Three Technical Reports in the Trial of Enzo Ferrari for the 1957 Mille-Miglia Car Crash

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Abstract. In 1957, a car crash at the Mille Miglia – an Italian competition on a street circuit – caused the death of 11 people. As a matter of course, the car manufacturer, Enzo Ferrari, was investigated for negligent homicide. In order to clarify the car dynamics and the root causes, a first committee of technicians and academics had been assigned to produce an expert report. This report pointed directly towards the specific design of the tires used (made by the Belgian manufacturer Englebert) and, as a consequence, towards the Ferrari team and his owner. Other two reports followed, one provided by the defense and a third one to finally settle the issue. This paper won't focus on the media aspect that the personalities involved aroused, but on the technical aspects of the reports produced by the three committees. Accidentally, these memories differ in the approach followed and allow a comparison on what the optimal approach should be to solve a technical problem, as well as a memory of a significant event in Italy which saw technical-scientific reasoning as the key to arriving at the truth and clearing Enzo Ferrari of all charges.

Keywords: Ferrari · Mille-Miglia · De Portago · History of MMS · Capocaccia-Casci-Funaioli

1 Introduction

May 12, 1957 is a date that runs in the double track of crime news and Italian sports news. For the latter it was the "fatal epilogue of the Mille Miglia car competition", for the crime news it is instead known as the "Guidizzolo Tragedy", where 11 people died, including 5 children and the 2 car drivers. On the straight that led from Mantua towards Brescia and therefore to the finish line of the XXIV Mille Miglia in 1957, the Ferrari 335S driven by the Marquis Alfonso De Portago and his co-driver Edmund Nelson suffered a burst front left tire in the locality of Guidizzolo, in the municipality of Cavriana (MN). For more information on the Mille Miglia competition, please refer to [1]. Within a few seconds the car - no longer controllable - went off the road, mowing down 9 spectators who were waiting for the drivers to pass. Subsequently, the car collided violently against a telephone pole, putting an end to the lives of the two drivers and stopping shortly after a collision of several meters. Figure 1 shows the dynamics of the car crash as reconstructed by a car journal [2]. In the following days and months, newspapers analysed the possible causes

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of the accident, published testimonies and told the lives of the drivers and spectators involved. The popular indignation that arose throughout the country decreed the end of the competitive Mille Miglia. In this story, public opinion left Enzo Ferrari as the culprit, as the manufacturer of the car driven by De Portago. The Public Prosecutor's Office, having determined that the triggering cause had been the bursting of a tire, took action to understand whether it had been a mere accident or whether there had been design negligence or a negligence on the part of the pilot himself. A committee of official technical consultants is tasked with producing an expert report to determine the dynamics and triggering causes. On 14 January 1958 the experts' report was received by the Public Prosecutor. The report pointed the finger, as will be described below, on the choices done in the design of the car. In particular, the tire pressure was considered too low but also the characteristics of the Englebert tires were considered unsuitable for that type of racing. On 24 June 1959, the deputy public prosecutor of Mantua informed the investigating judge to proceed with the indictment of Enzo Ferrari for manslaughter and negligent injury.

Ferrari, from his side, committed an expert report from Giovanni Francia - a professor at the University of Genoa – that was deposited at the Chancellery of the Court of Mantua on 14 July 1960. The report refuted the thesis of the court experts, proposing a different interpretation of the accident. Both reports, although pointing in opposite directions, were based on findings made by the police and on technical and scientific considerations carried out by recognized academics. The investigating judge of the Court of Mantua therefore decided to request a final technical report with the aim of definitively clarifying the dynamics of the car crash. The chosen committee is made up of professors Agostino Antonio Capocaccia, Corrado Casci and Ettore Funaioli. At the end of the work, the committee sends a detailed report with the typical features of a scientific publication, citing international publications and reporting experimental tests. On 4 May 1961, at the conclusion of the work, the committee filed the third and definitive report, determining that the burst of the tire was not attributable to an incorrect choice of wheels or inflation pressure, but was reasonably due to the impact against a external obstacle. On 12 May 1961, the Court of Mantua declared Enzo Ferrari not guilty, thus concluding the procedural process relating to that tragic accident.

This brief memoir wants to focus only on the technical-scientific aspect of the three reports produced, like the way the scientific reasoning, the rigorous formulation of the problem and the consequent deductions could lead to ascertaining the truth. All the material cited - unless otherwise attributed - comes from documents kept in the State Archives of Mantua (Italy) and publicly accessible. The story of that tragic accident is reported in a few detailed books [3–7] which I invite the interest reader to read so as not to forget that beyond the technical aspect of ascertaining the truth about the accident, there remains the memory of the people involved. Figure 2 shows the monument in memory of the people died in the accident in Gudizzolo (Mantua), Italy.

