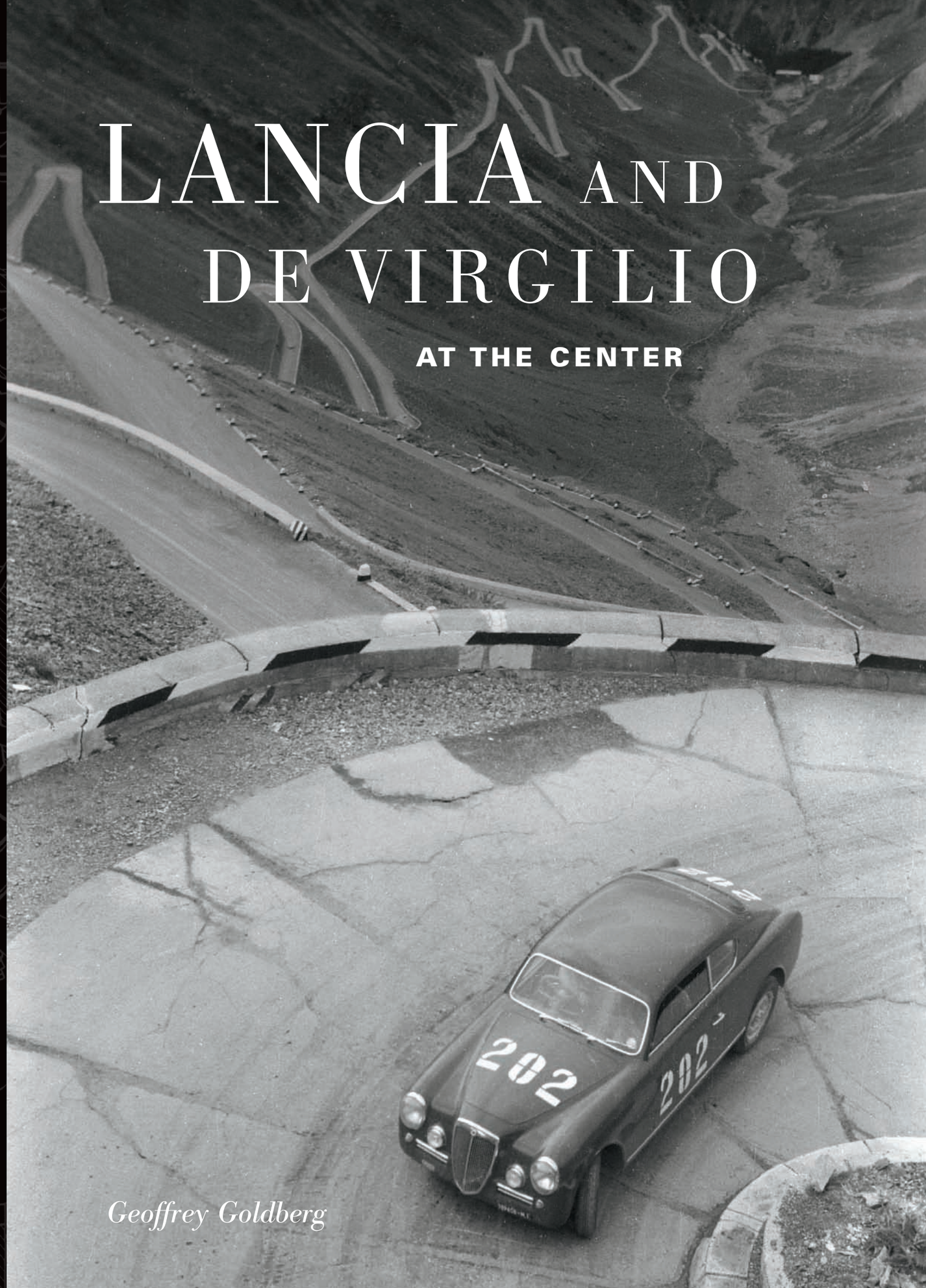
LANCIA AND DE VIRGILIO

AT THE CENTER



Geoffrey Goldberg

CONTENTS

De Virgilio, 1939, in Turin, about to embark on his career. (De Virgilio Archive)

Foreword

My first sighting of the papers of Francesco De Virgilio was late one afternoon at the family apartment in Turin. De Virgilio's son, Luigi, pulled out binder after binder, opening each in the soft light, unveiling notes and drawings from his father's many years of work at Lancia. These documents and records were part of the inner workings at Lancia, unpublished information rarely seen. The paper was aged, but the story—rich and full of details and thoughts—was fresh, vivid, and read as if it could have been written yesterday.

Lancia & Co. was an independently minded automotive manufacturer deeply committed to high levels of engineering innovation and quality. Their stunning postwar car, the Aurelia, was one of the most advanced cars of its time and became an icon of 1950s automobiles, a high point of Italy's postwar design renaissance. Among its many features, it had a unique and historically significant motor, designed by Francesco De Virgilio, a lead engineer at the company. With a 36-year career there, De Virgilio was central to many of Lancia's groundbreaking products, so his documents tell the story from inside. While largely known for designing the first workable V6 engine, De Virgilio's achievements extended into other areas of automotive design, including suspension design, prototypes, truck engines, and competition.

His solution for the V6 was not just one of organizing its design but required a fundamental engineering contribution in balancing theory to what had previously been considered an insolvable problem. His solution was a rare combination of analysis and practicality, and the world is still using it.

This book also explores De Virgilio's personal story, that of a young man from southern Italy who went north for his graduate education, joined a major company, and married into a prominent industrial family. De Virgilio lived in both the professional and the familial world of Lancia.

The issue of his contribution remains of interest as we seek to understand the place of inventiveness in industrial design. That he contributed in many different ways over his long career is without question. De Virgilio's evolution and his adaptability over his life with Lancia suggest how creative individuals can change and adjust, remaining active and fruitful in both good and bad circumstances.

The broad view of this history entails the rich context of postwar Italy and the rise of Italian design and engineering. This includes the special Italian application of an individual's creative energies to larger-scale work, and De Virgilio was one who combined older, more basic, and empirical ways of manufacturing with newer analytical tools and methods. Classically, these threads continue today, as they resurface in different contexts and in different ways. Yet the issue remains: What is the role of innovation; how does one balance theory and making? Where do ideas come from, and how are they implemented? And finally, how much creativity comes from the individual's personal story?

Beginnings

On the morning of August 2, 1947, two people were married in a Torinese church. The bride was Rita Lancia, a member of the Lancia family, important makers of cars. The church was filled with many friends and her proud industrial family.

The groom was Francesco De Virgilio, a 35-year-old engineer who had joined the family company eight years before. From the south of Italy, this bright young man was helping to lead the company forward. Their marriage was to become a bond of loyalty—to one another, to both of their families, and to the company.

OPPOSITE
Francesco and Rita at the altar on their wedding day. (De Virgilio Archive)

LEFT TO RIGHT
Rita at age 20 with her mother, Teresa (on the left), in Fobello in 1936. (De Virgilio Archive)

Rita outside her new home in Via Grassi in Turin in 1947, the year she married. (Francesco De Virgilio)

Giovanni married Teresa Albertetti (also from Fobello) in 1908, and they had eight children: Valerio, Claudio, Massimo, Ennio, Anna Maria (called Rita), Terenzio, Fausto, and Teresina. Of the six boys, only Valerio was to marry.

