RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE-TOGGENBURG RAILWAY.

No. I.

The Ebnat–Nesslau Railway is a branch line of the Bodensee–Toggenburg Railway, well known on account of its important engineering works, tunnels, and high viaducts. If the main line was constructed with great difficulty, and at considerable expense, as it had to cross a country of extremely broken character, the Ebnat–Nesslau branch also had its difficulties, though they were of a less expensive character. A plan of the line is given in Fig. 1 and a profile in Fig. 2.

The Ebnat–Nesslau line, a prolongation of the line from Wil to Ebnat, had to follow the course of the river Thur, where the valley is of a very broken character and the geological formation of an unreliable nature, as is frequently the case in that part of Switzerland. The ground rock consists at some places of rather hard puddingstone, marls, and sandstone or lime-sandstone. The ruling geological strata are favourable, as the line could generally be located nearly parallel to the direction of the strike of the strata. The rocks are, however, partly covered with clay—at places of a loamy character—and material left by earlier landslips. The ground is also very wet and treacherous in many places, and shows a tendency to slip.

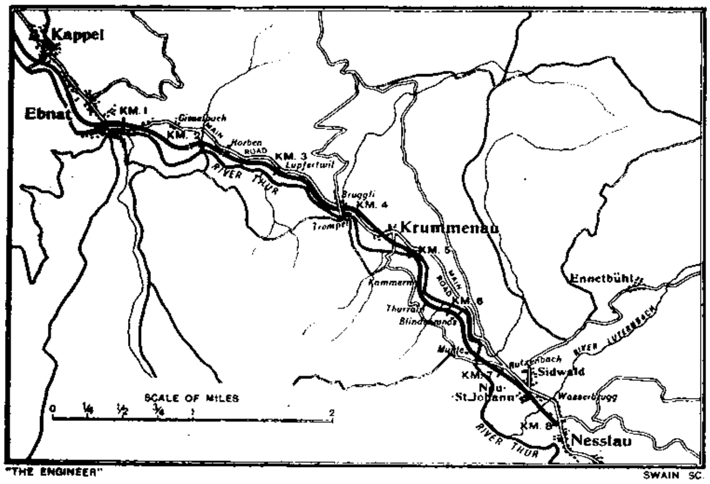


Fig. 1—THE EBNAT-NESSLAU RAILWAY

The rock-cuttings through the puddingstone yielded useful ballast as well as rough building stone, while the lime-sandstone yielded an excellent building material, very easy to work, with a compressive strength of from 1100 to 1200 kilos. per square centimetre. Sand and shingle were somewhat scarce, but were sometimes to be had.

The particulars of the gradients and curvature of the line are as follows:—

Length of level line	= 15·4 p.c. of the total length. 8014 m.
Length of line on a gradient ...	= 84·6 p.c. of the total length
The "virtual" gradient	= 2·6 p.c. = say, 1 in 38½
The maximum gradient	= 2·5 p.c. = say, 1 in 40
Average rise of all gradients ...	= 1·03 p.m. = say, 1 in 51·8
Total rise	= 128·6 m. = say, 422ft.
Minimum, ordinary radius... ...	= 250 m. = say, 820ft.
Minimum, exceptional radius ...	= 200 m. = say, 656ft.
Average radius of all curves ...	= 283 m. = say, 928ft. 3in.
Number of curves	= 29
Total length of straights	= 38·9 p.c. of the whole line
Total length of curves...	= 61·1 p.c. of the whole line

The line is of the normal gauge.

In 1909, when the writer took over the work, a good working scheme already existed. First, a contour-lined map with a scale of 1 : 5000 had been made of the country. After the project had been worked out on this map the line was staked out and shifted a little to one side or the other, as was considered desirable. On looking into the matter, however, it was seen that certain improvements could be made. First, it was found possible to lessen the gradient a little and to introduce the gradient rule set out in the Roeckl formula, which is:—

$$\frac{65 \cdot 0}{R - 55}$$

where R is the radius of curvature. A few words about this formula may be of general value.

The Roeckl Formula.

On railways, and especially those with steep gradients and sharp curves it is, of course, of great importance, at least in some cases, so to arrange the longitudinal section that the resistance to traction nowhere exceeds a certain limit or that no special part has a resistance exceeding this limit. In locating the railway and arranging its longitudinal section a certain gradient, which may be called the "virtual" gradient has to be chosen. The definition of the term "virtual" gradient is the steepest gradient which can be used having regard to the resistance caused by curves, as well as the possibly diminished adhesion experienced in tunnels.

For instance: Take a line or section of a line calling for a maximum gradient of about 2·5 per cent. and curves of 250 m. radius. Then, if the gradient be made 2·6 per cent. in the straight portions, this figure must be reduced in places where there are curves in accordance with the formula 65·0 ÷ R – 55. If R, for instance, = 250 m., the reduction is 65·0 ÷ 195 = ·33 per cent., the gradient on this curve thus being made only 2·6 – ·33 = 2·27 per cent. If the curve be in a tunnel longer than 300 m.—tunnels shorter than 300 m. are not considered—a further reduction of gradient takes place, the 2·27 per cent. being multiplied by, say, 0·75, thus reducing it to, say, 1·7 per cent. The reason for the special reduction of gradients in tunnels is that the rails are frequently wet, and that there is thus diminished adhesion. As a coefficient of reduction for tunnels Mr. R. Weber, the chief engineer for the locating and construction of the well-known Bodensee-Toggenburg Railway, recommends 0·7; 0·8 is recommended by others, and 0·75 is a mean of these. Too many breaks of gradient have, of course, to be avoided. The shortest distance between two breaks of gradient ought not to be made less than 300 m.

The Roeckl formula quoted above applies to the normal gauge of 1·435 m. (4ft. 8½in.), and if it be desired to use it for a narrower gauge, such, for instance, as the 1 m., the formula has to be multiplied by 1 ÷ 1·435, as the resistance of curvature diminishes in proportion to the ratio of gauge. With 1 m. gauge and 100 m. radius we should get $\frac{65 \cdot 0}{100 - 55} \cdot \frac{1}{1 \cdot 435}$ = say, 1·0 per cent., with which to reduce the heaviest gradient used on the straight, or, if this be 2·5 per cent., there would on a curve of 100 m. radius be applied 2·5 – 1·0 = 1·5 per cent. gradient, the 2·5 per cent. in this case being the "virtual" gradient.

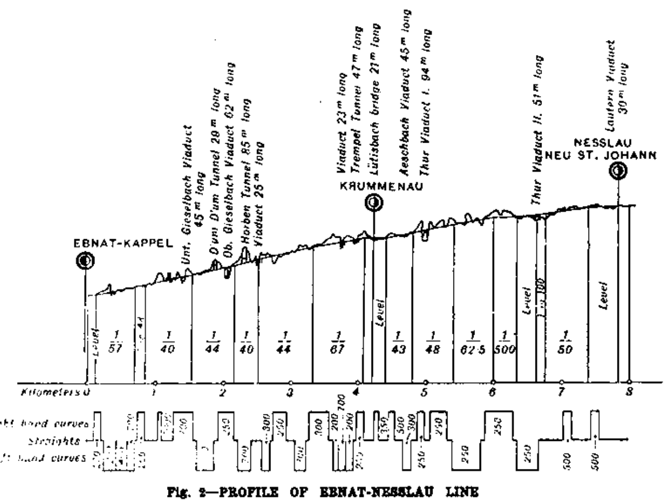


Fig. 2—PROFILE OF EBNAT-NESSLAU LINE

Formerly this consideration of "virtual" gradient—the German expression is "massgebend steigung," literally "standard gradient"—was not sufficiently thought of, and, in consequence, corresponding defects are found on the longitudinal section of some of the most important railways. On the well-known St. Gothard Railway, for instance, the resistance to traction in the long spiral tunnels is far heavier than in the open part of the line, as they have only a reduction of ·2 per cent., whereas the reduction should really have been 2·6 (1 – 0·75) = ·65 per cent. The practical effect of this was immediately seen when the first heavy service train was taken over the still unfinished line. It got on all right until it arrived in Pfaffensprung spiral tunnel—about 1600 m. long, with curvature of 280 m. radius—where it stuck, and had to back down to Gurtnellen Station to detach some of the cars.

On the Bodensee–Toggenburg Railway the longitudinal section is so well laid out in accordance with the Roeckl principle that the engine drivers running the trains up gradient scarcely need to touch the regulator, and the graphical speed diagrams show a very uniform speed. It must, however, not be forgotten that the task of locating and setting out of railways is getting more complicated by reason of such demands, and calls for a considerable amount of thought, as in most cases economy of construction has to be duly considered at the same time.

In the case of the Ebnat–Nesslau branch, the "virtual" gradient of 2·6 per cent. was not directly used, as the straight portions on the heavy gradient section were not long enough to apply it. The heaviest gradient carried out was 2·5 per cent. The gradient and alignment of the line were thus altered to agree with the demands of "virtual" gradient, as well as other demands, such as reduction in the number of level crossings, cheaper construction, &c.

Lay out of the Line.

In all kinds of broken country the use of the contour-lined map is the best and surest way of getting in the right railway location, facilitating any control and later alteration, as well as giving a good true map of the ground along the railway.

These contour-lined maps have, of course, to be of a suitable scale in order to be useful. The scale 1 : 5000 demands a very accurate map if the ground be broken or of uneven character. For difficult details scales of from 1 : 200 to 1 : 1000 ought to be chosen.

The survey, staking out, and plans for the Ebnat–Nesslau line were completed in 1909. Following a period of somewhat dry years, the weather had changed, and after the autumn of 1908 the rain became excessive, and continued to be so up to the extremely dry summer of 1911. As the excessive rain in 1909 had already begun to do very serious damage at various points of the main line, the writer proposed to have numerous drainage works carried out as a continuation of the trial holes—which had been taken in hand just after the staking out of the line—so as to have the benefit of their draining influence as long as possible before the formation works had to be commenced. Some of the trial holes had previously been placed so as to serve for drainage purposes.

GENERAL DESCRIPTION.

The Ebnat-Nesslau line is, as has been said, a prolongation of the railway from Wil to Ebnat, both these big villages being in the district of Toggenburg, in the Canton of St. Gallen. Nesslau is the main village of the upper part of Toggenburg, and is beautifully situated in view of the Churfirsten and other mountains. The Sentis can also be seen from some points. The upper Toggenburg Valley is imposing, not being too closed in by mountains, and having fine undulating slopes, which are partly wooded. Along the valley passes the main road which traverses the pass at Wildhaus and connects Toggenburg with the Rhine Valley at Buchs.

After leaving the station of Ebnat, the line has to cross the main road in the valley twice—first, by a level crossing in the village of Ebnat at km. 0·7, which level crossing was necessitated because any other course would have been too expensive; and, secondly, at km. 1·2, where the road is taken over the line on a bridge. After the level crossing at km. 0·7 the maximum gradient had to be made use of up to km. 3·3, where it changes into a 1·5 per cent. (1 in 66·6) gradient. Between kms. 1·4 and 2·1

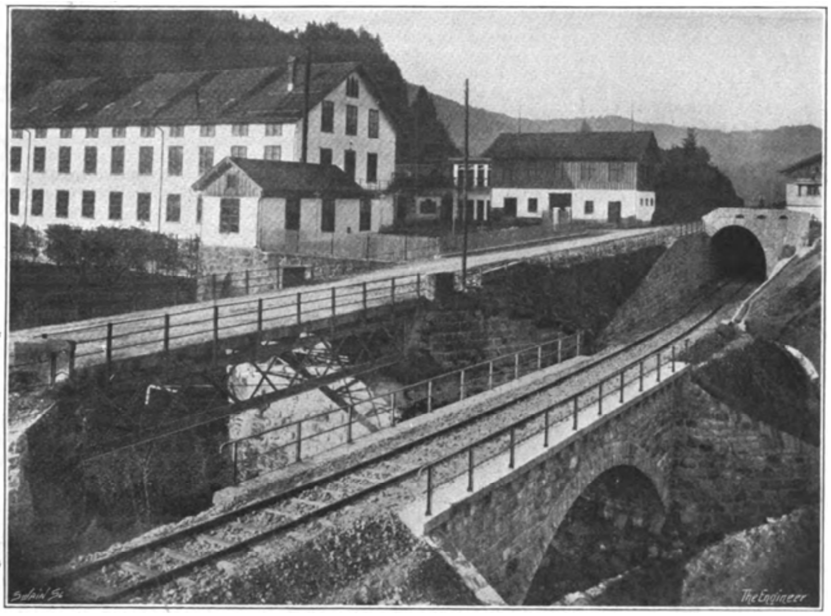


Fig. 3—TREMPEL TUNNEL—UPPER PORTAL

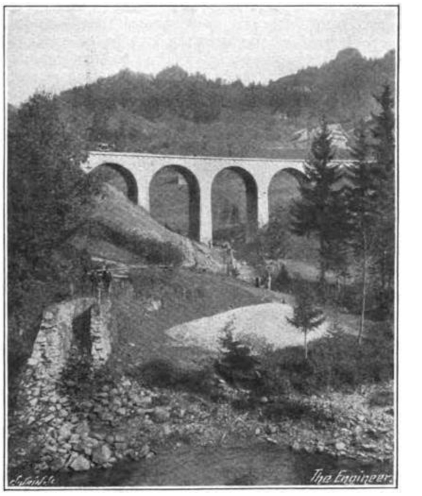


Fig. 4—VIADUCT AT KM. 2·05

the line is taken across side valleys on viaducts. One of these viaducts which comes at km. 2.05 is shown in Fig. 4.

Between kms. 2·46 and 3·79 difficult slopes had to be passed partly on viaducts. Between kms. 3·7 and 4·0 is a narrow pass, the valley only leaving small room for accommodating both road and railway, and the latter, after passing along a steep slope, is taken under the road in a tunnel—see Fig. 3. Between kms. 2·4 and 3·0 another difficult part had to be passed, a special description of which is given later on as being of uncommon interest.

At km. 4·2 is the station of Krummenau. The station buildings are not of the usual uniform type, but are in keeping with the architecture of the old buildings of Toggenburg, the wooden houses of which have a very fine style of their own. After the station at Krummenau the heaviest gradient used is 2·33 per cent. (1 in 42·9). At km. 5·0 the river Thur is crossed on a stone bridge with a main arch of 63·3 m.

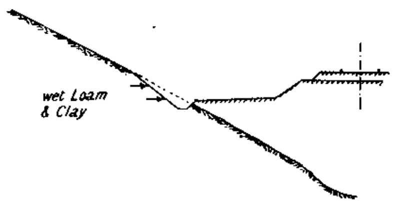


Fig. 5 · DRAINAGE CHANNEL

span, and at km. 6·7 it is crossed a second time, also on a stone bridge with a main span of 24·8 m. As both these bridges are of interest, they are also specially described later, and the general principles entering into their construction discussed in detail. At km. 7·7 the station of Nesslau is reached, and, being a terminus, it is provided with a turntable, water crane, and locomotive shed. The line has altogether three tunnels and nine railway bridges and viaducts, besides seven road bridges or arched culverts, and a great number of smaller culverts. There is a number of rock cuttings, the deepest being 20 m. deep. The highest embankment—at km. 2·8—is 12–14 m. high. It was necessary to construct a great number of retaining walls. The contract for the works was let in April, 1910, and the line was opened in October, 1912.

FORMATION WORKS.

Drainage.—When constructing embankments on swampy ground, especially if the latter be on the slope, great care has, of course, to be taken to prevent the ground water being held up by reason of the weight of the embankment on the soil. Should this happen, then, as a rule, the water will collect and in time make the ground so wet that it will yield and cause the embankment to slip with the usual expensive consequences. Intercepting the water on the upper side of the embankment and taking it to the lower side in a safe manner is thus the first thing to look after.

Between kms. 1·7 and 1·8 a swampy place with wet clay and with a slope of 7 to 8 per cent. was met and dealt with in this way. Between kms. 2·4 and 2·5 there was another dangerous place with very wet clay and loam with a slope of from 30 to 40 per cent. Fortunately, the bank was at this point neither high nor long. Drainage channels were cut into the slope and filled with rip-rap. The bottoms of the channels were, as is usually done, given a paving of concrete, on which a small rough dry stone sewer was built, the channel being then filled up with rip-rap with a layer of hurdles on the top. A hill to the left of the line was only cut into a little, as shown in the accompanying sketch, Fig. 5, but the hill, consisting of wet clay and loam, was in such unstable equilibrium, that this slight disturbance caused it to commence slipping. To meet this difficulty a shallow ditch was cut in the slope passing above the hill so as to catch the water and partly relieve the hill from surface water, after which the slope kept quiet and no further trouble was experienced. Between kms. 2·5 and 2·6 a slipping movement had to be dealt with in a special way, about which more will be said later on.

The most dangerous place was between kms. 2·75 and 2·9. Here the trial holes indicated wet clay up to a depth of 5½ m. to 6 m. The slope of the ground was from 10 to 16 per cent., and the height of the embankment 11 m. to 14 m. The difficulty at this place was of a kind which deserves a thorough general investigation, as also does a similar characteristic case met with during the construction of the main line of the Bodensee-Toggenburg Railway, viz., the embankment at Hohenbühl, between St. Gallen and Romanshorn.

At several places on the latter line great difficulty was experienced with the heavy embankments, as the ground would not stand the load put on it, but slipped and squeezed out, causing very heavy extra expenses. The most interesting of these cases was the

HOHENBÜHL BANK.

This embankment—see Figs. 6 and 7—is 300 m. long, and has a height of 14 m. As originally designed, a concrete culvert was arranged to pass under it nearly in the middle of its length. The soil was blue clay on the top of a layer of yellow clay mixed with stones, below which was a layer of sand and shingle on top of the hard moraine. No unusual sign indicated beforehand that trouble was to be experienced. The culvert was made, and the tipping for forming the embankment commenced and carried past the culvert, due care being taken not to load it too heavily on one side. Soon, however—in the summer of 1909—the culvert commenced to show cracks, indicating undue settlement, and the cracks widened in such a way that it was determined to fill the culvert up with dry masonry, only leaving space for a strong Mannesmann steel tube, so as to secure an outlet for the water from the upper side of the embankment.

The tipping for the embankment was continued, but the latter slipped continuously, mainly on the down side, though the slope of the ground was but slight, being only from 1 to 1½ per cent. By-and-by

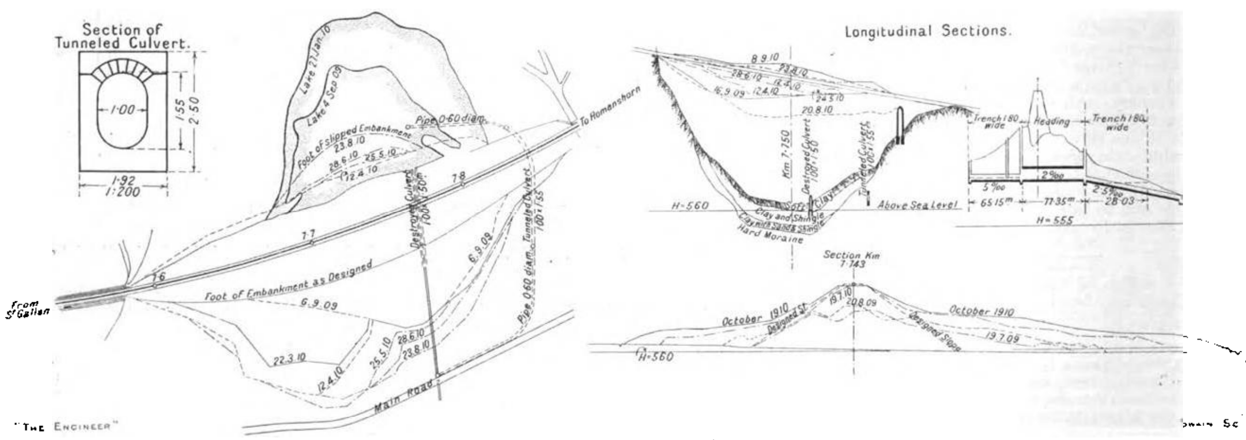


Fig. 6—SLIPS ON THE HOHENBÜHL BANK

the culvert entirely disappeared, and the passage of water was stopped, causing the formation of a steadily increasing small lake on the upside of the embankment, which circumstance, of course, aggravated the trouble.

Fig. 7—SLIP ON THE HOHENBÜHL BANK

It was then resolved to build a new culvert, arranging it in the hillside at the base of the bank—see the plan Fig. 6—part of it having to be run in tunnel. Meanwhile a centrifugal pump with a capacity of 2000 litres—or, say, 440 gallons—per minute driven by a 10 horse-power benzene motor, was installed,

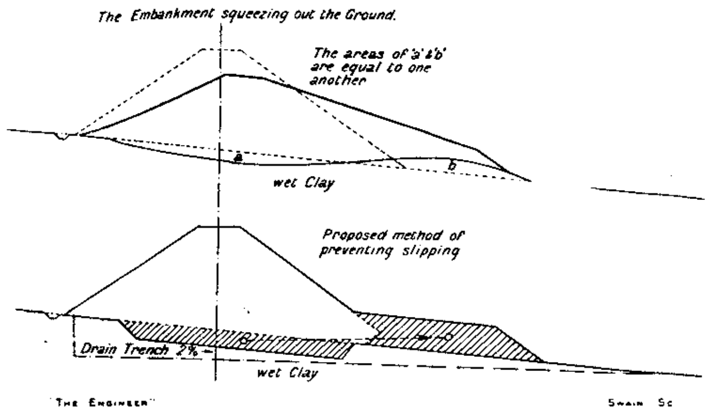


Fig. 8—CROSS SECTION OF EMBANKMENTS ON SOFT GROUND

so as to keep the level of the lake within certain limits. The tipping was continued, but the slipping went on for a long time subsequently, and the work was only finally finished in August, 1910, just in time not to interfere with the opening of the line, which took place on the 1st of October of that year. During a long portion of the tipping operations the embankment would only stand at a height of 10 m. Additional material laid on the top steadily sank to that level, thus showing that the ground beneath was incapable of supporting a heavier weight than that represented by that height. The embankment as designed originally contained 78,000 cubic metres, but this quantity had to be increased by 80,000 cubic metres to finish it. At last, as a matter of safety, the bank was made 1·5 m. higher than it was actually required to be, and the top metre and a-half were taken off just before the permanent way was laid, and there has since been no trouble whatsoever. The extra cost of making the embankment amounted, however, to £10,500. In seeking for the cause of this expensive experience, it has to be remembered that the two or three years before the autumn of 1903 were of a rather dry character, but that in the autumn of 1908—a few months after the works had been started—wet weather set in, and there was a pronounced excess of rainfall.

The layer of clay in the ground under the embankment got too wet to carry the load put on it, and had to yield. Though this layer of clay was of no great thickness, the foot of the slipping embankment at places carried a wave before it which at times had a height of 3 m. The case was interesting, as showing how difficult it is to foresee what may happen under any given circumstances. The question arises what to do to prevent such slippings, or at least to reduce such heavy additional expenditure as that mentioned above.

As the danger consists in the layer of clay, loam, or slippery soil, which at a certain degree of wetness yields, owing to the weight of the load placed upon it, and rolls out in a wave-like manner, not only causing the embankment to sink down in the hollow left, but also carrying with it the slope of the embankment which rests on the top of this ground wave, the best remedy would seem, in the writer's opinion, to be the digging out of this dangerous layer of soil. To trust only to the effect of drainage would scarcely do, as experience has shown that the effect of drainage on wet clay or loam works in many cases extremely slowly, so that such a method meets with very small success. There are, of course, cases of successful drainage of clay which have not been slow in taking effect, but they are few, according to the experience of the writer, and have embodied specially favourable conditions.

To what depth this excavation on the future site of the bank should be carried out depends on the thickness of the layer and on its degree of wetness. The writer thinks that as a rule no great depth is needed 3 m. at the utmost should be sufficient, whereas ordinarily from 1·5 m. to 2 m. will suffice. But, first of all, provision has to be made for drainage well below the depth of the proposed excavation. The dangerous soil is then excavated to a depth of, say, 1·5 m., and the excavated material dumped at the toe of the embankment, which operation loads the ground and aids it to resist sideways and upward pressures. The writer's proposals are embodied in the accompanying sketch, Fig. 8.

THE MUMFORD PARAFFIN MOTOR.

As in the highest powered ships to-day the turbine has ousted the ordinary reciprocating steam engine, so at the opposite end of the scale for launches and similar craft, the internal combustion engine is irresistibly forcing its way into the field hitherto exclusively occupied by the small steam engine. The results of this attack are to be seen on all sides. Well-known firms which have made a reputation by building light high-speed steam sets—such as J. Samuel White and Co., Limited, of Cowes, Thornycroft and Co., of Southampton, Vosper, of Gosport, and Simpson, Strickland, Limited, of Dartmouth, and others—have been forced to take up the manufacture of motors, and now the name of Mumford and Co., Limited, of Colchester, must be added to the list. As is the case with all these old-established firms, Mumford and Co. have begun in a quiet manner and kept their preliminary work to themselves, and hitherto they have only been supplying engines to the Admiralty for use on pinnaces, dingheys, &c. Now, however, they are entering the open market and are offering very nice little sets of paraffin engines, which we are afforded the opportunity of describing. These engines are made in sizes varying from a single cylinder giving 7 horse-power—Fig. 1—up to those with six cylinders giving 130 horse-power at about 850 revolutions per minute, and we propose to confine our description to the four-cylinder engines with cylinders 4½in. by 6in. giving 28 brake horse-power at that speed when using paraffin—Fig. 2.

The general outline of the engine—as shown in the cross section in Fig. 9, page 117—reminds us forcibly of the Simpson-Strickland engine, which we commented upon so favourably in our issue of May 3rd, 1912. There is the same section of crank case with good doors on each side through one of which the piston can be removed. Curiously enough, too, there was in the first engines—as shown by the engravings—the same little weakness in design that we commented upon in the older engine, in that, though one of the doors was arranged to be taken off by the simple turning of a handle, in the case of the other door a number of nuts had to be removed, though the two were reversed, and it was the door which gave access to the cranks and pistons which in the Mumford engine had the nuts on it. We only mention this point as indicating the liability of a designer to intermingle a poor piece of design with his other excellent work, for the point has been corrected in later engines. Then, too, the Mumford engine has the main bearings borne in the bottom half of the crank chamber, so that the upper part can be removed for adjusting the bearings without interfering with the main alignment. As with the Simpson-Strickland engine, the cylinders are cast singly and the exhaust outlet is sloped downwards in order to provide a neat pipe arrangement, which is otherwise so difficult to obtain with this form of construction. The water jackets have also removable covers and inspection doors, and here the resemblance ceases as the cylinders are not *desaxé*. We must plead guilty to having a liking for the *desaxé* cylinder, as in our experience it gives a smoother running engine, and, according to the paper recently read by Mr. F. W. Lanchester

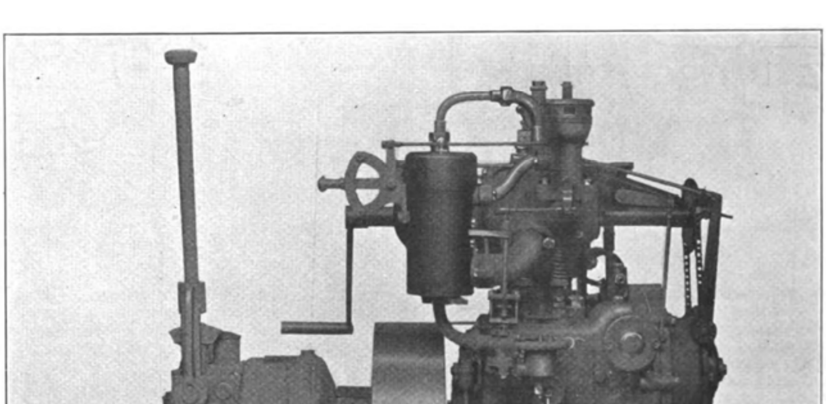


Fig. 1—SINGLE CYLINDER 7 H.P. MUMFORD MOTOR

more rapidly than the population. New factories were built and existing works extended, and during a dry summer the watering of public and private gardens, the numerous tree-lined avenues, and other thoroughfares, was lavish. A day would commence with the Luythaegen reservoir full, and, notwithstanding that the Waelhem pumps worked at full pressure, it would be nearly empty before the demand slackened in the afternoon. To cope with this fluctuating demand it was decided in 1911 to construct a second reservoir on the other side of the engine-house at Luythaegen. This reservoir is 85 m. long, 30 m. wide, and 3 m. deep, the capacity, like that of the first one, being 7500 cubic metres—see together with three clear water tanks holding 4500 cubic metres. But as Antwerp is still growing rapidly, and the demand for water increasing, the company decided, in order to keep well ahead of all requirements, to prepare for the additions to its works, which might become necessary during the remaining years of its concession.

