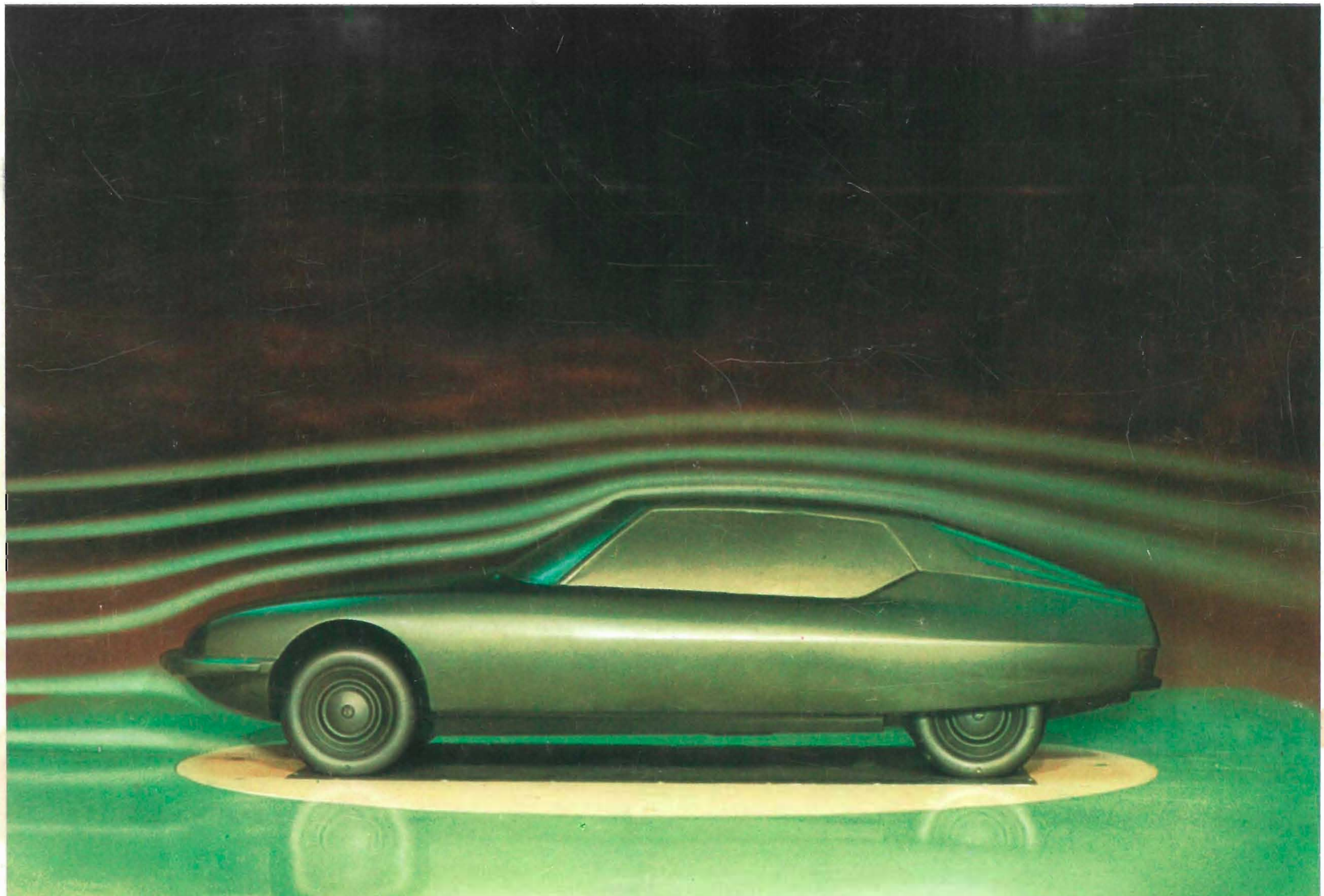
style auto

bimonthly **architettura della carrozzeria**



citroën sm / sessano dunja lancia / academy of automobile design / renault 15 & 17 / intermeccanica indra / michelotti pulsar fiat-giannini / style auto 1971 award / memory of giovanni bertone / zagato 3.z ferrari

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Sped. in abbon. post. gruppo IV - 2 sem. 1972


citroën sm

1 - Generalities on the aerodynamic studies for a high-performance vehicle

The incessant increase in cars' top speed urges design and research Centers to get involved in solving always more important aerodynamic problems. Performances, safety, comfort and economy may be considered as parameters widely depending on the seriousness put in facing the studies of aerodynamic phenomena.

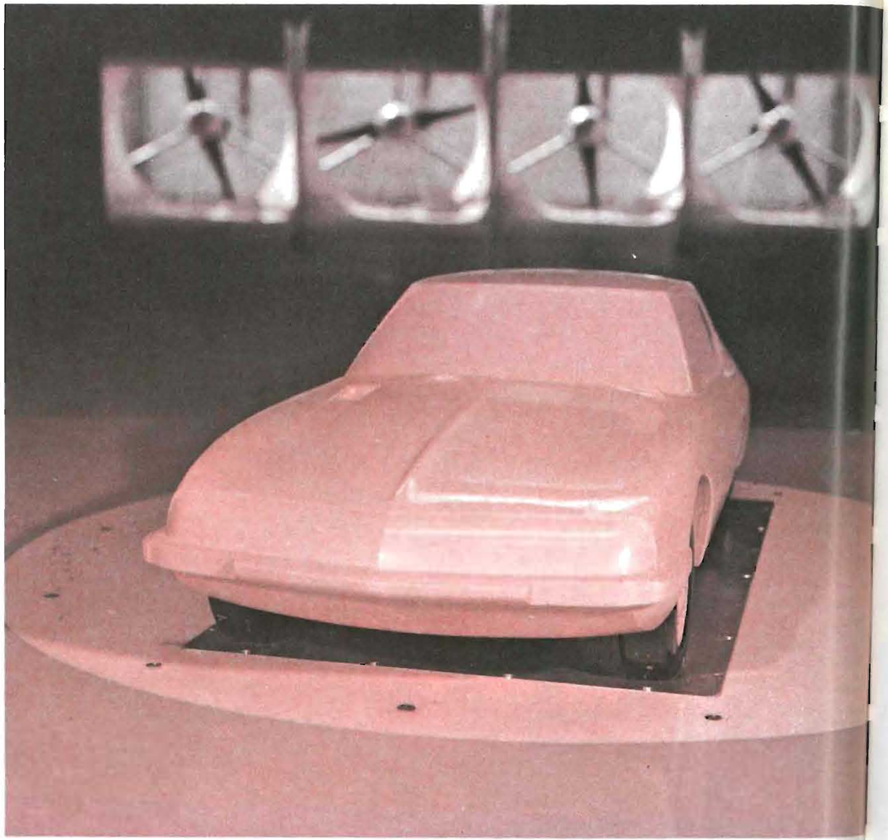
Among bigger-displacement European GranTurismos today in production, there are many capable of easily going beyond the longed for goal of 200 Kmph, thus reaching the cruising speeds of planes built around the thirties. The history of aeronautics reminds us that it is right at that time, that tunnel testing acquired a decisive importance due to the aggravation of the problems set by aerodynamics with the increase in performances. At this moment, car designers have thus to cope with a similar situation, specially if they wish to achieve a perfect tuning of very fast vehicles, whose behavior and driving should not be exclusive apannage of a small élite of specialists.

The field covered by these researches is very wide, going beyond the typical drag, of course conditioning absolute performances and remained over a long period of time the main vorry of a minority of manufacturers. The problems of trajectory stability are bound to the distribution of aerodynamic loads of lift and side thrust on the vehicle's two axles: when the mobile moves within a field of velocity varying in intensity and direction (as it happens in presence of wind, either transversal or longitudinal), the system of forces to which it is subjected varies considerably. Delivery of interior air circulation, either for engine and brake cooling or for passenger compartment ventilation, are bound to the field of the pressures settling on the car's body. Among the various phenomena - from aerodynamic noise engendered, for instance, by drips or eaves to the effects of windshield wipers detachment at high speeds - numberless are the problems of which an effective and often rapid solution can be foreseen through serious preventive studies, consisting of tunnel tests either on scale models or on the full-size vehicle.

