MELBOURNE AND METROPOLITAN TRAMWAYS BOARD

MELBOURNE CABLE TRAMWAYS

GENERAL REPORT ON THEIR CONSTRUCTION OPERATION AND MAINTENANCE

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By

I. MACMEIKAN

ASSISTANT SUPERINTENDENT. CABLE WORKSHOPS 1920 - 1930.

MANAGER. PRESTON WORKSHOPS 1951 - 1956.

INTRODUCTORY REMARKS.

In preparation of this report on the Melbourne Cable Tramways, which operated from 1889 until 1940, I shall endeavour to record items which may be of general interest, (including events leading up to the construction and opening of the various lines) and set down certain procedures and developments of a technical nature indicating some of the problems which had to be solved by the Engineering Branch of the undertaking.

In 1883 Victorian Parlimentary Powers were sought for the construction of a tramway system in Melbourne, however before such powers were granted, it was arranged that Mr. F.B. Clapp and Mr. G. Duncan the future Manager & Engineer respectively of the undertaking, should visit Europe and America to familiarise themselves with the latest developments in the field of Tramway Traction. On their return the necessary Government approval with requisite powers was obtained and the Melbourne Tramways Trust was formed. Plans, specifications, and estimates were prepared and a loan floated in London in 1884 to finance the commencement of the project. The Principle Act embraced a previso that all the tramways scheduled in the act were to be constructed before the 12th October, 1889. This objective was achieved, and the only cable ways opened later were these lines originally planned for horse traction, namely North Melbourne, West Melbourne, South Melbourne and Port Melbourne. However, these lines were completed and opened for service during the first six months of 1890.

The first two routes constructed and opened for traffic were Richmond to Spencer Street in November 1885, and Fitzroy to Spencer Street in October 1886. The operation of these lines met with great success and I quote the Age of 13th January, 1887, giving a general impression of the development and operation of the system to date, and the proposed construction of other lines with information relative to them as follows:-

"The working of the Richmond and Collins Street tramway lines is generally regarded as valuable proof that the cable system is the best that could possibly have been adopted for the requirements of Melbourne and suburbs. So far the running of the cars has resulted very satisfactorily. The traffic in Flinders and Collins Streets has been considerably relieved thereby, the convenience of the public is beyond question, and accidents, comparatively speaking are few and far between. The regularity of the service is a feature upon which the company may fairly be congratulated, as it is evidence of good management and excellent organisation. In the opinion of most people the remaining routes cannot be too soon completed, and some information relative to the progress of the works and the operations of the Tramway Trust may, therefore be found interesting. At the present date there are 10 miles of double track in running order, serving an estimated population of something like 80,000 drawn from Richmond, Fitzroy, and portions of Hawthorn and Collingwood. These lines have cost an average of 32,000 Australian pounds per mile including purchase of land, erection of Engine Houses, laying of track, rope, and all other particulars, except rolling stock. This therefore, would bring the total expenditure on the part of the trust, upon the Richmond, Fitzroy and Simpsons Road lines up to 320,000 Australian pounds. The Tramways Trust as everybody probably knows, constructs the lines, and hands them over in complete working order - minus the rolling stock - to the Melbourne Tramway and Omnibus Co. Ltd. The trust, however, for a certain prescribed time has the care and maintenance of the track, after which it passes entirely into the supervision of the Company. The Richmond and Fitzroy lines are now under the care of the Company, who are responsible for their maintenance until the expiry of the lease. Upon these lines 100 cars are running, and it is estimated that the 10 miles of track has necessitated on the part of the Company an outlay of 400,000 Australian pounds. This is principally represented in the building of cars and the erection of sheds. To complete the northern system of tramway communication, as scheduled in the set, there yet remains the Collingwood, Nicholson Street, Brunswick, Carlton, North Carlton, Hotham and West Melbourne services. With the exception of North Carlton, Hotham and West Melbourne these lines are well forward. The next track to be opened is that which runs up Bourke Street, along Nicholson Street and down Gertrude and Smith Streets, just as the Collingwood Omnibuses do now. Simultaneous with this line, will also be opened one running down the whole length of Nicholson Street, intended to serve portions of North Carlton and North Fitzroy. The works in connection with these routes are well advanced, the engine house at the corner of Nicholson and Gertrude Streets, from which they will be worked, is nearly completed, and it is expected within the space of five months at the latest, the lines will be ready for traffic. By that time cars will be running along Bourke Street, furnishing a service similar to that provided in Collins Street at the present moment. These tracks cover a distance of 6 miles, and when fully completed will have cost a total expenditure of 170,000 Australian pounds. The Brunswick line will be opened a month later. Everything in connection with this route is in a forward condition and there is nothing to prevent the track being in working order within the time specified. The engine house, the site of which is at the rear of the Sarah Sands Hotel, is in course of erection, and is being rapidly pushed on by the contractor. The length of line is to be 4 miles and will cost altogether 130,000 Australian pounds. By the end of next June, therefore, the trust will have opened 20 miles of running track, constructed at a total outlay of 620,000 Australian pounds.

The Carlton line is expected to be opened in about seven months time - that is immediately after the Brunswick track. The machinery is all ready, and the engine house-situated in Johnston Street, between Fitzroy and Brunswick Streets - is being built. The line will be about 3¼ miles long, and the estimated cost of construction 90,000 Australian pounds. This it will be observed, is the lowest figure yet given, and is accounted for by the fact that the line is shorter than any previously mentioned, and will not require machinery of quite so powerful a character to work it.

The lines to North Carlton, Hotham and West Melbourne complete the northern system of tramway communication. A commencement of these works cannot, however, be made until the various interested local councils come to a decision as to what tractional power shall be employed. The trust, as far as it is concerned, can make a start at once and complete the lines in a very short space of time.

The southern system embraces the lines to St. Kilda, Prahran, Toorak, South Melbourne and Port Melbourne. The trust, is in the same position as it is with regard to the Hotham and West Melbourne routes. The councils have not yet decided whether horse, cable or motor power shall be used, and until that question is finally settled matters must of course remain at a standstill. There is nothing, however, to prevent a speedy completion of the works as soon as the trust is authorised to proceed.

St. Kilda, South Yarra, Prahran and Toorak have given their voice in favour of the cable, and accordingly plans and specifications are being prepared with a view of calling tenders for the work at an early date. The construction of these lines will be carried on so as to have them ready on the date of the opening of the new Princes Bridge. Mr. Duncan the engineer of the trust, is making arrangements to that end, so that we may expect the opening of the new bridge and the running of cars over these lines to take place on the same day. The service will be worked from two engine houses. The motive power for the South Yarra, Toorak and Prahran routes will be supplied from the machinery erected on the site at the corner of Chapel Street and the Toorak Road. For the St. Kilda Engine House a site has been selected near the junction of the Toorak and St. Kilda Roads. With the completion of these lines will be finished the whole tramway service authorised by the act. - the estimated cost being 1,200,000 Australian pounds. In the construction of tramway lines the trust finds drainage a heavy and expensive item. Thorough and ample drainage is of first importance to the smooth working of the track. For the purpose of the line itself elaborate drainage works would not be necessary, as small channels could carry off all the water that would be likely to effect the running of the gear. In laying down the track, however, the existing system of drainage is often intercepted and has to be provided for in the shape of large and expensive sewers. In work of this character alone the trust has found it necessary to expend a great amount of money, so large indeed, that had Melbourne and Suburbs been supplied in the first instance with an underground system, the expense of lines even to the present time would have been lessened by the sum of 30,000 Australian pounds. A very large sewer had for instance, to be built the whole length of Victoria Street from Simpsons Street to the river. Sewers are also now being put down in Fitzroy, Brunswick and the City of Melbourne.

It is satisfactory to find that the engineer of the trust believes the Melbourne cable tramway service, so far as at present operating, to be the best in the world. The tracks are said to be splendidly built, whilst the machinery and appliances for the working of them combine all the latest improvements that the most recent experience could suggest. As an instance of the smoothness with which the machinery works, it is stated that the stoppages occasioned on the Fitzroy line during the three months that the cars have been running along it, would not put together exceed an hours duration.

The cable as a tractional power, has proved applicable to all localities, and the system which is being everywhere adopted. It is supposed to effect a saving of 25 to 30 per cent. in the working expenses as compared with horse or motor. The maximum gradients of the Melbourne lines is 1 in 14. The heaviest gradient in the world exists in Dunedin, New Zealand, where it is 1 in 3½. San Francisco comes next with 1 in 5.

The act stipulates that the whole of the Melbourne and suburban tramways shell be completed by October 1889. Mr. Duncan the engineer to the trust, is however, so satisfied with the organisation effected and the means and advantages at his disposal for rapidly building the lines, that he is confident, should occasion require it, the whole lot could be finished before the close of the present year."

INDEX

CAR DEPOTS

ENGINE HOUSES

PERMANENT WAY

REPAIR SHOPS

ROLLING STOCK

1. CAR DEPOTS - GENERAL.

The general practice of the Melbourne Tramway & Omnibus Company, was to establish the Car Depots at the termini of the various lines. The only exception to this procedure being the Toorak Depot, which was situated at the corner of Toorak Road and Chapel Street at the rear of the Toorak Engine House, and at a distance of approximately $1\frac{1}{4}$ to $1\frac{1}{2}$ miles from the Toorak Terminus.

From a traffic view point, the depot at the terminus gave the Line Manager, who had complete control of the service running from his depot, the opportunity to readily reorganise the service in case of delays or accidents, by running in or out cars to make adjustments to the time tables. A disorganised service was very quickly re-established by the Line Manager who was a thoroughly competent traffic officer with authority to set in this capacity. The Car Depots had frontages to the roads on which the tramway service operated at 14 of the 16 Depots. The 14 Depots referred to had car run-outs and run-ins provided which were of minimum length. This was advantageous because cars and dummies were man handled in and out of depots in most cases. Horses were used at 4 depots, 2 of which had run-outs to very wide roads, the other 2 were in one case a heavy car (bogie) and in the other a comparatively long run-out on a gradient. The majority of Depots had a run-out track to the up line and a run-in from the down. This was particularly advantageous for the man handling of rolling stock, when the run-out or up track was slightly down graded and consequently the run-in from the other track was also on a down gradient. Other layouts were level which were reasonably convenient for the man handling of trams at these depots. In a very small minority of cases a single run-in and out track was provided. The following table sets out the 16 Depots, where situated, their capacity, and Rolling Stock housed at each in 1923, at which time the whole cable system was operating.

CAR DEPOT	SITUATED AT	TOTAL CAPACITY.		1923. OPERATING CAPACITY.		REMARKS
		days	cars	days	cars	
BRUNSWICK	C/o Sydney Rd. & Cozens St.	70	70	64	66	Bogie Cars 24' saloons.
NORTH CARLTON	C/o Rathdowne & Park Sts.	34	34	33	35	
NICHOLSON STREET	Nicholson St. E side, near Liverpool St.	38	38	25	25	
FITZROY	C/o St.George's Rd.& Holden St.	44	44	33	33	
CLIFTON HILL	Queen's Pde. W side, near Brennand St.	51	51	45	43	
CARLTON	C/o Johnston St & Trennery Crescent.	34	34	31	31	
VICTORIA STREET	Victoria St. S side, near Victoria Bdge.	50	50	47	46	
RICHMOND	C/o Bridge Rd. & River St.	52	52	38	33	
TOORAK	C/o Toorak Rd. & Chapel St.	21	21	22	21	1 dummy standing on traverser.
PRAHRAN	C/o Chapel & Carlisle Sts.	43	43	31	31	
BRIGHTON ROAD	C/o Brighton Rd. & Brunning St.	42	42	42	42	
ST. KILDA ESPLANADE	Acland St. W side, near C/o Barkly St.	50	50	47	50	
SOUTH MELBOURNE	C/o Victoria Ave. and Beaconsfield Parade.	41	41	36	37	
PORT MELBOURNE	C/o Beach and Donaldson Sts.	21	21	17	17	
NORTH MELBOURNE	Flemington Rd. S side, near Flemington Bdge	43	43	34	33	
NORTHCOTE	C/o High St. & Martin St.	15	15	15	15	
			Total	560	558	
Spares for Depots where required.				25	20	
Cars and dummies at workshops				12	23	
	Total Rolling Stock			597	601	

1.1 CAR DEPOTS - CONSTRUCTION.

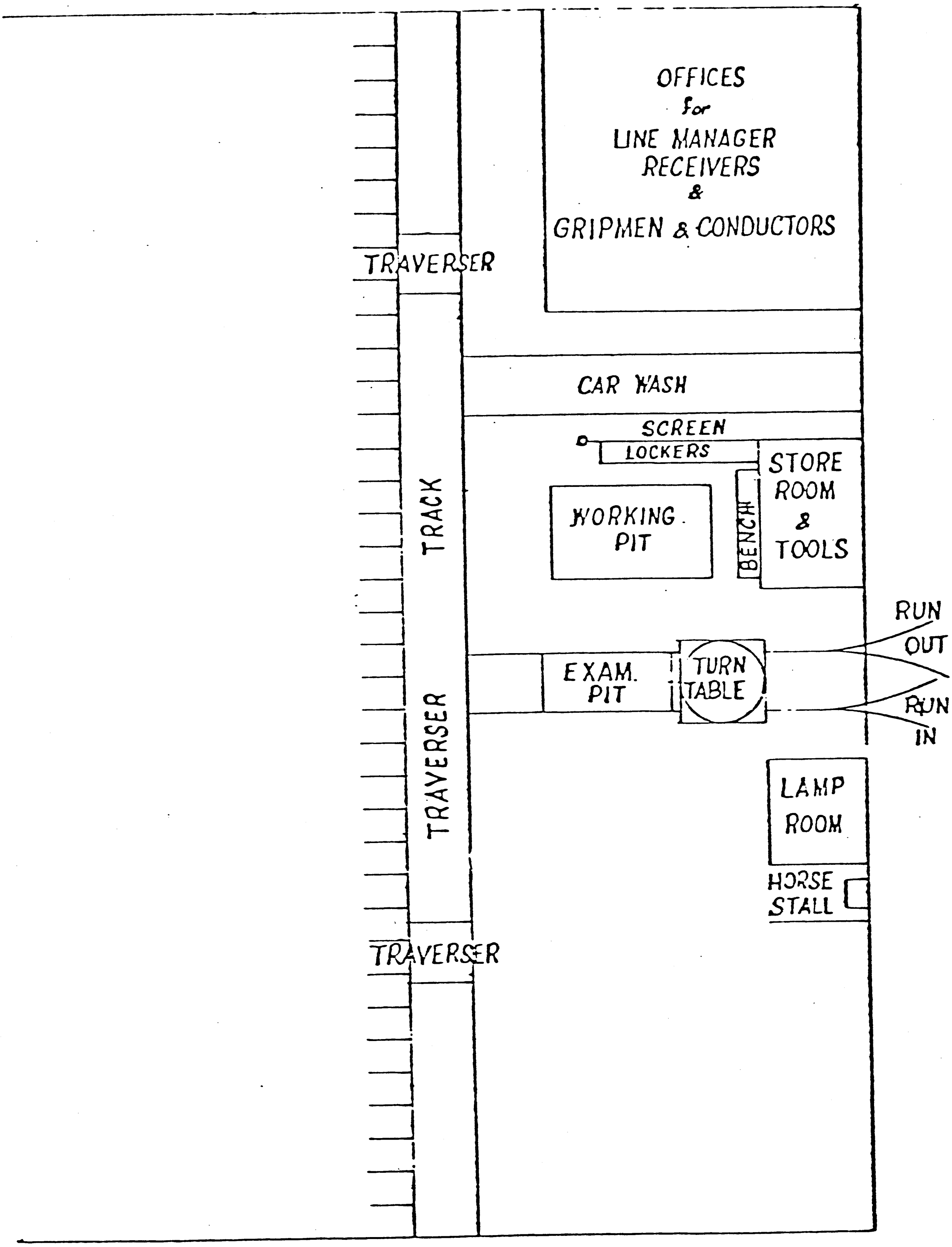
The construction of all Car Depots was practically of the same design. A brick dwarf wall on concrete foundations, carried a timber bottom wall plate, on which wooden pillars were mounted supporting the timber top wall plate and roof principals. Intermediate studs and lateral timbers were positioned where required for windows etc. The walls were braced with the customary diagonal bracings, and further timber pillars were erected on concrete foundations throughout the depot, in the position required to carry the timber roof principles with purlins, skylight frames etc. The walls and roof coverings were of 16 gauge corrugated galvanized iron, and the timber used in the building construction was oregon. Heavy timber sliding doors were installed to close the main Depot Entrance where the trucks were laid for the running in and out of trams. These doors had small doors in them for use by shedmen and other staff requiring entrance to the Depots when the main doors were closed. Side wall windows and skylights were used to provide natural lighting.

With roof guttering, downpipes, water supply, lighting and drainage completed, the Depot was ready for the laying of tracks and traversers, also the installation of pits, turntable, car wash, store room and lamp room.

Under the same roof, but with a separate entrance door, three offices were built for the Line Manager, Receivers and Gripmen and Conductors.

A typical layout of a Car Depot is shown with the following equipment and plant with which each Depot was originally provided.

- Working Pits (including tools, jacks, block and tackle etc.)
- Traverser Tables and Track.
- Turntable.
- Examination Pit.
- Car Wash.
- Working Bench with vyce, cupboards and drawers.
- Store Room for spare parts (including shoes, dies etc.)
- Lamp Room.
- Horses for running trams in and out, where man handling is impossible.



TYPICAL – LAYOUT

1.2 OPERATION OF CAR DEPOTS.

Each Car Depot had a Line Manager who was virtually the Superintendent of the Depot and Line or Lines operated from that Depot. Traffic Clerks, Gripmen and Conductors were under his control, but the Shed Leading Hand and Shedmen (later known as Shed Mechanics) were the Workshops Superintendent's Staff and were directly responsible to him for the running repairs and maintenance of all rolling stock and Car Depot Equipment and Plant. The Leading Hand Shedman was furnished with a copy of the time table by the Line Manager so that trams would be made ready for service when required. The shed staff assisted by the gripmen and conductors attended to the running in and out of trams and the lowering or lifting of grips. The turntable was employed to reverse the dummy when necessary so that it went into service with the grip dies opening in the correct direction which was essential, this was checked with the destination sign when the grip was placed in the dummy. Cars were also turned periodically to allow the exposure of panels to the sun and weather conditions to be equalized. All dummies and cars when going into service passed over the examination pit, where a member of the shed staff inspected the undergear and sounded each wheel with a hammer for crack detection. The movement of cars inside the Depot was carried out by the shedmen for the purpose of cleaning, washing, running repairs and maintenance. Traverser Tables were used to transfer rolling stock from one track to another, and a suggestion was put forward that ball-bearings be used on the traverser table to ease this particular work. A trial table was fitted up but was immediately condemmed as unsatisfactory owing to the difficulty in stopping it at the required position. In addition it was too lively when a dummy or car was being pushed off it, because the table rolled whenever a slightly greater force was applied to one side or other of the vehicle which caused derailments. To overcome these difficulties it would have been necessary to provide some braking arrangement and a means of locking the table in position before running the vehicle on or off the traverser. This would have taken extra time which was not available at busy periods. The only depot where traverser tables were locked was Brunswick, where horses were used inside the depot for the movement of bogie cars. This was necessary due to the weight of cars and the occasional indirect pull by the horses in moving the cars on and off the traverser tables. The traverser tables (3) at Brunswick were 22 feet long to accommodate bogie cars, and were equipped with 3 pairs of wheels having 3 rails in the traverser track. Horses were also used to pull the traverser with bogie car along the traverser track. All other depots had traverser tracks 8 feet wide with the tables running on 2 rails and moved by manpower. "Fordson" tractors were employed later in place of horses at all depots except Brunswick. This Depot continued operating with horses, because as mentioned above the horses had to cross the traverser track and also work there which necessitated their stepping up and down approximately 12 inches.

Owing to transportation difficulties arising with bogie cars, all body repair work was carried out at the Brunswick Depot, and a Paint Shop was provided for repainting and touching up repair work. The bogie trucks were transported by lorry and the dummies were run to the workshops in the same manner as these from other depots. Another feature confined to the Brunswick Depot was the provision of a run-out track with a slot and tunnel for the grip. This enabled the grip for one dummy to be lowered into position while it was standing over the inspection pit at the same time as another dummy was being equipped outside on the track. This procedure was necessary to cope with the running in and out of trams for the heavy traffic on the Brunswick Line calling for approximately a half to three quarter minute service at peak loading.

1.3 CAR DEPOT MAINTENANCE.

The maintenance of Car Depots and Plant was entirely carried out by the Workshops Staff under the direction of the Workshops Superintendent. The necessary staff to handle all building repairs were employed at the Workshops, including Plumbers, Carpenters, Painters etc. If work in the nature of new buildings or bricklaying became necessary, tenders were called for the work to be donc.

The traversers and turntables together with any tools or equipment were kept in good condition by the Workshops. The equipment being standardized enabled the changeover of spare traversers or turntables (which were held at the Workshops), to be carried out at very short notice in the event of any unusual and sudden failure occurring at any of the depots. Brunswick, where long traverser tables were employed for the bogie cars, had two in use and one on hand as a spare.

The tracks in the Depots, including the run-ins and run-outs, were maintained by the Permanent Way Staff under the Engine House Superintendents.

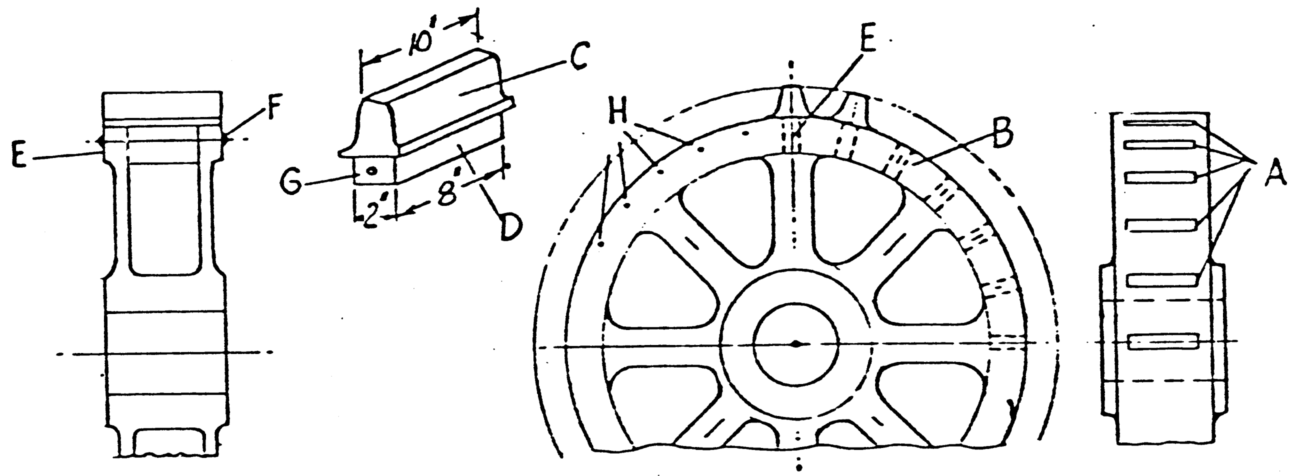
2. ENGINE HOUSES - GENERAL.

The Cable Power Houses were always officially known as Engine Houses, probably due to the original plans, specifications and documents setting them out as such, and referring to the plant and equipment as Engines, Boilers and Gearing.

The Engine House layouts were all arranged in very much the same manner, with the offices along the front facing the street and having passages giving exit to the footpath. The Engine Room occupied the area from the Offices to the wall of the Boiler House which was situated at the rear of the building. An area on the left hand side of the Engine Room was occupied by the Cable Races, Drivers, Tension Carriages, etc., and extended from the Offices to the rear of the building, being separated from the Boiler House by a brick wall running from the Engine Room to the rear of the building and parallel with the Cable Race. The Engines were duplicated, and when one set was closed down, it was overhauled and reconditioned ready for service as speedily as possible. This resulted in one set of Engines in first class condition operating, while the other set was standing in readiness for immediate changeover if required. The Boilers were also duplicated and were laid off for inspection and repairs as required. This gave a complete changeover of all Engine House machinery including feed pumps, feed water heaters, and cable reels. The duplication ceased at the Rope Wheel Driver mounted on the engine shaft. This Driver Wheel carried approximately 16 or 18 manilla ropes transmitting the drive from the Engines to the 24 ft. diameter wheel which revolved the main shaft on which the Cable Drivers operated. The Cable Drivers, Cable Races, Tension Carriages, Pulleys, Sheaves etc. were all individual cable units. The number of these units depended on how many separate cables were driven from any particular Engine House.

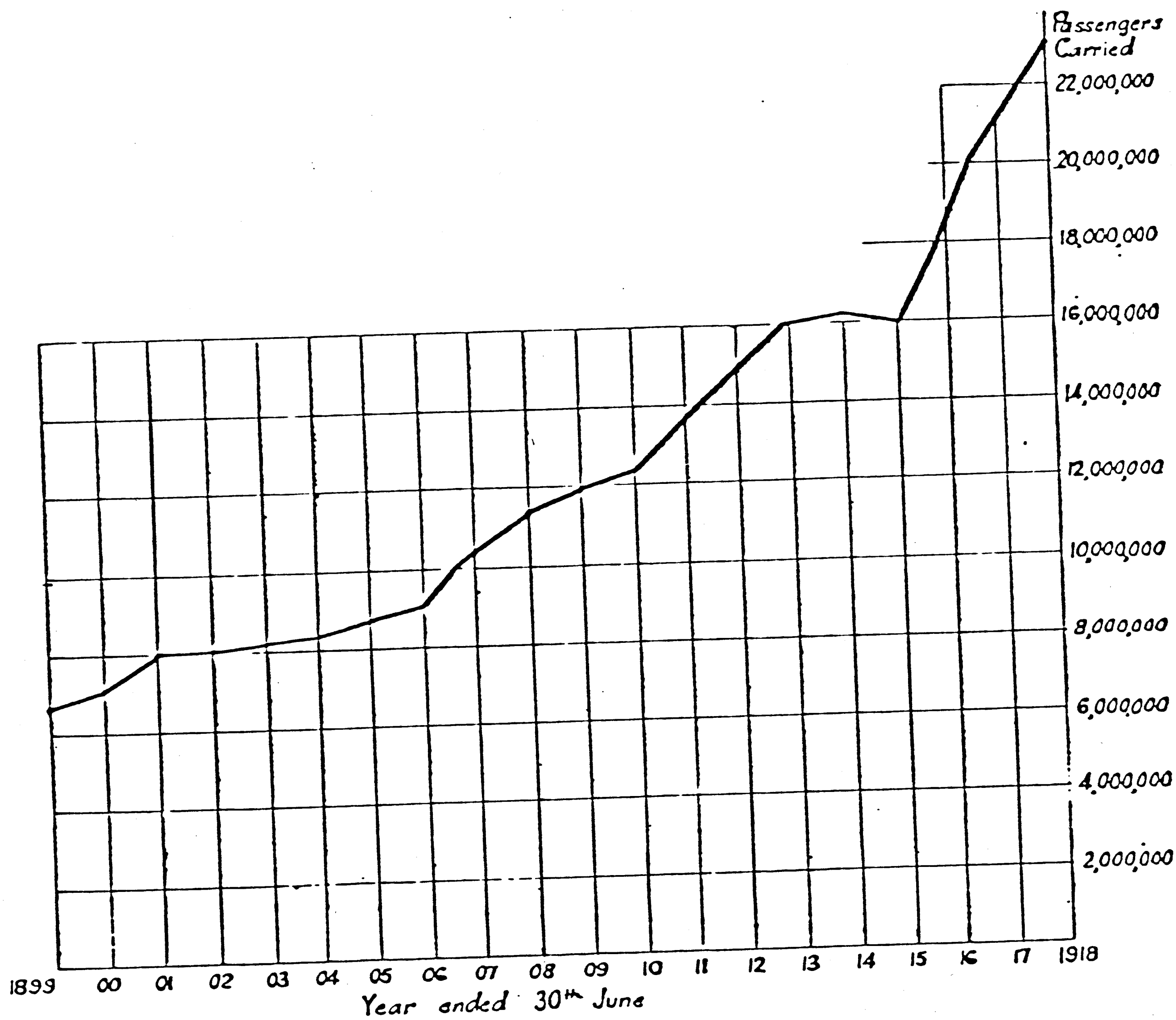
The Richmond Engine House differed from the others regarding the reduction of speed from the Engine Shaft to the Driver Shaft. This was obtained by gear wheels which were very noisy and caused great annoyance to residents in the vicinity of the engine house. After influential protests, the problem of overcoming the difficulty had to be solved. This was done by the introduction of gear wheels with renewable horn-beam teeth, designed to replace the solid metal gear wheels.

