

The
VIRTUAL MUSEUM
of the
LANCASHIRE & YORKSHIRE RAILWAY

Operational Documents, Reports & Pamphlets

1911

Description of the
LIVERPOOL, SOUTHPORT, TOWN GREEN
& CROSSENS
ELECTRIC SECTION

LYR publication describing the electrification of the routes,
trains, workings and of Formby power station

(26 Pages)



DESCRIPTION
— OF THE —

**LIVERPOOL,
SOUTHPORT,
TOWN GREEN
& CROSSENS**

**ELECTRIC
SECTION.**

LANCASHIRE & YORKSHIRE
RAILWAY.



Description
of the
Liverpool, Southport, Town
Green, and Crossens
Electric Section.



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March, 1911.

DESCRIPTION OF THE LIVERPOOL, SOUTHPORT, TOWN GREEN, & CROSSENS ELECTRIC SECTION.

General Description.

THAT portion of the Lancashire & Yorkshire Railway which has been converted from steam to electric traction is about 37 miles in length and consists of the main line between Liverpool and Southport, an extension in the direction of Preston to a suburb of Southport, called Crossens (see Diagram "A"), and to Town Green Station, near Ormskirk, via Walton Junction and Marsh Lane. There is in addition, a connection with the Liverpool Overhead Line at Seaforth.

Reasons for Electrification.

IN 1903 the traffic between Liverpool and Southport was of such a magnitude that it was imperative either to increase the platform accommodation at the terminal stations, or to adopt some easier method of working the trains in and out of these stations. It was also desirable to provide an accelerated service between Liverpool and the popular residential district that extends northwards from that town towards Southport. As an increase of terminal facilities meant the expenditure of a large sum of money on acquiring expensive land in the towns of Liverpool and Southport, and as a considerably accelerated steam service presented many difficulties, the Directors decided to adopt electric traction.

LANCASHIRE & YORKSHIRE
RAILWAY.

System
Adopted.

THE system decided upon was one that had been well tried elsewhere for heavy tramway and inter-urban services, but had never up till then been tried for heavy trains for main line work.

From the Diagram "B" it will be seen that electricity is generated at 7,500 volts A.C., three-phase, at a point midway between Liverpool and Southport, and delivered by underground and overhead cables to five sub-stations. In the sub-stations it is transformed and then converted by rotary converters to direct current at 620-630 volts, at which pressure it is fed to the trains by means of an insulated rail.

Work of
Converting Line.

THE whole of the work in connection with the Contract for the Liverpool, Southport, and Crossens Line was let to Messrs. Dick, Kerr, & Co., Ltd., of London, Preston, and Kilmarnock, with the exception of the construction of the rolling stock, which was built at the Railway Company's own works at Horwich and Newton Heath.

The work of conversion from steam to electric traction was commenced in April, 1903. The first electric train ran its trials in December, 1903, the line being formally opened for electric traffic in March, 1904, and the full service of electric trains was introduced in October, 1904.

The electric service put into operation in October, 1904, gave a largely increased accommodation, as will be seen from the following table, also Diagram "G."

LIVERPOOL, SOUTHPORT,
TOWN GREEN, & CROSSENS
ELECTRIC SECTION.

TABLE SHOWING COMPARISON BETWEEN STEAM
AND ELECTRIC SERVICE.

Class of Train.	From	To	Distance between Terminal Stations Miles	No. of Stops	Average distance between Stations Miles	STEAM			ELECTRIC		
						No. of Trains daily	Average frequency of service per hour	Schedule speed per hour Miles	No. of Trains daily	Average frequency of service per hour	Schedule speed per hour Miles
Stopping..	Liverpool...	Hall Road...	7 $\frac{1}{8}$	8	.89	38	4	17.0	58	6	25.0
"	Hall Road...	Liverpool ...	7 $\frac{1}{8}$	8	.89	38	4	17.0	56	6	25.0
"	Liverpool ...	Southport...	18 $\frac{1}{2}$	14	1.32	34	2	20.0	50	3	30.0
"	Southport...	Liverpool ...	18 $\frac{1}{2}$	14	1.32	34	2	20.0	50	3	30.0
Express ..	Liverpool ...	Southport...	18 $\frac{1}{2}$	1 stop outside Southport	1.32	(4	3	44.5	10	1	44.5
"	Southport...	Liverpool ...	18 $\frac{1}{2}$	Southport	1.32	(4	3	44.5	12	1	44.5
Stopping..	Liverpool ...	Aintree	5	5	1.0	...	...	...	58	3	23.0
"	Aintree	Liverpool ...	5	5	1.0	...	...	...	58	3	23.0
"	Aintree	Town Green	5 $\frac{1}{4}$	2	2.625	...	...	...	17	1	35.0
"	Town Green	Aintree	5 $\frac{1}{4}$	2	2.625	...	...	...	17	1	35.0

Further
Extensions.

DURING 1905 the standard four-car trains were increased to five-car trains at the rush hours of the day, and a number of additional trains were introduced. In July, 1905, a connection was made with the Liverpool Overhead Railway, and in January, 1906, a through service of trains between Dingle on the Liverpool Overhead Railway, and Southport, was instituted.

In the autumn of 1905 four large battery stations were installed (see Diagram "B," also map in Diagram "A") for the purpose of giving an improved load factor at the Generating Station, an improved and steadier voltage at the trains, an increase in the number of spare engines at the Generating Station, and a standby in case of partial failure of the supply of current.

In 1906 the lines to Aintree via Seaforth and via Kirkdale were electrified, and also a second pair of lines between Sandhills and Seaforth.

To meet these extensions, a combined rotary converter and battery sub-station was constructed at Aintree.

In October, 1909, the electric lines were extended from Aintree to Maghull, and in March, 1911, from Maghull to Town Green, near Ormskirk.

Technical Description
of Generating Station.

FORMBY Power Station (see Diagram "C") is situated about half way between Liverpool and Southport, close to the River Alt, thus ensuring

a cheap and abundant supply of water for condensing purposes. Coal brought from the Collieries about 20 miles away is delivered by gravity from hopper wagons on to a bucket conveyer, by which it is delivered to overhead bunkers. From the bunkers, which hold about 130 tons, the coal is fed into the boilers by mechanical stokers. The bucket conveyer is also used for the disposal of ashes.

The boiler room is 280 feet long, and 56 feet wide, and contains 16 Lancashire boilers; each boiler is 32ft. 6in. long, 8ft. 6in. diameter, grate area 42 square feet and 1,200 square feet heating surface, normal evaporation 12,000 lbs. per hour.

The products of combustion on leaving each boiler pass through a superheater of 35 tubes, of 158 square feet heating surface, and then go to the main flue, 10ft. by 6ft. which runs parallel to and against the wall between the engine room and boiler room. The draught is induced by two fans (114 inches in diameter), one placed at each end of the main flue, each fan having eight radial blades, being driven at a normal speed of 160 revolutions per minute by a compound vertical enclosed engine of 100 I.H.P.

The products of combustion on their way to each fan pass through "Green's" economisers, one being placed at each end of the flue—each economiser consisting of 720 tubes, 9ft long by $3\frac{1}{8}$ in. internal diameter, with 7,200 square feet total heating surface.

Steam is generated at a pressure of 160lbs. per square inch, and passes from each boiler through a superheater formed of a nest of **U** tubes, giving 150° Fah. superheat into the main steam range.

**Engine
Room.**

THE Engine Room is 280 feet long by 70 feet wide, and contains: --

Four 1,500 K.W. three-phase 7,500 volt, 25 cycle Generators, driven by horizontal compound engines, 75 R.P.M., 32in. and 64in. cylinders, by 52in. stroke.

One 750 K.W. Generator, driven by a vertical compound engine, 94 R.P.M., 23in. and 46in. cylinders by 42in. stroke.

A 4,000 K.W. Turbo Alternator, 750 R.P.M. reaction type.

Three 100 K.W. 125-volt D.C. Generators, driven by Willans' single-acting compound vertical engines, 390 R.P.M., for exciting the main generators, and for light and power in the Generating Station.

Switchboard.

IN the north-east corner of the engine room is the Formby Sub-station and the main Switchboard. The high pressure alternating current is controlled by oil switches, operated by hand. These oil switches are placed in a fireproof chamber under the switchboard. There are no overload or reverse current relays, the switchboard operator opening the circuit, should any fault occur, but overload relays without time limit are fitted to the feeders to the sub-stations.

From the switchboard the current at 7,500 volts is distributed to five sub-stations equipped with air-cooled transformers and rotary converters (see Diagram "D").

An internal view of one of these sub-stations is shown on next page.

From the sub-stations the third rail is fed through short connecting cables, with current at 620-630 volts. On each of these cables an automatic circuit breaker is fixed (see Diagram "B").

**Third
Rail.**

THE Third Rail weighs 70lbs. per yard, has a conductivity equal to one square inch of copper, and is supported at intervals of about 16 feet on porcelain insulators.

For details of return rail bonding (see Diagram "F").

The current returning from the motors passes through the train wheels into the running rails which are not bonded together, but are each cross-bonded to a fourth rail or return conductor weighing 70lbs. per yard which is laid between the running rails. On the later extensions the fourth rail has been dispensed with, and the running rails are bonded at the joints.

