(*Paper No. 2799.*)

(*Abridged.*)

"Railway Work in Argentina."

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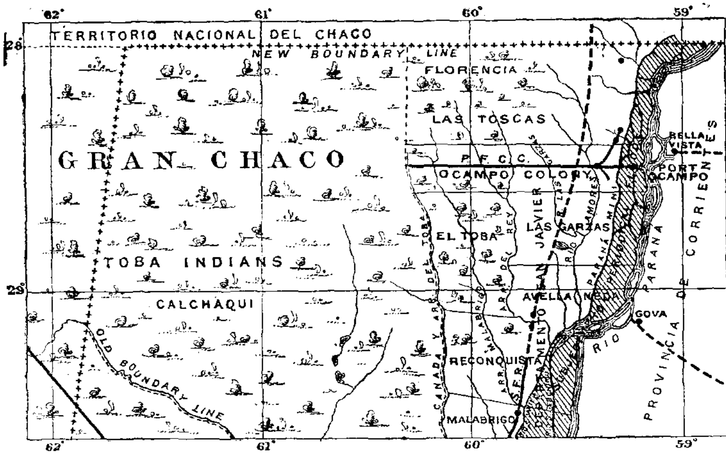
In January, 1885, the Author became engaged for a colonisation company in working and developing the Gran Chaco (now Province of Santa Fé), in the Argentine Republic, *Fig. 1.* It covers an area of 42 square leagues, is generally flat or slightly

Fig. 1.



undulated, and consists of large forests of hardwood and clear land. The Chaco is crossed by several rivers and lagoons running south-east and emptying into the River Paraná, which is subject to periodical floods, during which an area of from 3 to 4 square leagues is covered with water to a depth of 4 to 5 metres. This liability to floods constitutes the principal difficulty which has to be contended against in railway construction;

embankments have to be well guarded by fascine-work and long-rooted plants; and a number of bridges and culverts of ample waterway are necessary. The first operation undertaken was a survey of the colony. As the depth of water in the rivers could not be depended upon for navigation all the year round, and as they are very tortuous and rapid, and as the cost of canalising would have been great, surveys were made and levels were taken for a metre-gauge railway 60 kilometres in length, running from the River Paraná westwards through the colony. The construction of this railway was commenced in July, 1885, and a jetty, derrick, stores, and custom- and agents' house were erected at Port Ocampo, on the River Paraná. The earthwork was commenced shortly afterwards. On the completion of the jetty, rail-laying was begun. Rough log trestle-bridges were employed for crossing rivers, and when the rails were laid as far as the 33rd kilometre, the construction of a saw-mill and tannery was commenced, and the line was then carried on nearly to the western boundary. Obrajes (wood-cutting encampments) were then opened, and wood-cutting gangs commenced to fell trees to the right and left of the line. The timber was roughly adzed, loaded, and sent to the saw-mill, where the wood was prepared for bridges, buildings and sleepers —the refuse being used as firewood for the locomotives and saw-mill engines and the sawdust for the tannery. In the meantime, two locomotives, wheels, axles and under-frames for fifty wagons, as well as brick-making machinery, arrived from Europe and Buenos Ayres. Six months after work was commenced at the saw-mill and tannery (large contracts having been made for supplying sleepers and logs to various railways in course of construction in the Republic), it was decided to build a sugar-mill and distillery to deal with the products of the sugar-cane plantations of this and adjacent colonies. Accordingly the construction of branch lines, sidings, and various buildings and sheds was commenced; and within four months the masonry work of the mills was sufficiently advanced to receive machinery and boilers, which arrived from France, Germany and Switzerland.

The length of the railway as constructed is, including branch lines, $86\frac{1}{2}$ kilometres. The gauge is 1 metre; the rails are of steel, of the Vignoles type, weighing 16 kilograms per metre ($32\frac{1}{4}$ lbs. per yard); they are spiked to hardwood sleepers 2·00 metres by 0·20 metre by 0·10 metre, spaced 0·80 metre from centre to centre, and laid in 0·25 metre of gravel and earth ballast, or broken "tosca" (a kind of soft limestone) found in some of the cuttings. The following Table contains some additional particulars of the line:—

Maximum gradient	1 in 80.
Minimum radius of curves	120 metres.
Percentage of straight to curved line . . .	89 per cent. (straight).
Percentage of gradients to level line . . .	32 per cent. (gradient).
Formation level	3·50 metres wide.
Slope of embankments	2½ and 3 to 1.
Slope of cuttings	1½ and 2 to 1.

