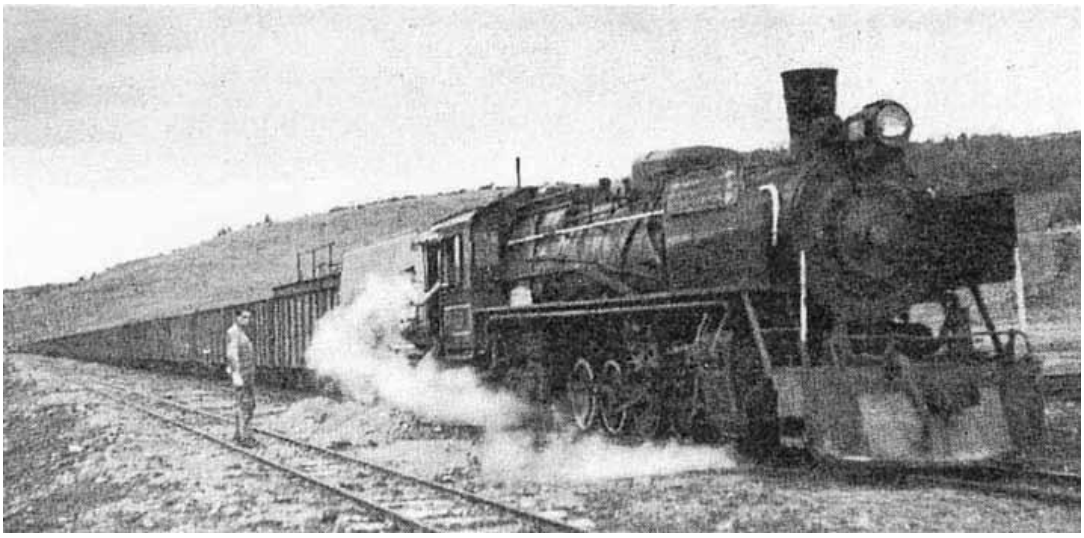
RFIRT Mitsubishi 2-10-2 Locomotives – by Shaun McMahon - 2004

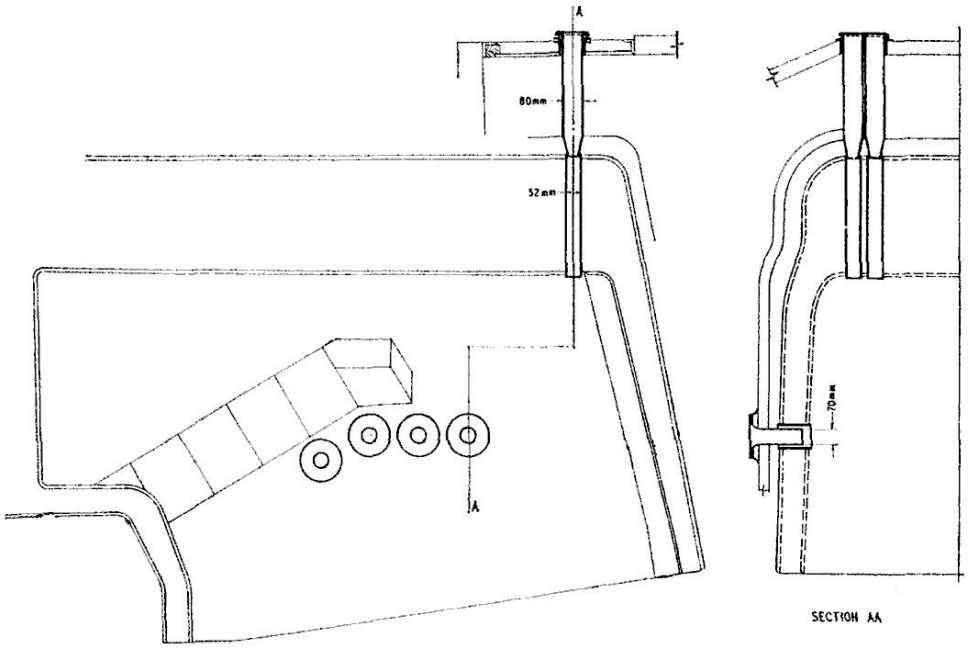
With no possibility to continue his work for the State Railways, Porta took the job of manager of the Rio Turbio Railway in 1957. Belonging to the Yacimientos Carboniferos Fiscales (YCF, the Argentine Coal Board), this 750 mm gauge line runs 255 km (158.5 miles) from the port of Rio Gallegos to the Rio Turbio coal mines situated close to the Chilean border. Opened in 1951, it was originally laid with 17.4 kg/m (35 lb/yard) rail limiting axle load to 7.6 tons. Maximum grades (uncompensated) were 0.3% (1 in 333) against eastbound loaded trains and 0.7% (1 in 143) against westbound empties. However it was the very cold south-westerly winds that pose the greatest operating problem - indeed the wind tends to dominate everything at the southern tip of Patagonia. Blowing almost constantly at 100 km/h and regularly reaching 150 km/h in spring and autumn (gusts of up to 220 km/h have been measured) it strikes empty trains at 45°, increasing train resistance to such an extent that practically the entire westbound trip requires hard work from the locomotive. Winter temperatures can fall as low as minus 20°C, sometimes with snow (the so-called 'white wind') but more often with frost on the rails which makes adhesion difficult, especially as the wind made effective sanding of the rails almost impossible.



