"The waved lines show water-courses, *G G* being the river Reuss. The full lines show the location of the railway lines, and the dotted lines the tunnel. The points *A*, *B* and *C* show bridges over a cascade. The bridge at *B* is about 500 feet above the bridge at *A*, and the bridge at *C* is about 300 feet above that at *B*. The circles in the tunnels are 2000 meters, or 6502 feet diameter.

"On the south or the Italian side of the big tunnel are more difficult locations still. The roads here are beautiful, built and kept in order by the state.

"The tunnels of this railway (even the big tunnel is solid granite, and wide enough for three tracks) are arched with granite, but little inferior to the face work of the Astor House. None but the rich nations of Europe could, for a moment, think of building such a railway.

"I was run into the big tunnel for two kilos, on one of their air engines, to see a drilling machine I once explained to you. Baron Lauber tells me it is pressed against the rock with a pressure of 130 atmospheres, and that it walks into granite, as if it was cheese."

* * * In regard to the abundance of water-power in Switzerland, Mr. Evans says: "There is a tremendous water-power going to waste all over Switzerland; you can see in hundreds of places streams of water coming down nearly perpendicular for 1000 or 2000 feet. At the great tunnel of the St. Gothard Railway the river Reuss crosses the very mouth of the tunnel, and gives the engineers a water-power fifty times greater than they can use for compressing air, making repairs, etc., etc."

THE ST. GOTHARD TUNNEL.

In a paper just communicated to the French Academy, M. Colladon gives some interesting details of the progress of this great enterprise. Besides the excessive hardness of the banks of serpentine and quartz, and the insufficiency of hydraulic forces on the Airolo side (after the lowness of water in winter), there has been a very troublesome infiltration in the south portion, the volume of water having increased since the second year to more than 230 liters (70 gallons) per second in the advance gallery. The difficulty of working here under jets, which had often the force of those from a fire-engine pump, can be readily imagined. Another difficulty arises from a mass of decomposed feldspar mixed with gypsum, found under the plains of Audermatt. This plastic material swells on contact with moist air, and exerts a pressure of terrible force, capable of crushing the strongest woodwork, and even arches of granite. In some of these parts the workers thought themselves happy when they were able to advance (with manual boring) about 1 meter in three or four days; whereas, through granite, with compressed air and mechanical perforation, a regular advance of 4 meters in 24 hours has been achieved; through gneiss, 6 metres, and more. As regards apparatus, M. Colladon states that the volume of water from the Tremola (Airolo side) having been found insufficient, M. Favre brought water in an aqueduct, 3000 meters long, from the Tessin, to work new turbines and four compressors, on the same system as the others, but of greater volume. These turbines are of cast iron. It is noticeable that the old and smaller bronze turbines (formed of one piece), which have made some 155,000,000 revolutions per annum, are in good preservation after four, or even five years' service, and still work usefully, after slight renewals. On each side of the tunnel there are at present sixteen air compressors in action, serving both for aeration and for boring operations. They send into the tunnel air under a pressure of eight atmospheres, sufficient to drive eighteen to twenty drills, and effect good ventilation of the part already bored, which is at present 6100 meters on the north side, and 5390 meters on the south side. On either side there are, night and day, several hundreds of workmen with lamps, and about 300 kilogrammes of dynamite are consumed. The compressors are found to suffice for good ventilation, rendering unnecessary two large exhaust vessels, placed two years ago at either mouth of the tunnel for drawing off smoke and vitiated air. The transport of materials is effected by horses in the more advanced part of the tunnel, and by compressed air locomotives in the portions near the mouths. To feed these locomotives eight of M. Colladon's compressors are placed at Airolo and Goeschenen. They draw air from the ventilating pipe, and force it, under a pressure of 12 or 14 atmospheres, into a pipe which passes along the part traversed by the locomotives. A great variety of rock drills has been used. Each year brings new improvements.

FIREBRICK FIRE BOXES FOR LOCOMOTIVE BOILERS.