The paper continues with a brief description of the reports made by the Speluzzi-Mandella-Rinaldi committee (Sect. 2), by Francia (Sect. 3), and by the Capocaccia-Casci-Funaioli committee (Sect. 4). Conclusions about the three different approaches used in the reports close the paper.

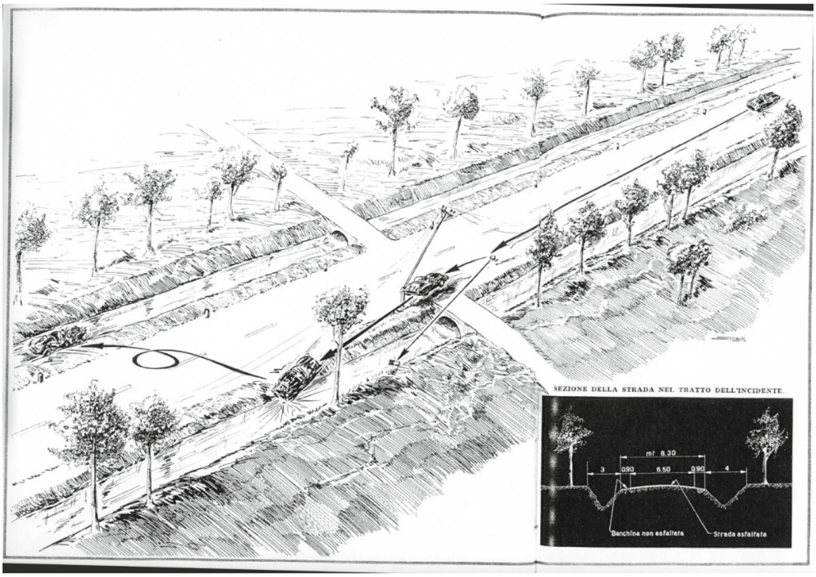

Fig. 1. The dynamics of the car crash as reconstructed by a car journal [2]

Fig. 2. Monument in memory of the people died in the accident in Gudizzolo (Mantua), Italy. (Photo taken on the 15th of May 2023)

2 Speluzzi-Madella-Rinaldi Report

The first committee was made up of Mario Speluzzi (1903–1959) – full professor of machine and project design at the Politecnico of Milan - Tarquinio Madella and Rinaldo Rinaldi. The prosecutor of the Republic of Mantua asked them to express their opinion on seven questions aimed at determining the dynamics and causes of the accident. The first question was the description of the location where the accident occurred. The second was the description of the traces left by the accident. The third was the description of the accident. The fourth was the description of the car in the current conditions. The fifth was whether or not the tragic event resulted from construction defects. The sixth was the reporting of other factors that may have determined, even if only in part, the accident. The seventh was the collection of any other technical information that they deem useful in the interests of justice. To contain the space of this paper, the results of questions three, five and seven are briefly reported.

Question three, the description of the accident. The committee considered that the final part of the Mille Miglia race, in particular the interval Cremona -Mantua-Brescia (about 165 km), contributed to assigning the Tazio Nuvolari speed award, that was established to remember the memory of Tazio Nuvolari (1892–1953), one of the most-influencing racing drivers who born in Mantua. As a consequence, the committee believed that all drivers had to run at the maximum speed allowed in order to win the trophy. Moreover, the accident occurred on a long straight and considering the ratios of the bevel gears and the probable speed of the motor (rpm), the experts suggested that the car must have been traveling at 270–280 km/h and regarding the blowout of the left front tire: "it is evident that this blowout must have been preceded by part of the tread detaching (usually called "dechappage") which is determined in a sudden and violent way".

Question five, whether or not the tragic event resulted from construction defects. With reference to the analysis of the burst tire, the experts note irregular wear of the tread with a greater height in the external area due to the type of tread used and an inflation pressure of the surviving wheels of 2.5 kg/cm^2. Considerations on the mechanics of the rolling of the wheel on the asphalt lead the experts to believe that the tires used can be considered safe up to a speed of 220 km/h only, well below the speed estimated at the time of the crash.

Question seven, collection of any other technical information that they deem useful in the interests of justice. In the days after the car crash, newspapers collected and published opinions from people involved and experts. Many of those interviewed suggested that the cause of the tire burst was a collision with an obstacle, for example a "cat's eye", i.e. a reflective sign placed on the road. With reference to the latter hypothesis, the members of the committee highlighted how the external and internal sides of the tire did not bear any signs and proving that no impact occurred against these obstacles. Figure 3 shows the "photo 24" from the report of the committee, showing the burst tire. The detachment of the tread and the diagonal tear that reaches the sidewalls of the tire are evident.