The first step taken in 1912 was to provide increased carrying capacity of the mains between Waelhem and Luythaegen, to effect which the older of the two 20in. mains was replaced by one of 80 cm. (31½in.) diameter. After careful investigations, it was decided to adopt the Bonna system of reinforced cement pipes. These pipes—see illustration, Fig. 3—consist of a steel

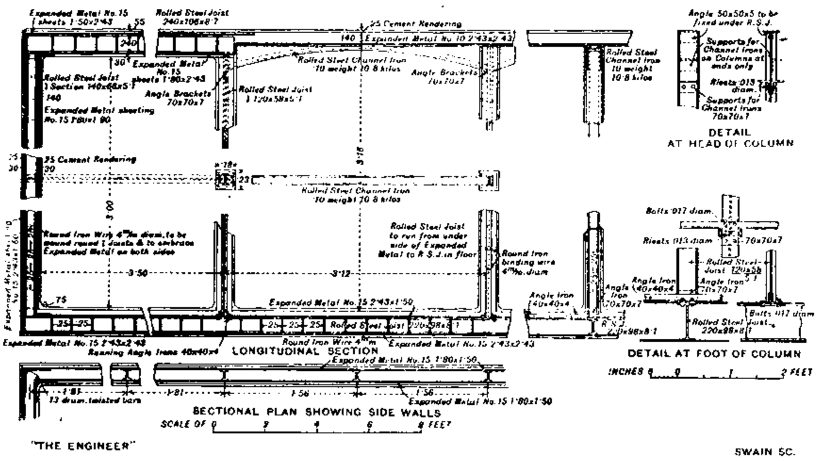


Fig. 4—CONSTRUCTIONAL DETAILS OF SECOND LUYTHAEGEN RESERVOIR

Fig. 2. Both these reservoirs are constructed in reinforced concrete on a bed of broken brick, suitably drained by collecting pipes into a sump. The ground in and near Antwerp is of a sandy nature, the level of the underground water being only a few feet below the surface. Consequently the outer walls of the reservoirs are as much exposed to water as the inner, and had to be finished and rendered with the same care. The details of construction will be seen on Fig. 4; the floor, walls, and roof are supported by rolled steel joists connected by steel longitudinals and covered on both sides with expanded metal tied to the joists with steel wire. This formed a key for the concrete, which was thoroughly tamped liner 2 mm. thick, acetylene welded at the circumferential and longitudinal joints, and reinforced internally and externally. The external reinforcement is of 10 mm. steel rod, wound spirally round the liner with a pitch of about 75 mm. It is kept clear of the liner by rods of 4 mm. diameter, spaced every 10 cm. round its circumference. The internal reinforcement is merely to hold the internal cement, and is formed of a 4 mm. steel rod wound spirally, with longitudinal rods of the same diameter, arranged as in the external reinforcement. The reinforced liner is placed in a vertical mould, and the pipes are cast from the platform of a travelling gantry. The mixture used was half Rhine sand, one-third

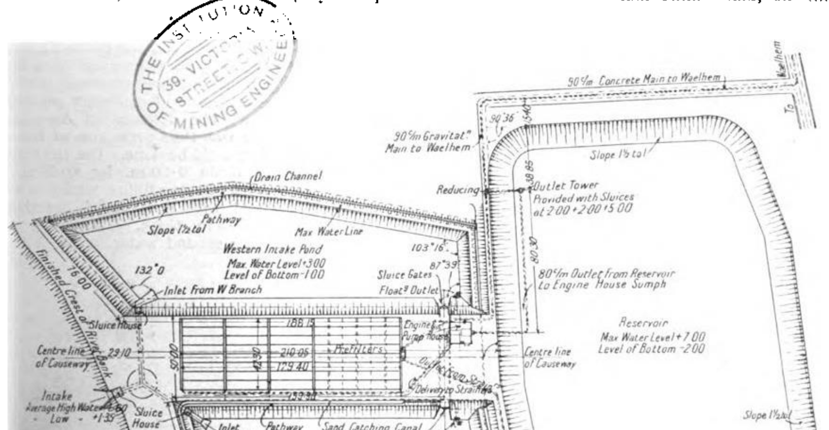


Fig. 5—INTAKE AND RESERVOIRS AT NOTMEIR

as the work advanced. The roof is carried on concrete arches. The columns, like the rest of the structure, are steel stanchions, surrounded by expanded metal, and concrete. The reservoirs are covered with earth, on which grass has been sown.

Whilst the construction of the second reservoir was proceeding at Luythaegen, three new filter beds, each with an area of 1500 square metres, were made at Waelhem. There are now three intake reservoirs, or settling ponds, with a total capacity of 24,000 cubic metres, ten gravel strainers with 600 square metres area, ten pre-filters with 800 square metres, and twelve sand filters with 15,100 square metres surface, Portland cement, and one-sixth "Porto de Franco"—a special quick-setting cement—and the moulds could be removed in about 25 minutes. The ends of the steel liners are left uncovered for a length of 10 cm. when casting the pipe, and the joints are made by butting these ends and placing a steel band round them. Yarn, soaked in bitumen, is caulked into the band, and the joint is finished with lead tubing filled with yarn; a ring of reinforcement is then slipped in place, and the joint cast solid in cement.

As many as twenty-five pipes of 4.20 m. length were cast in a working day. They were made at two depots, one at either end of the main. The manufacture of the 12.5 kiloms. (nearly 8 miles) of piping was commenced in March, 1912, and by the end of the year water was running through the pipes from Waelhem to Luythaegen. The total thickness of these pipes is 8 cm., and they will stand a pressure of 11 atmospheres (say, 150 lb. on the square inch).

The desirability of a fresh intake from the river, providing for an increased supply and a larger settling area, was next considered. The upper reaches of the river were inspected, and a site for the construction of new works was selected at Notmeir, about midway between Waelhem and Duffel. The relative positions of the Waelhem and Notmeir works are shown on Fig. 1, while the general arrangement of the latter installation is shown on Fig. 5. The intake is made with a reinforced concrete culvert, 3 m. wide by 1.50 m. high. After passing through the river bank it branches right and left to the two settling ponds, and it is provided with all necessary sluice gates, valve-houses, &c. The level of the floor of the intake is at 0.44 m., with an apron at the level of zero. Each settling pond will hold 40,000 cubic metres of water. As at Waelhem, water is admitted just before low tide, twenty minutes being sufficient to fill one pond. They are used alternately, so as to provide a maximum period for settlement.

In the engine-house there are two 18in. horizontal low-lift centrifugal pumps, each driven through gearing by a 100 brake horse-power oil engine of the semi-Diesel type, running at 250 revolutions per minute. The settling ponds are also connected at the northern end by a culvert 5.00 m. by 6.00 m., fitted with sluice gates. This culvert will allow the passage from one pond to the other of any necessary cleaning barge or suction dredger. The water is drawn from the settling ponds into the main sump by means of floating suction arms.

Between the ponds there are eight parallel sets of gravel strainers and pre-filters, having areas of 2880 and 2000 square metres respectively. The water is pumped to the gravel strainers through a Bonna pipe, 80 cm. diameter, and passes upwards through the gravel strainers, of which there are three compartments in series, in each of the eight complete sets. It then passes downwards through the prefilters, which, like the gravel strainers, have their bottoms formed of perforated reinforced concrete slabs.

The water level at the outlet of the prefilters is at + 7.00, and in ordinary work the water passes from these to an impounding reservoir, which will contain 400,000 cubic metres (say, 88 million gallons). The top water level is such that water will flow by gravitation to the filter canals at Waelhem, or in case of emergency it may be delivered direct from the prefilters at Waelhem through a concrete main 90 cm. diameter. This pipe, and that of 80 cm. delivering into the gravel strainers, differs from the main between Waelhem and Luythaegen in having no steel liner, the total thickness of cement being 6 cm. instead of 8 cm. The joints are cast in cement with a simple ring of reinforcement. The maximum pressure to which this main may be subjected is only that due to a 4 m. head. In order to draw off the water in its most efficient state the outlet tower is provided with sluices at levels of − 2.00, + 2.00, and + 5.00. Water can be admitted into the reservoir by the inlet tower at − 2.00 and at + 5.00. The works, as completed, will deal with 50,000 cubic metres (say, 11 million gallons) of water per diem.

The second reservoir at Luythaegen, the extensions at Waelhem, and the new works at Notmeir have been carried out to the designs and under the supervision of the consulting engineer to the company, Mr. F. S. Courtney, M. Inst. C.E., 25, Victoria-street, Westminster.

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE-TOGGENBURG RAILWAY.

No. II.*

We now return to the case of the embankment at km. 2·8 on the Ebnat-Nesslau line. Here the procedure followed was in accordance with the idea just mentioned. Fig. 9 shows the situation. At first the culvert had been designed at the place indicated, but as a thorough examination by trial holes proved the site to be far too risky for building an embankment without some special precautions, this culvert was arranged in tunnel in the hillside, a method which proved easy enough, as rock was mostly met with. An extensive system of drainage channels, indicated on the plan Fig. 9, were made; first of all, the big channel *a*–*a*—Figs. 9 and 10—which had to drain the pit to be made on the site of the embankment—*vide* cross-section km. 2·78, Fig. 10.

The drains took away the excess of water originally present in the ground, but the clay continued very wet all the same. Even after the pit had been excavated for about a year, the clay was still quite wet and plastic only 0·3 m. inside the wall of the excavation. This phenomenon in itself was not to be wondered at, as there was reason to believe that the layer of clay, the depth of which, however, was unknown, but was at least 6 m., was fed with water from strata lower down.

* No. I. appeared July 31st.

Between kms. 2·2 and 2·9 the line crosses an old and, perhaps, prehistoric landslip, which had covered up the country with material containing blocks of rock and trees, the whole being itself covered in with clay and loam. This material formed the ground at the point in question. At a depth of about 2 m. below the surface a layer containing trees and blocks

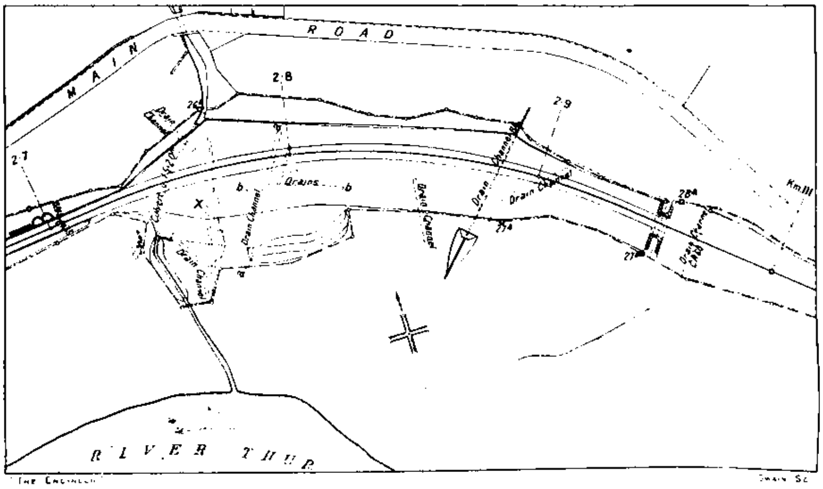


Fig. 9—SECTION OF THE LINE BETWEEN KM. 2.7 AND KM. 3.0

of rock was cut into, the quantity being about 7 per cent. of the total layer. In the bottom of the pit a dry stone drain—*b-b* on the plan, Fig. 9—was laid so that it could drain into the channel *a-a*. On the mountain side of the bank a big ditch was made, this having to be mostly blasted out of the blocks of rock cropping out there, in order to intercept the surface

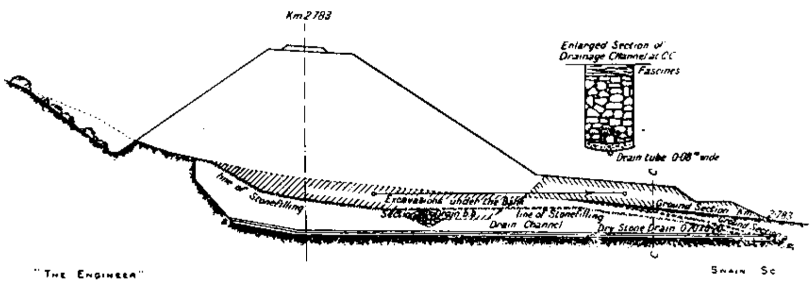


Fig. 10—CROSS SECTION OF EMBANKMENT AT KM. 2.78

water as well as any surface watercourses which might exist. As a matter of fact, only one intermittent spring was met with, but it occasionally had a yield of about 10 litres per minute, or enough to have been the cause of damage.

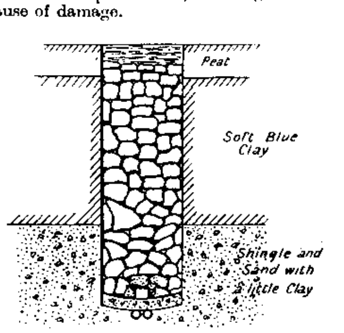


Fig. 11—DRAIN AT KRUMMENAU STATION

The work proved a success. No movement at all saving the natural settlement of the bank was experienced. The total cost of drainage and excavation amounted to £550, or, as the embankment contained

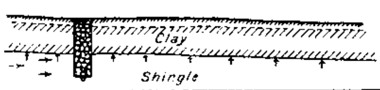


Fig. 12—CROSS SECTION AT KM. 4.25

30,000 cubic metres, about ½ shilling per cubic metre.

In spite of the very careful drainage, a spring—marked with a cross on the plan—had been blocked up. This spring caused the embankment on which the tipping was going on to commence to slip. Fortunately, the place where the spring appeared was not then thickly covered with material, so that it could be got at without much trouble and a special drain laid; but the incident showed how careful the engineer has to be in cases of the kind. At this place, as also on a considerable part of the embankment, excavated material from clay cuttings had to be used, and the effect of a ground spring on such material would have been very disastrous indeed.

It is quite clear that with the dangerous kind of ground above mentioned the trouble experienced very much depends upon the steepness of the slope of the ground; the steeper it is the worse, of course, the difficulty. At all events, if the slope does not exceed 10 per cent., a certain height of embankment can be put on the clayey ground by draining alone, and not excavating. The clay has a certain stiffness and carrying capacity, and will always, even if rather wet, carry up to from 5 m. to 7 m. of embankment,

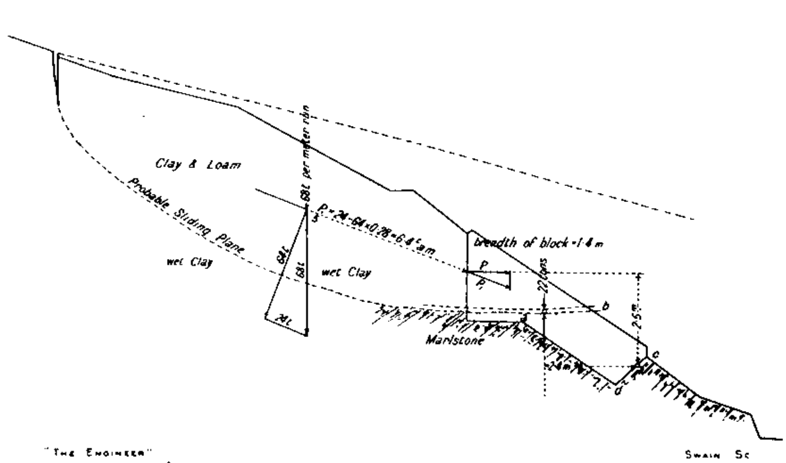


Fig. 15—CROSS SECTION OF SLIP AT KM. 2.56

which only means a pressure of about 1 kilog. per square centimetre. However, if ground water be in excess, great care and caution have to be exercised. As there were indications of springs in the sloping hillside, the culverts necessary at kms. 2·89 and 2·97—0·45 m. and 0·60 m. concrete pipes—were placed at a depth of some metres below the ground surface, and the excavation over the pipes was arranged as drainage channels. In both cases water-bearing strata were cut.

The site which had to be chosen for the station of Krummenau (km. 4·2) was very swampy. The ground water was generally close to the surface, which consisted of a layer of peaty material 0·5 m. thick, having under it from 2 m. to 3 m. of wet very soft clay and then shingle and sand. To provide for the drainage necessary a culvert—a concrete pipe 0·6 m. in diameter—was laid in at the lower end of the swampy part, as low as the level of the river Thur, into which the pipe had to discharge, would permit. At the upper end of the pipe was a deep

Fig. 13—SLOPE WITH CONCRETE BLOCKS

shaft, into which a specially constructed drain discharged. This drain, which was 240 m. long, was laid parallel with the line on the mountain side, its section being as shown in Fig. 11. The bottom of the drainage channel was concreted. In order to keep the concreting clear of the water, which drained heavily into the trench, the concreting was commenced at the lower end, where one or two earthenware pipes 0·15 m. in diameter—or enough to clear away the water—were first of all laid down in the bottom of the excavation. These pipes were then bedded into the concrete, or, rather, covered with it, and laid in advance of the concrete, thus keeping it clear of the water. Care, of course, had to be taken that the pipes

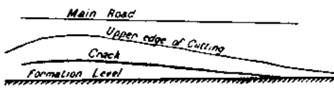


Fig. 14—SIDE VIEW OF SLIPPING SLOPE KM. 2.56

did not get choked. This way of putting in the bottom floor of the drainage trenches or channels was used everywhere on this section, and proved a success. A 0·15 m. earthenware pipe only costs 1f. a metre, and was as a rule with the gradient generally used, viz., from 1 to 4 per cent., quite of sufficient capacity to carry off the water. The difficulty of keeping the trench free of water was thus overcome at low cost, and clean concreting could be done. On the concrete floor a dry stone drain 0·20 m. by 0·20 m. was constructed by means of stone filling, which as a rule had its top covered with a layer of branches or fascines 0·3 m. to 0·5 m. thick. The drain, intercepting as it did the ground water falling from the mountain towards the railway, lowered the general water level in the immediate neighbourhood, and the effect was very pronounced.

When the line was staked out, pegs 1·2 m. to 1·5 m. long had to be used in order to secure a reasonable stability, since the water, as has been said, nearly covered the surface of the ground; but one and a half years after the completion of the drainage operations the ground water did not appear above 2·5 m. below the surface—25 m. from the drain valleywards —and the carrying capacity of the clay had already become sufficient to stand the pressure of the station foundation without any extra widening. The cellars under the station also proved to be quite dry.

This successful drainage of wet clay had, of course, its special reason. The ground water penetrating the clay—see Fig. 12—came from the strata of shingle and sand, the water pressing up on the underside of the layer of clay. The drain not only relieved this pressure, but by lowering the level of the ground water it made the upper part of the shingle dry, transforming it into a water-absorbing stratum and making it act as a factor in drying the clay above it. It is quite clear that the natural conditions in this case were specially favourable.

During the excavation in October, 1911, of the cutting at kms. 2·5 to 2·6—see Fig. 13—which was through old landslip material, clay and loam mixed with blocks of rock and tree trunks on top of marlstone, the preliminary indications of a slip were suddenly observed. The slope of the cutting was nearly finished, when a crack appeared on a length of some 60 m.—see Fig. 14. Corresponding cracks developed on the surface of the slope above the cutting at the same time, and the slipping body advanced at a rate of 1 cm. to 3 cm. a day. It was quite evident that, having regard to the mass of material involved—the dimensions of which were constantly increasing and the weight of which was certainly 3000 tons—it was most necessary to arrest the movement as quickly as possible, because any delay meant that the trouble would increase. Moreover, a little higher up the slope, at a distance of only some 10 m., was the main road, and above this a gentle, somewhat uneven mountain slope, all evidently consisting of the material of the old landslip.

The idea of trying to build a retaining wall had to be abandoned, as the wall would most likely have been destroyed before it could be finished, even if quickly setting mortar had been used. As the only remedy likely to meet with success, concrete blocks—see Fig. 15—were introduced at the foot of the slope and in the hard ground, over which the slipping mass was sliding. In order to hasten the work as much as possible, the excavation for two of the blocks was done at the same time, and concrete 1 : 5 : 10 filled in. At the head, which had to take the thrust of the slipping mass, a cushion of stone filling was put in, so as not to bring the full thrust to bear on the concrete before it had had some time to harden. Four blocks arranged at 10 m. centres were first tried, but, as this distance proved too great, the clay being pushed out between the blocks Nos. 2 and 3 and 3 and 4, two more blocks were introduced in the spaces mentioned, making a total of six blocks. The slope then stood all right, but the thrust was strong enough to turn the blocks, and there was a tendency to lift them into an upright position. The block which moved most had its upper edge forced out 8 cm., whereas its base remained firm. The cause of the slip, of course, was the water, which in this case mainly acted in a hidden way, and the sliding plane was evidently on the surface of hard marly strata, which, dipping a little inwards, kept the ground water back so that the lower layer of clay or loam got converted into a more or less plastic mass, on which the main part of the body, not having lost its cohesion, stood, but, of course, with a very unstable equilibrium. Having regard to the, to a certain extent, favourable inwards inclination of the hard strata, which was most likely the cause of the very sluggish behaviour of the large-sized slipping body, it might possibly have been worth while to wait and see how matters would develop, on the off chance that the movement might cease by itself; but as, on the other hand, there was no certainty that the movement would not commence to accelerate, it was not thought prudent to face the consequences, which might easily have meant an extra expense of 50,000f.

In arresting, or trying to arrest, slipping movements it is frequently found that the most difficult part of the problem is that there is not enough time for arranging the necessary resistance, but with the block system mentioned there is at any rate a remedy of comparatively high resistance, that can be resorted to, which can be applied where it seems to suit best and which can be strengthened by putting in more blocks if necessary.

In urgent cases it might be advisable to reinforce the concrete by putting old rails or iron of suitable section into the lower parts.

THE SCHERZER BRIDGE OVER THE PAMBAN CHANNEL.

We have several times alluded to the new means of communication which have recently been provided between India and Ceylon. We may, for instance, refer our readers to our issues of May 2nd, 1913, and February 27th of this year. Up till February of this year communication between Ceylon and the mainland had been effected mainly by steamer between Tuticorin and Colombo—a distance of 150 miles. Now, however, by extending the railways on both sides, the length of the sea passage has been reduced to some 22 miles. We have already described the noteworthy vessels—the Curzon, Elgin and Hardinge—which are to carry on the service between Dharusnkodi Point in India and Talamanaar in Ceylon, and in the present article we propose to give some particulars concerning the Scherzer rolling lift bridge which forms the chief feature of the viaduct spanning the Pamban Straits between the mainland and Rameswaram Island by means of which the South Indian Railway has been extended so as to reach Dharusnkodi Point. The viaduct from Toniturai Point to Pamban is 6776ft. long, and the Scherzer Bridge is thrown across the Pamban channel, which is deep enough to allow of the passage of vessels of light draught. The viaduct has 145 openings, 143 of which are of 40ft. span, one being 43ft. and one 44ft. The accompanying map, which we reproduce from our issue of Febuary 27th last, will show its position relatively to the other points on the route to which we have alluded.

The opening bridge is a double-leaf through Scherzer rolling lift bridge, measuring 225ft. from centre to centre of its main bearings and 16ft. between the centres of main trusses. At each end of the bridge is a fixed structure carried on steel cylinders. This structure includes two track girders upon which roll the segmental girders of

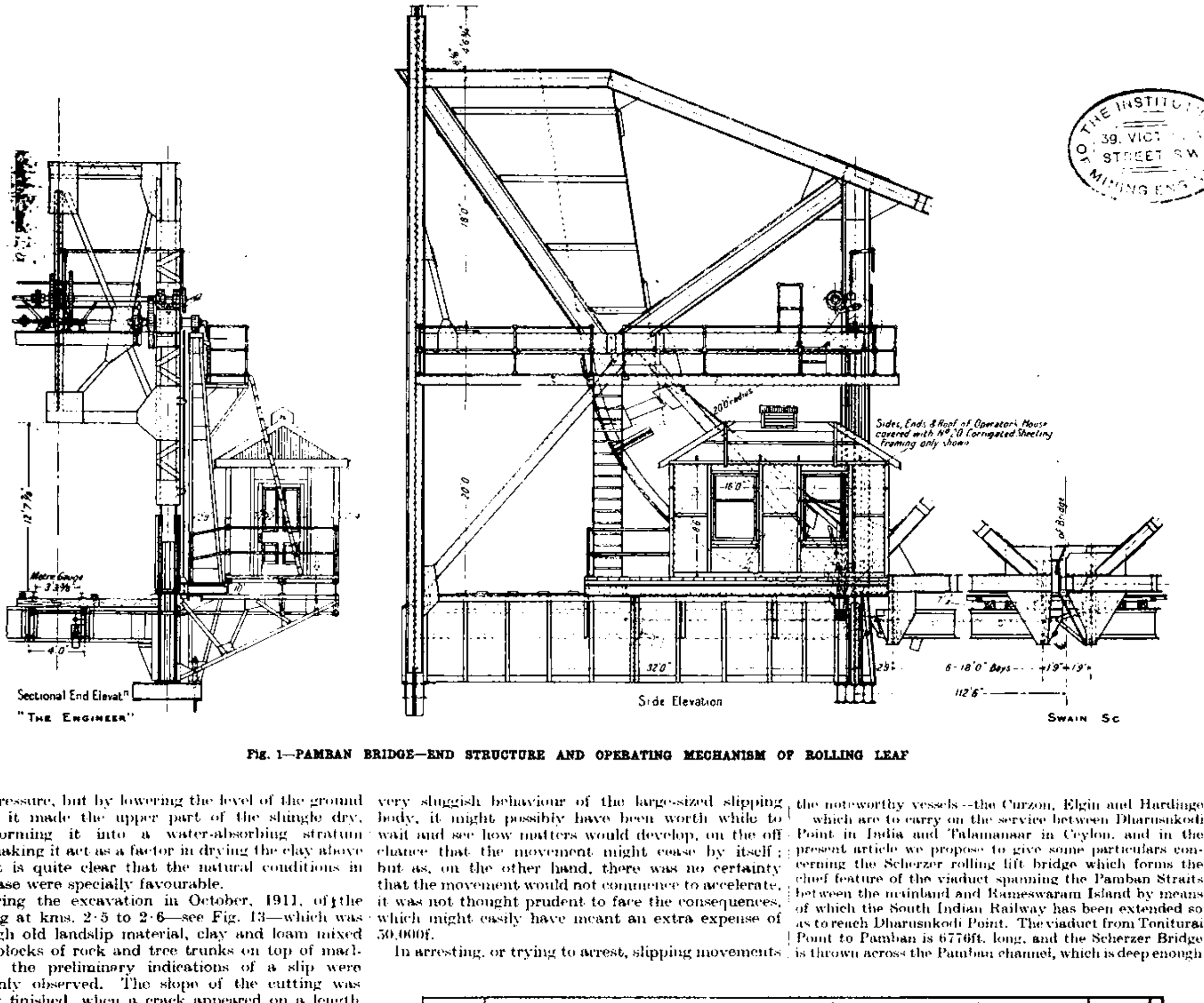


Fig. 1—PAMBAN BRIDGE—END STRUCTURE AND OPERATING MECHANISM OF ROLLING LEAF

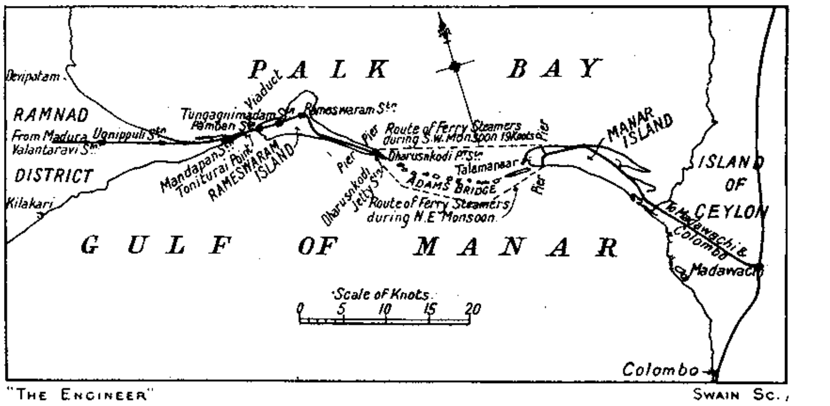


Fig. 2—COMMUNICATION BETWEEN INDIA AND CEYLON

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. III.*

THE FACING OF ROCKY SLOPES.

The arranging of stones on the faces of embankments consisting of rocky material needs, of course, its special rules. Some typical sections on the Ebnat-Nesslau line are to be seen in Fig. 16. The slope of the embankment can be made more or less steep, according to the nature of the rock employed, and it varies as a rule between 1 in 1 and 1 in 1½. When the embankment is being tipped suitable facing stones are chosen from amongst those near at hand, and are placed square to the slope—see Fig. 17. If the slopes be high, it is advisable to let a certain number of heads project well out from the slope—see Fig. 18. These heads serve to help the permanent way men in walking on the slope, which otherwise might easily be dangerous, as well as to prevent the slipping of the snow. Embankments of this character should only contain broken rock, or, at any rate, there should not be too great an admixture of softer material. The rock should also be capable of withstanding the action of the weather. If the rock should show signs of being affected by atmospheric influences, the steepness of the slope ought not to exceed 1 in 1½. When the embankment is completed, it should be covered with a layer of soil so that grass may grow upon it. This, even if it be not a very great protection, yet helps to make up a crust which will assist in withstanding the effects of rain and frost.