The new design was as sketched below:-

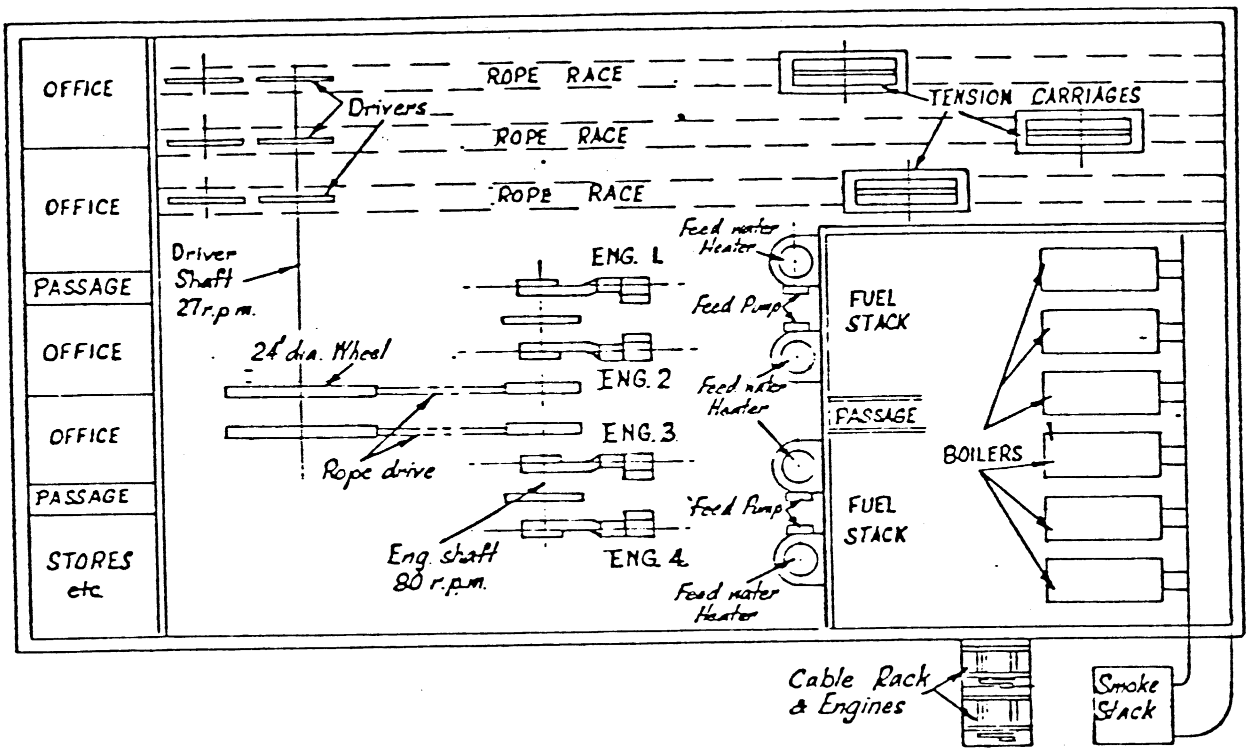


The wheel had rectangular slots (A) round the periphery and through the rim (B). Teeth cut out of horn-beam as shown at (C) with approximate measurements had a tongue (D) which was shorter and narrower than the tooth formation, about 8" x 2" and slightly tapered. This portion (D) was covered with material such as calico impregnated with whitelead, and driven tightly into the recess (A) in the wheel as shown at (E). A steel pin (F) was driven through the hole (H) on each side of the rim of the wheel (B), and through the tongue (D) of the tooth as indicated at (G), locking the tooth firmly in position. The pin (E) was riveted on the outside of each face of the gear wheel. The remaining teeth were similarly fitted, the wheel greased and put into operation. The wheels ran for a very lengthy period and gave satisfactory results. The teeth were always kept on hand, a complete set being machined and finished ready to replace the old ones when worn. The conventional rope drive was later installed, but the gears as described above overcame a difficulty and costly changeover earlier.

The Engine Houses as described above had the required capacity to operate the lines for which they were designed. The period of operation from the date of their opening to about 1918 was satisfactorily performed, but required heavier cables to cope with the growing traffic. The growth of service in 1920 became very pronounced at peak loading, causing a considerable reduction in speed of the cable at two of the Engine Houses due to the limited power of the boilers. The first step taken was to increase the power of the Engine House at St. Kilda, where a forced draught installation was employed on the boilers to increase their steaming capacity. This satisfactorily overcame the difficulty temporarily, but later auxiliary power had to be provided by the installation of an electric motor, which was put into operation when required to cope with heavy loading. The following graph shows the increase of cable traffic over Princes Bridge from 1899 to 1918 and indicates the problem above which eventuated at the St. Kilda Engine House.



At the Nicholson Street Engine House similar increases in traffic called for the employment of a motor as an extra unit to supplement the power of the engines at heavy load periods. Other Engine Houses were able to successfully carry out the heavier duties imposed on them although some were operating at maximum boiler capacity.



2.1 ENGINE HOUSES - CONSTRUCTION.

The Melbourne Tramway & Omnibus Co. constructed 11 Engine Houses, and a twelth was built in Northcote by other authority.
The buildings were of solid brick construction on bluestone foundations with all interior walls in brick. The floors were asphalt in the engine rooms and brick generally in the boiler houses.
All foundations for machinery were concrete, also the cable races, pits etc.
The offices had wood flooring, and the entire building was covered with galvanised corrugated iron roofing.
The location of the 12 Engine Houses was as follows:-

ENGINE HOUSE	LOCATION
Brunswick	N side of Brunswick Rd. on W corner of Black St.
North Carlton	W side of Rathdowne St. on W corner of Park St.
Carlton	N side of Johnston St. 75 Ft. from W.B.L. Brunswick St.
Nicholson St.	E side of Nicholson St. on S corner of Gertrude St.
Fitzroy	N side of Victoria Pde. on E corner of Brunswick St.
Richmond	N.E. corner of Bridge Rd. and Hoddle St.
Toorak	N.W. corner of Toorak Rd. and Chapel St.
St. Kilda	E side of St.Kilda Rd. on S corner of Bromby St.
Windsor	N side of Wellington St. opposite Marlton Cres.
South Melbourne	E side of City Rd. 150 ft. from S.B.L. Cecil St.
North Melbourne	S.W. corner of Abbotsford St. and Queensberry St.
Northcote	E side of High St. on N corner of Martin St.

The following is a typical Engine House layout, showing the engine room, boiler house, cable races, offices etc.

2.2 ENGINE HOUSE - OPERATION.

The Engine Houses were operated under a special staff, controlled by two Superintendents, who were responsible to the Chief Mechanical Engineer, and in later years to the Chief Engineer. One of the Superintendents was in charge of the operation of Engine Houses and Lines on the North side of the Yarra and the other for the Engine Houses and Lines on the south side. Each Superintendent had Foreman or Gangers, as they were originally called, under his control. These men were provided with transport to oversee the operation and maintenance of the portion of the system for which their Superintendent was responsible.

The staff under the Foremen included Engine Drivers, Boiler Attendants, Stokers, Oilers, Greasers, Ropemen, Trackmen and Labourers.

The general layout of the engine houses was very similar, and the type of engines and boilers were generally much the same in design. The boilers which were hand stoked, burnt coal and operated at a steam pressure of 80 to 100 lbs. per square inch. The operation of the engines gave a speed of approximately 80 revolutions per minute to the engine shaft, which by means of a rope drive reduction, made the speed of the main driving shaft 27 revolutions per minute. The main driving shaft revolved the cable driving wheels known as the "Drivers". The drivers varied in diameter over the years, and originally drove the cables at a speed of approximately 8 miles per hour. Later the speed was increased to 10 miles per hour, and finally to 12 and 13 miles per hour by the employment of 13 ft. and 14 ft. diameter drivers.

The exhaust steam from the engines was delivered to vertical cylindrical feed water heaters, entering at the bottom, and passing up through quartz pieces heating the feed water, which was sprayed in at the top and drawn off by the boiler feed pump at the bottom. The cable driven by each driver had its individual race, tension carriage, pulleys etc. The number of cables operating from any particular engine house, depended upon the situation of the engine house and the method to be adopted in operating the cables therefrom. The speeds of the different cables running from any one engine house could also vary, due to the different diameters of the drivers employed to drive each individual cable.

The following table shows the engine houses with the number, speed and approximate lengths of the cables operating from each at the time when they were closed down.

ENGINE HOUSE	NUMBER OF CABLES	SPEED OF CABLES	APPROXIMATE LENGTH OF CABLES
		miles per hour	feet
Brunswick	2	12 & 13	32,000 & 16,000
North Carlton	1	13	13,500
Carlton	2	12 & 13	16,000
Nicholson St.	3	13	21,000 & 20,000
Fitzroy	3	12 & 13	23,000 & 20,000
Richmond	2	13	25,000 & 14,000
Toorak	3	11 & 12	21,000, 17,000 & 14,000
Windsor	1	13	21,000
St. Kilda	2	13	27,000 & 24,000
Sth.Melbourne	3	12 & 13	21,000, 18,000 & 12,000
Nth.Melbourne	3	11 & 12	18,000, 13,000 & 11,000
Northcote	1	13	24,000

The operation of all cables was the responsibility of the engine house Superintendent, including the receipt of new cables, their installation, and the transference of secondhand cables from one line to another.

2.3 ENGINE HOUSE - MAINTENANCE.

The maintenance work in connection with the Engine Houses was undertaken at the Fitzroy Repair Shops. This work covered all engine, boiler and equipment repairs including:-

Renewal of
- Engine Shafts, Crank Discs and Pins.
- Cylinder Liners.
- Pistons, Rings, Rods and Glands.
- Slide Valves.
- Eccentric Sheaves and Straps
- Bearing Brasses.
- Exhaust Pipes, Sheaves, Rope Pulleys and sundries.

Overhaul and Repairs to
- Feed Pumps.
- Feed water Heaters.
- Cable Reel Engines.
- Boilers.
- Stop Valves and Piping.
- Tension Carriages.
- Rope Drivers.

In addition to the above, all tools and plant were maintained in good working order.

The maintenance and repairs to engine house buildings was also undertaken by the workshops, including plumbing and painting. Ordinary running maintenance was attended to by the Engine House Staff, the materials for which were requisitioned from the Stores at the Workshops.

2.4 CABLES.

The important function performed by the cables, which were so inconspicuous in their operation, merits more than general comment. The following, therefore, is a brief record of the life of the cables from the time of their manufacture to the final scrapping.

The cables obtained for the first lines to be opened were imported from England, being manufactured by Bullivant & Co. of Millwall and George Cradock & Co. of Wakefield. The size of these cables was 3½ inches circumference and the tensile strength of the steel employed in their construction was 90 tons per square inch of sectional area. The longest single length was approximately 20,000 feet and the weight about 25 tons. These lengths were produced with continuous wires, free from tucking or splicing a strand, which involved special machinery for their manufacture. From the firms works in England, the cables were transported in special lengths and shipped to Melbourne. On arrival at the Melbourne wharf, the cable which was coiled in the ship's hold, was withdrawn and loaded on to horse drawn lorries. The lorries were arranged side by side in pairs, and the cable coiled on to the first pair until they were loaded. The cable was then led past the horses and on to the second pair of lorries, which were similarly loaded, and so on to the third, fourth etc. until the complete cable was loaded. The lorries in a train proceeded to the Engine House for which the cable was required. It was then unloaded from the lorries and guided by pulley blocks to the cable reel on which it was wound. The cable reel was revolved slowly by its individual steam engine mounted on the end of the cable reel stand.

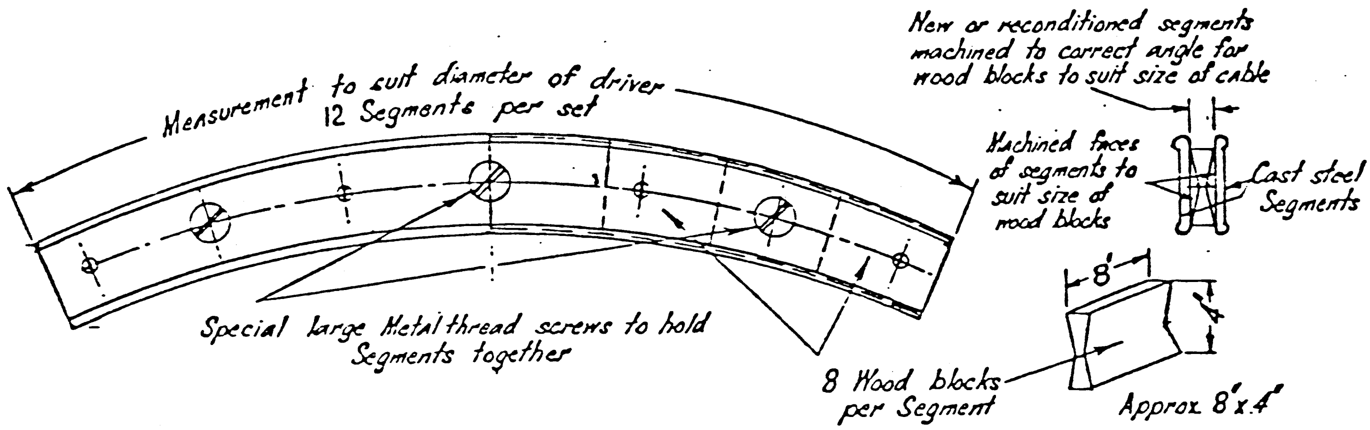
A small pinion mounted on the engine crankshaft engaged with a circular rack on the end of the reel reducing the revolutions to the desired speed. The cable thus stored on the reel was later used to replace an existing worn rope. The replacement of a cable was carried out by first parting the existing one, and temporarily splicing the new one to it. The main engines were then used to drive the old rope, which drew the new one after it until it was replaced. Pulley blocks were used in conjunction with the cable reel engine to pay out the new rope as required and guide it to the rope race where the changeover of cables was carried out. The old cable by similar means was wound on to a second cable reel for future use or to be sold as scrap.

Before further following the performance of the cable, it may be of interest to note an account of the threading of the first cable into Collins Street by J. Bucknell Smith, C.E., from his "Treatise upon Cable or Rope Traction" which I quote as follows:-

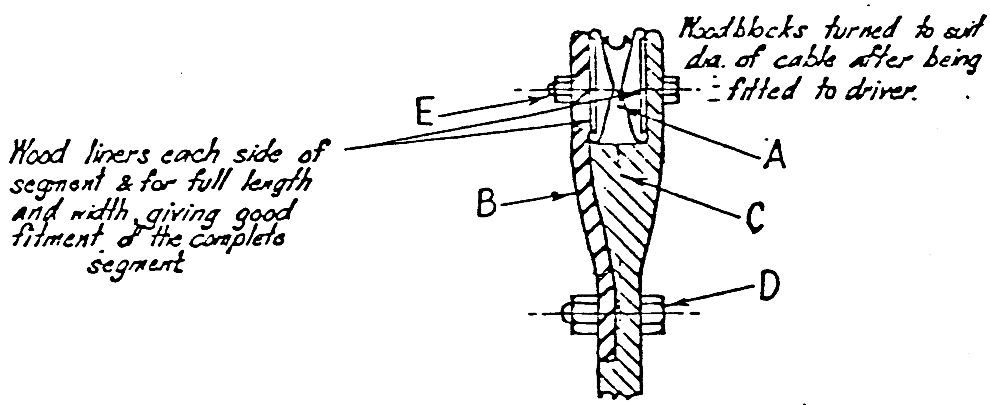
> "The operation of threading the cable from the engine-house at Brunswick-street to Spencer-street and back, a distance altogether of 3½ miles, was watched with great interest by a large number of spectators. The rope weighed 28 tons, and was manufactured by Messrs. Cradock and Co. This was rolled on an immense drum, and had to be drawn from same through 1¾ miles of covered track and back again. The end of the cable was made fast to the gripper of a dummy car, which was drawn forward by a gang of men, carrying the rope with it. In a short time, however, the resistance became too great to be overcome in this way, and horses were employed. Eight animals were harnessed, but proved too few, and four more were added. These carried the car along for a time until the gripper suddenly snapped, and operations had then to be suspended until it was welded. A fresh start was made two hours after, and the terminus was ultimately reached without any serious mishaps. The cable was then led round the end pulley by means of a short auxiliary piece which had been previously placed in position, and then the return journey was made with twenty-four horses."

Continuing from the replacement of the old cable with the new one, it was then taken round the tension carriage sheave and permanently spliced. The tension carriage was brought well forward to a position where as much length as possible could be allowed for stretch of the cable. The lower portion of the tension carriage was located by large pawls being engaged in a rack on each side of the cable race, permitting the carriage to be moved back as the cable stretched. The upper portion of the tension carriage, on which the 13'-2" diameter cable sheave was mounted, was free to run on rails fixed on the lower portion, and by means of a heavy weight a tension was maintained on the cable.

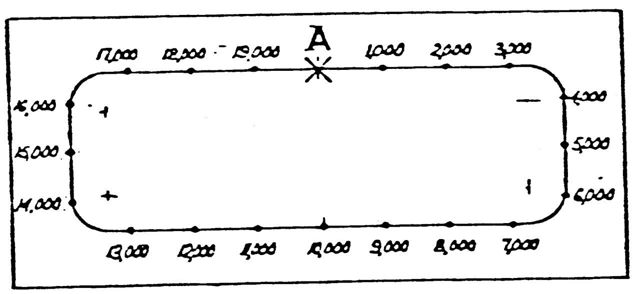
The wheels used for driving the cable were 12 ft., 13 ft. and 14 ft. in diameter and were known as the Drivers, being situated at the front end of the cable race (see engine house layout). The drivers were fitted with segments which were renewed or reconditioned when they became worn or when a new cable was placed in operation. The segments were cast steel with hardwood blocks, the arrangement of which is shown in the following sketch:-



The driver rim into which the segments (A) were fitted, had loose segments (B), which were bolted to the main wheel (C) by the bolts (D) and bolted through the segments as indicated at (E) in the following sketch:-



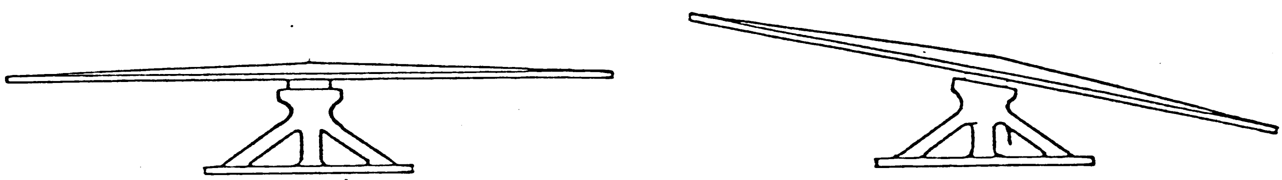
The new or reconditioned segments were always employed for driving a new cable to prevent undue wear. From the rolling stock side, new dies were fitted to all grips operating on a line where a new cable was running. This minimised wear on the rope because the old dies, being worn, tended to damage the new cable by forcing it into the deep grooves formed by the old one, also the deep grooves in the worn dies gave rise to severe and dangerous operation of grips.
The rope driver shaft was fitted with a revolution counter, and by this means the splice and any faults in the cable could be kept in view after being recorded on the blackboard. The blackboard was mounted in a convenient position for chalking records of cable faults. The permanent marking on the board was a line representing the cable and figures indicating its length. Separate boards were used for each rope being driven from the same engine house, and the lengths marked on them. In the sketch below a 20,000 ft. cable is represented with the splice at (A), and each 1,000 feet of its length marked.



If a fault, such as a loose strand, kink, or any other damage to the rope be observed, it was chalked on the board, and specially examined after service at night, unless urgent attention had to be given immediately. When repairs had to be carried out during service hours, serious delays occurred, this was often avoided by slowing the speed of the rope down for inspection when the fault came through the engine house, to see that it had not deteriorated. Some times a stoppage of a few minutes sufficed to execute temporary repairs, such as cutting off or tucking a strand, which enabled the cable to operate until after service at night.

An alarm bell was installed in the cable race, which rang if the incoming cable had a strand protruding. If the alarm sounded, the engine driver shut down the engines to a very slow speed or stop, while the ropeman examined the fault to determine what action was necessary and to record the fault on the rope blackboard.

The cable when leaving or entering the engine house is guided round sheaves which are known as "horimontals"; these sheaves revolve either flat or angular, depending on the direction of the rope to or from the cable tunnel, as sketched below:-



In the tunnel along the straight track, line pulleys were spaced about 33 feet apart, on which the cable ran. When an angular change in direction occurred between one road and another, the cable either ran round a 12 ft. diameter angle sheave mounted on a pedestal as above or round drums. Where a sheave was used, the cable was thrown out of the grip, but with curve drums, it was carried round the curve in the grip. This operation is covered in the section of this report dealing with the operation of grips.

The cable at termini was carried round a 12 ft. diameter terminal sheave, mounted on a pedestal as previously referred to, and installed in a terminal pit specially constructed for its operation and maintenance.

Other pulleys used throughout the service were of the following types:-

Line Pulleys used on straight tracks.

Race Pulleys used in engine house cable races.

Elevating Pulleys used to elevate the cable where necessary.

Pick-up Pulleys used where the cable had to be lifted into the grip.

Curve Drums used on various curves with rubbing bars.

Line Drums used where cable became unsteady, as when being thrown out of grip.

Depression Pulleys used to depress cable where necessary.

There were several of each of the above types of pulleys, which varied in diameter and width of face to suit individual requirements. The conditions governing these requirements were such as, depth of tunnel, radius of curves, location of pick-ups, location of depression and elevation of cable etc.

Great damage was caused to the cables in the early years of running due to the gripman failing to throw the cable, resulting in cutting or badly kinking it. This damage sometimes caused very great dislocation of services, and as a result "check bars" were installed. The check bar which was made of 4" x 1¼" mild steel, was set in concrete at the bottom and fixed to the slotbeam at the top, so that the grip passed one side of it and the cable the other. Should the rope be retained in the grip it pulled the grip over so that it struck the check bar, with the immediate result that the brittle grip parts broke and automatically the cable was released without serious damage.

The cables after running on busy lines for a certain period, showed indications of wear depending on the severity of serice. When they were considered to be beyond use for heavy service, they were transferred to a suburban end of the line. Having completed a further life on the lighter service, the cable was scrapped and sold locally as such.

As recorded above the original cables were 3½" circumference, but due to increased traffic, the final size employed was up to 4¼" for St. Kilda Road and Collins Street and 3¼" for other cables running on suburban ends.

It is of interest to note that a cable taken out of the Fitzroy Line about 1912 ran for 4 years and 7 weeks and covered a distance of 286,115 miles.

3. PERMANENT WAY - GENERAL.

The Melbourne Tramway & Omnibus Co. in its system of Cable Tramways in Melbourne and Suburbs operated 88.32 miles of single track. These lines were constructed, and opened for service between 1885 and 1890.

The following table sets out the various routes operated, the length of the route, the date on which it was opened for service, and its track mileage. An additional column shows the extra miles of track opened when the route traversed portion of a route previously opened.

ROUTE OPERATED	LENGTH OF ROUTE	DATE OPENED FOR TRAFFIC	TRACK MILES	
			FOR ROUTE	TO COMP ROUTE
	Miles			
Richmond & Spencer St.	3.605	11/11/85	7.21	
Fitzroy & Spencer St.	3.695	2/10/86	7.39	
Victoria St. & Spencer St.	3.605	23/11/86	-	4.11
Clifton Hill & Spencer St.	3.795	10/8/87	7.59	
Nicholson St. & Spencer St.	3.345	26/8/87	-	3.53
Brunswick & Flinders St.	4.450	1/10/87	8.90	
Carlton & Flinders St.	3.215	21/12/87	6.43	
Brighton Rd. & Queensberry St.	5.000	11/10/88	-	9.40
Prahran & Flinders St.	4.930	26/10/88	-	7.20
Nth.Carlton & Flinders St.	2.715	9/2/89	-	2.48
Toorak & Queensberry St.	4.950	15/2/89	-	2.70
Nth.Melb.& Flinders St.	2.915	3/3/90	-	4.61
West.Melb.& Flinders St.	2.050	18/4/90	-	3.50
Sth.Melb. & Spring St.	3.600	17/6/90	-	5.68
Port Melb. & Spring St.	3.535	17/6/90	-	3.70
Windsor & Esplanade	1.945	27/11/90	-	3.89
Esplanade & Flinders St.	4.525	27/11/90	-	-
			37.52	50.80

M.T. & O. Co. TOTAL TRACK MILES		=	88.32
Northcote and Clifton Hill	2.250		4.50
TOTAL CABLE LINES		=	92.82

The permanent way design as originally adopted, gave very satisfactory service. After the lines had been constructed, standardisation of certain items used was given urgent attention. Details were not specifically stated for the permanent way fittings such as sheaves, switch points, pulleys etc., with the result that contractors used these items with minor variation. This called for the selection of a suitable standard for adoption. An instance of this trouble was cable pulleys with over 100 different sizes in use on the various lines. This number was finally reduced to between 25 and 30.

Another problem in recent years, with heavier and faster road vehicles, was that the cast iron manhole covers (one every 33 feet of single track) were frequently broken. This trouble rapidly increased and urgent action had to be taken to manufacture mild steel covers to replace the cast iron ones.

All permanent way curves throughout the service were concentric; and radius of any curve stated was the centre line measurement between tracks. The following is a summary of all curves:-

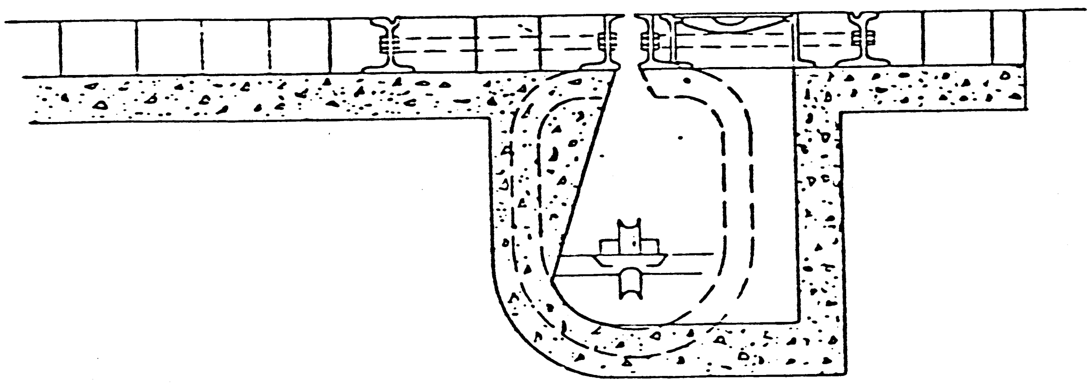
SINGLE CURVES.		
RADIUS	AVERAGE LENGTH	NUMBER OF CURVES IN SERVICE.
50'-0"	78'-8"	3
55'-0"	85'-8"	1
65'-6"	102'-0"	1
90'-0"	119'-5"	17
100'-0"	86'-2"	5
132'-0"	92'-5"	9
198'-0"	62'-9"	6
264'-0"	74'-1"	28
396'-0"	62'-8"	16
COMPOUND CURVES.		
50'-0" & 65'-6"	84'-8"	2
65'-6" & 80'-0"	115'-9"	2

NOTE. No casement curves were used, trams swinging straight into curves.

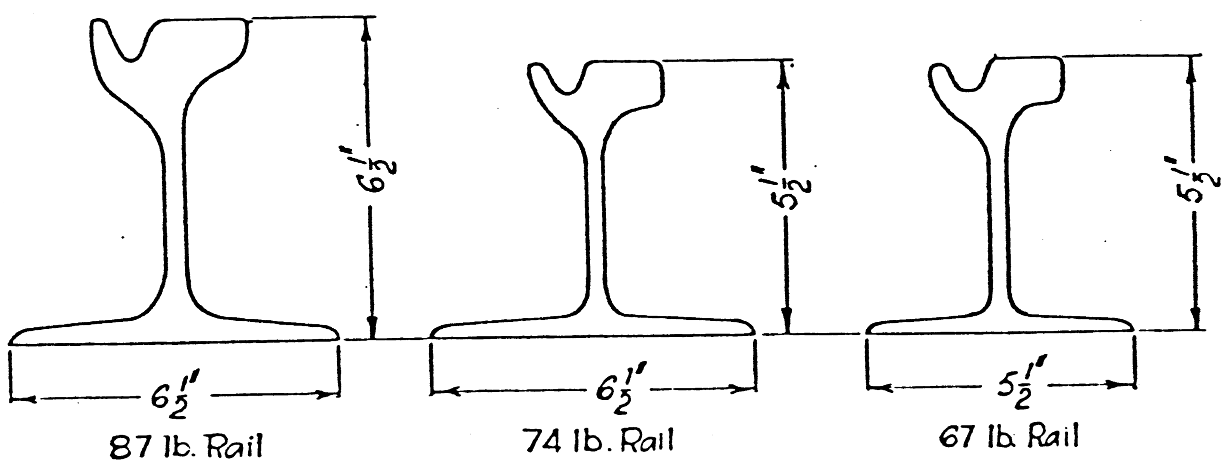
3.1 PERMANENT WAY - CONSTRUCTION.

The construction of all the Permanent Way was very similar. The only variations being in the rail and slotbeam sections used, and as previously mentioned, differences in the details of fittings such as pulleys etc.

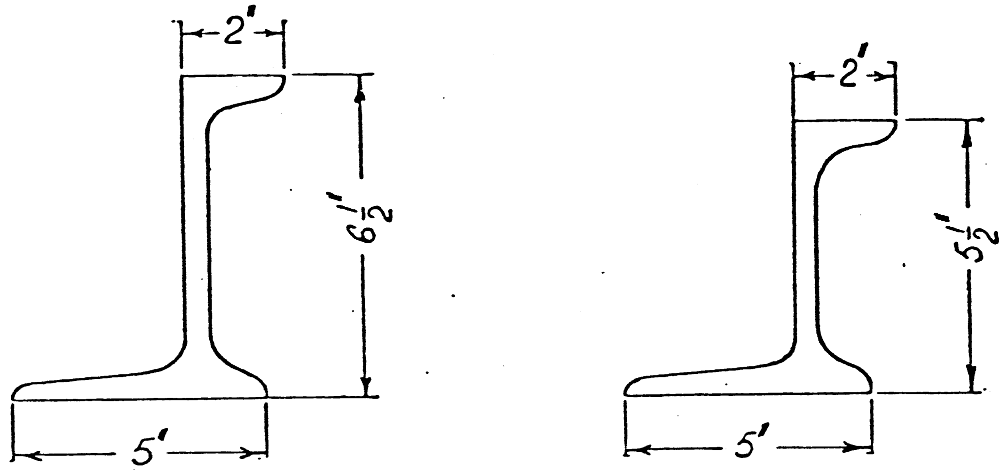
The following sketch shows a typical cross section of one track, to the centre line between tracks.