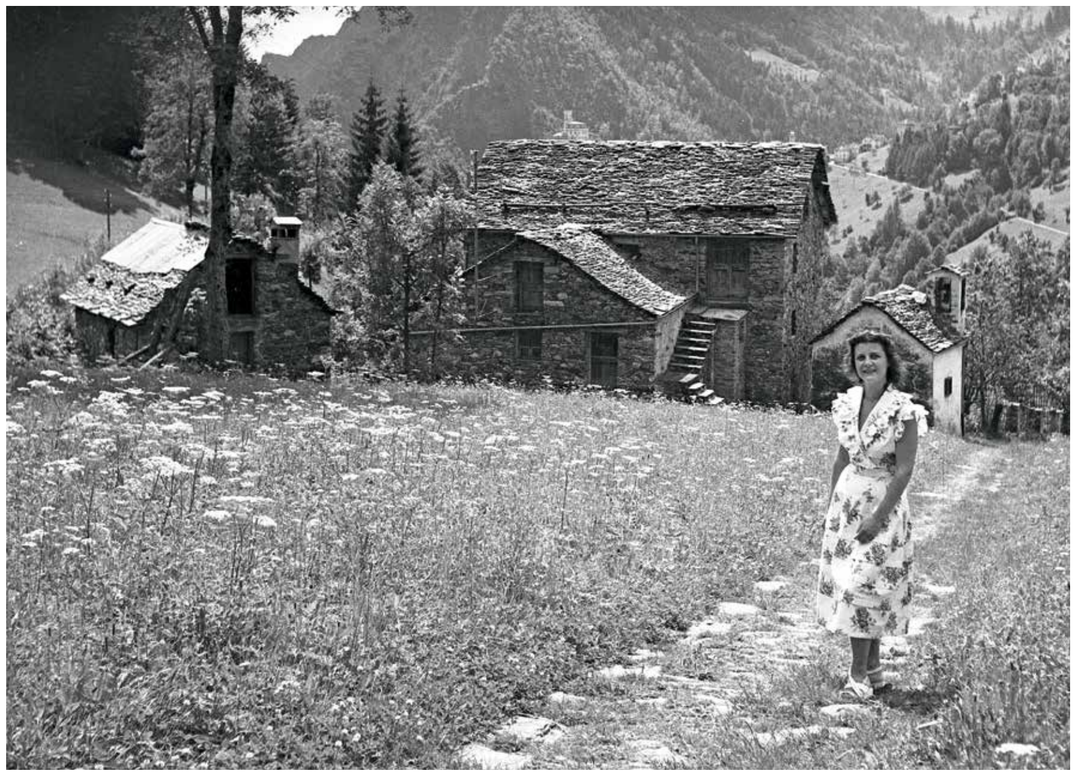
Rita Lancia (1916–1964) was the eldest of Giovanni and Teresa's two daughters. Born in Fobello, she spent her youth and early school years there. At age 12, Rita continued her education at an all-girls school in Turin. Surrounded by her six lively brothers, she was a more reflective and thoughtful family member. Genuinely unpretentious, she had inherited her father's soft-spoken disposition. Studious and well versed in English, French, and German, she had an ability to reach out to others, looking at things from their different points of view. She was well respected for her common sense and was close with Teresina, her younger sibling by nine years.

As a young adult, Rita lived in Turin, returning to Fobello frequently to be with her family; she spent holidays there hiking and enjoying the countryside. Fobello provided a contrast to the bustling life of the industrial city of Turin; both were to remain central for Rita and her family throughout her life.

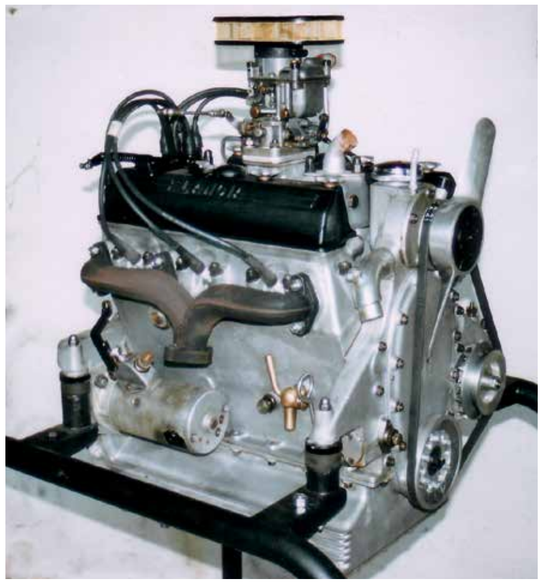
Uncle Vincenzo and his family

Rita's uncle, Vincenzo Lancia (1881–1937), was a much more lively man than his soft-spoken brother Giovanni. He had an interest in manufacturing, was restless in school, and started work at a young age for Giovanni Ceirano, an early bicycle maker whose premises were located in the courtyard of Vincenzo's father's house in Turin. The Ceirano company grew to become the foundation of a new automotive company, FIAT, for whom Vincenzo Lancia had a prominent early career as a race driver. Competing in Europe and even America, he was at one time the fastest driver in the world, racing FIAT's highly successful competition cars.

In 1906, Vincenzo started his own automotive business, Lancia & Co., as a manufacturer of fine automobiles and trucks. He was helped by a



Rita in Fobello, in 1948. (Francesco De Virgilio)



TOP
The 538 motor was De Virgilio's first running V6. Two were made, including this one from 1946, recently restored. (Lancia Family Archive)

RIGHT
End view of De Virgilio's crankshaft design, with its six separate crankpins. (Centro Storico Fiat)

since the end of World War I. He had management experience, having represented the family when setting up a large manufacturing and assembly plant for Lancia outside Paris, where, starting in 1931, Augustas (called Belnas in France) and then Aprilias (called Ardennes) were made for the French market. In March 1941, Arturo joined Manlio Gracco de Lay and Pompeo Vaccarossi in a senior management group, electing Adele Lancia as president.[29]

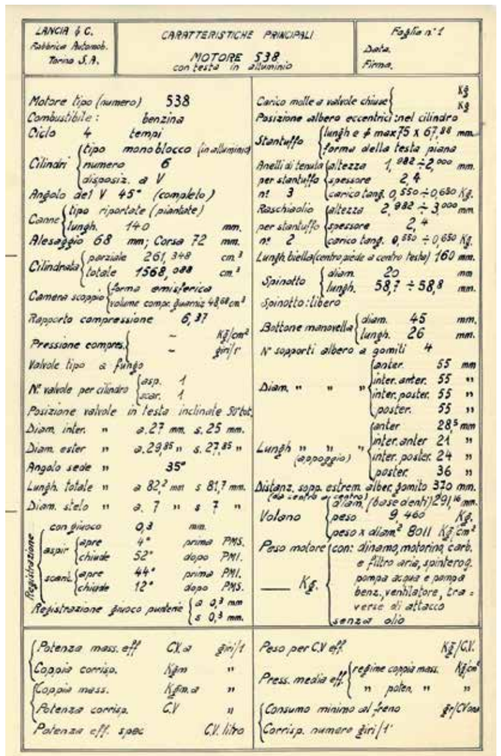
De Virgilio recalled that upon his return to Turin in the fall of 1943, the existing directors (the heads of departments within the company) were let go with six months' notice; even Falchetto—who had been there for more than 20 years and had been instrumental in the Lambda success—took a leave of absence, resigning on September 30, 1943, only to return to Lancia 10 years later. Part of the plan to reorganize the company was the goal to provide a single point of responsibility for developing new cars. As a result, Jano was put in charge of all engineering as the new technical director, a position of distinct authority.[30]

A year later, at the end of 1944, Zorzoli was replaced by Aldo Panigadi as head of administration. In May 1945, Manlio Gracco de Lay was replaced by Arturo Lancia, now general director in charge of the company. The family was reasserting control, as it had during Vincenzo's time.[31]

Gianni's role at the factory was only just emerging, as he was still in his early 20s during the mid-1940s. He was attending school at the University of Pisa while also working at the factory. But even at this young age, he began to show signs of leadership more fitting to someone of greater experience. Along with his father's zeal, he also had an intuitive understanding of the marketplace and was an enthusiastic and active participant in managing the details and particulars of the company's products. He had the benefit of Arturo Lancia, a family member familiar with production, leading the company.

Gianni also enjoyed the technical guidance of Jano, the main engineer of the company, and both of them worked closely with the more junior De Virgilio. Together, these three men would be pivotal in preparing the designs needed to move the company forward. Their formal relationship was well defined: Gianni was the young and emerging head of the company; Jano was the very experienced head of engineering; and De Virgilio was the project engineer, the man in the trenches, working out new ideas under Jano's supervision.

Informally, there was another order: Gianni was the inspiration, his energy driving the search for new projects; Jano provided expertise to keep the new work focused and assure it was well integrated; and De Virgilio, the young graduate engineer, brought theoretical basis to the work, as well as hands-on development to make sure the new ideas would work. The group built off each other's strengths and canceled out each other's weaknesses. Of course, others from within the company were brought in as needed, but these three were the central force in developing the new projects.