Rio Turbio 2-10-2 locomotive (second series) with coal train of 75 bogie wagons.

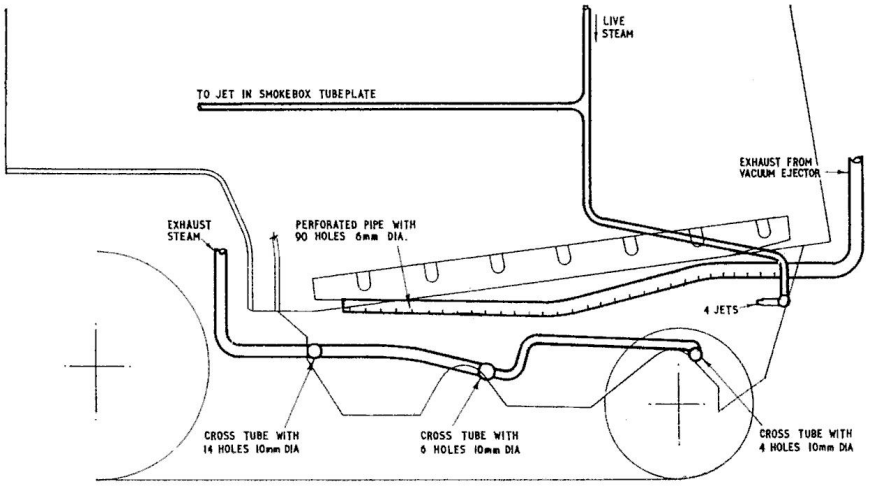
When Porta arrived traffic was handled by ten 2-10-2's supplied by Mitsubishi in 1956. They were a scaled-down version of the Skoda-built variant of a Belgrano Railway metre gauge 2-10-2 design, constructed to contemporary Japanese standards, and had an engine weight of 48 tons of which 38 tons were adhesive. They were rated for traffic purposes at a continuous drawbar power of 520 kW (697 hp) but their operation was hampered by the clinkering tendency of Rio Turbio coal and due to this problem the locomotives proved unable to sustain 700 drawbar kW (939 hp) on test. It was whilst he was at the Rio Turbio Railway that Porta started to develop the Gas Producer Combustion System (GPCS) which combined a thick firebed and the admission of secondary air over the fire (as already partially applied to the experimental 4-8-0) with the addition of steam to the primary air to control clinkering. Three of the 2-10-2's were fitted with the GPCS and Kylpor exhausts which increased their rated drawbar power to 895 kW (1200 hp) and eliminated the clinker problem. The power to weight ratio was an excellent 28 hp/ton. This power could now be sustained indefinitely without stopping for fire cleaning, there being no field fire risk so that ashes could be dropped on the track whilst running, frequent light grate shaking being practiced to maintain a uniform active firebed thickness. The specification for the second batch of ten 2-10-2's supplied by Mitsubishi in 1963 included these alterations plus a number of other improvements to the boiler, valves, pistons and sanding gear, as well as a higher boiler pressure, increased from 1373 kPa (199psi) to 1570 kPa (227psi.) The number of small tubes was reduced from 108 for the first batch to 88 for the second, to increase the proportion of gases passing through the large tubes carrying the superheater elements, which are of standard A type and eighteen in number. Maximum steam temperature was 410 - 420°C when working hard. Boiler tubes were

welded to the tube plate and there is no record of tube leakage or replacement of fractured boiler stays, despite wide variation in steam demand and winter temperatures as low as -20°C.