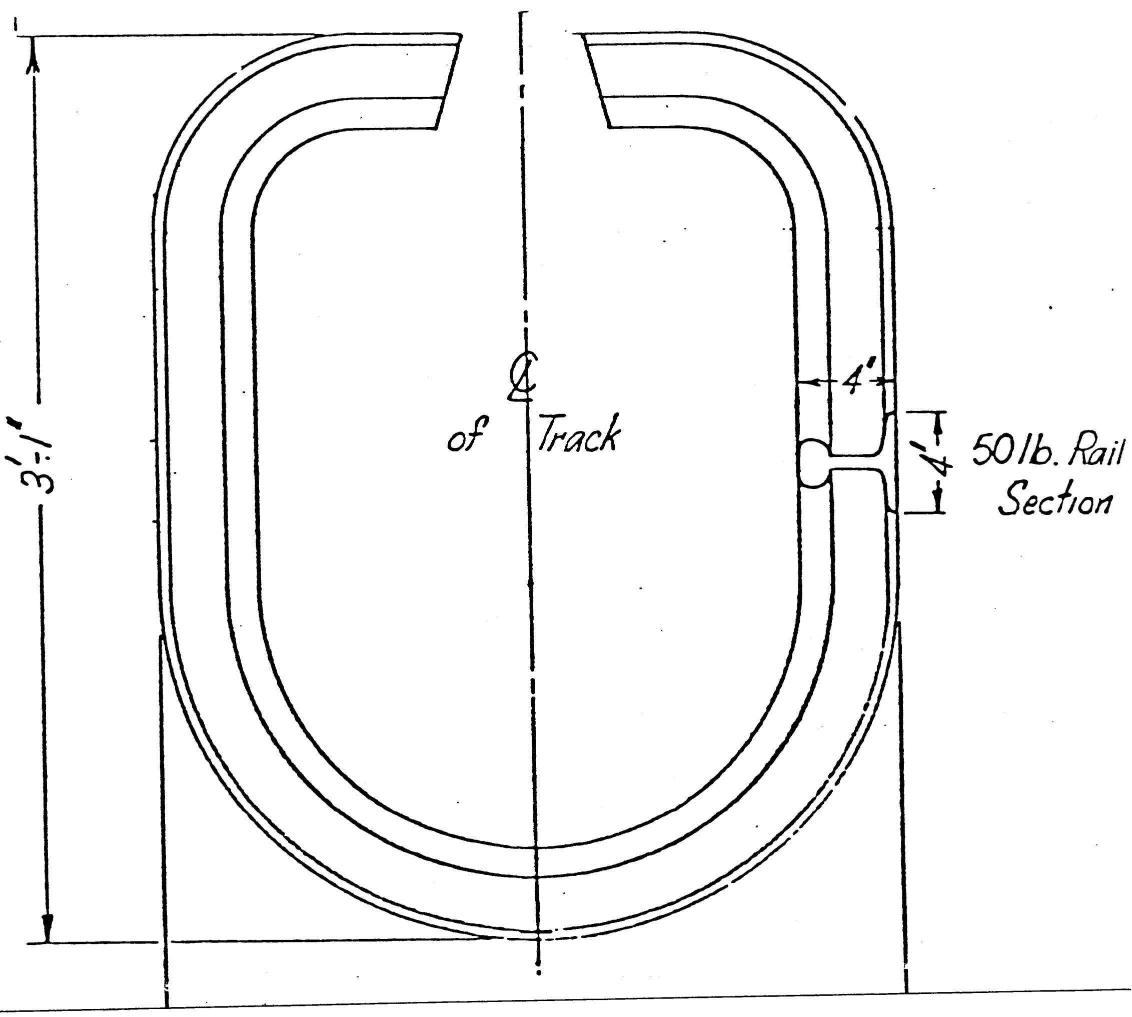
The three sections of rails used are shown below. The fish-plates employed for all three sections were 18 inches long, with 4 bolts per pair, the bolt spacing being 4 inches centres.



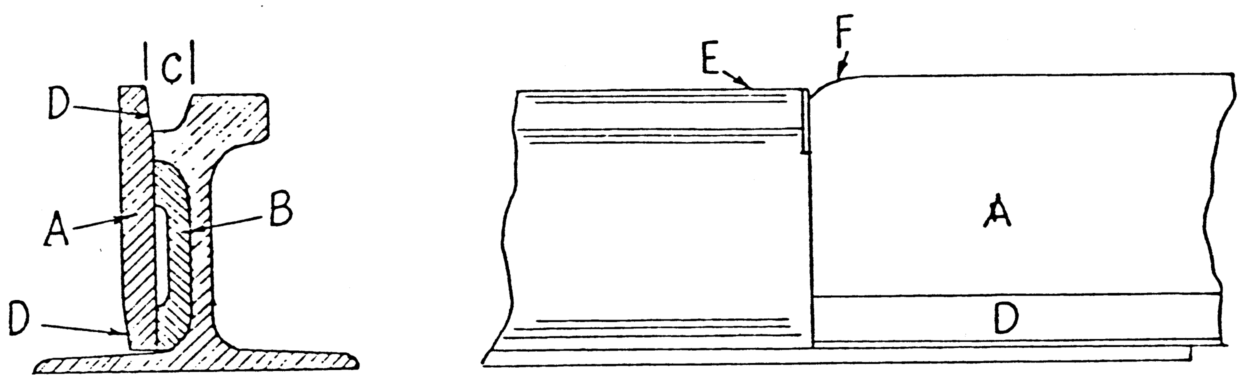
Two sections of slot beams were used, as shown below. The fishplates used for both sections were 18 inches long with 4 bolts per pair, spaced at 4 inch centres.



The yokes set in the concrete to form the tunnel and support the slot beams were made of 4" x 4" x 50 lb. rail section as shown, and spaced at 3 ft. centres along the tunnels of each track.

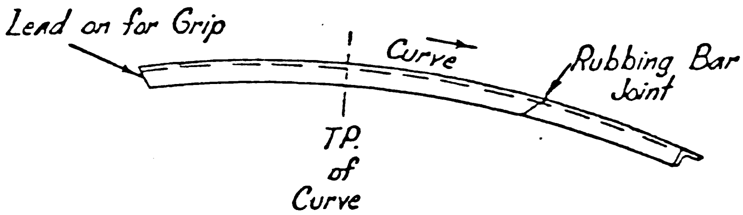


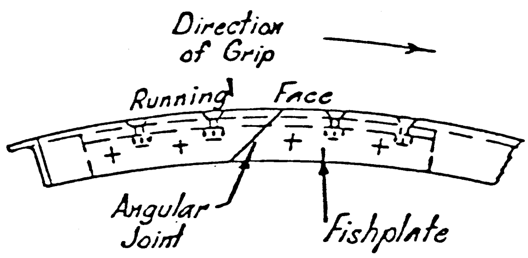
As previously mentioned, the curves in the cable system were all concentric, and the radius taken to the centre line between tracks. All the lower radius curves had the inner rails of each track fitted with guardplates. The guardplates commenced before the tangent point of the curve was reached, and carried round beyond the T.P. at the trailing end of the curve. At the commencement of the guardplate the lip of the rail was planed off to $\frac{3}{4}$ inch from the running edge and then increased to the desired maximum width of groove for the curve, after which it was reduced back to the $\frac{3}{4}$ inch width at the other end of the curve. The guardplate was also fitted to give the desired height above the head of the rail to suit location and speed of trams. The following sketch indicates the method of construction:-



The guardplate (A) is fitted to the rail as shown, with the cast spacing block (B) packing it out to the desired width of groove (C). The spacing blocks (B) were cast in thicknesses of from $\frac{3}{8}$ inch to $1\frac{1}{4}$ inches in $\frac{1}{8}$ inch steps. This provided for the guardplate being packed out gradually to the desired width of groove and reduced again on the other end of the curve. The guardplate which was $5\frac{3}{8}$ inches high by $\frac{3}{8}$ inch thick was reversible the section providing for double wear, it being slightly tapered as indicated at (D). The height of the guardplate (A) was above the top of the lip of the rail (E) at its commencement and rounded as shown at (F).

Bolts were used at each spacing block, bolting the guardplate, spacing block, and rail together. Spacing blocks were 2 to 3 ft. centres. Tie rods passed through rail and guardplate only. The rubbing bar used at curves for the grips was constructed of 3" x 3" x $\frac{1}{8}$" angle steel in suitable lengths for their installation. A lead on for the grip was provided, and the general construction was as shown below. The fishplates were made of $2\frac{1}{2}$" x $2\frac{1}{2}$" x $\frac{1}{8}$" angle steel, being curved and ground to fit inside the rubbing bar angle. Countersunk fishbolts were used on the running face and ordinary hexagon bolts on the horizontal. The rubbing bar joint was made as shown in the sketch by cutting the rubbing bar at a 45 degree angle. It will be observed that this joint provided a smooth run for the grip off one length of bar and on to the next length, even if the joint became slightly faulty.





Cable Pulleys were employed every 33 feet of straight track to support the cable in the tunnel. Manholes were also placed at each pulley so that maintenance of pulleys and their bearings could be carried out. Where the manholes existed, a square recess was concreted as shown in the track cross section. The tunnel formation on both sides at all other places was as shown on the side opposite to the manhole recess.

3.2 PERMANENT WAY - OPERATION.

The permanent way operation was under the supervision of the Engine House Superintendents.

The section of permanent way operating from any particular engine house was the portion of the line operated by the cable driven from that engine house.

The operation of the tracks and tunnel equipment was given regular inspection. Curves were greased as a general practice, but particularly in places where the cable was thrown out of the grip and the tram operated on momentum for any distance or on an up grade. These conditions existed at the corner of Chapel St. and Toorak Rd., where the cable was thrown out of the grip in Chapel St., and the tram ran round the curve on to an up grade to the pick-up mark in Toorak Rd. When a north wind was blowing, and this curve became dirty with grit and dust, men were employed to uncouple and push the dummy, then the car, round the curve, and recouple the tram again. This operation created a problem to improve these conditions. About 1924 an easement curve was designed and manufactured at the repair shops after observing the following limitations:- Firstly the slot had to remain in its present position, and secondly the rails were not to vary more than 2½ inches from their existing position. After installing this curve one Saturday night, the gripman on the first tram was instructed to approach the curve at under half speed. This was carried out and the tram easily ran round to the pick-up; the men who were ready to uncouple and manhandle the tram were not required. The success of this curve was evident, in that no trouble developed at any time after it was placed in operation. This was the first and only easement curve ever used in the cable system.

The operation of shunts or crossovers and turnouts performed important functions throughout the system and at termini. The operation of the "flying shunt" has been described under the heading of "Operation of Grips" due to the important part the grip performed in the switchpoint operation.

Other methods of shunting which operated at termini were:-

1. On up grades

Diagram A.

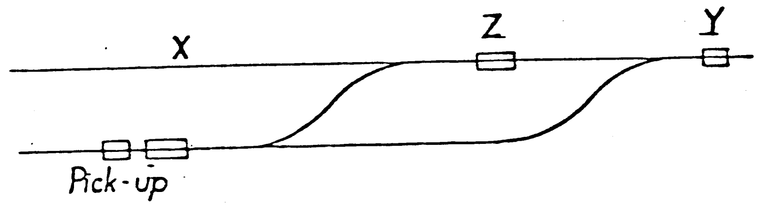
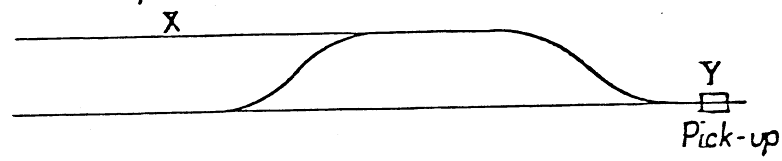
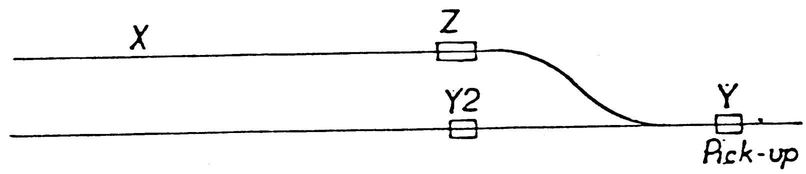


Diagram B



2. On down grades



1. On up grades as shown at diagram A, the tram reaches the position X, where the coupling pin is withdrawn, allowing the dummy to proceed to the position Y, the car being stopped at the position Z. The dummy brakes are released, allowing it to run down grade to the pick-up. The car brakes are then released, allowing it to run down to the dummy, to which it is then coupled.
   At diagram B, a very similar procedure is carried out, the difference being that the dummy runs over the turnout before stopping at the position Y where the cable is picked up. The car operation is the same as at A. This second method B was usually adopted if the gradient was only slight.
2. On down grades the coupling pin was withdrawn at X, the dummy running over the turnout to the position Y where

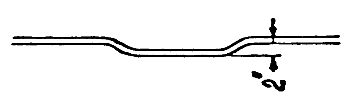
the cable was picked up. The car was stopped at Z. The dummy by gripping the cable moved up to the position Y2.

The car then ran down over the turnout, where it was stopped and the dummy allowed to run back to the car for coupling.

In many places car crossovers were installed in order that shunting of trams could be managed in cases of emergency. At these shunts, grip hatches were placed on each track, so that the grip could be lifted out of the tunnel on one track and lowered into the tunnel of the other track. This operation enabled a dummy to be shunted on a car crossover and so avoid the expensive installation of dummy crossovers.

Other positions where grip hatches were installed, included places adjacent to junction or intersections, in order that the grip could be lifted out of the tunnel in case of any emergency. The slot opening between slotbeams was important for the efficient operation of the permanent way, in order that grips were not unduly worn. This opening had to be maintained at $\frac{7}{8}$". A point of interest was on the occasion of a fire in Chapel Street near Greville St. one Sunday morning. The water from the fire hoses, together with the heat of the fire, swelled the wood blocks in Chapel St. and entirely closed the slot. This caused considerable delay to traffic on Sunday afternoon, before the blocks were removed and the slot opened.

Slot deviations were used to move the grip across for automatic pick-up operation. The deviations were shaped thus:- and were approximately 2 inches.



Dummy Heads were in operation where the slot branched, as at a junction or crossover. The dummy heads were very substantial and were provided with a slot tongue, which operated between the two top plates of the dummy head and closed the slot on one track where the slots divided. The point mechanism was connected with the slot tongue and manually operated where facing points existed. When trailing, the points and tongue were operated by the wheels and grip.

Rubbing Bars were in operation on all curves where the cable was carried round the curve in the grip. The spacing of curve drums depended on the radius of the curve, the greater the radius the greater the distance between drums. The grip when carrying the cable pressed hard against the rubbing bar. This pressure was taken on the grip top die holder or the backguard depending upon which way the curve turned. The backguard was fitted to the grip for the rubbing bar operation only, and provided a face on the opposite side of the grip corresponding to the top die holder.

3.3 PERMANENT WAY - MAINTENANCE.

The maintenance of permanent way together with all tunnel and underground equipment was carried out by the engine house staff under the Superintendent of the northern or southern section of the system.

The permanent way and tunnel maintenance work, which required regular attention, included all road surfacing such as wood blocking, rail levels, rail joints and openings between slot beams; also cleaning of grip hatches, switchpoints, stop marks etc. The underground work embraced the greasing of pulleys, sheaves, pick-ups and point mechanism, together with any minor repairs or adjustments required. Any replacement work considered necessary was ordered for manufacture at the repair shops. The items manufactured for permanent way replacement work included curves, special work, dummy head tongues, switchpoints, slot deviations, operating mechanism etc. and for tunnel or underground sheaves, rubbing bars, pick-ups and all rope drums, pulleys, bearings etc. The installation of all work made for replacement was done by the permanent way staff under the control of the Superintendent concerned.

Annually sweeping, tarring and sanding of woodblocking on all lines was carried out during summer.

The straight tracks were cleaned by scraper cars, referred to under "Rolling Stock General", and at curves or special work men swept the grooves and greased the guard rails.

Tunnels were maintained in clean condition by the use of tunnel tools, which were scrapers with blades shaped to the tunnel, which were let down the slot and drawn along from manhole to manhole, where the dirt was removed by the use of a rectangular scoop, being lifted up through the manhole.

4. REPAIR SHOPS - GENERAL.

The Tramways Repair Shops at Nicholson Street, North Fitzroy, were constructed and equipped to carry out all works in connection with the operation of the cable tramway system.

After the bogie cars were constructed at the Repair Shops for the Brunswick line, a shop was set up at the car depot, for convenience in painting the long bodies; the bogie trucks, brake gear etc. being transported to the Nicholson Street Shops for overhaul.

The only other minor workshop used was a room at Head Office equipped for the maintenance and repairs of bell-punches and ticket nippers for the traffic department.

The following is a general summary of the work performed at the Tramway Repair Shops:-

Rolling Stock.	Construction, overhaul and maintenance of all vehicles including grips, also manufacture and maintenance of rolling stock tools and equipment.
Permanent Way.	Manufacture of renewals of shunts, special work, curves, dummy-heads, kicker bars, switchpoints, rails, slotbeams, slot deviations, switchpoint mechanism, signalling gear, tie rods and track fittings, also repairs to tar carts, drays, tools etc.
Cable & Tunnel Equipment.	Manufacture or renewals of sheaves, pulleys, pulley frames and grease boxes, check bars, rubbing bars, manhole frames and covers, cable pick-ups, grip hatches and special tunnel tools.
Engine Houses.	Repairs and replacements of engine and boiler components and fittings, feedpumps, engine shafts

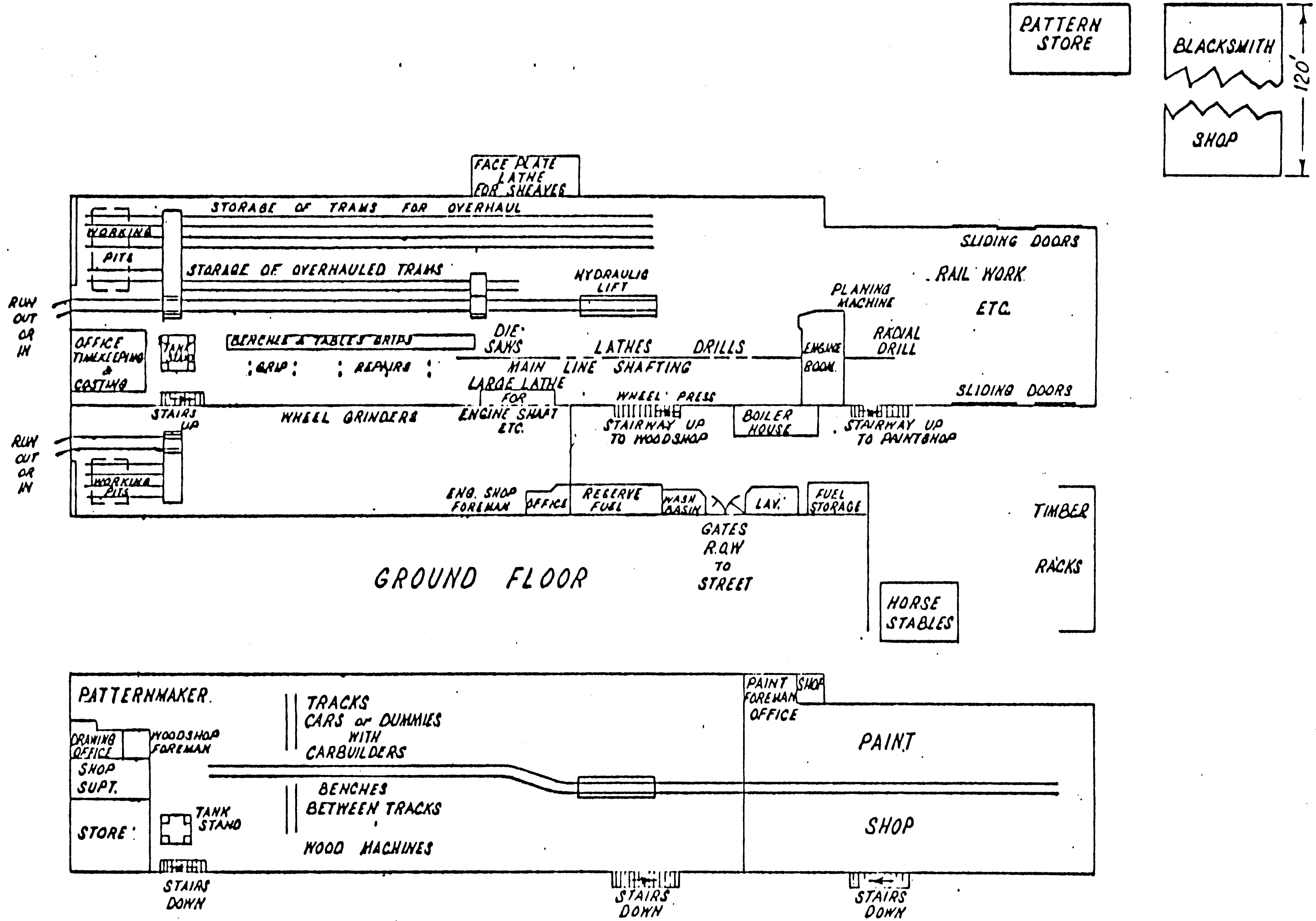
cable drivers, tension carriages, cable drums and engines, tools and equipment.

Buildings. Repairs and maintenance of engine houses, car depots, Head Office and Repair Shops, also all maintenance of hydraulic lifts at Head Office and Repair Shops.

4.1 REPAIR SHOPS - CONSTRUCTION.

The construction of the Repair Shops building was very similar to the car depots. The supporting pillars, wall timbers, windows, roof principals, skylights etc., also the corrugated iron wall and roof were of the same materials and very similar in design. The main point of difference being that the main building from Nicholson Street to the rear was two storied. The ground level was used for the engineers' shop, engine room and machine shop, with the exception of a small area fronting the street which was employed as a general office for timekeeping costing etc. The upstairs area immediately above the ground floor office was occupied by the Shops Superintendent, his staff clerk and assistant, also a store. The remainder of the floor was employed by wood machinists, car builders, carpenters, patternmaker and painters. The paint shop was situated at the rear and partitioned off from the woodworking section. A hydraulic lift was built about midway through the building for elevating cars and dummies from the ground floor up to the woodshop or paintshop. From the lift a combined traverser and turntable was used to convey the dummy or car to the woodshop or paintshop and turn it into the bay desired.

The following general plan of the Repair Shops shows the area on which the workshops were constructed. The layout of the various shops is indicated, together with tracks, and the special machines installed for the cable tramway work. The run-out or run-in tracks from Nicholson Street are also shown. The tank stand situated behind the general office supported a tank above the roof level, which was erected as an emergency water reserve for fire fighting.


PATTERN STORE
BLACKSMITH
SHOP
120'
FACE PLATE LATHE FOR SHEAVES
STORAGE OF TRAMS FOR OVERHAUL
WORKING PITS
STORAGE OF OVERHAULED TRAMS
HYDRAULIC LIFT
SLIDING DOORS
RAIL WORK ETC.
PLANING MACHINE
RADIAL DRILL
ENGINE ROOM
RUN OUT OR IN
OFFICE TIMEKEEPING & COSTING
TANK STAND
BENCHES & TABLES GRIPS
GRIP
REPAIRS
DIE SAWS
LATHES
DRILLS
MAIN LINE SHAFTING
LARGE LATHE FOR ENGINE SHAFT ETC.
WHEEL PRESS
SLIDING DOORS
STAIRS UP
WHEEL GRINDERS
STAIRWAY UP TO WOODSHOP
BOILER HOUSE
STAIRWAY UP TO PAINTSHOP
RUN OUT OR IN
WORKING PITS
ENG. SHOP FOREMAN
OFFICE
RESERVE FUEL
WASH BASIN
LAV.
FUEL STORAGE
TIMBER
RACKS
GATES R.O.W TO STREET
GROUND FLOOR
HORSE STABLES
PATTERNMAKER.
TRACKS CARS or DUMMIES WITH CARBUILDERS
PAINT SHOP FOREMAN OFFICE
DRAWING OFFICE
WOODSHOP FOREMAN
SHOP SUPT.
PAINT
BENCHES BETWEEN TRACKS
STORE
TANK STAND
SHOP
WOOD MACHINES
STAIRS DOWN
STAIRS DOWN
STAIRS DOWN

track for return to its depot. All repairs and overhaul of grips was performed separately to the dummies and cars, being handled by the engineers' shop to which the grips were directly delivered after being transported from the car depots by lorry.

All engine house or permanent way work for repairs, of a portable nature, was collected from the various engine houses by lorry and brought to the repair shops, it being placed in the particular shop where the necessary work to be performed was carried out. Permanent way curves, special work, rubbing bars etc. required for replacements were manufactured at the workshops, the necessary authority for the work being supplied by the engine house Superintendent.

All work other than rolling stock was carried out on written authority from the officer responsible for the operation of the department concerned.

The power required for the operation of all machines at the Repair Shops was obtained from a steam plant, the engine driving a main line of shafting (see plan under Repair Shops Construction). The individual machines were equipped with their countershafts and other necessary gearing. The wood machines on the upstairs floor were also driven from a line of shafting driven by belting from the main line shaft below.

The workshops were called upon to carry out special operations for specific tramway requirements. This necessitated the installation of machines and equipment for the work, the following being the more important ones:-

1. Centre Lathe used for turning engine shafts, approximately 15 ft. long by 16 inches in diameter, crank discs about 4 ft. 6 ins. diameter, sheave pins 9 ins. diameter and similar work of this nature.

2. Large Faceplate Lathe used for mounting and turning complete sets of driver segments, machining sheaves including 13 ft. and 14 ft. diameter cable drivers.

3. Grinding Machines for dummy and car wheels with the axle mounted between centres and geared to revolve at very low speed. Two saddles, one for each wheel, were employed with grinding wheels running at high speed, being revolved by a special belt drive. The grinding wheels were fed to the car wheels very slowly by large ratchet wheels operated by pawls on long levers,

which were moved by a bar clamped to the axle. The feed of the grinding wheels could be manually operated if desired.

4. Cutting Machines for grip dies. These machines slowly revolved disc saws with special tooth formation to cut the double bevelled end on the dies.

5. Special Grinder for rope pulleys and drums. The machine was specially adapted to take the various types and sizes of pulleys used in the system. Easy changing of grinding wheels to suit the various types of pulleys and drums was also a special feature of the machine.

6. Special Equipment for boring out cylinder liners in situ at the engine houses, and work of a similar nature was maintained at the Repair Shops. This equipment, including a steam engine, gearing, piping, cutter bars, feed screws etc., was kept in first class order at the Repair Shops. It was always an operation carried out by the workshops staff under the Workshops Supt. A portable steam boiler was also kept available for work to be undertaken where steam was not available.

The Blacksmiths' Shop had 16 forges in constant operation to cope with the forging requirements of the system. The rolling stock, including grips, called for many forged components, and, in addition, engine house and permanent way forgings were numerous. All cartage, including stores, was done by the Repair Shops.

4.3 REPAIR SHOPS - MAINTENANCE.

The staff employed at the Repair Shops under the control of the Repair Shops Superintendent, carried out all maintenance work, including the building and plant.

The building construction as previously described called for very little maintenance, but the plant, including the machines, engine, boiler and hydraulic lift required considerable upkeep and were repaired or overhauled when necessary. This work was done either at weekends, or if a lengthy job was demanded, it was usually carried out during the Christmas Holidays; minor maintenance work was performed at night or on Saturday afternoons.

At Easter, machines were checked over and stock of all machine tool equipment was taken. Under the supervision of the Machine and Engineers' Shop Foreman it was possible to maintain the various machines and equipment in good order and have available all cutting tools and accessories for which the operators were made responsible. Lockers were provided for the safe-keeping of these items.

The maintenance of vehicles attached to the Repair Shops, which were also portion of the Shops equipment, was maintained by the staff which included a wheelwright.

The maintenance of run-out and run-in tracks, together with track-work within the shops, was carried out by the permanent way staff.

5. ROLLING STOCK - GENERAL.

The original Rolling Stock for the Richmond Line was imported from America, and subsequently all further construction of trams was carried out at the Tramway Workshops. The construction of the Cable Rolling Stock was of a light design and proved capable of standing up to the service for which it was designed. The various parts used were standardised and carried in stock to meet all immediate requirements for accident or maintenance purposes. Most of the metalwork parts were forgings, which included brake gear, drawbars, safety hooks, lifeguard supports, dash frameworks, scrolls, braces, knees and many other small parts. These components were manufactured at the Tramway Workshops and stocked in a finished condition at the Workshop Stores. The woodwork parts were also machined and finished at the Workshops and stored in a similar manner to the metalwork. Other items required for the construction and maintenance of the rolling stock were also held at the store, whether of local manufacture or purchased.

A very evident advantage of the light weight rolling stock was its portability. This enabled vehicles to be moved by a horse-drawn lorry designed for the purpose. The lorry decking was approximately 2 feet above ground level and had rails fixed on it to track gauge. Ramps were provided with attachments for fixing it to the lorry and fitted with metal tie rods and spreaders. These ramps were readily assembled or dismantled for man handling and transport. A winch was mounted up forward on the deck of the lorry, and by means of a cable the dummy or car was drawn on to the lorry for transport. The winch was also used for lowering the vehicle off the lorry. This method of moving rolling stock was particularly useful in the event of accident or during full service periods when a vehicle had to be moved from Depot to Depot or to or from the Workshops.