Four and a half kilometres of embankments between the River Paraná and Port San Vincent, a total distance of 14 kilometres, were protected by fascines formed of "tacuaras" (a large bamboo), branches and twigs; and the first 14 kilometres of slopes of embankments were planted with lagoon grass and shrubs which, being long-rooted, protected the slopes against floods. About 10 kilometres of drains or ditches were cut, and two dams and weirs were constructed to divert some of the adjacent lagoons and streams.

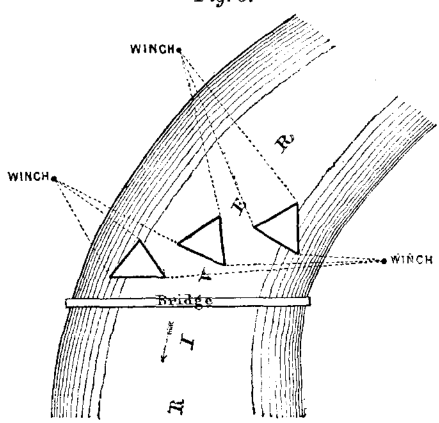
Nine bridges were built on the line, as follows:—

Description.	Span.	Name.
	Metres.	
Wooden bridge	40·00	..
Iron girders on wood piling	101·60	Ñiatui.
Wooden bridge	50·00	..
Iron girders on wood piling (Figs. 2, 3 and 4, Plate 8)	118·40	Pindo-tý.
Steel girders on screw piling	118·20	Paraná-Miní.
Road and railway bridge of wood	54·00	Rio Amores.
Wooden bridge	40·00	Rio Garzas.
,, ,, ...	62·00	Rio del Rey.
,, ,, ...	84·00	Rio Malabrigo.

In addition, sixty-six culverts, varying between 2·50 metres and 10·00 metres in span, were constructed of hardwood.

The reason for adopting the various types of bridges was that the Company considered it more convenient and economical to make use of the plant, materials and workshops at their disposal in Buenos Ayres and the colony. The Author had, therefore, to base his calculations, designs and estimates on the class and quantity of the material at his disposal; and as some of the iron and steel work was buckled, trouble was experienced at times, both in erection and in working it, owing to the scarcity of skilled labour. A wooden bridge over the Paraná-Miní having been carried away by "camallotes" (floating masses of drift, tree-trunks and long roots or weeds) owing to a great flood, a new bridge having greater spans was erected. This consisted of steel girders resting on screw piles composed of hydraulic piping with cast-iron screws keyed and cottered on them. Hardwood piles were abandoned over this river, as they could not be driven more than $3\frac{1}{2}$ metres through the bed without shattering, notwithstanding the use of a heavy monkey weighing $1\frac{1}{2}$ ton, a low drop and iron caps and shoes. Extra spans were given in all bridges and culverts to increase the waterway above flood-level; and, on account of the large masses of "camallotes" carried down by floods, the Author devised an apparatus, *Fig. 5*, for loosening them before they pass through the bridges, where larger spans were not adopted for economy's sake. This consisted of three sets of floating "spreaders," formed of three long balks, their ends being linked together with chains and worked from the shore by

Fig. 5.



winches. This arrangement made it possible to vary the positions of the spreaders, and the "camallotes" could thus be readily dealt with. Large tree-trunks were shored and cut up, but this operation was only necessary during floods.

