

The economy of the compound over the simple expansion of this type is, first, that the full expansive effect of the air is realised; second, on account of the large combined cylinder-surface, new energy is imparted to the air from the surrounding atmosphere; and, third, in the practical use of the locomotive.

In making the calculations for air-consumption the various cut-offs are considered, while in the use of the locomotive the engineer invariably cuts off later in the stroke than necessary, and hence exhausts at high pressure with simple cylinders; but with compound this exhaust is caught in the low-pressure cylinder and utilised. The best practical example of this saving, which is fully 50 per cent., is shown in the use of compressors of same size and make. Where the simple cylinders are used it is impossible to keep a supply of air, whereas with the compound the compressor is running half-speed most of the time and the pipe at maximum pressure. On account of the high pressure carried many people are fearful of the results from explosions, and go so far as to say that the factor of safety with such pressures should be greater than with low ones, but this is not the correct idea. These pressures are a maximum which it is difficult to maintain and almost impossible to exceed, hence the possibility for explosion is scarcely to be considered; while in low pressures it is easy to excel and hence increase the possibility of explosion. It is therefore considered good practice to use a factor of safety of three in designing the storage-tanks. In the compression of air it is impossible to get the ideal; hence in compressing 100 cubic feet of free air we get practically 3 cubic feet at 750 lb., instead of 2—the theoretic amount. If this air is expanded adiabatically, we will have 75 ft. free air, or a loss of 25 per cent. It is customary to base calculations on adiabatic compression and expansion, but in the use of high pressures the errors are such that we must work with closer values if we desire reliable results.

In order to show the working of a Vauclain compound air-locomotive we will refer to the records taken at the Alaska Colliery of the Philadelphia and Reading Coal and Iron Company: On the 20th October, 1897, the average of twelve trips was twenty-six empty cars, weighing 75,000 lb., hauled up an average grade of 1.4 per cent., 2,400 ft. long, with an average indicated horse-power of 49.4 and an air-consumption of 114 cubic feet at 200 lb. pressure. In practice this would require 9 cubic feet at 750 lb., or 300 cubic feet free air, and to compress same would require approximately 95-horse power, thus showing an efficiency of over 50 per cent. for the entire system. Had the air been compressed to 200 lb. it would have only required 57-horse power to do the compressing, and the efficiency would have been 87 per cent.

In the use of compressed air in Paris it has been determined that it required 11 ft. of free air heated and 115 ft. cold to produce 1-horse power. In the work cited above it required about 6 ft. free air per indicated horse-power, and to transport 1-ton cars and lading one mile on level track, with a car-resistance of 1 per cent., 23 cubic feet free air. The air used at this point is filtered through water in order to remove all dust, and comes to the three-stage Norwalk compressor thoroughly saturated with moisture; yet this moisture does not assert itself until the working-pressure is reduced to 120 lb., when there is trouble in freezing.

For gassy mines this is the only form of haulage, and, since it is necessary to have sufficient storage-capacity to charge the locomotive almost instantaneously, it is customary to extend the pipe-line sufficiently far into the mine so that it may act as a reservoir, and at the same time afford charging-stations at convenient points or for future demands.

About the time of the introduction of electricity into street-car service it became a question for discussion among the mining people as to its practicability for their use. In the early days the failures were numerous, due principally to the inability to fully understand the various freaks of motors and kindred troubles. The system in general was looked on with suspicion, and considered entirely theoretic, and, with the rough usage of mine machinery, considered entirely of too dainty a nature for practical use. The dangers arising from its use were also detrimental to its installation, but this has all passed away to such an extent that bare wires are now used for feed-wires. On account of the methods for supporting these wires it often happens that they fall down, and cause serious accidents to mules. In the use of 250-volt current it is found that simple contact does not kill the mule, but if he falls on it he is certainly killed.

Of the many electric haulages installed during the past five years very few of them have been of 500 volts, due principally to the fear of the high tension; yet the number of accidents from this voltage is no greater proportionally than for the low, and when it is considered that in the low the amount of feed-wire is greatly increased the chance for fallen wires and danger from contact are also increased.

The numerous accidents to mules coming in contact with these wires raised a demand for some sort of a system whereby the animal will become an unnecessary evil in the operation of a mine. To construct a bonded track and stretch a trolley-wire to the face of all workings would be too expensive for general mine practice, and in consequence it is the custom in some mines to use a small mine-wagon, and have the miner push it to and fro from face to parting, from which place it is taken with the locomotive. In order to eliminate the mule from the mine and haul from the face of all workings, a combined storage and trolley locomotive has been devised, whereby the heavy work on headings is done from trolley, and while so running the attached battery, which is carried in circuit, absorbs sufficient current to do the necessary room-work. Such a locomotive, the only one of its class, was built by the Baldwin-Westinghouse combination for the South-west Virginia Improvement Company, having the following dimensions: Gauge, 36 in.; width over all, 42 in.; height, including battery-box, 44 in.; length, 124 in.; weight, including battery, 9,000 lb.; electric equipment, two 10-horse-power motors; rheostatic controller. This locomotive was designed to haul on the level one loaded car weighing 9,000 lb. on storage, and was accordingly equipped with 90 5-D. cells, and having mounted therewith a special battery circuit-breaker, &c.

After the locomotive was built the mine-manager changed his plans, and concluded to try it in a part of the mine where the battery would be required to handle loaded cars up a 4-per-cent.