Secondary air admission to firebox for gas producer combustion system. There are four intakes in firebox crown and four in each side.

Some 70% of the total air required for combustion was admitted as secondary air above the firebed through intake ducts to the sides of the firebox and through the firedoor, which is kept open continuously. Some 3-4% of exhaust steam from the cylinders is introduced into the ashpan for mixing with the primary air, amounting to about 30% of the total.

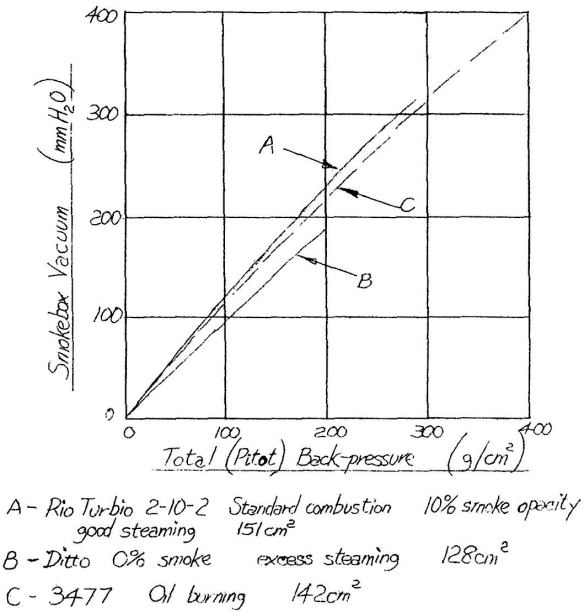


Arrangement of jets supplying exhaust and live steam below firegrate to prevent clinkering

Boiler efficiency as recorded on official tests reached 78 - 80% assisted by the use of a long brick arch arranged to prevent carryover of coal particles entrained by the draught. Combustion was virtually complete and tube cleaning is almost eliminated. The grate was, of the Hulson type and the ashpan is self

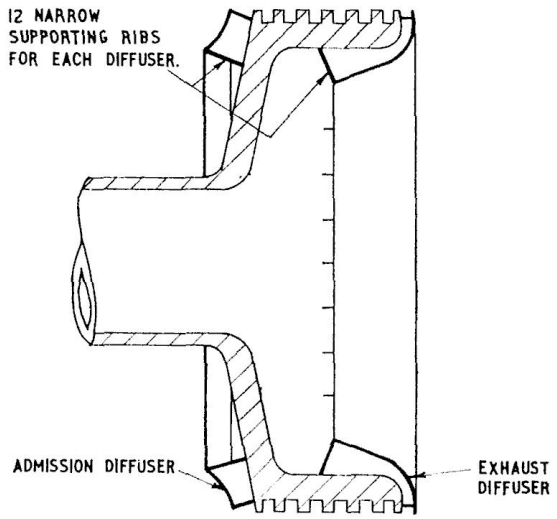
emptying.

Sustained evaporation rates of about 22000 lb/hour were maintained for several hours with this small boiler having an evaporative heating surface of only 950 $ft.^2$ and effective grate area of 22.5 ft^2, burning slack coal with a calorific value of 9000 - 10000 B.Th.U/lb.



Smokebox vacuum/back pressure characteristics, Kylpor exhuast system.