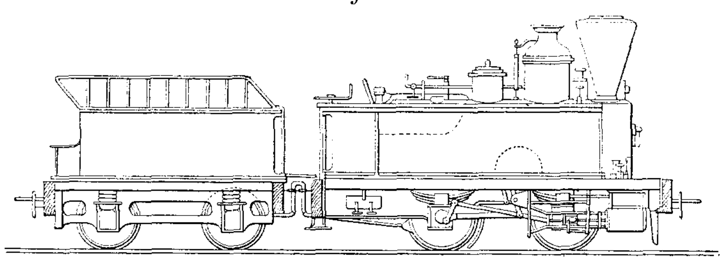
The erection of the bridges was carried out as follows: The girders were erected or riveted in the workshops and were taken down on two bogie trucks supplied with swivelling bolsters and side-struts, being launched and placed in position by barges or pontoons. The cross girders and gusset-plates were then bolted up and the barges removed. The riveting was afterwards completed, and the way-beams and road laid. The piling of bridges and culverts was accomplished by means of ordinary pile-drivers. The screw-piles were driven by two steam-winches, one on each side of the river, a pair of piles being driven together and held in position by a large hardwood frame weighted with rails. The centering and plumbing was done by means of chocks and wedges. When a set (four piles) was driven and the lower bracing had been fixed, the frame was tilted over and floated away to the position of the next set of piles. When slipping or any difficulty occurred in driving or screwing down piles, the capstan-head was weighted. If this did not suffice, a "trepan" was employed, and water was forced by a pump worked from a portable boiler through a 2-inch diameter hose with an iron nozzle through the inside of the pile. This arrangement facilitated the work considerably when going through or into red clay. The average time required to drive a set of piles was eight days, and this could not be reduced on account of the back-lash of the ropes. All girders have cast-iron bed- and bearing-plates with oval holes for play, and are united by cross bracing and horizontal wind-ties, the gusset-plates giving sufficient lateral stiffness. All holes were drilled and the bolts for screw-piling turned to fit, and all girders were tested before leaving the workshops and also when in position.

Narrow-gauge lines were commonly used in plantations, woods, mills and brickworks, as feeders to the main line, and for local or internal transport of materials. The total length laid was 64 kilometres, the gauge being 0·50 metre. Iron and steel Vignoles rails were employed, weighing 7 kilograms per metre (14 lbs. per yard) and spiked to hardwood sleepers, 1·00 metre by 0·15 metre by 0·10 metre. The sharpest curves were of 10 metres radius; and the maximum gradient was 1 in 60.

At Porto Ocampo a large building forming the station and goods-shed was erected, as also a water-tank and fuel platform, all being constructed of hardwood. On account of the soft nature of the ground and the periodical floods, these buildings were built on trussed frames 1·50 metre above the ground-level, resting on 12-inch balks and skids of hardwood, which thus allowed of their removal. A triangle and sidings were laid for turning locomotives and for shunting purposes, also a slip for repairing barges and tug-boats. A small wooden house was built close to each of the larger bridges, to accommodate permanent-way gangs, one of the men in the gang doing duty as bridge guard. At Port San Vincent a tannery, small station and shed and water-tank were built. Four kilometres from that point, brick and tile works with drying-sheds and kilns were erected. In the colony were constructed a sugar-mill, distillery, workshops, running shed, station and goods-shed, and carriage and wagon sheds; also offices and dwelling-houses for the engineer, secretary, accountant and a portion of the staff, and cottages for workmen. In addition there were erected a large municipal building which served for the court, police barracks and prison; a small church, schools and priests' dwelling-house combined; also a market and large stores. The remainder of the houses in the colony were built by the colonists, the Company supplying material at cost price. All the buildings were of brick with tiled roofs, except the sugar- and saw-mills, distillery and workshops, which were of corrugated galvanized iron.

A telegraph was constructed along the main railway consisting of two wires suspended by porcelain insulators bolted to posts of quebracho or palm, and was served by six Morse telegraph instruments and six telephones (Van Rhysselberghe system) for the

Fig 6.



Scale $\frac{1}{60}$.

Company's and for private use between the adjacent colonies and stations, port, mills, brickworks, etc.

