fened by the collecting smoke chamber which extends through it. A separate valved connection is made through this interior smoke chamber for the steam as well as for the water in the boilers, so that both steam and water can circulate freely from one boiler to the other, or may be shut off if it is desired to use one boiler only. The steam cylinders are vertical, and placed outside the steam dome, their axis being in the vertical transverse extending through the center of gravity of the locomotive, and preferably placed as high as possible, so as to take the steam by means of pipes which receive their steam supply from a common opening at the highest point in the steam dome, the opening being closed by a throttle valve operated in the usual manner. The steam chests are placed inside the dome as shown in Fig. 3.

The driving-wheels are situated equidistant from the center line, and upon them rests the whole platform, and in the centre-line, and as near the rails as possible, is placed an intermediate driving shaft, to the cranks of which, on opposite sides of the locomotives, extend the connecting rods from the cross-heads of the piston rods above. The cranks of the two drivers on each side of this vertical connecting rod are connected in the usual manner by a horizontal driving rod, which, near its center, extends downward to the crank of the intermediate driving shaft and is connected with it. The driving rod is slotted in its centre to allow the vertical connecting rod free play.

The eccentrics are placed upon the intermediate driving shaft, while the link motions are arranged on an auxiliary shaft vertically above it.

The locomotive may have horizontal cylinders, if they should be preferred. In that case they would be placed lower down in a line with the center of the driving wheels, but in the same central position.

At each end of the locomotive the frame rests upon a truck, but as the whole engine is evenly balanced upon and supported by the driving wheels, the object of the trucks is not so much to support any specific weight, as in other locomotives, as to serve as a guide over curves. Each end truck has one transverse axle with one pair of wheels and a frame which incloses the wheels and is connected by an arc-shaped guide piece, which is transversely guided in a fixed center box at the end of the locomotive.

The water tanks are below the boilers, openings being provided to allow the axles of the wheels to pass through. The fuel is carried in bunks arranged sideways and above the boilers.

A novel and ingenious plan is devised for feeding the boilers. The return flues being situated but a few inches below the water level, it is important that the level should be continually kept up. The inventor has, therefore, arranged a steam pump, which is worked by a lever connection with the main piston, and which injects into the boilers at each stroke of the piston the equivalent of water for the steam used.

These are the main features of this novel engine, which the inventor claims as the first locomotive built upon strictly scientific principles.

The advantages claimed for this new style of locomotive, and to which Dr. Raub has given the appropriate name of central power locomotives, are numerous.

This engine has no dead weight, therefore its whole power can be utilized for drawing freight; and it is claimed that a central power locomotive of a given size will do more work than another locomotive of the same size under the same conditions. The heat is better utilized, as it is led back through the boiler by means of the return flues, and the fuel will be more fully consumed than it is now. The collecting smoke chamber which extends upwards through the steam dome, serves to superheat the steam, consequently dry steam will be obtained, and the steam chests being inside the dome, no loss of steam from condensation, will take place. Should an accident happen to one of the boilers the connection between the two may be interrupted, and the remaining boiler will be sufficient to propel the train to the next station thus preventing blocks on the road and delays to traffic.

It is claimed that a train may be run at a much higher rate of speed with this engine and with much more safety than now, owing to the balanced driving wheels and the peculiar relation of the parts; and there is less danger of breaking the driving rods and less strain upon the track.

A separate tender will not be required, as both water and fuel are carried upon the locomotive itself; and, furthermore, turn-tables with their necessary attendance will become superfluous, since the locomotive is a perfect double-ender, and runs in either direction with equal efficacy and without any damaging effect to the gearing.

We understand that Dr. Raub is now making arrangements to build several locomotives according to his new system of different patterns and sizes, in order to practically test their merits and superiority and to ascertain the actual percentage of saving in running them.

The doctor has for many years been identified with several large Western roads, and is well known as a prominent and able railroad engineer.—*Scientific American.*

## THE HARDENING OF STEEL.

The tempering of steel is a question which is attracting considerable attention at the present time, especially the relation between the metal and the gases which come into contact with it during the process of manufacture. An interesting communication on the subject was recently made to the Physical Society by Professor Chandler Robert of the Royal School of Mines, and his principal result, though of a negative kind, is valuable as narrowing the question at issue. Professor Roberts began by tracing the history of our knowledge concerning the carburization of iron, from the work of Clonet, at the end of the last century to that of Margueritte, in 1856. Margueritte showed that although the conversion of iron into steel could be effected by contact with carbon even in the diamond form, it is, nevertheless, true that carbonic oxide ordinarily plays a considerable part in the process. Graham's paper "On the Occlusion of Gases," read in 1867, gave singular point to this conclusion by showing that carbonic oxide can penetrate to the centre of a mass of iron. This gas is in fact introduced into the iron at a comparatively low temperature, while a high temperature is necessary to enable the metal to appropriate the carbon in order to become steel.

The effect of occluded gases in iron and steel is now being carefully studied by metallurgists in general, and a committee of the Institution of Mechanical Engineers recently raised the question in one of their reports as to whether the hardening and tempering of iron and steel might not be produced by the expulsion of occluded gases during the heating process, and their subsequent exclusion by the sudden cooling and contraction. Professor Roberts has undertaken to answer this question, and by heating rods and spiral wires of steel in *vacuo* by means of the electric current and suddenly quenching them in cool mercury, he demonstrates that steel will harden when there are no gases to absorb. The metal was of course robbed of its occluded gases by means of an air pump connected to the vacuum chamber, and the parts which were quenched in the mercury were found to be glass hard, while those which did not reach the cold fluid were found to be quite soft. Professor Robert therefore concluded that gases do not play any part in the process of hardening and tempering. Historically interesting are the facts mentioned by Professor Roberts that as early as 1781, Bergman clearly stated that fixed air could give up its carbon to iron, and that Reaumur in 1722 actually employed the Toricellian vacuum in experiments on the tempering of steel, the metal being placed red-hot in a highly-rarefied atmosphere, thereby anticipating the methods of to-day by more than 150 years.

An interesting discussion followed the reading of the paper. Professor Hughes who has made numerous experiments on the subject, expressed his opinion that the temper of steel was due to the chemical union of the iron with the carbon. At low temperatures this union takes place only in a slight degree, and hence in soft steel we have the carbon keeping aloof from the iron; but as the temperature is raised the combination is furthered, until in the case of grey or glass hard steel we have really a kind of diamond alloyed with iron. Sudden cooling is necessary to fix the combination, for in slow cooling the carbon separates out again from the iron. This theory is a very promising one, and is supported by a variety of facts; Mr. Stroh, for example, having observed that when an electric spark passes between the two iron contact-pieces and fuses them, the fused part becomes diamond-hard and will scratch a file. Recent researches by Mr. T. W. Hogg have also led him to a similar conclusion, namely, the temper of steel is due to the presence of an unstable compound of iron and carbon. The theory might very well be tested by chemical analysis in order to see whether the proportion of carbon appropriated by the metal increased with the temperature, or if any change took place in the refractive index of the steel.

It was generally agreed by all the speakers at the meeting that the color of the surface of tempered steel depends on the temperature, and is due to the thickness of the film or skin of oxide; the blue film signifying a higher temperature than the yellow, as well as a thicker coating. In this connection Professor Hughes has demonstrated that the electric resistance of the