* No. II. appeared August 7th.

On the Ebnat–Nesslau line stone facings, such as above described, were applied to a certain extent, though the rocky material had too large an admixture of softer matter to afford an ideal substance for work of the kind. At places the fact of this admixture of wet loam or clay caused the usual consequences of very uneven settlements and heavily increased pressure on the foot-walls, &c.

Slopes.—As the material met with in the rock cuttings was of such very varied character, it was difficult to standardise the steepness of the slopes. The hard and weather-proof rock could stand at an angle of 3 in 1 or 5 in 1, or even vertical, according to circumstances, regard being had to the lie of the strata and the incidence of fissures, whereas the marl in most cases demanded a slope not less than 1 : 1, in order that the layer of soil with which it would be covered might remain firmly on it. Hence many of the sections had to be made with several different degrees of slope quite close together, a circumstance which certainly neither facilitated nor went to cheapen the work. As regards the slope of embankments, if not made of rocky material, the usual standard 2 in 3 slope dominated, and there was no reason for departing from it. With dry stony material it is, however, not at all necessary to adhere to the 2 in 3 slopes for embankments. The engineer can just as well employ, according to the character of material used, a 140 per cent. or 130 per cent. instead of a 150 per cent. slope. The writer has occasionally done so even in Switzerland, and to do this, of course, means a considerable saving in material. An embankment of dry stony material and with a 130 per cent. slope is likely to be much more stable than an embankment made of clay with a 150 per cent. slope.

RETAINING WALLS.

Some typical sections of retaining walls are shown in the drawings given in Figs. 16 and 20.

Dry Stone Walls.—Dry stone walls were used to a certain extent. The economical application of this class of wall depends largely upon the facility for getting suitable stone, and especially upon the ability to get it in neighbouring cuttings. It has to be remembered that for dry stone walls the stones must be of the largest size practicable. The condition that the stones should have an area of face of not less than one-tenth of a square metre was inserted in the specifications for this line, but this limit is rather too low, and ought, at any rate, to be 0·15 of a square metre. The advantage of dry stone walls as compared with walls set in mortar is, subject to the above condition, economical as well as technical. Given the wages of a mason to be 0·65f. an hour, and the wages of an ordinary labourer as 0·45f. an hour, a dry stone wall can be built at a net cost of 10f. per cubic metre, the cost of a masonry wall set in mortar being 18·10f.

The analysis of cost is as follows, the stone in both cases being taken from the rock cuttings, where its cost is included in the price for the cutting.

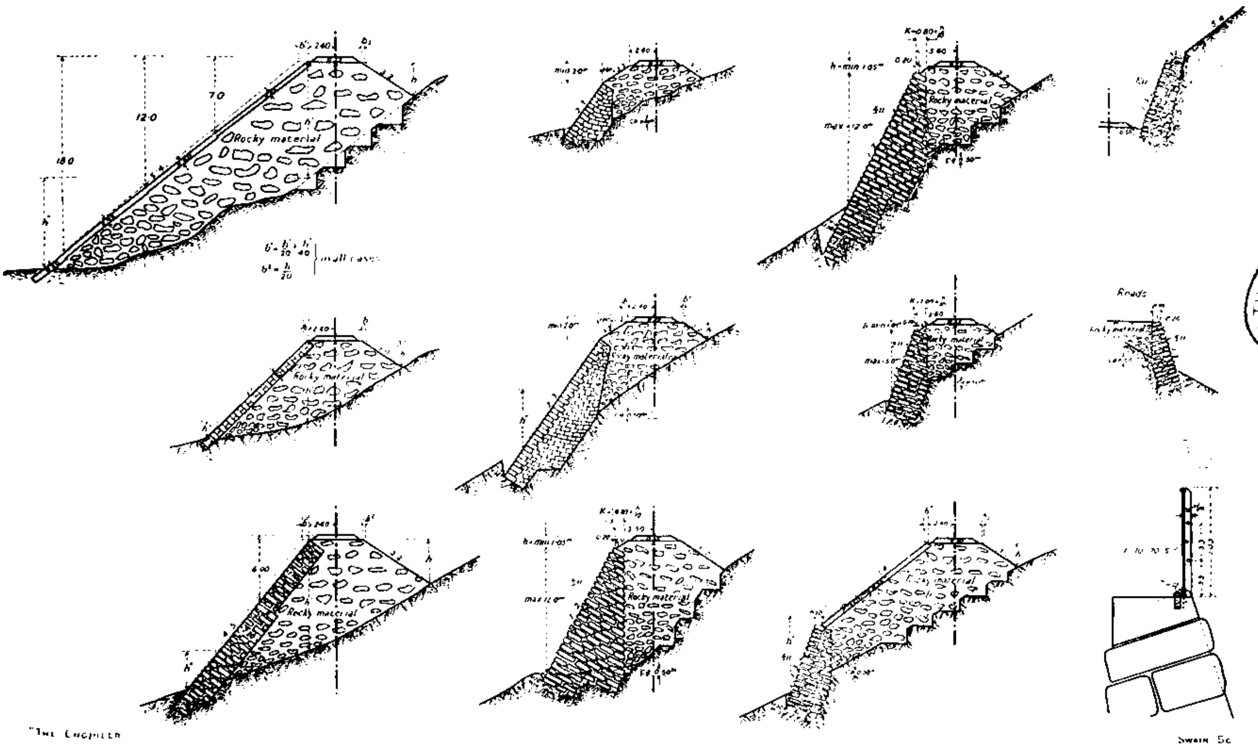


Fig. 16—TYPICAL SECTIONS OF EMBANKMENTS WITH STONE FACING AND DRY STONE WALLS

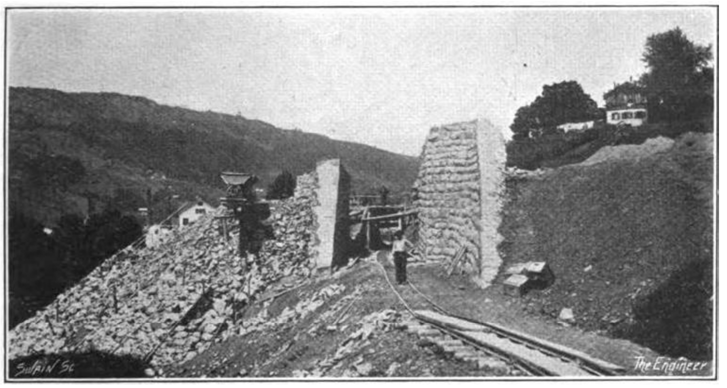


Fig. 17—VIEW LOOKING DOWN LINE AT Km. 1.2

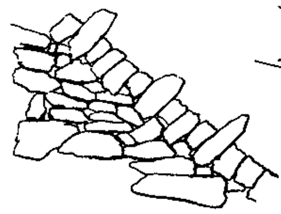


Fig. 18

Fig. 19

Dry Stone Wall.

	Francs.
Preparing and transporting the stones, per cubic metre	3·50
Masonry work, per cubic metre	4·50
	8·00
General expenses, 25 per cent.	2·00
Total	10·00

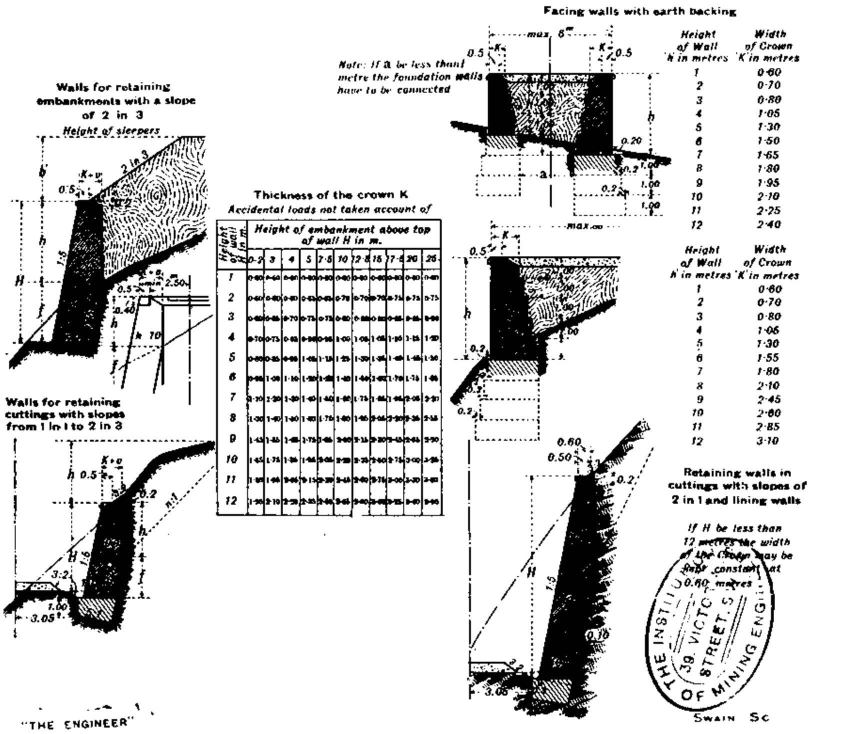
Masonry Wall Set in Mortar.

Preparing and transporting the stones, per cubic metre	2·20
Portland cement, 100 kilos....	4·40
Sand, 0·3 of a cubic metre, at 8f. per cubic metre ...	2·40
Masonry work and preparing of mortar	5·50
	14·50
General expenses, 25 per cent.	3·60
Total	18·10

The stones for a dry stone wall are estimated to cost 1·3f. per cubic metre more than those for a wall set in mortar, because the larger stones—though there is a saving in the cost of splitting up—are more expensive to deal with than the smaller ones.

Using only 65 per cent. of the cubic content of the dry stone wall to construct a wall with mortar, the cost of 10 cubic metres of dry stone wall is 100f., whereas the corresponding cost of 6½ cubic metres of wall in mortar is 117·65f., or a saving of 17 per cent. in favour of the dry stone wall.

It has further to be noted that as a rule, if any movement takes place, a dry stone wall is much less troublesome than a wall set in mortar. Even a tolerably pronounced movement shows little or nothing at all remarkable in a dry stone wall, whereas the other wall soon looks like a ruin, and, in spite of the extra cost, a wall set in mortar will not stand, and will cause great additional expense, whereas the dry stone wall, even though it has not kept its original position, may pass inspection as being serviceable, and it may even be that its movements—as actually has happened—may not be noticed at all. In addition the dry stone wall has another advantage, the importance of which is frequently not sufficiently recognised, viz., that water drains away from it so readily.



Height of wall in m.	Height of embankment above top of wall H in m. 0·2	3	4	5	7·5	10	12·5	15	17·5	20	25
1	0·60	0·60	0·60	0·60	0·60	0·60	0·60	0·60	0·60	0·60	0·60
2	0·60	0·60	0·60	0·65?	0·65?	0·70	0·70	0·70	0·75	0·75	0·75
3	0·60?	0·65?	0·70	0·75	0·75	0·80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	0·70	0·75	0·85?	[illegible]	[illegible]	1·00	1·05?	1·05?	1·10	1·15?	1·20
5	0·80	0·85	[illegible]	1·05?	1·15?	1·25	1·30	[illegible]	[illegible]	[illegible]	1·50
6	[illegible]	1·00	1·10	1·20	[illegible]	1·40?	1·40?	[illegible]	1·70	1·75	[illegible]
7	1·10	1·20	1·30	1·40	1·40	[illegible]	1·75	[illegible]	[illegible]	2·05?	[illegible]
8	1·30	1·40	1·40?	1·40?	1·70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	1·45?	1·65?	[illegible]	1·75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	1·45?	1·75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Height of Wall H in metres	Width of Crown K in metres
1	0·60
2	0·70
3	0·80
4	1·05
5	1·30
6	1·50
7	1·65
8	1·80
9	1·95
10	2·10
11	2·25
12	2·40

Height of Wall H in metres	Width of Crown K in metres
1	0·60
2	0·70
3	0·80
4	1·05
5	1·30
6	1·55
7	1·80
8	2·10
9	2·45
10	2·60
11	2·85
12	3·10

Fig. 20—NORMAL DIMENSIONS FOR RETAINING WALLS

The comparison is not, however, always in favour of the dry stone wall. If there be any serious earth pressure on the wall, the dry stone wall lacks the great advantage of continuity. Even if built in the proper way and with big stones, the pressure, which will nearly always act in an unequal manner, will cause the wall to split in places, and frequently the upper courses will be pushed out so as to project over those below them—see Fig. 19.

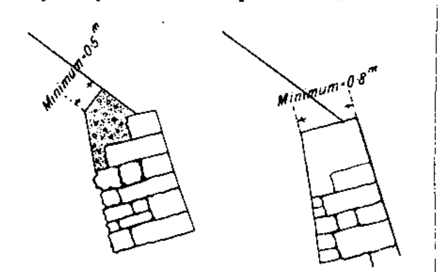


Fig. 21

Cases of heavy pressure frequently occur just where the material to be retained is wet and slippery, and most in need of drainage, and a drying influence such as that afforded by a dry stone wall, which lets air in through all joints, whereas a wall set in mortar only has its weeping holes to provide for this.

The remedy in such cases seems to be to try to give the dry stone wall additional strength, and, as the weak points seem to be the crown and upper courses of the wall, the crown ought to be backed with concrete or actually made in concrete, as indicated in the sketches shown in Fig. 21.

A case of a partial failure of a dry stone wall was the following—a drawing is given in Fig. 22:—To the right of the railway, between km. 1.0 and 1.2, the main road had to be reconstructed and given a steeper gradient. The main road came on the top of a big embankment, the foot of which had to be supported by a wall so as to leave room for a pathway and a canal belonging to a manufactory. For this wall the dry stone type was chosen, and it was supposed as also prescribed that the embankment had to be made of rocky material. A good deal of wet or quite liquid clay was, however, tipped into the embankment, and, in consequence, the earth pressure became too great for the wall, which for a length of 45 m. out of a total of 90 m. was turned about on its toe, and forced into a position of steeper batter than when first constructed. This wall was built in the autumn of 1910, and the embankment was completed in the spring of 1911, having been tipped during very wet weather. In the autumn of 1911 the wall yielded to the earth pressure, partly turning on its toe and partly having its upper courses dislocated, so that they projected over those below them. An official inspection on the 4th November, 1911, resulted in the opinion that there was no reason for any kind of reconstruction. A number of points of sections had been selected for a continued observation of the movements of the wall, which then at the worst place had altered its batter from 33 per cent. to 22 per cent.

In order to strengthen the wall and facilitate the control of any movement the joints from the face inwards were filled with mortar to a depth of about 15 cms., but only on vertical strips of 2 m. breadth, leaving strips 1 m. wide unfilled, in order not quite to deprive the wall of its ventilation and ability to drain. The movement still continued, but in the course of 1912 it almost ceased, so that it was believed to be stopping. However, between December, 1912, and February, 1913, the movement began afresh, so that it became evident that reinforcement would have to be taken in hand, since the consequence of the wall falling might easily have meant that heavy damage might have to be paid to the manufactory, so that there was no use in taking any risks. At the end of February, 1913, the batter of the portion which had moved varied from 15 to 28 per cent., which represented a change varying from 18 to 5 per cent. from its original batter of 33 per cent. The wall had not, of course, a very beautiful appearance, but compared with what would have been the the appearance of a wall set in mortar undergoing the same movement, it did not look very bad.

As the easiest and cheapest way of effecting reinforcement, five buttresses were constructed along that part of the wall which was most affected, digging out shafts behind the wall deep enough to reach a good foundation, which in all cases was not far off. A concrete cap was also constructed along the whole of the crown of the wall, as shown in Fig. 22. These works of reinforcement, together with two drainage trenches in the embankment, cost 2300f., whereas the original cost of the wall was 7520f., as paid to the contractors. It has also to be mentioned that the wall had a slight outwards curvature—of radius 200 m. to 400—m., which, of course, weakened it a little.

Looking into what it means as regards earth pressure, whether we have an embankment of rocky material or of material, at all events, resting on wet clay, we find—see Fig. 22—the coefficient of friction for rocky material being 0.8, and for wet clay 0.33, that the earth pressure if wet clay be employed is = + 9 tons, and if rocky material = − 7.8 tons, the minus sign meaning that in order to get the rock to move it has to be pushed with a force = 7.8 tons. Now, we have in this case got the aggravating circumstance which especially counts in this kind of section, that the stone facing carries on the pressure to the top of the wall, the facing, naturally, following the movement of the slope, into which it is bonded, and the resulting force is thus brought high up on the wall into the most unfavourable position possible. That the dry stone wall should have yielded under such circumstances, though all the sections were not of this most unfavourable character, is not to be wondered at. It is rather to be supposed that the earth pressure—the real value of which is in most cases very difficult or impossible to find—was not quite as much as was calculated. In the case of a dry stone wall not to consider the friction between the back of the wall and the earth is also incorrect, as there is bound to be a heavy resistance which will direct the resultant force into a favourable direction, but in this special case there was the circumstance of the stone facing influencing the resultant force in the unfavourable way described.

In dealing with retaining and similar walls, the sizes of which are often worked out according to tables or quite empirical rules, it frequently happens that a very important detail is neglected.

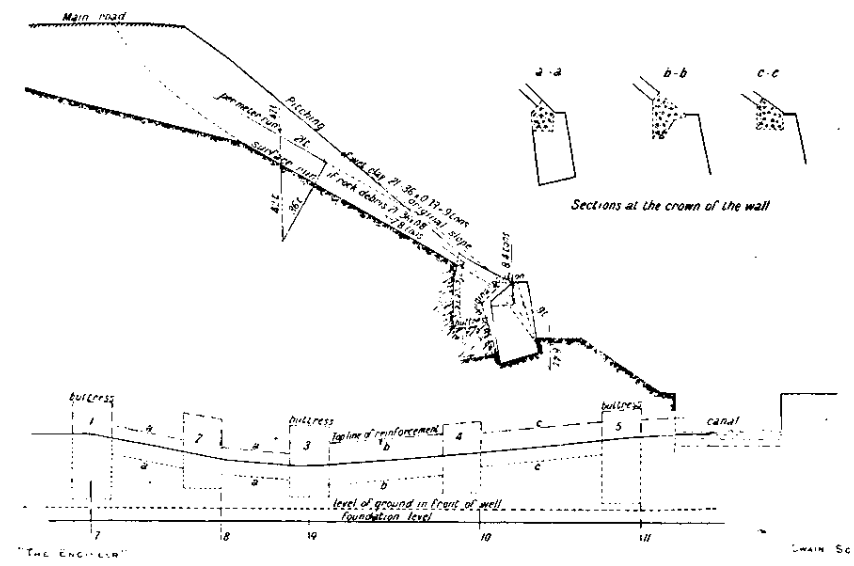


Fig. 22—STRENGTHENING A FAILING DRY STONE WALL

The foundation part of the wall is usually given an offset—see Fig. 23—as a rule only 0.2 m. to 0.3 m. Now, it is quite clear that the stability of the wall is not only dependent on the pressure at *a*, but also on the pressure at *b*. As a rule, we can put 20 kilos. per square centimetre on at *a*, but frequently not even 5 kilos. per square centimetre at *b*. In order to have harmony in the stability of this section, we must have $ac \times$ pressure at $a = bd \times$ pressure at *b*, or, if pressure at a = 20 kilos. per square centimetre, and the foundation is not able to carry more than 5 kilos. per square centimetre, we must have *b d* = 4 × *a c*—that is, the offset must be much greater than that usually given. The foundation must also have a certain proportional thickness, so that the projecting toe may not be broken off. Assuming 20 kilos. per square centimetre pressure at *a*, and *a c* = 0.20 m., we get R = $\frac{3}{2}$ × 20 × 100 × 20 = 60,000 kilos., or 60 tons, of which 34 tons per metre run will act to break off the toe at *a d*. The moment is about 34 t. × 0.42 m. = 14.3 metric tons, and if *a d* = 1.2 m., we get W × F = 14.3 t. = $\frac{1.2^2 \times 1.0}{3}$ × F, or F = 30 tons per square metre, or 3.0 kilos. per

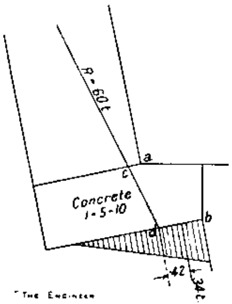


Fig. 23

square centimetre, which is not too much. This calculation is only approximate, but serves to illustrate the principle.

The writer has seen several failures owing to this cause, but they have mainly happened to bridge abutments, where the centre part got torn out of bond with the wing walls—see Fig. 24—this being one of the cases where the earth pressure is fairly heavy and generally distributed, and, consequently, trying to the weak points of the wall.

What aggravates the question of edge pressures on retaining wall foundations is that it is an edge pressure, and not a pressure evenly distributed. Whereas the back edge gets nothing, the front edge gets too much, which, naturally, makes it yield comparatively more, thus starting a movement which will tend to upset the wall.

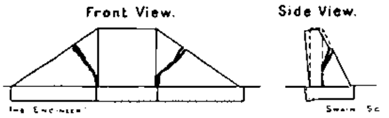


Fig. 24—CRACKED BRIDGE ABUTMENT

Specifications for dry stone walls ought to contain the following stipulations:—(*a*) The minimum face area of any stone should not be less than 0.15 square metre. (*b*) Stones under 0.25 m. high not allowed. (*c*) The length of stretchers should not be less than 1½ times their height. (*d*) The breadth of binder heads must not be less than their height. (*e*) The binder must overlap a neighbouring stretcher with at least the greatest depth of that stretcher, or, if the thickness of the wall amounts to less, it must at least reach through to the back side of the wall. (*f*) The binders must at their rear ends have a breadth at least 10 per cent. greater than their breadth at the

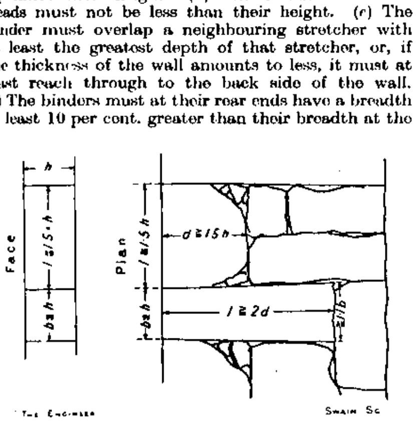


Fig. 25—NORMAL BONDING FOR DRY STONE MASONRY

face of the wall. (*g*) The inside and back part of the wall must be made in good bond with the stones of the facing—see Fig. 25.

In Scandinavia dry stone walls are used to a great extent, and usually they are made of very hard rock. The Scandinavian masons—mostly Swedes—are very skilled in making this kind of masonry accurately, with astonishingly close joints, as also in building with excellent binders and very good bond.

On the railways in Norway the writer has seen dry stone retaining walls as well as dry stone bridge abutments—for iron bridges—made in the most perfect manner—see Figs. 26 and 27. Where the stone is not favourable for working or easily got this kind of masonry, however, is very expensive. The two pictures show a retaining wall which cost 17f. per cubic metre and a bridge abutment which cost 35f. per cubic metre. The reason for adhering to the dry stone system in Norway is mainly that the long winter is unfavourable for the making of walls in mortar, and it is desired to keep the men at work in the winter time, for, as a fact, the railway men in Norway work all the year through, except between Christmas and the end of January.

In all cases of retaining wall foundations in ground

Fig. 26—DRY STONE RETAINING WALL

which is other than rocky or gravelly, it ought to be clearly remembered that the greatest care has to be used to prevent water from penetrating into the foundation so as to saturate the soil under it. Where dry stone walls are exposed to this danger, it is better to give them a base of concrete over the whole area of the foundation, and in all cases of the kind the foundations of walls set in mortar ought to fill the

Fig. 27—DRY STONE BRIDGE ABUTMENT

excavation in the closest possible manner, so as to prevent any possibility of water gaining an entrance.

ELECTRIC VEHICLES.

No. III.*

Another battery specially designed for electric vehicles is the Philadelphia thin plate battery, which has been in service in America for about six years. The plates are formed of diamond grids, and are said to be incapable of buckling. The active material is locked between two grids; thus every particle of the active material is close to a conductor. In the top left-hand corner of Fig. 14 an early form of plate is shown at A. Here the active material is not locked at all; it is packed in isolated blocks, which can easily work loose and fall out. At B a double lattice grid is shown, which in the case of thick plates is a distinct improvement on the single lattice grid. The material is continuous, and offers a more or less mutual support. On a thick plate there is a certain amount of locking, due to the wide space between the lattices, but when the plate is made thin the plate loses this locking property. At C a portion of a diamond grid is shown. Here it will be noticed there are four locking points in each diamond-shaped section, and if the plate is made thin this locking property is maintained. In a thin plate the material is bound between the lattices just as firmly as between the lattices of a thick plate. The makers also direct attention to the fact that the diamond grids are continuous, and to bend the plate the resistance of the vertical and diamond members must be overcome. Wood separators extend ⅜in. above the plates. Rubber separators also extend to the same height as the wood separators. The webs are as thick as the ribs. Wide solid margins are left unribbed to give additional strength to allow for trimming and to eliminate chances of short-circuits around the edges of the separators. The wood separators are treated so as completely to remove impurities without materially reducing the strength, and they are said to last as long as the other parts of the battery.

* No. II. appeared July 24th.

The composition of the active material is specially prepared for thin plate batteries. It is said to embody high coherence and porosity. The positive material softens very slowly and the negative material does not shrink and so lose contact with the grid.

Many different types of these plates are manufactured, but it is unnecessary to deal with them all. It will suffice to say that one type of plate designated by the letter "W" is $\frac{17}{64}$in. thick, another plate "W M" $\frac{15}{64}$in., a third "W T" $\frac{13}{64}$in., and a fourth "W T X" $\frac{11}{64}$in. The first plate "W" is classed as a thick plate, "W M" a medium plate, "W T" a thin plate, and "W T X" an extra thin plate. The "W T X" plate is 64 per cent. as thick as the "W" plate. A car fitted with a battery containing "W T X" plates will show an increased mileage of 46 per cent. above that of a car of corresponding weight, fitted with batteries of the "W" type. The "W T" batteries will give 35 per cent. more mileage

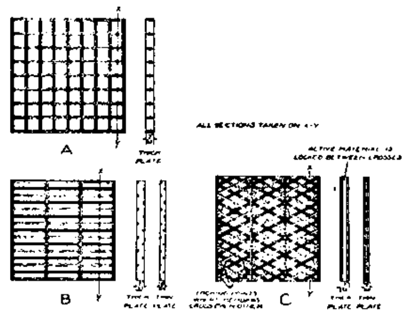


Fig. 14—DETAILS OF PLATES

than the "W" type battery, and the "W M" batteries 20 per cent. more. The diagram Fig. 15 shows the discharge voltages for "W" and "W T X" cells, the rate of discharge being the same in each case. The average voltage of the "W" cell is 1.965, and that of the "W T X" battery 1.98 volts. It will be noticed that the voltage of the "W T X" battery is maintained until almost the end of the discharge, which, of course, means that the speed of the car is maintained also. The makers say that in practice the average pressure of the thin plate battery is often well over 2 volts. This arises from the fact that the full capacity is not usually required every day.

The "W T X" cells contain about 54.5 per cent. more plates than the "W" cells of equal size. This compares closely with the 46 per cent. increase in capacity. In Fig. 16 is shown the distribution of discharged active material—lead sulphate—in thick and thin plates discharged to 1.7 volts. These plates were analysed layer by layer, working in from each side until the centre was reached. The heavy shading indicates the high percentage of discharged

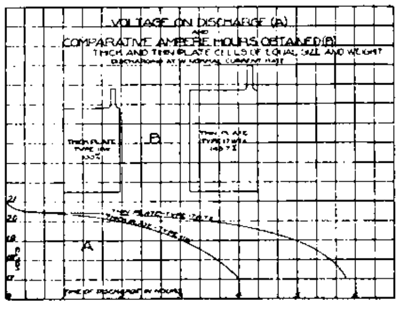


Fig. 15—VOLTAGE CURVES

material and the light shading little or no discharge. The heavier the shading the larger the amount of lead sulphate found. It will be noticed that the discharge only takes place through to a depth of $\frac{1}{16}$in. The layers deeper than this show a rapid decrease in discharged material, and at the middle of the plate there is scarcely any discharge. Since this part of the plate performs so little work the manufacturers of the Philadelphia battery—the Philadelphia Storage Battery Company—have thought it advisable to reduce the centre core to a minimum.