The Author found difficulties in transmitting telephonic signals through a telegraph wire running through or parallel to other wires which were being used for telegraphic purposes, induction currents being produced in the telephone wires, which greatly interfered with the distinctness of the sounds, no extra return wire being used. Sounds were more distinguishable when lines consisted of two on the three wires than of one only. As a rule the annunciator disks fell, and the armature lever commenced ticking the Morse signals. The generator on the telephone was a compound magnet with a Siemens armature spring-connection and ringer.

Rolling-Stock.—Four 6-wheel coupled, four 4-wheel coupled, and five small Decauville locomotives, *Fig. 6*, were employed, all with outside cylinders, and weighing, when loaded, 20 tons, 12 tons, and 4 tons respectively, of English, German, and French make.

The fuel used was quebracho wood, having a calorific power about 50 per cent. that of coal.

LOCOMOTIVE DETAILS.

	6-wheel Coupled.	4-wheel Coupled.	Decauville.
Diameter of cylinder . .	13 inches	10 inches	5 inches
Length of stroke. . . .	20 ,,	16 ,,	7 ,,
Wheel-base	3·20 metres	1·60 metre	1·00 metre
Diameter of wheels . . .	36 inches	30 inches	18 inches
Length over bufferbeam .	6·20 metres	4·80 metres	3·00 metres
Length of boiler	3·60 ,,	2·80 ,,	1·60 ,,
Diameter of boiler . . .	1·10 ,,	0·80 ,,	0·54 ,,
Heating surface of fire-box.	48 square feet	30 square feet	18 square feet
Heating surface of tubes .	320 ,,	190 ,,	88 ,,
Area of fire-grate . . .	15 ,,	10 ,,	6 ,,
Working pressure . . .	120 lbs.	110 lbs.	100 lbs.
Tank capacity (water) . .	800 gallons	500 gallons	500 gallons in tender and engine
Fuel-capacity	40 cubic feet	25 cubic feet	30 cubic feet in tender and engine
Weight of engine loaded .	20 tons	$12\frac{4}{10}$ tons	$4\frac{1}{10}$ tons
Feed	2 injectors and pump	1 injector and pump	1 injector and pump

The wagons were of two types, and consisted of—

50 Bogie truck wagons (Figs. 7, 8 and 9, Plate 8).
40 Two-axled covered wagons.
40 Two-axled low sided wagons.
42 Two-axled flat wagons (Figs. 10 and 11, Plate 8).
6 Brake-vans, two-axled.
6 Goods-vans, bogie.
8 Second-class carriages.
5 First-class carriages.

The platforms and bodies of the rolling-stock, with the exception of the carriages, brakes, and goods-vans, were of native wood, sawn in the colony. The brakes were of the screw-down and chain-and-pawl type; the latter were ultimately changed, as the former were found more reliable. The body of one of the first-class carriages was built in the colonial workshops (Figs. 12 and 13, Plate 8), and fixed on bogie-trucks, the panelling being made of "tatané" and "timbó" wood, which stand the heat well; the framing was of "lapacho," "algarrobo," and "yvirapitá" woods; the seats were of "pindó" cane, and the cushions were covered with leather tanned in the colony. The cost complete was about £216.

Water-Supply.—Sixteen semi-artesian wells were sunk in the colony. The ordinary water-bearing stratum was intersected at about 8 metres depth, and the lower bed at 25 to 30 metres depth (approximately the level of the bed of the River Paraná). The method of sinking and boring generally adopted was to build a brick lining bolted through and upon a strong hardwood ring curb; this was weighted till it sank 5 to 6 metres; then boring was carried down in wrought-iron pipes 6 inches or 8 inches in diameter, screwed to the required depth. The water then rose to within 5 metres of the ground-level. A treble-barrelled pump was fixed and worked by lasso-belting. The majority of the colonists employed wind-mills or leather scoop-bags worked by horses. A cleaning-out valve was fixed in some wells, while filtering-tanks and eucalyptus leaves or sawdust were employed at the saw-mills, as the water was rather hard and brackish.