**Rolling
Stock.**

THE Rolling Stock consists of 38 standard motor cars, 2 baggage cars, 12 multiple unit motor cars of smaller type, 59 trailer cars, and 12 multiple unit cars of the standard type.

**Train
Equipment.**

THE trains, normally are composed of 3, 4, 5 cars, with 2 motor cars in each case to suit the traffic requirements.



INTERIOR OF SUB-STATION.



STANDARD FOUR-CAR TRAIN.

Each standard motor car is equipped with four motors; each motor is capable of carrying a starting current of 300 ampères for a short period and is rated at 150 B.H.P.

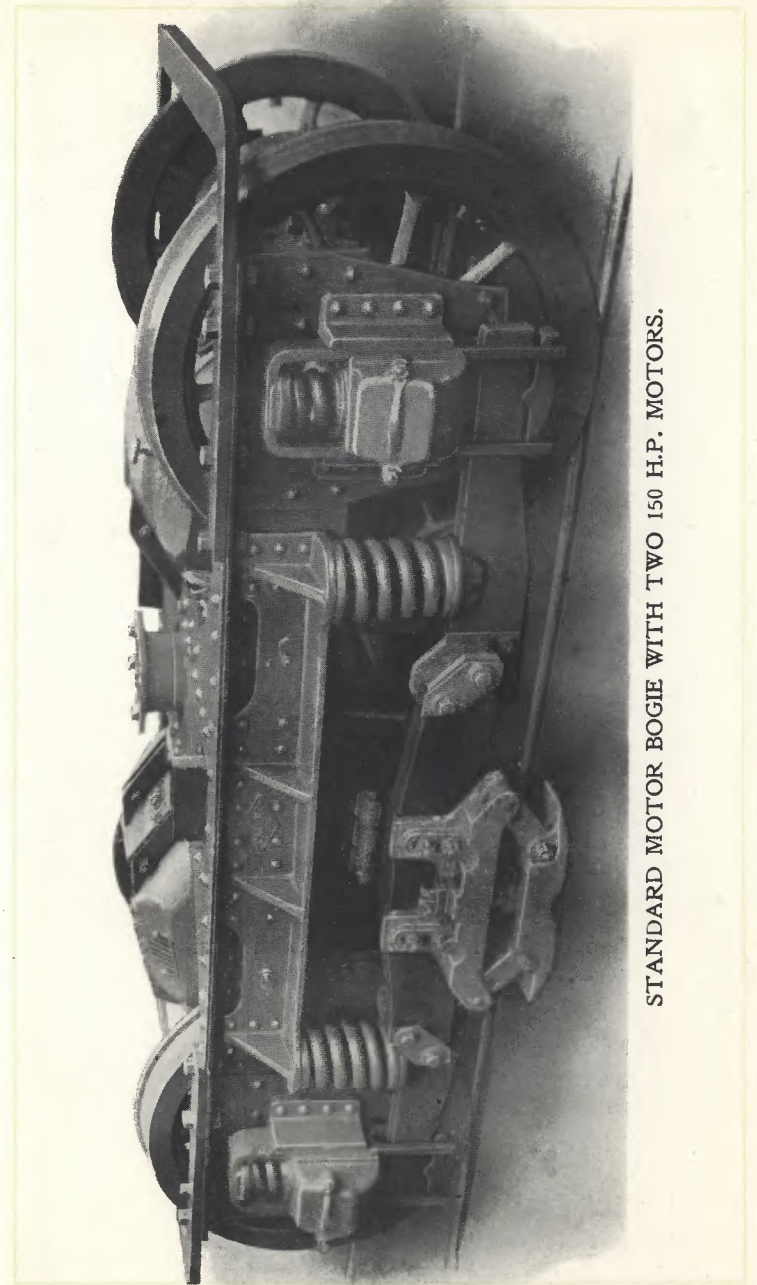
The gear ratio is 43/22 and the diameter of the car wheels is 42in.

The standard direct control motor cars are single ended, and the multiple unit are double ended. At the driving end of the direct control cars a large controller with two barrels deals with the current for both motor cars. As the resistances on the leading motor cars serve for both motor cars, only four train cables are necessary. Each car is protected when running by an automatic circuit breaker of 2,000 ampères capacity, the circuit breakers for both cars being in the motorman's cab at the leading end of the train.

The vacuum brake is used, the vacuum being produced by an electrically-driven air pump. The vacuum is also used to sound the horn.

For through services over the Liverpool Overhead Railway and other extensions several new cars have been built; these cars are equipped with two motors of 125 H.P.

The motors are controlled by a Multiple Unit System, in which the return current from one of the motors operates contractors for the remaining motors.



STANDARD MOTOR BOGIE WITH TWO 150 H.P. MOTORS.

**Working
Data.**

THE following data are of interest in showing the working conditions of the plant:—

Average number of trains in service - -	20
Maximum momentary current per train (ampères) - - - - -	2,400
Average current per train at full speed (ampères) - - - - -	550
Train miles per day - - - - -	4,900
Kilowatt capacity of rotary converters on load in hour of maximum load - -	7,200
Kilowatt capacity of generators on load in hour of maximum load - - - - -	6,500
Combined efficiency of H.T. cables and rotary converters - - - - -	89%
Average load during heaviest hour (kilowatts) - - - - -	6,400
Average Cos Ø - - - - -	'95
Maximum momentary load during heaviest hour (kilowatts) - - - - -	9,000
Maximum momentary load during heaviest hour (kilowatts). without batteries - - - - -	10,600
Number of boilers in service - - -	12 to 13
Average coal consumption in pounds per kilowatt hour at power station - -	3'2 to 3'3
Calorific value of one pound of coal in British thermal units - - -	about 11,500
Maximum number of generators on load - - - - -	4-1500 K.W.
*Load factor - - - - -	90%

*Ratio = $\frac{\text{Actual output of station for any hour.}}{\text{Full load output of engines on load for that hour.}}$

	Tons	Cwts.
Weight of one standard motor car with four 150 H.P. motors (unloaded)	45	10
Weight of one trailer car complete - -	26	2
Weight of one 150 H.P. motor complete with gear - - - - -	2	16
Weight of one motor bogie with two 150 H.P. motors, complete with electrical equipment - - - - -	11	19
Total weight of electrical equipment in car body of standard motor cars - -	3	0
Weight of one contact shoe - - - - -	64lbs.	



Carriage Repairing Shop, Southport.

FOR the purpose of carrying out repairs and periodical overhaul of the cars, use is made temporarily of an existing shed formerly used by the Carriage and Wagon Department for carriage repairs in the Southport district. This shed is 272 feet long, and 55 feet wide, and has three roads, two of which are equipped with pits. A wagon turntable is placed on each road to enable bogies to be shifted from one road to another. Overhead runways are provided for the moving about of armatures and light material, and fixed jacks in each pit for dropping the bottom halves of the motors. The end of the shop is occupied by the fitters' benches, and is reserved for dismantling and erecting bogies. For this purpose, two roads are served by a five-ton walking crane. A small machine shop contains two lathes, a drilling machine, and a planing machine. Re-winding of motors, turning up of journals, and the actual manufacture of the repair material is carried out at the Horwich shops. The capacity of the shop roads is twelve 60 feet cars, but only four require to be dealt with simultaneously.

DIAGRAMS.