LANCIA & C.
Fabbrica Automob.
Torino S.A.

CARATTERISTICHE PRINCIPALI
MOTORE 538
con testa in alluminio

Foglio n° 1
Data.
Firma.

Motore tipo (numero) 538
Combustibile: benzina
Ciclo 4 tempi
Cilindri (tipo monoblocco (in alluminio)
numero 6
disposiz. a V
Angolo del V 45° (comaleo)
Canne (tipo riportate (piantate)
lungh. 140 mm.
Alesaggio 68 mm; Corsa 72 mm.
Cilindrata (parziale 261,348 cm³
totale 1568,088 cm³
Camera scoppio (forma emisferica
volume compr. (unitario 43,88 cm³
Rapporto compressione 6,37
Pressione compress. (– Kg/cm²
(– gm/r
Valvole tipo a fungo
N° valvole per cilindro (asp. 1
scar. 1
Posizione valvole in testa inclinate 30°+30°
Diam. inter. " ø 27 mm. s. 25 mm.
Diam. ester. " ø 29,85 " s. 27,85 "
Angolo sede " 35°
Lungh. totale " a 82,2 mm s 81,7 mm.
Diam. stelo " ø. 7 " s 7 "
Registrazione con giuoco 0,3 mm.
aspir (apre 4° prima PMS.
chiude 52° dopo PMI.
scarich (apre 44° prima PMI.
chiude 12° dopo PMS.
Registrazione giuoco posteriore (a 0,3 mm
s 0,3 mm.

Carico molle a valvole chiuse (Kg
Kg
Posizione albero eccentrici nel cilindro
Stantuffo (lungh. e ø max 75 x 67,88 mm.
forma della testa piana
Anelli di tenuta (altezza 1,982 ÷ 2,000 mm.
per stantuffo (spessore 2,4
nº 3 (carico tang. 0,550 ÷ 0,650 Kg.
Raschiaolio (altezza 2,982 ÷ 3,000 mm.
per stantuffo (spessore 2,4
nº 2 (carico tang. 0,550 ÷ 0,650 Kg.
Lungh. biella (centro piede a centro testa) 160 mm.
Spinotto (diam. 20 mm
lungh. 58,7 ÷ 58,8 mm.
Spinotto: libero
Bottone manovella (diam. 45 mm.
lungh. 26 mm.
N° supporti albero a gomiti 4
Diam. " " " (poster. 55 mm
inter. anter. 55 "
inter. poster. 55 "
poster. 55 "
Lungh. " " (appoggio) " (anter 28,5 mm
inter. anter 21 "
inter. poster. 24 "
poster. 36 "
Distanz. sopp. estrem. albero gomito 370 mm.
Volano (diam. (base dentif) 291,16 mm.
peso 9,460 Kg.
peso x diam² 8011 Kg/cm²
Peso motore (con: dinamo, motorino, carb. e filtro aria, spinterog. pompa acqua e pompa benz, ventilatore, tra - verso di attacco
—— Kg. senza olio

(Potenza mass. eff. CV a giri/1'
Coppia corrisp. Kgm "
Coppia mass. Kgm a "
Potenza corrisp. CV "
Potenza eff. spec. CV. litro

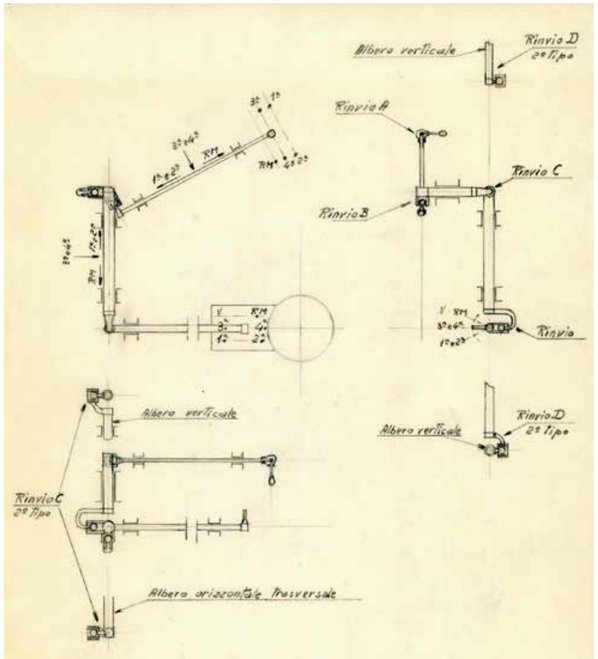
Peso per CV eff. Kg/CV.
Press. media eff. (regime coppia mass. Kg/cm²
" " potenza " "
Consumo minimo al freno gr/CVora
Corrisp. numero giri/1'

The factory data sheet for the prototype 538 engine, c. 1945. Such documents were essential for internal coordination but are rarely seen today. (De Virgilio Archive)

538

They decided to let me draw a six-cylinder engine for the Aprilia. There was no room for the 60-degree in the Aprilia engine bay. I created an engine that was quite acceptable from the standpoint of the balancing process. The displacement was only 1569cc. On normal petrol the engine gave little power. We built two of these engines to be mounted on the Aprilia (I remember it was colored dark red [amaranto in Italian]) and then alternated them between testing room and car. This Aprilia was used a lot by Gianni Lancia, then a student in engineering at Pisa. On one trip home he said the car caused much interest. His fellow students, passionate about cars, could not explain the twin exhausts, and got down to look underneath to see what was new. This experiment was then ended, because it was a mistake to fit the Aprilia, a car that had a great success, with a new engine, a V6, when the Lancia tradition was the narrow V4.

—De Virgilio, the AISA Conference



This sketch by De Virgilio in March 1947 outlined the gearshift linkage for the 50-degree car with its rear-mounted transmission. (De Virgilio Archive)

Normal with rear gearbox, rear clutch, but ugly body. Ugly one. Thank God, then, we got to the B10, a car made there by our designers, Lancia designers.

—Francesco De Virgilio on the 50-degree car

In fact, 10 to 12 days later, Gianni telephoned me again about 10 a.m., saying, "Franco, come up. Professor Capetti is here. You were right!" I went into the living room, and they were all smiling, especially Gianni Lancia, because after the first visit by Capetti he had lost hope that the engine would work for the new Lancia cars. After it was confirmed in the second visit that all was well, it was the happiest moment of all.

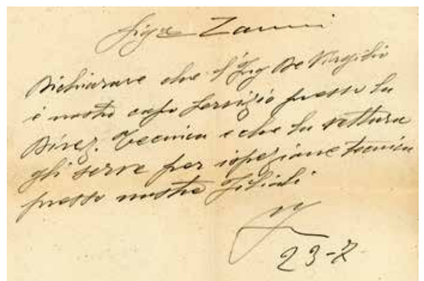
—De Virgilio, the AISA Conference

A new car—the 50-degree motor

There was, however, yet one more intermediate step before Lancia fully embraced the 60-degree motor. In October 1946, De Virgilio prepared a design for a 50-degree V6 engine, initially called the *538 2nd Tipo*, which he later renamed *B10 1st Tipo*, the earliest found use of the B10 name. The "B" prefix fit within Jano's new classification system in the company, with A for the largest, B for midsize, and C to be used for a future, smaller car.

The engine displacement for the new B car was identical to that of the earlier 538 at 1569cc, but some details, like valve angles and cylinder spacing, were slightly altered. Valve springs were calculated in December 1946, a balancing study prepared in 1947, and the engine was likely running that year.

