate reversing screws, which, however, may be coupled together in their operation from the cab. This renders it possible to change the ratio of expansion between the cylinders and it also divides the work which each valve gear has to perform. 3. A starting valve admits boiler steam to the low pressure cylinders and opens the high pressure exhaust to the atmosphere. This is controlled from the cab and makes it possible to use either high or low pressure cylinders alone in case of a break-down, in addition to the function of increasing the starting power of the engine.

The remarkably fine set of drawings reproduced in the inset accompanying this issue must be allowed to speak for themselves, and they are well worthy of careful study. In reproducing the drawings the metric system units are retained as it is undesirable to attempt to translate them. Attention is called to the Walshaert valve gear, with two eccentrics on the crank axle for the inside cylinders and return cranks for the outside cylinders. The plate frame construction is exceedingly interesting in the depth of the plate at the driving boxes and its reinforcement at this point. The depth here is nearly 35 in.

The bracing of this frame is remarkable. The bracing occurs at the bumper, at the low pressure cylinders, a box casting at the high pressure cylinders, between the driving wheels, in front of the fire box and at the draw casting. Most of these braces are very deep and they will permit no weaving or twisting of the frames. This frame construction is flexible



HIGH-PRESSURE MOTION.

LOW-PRESSURE MOTION.

DIAGRAMS OF VALVE MOTIONS, DE GLEHN 4-CYLINDER COMPOUND LOCOMOTIVE.—PARIS-ORLEANS RAILWAY.

horizontally, very stiff vertically, and frames seem to be very free from breakage in France.

The boiler is long and is not packed full of tubes; the tubes, 139 in number, are 14 ft. 5 in. long and of the Serve ribbed type of 2 9-16 in. inside diameter. The tube spacing provides plenty of room around the group for circulation of water between the tubes and the shell. This is shown in one of the sectional drawings. The grate has a sharp slope and is narrow. It is designed for coal which is rather better than ours, and for American conditions a wide fire box would be exceedingly desirable.

The smoke box is perfectly clear of obstructions. It has no steam pipes or diaphragm, the stack, which is 20⅛ in. at the top and 17¾ in. at the bottom and 2 ft. 8⅞ in. high, is extended downward into the smoke zox, with a flaring base. The exhaust nozzle is high and fitted with a variable exhaust attachment; as used in France this device is invaluable. The stack has a plate cover, which is a great protection to the fire box and tubes when closed.

In this particular locomotive the low pressure cylinders develop somewhat less than half the total amount of work and the crank axle is therefore relieved of that proportion of the work which it would have to do if all four cylinders were coupled to the same axle.

The reciprocating parts are very light. The crossheads weigh 238 pounds each; the high pressure piston, 100 pounds; the low pressure piston, 242 pounds; the high pressure main rod, 278 pounds; low pressure main rod, 425 pounds.

An examination of this locomotive is convincing of two things: First, that the design, as a whole and in every specific detail, has been carefully and systematically studied and, second, that the operation of such an engine must be carefully looked after. The fact is that American roads are not up to the handling of locomotives like this. Instead of condemning the design this is one of its strongest recommendations, indicating, as it does, how far foreigners are in advance of us in the handling of locomotives on the road. The work which the French engineman gets out of light locomotives is also an important study for our roads.

American railroad men, on examining these drawings, are sure to express their impressions in the word "complicated." There is no question of the fact that in order to get more work out of the weight allowed for locomotives more complication than that of current American practice is absolutely necessary. In order to secure the necessary results, under present conditions of train operation, it is necessary that methods of treating locomotive running repairs should be radically improved, even for present simple methods of construction. If our ordinary locomotives are to give satisfactory service, they must be properly maintained and methods which are really adequate for the proper maintenance of ordinary two cylinder, single expansion locomotive will be sufficient for taking care of more complicated machines. The trouble is that maintenance methods now are known to be grievously at fault, and must be improved irrespective of improvements in the locomotive itself.

There is nothing about a railroad train as complicated as the air brake. We must have the air brake and must maintain it for what it will do. If by complicating the locomotive, more work can be had per ton of weight, the complication is justified exactly as it has been in marine and stationary practice. The value of the complication in this particular locomotive will soon be ascertained on the testing plant at St. Louis.

GENERAL DIMENSIONS, DE GLEHN COMPOUND.