Fig. 3. Picture number 24 included in the committee's report: the burst tire

3 Francia's Report

The expert report was drawn up by Giovanni Francia (1911–1980), full professor of Machine and Project Design at the University of Genoa. The final report, through a theoretical and analytical analysis of the problem, contradicted the conclusions of the previous one point by point. Summarizing the most significant steps:

- Dechappage takes place on the driving wheels and in new tires. The detachment of the tread from the plies is a combination of the increase in temperature due to the hysteresis of the deformation of the rubber during rolling, and the consequences of the torque of the engine. The detachment is subsequently favoured by the centrifugal force acting on the tread and proportional to its mass. As a result, it is more likely to happen in a new tire rather than a worn one.
- The detachment of rubber at those speeds would have caused obvious marks on the sheet metal mudguard. Should be pointed out that the bodywork of the car was made of light sheet metal to contain the weights and, consequently, the impact with the rubber launched at high speed would certainly have left traces on the mudguard.
- Regarding low tire pressure, Francia notes how the measurement was made cold and how a working pressure of 2.7 kg/cm^2 should be estimated by applying the ideal gas law as a first approximation, in line with what was declared by the manufacturer. The higher pressure of the tire implied lower deformations during the rolling and an allowable speed of the car compatible with the cruising speed estimated by the previous committee.

The reports ends suggesting a plausible hypothesis of the crash cause. Figure 4 shows the draft included in the report, with the formula used by Francia to estimate the force in the impact of the tire against an obstacle. With reference to the standard size of a "cat's eye", and a running speed of 270 km/h of the car, Francia computed a force equal to 2172 kg weight (21.3 kN) exerted on the small contact area for 1.5 ms, which is sufficient to trigger the tearing of the canvases.

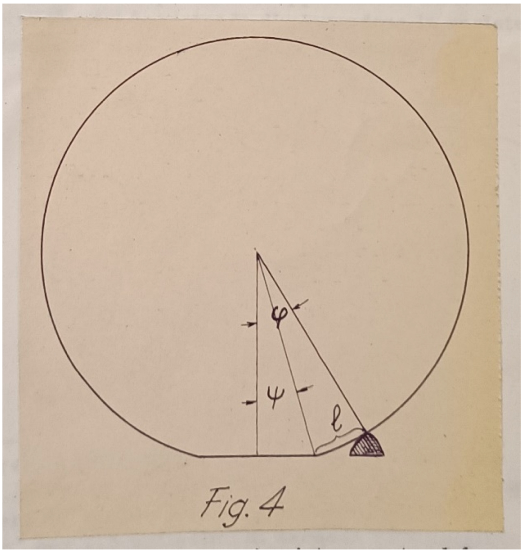

Fig. 4. Draft scheme of the tire hitting an obstacle, as reported in the Francia's work

4 Capocaccia-Casci-Funaioli Report

Both the first and second reports were made by well-known academics and some considerations supported by equations and models. Nevertheless, the conclusions were the opposite of each other. As a consequence, the judge requested a third technical report with the specific aim to solve any doubts on the correct interpretation of the dynamics of the car crash. The third committee was made up of Antonio Agostino Capocaccia (1901–1978) and Ettore Funaioli (1923–2006), full professors of mechanics applied to machines at the University of Genoa and the University of Bologna respectively, and by Corrado Casci (1917–1999), full professor of aircraft engines at the Politecnico of Milan. Starting from experimental evidence and scientific literature, the final report rigorously reconsidered the results of the first report.

The committee believed that the first estimate of the car's speed was calculated on the basis of the indication of the tachometer (7350 rpm) which stopped during the impact. They believed that the indication was erroneous and due to the fact that the car's engine, which rose during the accident, became "crowded" to an even higher value and then decreased in the contact with the ground until it stopped. The speed should therefore be calculated on the basis of the engine characteristic at full throttle obtained from the brake bench. The motor characteristic was requested to Ferrari and Fig. 5 shows the results obtained from experimental tests in Maranello at the Ferrari's facility. Some members of the commission participated personally in the tests [3]. The optimal working condition of the engine corresponds to the maxima of the curve, as a consequence, the commission estimated that a realistic rpm value to be considered was 6800 rpm and the consequent speed was 250 km/h. The estimation was confirmed by evaluating the average speeds in the Cremona-Brescia stretch of the other Ferrari drivers in the race (199.4 km/h for Gendebien and 197.2 km/h for Von Trips).