The importance of the 50-degree motor was its use in a new prototype, described by De Virgilio as having a front-mounted engine with a rear transaxle, the first example of this solution, which was the basis of the Aurelia that followed. While no photos have been seen of the motor or car, in the Archive is a 1947 study for a gearshift linkage for a rear-mounted transmission, likely for this vehicle. De Virgilio recalled in the AISA Conference that a car fitted with this engine was running as late as the summer of 1948. But the prototype, which he noted as designed by Pinin Farina, was quite heavy with its special bodywork, and was not a production car that had to be slender, light, and with harmonious lines. He recalled that Jano and Gianni then struggled to improve the chassis and lighten the car, but to little avail. De Virgilio later described the car as most unpleasing, with an ugly body.[37]



ABOVE
De Virgilio, Gianni, and Jano standing by an Aprilia Bilux, Lancia's large-bodied model, near Stresa. With luggage loaded in the back, they were likely on their way to the Geneva car show, in March 1948. (De Virgilio Archive)

LEFT
A rare document in Jano's own hand, this note is to Sig. Zanini at Lancia on July 23, 1947, to allow De Virgilio the use of a factory car during his 1947 honeymoon, as "Ing. De Virgilio is member of Technical Office, and that the car is needed to make a technical inspection of our filiali." *In the end, they took the Ardea belonging to Rita's family. (De Virgilio Archive)*

Aurelia

The presentation was in April 1950. The car was presented on real grass, something requested by Signora Lancia. A beautiful, carefully cut lawn of real grass, laid in the Palazzo Esposizioni on the Corso Massimo d'Azeglio. The Salone dell'Automobile was wonderful; it was a salon with stands from Lancia, Alfa Romeo, Mercedes, Fiat, and every Italian carmaker.

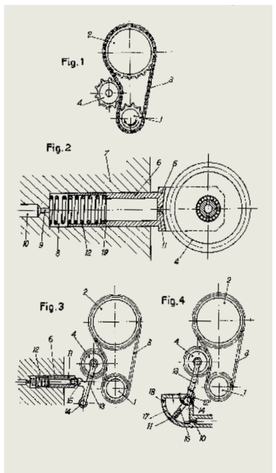
—De Virgilio, the Interview

Presentation

The Aurelia was first seen by the press and key dealers on April 15, 1950, at a private showing in a garden behind Lancia's downtown business villa at 83 Corso Vittorio Emanuele II.[1] The general public saw the car a few weeks later, when it was featured at the 32nd *Salone dell'Automobile*, held at Turin's Palazzo Esposizioni from May 4 to 14. There the new car was placed high on a unique grass-covered rotating platform; also featured were cutaway mechanical assemblies, as if mounted in the car with the body removed for visibility, to allow close inspection of all the new technical solutions. Along with the berlina were two cabriolets on the new Aurelia chassis, one a traditional,

OPPOSITE
The new B10, strikingly presented at the Turin show in 1950 in a grass field on a revolving stand. (Rodolfo Mailander, The Revs Institute)

ABOVE
Aurelia motor for the s.2 B20 of 1952, identifiable by notches in the valve covers for the spark plugs and two Weber single-choke carburetors. (Centro Storico Fiat)



RIGHT
Patent drawings for the hydraulic timing chain tensioner, from 1948. Fig. 2 shows hydraulic action on the the tensioning sprocket (4). Figs. 3 and 4 show alternate solutions not used. (Patent file No. CH 279415)

be fore and aft, to respond to lateral loads, the other at right angles to respond to acceleration and braking forces. Of course, this would result in an included angle of 90 degrees, and be unworkable (nothing could pivot), so the more conventional answer would be to put the bushings on the pivoting axis of the semi-trailing arm.

Lancia took an ingenious middle path, partially rotating the bushings and achieving two goals with this one solution: The inner bush was rotated 20 degrees toward the center of the car, while the outer bush was adjusted 10 degrees toward the outside, combining to be 30 degrees to one another. This was a solution only possible with the use of rubber bushings. The unorthodox answer was closer to a response to the differing loads (side loading from the suspension and front/back loading from acceleration or braking), and also solved a practical problem of the time: If the bushes were located conventionally in-line along the pivoting axis, bushing wear would result in sloppy movement of the suspension and affect wheel location. Pivoting the bushings off-axis addressed this and held the suspension in proper alignment independent of wear. The solution was counterintuitive but effective. It was, however, most unusual, and gave the critics of the period much to consider.[10]

The significant breakthrough of the rear suspension design was recognized by the leading press at the time. Manufacturers were studying the use of IRS, and Lancia was seen as a leader in the field. The semi-trailing arm was understandable, but Lancia's clever use of offset bushings remained difficult to assess. It only took someone driving the car to realize how well it worked:

> *There were those, observing the very individual suspension of the rear wheels, who were more than skeptical of its capabilities, but only a short run was enough to convince most of the doubters that here was a car with exceptional qualities.*
>
> —Robert Neil, editor, *Auto Course* (1954)[11]

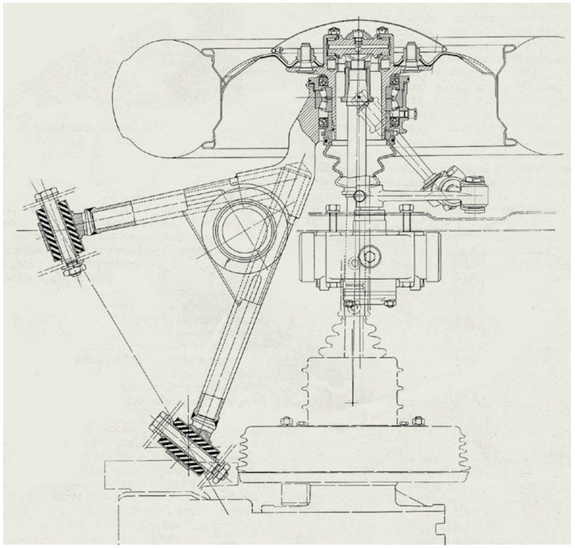
How did Lancia get to their breakthrough design for the rear suspension? The stage was set by De Virgilio's extensive work on trailing arms and coil-spring locations from 1942 to 1946. He prepared several designs for rear suspensions, including one with extensive exploration of alternate coil-spring locations when used with trailing arms (not semi-trailing) in March 1944. Another contribution can be seen in his 1944 proposal for independent suspension with coil springs, submitted for patenting in 1945. In the patent, it is noted as being applicable to either front or rear wheels.[12]

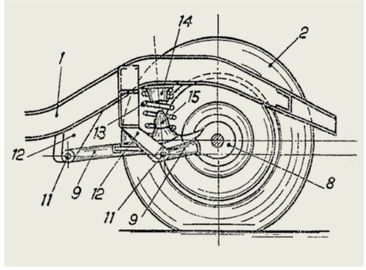
On the design used on the Aurelia, Wim Oude Weernink wrote that De Virgilio told him that he had made a model of the suspension and shown it to Jano for his approval. In 1990, De Virgilio himself wrote: "Finally, I wish to recall that the rear suspension of oscillating independent triangles on the Aurelia was my own creation, subsequently developed in detail by the suspension design group." However, no information on the semi-trailing link used on the Aurelia was found in the Archive, and thus assigning full credit is problematic. As the suspension was developed under Jano's leadership, surely credit is due to him as well.[13]

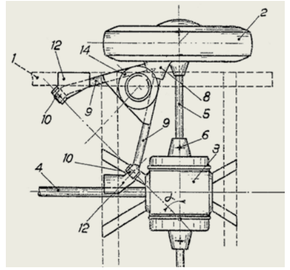
Interestingly, Lancia used its swinging-arm design and its offset bushings on another vehicle, for the front suspension of their Beta truck in this same period. Combined with a large transverse leaf spring, it gave the truck a robust independent front suspension.[14]

Chassis

The Aurelia's efficient use of interior space benefited from Lancia's long history of innovative chassis design. The company had started work on unit bodies with its seminal patent in 1919, and production of the open Lambda car in the early 1920s, with further improvements being made in the Augusta berlina of 1932. The Aurelia structure clearly fits within this tradition, and its sophisticated floor pan was a development of the rigid structure designed and patented for the Aprilia in 1936. The chassis utilized many subtle solutions, such as a small upturned rear section of the floor pan that stiffened the structure.

