THE LATEST DEVELOPMENT IN BRITISH RAILWAY LOCOMOTIVE DESIGN.

BY F. C. COLEMAN.

For the operation of their several long-distance non-stop services, which include daily runs between London and Plymouth, 225¼ miles in 4 hours 7 minutes; London and Exeter (four runs daily) 173¼ miles in 3 hours; and London and Bristol, 118½ miles in the even 2 hours, the Great Western Railway Company have recently constructed at their Swindon works a large locomotive of the "Pacific" type. This locomotive is unique, inasmuch as it is the first locomotive having this wheel arrangement to be designed for any British railway and is moreover by far and away the heaviest and most powerful railway engine ever built in Great Britain. This locomotive, which has been christened "The Great Bear," is a development of the "Star" class of six-wheeled coupled bogie locomotives, several of which have during the past few years been built at the Great Western Railway Company's works at Swindon, having the same cylinder, driving wheel, valve and valve gear arrangements. By the adoption of the pair of trailing wheels, it has been possible however to obtain in the "Pacific" engine a greatly increased size of firebox and to lengthen the boiler very considerably, as will be seen by a reference to the accompanying photograph and dimensioned diagram. The engine has coupled wheels 6 feet 8½ inches, bogie wheels 3 feet 2 inches, and trailing wheels 3 feet 8 inches in diameter. The leading coupled wheels are directly driven by a pair of inside cylinders set in advance of the bogie center, with connecting rods acting on the crank axle, while a second pair of cylinders outside the frames to the rear of the bogie center drive the middle coupled wheels. Steam distribution is by means of piston valves to all cylinders, the four valves being actuated by two inside valve gears of the Walschaert type, modified to meet the special conditions of the Great Western Railway service, and having inside and outside valve spindles on each side connected by a cross lever with two arms fulcrumed near the center on the main frame of the engine. This arrangement of valve mechanism is claimed to give eminently satisfactory results, and such as to completely overcome the objec-

tion entertained in some quarters to operating four valves by only two valve gears. The four cylinders, 15 inches diameter and 26 inches stroke, are supplied by steam superheated on the Swindon system. The coupled wheelbase is 14 feet, and the total engine wheelbase 34 feet 6 inches. The boiler is of somewhat unusual size for British practice, the barrel having a

the 162 fire tubes, all of which are 22 feet 7 inches in length, 141 have a diameter of 2½ inches, and the remaining 21 a diameter of 4¾ inches. In addition there are four arched tubes, each 7 feet 8½ inches in length and 3½ inches in diameter. The area of the fire grate is 41.79 square feet. The working pressure of the boiler is 225 pounds, and the tractive effort

29,430 pounds. In working order the engine (exclusive of tender) weighs 97 tons 5 hundredweight, and the tender—carried on two four-wheeled bogies, a further innovation in Great Western practice—weighs in working order an additional 45 tons 15 hundredweight, giving the locomotive an aggregate weight on metals of no less than 143 tons. The total length over buffers is 71 feet 2¼ inches. For some years the heaviest locomotives in Great Britain have been the six-wheeled coupled bogie engines built by the Caledonian Railway Company for working the heavy Anglo-Scottish West Coast express services, as between Carlisle and Glasgow, on which section of 102¼ miles of track is to be encountered the famous climb over the Beattock Summit. Of these Scottish-built engines, the "Cardean," weighing 130 tons, has previously held the British record. This engine, exclusive of its tender, weighs 73 tons, or 24 tons 5 hundredweight less, but its tender, which, unlike that of the Great Western locomotive, is not fitted with the pick-up water apparatus and is consequently of abnormal dimensions, weighs 11 tons 5 hundredweight more than the tender of "The Great Bear."

WEATHER VANE WITH ATTACHMENT FOR INDOOR READINGS.

BY WILLIAM H. PLACE, JR.

The fact that a weather vane must be located in an elevated and isolated position renders it difficult at times

accurately to determine the direction of the wind when it blows from certain points of the compass. Furthermore, it is impossible to tell at night which way the vane is pointing. Hence, any indoor device which will at all times indicate the position of the weather vane would not be without value. Such an apparatus can be quite easily constructed by following the directions here given. Briefly stated, it consists of a compass dial having a needle actuated by electro-magnets which are individually energized according to the position of

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Fig. 1.—Details of the Vane.

Fig. 2.—Contact Table.

Fig. 3.—Contact Roller.