The advantages of this battery do not arise from the fact that thin plate cells have greater capacity per plate than thick plate cells—as a matter of fact, the capacity per thin plate is somewhat less than the capacity per thick plate—but owing to the larger number of plates which can be used the capacity obtainable from a given sized container is in the former case much greater. A "W" positive plate will give 28 ampère hours at the four-hour rate, and a "W T X" positive plate 25.5 ampère-hours at the same discharge rate.

the inclusive cost is approximately 13s. 6d. per million gallons treated. The chalk costs 50s. per ton delivered on the site, and the alumina £5 5s. per ton. The contract, exclusive of the buildings, was carried out by the Candy Filter Company, of Westminster, and the plant was erected under the supervision of the firm's engineer, Mr. Alex. C. Jarvis.

material met with is not absolutely proof against the influence of water, drainage has carefully to be looked after. In the above cases there was marl to deal with, and care was taken to insert a drain pipe well bedded in concrete, and arranged in such a way that the foundation of the wall near to it was kept free of any water—see Fig. 29.

can be carried out quite safely; secondly, the main part of the tunnel section is worked out from above downwards.

The underpinning of the vault masonry is as a rule not a task of any great difficulty, for it is easily done if due care be exercised, and there need not be any settling at all of the masonry. Even with rather

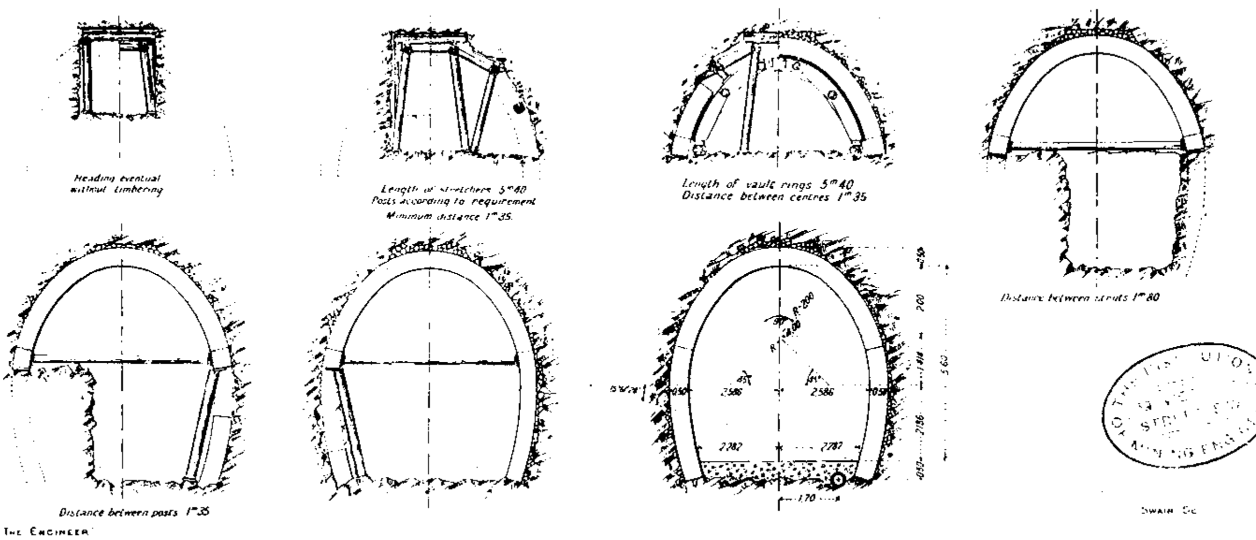


Fig. 28—SECTIONS OF TUNNELS—BELGIAN SYSTEM

A series of engravings showing different parts of the installation is given on page 192. In this Fig. 5 represents the battery of twelve Candy filters as modernised. The clutch gears in connection with the scouring apparatus will be observed. Fig. 3 shows the chemical bays with the skip and overhead run-

The tunnels, saving for this, presented no difficulties whatsoever, and were constructed on the Belgian system. A German author recently condemned the Belgian system, but apparently he cannot have had much experience in its application, or, at any rate, in its correct application. The

difficult tunnelling with which the writer had to do —on the Albula railway—there was no settlement of vault masonry observed when the Belgian system was employed, and in spite of difficulties with pressures, &c., it was still the easiest method of getting through the work.

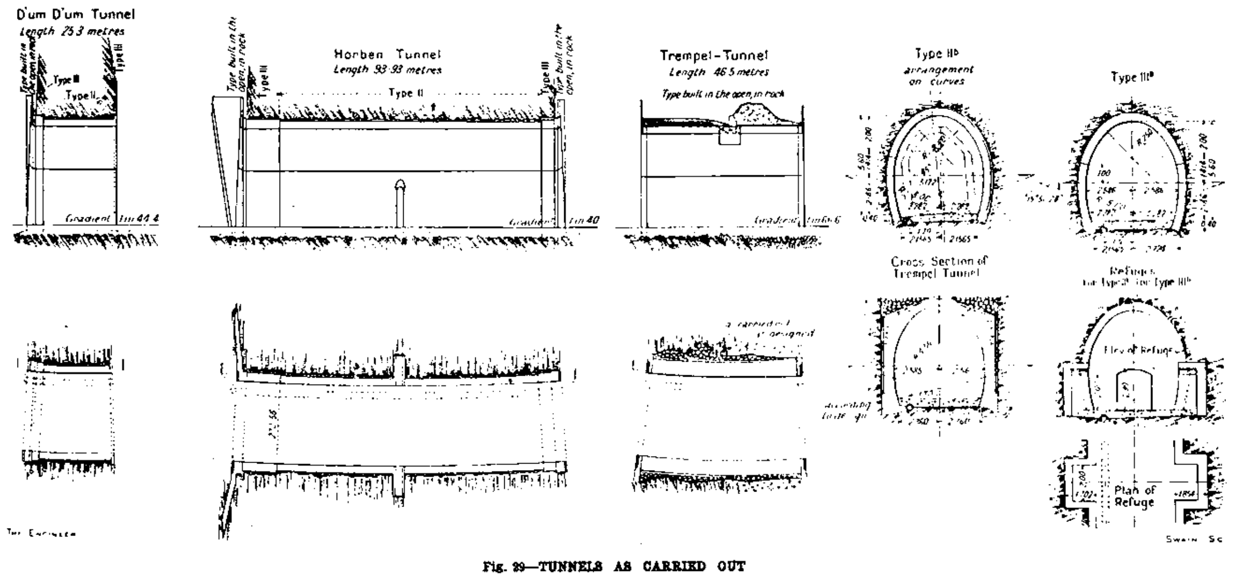


Fig. 29—TUNNELS AS CARRIED OUT

way. In Fig. 4 may be seen the chemical pumps, tanks, &c., while Fig. 6 is a view of the turbine, pumps, &c., as seen from the chalk and alumina bays.

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. IV.*

TUNNELS.

The line has got three short tunnels. These are as follows:—

Between kms. 1.8 and 1.9, D'um D'um, 26 m. long; between kms. 2.25 and 2.35, Horben, 94 m. long; between kms. 3.88 and 3.93, Trempel, 46 m. long.

Engravings showing these tunnels and various details are given in Figs. 28, 29, 30 and 31, and in Fig. 3 *ante*.

The Trempel tunnel was built in the open, as the line had to be covered only in order to take a road over it. Fig. 31 shows the site of this tunnel before the railway was constructed. In all tunnels where the

* No. III. appeared August 14th.

advantages of this system are very clear. First, the top is excavated and lined, with the use of a

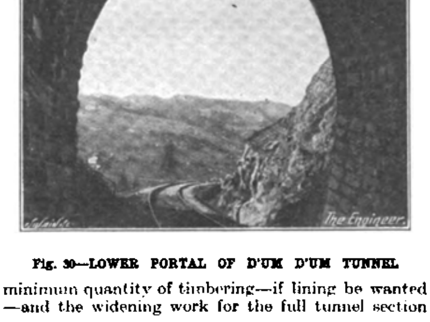


Fig. 30—LOWER PORTAL OF D'UM D'UM TUNNEL

minimum quantity of timbering—if lining be wanted —and the widening work for the full tunnel section

In cases where the tunnel has to be quickly employed for transport purposes, it may, of course, be advisable to run a bottom heading through, so as to avoid the gradients up and down to and from the top heading, which are a necessary concomitant of the Belgian system; but all the same, the top heading can be driven at the same time or later than the bottom heading, and the Belgian system then carried out to advantage. For progress of the work and different states of timbering, see Fig. 28.

In long tunnels there are, of course, the rate of progress and the organisation of transport, &c.—frequently matters of difficulty—to be considered, but all the same the system of vaulting the tunnel before breaking out the material below is in many cases sure to be of great advantage, though, of course, not applicable where extreme pressures are met with. A fairly reliable gauge of the utility of the Belgian system is that nearly all contractors with experience in tunnelling readily take to it, as they fully realise its advantages.

BRIDGES AND CULVERTS.

In addition to seven road bridges—all arched but one—and masonry culverts, and a great number of small culverts, there are nine viaducts, all of masonry, viz.:—

At km.	1·4	viaduct with	3 spans of	10 m.
,,	2·0	,,	4 ,,	10 m. and 1 of 6 m.
,,	2·52	,,	2 ,,	10 m.
,,	3·78	,,	3 ,,	6 m.
,,	3·98	,,	1 ,,	15 m.
,,	4·7	,,	4 ,,	9 m.
,,	5·0	,,	1 ,,	63·26 m. and 2 of 6 m.
,,	6·64	,,	1 ,,	24·8 m. and 4 of 4 m.
,,	7·68	,,	1 ,,	15 m. and 2 of 4 m.

As materials of construction stone and concrete were nearly exclusively used, and only in one case, namely, in a bridge carrying the main road over the railway at km. 1.8, was iron used. By far the most important of the viaducts were the two bridges crossing the river Thur. Views and drawings of various viaducts, &c., are given in Figs. 32, 33, 34, and 35, and in Fig. 4 *ante*.

FIRST BRIDGE OVER THE RIVER THUR.

This bridge—see Fig. 33—crosses the river at an angle of 43 deg., and the rails are 18 m. (say, 59ft.) above mean water level. The largest arch in the bridge has a span of 63.26 m. (say, 207ft. 6in.), with a rise of 13.85 m. (say, 42ft. 5in.). The dimensions of this arch are:—At the keystone, 1.80 m. (say, 5ft. 10in.) thick and 4.43 m. (say, 14ft. 6in.) broad; at the imposts, 2.72 m. (say, 8ft. 10in.) thick and 5.22 m. (say, 17ft. 1in.) broad. The calculated maximum pressure is 46.2 kilos. per square centimetre (say 657 lb. per square inch), including the pressure caused by the influence of temperature, which, however, is only small, being about 2 per cent. of the total. The arch is built of lime sandstone quarried on the railway itself at km. 4. This stone is very easily worked, is weatherproof, and has an ultimate compressive strength of 1200 kilos. per square centimetre (over 7½ tons per square inch). This arch has the greatest length of span of any stone bridge yet built on Swiss railways.

The working out of the stresses was effected according to the theory of the elastic arch without hinges. This theory is somewhat complicated, and does not, as a rule, lead to a quick result. The coefficient of elasticity for the material in question, masonry in cement mortar, is not only of uncertain value, but also varies in the different parts of such a large arch. The fixing of the value of the coefficient of elasticity for that kind of material is a matter of great difficulty, since the movements to be observed are so extremely small and are thus easily subject to error. It is quite another thing to apply a coefficient of elasticity in the case of metals, where its value is known with comparative accuracy.

It seems doubtful that the accuracy claimed for this method can be said to hold throughout for stone arches, and certainly the time generally taken up in working it out is a decided drawback.

In the writer's opinion, there does not seem any great reason to prefer the elastic method to the ordinary method of finding the centre line of pressure passing through three points of the arch; this method having the advantage of being very clear and not demanding much time. As the pressure caused by the influence of temperature is very small, it can be neglected as long as the arch is not flatter than span ÷ rise = 5, whereas the wind pressure, in many cases neglected, has to be considered, as it represents a considerable stress, especially in the larger arches, mainly coming on at the points where the piers carrying the viaduct—according to the arrangement adopted for large arches in which economy has been really aimed at—stand on the main span. At these points the wind pressure causes an excentric influence on the centre line of pressure, resulting in a greater stress on the lee side than on the windward side of the arch. This whole question is well worth a special research.

Both of the abutments were founded on rock. The rock on the right-hand side of the river consisted of hard conglomerate and lime sandstone. On the left-hand side of the river there were also layers of marlstone, partly of a rather soft character, and on this side a very unpleasant surprise was experienced. For the abutment on the left-hand side—see Fig. 33—the rock had to be blasted out through the whole height of the cliff, some 25 m. (say, 82ft.). This blasting work commenced in June, 1910, and when in the month of October it arrived near the designed bottom of the foundation, a sounding bore-hole proved that there was a considerable hollow below. As was clearly shown by subsequent excavation, a cavity at some remote period had been hollowed out by the river, and the space subsequently filled in with shingle, sand and blocks of rock, &c. At the point where the abutment came all this filled-up cave was below low-water level. The river entrance to the cave had been so completely covered up with big blocks broken off from the cliffs and so bedded in the river bottom that it had not been discovered during the preliminary investigations.

The rock covering the cave was not completely removed before the middle of December. Some attempts at pumping proved a failure, and even a 22·5 c.m. centrifugal pump capable of delivering over 1500 gallons of water per minute, and worked by an 18 horse-power benzene motor, could not keep pace with the water entering the cave. After having dug to a depth of 3 m. below water level, the water on December 23rd broke in very heavily, and after this the pump could not get it lower than 1.5 m. below water level. As it was necessary to go 5 m. down to get at rock, all idea of further pumping was given up, it being determined to dig out the foundation by under-water work. Only 1.7 m. remained to be excavated, but the material was of a very mixed character, consisting of sand and stones, blocks of rock and pieces of trees. The excavation had to be done up to a depth of 5 m. under water level, and the use of divers was quite out of the question, because the water was too opaque and too cold. A drawing showing the excavation is given in Fig. 36.

Tools for working under water had then to be obtained. First, screw dredgers combined with stone pincers were employed, but as the material got too hard for this class of machinery, attempts were made to loosen it with small blasting charges. This method, however, was found not to work, as the blasting blew some of the timbering away, and to replace this under water was rather troublesome. Then a big falling chisel, 100 kilos. weight, was used, and to make it work systematically it was

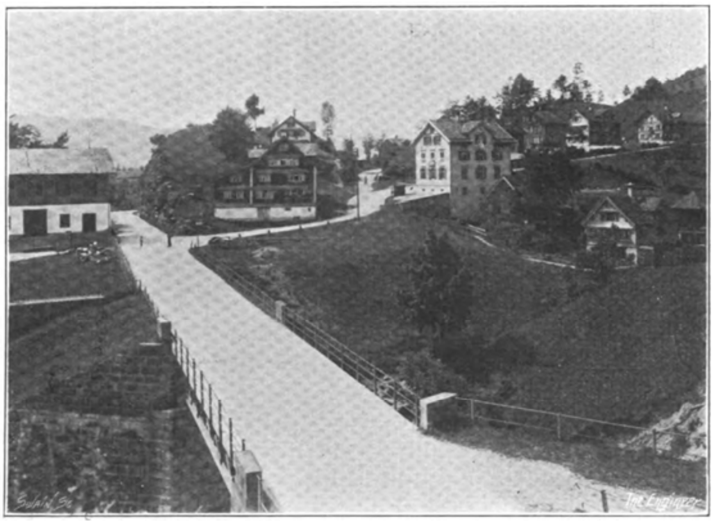


Fig. 31—SITE OF TREMPEL TUNNEL BEFORE COMMENCEMENT OF WORK

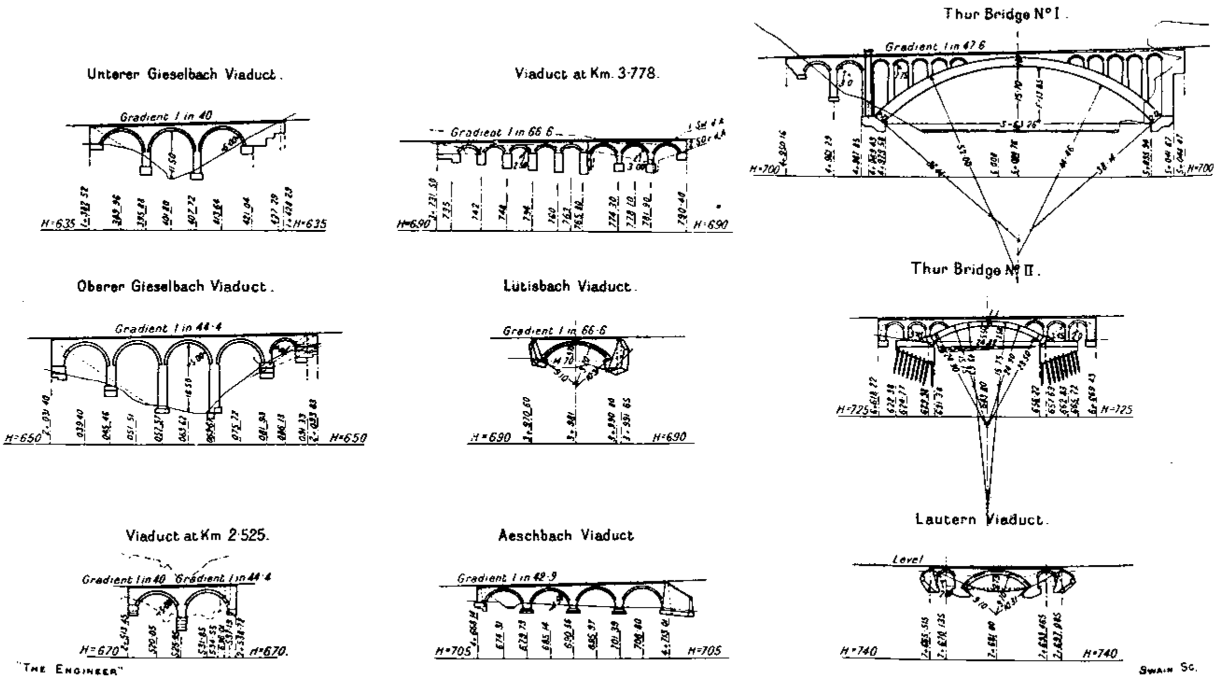


Fig. 32—VARIOUS BRIDGES AND VIADUCTS ON THE LINE

MASONRY BRIDGE OVER THE RIVER THUR

(For description see page 185)

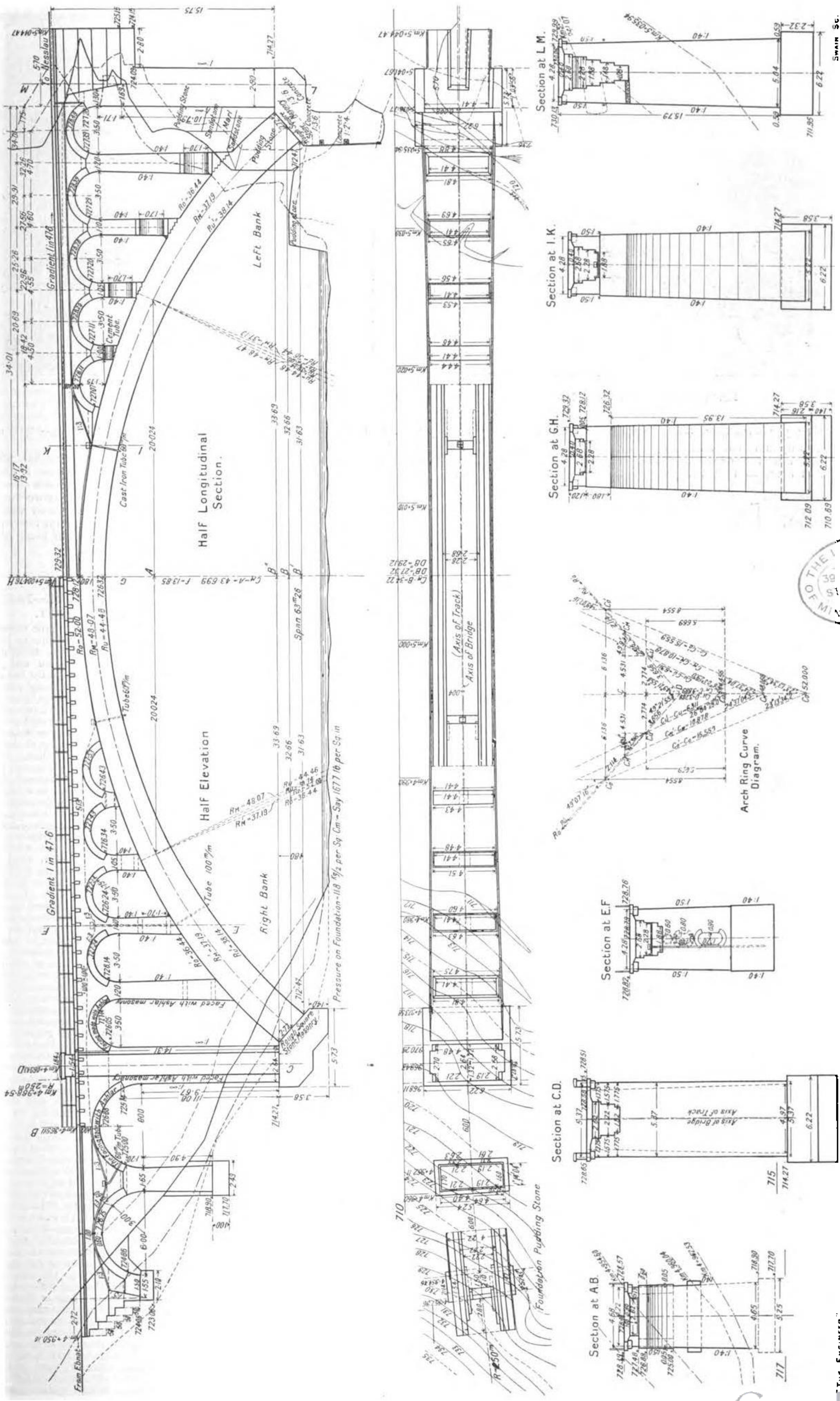


Fig. 33

mounted on a sliding bed provided with a double movement, so that the chisel was pushed sideways 0·1 m. at a time. At the same time the screw dredger, or a sack dredger, which latter tool was mostly employed for finishing the work, was used for excavating the broken-up material. At last a firm foundation was reached, but the excavation had somewhat diminished in area, so that the pressure from the arch abutment would amount to about 20 kilos. per square centimetre. The method of finding this pressure is shown in the diagram Fig. 37. It had to be considered that the nose *a b c d* could not be absolutely relied on, as it contained a fissure only partly filled with sand. In order to get the rock surface as clean as possible, the centrifugal pump was transformed into a sand pump by giving it a reduced suction tube, 100 mm. in diameter, on which was fitted a rubber hose provided with a rose.

A thorough flushing of the bottom was brought about by means of water from a reservoir high up on the other side of the river. The water had a pressure due to a head of 70 m., and was taken down by means of a fire-hose with a nozzle having a diameter of 16 mm. This nozzle as well as the rose of the sand pump was fixed on the same long rod, which was drawn over the bottom, so as not to leave any part untouched by the flushing.

To ascertain the condition of the surface of the bottom of the excavation, systematic soundings with a 42-kilo. jumper, used with a fall = 0·3 m., were carried out. The result was that the jumper penetrated 0 cm. on 25 per cent. of the total bottom area; from 0 cm. to 2 cm. on 40 per cent. of the total bottom area; more than 2 cm. on 35 per cent. of the total bottom area. The total bottom area was 13·6 square metres, of which 2 square metres were covered with loose stones.

These under-water works were started at the end of December, and were finished on February 18th. The work had been hindered through the very severe winter, during which there were heavy falls of snow, and the temperature went down to − 22 deg. Cent.

The cost of the under-water excavation, amounting to 250f. per cubic metre, was necessarily very heavy, since so many special tools, &c., had to be made. To have made this foundation on the pneumatic method would have been still more expensive, but it would, of course, have had the advantage of greater security. The foundation up to water level was made of concrete 1 : 2 : 4, sunk in tipping boxes of half cylindrical shape.

Before the filling in of the concrete, a thorough examination of the bottom of the excavation and of the rock in the direction of the resultant foundation pressure arising from the arch when built, was made by boring six holes 3.7 m. to 8.1 m. deep. Nowhere were other hollows or caves, excepting fissures, found, and the trials with a pump used to force cement mortar into the holes corroborated this. After the filling with concrete, it was again tried if it were possible to pump cement into any hollows which might possibly have been left, with but very little result.

In spite of the great load brought upon this foundation and the somewhat uncertain method of making it, which did not render it possible to see any struck finished surface, when the arch centerings were struck as well as later on, there was no settlement whatsoever to be observed, so that the maximum movement probably has been less than 2 mm., this being about the limit of accuracy of observation.

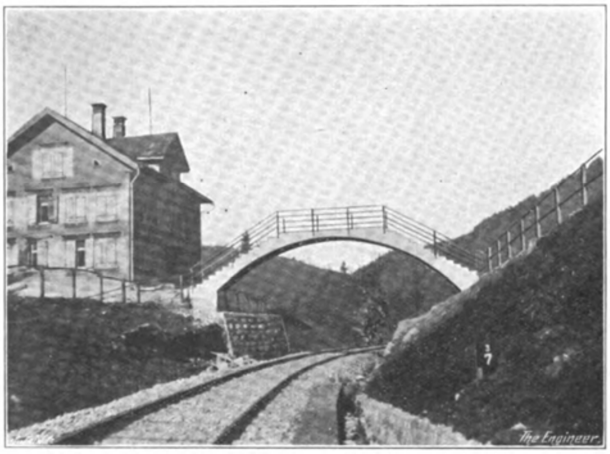


Fig. 34—FOOTBRIDGE AT Km. 3.67

Fig. 35—ROAD BRIDGE AT Km. 5.26

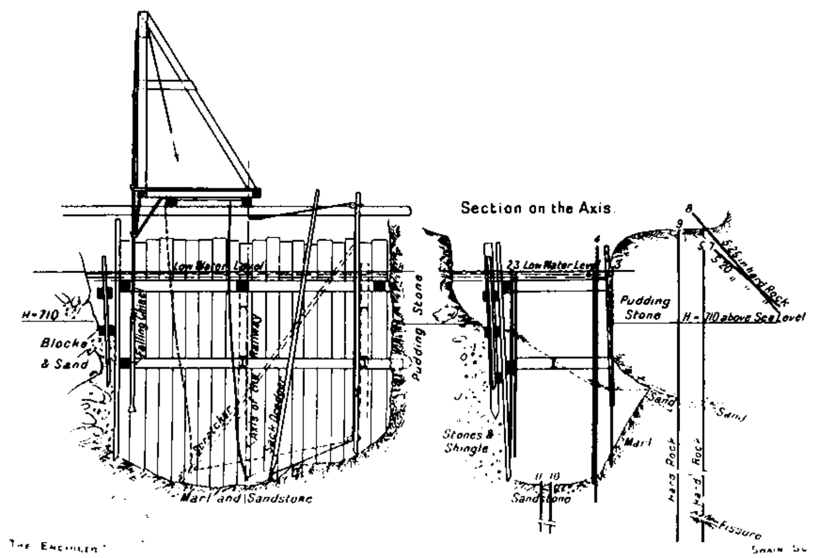


Fig. 36—LEFT-HAND ABUTMENT OF FIRST THUR BRIDGE

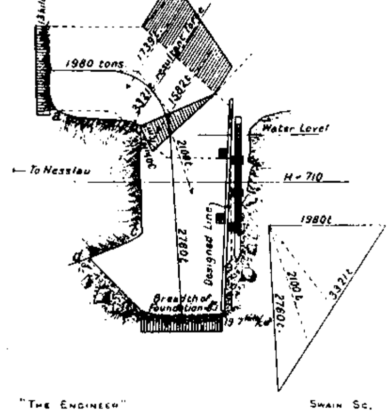


Fig. 37—FIRST THUR BRIDGE—LEFT-HAND ABUTMENT

THE RAILWAYS RETURN—PRELIMINARY STATEMENT.

JUST about this time of the year there has generally appeared the Board of Trade "Railway Returns," giving particulars of the capital, traffic, receipts and working expenditure of British railways for the preceding year, but thi year there has only recently been published the Preliminary Statement that generally comes out in May. The delay is, of course, due to the Railway Companies (Accounts and Returns) Act, 1911, under which a very much enlarged form of accounts had to be kept as from January 1st, 1913, which gives more detail, and therefore gave more work in the summarising of the annual returns for the year ended December 31st last. Past preliminary statements gave the corresponding figures for the previous year, but the present return is prefaced with the remark that no attempt has been made to compare the results given, as, owing to the changes in the method of compiling, the figures are, in several important respects, not properly comparable. An intimation is also conveyed that the figures given are, in many cases, the subject of inquiry, and they must therefore be regarded as purely preliminary in character. We have, however, been able, in most instances, to get from the return for that year the corresponding figures for 1912, and as far as possible will use them in our present review.

The mileage of running lines opened at the end of 1913 was 40,689 miles, single track—60 miles of double-line equals 120 miles of single track, and 40 miles of quadrupled road equals 160 miles of single track—and 14,749 miles of sidings. This was an increase over 1912 of 655 miles of double line, but a decrease of 126 miles of sidings. As there ought, all things considered, to have been an increase in the mileage of sidings—of about 200 miles, judging by the figures of previous years—this decrease may be due to greater accuracy in compilation, or, possibly, a large number of sidings have been converted into running lines. These figures show that 57 per cent. of the railways in the United Kingdom are single, and taking the 1912 returns as a guide, it may be taken that 33 per cent. of those in England and Wales, 58 per cent. of those in Scotland and 80 per cent. of those in Ireland, are single lines. The authorised capital has been increased from 1410 millions sterling to 1421 millions, and the total paid up from 1334 millions to 1343 millions, of which ordinary capital rose from 493 millions to 498 millions.