Another useful device was a portable shunt or crossover, used when a line was likely to be blocked for a lengthy period. The shunt could only be placed where grip hatches (see 5.3.2) existed near to the point of blockage or hold up. The construction of the shunt was wood with metal facings and fitments for spiking down to the woodblocking and bolting a moveable portion to the section secured. The moveable portion was that which covered the track on which the approaching trams ran;

this could be easily man handled and when in position it was located in the rail grooves. Later, many more permanent shunts were put in where required and the portable shunt went out of use.

Trams were painted colours to indicate the route on which they ran. The colours used were red, blue, green, yellow and white. At night an amber light was shown on white cars because the kerosene lamps showed yellow if placed behind a white or plain glass, making a white light impracticable. Amber was decided upon as this colour glass was noticeable different to the white glass showing yellow.

The colours used and the routes denoted were as follows:-

CAR COLOUR	LIGHT COLOUR	ROUTE
Red	Red	Prahran & Carlton. Clifton Hill & Spencer St. Northcote & Spencer St. Brunswick & Flinders St. Victoria St. Bridge & Spencer St.
Blue	Blue	Richmond & Spencer St. Nicholson St. & Spencer St.
Green	Green	St. Kilda Beach & North Carlton. South Melbourne & Spring St. North Melbourne & Flinders St.
Yellow	Yellow	Toorak & Queensberry St. Chapel St. & St. Kilda Beach. Fitzroy & Spencer St.
White	Amber	Brighton Rd. & Queensberry St. Port Melbourne & Spring St. West Melbourne & Flinders St.

<u>Note.</u> The lettering on dashes of cars showing the termini of the routes always had the name of the home depot for that car on top. For example, the Prahran and Carlton route, the Prahran Depot Cars had the dashes lettered PRAHRAN
CARLTON
and the Carlton Depot Cars CARLTON.
PRAHRAN.
Certain Lines such as Brunswick and Richmond had only the one destination, the

depot terminus, on the dash, the City terminal being omitted. Special trams were run on early morning service to carry workers to their factories or places of employment. These trams were called "WORKMEN'S SPECIAL" and charged half fare. Sometimes it became necessary to increase the accommodation for workers travelling on these trams; this was accomplished by coupling an extra car to the rear of the first one. The second car was attached to the first by means of a large shackle, the pin of which passed through the two drawbars.

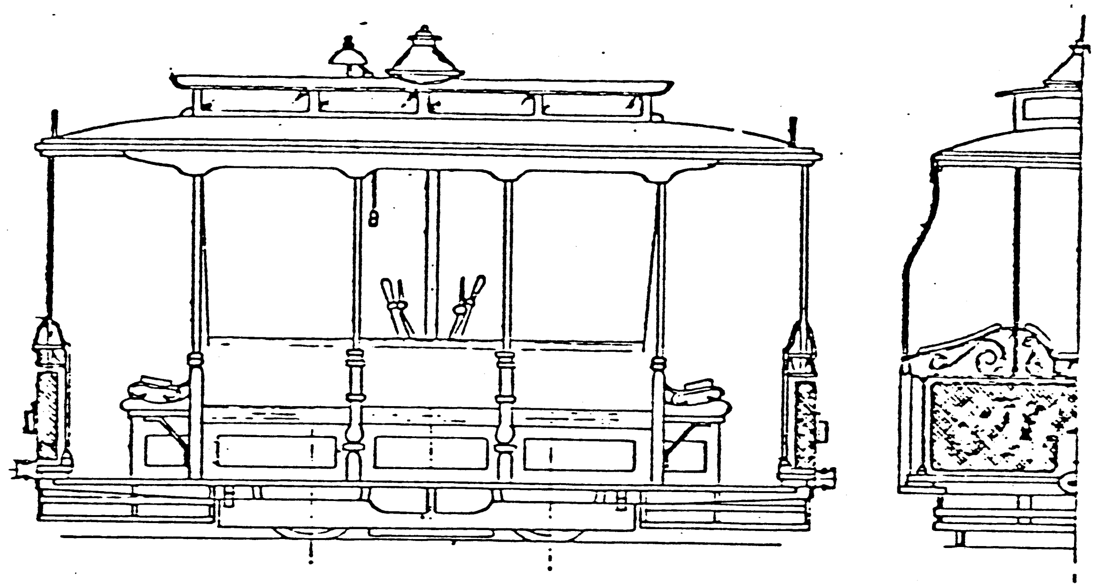
A car with scraper gear was housed at each depot and was employed to clean out the rail grooves. These cars were run in service all day and used for cleaning as well as service cars during the early morning. The device used was a steel scraper mounted in a head on a bellcrank which was pivoted under the car and controlled by a gooseneck handle and staff similar to the brake gear. By turning the handle the bellcrank was revolved, feeding the scraper into the groove. Immediately behind the scraper a V shield was arranged to throw the dirt to the side of the rails. When the cleaning was completed the scraper gear was withdrawn from the rails by operating the gooseneck handle, which was then removed and the gear locked by shackling the staff to the dash frame. The car then remained in service for ordinary passenger traffic. The scraper gear described above was duplicated on each end of the car and only used from the trailing end.

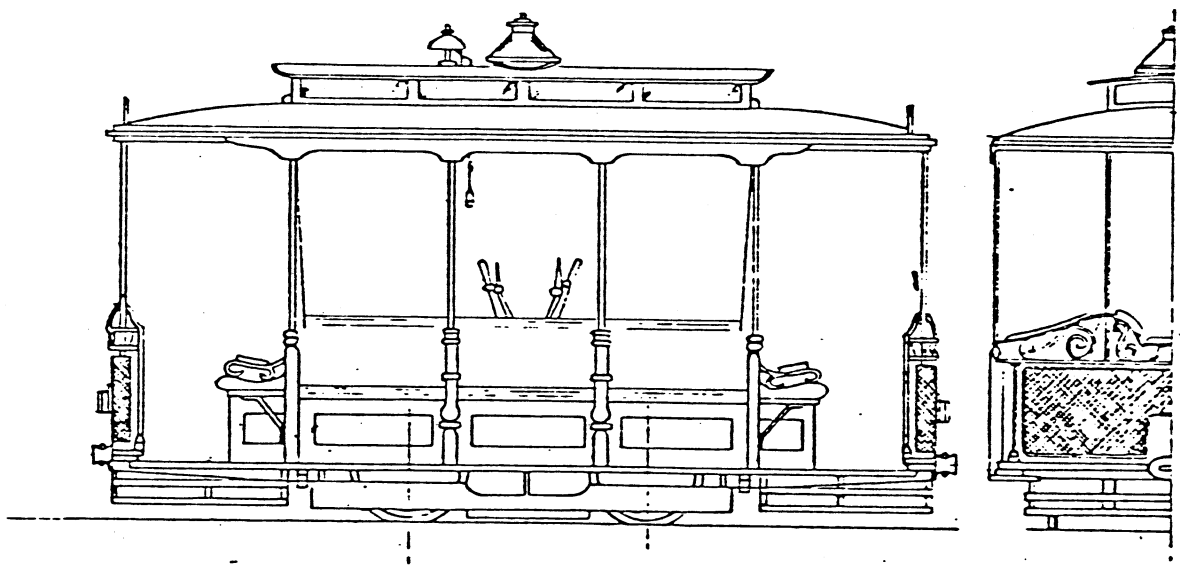
Following is a list of general information appertaining to the Rolling Stock covered in this report:-

ROLLING STOCK - GENERAL INFORMATION.

	DUMMIES		CARS	
	4 Post	6 Post	Stan.	Bogie
Length Overall (drawbars or drawheads).	16' 8½"	16' 1"	23' 8"	31' 6½"
Length Over Roof.	15' 9¾"	15'5¼"	22'1¾"	30' 1¾"
" " Dashes.	15'10½"	15' 3"	22' 1"	30' 0½"
" " Saloon.			15'11½"	23'11½"
Width Over Drip Rails.			7' 0"	7' 0"
" " Steps.	7' 2½"	7' 2½"	6'10"	6' 9¾"
" " Roof.	7' 1½"	6' 8½"	6'7¾"	6' 7½"
" " Band Panel.	7' 2½"	6' 9½"		
" " Fence Rail.			6'7½"	6' 7¼"
" " Pillars.	7' 0¼"	7' 0¼"	6'6¼"	6' 6½"
" " Underframe			6' 0"	6' 0"
" " Crown Plank.	6'11½"	6' 7½"	5'11½"	5'11½"
" " Platform max.			5' 4½"	5' 4½"
" " Platform min.			4'10¾"	4'10¾"
" of Door.			2' 1"	2' 1"
" " " Opening.			1' 8½"	1' 8½"
" between Seats.				
Height above Rail.	10' 1"	10' 1"	9' 3"	9' 6"
" of Floor.	1' 7½"	1' 7½"	2' 1"	2' 2½"
" " Platform	1' 2½"	1' 2½"	1'11¼"	2' 0½"
" under Sill.			1'10¼"	2' 0"
" of Step.	1' 2¼"	1' 2¼"	1' 0¾"	1' 1¾"
" " Dash above platform.	2' 5½"	2' 5¾"	2'10½"	2'10½"
Height above Door Opening.			5'11¾"	5'11¾"
Wheel Base.	4' 6"	4' 6"	6' 0"	15' 0" 4' 0" trucks.
Seating Capacity.	20	20	22	34
Weight of Vehicle.	54 cwt. (est.)	54¾ cwt.	49¾ cwt.	88 cwt. (est.)
Weight of Wheel.	224 lbs.	224 lbs.	224 lbs.	116 lbs.
" " Axle.	116 lbs.	116 lbs.	148 lbs.	148 lbs.
" " Brake Shoe.	23 lbs.	23 lbs.	20½ lbs.	22 lbs.
" " Axle Box.			68 lbs.	58 lbs.
Length of Axle.	4' 9¼"	4' 9¼"	6' 1"	6' 1"
" " Journal.	6⅝"	6⅝"	4½"	4½"
" " Wheel Seat.	4½"	4½"	4⅝"	4⅝"
" " C to C Journals.	3' 5"	3' 5"	5' 7½"	–
Weight of Grip complete	3 cwt. 2 qrs.			

5.1 DUMMIES GENERAL.





The dummy as shown in sketch 1 was the type imported from America for operation on the first lines opened. The principle differences introduced in the later dummies built at the Fitzroy Workshops, as shown in sketch 2, are in the roof construction and roof support. The latter design had, firstly, the roof width increased by 5 inches and the downpipes made straight, secondly, the wooden posts were reduced to four (one at each corner of the grip space) and a truss rod employed between the posts for extra roof support, and, lastly, the overall length of the dummy was increased by 7½ inches. The method of distinction of the two groups of dummies described above was that the type shown in sketch 1 was known as the 6 post dummy and the type in sketch 2 as the 4 post dummy.

The imported dummies were equipped with kerosene headlamps and interior lamps. This equipment became standard and was used throughout the service until about 1918 or 1919 at which time it was superseded by electric lighting powered by Edison Sodium Hydrate Storage Batteries. The batteries were type B2, each having 5 cells, and 2 batteries were used connected in parallel per dummy. The lamps illuminated were headlamp 10 watt and interior lamp 36 watt x 6.5 volt.

One of the 2 passenger seats of the dummy was hinged, forming a box in which the battery was placed for use. The wiring from this box was run to the headlamps and the interior lamp under the dome, the circuit having a changeover switch installed to transfer the headlamp lighting from end to end.

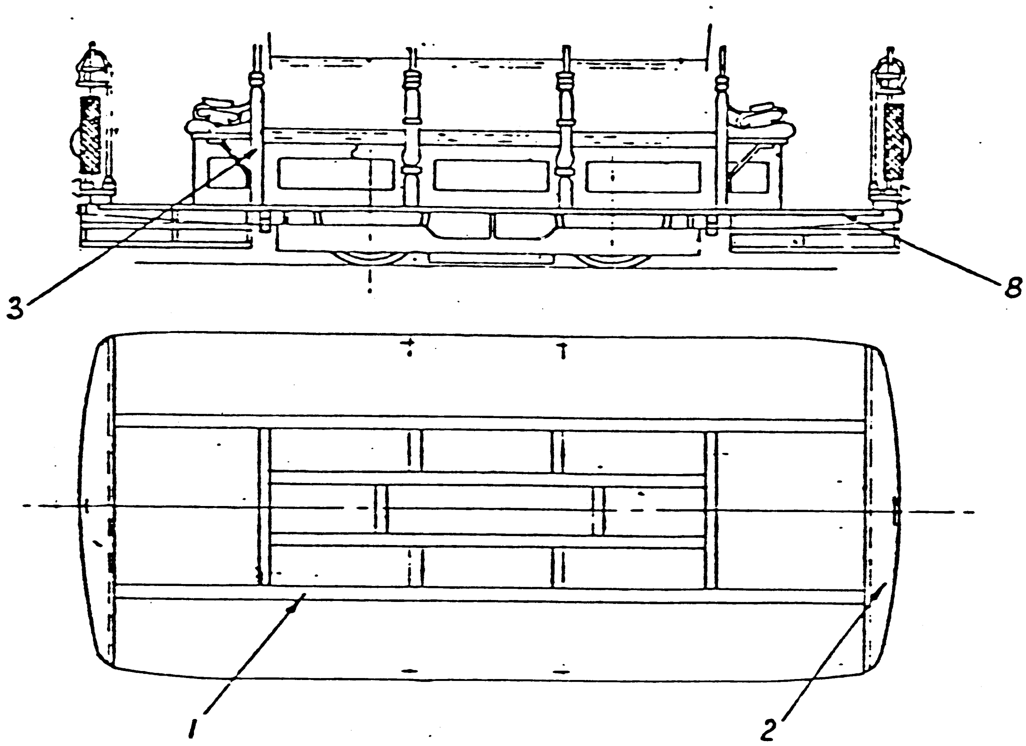
The batteries were removed from the dummies at the depots, after service at night, for maintenance and recharging. When being replaced the batteries were connected to the leads in the box under the seat by plugging the leads into sockets either end of the battery. This was usually carried out for service trams, when the tram arrived at the depot between 3 and 4 o'clock in the afternoon. Other dummies going into service for peak load were equipped before leaving the depot.

The dummy domes and fascia boards were painted a colour to indicate the route on which the tram ran. The glasses in the canopy roof were also the same colour, which showed prominently at night. Early dummies had the streets they traversed shown in clear lettering on the coloured glasses on each side of the canopy roof. This painting of dummies for individual lines was discontinued by the Tramways Board about 1923 - 1924, and made uniform in brown and cream, the coloured glasses in the canopy roof being replaced with clear ones. The domes, which were originally for the purpose of conducting the fumes from the kerosene lamps, were also removed and a flat conical cover placed over the area previously occupied by them.

Windshields were fitted on a dummy after much discussion, following representation from the Union on the question of shielding the gripmen from inclement weather conditions. The windshields were built along each side of the grip space above the side longitudinal seats, and a moveable shield constructed at the ends, which was opened at the rear end to allow the conductor access to the dummy.

The above arrangement was considered by the Union to be acceptable and was put into service for trial. The dummy was run on all lines and a complete trial carried out. The result of all the tests was to the effect that gripmen found dust, rain or mist interfered with their vision both in front and at the sides of the dummy and in consequence the dummy was taken out of service and the scheme discontinued. The difficulties of employing wipers were discussed and it was agreed that no suitable scheme could be evalved with the windshields arranged in a manner to suit the construction and operation of the dummies.

5.1.1 CONSTRUCTION OF DUMMY.

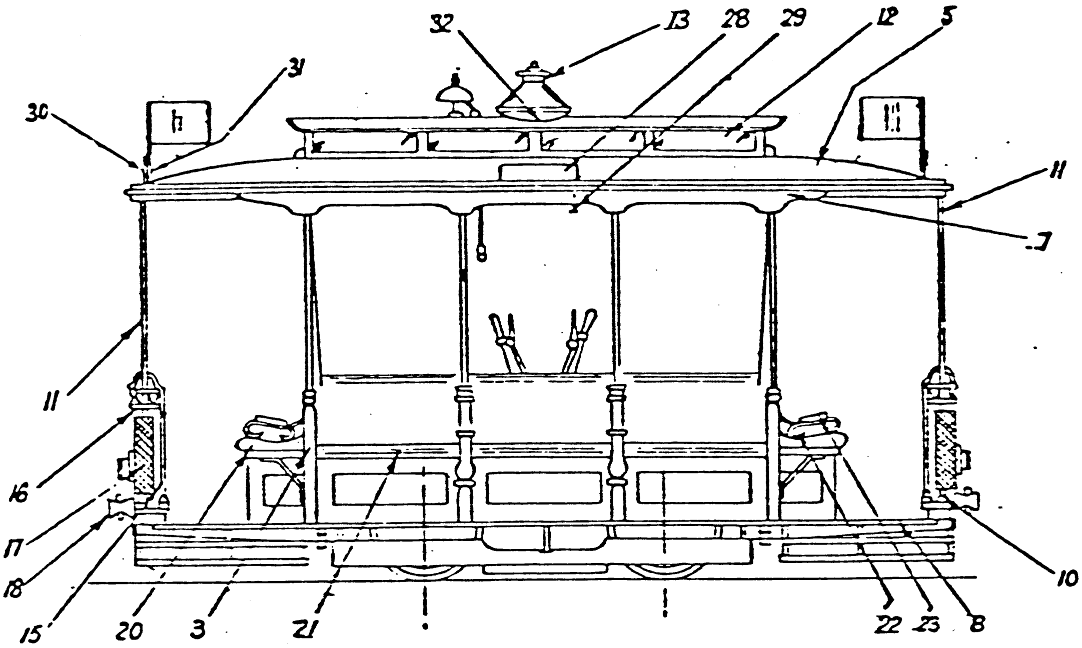


The Underframe of the dummy, constructed of spotted gum, is formed by four longitudinal timbers and a number of laterals. The longitudinals being $5\frac{1}{4}$" x $2\frac{1}{2}$" for the outers (1) and $5\frac{7}{8}$" x $2\frac{7}{8}$" for the inners, the laterals which are morticed into the longitudinals are $2\frac{7}{8}$" thick although varying in length and depth depending upon where they are positioned. Mild steel plates and angles are also employed to strengthen the structure.

A Crown Plank (2) at each end of the dummy, made of spotted gum $8\frac{1}{2}$" x 2" and 7" x $2\frac{1}{4}$" bolted together, ties the ends of the longitudinals and forms the complete framework on which the superstructure is built.

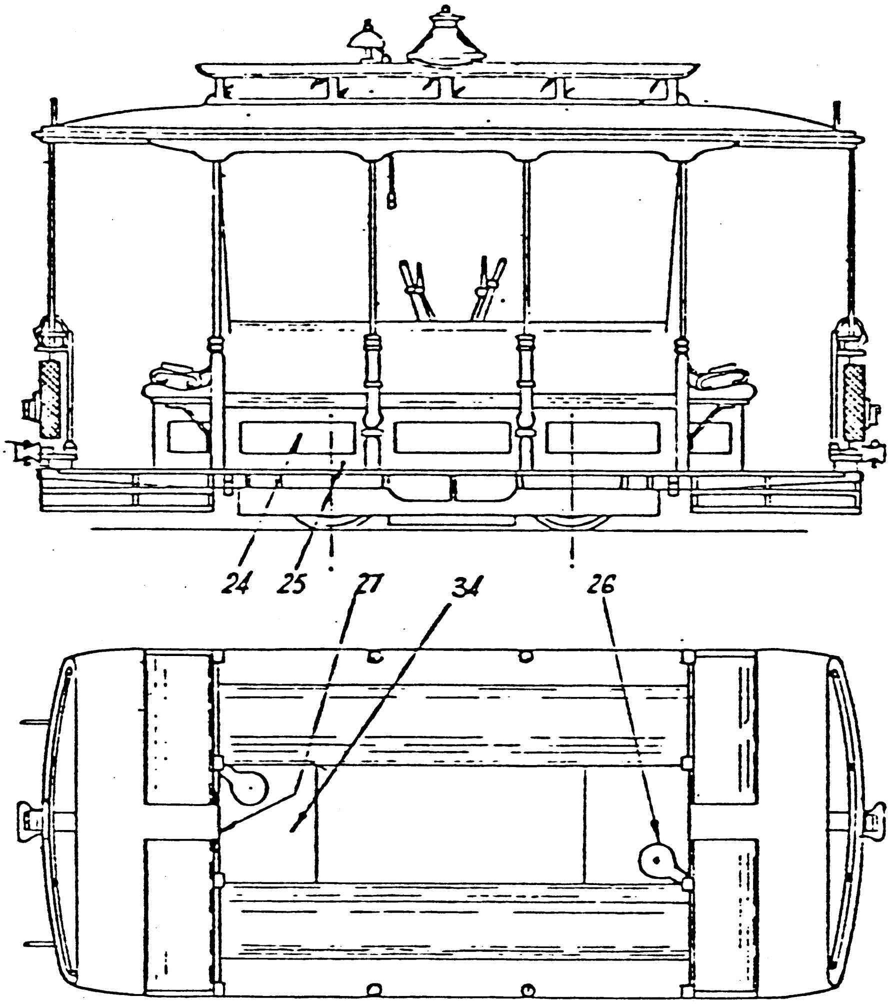
The Superstructure, consisting of $2\frac{3}{4}$" x $2\frac{1}{4}$" yellow-wood Pillars (3) mounted on either side of the area used by the gripman to operate the grip and the brake levers. The Pillars (3) with mild steel bracings and scrollwork (4) carry the Canopy Roof (5) which is also supported by Downpipes (6) made of 1" galv. iron pipe secured to the inside of the Pascia Board (7) at the top and to the $12\frac{1}{4}$" x $1\frac{1}{4}$" spotted gum Footboard (8) at the bottom.

The Downpipes at the side of the dummy are covered over the bottom portion by a cast iron Ornamental Sleeve (9) about 2'-6" long, which is secured by mild steel Knees (10) to the Footboard (8). The End Downpipes (11), 2 at each end, are plain G.I.Pipes



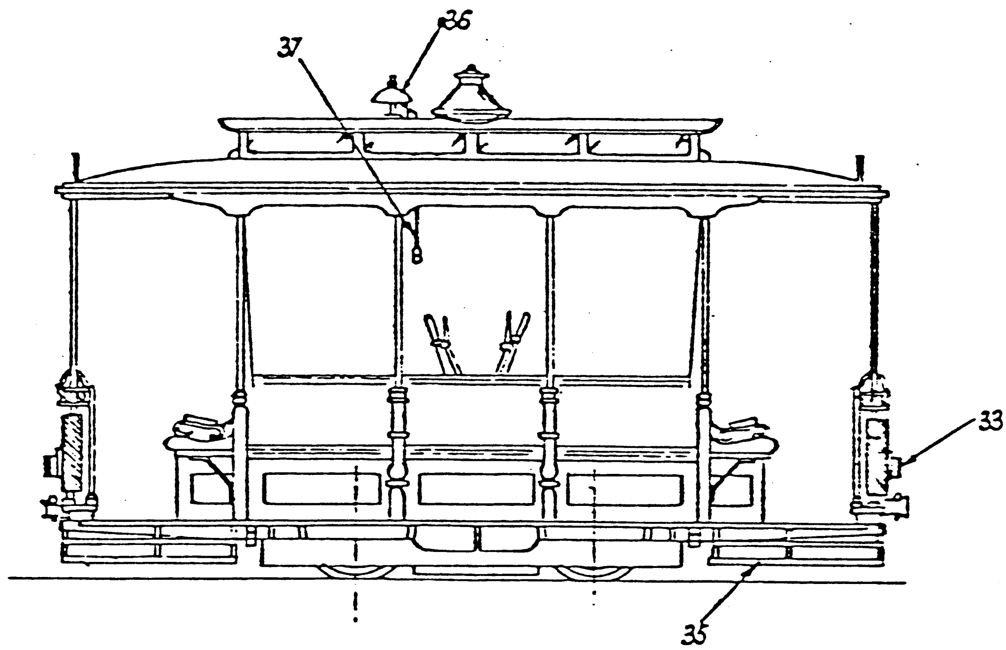
secured to the roof bow at the top and the Crown Plank (2) at the bottom.

The Roof constructed of Tasmanian Oak longitudinals 4" x $1\frac{3}{8}$", ribs $2\frac{1}{2}$" x $1\frac{3}{8}$" and 2" x $1\frac{3}{8}$", blackwood cant rails covered with $2\frac{3}{4}$" x $\frac{1}{4}$" hoop pine T and G boards. The raised canopy section has glasses (12) at the sides and ends and a Dome (13) in the central position on top. The Roof Boards were heavily covered with white lead and canvas then stretched over it, a further heavy coat of white lead and a coat of paint finished the roof.
A Dash (14) each end of the dummy was made as follows:- Two mild steel Posts (15) are firmly bolted to the Crownplank (2) one at each side; these posts and the downpipes (11) support a steel Frame (16) with scrollwork between the upper and lower rails; under this steel Frame (16) is fitted a wire mesh Apron (17) which is also secured to the Crownplank (2). A cast steel Drawhead (18) is fitted and securely bolted to the centre of the Crownplank and at each end of the Crownplank bent to its shape is a mild steel Facing Piece (19).
The Seats which have their backs fastened to the dummy Pillars (3) are two (2) passenger lateral seats each end and a 6 passenger Longitudinal Seat (21) each side. The End Seats (20) have a space of 10" between them to give access for the gripman and conductor to the grip space. The outer end of each 2 passenger seats (20) has a metal scroll Arm Rest (22) with Wood Facings (23).



The seat panels (24) at the ends and front of the 2 passenger seats and at the front of the 6 passenger seats are sheet steel in wood framing (25). The two side Seats (21) are moveable and built up on mild steel supports shaped to the seat and back, fixed to the Pillars (3) at the back and the Footboard (8) in the front. The Gripman's Seats (26), which are hinged to the diagonally opposite corner pillars, are fitted with a mild steel strut which is held in a socket lower down the pillar. The seat is lowered by lifting the strut out of the socket.

Wind Board (27) is a board fitted between the end seats in wood runners in line with the pillars. The Board is moved to the front end of the dummy to prevent the wind blowing on the gripman. Full Boards (28) which are mounted above the dummy fascia each side of the roof are turned by a T Handle (29) which projects down through the roof and is operated by the gripman. One side of the board is blank and on the other side the word FULL. Destination Boards (30) are fixed each end of the dummy showing the two destinations of that tram. Flag Sockets (31) are fixed in the centre of the back of each board.



A Lamp Box (32) was provided in the centre of the raised portion of the dummy roof above the grip space. This Box surrounded by glass provided illumination for the dummy interior. The Dome (13) on the roof above the Lamp Box (32) provided an outlet for the Lamp fumes.

The Lamps on the dummy which were kerosene burners were:- 1. The interior lamp in the Lamp Box (32) and 2. The Headlamp (33) which was supported on pins on the outside of the Dash (14). It was the gripman's duty to move the Headlamp (33) from end to end of the dummy at each terminus.

The dummy flooring is of $\frac{7}{8}$" thick spotted gum throughout. At each end of the grip space a Platform (34) is let into the flooring, being about 24" square. This Platform has flat springs bearing on the longitudinals and set so that the gripman stands on a sprung floor and is relieved from the vibration.

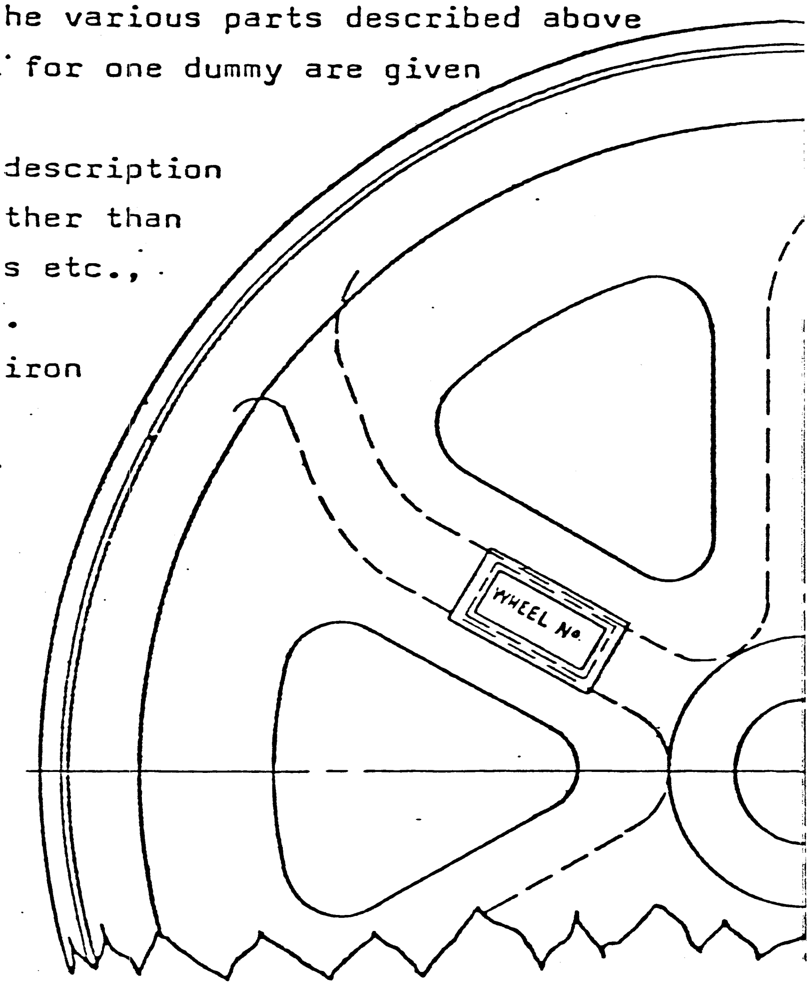
Lifeguards (35) on each side of the dummy are 7" x $1\frac{1}{2}$" hoop pine and the ends approximately 2" x $\frac{3}{8}$" rubber and canvas lining. All lifeguards are supported by mild steel angle brackets.

