6A and the Lempor

FOR more than a hundred years, the distinctive exhaust note of the NA class locomotives has echoed around Victoria's narrow gauge lines. The harder the locomotives were worked, the louder was the noise that became synonymous with the Puffing Billy engines.

Unfortunately the sharp exhaust `bark' much beloved by enthusiasts and the public alike was (and still is) an indication of inefficiency, because it indicates high cylinder back pressure which not only wastes energy but also creates a strong vacuum which, amongst other things can cause quantities of unburnt fuel to be carried over into the smokebox.

Now there is a `new kid on the block' (well, at Belgrave at least) producing a quieter exhaust note and requiring a totally different firing and driving technique. Don Marshall, our Manager Mechanical Engineering, in the first of a two part article, presents a history of the research and development which went into the manufacture and installation of the multi-nozzle exhaust system fitted to No.6A.

"6A and the what?" "6A and the Lempor exhaust system" I explain patiently for about the tenth time in as many days, expanding the answer to describe a system of nozzles designed to efficiently use the exhaust steam from the cylinders, at a relatively lower pressure than that used on the other NAs, to create a strong vacuum in the smoke box, which in turn promotes vigorous combustion in the fire box, thereby greatly aiding the production of steam.

A feature of the Lempor is the reduction of back pressure in the cylinders during the exhaust cycle which has the added benefit of allowing the engines to run more freely when steaming hard. (There are two engines on an NA locomotive).

There is very little in the way of rocket science associated with the basic steam locomotive and steam locomotive engineers down the years have often expounded the view that a locomotive's usefulness is directly related to its ability to boil water!

In 6A, early indications are that we have a locomotive which boils water at a remarkable rate and which keeps on doing just that provided coal is fed to the fire box at the correct rate.

Not-withstanding the fact that the locomotive has new piston rings and valves, the water consumption is less than the other locomotives and it is anticipated that the coal consumption will drop even further as crews get used to the different handling techniques.

So where did it all start? In 1986, whilst on an engineering study tour of the British preserved railways, I heard of some work being carried out on locomotive front ends and gas producer fire boxes by both the Festiniog Railway and the Ravenglass and Eskdale

Railway. Both these organisations made me most welcome and I came away with copious notes and drawings in the hope that at some time in the future, when some of our early locomotive problems had been overcome, we may be able to improve the thermal efficiency of the NAs and also modify them to bum lower grades of coal.

Much correspondence followed as an attempt was made to keep track of locomotive front end development, both in the UK and elsewhere in the world. Subsequent trips to the UK provided the opportunity to make useful contacts and increase the information file but pressure at home to keep the operating fleet running prevented any further practical development.

Although the use of steam traction has been in worldwide decline since the 1960s, efforts to improve the thermal efficiency of the steam locomotive have continued.

The work of David Wardale, Phil Girdlestone, Shaun McMahon and Nigel Day in the UK, South Africa and elsewhere is well known as is the work of their mentor, the South American steam loco-motive Engineer, L.D.Porta.

In 1996, G42 project leader Harold Hibgame and I were able to travel to South Africa in connection with the proposed purchase of the NGG 16 Garratt. This was somewhat akin to putting Dracula in charge of the blood bank for here, for the touching and the asking was a veritable treasure chest of practical application and theoretical information concerning steam locomotive front end design.

We returned home not only with the NGG but with a wealth of information and the promise of assistance when we eventually proceeded to the design stage of a new exhaust system for the NAs.

Recognising the fact that we were, to a certain extent, in uncharted waters, it was felt that we could not justify modifying one of the existing locomotives and risk having it out of service for an unknown length of time in the event we were not able to make the system work first up.

Accordingly, it was decided to re-design the front end on 6A which had to be almost completely rebuilt as there was little left of the original. In order to keep the costs down Harold offered to fabricate the components in his own time and to assist with the design work where possible.

Whilst in South Africa we met up with Nigel Day a driver on the Snowdon Mountain Railway and a partner with Shaun McMahon in a business specialising in the design and manufacture of steam locomotive systems and components.

Nigel and Shaun both offered assistance, however Shaun ended up at the railway at the bottom of the world in Tierra del Fuego in South America and it fell to Nigel to assist us with the design and produce the detail drawings which were required. This work commenced in 1997 and involved not only much correspondence with Nigel in the UK but also with L.D. Porta in South America. Nigel was also heavily involved in re-draughting some of the locomotives at the 2'6" gauge Welshpool & Llanfair Railway in Wales where, like the NAs, the Lempor chimney had to be concealed inside the existing chimney.

If the foregoing then is the background, just what then is the Lempor?

Front end design has been under almost constant development since the days of George and Robert Stephenson's *Rocket* in 1829. Well before the advent of *Rocket*, the early locomotive engineers *were* well aware that by directing the exhaust steam into the chimney a vacuum could be created which, in turn, increased the draught through the fire.