Coming to receipts, we find that the decrease in the number of passengers carried noticed in 1912 was apparently continued to an accentuated degree in 1913. In 1911 the total carried was 1326 millions, and fell to 1294 millions in 1912, a decrease of 32 millions. But in 1913 this is shown as having dropped to 1228 millions, a further decrease of 66 millions, or nearly 100 millions in two years. The decrease in 1912 over 1911 was ascribed at the time to the coal strike of February-March, 1912, and the "Railway Returns" report for 1912 said: "An examination of the half-yearly accounts of the principal companies shows that the number of passengers carried by these companies collectively in the second half of 1912 was rather greater than the number carried in the second half of 1911. Thus, the decrease in 1912 occurred wholly in the first half-year, and it seems reasonable to conclude that but for the coal strike, there would have been some increase in 1912 in the total number of passengers carried." There is also a very big decrease in the number of season tickets, which were 595,000 in 1913, as against 785,135. Both these headings, however, bear in the Preliminary Statement a foot-note to the effect that passengers booked through over more than one system are recorded once of the money actually finds its way back into the public Treasury in the form of taxation. Master and man and sub-contractors between them at the present day have directly and indirectly to find in taxes and rates amounts varying between eight and ten per cent. of the whole money paid for such a contract.

It is equally wrong to place such contracts with foreign firms even when their prices are so low that the difference is even greater than can be accounted for by the discrepancy in the wages. It is wrong, because it often answers the purpose of the foreign contractor to take such work at a loss in order to secure the prestige which attaches to him in cutting out the British firms on their own ground. The most pernicious argument that has ever been used against our industry by our foreign competitors has been that the British Government has to go abroad because it cannot find makers in England to do the work properly. The unsophisticated overseas purchaser does not know the conditions that have surrounded such contracts. He does not realise that the British Government has been selling the prestige of the British engineering industry. That selling of our industrial prestige by those who ought to protect it has done more to strangle our engineering trade abroad than all other influences put together.

What do we think of a British consulting engineer who, after asking for tenders from British firms, takes on one side a foreign manufacturer and says to him, "Look here! If you will make your price so and so I will give you the order. I will undertake not to be unduly severe in enforcing the conditions of contract and you may sweat your workmen as much as you like. If by any chance you should lose money on it, think of the prestige that you will gain by knocking out the British manufacturer in his own country." Such a transaction would be an infamy. But it is precisely that class of transaction that the Government and certain other purchasers have been carrying through time after time. This is one of the evils which it is hoped will be overcome by the new patriotic spirit that has been created by the war. But to ensure this the manufacturers must put their case collectively and clearly before the Government before the war is over. It is not the manufacturer alone who must do this. Every trade union in the country must insist on the abolition of this disgraceful practice. Every member of Parliament who receives his mandate from our manufacturing districts must vote for the abolition of this system.

Before leaving this subject I would recall an argument that was recently used in connection with a contract given to Germany not so long ago, and which was to be paid for by ratepayers' money. The difference in the wages more than accounted for the difference between the German and the British price. In defence of his conduct the British engineer who had to do with the placing of the order pointed out proudly that he "had obtained a guarantee from the German contractors that while their fitters were employed in erecting the plant in this country they would receive wages according to British trade union rates." Really this would be extremely humorous were it not for the fact that it shows the depths to which want of patriotism can go. Perhaps, after all, it is not want of patriotism, but merely a want of the commonest form of intelligence. How on earth could the payment of British trade union rates to a few German workmen for a couple of months while erecting a plant do away with the fact that some hundreds of them had been engaged in the manufacture of it at not much more than half those rates?

One of the most pernicious features in these foreign contracts is that they have the effect of introducing into our dockyards and arsenals alien workmen for months at a time. It is ridiculous for the Government to say that they can learn nothing of importance. Their constant contact with the other men whose work covers the whole of the ground is in itself sufficient to give them all the information they need. Over and over again German engineer officers and skilled draughtsmen have donned the overall and posed as workmen in our Government factories.

I have dealt at some length with this question of placing contracts abroad because it is the fundamental obstacle to our advancement, and until it is overcome we can never develop our industry to its full extent. It knocks the bottom out of every argument that can be put forward by those who have the selling of British engineering plant abroad. Its abolition would remove with it many of the other obstacles which stand in the way of our trade, for the Government would then have realised that it must become the ally and not the enemy of our industries.

We now have to consider the British purchaser as an enemy to national interests. I have already dealt with the question of Government purchases from abroad. The Government is the greatest sinner in this respect, but the private purchaser follows its lead. The private purchaser, it is true, has more excuse, for it is with him often a question of ways and means. I am not going to labour this question here beyond saying that the war should give so great an impetus to the national instinct that we may reasonably hope that after it is over the tendency to buy from abroad will be decreased, especially as during the war it is to be hoped that many of our firms will have taken the necessary steps to produce some of the articles that we now purchase abroad at a price which will keep the orders in the country.

Of the British manufacturer as his own enemy I have said enough when dealing with the other cases. He is his own enemy because he has the means to overcome all those obstacles to his trade enumerated above and does not use them. I am not going to reiterate here the worn-out arguments that we are all sick of reading, to the effect that he does not study requirements, does not back up his agents, is not a competent linguist, does not price his catalogues, and does not give credit. There is a good deal that is true and a good deal that is false in those contentions, which seem to be stereotyped for especial use in every consular report. They are about as just as is the counter-argument to the effect that "all Consuls are fools." The real truth about the British manufacturer's apathy is that he still retains the pick of the trade. He has, consequently, been spoiled by prosperity in the past. He is blamed for not extending, so that he can tackle more work. The reason he does not extend as much as he might is because he has not troubled to put himself in a position to carry on the trade on the long credit and other conditions adopted by his foreign competitors, and that he has not been backed by his Government, his banks, and so on, sufficiently to enable him to do so. He is his own enemy because until recently he did not care to combine for the purpose of obtaining the proper support of his Government. Here, again, the remedy is in his hands, and the new conditions brought about by the war afford him an opportunity that he has never had before and assuredly will never have again.

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. V.*

The staging and centering can be seen from the illustrations—Figs. 38, 39, 40, and in our Two-page Supplement. The six centering ribs were placed 0·96 m. apart, and with a superelevation at the crown

$$= \frac{1}{400} \times (l - f) + 0{\cdot}004 = 0{\cdot}13 \text{ m.}$$

l = span of arch.
f = rise of arch.

The centerings rested on piles, each bay having two rows of piles driven into the river bottom, and nearly all going down to firm rock.

For the driving of the piles, the following rule was adhered to:—

Maximum movement of pile at the last stroke in millimetres.

$$e = \frac{h \times W^2 \times g}{m \times P \times (W + g)^2} \text{ (Brix formula).}$$

Where P = the safe carrying capacity of the pile in kilogrammes,
W = weight of monkey = 480 kilos.
g = weight of pile in kilogrammes = 400,
m = factor of safety taken in this case = 5,
h = height of fall of monkey in millimetres = 4000.

$$\text{Hence } e = \frac{4000 \times 480^2 \times 400}{5 \times 13{,}000 \times (480 + 400)^2} = 7 \text{ mm.}$$

Concerning the design and the working out of the stresses in the centering, it has to be considered that as the arch is closed before being finished, only a certain percentage of the full weight of the arch has to be carried by the centering. As soon as one or more courses of the arch have been closed, the arch carries itself entirely or nearly so, and the centering only gets what further load is brought on by reason of the settlement of the arch.

The weight of the arch stones, which are laid with radial joints, acts upon the centering in a radial direction. There is a reduction in the weight due to the stones—see Fig. 41—so that the load acting upon the centering = P sin $\alpha - \mu$ P cos α; where P = the weight of the stone, α = the angle between the joint and the horizon, and μ = the coefficient of friction between the two stones, which may be taken as being from 0.5 to 0.7. This equation holds, if the stone b be fixed or if it be not fixed, but when b is not fixed, $\mu \times$ P cos α produces a reaction, and this reaction naturally having just the same value, must be taken by the centering, which prevents b from gliding inwards, and thus μ P cos α falls out of the equation for ascertaining the load.

In Fig. 38 are shown two load curves, one being calculated by means of the formula:—P $\times$ sin α $- \mu$ P $\times$ cos α; μ being taken = 0·7, the other calculated with P sin α.

The writer thinks that the load curve obtained with P sin α alone is the right one to use, and that to compensate for this fact, it is justifiable to design the centering to take only 55 per cent. of the weight of the arch ring, since, as will be seen shortly, the arch ring is completely closed, and therefore self-supporting, to all intents and purposes, when 55 per cent. of the stonework is in place. Alternatively, the centering might be designed for the full weight of the arch, but with a reduced factor of safety, say, such as would bring the permissible working stress to 150 kilos. per square centimetre instead of 80 kilos.

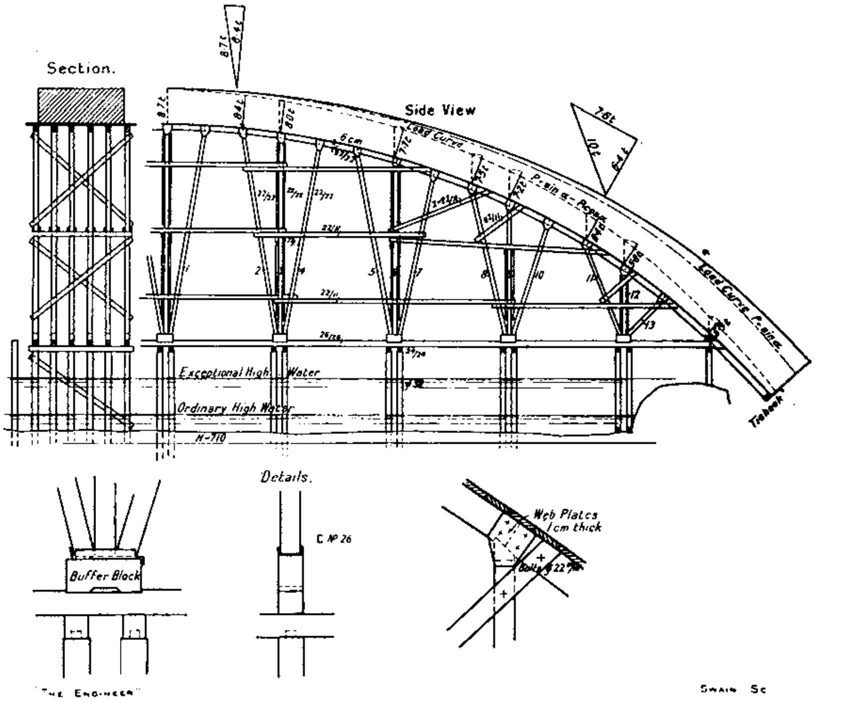


Fig. 38—DETAILS OF CENTERINGS

The posts and struts are, of course, calculated as columns.

If I = the moment of inertia,
l = the length of column considered as "free" length,
E = the coefficient of elasticity = 100,000 kilos. per square centimetre,
m = the factor of safety,

we have for the strut No. 2—see Fig. 38—the carrying capacity $= \frac{\pi^2 \times E \times I}{m \times l^2}$, where $l = \frac{3}{4} \times 10.5$ m. = 788 cm.; hence

$$\frac{10 \times 100{,}000 \times 19{,}500}{3 \times 788^2} = 10{,}400 \text{ kilos.}$$

* No. IV. appeared August 21st.

The arch ring timbers have a cross-section = 32 × 22 cm. = 704 square centimetres.

Choosing the piece of the arch between struts 10 and 11, we get—

The compression stress at the panel point at 11

$$\frac{7600 \text{ kilos.}}{704} = 10.8 \text{ kilos. per sq. cm.}$$

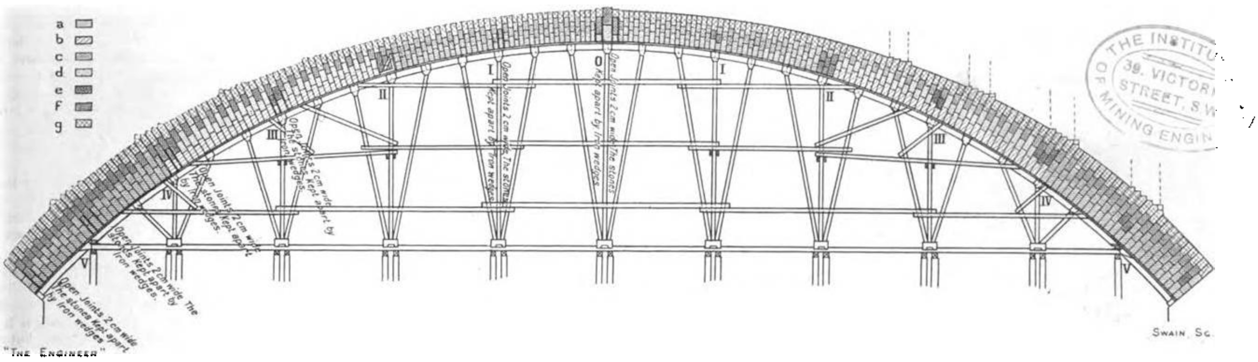


Fig. 39—THUR BRIDGE No. 1.—METHOD OF LAYING MASONRY

The bending force =

$$\frac{Pl}{8R} = \frac{6400 \times 230}{8 \times 3750} = 49.0 \quad ,, \quad ,, \quad ,,$$

where R = the moment of resistance.

Total maximum compression stress } 59.8 ,, ,, ,,

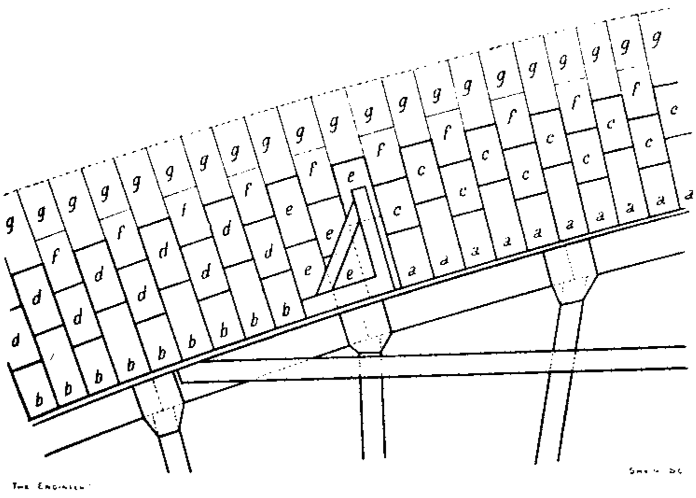


Fig. 40—THUR BRIDGE No. 1.—METHOD OF LAYING MASONRY

Each pile is considered to be equivalent to a free column having a length of 4 m. and taking $m = 4$, and a factor of safety of 4, we have in this case the carrying capacity

$$= \frac{\pi^2 \times I \times E}{4 \times 4 \times l^2} = 15{,}500 \text{ kilos.}$$

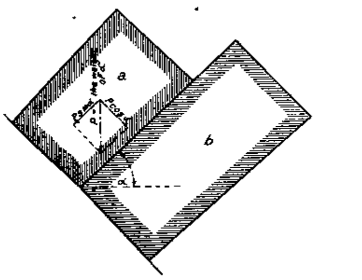


Fig. 41

The maximum load to be carried is

$$= \frac{3 \times 8700}{2} = 13{,}000 \text{ kilos.}$$

For striking the centering the wooden block system invented by the Austrian engineer, Zuffer, was used, and worked as follows:—

The blocks are introduced between the bearing pieces of the centering and their supports. Just before striking the centerings the pieces *a b c d* Fig. 42, are cut out; the cut $c_1 a_1$ can also be made halfway. On the day of striking the centerings, commencing in the middle and working towards the abutments, the cuts $c_1 a_1$ are cut through, after which the cuts $c\, b_1$ are made, this leaving so small a bearing area that the centering yields and is practically relieved of any pressure from the arch. To get the centerings struck quite free, the toes at $b_1\, b_1$ had in the case under consideration to be hewn off.

To transfer the pressure from the main arch to the rock foundations three courses of rough square stones in Portland cement mortar were introduced, which in their turn were bedded on a strong layer of concrete 1 : 3 : 6, filling the excavation blasted out of the rock, which at both abutments was well sounded with bore-holes to make sure that no fissures or other cavity were in dangerous proximity to the excavation.

The building of the arch was commenced in the middle of May, and was carried out as shown in Figs. 39 and 40. In the middle of July the first two courses of the arch were closed, and on the 1st of August the arch was finished. With such large arches it is a difficult matter to avoid undue settlements

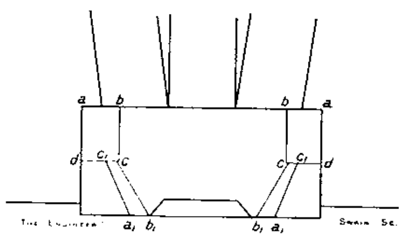


Fig. 42—ZUFFER BLOCK

during the construction, which, of course, might easily cause cracks. To that end a number of open joints—in groups of two or three adjoining one another—were introduced at the vertical centre posts, with the object that the arch pieces between these open joints might keep entire while the inevitable small movements of the staging were going on. Everything went well in the present instance.

At point II.—see the left-hand side of Fig. 39, and the view to an enlarged scale given in Fig. 40—of the centerings a so-called "coffer" was built in, viz., an artificial impost, from which to start vaulting, in order to carry on the work at four points simultaneously. Working from the ends towards the middle, the *a* stones were first put in and bedded in mortar, though where the open joints came the stones were kept apart with iron wedges. After the *a* stones came the *b* stones, and then the *c* and *d* stones, and then the closing of the first double course was effected by the introduction of the *e* stones. This closing was also carried out by working from the ends towards the middle. When the "coffer" was reached it was carefully removed and replaced with *e* stones. For this joint-closing the mortar was used in a somewhat dry state, and was well rammed down, so as to fill the joints in the most compact way possible. In their turn the *f* and *g* stones completed the work. Views showing different stages of building the arch are shown in Figs. 44 and 45.

The mortar had to be made of 1 Portland cement to 3 of clean sharp sand. For the closing of the joints the mortar had to be just moist and the ramming had to be continued till the water appeared on the surface of the joint. To facilitate the filling of the joints two different tools were used—see Fig. 43—the tool *a*, for moving up and down in the joints after they were filled, and the tool *b*, for ramming by striking it with a hammer.

The stones were roughly dressed to certain dimensions and marked so that they should be used in the right order. A certain latitude in dimensions and shape was tolerated so as not to make the stone dressing too expensive. The material was easy to

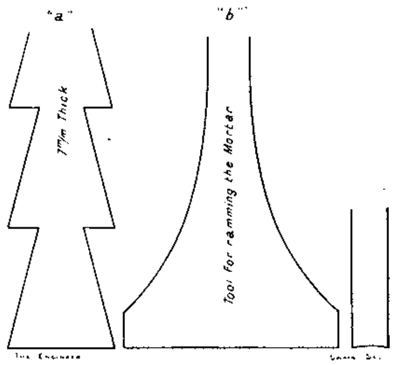


Fig. 43—MASON'S TOOLS

work, and the rough square stones could be made fairly accurate at a price of 38f. per cubic metre for cutting and dressing in the quarry. The width of the joints varied between 1½ cm. and 7 cm., but was, as a rule, not very irregular, being about 2½ cm.

After the closing of the arch the upper masonry resting on it was commenced. For the purpose of levelling observations after the introduction of the *e* stones seven bolts were fixed in each arch face. The total deflection of the arch from the first closing in the middle of July to the 19th of September was 20 mm., which increased to 33 mm. when at the commencement of December the total load had been brought on. About one year later the deflection had increased to 37 mm. Striking the centerings made the arch deflect 3 mm., which are included in the above figures. At the trial loading before the opening of the line by putting a train on the bridge no deflection was observable. No effect of temperature could be detected.

During the building of the arch the centering was also observed by means of five bolts on each face. A table of settlements of the centering as well as of the arch is given on page 206.

It will be observed that from the commencement of vaulting—middle of May—to the first closing of the arch—July 19th—the centerings settled 20½ mm. at the crown and more towards the abutments, points 1, 2, and 4, 5, viz., 27 mm. to $37\frac{1}{2}$ mm. The building of the rest of the arch only caused a settlement of $3\frac{1}{2}$ mm. at the crown, whereas the other points remained nearly stationary, showing that the arch after closing very nearly supported its own weight.

As to why the settlement of the centering was heavier at points 1, 2, 4, and 5 than at the crown, there seems to be a double reason. Some of the centering struts were not placed radially near the ends of the centering, whereas the forces acted radially, which might cause some undue yielding, but the principal reason is to be found in the wrong load curve used for the calculation, this causing a comparatively greater stress in the timbers near the abutments than at the middle, and, naturally, resulting in a greater settlement.

Below is given the cost of the work on this viaduct as paid to the contractors :—

Thur Bridge I.—Cost of Work.

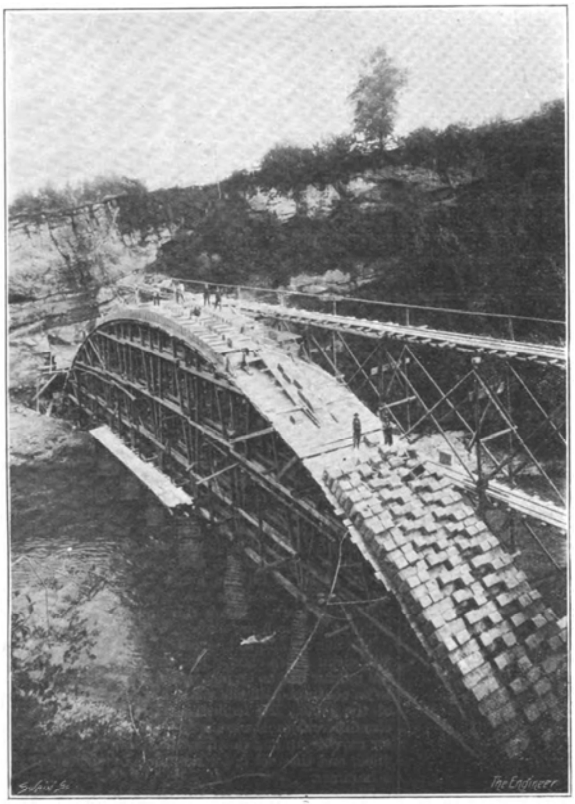
	Francs	cent.
Excavation, 1160 cu. m. at 4·56f....	5,289	60
Foundation concrete 1 : 5 : 10, 40 cu. m. at 20·52f.	820	80
,, ,, 1 : 3 : 6, 100 cu. m. at 26·22f.	2 622	00
,, ,, 1 : 2 : 4, 70 cu. m. at 33·06f.	2,314	20
Rough square stone masonry, 50 cu. m. at 57f....	2,850	00
Regular rubble masonry, 860 cu. m. at 26·22f....	22,549	20
Regular rubble vault masonry, 115 cu. m. at 31·92f....	3,670	80
Rough square stone vault masonry, 780 cu. m. at 62·70f.	48,906	00
Ashlar vault masonry, 29 cu. m. at 45·60f. ...	1,322	40
Ashlar vault masonry, 11 cu. m. at 57f.	627	00
Concrete filling 1 : 5 : 10, 65 cu. m. at 20·52f. ...	1,333	80
Vault coating, 236 sq. m. at 7·41f.	1,748	76
Vault drainage apparatus, 4 pieces at 34·20f. ...	136	80
Vault cast iron pipes, 15 m. at 8·26f.	123	90
Plastering on the back of the facing walls, 117 sq. m. at 2·85f.	333	45
Stone filling, 163 cu. m. at 3·42f.	557	56
Smooth dressed square stones, 37 cu. m. at 79·80f....	2,952	60
Ashlar masonry on the edge of pillars, 300 m. at 5·70f.	1,710	00
Concrete pipe (0·60 m. wide), 2 m. at 19·38f. ...	38	76
Sounding bore-holes, 65 m. at 5·70f.	370	50
For stagings and difficulties	20,520	00
Extra for foundation	15,000	00
	135,798	13

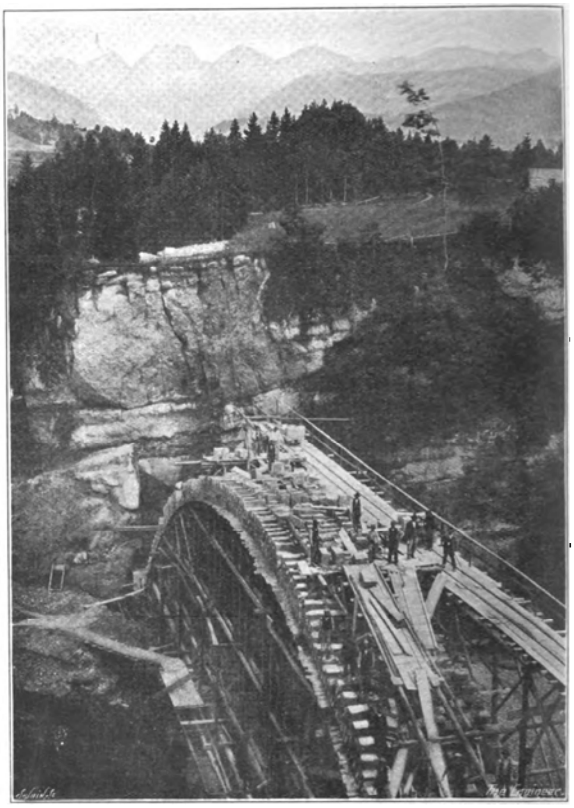
The total net cost of centerings and foundations was 25,500f., or 32.70f. per cubic metre of arch masonry ; 11,640 hours of work were spent on the whole of the centerings, the wages ranging from 0.45f. to 1f. per hour—or an average about 0.60f. per hour.

The quantity of timber and boards, &c., used was as follows :—

For the piles and bay timbers...	49·3	cu. metres
,, centerings	217	,,
,, planking...	7	,,
,, different stagings	11·7	,,
Total	285	,,

Eight tons of iron were used for web plates, bolts, &c. (including 900 kilos. for pile shoes), or 28 kilos. per cubic metre of wood employed.



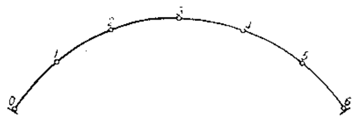


Figs. 44 and 45—THUR BRIDGE No. 1.—CONSTRUCTION OF THE MASONRY ARCH

The transport staging, which was only 2 m. broad, and was connected to the centering—see Supplement—represented a total net cost = 4200f. To this has also to be added the cost of the different stagings, the centerings for the 6 m. and other arches, a net total of 2400f., making in all a net total of 32,100f., or 25f. per square metre of bridged area.

Under certain favourable conditions stone arches of large span can compete favourably with steel bridges, their superiority as regards cost of maintenance not being the only point to be considered.

It may be deemed possible to go to spans of at least 150 m., but under the condition that favourable stone combining great resistance to pressure with ease of working can be readily obtained and timber for



Settlement of Centering in Millimetres.

Date.		To the left of the centre line.					To the right of the centre line.				
	Number of points	1	2	3	4	5	1	2	3	4	5
1911.											
May 27th ...	*a* stones half brought on	−4	4	−½	6	−3	½	3	−½	7	½
June 6th ...	*a* stones all brought on	7	5	6	3½	8	10½	4	6½	8	10
,, 10th ...	*b* stones half brought on	11½	9	7	2½	7½	13½	8½	7½	2½	11½
,, 16th ...	*b* stones all brought on	12½	11	8½	8	7½	14	10½	9	7½	11½
,, 23rd ...	*c* stones added	13	11½	5	7	8	13½	11½	6	7	15
,, 28th ...	*d* stones half brought on	17½	13½	11	11	14	17½	13	11	10	18½
July 11th ...	*d* stones all brought on	29	21½	18	24	26	34½	26	18	25	37½
,, 19th ...	*e* stones all brought on and first double course closed	33½	27	20½	28	28	35	27	20½	28½	37½
,, 25th ...	*f* stones all brought on	31	28½	22	29	26½	32½	28	22	30	35
August 1st...	*g* stones all brought on and the deck completed	30½	27½	24	28	28	33½	27	24	28½	36½
Sept. 8th ...	Centerings struck										

The figures with minus indicate a lifting of the centering, or rather of the arch ring timbers, which, under the influence of the advancing load, behaved like an elastic circle.

Settlement of Arch in Millimetres.

