# T H E  I N S T I T U T I O N  O F  L O C O M T I V E  E N G I N E E R

## S C O T T I S H  C E N T R E. G L A S G O W.

# S A L I E N T  F E A T U R E S  O F  U.S.A.  2-8-0  A U S T E R I T Y  L O C O M O T I V E.

T. H. Shields.

Member.

FIGURES:- 46.

APPENDICES:- 5.

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## ...ODUCTION.

From the Autumn of 1942 till the Spring of 1945, there arrived ..n this country from the U.S.A., batches of austerity 2-8-0 type locomotives. The majority of these engines, before being shipped to the Continent, were operated in this country for a period, giving an opportunity to compare their main and detail design with British practice.

On two previous occasions American locomotives have been used on English railways. During 1839-41, fourteen Norris American-built locomotives of the 4-2-0 type were obtained by the Birmingham and Gloucester Rly. for use on the Lickey Incline. These locomotives proved rather light for this work and were later converted into tank engines. Fig.1 shows the general lay-out of the Norris locomotive as designed by Jas. Harrison of Philadelphia. The engine weighed 9½ tons and tender 6¾ tons, cylinders were 10½ inches diameter by 18 inches stroke, the single pair of driving wheels being 4 feet, and the bogie wheels 2 feet 8 inches diameter. When working, additional weight was obtained for adhesion by part of the tender weight being carried by the driving wheels.(1) The boiler had 78 copper tubes, each 2 inches diameter and 8 feet long, boiler pressure being originally 60 pounds per sq. in.. The coke consumption on the Norris engines was very heavy due, it was supposed, to the sharp blast.

Again, during 1899-1900, a total of eighty 2-6-0 American locomotives were obtained by the M.Rly., G.C.Rly., and G.N.Rly., these engines having bar frames, outside horizontal cylinders, compensating spring gear and double bogie tender. (Fig.2) The cylinders were 18 inches diameter by 24 inches stroke, driving wheels were 5 feet 1½ inches diameter and boiler pressure 175 pounds per sq. in.. It has been stated that under similar conditions the American engines burned 25% more coal than English locomotives of like capacity.(2) The firebox was made of copper with a grate area of 16.7 square feet. These engines worked for a period of nine to fifteen years before being broken up.

## GENERAL.

The American-built 2-8-0 locomotives were constructed to conform to the British loading guage by the American Locomotive Company, Lima Locomotive Works and Baldwin Locomotive Works, from specifications prepared according to the Association of American Railways' Practice. (Fig.3). A similar design of locomotive with a few modifications was later built for use in India, operating on the 5 feet 6 inches guage; the general arrangement of this later design is shown by Fig.4 and sections by Figs.5,6,7,and 8.

The first striking feature of the American Austerity locomotive was the method of lifting engine from deck of ship to rails on dock side. In this country, locomotives are usually lifted at dock side by chains or wire rope suspended from a heavy beam placed parallel to length of engine, while the U.S.A. austerity locomotives were practically lifted from the boiler dome. Boiler clothing over dome is first removed and boiler dome cover replaced by a specially made cast steel dome cover or cap (Fig.10) which is securely screwed down by 32 nuts on the 1⅛ inch dome cover studs. The tapered built-up lifting beam is secured at it's narrow end to a top extension on smokebox front plate and the large end of beam to the dome cap. The main lifting link is 21 inches from the centreof dome, the total length of beam being 14 feet 6 inches. Fig.9 shows arrangement of lifting beam when ready to lift the engine, this method being made possible by construction of engine and method of securing boiler to frames. Radial wheel truck of engine and tender bogies has to be fastened by lifting slings and plates as shown by Figs.11 and 12, before lifting.

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(1). B. Colburn. -- Locomotive Engineering, 1871 - Pages 51-52.

(2). Proc. Inst. Mech. Engs., 1922 - Page 495.

The second noticeable feature was the rough finish of the American locomotives and the extensive use of welding. Bearing and bolting surfaces appear to be the only machined parts. Except for position of trailing engine springs, most of the details appear to be accessible. The high pitched boiler with firebox extending over trailing coupled wheels, bar frames and double bogie tender are other notable features.

Although the American locomotives were built for service in Britain, on the Continent and in India, their design may be taken to represent general American practice, and some constructive discussion may be promoted by comparing the different systems of attaining the one end of an efficient and economical locomotive.

## MAIN FRAMES AND AXLEBOX SHOES.

The main frames of the U.S.A. austerity locomotives are of the bar type, 4½ onches thick, the distance between the frames being 2 feet 10½ inches for standard guage and 3 feet 10 inches for 5 feet 6 inches guage. The bar frames allow a wide firebox to be placed over the trailing coupled wheels, and their vertical legs which are called the pedestal, hold the coupled wheel axleboxes in place. The front pedestal is made vertical and the back sloping for convenience of axlebox wedge. Axlebox wear is easily taken up with bar frames, the front surface of the shoe or horn being made detachable. The absence of horn blocks with bolts or rivets, combined with a strong pedestal binder or stay, locking the main frames securely, is another good feature. Also, with the bar frame, the centre line of axlebox coincides with centre line of frame and shoe, a condition not possible with plate frames. Bar frames give greater accessibility to details for examination and repair, especially with spring and axlebox details. On the other hand, bar frames can be fractured at top rail and are weak at front section, and in event of serious derailment the lifting of engine presents a problem not met with plate frame locomotives.

It may be stated that so far as previous American practice was concerned, bar frames were not so much a rival in design to plate frames as a necessity occasioned by the use of poor quality fuel requiring a large grate area, and thus it was only possible to keep the length of firebox within reasonable limits by placing the firebox over main frames, the outside breadth of fireboxes between frame plates being restricted to 4 feet for standard guage.

Bar frames provide a robust and effective method of fixing axlebox horns or shoes and wedges. Axlebox wedges are common to both American and British practice although they have lately gone out of favour in this country. With plate frames the wedge is held in position by a tongue working in a groove in horn cheek, while bar frame axlebox wedges are held in position by lips on each side of the frame and give a better support against side thrust of axlebox. The method of adjusting axlebox wedge by wedge bolt through pedestal binder or horn plate clip is common to both countries.

## AXLEBOXES.

Coupled wheel axleboxes follow the usual American practice of having a cast steel axlebox with a pressed-in plain brass unlined with anti-friction metal. The axlebox keep or cellar is capable of being removed with wheels in position, and is packed with cotton or wool waste with a little horse hair. Lubrication is supplied from mechanical pump through a flexible hose and ball check valve as shown in Figs. 15 and 16. Steel hub liners are attached to inside of cast steel coupled wheels. Coupled wheel axlebox journals are 8 inches diameter by 11 inches for an axle load of 15 tons 15 cwt..

**...INGS AND SUSPENSION.**

Weight is transmitted from the overhung springs on the first and second coupled wheels by means of an axlebox saddle and from the driving and trailing springs by means of an axlebox yoke(Fig.4). The front springs of the driving and trailing group are of the spiral type, all other coupled wheel springs being of the laminated pattern. The leading group has springs of 16 plates, 4½ inches by ⅜ inches, with a span of 34 inches, and springs in the trailing group have 19 plates, 4½ inches by 5/16 inches, the span being 27 inches.

The method of supporting the bearing springs by means of keys and gibs passing through slotted links is a notable featurein American practice. The springs on the U.S.A. austerity locomotive are compensated in two groups, the pony truck and two leading coupled wheels being in one group, and the driving and trailing wheels in another group.

Compensated springs serve a useful purpose when permanent way is poor, but this method of spring suspension has the disadvantage of one broken spring or hanger affecting other springs coupled in same group on one side of engine. American laminated springs, however, have not the same tendency to fracture as British made springs, as the former being tempered softer, tend to flatten rather than fracture in any of the plates.

**PONY TRUCK.**

The pony truck springs are compensated with leading coupled wheels through the radius bar. The cast iron centre extending above engine footplate and the position of swing links are shown in Fig.8. Axlebox bushes can be removed from steel axlebox with wheels in position and the unlined brass bush is lubricated by cylinder oil from the cylinder mechanical lubricator. The weight is transmitted to each axlebox through spiral springs at each side of axlebox, by a horse shoe shaped axlebox yoke. Pony truck wheels are of the disc type, 2 feet 9 inches diameter, and the axle load of 9 ton 12 cwt is carried by journals 6 inches diameter by 9 inches.

**CYLINDERS.**

Following the almost universal American practice, the cylinders are positioned horizontally on the frames, and are cast solid with half of boiler saddle making a bolting face on a vertical plane on centre line of engine. It is also the practice in America to make the cylinder casting reversible for either right or left side of engine. Cylinders are 19 inches diameter by 26 inches stroke with a piston valve diameter of 10 inches and a valve travel of 6¼ inches. No anti-vacuum valves are fitted to the cylinders, air being admitted to the cylinders, while coasting, through the drain cocks. The drain cock valves being as shown in Fig.23 are free to rise off their seats when regulator is closed. cylinder relief or anticompression valves are not fitted to American austerity locomotives.

**PISTON ROD AND VALVE SPINDLE PACKING.**

Piston rod and valve spindle packing is of the Paxton-Mitchell type (Figs.21 and 22). Two packing segments, shaped as shown, are used and are kept in position by four supplemental ~~xxxxx~~ springs and an outside retaining ring. Between the packing and gland is a split joint ring held by a garter spring. The piston rod is lubricated by a pipe leading from an oil box or cup into the swab attached to packing gland

**VALVE MOTION.**

Valve gear is of the Walschaerts type with die block at top of link in foregear, as against the usual practice of die block being at at bottom of link for fore gear. Valve motion is of exceptionally light construction and reversal is by lever with fine notches in quadrant. On gines built for India, reversal is obtained by screw and wheel as own in Figs.4 and 5.

DRIVING GEAR.