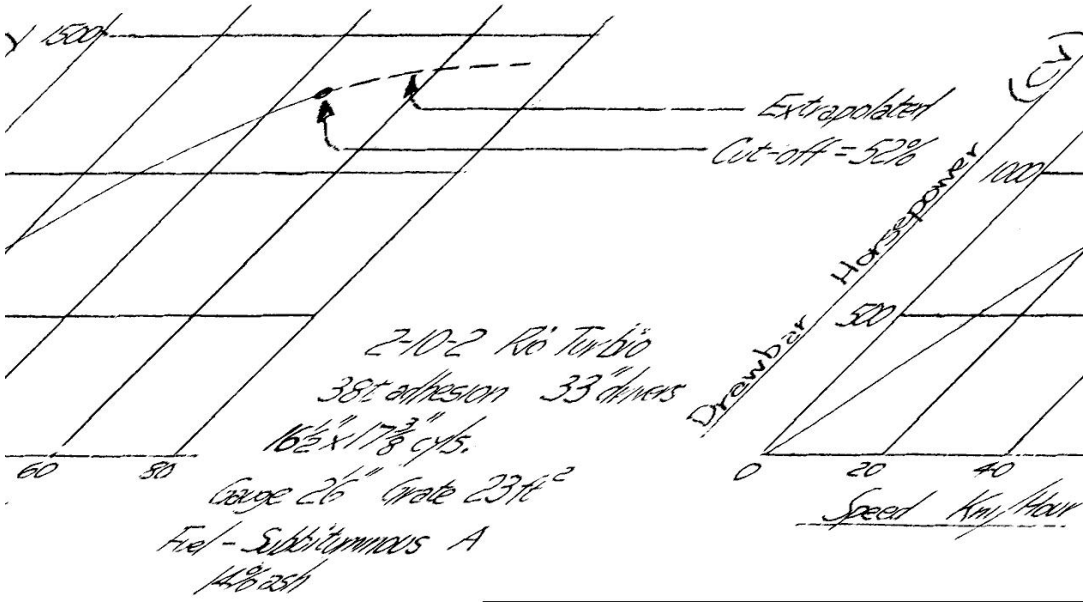
Steel pistons were provided with six narrow piston rings, to standard diesel quality and workmanship. The Fukao gland packings used gave extremely good results and enabled steam tightness to be maintained over nearly 200,000 miles running.



Piston valve with admission and exhaust diffusers

Axleboxes were provided with side bearings to deal with piston thrust, wear of about 0.007 in. per 1000 miles running being taken up by placing shims between bearing and box at periodic inspections every 12500 miles. Axleboxes were spring-pad lubricated. Bronze wedges and horn cheeks were provided which it is anticipated will not require renewal during the working life of the locomotives.

An interesting feature was the adoption of Walschaerts valve gear arranged to give increasing lead with increasing forward gear cut-off, the opposite to what most engineers had hitherto thought was correct.* Locomotives of the second series were able to sustain a drawbar power of some 1000 kW (1341 hp) at 50 km/h (31mph)(the maximum line speed due to track conditions and poor wagon springing) and all the improvements due to Porta were gradually incorporated into the locomotives of the first batch as they were given major overhauls, with the exception of No. 106.



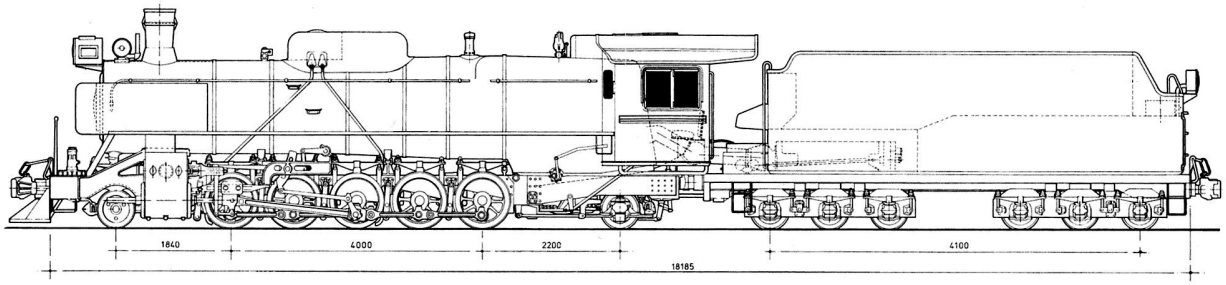
Drawbar horsepower/speed characteristics, 2-10-2 locomotive (second series), Rio Turbio Railway

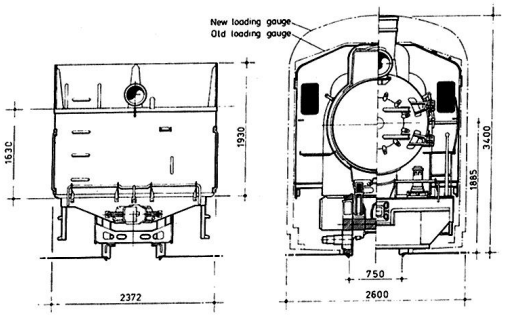
These 2-10-2's normally handled 1500 - 1700 ton coal trains unaided the maximum load taken by one locomotive in normal service being 2000 tons. Some locomotives accumulated 12000km (7456 miles) per month. These were remarkable figures for a 750 mm gauge railway and could to a large extent be attributed to the good detail design of the locomotives which resulted in high power capacity, good fuel economy, and good reliability. Some measure of the reliability achieved can be gauged from a few statistics supplied by Porta.