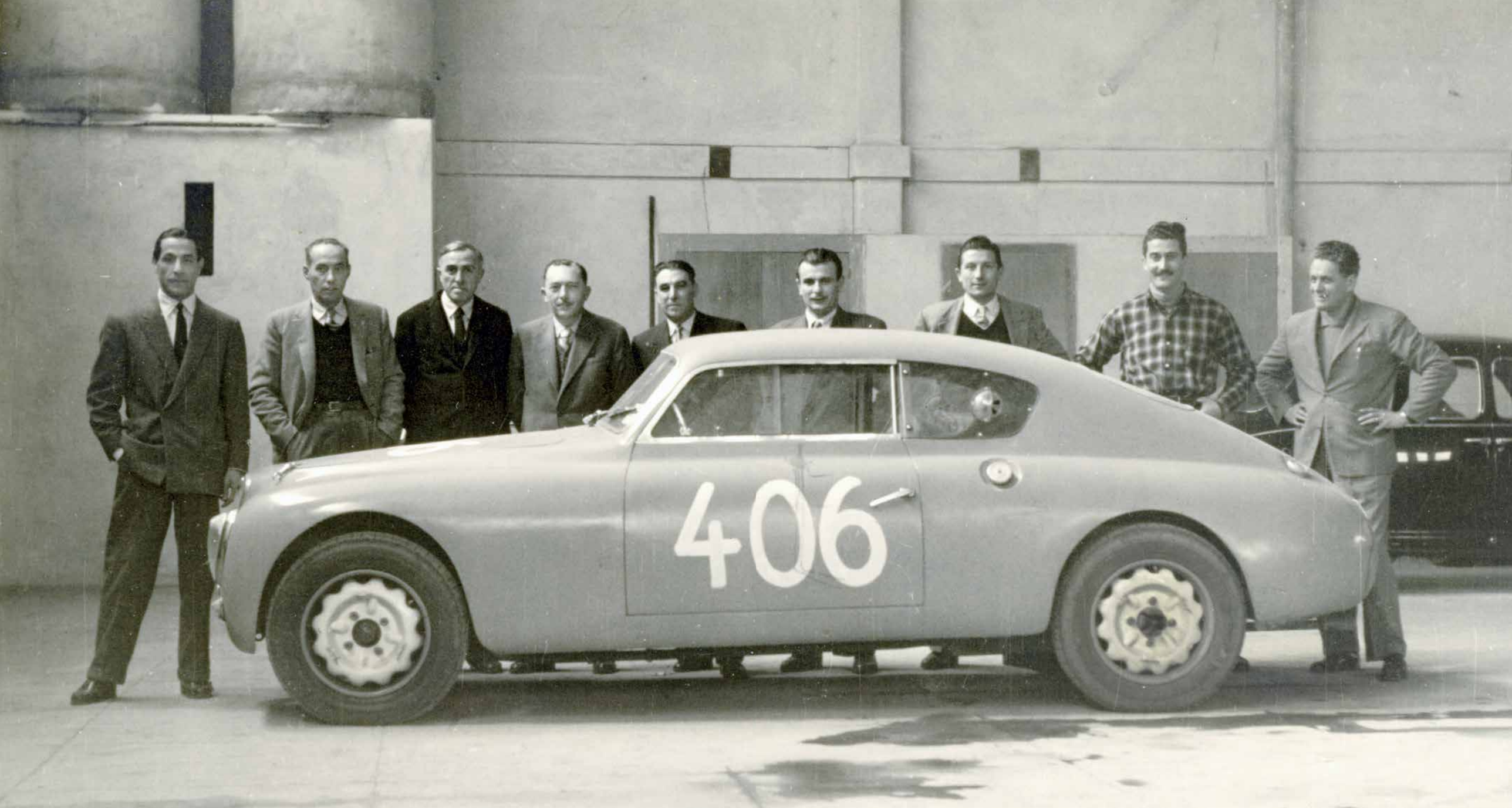






TOP
The independent rear suspension of the Aurelia (for the right rear wheel). On the left of the drawing are the offset bushings for the semi-trailing arm; at the top of the drawing can be seen the outside universal joint located as far as possible from the inner pivot point, so as to reduce wear. (Automobile Engineer, *1951*)

ABOVE LEFT AND RIGHT
Lancia's 1947 patent drawings for the rear suspension show the semi-trailing arm (Nos. 9 and 14) but without offset bushings. The height of the pivot point (No. 11) was identified as an influence on the ride characteristics of the suspension, a subtle point not generally known at the time, now more widely appreciated. (Patent file No. IT 454511)


406

LEFT TOP TO BOTTOM
De Virgilio, Faleo, and Zaccone at Monaco on May 21, 1955. (De Virgilio Archive)

Jano talking with Giuseppe Navone, while testing the D50 in 1954 at Ospedaletti. (Rodolfo Mailander, The Revs Institute)

ABOVE
Gianni Lancia, active in a workshop at Le Mans in 1953. (Corrado Millanta, © Archivio Millanta)

Supporting the Lancia team was Gianni Lancia himself, who was of some help with his training as an engineer. One recalls seeing him doing some tricky welding during the final preparations.

—*Auto Course*, 1953 Le Mans coverage [28]

TOP TO BOTTOM
Ascari in his D50 at the Monaco Grand Prix, with the Lancia team mechanics; De Virgilio is on the left, Villoresi in a white helmet in the background. (Bernard Cahier Archive)

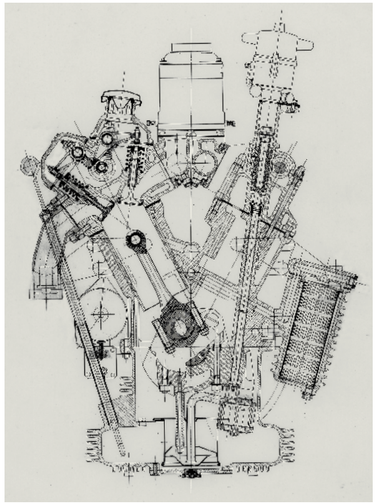
Gianni talking closely with his racing team drivers at Ospedaletti, February 8, 1954. (Caffarena Spallarossa Bevegni Archive)

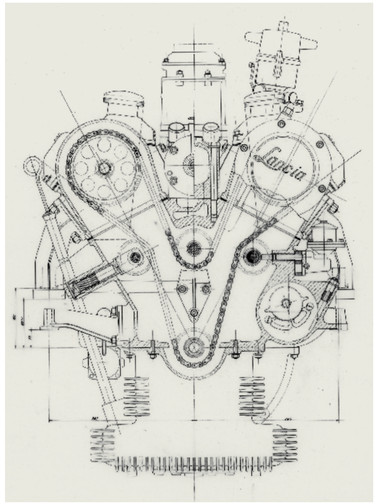
TOP LEFT
B20S engine, with two rocker shafts in the head above the overhead camshaft on left, and angled distributor shaft on right. (De Virgilio Archive)

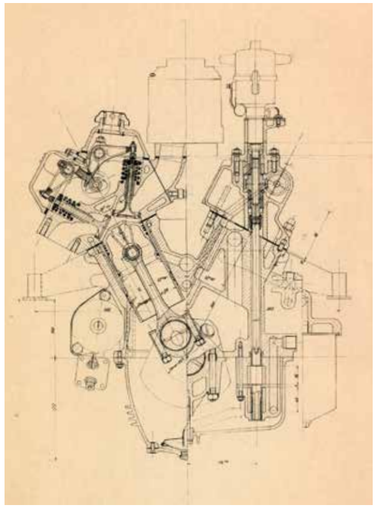
TOP RIGHT
Timing chain design for B20S engine, with hydraulic tensioner on left and eccentric drive sprocket for the fuel pump on right. (De Virgilio Archive)

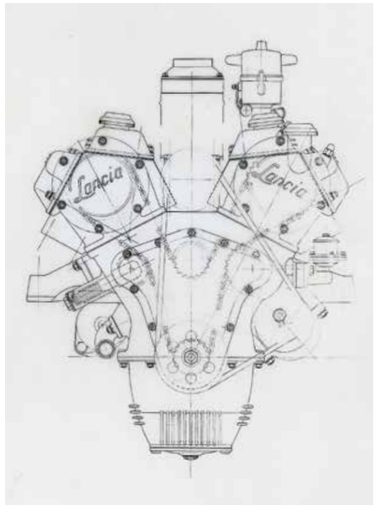
BOTTOM LEFT
B54 engine section, with overhead cam, rocker arms, dry sump, and vertical distributor shaft. (De Virgilio Archive)

BOTTOM RIGHT
B54 front elevation, with timing chain routing and mounting points for ancillaries. (De Virgilio Archive)









and asymmetrically located (34 degrees for the intake, 26 degrees for the exhaust). Crankshaft journals were the same as those on the new GT 2500 motor.