Two slide bars are placed above the piston rod, the crosshead being of the Laird pattern. Both small and big end brasses are of the unlined plain cylindrical pattern. Lubrication of big ends is by means of two trimmings and lubrication of connecting rod small end is by a round oil cup on the crosshead. A felt pad at bottom of oil cup is used to assist in restricting oil supply to bearing.(Fig.14). One trimming serves to lubricate the coupling rod bushes, oil boxes on coupling rods being welded on to rod. Solid screwed oil cup covers are fitted to big end and coupling rod oil boxes in place of cane corks used in this country. Slide bars are lubricated from the cylinder mechanixal lubricator.

MECHANICAL LUBRICATORS.

Two eight feed Nathan D4 valveless mechanical lubricators are fitted and positioned at each side of engine gangway above slide bars and are driven direct from a link fitted to the centre of each combination lever(Fig.4). The right hand lubricator suppliesthe cylinders, slide bars and pony truck axleboxes, while the left hand lubricator supplies the eight coupled wheel axleboxes.

DESCRIPTION. IN the oil reservoir there is a seperate valveless pump for each feed outlet, and each pump consists of a plunger P,(Fig.26), which at its highest and lowest positions automatically opens and closes the oil inlet and outlet through a turning movement of the plunger. The plunger thus replaces the suction and discharge valves, the pump being therefore valveless. The crank disc on the x end of the ratchet shaft E, contains a circular hole which receives the ball end of the rocker arm attached to the shaft W. The centre of the circular hole is eccentric to the centre of the ratchet shaft E, so that, as the ratchet shaft rotates, the vertical throw of the eccentric causes the shaft W to oscillate, while the horizontal throw of the eccentric causes the shaft to slide back and forth. These oscillating and reciprocating motions are definite, since the arm is rigidly attached to the shaft W. The two motions are utilised to operate the plungersfor pumping and for control of admission and discharge ofoil. Each plunger isoperated by a small arm attached to shaft W, the ball end of the arm in the elongated slot of the enlarged circular top of the plunger being called the crosshead. The slot on the crosshead is such that on the upward or suction strokeof the plunger, the oscillating motion of the small arm will leave the plunger free to be pushed upwards by the spring below the crosshead. On the downward or pressure stroke the ball of the small arm contacts the bottom of the slot, pressing the plunger down. As the elongated slot is situated on the periphery of the crosshead, the reciprocating motion of the shaft W causes the plunger to oscillate, and the turning motion thus produced causes a groove on the plungerbto make connection with the suntion chamber O,on the upstroke, and with the discharge chamber K on the downstroke. The amount of the upward motion of the plunger is limited by the adjusting screw R. The heating chamber U, at the bottom of oil reservoir is used in cold weather and a heating control valve is fitted at front of heating tube to give a change over from summer to winter working. Ecah outlet connection is provided with a non-return valve of the double ball type as an additional check against the retumn of oil in the ffed line. Fig.26 shows outside and sectional views of pump.

BOILER.

The somewhat large boiler has a parallel barrel 5 feet 10 inches in diameter and 13 feet 5 inches between tubeplates, the firebox casing being of the round top pattern. The inside firebox is of steel plates ⅜ inches thick with tubeplate ½ inch thick. No rivets are used to join the seams of firebox, the seams being electrically welded. The firebox is 7 feet 0⅝ inches long by 5 feet 10¼ inches wide, with 150 steel tubes 2 inches diameter, and 30 steel superheated flue tubes 5⅜ inches diameter.

[illegible] toal evaporative heating surface is 1773 sq. ft., superheated surface [illegible]0 sq. ft., grate area 41 sq. ft., and boiler pressure 225 lbs. per sq. in.. Comparative figures with respect to British austerity locomotives and L.M.S. Rly. 2-8-0 locomotives can be seen from Appendix 1.

The round top type of firebox has the advantage of being easy to make and the position of firebox above frames facilitates the renewal of firebox stays and other firebox repairs. The sloping backplate at once increases the grate area and provides for more room in engine cab.

FIREBOX STAYS.

Flexible stays are fitted within the 'breaking zone' of the firebox. This type of stay is difficult to locate when broken without removing the outside cap. In the U.S.A. flexible stays are sometimes tested for breakage by an electric current tester.

Hollow steel stays are fitted to firebox outside the 'breaking zone' the hole through the centre of stay giving an indication when stay breaks in service with a claimed saving in time spent on firebox examination. On the other hand the hole through the stay gets choked at inside end. It is also claimed[3] that the velocity of air through the hole in the stay tends to protect the end of the stay from burning and moderates the expansion of stay within limits of the temperature of steam in the boiler and the air passing through the hollow stay unites with the combustibles in the firebox and aids combustion.

FIREDOOR.

The firedoor is of the hinged type on the right side, (Fig.5) but no firedoor scoop is fitted. Firehole has semicircular ends and measures 1 foot 11 inches by 1 foot 6 inches.

WATER TUBES AND BRICK ARCH.

Three circulating water tubes 3 inches diameter extend from firebox tubeplate to firebox backplate (Fig.4), serving the dual purpose of promoting circulation of water in the boilerand of supporting the brick arch. Brick arch tubes must have careful attention to be kept free from scale, and inspection plugs are fitted opposite each end of tube on throat plate and back plate. The circulating tubes add 15 sq. ft. to evaporative heating surface. The brick arch is of the security three tube setting type.

FUSIBLE PLUGS.

AS in British practice, two fusible plugs are fitted to crown of firebox, these being situated on centre of crown sheet (Fig.27). See Appendix 2 for remarks on design of American fusible plugs.

WASH OUT PLUGS.

These are positioned as shown in Fig. 24. Appendix 3 gives instructions regarding washing out of boiler and removing of plugs, as issued to wash out staff for engines working in this country.

FLEXING PLATES.

The firebox of the U.S.A. austerity locomotive does not rest on

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(3). Utility of Hollow Stay Bolts. T. Livingstone - 1905. (U.S.A.)

the main frames as in British practice, with plate frames. On the NE American engines, flexing plates are fitted to the front and rear sections of the boiler founfation ring and secured to a cross stay on main frame below boiler throat plate, and to the footplate casting under boiler back plate. This method at once allows for the expansion of the boiler and for holding down boiler in position, as the flexing plates readily yield to the variations of boiler temperature.

In comparison, the 2-10-0 British austerity locomotive with wide firebox above plate framed has firebox carried by a bracket attached to a cross stay between main frames on which front of firebox foundation rests, and a steadying plate is also fixed to rear of foundation ring, this plate being attached to front of built-up drag box.

ROCKER GRATE.

The rocker grate is of the two section assembly Hulson tuyere type with unit finger castings 11½ inches long by 2¼ inches broad. Fig.28 illustrates arrangement of grate abd rockers. The design of unit tuyere so arranges the tuyeres or orifices that each jet of incoming air is opposed by a similar jet, resulting in a baffling action which reduces the velocity but not the volime of primary air, the result being a reduction of the lifting action of the fire from the sudden increases in intensity of firebox draught, when starting or during heavy working.

The tuyere unit has 13 fingers or small firebars on each carrier bar, this making 156 units per engine, each finger or unit weighing 8½ lbs.. Each of the twelve carrier bars weighs 48 lbs. and, (Fig.28) the remainder of the grate consists of:-

A - 2 Side Frames weighing 129 pounds each.

B - 1 Centre Frame weighingn 396 pounds.

C - 4 Dead Grates weighing 48 pounds each.

The whole grate weighs 2563 pounds or 64½ pounds per square foot of grate area. Each side of rocker grate is coupled up separately to enable one side of fire to be shaken or cleaned at a time. The facility that this type of grate gives for firedropping is the chief advantage of this design so far as engines working in this country are concerned.

HOPPER ASH PAN.

From the British standpoint, the first notable feature of the ashpan was the open space left round the upper sides of ash pan at boiler foundation ring, although on later engines horizontal hinged doors were provided at firebox sides to control the flow of air under the grate. On early batches of U.S.A. engines, this open space had to be covered for A.R.P. requirements, but little attempt appears to be made to secure anything like an airtight joint between ash pan and foundation ring, a condition that has an obvious adverse effect on fuel consumption.

The two ash pan hoppers, shown chain dotted in Figs.4and 5 are operated from left side of engineby a lever, attached when required, to a cross shaft below engine footplate. Ash pan can hold ash and clinkerfor 28 hours working, but care has to be taken not to drop ash on top of wooden sleepers. Damper gear and doors, common to British locomotives are absent, the cast iron hopper doors being kept closed during working period.

SMOKEBOX AND DIAPHRAGM PLATES.

Smokebox fastening is the saddle type with drumhead tubeplate The ⅜ inch thick smokebox front plate is detachable, being bolted to the ½ inch thick wrapper plate illustrated in Fig.29. Smokebox door opening is 2 feet 6 inches diameter and door is of light construction. The small smokebox door gives a greater distance between bottom of door and bottom of smokebox, giving a door not so liable to burn as experienced in this country. Smokebox door is hinged from right side of engine and is secured by 12 clamps, the door being positioned about 6 inches off centre line of engine towards right side. On engines built for India smokebox door is hinged from left side and is placed directly on centre line of engine, no air pump being fitted to smokebox front plate.

Deflecting and diaphragm plates with front spark arrester netting are fitted in smokebox. American practice provides deflector plates to give an equal distribution of draught and to equalise the heat passing through the tubes. The diaphragm absorbs about 25% of the energy of the exhaust jet,(4) this figure increasing as the angle of diaphragm is increased. The smokebox is of the self-cleaning type obtained by locating the horizontal table plate, '10' Fig.29, just under flange of blast pipe top and setting diaphragm plates '12' and '13' at such an angle which, combined with sufficient area of nettign, will allow for free steaming of engine. Deflecting plates '9' ensure a fair draught through the lower tubes and, with netting, cause the smokebox ashes to traverse the lower part of smokebox before being ejected through the netting into the exhaust jet, and by that time ashes are small, dead and harmless.