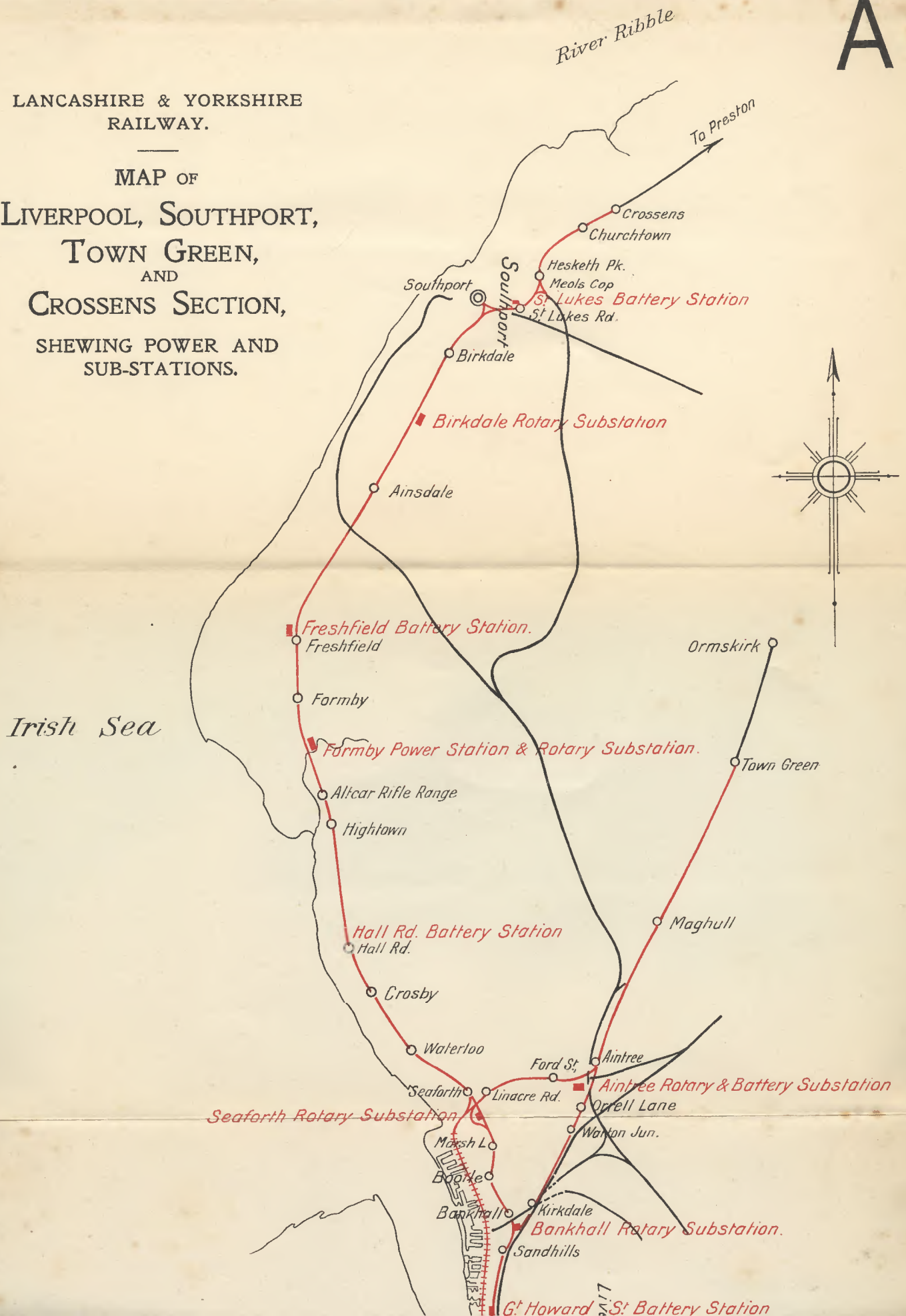


- A.—MAP OF LINE.
- B.—DIAGRAM OF ELECTRICAL CONNECTIONS.
- C.—PLAN OF POWER HOUSE AND ROUTE FOR VISITORS.
- D.—PLAN OF ROTARY SUB-STATION.
- E.—PLAN OF BATTERY SUB-STATION.
- F.—DIAGRAM OF TRACK, SHOWING BONDING.
- G.—DIAGRAMMATIC TIME-TABLE FOR ONE HOUR.
- H.—PLAN AND ELEVATION OF STANDARD TRAIN SHOWING SEATING ACCOMMODATION.

PLAN AND ELEVATION OF TWO-CAR
(1906) MULTIPLE UNIT TRAIN.



LANCASHIRE & YORKSHIRE
RAILWAY.
MAP OF
LIVERPOOL, SOUTHPORT,
TOWN GREEN,
AND
CROSSENS SECTION,
SHEWING POWER AND
SUB-STATIONS.

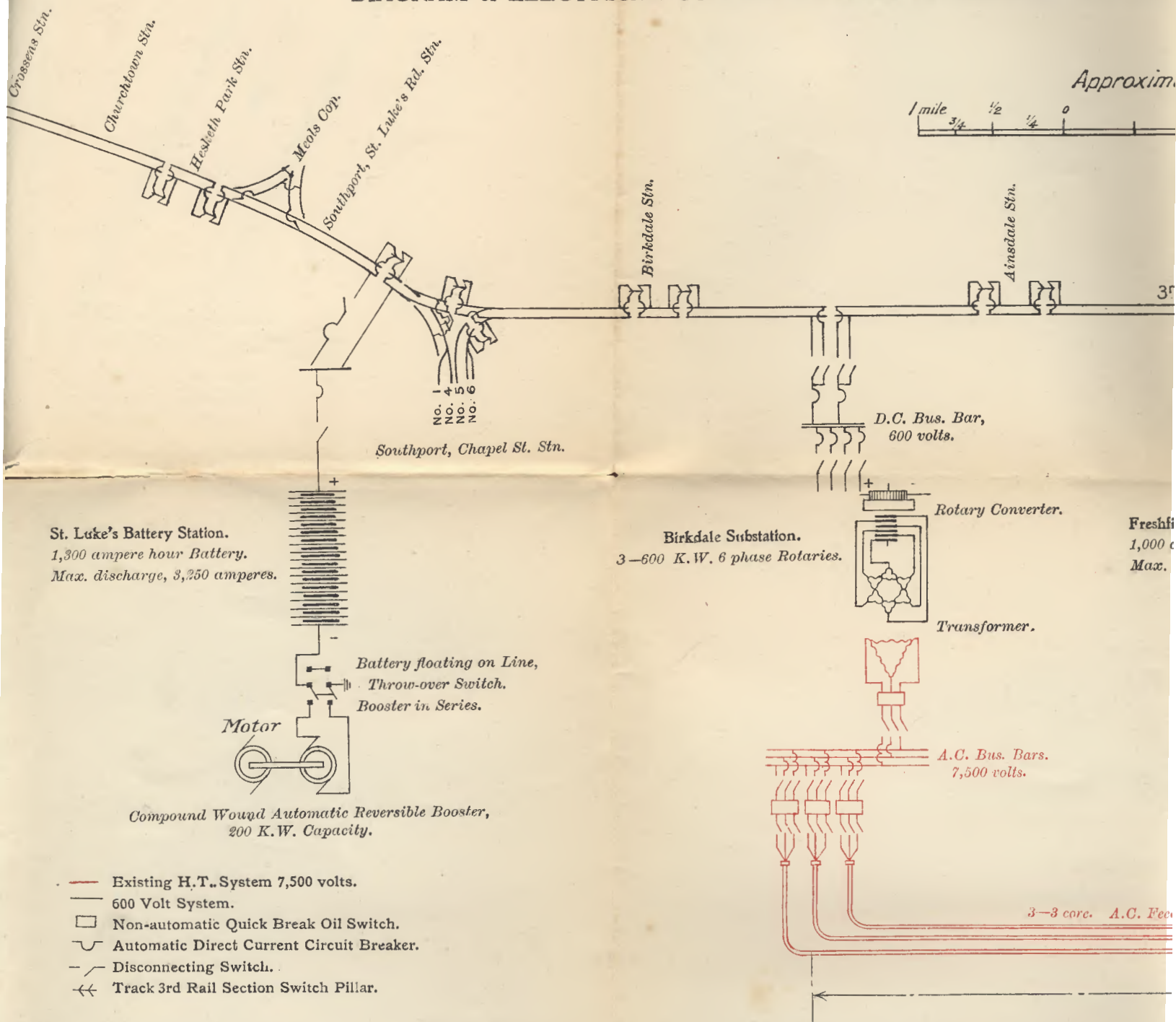


TOWN GREEN,
AND
CROSSENS SECTION,
SHEWING POWER AND
SUB-STATIONS.



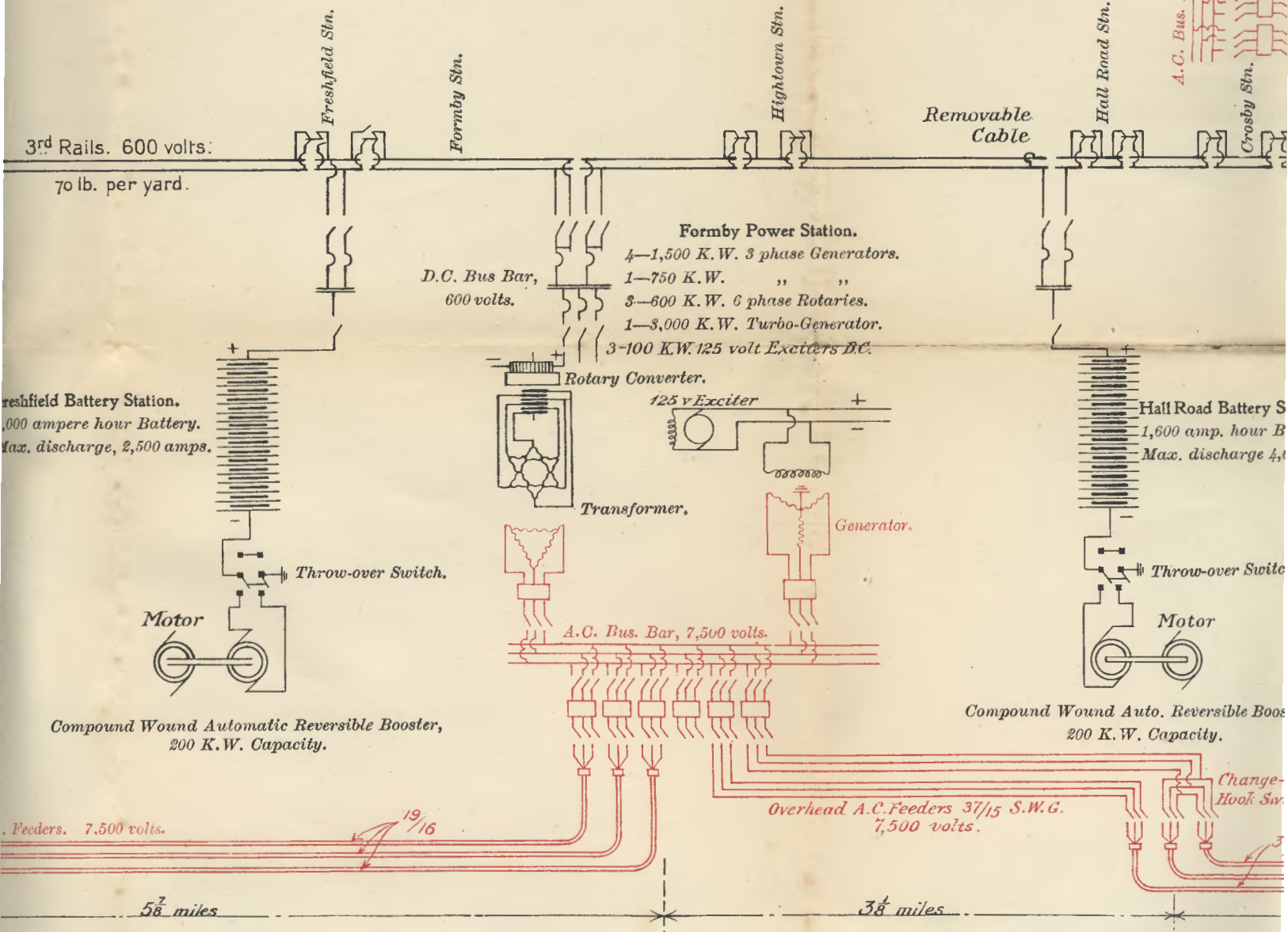
LIVERPOOL, SOUTHPORT, AINTREE & TOWN GREEN
ELECTRIFIED LINE SHEWN ————
LIVERPOOL OVERHEAD RAILWAY SHEWN ++++++
OTHER RAILWAYS (steam) SHEWN ————

