



RUOTE ULTRALEGGERE IN ELEKTRON

Campagnolo
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bike

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**INTERNATIONAL MAGNESIUM
ASSOCIATION**



1975

**BREVETTI INTERNAZIONALI
CAMPAGNOLO**

VICENZA, ITALY
For their USE and ADVANCEMENT
of the LOW PRESSURE DIE
CASTING PROCESS for MAKING
MAGNESIUM AUTOMOBILE
WHEELS

Presented at the 32nd ANNUAL MEETING
DEARBORN MICHIGAN U.S.A., MAY 20, 1975

Campagnolo Brevetti Internazionali S.p.A. are a leading Company, operating in the area of precision engineering. The long, proven experience of their technicians, backing the Research, Design and Planning Department, and the high standard of technical ability of their workers combined with the advanced production facilities in their machine shops, has enabled Campagnolo to establish their wide range of products throughout the World. Although Campagnolo have established and maintained a worldwide reputation for their production of bicycle accessories (which have been adopted by the champions of all times for all forms of cycling; road, race-track, cycle-cross, tandem, etc.), it is not commonly known that Campagnolo's activities also fall within the strictly specialized and technologically advanced sphere of motorcar, motor-cycle, aviation and aerospace industries.

Campagnolo produce:

FOR THE MOTORCAR INDUSTRY

Ultralightweight wheels of «Elektron» alloy for Formula 1 cars, as well as for sporting, racing and touring cars, in addition to special engine and bodywork components (most well known car manufacturers, after having successfully conducted very severe trials and tests, use Campagnolo wheels because they have proved to be light in weight, very robust and extremely safe).

FOR THE MOTOR-CYCLE INDUSTRY

Wheels, brakes, hubs and special components for racing, sporting and cycle-cross motor-cycles.

FOR THE AVIATION AND AEROSPACE INDUSTRIES

Components for aeroplanes, helicopters, scientific research rockets, sounding balloons and satellites.

FOR THE BICYCLE INDUSTRY

Gears, derailleurs, quick release hubs, pedals, seat posts, bottom bracket sets, heatsets, chainwheel sets, fork ends,

pump adaptors, clips, cables, cable casings, control levers, brakes, tools and bicycle assembling stands, etc.

Every item that comes out of the various Campagnolo departments is designed by following a criteria of high standards of design and is built with specialist materials, through the most modern production processes and with the most stringent controls which guarantee high quality in the end product.

In 1975, at Detroit (Michigan, U.S.A.), the world centre of the automobile industry, the International Magnesium Association, an organisation established by the magnesium producers of the whole World and by the technologically most advanced utility industries, assigned to Campagnolo the **design and applications award** for their use of a new technique in the production process, in relation to the industrialisation of the die-casting by using low pressure methods for the manufacture of automobile wheels, thereby attesting that this process is now the best for obtaining high quality magnesium alloy wheels.





Light alloys

When discussing light alloy wheels it should be made clear, for the sake of accuracy, whether one is talking of aluminium or magnesium alloy wheels, because there is a considerable difference between the two. Needless to say wheels of a aluminium alloy are lighter in weight than those of press formed steel, but they are heavier than those cast from magnesium alloy, and so the latter type are said to be ultralight wheels.

The specific weight of steel is about 7.8 kilogrammes per dm^3 , whereas that of aluminium alloy, commonly used