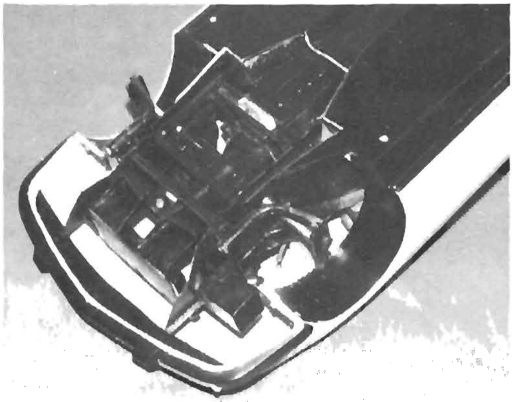
2 - Wind tunnel testing

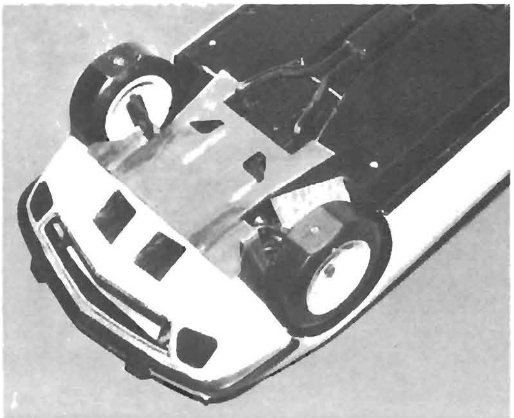
It is at the origin of a shape study for a new model that the specialist in aerodynamics makes his entry: namely, it will be the first plaster model to provide - well ahead of the vehicle's formal finalization - the data needed to evaluate its potential performances and their comparison with the specifications of the product guidelines. These results are achieved starting from tunnel testing, where wholly particular precautions are necessary in order to obtain a satisfactory road/wind-tunnel correlation.

2.1 - Ground simulation. One of the difficulties encountered in the aerodynamic 'lab' study of a road vehicle, comes up when one wishes to reproduce - in order to insure the similarity among the respective fluid flows (écoulements) - the phenomena connected with the body proximity to the ground. On the road and in absence of wind the air is still as compared to the ground, while in the tunnel the model integral with the ground is swept by a wind equivalent in absolute value, but of opposite direction to that of the car's. This arrangement entails the engendering, on the walls bordering the experience flow, of a boundary layer (fluid whose energy is degraded by the viscous surface friction) which deeply



modifies the phenomena bound to the ground-effect. Besides, this boundary layer tends to detach from the wall if stressed by positive pressure gradients due to the presence of the scale model. On the road the absence of this sort of phenomenon calls therefore for the adoption of experimental devices, suitable for the carrying out of either its entire suppression or its minimization as compared to the model's size.
A first simulating device may be obtained by means of a rollaway running in the same direction and at the same speed of the overall air flow. Though obtaining under similar conditions the respect of the phenomena connected with the ground presence, this device entails various complications at the stage of its practical implementation as to the fixing of the model on the band and, what is worse, considerable difficulties of measurement bound to interaction phenomena between the model and its support.
The solution adopted by Citroën (particularly visible in the largest color picture on page 47) consists of representing the road by means of a counter-floor composed of a very smooth flat surface located above the vein floor and dipped in the constant-speed flow, in such a way as to eliminate the boundary layer of the latter. Several experiments performed in English and American aerodynamic labs confirmed the validity of this method for moderate-lift bodies, as in the case of automobiles. To maintain an air delivery under the car identical in scale to that existing on the road, the clearance under the model's wheels is increased by the thickness of the boundary layer developing on the surface simulating the road. On the other hand, this value is reduced to the minimum (2 mm in tests on 1:5 scale models with the Citroën device) when a thorough surface 'finishing' of the counter-floor is insured. This preliminary stage is extremely important and requires the maximum accuracy as the validity of subsequent experiments depends on it.
2.2 - Body shape model. The model scale in use at Citroën is 1:5, which permits a satisfactory compromise between the accurate reproduction of certain details, execution rapidity (it is necessary that the model be readied prior to selecting the final shape) and ease of handling. A similar scale further permits to obtain in wind tunnel testing a sufficiently high number of Reynolds (parameter, whose importance will be hinted at later).
Initially modeled in plaster on an underbody conforming to that foreseen for the future vehicle, the body shape can be repeatedly modified until determination of the nearly final one in plastic material. The opposite picture shows the appearance of such a model served for the Citroën SM development: though made in the configuration without interior flow, it does already





entail an accurate rapresentation of the underbody particulars. A certain amount of minor details, engendering flow conditions differing from the real size, are purposely omitted just because of their reduced dimensions. Simulation of under-hood air circulation - needed to obtain exact values of the aerodynamic characteristics - brings to a thorough layout of air entries and exits as well as the execution of particulars under the hood, as shown by the pictures on this page referring to the same model. The losses of aerodynamic load of the radiators are simulated by means of adequately permeable grillings.

2.3 - Checking on the shape model of the body aerodynamic efficiency. The two main measurements carried out on the scale model are on one side the determination of the aerodynamic resultant and on the other the measurement of pressure distribution on the body walls. This information will be used together as regards the aerodynamic aspect of the problem, while the pressure diagram will be a precious help to engineers responsible for interior air circulation (both in engine and passenger compartments: air conditioning and ventilation).
2.3.1 - Measurement of the six aerodynamic components. In the most common case, the ensemble of air reactions on the model can be reduced to a resultant and a moment which break up into three forces and three moments according to a reference trihedron we would assume tied to the vehicle. Lift, drag, side thrust and their respective pitch, roll and yaw moments. The model is set on an aerodynamic balance (buried into the thickness of the counter-floor) that will provide directly the 6 components sought for, to which it is anchored by means of 4 pins (integral with the weighed part of the balance) fixing the model under the wheels in order not to introduce any interference in the flow. The support of the balance rotates around a vertical axis, allowing the setting in aerodynamic drift of the model being tested: this arrangement permits to observe apart from the aerodynamic behavior in presence of side wind, all the configurations in which the relative speed is not parallel to the vehicle's plane of longitudinal symmetry (as it happens when turning, sliding athwart etc., where a transversal component exists in absence of actual wind).
Generally overlooked in tunnel tests of touring car models is the influence of the Reynolds' number, adimensional parameter usually indicating the nature of the flow and playing a very important role in the similarity of the two écoulements (in test and in reality). For every new model, however, Citroën performs a test with a variable number of Reynolds to check the constancy of the aerodynamic coefficients, which is obtained with R_e above 2.10^6.
The measuring results of the longitudinal force called drag provide

the data for calculation of the performances, which will become always more precise as the model will acquire a formal definition and will complete its equipment (air circulation inside the engine compartment, exhaust details). The drag absorbs almost 50 per cent of the driving power at 60 Kmph, 75% at 160 Kmph: these figures underline the interest in the search for the most favorable shape for vehicles going beyond 200 Kmph.
On this page at top we are presenting for example (picture 1) the drag evolution R_x of a 1:5 scale model full (that is without inner ducting) of the Citroën SM for different values of the yew angle J^0 at a 160 Kmph speed. This graph shows a moderate increase in the adimensional shape coefficient C_x with the varying of J^0, indicating a feeble action of the cross wind on the drag. This curve, obtained after numerous experiments, meets the specs posed by the product guidelines.
Once the final shape allows the achievement of the expected performances, it is better to check that the latter be attained under satisfactory safety conditions, with particular reference to direction stability. The examination of the lift (R_z) and side thrust (R_y) curves as well as their respective moments, will permit to check that no disquieting phenomenon of aerodynamic origin comes up to abruptly modify the dynamic behavior of the vehicle (which is usually translated into curves free from discontinuities under yawing). Lift measurements on each axle inform on the variations of the vertical loads set on the wheels and play an important role in case of yawing. The effect of a cross wind on the lift entails a considerable increase in its coefficient C_z, due to the wakes (shape resistance) of the uncovered lower parts of the wheels. This component decreases the vertical load on the wheels at the same moment when a transversal force comes up, which tends to stray the car laterally; the thrust is null if the yaw angle is null and varies linearly with it. The point of intersection (called center of side thrust) of this force with the symmetry plane is located on most vehicles before the center of gravity, which determines a de-stabilizing moment - namely static aerodynamics instability - and it is conceivable that