The Alarm Gong (36) on the top of the dummy roof is operated by a Cord (37) hooked to a link passing through the roof. The Cord (37) hangs down in the grip space and provides the gripman with a warning device.

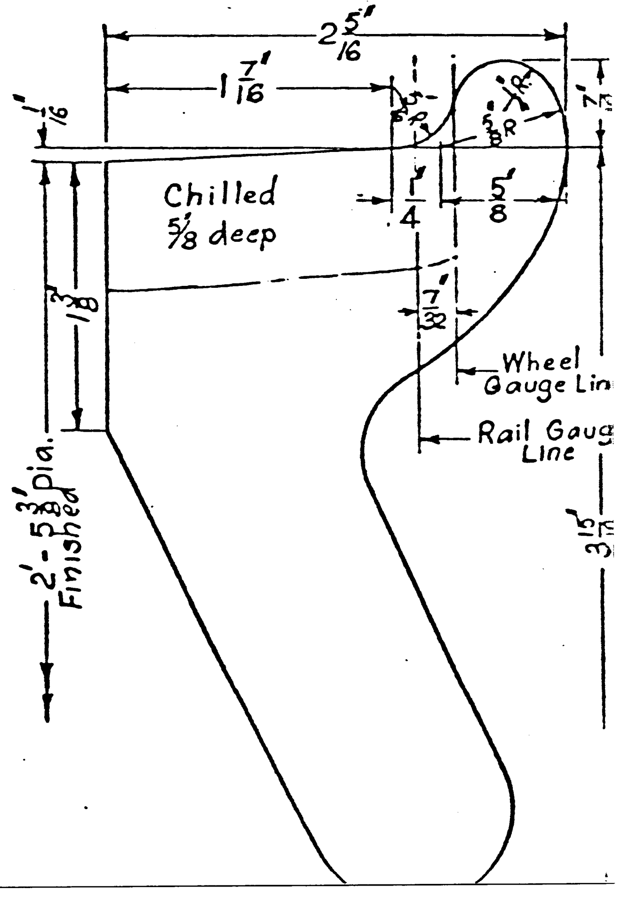
A list of timber used for the various parts described above and the quantities required for one dummy are given in (5.1.4).

The foregoing is a general description of the dummy construction other than the undergear brakes, wheels etc., which will now be described.

The Wheels, which are cast iron with chilled flanges and treads, were 29¼" diameter in the rough. The minimum depth of chill specified with ⅜" but generally this depth was exceeded. The Wheels had a pocket cast in one of the spokes for filling with lead and numbering each wheel.

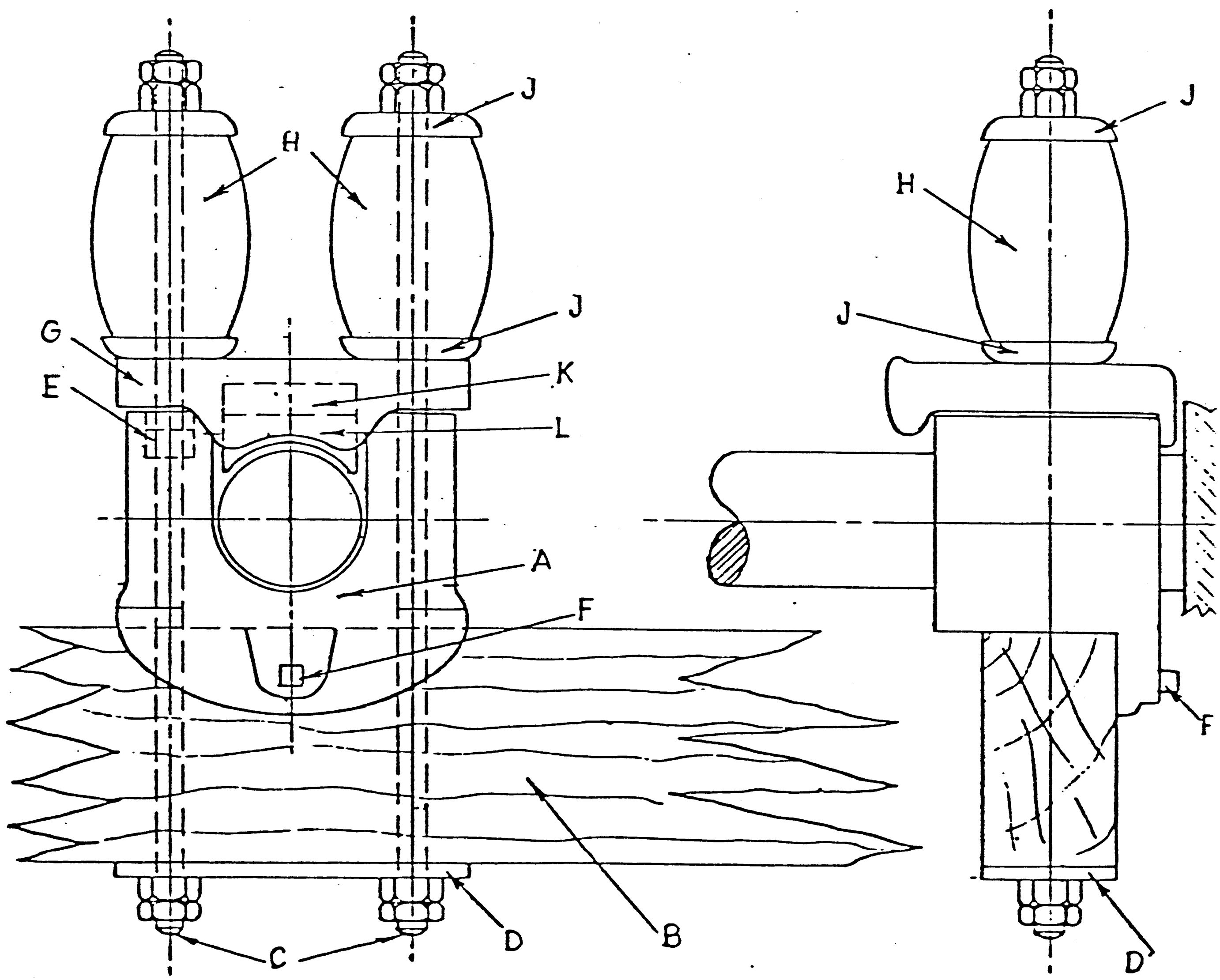


The accompanying sketch shows the general view of the wheel and a full size section of the rim. The Contractors supplying the wheels guaranteed a mileage of 20,000 and if this was not obtained no payment was to be made for the wheel; however many wheels ran up to 150,000 miles and higher figures were recorded. The wheels when pressed on the axles were ground on the tread to give a finished 29⅛" diameter.



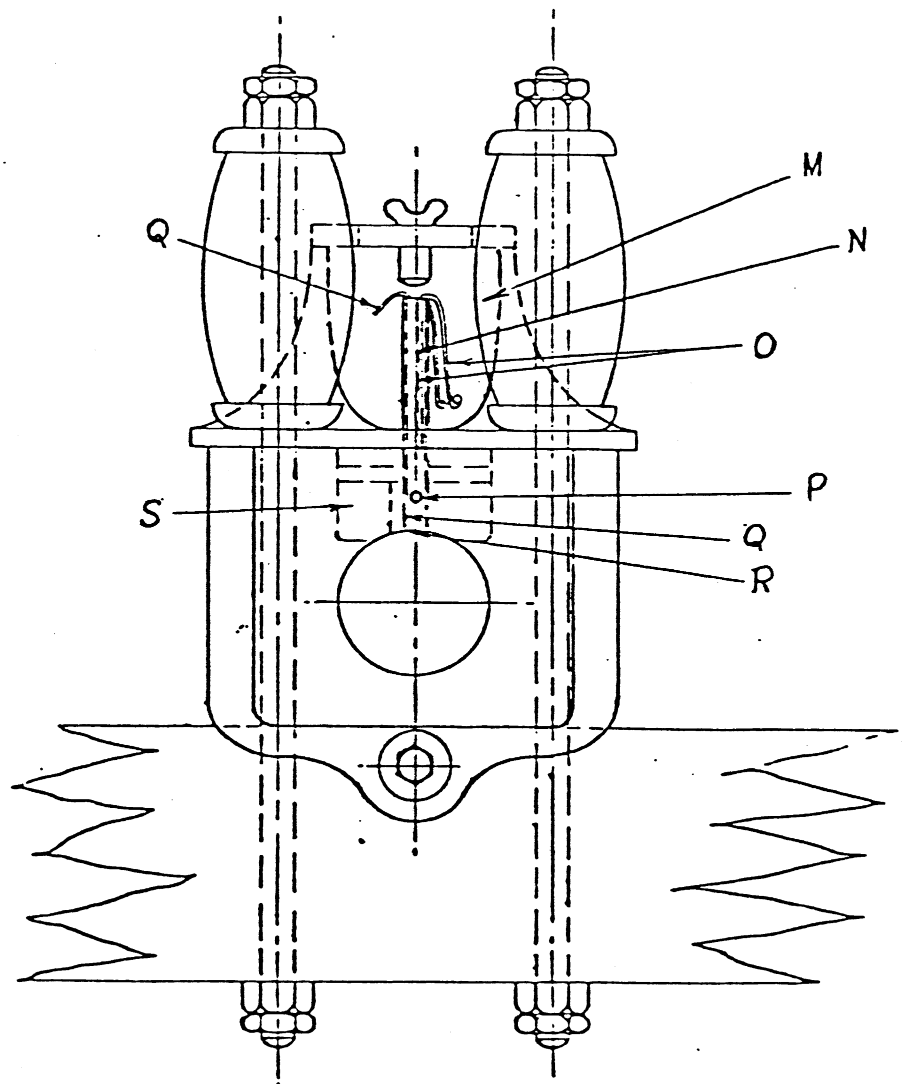
SECTION OF RIM

The cast iron Axle Boxes (A), see sketch below, are mounted on top of the outer longitudinal timbers (B), secured in position by means of axle box bolts (C) which pass through the timbers (B), with mild steel plates (D) on the under side. These forged steel axle box bolts have a square section shown at (E) which fits into a recess in the axle box (A), holding it firmly down on the timber, a coachscrew (F) holds the outside flange of the box against the timber. The axle box bolt above the section (E) is carried through the axle box lid (G) upwards through the rubber blocks (H) which act as springs, being fitted with cast iron caps (J) top and bottom. The axle box bolt nuts above the top of the rubber (H) are screwed down and locked in position when the required compression of the rubber is obtained. The oil pan (K) is located under the axle box lid above the journal brass (L). Oil is supplied into the oil pan (K) by means of a can through an oil hole in the axle box lid (G). This method of lubrication is similar to that adopted for the car axle box.



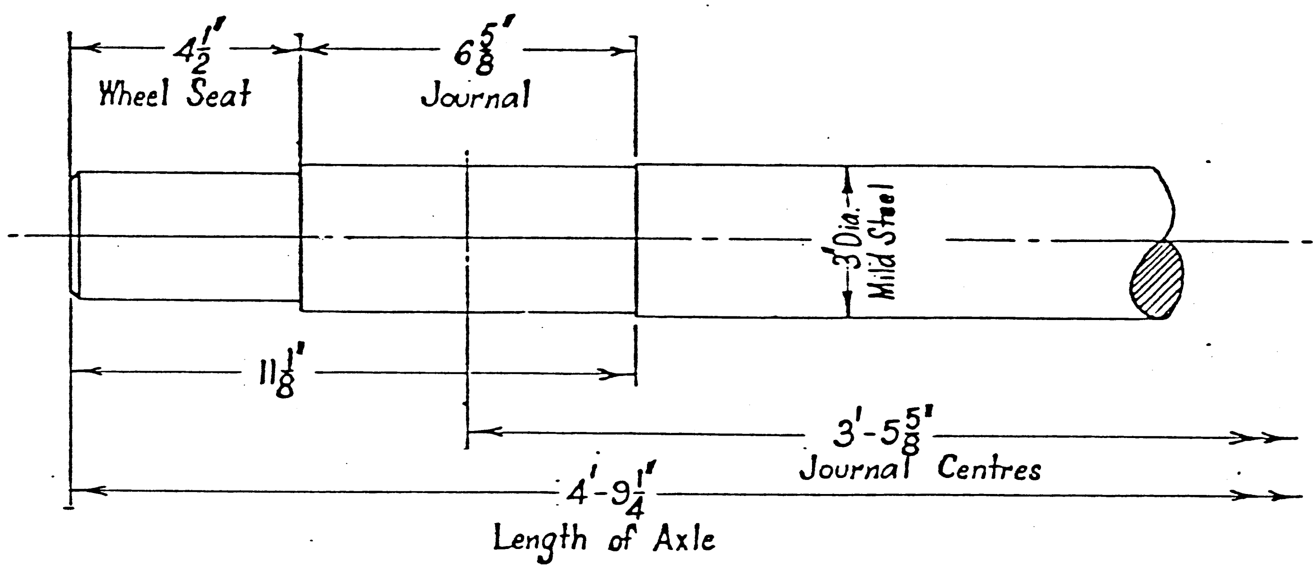
An improvement was made to the axle box when the speeds of the cables were increased. This took the form of an improved method of supplying the lubricant to the axle brass and journal by a new design of axle box lid which fitted the original axle box. This method is shown in the sketch below, which indicates the new cover or oil box (N). The oil box (M) is fitted with a brass tube (N) used to supply the oil to the bearing by means of wool strands (O) which siphon the oil from the reservoir in the oil box (M). The strands of wool pass through an eye (P) formed in the copper wire (Q) higher up. This arrangement allows the wire to bear on the journal (R) after passing through the axle brass (S). Otherwise the axle box and rubbers are arranged in a similar manner as with the old type box.

Both these arrangements result in the dummy being suspended on the axle journals with the rubbers in compression setting as springs.



The Axles, made of 3" diameter commercial black mild steel, were machined with the wheel seats at the ends of the axles as shown in the sketch below, and the axle box journals machined immediately inside the wheel seats.

The wheels were pressed on to the axles at approximately 40 tons.

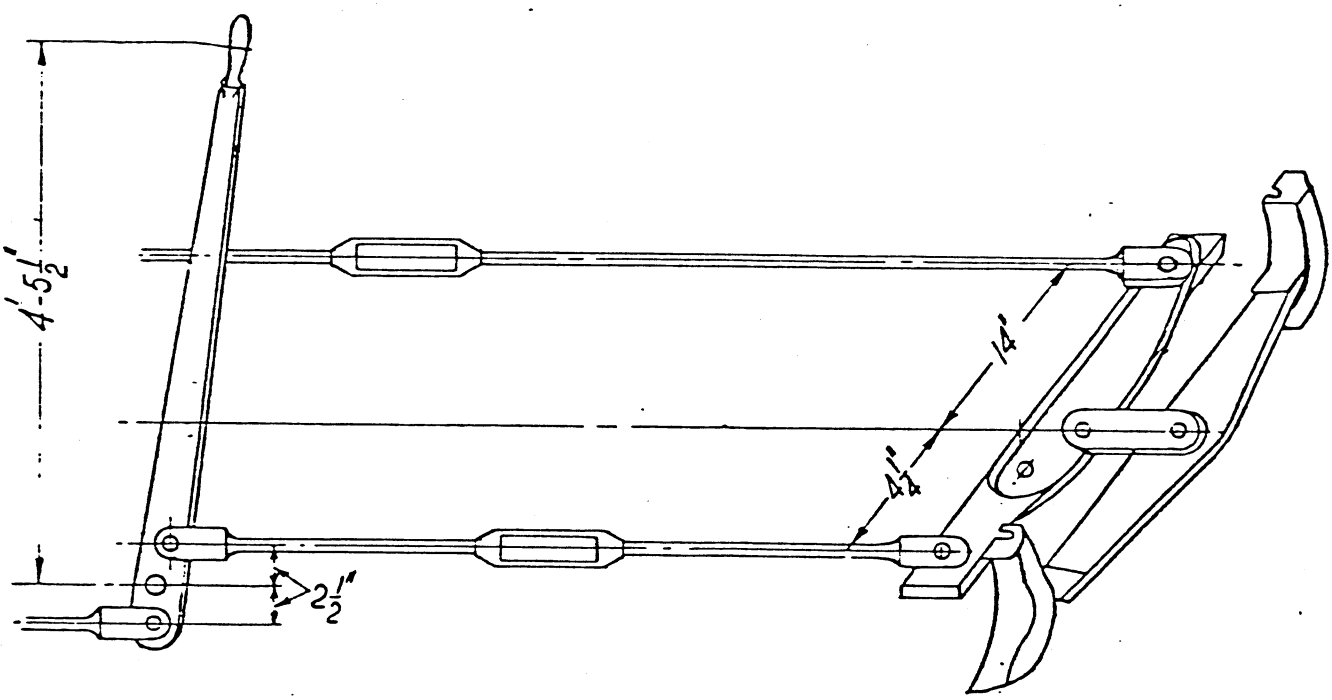


The Hornbars, which were for the purpose of carrying the grip and transmitting the pull of the rope in the grip to the dummy, were made of mild steel approximately 60" and 30" in length. The short hornbar was situated towards the end of the dummy where the track brake gear was located. Draught Plates were bolted to the inner longitudinal timbers and the screwed ends of the hornbars passed through these plates, with wingnuts to provide means of adjustment for length. On the other end of the hornbar a jaw was forged and a plate fitted in the jaw at right angles to the bar. A pin or horn was then riveted through the plate and jaw. This plate was supported by guides on the underside of the inner longitudinal timbers, making provision for side movement of the bar. This side movement allowed the grip to deviate $2\frac{1}{2}$" either side of the centre line of the dummy.

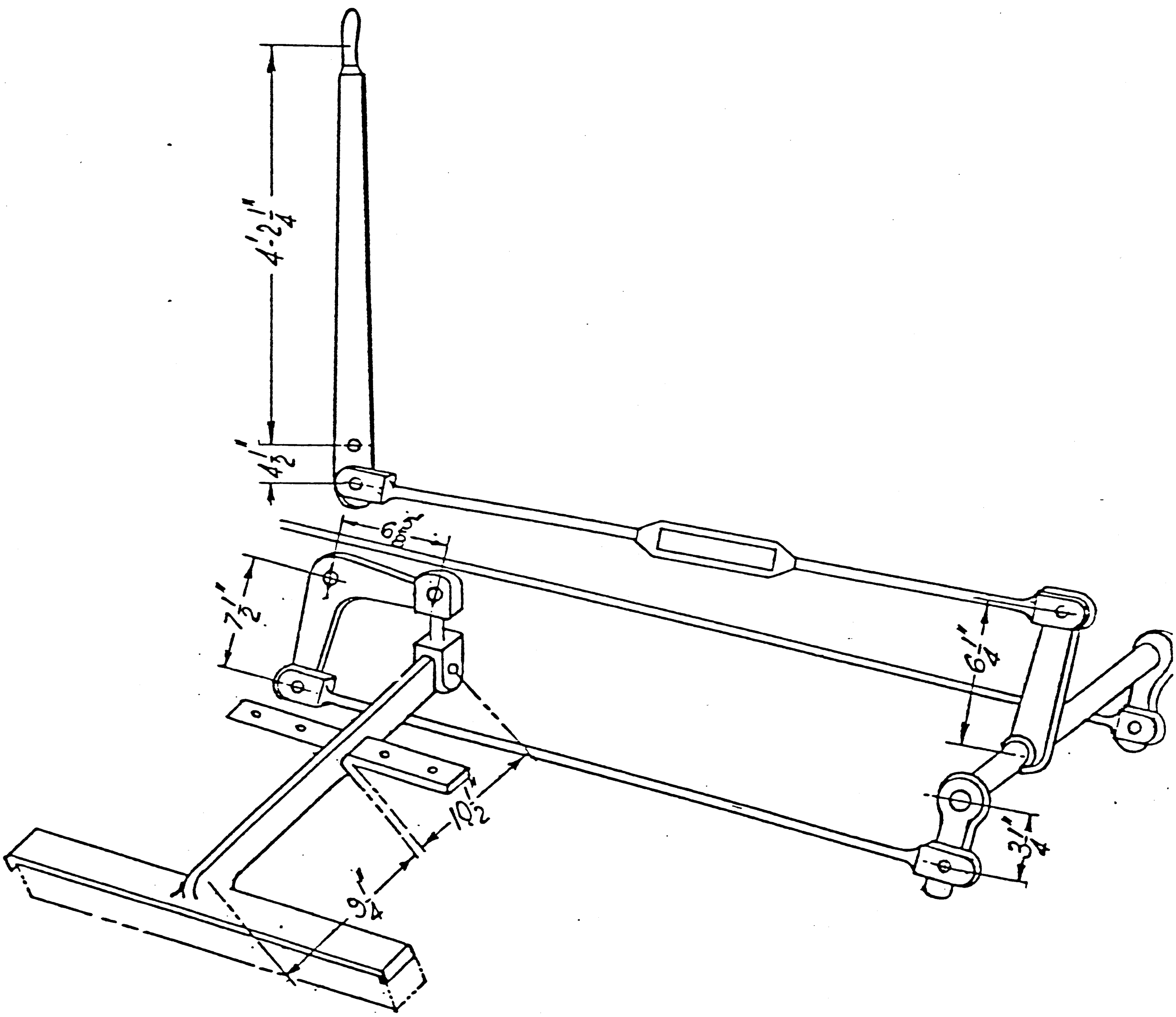
The area between the inner longitudinal timbers and a little beyond the hornbar pins was left unfloored for lowering the grip into position.

The dummy is equipped with two separate brakes known as the "Wheel Brake" and the "Track Brake".

The Wheel Brake (see sketch diag. below) is operated by a lever 4'-5½" long pivoted on a stud which is screwed into a stud plate and riveted over on the other side. This stud plate is bolted to the inside of one of the dummy inner longitudinals. Pull rods are connected to the lever at 2½" centres from the lever pivot stud and are fitted with turnbuckles for adjustment which are accessible from the grip space. The pull rods are connected to equaliser bars, these bars being connected to the centre of the brake beams carrying the cast iron brake shoes. The other end of the equaliser bars are joined by a long connecting rod.



The Track Brake is operated by a lever 4'-6¾" long, pivoted in the same manner as the wheel brake lever, but on the inside of the opposite inner longitudinal timber. Connected to the lever is a pull rod with a turnbuckle and connection to a 6¼" arm on a rocker shaft. The rocker shaft has a 3¼" arm each end connected to bellcranks each side of the dummy. These bellcranks operate levers carrying the 3" x 2" hardwood shoes at their outer ends, which are forced down on the rail head. The following sketch indicates the general arrangement of the gear.



5.1.2 DUMMY - OPERATION.

The operation of the dummy was governed more by the grip requirements than by the vehicle itself.

The first essential was to place the grip in the dummy so that the dies opened in the correct direction when lowered into the tunnel. The dummy, having fixed destination signs for each terminus of the route it traversed, established its position on the track. Knowing to which side of the road the dies had to open determined the correct placing of the grip in the dummy. A grip could not be reversed without removing it from the dummy and the turntable was employed to turn the dummy when it operated from a depot where the run-out and run-in tracks formed a Y connection. The dummy when run out for service was stopped with the grip hatch on the track coinciding with the opening in the grip space of the dummy through which the grip was lowered. The grip hatch was then opened to receive the grip. The centre line of the cable being $1\frac{3}{4}$ inches from the centre line of the slot, to suit the grip design, explains why the grip as mentioned above, must face the correct direction to suit the arrangement of all tunnel and underground equipment.

The grip was raised from or lowered into the tunnel by means of a rope tackle block supported by a steel grip lift bar into which it was hooked. The lift bar was permanently fixed to the dummy roof longitudinals on each side of the grip space. After lowering the grip with its crossbar supported on the hornbar pins, cotters and washers were used to hold the crossbar firmly in position. The grip hatches were then closed and the dummy ready for service. The position of the cable relative to the centre line of the slot as described above prevented the through routing of Bourke, Collins and Flinders Streets trams, which was often put forward by the public as a means of relieving some of the congestion caused by the city shunting.

The following table shows the direction in which dies opened in the streets of the various routes:-

LINE	GRIP OPENS TOWARDS			
	NORTH IN	SOUTH IN	EAST IN	WEST IN
NICHOLSON STREET	Bourke St.			Nicholson St. Evelyn St.
FITZROY	Collins St.			St.George's Rd. Brunswick St. Gisborne St.
CLIFTON HILL	Gertrude St. Bourke St.			Plenty Rd. Heidelberg Rd. Smith St. Evelyn St.
NORTHCOTE				High St.
CARLTON	Johnston St. Elgin St. Lonsdale St.			Lygon St. Russell St. Swanston St.
VICTORIA STREET	Victoria St. Victoria Pde. Collins St.			Gisborne St.
RICHMOND	Bridge Rd. Wellington Rd. Flinders St.		Spencer St.	
TOORAK		Toorak Rd. Domain Rd.		Park St. St.Kilda Rd. Swanston St.
PRAHRAN		Toorak Rd. Domain Rd.		Chapel St. Park St. St.Kilda Rd. Swanston St.
BRIGHTON ROAD				Brighton Rd. High St. St.Kilda Rd. Swanston St.
ESPLANADE ST.KILDA	Fitzroy St.			Acland St. Esplanade St.Kilda Rd. Swanston St.
WINDSOR	Fitzroy St. Wellington St.			Acland St. Explanade.
SOUTH MELBOURNE	Bridport St. Park St. Collins St.			Victoria Ave. Montague St. Clarendon St. City Rd. Moray St. Market St.
PORT MELBOURNE	Beach St. Collins St.			Bay St. City Rd. Moray St. Market St. Gisborne St.
NORTH MELBOURNE		Flemington Rd. Queensberry St. Victoria St.		Abbotsford St. Errol St. Elizabeth St.
WEST MELBOURNE		Lonsdale St.		Abbotsford St. Spencer St. Elizabeth St.
BRUNSWICK				Sydney Rd. Elizabeth St.
NORTH CARLTON	Elgin St. Lonsdale St.			Rathdowne St. Lygon St. Russell St. Swanston St.

In the early 1920's the Tramways Board constructed double cable tracks in Lonsdale St., between Swanston and Elizabeth Sts., to through route the Brighton Road and North Melbourne trams. This reduced the city shunting of Brighton Road trams at Queensberry Street and North Melbourne trams at Flinders Street. It will be seen from the above table that the cables were correctly positioned for this connection to be made.

The general features of the operation of the dummy in service were the grip by which rope haulage power was obtained to move the tram and the two types of brakes employed to stop it. The gripping has been explained under the "Operation of Grips". The brakes used were the "Wheel Brake" and the "Track Brake". Both brakes were operated to stop the tram, and only on steep gradients was the car brake used to assist the gripman. The following is a tabulated list of ordinary service stops observed at different localities and made by the application of the dummy brakes only. These service trams were lightly loaded with approximately 15 to 20 passengers. The average speed of the cable was about 11 m.p.h.

STOPS WITH WHEEL AND TRACK BRAKES.

STOP NO.	DMY	CAR	TRAM	GRIPMAN	DISTANCE TO STOP.	REMARKS
1	395	568	SM	Patch	86' 0"	Stops in Market St. between Collins & Flinders Sts.
2	387	427	SM	Wright	117' 0"	"
3	377	510	SM	Wright Jr.	116' 0"	"
4	413	35	PM	Brooks	65' 0"	"
1	175	155	CH	Hicker	56' 6"	Stops in Bourke St. between Queen & Elizabeth Sts.
2	171	171	CH	Hargraves	58' 9"	
3	100	100	N.St.	Mackay	98' 0"	
4	101	101	N.St.	Sharp	42' 5"	"
1	127	47	B	Stranger	47'11"	Stops in Elizabeth St. between Pelham and Queensberry Sts.
2	530	192	B	Batten	51' 7"	
3	283	45	B	McCluskey	53' 6"	
4	142	477	B	Tonkin	52' 9"	"
1	49	514	V	Smith	87' 6"	Stops in Collins St. between Russell and Swanston Sts.
2	99	99	F	Brown	76' 5"	
3	85	505	V	Wave	79' 0"	

Another limitation imposed on the operation of the dummy was the grip height relative to the rail level, which was very important in order that reasonable height clearances were maintained between the grip and underground equipment. This figure was $22\frac{1}{2}$" from the rail level to the bottom of the grip soleplate with an allowable variation of $\frac{5}{8}$" up or down. It will be obvious that the use of lively springs on the dummy was most undesirable and therefore the rubbers as previously described were used, which limited the deflection within the allowable tolerances. The dummies had axle box liners, which were used to compensate for axle box, brass, axle journal or wheel wear, and adjustments were made to maintain as closely as possible a measurement of $5\frac{1}{8}$" from the bottom of the hornbar to rail level, which fulfilled the requirements stated above.

At intersections, special work and curves and when passing engine houses, it became necessary in many instances to throw the cable cut of the grip, coast for a certain distance and then pick up the cable again. The operation of the grip is explained under that heading, but the dummy operation is as follows. When the front of the dummy reaches the "throw rope" mark, the gripman operates the grip and throws the cable out, allowing the tram to coast to the "pick up" mark, at which point the grip dies are closed on the cable again and the dummy driven onwards. In the first place, should the gripman fail to throw the rope out of the grip, the grip would be drawn over to one side by the cable, causing it to strike a check bar, breaking the grip, which would release the cable and prevent serious damage being done to the cable. After the dummy had run to the "pick up" mark, the cable was replaced in the dies either automatically or by manually operated pick up. Where automatic operation existed, the cable was elevated by pulleys to the grip die position and then by a rubbing bar and slot deviation the grip was moved over to take the cable between the dies, which were immediately closed. If automatic operation did not exist, the dummy was stopped and a hand pick up operated which, by means of a bell crank and conical pulley, lifted the cable upwards and sideways into the dies while the grip was held over at an angle by the gripman.