The opening under the diaphragm plates must be of such width as will allow an area of opening about equal to the total cross sectional area of the opening through tubes. At the same time it must be sufficiently contracted in self-cleaning smokeboxes to obtain sufficient velocity to keep the front end free from smokebox ashes. In the engine u under consideration the area of opening under diaphragm plates is restricted to 72% of area through tubes and flues, the figures being 761 sq. ins. through tubes and flues, 910 sq. ins. under table plate and 552 sq. ins. under diaphragm in front of exhaust pipe (See Fig.29). The angle of diaphragm plate is 60 degrees from the horizontal.

Smokebox plates of a modified type are used in this country, but these being open at the sides do not assist in cleaning smokebox.

BLASTPIPE AND CHIMNEY.

Blast pipe in smokebox is of the usual pattern with chimney 8¼ inches above top of smokebox and xetending 29½ inches into smokebox. Inside of chimney is parralel and 16 inches diameter except for being bell mouthed at bottom for a distance of 9 inches. Blast pipe top orifice is 5¼ inches diameter but orifice is covered by a 'cross spreader' as shown in Fig.30. The section of cross spreader is either as shown or, as in some later engines, made of plain ⅜ inch diameter iron. The cross spreader is a flattened pattern of the basket bridge blast pipe top common at one time in America.

MAIN STEAM PIPES.

The two main steam pipes in smokebox are 6 inches inside diameter and are made of cast iron with ring joints at superheater header and at top of cylinder. Cast iron steam pipes are much heavier than the copper or steel steam pipes used in this country, and usually last the whole life of the engine but sometimes fracture in service.

REGULATOR VALVE AND HANDLE.

The cast iron regulator valve is positioned in dome and is of a large double beat type. A cross stirrup linked from the regulator rod lifts the valve from the top(Fig.4). The regulator handle is of

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(4). Locomotive Sparks. - Goss.

single-ended pull-out lever type fitted with a catch in a finely ...ched quadrant (Figs.4,5,&32). This type of handle gives the driver a ...od control, driver notrequiring to turn sideways when opening regulator. Regulator handle is brought to a convenient position to enable driver to look ahead from his seat (19'Fig.32). The various brake handles can be also operated from seat without driver taking his eyes off the road.

STEAM TURRET OR MANIFOLD.

On top of firebox outside front panel of cab is positioned a cast iron steam turret or manifold to which are fitted the steam valves for injectors, blower steam brake, vacuum ejector, air pump and mechanical lubricator warming cock. Wheel handles, suitably marked, extend into the cab from each of these valves on manifold (Fig.32). A dry three inch pipe leads from the dome to steam turret. See Fig.4. The outside position of steam turret is a good feature from the maintenance aspect, as turrets inside cab are generally placed too near cab foof, and defects thereon are difficult to locate and repair. Onthe other hand, the exposed position of outside turret will lead to a greater heat loss. The main steam valve on turret is shown by Fig.20.

SAFETY VALVES.

The two safety valves are not fitted direct to top of firebox or boiler barrel but at a distance of 11 inches from centre line to left side of boiler barrel immediately in front of firebox. The front safety valve is of the muffled pattern and the rear valve of the pop type (Fig.37). An adjusting RING '11' is fitted to base of valve to intercept the current of escaping steam, increasing lift of valve and giving a quicker opening and closing movement. Safety valve diameter is 3 inches and height of valve 8¾ inches

WATER GAUGE COCKS AND TEST COCKS.

Only one gauge cock is fitted to U.S.A. austerity locomotives, this being positioned on left side of boiler back plate as shown by '9' Fig.32. American enginemen appear to trust a good deal to the three boiler water level test valves fitted conveniently to right on driver's side of boiler back plate, '13' Fig.32 & Fig. 27.

The water gauge (Fig.31) is of the Nathan'Reflex'type, differing from the ordinary round gauge glass in that the visual glass is a flat sheet. The gauge fitting has no direct attachment to the boiler at top of gauge, connection being made to boiler steam space by a copper pipe leading from topof gauge to an entrance on top of firebox shell, (Fig.27). The use of screw cocks on the reflex gauge is a poor feature, screw cocks taking some time to shut off in comparison with plug cocks shutting off by a quarter turn of handle, and there is also lack of visual indication whether cocks are opened or closed. The screw type of cock may be stiff and appear open while it might only be tight on the screw thread, and there is nonautomatic closing of the valve in the event of a fractured glass, although this defect may be not so frequent with the thick flat glass on the reflex gauge.

One peculiarity of this type of gauge is that the water appears black and the steam space above the water has a silvery lustre. This effect is produced by the prism shaped longitudinal grooves cut into glass on inside surface as Fig.31 indicates. As the edges of these grooves become blunt and worn this black and white effect becimes less apparent.

The advantages of the reflex gauge glass are the quick and reliable observation of the waterlevel, the glass will not shatter or explode, and if glass should break, it will not fly out of the casing. With the tube glass, cases arise where an empty glass has been taken as being full, resulting in fusible plug being dropped, whereas with the reflex gauge the dark colour of water obviates any ambiguity as to glass being full or empty. During the period U.S.A. engines were being 'run in' water gauge glasses had to be frequently cleaned owing to glass being obscured by an oily deposit gathering on inside of glass.

The reflex gauge having a top stop valve apart from the gauge proper, is an obvious trap in event of the steam cock being unintentionally closed or partially closed, thus giving a false water level in the glass. Another bad feature is that the single gauge glass faces half left, towards the fireman's side of engine and, unlike British gauge cocks which usually show water level through three sides of gauge glass protector, the Ameeican gauge glass is only visible in direction in which the front of glass is facing and therefore not under direct observation of the driver. British drivers are not used to WATER LEVEL TEST COCKS as fitted to boiler back plate on U.S.A. austerity locomotives, and these were probably seldom used. Similar test cocks have been used in this country on locomotivex boilers having onlx one set of gauge cocks, but these disappeared, to the Author's knowledge, over twenty years ago. Even previous to that date test cocks were seldom used by enginemen and tast cock screws were usually unworkable.

Unfortunately, the closing of steam cock attached to piper leading to top of reflex gauge led to two FATAL accidents while engines were working in this country, enginemen being misled by the water gauge shewing a false water level. A Ministry of War Transport Inquiry into one case of boiler failure is given in Appendix 2.

It will be seen, therefore, that plug cocks on water gauges have an advantage over the screw valves especially when the latter are in the hands of enginemen used to the plug type of gauge cock. Notices were posted (Fig.27) at Motive Power Depots operating U.S.A. engines to impress upon the footplate staff the necessity for making sure that water gauge steam cock is fully open, and a plate was fixed to the steam valve handle reading, 'THIS VALVE MUST BE FULL OPEN'. Appendix 4 gives instructions issued to enginemen operating engines fitted with reflex water gauge.

## GAUGE LAMPS.

Three gauge lamps are fitted in engine cab, one in front of water gauge, one for steam pressure and air brake gauge and one for vacuum brake gauge. Fig.25 illustrates type of gauge glass lamp used.

## BLOW OFF VALVES.

At each side of firebox above foundation ring is fitted a two inch Okedee type blow off valve. This valve (Fig.39) is operated by a level '28' Fig.32, inside cab. The seat of the blow off valve is formed by the contact of a disc valve over a valve on the outer cover, the surfaces of each being ground perfectly flat. The disc valve in operation is moved across its seating by a radial movement which in effect gives the disc a rotative movement, thus tending to regrind the seating faces to each other whenever valve is operated, at the same time removing any foreign matter which may have settled on the outer face. This valve makes a safe fitting for blowing down under steam pressure with perfect control of discharge. Operating lever through front panel of cab is fitted with a pin to prevent valve being opened unintentionally. In Appendix 3 are particulars of 'Blowing Down' as carried out on American engines on the L.M.S. Rly..

Plug type blow off cocks were a standard fitting on a few British railways previous to the grouping in 1923. At that time blow off cocks were usually opened at wash out period to get rid of scale round firebox side and above foundation ring. Blow off VALVES again being fitted to recent locomotives, gives one of a few instances of a discarded fittings returning to favour.

## INJECTORS.

The two injectors are of the Nathan 'Monitor' type of 4000 l./hour capacity, with manual overflow control, Fig.33. This type of injector corresponds with the 10mm. discharge cones. Injectors are fitted outside engine frame under footplate and are easy of access. Each injector is fitted with a 'tell tale' arrangement, '29'Fig.32, connected to overflow chamber. A pipe leads from injector intom the cab terminating in an elbow nozzle within sight of enginemen, the 'tell tale' indicating when injector flies off or is not working properly.

The 'Monitor' injector is fitted with a double type steam cone and the gap pattern combining cone, there being no moving parts in the injector. The steam cone consists of the inner cone '3' and outer cone '4', Fig.33, the steam being admitted by an annular jet from the outer cone and a solid jet from the inner cone, these being termed the lifting and forcing jets respectively. The water first contracts the annular jet which forces it into the top of combining cone '6', past the point of inner cone '3', where the water meets the solid jet of steam and is forced into the delivery cone '8', past the delivery check valve '31' into the boiler. There are gaps in the three sections of combining cone which allow the steam and water to escape freely when starting injector. An overflow valve '29' is also fitted to prevent air being drawn into injector and boiler.

'Monitor' injectors of British manufacture are fitted to British austerity locomotives, the main advantage of this type of injector being their improved range, the injector commencing to work at any pressure above 40 pounds per sq. in. without regulation of water valve. When working, injector will continue without adjustment so long as pressure in boiler is above 40 pounds.

PULL-OUT INJECTOR STEAM VALVE.