Fig. 5.—The Indicator.

Fig. 4.—Arrangement of the Magnets.

Fig. 6.—The Complete Vane, Indicator, and Electric Currents.

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length of 23 feet and an outside diameter of 6 feet, these figures being 8 feet 2 inches and 6 inches respectively in excess of the boiler measurements of the Great Western Railway Company's 4-6-0 type of engine previously mentioned. The total heating surface is no less than 3,400.81 square feet, to which the superheater tubes contribute 545 square feet, the fire tubes 2,673.45 square feet, the arched tubes 24.22 square feet, and the fire box the remaining 158.14 square feet. The superheater tubes 84 in number are each 21 feet 4 inches in length and 1¾ inches in diameter. Of

Boiler: Heating Surface, 3,400 square feet. Superheater Tubes, 545 square feet. Length of Fire Tubes, 22 feet 7 inches. Boiler Pressure, 225 pounds. Four Cylinders, 15 inches diameter by 26 inches stroke. Traction Effort, 29,430 pounds.

THE HEAVIEST AND MOST POWERFUL BRITISH EXPRESS LOCOMOTIVE.

If it is desired to know the latitude with extreme accuracy, the value obtained by this rule must be corrected for the deviation of the north star from the true celestial pole, for the observation and refraction of light, etc.

In the eighties of the last century, Dr. Küstner at Berlin, in seeking to apply a method for the determination of the constant of aberration, was confronted with apparent errors of observation which refused to be explained by ordinary methods. Finally, he announced that the determinations of the latitude of Berlin showed a variation of 0.2 sec. to 0.3 sec. in the course of not many months. If the latitude had really changed, this would mean that the terrestrial pole had shifted from 20 to 30 feet.

It was found that the theory of a shifting pole was suggested by other facts. Finally, it was determined to set this matter at rest by an expedition to the Sandwich Islands. These are located about 180 deg. west or east of Berlin. If observations here showed a receding pole at the same time that European ones disclosed an approaching pole, and *vice versa*, then there could be no reasonable doubt that the axis of the earth is not fixed relatively to the earth itself. The United States government sent an officer to participate in the observations in the Pacific. Concurrently with these, similar work was carried on in the United States, in Berlin, and other places. The result of this work was to confirm the suspected shifting of the axis.

About the time of these occurrences, Dr. S. C. Chandler at Cambridge, Mass., became aroused over the same subject. In examining a series of determinations of latitude, he found not only variations, but that these variations appeared to conform to some law. At first, he felt that while the discrepancies seemed to indicate a shifting pole, this was too startling a proposition to put forth without further confirmation. However, after an immense amount of labor, he established the fact that two periodic influences were at work, at times co-operating to shift the pole to a maximum distance, and at others to limit its variation to a very small minimum. One of these influences was a yearly one; the other had a period ranging from 12½ to 14½ months. The combination of these two influences produced a cycle of about seven years.

The amount of displacement to which the north pole is thus subject is about 30 or 40 feet from a mean position. Dr. Chandler's first announcement was made in 1891.

In 1893 the fact of polar variation was pretty well admitted. The International Geodetic Association undertook the task of carrying on the observations and reducing them to order. At times they established four observational posts at widely separated points, but within about 12 sec. of the same degree of latitude; that is, at about 38 deg. 8 min. N. These were at Carloforte, in the island of San Pietro; Mizusawa, Japan; Ukiah, California, and Gaithersburg, Maryland. The officer of the last-named station is an officer of the U. S. Coast Survey. Aside from him, the expense involved is about \$14,000 annually. Tschardjui in Siberia and Cincinnati, Ohio, have joined in the work. More recently, the association has added two more stations in the southern hemisphere—one in Australia and the other in South America.

Fig. 4 is a curve representing the polar movement. This covers a period of six years, divided into tenths from 1899.9 to 1906.0. These points of time are indicated by the numbers shown on the curve. By referring to the numbers shown on the margin, the extent of the movement may be accurately noted, remembering that 1 sec. of arc is equal to about 100 feet.

The discoveries and investigation of Dr. Chandler have removed a mass of discordant results in the national observations of Great Britain, Russia, and the United States from the field of unaccountable error to that of agreement with fact. Indeed, the accuracy of both instruments and men had been under suspicion.