The sugar-mill was built of brick with a corrugated-iron roof. It was 100 metres long by 50 metres wide, and was divided into two sections, the front one containing the cane and "megass-" carriers, a cane-slicer and motor, a "trapiche" or mill, consisting of three rollers 6 feet by 3 feet diameter, and a 60-HP. motor geared 5 to 1. Defecators, clarifiers, filters, vacuum-pans and pumps, cooling tanks, centrifugal water-extractors, magneto-electric light motor, sugar-grinding and molasses-churning mills were also provided. The two front wings served as offices, laboratory and sugar-store. The other section contained workshops, stores, pumps, filter-presses and motors; also boilers and megass-ovens, tanks and deposits of molasses. Outside and behind the main building were the water-cooling pond, reservoir, deposits for drying megass, chimney-stack, fire-wood deposits and water-cooling tower.

The saw-mill consisted of a large open shed 50 metres long by 15 metres wide, with engine- and boiler-houses at each end; to avoid long shafting, and enable one-half or all the saws to be worked simultaneously if necessary, a coupling was fixed on the main shaft. The machinery and benches rested on strong timber frames laid on brick foundations bolted and braced together to withstand the vibration when the saws were working, leaving a space between the floor and the ground line of 1·60 metre to enable men to oil, repair or examine the machinery. All the belting used was made from leather tanned in the colony, and run with the rough side out at the commencement. The Author prefers English saws and benches on account of their superior temper, simplicity and durability; and thinks the most useful and economical type is the endless-band saw. The main point to be watched is the tension and brazing; the former is easily controlled by carefully counter-weighting the levers, and the latter by a skilled brazier.

LIST OF TIMBERS USED IN THE COLONY.

Names of Timber.[1]	Specific Gravity.	Uses.
Algarrobo	0·700	General carpenter's work.
Quebracho colorado (very hard and heavy).	1·234	Bridge piling and submarine work; the sawdust gives first-class tanning.
Quebracho blanco (hard and heavy)	1·120	
Ururday (hard and heavy)	1·120	
Lapacho	1·000	Purlins, rafters and roof-ties, boat- or barge-building.
Guayacan	1·120	Wheels, spokes, shafts and pulley-blocks.
Tatané	0·600	Cabinet-making.
Timbó	0·640	,, ,, and canoe-building.
Yvirapitá	0·870	Wheel-hubs, doors, furniture, and ship-building.
Palo lanca (lance-wood)	0·800	Wheel-spokes and shafts.
Yviraró	..	Similar uses to Yvirapitâ.
Espinillo	0·640	Fencing-posts.
Guayibi	0·780	Furniture, carts, shafting, boat-building and pick handles.
Jacaranda (rosewood)	..	Furniture.

These woods are found in large quantities, and vary in length between 2 and 12 metres, and in diameter between 1 and 3 feet; their resistance to breaking, or modulus of rupture (from tests made in Buenos Ayres) ranged from 7,000 lbs. to 27,000 lbs. per square inch. The harder and heavier woods last longer if immersed in water than if exposed to the atmosphere, when they are liable to crack longitudinally.

The Paper is accompanied by a map and twenty-four drawings, from a selection of which Plate 8 and the *Figs.* in the text have been prepared.

[1] Specimens of the timbers have been presented by the Author to the Institution.

[APPENDIX.

APPENDIX.