During period engine is in operation, injector stop valve on steam manifold is kept open. A balanced lever starting valve, Fig.34, positioned on each side of firebox in front of cab is mused to supply steam to injectors and is operated from cab by handles '16', Fig.32. The pull-out starting valve consists of a main valve connected to a one piece casting with balancing piston part. When the pilot valve is first opened by pulling starting lever a short distance, steam is admitted underneath the balancing piston, the diameter of this piston being only slightly less than that of the main valve, and the pressure on top of main valve is balanced to such a degree that the further movement of the starting lever will cause the main valve to lift from its seat easily. The quadrant for starting handle is notched for different positions. Pull-out starting levers for injectors were discarded in this country over seventy years ago, but have remained in favour in America. While this fitting is simple to operate, it appears rather expensive and involved in comparison with the simple screw type of injector steam cock used in this country.

BOILER CHECK VALVE.

The boiler check or clack valve shown by Fig.38, is placed at each side of boiler barrel and valve is constructed so that it may be used on either side of boiler by interchanging the elbow at bottom of valve with nut or cap at top. The stop or shut off valve is at side of valve casing and permits the removal of check valve for examination or repair without blowing down steamfrom the boiler. Although this fitting is at side of boiler barrel, top delivery clack valves are common in ~~xxxx~~ ~~xxx~~ America as well as in this country. From maintenance aspect the stop valve on boiler clacks is a good feature that has gone out of favour in recent British practice.

COAL SPRAY HOSE.

This is situated at left side of boiler back plate, '15' Fig.32, and is taken from a pipe leading from left injector.

**WER VALVE.**

Blower steam pipe leads from the main stop valve on manifold and runs down left side of boiler back plate. Halfway down this pipe is a globe valve '14' (Fig.32) for controlling steam to blower. Blower pipe travels along left side of boiler barrel to smokebox and terminates in a perforated blower ring on top of blast pipe on smokebox (Fig.30), there being no 'live' blower steam pipe in smokebox.

**ENGINE WHISTLE.**

Fig. 36 gives type of engine whistle. The bell is 5 inches diameter and whistle is positioned in front of safety valves on left side of boiler barrel. A cord '36' (Fig.32) operates the whistle valve from either side of footplate.

**SANDING APPARATUS.**

The sand box is mounted on top of boiler under dome casing as is usual in American practice. Steam sanding is provided to front of leading coupled wheels and to rear of driving wheels. The position of sand box on top of boiler is presumed to keep sand dry, although sand on top of boiler can become damp if special care is not taken with ventilation. Steam sanding on U.S.A. austerity locomotives is as liable to give trouble in pipes and at sand ejectors as with British locomotives, although the same trouble is not experienced withn wet sand boxes. In this country where thr sand had to be manhandled in buckets to top of boiler of U.S.A. engines, great care had to be taken to prevent spillage on axleboxes and framing. See Appendix 3.

**TENDER.**

The main frame of tender consists of two 18 inch X 5 inch channel irons placed 14 inches apart, i.e. 7 inches on each side of the longitudinal centre line of tender, somewhat similar to wagon construction. The water tank of 5400 British gallons capacity is of the water bottom type with sloping coal space. No water gauge is provided for tank. The open space in front of tender is boarded with five sloping boards inserted in grooves on side of tender front plate.

The intermediate buffing or chafing block is provided with a strong spring, the engine and tender having to be pressed together to couple up intermediate draw bar. Draw bar pins on American engines sent to this country were inserted from bottom of drag box and kept in position by a retaining plate securely bolted to bottom of drag box, this method being modified on engines built for India. No cab doors are fitted between engine and tender. Side frames of tender bogies and tender axleboxes on one side are made in one steel casting and separate from the bolster which transmits the weight of tender through a nest of four coil springs to the side frame and axleboxes.

**TANK WATER VALVES.**

External tender water valves are situated at each side of front tender buffer beam, and these valves are of the Crane wedge gate pattern two inches inside diameter (Fig.35). No connection is made to water valves from the footplate, and valves cannot be closed while engine is in motion.

**TENDER WHEELS.**

Cast steel disc wheels without tyres, 2 feet 9 inches in diameter are used for tender bogies. Axleboxes packed with cotton waste are easily examined by spring flapdoor.

BRAKES.

The tender hand brake is operated from right or driver's side of tender, and consists of a vertical wheel operating a chain attached to main brake shaft, and is fitted with a locking device to retain brake in 'off' or 'on' position. In some cases hand brakes were converted to the usual British pattern, having a vertical brake standard with screw and horizontal brake handle.

Two vertical steam brake cylinders 8 ionhes diameter by 8½ inches stroke are positioned on main frame stretcher behind the leading coupled axle, and supply power for enine brake (Fig.17). One horizontal cylinder 6 inches diameter by 8½ inch stroke situated between the two tender bogies serves for the tender brake (Fig.18). The engine brake cylinders are easy of access under boiler barrel, not being so crowded as with general practice of fitting brake cylinder below engine footplate.

Brake shoes are applied to rear of engine coupled wheels and tender bogie wheels. The reason given for this position of engine brake shoes is that the action of brake, with brake shoes in front, adds to normal weight on engine springs the pull of the brake shoes. Brake shoes or blocks are attached to a brake head or hanger, the shoe being secured tom the hanger by a flat wedge shaped piece of steel inserted in brake head and through a slot on brake shoe. The brake shoes for engine wheels embrace the tread and flange of wheel but only contact the tread on tender wheels.

INTERMEDIATE STEAM BRAKE PIPE.

The steam brake pipe between engine and tender (Fig.40) is of the 3v type of Barco flexible joint, making an all metal joint connection accomodating itself to all normal movement between engine and tender. The universal joint has an easy rolling movement and yields freely in every direction. The end joints are provided with suitable flanges which are bolted direct to engine and tender brackets. The lower joints and pipes, which are suspended like a pendulum, provide a combined swivel and angular motion. The ball of each joint rides easily on the gasket, ensuring a perfect fit and preventing any accumulation of dust between bearing parts.

COMBINED VACUUM AND AIR OPERATED STEAM BRAKE VALVE.

This is a British fitting added after engines arrived in this country, and is also fitted to British austerity locomotives. the valve is for use on locomotives provided with steam brake cykinders and also fitted for operating trains using either vacuum or air brakes, giving simultaneous and proportional application of steam brake on engine. With reference to Fig.41 the action of valves is as follows:-

OPERATION UNDER VACUUM.

When vacuum brake is initially charged the normal train pipe vacuum is created below piston '70' directly through the train pipe connection, and on the upper side of this piston and in the control vacuum chamber through the auxiliary pipe connection to the ejector release valve, the piston being maintained at its lowest position by the spring '12'. At the same time, steam at boiler pressure is supplied to the chamber above the valves '19' and '20', and steam brake cylinders are open to atmosphere past exhaust valve '16'. Application of the vacuum brake on the train admits air to the under side of the piston '70' which moves upwards to lift the steam ~~xxixx~~ operating unit, the first movement of which closes the exhaust valve '16'. Further upward movement then raises the pilot valve '20' to admit steam below the balanced piston '17', and allow the main steam valve'19' to open and pass steam direct to the brake cylinder and top of exhaust valve'16'. This condition persists until the steam brake cylinder pressure acting downwards on the exhaust valve'16'is just sufficient to overcome the upward pressure on the vacuum piston '70' which is then forced down to allow valves '19' and '20' to close. Further downward movement of piston '70' on release of the train brake, permits the opening of the steam brake exhaust valve and corresponding release of the locomotive brake.

tate of balance betweenthe vacuum and steam brakes is thus established, area of piston '70' being proportioned to ensure that the maximum eam brake application ~~fxam~~ corresponds to a full vacuum brake applicat-ion from 20 inch initial vacuum. Under these conditions of vacuum control the lower compressed air piston remains inoperative.

OPERATION UNDER COMPRESSED AIR.

When the train is being handled by compressed air brakes, the initial brake pipe pressure passes freely to the upper side of piston '7' and through the feed port to the under side of the piston and to the control reservoir. When the train brakes are applied the initial reduction of brake pipe pressure immediately allows piston '7' to rise into contact with the lower end of vacuum piston '70' and, at the same time, to close the feed connection to the control reservoir. Continued reduction of brake pipe pressure to apply the train brakes then causes a further upward movement of piston '7' which, acting through the freely moving vacuum piston, brings the steam unit into operation in exactly the same way as described under vacuum control, the degree of steam brake application being similarly proportioned to the pressire reduction ~~XXXXXXXXXX~~ made in the main air brake pipe. The area of piston '7' is so proportioned that the maximum steam brake application is obtained with an air brake reduction of 20 pounds. When the train brake is released, full brake pipe pressure is restored to the cavity above piston '7' which is again forced to its lowest position to enable control reservoir to be recharged through the feed port.

MANUAL OPERATION.

This is carried out by means of a lever and quadrant. The operating lever gives movement to the steam operating unit of the valve through the medium of a compressed air spring '29', so arranged that the degree of steam brake application is proportional to the compression of the spring. Full application of the brake is obtained when this lever is placed in last notch, in which position the spring box is solidly closed.

PIPING AND FITTINGS FOR STEAM BRAKE.

Fig.42 shows the arrangement of piping and fittings for Graduable Steam Brake Valve. The timing chamber and choke valve 'D' between compressed air piston on brake valve and air brake pipe, are fitted to prevent sudden changes of pressure in the valve and to provide the requisite brake lag on the engine.

S.J. VACUUM EJECTOR.

This fitting was also added after engines arrived in this country. The solid jet ejector is designed to ensure minimum attention being required at Running Sheds.

SMALL EJECTOR.

With reference to Fig.13, steam for the small ejectors is supplied in the usual manner with an independent steam valve '47'. This has a renewable seat and a floating steam valve ensuring accurate seating at all times. The small ejector, when in operation, lifts the valves '28' and '18', thence drawing air direct from the train pipe. Valve '26', of course, closes down preventing the small ejector drawing back on the exhaust branch of the large ejector.