1. Period between white-metalling of coupled axle bearings = 120000 km (74564.5 miles); total life of these bearings > 480 000 km (298258 miles)(180 x 10^6 coupled wheel revolutions).
2. Distance between tyre reprofilings = 70000 km (43496 miles)(850 mm diameter coupled wheels frequently operated on the limit of adhesion. Porta applied a 'high adhesion' tyre profile to these locomotives and turned the driving wheel tyres 3 mm larger in diameter than those of the coupled wheels.)
3. Superheater elements: no replacement in 500000 km (310686 miles)(maximum steam temperature normally 400°C, absolute peak 420°C).
4. Boiler tubes: 10% repaired in 400000 km (248548.5 miles) due to longitudinal cracks because of overexpanding during assembly, otherwise zero repairs.
5. Boiler shell and firebox plates: zero repairs in the first twelve years of service. 6 Broken stays: zero in 400000 km (248548.5 miles.)
6. Main steam pipe joints: no leakage in 400000 km (248548.5 miles.)
7. Life of piston rod packings - 400000 km (248548.5 miles.)(150 x 10^6 coupled wheel revolutions).

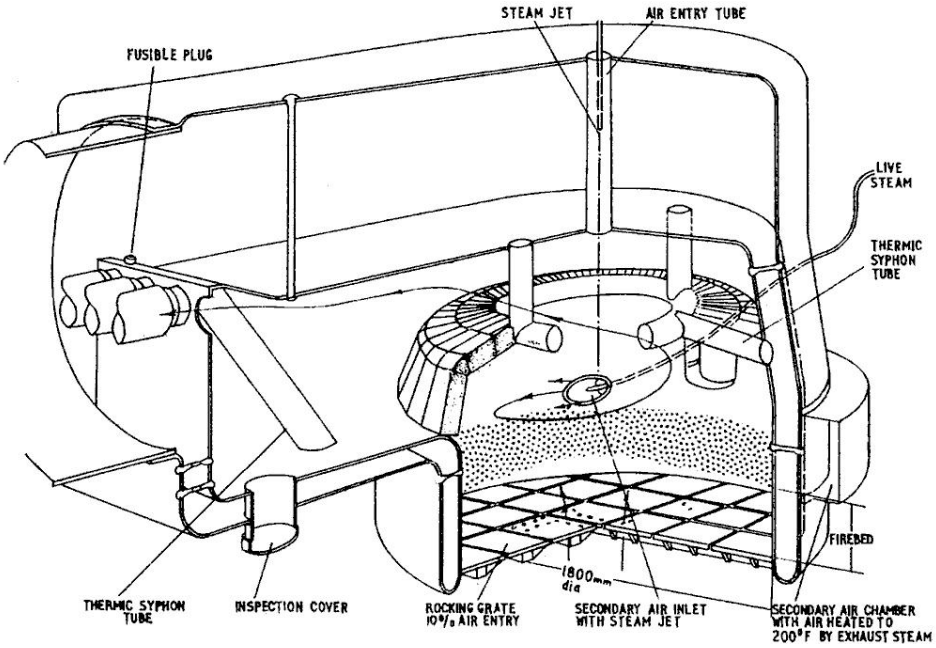
8. Steam leakage (all sources): maximum of several locomotives tested = 1.7% of the rated maximum evaporation with piston and valve rings 70000 km (43496 miles) old.

Some of these figures are outstanding compared to what was being achieved elsewhere, including on the SAR. The thermal performance of the locomotives was no less impressive. Tests carried out over the full length of the line showed the overall boiler efficiency in normal service to be 80% when burning Rio Turbio coal of about 24 MJ/kg lower calorific value, and dynamometer car tests found the drawbar specific coal consumption when burning coal of 31.4 MJ/kg lower calorific value to be 0.37 kg/MJ, giving an overall drawbar thermal efficiency of 8.6% for a complete trip.