PARIS-ORLEANS AND PENNSYLVANIA RAILROADS.

Weight—On driving wheels	79,500 lbs.
On truck	46,500 lbs.
On trailers	34,000 lbs.
Total, in working order	160,000 lbs.
Tender, loaded	132,500 lbs.
Wheel Base—Driving	7 ft. ½ in.
Truck	7 ft. 6½ ins.
Total, engine	28 ft. 6½ ins.
Tender	20 ft. 6 ins.
Total, engine and tender	59 ft. 5 ins.
Driving wheels, diameter	6 ft. 8 3-16 ins.
Truck wheels, diameter	3 ft. 1 13-16 ins.
Trailing wheels, diameter	5 ft. 11-16 in.
Cylinders—Diameter..High-pressure, 14 3-16 ins.; low-pressure,	23⅝ ins.
Stroke	25 3-16 ins.
Boiler, straight top—Diameter	4 ft. 11½ ins.
Pressure	227 lbs.
Tubes, Serve, ribbed—Inside diameter	2 9-16 ins.
Length	14 ft. 5¼ ins.
Heating Surface—Tubes	2,435.7 sq. ft.
Firebox	181.1 sq. ft.
Total	2,616.8 sq. ft.
Grate area	33.9 sq. ft.
Capacity of tender	Water, 5,500 gals.; coal, 22,000 lbs.

Length of engine	42 ft. 8⅝ ins.
Length of tender	28 ft. 3¼ ins.
Length from pilot to tender coupler	70 ft. 11⅞ ins.
Width of engine	9 ft. 9½ ins.
Height to center of boiler	8 ft. 10 5-16 ins.
Firebox—Length inside	10 ft.
Width inside	4 ft. ½ in.
Thickness of plates (sides, crown and back)	⅜ in.
Tube sheets, thickness of	1 5-16 ins.
Valve gear	Walschaert's
Steam ports:	
High-pressure, 14⅛ x 1⅜ ins.; low-pressure, 20½ x 2 1-16 ins.	
Exhaust ports:	
High-pressure, 14⅛ x 3⅛ ins.; low-pressure, 20½ x 3⅛ ins.	
Bridges	High-pressure, ¾ in.; low-pressure, 1 1-32 in.
Eccentric throw	High-pressure, 7 15-32 ins.; low-pressure, 9 1-16 in.
Valve travel, maximum:	
High-pressure, 5½ ins.; low-pressure, 5 9-16 ins.	
Outside lap	High and low, 1 1-16 ins.
Lead, full forward gear:	
High-pressure, 5-16 in.; low-pressure, 9-32 in.	

RATIOS, DE GLEHN FOUR-CYLINDER BALANCED COMPOUND.

Maximum tractive force, operating simple (lbs.)	18,270
Maximum tractive force, operating compound (lbs.)	19,527
Volume of two high-pressure cylinders (cu. ft.)	4.61
Ratio total heating surface to volume high-pressure cylinders	559.24
Ratio low-pressure to high-pressure cylinder volumes	2.77
Tractive weight to total heating surface	30.85
Tractive weight to tractive effort, compound	4.07
Tractive weight to tractive effort, simple	4.35
Tractive effort to heating surface, compound	7.58
Heating surface to grate area	77.16
Heating surface to tractive effort, compound	13.19%
Total weight to total heating surface	62.09
Tractive effort × driving-wheel diameter to heating surface	609.95

BIG LOCOMOTIVES OVERLOADING AND LOCOMOTIVE FAILURES.

In order to ascertain the attitude toward and the appreciation of the position of the big locomotive, five questions were addressed to a number of leading railroad officials as follows:

1. Are big locomotives satisfactory?

2. Are locomotive failures increasing as the size of locomotives increases ?

3. If so, is it due to the fact that the locomotives are big, or to overloading ?

4. Stated generally, is it not good policy to load engines lightly enough to get an average speed of, say, about 15 miles an hour when business is heavy and to load them heavily when business is light?

5. Given a distance of, say, 6 miles between side tracks, is not the capacity of the road limited by the time required for the slowest train to make this distance ?

The replies constitute a remarkable reflection of opinions from some of the best operating men in the country. What these men say on any subject will be eagerly read, but their comments on the increasing size of locomotives and its effect on questions of operation and maintenance must be considered as specially significant of the necessity for proper design, operation and adequate facilities for maintenance of big locomotives.