DIAGRAM of ELECTRICAL CONNECTIONS for LIVERPOOL, SOUTHPORT



PORT, TOWN GREEN, and CROSSENS ELECTRIC SECTION.

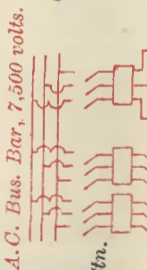
Approximate Scale for 3rd Rail



Compound Wound Automatic Reversible Booster.
200 K.W. Capacity.



Aintree Combined Substation.
3-600 K.W. 6 phase Rotaries.
1-1,000 ampere hour Battery.
Max. discharge 2,500 amperes.



Freshfield Battery Station.
1,000 ampere hour Battery.
Max. discharge, 2,500 amps.

Formby Power Station.
4-1,500 K.W. 3 phase Generators.
1-750 K.W. " "
3-600 K.W. 6 phase Rotaries.
1-3,000 K.W. Turbo-Generator.
3-100 K.W. 125 volt Exciters D.C.

Rotary Converter.

125 v Exciter

Transformer.

Generator.

Hall Road Battery Station.
1,600 amp. hour Battery.
Max. discharge 4,000 amps.

Compound Wound Automatic Reversible Booster,
200 K.W. Capacity.

Compound Wound Auto. Reversible Booster,
200 K.W. Capacity.

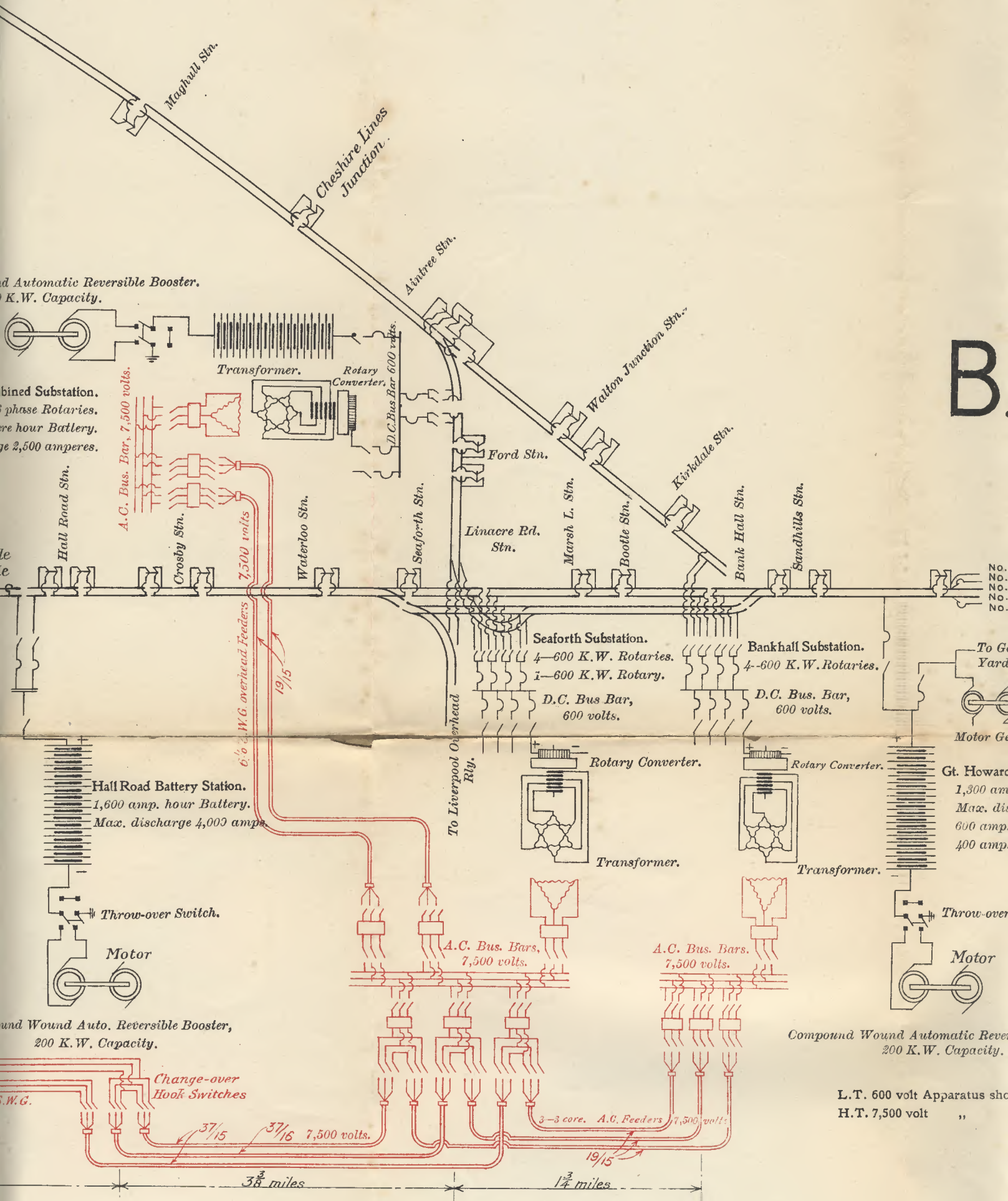
Overhead A.C. Feeders. 7,500 volts.

Overhead A.C. Feeders 37/15 S.W.G.
7,500 volts.

Change-Hook Switch

5 7/8 miles

3 3/8 miles



Compound Wound Automatic Reversible Booster,
200 K.W. Capacity.

Combined Substation,
3 phase Rotaries,
1,600 amp. hour Battery,
Max. discharge 2,500 amperes.

Hall Road Battery Station,
1,600 amp. hour Battery,
Max. discharge 4,000 amps.

Compound Wound Auto. Reversible Booster,
200 K.W. Capacity.

L.T. 600 volt Apparatus shown
H.T. 7,500 volt

B.

NO.
NO.
NO.
NO.