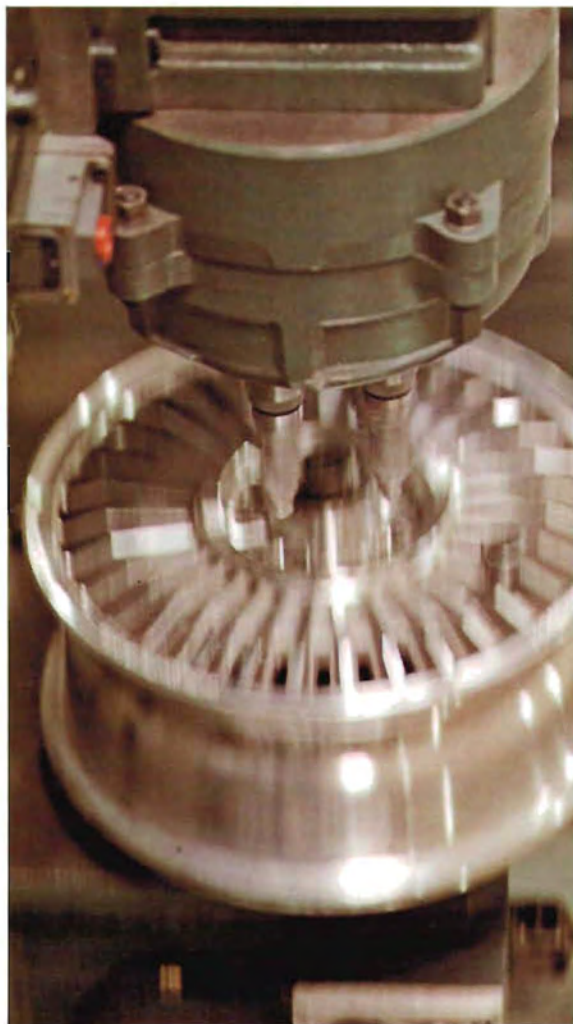
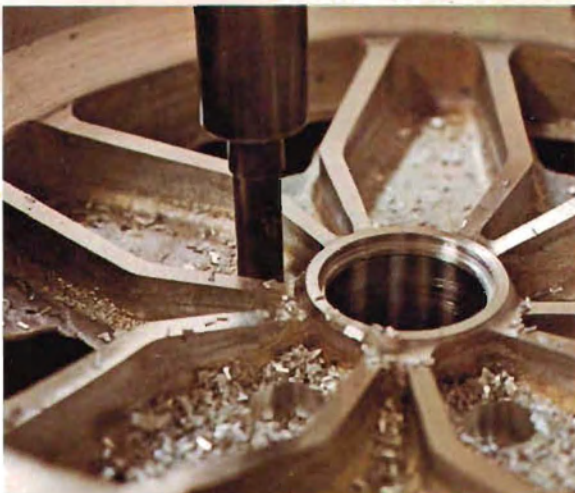
to cast car wheels, is 2.5 kilogrammes per dm^3 . The specific weight of magnesium alloy is 1.8 kilogrammes per dm^3 . This is the lowest specific weight among all the metals used in mechanical engineering.

The mechanical resistance, or to use a technical term, the «tensile strength» of steel used for press forming car wheels is 2.5 times that of aluminium and magnesium alloys used for the same purpose.

From the above it follows that if the three metals mentioned, steel, aluminium alloy and magnesium alloy, are used to produce three identical wheels for the same car and manufactured with wall thicknesses to obtain a similar tensile strength value, and if the ratios between the three different specific weights and the ratios between the three different tensile strengths are taken into account, then the wheel of aluminium alloy will weigh 50% less than the wheel press-formed from steel.

That is why Campagnolo's highly advanced technology has tackled and brilliantly solved the problems associated with the manufacture of wheels manufactured from «Elektron» alloy, which is a special magnesium alloy.





Advantages of wheels made from elektron alloy

If compared with standard wheels, either press formed from steel or cast from aluminium alloy, Campagnolo wheels manufactured from Elektron alloy have many advantages.

LIGHT WEIGHT

1. The lower the inertia of the rotating mass, the higher the acceleration and the quicker the deceleration.
2. A smaller mass puts less stress on the steering gear.
3. The unsprung mass decreases in weight to the advantage of the shock absorbers and consequently the road holding.
4. It is possible to use wide section wheels without excessively increasing the suspended mass, a wheel built for a Formula 1 racing car is the most significant example. This wheel has a profile cross section measuring 43.2 centimetres between the rim inner edges, and an offset distance, from the hub face to the outside measuring 32.2 centimetres. It is very hard to imagine a wheel of such a size made from steel.

The structure and thickness of wheels made from magnesium give the wheel more stiffness than those wheels manufactured from press formed steel and this results in less rim deformation under lateral thrust conditions (i.e. those conditions generated by centrifugal force during cornering). It follows that all the lateral thrust is transmitted to the suspension and to the shock absorbers thereby permitting better road holding on a corner and easier control of the car on the part of the driver.

PRECISION ENGINEERING

After ejection from the press, a car wheel formed from steel cannot be finished ground. The so-called axial and transverse «wobbling» (either the rim flange edge is not true with respect to the rim centre line during rolling or the rim itself is not perfectly round over its circumference to use elemen-

tary terminology) in a wheel press formed from steel, has a maximum tolerance of 1.5 mm and this is reduced to 0.3 mm for wheels cast from magnesium alloy.

In fact, magnesium alloy wheels when ejected from the die undergo corrective machining of the rim profile and nave mounting face, in order to achieve the above mentioned 0.3 mm tolerance. Therefore, better and easier balancing of the wheel and tyre is obtained and less tyre wear due to more accurate wheel to road contact occurs.



Elektron casting methods used by Campagnolo



When small quantities of wheels, or wheels of a special size have to be produced, the method of sand casting is used. This is the oldest method and is carried out in the traditional craftsmanlike manner by pouring molten metal into and filling up the mould cavity slowly by hand.

When medium or large quantities of wheels have to be produced the method followed is the one of casting by low pressure, into a metal chill.