DELAWARE, LACKAWANNA & WESTERN RAILROAD.

1. Our experience with such locomotives, being the standard consolidation freight engines we are using and which we have been buying for several years, is, I think I may say, entirely satisfactory. We are so well satisfied with these that we are buying more each year to take the place of the lighter engines we are retiring from service.

2. Our experience does not show that locomotive failures are increasing as result of the larger power we are using. I think probably during the last three years locomotive failures have increased in number, as compared with the similar period immediately preceding, but my view of this is that the abnormally large tonnage handled, with the general shortage of power, has required the railroads to run their locomotives harder and with less attention in shops and ronnd-houses than previously, and as a result of trying to get increased mileage out of them in this way failures on the road have appreciably increased.

3. It is quite possible, too, that the desire of the transportation department to get as much service out of the locomotives when on the road as possible has led to their being overloaded at times, and this, of course, is bound to result in more failures.

4. Generally speaking, I should say that it is not good policy to load engines to an extent that results in their dragging along over the road, making a low rate of speed and getting in the way of other trains. As a result of our practice in this regard we feel that it is better to give a fair load and one that will enable slow freight trains to make 15 to 18 miles an hour running between stations and thus get them over the road in good time. More service can be gotten out of engines and crews both in this way than by loading the engines to the very last limit. Especially is this true on lines having as heavy traffic as ours.

5. I think, without question, the capacity of the railroad is limited to a great extent by the time required by the slowest trains to make distances between the passing points along the line.

W. H. TRUESDALE, President.

SEABOARD AIR LINE RAILWAY.

1. I believe there is great economy in the use of heavy engines. The maximum economic weight of the engine used must, however, be adjusted to the conditions under which traffic is moved. I do not believe it would be economy to use in road service as big an engine as could be economically used on mountain grades.

2. Engine failures have increased with increase in size of engines. I do not know whether the ratio of increase in engine failures agrees with the ratio of increase in weight.

3. I believe the increase in failures with big engines is due to overloading and increased steam pressure carried, in comparison with pressure formerly carried by engines of less capacity.

4. It is economic, and therefore good policy, not to load heavy engines in excess of their efficient rating. This must be determined by traffic conditions. When the movement of business is heavy a larger tonnage can be successfully moved by reducing the engine rating measurably. When traffic is light engines can be loaded economically up to the limit of their efficient rating.

5. The capacity of a railroad is limited by the time consumed by the slowest train moving between stations.

J. M. BARR, President.

NORFOLK & WESTERN RAILWAY COMPANY.

1. The larger engines now in use are not only satisfactory but, in my opinion, have proven to be an absolute necessity, because the vastly increased traffic would have been congested to a greater extent but for the increased train load and relatively decreased train mileage effected by increased capacity of engines.

2. The increased size of locomotives has increased the number of engine failures, but I do not think that the increase has been out of proportion to what should have been anticipated under the new conditions brought about thereby, and that when railways have adjusted their methods and facilities to the new conditions requiring time and the expenditure of money the failures will not show a relative increase. The increased failures are also due to the improved method of loading engines up to their capacity from the beginning to the end of runs, over the minimum as well as the maximum grades, which has been effected by a more perfect system of helper and pusher service, and practiced to a greater extent since the introduction of the big engines, whereas engines formerly were fully loaded only on mountain grades, and hence were very lightly loaded over the greater distance run.

3. The increased failures are due to new conditions referred to in answer to question 2.

4. In my opinion, engines should be loaded up to their effective rating, which is a load with which they can make maximum speed with class of freight hauled, while under way.

5. In my opinion, the necessity for passing sidings is determined by the time between terminals, hence on a train basis the capacity of a road is limited by the time consumed, and not by the distance, between side tracks.

L. E. JOHNSON, President.

BUFFALO, ROCHESTER & PITTSBURGH RAILWAY COMPANY.

1. As big locomotives are termed to-day weighing anywhere from 230,000 to 300,000 lbs., we have none of these which could be considered as our engines weigh only about 180,000 lbs. in working order. If you assume to call these big engines, our records show them to be very economical. They not only make their mileage, but the cost to operate them per mile is low. Comparing these engines with the lighter or smaller type of engines, we find the cost for repairs, coal and water consumed, are approximately proportional to