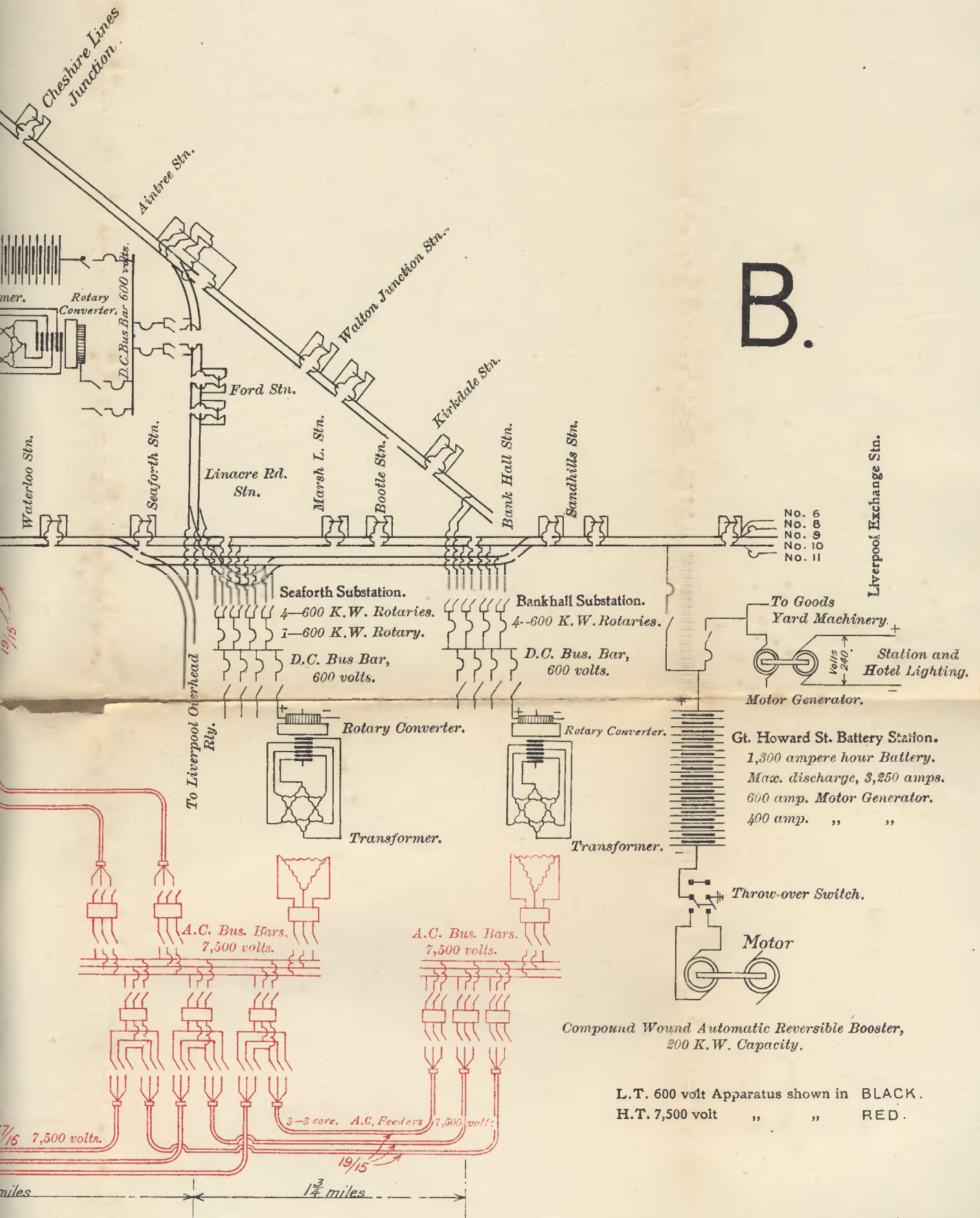
To Gt. Howard Yard
Motor G...

Gt. Howard
1,300 amp. hour
Max. discharge
600 amp.
400 amp.

Throw-over Switch
Motor

Compound Wound Automatic Reversible Booster,
200 K.W. Capacity.

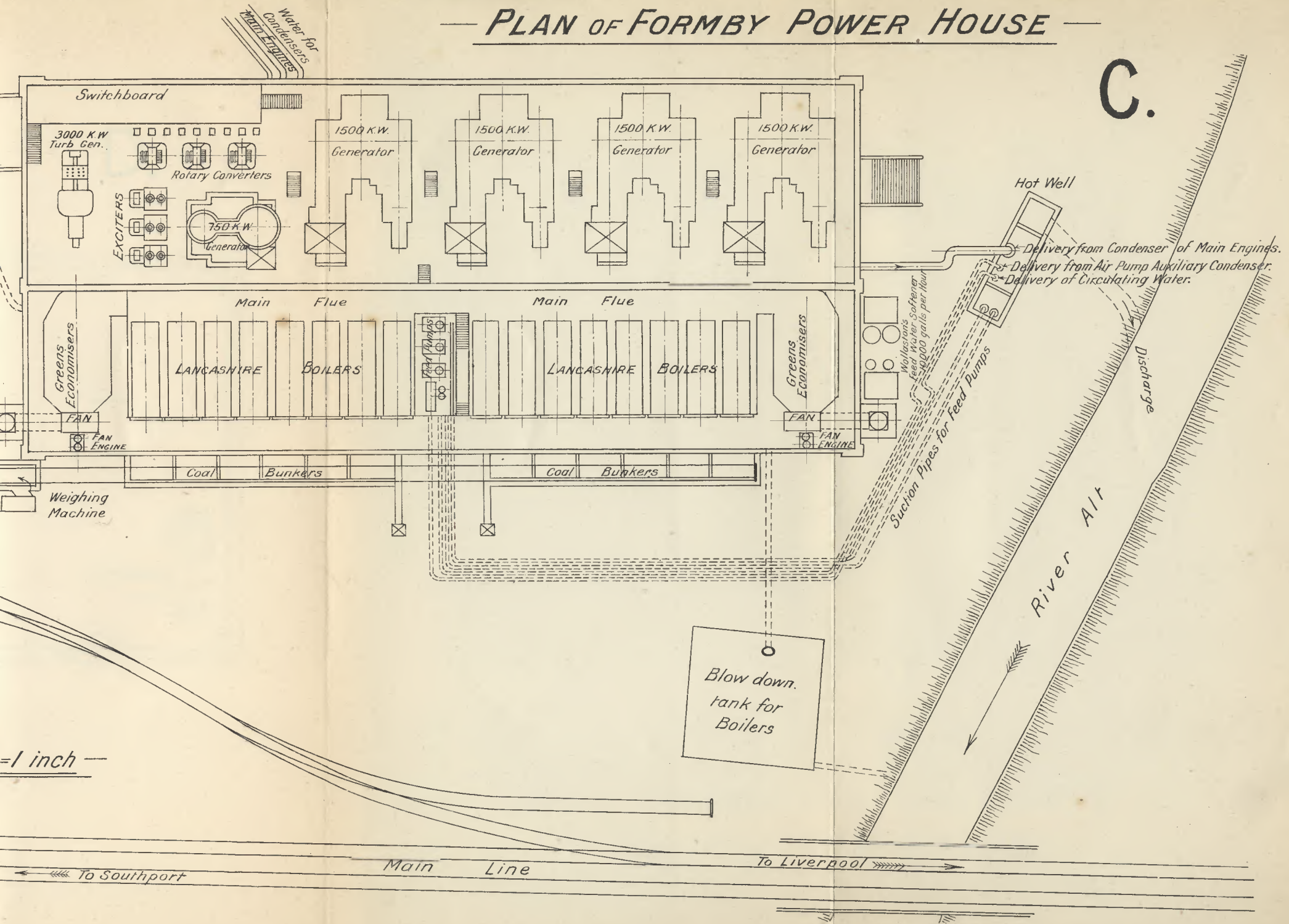
B.



L.T. 600 volt Apparatus shown in BLACK.
H.T. 7,500 volt " " RED.

PLAN OF FORMBY POWER HOUSE

C.



1 inch

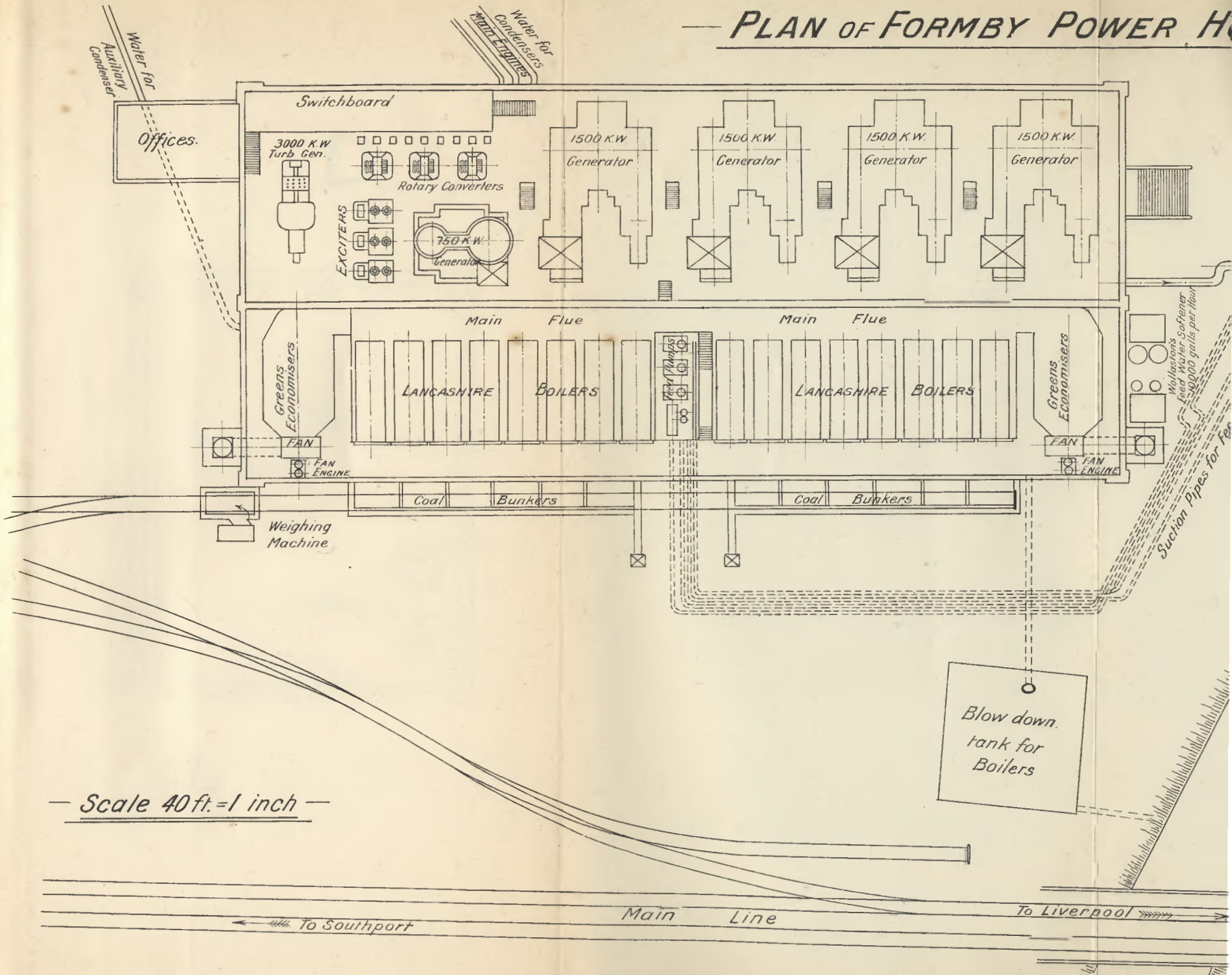
Delivery from Condenser of Main Engines.
 Delivery from Air Pump Auxiliary Condenser.
 Delivery of Circulating Water.