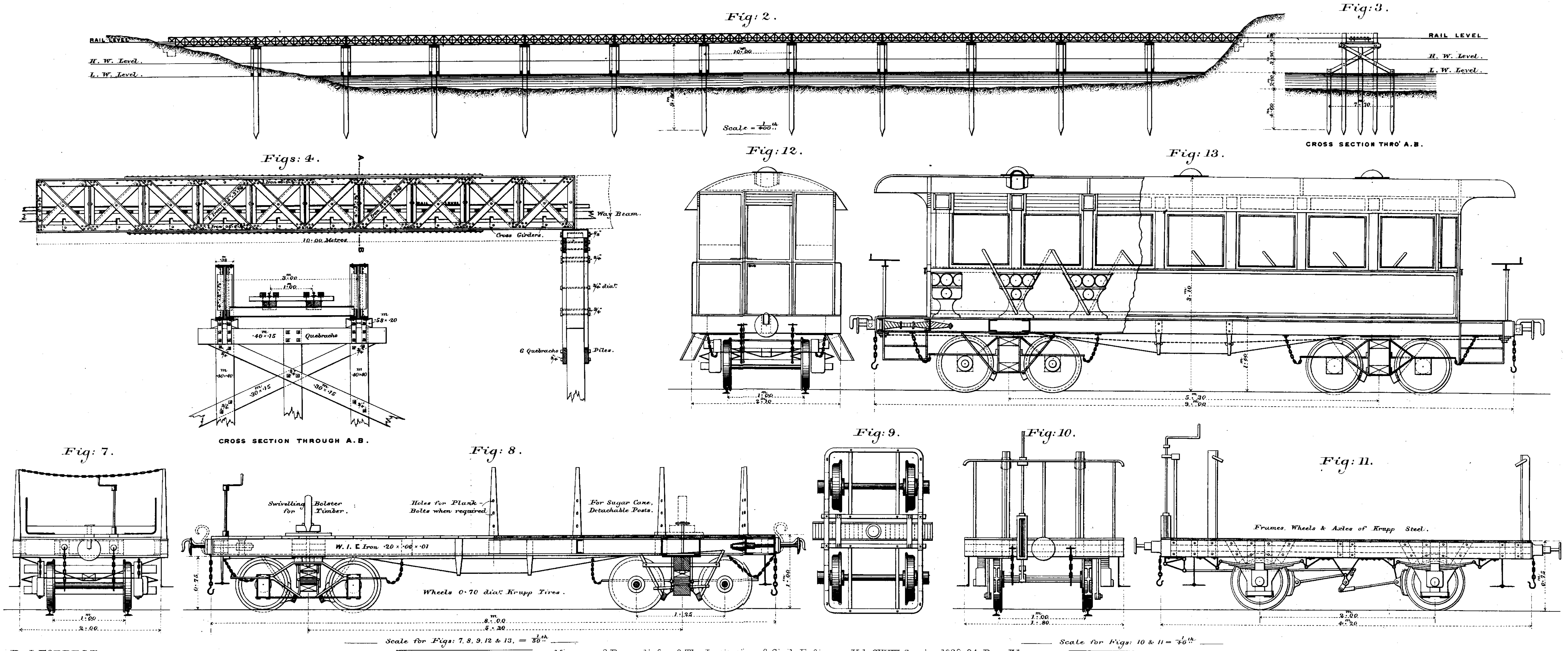
PRICES OF LABOUR AND MATERIALS.

	$	$	
Earthworks in embankments	0·30 to	0·50	per cubic metre.
,, in cuttings	0·60 ,,	1·00	,, ,,
Ballasting	0·30		,, ,,
Ditching	0·40		,, ,,
Fascine work	0·25 ,,	0·30	per square metre.
Rail-laying	250		per kilometre.
Boxing-up and levelling	250		,,
Masonry—			
Brickwork, ordinary, labour and material	12·50		per cubic metre.
,, in hydraulic lime	19 ,,	20	,,
Plastering, ordinary	1		per square metre.
,, semi-hydraulic	1·25		,,
Tiling, including laths	16		,,
Portland cement	40		per 1000 kilograms.
Sand	1		,,
Lime	30		per arroba (11 kilos.).
Bricks, ordinary	6		per 1000.
,, first class and second class	10 and	8	,, respectively.
,, pressed	12		,,
Tiles	25		,,
Timber and wood work—			
In bridges—Labour	30		per cubic metre (erected)
Wood	15		,, ,,

WAGES.

	$	$		
Foremen	150 to	200	per month.	
Mechanics	100 ,,	150	,,	
Blacksmiths	80 ,,	100	,,	
Saw sharpeners and braziers	80 ,,	90	,,	
Carpenters	80 ,,	100	,,	
Masons	60 ,,	80	,,	
Well-sinkers	90 ,,	100	,,	
Firemen	50 ,,	60	,,	
Sawyers	40 ,,	50	,,	
Agricultural labourers	30		,,	with rations.
Wood-cutters and fellers	25 ,,	30	,,	,,
Carters	25		,,	,,

RAILWAY WORK IN ARGENTINA.



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