It was quickly discovered that if the diameter of the exhaust or blast pipe nozzles was reduced, the draught on the fire was increased, thereby improving combustion. The down side to this was increased cylinder back-pressure which, amongst other things, detracted from the amount of useful work which could be extracted from the steam during its passage through the engine.

Many old steam locomotive drivers in fact carried with them devices which could be clamped to the blast pipe nozzles of poor steaming engines which effectively reduced the diameter of the nozzles, increased the smoke box vacuum and, as a consequence, the draught on the fire.

The name given to the device which is made up of the blast pipe, blast pipe nozzle and chimney is the draught ejector. Probably no other item of equipment on a steam locomotive has the inherent ability to 'make or break' the reputation of a locomotive, its designer and/or its crew than the ejector, or front end as it is known. It has been demonstrated over many years that quite minor alterations in component details can have an enormous affect on locomotive performance.

Modern ejector design is based on a thorough understanding of the fluid dynamics involved and can be carried out with a high degree of predictability of the outcome so that much less 'fine tuning' is required.

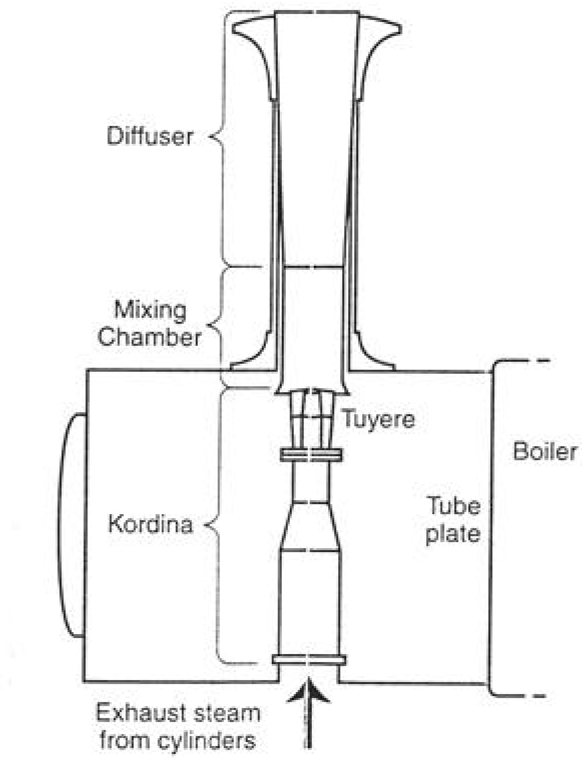
Ejector design has been under constant development throughout the steam era and the modem ejector is a far cry from the exhaust nozzle and chimney combinations of the early steam locomotives.

The names of the great steam locomotive engineers are almost without exception synonymous with locomotive front end design and such names as Churchward, LeMaitre, Chapelon, Giesl and Porta come readily to mind.

The word 'Lempor' is in fact a joining of the names of LeMaitre and Porta and the design and development of the Lempor exhaust by Porta contains certain elements of the LeMaitre system.

The modern Lempor Ejector consists of four main components: (refer to diagram)

1. The blast pipe or Tuyere made up of four nozzles which have convergent/divergent sections;
2. The mixing chamber;
3. The diffuser;
4. The Kordina which is so designed that each 'puff' of exhaust steam creates a vacuum in the other cylinder.



Basically the system is a very efficient steam pump which takes exhaust steam at a relatively low pressure and then accelerates it from the exhaust nozzles into the mixing chamber where it mixes with the hot gases from the fire box. From the mixing chamber, the steam and hot gases pass into the diffuser where their velocity is reduced and the velocity energy converted into pressure as they pass through the diffuser and into the atmosphere.

To cause air to flow through the fire bed of a locomotive fire box, a pressure drop must exist between the fire grate and the smoke box. The ejector creates this drop by reducing the pressure in the smoke box below that of the atmosphere thus causing atmospheric pressure to force air through the fire bed into the fire box and then through the fire tubes into the smoke box.

The system must then discharge the products of combustion and steam into the atmosphere. Whilst most steam locomotives achieve this exhaust cycle in a similar manner, the Lempor does it far more efficiently in that:

1. It uses less steam to achieve a similar vacuum which in turn results in less coal and water consumption;
2. The Lempor will perform its primary function of producing a satisfactory smoke box vacuum across all boiler loads, i.e. the locomotive does not have to be working hard to produce a strong draught in the fire box.

The locomotive can be worked at shorter valve cut offs
with a consequent saving in coal and water. (To be continued).

- *Don Marshall*

References:
Letters and papers from L.D. Porta
Letters and papers from N.A.H. Day
ETRB Locomotive Boiler notes 1998