In general the dummy was a very reliable vehicle in operation, and any minor repairs could be dealt with expeditiously by the car depot staff when the tram arrived at the terminus, and in most cases changeovers avoided.

The dummy was unsuitable for bad weather operation, due to its open design, which exposed passengers to all weather conditions. In other respects it operated splendidly in the following ways. Firstly, it was a most convenient vehicle to step on to, with a 14 inch step and the downpipes acting as stanchions along each side of the dummy. Secondly, it was very fast loading, passengers being able to board it at either side and at either end. Thirdly, it carried a very large crush load, passengers standing on the stepboard in front of those seated and holding on to the stanchions or downpipes.

A bad feature of the dummy operation in traffic was the sudden jolt when it entered a small radius curve at any speed. Another disadvantage from a traffic viewpoint, was the difficulty in collecting fares from a crowded dummy on a small run, as from a football match or on suchlike occasions.

5.1.3 DUMMY - MAINTENANCE.

The general maintenance of dummies was carried out at the car depots where spare parts were stocked. In the event of a dummy being damaged in accident, replacement parts were sent to the depot to enable repairs to be effected, unless damage was considerable and repair shops attention needed.

Rewheeling was one of the largest jobs regularly undertaken, and the procedure was as follows:- The dummy was lifted with a jack placed under the drawhead one end, with the other end wheels chocked, and raised until the wheels at the jacked end left the rails. The truss rods were then disconnected after removing both side seats, enabling the axle boxes to be unbolted, the lids, liners and brasses removed, and the set of wheels lifted out. A new or reground wheel and axle assembly was then placed in position, new brasses fitted, followed by the replacement of axle box lids, rubbers and truss rods. The dummy was then lowered on to the rails and adjustments for height carried out, after which the side seats were replaced. Other worn brake gear or metalwork was also replaced when necessary, with renewal of brake shoes and track shoes to suit traffic requirements. Dummies were brought to the workshops for general overhaul on a time and mileage basis; the work performed being the complete dismantling of all brake gear, hornbars, chains and rods for annealling or replacement if wear prevented reconditioning. All metalwork and woodwork was examined and thoroughly overhauled or renewed. Wheels and axles, axle brasses, rubbers drawhead pins, brake shoes, bell cords etc. were nearly always renewed. Drawheads were bored out and tapped when worn by the coupling pins. Hardened bushes were then screwed in and new pins fitted. After carrying out the complete reconditioning and cleaning of all metal and woodwork, the dummy was repainted, including the roof, and then returned to its depot for further service.

5.1.4 PARTS. TIMBER AND QUANTITIES FOR DUMMY.

PART	TIMBER			QTY. SUP. FT.
CENTRE SILLS	3"	SPOTTED	GUM	52
SIDE SILLS		"	"	48
CROSS BARS		"	"	$22\frac{1}{2}$
SHORT BLOCKS		"	"	$6\frac{3}{4}$
BRAKE LEVER BLOCKS		"	"	$5\frac{1}{2}$
SHORT CROSS BARS		"	"	$8\frac{1}{4}$
PLATFORM SUPPORTS		"	"	9
				152
CROWN PLANK (bottom)	$2\frac{1}{2}$"	"	"	$23\frac{1}{2}$
CROWN PLANK (top)	$2\frac{1}{4}$"	"	"	21
BOTTOM PLATES		"	"	$20\frac{1}{4}$
				$41\frac{1}{4}$
END FLOOR SUPPORTS	$1\frac{1}{2}$"	"	"	$5\frac{1}{2}$
END FILLING PIECES		"	"	$2\frac{3}{4}$
SPRING BLOCKS		"	"	$3\frac{1}{4}$
STEP BOARDS		"	"	52
				$63\frac{1}{2}$
WIND BOARD BATTENS	1"	"	"	1
FLOORING		"	"	59
FLOORING BATTENS		"	"	$7\frac{1}{2}$
SPRING FLOOR BLOCKS		"	"	1
GRIPMAN'S SEAT		"	"	2
LINING BATTENS		"	"	$3\frac{1}{2}$
				74
MAIN PILLARS	3"	YELLOW	WOOD	23
SIDE SEAT CENTRE RAILS		"	"	$13\frac{1}{2}$
				$36\frac{1}{2}$
SIDE SEAT CENTRE LEGS	2"	"	"	$7\frac{1}{2}$
DOWN PIPE PILLARS	$1\frac{1}{2}$"	"	"	$8\frac{1}{4}$
SCROLL FACINGS	$2\frac{1}{2}$"	BLACKWOOD		$11\frac{1}{4}$
CANOPY CORNER BLOCKS	2"	"		1
SCROLL FACINGS		"		$8\frac{1}{2}$
				$9\frac{1}{2}$
GANGWAY PIECES	$1\frac{1}{2}$	"		$2\frac{1}{4}$
HORIZONTAL ELBOW SUPPORTS		"		$3\frac{3}{4}$
STANCHION ELBOW SUPPORTS		"		$3\frac{3}{4}$
HORIZONTAL ELBOWS		"		12
VERTICAL ELBOWS		"		12
PILLAR FACINGS		"		13
END SEAT STILES		"		$18\frac{3}{4}$
END SEAT RAILS		"		$23\frac{1}{2}$
SIDE SEAT STILES		"		$5\frac{3}{4}$
SIDE SEAT RAILS		"		27
SIDE SEAT SUPPORTS		"		9
CANT RAILS AND BOWS		"		12
				$142\frac{3}{4}$

PART	TIMBER	QTY. SUP. FT.
SIDE COW CATCHERS	1¼" HOOP PINE	13½
CENTRE LEG STOPS	" "	1
SHORT SEAT HOLLOWS	" "	4
PILLAR MOULDINGS	" "	1½
CORNER DRIP MOULDS	" "	2
		22
WIND BOARD	1" HOOP PINE	3¾
LAMP RINGS	" "	14
GLASS STRIPS	" "	5
DESTINATION BOARDS	" "	12
FULL BOARDS	" "	1½
MOULDS AND BEADS	" "	12½
HEAD BOARDS	" "	4½
LININGS	" "	16½
ROOF BOARDS	" "	69
		138¼
END GLASS RAILS	2" TASMANIAN OAK	2
ELBOW SUPPORTS	1½" TASMANIAN OAK	2½
END SEAT RAILS	" "	6
SIDE SEAT RAILS	" "	7
SIDE SEAT LATH SUPPORTS	" "	3¾
ROOF LONGITUDINAL RAILS	" "	16¼
ARCH RAILS	" "	7½
CANOPY RAILS	" "	4
CANOPY PILLARS	" "	2¼
CANOPY RIBS	" "	2
END SEAT LATH SUPPORTS		4½
		55¾
FRONT SEAT FACINGS	1" TASMANIAN OAK	9½
INSIDE ELBOW SUPPORTS	" "	2
SIDE SEAT FACINGS	" "	9½
SIDE SEAT TOP RAILS	" "	7½
CANOPY RAILS, OUTER	" "	1¾
CANOPY RIBS	" "	8½
SIDE RIBS	" "	
		45½
END SEAT LATHS	2½" CALIFORNIAN PINE	10½
SIDE SEAT LATHS	" "	15½
		26
PANEL HOLDERS	1" " "	5
SEAT BACK LATHS	¾" " "	27

TIMBERS AND QUANTITIES REQUIRED FOR DUMMY.

TIMBER.	SUPER FEET PER DUMMY.
3" SPOTTED GUM	152
$2\frac{1}{2}$" " "	$23\frac{1}{2}$
$2\frac{1}{4}$" " "	$41\frac{1}{4}$
$1\frac{1}{2}$" " "	$63\frac{1}{2}$
1" " "	74 = Total $354\frac{1}{4}$
3" YELLOW WOOD	$36\frac{1}{2}$
2" " "	$7\frac{1}{2}$
$1\frac{1}{2}$" " "	$8\frac{1}{4}$ = Total $52\frac{1}{4}$
$2\frac{1}{2}$" BLACKWOOD	$11\frac{1}{2}$
2" "	$9\frac{1}{2}$
$1\frac{1}{2}$" "	$142\frac{3}{4}$ = Total $163\frac{1}{2}$
$1\frac{1}{4}$" HOOP PINE	22
1" " "	$138\frac{1}{4}$ = Total $160\frac{1}{4}$
2" TASMANIAN OAK	2
$1\frac{1}{2}$" " "	$55\frac{3}{4}$
1" " "	$45\frac{1}{2}$ = Total $103\frac{1}{4}$
$2\frac{1}{2}$" CALIFORNIAN PINE	26
1" " "	5
$\frac{3}{4}$" " "	27 = Total 58

TOTAL OF ALL TIMBERS FOR ONE DUMMY...$891\frac{1}{2}$ sup.ft.

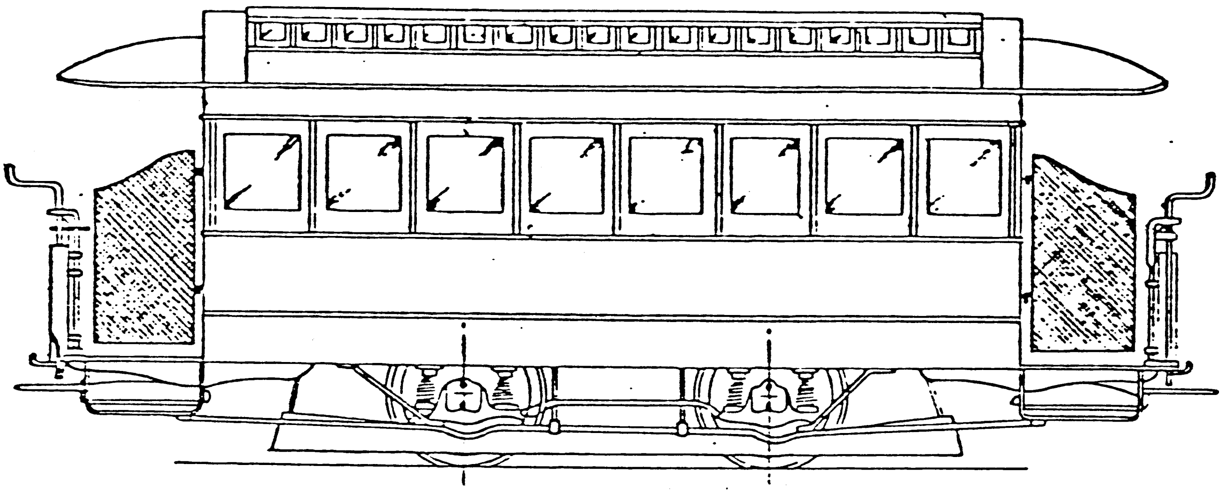
5.1.5 DUMMY TRACK SHOES.

Experiments were conducted by the Melbourne Tramway & Omnibus Co., in the use of various different timbers for dummy track or rail brake shoes. These tests were carried out during the years 1897, 1898 and 1899 to ascertain whether any other timber would be as economical or a superior substitute for the commercial hardwood. The size of wood used for track shoes was 3 inches deep by 2 inches width of bearing on the rail head by 2 ft. 3 ins. long. It was eventually found that the most suitable timber was the ordinary 3" x 2" hardwood straight off the saw and with as much moisture (sap) as possible. This material was delivered to the Repair Shops by local suppliers who held standing orders for the wet wood whenever available. Shoes made of commercial hardwood were used until the cable system closed down.

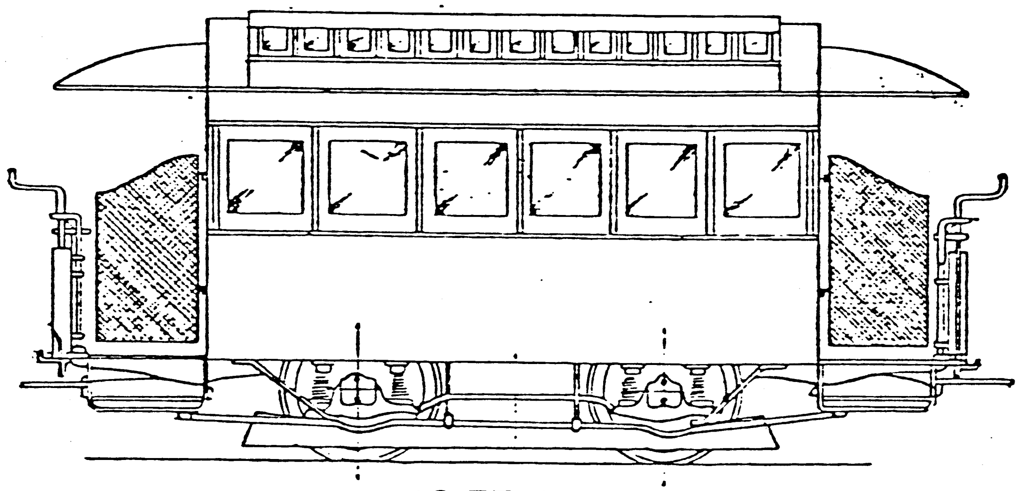
The average mileage obtained from hardwood during 1920, 1921, 1922 or thereabouts was 540 miles for each shoe on the dummy. The figures below show the comparative mileages obtained for the various timbers on different routes in the experiments conducted by the M. T. & O. Co. In viewing these figures, consideration must be given to the fact that loading and speed of trams was much greater in 1920 than in 1900.

TIMBER	ROUTE	MILEAGE	REMARKS
Red Gum	Richmond	282.37	
	Clifton Hill	467.82	
Oregon	St. Kilda	373.46	
	Nth. Carlton	300.00	
Blue Gum	St. Kilda	492.61	
	Prahran	511.15	
	Fitzroy	631.96	
	Port Melb.	364.55	
	Nicholson St.	496.60	
	" "	376.80	
	" "	555.50	8 - $1\frac{1}{4}$" dia. holes drilled in shoe and filled with pitch and sand.
Kauri	Nicholson St.	315.70	
	" "	354.20	8 - $1\frac{3}{4}$" dia. holes drilled in shoe and filled with pitch and sand.
Blue Gum	Nicholson St.	507:09	
	Fitzroy	760.30	

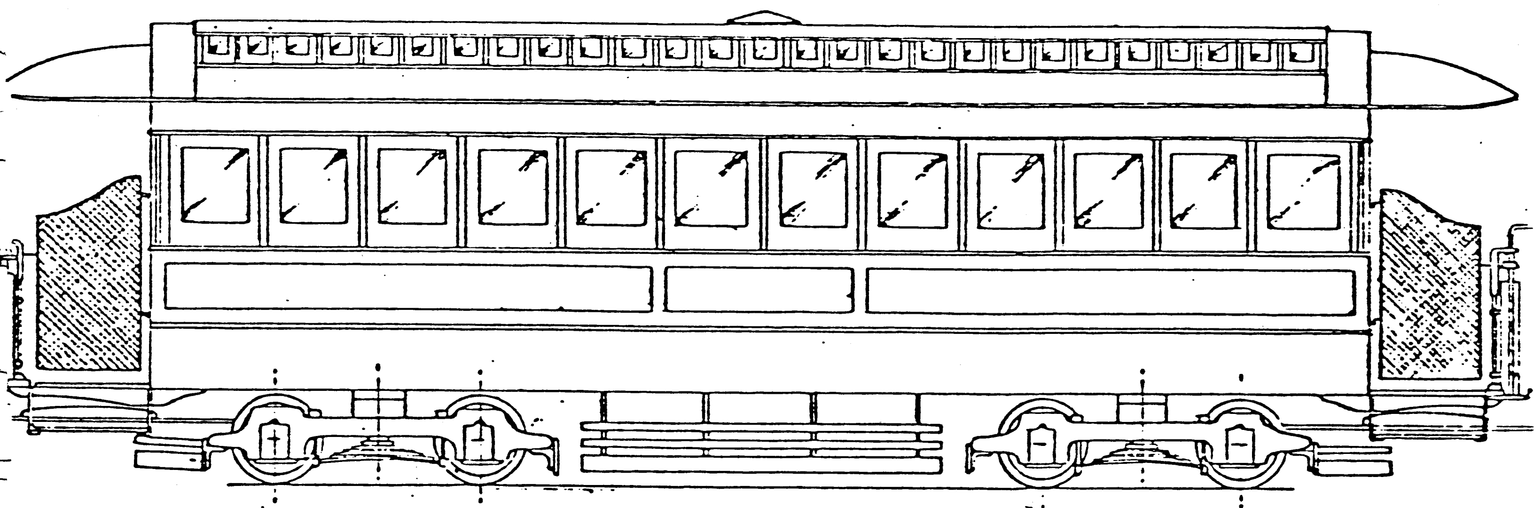
5.2 CARS - GENERAL



STANDARD CAR



12 FT. CAR



BOGIE CAR

The original cars imported from America and placed in service on the Richmond Line had saloons 16 feet long. This car was termed the "Standard Car" from which full size templates were made, and used for the construction of all future cars built at the Fitzroy Tramway Repair Shops.

For lines where traffic was very light, notably the West Melbourne line, cars were constructed with 12 foot saloons.

In contrast on the Brunswick line, where standard cars ran originally, the traffic became so heavy that cars of a greater capacity were required. The bogie car was then designed to cope with the increased loading, and operated in service until the line was converted to electric traction.

The three types of cars referred to are shown on the preceding page. Although these cars were of different lengths the construction of the bodies was exactly the same. The sliding doors, windows, blinds, pillars and pillar spacings, roofsticks, ventilators etc. were common to all types of cars. The bonnets on the ends of the cars and also the platforms were made separately from templates and attached to the cars as sub-assembly units. The bonnets were secured to the body bulkhead by means of brackets bolted securely to the corner pillars and screwed through the arch rail of the bonnet to the bulkhead. The platform was constructed on its bearers, which were bolted to the body side sills and underframe timbers.

It will be seen from the above that all car parts were reduced to a minimum, and standardised so that repairs could be made immediately by drawing from stock any finished component required. Metalwork was also standardised as far as possible, but with the design of the bogie car departure from standard parts became inevitable.

When the West Melbourne 12 foot cars were replaced by the standard type, they were used to construct bodies for the bogie cars. The bogie bodies built from the 12 foot cars could always be detected by the thick centre pillar, produced by the bolting together of the corner pillars of the short cars.

The cars were illuminated by kerosene lamps. The original standard cars had lamp boxes constructed in the left hand corners of the saloons with a vent pipe passing up through the roof. These lamp boxes had large glazed doors in the interior to allow illumination of the saloons, and in the bulkhead a round coloured glass to denote the destination of the tram at night. This method of lighting became standard and was adopted in all cars built at Fitzroy.

The 12 foot cars were similarly equipped, but the bogie cars, owing to their length, had an additional centre lamp. This central lamp was of a similar pattern to those used in the dummies, with glasses all round the lamp. One glass was set in a metal frame and hinged, to permit the kerosene lamp to be placed in position. A dome was also used on the roof to provide an outlet for fumes from the lamp. These domes were painted red, similar to the dummy domes to denote the Brunswick route. The above standard lighting equipment was in operation until 1918 or 1919, at which time it was superseded by electric lighting, power being obtained from Edison Sodium Hydrate Storage Batteries.

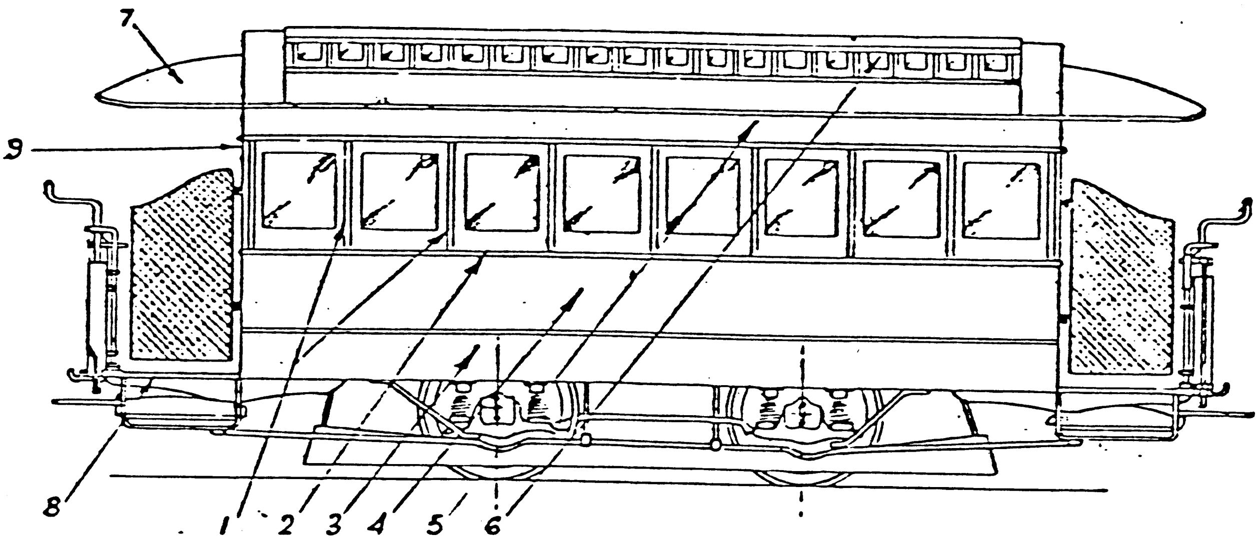
When the cars were wired for the electric lighting,provision was made for the batteries under the car seats where the leads terminated and plugged into sockets each end of the batteries. Two 36 watt x 6½ volt lamps were used in the saloons of standard cars and three 36 watt lamps in the bogie cars. One 2½ watt lamp was placed in the bulkheads of both types of cars to illuminate the route colour signal disc. Both types of cars had fuses and rotary switches installed in the lighting circuits. The batteries were handled in the same manner as the dummy batteries for charging etc.

The cars were painted with a background colouring, on dashes, bulkheads above doors and windows and side band panels, to denote the route on which the car ran. The car body panels were ornamented with transfers lining and lettering. Gold leaf was used extensively for the car numerals on sides and dashes, names of the streets (traversed by car) on band panels, lining and lettering of dashes etc.

The general finish of the cars was to a high standard, and to give as even an exposure as possible to the sun and weather conditions, the shed staff methodically turned them. They were also regularly washed and cleaned by the shed cleaner, who took a pride in the work of maintaining the excellent appearance of the rolling stock.

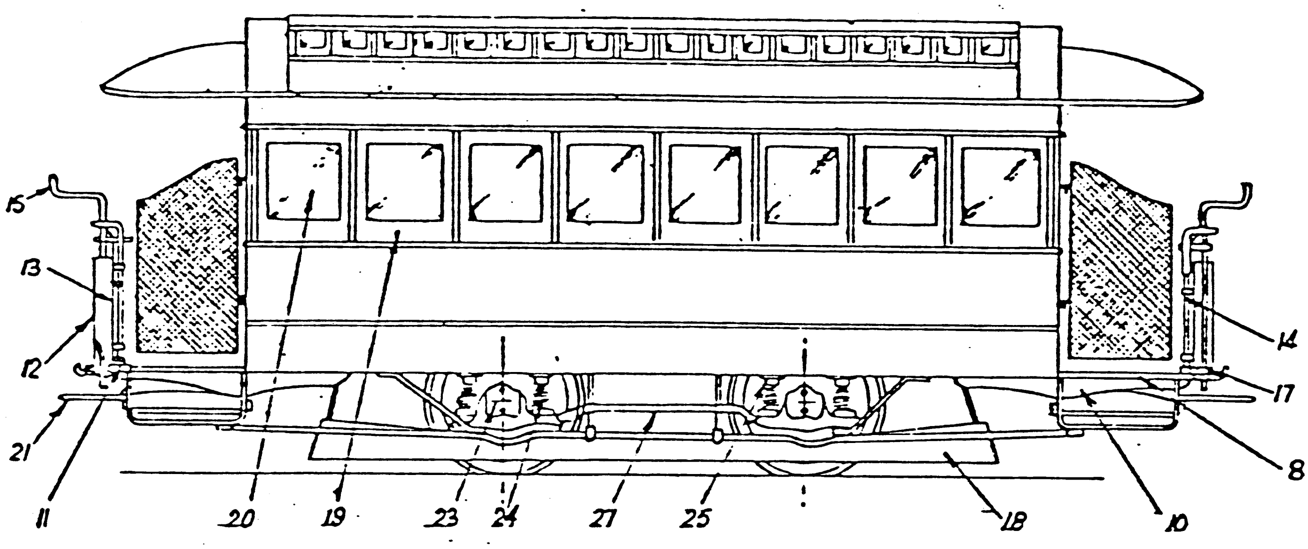
The Tramways Board decided about 1923-1924 to discontinue the use of cars for individual lines. This resulted in cars being uniformly painted in brown and cream, with practically all lettering omitted, the car numerals on sides and dashes remaining. After uniform painting, revolving destination signs were mounted on the car bonnets. The signs were four sided and springs engaged in grooves on one of the end flanges to hold the sign as desired. A Nicholson Street car, for example, carried a sign to show Nicholson St., Clifton Hill, Northcote or Spencer Street.

5.2.1 CONSTRUCTION OF CAR.



The cars, which were of different lengths, were of similar construction but had saloons of 12 ft., 16 ft., and 24 ft. The 16 ft. saloon car was known as the Standard Car and was regularly run on all lines with the exception of Brunswick and West Melbourne. The following is a description of the construction of the Standard Car:-

The Underframe of the car was built of spotted gum, the side sills being $3\frac{1}{2}$" x $3\frac{1}{4}$" and the laterals 3" x $2\frac{1}{4}$", this with diagonal braces formed a frame approximately 16 ft. long x 6 ft. wide. On this frame the car body is built, having the seven posts (1) on each side of the car. These posts (1) are morticed into the sills at 2 ft. centres, a belt rail (2) is run the full length of the saloon and the sides then finished with a 17" x 5/16" cove panel (3), a 19" x 5/16" body panel (4) and 8" x 5/16" band panel (5). The roof of the car is covered with $2\frac{1}{4}$" x $\frac{1}{4}$" hoop pine T & G boards, being white leaded, canvassed and painted similar to the dummy roof. The roof is supported by roof sticks spaced approximately every 12" and morticed into the cantrails. Small ventilator windows (6) are fitted in the side of the canopy roof between each roof stick; these windows, being pivoted about their centre line, enables them to be left either open or closed. A bonnet (7) is fitted on each of the saloon ends to roof over the platforms



(8), the bonnets are secured by steel brackets, white leaded, canvassed and painted over the roof boards in conformity with the rest of the roof. The end bulkheads (9) of the car are fitted with sliding doors, with windows on either side of the door, similar width and thickness of panels to those used on the car side complete the bulkhead. A platform (8) is constructed on each end of the car, being supported by 5" x 2" & 6" x 2" spotted gum bearers (10) bolted to the underside of the car body frame.

A crownplank or bumper (11) made of 8¼" x 1¾" spotted gum is bolted to the end of the timber bearers (10) and a dash (12) secured to same. The 4" x 13/16" hardwood platform flooring is also screwed down to bearers (10). The dash (12) is screwed to the outside of the bumper (11) and a steel frame (13) built round it with steel pillars (14) each side bolted down to the bumper (11). The gooseneck brake handle (15) with ratchet wheel (17) and pawl completes the dash.

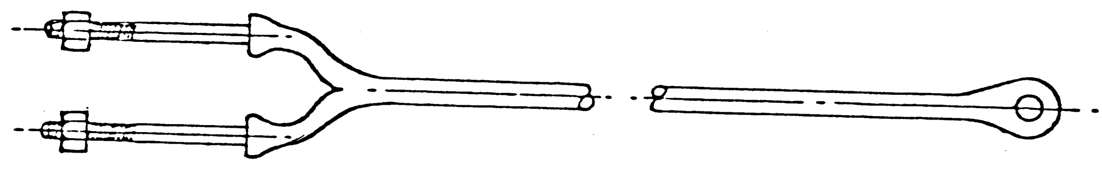
Lifeguard framing (18) is suspended by steel brackets round the wheels and undergear, being constructed of hoop pine.

Wooden full drop sashes (19) are provided with venetian blinds (20). The car seats and backs are of shaped plywood and supported on a wooden frame with wooden legs.

A hoop pine drawer under the side seat at one end of the car provides a space for the conductor to keep his property.

Lamp boxes are fitted at the near side front corners of the saloon, and the interior has a glazed door for illuminating the car. On the outside of the bulkhead a coloured glass disc shows, which denotes the route on which the tram is running.

