(B). VORTEX FLOW

***AERODYNAMIC DEVELOPMENT OF THE PORSCHE 907LH/005 ***

(1968 Daytona 24-hour race winner)

The 907LH is a unique race car[1]. Its drag coefficient of approximately 0.27 is the lowest ever measured for any Manufacturer's Championship racer to the present. This was achieved by minimizing all air-intake openings as well as eliminating all extraneous parts that might create disturbances to the streamlined bodywork. (This can be seen visually by the driver as 5th gear takes on an all new meaning by effortlessly reeling in other higher power cars on long straights, Figure-1)

In addition, this racer continued Porsche's "flat-bottom", clean underside that was a feature of its first plastic Porsche, the 904, introduced in 1964. However, its high-speed stability was poor, as noted by its primary Daytona driver, Vic Elford and a sister car's driver Joe Buzzetta.[2]

Low drag is fine for a race car, but it must be achieved along with low lift, or even negative lift, if possible. Front-end lift and rear-end lift are the primary reasons for race-car instability, and must be reduced in order to improve the race stability of any car.

AIR VENTS:

Restoration of 907LH/005 started in the early 1990's with many of its original parts, including the long, sweeping tail and its unusual plexiglas rear window. The four wide(30mm x 550mm) horizontal ejector type slots were designed to supply the 2000 liter/sec. engine cooling fan. The 14 per side (7mm x 70mm) vertical engine air louvers were designed to ensure that the 200 liter/sec. fuel injection ram tubes were well supplied. (4237cfm & 424cfm)

Tuft tests of the four horizontal slots showed all four pulling air in at low speeds of 40-60mph. However, at race speeds of over 100mph only the first slot is pulling air in. The others all show a significant out-flow of air. In addition, colored oil smears on the transmission bell-housing all go upward verifying the tuft indication of significant air flow from under the engine/transmission to exit the rear louvers.

The only other air openings are two 70mm x 140mm front brake-cooling ducts and one 110mm x 540mm oil cooler inlet.

REAR SPOILERS:

On the initial test race-weekend, several horizontal flat-plate aluminum spoilers were made up as follows: 70mm x 1040mm, 140mm x 1040mm, 140mm x 1040mm w/12mm Gurney lip. These were fitted flush with the end of the rear deck and between the vertical fins. The addition of the smallest spoiler eliminated significant high-speed over steer and resulted in lap-time improvements of 3 sec/lap. Trials of the larger spoilers showed further lap time improvement of another 3 sec/lap (although some chassis ride-height adjustments were done at the same time).

Racing in the rain observations indicated a very high rooster tail, equal to that of formula cars with rear wings under the same conditions. The strong vortices generated from each side at the rear wheels--easily visible--would verify that there is down force on the rear with good extraction from underneath the upswept long-tail.[3]

RIDE HEIGHT and RAKE (pitch) ANGLE:
(to minimize drag and maximize down force, i.e., neg. lift.)

The influence of the ground presence on the lift and drag of flat-bottom race cars is very strong. Serious test work on this phenomenon was begun in the late 1960's when speeds on the Mulsanne straight at LeMans began to exceed 200mph on a regular basis. Unfortunately, some of these lessons were not considered 30 years later in 1998-1999 when the Mercedes (and other) Lemans racers performed spectacular take-offs from the ground, including back flips. This resulted in arbitrary rule changes to prevent this from happening again, similar to the "no movable aerodynamic device" rule that was put in place in 1968. This rule is still in effect today because of the "unreliability" of the various schemes that were tried in the late 1960's. A "flat bottom" rule has also been applied to Formula 1 and many other race series since the early 1990's.

With any flat-bottom vehicle, there are possibilities to minimize the amount of air that is allowed to pass through the gap between the road and the vehicle's flat bottom. The most obvious is to lower the vehicle's ground clearance. Next is to provide a negative "rake" or pitch angle of attack. The latter is, typically, -.50 to -2.0 degrees when measured on the side sills of a race car.

This rake-angle also opens up the bottom rear of the car so that it could act as a diffuser to assist in extracting the higher velocity bottom air from the front of the car. This would help to lower the pressure under much of the cars flat bottom. The long upswept tail of the 907LH assumes a 7ø angle with the horizontal for much of its 1075mm length, which is the maximum for good diffuser design. However, there are several other important issues which should be noted:

1) The Porsche engine cooling fan air is injected into the bottom rear and its 2000l/s will definitely affect the rear underbody flow to the diffuser.

2) The rear spoiler--from experimental observation--clearly increases the "circulation" , i.e., turning upward of the diffuser-exit air, by using the energy of the upper rear airflow. In order for this to happen, the upper body airflow must be well attached to the plexiglas rear window area.

3) Also from rain observations, two trailing vortices are created by the "Morel body" shape of the lower rear body with horizontal separation of the vortices encouraged by two long vertical plates attached to either side of the 680mm wide exhaust cut-out in the bottom of the long tail.

4) Channeling high-velocity air from the front to the flat bottom of the car must be done in such a way as to prevent leakage out the sides between the front and rear wheels on each side of the car.

References:
1. Race results for this car proves the efficiency of its VORTEX flow aerodynamics:
-Raced on 40 weekends and 80 races over a 10 year period.
-Took 1st place 52 times.
-2nd and 3rd place 17 times.

2. Author's discussions, 2/92 and 6/96.

3. AUTOMOBILE DYNAMICS, by:
W.F.Milliken, MILLIKEN RESEARCH ASSOCIATES, 1995

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Examples of the VORTEX aerodynamic design of race cars in actual races.

Figure-1 **907LH/005 in the SVRA race at Mid-Ohio, August 2006** (photo by Bob Harrington)

Figure-2 **908/02/017 in the SVRA race at VIR, October 2006** (photo by Bob Harrington)