The first sketches in the Archive for the B20S engine date from May 1953, but most work dated from August 1953, when De Virgilio prepared engine layout drawings. He continued ongoing detailed development into October, when he drew up a manifold for three carburetors. Three prototypes were assembled by November; the first engine was run that month, with testing in December. With only one carburetor, the initial power was a disappointing 119hp at 6,000 rpm. Revisions ensued, modifying intake passages and changing to three carburetors. By January 1954, the engine yielded a healthier 151hp at 5,800 rpm. In April, larger venturis (28 vs. 26mm) were tried, but no more power was found.

The next reports of this motor are from February 1955, when a B20S motor was compared with a stock GT 2500 B20 s.3 motor. Both were tested with single carburetors, and the results were modest. The B20S achieved 127hp at 5,600 rpm vs. 118hp from the stock motor at 5,800 rpm.[23]

The exact application for this motor remains unknown, designed with both single- and triple-carburetor setups. Testing with one carburetor suggests that the motor was being considered for a production car. But such tests would not show the B20S in its best light, as it would only provide its greater power at higher rpm and with more carburetion. Its motor mounts were spaced identically to the Aurelia, allowing for a possible "drop-in" fitting.[24]

Perhaps a human factor affected development of the B20S motor: With the attention on the D series motors, Gianni's interest was now focused on the racing cars, with Jano and Zaccone's engines. Yet De Virgilio still had his good friends: In the fall of 1953, Felice Bonetto, one of Lancia's leading race-car drivers, was excited about these new motors.

Before leaving for the Carrera Panamericana, Bonetto told De Virgilio, "I recommended to Ing. Lancia to fit your new B20S engine on a car, so I can test it when I get back." Bonetto's unfortunate death in the Carerra ended those plans.[25]

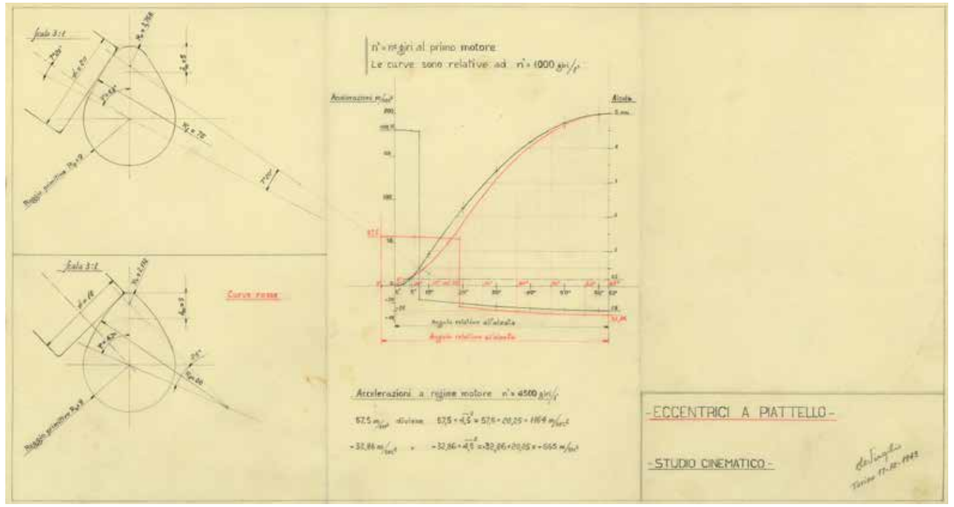
B54

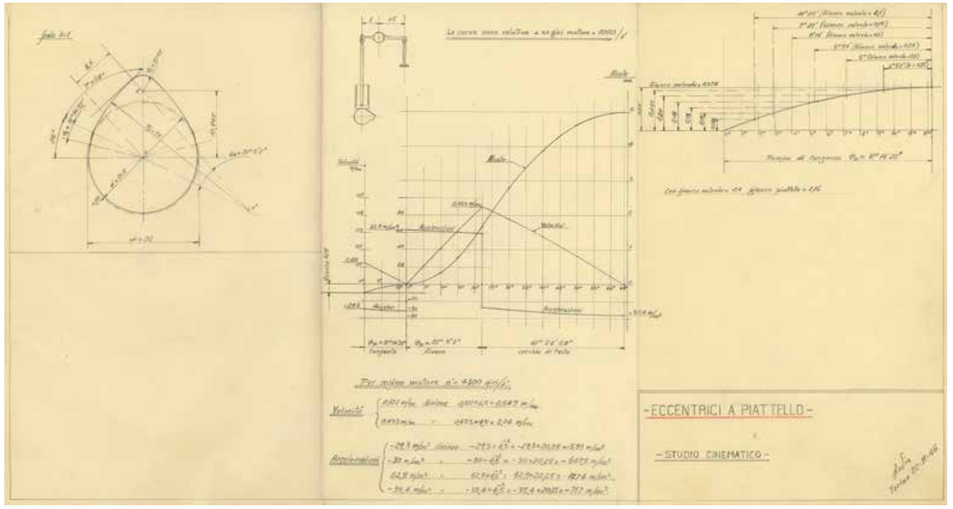
> *The engine block was in magnesium, as Gianni wanted, who followed me in this work: "Let us design an engine more suited to the Mille Miglia. Engine sump, in magnesium, dry sump with two oil pumps, one for supply, one for recovery." This engine was intended for a coupe we called the B54, because it would probably come out in '54.*
>
> —De Virgilio, the AISA Conference

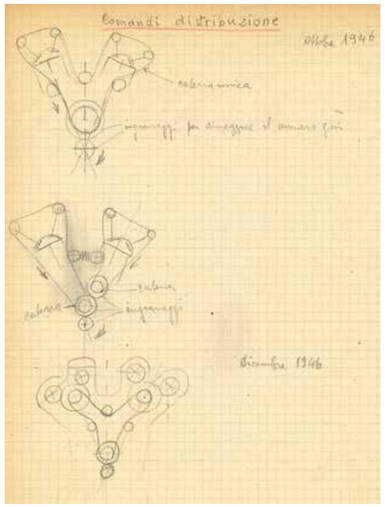
The B54 had overhead cams and rockers similar to the B20S, but its larger valves (now 46mm intakes and 40.5 exhausts) were now symmetrically located. The earliest Archive documentation for the B54 dates from August 6, 1953, with outline specifications prepared on August 14. But it was put aside until December, to be worked on steadily throughout 1954, with manifold layout and valve springs sized in February, valve seats detailed in May, and cam timing adjusted in June. Intake manifolds were revised to have larger inlet tracts, changed from 32 to 36mm. Valve-train modifications reduced weight, as rocker arms were lightened from 158 to 138 grams in November 1954 and to 115 grams in early December. De Virgilio noted in his diary additional revisions to water circulation prior to testing on December 1, 1954, when it achieved 170.5hp, running with three Weber 40DCZ carburetors.

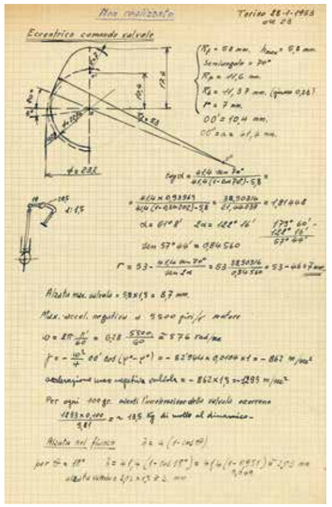
For the sake of comparison, the B110 motor was tested in March 1954, and it yielded 187hp at 6,800 rpm. The new single-overhead camshaft B54 provided the same power as the earlier double-overhead camshaft B110 up to 6,000 rpm, and was a simpler, more serviceable design.

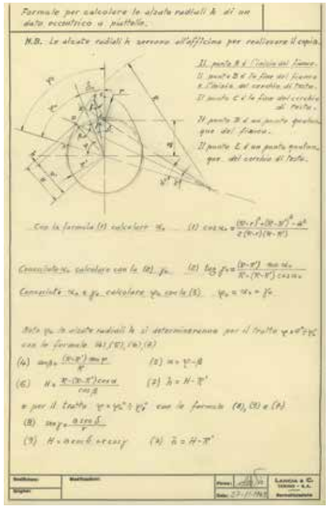
By this time, though, Gianni was only interested in the racing cars and possibly selling the company, so neither of De Virgilio's single-overhead cam motors was put into production.