LARGE EJECTOR.

The large ejector in the BRAKE OFF position is operated by the driver's brake handle, by means of the lift finger '31' This gives a true vertical lift to the main steam valve '34'. This valve has a renewable combined seating and valve guide which can be readily withdrawn. Both small and large ejector cones are of the solid type, shown by '38' and '40' respectively, and cones are readily accessible by the removal of the back cap.

DRIVER'S APPLICATION HANDLE.

The disc type of admission valve has been dispensed with, and the separate auxiliary valve has been embodied in the main function of the application valve. The movement of driver's brake handle towards the 'BRAKE ON' position gives a vertical lift to the air valve through the lift finger '9'. A ¾ inch valve '5' first opens to allow small applications to be made, this valve '5' taking the place of the auxiliary valve in the older type ejectors. After the valve '5' has attained its full lift, the shoulders of the wings of the lifter come in contact with the main admission valve '6'. Before this valve lifts, the opening of the valve '5' has necessarily put it patrially in balance so that very little effort is required to lift the valve '6'.

To effect isolation of the main train pipe from the action of the small ejector in the full 'BRAKE ON' position, the main back valve '18' is provided with a spindle extension actuated by the sleeve '13'. Bell crank '10', worked from the cam on the opposite side of the lift finger, '9', is operated increasingly as the driver's brake handle comes to the 'FULL ON' position. In the 'FULL ON' position the arm of the bell crank '10' fully depresses the sleeve '13' taking with it the back valve '18', so shutting off the small ejector fromthe train pipe.

WORKING DOUBLE HEADED TRAINS.
The ball '65' is provided to enable the brake to be worked from the leading engine only, when operating double headed. The driver's handle on the rear engine is put on the running position, with the small ejector optionally working or shut.

COMPRESSED AIR BRAKE.

U.S.A. austerity locomotives sent to this country were also piped for use of air brake, the air compressor being situated on smokebox front plate at left side. Air reservoirs are positioned under the running platforms at each side of engine, the reservoir connecting pipes being extended for radiating purposes. Air pump is of the 9½ inch x 9½ inch x 10 inch size, and is provided with Nathan mechanical lubricator and also with air filter.

AIR PUMP LUBRICATOR.
The Nathan air compressor lubricator is of novel design. Refeering to Fig.44, the lubricator serves the steam and air cylinders and is of two pint capacity. Two pump units P are provided, one for steam and one for air cylinder. These units pump without valves, and the pistons T combine a reciprocating and oscillating movement whereby the intake and discharge ports are opened and closed. The lubricators is operated from the air pump, the piston K being reciprocated by the changing pressure from the air cylinder and the return spring F, this movement being transmitted to the pump piston T by means of the paul Z, driving shaft W, and cross head U. The lubricator makes one stroke while the air pump makes 18 double strokes. The crank handle H serves for filling the oil pipes and increasing the oil supply if required. Lubricator is filled with oil through the strainer '5'. The screws, $R_1$ and $R_2$, serve for adjusting oil feed.

AIR PUMP SUCTION FILTER.
The L type suction filter (Fig.45) is located in the air intake, is enclosed in a shell, and is supported from the main cover by a central bolt. The shell is positioned on cover ribs forming the annular air intake into which the cover skirt extends, and acts as a baffle to diffuse air flow and to precipitate dirt particles into the dirt chamber bottom which has drainage holes.

DRIVER'S BRAKE VALVE.
The driver's brake valve (Fig.46) is of the H6 type wuth bye-pass equalising piston, and has the six positions of Charging and Release, Running, Service, Lap, Holding and Emergency.
CHARGING AND RELEASE POSITION:- The purpose of this position is to provide a direct passage from the main reservoir to the brake pipe to charge the train brake system and release the brakes. If the handle were allowed to remain in this position, the brake system would be

rged to main reservoir pressure. To avoid this, the handle must be ved to running position.

RUNNING POSITION:- This is the proper position of the handle when brakes are charged and ready for use. In this position a direct passage is opened from the feed valve pipe to the brake pipe, so that the latter will charge up as rapidly as the feed valve can supply the air, but can not attain a pressure above that for which the feed valve is adjusted. The equalising reservoir charges uniformly with the brake pipe, keeping the pressures on the two sides of the equalising piston equal. Air at main reservoir pressure above the rotary valve passes to the air pump governor.

SERVICE POSITION?- This position gives a gradual reduction of brake pipe pressure to cause a service application.

LAP POSITION:- This position is used while holding the brakes after a service application, until it is desired, either to make a further brake pipe reduction, or to release them. All parts are closed.

HOLDING POSITION:- In this equipment, Holding position is same as Running position.

EMERGENCY POSITION:- This position is used when the most prompt and heavy application of the brakes is required. A large and direct communication is made between the brake pipe and the atmosphere. The direct passage makes a sudden and heavy discharge of brake pipe air, causing the triple valves and air-steam valve to move to emergency position and give maximum braking force in the shortest of time. Inthis position also, main reservoir pressure is permitted to flow to the emergency relay valve.

TOOL EQUIPMENT.

List of tool equipment is given in Appendix 5. Heavy tools are kept in large box on top of tender behind coal space, and a wooded box on footplate serves for a fireman's seat and holds the smaller tools. Fire irons and levers for ash pan hopper and rocker grate are kept on top side of tender tank. A box is provided at back of cab roof to hold red and green flags, this being shown in Fig.4.

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## PRECIS.

The main purpose of this paper is to have a permanent record of what will be probably the last type of steam locomotive to come into this country from abroad, and to promote discussion on the respective merits of British and American practice. The principal points dealt with are as follows:-

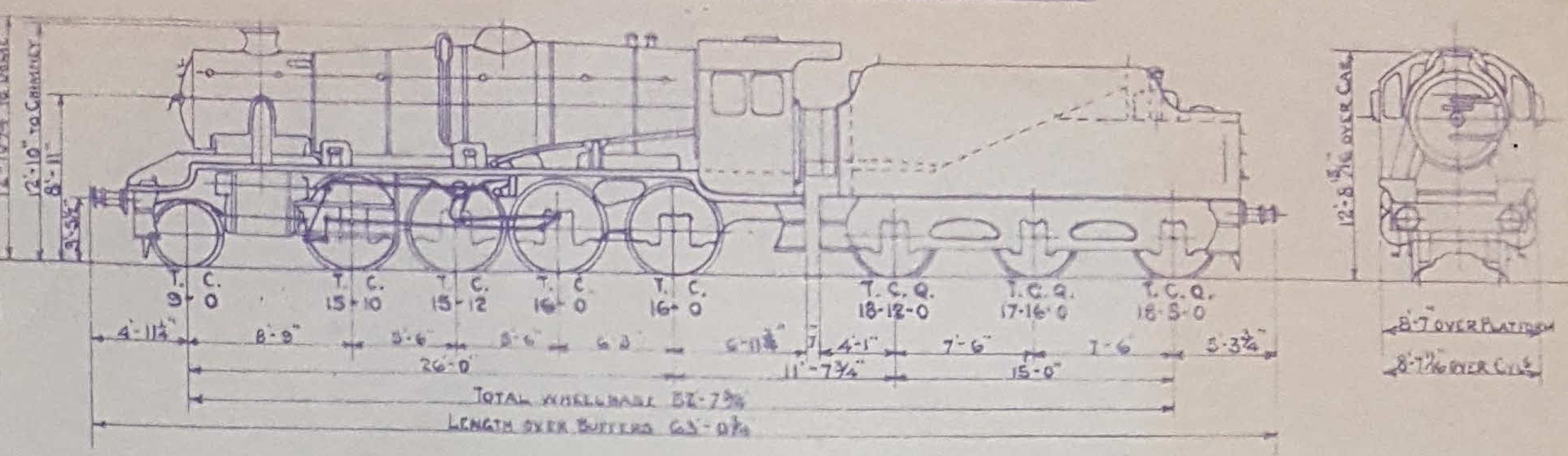
Lifting Arrangement: Bar Frames: Axlebox Shoe and Wedge Design: Spring Suspension: Expansion or Flexing Plates: Horizontal Cylinders: Position of Die Block in Expansion Link: Design of Crosshead: Lubrication of Motion Bearings: Screw Caps or Cane Corks for Oil Boxes: Drive for Mechanical Lubricators: Valveless Mechanical Lubricators: Welded Steel Fireboxes: Flexible and Hollow Firebox Stays: Brick Arch Tubes: Position of Wash Out Plugs under Boiler Barrel:Rocker Grate: Unit Finger Fire Bars? Hopper Ash Pan:Self Cleaning Smokebox:Diaphragm Plates: Blower Ring: Tube Cleaning: Cross Spreader Over Blast Pipe: Parallel Chimney: Regulator Handle: Steam Turret for Auxiliaries: Reflex Water Gauge: Water Level Test Cocks: Bloff Off Valves: Monitor Injectors: Tell Tale in Cab: Pull Out Injector Steam Valves: Sanding Apparatus? Tender Frame: Tender Bogies: Tyreless Disc Wheels: Intermediate Draw Gear: External Tender Water Valves: Position of Engine Brake Shoes: Position of Steam Brake Cylinders: Automatic,Steam,Air and Vacuum Brake Valve. Tool Equipment:

# FIGURES AND APPENDICES.

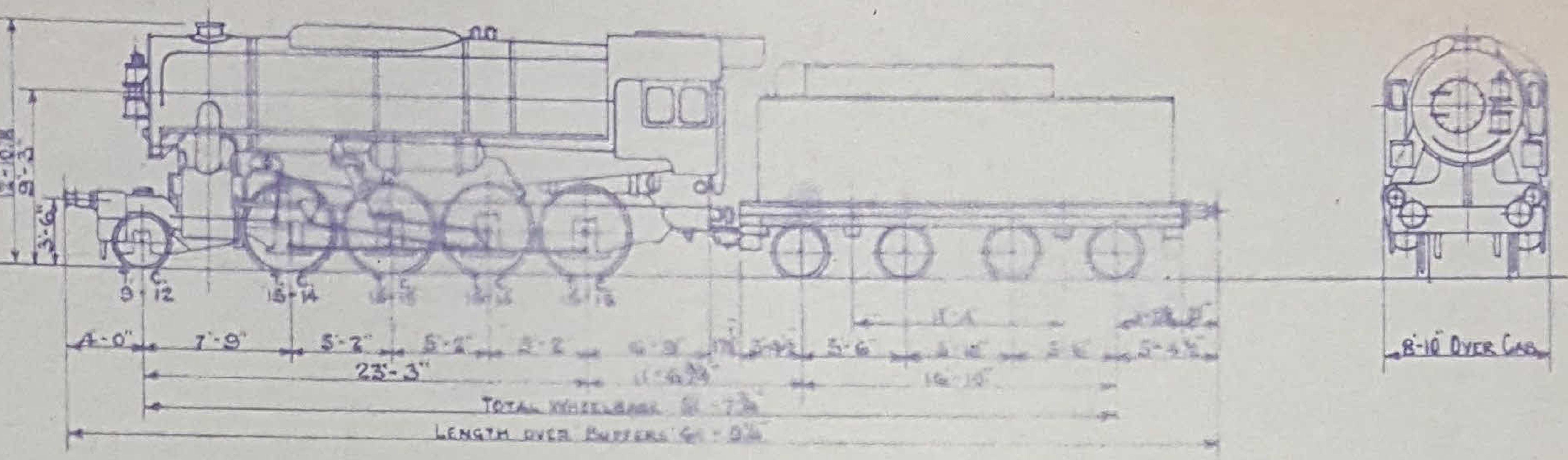
APPENDIX - I

# 2-8-0 & 2-10-0 LOCOMOTIVES

(1)




(2)

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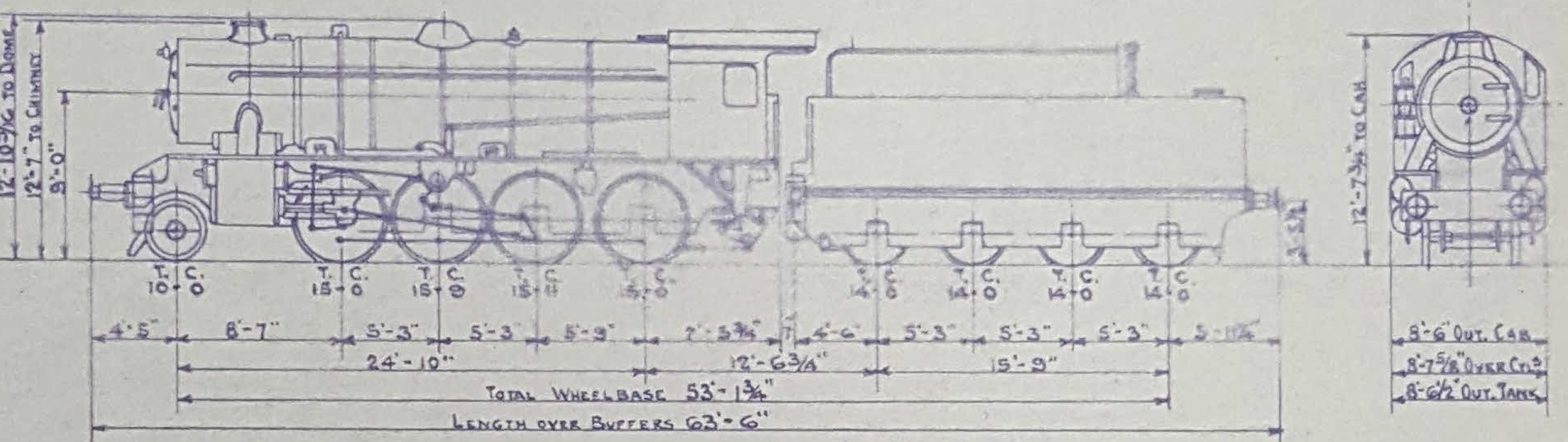


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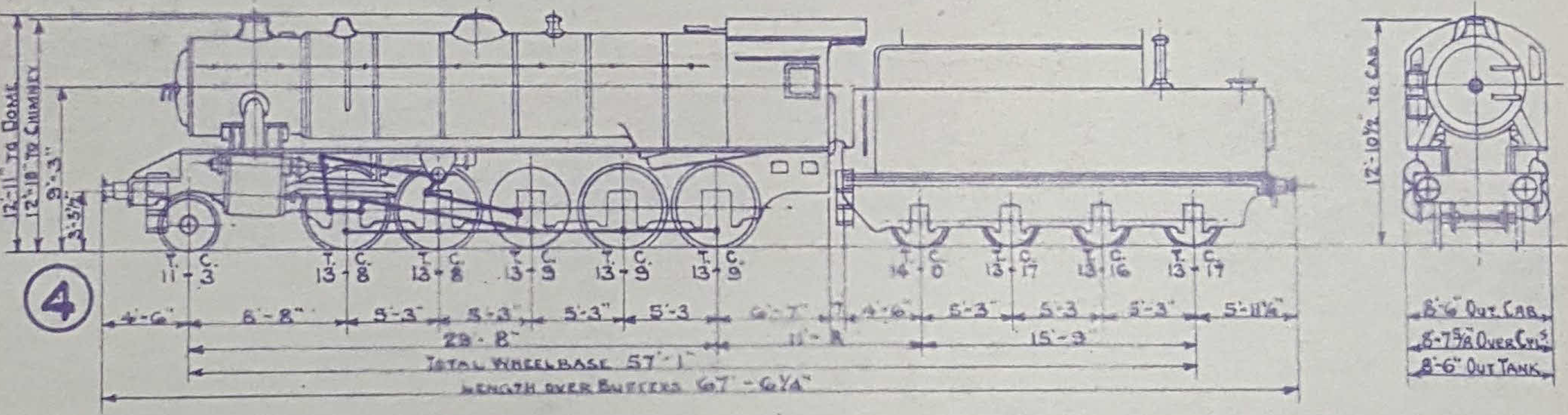


| | (1) LMS 2-8-0 | (2) AMERICAN 2-8-0 | (3) AUSTERITY 2-8-0 | (4) AUSTERITY 2-10-0 |
|---|---|---|---|---|
| CYLINDERS (2) | 18½" DIA. | 19" DIA. | 19" DIA. | 19" DIA. |
| PISTON STROKE | 28" | 26" | 28" | 28" |
| WHEELS (COUPLED) | 4'-8½" DIA. | 4'-9" DIA. | 4'-8½" DIA. | 4'-8½" DIA. |
| WHEELS (LEADING TRUCK) | 3'-3½" " | 2'-9" " | 3'-2" " | 3'-2" " |
| WHEELS BASE (COUPLED) | 17'-3" | 15'-6" | 16'-3" | 21'-0" |
| " " (TOTAL) | 26'-0" | 23'-3" | 24'-10" | 29'-8" |
| BOILER HEATING SURFACE | | | | |
| LARGE TUBES, SMALL TUBES, FIREBOX | 1650 SQ. FT. | 1773 SQ. FT. | 1680 SQ. FT. | 1951 SQ. FT. |
| SUPERHEATER | 245 " " | 480 " " | 310 " " | 423 " " |
| GRATE AREA | 28·65 " " | 41 " " | 28·6 " " | 40 " " |
| BOILER PRESSURE | 225 LBS./SQ.IN. | 225 LBS./SQ.IN | 225 LBS./SQ.IN. | 225 LBS./SQ.IN. |
| TRACTIVE FORCE (85% BOILER PRESSURE) | 32438 LBS. | 31492 LBS. | 34215 LBS. | 34215 LBS. |
| WEIGHT OF ENGINE (LOADED) | 72 TONS 2 CWT. | 72 TONS 10 CWT. | 71 TONS 0 CWT. | 78 TONS 10 CWT. |
| " " TENDER ( " ) | 54 " 13 " | 58 " 0 " | 56 " 0 " | 55 " 10 " |
| TOTAL WEIGHT OF ENGINE & TENDER | 126 " 15 " | 130 " 10 " | 127 " 0 " | 134 " 0 " |
| WEIGHT AVAILABLE FOR ADHESION | 63 " 2 " | 62 " 18 " | 61 " 0 " | 67 " 5 " |
| *COAL CAPACITY | 9 TONS | 8 TONS | 9 TONS | 9 TONS |
| WATER " | 4,000 GALL. | 5412 GALL. | 5,000 GALL. | 5,000 GALL. |

APPENDIX 3.

## SERVICING AND MAINTENANCE OF U.S.A. TYPE 2-8-0 ENGINES.

The use of U.S.A. built type of Locomotives in this country has introduced many new features with which we have not been familiar and these have made it necessary to modify to some degree the Standard practices, common to British Railways, when applying them to these locomotives.

The following is therefore intended to give the reader some idea of the operations necessary when servicing and carrying out maintenance to those engines.

**DISPOSAL.**

Arriving on the shed from traffic, the first operations necessary, i.e. coaling and watering, do not present any unusual feature, except that owing to the tender not being fitted with doors it is necessary to place the 5 wooden planks in position across the tender front when obtaining maximum coal capacity.

For normal disposal i.e. when the engine is not required for washing out, it is not necessary to clean out the smokebox, the performance of these engines making this necessary only at each Washout, i.e. 12-16 days.

The quantity of ash removed from the smokebox at this time is variable, consistent with the class of work the engine has been performing i.e. from 1 to 4 barrow loads.

The smokebox door is held in position by 12 'lugs' secured by ¾"nuts.