Regarding tire pressure, the committee recalled a publication by Lugli [8] which shows how beyond a certain critical speed, wavelets appear on the tire. In particular, in the part of the tire just downward of contact with the ground. The commission attached also some pictures taken from scientific literature to prove this phenomena, as reported in Fig. 6. The power absorbed by the tire is transformed into heat (due to the hysteresis of the rubber), and the power linearly increases with the car speed. Figure 7 shows an example of power/speed curves as included in the report of the commission. The elbow in the curve is the critical speed beyond which the power (and consequently the temperature of the tire) grows non-linearly. This critical speed is linked to the inflation pressure of the tire according to a quadratic law [8], meaning that higher the pressure of tire, higher the value of the critical speed. The committee agreed with Francia's report that the inflation pressure cannot be taken cold and considered the indication of 2.7 kg/cm^2 provided by Englebert's engineers plausible. The committee also observed that the tire has a certain thermal inertia [9] and that the estimate of the temperature reached should not be computed based on the maximum speed reached by the car, but more realistically on a value halfway between average and maximum speed.

Starting from the results of Hartley and Turner [10], the commission calculates the critical speed for the Englebert's tire using the formula:

$$v_c = \sqrt{\frac{a\,p\,g}{\gamma\, b(\tan\alpha)^2}} \tag{1}$$

Where v_c is the critical speed, a is the average curvature radius of the tire section (with respect to a plane passing through the axle), p is the pressure of the tire, g is the gravity acceleration, γ is the average specific weight of the tire, b is the average overall thickness of carcass and tread and α is the angle formed by the threads of the plies with the average plane of the tire. The calculus for the Englebert's tire returns a critical speed of 275–285 km/h, that was much higher than that of De Portago's car.

The report moves on to the analysis of the alleged dechappage, stating that:

- The dechappage occurs almost exclusively on the driving wheels, for the reasons detailed also in the Francia's report.
- The breakage occurs on the side of the tire. Once the dechappage occurs, there is an initial separation of the tread from the carcass but within the tire (i.e. there is no external sign). Due to the centrifugal force acting on the mass of the rubber material, the detachment of the tread increases until the only resistant part are the sides of the tire. So far, a breakage occurs on the side with the ejection of a big part of the tread (i.d. the dechappage).
- The separation zone is generally large and rapidly progressive.
- It usually occurs in new tires.

The final part of the report analyses other technical characteristics of the Englebert's tires, like the angle of inclination of the tire plies (the α in Eq. 1) or the connection between tires and tread. The commission considered the construction features of the tires correct and suitable for the sporting use. The authors finally reaches two conclusions: "the explosion was due to a collision with an unspecified obstacle" and "the tires were suitable for the type of car and the type of racing in which they were used and were inflated to a pressure believed to be adequate".

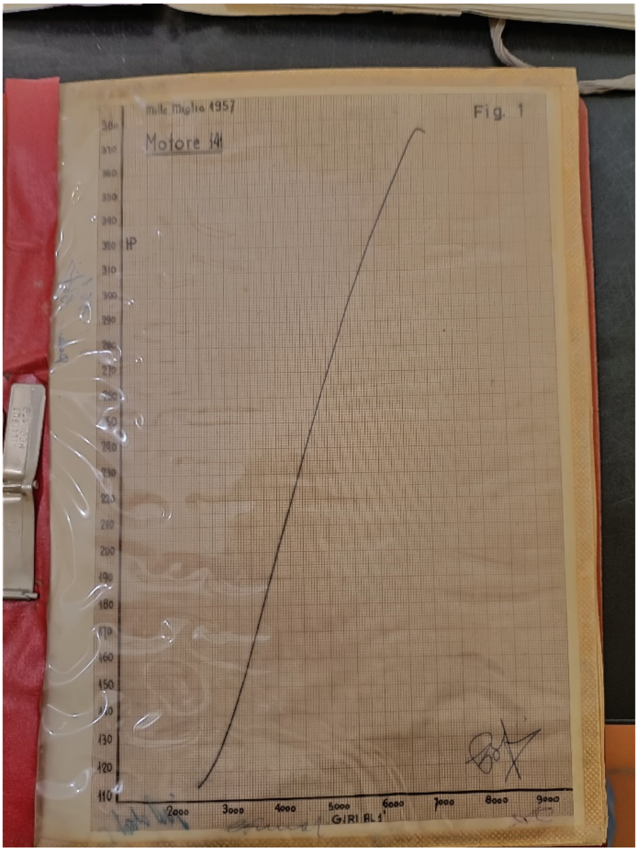

Fig. 5. Horse Power/rpm characteristic curve for the Ferrari's engine included in the report of the Capocaccia-Casci- Funaioli commission.