These two methods of casting by gravity in sand and by low pressure, permit analogous technological results to be achieved. In casting by the low pressure method, the whole mould acts as a large fluid feed vessel, to feed (through the injection channels) the casting during the contraction of the molten metal taking place during the solidification process, when progressing from a liquid to a solid. These two casting methods permit the best structural soundness to be achieved, and these castings are then subjected to a heat treatment so that the highest mechanical properties of the alloys used can be employed.

Though possessing very wide experience and eminently qualified to produce alloy wheels by die casting, Campagnolo did not want to adopt the method of casting by high pressure for their wheels. Die casting using high pressure is the quickest method to produce wheels, but it is certainly not the method which produces the highest quality of casting, and is specifically not suitable for castings which have to withstand high mechanical stresses. The reason for this is that when high pressure die casting is employed, the casting cannot be heat treated afterwards, due to gas and air being trapped in the structure when the material progresses from the liquid to the solid state.





When producing road wheels, each car manufacturer, as a general rule, draws up his own detailed specification and includes all the relevant data and processing instructions. This is because in Italy, at the present time, no precise standards exist which wheel manufacturers should comply with. This may appear strange but the situation exists and anybody may build a car wheel without any limitations. The consequences of this could be extremely serious.

Instead Campagnolo take the greatest care in designing and fabricating their wheels, and the following process is strictly adhered to when the design of a new wheel is being considered:

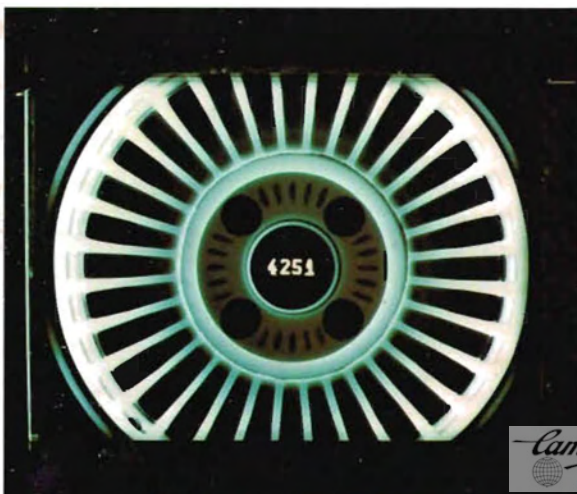
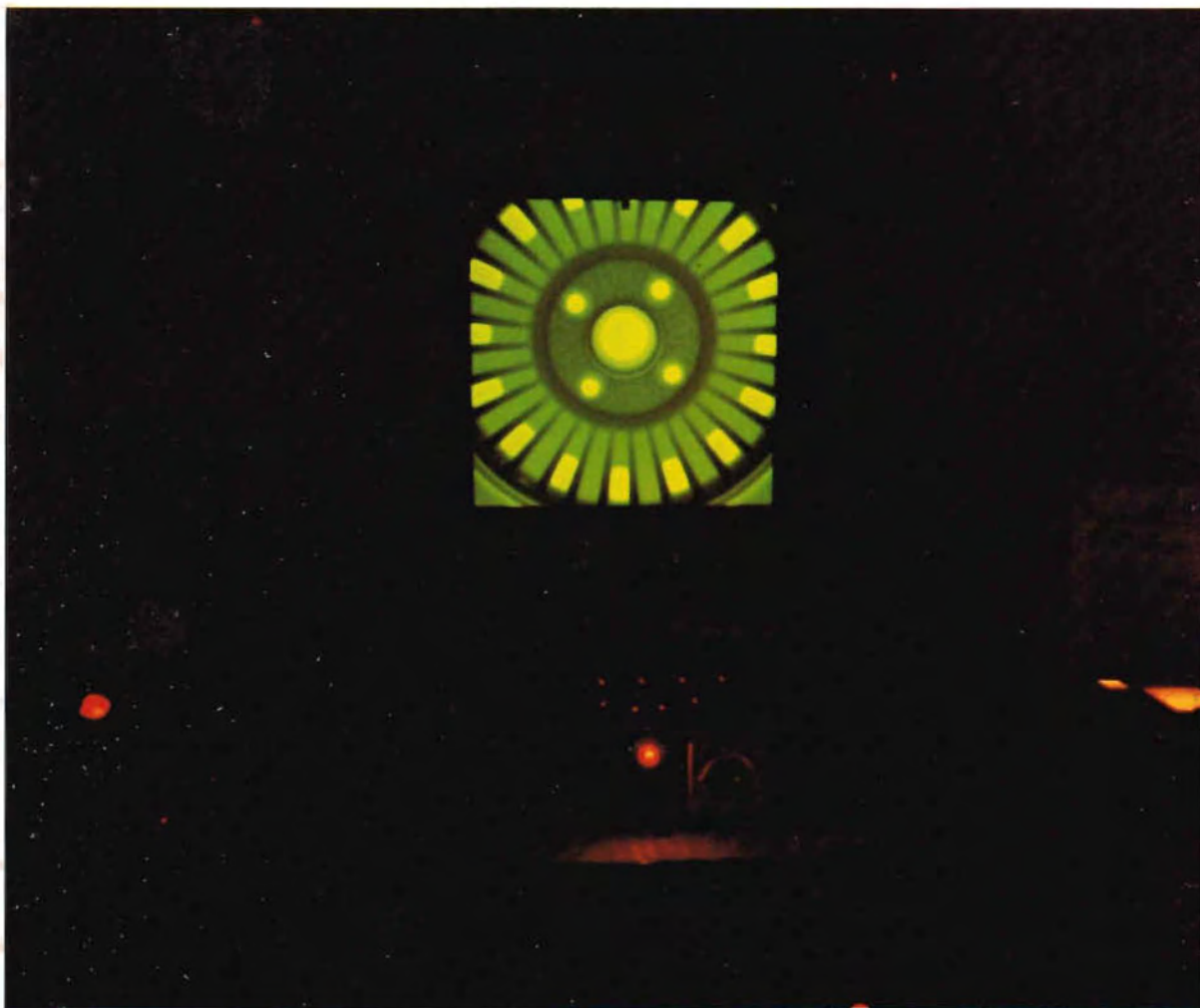
1. First the design.
2. The execution of the drawing.
3. The implementation of a model.
4. The casting of prototypes.
5. Checking the soundness of the metal structure by means of die penetrant and X-ray examination, stringent tests on stress simulators and rigs.