	To the left of the centre line.							To the right of the centre line.						
Number of points ...	0	1	2	3	4	5	6	0	1	2	3	4	5	6
July 19th, 1911	0	0	0	0	0	0	0	0	0	0	0	0	0	0
July 25th, 1911		−1½	2	2	1½	½			−1¼	1¼	−¼	1¼	−3	
August 1st, 1911		−1	2	4½	2	0			1¼	1	4¼	2	−¼	
August 11th, 1911		1	7½	7	7	1¼			3¼	2½	4¼	4¼	2¼	
September 5th, 1911		9	10½	10½	9	8			6	10¼	7	9	3½	
September 19th, 1911		10½	19	22½	21	10½			10¼	19	17¼	20¼	12	
October 16th, 1911		15	24½	34	35	19			12	22½	30	34¼	14	
December 1st, 1911...		16½	25	33	34½	20½			12¼	23½	31	34	13½	
February 26th, 1912		18½	29	37½	38½	23			17¼	26¼	34½	39	16½	
August 16th, 1912	0	22½	30	41	40½	25½	0	0	16½	27¼	33¾	40¼	16	¼
At the striking of centerings the 8th September, 1911 ...	0	¼	2	3	2	1		0 = means of the observations of both sides						

NOTE.—An allowance of 2 mm. has to be made for inaccuracies in the observations.

the staging works not being too expensive. The abutment foundations must also not present any great difficulty. If these conditions cannot be fulfilled the comparison with a steel bridge is no longer favourable—at any rate, in first cost.

In our Supplement are given three views of Thur Bridge No. I., one of these showing the staging, another the centerings, and the third the completed bridge. The fourth view in the Supplement shows the completed Thur Bridge No. II., which will be referred to later on in this series of articles.

OUR CHEMICAL TRADE AND GERMAN COMPETITION.

(By an Expert Correspondent.)

IN commercial circles an immediate outcome of the European War in which we are engaged has been a laudable and widespread desire on the part of British manufacturers to win back markets which have been lost to them by the increased German competition of recent years. This desire extends to a multiplicity of manufactures and interests, some of which are referred to elsewhere in these pages. In the present article we shall confine our remarks to the chemical industry, in which it is a hackneyed phrase—emanating largely from the non-technical advocates of technical education—that we have passively allowed ourselves to be beaten all along the line by the Germans. It will be convenient to follow a recognised, though somewhat rough, classification and bring our remarks under the two headings of heavy chemicals and fine chemicals. The former comprises goods such as carbonate and caustic alkali, bleaching powder, mineral acids, alum, ammonium sulphate, and crude coal tar products; while in the latter category we may place synthetic dyestuffs, medicinal chemicals, photographic chemicals, synthetic perfumes, and, generally speaking, products which are sold by the pound or the ounce rather than by the ton or the hundredweight.

Now, in this matter of new competition with Germany it will be interesting, and important withal, to note where we have merely to get back what we have lost and where, on the other hand, we have to compete in markets which we have not hitherto invaded; in other words, it is one thing to supply goods we have been making successfully for years and another to compete in chemicals which we have not hitherto made or, if we have made them, only to a trifling extent. Chemical works are not put up in a day, nor is the necessary capital found by a wave of the wand, as would appear to be the idea of some writers to the newspapers.

Whatever may be the ultimate result of the new movement in the chemical industry, we shall certainly not be able to supply the textile trades of the country in the next month or two with the aniline dyes they require, and which at the moment they have difficulty in obtaining. As we write we only know in the terms of an Act the course the Board of Trade proposes to follow with regard to the suspension or cancelling of German and Austrian patents now being worked as monopolies in Great Britain. A test case or two is required to make the position clear. It is noteworthy, however, that the Manchester Chamber of Commerce has passed a resolution proposed by a prominent chemical manufacturer that any drastic action by the Board would not be in the interests of this country—first, because our enemies would be sure to retaliate in their own domains, where several British patents and factories are in operation; and, secondly, because in most cases we are by no means ready to make similar products. In addition to what has been already said about time and capital, it must be remembered that chemical manufacturing is usually carried on behind closed doors, trade secrets looming much more largely in chemical manufacturing than in the great majority of trades. It is all very well to buy a patent specification, but in how many cases, we wonder, is the manufacture carried on according to the strict lettering thereof?

As aniline dyes, to use a common expression for coal tar dyes generally, always take such a prominent place in discussions on German chemistry, we may point out that our production from a very few works is by no means insignificant, amounting in value to £500,000, while we import, mainly from Germany, £1,700,000 worth. Orders, it is stated, are now pouring in from neutral countries, such as Italy and America, in excess of the capacity of our works to deal with. It is recognised, of course, that this state of affairs is abnormal, and that various factors on the commercial side of business which obtain in ordinary times now go by the wall. It may, however, be taken for granted that the new business now being obtained by British firms in this branch will not be allowed to go without a struggle when times become normal again. As to how far we are likely to progress in this future competition with Germany is a matter on which it would savour of presumption for us to speculate, and it can well be left in the hands of those whose interests are closely involved. It may, however, prove useful to enlarge on one or two factors in the situation.

Synthetic dyestuffs, in which category come artificial madder and artificial indigo, our imports of which, amounting in value to probably over a million sterling, are, of course, not included in the figures given above for aniline dyes, are not made in their entirety in the same factories. There are numerous factories in Germany making special chemicals, such as, for instance, fuming sulphuric acid and chlor-acetic acid, which are bought by the colour manufacturers, and it is clear that if we are to carry on the synthetic colour industry on a large scale it will be necessary to put up factories to make these intermediate products. At the moment there is obviously little inducement to sink capital in this direction, as the British demand could not for a long time be large enough to be remunerative. At the present time many of such intermediate products are imported from Germany both by British manufacturers of dyestuffs and by the important German artificial indigo producers on the Manchester Ship Canal. It must not be overlooked that the vast synthetic colour industry in Germany has been systematically developed from small beginnings, and that, in fact, the industry as such has been created by the Germans. Certainly the first aniline dye was discovered and made for sale in England, but we have to stretch the meaning of words to say that the industry has been seized from us by Germany. Two factors which have militated against our progress have been lack of patriotism and of cheap alcohol, if one may be permitted to couple such dissimilar causes. With regard to the latter concessions of value have certainly been made by our Excise authorities in recent years, but our facilities in this respect are still much behind those enjoyed by German manufacturers. This is obviously a matter that calls for further consideration at the hands of the authorities. In turning now to what we have termed lack of patriotism, we wish to avoid a certain political controversy which has been so much to the fore in this country in the last decade. We may, however, quite independently of this indicate certain possibilities for the augmentation of home industry based upon what is now actually in operation. To take a concrete instance from the very industry we are discussing, we are sure we are giving away no secret when we say that the British Alizarin Company, of London, owes its survival and successful existence to the fact that its capital is largely held by an important dyeing combination which has undertaken to purchase, if not all, at any rate a large proportion of its output. It would not be easy to point to many similar cases, we imagine, in England, but in these days of great combinations of large capital we see no reason why considerable development on these lines should not take place to ensure, at any rate, the filling of our home requirements, if not to compete with the Germans in the world's markets. So much for the synthetic dye industry.

As far as our remarks have been of a general nature they will apply also to the other groups of fine chemicals, such as medicinal and photographic requisites, industries which have been largely created by the Germans and not taken from us. The synthetic perfume business has been almost entirely developed by the Germans, who now manufacture to the value of over two millions sterling per annum. Our business with them, though of some importance, is, however, not much more than one-tenth of what we do in natural perfumes for which our soap makers have a preference. Among the numerous letters in the daily Press on the German competition question we have noticed more than one reference to the cyanide industry, an industry the position of which may be considered as on the borderland of the fine and heavy chemical classification. We do not agree altogether with what has been recently put in print on the subject, but space prevents us from discussing the matter at any length. The demand for cyanide has grown largely since its introduction into the gold mining of the Rand and the silver mining of Mexico, and the output may be roughly stated as 10,000 to 12,000 tons a year. The present price is 7d. per pound, it being kept at this low figure in order to prevent further development of certain synthetic processes, which cannot compete successfully at less than 8d. or 9d. per pound. To the expected large production from gasworks should the price rise above 8d. per pound, we do not attach much importance. Though not the only producers, the two firms which really count in the cyanide manufacture are the Cassel Cyanide Company, of Scotland, and the Dessau Company, of Germany, which each hold successful patented processes, the former manufacturing from ammonia and the latter from the waste beet sugar residues, a source of nitrogen which is abundant in Germany. Of the South African imports of cyanide about three-fourths come from Germany and one-fourth from Great Britain, though this ratio is not on a par with the relative outputs of the two countries.

Going on now to speak of heavy chemicals, we are already equipped for a heavier export trade than is now in existence, and it is satisfactory to hear of sudden activity in important centres of the trade. The principal anxiety is the supply of certain raw materials. Salt, the basis of the alkali industry, we have always with us, but difficulties have arisen with regard to the delivery of pyrites, and more especially of potash and magnesium compounds. We cannot get on without Germany in the matter of the supply of potash, which is produced so largely from the natural deposits underground, as well as from the beet sugar residues. America, of course, is in a similar predicament, all her efforts to find natural sources of potash in her territory having proved of no avail. With regard to competition with Germany in soda compounds, it must not be overlooked that the selling price has now for many years been a matter of agreement between the principal producers of both countries. With regard to the forthcoming Magadi soda competition, Germany will be the greater sufferer from the national standpoint.

Our space is becoming exhausted, but we cannot refrain from a reference to the latest competition from Germany—this time not in fine, but in heavy chemicals. This is with regard to a body, ammonium sulphate to wit, which we now produce in very large quantities as a by-product of gasworks and coke ovens. The Germans, after their triumph in the fine chemical industry, seem disposed to rest on their oars in this department, and have assiduously attacked other branches, special attention having been directed to the synthesis of fertilisers and india-rubber. We hold no hopeful view of the future for synthetic rubber, but it is a fact that the Badische Company has made 30,000 tons of synthetic ammonium sulphate, and it is not surprising that considerable perturbation has been caused in our home producing circles.

Turning to another of our chemical industries, the soap trade, of which something has been said in the Press, what competition we have met with from Germany has been comparatively insignificant, and, like that from France, in specialised toilet articles. Owing to their high protective tariff on soap-making materials, such as palm and coconut oils, we have been enabled to keep the great bulk of the heavy soap business, and our large works have been more concerned in doing bulk business in hundreds of tons than in competing in high-priced fancy goods which cannot be expected to have a large sale. It is our production of soap in bulk that has given us the first place in the output of that important by-product glycerine.

Many other chemicals come to mind on which a few observations might prove of interest, but we must draw our remarks to a close. Enough has perhaps been said to indicate that whatever may be the case with cheap earthenware, bentwood chairs, &c., to mention only two of the articles with which our re-energised commercial branch of the Board of Trade is now dealing, the capture of the German chemical trade by England to any appreciable extent may in some cases be impossible, and will in most cases prove somewhat difficult of attainment.

OBITUARY.

ALFRED DOWSON.

ON the 14th instant, at Fleet, Hampshire, the death occurred of Mr. Alfred Dowson, civil engineer, at the age of sixty-eight. The late Mr. Dowson was for nearly a quarter of a century actively engaged in the design and construction of engineering works on the sea coast, including piers and landing stages at New Brighton, Hunstanton, Redcar, Cleethorpes, Wallasey, St. Anne's-on-Sea, &c. He was also consulted on the improvement of the harbour at St. Helier's, Jersey, and much of the work subsequently carried out followed the lines he advocated. He also made a thorough study of coast erosion and constructed breakwaters and other sea defence works at various parts of our coast, eventually bringing out a novel system of open groynes which he patented and applied with success at the mouth of the river Ribble, in Lancashire, and at Brighton.

On the passing of the Tramway Acts in 1870 Mr. Dowson carried out schemes in this country and in India. Several of the early track details were improved, and he actually designed and protected the present standard rail section, but at that date was unable to get the rolling mills to tackle its manufacture. In conjunction with his brother, Mr. J. Emerson Dowson, a treatise on "The Construction of Tramways" was published in 1875.

After giving up sea work, Mr. Dowson acted as engineer to his brother's undertaking, the Dowson Economic Gas Power Company, subsequently taking charge of its works at Basingstoke, which position he held for sixteen years until his retirement in 1908.

The late Mr. Dowson was keenly interested in the movement to preserve our commons and open spaces, and for some years acted as honorary surveyor to the Reading branch of the Commons Preservation Society. He also took great interest in sanitation and was for many years a fellow of the Royal Sanitary Institute.

THE RAILWAY CLUB.—The following papers will be read before the Railway Club during the session 1914-15:—September 15th, "Bournemouth and its Railway Facilities," by A. W. Bartlett; October 13th, "History of the Great Central—late M.S. and L.—Railway," by Rev. W. J. Scott; November 12th, "The Cheshire Lines Committee," by Basil Mercer; December 8th, "The West Highland Section of the North British Railway," by J. B. Sherlock; January 12th, 1915, "Railway Nationalisation: Is it Desirable, Practicable, or Probable?" by J. F. Gairns; February 9th, "The Railways of Wales" by H. L. Hopwood; March 9th, "Anglo-Scottish Train Services," by C. J. Allen; April 13th, "Characteristics of Swiss Railways," by E. J. Miller; May 11th "Some Early Railway Maps," by G. W. J. Potter; and June 8th, "The Aim of the Model Railwayist," by W. R. S. Smart.

the prices charged for the plant by the German firms to the Chinese have sometimes exceeded by more than 100 per cent. offers for cash made by British firms. It stands to reason that such transactions were extremely profitable, provided always that the purchasers were able to redeem their debt. The danger of such a method, however, is proved by the fact that German banks have lent millions of pounds to the Chinese in this manner, and it is difficult to see how they will be able to get them back, unless Germany can bring this war to a successful issue. The Germans have carried on the same policy in other parts of the world, and it is this which has secured the trade to them to the detriment of other nations.

The Future.

If the result of this war is to be the breaking of Germany's credit, some of those countries which have been attempting to follow her methods will no doubt modify their policy. It will thus be possible in carrying on the overseas trade to revert to the more legitimate methods of the past before German methods were introduced. The chances for British engineers will then be greatly improved, as machinery will once again be sold on its merits.

One must not imagine, however, that the destruction of Germany as a competitor will mean an absence of competition. If it eliminates the unfair element in competition for the overseas trade of the world, that is as much as we have a right to expect.

With the influx of work that we are bound to obtain in this country in the immediate future, and, in fact, which is already coming to us on account of the war, I shall deal in another article, but we must bear in mind that after the war, and when time has made it possible for firms in France and Belgium to cater for the world's trade again, the hands of the manufacturers in both those countries will be strengthened as competitors. This is quite as it should be, and with the accessions to their territory by absorbing portions of Germany, which we hope will be the result of this war, many of the existing German factories will in effect merely be working under another flag.

Then, again, however much the map of Europe may be altered with regard to German territory, the productive ability of the people inhabiting that territory, whether they are to be called Germans or anything else, will remain the same, and it is reasonable to suppose that if factories are destroyed they will in time be reconstructed or others will spring up in their place.

The most lasting feature, therefore, in the suppression of what we are now in the habit of calling German competition will lie in the breaking up of her governmental methods and her financial credit. The absence of the former will put it out of her power to use the fear of offending Germany as a lever to get trade in the weaker countries of the world. This has been one of the most important of her weapons in the past. Whereas, without money and without credit herself, Germany will not be in a position to give those long terms of payment which have told so strongly against the trade of her competitors.

Just as owing to her diplomacy, Germany has alienated the friendships of practically every other country in the world, so her methods of trading have caused her to be cordially detested, not merely by her competitors, but by her customers. It is for this reason that she has come to grief politically and commercially. It is for this reason that she has not been able to create a trade for her goods without giving facilities which it has not been necessary for all her competitors to grant, but which have proved very disastrous to British trade.

Some other European countries have been tarred with the same brush as Germany in their foreign dealings, though they have been much less important as competitors.

Belgium, of course, has become a very formidable competitor to British engineering firms in their overseas trade. It is not the time to say anything unfavourable to Belgium, for I take it that there is not a British manufacturer worthy of the name who would not rejoice to see Belgium on her feet to-day and in full possession of her industrial power as a competitor. Certain Belgian firms, it must be admitted, had come somewhat under the spell of German influence and consequently had, in co-operation with Germany, adopted some of the objectionable methods above referred to in the conduct of their foreign trade. But it may be assumed, whatever the result of this war may be, that Germano-Belgian co-operation will be a thing of the past. Belgium, like France, is a competitor who turns out good stuff, and we do not grudge her her success.

A RECENT issue of the *Journal des Transports* gave the following particulars as to the number of men employed on French railways :—State, 73,127 ; Est, 51,471 ; Midi, 26,268 ; Nord, 56,546 ; Orleans, 49,600 ; P.L.M., 86,124. These figures were given in an article as to the number of Syndicalists employed, and it appears that out of this total of 343,136 employees there were 16,503, or 4.8 per cent. members of the National Railway Syndicate. These particulars, as showing that the French railwayman is not a discontented mortal, are instructive, but the main interest lies in the fact that the proportion on the State lines is 9 per cent.

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. VI.*

The general questions of large stone arches may be divided into the following headings :—

The Working Out of Stresses.—The calculation of stresses and its cost is of course not a matter of fashion. The modern idea at least in Germany strongly favours or advocates the very mathematical method of elastic theory, in spite of its shortcomings concerning the coefficients of elasticity, and this tendency has to be respected, though, of course, not blindly accepted.

The old method of designing the centre line of pressure passing through three points of the arch has the great value of being very simple and clear, and the well-known French chief engineer, M. Séjourné, who has made a number of the greatest modern large span bridges, uses this method or the method of Méry.

One thing ought to be done from the first, viz., the entire arch should be dealt with, and not only a strip of 1 m. broad. This is a method adopted for the smaller arches of bridges with vertical or nearly vertical faces, but as the big arched bridges necessarily have more or less strongly battered faces, this method of the strip 1 m. broad gives an entirely inaccurate result, as the sections near the imposts become much broader as the span increases—even upwards of 50 per cent.—than those at the keystone.

The wind pressure ought not to be neglected, but considered in the right way with all its influences, which are by no means small in the case of the bigger arches of 100 m. span or more, and if the pitch is not small, they are of much greater importance than the stresses set up by variations of temperature.

The Austrian engineer, Dr. Oerley, in his research on this subject in connection with the great Solcano bridge in Austria, finds that the stresses caused by temperature are—

At the keystone $\pm$ 2.8 kilos. per sq. cm.
At the imposts $\mp$ 3.5 kilos. per sq. cm.

The Solcano bridge has the following dimensions :—

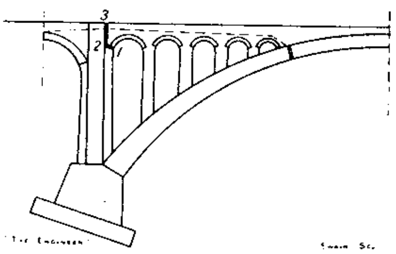


Fig. 46

Span of arch, 85 m.; rise of arch, 21 m.; at the keystone, 5.8 m. broad and 2.1 m. thick; at the imposts, 7.9 m. broad and 3.5 m. thick; the heaviest stress worked out is 51 kilos. per square centimetre.

At the Solcano bridge the remedy employed for preventing changes of temperature from causing the masonry to crack was the following :—The joint at the impost 1—2—Fig. 46—was made with a quite smooth surface; on this were laid three layers of asbestos plate, together 9 mm. thick, on which in their turn the arch stones were laid. The latter were quite smoothly dressed on their beds. This impost joint was continued straight up to the formation level as a through dry joint (2—3), thus leaving the two parts of masonry without any bond. To fill this joint asphalt felt plates were put in, and the faces of the joint were pointed with cement mortar in the usual way.

As regards the factor of safety, there ought not to be much anxiety. From an economical point of view it seems almost ridiculous to use factors of safety of 15 or more. If we can rely at all upon the work we are doing, we ought to face the risk of using a factor of safety of reasonable proportion. Engesser† recommends a factor of safety for large arches of from 4 to 8, and this seems to be reasonable.

If for iron or steel we use factors of safety from 4–5 then 4–8 does not seem too risky for stone and cement mortar, as the stone arch bridge has the very great advantage of its great mass, on which the capricious influences of the accidental load have very little power to act, whereas experience clearly points to the contrary with iron and steel structures.

In connection with this there is the question of mortar, which is usually tested in the form of cubes, though it has been proved that in prismatic forms of smaller thickness the resistance greatly increases. For instance, a test-piece with a thickness of 2 cm. has double the resistance to crushing than has a piece with a thickness of 4 cm. From which it follows that the well-filled mortar joint has a greater resistance than we usually reckon when calculating the results arrived at by testing cubes.

* No. V. appeared August 28th.
† Professor Engesser. Heft 5, "Zeitschrift für Architectur und Ingenieurwesen," Hannover 1907.

With a factor of safety of 6 there need be but little effort made to work out the stresses minutely. It may be desirable to do it quite properly and minutely, but the engineer ought not to be called upon to wait for the result. If a stress of 90 kilos. per square centimetre out of 640 kilos. per square centimetre has to be corrected to 105 kilos. per square centimetre, it really does not matter, and with an approximation of 15 per cent. tolerably quick results may be arrived at. Further, it has to be considered that the breadth b of the arch at the keystone must not be under a certain limit in relation to the span l. Not only has the wind pressure to be taken into account, but there must also be some margin in the breadth so that the resultant force, which is not, perhaps, in reality quite centrally applied, since it may come somewhat outside the symmetrical axis of the sections, may not too unfavourably influence the stresses. As with long columns, there might be a danger of the bridge bending sideways.

If the bridge has to carry two lines, the question of $\frac{b}{e}$, if l be less than 150 m., does not occasion trouble, but otherwise it seems that $\frac{b}{e} = \frac{1}{25}$ is a limit, which for stone arches ought not to be passed. In stone bridges carried up to the present the limit of $\frac{b}{e} = \frac{1}{16}$ is not exceeded, as far as the writer is aware.

Centerings.—The question of staging is very important, not only on account of its great expense, but also by reason of the difficulty of designing and making it. In crossing a very deep valley or gorge, the centerings directly supporting the structure may easily be very extensive and correspondingly difficult to make if uneven settlements are to be prevented. In crossing river beds or other ground of a difficult character there are foundation difficulties which may militate against the application of centerings as a means of direct support. In cases where great depths, difficult rivers, or soft ground have to be negotiated, the application of free bearing centerings seems to recommend itself. Free bearing centerings are, as is generally known, used in connection with spans up to, say, 45 m., but the use of this kind of centering for spans of more than 30 m. is, as far as the writer's experience goes, not to be recommended, as the system is not statically sound, and, at any rate, has its limit as mentioned above, at 45 m., whereas what is required is a system applicable to the largest spans, say, of over 100 m.

The making of large centerings demands very skilled workmanship, and only good and thoroughly trained carpenters ought mainly to be used for such work. If suitable timber be not fairly easily obtainable the cost may well increase to such an extent as to counterbalance the advantages of a stone arch.

The approximate cost of the centering of three stone railway arches was as follows :—

	Wood, cu. metres.	Total cost in francs.	Bridged area, sq. metres.	Cost in francs per sq. metre.
1. The Landwasser viaduct at Wiesen, in the Grisons Switzerland, span of arch = 55 m., narrow gauge	600	47,500	3700	13
2. The Solcano bridge, Austria, span of arch = 85 m., bridging a difficult river, which made a pier, built by compressed air work, necessary. It alone cost 140,000f. Normal gauge... ...	1209	280,000	3530	80
3. Thur Bridge No. 1. Ebnat-Nesslau, normal gauge	285	25,500	1000	25

The enormous difference between 1 and 2 is at once observable. Not only do the span and gauge, but also the difficult river make the Solcano bridge appear expensive by comparison.

Stones.—The questions as to whether the stone (*a*) be not too expensive to transport; (*b*) is of the necessary weather-proof quality; (*c*) does not cost too much to quarry and dress; (*d*) is of the ultimate strength required, have further to be considered.

Natural stones as a rule have an ultimate compressive resistance ranging from 1000 to 2200 kilos. per square centimetre—say, roughly from 6 to 14 tons per square inch—and are thus far superior to any artificial stone, and, of course, also to concrete. Experience—at least, that of the writer—shows that excellent natural stone is frequently, or at least not seldom, found on the railway lines in Switzerland. A natural stone of 1200 kilos. per square centimetre, —say, 7¾ tons per square inch—ultimate strength is frequently not difficult to work or too expensive to dress to approximately the correct size, and, while being much more reliable than, for instance, blocks of concrete or artificial stone, it has the further advantage of being 4 to 5 times stronger.

Making use of the Engesser formula: ultimate compressive strength of masonry = ¼ strength of stone + ¾ strength of mortar—and, taking the ultimate strength of natural stone as 1200 kilos. per square centimetre, of concrete in blocks as 270 kilos. per square centimetre, and of Portland cement mortar as 360 kilos. per square centimetre*, we get for

* As pointed out above, the mortar in the joints has a much greater resistance than is represented by this figure.

masonry made with natural stone an ultimate compressive strength = $\frac{1}{3} \times 1200 + \frac{2}{3} \times 360 = 640$ kilos. per square centimetre; for masonry made with concrete blocks $\frac{1}{3} \times 270 + \frac{2}{3} \times 360 = 330$ kilos. per square centimetre; and, as the greater security of the natural stone justifies a smaller factor of safety, we can make this 6 for natural stone and 8 for concrete blocks, and thus get a permissible stress of 105 kilos. per square centimetre for natural stone masonry, as compared with 41 kilos. per square centimetre for concrete block masonry.

Concerning the dressing and size of natural stones, there has been a certain tendency to specify very accurate dimensions of stones for large arches, this necessarily causing a considerable outlay in dressing. This demand originated in the idea that the joints must necessarilye as bnt arrow as possible. In he great Solcano bridge in Austria, which has a span of 85 m. (say, 278ft. 9in.), the joints were originally fixed at a width of 12 mm. (just under ½in.), and the stones were very accurately dressed so as to enable this dimension to be adhered to; but the joints proved too narrow, and were widened to 18 mm., which necessitated the cutting of a layer of from 6 mm. to 8 mm. from 198 arch stones with a total area to be cut of 250 square metres. The stones used in the Solcano arch were of large size, varying from 0.2 to 0.7 cubic metres apiece, and were necessarily very expensive to make and also to handle. The cost of this arch is stated to have worked out at 160f. per cubic metre.

The size of stone used ought, as a rule, not to exceed 0.2 cubic metres apiece. An average of 0.15 cubic metres should suffice; with this dimension stone is neither difficult nor expensive to handle. If narrow joints are not insisted upon, we are able to moderate the demands as to dressing and to tolerate a certain latitude of dimension and form, thus bringing down the cost to a reasonable figure.

The Joints.—The idea that the joints ought to be made as narrow as possible possibly originated in the quite correct assumption that the mortar part of the arch was the weakest part, and therefore should be kept small. This, of course, only was so when dealing with natural stone, the artificial stone not then being much used for arch building purposes. The filling up of the joints with mortar in a liquid state naturally called for narrow joints; but the use of mortar of this consistency has been abandoned for the good reason that to make the mortar so wet incurs the risk of weakening it, and, moreover, one is never quite sure that no voids have been left, as it is not at all easy to get all joints so well closed that the liquid mortar nowhere finds an escape. A joint must have a reasonable width in order that it may be well filled; but, on the other hand, it must not be too wide, since, when bedding the stone in the usual way, the mason using the trowel, mortar with a certain degree of moisture has to be used. The really sound way of filling the joints of greatest importance, viz., the radial arch joints on which the chief forces act normally, is to place all the stones in position, dry; to space them with iron wedges, and then to fill in the mortar with a moisture similar to that of earth, ramming it well down to such an extent that the water is squeezed out and appears on the surface of the joint. To do this a joint of a reasonable width is necessary, and for this reason it does not matter very much if the joints be somewhat wide and somewhat irregular, as the mortar fills them in such a compact and perfect way, and is itself strengthened by reason of the ramming process, so that its resistance is considerably augmented. According to the experience gained in Thur Bridge No. 1, at Krummenau, described above, joints with a variation in width of from 2 cm. to 6 cm.—2 cm. and 6 cm. being absolute minima and maxima—give the latitude necessary for having a not too expensive rough square stone dressing, and can be recommended for pressures of below 100 kilos. per square centimetre. The stones ought, of course, to be thoroughly cleaned from dirt and stone dust before being placed in the arch.

THE EFFECT OF AUTOMATIC SIGNALS.

THE following figures show the good effect the provision of automatic signals by the Southern Pacific Railroad Company has had upon its accident records:—

Year ended June 30th	Mileage of automatic signals.	Percentage of total mileage.	No. of accidents.	No. of persons killed.	No. of persons injured.
			Per million engine miles run.		
1905	359	3.87	19.71	1.32	7.31
1906	715	7.65	23.97	0.74	4.42
1907	1491	15.59	31.33	2.10	14.49
1908	2321	23.83	26.21	0.62	5.36
1909	2682	27.12	8.93	0.57	4.02
1910	2883	28.88	8.71	0.45	6.32
1911	3167	31.24	7.59	0.24	4.65
1912	3216	30.95	6.67	0.22	4.24

It will be seen that, whereas in 1905, when the mileage equipped with automatic signals was 359, or 3.87 per cent. of the total mileage, there were 19.71 accidents per million engine miles run; in 1912, when the mileage equipped had increased to 3216, or 30.95 per cent. of the total, the accidents had fallen to 6.67 per million engine miles. Until 1909, however, the real advantage had not become apparent, for the accidents in 1906, 1907, and 1908 were higher than those in 1905.