ESSAIS AERODYNAMIQUES : MAQUETTE DU VEHICULE CITROEN SM

Echelle 1/5 Maquette sans circulation interne

$$C_y = \frac{F_y}{\frac{1}{2}\rho S V^2}$$

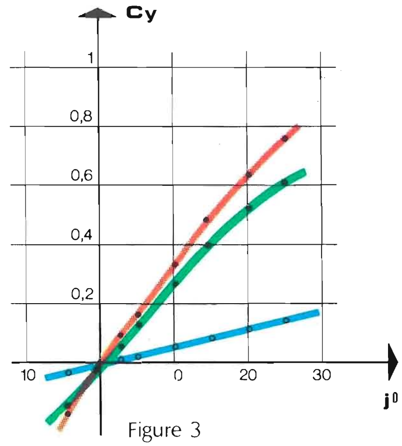


Figure 3

Cy total
Cy essieu avant
Cy essieu arriere

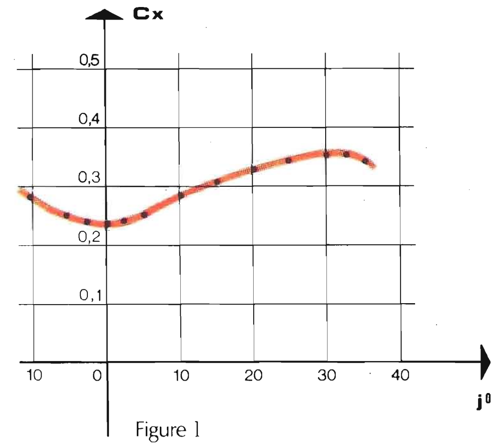


Figure 1

Cx

$$C_x = \frac{F_x}{\frac{1}{2}\rho S V^2}$$

$$C_z = \frac{F_z}{\frac{1}{2}\rho S V^2}$$

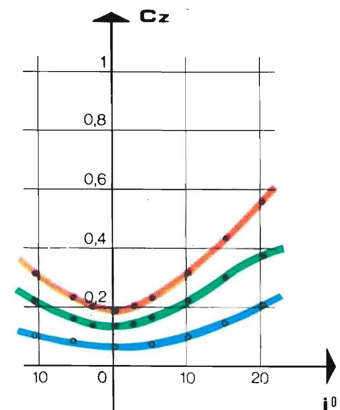
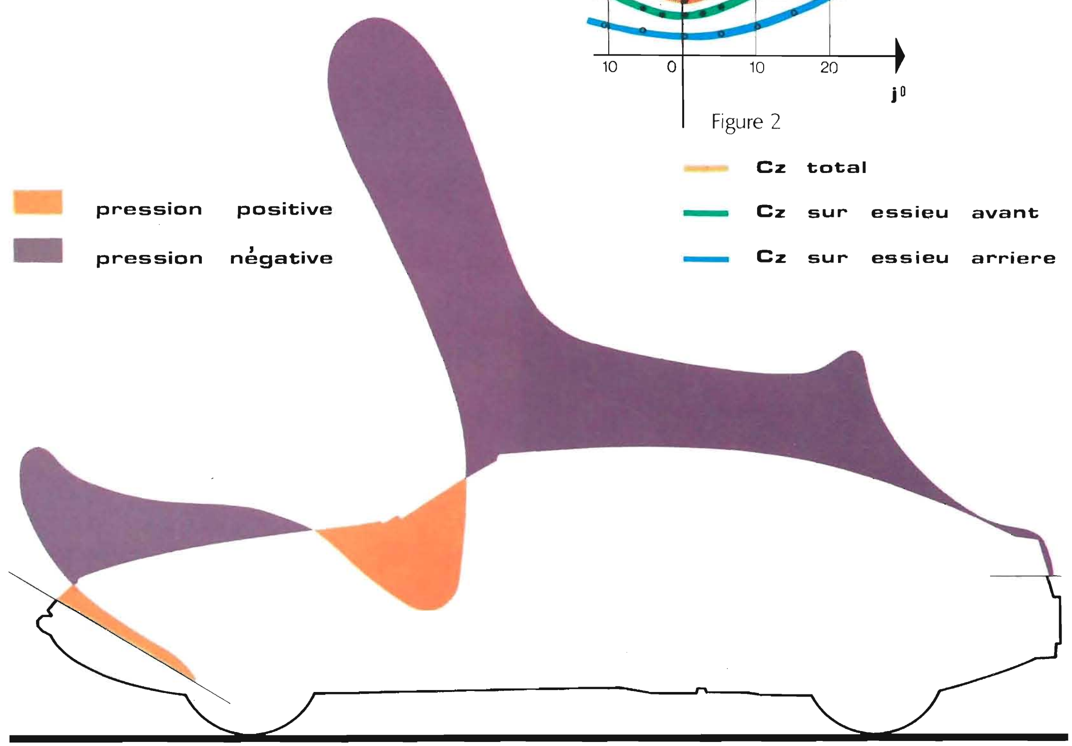


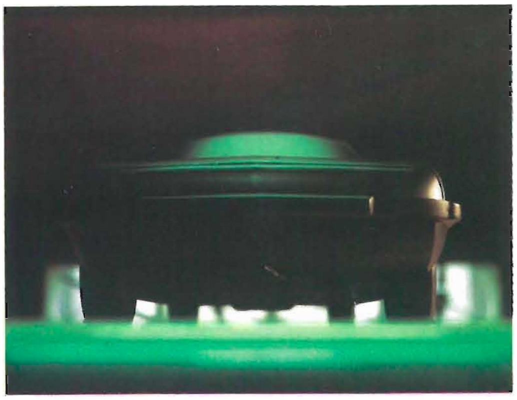
Figure 2

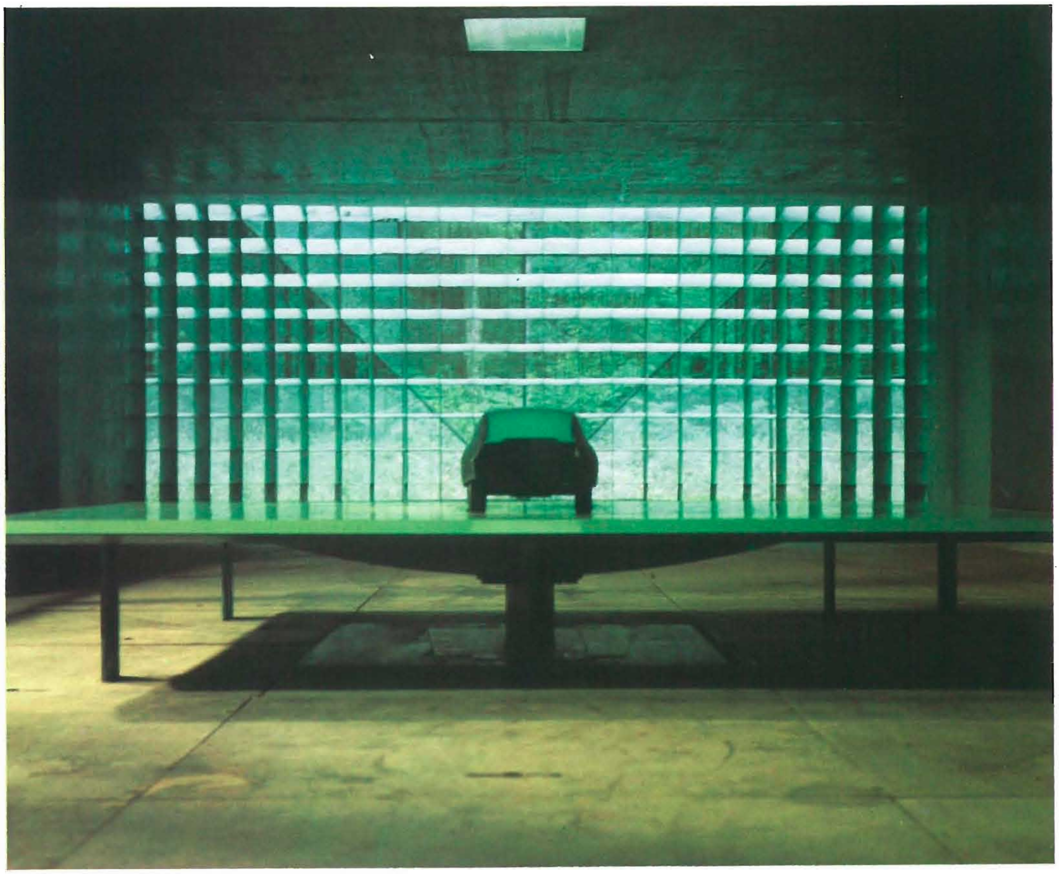
Cz total
Cz sur essieu avant
Cz sur essieu arriere