These results are valuable. Thus, one method of determining the solar distance is by means of the constant of aberration of light. This in turn is affected by variation of the rotational axis in the body of the earth. The reason for this is that it is necessary to know the position of the observatory in order to carry on the calculations. This it will now be possible to ascertain with a very high degree of precision.

WEATHER VANE WITH ATTACHMENT FOR INDOOR READINGS.

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the weather vane. To make the vane, procure the front hub of an old bicycle which contains all the ball bearings, a piece of galvanized iron rod, 6½ feet long, of the same diameter as the spindle in the hub to which the cones are attached, and a piece of brass tubing 4 feet long the inside of which will snugly receive the end of the hub by driving it in. First saw off a foot and a half from the rod, then take the spindle out of the hub, saving the cone *D*, which is tapped. Now saw the hub in two in the center. On the end of the 5-foot piece of rod *C* for a length of 1 inch cut a thread, corresponding to the tap in the

cone *D*. Measure half an inch from the end of the thread, and file a shoulder one-sixteenth of an inch all around; then measure 9 inches from the other end and drill a ½-inch hole. Take the remaining foot and a half of rod *A* and drill a hole 7 inches from the forward end which will fit over the filed end of the rod *C* down onto the shoulder. Take a half ball *M* from the end of an old curtain pole and fasten to the forward end of the rod. The tail of the vane must be made with two spreading boards on the sides, braced in the center, and nailed to a firm block into which the end of the rod is driven. After this is done melt up some lead and pour into the half ball *M* until the rod balances on the point where the hole has been drilled. Screw the cone *D* on the rod as tightly as possible, and after placing the vane down over the point onto the shoulder, rivet it on, being sure that it points in the same direction as the hole drilled near the lower end. Now drive the sawed end of the hub into one end of the brass tubing and the vane is complete (Fig. 1).

A contact table should now be made as follows: The table is a circular board 6 inches in diameter and ½ inch thick on which eight sheet brass segments or points of contact *J* are arranged as in Fig. 2 to form the eight points of the compass. A ½-inch hole should be bored through the center of the table. To connect the vane to the table in order to form a circuit a small brass pulley wheel *I* is used; this can be bought at any hardware store. The wheel should be about ¾ inch in diameter and have a long wood screw on the end of the brass yoke in which it revolves. The wood screw must be sawed off so that a piece of brass rod 3/16 inch in diameter and 2½ inches long may be soldered on in its place at right angles to the yoke and in the plane of the wheel. An annular shoulder half an inch from the end and a thirty-second of an inch deep must be filed in one end of the short piece of brass rod, the other end of which should be soldered where the wood screw was cut off as stated above. The rod should be threaded as far as the shoulder and a nut procured to fit the thread (Fig. 3).

To make the reading instrument or indicator procure eight single magnets 1 inch long wound with No. 24 single cotton-covered copper wire, also eight screws ¼ inch longer than the taps in the magnets, and eight copper burrs with holes in them large enough for the screws to slide through easily. Now make a board for the magnets to be placed on 6 inches square and ¾ inch thick, and eight wooden blocks 1 inch square by ¼ inch thick. Drill a hole in each of the blocks large enough for one of the screws to go through easily.

Describe a circle with a diameter of 1¾ inches in the center of the 6-inch board, and draw lines in it representing the eight points of the compass, viz.: N, S, E, and W, NE, SE, NW, SW.

Lay the magnets *N* radially around this circle, as shown in Fig. 4. Now at the other end of each magnet nail the little blocks which are set up on edge, and secure each magnet in place with a screw which has been run through a burr, to prevent the head of the screw from sinking into the block. Now connect all the inside magnet wires to a main wire *P* extending around the board about ½ inch from the ends of the magnets. Bore nine holes through the 6-inch board, one at the end of each magnet and one for the main wire to go through. Place the board and magnets in a box *K* with a glass cover which will exactly contain them. Now make a small wooden cone, insert in it a small steel needle and place it in the center of the circle around which the magnets are arranged. A small arrow-shaped piece of steel *O* must be balanced delicately on the cone after the manner of a compass needle. A paper face 6 inches square with a hole in the center 1¾ inches in diameter may be placed over the magnets. This may be as elaborate as desired (Fig. 5).

Set up as per diagram, being sure that the weather vane is a foot above the roof, and away from all trees, buildings, chimneys, or other obstructions.