BRITISH versus GERMAN TRADE IN LATIN-AMERICA.

(*By our Special Commissioner to South America in 1910 and 1911.*)

No. I.

THOUGHTFUL Germans have long foreseen that their commercial success in most parts of the world—and in none more notably than in Latin-America—would excite the attention and promote the emulation of their great rivals, the British. The blow has, nevertheless, fallen in a totally unexpected quarter, for it was expected by few Germans that it would assume the form of forcible seizure of their trading vessels, and the closing of their ports by means of a fleet of hostile battleships; they looked rather for it to come through political influences. All the efforts of the past twenty years and longer, all the millions of good marks expended—legitimately and otherwise—upon building up a trade connection for German manufactures, all the skilful diplomatic exertions in which even princes "of the blood" took part, all the high hopes cherished and the bold prophecies made regarding "the smashing of the British trade in the Americas"—all, all are coming to nought. Already we, in conjunction with our unsleeping competitors from the United States, are attempting to seize the vacant places of our whilom rivals, the Germans, and the chances are that we shall succeed. I say "chances" advisedly, for the complete replacement of a great commercial nation like that of Germany in the esteem and the custom of the Latin-American peoples is far from the easy undertaking that so many enthusiastic writers appear to imagine.

First, let us study the markets to be attacked; secondly, let us see how far we are in a position to attack them; and then let us consider whether the Germans are, after all, so helpless as we judge them to be. If these and other questions are carefully studied, and the experiences already gained in our long-sustained struggle against German competition are made to serve a good purpose, succeed we shall. While offering to British manufacturers every encouragement, I do not wish it to be accepted for granted, as so many unthinking individuals are inclined, that the battle will be easy. It is a difficult, but not an insuperable task which we are undertaking.

German Trade in Latin America.

In the case of Europe's most important South American customer—Argentina—the Germans hold a particularly strong position, one which has been consolidated by judicious investment in an immense variety of local undertakings, from which no foreign rival could hope to eject them. These enterprises are also largely financed and supported by native capitalists, while in many of the large importing and distributing houses in the republic in Buenos Aires, Rosario, Mendoza, Santa Fé, Cordoba and elsewhere German capital is heavily interested and German influence has to be reckoned with. Is it to be assumed that because the Fatherland is at war with one half of the world, the other half, which has suffered from no particular cause of offence, is to take up the feud as its own? If we are to fight Germany in the commercial markets of the world, it must be upon sounder ground than the present embarrassments from which that country is suffering.

From a commercial point of view, the Germans rank next in importance to the British in the Argentine Republic. They sustain there their world-wide reputation for extreme thriftiness and enterprise, and some of the finest and most prosperous establishments bear Teutonic names. Like the members of German communities all the world over, the Teutonic residents of Argentina display little inclination to travel socially beyond their own immediate circle, but financially and commercially their tentacles reach to the extreme ends of the republic. There is a powerful German bank, a German church, more than one German newspaper, and numerous German manufacturing establishments in Buenos Aires alone; other cities know them, trade with them, and—as seems to be inevitable—cordially dislike them.

Of the total Latin-American trade conducted with the whole of the world, and amounting to the considerable sum of £762,422,887, Germany participated to the extent of £78,950,913, while Great Britain scored £123,980,707. Germany took a great deal less from Argentina than she sent, while Great Britain bought almost as much as she sold. The distribution of Latin-American trade for 1912—to which year all the figures given apply—were approximately as follows:—

Total Trade: All Latin-America, 1912.

	Value, dollars.	Per cent. of whole.
Total	2,842,114,436	100
United States	830,686,102	29.54
United Kingdom	619,703,536	23.63
Germany	394,754,566	14.04

Imports: All Latin-America, 1912.

	Value, dollars	Per cent. of whole
Total	1,241,773,366	100
United States	304,217,287	24.49
United Kingdom	309,681,730	24.93
Germany	207,789,113	16.73

Exports: All Latin-America, 1912.

	Volume, dollars.	Per cent. of whole
Total	1,570,341,070	100
United States	526,468,815	32.52
United Kingdom	310,021,806	19.74
Germany	186,965,453	11.90

The proportions of European and United States trade conducted with the ten North American republics—Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Dominican Republic, Cuba and Haiti—were as follows:—

North America, 1912.

	Imports, dollars.	Per cent. of whole
Total	281,268,607	100
United States	150,911,934	53.65
United Kingdom	36,574,798	13.00
Germany	28,936,304	10.28
	Exports, dollars.	**Per cent. of whole**
Total	393,369,524	100
United States	283,965,903	72.18
United Kingdom	40,793,173	10.37
Germany	30,093,447	4.69

With regard to the ten South American States—Argentina, Brazil, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela—the proportions were as follows:—

South America, 1912.

	Imports, dollars.	Per cent. of whole
Total	960,504,759	100
United States	153,305,353	15.96
United Kingdom	273,106,932	28.43
Germany	178,852,809	18.62
	Exports, dollars.	**Per cent. of whole**
Total	1,176,971,546	100
United States	242,502,912	20.60
United Kingdom	269,228,633	22.02
Germany	156,872,006	13.31

German Trade in Argentina.

Having seen to what extent the Germans share in the whole of the trade of Latin-America—and it will be obvious that their position is a strong one—it will be of interest to examine into their commercial holding upon Argentina, and take note of the principal markets which they affect, particularly those in which they come into violent competition with the United Kingdom.

Practically all European countries and the United States of America have increased their trade with Argentina during the last five years, but Germany did better than we in actual increase. Thus between 1909 and 1913 this increase has been tolerably steady, as the subjoined figures conclusively prove:—

	Dollars.
1909	44,555,770
1910	61,128,888
1911	65,862,211
1912	63,941,503
1913	71,311,628

British trade for the same period, apart altogether from the very considerable business carried on with British possessions, amounted to the following:—

	Dollars.
1909	99,198,269
1910	109,377,394
1911	108,637,430
1912	118,669,266
1913	130,886,587

If we look at the respective percentages of the countries for these five years, we see that while the United Kingdom decreased its proportion from 32.8 per cent. in 1909 to 31.1 per cent. in 1913, Germany increased her share from 14.7 per cent. in 1909 to 16.9 per cent. in 1913. The exact progress was as shown below:

	United Kingdom, per cent.	Germany, per cent.
1909	32.8	14.7
1910	31.1	17.4
1911	29.6	18.0
1912	30.8	16.6
1913	31.1	16.9

The German Government and Trade.

The question will naturally arise why we should have fallen behind, notwithstanding the fact that we still stood absolutely at the head of all European nations in the volume of trade with the Argentine Republic. An answer may be found in the excellent arrangements which the Germans, aided and encouraged in every manner by their Government at home, conduct their foreign trade with the rest of the world in competition. We may imagine, indeed, the Imperial Government saying to the manufacturer and shipper at Hamburg, Berlin, Leipsig and other great centres of industry: "*You* get the customers, and *we* will do the rest." Certainly, the German Government stands strongly at the back of the commercial classes of the country, and, while asking for no share of the profits, lends the whole of the economic resources of the Fatherland to earning them. Thus we see the railroads and the canals operated entirely in favour of German travellers and German goods. To enable the latter to meet foreign competition—which remains unsubsidised and granted no distinctive advantages—transportation rates are adjusted and re-adjusted. On the other hand, no facilities are offered to German shippers if any but purely German routes are selected.

The German Post-office Department, again, reflects the friendly attitude of the Government towards its traders, especially in connection with the carrying of samples and the delivery of all printed matter, such as catalogues, price lists and samples. In fact, the German trader is put to no trouble at all, either in receiving or in shipping his goods. He may deliver them to the nearest railway station, marked for an extreme part of the world, pay his rates, take his receipt, and go away content with the knowledge that in all human probability those goods will be delivered by German ships under the direction of responsible German officials, and that in the event of any accident taking place between the time that

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. Berg.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. VII.*

THUR BRIDGE No. II.

This bridge crosses the river Thur at km. 6.65, and is of a totally different character from the first bridge already described. The foundation level is only 6.5 m. above mean water level, and of rocks

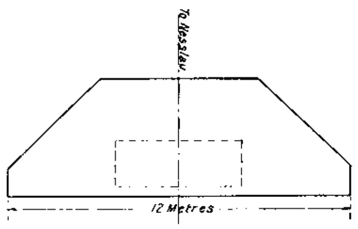


Fig. 47

there are no visible signs. A view of the bridge was given in the Supplement in our issue of Aug. 28th. The ground on both banks of the river is soft clay, and on the right side was covered with a layer of sand and shingle. As iron bridges, as a matter of principle, were to be excluded if possible, another stone bridge was arranged for. The span was made 24.82 m., and the rise 3.58 m. Considering the somewhat uncertain foundation and the small rise, it was deemed advisable to make the arch three-hinged, and in view of the results

The 806 tons rest upon the piles, which at an angle of 7½ deg. produce a horizontal force counteracting the horizontal thrust of the arch, and being = 806 × 0.13 = 105 tons. We have thus 663 - 105 = 558 tons of horizontally acting thrust to be taken by the area normal to the axis = 4.5 × 5.6 = 25.2 square

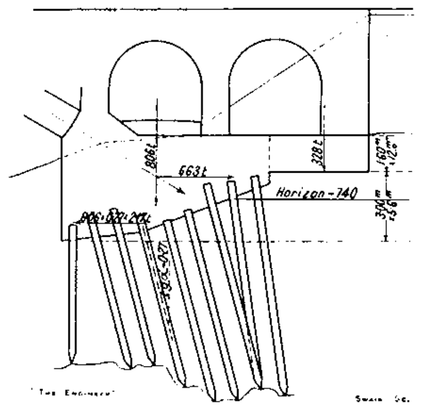


Fig. 48

metres, or 558 tons ÷ 25.2 square metres = 22.1 tons per square metre = 2.2 kilogrammes per square centimetre, which for this kind of soil is a far too great sideways pressure. It is true that the end of the viaduct and the adjoining bank aid in

given in Fig. 47—was laid down. This platform served also as a foundation for the abutment of the viaduct, and was made of such a thickness as not to go below the layer of sand and shingle on the right bank of the river, so as to keep it out of actual contact with the soft clay. The width of the raft, of course, increased the area of resistance. By using this contrivance, the passive resistance of the earth pressure of the adjoining bank could be counted upon, though as a matter of fact this is not done in the following calculation, showing the improved statical conditions. Moreover, the angle at which the piles were driven was changed from 7½ deg. to 15 deg., thus correspondingly increasing the horizontal thrust of the load resting upon them—see Fig. 48.

	Tons.
Weight of the concrete = raft = 74·2 cu. m. × 1·2 t.* =	89
Weight of load upon the raft = 140·7 cu. m. × 1·7 t. =	239·2
Total ...	328·2
Taking the coefficient of friction between platform and soil as 0·3, we have—	
Its resistance = 328·2 × 0·3 ... =	98·5
The load on the piles = 806 t. This with the wider angle of the piles affords a resistance = 806 × 0·27 ... =	217·6
Total ... =	316·1

* 1 ton being deducted to allow for buoyancy during floods.

The area taking the horizontal thrust now being = 5.6 × 3.0 + 12 × 1.6 = 36 square metres, we have a pressure = 663 - 316 ÷ 36 = say 10 tons per square metre, or 1.0 kilo. per square centimetre.

The dimensions of the arch at the keystone are 4.33 × 1.10 m. and at the impost 4.50 × 1.40. It will be observed that the arch has a peculiar form, being as thick at one-quarter of the span as at the impost, this being a natural consequence of the three-hinged arrangement, in which the arch acts as two rafters placed against each other. In

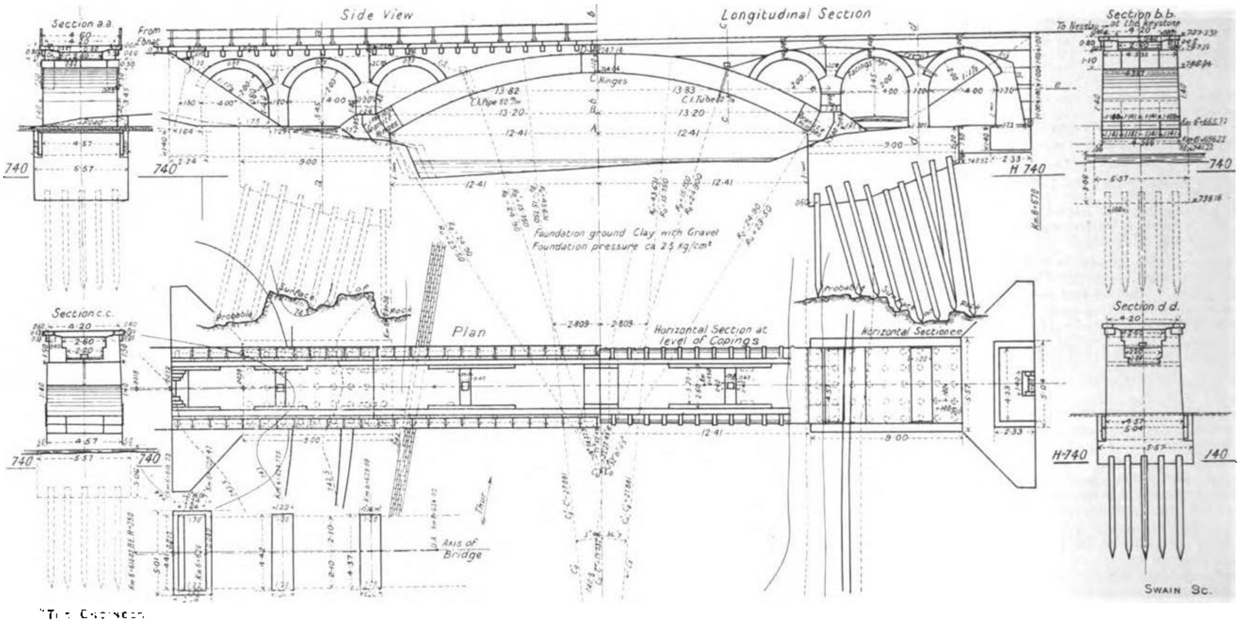


Fig. 49—PLAN AND ELEVATION OF THUR BRIDGE, No. II.

this type of arch the hinges are by far the most difficult part. They must be of the hardest and most resistant material which can possibly be obtained, and made very true to their theoretical form. Granite of an extra good quality—obtained near the St. Gott-

of the preliminary borings, the abutments were to be placed on piles. However, when the foundation was excavated and the pile driving commenced, it was found that the material—very soft wet clay—was of yet softer quality than had been expected.

The following test was then made:—A piece of square timber with a cross section of 320 square centimetres was prepared, and laid on the ground so that weights could be applied to it. The load was put on gradually with the following results:—

Loading per sq. cm. Kilos.	Penetration into the ground. mm.
0·62	7·5
0·90	19
1·21	34·5
1·52	56·5
1·74	77

These results were regarded as very bad, and though no fear was felt concerning the vertical carrying capacity of the foundations which would be mainly secured by the piles, there was considered to be a lack of safety as regarded the horizontal component of the arch thrust.

Taking into account the amount of buoyancy caused by the water when covering the abutments in times of flood, the following figures were arrived at:—

The horizontal thrust of the arch =		663 tons
„ vertical „ „ =	327 tons	
„ weight of the abutment and the load upon it ... ... =	479 tons	
Total	806 tons	

* No. VI. appeared September 4th.

increasing stability, but as there is only a connection by means of the last arch, it was decided that this could not be counted on. Moreover, it was deemed safest to disregard the friction between the abutment and the soil under and beside it, as the very wet

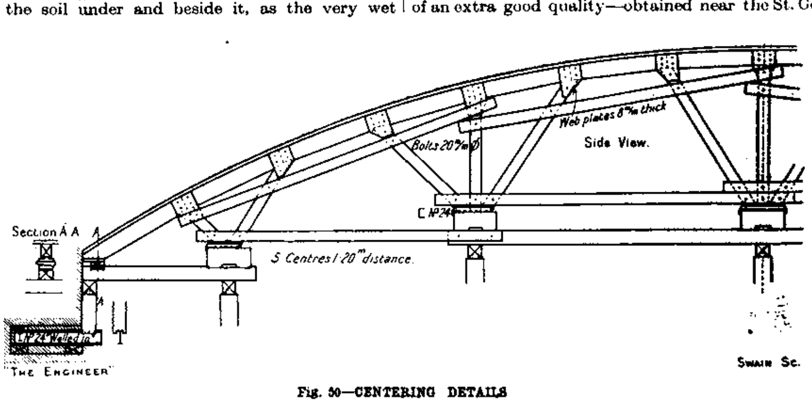


Fig. 50—CENTERING DETAILS

condition of the soft clay showed that the coefficient of friction would be very small.

In order, therefore, to secure the resistance necessary for the safety of the construction, the abutments were widened, and a concrete raft—a plan of which is

hard Railway in the Canton Ticino—was used, and the stones were very accurately dressed. Zinc templates were used for checking the forms of the hinge planes, and the latter were made as accurately as it was possible; that is to say, they were made true within an approximation of 1 mm. to 2 mm., a first-class stone mason doing the final dressing.

The author occasionally has had to do very accurate work of this kind demanding very exact templates or models, and has had the rather curious experience that the engineers in charge of the work have themselves had to make the templates, as the ordinary artizans available, even the best of them, were not able to work with the minute accuracy required. The accurate setting of such big stones is also not an easy matter, as with a small work like the bridge under consideration, questions of economy do not allow any expensive or complicated apparatus, and accordingly the accurate setting did not prove quite successful, but with the very flat curvature of the parts in contact, this, apparently, did not do any harm.

The form of the hinge stones was chosen according to the formulæ of the German Barkhausen, in accordance with which the greatest pressures at the surfaces in contact were :—At the key hinge, 70.5 kilos. per square centimetre ; at the impost hinge, 75.5 kilos. per square centimetre ; and the pressures carried on to the masonry by means of the hinge stones were at the key 15.6 kilos. per square centimetre, and at the movement of the abutments could be observed either then or later.

For carrying out the excavation for the abutment foundations pumping with centrifugal pumps was resorted to. The concreting was done under water by means of a funnel. As much of the shuttering was pulled out as possible, and care was taken that all foundation excavation was quite closely filled with concrete up to the surface of the ground.

The piles were required not to descend more than 1 mm. at the last stroke. All the piles were, as a matter of fact, easily driven down to rock.

WAR ITEMS.

Motorists who are willing to convert their cars into ambulance vehicles at a reasonable cost are earnestly requested to communicate with the Secretary, Automobile Association and Motor Union, Fanum House, Whitcomb-street, London, W.

* * *

We are informed that, up to date, 118 men from the works and offices of the Westinghouse Brake Company, by the Board of Trade cable from H.M. Consul-General at Shanghai :—" Business may be said to be more or less at a standstill. The situation is governed by the export trade, which is held up ; and money is kept tight principally on account of this stagnation. The Germans are accepting export cargo, which is being deposited in godowns, but Chinese sellers are at present without payment. This fact will undoubtedly react in favour of British interests."

* * *

His Majesty's Consul at Milan telegraphs that the British Chambers of Commerce there have received inquiries from local firms which are desirous of purchasing dyeing and bleaching materials, chemicals, machinery, dynamos, bicycles, iron and steel, motors, carburetters, motor cycles, and cutlery.

* * *

An emphatic denial to the statement that they are an alien company is made by Wm. Geipel and Co. No alien or foreign-born person has, they say, ever been connected with them. Their principal and his entire staff are English born and bred.

* * *

In view of letters inquiring into the composition of the British Thomson-Houston Company, Limited, which have appeared in some papers, Mr. H. C. Levis, the managing director, sends us the following particulars :—

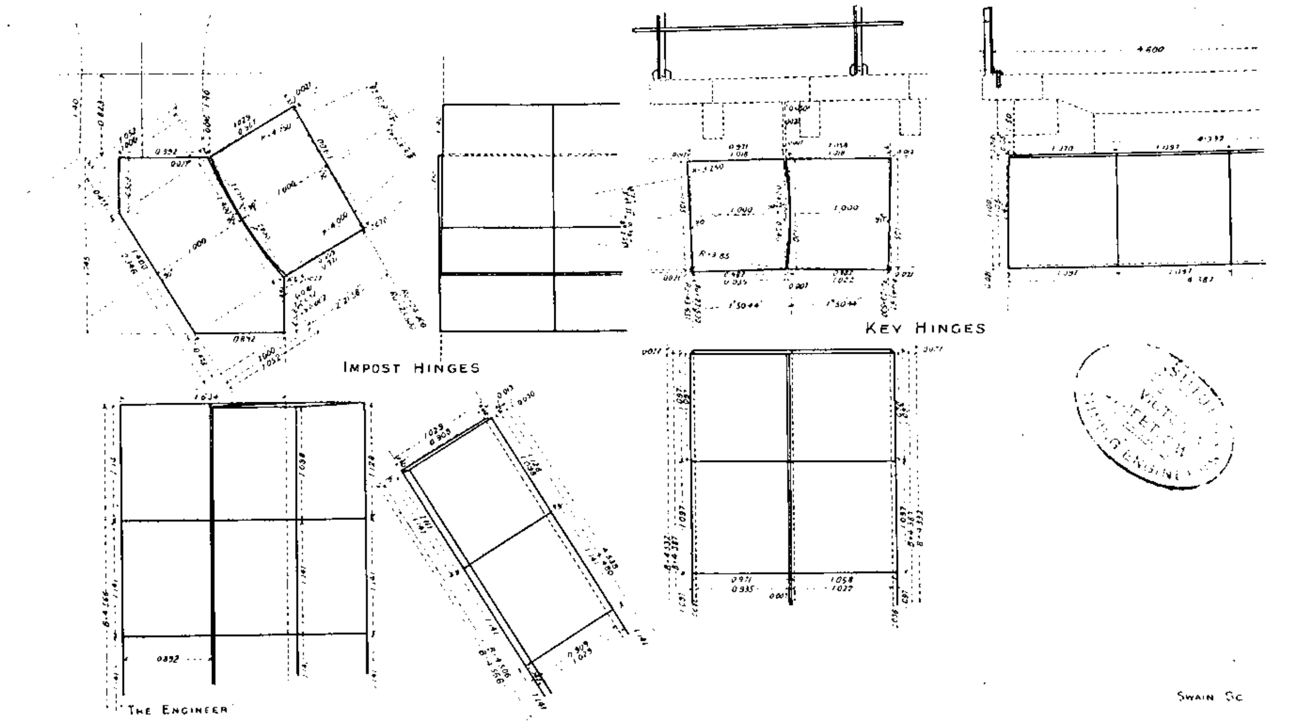


Fig. 51—HINGE STONES FOR THE SECOND THUR BRIDGE

impost 14 kilos. per square centimetre—all very low pressures.

The cost of this bridge as carried out was as follows :

	Francs	cent.
Excavation of foundations, 636·5 cu. m. at 11·40f.	7,256	10
Foundation = concrete in Portland cement 1 : 3 : 6, 464·4 cu. m. at 26·22f.	12,176	57
Foundation = concrete in Portland cement 1 : 5 : 10, 150·5 cu. m. at 20·52f.	3,088	26
Filling concrete in Portland cement 1 : 5 : 10, 29·2 cu. m. at 20·52f.	599	18
Rubble masonry, 192·7 cu. m. at 26·22f.	5,052	59
Rubble vault masonry, 49·0 cu. m. at 31·92f. ..	1,564	08
Ashlar vault masonry in Portland cement, 133·6 cu. m. at 57f.	7,615	20
Hinge stones of granite, 39·8 cu. m. at 273·60f.	10,889	28
Ashlar vault masonry, 18·6 cu. m. at 45·60f. ...	848	16
Vault coating, 131·2 sq. m. at 7·41f.	972	19
Vault draining apparatus, 4 pieces at 34·20f. ...	136	80
Stone filling, 60·5 cu. m. at 3·42f.	206	91
Smooth square hard stone, 19·7 cu. m. at 79·80f.	1,572	06
Edge facing stones, 47·6 m. at 5·70f....	271	32
Cement pipes, 0·60 m. diam., 2·4 m. at 19·38f.	46	51
Piles, 666·9 m. at 7·98f.	5,321	86
For centering, pumping, &c....	6,840	00
Total	64,457	07

The details of the bridge and the centerings can be seen in Figs. 49 and 50, while the hinge stones are shown in Fig. 51. The settlement of the centerings during the building of the arch amounted to 60 mm. at the crown. The movements of the arch were observed by means of five bolts on each face.

The arch was made in two courses, and the centering was not struck until the whole viaduct had been finished, including the adjoining approaches, so as to have the force of resistance against the horizontal arch thrust practically complete before striking. From the closing of the first arch course to the striking of the centering, the arch settled at the keystone 50 mm., and at the imposts 7 mm. When the centering itself was struck, the settlements were :—At the key, 6 mm.; and at the imposts, 1 mm. No horizontal

Ltd., representing upwards of 28 per cent. of the Company's normal establishment, have joined the colours. The Westinghouse Brake Company, Limited, is paying these men half rate wages, and has agreed that all who return to them on the expiration of such service shall find their places open for them.

* * *

We are informed that men are gradually returning from the front, where they were engaged to guard the neutrality of the country, to the Oerlikon Works, Switzerland, and that the factories are now working with approximately half the men and staff on half time. All the contracts, and particularly those for British clients, are making good progress, considering the circumstances. Transit and export routes are still kept open from Switzerland to this country and others.

* * *

The question of the course of action to be pursued by the Institution of Automobile Engineers during the forthcoming session in view of the situation brought about by the war has been very carefully considered by the Council, and as a result it has been decided that, in spite of the absence of a number of officers and other members in the service of his Majesty and of the difficulties with which a number of firms are faced, it will be to the best interests of the industry generally and of the Institution to proceed with the normal work of the session and to hold the usual monthly meetings. It is proposed that, as far as possible, the papers to be read shall deal with the special difficulties which have been imposed upon the automobile engineer by the war, such, for instance, as those connected with labour, finance, the reduction in the demand for pleasure cars, and the impossibility of obtaining parts from abroad. Papers have already been promised on these lines. The Council also desires that these discussions shall be of the greatest possible value to the industry generally, and in view of the special circumstances it is prepared to extend a general invitation to all the meetings to those who are interested in the manufacture of automobiles or components, whether members of the Institution or not. Full particulars will be sent on application to the secretary.

* * *

The following further information has been received

The capital of the company consists of 80,000 shares of the par value of £10 each and £186,215 of debentures. The shares are held by : Forty-four English shareholders, holding 10,458 shares ; eleven French shareholders, holding 3109 shares ; one Belgian shareholder, holding 83 shares ; nine American shareholders, holding 64,876 shares ; one German shareholder, resident in Cologne, holding 333 shares ; one German shareholder, resident in England, holding 1141 shares ; total, 80,000 shares. Neither of these last two mentioned shareholders, as far as is known, are in any way connected with electrical manufacturing companies, either here or in Germany. The debentures are held by 106 shareholders, all resident in England and all English, with the exception of one French lady, who holds £2000 par value. There is not a single German in the employment of, or in any way connected with, the company. The active board consists of the following : J. F. Nauheim, who represents the shares held by Lord Rothschild in the company ; he has lived here most of his life, and has been naturalised between thirty and forty years. George Franklin, of Sheffield and London, who was at one time Lord Mayor of Sheffield, and who was chairman of the National Telephone Company. Owen H. Smith, who came on originally to represent the debenture holders ; he is one of the partners of "The Proprietors of Hay's Wharf, Limited." F. Fraser, a Scotsman, who is also the secretary. W. C. Lusk, manager of the commercial departments. H. N. Sporborg, the chief engineer : and H. C. Levis, the managing director. The last three are American born, and have been in England from ten to twelve years. The other members of the board are : Three Americans residing in New York, who represent large shareholders, and of whom one for many years lived in London, namely, C. A. Coffin, E. W. Rice, jun., and E. A. Carolan. The two former are chairman and president respectively of the General Electric Company of New York, the patents of which company and its predecessor—the Thomson-Houston Company—forming the original basis of the company. C. Burrell, an Englishman, who has spent most of his life in France, now living in Paris. E. Thurnauer, who is an American citizen, also living in France. These two are managers of the Compagnie Française pour l'Exploit des procédés Thomson-Houston, and ival, and the German coal syndicate, like the other associations of the same kind, has persistently subsidised exportation. There has been a big increase n the shipment of German coal, mainly in competition with British coal, these late years, and in the last few months before the war Germany was exporting coal t the rate of nearly 35,000,000 tons a year, besides oke at the rate of 6,000,000 tons. Naturally, the war seriously interfered with our coal exports, amounting in volume to about double those of Germany, and practically suspended those of our rivals. In the irst month of the war—August—our British coal xports declined by 2,750,000 tons. Two-thirds of hat loss was represented by the suspension of our xports to France, Germany, and Russia. To Italy our exports declined by more than 200,000 tons; o Belgium by more than 100,000 tons; and to the South American Republics by 250,000 tons. Now, with stocks of coal held by foreign consumers and at he various coaling stations depleted, and with shipping facilities and freights resuming something like normal conditions and terms, and with our greatest ival, Germany, knocked out of the race, we can look confidently to a very early resumption of the bulk of our own business, plus a large share of the trade hitherto done by our continental competitors, whose production of coal, as well as the exportation of it, is very seriously cut down. About the only serious obstacle remaining in the way of our coal export business is the continued lack of international exchange and the difficulties of arranging payments from abroad. Thanks to the Navy, nearly the whole of our trade avenues are open, insurances and freights no longer stand at prohibitive levels, and the general international demand for coal is steadily assuming ordinary proportions, inquiries from abroad increasing daily. The Government's general proposals for meeting the exchange problem created by the war are working very satisfactorily; but the case of the coal trade is somewhat special. Such being the case, the Newcastle Exchange at once appointed an advisory committee, which has paid special attention to this question of payments. A deputation has interviewed the Treasury and suggested that what is needed to facilitate the exportation of coal is an arrangement whereby money due to coal shippers can be first collected and then deposited abroad to their credit, the Government issuing against these deposits certificates upon which bankers here may grant the necessary cash advances. The deputation has been courteously received, and sympathetic and immediate consideration of its proposals promised. There are good grounds for believing that a scheme on the lines suggested may be introduced any day now. If this be done our trade, notwithstanding the closure of the Baltic, will soon attain a volume at least equal to that prevailing before the war.