Drawbars (21) made of "Special Netherton Iron" coupled the car to the dummy drawhead by a pin which passed through the top and bottom of the drawhead and through an eye at the end of the drawbar. The drawbar was forged with a forked end as shown in the sketch below:-

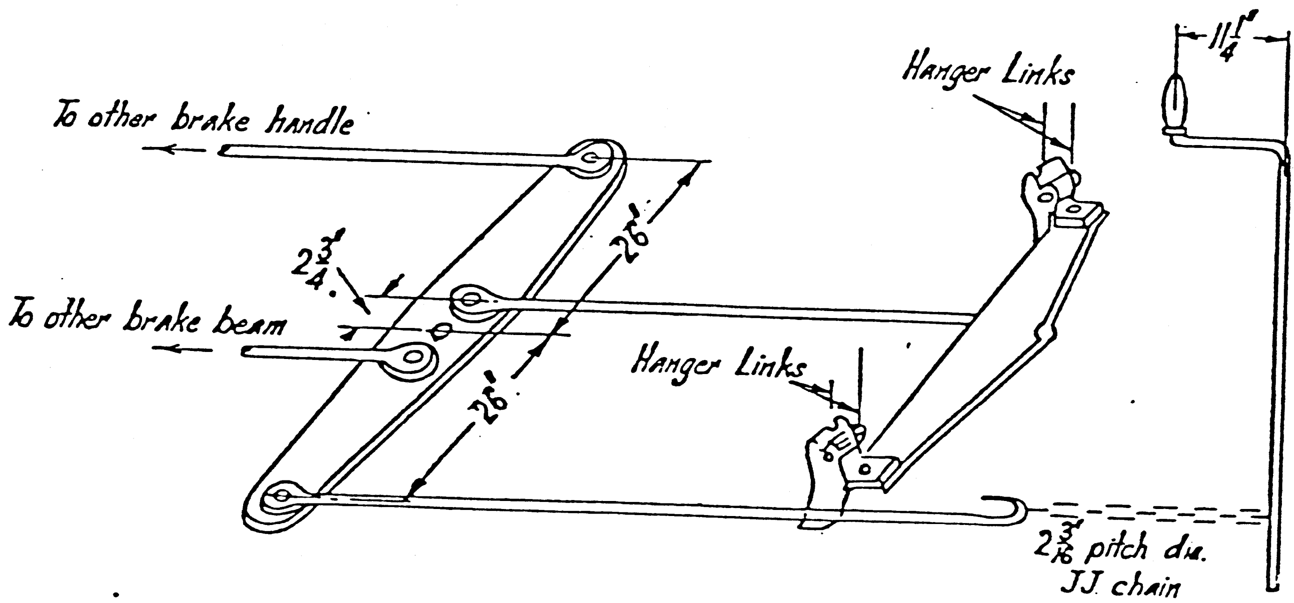


The fork end of each drawbar passed through a draught plate, one being bolted to the underframe each end of the car. Springs are provided, also special cast washers, on each side of the draught plate, which allows the necessary flexibility required for the drawbar operation.

Safety hooks (22) are bolted to the centre of the car crownplanks and are used as a safety device in case of drawbar faulure. A chain attached to the dummy crownplank was coupled to the safety hook.

Axle boxes (23) are fitted with spiral springs (24) housed in the top spring cap (25) which is bolted to the car side sill. The lower ends of the springs (24) are housed in spring seats on the axle boxes (23). A mild steel brace on each end of the axle boxes is bolted to the side sills and a forged mild steel centre stay (27) connects the two axle boxes.

The brake gear, as sketched below, shows the centre brake lever, which is supported by a bracket (not shown) and pivoted at the centre. This lever is connected to the gooseneck brake handles and staffs at each end of the car by a pull rod and chain and to the two brake beams by connecting rods. The shoes are bolted to hanger links pivoted to the car underframe.



5.2.2 CAR OPERATION.

The car operated as a trailer, being drawn by the dummy to which it was coupled as described below.

On occasions when traffic was heavy two cars were coupled to the one dummy; to operate this arrangement of vehicles, one gripman and two conductors were employed.

The car, when leaving the depot for service operation, ran over the examination pit for inspection of undergear and sounding of wheels for cracks. After running out the car was coupled to the dummy as follows:- The conductor standing on the car platform lifted the drawbar by means of a chain which slid through a conduit attached to the inside of the dash. This enabled the drawbar to be held at the correct height to engage with the drawhead of the dummy. The gripman, standing on the end platform of the dummy holding the coupling pin by its chain in position at the top of the drawhead, allowed it to drop through the drawbar when the drawbar was in position. A safety coupling chain attached to the dummy was then hooked on the car safety hook, which completed the coupling operation. The same procedure took place at termini after shunting.

The car brakes were operated on steep gradients to assist the gripman in stopping the tram. The conductors were called on to use judgment in the application of the car brakes, in that they were to allow the gripman to control the tram as much as possible. Frequently the tram speed was rapidly retarded and the conductor would immediately release the car brakes, allowing the gripman to take control and at the same time hold himself in readiness to make further application of the car brakes if required. If, on the other hand, the dummy brakes were not retarding the tram speed sufficiently, the car brakes would be applied more vigorously. Two grades where the above procedure was always observed under instructions to crews, were in Bourke Street (from Queen Street to Elizabeth Street) and in Collins Street (from Russell Street to Swanston Street.)

Wire gates were used on each platform to prevent passengers boarding or alighting from the off side of the car. The gates had hooks on their long sides which engaged with brackets on the car bulkhead, the other side of the gate being held by a shackle attaching it to the metal framework surrounding the dash. The gates were moved from side to side of the platforms by the conductors at each terminus.

The car windows were of the full drop type and consequently very suitable for most weather conditions. The louvre sun blinds were also full drop and functioned satisfactorily for operation with the windows. The ventilators between the roof sticks on the canopy roof could also be opened if desired. Bells were fixed under each bonnet on the centre line of the car and connected by a bell strap. The bells served to signal the gripman to stop the tram or proceed during traffic operations. The bulkhead windows each side of the door were protected by three steel bars, to prevent platform passengers from leaning against and breaking the glasses.

Hand rails were provided under the bulkhead windows and down the corner pillar, to assist passengers getting on or off the tram.

The car doors were of the sliding type, being suspended by rollers. The door was guided at the bottom by a cast guide plate screwed to the wooden bulkhead crossbearer.

In general the car was a very satisfactory vehicle, giving good service to the public and minimum axniety to those responsible for its operation. The car was light in construction but carried heavy crush loads and stood up to all that was demanded of it. If any mishap occurred to a car in service likely to cause general delay, it could be lifted off the track and the line maintained in normal operation. The car could then be repaired or transported by lorry to the car depot or workshops for attention.

5.2.3 CAR MAINTENANCE.

General car maintenance was carried out at the depots where most of the spares were held in stock at a subsidiary store under the control of the depot staff.

Some of the replacements made during general maintenance were:-

Platform Boards. The platform of the car, being wider at the saloon bulkhead than at the crownplank, called for a set of boards varying in length and tapering from the longest to the shortest. The finished boards were drilled and countersunk ready to screw down to the platform bearers in place of the worn ones.

Step Boards. These were drilled and shaped to replace worn steps being bolted to the metal step hangers.

Lifeguards. Sections of lifeguard made to templates and drilled were used to replace any faulty boards.

Sashes - Blinds - Sash runners - Sash anti-rattlers & bumpers.

Door anti-rattlers - Door rollers & runners - Door bumpers.

Bells - Bell straps - Strap brackets.

At times certain replacement parts had to be forwarded from the Workshops Stores, for unusual requirements, being generally the outcome of accidents.

All running maintenance, such as replacement of brake shoes, axle brasses, axle box springs etc., were also attended to at the depot.

Brake Shoe consumption was low, the car brakes being used principally in running in and out of depots and at termini when shunting. This did not give rise to any appreciable wear and, consequently, attention to brake rigging and wheels on cars was light but replacements were made when necessary.

Cars were overhauled at the workshops on a general inspection basis which took into account, length of time in service since last overhaul, condition of body and equipment and general appearance. An effort was always made to save the car body finish if possible, in order to avoid burning off. Painting a new or burnt-off car was very costly, due to the high class finish desired. The following coats of filling, paint and varnish (with the requisite surfacing between coats) was applied to new and burnt-off cars:-

2 coats Lead Colour
4 coats Filling
1 coat Facing Lead
1 coat Brown Lead
2 coats Body Brown Paint
4 coats Varnish

In addition, new ornamental transfers were required, together with necessary numerals, lettering and lining.

It will be obvious from the above that a great saving was effected by having cars to the workshops in time to avoid burning off.

When cars were in for general overhaul, drawbars, brake gear, safety hooks, truss rods, stays etc. were annealed or replaced if unserviceable. Woodwork was examined and renewed where necessary; also all fittings including sash bumpers, anti-rattlers, bell straps and such like were usually replaced. Wheels, axles, axle boxes, axle brasses etc. were also renewed if required.

5.2.4 PARTS. TIMBER AND QUANTITIES FOR CAR.

PART	TIMBER	QTY. SUP. FT.
BOTTOM SIDES	4" SPOTTED GUM	43
		43
END BARS	3" SPOTTED GUM	16½
DRAUGHT TIMBERS	" "	8
SEAT BLOCKS	" "	3½
SASH RESTS	" "	13
		41
CROSS BARS	2½" " "	22
		22
DIAGONALS	2" " "	7
PLATFORM BUMPERS	" "	13½
PLATFORM BEAMS	" "	40
SEAT LEGS	" "	3
SEAT LEG SUPPORTS	" "	3½
NOSE BLOCKS AND STRAINERS	" "	29½
		96½
STEP BOARDS	1" " "	10
		10
CORNER PILLARS	4" YELLOW WOOD	44
		44
SEAT BACK TOP RAIL	1" BLACKWOOD	3
PILLAR FACINGS	"	2½
END FACINGS AND SILLS	"	2
LICENCED BOARDS & ½" MOULDING	"	4
		11½
COW CATCHERS	1¼" HOOP PINE	30
		30
SEAT SHEATHING	1" " "	32
VENTILATOR STOPS	" "	5
BULL BOARDS	" "	1½
BEADING MOULDINGS & CANVAS BINDERS	" "	19½
WHEEL BOXES	" "	24
CAR DRAWER	" "	3½
LAMP BOXES	" "	3½
CORNER LININGS	" "	11
SWING SASHES	" "	5
DOOR MOULDINGS	" "	3
HEAD LININGS	" "	18
VENETIAN BLINDS	" "	31
ROOF BOARDS	" "	105
		261½
SASHES	3" TASMANIAN OAK	63
		63
SEAT FRONT RAILS	2½" " "	17
		17

PART	TIMBER			QTY. SUP. FT.
DOOR PILLARS	2"	TASMANIAN	OAK	11
CANT RAILS		"	"	13
END MAIN PLATES & RISERS		"	"	19½
DOOR ARCH BLOCKS		"	"	4
SEAT BACK RAILS		"	"	11
				58½
SIDE PILLARS	1½"	"	"	54
CENTRE AND WAIST RAILS		"	"	18
FENCE RAILS		"	"	6½
END CENTRE WAIST DOOR ROLLER RAILS		"	"	7
O.G. VENTILATOR RAILS		"	"	8½
BONNET BOWS AND MAIN RIB		"	"	7
SEAT FRONT RAILS		"	"	13
SEAT BACK RAILS		"	"	8
LINING BLOCKS		"	"	2½
				124½
DOORS	1¼"	"	"	27½
SIDE PILLAR SLIPS		"	"	3
				30½
TOE BOARDS	1"	"	"	4
WHEEL COVER BATTENS		"	"	3½
END VENTILATOR RAILS		"	"	2
WHEEL BOX BATTENS & LEVERS		"	"	4½
END VENTILATOR FLAPS		"	"	2
END BODY MOULDINGS & ½" MOULD		"	"	2
SEAT SUPPORT RAILS. BLOCK BATTENS & FLOOR BLOCKS		"	"	5
MAT LATHS		"	"	7
SEAT BACK RAILS TOP		"	"	5½
SEAT BACK RAILS		"	"	13
ADVERTISEMENT RAILS		"	"	5½
HAND RAILS		"	"	2½
BONNET RIBS		"	"	4½
CANOPY RAILS		"	"	2½
ROOF RIBS		"	"	44
LAMP BOX BATTENS		"	"	1½
END FALSE RAILS		"	"	1½
SIDE FALSE RAILS		"	"	5½
DRIP RAILS		"	"	9
PLATFORM SHEATHING		"	"	42
SEAT SCROLLS		"	"	2
				169
GLASS BEADS	1"	CALIFORNIAN	PINE	4
				4
VENETIAN BLIND SLATS	1¼"	SUGAR	PINE	27
				27

NOTE: For PANELS, FLOORING and LINING see next page.

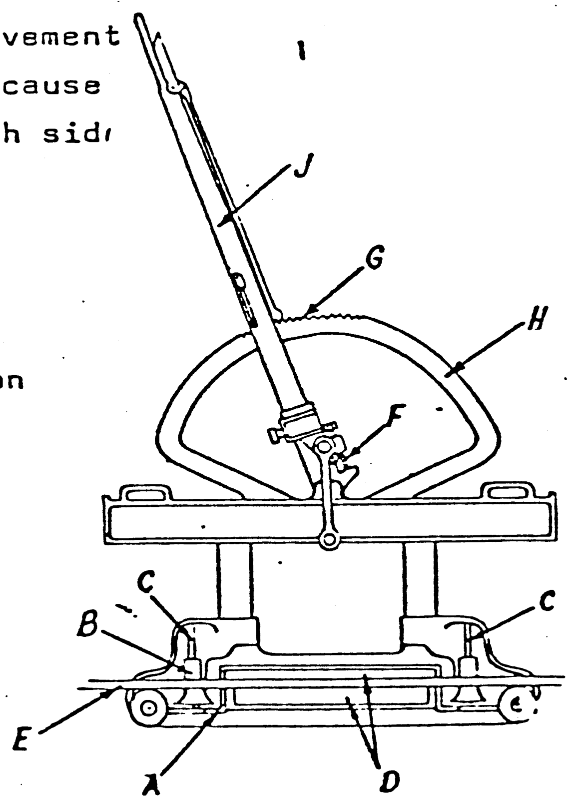
TIMBERS AND QUANTITIES REQUIRED FOR CAR.

TIMBER	SUPER FEET PER CAR
4" SPOTTED GUM	43
3" " "	41
2½" " "	22
2" " "	96½
1" " "	10 = Total 212½
4" YELLOW WOOD	44 = Total 44
1" BLACKWOOD	11½ = Total 11½
1¼" HOOP PINE	30
1" " "	261¼ = Total 291¼
3" TASMANIAN OAK	63
2½" " "	17
2" " "	58½
1½" " "	124½
1¼" " "	30½
1" " "	169 = Total 462½
1" CALIFORNIAN PINE	4 = Total 4
1¼" SUGAR PINE	27 = Total 27
5/16" AVAILABLE TIMBER FOR PANELS	94¼ = Total 94¼
4" x ⅞" T & G FLOORING 300 LIN. FT.	87½ = Total 87½
6" x ¾" T & G LINING 32 LIN. FT.	7¼ = Total 7¼

TOTAL OF ALL TIMBERS FOR ONE CAR ....1242¼ sup.ft.

5.3 GRIPS.

The Cable Grips were imported from America with the rolling stock for the Richmond Line. These grips were of the design shown below, and were later manufactured at the Tramway Workshops at Fitzroy. This type of grip was not entirely satisfactory for local conditions, the objections being (1) that when the rope was thrown out of the grip by the lifter bar (A) raising the conical pulley (B) up the vertical spindle (C) it resulted at times in the conical pulley (B) becoming jammed by grit and dirt on the vertical spindle (C) and would not drop back to its original position, this resulted in the rope being taken in between the dies (D) with the conical pulley (B) above the rope (E) and not in a position to force the rope (E) out of the dies (D) when such operation was required. (2) that the method of adjustment of the dies (D) was unsatisfactory for various conditions of worn ropes and dies. The adjustment was made by the adjusting screw (F) before the grip was placed in service in the morning. To provide for die and rope wear, a long rack (G) was cut in the quadrant (H) so that sufficient travel was available for the lever (J), this movement of the lever was most undesirable because the brake levers situated one on each sid of the grip lever were adjusted to operate at approximately a vertical position. It will be understood therefore that the most desirable position for the grip lever operation was somewhere about the vertical.



To minimise the first trouble, men were employed at termini to hose the grips and wash out the dirt on days when donditions were unfavourable with rain washing the road grit etc. down the slot. It was also necessary for gripmen to feel that the cone pulley (B) was down the spindle (C) by operating the lever (J).

Resistance would be felt when the conical pulley (B) came in contact with the cable (E). If the cable (E) was accidently thrown out of grip it had to be replaced between the dies by means of a hook which was put down the slot in front of the dummy and the cable lifted by the conductor to elevate it into the grip while the gripman moved the lever to close the dies on the cable.

The second difficulty was overcome by having frequent adjustments made to the grip by the car depot staff.

A new design of grip was put in hand to make the mechanism for throwing the cable more positive and also to enable a ready adjustment of dies to be carried out. The new grip when completed gave a splendid performance and with very minor alterations was in use until the last Cable Tram Line was closed.

Experimental work was carried out with different types of grip dies made of various metals and of different lengths. (See 5.3.5).

5.3.1 CONSTRUCTION OF GRIP.

The grip lever (1) of mild steel, forged in one piece, fits into the cast steel socket (12) which is pivoted to the cast steel slide (18) by the mild steel pin (47).

The palm handle (2), having a base or cheeks (58), is also a one piece mild steel forging and is attached to the lever (1) by the mild steel lever bolt (73) and to the pawl rod (59) by another mild steel bolt (73) at the pawl rod end (60).

The mild steel pawl rod (59) passes through a bronze bracket (3), a bronze pawl spring box (50) and a bronze pawl box (7). The spiral steel pawl spring (4), held by the pawl spring pin (49), forces the mild steel pawl (5) downwards into the rack of the cast steel quadrant (16). The bronze pawl box (7), which has a mild steel guardplate (55) to keep the pawl (5) in position, is bolted to the lever (1) and is a guide for the pawl rod (59) at its lower end. There are two mild steel latches (6) for operating the pawl (5) by foot instead of the palm handle (2). The latches (6) are carried by a cast steel pawl latch bracket (8), which is attached to the lever (1).

The adjusting rod (9) of mild steel has a bronze adjusting wheel (11) secured by a nut at the top end. The adjusting rod (9) passes through the bracket (3) and down to the mild steel adjusting screw (10) to which it is held by a cotter pin. The adjusting rod (9) is pinned to the adjusting screw (10) which engages with R.H. and L.H. nuts (14) in the cast steel shoe (13) and the cast steel socket (12).

The mild steel adjusting screw (10) is machined with a R.H. and L.H. thread, which, when turned by the adjusting rod (9), moves the shoe (13) and socket (12) together or apart, resulting in an altered relative distance between the shoe trunnion (38) and the slide pin (47), giving an adjustment for the varying sizes of cables.

The shoe (13) slides on the lever (1), which has screws (69) to adjust for wear while the lever (1) and the socket (12) remain fixed to the slide (18).

The mild steel links (15), one on each side of the grip, are attached to the shoe (13) by the shoe trunnion (38) at the top end and to the crossbar (17) by a mild steel pin (48) at the bottom end, in both places washers and cotter pins are used to secure the links (15).

As described above, the lever (1) and socket (12) are fixed to the cast steel slide (18) at the mild steel slide end (45) by the slide pin (47), also the cast steel quadrant (16) is riveted to the slide (18) which maintains the same relative position to the quadrant (16) and lever (1). This enables the lever (1) to operate round the quadrant (16) for the engagement of the pawl (5) in the rack cut in the quadrant (16).

The cast steel slide (18) is guided between two cheeks (19) made of shear steel;these cheeks are protected from wear due to rubbing against the slotbeam by the protection pieces (20) which are cast steel and reversible to obtain double life out ot them. A top guide plate (46) in cast steel and a bottom guide plate (51) in mild steel serve as guides for the slide (18).

The protection pieces (20) are held in mild steel top and bottom slips (21 and 22) which are bolted to the cheeks (19).

The slide (18) carries the top die holder (24) which is bolted to the backguard (25) by the top die holder bolts (52).

The cheeks (19) are bolted to the crossbar (17) by the mild steel bolts (65 and 66) at the top end and held firmly in position by the mild steel wedges (37), and at the bottom end the cheeks (19) are held by the bolts (68) and set screws (71) to the cast steel soleplate (29).

The cast steel bottom die holder (28), bolted to the soleplate (29) by the bottom die holder bolts (56 and 57), is fitted with the rolled steel bottom die (27) which meets the rolled steel top die (26) fitted to the top die holder (24).

The cast steel soleplate (29) has fitted into it cast steel swinger frames (35) which are secured at the top and bottom by mild steel bolts (63 & 64). The swinger frames (35) have cast steel swingers (34) held in them by the mild steel swinger pins (40) on which they pivot. The swingers (34) carry cast iron cones (32) attached to them by mild steel cone pins (39) held by mild steel washers and cotter pins. At the top of the cast steel swinger (34) cast steel kickers (33) are pivoted on mild steel kicker pins (53) held by cotters. This mechanism is for "throwing the rope" and its use is described under the "Operation of the Grip".

The top die holder (24) has bolted to it a small cast steel lifter bar (23) which rises with the top die holder (24) and engages with the cast steel kicker (33) which rotates on the kicker pin (53) causing the swinger (34) carrying the cones (32) to swing outwards and force the cable out of the dies (26 & 27).

Cast steel sheaves (31) and cast steel sheave centres (62) are bolted by a mild steel sheave stud (43) and washer (70) to the soleplate (29). These sheaves (31) carry the cable when it is released by the dies, and cast steel sheave protectors (61) are provided to guard against the sheaves being damaged due to worn dies.

The lever (1) is limited in its travel by a mild steel lever stop (42) at its lowest position, i.e. with the dies fully opened and a mild steel bolt (41) through the quadrant (16) at a position where the dies are fully closed at the end of their travel.

The cast steel backguard (25) is used on curves and will be reviewed under Permanent Way Operation.

CABLE GRIP

Nº	PART	Nº	PART
1	Lever	71	Soleplate Set Screws
2	Powl Handle	72	
3	" Rod Bracket	73	Lever Bolts
4	" Spring	74	Hornbar Washer 1/8"
5	"	75	" " 1/4"
6	" Latch	76	" " 3/8"
7	" Box	77	" " 1/2"
8	" Latch Bracket.	78	
9	adjusting Rod	79	
10	" Screw	80	
11	" Wheel		
12	Socket		
13	Shoe		
14	adjusting Nut		
15	Link		
16	Quadrant		
17	Crossbar		
18	Slide.		
19	Check		
20	Protection Piece		
21	Top Clip		
22	Bottom Clip		
23	Lifter Bar		
24	Top Die Holder		
25	Back Guard		
26	Top Die		
27	Bottom Die		
28	" " Holder		
29	Sole plate		
30			
31	Sheave		
32	Cone		
33	Kicker		
34	Swinger		
35	" Frame		
36	" " Set screw		
37	Wedges		
38			
39	Cone Pins		
40	Swinger Pin		
41	Lever Check Bolt		
42	Lever Stop		
43	Sheave Stud		
44			
45	Slide End		
46	Top Guide Plate		
47	Slide Pin		
48	Crossbar Pin		
49	Powl Spring Pin		
50	" " Box		
51	Bottom Guide Plate		
52	Top Die Holder Bolt		
53	Kicker Pin		
54			
55	Powl Rod Box Guard Plate		
56	Bot Die Holder Bolt (end)		
57	" " " " (centre)		
58	Powl Handle Check		
59	" Rod		
60	" " End		
61	Sheave Protector		
62	" Centre		
63	Swinger Frame Bolt (top)		
64	" " " (bottom)		
65	Crossbar Bolts 2¼ x ⅝d		
66	" " 1¾ x ⅝d		
67			
68	Soleplate Bolts		
69	Shoe Screws		
70	Sheave Washer.		

MELBOURNE & METROPOLITAN TRAMWAYS BOARD

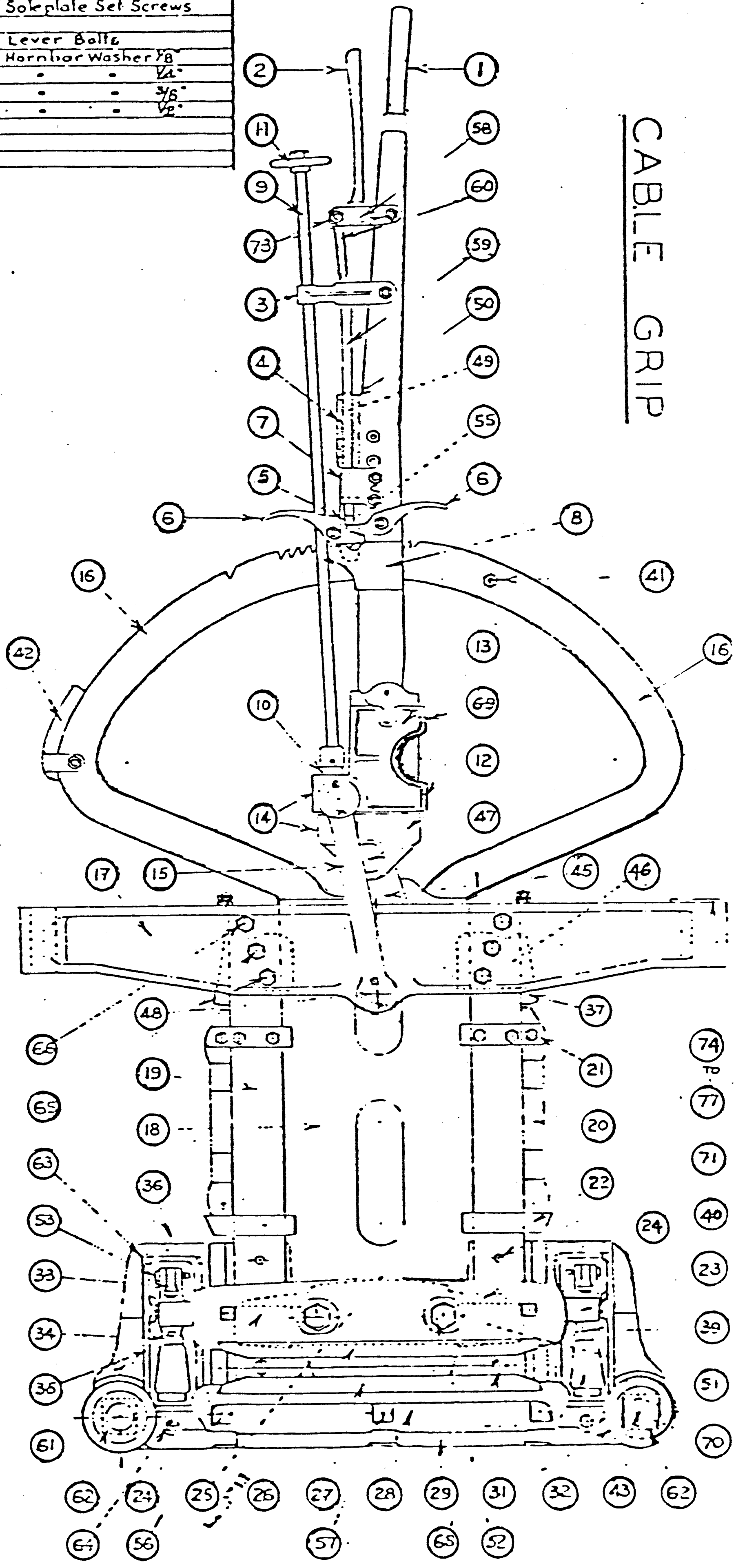
CHIEF ENGINEER

DRAWN | TRACED | CHECKED | PASSED

Date 13.1.33

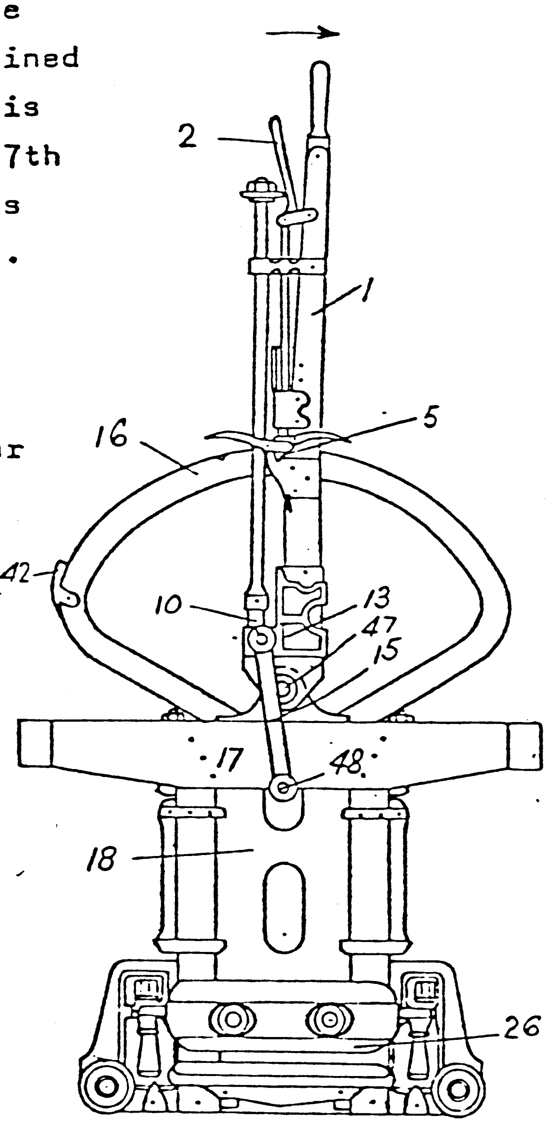
SCALE

R-3485



5.3.2 OPERATION OF THE GRIP.

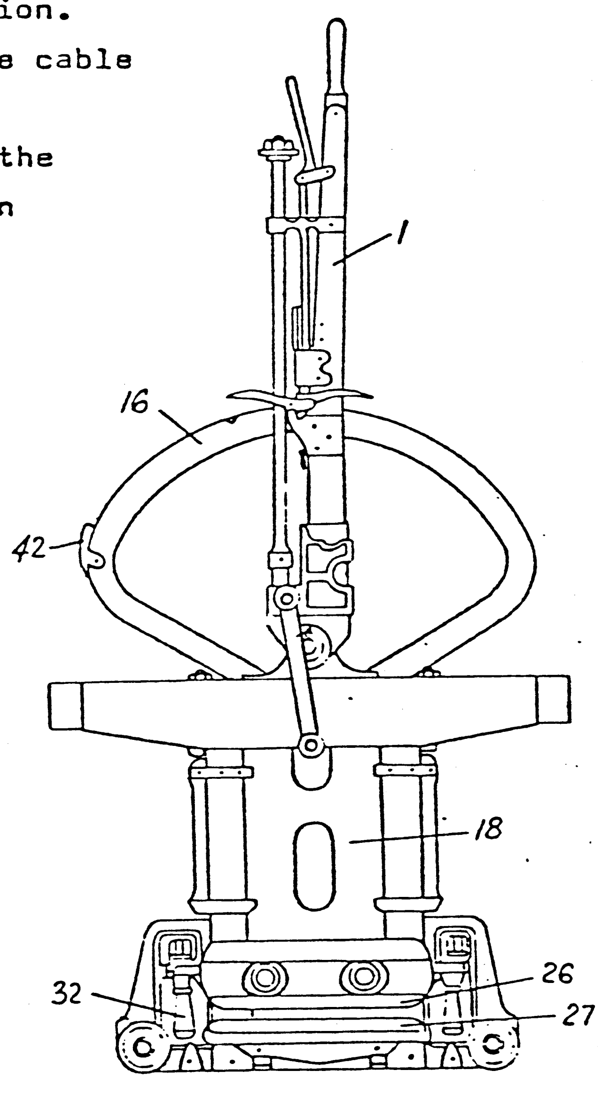
The grip is operated by the grip lever (1), which is moved in the direction shown by the arrow in order to grip the cable. When the grip lever (1) is adjusted by the adjusting screw (10) for normal running conditions, the pawl (5) is in the 7th notch of quadrant (16). From this running position the operation of the grip is as follows:- The grip lever (1) is moved in the opposite direction to the arrow to the lazy notch on the quadrant (16) to release the cable and allow the tram to stop. To start the tram the gripman forces the lever (1) in the direction shown by the arrow, maintaining pressure on the palm handle (2). To hold the pawl (5) from engaging in the quadrant rack until the tram has attained full speed, then the palm handle (2) is released and the pawl (5) drops into 7th notch on the quadrant if adjustment is correct for the size of cable gripped. The action of this operation is to force the SLIDE (18) carrying the top die (26) downwards, owing to the links (15) being fixed to the crossbar (17) by the pin (48) at one end, and to the shoe (13) on the lever (1) at the other end. It will be observed that this gives a toggle action and that if the lever (1) were to be moved in the direction of the arrow so that the links (15) took up a vertical position the slide (18) would not move downwards because pin (47) attaching the lever (1) to the slide (18) would be in line with the links (15); on the other hand the further the lever (1) is moved down towards the stop (42) on the quadrant the greater the movement of the links (15) from the vertical position and, consequently, the greater the movement of the slide (18) carrying the top die (26); this gives a rapid opening of the dies.