At all times during the design of the wheel the designers, technical department and the foundry technicians work in close liaison.

Once the prototype has been manufactured the structural soundness of the castings are then checked.

Dye penetrant test

This inspection process is carried out to check for freedom from linear defects in the surface of the casting, these linear defects might not be visible to the naked eye. The wheel is dipped into a liquid having a low viscosity, and is capable of penetrating the innermost recesses and pores of the surface of the material down to a size of one hundredth of a millimetre. The wheel is then subjected to the glow from a special lamp after having first been cleaned, the defects showing up in the light from this lamp.



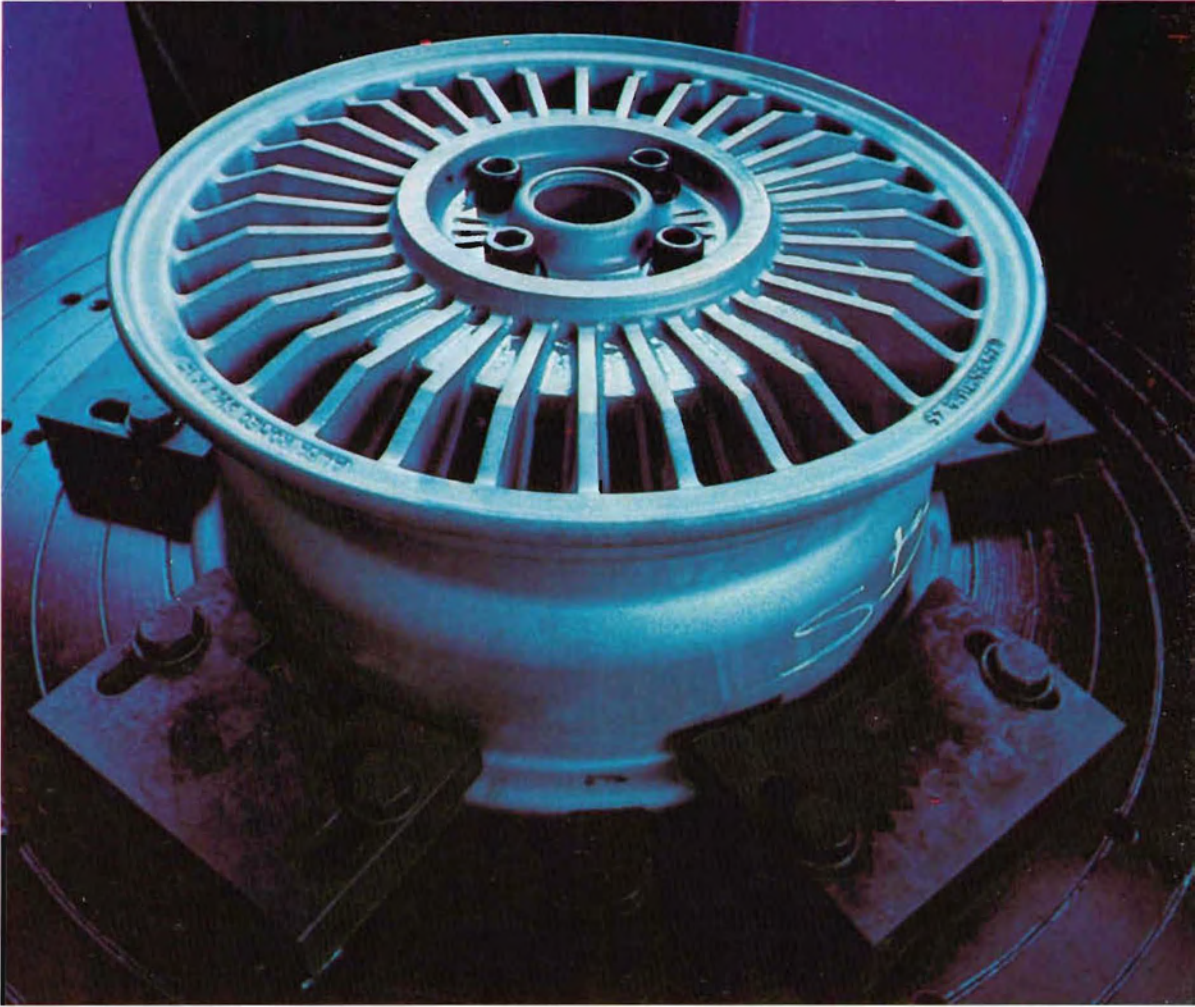
X-Ray examination

This method of inspection enables defects on the internal structure of the wheel to be detected. Only when the above two tests have been passed and the wheels are found to be sound in structure are they allowed to carry on to the next stage which is the testing of the wheels on stress simulators and rigs. If defects are found in the castings then they are re-cast with corrective measures having been taken.

Dynamic deflection fatigue test

This test is carried out by using a test machine which simulates the constant rotational cornering stresses imposed upon a wheel. The machine reproduces the maximum stress multiplied by at least two the forces exerted upon the wheel when rolling on a road or turning i.e.

1. The radial load exerted upon the wheel by the car weight.



2. The reaction to the centrifugal force generated by the friction between the tyre and the road.

The wheel, under the strain of these increased loads, must withstand the test for a determined number of revolution or stress cycles, without suffering any fatigue fractures or cracks. Under these test conditions the stress is imparted to the centre member of the wheel i.e. the area between the stud holes and the rim.

Campagnolo have at their disposal both vertical and orizontal test machines designed specially for carrying out this type of fatigue test.

Dynamic radial fatigue test

This test is carried out using a test machine which simulates the fatigue stress exerted upon a car wheel travelling in a straight line. The machine reproduces the load imposed upon the wheel by the car weight during its motion in a straight line on a road surface, and increases it by at least twice the normal load. The wheel, under the strain of this