If clinker is present in the firebox it is first necessary to break this up with a 'dart' before actuating the rocker grate. The grate is in two sections, operated independently by triggers located immediately in front of the firehole door, in the cab floor. A detachable lever with which to operate these is supplied to each engine; to clean the fire it is then only necessary to work the grates to and fro' in turn retaining the best of the fire by transferring it from one side to the other as each side is dealt with.

Full movement of the grate causes the ash and clinker to drop into the hopper ashpan and the fire is thus completely disposed of with the exception of a portion about 9" wide across the front of the box; this has to be raked forward.

The slope of the ashpan at the sides is such that ashes lodge and accumulate and unless removed regularly there is a possibility of the firegrate becoming burned - to facilitate this cleaning a special rake is provided on each engine.

To operate the hopper ashpan, a cranked lever, also provided on each engine, is fitted on to the hopper door shaft, situated under the footplate on the fireman's side, and it is necessary to ensure that the safety catches are in position after disposal is complete.

The design of hopper ashpan does not allow for the slaking of the ashes until they have dropped into the pit and this point has to be watched at night.

Full disposal for washing out takes approx. 30 mins. for ordinary duties i.e. no smokebox to be cleaned - 15 mins.

The engine is now ready and stabling.

**COOLING DOWN.**

After engine has been examined in steam for 'X' Repairs the blowing down of the steam is commenced prior to 'cooling' down for washing out.

p.t.o/

It is essential that a good level of water is present at the commencement of this operation. The steam is first blown out of the engine by opening an injector steam valve - this takes between 3 to 4 hours.

Artificial cooling is then commenced and is carried out as follows

A tube connection, bent at right angles, is screwed into the plug hole 'A' (see sketch) on the side of the boiler barrel over the R.H. Injector clack box, care being taken that the level of the water is below this point when removing the plug.

To this connection is then coupled the standard washout hose pipe, which in its turn is connected to the hydrant through the standard variable valve.

Another length of hose pipe is connected by means of a screwed adaptor to the plug hole 'B' on the opposite side and other end of the boiler barrel (see sketch) the pipe being of sufficient length to lead the water away conveniently.

The boiler is then ready for cooling and the following rates of water flow are used through Classes 5 - 8 range of holes in the variable valve :-

| | | |
|---|---|---|
| No. 1 position | - | 3 hours. |
| " 2 " | - | 2 " |
| " 3 " | - | 1 " |
| Total | | 6 hours. |

This is for cooling when the engine is to be washed out, if it is intended to examine same with the boiler full then the following rates of flow are used :-

| | | |
|---|---|---|
| No. 1 position | - | 3 hours. |
| " 2 " | - | 1 " |
| Total | | 4 hours. |

WASHOUT OUT.

When the boiler has been emptied by means of the scum cocks, the 24 washout plugs indicated on the attached sketches are then secured using the special box spanners which have been made to facilitate this work. The 2 plugs that have been provided in the smokebox are very inaccessible and it is necessary to use a box spanner 4'0" long to remove these.

Considerable difficulty is experienced owing to the confined and dirty space in which the men have to work, it being necessary for them to go on their hands and knees under the deflector plates in the smokebox as these are not removable.

The plug marked 'C' on the sketch is also difficult to remove owing to the close proximity of other fittings.

Washing out is commenced in the crown of the firebox and then follows through to the smokebox and back along the base of the boiler barrel to the firebox.

It is necessary to use a straight nozzle 3'6" long, when working from the plugs in the smokebox, the nozzles used at the other points in the boiler being generally as follows :-

| | | |
|---|---|---|
| Tops of Barrel | - | Flexible and straight side orifice. |
| Bottom of Barrel | - | Straight side orifice. |
| Firebox Crown | - | Straight nozzle |
| Front of Firebox | - | Straight and side orifice. |
| Water tubes | - | Straight nozzle. |

The three water tubes running through the firebox receive

special/

p.t.o/

special attention and it is essential that these should be thoroughly cleaned and. the dirt not allowed to accumulate in the bottom bend as it is prone to do.

Two scrapers, one in the shape of a disc, the other 'half moon' are used to carry out this operation, after which they are swilled through.

Apart from the difficulty experienced at the smokebox end, the washing out does not present any hardships and following the normal standard procedure.

Upon completion of the washing out the Boilersmith carries out his examination of the water spaces and subject to everything being in order the washout plugs can be replaced.

There is little dirt accumulation on the Bricharch and furring of the tube ends only occurs to a minor degree on the bottom half of the small tubes, consequently the operation of cleaning down the firebox etc. is considerably eased.

The sweeping of the tubes is not found to be necessary as these maintain a clean condition without attention.

During the time that the engine is being washed out and before the boiler is refilled ant boiler repairs found or shown on the 'X' Repair Card and any Standard Examinations that are due are given attention by the R.E. Staff.

Upon completion of these repairs, etc., the boiler is refilled through the Plug 'A' care being taken to see that this is not taken over half a glass. The engine is then ready to be fired.

It is essential during steamraising to watch that the level of the water does not rise above ¾" of a glass.

__BLOWING DOWN.__

This operation is carried out each day prior to the engine leaving the Shed for work and is essential owing to the absence of any automatic blowdown arrangement on these engines.

The operation is carried out by the R.E. Staff and record kept of this work. The scum cocks which are situated on either side of the firebox are actuated from the cab by levers held normally in their shut position by locating slots cut in the levers. A bolt placed through these immediately outside the cab prevent these from being operated in error.

The blowing down is carried out with a fullglass of water, the cocks remaining open on either side in turn, whilst the water level falls a ¼ of a glass (approx. 1 min.) i.e. to half a glass.

It is essential that this operation be carried out where the surface of the surrounding floor is of a solid nature as the force of the blow when the cocks are open will readily break up a loose surface.

__PREPARATION.__

The preparation duties on this type of engine do not depart from the standard practice to any great degree and are on the whole of simple nature.

As in the case of steamraising it is necessary to see that the boiler does not become over filled i.e. more that ¾ glass and this along with the checking of the water gauge cocks should command the first attention of the footplate staff. It is only necessary to go underneath the enging for the purpose of oiling brake gear etc., and examination - there being no oil cups to fill.

The side rod and big ends are worsted trimming fed, the reservoirs are of generous propostions and fitted with screwed cap nuts.

p.t.o/

These do at times present some difficulty owing to their not being of British Standard sizes.

These are the only worsted trimming fed fittings on the engines, lubrication to the little ends, valve spindle guides, etc., being by means of oil cups with pad and restrictor feeds. The lubrication to the slide bars is by mechanical feed as likewise the axleboxes and front end.

The cylinder and axlebox lubricators are filled by the R.E. and footplate staffs respectively.

Filling of the sand boxes which are situated on the top of the boiler barrel present some difficulty in as much that the sand has to be carried up to this point.

Further it is necessary to push the sand in the centre of the box, to the sides, as in practice the sand in the centre does not gravitate away and one is liable to be misled and think that the sand box is full.

The absence of a water gauge on the tender makes it necessary for the footplate staff to climb on to the tender to ascertain the water level, but a diagram has been issued to all running sheds showing the calibration of the tender and this coupled with the fact that the tank holds 5,400 gallons of water should make it unnecessary for enginemen to specially water level in tank except at preparation of the engine.

It should be specially noted that in boilers with steel fireboxes, when engine is standing in shed fired, the fire must be spread all over the grate.

APPENDIX. 4.

## U.S.A. 2-8-0 Austerity Locomotives.

### To Test Level Of Water In Boiler.

1. Close Top and Bottom Gauge Cocks.

2. Open bottom gauge cock first and then open top gauge cock and note whether water level in the glass registers with the test cocks.

### Instructions for Blowing out Water Glass.

1. To blow out water glass open drain valve.( This should entirely clear the gauge)

2. To blow out bottom water gauge cock.

   (a) Close top gauge cock.
   (b) Open drain valve.

   (This should remove any obstruction at lower end of water glass)

3. If top and bottom gauge cocks are closed,the bottom gauge cock should be opened first to insure against bursting glass.

~~xxxxxx~~.

CAUTION. Top gauge cock must always be fully open when locomotive is under steam.

IMPORTANT. Level of water in glass must be compared at regular intervals by use of the Test Cocks.

# U.S. 2-8-0 LOCOMOTIVES - HEATON DEPOT.

| ENGINE NO. | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|
| 2305 | 16,168 | |
| 1904 | 17,245 | |
| 2309 | 17,502 | In D'ton Shops. R. Cyl. Patch bkn. away. |
| 2285 | 19,657 | |
| 2291 | 21,245 | |
| 2311 | 21,370 | |
| 2283 + | 21,626 | |
| 2316 | 22,846 | |
| 2304 | 23,722 | |
| 2317 | 24,103 | |
| 2282 | 25,018 | |
| 2119 | 25,200 | |
| 2303 | 25,693 | In Darlington Shops. Arch Tubes. |
| 2308 | 25,799 | |
| 2293 | 25,937 | |
| ~~1903~~ | ~~26,751~~ | |
| 2289 + | 27,032 | |
| 2297 | 27,035 | |
| 2301 | 27,251 | |
| 2302 | 27,387 | |
| 2284 | 27,671 | |
| 2306 | 30,106 | |
| 2310 | 30,535 | |
| 2300 | 32,599 | |
| 2307 | 34,377 | In Darlington Shops. Pony Truck Exam. |
| 1903 | 29,564 | |