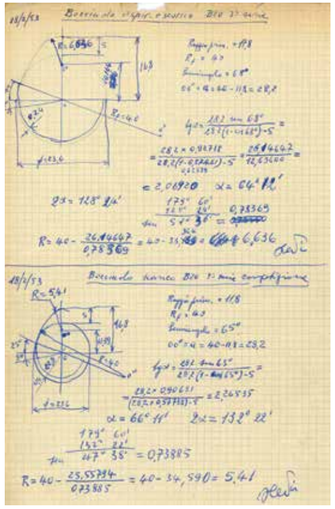












Cam drawings

OPPOSITE TOP TO BOTTOM
De Virgilio's first study of valve acceleration from 1943, showing the effect of changing the lobe profile. The base circle of the cam was small, only 18mm, as was used on the 538 motor. (De Virgilio Archive)

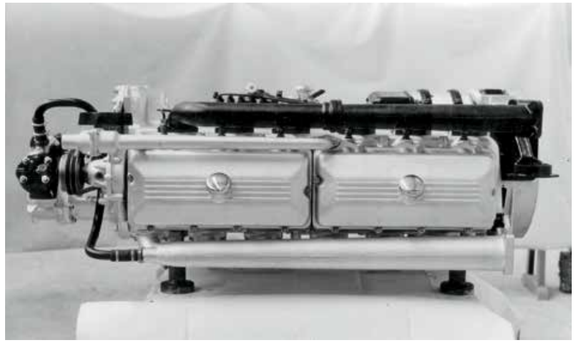
Valve acceleration study from 1946, with more detail, using a rocker ratio of 1.5:1 and 5mm lift (at the cam), which was used for the Aurelia. The base circle was increased to 21.5mm. (De Virgilio Archive)

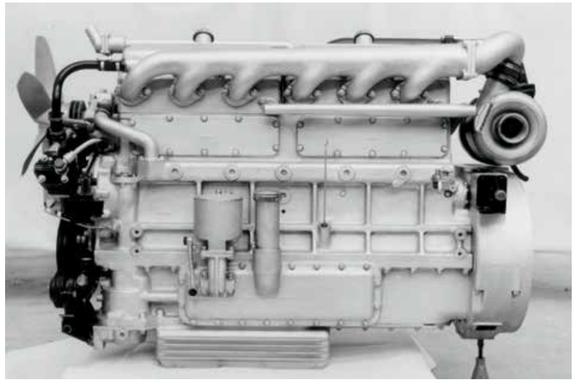
THIS PAGE CLOCKWISE FROM TOP LEFT
Early sketch of V engine using double-overhead cam from October and December 1946, considered timing chain alignments. Nothing at Lancia would suggest such a solution until the B110 motor in 1952. The lower study (from December) suggests the arrangement used in the bialbero *motors with their single-overhead cam and rocker arms.*

Camshaft lobe study, January 1953, one of many that De Virgilio prepared for the Aurelia motor, using the 1.5:1 rocker-arm ratio.

Two camshaft lobe studies from February 1953; the upper is for the s.3 B20 2.5-liter motor, and the lower for s.3 competition cars.

Outline of an approach for determining lobe geometry, from 1949. (All drawings, De Virgilio Archive)





Esagamma engines, the naturally aspirated horizontal version and a turbocharged vertical configuration, which was not put into production. (De Virgilio Archive)

Ferrari wrote him many personal letters from the 1940s through the 1950s. He made his first offer to De Virgilio in 1945, facilitated by Enrico Nardi. They exchanged letters, with Ferrari suggesting he start work at Modena in 1946. Indicative of Ferrari's well-known ability to spot talent, he was offering a position to a young engineer who had just begun his important work on the V6 motor. De Virgilio declined.

In July 1952, Ferrari sent another letter to De Virgilio, referring to his earlier June letter to Gianni, repeating his strong desire for a left-hand-drive B20 (not yet in production). He concluded: "I had thought about making this transformation (from right to left hand drive) in my workshop but to fulfill this wish, I would be obliged to buy two cars, a Gran Turismo and a B21, so as to have all the materials for the conversion."

After taking over the Lancia D50 race cars in 1955, Ferrari wrote De Virgilio in November, asking for the design drawings, with a personal note that recent tests of the D50s at Maranello had been very good.

In the fall of 1956, Ferrari again reached out to De Virgilio, while he was on leave in Reggio Calabria. Recognizing De Virgilio's talent and his important role in the development of Lancia's engines, this time Ferrari tried to lure him with the title of *Capo Ufficio Tecnico* (head of the technical office). He had no success, as De Virgilio had decided to stay with Lancia through all the difficulties. Even though De Virgilio had elected not to publish his work, he had nevertheless achieved a solid engineering stature, validated by Ferrari's repeated employment offers.

Truck Engines

By the end of 1956, De Virgilio had returned to Lancia to design truck engines, the only work he would do under Fessia's leadership. Lancia had historically made all its own engines for its commercial vehicles, starting before World War I, and had designed them all in-house, with only a few exceptions (such as the Ro engine, licensed from Junkers). In 1957, De Virgilio started updating the 8.2-liter diesel Esatau motor, in production since 1947, to be introduced as the new Esadelta of the same displacement in 1959.[8]

At the same time, Lancia's engineers were also preparing a new truck for a competition to supply the NATO forces, and while maintaining the six-cylinder configuration of the earlier truck motors, this was an opportunity to rethink many previous assumptions. Their second-place entry was subsequently marketed as the 506 to the Italian armed forces. Production of this gasoline-engined truck started in 1959, with 389 made through the 1960s.

Among the many new ideas in the 506 was a revised engine location, quite different than the Esatau, located next to the driver. The truck motor was set far forward, and the motor was angled to the side to fit. The cam was also shifted to the opposite side of the motor, a change from Lancia's previous truck engines.

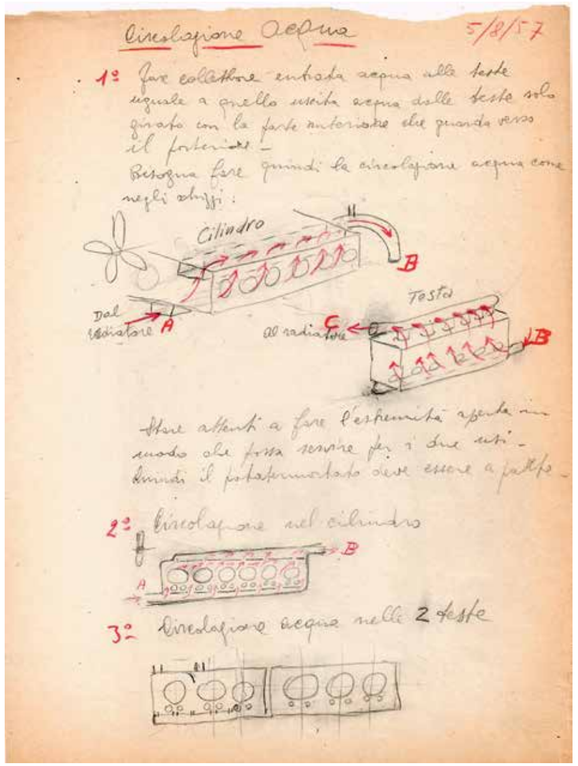
A variant of this truck, the 206, was made with rear-tread drive, but only four were built. Yet even for this, the motor was again rotated another 20 degrees. Angular engine mounting was not unfamiliar to Lancia; the D50 race car had its motor angled so the driver could sit lower, and the Aurelia motor had been slightly canted to the rear (3° 13' 26") for better alignment of its driveshaft. This approach surfaced just a couple of years later in a new Lancia car, the Fulvia, which had its V4 motor shifted 45 degrees to the side.

Esagamma

With the 506 project occupying much of the staff, Fessia assigned De Virgilio to a different project. His work on the Esagamma, Lancia's largest-ever production motor, at 10.5 liters, began in 1957, and he designed it for both horizontal and vertical mountings, using the revised cam location introduced in the 506 motor. Engine capacities were studied at length, until dimensions were finalized in September 1959.