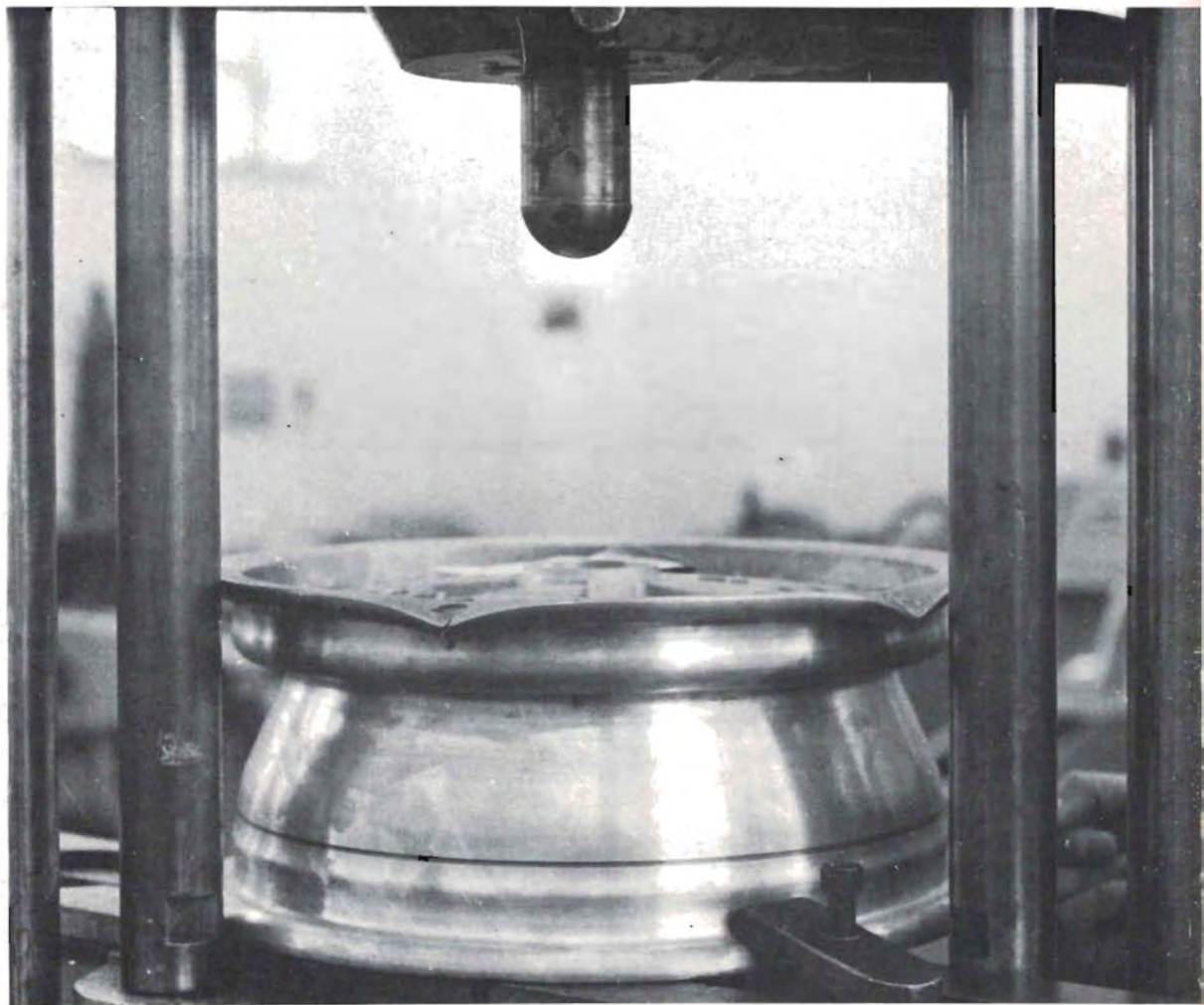


increased load must withstand the test for a determined number of revolutions or stress cycles, without suffering any fatigue fractures or cracks. Under this test condition the maximum concentration of load is imparted on the rim edge or the part of the wheel which accommodates the tyre

Rim edge deformation test

This test is carried out to test the ability of the rim external flange to absorb energy. The test is carried out on a machine in which a compressive load is imparted laterally to the rim edge using a purpose designed round-headed punch and during the test a

cannot use this process as during heat treatment the rims distort due to expansion of gas in small blow holes caused during the casting process. All Campagnolo