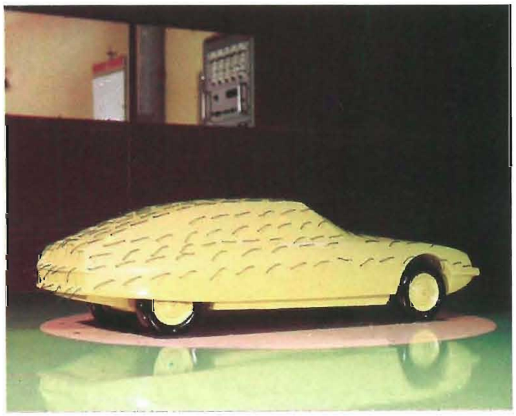


DISTRIBUTION DE PRESSION A LA PAROI DANS LE PLAN DE SYMETRIE

beyond a certain speed the directional power of front wheels is insufficient to insure maintenance of a trajectory. The tests done in the Citroën wind tunnel on a SM scale model have shown no discontinuity in the lift (picture 2 on previous page) and side thrust (picture 3) curves, up to the yaw angle tested j = 20°. To fix one's mind, this angle corresponds to a transversal wind of 68 Kmph for a vehicle's running speed of 200 Kmph. The comparative behavior of the three lift curves shows for example how at j = 15° (that is with a transversal wind of 54 Kmph associated with a longitudinal speed of 200 Kmph) the lift lightens the front axle about twice as much as compared to that induced by motion at the same speed but in still air. The calculation does however indicate that under this latter circustance, the front lifting force of aerodynamic origin does not exceed a value in the order of 45 daN, by virtue of a correct shaping of the front end; quantities so reduced may thus be neglected even in presence of a strong side wind. On the other hand, apparent in the picture beside is the linearity in the behavior of side thrusts with the varying of the yaw angle: the distribution of this force on the two axles gives to the center of thrust a position not too far from the center of gravity, guarantee of a reduced sensitivity to side winds.
The aerodynamic study of the Citroën SM has been completed by a series of tests, destined to emphasize the influence of the longitudinal trim on the different components. Although the vehicles provided with hydro-pneumatic suspensions maintain a constant trim, the knowledge of the efforts to its varying is advisable inasmuch as configurations of this kind may occur casually on the road (high speed braking, 'humping and ditching' etc.).
It is further advisable to get interested in the reaction of a model invested for example by strong wind blasts with random character; even though researches in this field have not yet reached a stage of immediate practical utilization, they are no doubt destined to bring new knowledge in the study of directional stability at high speeds.
2.3.2 - Pressure measurements. The testing of scale models in the wind tunnel is completed by the measurement of pressure distribution on the body,

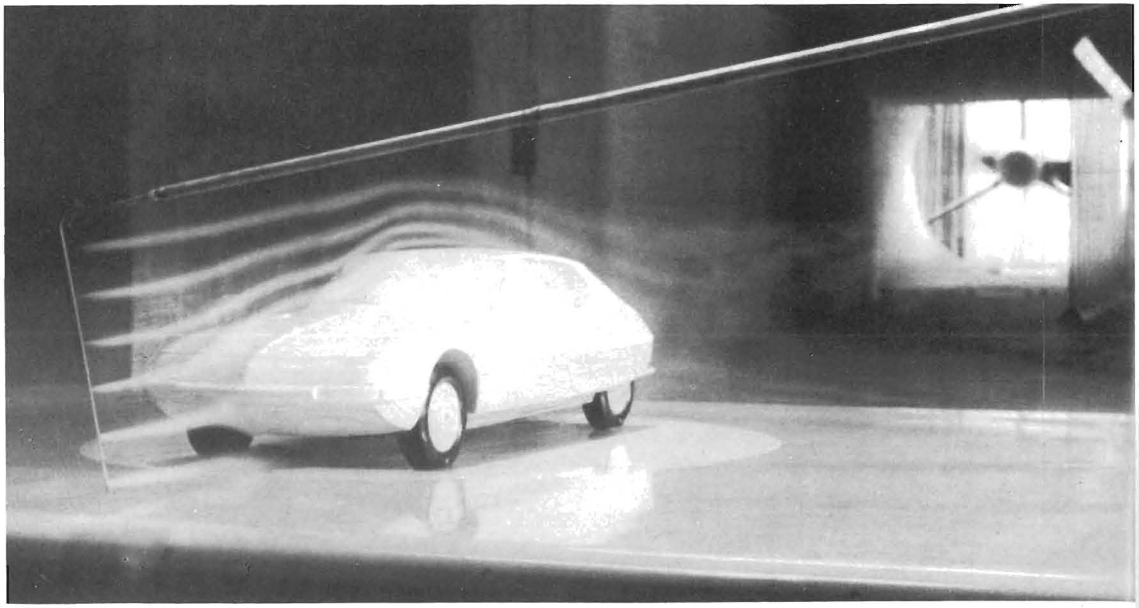


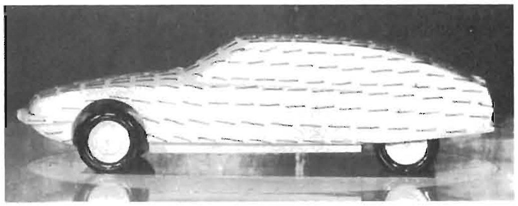


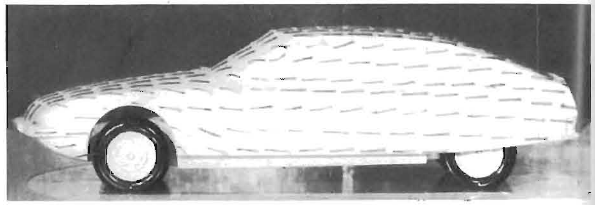


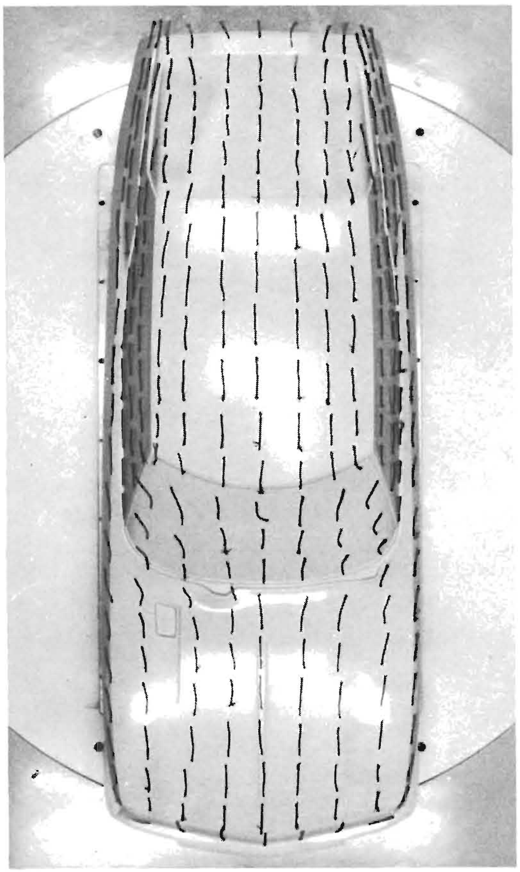
which usually requires the taking of 600 to 700 pressures. As we have already said, the graph of the isobaric curves is indispensable to successfully solve the problems of under-hood air circulation, of interior ventilation, of air entry and exit positioning. The layout on page 46 (at bottom) shows the distribution of static pressures measured on the wall in the symmetry plane of the vehicle.