We have received from Mr. Verderber, the inspector-in-chief of the Hungarian State Railways, some very interesting particulars of the results he has obtained with a new construction of locomotive boiler of which we now publish illustrations. The peculiar feature in this boiler is that the heating surface of the firebox is dispensed with, there being employed, in place of the ordinary firebox, a combustion chamber lined with fireproof material. The account of the experiments which led to the adoption of this system of construction can best be given in Mr. Verderber's own words as follows:

On most lines of the Hungarian government railways the feed water is very bad, and forms large quantities of sediment; consequently the boilers of this company need more frequent and extensive repairs, particularly on their fire boxes, than those of other companies having at their disposal a better kind of feed water. Under these circumstances I endeavored, as many other engineers have done before, to remove or at least to lessen, this inconvenience caused by the failure of fireboxes. Examining the investigations of others, I became convinced that only by abolishing the water-surrounded fireboxes would there be a possibility of effecting a real remedy, and in consequence I tried to solve this problem, and contemplated the employment of a cylindrical tubular boiler combined with a fore-fire of fireproof material for receiving the firegrate.

The fact that the firebox, with a moderate application of the blast pipe, produces nearly fifty per cent of the whole steam produced by the boiler, has led to the false notion that the cylindrical part of the boiler is not capable of producing the necessary quantity of steam without the aid of the firebox. My observations, however, led me to another conclusion. It first struck me why the heating surface of the tubular boiler performs so little work in comparison with the firebox. The reasons for the small capability of the boiler tubes in comparison with the firebox are the following:

1. The burning gases pass only through a part of the tubes, consequently the other part is either quite or partly out of action.

2. The temperature of the burning gases diminishes during their progressive movement in the tubes, and therefore less heat will enter the boiler toward the smokebox end.

3. Finally, and principally, the deficient heating capability of the boiler tubes is accounted for by the fact that nearly 50 per cent of the available heat is absorbed by the firebox before the burning gases enter the boiler tubes, in consequence of which they cannot possibly take up more heat.

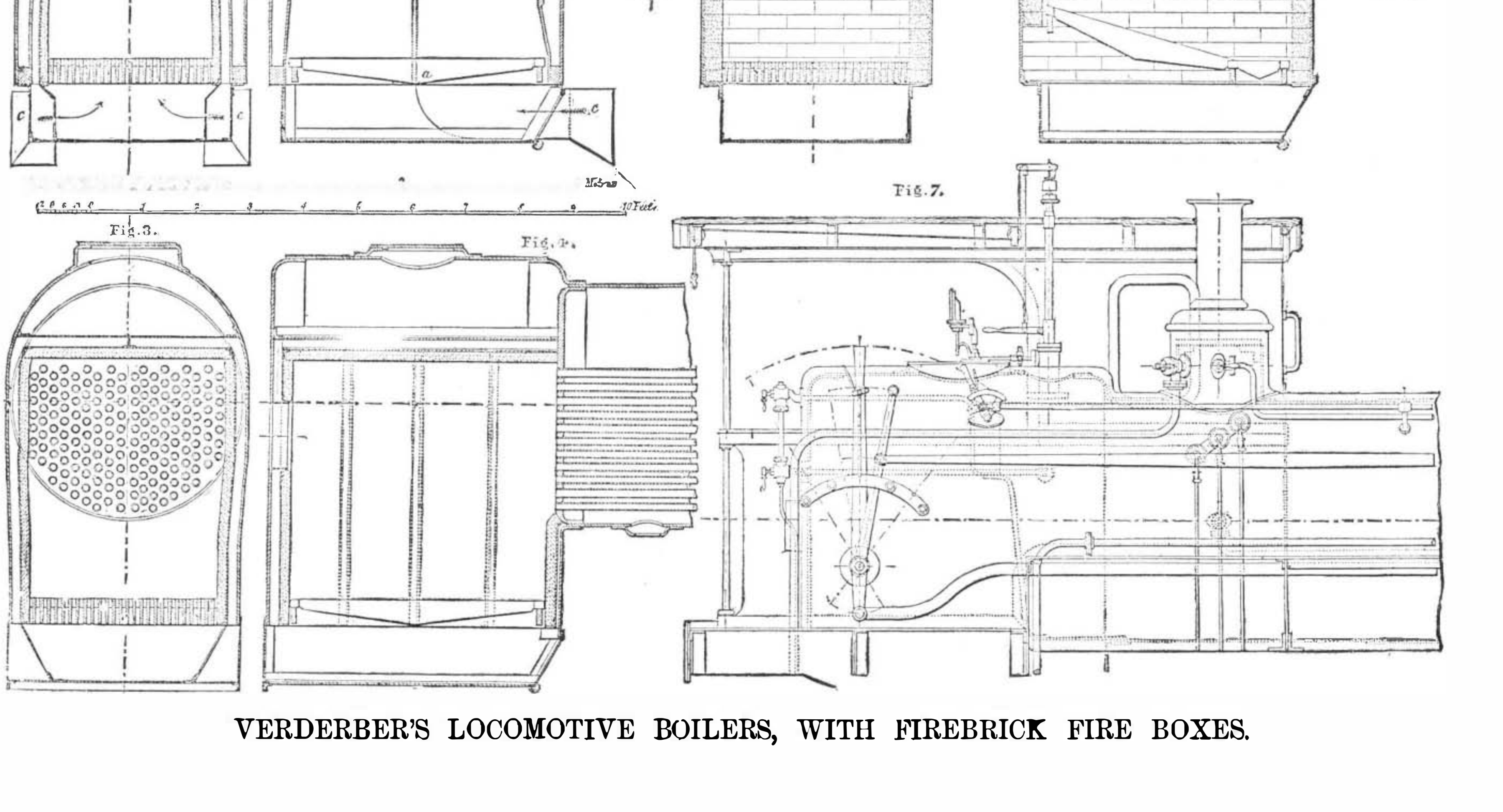
There is no reason at all why the tubes should—at equal temperature and density of the burning gases—evaporate less water per square foot of surface than the firebox; I had, therefore, no doubt whatever that if the burning gases at their original temperature could be led into the boiler tubes, they would receive the whole available heat, and consequently the tubular boiler would do as much work without the firebox as with it, that is to say, the firebox as a steam generating part of the boiler is superfluous.