Mollison's
 Feed Water Softener
 10,000 galls per hour

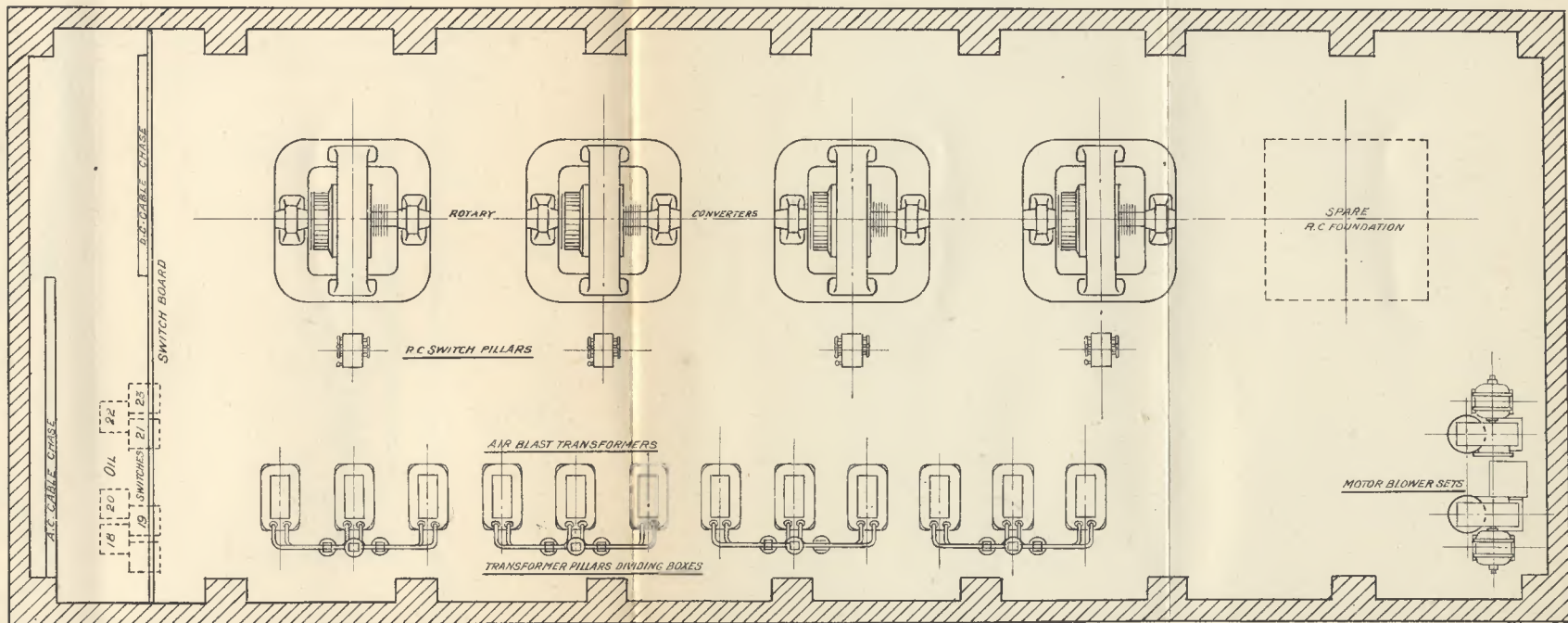
Blow down tank for Boilers

To Southport Main Line To Liverpool

PLAN OF FORMBY POWER HOUSE



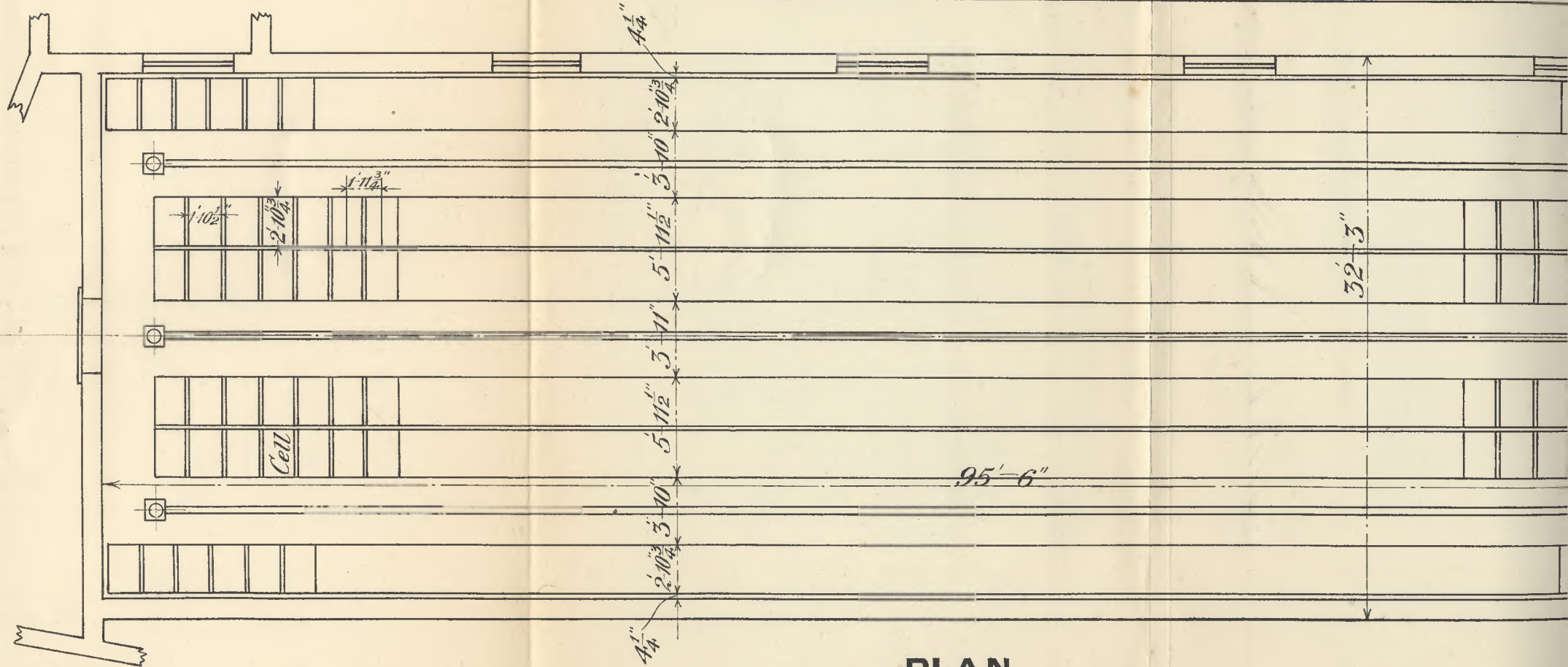
D.



PLAN OF SUB STATION (ROTARY)

DIAGRAM OF BATTERY SUB-STATION.