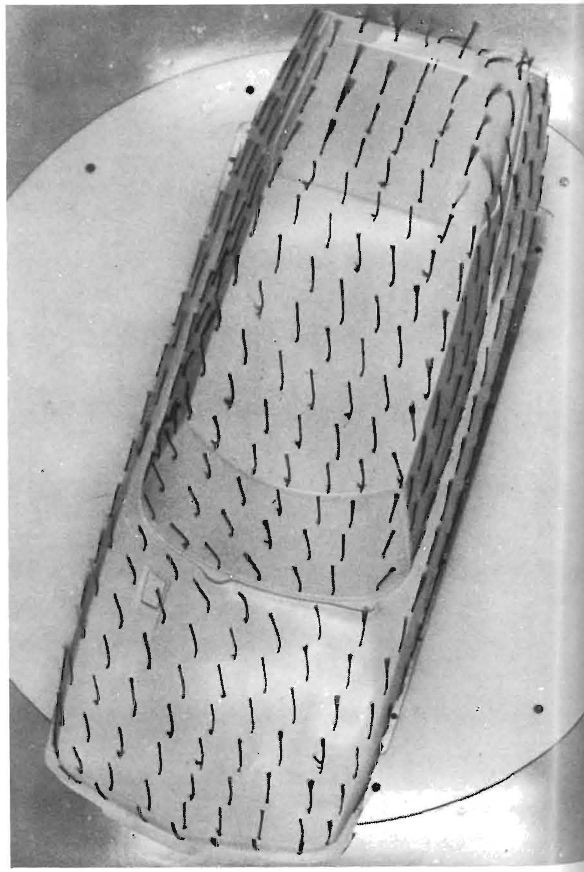
2.3.3 - Flow visualization. Usually associated with the above said measurements are several visualization tests of the fluid flow on the vehicle's walls, by means of smoke or wool tufts; the use of one of the two systems is complementary and not substitutive of the other and together allow a direct understanding of the physical phenomena, particularly useful in case the model is set 'athwart' to simulate a side wind. The quality of the flow may thus be evaluated, visualizing its possible detachments and get sure (together with the examination of the curves of the aerodynamic coefficients) of the absence of abrupt discontinuities in its evolution which might engender unstable forces and therefore start reactions impredictable at high speeds. Astride of these two pages we have grouped a few pictures regarding experiments of this kind made on the 1:5 scale model of a SM in the Citroën 'soufflerie'. The two photographs at top (as well as the color picture on cover) of the visualization by smoke show how on the vehicle's symmetry plane the external flow is just a little disturbed by the presence of the scale model and how the turbulent wake downstream of same is of feeble intensity. The state of the flow on the model's dorsal and lateral walls is instead shown by the photographs of wool tuft visualization (at center and below) presenting - from left to right, respectively - the flow behavior obtained at zero, moderate ($j = 15^0$) and considerable ($j = 40^0$) yaw. From the comparative examination between the first two pairs of pictures, it gives that the flow is scarcely influenced by the presence of moderate side wind (to give an idea $j = 15^0$ corresponds to a translation speed of 200 Kmph associated with a 50 Kmph wind). The third pair of pictures emphasizes instead the turbulent state involving the leeward side and the starting of a small area of detachment on the backlight surface. The extension

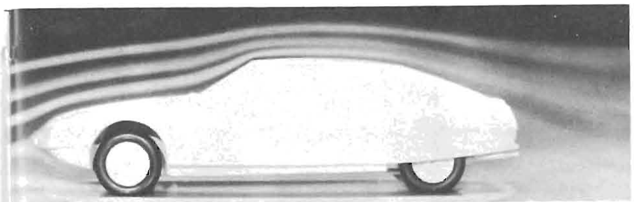
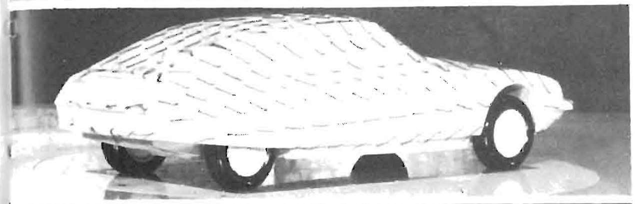
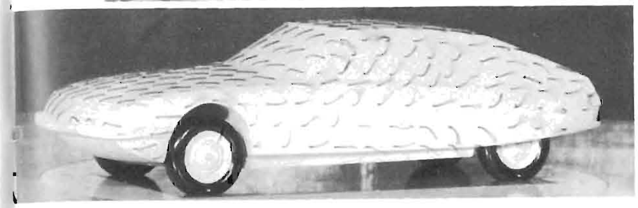
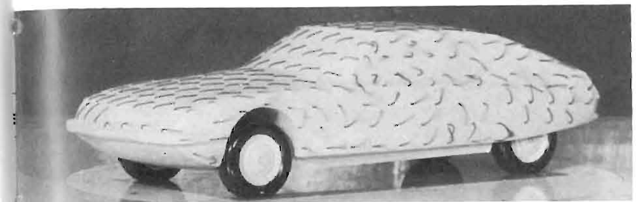
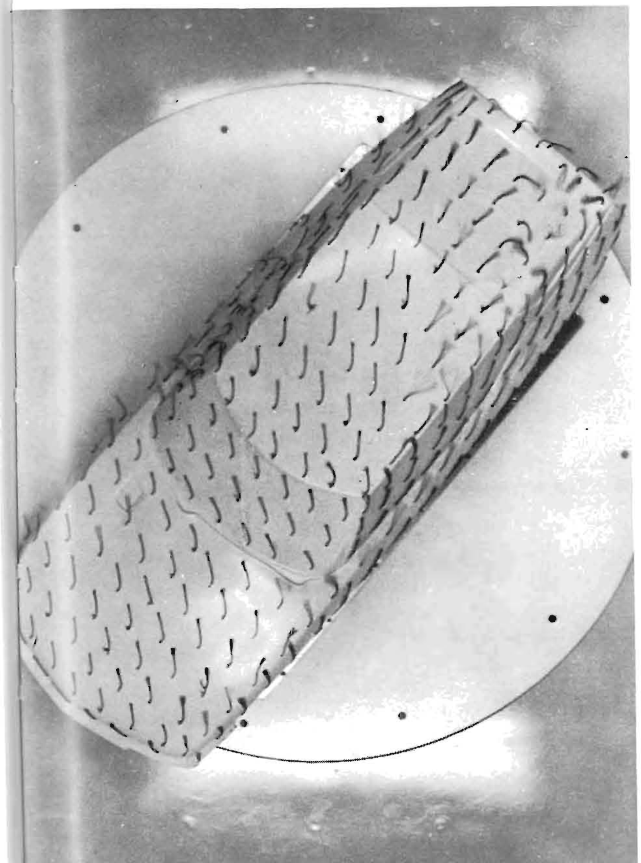