This toggle action and the movement of the lever (1) to the stop (42) is the procedure adopted when the cable is to be "thrown" or forced out of the grip dies (26 & 27). This operation is as follows:- The tram is running at speed and when it reaches a point where the cable is to be thrown, the gripman moves the lever (1) down to the stop (42) on the quadrant (16); this rapidly opens the dies (26 & 27), the top die (26) being fixed to the slide (18) at the same time as the dies open the kicker gear comes into operation and the cones (32) force the cable out of the dies (26 & 27). After the dies have opened nearly to their full extent, the cones (32) are freed and drop down, taking up their original position.

The grip is then ready to receive the cable with the dies (26 & 27) fully open. The tram arrives at the point where the cable is to be picked up, the gripman then moves the lever (1) from the stop (42) up to the lazy notch on the quadrant (16) which takes the cable between the dies ready to be gripped and the tram to proceed on its journey.

The above is a description of the operation of the grip mechanism, the die movements and calculations of which are contained in 5.3.6. In 5.3.7 is a quarter scale model showing the movements of the lever, links and slide with top die. The relative position of these parts for the various notches and stops can be observed by setting the lever to the markings on the quadrant.



The following is a description of how the grip operates in service. A dummy with its grip is run out of the car depot and stopped in position over the grip hatch, through which the grip is to be lowered into the tunnel. The grip hatch is opened from the inside of the dummy with a hook, which is carried on all dummies for this purpose and also for picking up the cable should the gripman accidently release it from the grip in service. After lowering the grip into the tunnel by means of a rope tackle block attached to the grip lift bar in the dummy as previously described, the hatch is then closed with the hook. The grip is now in position to receive the cable, which is lifted into the grip dies by a hand pick-up. The grip lever is then operated to close the dies on the cable and the grip is then ready for service.

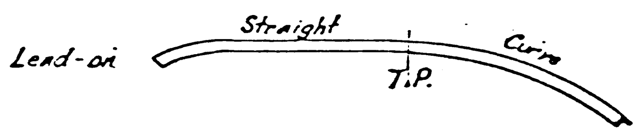
As the grip moves along the tunnel it lifts the cable clear of the pulleys, but after passing, the cable lowers on to the pulleys again.

When the grip arrives at an intersection, curve or other position where the cable had to be thrown out of the dies, special precautions were taken to prevent damage to the cable should the gripman fail to operate the grip correctly. The action taken in this direction was to install a check bar at a certain distance beyond the throw rope position. This bar and its functions are described under the heading of cables. Before the installation of check bars very serious damage was caused to the cables, due to the grip cutting or badly kinking them, when the gripman failed to operate his grip correctly.

When the grip arrived at the "throw rope" position the cable was running at its normal height and direction through the grip dies, but after this point had been passed the cable direction was changed by special pulleys, such as a depression pulley at an intersection. The effect of this was, that if the gripman failed to throw the cable out of the grip at the correct place or thereabouts, the cable gradually became pressed down into the bottom die of the grip. This pressure rapidly increased and prevented the gripman from releasing the cable, with the inevitable result of serious damage to it.

After the installation of check bars damage could still be caused to the cable by a careless gripman throwing it beyond the throw rope mark and before the check bar. This resulted in damage to the cable while it was being forced out of the dies by the sharp edge of the worn die cutting or burring it. This damage to the cable was detected during its examination at the engine house after service at night. The Repairs Shop Superintendent was notified the next day of this damage, and the rope involved. He then directed the shed staff at the depot or depots concerned to examine all dies. This usually resulted in the marked dies being found, and the dummy number obtained, from which the Line Manager was able to find the gripman responsible for the damage.

The curves where the cable is carried round in the grip dies, special curve drums and rubbing bars are employed. These drums are spaced at 4 ft.centres on a 50 ft. radius curve and are mounted on vertical spindles. The drums, which revolve horizontally, have a 10 inch vertical face with a flange at their lower edges. The face gives freedom of movement for the cable, when the grip lifts it away from and returns it to the drum. This also takes care of any variation in height of the grip. The flange is to prevent the cable running off the bottom edge of the drum. The faces of the drums are a few inches inside the centre line of the slot round the curve. The rubbing bar is supported by brackets attached to the yokes and at a height of approximately 6 to 8 inches above the cable. The rubbing bar is shaped to give a lead-on for the grip before it actually enters the curve thus:-



This enables the grip with the cable between the dies to enter the curve with the top die holder or backguard bearing against the face of the rubbing bar. The side of the grip which bears against the rubbing bar, depends on which direction the curve takes.

The rubbing bar is made of 3" x 3" x ½" commercial mild steel angle and is situated in front of the curve drums at their upper edges. This allows the grip to hold the cable away from the drums as it proceeds round the curve, the cable returning to the drums as the grip passes.

Another important function performed by the grip in service is its operation during shunting at termini.

The method of shunting is known as the "flying shunt" and is employed where practically level tracks exist. The following is a description of this mode of shunting:-

1. The coupling pin is withdrawn, freeing the dummy from the car.

2. The car is slowed down by the light application of its brakes.

3. The cable is thrown out of the grip.

4. The grip strikes a "kicker bar" which sets the points for the dummy to pass over the dummy shunt.

5. The grip strikes another "kicker bar" which resets the points for the car to proceed on the straight track and at the same time returns the first "kicker bar" to its original position.

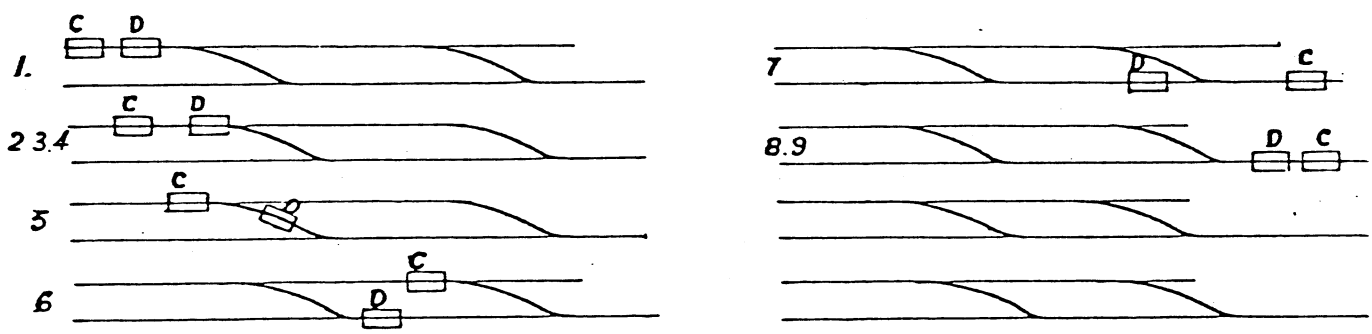
6. The dummy is slowed by light application of brakes, allowing the car to overtake it.

7. The car runs over the turnout on to the track ready for coupling to the dummy.

8. The dummy moves down to the car and coupling operations are completed.

9. A hand pick-up is used to replace the rope in the grip and the tram is ready to proceed.

The following diagrams set out the movements of the dummy and car as indicated above.



5.3.3 GRIPS - MAINTENANCE.

The general service maintenance of grips was carried out at the car depots. This work comprised mainly the replacement of parts worn or broken in service. The components used for ordinary running maintenance were, dies, protection pieces, sheaves, pins, adjusting screws, swinger cones, pawls, latches and bolts.

The dies were replaced when the wear gave a depth between the edge of the die and the bottom of the groove of $\frac{1}{8}$".

The protection pieces were used to prevent the slot beam from wearing the grip cheeks. The new castings were ground to a thickness of 21/32 inch and condemned at 17/32 inch. This gauging was carried out by the shed staff who were supplied with standard gauges for the depth of die wear and thickness of protection pieces. Adjusting screws were replaced when wear became noticeable in making grip die adjustments. This was a matter for the judgement of the leading-hand shedman who possessed a general knowledge of the operation of grips.

The sheaves and pins were also replaced when obviously worn. The shed staff were able to keep the grips in very satisfactory order, but when the wear became general after a lengthy period in service the grips were forwarded to the workshops for overhaul. The overhaul of grips was based on wear, which was shown as lost motion in the grip parts, when the dies were closed on a mild steel bar which represented the cable. The most obvious wear was in the links, slide end and pin, and shoe pin or trunnion.

The overhaul procedure was to dismantle the grip entirely and rebuild it. The parts which could be reconditioned, such as the lever, links, slide end, latches, pawls, quadrant, slide and cheeks, were used again, and other parts required were drawn from the stores and replaced. The practice as with all dummy and car parts was to stock every grip part and so draw out any material required and proceed with the assembly of the grip. A grip took 3 to 4 days to assemble and when complete was tested for die movement, adjustment and correct motion of all moving parts and passed by the leading-hand in charge of the grip section, who had a thorough knowledge of the work and the grips.

The grips were assembled on stocks, which were wood posts set in the floor with steel brackets and pins attached to them, being about 4'-6" above the floor level. On these pins the crossbar of the grip was mounted and from this part the grip was assembled, firstly the cheeks, then the soleplate and so on, each part being gauged for fit and movement.

5.3.4 SWINGER AND KICKER GEAR.

OPERATION OF GRIP KICKER GEAR

POSITION

A. The Lifter Bar which is fitted to the Top Die Holder remains approx. in this position while the Grip is operated in gripping & releasing the Cable.

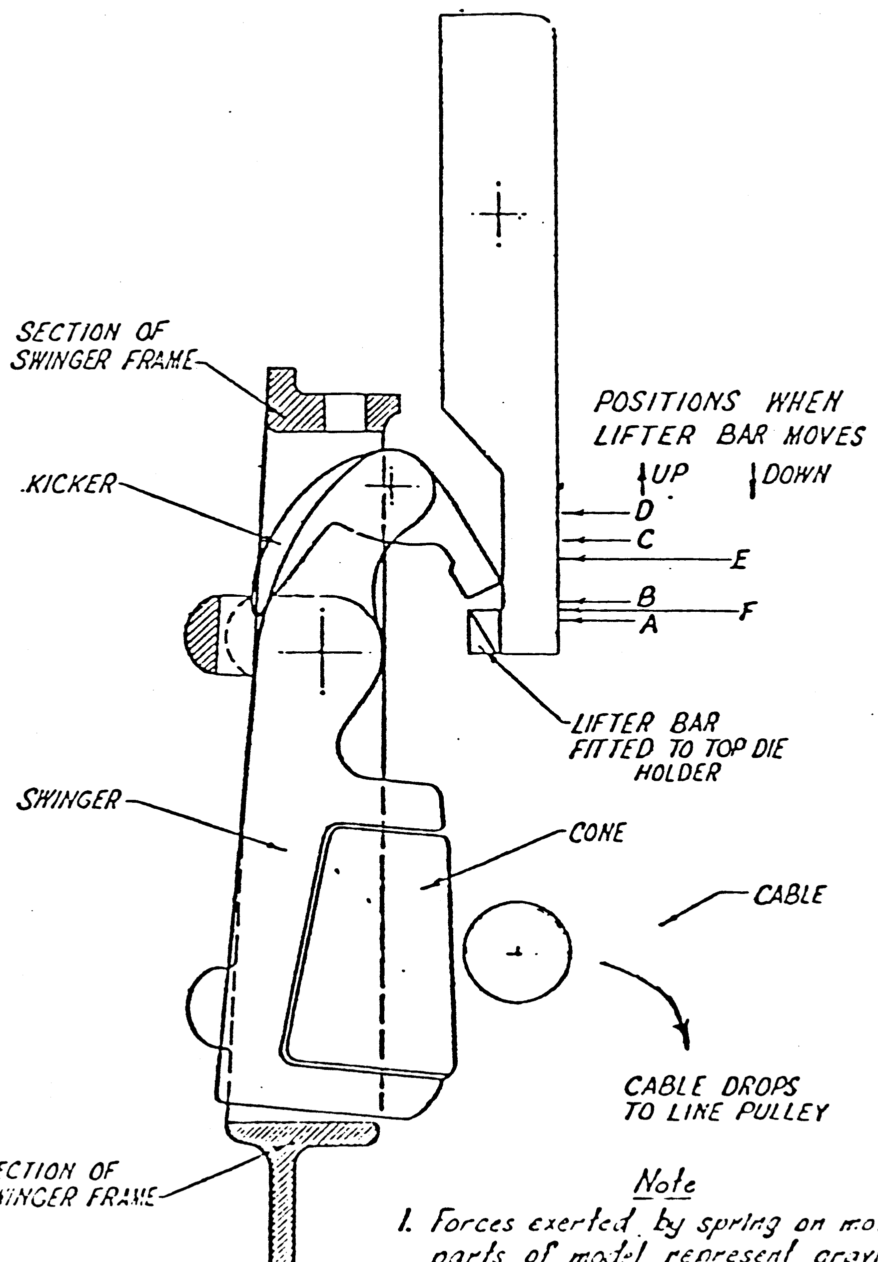
B. The Grip Lever is moved towards the position for throwing the Cable & by raising the Top Die Holder & Lifter Bar, causes the Lifter Bar to make contact with the Kicker.

C. The Lifter Bar forces the Kicker backwards, operating the Swinger, which in turn forces the Cable out of the Dies by contact with the Cones.

D. The Lifter Bar disengages with the Kicker, and the Swinger falls back into its original position in the Swinger Frame. The Cable having been thrown out of Grip.

E. The Kicker which is pivoted on the Swinger, moves to allow the Lifter Bar to pass and the Top Die Holder to regain its position where the Die is closed on the Cable.

F. The Kicker falls back to its original position on the Swinger, and the gear is in its position for a repetition of the cycle of movements.



Note

1. Forces exerted by spring on moving parts of model represent gravity forces in actual Grip Operation.

5.3.5 GRIP DIES.

The Melbourne Tramway and Omnibus Co. conducted experiments with the original grip, in an effort to obtain greater mileage from the grip dies.

Different cast metals were employed in tbe early tests, the dies and die holders being cast in one piece and the length of the die portion of the casting was 14 inches.

Later the die was increased to 18 inches in length and cast separately from the holder in special cast iron, being very similar to the finally accepted rolled steel die in appearance and performance. Dies 18 inches long were also forged in Wrought Iron and Lowmoor Iron.

Finally in 1903, the new grip with a 19 inch die was put into service and the rolled steel dies used. Rolled steel dies had been in service since 1892 in the old grips following the above mentioned tests.

In addition to the wearing qualities of the dies used in the experiments, special attention had to be given to the gripping qualities which, if too severe on the rope, introduced dangerous traffic operation.

Two other factors which had to be taken into consideration in making a comparison of the above tests were, first, the speed of the cable and, secondly, the condemning depth of wear of the dies. In 1934 an average of 800 miles per grip die was obtained with cable speeds of 12 and 13 miles per hour, but in addition much heavier traffic loading was experienced, with the resultant shorter life of the cables and, as has been recorded earlier, all dies in grips were scrapped and replaced on lines where cables were changed or renewed.

The following is a tabulated account of the tests conducted leading up to the final use of rolled steel dies.

METAL	LENGTH OF DIE	AVERAGE MILES PER DIE	DEPTH OF WEAR	SPEEDS OF CABLES	REMARKS
Phosphor Bronze	14"	413.17	7/16"	8 m.p.h.	Mileage too low.
Cast Steel - hard.	14"	3760.21	"	"	Condemned due to blow holes and breakages.
Cast Iron - soft.	14"	329.17	"	"	Mileage too low & bite on cable too severe.
Malleable Cast Iron.	14"	4312.28	"	"	Too hard for good gripping and castings expensive
Wrought Iron.	18"	1261.70	"	"	Similar results to rolled steel dies
Cast Iron - special.	18"	1438.93	"	"	" " "
Lowmoor Iron - forged.	18"	-	"	"	Bite on cable too dangerous, condemned immediately. Used for trial run only.
Rolled Steel	18"	2296.50	"	"	Used 1892 to 1900.
" "	18"	1226.00	3/8"	10 m.p.h.	" 1900 to 1902.
" "	19"	1061.00	"	"	For 1903 to 1904.
" "	19"	800.00	"	12 & 13 m.p.h.	" 1934.

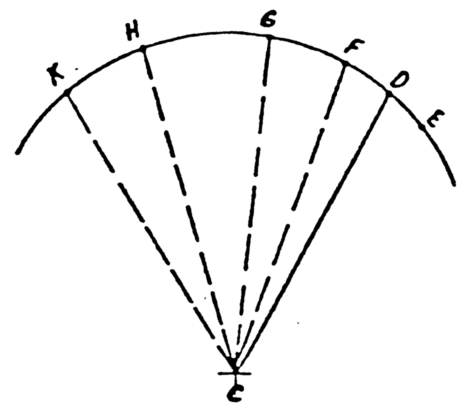
5.3.6 GRIP DIE MOVEMENT.

The following table shows the grip die movements corresponding to the lever movements from the lazy notch up to the stop at which point the straight line position of crossbar pin, slide pin and trunnion pin occurs.

LEVER MOVEMENT	DIE MOVEMENT	
Lazy notch to 1st notch	.201	.201"
1st " " 2nd "	.031)	
2nd " " 3rd "	.029)	
3rd " " 4th "	.027)	
4th " " 5th "	.024)	.153"
5th " " 6th "	.022)	
6th " " 7th "	.020)	
7th " " 8th "	.018)	
8th " " 9th "	.015)	
9th " " 10th "	.013)	
10th " " 11th "	.011)	.072"
11th " " 12th "	.009)	
12th " " 13th "	.006)	
13th " " Stop	.006	.006"

The following are the calculations made in arriving at the above die movements:-

Diagram below indicates the quadrant rack and lever length between the slide pin and rack, which are required to arrive at the angular movement of the lever.



In the diagram:-

C = Slide Pin.

D = Position of Pawl when lever is at end of its travel.

E = Stop on quadrant to prevent lever moving too far.

F = 13th Notch on quadrant (last notch).

G = 7th Notch on quadrant.

H = 1st Notch on quadrant.

K = Lazy Notch on quadrant.

Calculating the angles DCF, FCG, GCH and HCK.

$$\text{Angle} = \frac{\text{Arc of Rack}}{\text{Rad of Lever}}$$

Therefore angle DCF	=	3'	50'	0"
FCG	=	9'	51'	12"
GCH	=	9'	51'	12"
HCK	=	8'	34'	34"

The angles through which the lever moves from D to K, including each of the notches in the rack, are:-

D	to	F	3'	50'	0"
F	"	12th	1'	38'	32"
12th	"	11th	1'	38'	32"
11th	"	10th	1'	38'	32"
10th	"	9th	1'	38'	32"
9th	"	8th	1'	38'	32"
8th	"	G	1'	38'	32"
G	"	6th	1'	38'	32"
6th	"	5th	1'	38'	32"
5th	"	4th	1'	38'	32"
4th	"	3rd	1'	38'	32"
3rd	"	2nd	1'	38'	32"
2nd	"	H	1'	38'	32"
H	"	K	8'	34'	34"

Having obtained these angles for the lever it will be observed that the trunnion moves through the same angles (see diagram 2). The angle DCB being constant, the trunnion position L, M, N, O correspond to the lever positions F, G, H and K.

The angle α is obtained in order to check to the vertical line of the grip from A, C, B. 7/32" taken from design.

All angles from the stop to the lazy notch are obtained and the positive die movement becomes:-

$$(\cos.\ \alpha \times 4.125) - (\cos.\ \text{angle of trunnion} \times 4.125)$$

$\text{Cos.}\,\alpha \times 4.125 = \frac{B'\ C}{B\ \ C} \times 4.125$ therefore B' C = 4.1234.

Referring to Diagram 3. B' L' = 4.1234 - (cos. angle of trunnion) X 4.125

This gives the following positive movements:-

.0169"	at	the	13th	notch.
.0297"	"	"	12th	"
.0460"	"	"	11th	"
.0655"	"	"	10th	"
.0884"	"	"	9th	"
.1147"	"	"	8th	"
.1442"	"	"	7th	"
.1770"	"	"	6th	"
.2130"	"	"	5th	"
.2522"	"	"	4th	"
.2947"	"	"	3rd	"
.3402"	"	"	2nd	"
.3889"	"	"	1st	"
.6919"	"	"	lazy	"

The above figures were calculated on the assumption that the point B moves horizontally and the point C moves vertically as shown by the dotted lines in dia.3.
The above die movements have to be corrected as B does not move horizontally, but swings towards the position P due to the link A-B turning about a fixed pin at A as shown in diagram 3.

As indicated, the negative movement has to be deducted from the positive to get the actual die movement.

To obtain AB', AL' etc., the lengths BB', LL' etc. for all angles must be calculated, therefore sin of angle = BB' etc. x 4.125 this gives:-

BB' = .1146 at D
LL' = .3900 " 13th notch
.5075 " 12th notch
.6246 " 11th notch

	.7412	at	10th notch
	.8572	"	9th notch
	.9724	"	8th "
MM' =	1.0870	"	7th "
	1.2006	"	6th "
	1.3132	"	5th "
	1.4247	"	4th "
	1.5350	"	3rd "
	1.6441	"	2nd "
NN' =	1.7519	"	1st "
OO' =	2.2892	"	lazy "

To these figures 7/32" has to be added, this gives BB etc. To calculate AB etc. in order to obtain the vertical movement of B round the arc to P the formula becomes:-

AB etc. = AB - (sin of the angle x BC + .21875)

this gives AB = 11.9953 at D

AL =	11.9845	"	13th notch
	11.9781	"	12th "
	11.0704	"	11th "
	11.9616	"	10th "
	11.9517	"	9th "
	11.9407	"	8th "
AM =	11.9287	"	7th "
	11.9158	"	6th "
	11.9018	"	5th "
	11.8869	"	4th "
	11.8712	"	3rd "
	11.8545	"	2nd "
AN =	11.8371	"	1st "
AO =	11.7350	"	lazy "

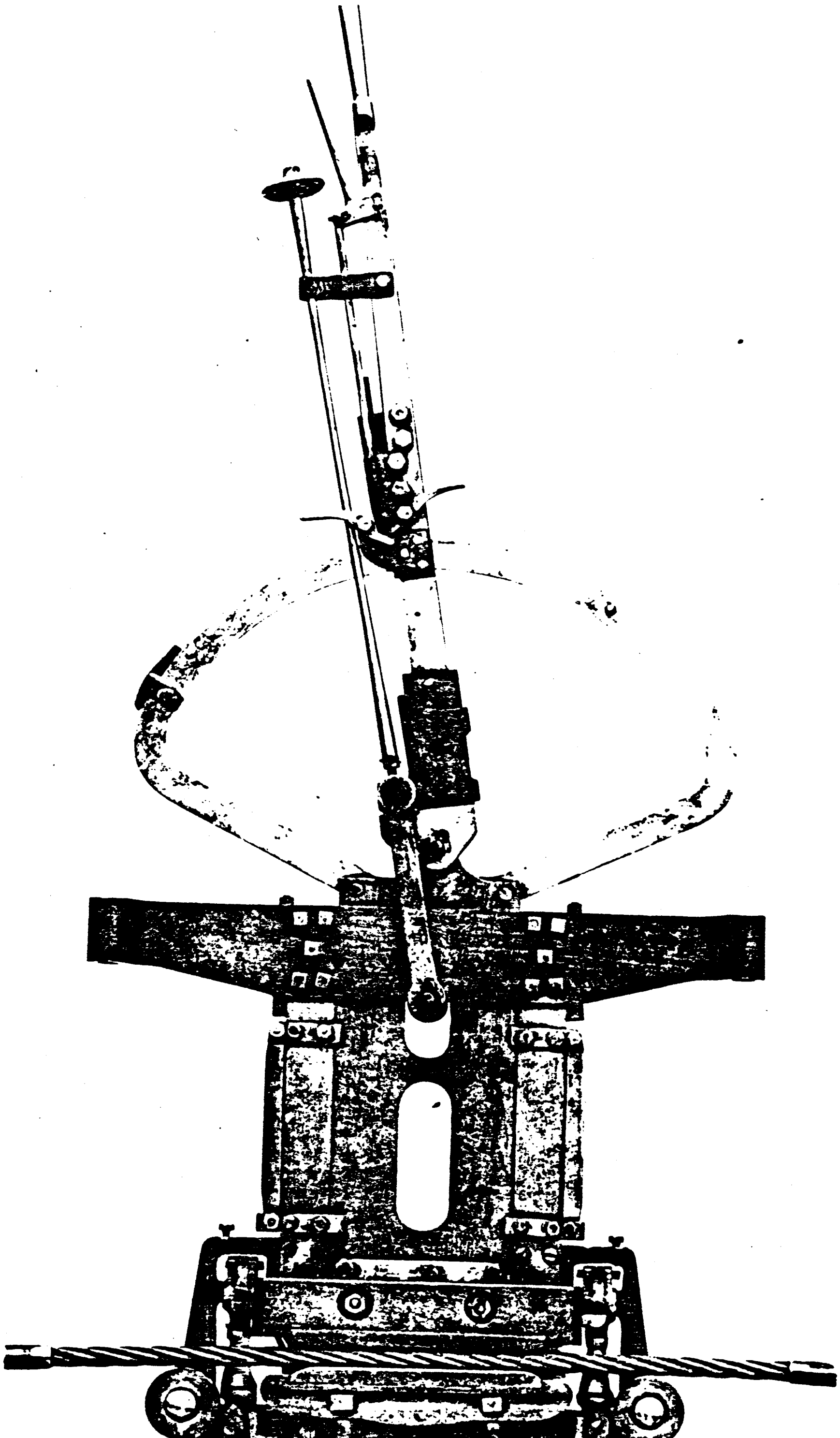
AB having been obtained, the negative die movement becomes

AB - AL etc. as follows:-

11.9953 - 11.9845 = .0108	at	13th notch.
11.9781 = .0172	"	12th "
11.9704 = .0249	"	11th "
11.9616 = .0337	"	10th "
11.9517 = .0436	"	9th "
11.9407 = .0546	"	8th "
11.9287 = .0666	"	7th "
11.9158 = .0795	"	6th "
11.9018 = .0935	"	5th "
11.8869 = .1084	"	4th "
11.8712 = .1241	"	3rd "
11.8545 = .1408	"	2nd "
11.8371 = .1582	"	1st "
11.7350 = .2603	"	lazy "

From the foregoing the ACTUAL DIE MOVEMENTS become the POSITIVE DIE MOVEMENT minus NEGATIVE DIE MOVEMENT as follows:-

.0169" - .0108"	=	.0061"	at	13th notch.
.0297" - .0172"	=	.0125"	"	12th "
.0460" - .0249"	=	.0211"	"	11th "
.0655" - .0337"	=	.0318"	"	10th "
.0884" - .0436"	=	.0448"	"	9th "
.1147" - .0546"	=	.0601"	"	8th "
.1442" - .0666"	=	.0776"	"	7th "
.1770" - .0795"	=	.0975"	"	6th "
.2130" - .0935"	=	.1195"	"	5th "
.2522" - .1084"	=	.1438"	"	4th "
.2947" - .1241"	=	.1706"	"	3rd "
.3402" - .1408"	=	.1994"	"	2nd "
.3889" - .1582"	=	.2307"	"	1st "
.6919" - .2603"	=	.4316"	"	lazy "



CABLE GRIP