first days of railroads that an annoying and dangerous jolt, sidewise, took place as a train either entered or left a curve, and the parabola was a first or rather a mistaken idea as to remedying this evil.

Instead of this, the concensus of opinion has fixed itself on the use of the circular curve, but with the modification of the use of easement curves at each end of it to join it on to the tangents in such a manner as to modify or wholly dissipate any disagreeable shock which would occur if the curve were to change instantaneously to a straight line. In the past the trackmen have been allowed to introduce these easements themselves in an approximate and makeshift manner, but at present there is a growing feeling that an accurately calculated and placed easement curve is necessary, especially as passenger speeds are becoming higher. Easement curves have been used for many years in Europe, and are becoming quite common in America.

## CONDENSERS.*

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The condenser may be said to have the inverse relation to the steam that the boiler has, for as the boiler raises the temperature of the water and increases its volume, the condenser reduces the temperature and volume. The boiler converts the water into steam, and the condenser reconverts the steam into water. The advantage of running condensing instead of exhausting against the pressure of the atmosphere is explained by reference to the principle by which the maximum efficiency of heat engines is calculated. For example, suppose two engines exactly alike and each driving the same load, each working with steam of say 60 lbs. pressure absolute, one working with a condenser and the other exhausting into the air, suppose one engine expands down to 3 lbs. absolute, the other to 2 lbs. above atmosphere or 17 lbs. absolute, the relative efficiency of the two engines may be expressed as follows: The temperature of steam at 60 lbs. absolute is 292.7, that of steam at 17 lbs. absolute is 219, and of 3 lbs. 141.5.

$$\frac{292.7 - 141.5}{461 + 292.7} = \frac{151.2}{753.7}$$

while that of the non-condensing engine is

$$\frac{292.7 - 219}{461 + 292.7} = \frac{73.7}{753.7}$$

or in the ratio of 73.7 to 151.2, or as 18 is to 37. From a mechanical point of view the advantages are more apparent as illustrated by an indicator diagram, for it enables us to reduce the back pressure from, say 2 lbs. above to 12 lbs. below the temperature of the atmosphere.

Condensing allows us to make use of much higher grades of expansion than is possible by non-condensing. The condenser itself is an apparatus into which the steam is discharged when it has done its work, where it comes into contact with a jet of water, or else with a large surface one side of which is kept cool by contact with water. The steam entering the condenser is instantly condensed, giving up its heat to the water. The result would be a practically perfect vacuum only for the fact that the feed water contains air which the steam gives up during condensation, and causes a back pressure on the piston. An air pump is attached to a condenser to pump out the air and the water of condensation, and in the jet condenser it has also to pump out the injection water and the air it contains.

There are many forms of the different types of condensers. The best known type is the jet condenser, once used almost universally when pressures did not exceed 35 pounds. It consists essentially of an air tight chamber into which the exhaust steam passes from the cylinder after having done its work. It is met on entering by a jet of water caused by the inrush of water through holes or slits in the pipe placed across the opening, or by many other spraying contrivances. If the water enters through holes in a shower, it mixes mechanically with the steam; if it enters through slits, it causes the water to enter like broad, thin sheets, and the cooling is done principally by surface contacts. In either case the result is the same: the turning of the steam into water, and it falls to the bottom of the condenser and is pumped out by the air pump.

It might be supposed that the mere turning of the steam into water, thereby causing it to occupy less space, will cause the vacuum. It does, but to so slight an extent that unless some other means to maintain it were provided the condenser would be useless, for the reason that water readily absorbs air when exposed to it, and gives it up again on being boiled. The feed water contains air, which becomes mechanically mixed with the steam in the boiler, and passes with it through the engine to the condenser, where it is freed from it when the steam is condensed, and remains as cool air. In the jet condenser the cooling water also contains air, and under the partial vacuum and the temperature of the exhaust steam it readily gives some of it up. The engine has only to make a few strokes without the air pump, when the air will have accumulated so as to raise the pressure to that of the atmosphere, and although the condenser may be kept cool there will be no vacuum. Now the water that has accumulated from the steam being condensed, might be arranged to run away by gravity; it is only the air that is of necessity pumped out, and hence the pump, although pumping both air and water, is rightly named the air-pump. The jet condenser has been made in many different shapes. The essential feature is that the inlet for the steam prevents the water running back to the engine, in case of flooding. A good arrangement for mixing the steam and water is to have the bottom so formed that the water will all drain into the air pump. Condensers are made to suit the various conditions and positions. In marine work they are made to suit the relative positions of engine and hull, and was often a part of the engine frame.

The columns of vertical engines were used for this purpose until the practice was forbidden by the Admiralty, but they are so used in some cases yet. The capacity of the jet condenser is usually one-third the capacity of the engine, and should not be less than one-fourth or more than one-half. The objection to a large one is, besides its extra weight and first cost, the longer time required to form a good vacuum. The objection to a small one is the liability of flooding. The quantity of injection water varies, and it depends on the temperature of the steam and its weight, also the temperature of the injection water and the water in the hot well.

The feed water is usually taken from the hot well, and there is an advantage in having it as hot as possible without impairing the vacuum. Therefore there should be just sufficient injection water used to cool the steam down to the required point to get a good vacuum with a jet condenser; 24 inches is a good vacuum; 25 inches is the most economical point. The temperature due to 24 inches vacuum is 140°. In actual practice the temperature of the hot well varies from 110° to 120°, but it can be got up to 130° with great care. To calculate the quantity of injection water per pound of steam to be condensed, let *T* be the total heat of the steam; let T be the temperature

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