the works were commenced two small locomotives from Creusot were employed at both ends of the tunnel. At first the boilers of these engines were filled with air at a pressure of four atmospheres, but of course their capacity was far too small to render them of any service, and a cylindrical reservoir of about 612 cubic feet capacity, was added by way of a tender to the engine. This arrangement is shown by Fig. 1 on page 338. As will be seen the engine is an ordinary four-wheeled locomotive with a wheel base 36-37, and a weight of 4½ tons. The air tender, to which it is coupled, is carried upon eight wheels; it is furnished in the upper part with a valve, through which, by means of a flexible tube, it is filled with air from the compressor. Below is a second valve through which the air is supplied to the engine, by means of two copper pipes and a flexible length of rubber tube. The air pipe of the engine passes through the fire-box and enters the boilers, where it expands and passes on the cylinders. The working of the engine is, with the exception of filling the tender as just described, and the absence of firing, exactly the same as that of an ordinary locomotive. At the commencement of a trip the gauge shows a pressure varying between 90 lb. and 105 lb. and after the transport of a train of twelve loaded wagons from the tunnel to the spoil bank, a distance of from 1600 ft. to 2000 ft., the pressure gauge 67.5 lb. The train could then be taken back empty, with a final pressure of 30 lb. to 35 lb.

The following particulars of this engine and its average performance will be found of interest:

Weight of engine	4 tons 12 cwt.
" tender and trucks	7 " 8 "
" sixteen wagons	20 "
Load in " "	32 "
Total weight of train	62 tons.
Length of line	983 feet.
Mean pressure at starting	70 lb. per sq. ft.
" " stopping	57 " "
Capacity of air reservoir	612 cub. ft.
Length of stroke	14.17 in.
Diameter of cylinders	8.05 in.
" wheels	29.92 in.

Although a very cumbrous apparatus, the reservoir measuring 25.26 ft. long, and 63 in. in diameter, these two engines, the "Reuss" and the "Tessin," have worked at Gœschenen and Airolo from December 1873 until the present time, and they have worked very economically, the whole of the air being supplied from the existing compressors, which is not the case with the new engine we illustrate. It may be mentioned, moreover, that at these great heights, coal costs more than 4*l.* a ton.

Without entering into any detailed calculations we may note as a result of numerous experiments made with the two engines, that they have shown a high effective duty. When the engine is at work, the chief loss occurs between the slide valves and their faces; this loss of air of course increases with the pressure, and it is therefore found advantageous to work at as low pressures as possible. When this is done, moreover, the cooling of the cylinders due to the expansion of the air, is of course less considerable than at higher pressure. The cooling of the air becomes a source of great inconvenience, when working at the higher pressures, 7 atmospheres for examples, and with a high rate of expansion.

As the air pressure constantly varies in the reservoir, the driver ought—to obtain a constant work in the cylinders—to vary the point of air admission, but this cannot be done gradually, so that the air in the reservoir is wasted, and the distance that can be traversed is reduced.

These unfavourable conditions led the engineer of the tunnel, M. Ribourt, to attempt to fulfil the following conditions:

1. To introduce the air at a low pressure into the cylinder in such a way that the cut-off should be at one-half or two-thirds of the stroke.

2. To scheme an apparatus which should maintain, automatically, a constant pressure for the cylinders, no matter what may be the pressure in the boiler.

These conditions appear to have been fulfilled in the air locomotive, with the automatic reducing apparatus, which we will now proceed to describe.

The machine which is illustrated on the page 365, December number, consists: 1. Of an ordinary locomotive frame, axles, wheels, cylinders, reversing levers, &c., without any modification to be alluded to.

2. Of a main cylindrical reservoir, A, containing the supply of air at as high pressure as possible. This pressure of course gradually diminished with the working of the machine.

3. Of the automatic reducing way R, in which the air is expanded from its variable pressure in the reservoir, to the constant working pressure to the cylinders.

4. Of a small reservoir B placed between the distributor just named and the cylinders, and used as an air chamber to absorb any shocks, caused in starting or stopping the engine.

The pressure in the main reservoir is limited by the capacity of the compressor, and by the efficiency of the joints of the pipes. The maximum is reached at St. Gothard at 210 lb. By a special arrangement in cases where the compressors will give a defective duty in raising the pressure from 15lb. to 20lb., they are adapted to force in the air already compressed to 105 lb., raising it to the final pressure of 210 lb.

As above mentioned, it is advisable to admit the air into the cylinders at a low pressure, and to make the expansion as complete as possible. When this pressure is once regulated by the automatic reducing valve, it can be increased or diminished, according to the gradient of the road, the weight to be hauled, or to other requirements of the traffic, by simply adjusting the screw which regulates the spring of the valve.

This apparatus is composed of a cylinder AA, Figs. 2 and 3, same page, the interior of which is placed in connection, by means of a pipe Z, with the main reservoir, in which the pressure may be either constant or variable. For a portion of its length the cylinder AA is enclosed in a casing BB. The annular space between the cylinder and the casing is filled with the expanded air, which can escape by the pipe Y. The sides of the cylinder in the portions within the casing BB are pierced with two series of holes *a a* and *b b*. The end of the cylinder towards which the latter are placed is closed with a cover, the other end being open to the atmosphere.

Within the cylinder A is a moveable apparatus composed of a cylinder C, fitting easily, and in one piece with a rod X, on which are fixed two pistons V and H. The cylinder C is pierced with a series of holes *e*, which according to the position of the movable system coincides either with the holes *a* a, or with the spaces left between these holes, in which case all escape of the air is prevented. During the movement of this part of the apparatus, the piston V is always between the series of holes *a* and *b*. It follows that the space between the bottom of the cylinder and the piston V is always in communication with the annular space B containing the expanded air. The two pistons V and H being of the same diameter, the moving portions remains always in a condition of equilibrium.

The end of the rod X carries a plate K, and opposite to it is another plate L, carried by a screwed spindle M, which is maintained at a constant distance from the cylinder A. A spring N is interposed between the two plates, and tends always to keep them separated. The plate L being fixed in relation to the cylinder A, the spring N tends to force the movable portion towards the bottom of the cylinder, and so to keep the holes *e* of the movable cylinder opposite the holes *a* of the fixed one. If compressed air be admitted into Z, it flows through the openings *e* and *a* and expands into the annular space B. In passing through the holes *b* it produces, by reason of its pressure, a motion of the piston V, opposed to the spring N. When this effort becomes greater than that exerted by the spring, the movable portion of the apparatus advances towards the open end of the cylinder, and the holes *a* are closed.

When there is a continued flow of compressed air through Y the movable cylinder C takes intermediate positions, the holes *e* partially coinciding with the holes *a*, so as to uncover more or less of their area, the dimensions of these openings depending directly upon the pressure of the air, increasing if this diminishes and *vice versa*. The pressure to which these results are due, depends only on the tension of the spring, no matter what the initial pressure of the air may be at Z. If therefore air be admitted, under either a constant or a variable pressure, it will flow from Y, at a constant pressure, always inferior of course, to the initial pressure.

When the pressure in Y is once determined by means of the spring N, it may be regulated at will within certain limit, by means of the screw M, by which the tension of the spring may be increased or diminished.

It will be seen from the above description that by means of this apparatus applied to the compressed air engine, the expansion of the air is effected by means of variable openings, the area of which is fixed by the pressure acting on the piston forming part of the apparatus, and balanced by a spring, the tension of which fixes the amount of the pressure. By adjusting the spring by means of a hand-wheel and screw, a range of pressures can be commanded with the same apparatus.