These were some of the results of Porta's four years work on the Rio Turbio Railway. In 1960 he moved back to Buenos Aires to join the Instituto Nacional de Tecnologia Industrial (INTI) where he worked for the next twenty two years as head of the thermodynamics department. He maintained a close working relationship with the Rio Turbio Railway and was able to continue to apply his developments there. For example the cyclonic GPCS (GPCS with the brick arch and secondary air inlets arranged to give cyclonic gas flow in the firebox to centrifugally separate entrained coal particles from the rising gas stream) was experimentally fitted to 2-10-2 No. 118 during the mid 1960's. It was during tests on this locomotive using 11% ash maize-size coal that a double-headed train of 3190 tons was pulled, No. 118 taking the full load except on the steepest grades and managing 30 - 35 km/h on level track at 35% cut-off.



Circular form cyclonic gas producer firebox.

His position at INTI enabled Porta to resume his collaboration with the State Railways on steam locomotive matters. Following the successful use of Rio Turbio coal on the modified Rio Turbio Railway 2-10-2's, similar modifications were made to a metre gauge 4-6-2 of the Belgrano Railway to demonstrate the practicality of burning this coal on main line railways. The locomotive used was 12A class no. 4674 built by Alco in 1919 and weighing just 48 tons without tender of which only 27 tons were adhesive. In its modified state it could sustain 820 drawbar kW (1100 hp) and pull 2000 ton trains on level routes. Using Polish coal (of higher calorific value than Rio Turbio coal) this locomotive once hauled 1000 - 1200 ton freight trains on a round trip from Santa Fe to Resistencia and back, about 1200 km (746 miles), without refuelling. Although the suitability of Rio Turbio coal for general locomotive use was successfully demonstrated it came too late to influence the railway's thinking and no further State Railway locomotives were converted to bum this coal using the GPCS.

** "Porta advocated variable lead and he had arranged this on his locomotives, including the Rio Turbio Railway 2-10-2's, simply by shortening the eccentric crank, the lead then decreasing from a maximum in full forward gear towards mid gear and even becoming negative in reverse gear"*

RFIRT Mitsubishi 2-10-2 Specifications		
Year Constructed	1956	1964
Built by	Mihara Eng. Works, Mitsubishi Heavy Industries, Japan	Mihara Eng. Works, Mitsubishi Heavy Industries, Japan
Running Numbers	101-110	111-120
Type & Gauge	2-10-2, 2 ft. 5½in. (750 mm) gauge	2-10-2, 2 ft. 5½in.(750 mm) gauge
No. Cylinders	2	2
Cylinder Dimensions	16½ inches x 17?z inches (419mm x 441.3mm)	16½ inches x 17?z inches (419mm x 441.3mm)
Coupled wheel diameter	33½ inches (850mm)	33½ inches (850mm)
Boiler pressure	199psi (1372 kPa)	227psi (1,565 kPa)
No. Tubes	108	88
No. Flues	18	18
Superheater	Type A	Type A
Heating Surface (saturated)	NA	950 square feet (88.3 m^2)
Grate Area	22.5 square feet (2.1 m^2)	22.5 square feet (2.1 m^2)
Fuel	Sub-bituminous coal, ~14% ash, ~10,000 BTUH/pound heat content	Sub-bituminous coal, ~14% ash, ~10,000 BTUH/pound heat content
Effective Firebox Volume	125 cubic feet (3.54 m^3)	125 cubic feet (3.54 m^3)
Adhesive Weight	38 tons	38 tons
Loco. Weight	48 tons	48 tons
Tractive Effort at 85% BP	23,380 lb (106 kN)	26,675 lb (121 kN)
Max. DB power	1075hp (801.6 kW)	1341 (1000kW)
DBHP per ton	22.4	28
Specific fuel consumption	2.64 pounds/DBHP/hour (estimated)	2.2 pounds/DBHP/hour
Rated tonnage	1200-1500 tons	1500-1700 tons
Remarks	Kylpor exhaust system, Gas Producer Combustion System, Belpaire firebox, light-weight, multi-ring piston valves and pistons, mechanical stokers	Kylpor exhaust system, Gas Producer Combustion System, Belpaire firebox, light-weight, multi-ring piston valves and pistons, mechanical stokers