That same year, De Virgilio was officially put in charge of engineering all the truck engines. He studied intake valve arrangements and airflow calculations, lessons learned years earlier from Jano and the test room, while maintaining Lancia's long-standing use of four valves per cylinder in their large diesels. Each newly designed truck motor was typically tested for 1,000 hours (40 days), running on the test bench.

The Esagamma was introduced in 1962 at the 44th *Salone dell'Automobile* in Turin. Its engine had an aluminum block with steel cylinder liners;



Preliminary sketch for the Esagamma, from 1957, analyzing water flow through the block and heads. (De Virgilio Archive)

ARCHIVE DOCUMENTS

The De Virgilio Archive preserves many documents, including calculations, drawings, and other notes. A list of its most important contents is provided so the reader can see the detail and the sequence of De Virgilio's work.

Documents are listed chronologically and color-coded by subject, highlighting various periods of focus.

- *"x" notes documents in De Virgilio's (DV) own hand.*
- *"Use" is typically for engine design, unless noted.*
- *"Model" is Lancia's car number; "type" is the motor number.*
- *"Sketches" are freehand; "drawings" are technical and to scale; "calcs" are written calculations.*
- *"Drawing analysis" is typically used for balancing studies, with both written and graphic calculations.*
- *"Page" is where the document can be found.*

DV	year	date (m.dd)	use (engine design typically, u.n.o.)	description or title	comments	document	page
x	1939	3.13	Aprilia car	model 238, type 97	A (cross-sectional area) = 1.73m², C_x = .59, 850 kg	data sheets	58
x		3.18	Augusta car	model 231, type 88	A = 1.75m², C_x = .71, 810 kg	data sheets	
x		3.24	Astura car	model 241, type 91, modif.	A = 2.15m², C_x = .65, 1630 kg	data sheets	
x		4.1	Artena car	model 228, type 84	A = 2.0m², C_x = .77, 1400 kg	data sheets	58
x		6.30	Ardea car	model 250, type 100	A = 1.62m², C_x = .57, 700 kg	data sheets	58
x		7.5	other	freewheel study	layout diagram	sketch	
x		7–8	other car	coupe, sedan views	freehand studies	sketch	32
x		12.31–1.2.40	Aprilia car	suspension sketches	repair studies for sliding pillar	sketch	38
	1940	1.8	general	oil analysis	for different temperatures (includes Jano note)	report	
x		1.29	Aprilia car	front suspension testing	internal oil temperature, done with Gismondi	test	
x		2.1–29	Aprilia car	front suspension design	additional note on detail on 2.11.41	sketch	
x	1942	(ND)	Ardea (or A10) car	front suspension design	offset horiz. spring location w/parallel arms	design drawing	59
x		10.20	Ardea car	front suspension design	alternate suspension, angled steering arms	design drawing	
x		11.5	general car	suspension sketches	alternate layouts	design drawing	
x		11.12	Ardea car	front suspension design	trailing arms, remote springing, a set of drawings	calcs, drawings	59
x	1943	4.16	V6	layout sketches	first diagrams	sketch	310
x		3.31–4.8	Aprilia car	pendulum suspension	isometric 3D view	design drawing	41
x		8.5–17	balancing study	V6	60°, solved 8.5.43, drawn 8.17.43	drawing analysis	48, 182, 289
x		8.19–21	balancing study	V6	39°, comparison of 12, then 3 crankshafts	drawing analysis	216
x		8.27	balancing study	V4	24°	drawing analysis	
x		9.7	balancing study	V8, type 111	39°	drawing analysis	
x		10.22	balancing study	V6	30°, narrow V, 3 crankpins	drawing analysis	
x		10.29	general	independent front suspension	general studies	design drawings	59
x		11.18	balancing study	in-line 5, type 102	3Ro motor, 6.9-liter	drawing analysis	218
x		11.29	538	V6	45° sizing , taxable power calculation for 1482,1524,1569cc	calc	
x		12.7	538	combustion chamber	design layout, full-size section	drawing	48
x		12.17	538	cam kinematics	lifter location, valve acceleration	study graph	214
x	1944	1.14	538	detail for spark plug mounting	spark plug in aluminum head	drawing	
x		2	Ardea	type 100A	hairpin spring	sketch	
x		2.22	balancing study	V6, type 538	45°, 1569cc	drawing analysis	218
x		3.20	general	rear suspension design	coil springs, trailing arm, for a 1200 kg car	sketch	59
x		4.26	balancing study	V6	120°, comparison of 12 crankshafts	drawing analysis	
x		6.6	538	detailed drawings, scale 1:1	complete package	design drawing	60–61
x		11.15	general	independent suspension design	trailing arm, patent applied for 3.1945, granted as IT 430857	sketch, patent dwg.	41
x		11.29	A10 car	suspension design	front suspension arm and spring sizing (date for calculations only)	drawing of arm (shown), calcs	59
	1945	(ND)	538	V6	45°, 1568cc, 68 x 72mm, 6.37:1 CR, combustion chamber of 48.7cc	data sheet	47
		1.3	538	general drawings, scale 1:5	Zaccone Mina's early work with FDV	design drawing	
x		3.8	Aprilia car	weight on axles	center of gravity calculation using vectors	drawing	
x		7.11	engine type 111	V8 cyl. block revised to V6	39°, tested first crankshaft; second test of Aurelia type crankshaft on 8.22.45	calcs and test	217
x		10.11–12	balancing study	V8, from A-10 car	45° and 50°, also 90° with crankpins at 180°	drawing analysis	
x		10.23	538	power curve	6.74:1 CR, Zenith, first running, De Virgilio drawing	test	49
		10.27	538	power curve	51.7hp (4,500 rpm), 6.74:1 CR	test	
x		11.9	V6	displacement studies	2092–2235cc	calcs	
x	1946	2.25	Ardea car	front suspension test	Ardea type 750B without shock absorber	test notes	
x		4.5	other	gearbox study	8 vs. 9 gears	design drawing	
x		4.24	Ardea car	front suspension test	suspension arm stiffness	test report	
		7.11	balancing	V6	Capetti review	memorandum	287
		7.12	Aprilia car	Suspension study	shocks with progressive hydraulic damping	sketch, notes	
x		9.5	balancing study	V6	90°, three crankpins	drawing analysis	
		9.46–3.47	Moretti 750 4-cyl	engine study	engine derived from Fiat 500, study for Moretti	calcs	
x		10.3	B10 1st type	V6	50°, 1569cc, 68 x 72mm, called B10 (538 crossed out)	calcs	49
x		10, 12	camshafts	camshaft control	SOHC and DOHC chain locations	sketch	215
x		11.22	camshafts, B10 1st type	cam kinematics	valve acceleration, rocker ratio 1.5:1	drawing analysis	214
x		12.5	B10	valve springs		chart	
x		12.16	B10 60°	calculation only	60°, 1988cc, 75 x 75mm, combustion chamber of 47.3cc	calcs	
x		12.24	B10 50°	calculations	1569cc CR 6.68 with combustion chamber of 46.0cc	calcs	
x	1947	2–12	general	furniture sketches	for the house	drawings	267
x		3.6	B10 50°	gearbox study	linkage for transaxle	drawing	50
x		5.8–11	538	motor No. 2	56.5hp at 4,500 rpm, Zenith	test 475/280, 284	
x		9.12	general	piston motions study		sketch	
x		9.13	balancing study	V6	16° 22', 50°	drawing analysis	219
x		10.2	testing room	fuel circuit for test bench	gasoline and diesel	sketch	
x		12.5	C15	4-cyl OHC engine layout	parallel staggered, 903cc	design drawing	224
		(ND)	C15	4-cyl OHC detailed sections	full-size drawings	design drawing	186
x		12.11	balancing study	V4 and parallel cyl, Ardea type 100A and C15	17° and 0°	drawing analysis	
x		12.15–30	balancing studies	V4, Aprilia 438, Ardea type 99, 100, 100A, 100B	17° and 19° 54'	drawing analysis	
x		12.31	balancing study	V4, from C15	0°	drawing analysis	219

general balancing V6 4-cyl bialbero competition