Liverpool, Southport, Crossens & Town Green Section

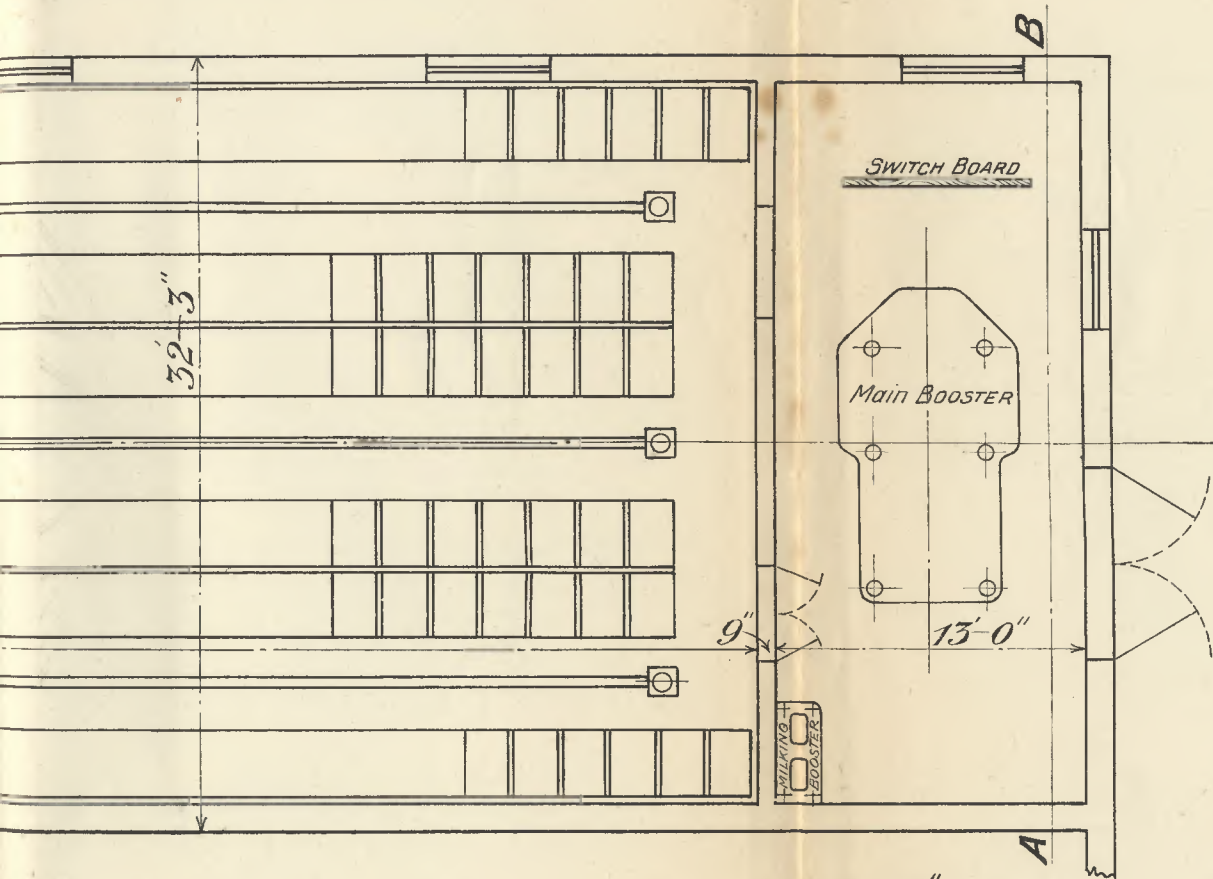


PLAN .

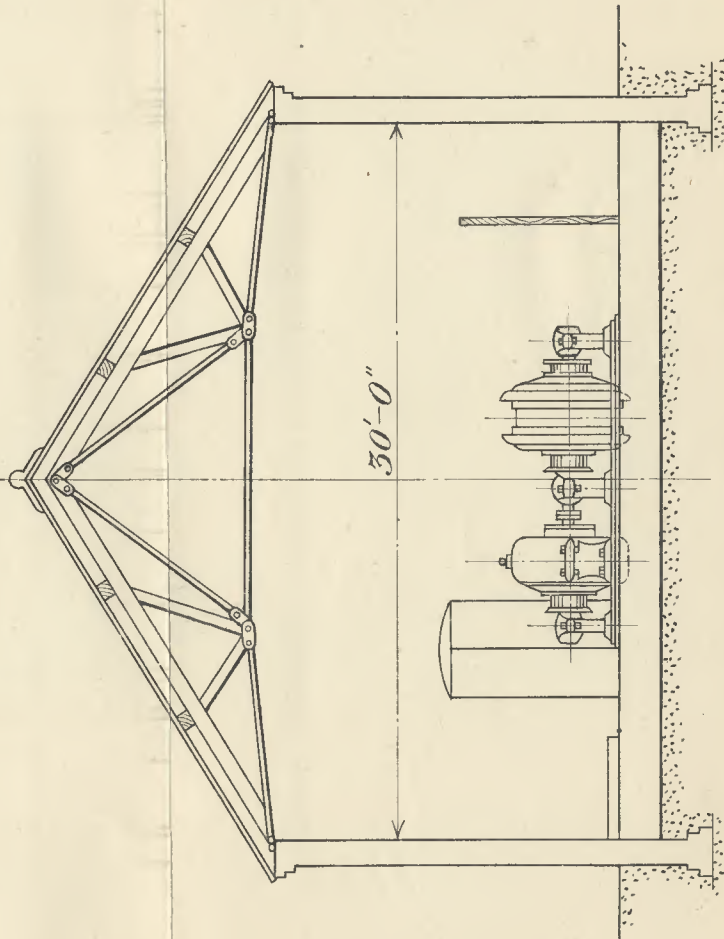
SECTION.

& Town Green Section.

E.

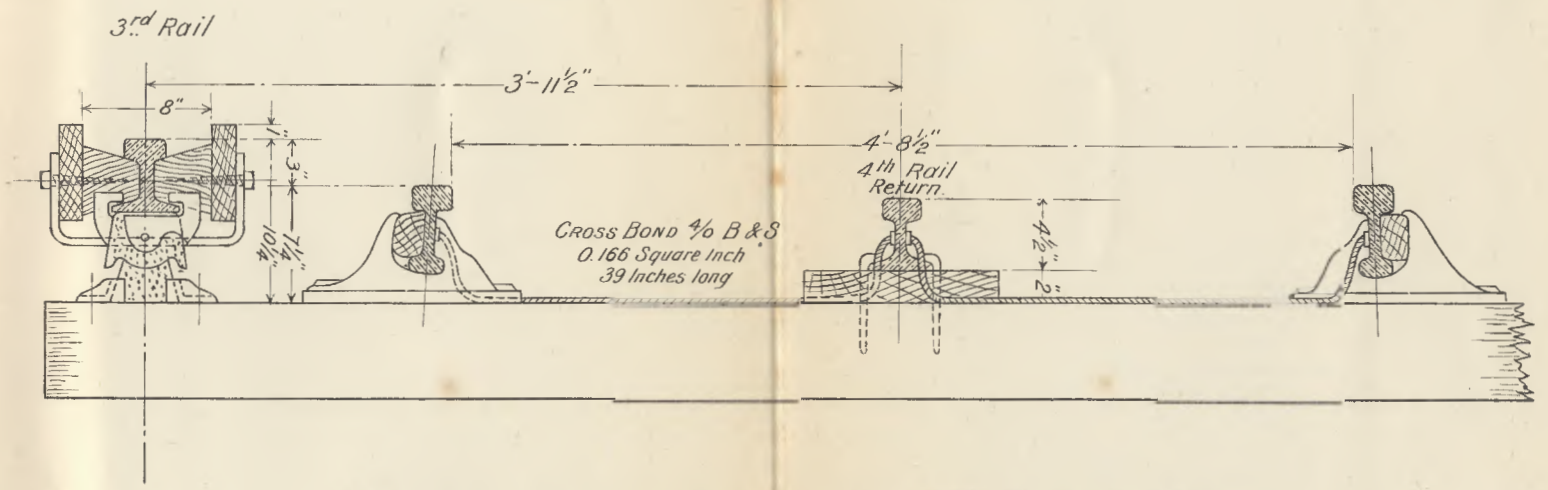


Scale $\frac{1}{8}'' = 1$ foot.



Section through A.B.

F.