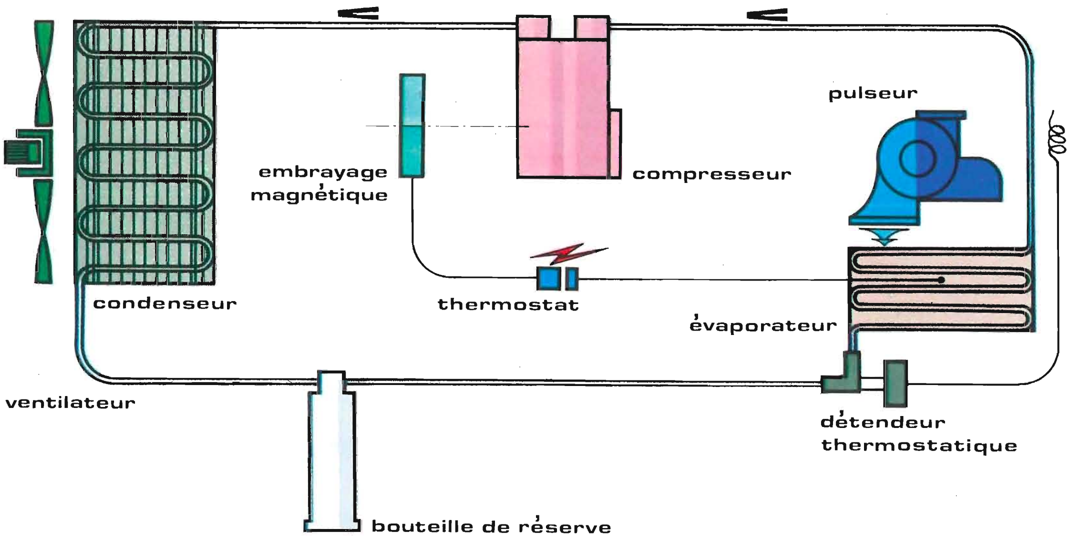
of the transition zones from the laminar state to the turbulent one may be checked, thus permitting to get sure of the variation continuity in the aerodynamic efforts. The last two photographs of this group illustrate the flows settling on the two sides of a vehicle moving in presence of a strong side wind: better than all comments they serve to explain the appearance of the violent transversal thrusts of aerodynamic origin. Here, the yaw angle is 35°, corresponding to a 150 Kmph speed of the vehicle submitted to a wind of about 85 Kmph.

2.4 - Full-size tests. The actual testing of the vehicle (final and probatory stage of its design) is done on the road. It entails, however, a certain amount of drawbacks, above all when it has to be dealt with a prototype to keep secret. Full-size tunnel testing does then present several advantages: first of all being practically reproducible, they enable to carry out a systematic research impossible to make on the road, due to the considerable changes in the parameters connected with weather conditions, road state and altitude etc.; the automated control of the tests and data processing by means of a computer speed up the acquisition of results; it is easier to keep the secret in the laboratory than on the road; in case of special tests one can 'see' what is going on by visualizing the flow on as different as inaccessible areas (brake disc for example), which is inconceivable on the road; some well equipped wind tunnels may simulate various climate conditions, while the testing installation permits to absorb the engine power in different running configurations.

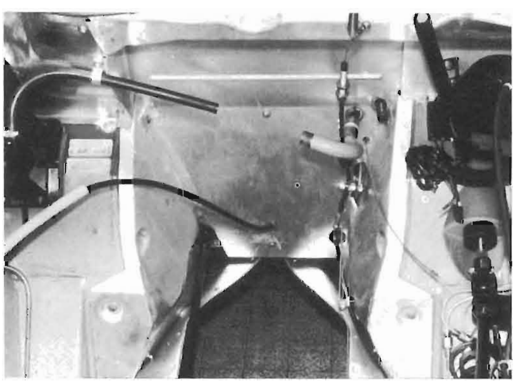
The photograph at far right shows one of the early pre-production SMs during tunnel measuring of air delivery for radiator and front brakes cooling; these tests require the taking from 400 to 500 measures of pressure for each value of delivery. The computer-aided sorting of the data is very fast and allows the utilization of a measuring method otherwise unusable.

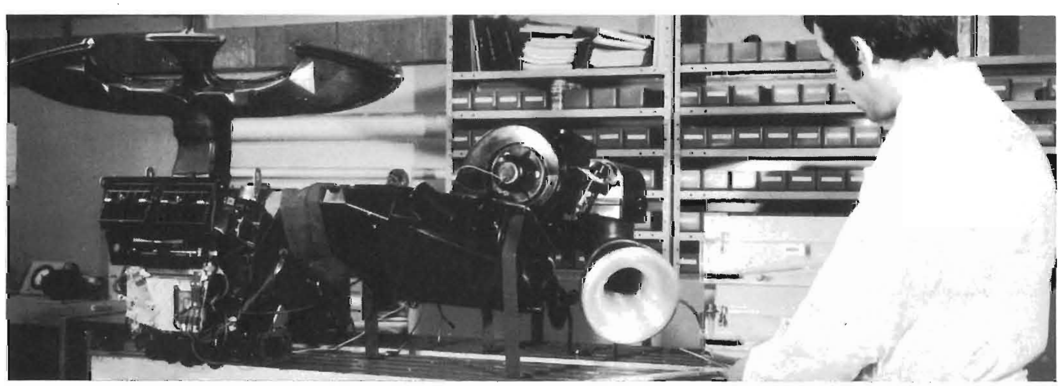
Among the several problems examined and solved through the tunnel experimentation of full-size prototypes, worth noting are those regarding windshield wipers, rear window, air entries and exits, aerodynamic noise, exhaust pipes, ventilation and conditioning circuits.

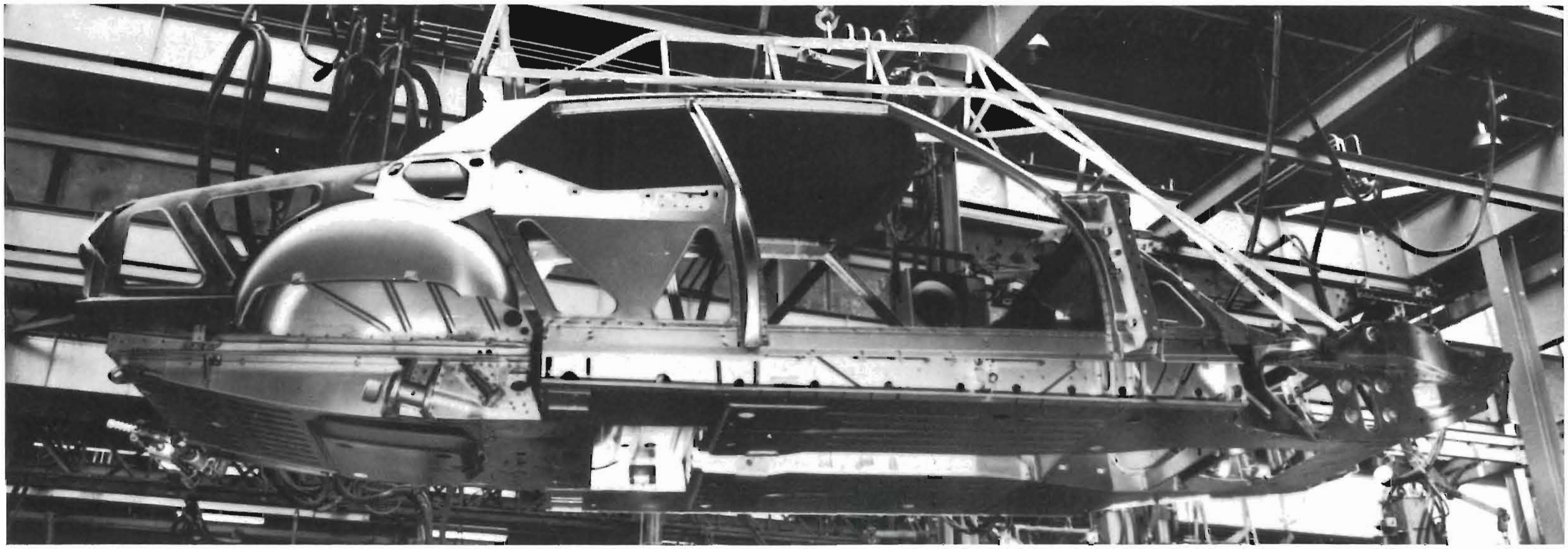
SCHEMA DU DISPOSITIF DE REFRIGERATION D'AIR