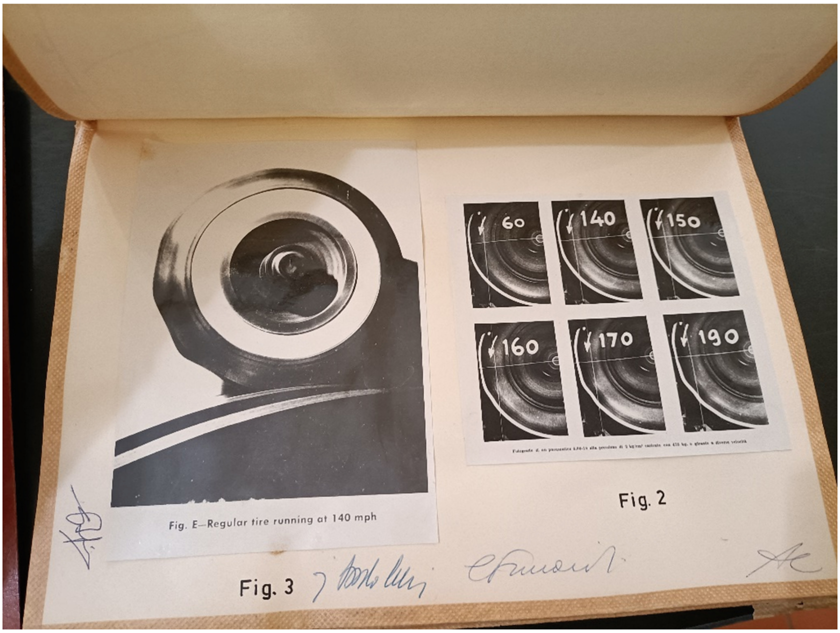

Fig. 6. These pictures are taken from the paper of Lugli [8] that the commission included to show the waves that arise in the tire following contact at different speeds.

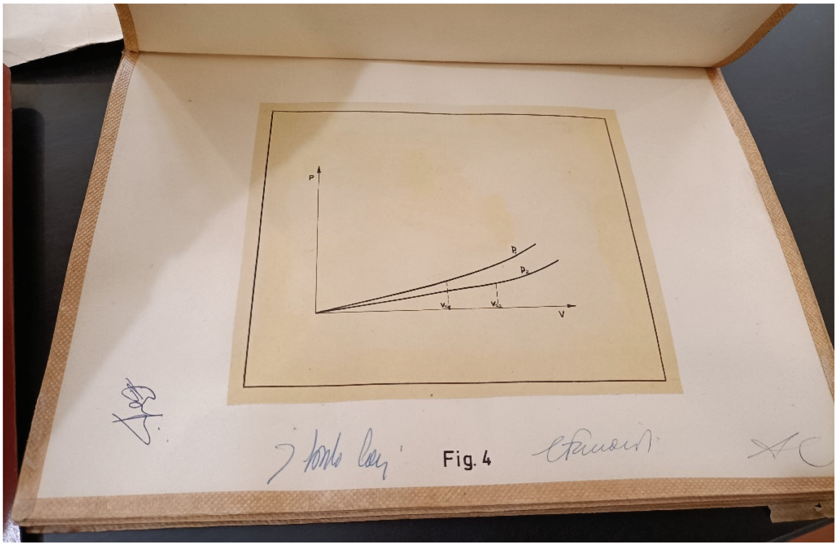

Fig. 7. Relation between the power dissipated by the tire and the speed of the car. Increasing the inflation pressure, the curve move towards the x-axis and the critical speed increases.

5 Conclusions

The report of the Capocaccia-Casci-Funaioli committee was deposited on 29 April 1961. Two months later, on 29 June, the public prosecutor formally asked the investigating judge not to proceed against Enzo Ferrari, who was acquitted of all charges. The differences between the three technical reports presented are evident and emblematic: in the first report the aim is to reconstruct the facts starting from objective data but lacking a critical and objective elaboration. It will be highlighted from many quarters how often, in the first report, the truthfulness of an assumption is assumed to be known without verifying the sources. The consequence is a description which, although correct in subsequent deductions, distorts reality starting from incorrect hypotheses. The second report is purely theoretical and formally impeccable. Once defined in its initial conditions, the problem is developed through reasoning and equations, but what is missing is perhaps a comparison with the experimental data. The third report is rigorous and in perfect balance: the theoretical part is developed starting from international scientific literature, but there is continuous experimental evidence both on the test bench and relating to measurements carried out in the field. An "engineering" approach that led to the correct determination of the events that occurred and, ultimately, to preventing a man from being unjustly convicted.

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