A new sand shield, invented by Mr. Bowen Cooke, the chief mechanical engineer, and Mr. Nash, the shed foreman, at Crewe, is now being fixed on the London and North-Western locomotives. Its purpose is to obviate sand being blown off the rails by a side wind and not passing under the tread of the wheel. Except that in this arrangement the mouth of the sand pipe is carried close up to the wheel, the ordinary sanding apparatus applies. Davies and Metcalfe, Limited, of Romiley, are the sole licensees.

RAILWAY CONSTRUCTION IN SWITZERLAND.

By S. BERG.

THE EBNAT-NESSLAU BRANCH OF THE BODENSEE TOGGENBURG RAILWAY.

No. VIII.*—(*Conclusion.*)

As an instance of a cheap method of taking a railway over a road, mention may be made of the arched bridge at km. 1.780—see Fig. 52. It is 3 m. wide and 3.5 m. high, the height of bank is 6.3 m. Details of the bridge are given in Fig. 53, and the cost as carried out is shown below:—

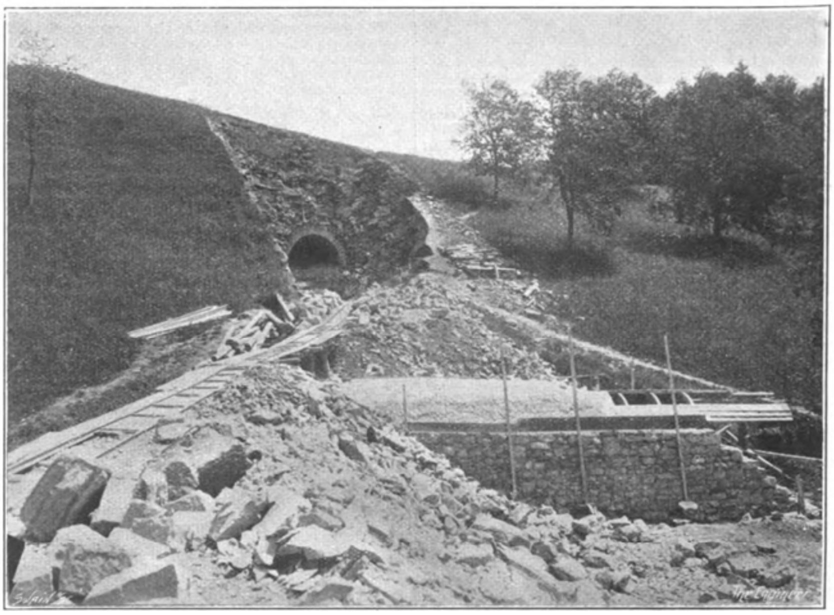


Fig. 52—BRIDGE AT Km. 1.78

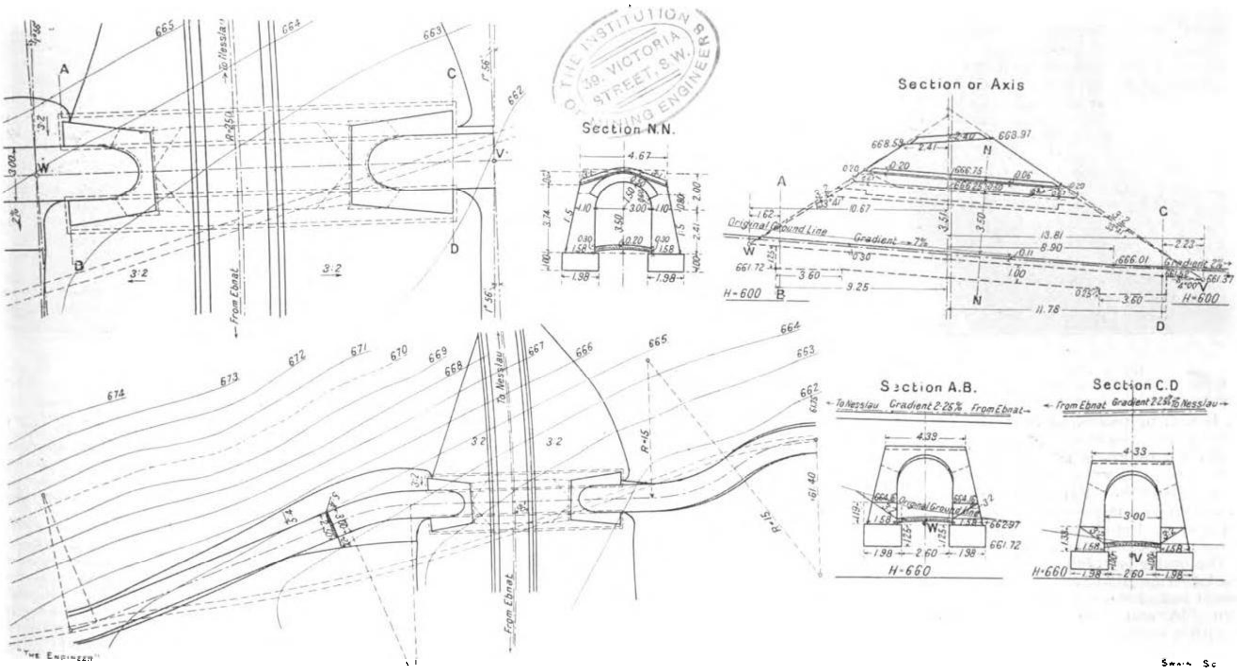


Fig. 53—BRIDGE AT Km. 1.78

	Francs	cent.
Excavation of foundations, 173 cu. m. at 2·28f. ...	394	44
Foundation concrete in hydr. lime 1 : 2 : 5, 108·5 cu. m. at 18·24f....	1979	04
Filling concrete in Portland cement 1 : 5 : 10, 9·5 cu. m. at 20·52f.	194	91
Concrete* in Portland cement 1 : 4 : 8, 146·5 cu m. at 25·08f.	3674	22
Vault concrete in Portland cement 1 : 3 : 6, 34·9 cu. m. at 33·04f.	1153	10
Vault coating, 51·7 sq. m. at 2·85f....	147	35
Extra for staging	285	00
Total	7828	09

* The contractor actually preferred to employ rubble masonry.

As an instance of how cautiously the carrying capacity of ground, if of clay or mixed with clay, has to be dealt with, the following experience may be cited:—The turntable at the Nesslau Station was designed with a pivot foundation 2 m. × 2 m. The ground consisted of very sandy clay with a little admixture of coarse gravel. The pressure, being about 2.5 kilos. per square centimetre, was considered not to be excessive, but when the turntable came to be tried the foundation block was forced down at a rapid rate. The pivot, being adjustable in height, was then lifted, but the block went further down still, and the limit of regulation was reached. Consequently, the foundation had to be widened, which was done by putting in crossways two pairs of rails let into the sides of the block, and concreting all around, thus making a bearing area of 14 square metres instead of the 4 square metres. This reduced the pressure on the ground to less than 1 kilo. per square centimetre. At the same time the turntable pit was paved with a layer of concrete. Altogether the pivot block had gone down more than 10 cm. At first it was thought that the movement would soon cease after a certain compression of the ground, but there was no sign of its ceasing, and it went on in an almost incomprehensible way. Looking into the details of the matter, it was found that it had been raining very hard for three months previously, and the drainage of the turntable pit had been neglected,

* No. VII. appeared September 18th.

so that the water had collected in the pit, and as it could not get away by reason of the side walls, it had waterlogged the ground, and decreased its carrying capacity.

To try the carrying capacity of the ground, a hole 1 m. deep was dug in the pit. An iron bar with a diameter of 24 mm. and weighing 8 kilos. (17.63 lb.) went down 8 mm. when the weight acting was 1.8 kilo. per square centimetre, and 130 mm. when the weight applied represented 6.2 kilos. per square centimetre. After this a similar piece of ground outside the railway embankment, where the rainwater had had no special chance of gathering, was tried in the same way, with the result that the bar went down 2½ mm. when 2.4 kilos. per square centimetre were put on, and 75 mm. when 7.2 kilos. per square centimetre were applied; these results clearly showing the special influence of the water in the turntable pit.

The equation for the transition curve is $y = \frac{x^3}{6 \times P}$ $l = \frac{P}{R}$, $h = \frac{s \times v^2}{g \times R}$.

The superelevation begins at the commencement of the transition curve, reaching its full extent at the end of it, and being equally distributed on both rails, the outer rail being lifted and the inner rail lowered, the middle of the track remaining on the line of gradient.

The gauge was widened at the curves to the following extents:—

Curves of R	=	800—900 m.	5 mm.
,, ,,	=	500—700 m.	10 mm.
,, ,,	=	400—475 m.	15 mm.
,, ,,	=	250—375 m.	20 mm.
,, ,,	=	200 m.	25 mm.

The widening had its full value at the commencement or end of the circular curve, being brought

ings, is 155 kilos. The rails were fastened to the sleepers in the usual way except that spring washers were not used. Moreover, special spring-plate washers were employed at the fish-plates—see Fig. 55. These spring plates seem to answer well. Iron sleepers have their advantages, but in most cases they are not so cheap as creosoted pine sleepers, and the expense of maintaining the permanent way is greater when they are used, especially at the commencement, when the ballast bed has not had time to settle. They are also much more easily damaged in cases of derailments.

Owing to certain difficulties in the execution of the work, the ballast applied was of a class rather different from what it ought to have been according to the specification. Puddingstone of very varied size was to a great extent used, and this kind of irregular ballast does not, of course, adapt itself well to the sharp-edged steel sleepers, which easily become

Fig. 54—KUMMENAU STATION

Now, it will, of course, be found that the greater the carrying area the more pressure the ground will stand, and the results of trials, which as a rule are made with small carrying areas, may be taken as safe data to work to. It is astonishing how well bad ground can stand a fairly strong loading.

Quite close to the station of Nesslau a mountain rivulet is crossed with an arched bridge of 15 m. span. The bridge is 9.7 m. broad, as it has to carry two tracks. One abutment was founded on sandy clayish soil just of about the same kind as that below the turntable, and very wet. This material was loaded with a pressure of 2.5 kilos. per square centimetre, and the foundation did not show any sign of yielding, whereas the ground in the case of the turntable would not stand the same pressure.

As showing the type of station employed on the line, we may refer to Fig. 54, which shows that at Krummenau.

PERMANENT WAY.

Transition curves were used as usual. The maximum velocity was fixed at 50 kiloms. an hour.

With R = the radius of the circular curve,

l = the length of the transition curve in metres,

s = the distance between centres of rails = 1.50 m.

v = the velocity = 13.89 m. per second,

h = the superelevation of the outer rail,

P = a constant, being:—

For R = 200 to 450 m.,		9000
,, R = 500,	... ...	10,000
,, R = 600,	... ...	12,000
,, R = 5000,	... ...	100,000

down to normal gauge in steps of 5 mm. per rail length. Thus, if 20 mm. widening be necessary, the widening is distributed on four rail lengths.

In setting out this railway it was in places found difficult to get in straights between the transition

unsettled on their bed. The writer has seen loose rock, only broken up to a small extent, affording an extremely rough large-sized ballast, but answering very well with wooden sleepers, which, of course, are much more easily kept stable than steel sleepers,

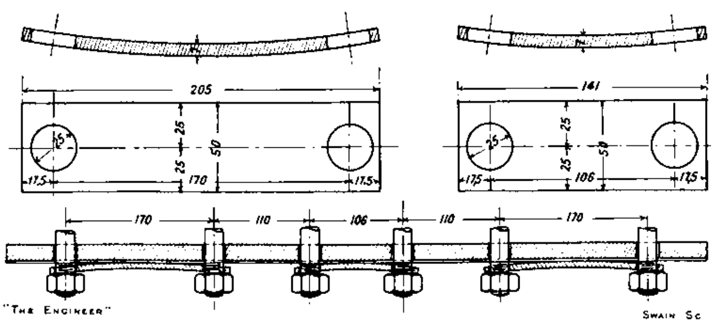


Fig. 55—SPRING PLATE WASHERS

curves of the reversed curves, the shortest straight applied being 8 m. long.

The permanent way is laid with steel sleepers. The rails weigh 36 kilos. a metre and the sleepers 61.6 kilos. each. The rails are 12 m. long and have for each rail length fourteen sleepers on straight lengths or curves of more than 400 m. radius, and sixteen sleepers on curves of less than 400 m. radius. The total weight of a metre of track, including fasten-

and if English engineers and railways prefer wooden sleepers, the writer thinks that they are quite right.

TESTS OF MATERIALS.

The mortar used was either so-called hydraulic lime or Portland cement. Hydraulic lime cannot really be called hydraulic, as its hardening is very dependent on the degree of moisture in the air. Under water it does not harden at all, and if the temperature be low, yet above freezing point, and the air damp it does not harden at all. Then when dry, warm weather comes it may harden even after having remained soft all through a winter. This is what happens as a rule, but there are exceptions, the mortar sometimes acting better and sometimes worse. Now it is clear that it may easily happen that mortar may be required to set hard and give strength very shortly after it has been applied. For instance, all retaining walls which are seriously stressed, as a rule, receive this stressing at an early date after their construction. In such cases it is much better to employ Portland cement. The difference in cost is only small, if there be any difference at all, as we can use a weaker mixture than with hydraulic lime, and still be certain of a much greater resisting capacity and a reliable mortar.

Mortar made of 1 part Portland cement to 4 parts of sand will for ordinary work answer exceedingly well, and even a mixture of 1 cement to 5 sand, if the mixing be done well, will give good results, and 1 cement to 5 sand is not more expensive than 1 lime to 2½ sand. From time to time samples of cement were taken for testing purposes, all the testing being carried out at the official Federal laboratory at Zurich. Samples of concrete were also taken and made into cubes so that the ultimate strength of this material might be tested. In all cases concrete samples were chosen from mixtures, where either the sand was dirty or not at all of a first-rate character, or, for instance, where concrete was mixed with salt to prevent it freezing, so as to get at the strength of the materials under unfavourable circumstances, which easily occur. The samples were taken without warning to the contractor in order to detect any unreliable mixing. The results obtained were, under the circumstances not at all bad, this being mainly due to the good quality of cement used.

COMPETITION WITH GERMANY AND AUSTRIA.

Continuing our summary of the reports recently issued by the Commercial Intelligence Branch of the Board of Trade, we take up one dealing with

Iron and Steel Wire.

The wire here dealt with is of many kinds, including rolled, drawn, galvanised, fencing, barbed, and uninsulated electric wire. We feel by no means certain that the figures for the three countries are strictly comparable, but, quoting the report, we find that the German exports for one year are valued at £3,176,000, Austria's at £51,300, and our own at £1,058,100.* The United Kingdom is by far Germany's best market for this class of trade, our imports being valued at £643,000. More than half this figure is accounted for by our imports of rolled wire. To Japan, Germany sends wire to the value of £275,000, of which sum 87 per cent. represents galvanised wire. Argentina takes £269,000 worth of German wire, 90 per cent. of it being galvanised. Australia and New Zealand also provide a good market, their imports of German wire being valued at £188,000, two-thirds of which stand for galvanised wire. In comparison with these figures Great Britain's export trade is unsatisfactory. To Australia and New Zealand we send wire to the same value as Germany. Our exports to Japan are not 6 per cent., and our exports to Argentina are barely 32 per cent. of Germany's. Germany also surpasses us in British India and Malacca, Denmark, Roumania, Switzerland, Portugal, Norway, Brazil, and Uruguay in each case by a very large margin. In South Africa, while the comparative figures show an advantage to us, it appears that last year Germany very considerably extended her trade, particularly in fencing wire, the market for which is very brisk and growing in magnitude. American manufacturers, however, surpass both German and British in supplying South Africa's demand for fencing wire. Turning to Australia, we find a probable explanation of Germany's success in the fact that the average value of German wire—excluding barbed wire—was about 10s. per cwt., while British wire was 3s. dearer. The notes on certain specified markets given in this report are particularly worthy of attention.

Iron or Steel Screws, Nails, Bolts, and Nuts.

According to this report, there is approximately an equality in the total value of Germany's and Great Britain's exports of the goods specified, the German figure being £1,241,150 and the British £1,201,400. The Austrian exports are valued at but £86,200. It may be noted that the German total includes a sum of over half a million, representing the country's exports of wire tacks, whereas there is no corresponding heading in the British total. There are further indications that the figures quoted are not strictly comparable. It appears, however, that the Australian, Indian, and South African markets are clearly in our hands, and that we hold more than half the trade in Egypt, China, Brazil, Argentina, Chile, and Cuba. In all the important European countries, in the Straits Settlements, Dutch East Indies, and Japan, German manufacturers have the upper hand. With Russia Germany does over four times as much trade as we do. Holland is returned as being Germany's best customer, although the persistence with which the Netherlands appear in this capacity in these reports makes us doubt whether or no Germany's exports through Holland are classified both as to Holland and to their final destination. The figure given for the Dutch trade is £98,200. Our exports to the country are valued at £24,600. Germany conducts a very large trade in wire nails with Japan, and one in screws, bolts, and rivets with Italy.

Anchors, Grapnels, and Chains.

British anchors and grapnels seem to hold almost undisputed favour, the exports being valued at £240,400, as compared with Germany's figure of £22,900. As for chains, the figure given for this country's export trade is £446,800 and for Germany's £142,800. Austria exports no anchors and but £11,910 worth of chains. The best opening for British chain makers would appear to be in Russia, to which country Germany exports goods to the value of £10,400.

Rail Locomotives.

In our issue of August 28th we published an article dealing with the German locomotive trade. The report now before us forms an interesting corollary to that article. We may say at once that the Austrian exports of locomotives are negligible. The German export figures are given for the years 1912 and 1913 and for the first six months of 1914. In 1912 Germany exported locomotives to the value of £1,857,500, and in 1913 to the value of £2,712,100. British exports were valued at £2,137,200 and £2,781,911. Thus both countries increased their exports, but Germany much more so than Britain. During the first six months of 1914 Germany's exports were valued at £809,950, as compared with £1,183,350 in the first six months of 1913. The German figures are set forth under four headings, namely, (1) tender locomotives weighing 10 tons or less, (2) tender locomotives weighing over 10 tons, (3) locomotives without tenders, and (4) locomotive tenders. It is perhaps significant that the drop in the figures for the first six months of 1914 is very largely accounted for by a decrease of 97 locomotives in the second class. It may also be noted that the engines of this class actually exported had an average weight of only 23 tons, whereas for the first six months of 1913 the average weight was 36 tons; for the whole of 1913, 38 tons; and for the whole of 1912, 35 tons. Comparing the German export trade of 1912 with the British of 1913, we find that this country holds an overwhelmingly strong position in India and Argentina, and has done well in Holland. Germany is predominant in France, Spain, Italy, the Balkans, Russia, Dutch East Indies, China, Japan, Brazil, and Chile. In Scandinavia, Denmark, Belgium, Tunis, Morocco, Egypt, Korea, Japan, and Cuba her position is also better than ours. The notes on certain of the markets should be of great interest to British locomotive builders. We may briefly summarise a few of the more important points:—

British South Africa.—What ground we have lost here seems to have been taken from us by the underquoting of the Germans. As an example, the case of ten locomotives ordered ultimately from Germany at a price of £5160 each may be quoted. The lowest British tender amounted to £6515 f.o.b. Glasgow and the highest to £7190 f.o.b. Birkenhead. By placing the order with the Germans the Government Railways of South Africa saved a total sum of £13,550. Late delivery seems also to be a point against our manufacturers, although it is not specifically alleged against the locomotive builders.

Egypt.—During the five years preceding 1912, Egypt imported 113 locomotives, 48 being from Britain and 53 from Germany.

Spain.—Locomotives weighing over 35 tons are bought, it seems, principally from Germany, Britain supplying the lighter engines.

Roumania.—This country seems worthy of more attention from our builders than it appears to obtain. For a recent contract twenty-eight manufacturers tendered, only one of whom was British. The State Railways have recently obtained a new credit of £640,000 for their various requirements.

Dutch East Indies.—In the locomotive, as in other industries, Germany recognises the importance of the Dutch East Indian market. On the Java State Railways 65 per cent. of the locomotives are of German origin and only 23 per cent. of British. On the East Coast of Sumatra Railway all the 65 engines in use are German.

Costa Rica.—Two tank and two tender locomotives recently acquired from Germany are said to be giving entire satisfaction. The costs were as follows:—Tank engine, 33 tons, £2125; tank engine, 45 tons, £2430; tender engines, 50 tons, £2350 each. The engines were paid for in twelve monthly instalments.

Argentina.—The following is quoted from an American consular report:—"In 1910-11 the Government purchased 150 locomotives, of which 90 were German and the balance English. The English locomotives were made by a concern that underbid the Germans, but without profit, as the order was taken simply to keep the factory going. It is expected that the Government will again call for bids in 1914 on another order for locomotives." It might be inferred from this that our trade with the Argentine is not very prosperous. Nevertheless, it is stated earlier in the report that in 1912 German locomotives were exported to the country to the value of but £76,600, while our manufacturers in 1913 executed orders to the total value of £695,600.

China.—The locomotive industry seems here to have good prospects, but it is stated that it is impossible for firms to compete for orders without having financial interest in the railway undertakings.

Japan.—We seem to be losing ground in this country to both Germany and America. In 1911, 60 locomotives were ordered, 24 from the States, 24 from Germany, and 12 from Britain. In 1912, 54 goods locomotives of the Mallet type were ordered, 42 from the States and 12 from Germany. The engines were of the 0 6-6 0 type, with tenders, and the prices quoted were as follows:—

	£
Henschel und Sohn	3641
Baldwin Locomotive Works	4062
American Locomotive Company	3769

Cycles and Parts thereof.

Great Britain leads easily in this field, the total value of her exports being £2,087,200 to Germany's £1,335,500 and Austria's £4700. We lead both as regards cycles and cycle parts. Thus of complete cycles we exported in 1913 goods to the value of £609,500, of rubber tires (separately) £411,500, and parts of metal, leather, &c., £1,066,200. The corresponding German figures for 1912 were £347,200, £238,800, and £749,500 respectively. Germany does a very good trade in this country in cycle parts (£64,250), and in tires (£43,200). Complete cycles, however, represented only £50 in £1912. Her best customer for complete cycles is Holland (!), with Russia second. Denmark is her best market for cycle parts, with Holland just a shade behind. Holland is first as regards tires. In many parts of the world American competition is more serious to us than German.

Motor Cycles.

Here, again, Britain leads easily, the exports of the three countries being:—Britain, £733,300; Germany, £124,600; Austria, £5600. Other causes than lowness in price have clearly at times an influence on a country's export trade, in spite of what we are so frequently told is Germany's secret of success. Thus, in the motor cycle trade, the dearer the machines the larger the exports seems to be the rule. The average price of the Austrian motor cycles covered by the returns works out at £36, of the German machines £40, and of the British actually £50. The German trade with Great Britain is small, being valued at only £8050. Germany leads, however, in Scandinavia, Denmark, Portugal, Roumania, and Russia.

Motor Cars and Parts thereof.

In the motor car trade, according to this report, we take second place to Germany. This is probably explained by the fact that the British returns exclude motor tires sold separately, while the German returns presumably include tires under the heading of "other parts." The difference in the manner of presenting the returns is too great to permit of any satisfactory comparison being made. We will therefore quote the statistics in full:—

Exports from Germany (1912).

	No. of cars, &c.	£
Passenger cars (including chassis)	7953	3,252,800
Commercial cars (including chassis)	695	388,650
Motor car parts—		
Engines	2086	68,950
Other	—	402,950
Total	—	4,113,350

Exports from Austria-Hungary (1913).

	No. of cars, &c.	£
Passenger cars (including chassis)	378	245,100
Commercial cars (including chassis)	23	21,900
Engines for motor cars	—	20,750
Total	—	288,050

Exports from United Kingdom (1913).

	No. of cars, &c.	£
Motor cars (complete)	7592	2,396,400
Motor chassis	1234	465,300
Parts of motor cars (except tires)	—	788,200
Total	—	3,649,900

It will be seen from these figures that the average price of a German passenger motor car is about £410 and of a German commercial vehicle £560. The corresponding Austrian figures are £650 and £950. The figures in the table, however, include an unstated number of motor chassis, so that their average prices are only broadly correct. The average price of a British car, passenger or commercial, works out at £315, while the average price of a British chassis is £380.† In view of the differences existing in the manner of making the returns, it is unsatisfactory to compare the positions of the three countries in the markets of the world. It appears, however, that Germany's principal market is Russia, followed by Brazil, the United Kingdom, and Argentina. Austria's principal market, and the only one in which apparently she is our serious competitor, is Russia. The whole of this report—it runs to 38 pages—should be carefully studied by our motor car manufacturers, as should two special reports drawn up by the United States Consular officers, copies of which may be inspected at the Commercial Intelligence Branch's Office, 73, Basinghall-street, E.C.

* The figures quoted here and throughout this article for the German trade relate to the year 1912, while those for Austria and Great Britain relate to 1913.

† That the average price of a British chassis comes out higher than the average price of a British car complete may be explained on the supposition that our export trade is conducted principally in the cheaper qualities of completed cars and the dearer qualities of chassis.

The Junior Institution of Engineers.—The Council of the above Institution has elected the Marquess of Graham as its President for the year 1914-15, in succession to Sir Boverton Redwood, Bart. The Vickers Prize, consisting of a gold medal and premium of instruments or books, has been awarded to Mr. James Richardson, Assoc. M. Inst. C.E., for his paper on "High-power Diesel Engines: Their Development for Marine Service." Mr. Richardson has also been fortunate enough to secure the Institution Medal for the same paper. The other awards of this Institution have not yet been announced.

Institute of Commerce.—We are asked to state that in connection with the proposal to form an Institute of Commerce representing all the specialised sections of British trade, a meeting will be held at the Savoy Hotel, in London, on Thursday, October 8th, at 2.30 p.m., to consider questions in connection with the movement. We are informed that invitations to attend the meeting are being issued to the chairmen, directors, and secretaries of the various British trade associations. Applications for tickets from trade organisations for their delegates should be addressed to Mr. J. Taylor Peddie, Exhibition Building, Aldwych Site, Strand, W.C.

Institute of Marine Engineers. At the Institute of Marine Engineers, on Monday, September 21st, a demonstration was given of the Amalgaline system of metal jointing by Mr. Harden, the inventor of the process. Before giving the demonstration Mr. Harden read a short paper in which he stated that the process effected a complete fusion between the surfaces joined. In marine work the principal uses to which the system is applied are the flanging of pipes, the seaming of lead used in refrigerating chambers and general sanitary work. The system of flanging was first adopted by Messrs. Doxford, of Sunderland, and the process is now in general use among shipbuilders on the Clyde, the Tyne, the Tees, and the Wear. The system is not confined to the use of small pipes, but is used in an ordinary way on pipes varying in bore from 3in. to 9in. Like lead burning, it is an autogenous process, but instead of using an intense local heat the fusion is effected by the action of the Amalgaline on the surfaces it is in contact with, forming an amalgamation between the lead of the flange and the lead pipe. The material used is in the form of a metallic ribbon .002in. in thickness, practically a pure metal, which, when placed between the surfaces of lead and subjected to heat, fuses at a temperature of 160 deg.—lower than the actual fusing point of lead—and in fusing it causes the lead surfaces to run together at a lower melting point than that of the body of the lead. This running together has an autogenous effect, and by intermolecular absorption the minute particles of Amalgaline are dissipated into the body of the lead, which, by reason of the absorption, becomes stronger at the junction than elsewhere. Demonstrations of flanging and various other uses of the process were given.