Although the minute examination of the results of the interesting experiments carried out by the French Chemin de Fer du Nord regarding the evaporative capability of locomotive boilers, published by M. Ch. Couche in his work, "Matériel Roulant et Exploitation Technique des Chemins de Fer," vol. iii., led me to the same conclusion, I hesitated to reconstruct a locomotive engine before my notion was proved by an experiment to be correct. I therefore isolated the firebox from the boiler of a locomotive by fitting to it plates covered with fireclay. Figs. 1 and 2, below, show how the isolation was carried out. The plates were placed at a distance of 60 to 70 mm. from the copper firebox, and the intervening space was divided into two parts by means of a diaphragm, *a b*. The cold air entered through the conical opening, *c*, into the space, and was led from there under the grate. The temperature in the space between the firebox and the fireclay covered plate was 300 deg. to 350 deg. Cels. (572 deg. to 662 deg. Fahr.), while the locomotive stood still, and 70 deg. to 90 deg. Cels. (158 deg. to 194 deg. Fahr.) while running, according to the speed, upon which the draught depended. The locomotive, working with a pressure of 8½ atmospheres, the temperature in the space was, during work, about half of that of the copper firebox sides, therefore not only was no heat given up to the boiler by the firebox during work, but the firebox even lost a part of its heat to the entering air.

The locomotive fitted out with this isolating plate-wall was a passenger engine, which took the trains between Budapest and Miskolcz ten weeks running. The result was found to be that 1 kilo of coal evaporated the same quantity of water as before putting in the plate. Now, after the locomotive had been in service through ten successive weeks, the isolating plate-walls inside the sides and crown of the firebox were taken out, and upon the same line, with equal speeds and weights, the observations were continued, the result showing the same effect as regards the heating power of the coal. By means of these simple experiments it was clearly shown that, with the present dimensions of the cylindrical part of the locomotive boiler, the firebox as a steam-creating part can easily be dispensed with. If, therefore, some engineers pretend to have, or really should have, gained favorable results by enlarging the direct heating surfaces, that is the firebox sides, then the increased capability of the boiler thus gained is not to be accounted for by the larger firebox surface, but probably by the enlarging of the firegrate, as, in consequence of this, larger quantities of coal have been consumed.

The experiment with the isolating plate-walls also gave information as to the durability of the fireproof material in the firebox. It was noticed that this material, if cooled from the outside—as was the case with the isolating walls—was not at all altered by the influence of the fire.

The dispensability of the firebox as a steam generating part of the boiler, and the durability of the fireproof material, having been clearly shown by the experiments with the isolating walls, the reconstruction of a locomotive was decided upon, and for this purpose our goods train locomotive, No. 39, was chosen, this engine having three coupled axles and 36 tons adhesion weight, and its copper firebox being defective and requiring renewal. The reconstruction was



VERDERBER'S LOCOMOTIVE BOILERS, WITH FIREBRICK FIRE BOXES.