wheels, both the series production and the Formula 1 wheels, are subjected to heat treatment. Only after all of these tests have been passed satisfactorily can the prototype wheel be considered fit for production.



recording instrument records the deformation load.

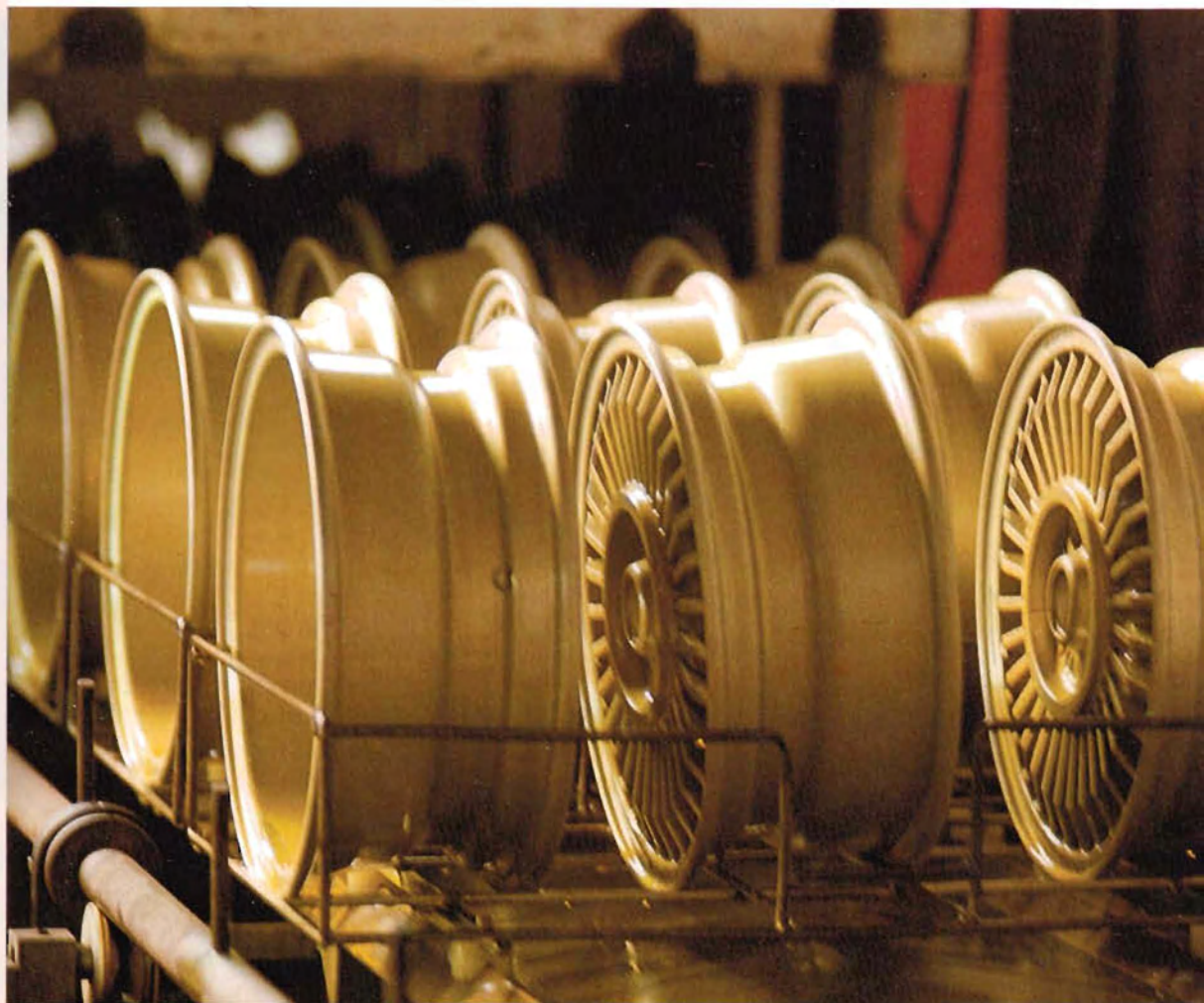
The absorption of energy should not be less than a predetermined value measured in kilogramme metres. In order for the wheel to pass this test the material must possess extremely high resilient properties, and so that this can be achieved, the rims are subjected to 24 hour heat treatment at a temperature of 410°C. Only wheels cast either by the low pressure or by the sand casting method may undergo heat treatment. Wheels cast using the high pressure method