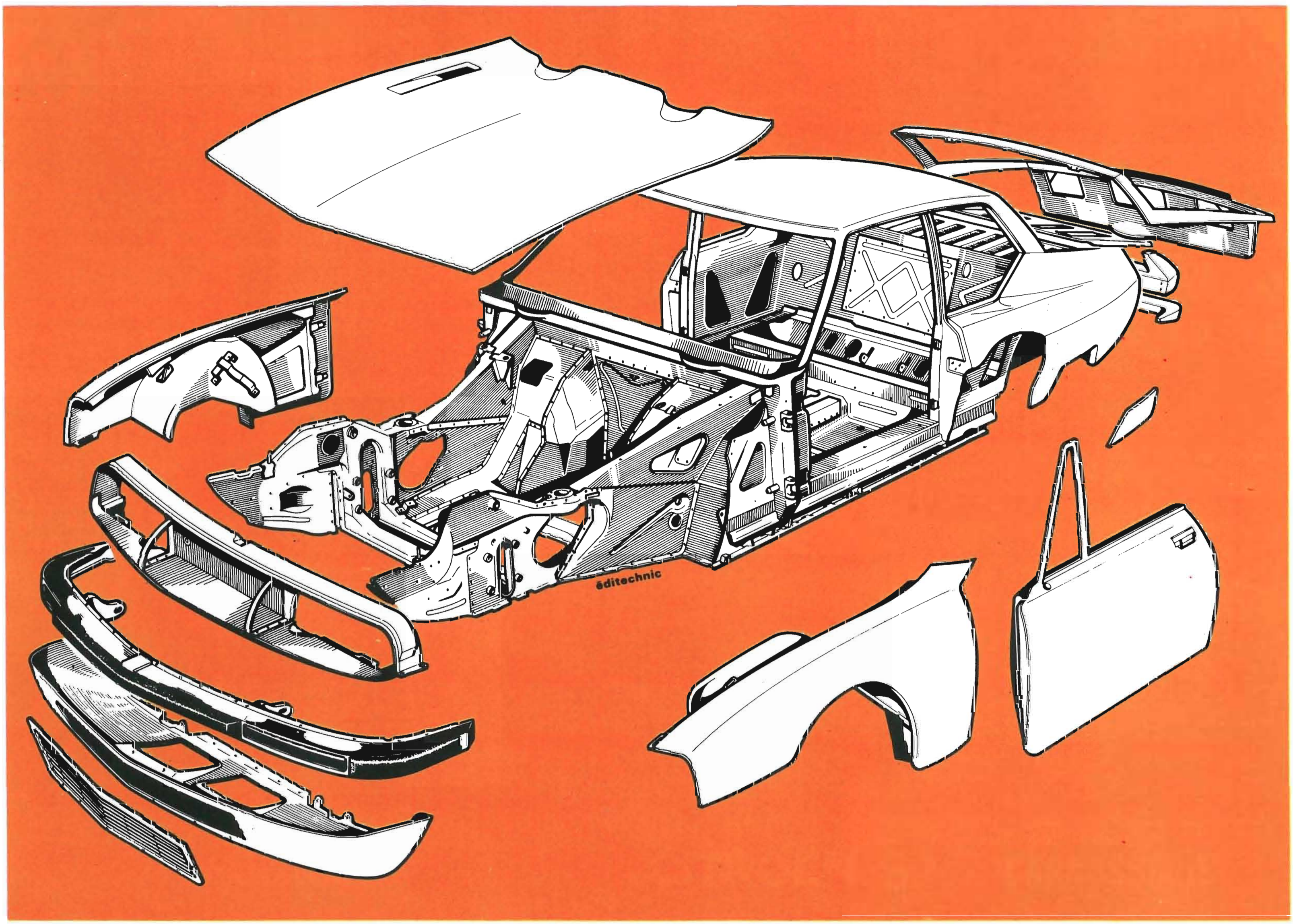


3 - Air conditioning
Interior air conditioning on a car is insured by two functions separate or paired in the latest systems: heating and ventilation.
The combination of these two functions entails an installation often referred to as air conditioner; but a similar device turns out to be inadequate to insure ideal conditions of comfort, when it comes to high values of room temperature and hygrometric rate. In hot and most of all in damp weather, to the ventilation (and heating) system a refrigerating one must be added; in this way alone, real air conditioning may be obtained.
The first generation of car conditioners was conceived independently of the heating system; the SM instead, is one of the first European cars to feature such a combined device. Actually, the advantages appear to be substantial for an external temperature of + 10° C requiring the use of the heater: the air is previously cooled down at about 0° C and dehumidified, then heated passing through the heat exchanger in such a way that glasses do not fog; a further interest is given by the adoption of only one very powerful centralized fan.
3.1 - Requirements relevant with air conditioning systems. Are those of maintaining a pleasant interior temperature oscillating between 18° and 24° C, at the same time of outside values between −20° and + 40° C and variable percentages of relative humidity.
The comfort is defined by the absence of sensorial nuisance. The human body badly adapts to a too intense convection and radiation, wherefrom the need to study an appropriate interior air circulation as well as wall insulation.
Actually, what counts is the feeling of temperature, which is function of: room temperature, wall temperature, air speed, relative humidity (parameters regarding the interior); nature and intensity of the work, dressing degrees (parameters regarding the occupants).
The thermic comfort is not therefore anything but the maintenance of ideal interior conditions even under unfavorable environmental circumstances: when outside is cold, passengers ought to be warm breathing controlled-humidity fresh air; conversely, when it is hot, one should stay within a relative humidity between 30 and 60 per cent and temperatures between 20° and 26° C at most, values which may be obtained only by means of an air conditioner.
On today's cars, the increase in aerodynamic turbulence (source of noise) at medium and high speeds inhibits ventilation through the windows; wherefrom the need to use ducted fans to accelerate the air current and guarantee a delivery independent of the vehicle's speed (cp. distribution layout of static pressures on the walls in the symmetry plane, pg. 46). The adoption of textures, carpets and athermic glasses favors the comfort, same as the thermic insulation between engine and passenger compartments (bottom photographs at left) and all along the exhaust ducting. In reference to warm and cool air distribution, the above physiological considerations command to heat the cold walls in winter and viceversa in summer, which may explain the interior circulation layout adopted on the SM. A significant example of the relationship between temperature and air speed, at constant relative humidity and similar comfort: 24° C in still air are equivalent to 30° C at a 1.5 m/s speed.
3.2 - Working principles of the integral conditioner on the SM.
a) **Heating system:** it must permit the maintenance of an interior temperature pre-selected and independent of the variable parameters such as car's speed, engine rpm, load variations and exterior temperature. On the SM this objective is reached thanks to the adoption of a thermostatic tap, of a four-speed fan and of a zero-pressure air inlet. The hot air produced can go out at foot (before and behind) and at windshield base for defrosting.
b) **Refrigerating system:** it will have to provide a certain amount of refrigeration to make up for the different amounts of heat, such as the conduction, the amount of calories from the passengers (due to metabolism, condensation and humidity), the one due to the sun (outstanding on a car with extensive seethrough surfaces), the losses in refrigeration due to the air exchange.
The refrigerating device used on the SM is of the compression type: the layout on this page shows how it works. A refrigerating fluid (Fréon 12) is compressed and heated by the compressor, then vaporizes in the finned coils of the exchanger (condenser) where it cools down due to the thermic exchange with the air blown; the cooling under pressure brings about the liquefaction of the Fréon. At the liquid state, the Fréon passes through a cylindrical collecting and desiccating tank and proceeds until the expansion thermostatic valve and on to a new exchanger (evaporator); the expansion of the liquid implements its passage to the gaseous state. The calories necessary to the evaporation