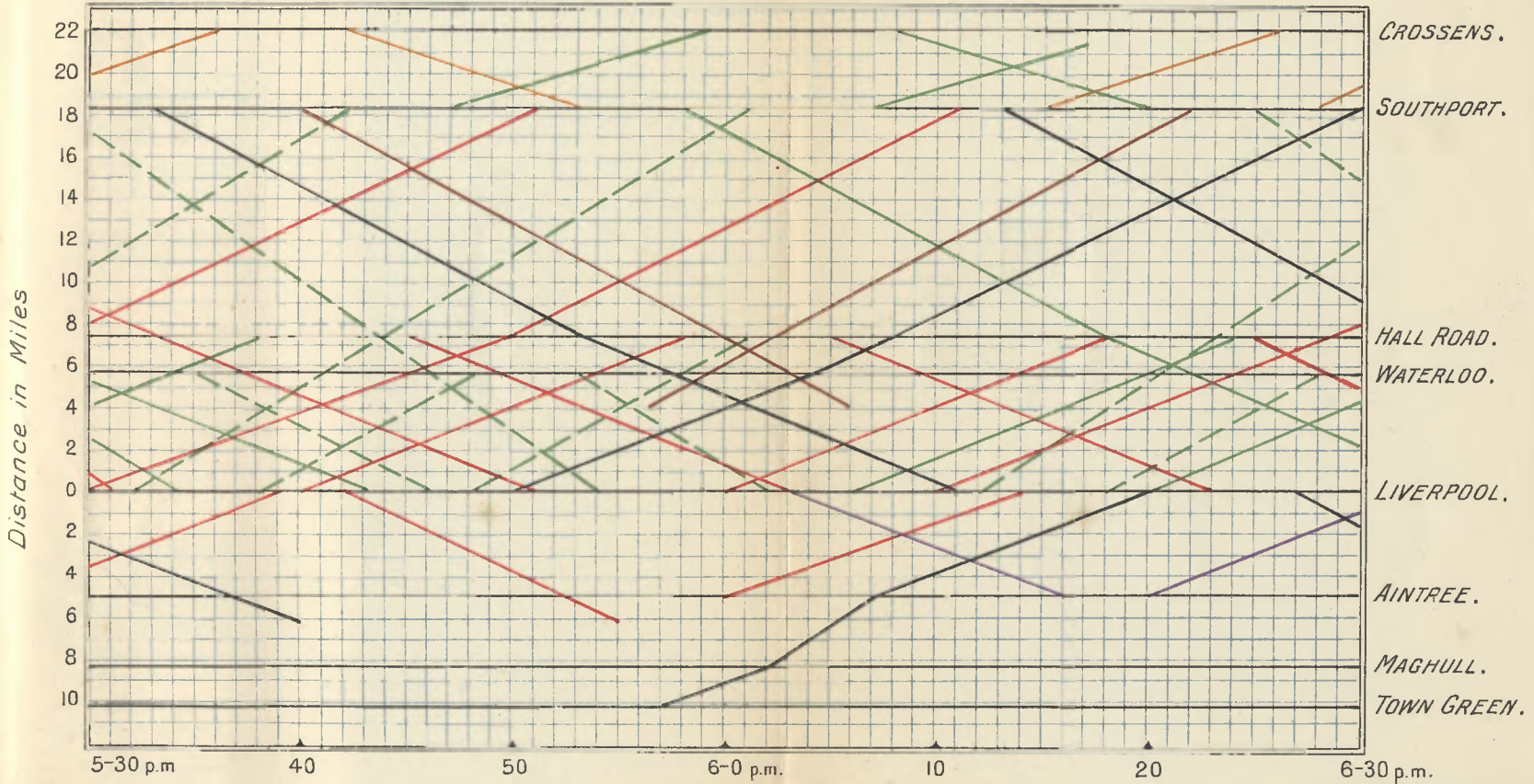


*CROSS SECTION OF PERMANENT WAY
SHOWING 3RD AND 4TH RAILS.*

L & Y. Ry. ELECTRIFIED LINES.

DIAGRAM OF ELECTRIC TRAIN TIME-TABLE FOR 1 HOUR

1911.

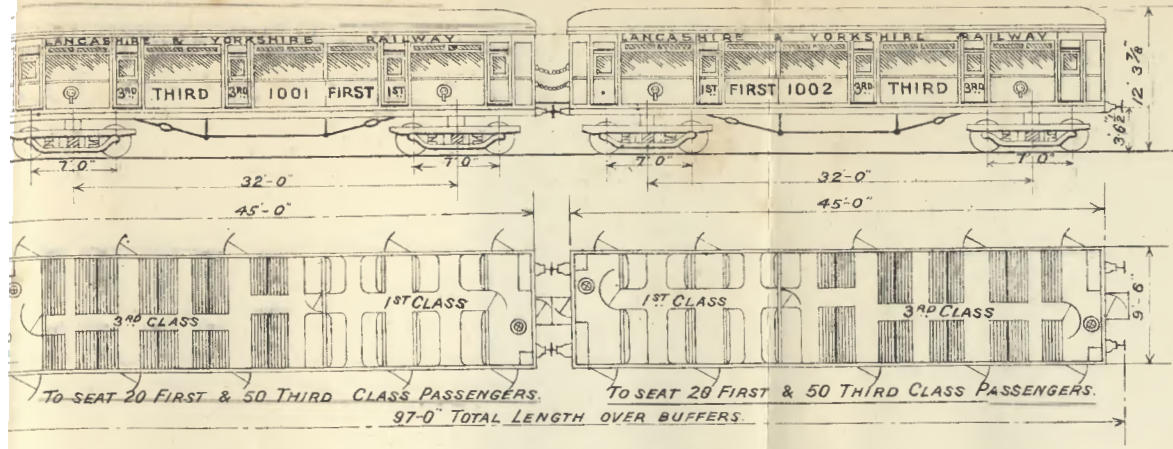


TIME.

Train of 1 M.U. Coach shewn ————
 " " 2 " " Coaches " ————
 " " 3 standard " " ————
 Stopping Trains shewn with full line.

Train of 4 Standard Coaches shewn ————
 " " 5 " " " " ————
 " " 6 M.U. " " " " ————
 Express Trains shewn with broken line.

H



GRAM OF ELECTRIC TRAIN. — MULTIPLE UNIT STOCK —

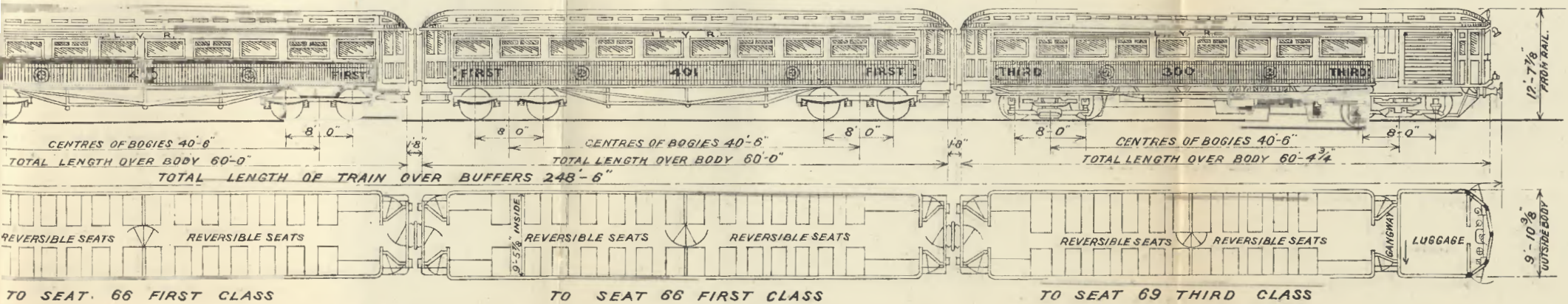


DIAGRAM OF FOUR CAR ELECTRIC TRAIN

PORT, CROSSENS AND TOWN GREEN SECTION.

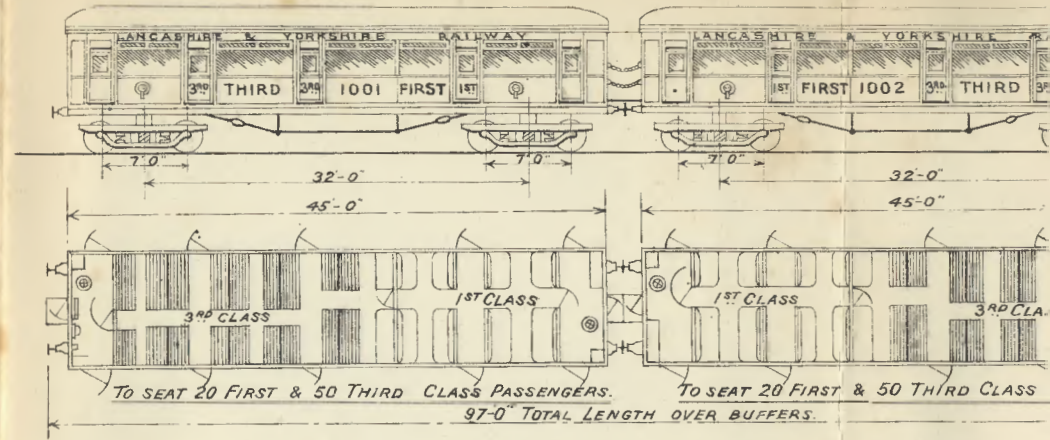


DIAGRAM OF ELECTRIC TRAIN. — MULTIPLE UNIT S

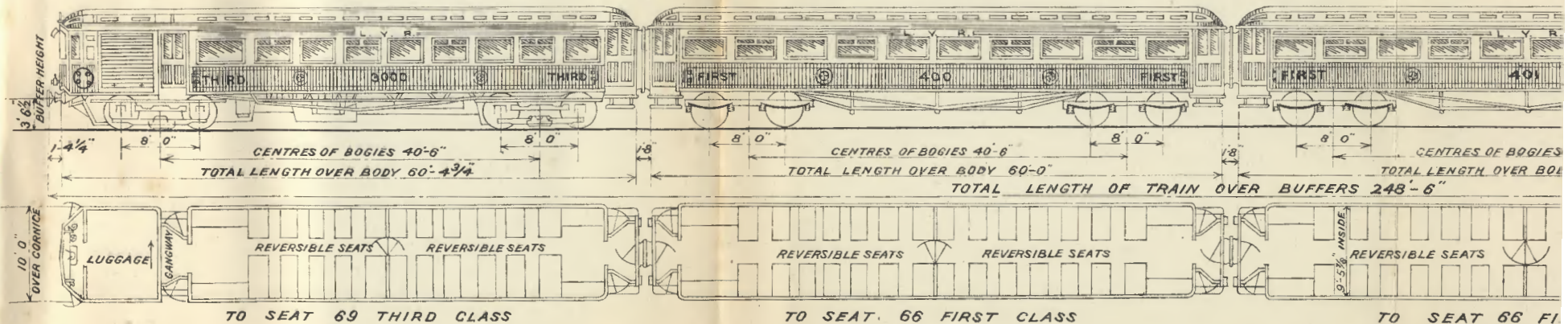


DIAGRAM OF FOUR CAR ELECTRIC T

LIVERPOOL, SOUTHPORT, CROSSENS AND TOW