Quality checks on production

In order to guarantee a high standard of quality during production, the above tests are carried out; 100% in the case of non-destructive tests and destructive tests are carried out on a percentage basis.

Anticorrosion treatment

All materials used in mechanical constructions, if exposed either to the atmosphere or to corrosive surroundings are adequately protected by corrosion resistant coatings or paints. The protective property and



ability of these coatings to withstand corrosion are determined by means of standardized tests (either the humidified cell test or a salty fog test).

Campagnolo wheels are subjected to anodic oxidization process and then receive a number of priming coats. This protection amply complies with the standard requirements for resistance to corrosion imposed by all car manufacturers.

The (alleged) inflammability of magnesium

Magnesium, is the same as other similar metals such as aluminium or zinc in that in the powdered state or in very fine chips or metal cuttings it can be inflammable. This only occurs when a outside source of flame or combustion is applied to the material.



This inflammability does not occur when the material is in a form of a thick section casting as in the case of a wheel. Even the so-called magnesium flashlight powder was originally composed of aluminium oxide not magnesium oxide. Even if an oxyacetylene torch is applied to a magnesium wheel it will melt the material but will not burn it.



Walter Villa, who was the World Champion in 1974, 1975, and 1976 for the 250 cc class and for the 350 cc class in 1976 rode a Harley-Davidson motorcycle equipped with Campagnolo wheels manufactured from Elektron magnesium alloy and Campagnolo hydroconic brakes.



The best sports car manufacturers place reliance on Campagnolo

Campagnolo are probably a unique Company in the World in that they transfer their experience acquired from serious competition directly into the production of wheels manufactured in their own factory.

They produce wheels for the rally, Grand Prix and prototype market. They also produce wheels for medium and large production runs. The same quality and test procedures are carried out on all these types of wheels. They are continually researching into better foundry techniques and better

use of new alloys in order to find greater reliability and greater technological improvement in their own products.

Wheel designations

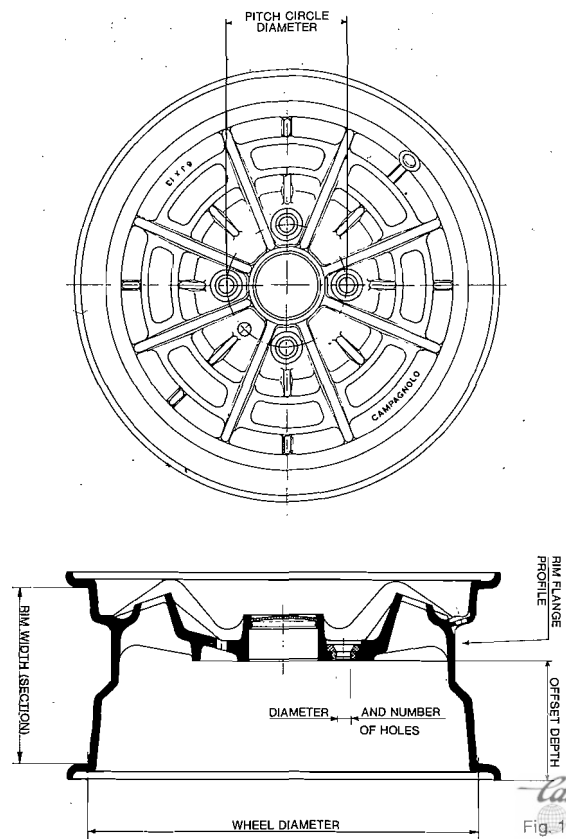
The following design perimeters are used to describe a type of wheel:

1. The wheel diameter, measured over the rim flat ledge in inches.
2. The rim width again in inches.
3. The type of rim flange profile which is designated by a letter.

The following is an example of a wheel designation or type:

6J x 13"

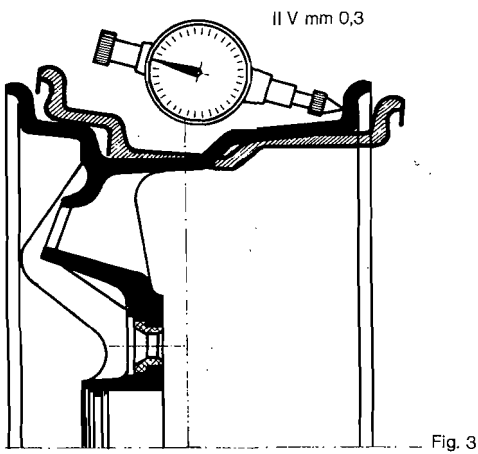
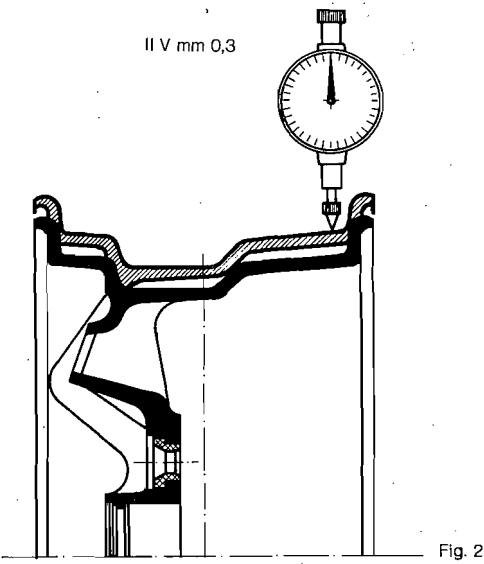
- 6 denotes the rim width in inches.
J is the letter designating the type of rim flange profile.
13" denotes the size of the wheel diameter over the rim bed in inches.
4. Depth of impression (either offset, inset or outset), this is the distance from the rim profile, or from the rim profile centreline to the nave mounting face.
 5. The pitch circle diameter which is the diameter of the circle on which the stud holes are machined.
 6. The number of fixing stud holes.



Functional characteristics of a wheel

EXCENTRICITY - this is the variation of the distance between the rim bed circumference and the centreline of wheel.

OVALIZATION - this is the variation in the rim bed circumference.



'WOBBLING' - this is the variation between the rim flanges which hold the tyre in position.

The techniques used by Campagnolo to machine wheels allows them to control the above dimension to within 0.3 mm (press formed wheels from steel cannot be held below 1 to 1.5 mm tolerance).

The ability to hold such low limits in wheel dimensions means greater rotational accuracy and consequently

less tyre wear.

Directly associated with Campagnolo's method of casting and machining is the amount of unbalance that can be found in a wheel. In Campagnolo wheels the unbalance is less than 30 grammes, the unbalance of a wheel manufactured from press formed steel can reach as high as 80 grammes.

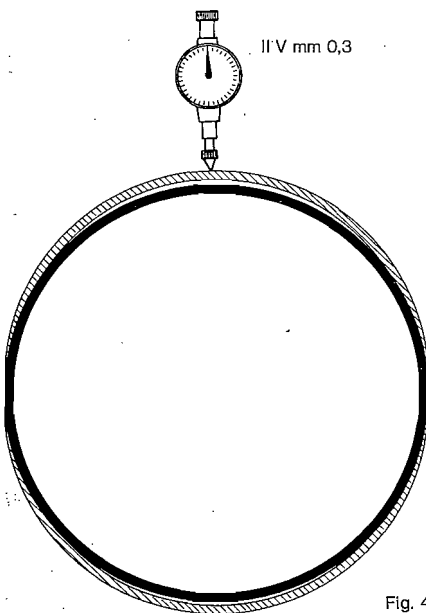


Fig. 4

Campagnolo

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