The main wire is soldered to the piece of brass tubing *B* and run to the batteries *H*. Thence a line *G* runs to the main wire *P* of the reading instrument *K*. A wire *L* should be soldered to each of the segments on the table *J*, and at the reading instrument should be connected with the corresponding magnet, i. e., the segment pointing north should be connected with the north magnet, etc. It will now be seen that if the weather vane points north it will turn the iron *C*, to which the brass wheel *I* is attached, to the north segment, thereby closing the circuit with the north magnet in the reading instrument. That magnet will become magnetized and will attract the steel needle around to it.

There are many valuable woods in Colombia. Where required, they are used locally, but difficulties of transport, and the phenomenal weight of some of the most useful kinds—e. g., guayacan and diomate—almost preclude export to other countries.

Correspondence.

Automatic Fire Valves.

To the Editor of the SCIENTIFIC AMERICAN:

With reference to article written by Mr. Frederic Bradlee Abbott in your issue of January 25, the writer cannot agree with Mr. Abbott for several reasons. First is that it has been positively proved that in a fire panic, persons have absolutely neglected to use any safety precaution, either for the safety of themselves or building they may be in, when a fire occurs. Depending on some one to turn a valve or allow water to enter the perforated pipes, as Mr. Abbott mentions, is out of the question.

In the second place, if the valve should be opened by a person, thousands of dollars of damage might occur before some one could get to the valve to close it. It would be left to the judgment of the occupants whether or not the fire might be of sufficient magnitude to warrant turning on the water and wetting everything in the building, and possibly causing ruin to the entire building. My opinion is that the sprinkler system, uncharged with water, is the safest and best protection that can be given for the immediate extinguishing of fire, together with the protection of lives and property. An automatic valve placed below the frost line or in the boiler room of a building, in connection with the sprinkler system, is in my estimation the best protection thus far afforded.

Chicago, January 24, 1908.

J. E. OSMER.

Hammer Blow of Poorly Balanced Locomotives.

To the Editor of the SCIENTIFIC AMERICAN:

I read with interest the retrospect for the year 1907 given in your valuable paper. The one that appeals to my mind as of the greatest importance, in relation to the unsafety of railway travel, was the special report of the Railroad Commission of the State of New York. The report says that in the winter months of 1907 nearly three thousand broken rails were removed from the tracks in that State alone. It seems to me that it is about time for the State to apply the remedy which is not far to seek. It has been shown from numerous experiments made by Prof. Goss that the counterweight in the locomotive driving wheels strikes a blow of 25 tons at each revolution—enough to break any rail under proper conditions of cold and frosty weather. They can remove at once this element of destruction, which is a relic of a prehistoric age, and make the conditions the same upon both sides of the center of revolution, thus eliminating this blow and bringing the locomotive into perfect balance. Who ever heard of a rail breaking under a locomotive at rest upon the rail? Neither will it break under a high rate of speed, if properly balanced; nor leave the rail by centrifugal force, as they frequently do without any apparent cause, leaving destruction all along the line.

Another reason for the removal of this relic of the past ages is the inefficiency of our locomotives produced by it. There are few machines that I have any knowledge of—in fact, I cannot recall any—whose transmission of power through frictional contact is as great as the locomotive engine. It is also well known that this contact must be constant to produce the best results. Let us look for a moment and see what occurs; in the downward movement of this counterweight we have the stress or blow; in its upward movement we have the lift from centrifugal force, a constant making and breaking of contact of the wheels with the rail, thereby losing its efficiency.

It is not only our locomotives that are off the track (owing to their construction), but our builders seem to think that with a tremendous boiler and cylinder capacity they have a tremendously powerful locomotive, without one thought as to the transmission of that power through the small frictional contact. The earning power of the locomotive lies in its contact of the wheels with the rail, and not in its boiler capacity.

In closing let me make a suggestion or two:

1. Balance up the locomotive and avoid that blow, and keep it in constant frictional contact, thus increasing its efficiency.

2. Reduce the size of the locomotives 20 tons and do the same work. This can be done if the friction is constant.

A locomotive constructed as I suggest will be much more safe at high speed, and there will be a great many less broken rails and accidents.

HENRY F. SHAW,

Mechanical engineer of the old school.

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[Much attention is being paid to the question of locomotive balancing. The best results have been obtained by the use of four cylinders, with the adjoining cranks set in pairs at 180 deg. There can be no doubt that insufficient or intermittent adhesion, due to imperfect balancing, accounts for much loss of hauling power in some locomotives, when they are running at high speed.—Ed.]