+ suggested to Mr Reeves for repair by US

## U.S. 2-8-0 LOCOMOTIVES - MARCH DEPOT.

| ENGINE NO. | | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|---|
| 1827 | SW 9 | 11,783 | ~~Waiting~~ In Stratford Shops. Fractured tubeplate |
| 1885 | SW 9 | 12,405 | |
| 1845 | SW 9 | 14,636 | |
| 2032 | SW 8 | 14,779 | |
| 2085 | SW 9 | 15,168 | |
| 1831 | SW 8 | 15,214 | |
| 1727 | SW 9 | 15,296 | |
| 1705 | — To Done | 15,315 | ~~Waiting~~ In ~~Stratford Shopt~~. Fractured Tubeplate. |
| 1889 | SW 7 | 15,731 | |
| 1886 | SW 8 | 16,675 | |
| 1882 | SW 8 | 16,738 | |
| 2113 | SW 7 | 16,769 | |
| 2043 | SW 7 | 16,774 | ~~In Stratford Shops. Tubes.~~ |
| 1879 | SW 7 | 16,879 | |
| 1890 | SW 8 | 17,015 | |
| 2099 | SW 6 | 17,320 | |
| 2273 | SW 6 | 17,799 | |
| 1714 | SW 7 | 18,175 | In Stratford Shops. Boilerwork. |
| 1843 | SW 5 | 18,273 | |
| 1830 | SW 6 | 18,274 | |
| 2097 | SW 6 | 18,528 | |
| 2242 | for E.g. | 18,600 | ~~Waiting Stratford Shops. Reversing Gear.~~ |
| 2111 | for E.g. | 18,907 | |
| 1850 | for E.g. | 18,914 | |
| 2033 | Specially for Repair by U.S. | 19,036 | In Stratford Shops. Fractured Tubeplate. |
| 2274 | for E.g. | 19,101 | |
| 2045 | SW 5 | 19,201 | |
| 1888 | SW 5 | 19,525 | In Stratford Shops. Broken cylinder. |
| 2114 | SW 5 | 19,652 | |
| 1712 | for E.g. | 19,659 | |
| 1708 | for E.g. | 19,890 | |
| 1713 | for Done | 20,182 | |
| 2083 | for Done | 20,224 | ~~Waiting~~ In Stratford Shops. Burst Water Tube. |
| 2094 | for E.g. | 20,228 | |
| 2108 | — To Done | 20,378 | In Stratford Shops. Fractured Tubeplate. |
| 1887 | for Done | 20,402 | |
| 2247 | for Done | 20,713 | |
| 2047 | for Done | 21,233 | |
| 2086 | for Done | 21,494 | |
| 1723 | for E.g. | 21,675 | In Stratford Shops. Bulged tube. |
| 1728 | for Done | 21,918 | |
| 1720 | for Done | 21,963 | |
| 2041 | for E.g. | 22,049 | |
| 1722 | — To Done | 22,378 | In Stratford Shops. Fractured Tubeplate. |
| 1842 | for E.g. | 22,677 | |
| 2246 | for E.g. | 22,976 | |
| 1721 | for E.g. | 22,982 | |
| 2101 | for E.g. | 23,296 | ~~In Stratford Shops. Burst small tube.~~ |
| 1828 | for E.g. | 23,971 | |
| 1703 | for E.g. | 24,663 | |

Proposal Reports to HCME

## U.S. 2-8-0 LOCOMOTIVES - LEEDS (NEVILLE HILL)

| ENGINE NO. | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|
| 2286 | 8,598 | |
| 2298 | 8,908 | InD'ton Shops. R.Cyl.fractured. |
| 2126 | 10,116 | |
| 2121 | 15,458 | |
| 2253 | 16,019 | |
| 2295 | 16,987 | |
| 2250 | 17,022 | |
| 2124 | 17,038 | |
| 2117 | 17,039 | |
| 2251 | 17,303 | |
| 2115 | 17,660 | |
| 2296 | 17,719 | |
| 2123 | 17,838 | |
| 2107 | 18,170 | |
| 2299 | 18,192 | |
| 2128 | 19,599 | InD'ton Shops. Lead plug fused. |
| 2125 | 21,096 | " " " Cyl.casting fractured. |
| 2120 | 21,570 | |
| 2252 | 21,658 | |
| 2106 | 21,764 | |
| 2105 | 21,998 | |
| 2287 | 22,210 | |
| 2146 | 22,545 | |
| 2104 | 24,011 | |
| 2127 | 24,747 | |

# U.S. 2-8-0 LOCOMOTIVES - WOODFORD DEPOT.

| ENGINE NO. | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|
| 1839 X ✓ | 13,931 | |
| 1846 | 14,508 | |
| 1706 | 15,066 | |
| 1832 | 16,094 | |
| 1829 X ✓ | 17,874 | |
| / 1836 | 18,351 | In Gorton Shops. Tube plate fractured. |
| 2050 | 18,891 | |
| 1847 X ✓ | 19,243 | |
| 1840 X ✓ | 19,343 | |
| 1844 X ✓ | 19,992 | |
| 1834 X ✓ | 20,204 | |
| 1849 X ✓ | 21,640 | |
| 2051 | 21,679 | |
| / 1833 | 21,866 | Waiting Gorton Shops. Tube Plate. |
| / 2048 | 22,421 | -do- Boiler Repairs. |
| 2049 X ✓ | 22,609 | |
| 2057 | 23,080 | |
| 1848 | 23,254 | |
| 1731 | 24,396 | |
| 1730 | 24,723 | |
| 1707 | 25,000 | |
| 1704 X ✓ | 26,193 | |
| 1710 | 26,218 | |
| 1709 X ✓ | 26,885 | |
| 1729 | 27,612 | In ~~Waiting Gorton Shops~~ Gorton Shops. Arch Tubes. |

X 10 of the above sent to Ebbw Jctn for repairs

## U.S. 2-8-0 LOCOMOTIVES - STRATFORD DEPOT.

| ENGINE NO. | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|
| 2446 SW 5 | 5,336 | |
| 1700 SW 4 | 6,101 | |
| 2364 SW 4 | 8,374 | |
| 2373 SW 4 | 9,019 | |
| 2363 SW 4 | 9,594 | |
| 2374 SW 4 | 9,906 | |
| 2444 SW 3 | 10,468 | |
| 1792 SW 3 | 11,029 | |
| 2436 SW 3 | 11,611 | |
| 1768 SW 2 | 12,036 | |
| 2437 SW 3 | 12,078 | |
| 2447 SW 2 | 12,154 | |
| 2445 SW 3 | 12,858 | |
| 1780 SW 2 | 13,277 | |
| 2361 SW 2 | 13,866 | |
| 1699 SW 2 | 14,097 | |
| 1769 SW | 15,219 | |
| 1788 SW | 16,474 | |
| 1773 SW ① | 17,280 | |
| 2362 SW | 17,380 | |
| 1772 SW | 17,651 | |

## U.S. 2-8-0 LOCOMOTIVES - ST. MARGARETS DEPOT.

| ENGINE NO. | MILEAGE TO 10.6.44. | REMARKS. |
|---|---|---|
| 2420 | 13,366 | |
| 2367 | 14,353 | — Int. Dar Shops |
| 1922 | 15,054 | |
| 1924 | 16,962 | In Stopped waiting Cowlairs Shops) |
| 2366 | 18,942 | Main Frame bkn.) |
| 1698 | 19,490 | |
| 2348 | 21,336 | |
| 2418 | 21,449 | |
| 1912 | 21,563 | |
| 1919 | 21,842 | |
| 1908 | 23,155 | |
| 1697 | 23,328 | |
| 1911 | 23,790 | |
| 2329 | 23,907 | |
| 1923 | 24,680 | |
| 2328 | 25,660 | |
| 2371 | 25,844 | |
| 1925 | 26,571 | |
| 1926 | 26,856 | |
| 2355 | 27,843 | |
| 2370 | 28,181 | |
| 2365 | 29,413 | |

## TOOL EQUIPMENT - U.S.A. AUSTERITY LOCOMOTIVE.

| DETAIL | No. per ENGINE | | DESCRIPTION. |
|---|---|---|---|
| Bar, pinch | 1 | | |
| Bar, slice | 1 | | 1"x 36" |
| Broom. | 1 | | Corn |
| Bucket, | 1 | | 12Qr. |
| Bucket, | 1 | | 14Qr. |
| Chisel, cold | 1 | | 3/4" Octagon. |
| Chisel, cape | 1 | | " " |
| Coal pick | 1 | | |
| CrowBar | 1 | | 5 Feet long. |
| Filler Lamp | 1 | | |
| Flags, red | 2 | | |
| Flags, green | 2 | | |
| Frogs, wrecking | 1 | pair. | |
| Hammer, machine | 1 | | Ball |
| Hose Sprinkler | 1 | | 3/4" I.D.x 6feet long. |
| Lantern, clear | 1 | | |
| Lantern, red | 1 | | |
| Oil Can | 1 | | 1 Gallon |
| Oil Can | 1 | | 5 Pint |
| Oil Can | 1 | | Long Spout. |
| Packing Hook | 1 | | |
| Packing Iron | 1 | | |
| Padlocks | 2 | | |
| Poker | 1 | | |
| Screw Driver | 1 | | Heavy Duty 6" |
| Shovel Scoop | 1 | | |
| Torch | 2 | | |
| Waste, cotton | 1 | pound | |
| Wrench, crank pin | 1 | | |
| " " " sock. | 1 | | |
| " Wrist Pin | 1 | | |
| " Rod, Knuckle Pin | 1 | | |
| " Monkey | 1 | | 12 inch |
| " " | 1 | | 21 inch |
| " Pipe | 1 | | 10 inch |
| " " | 1 | | 18 inch |
| " | 1 | | 3/8"x1/2" Bolt |
| " | 1 | | 5/8"x3/4" Bolt |
| " | 1 | | ~~xxxxx~~ 7/8"x1" Bolt |
| " | 1 | | 1 1/8"x1 1/4" Bolt |
| " Spanner | 1 | | |
| " Superheater | 1 | | |
| Crosshead Pin Puller | 1 | | |
| Ashpan Hopper Lever | 1 | | |
| Rocker Grate Lever | 1. | | |