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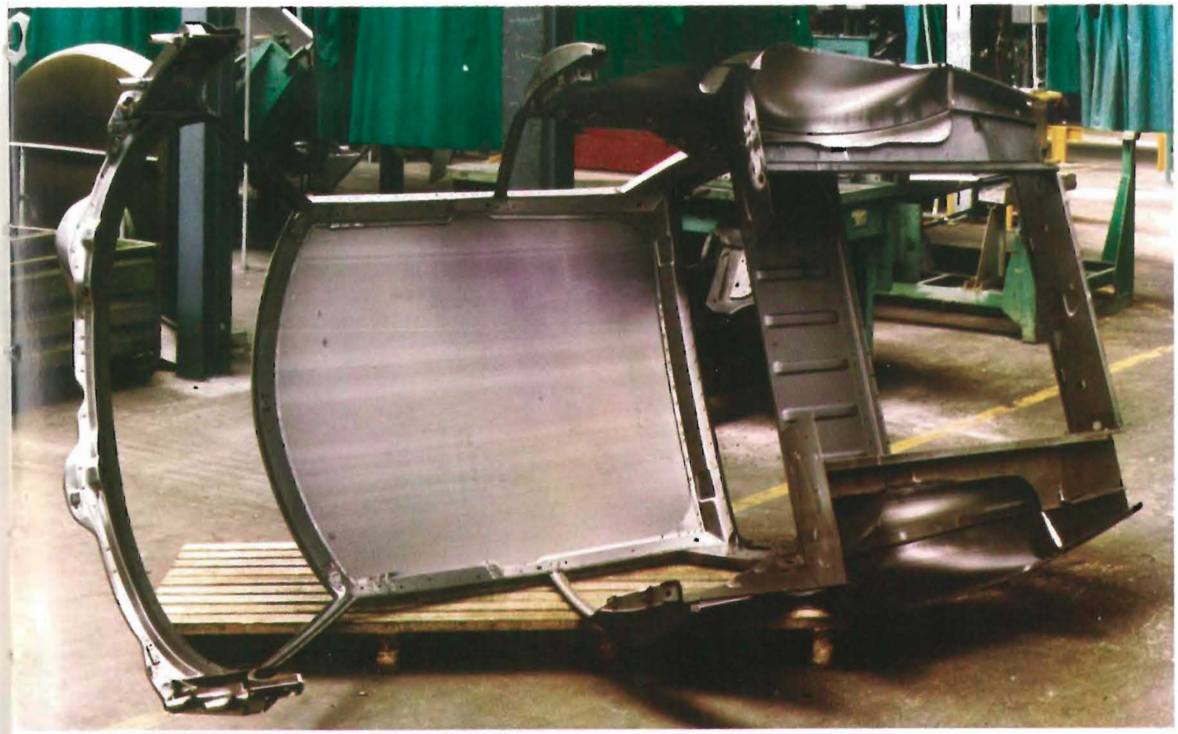
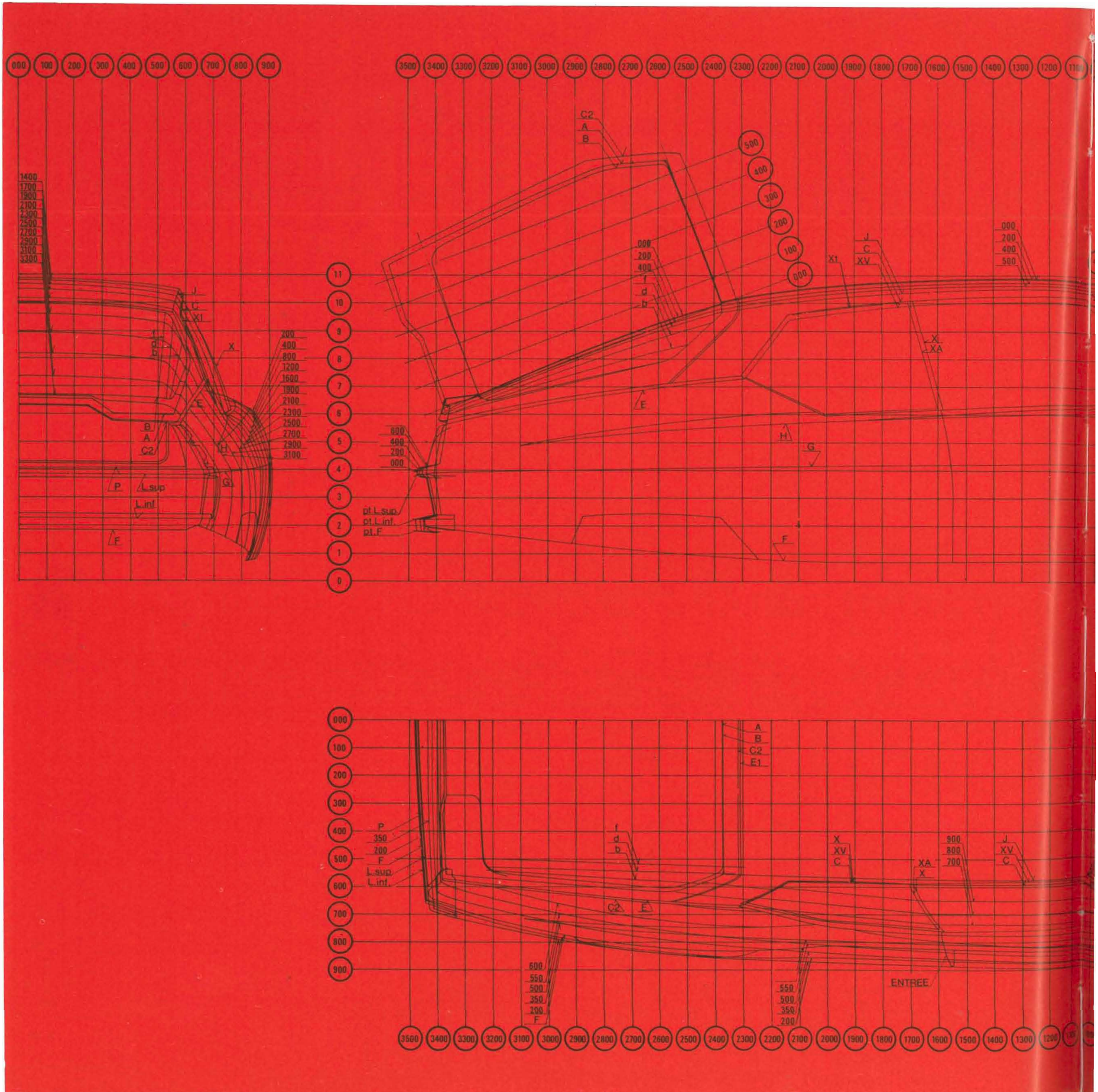


are obtained from the air traversing the evaporator, wherefrom the supply of refrigeration quantities to the passenger compartment. After the expansion, the fluid returns to the compressor and the cycle is again started.

4 - Body production methods and tooling

As in the European industrial tradition and due to the reasons already expressed in more than one case under similar circumstances (high quality productions but comparatively low in quantity) Citroën has entrusted to a specialized external supplier the preparing and manufacturing of the SM bodies. Main tasks of the Body Division of the Sté des Usines Chausson: development and construction of the prototype-bodies; study of production methods and tooling; pressing, assembly and body-in-white finishing. In the Citroën plants of Paris instead takes place the completion of the bodies (painting, trimming), the mounting of the mechanics and the SM final testing. The 1:1 scale model made by the Citroën Styling Center was translated into the preliminary shape plan which made up the basis to the study of the outer paneling. Initially, the underbody derived from the well-known one of the DS, with three variants of fundamental importance: the attachments of the front suspension arms were located before the wheels' axis; the passenger compartment floor was divided along the symmetry axis by the tunnel containing the main exhaust muffler; due to the secondary muffler, to be placed transversally under the rear seat, the anchoring of the rear suspension to the center section of the underbody turned out to be completely under discussion. The detailed study of the underbody was therefore developed in parallel with the exact drawing of the final full-size shape plan, which will be used directly either to make the reference models for the outer paneling dies or to design the body structure. Starting from this structural study - also comprising the mobile paneling (doors, lids, front fenders, etc.) - were made the construction drawings of each piece, then of the sub-assemblies and finally of the assembly units.

The designers of the SM body would have liked the use wherever possible of light-alloy paneling; in the end, only the engine hood with relevant framework.



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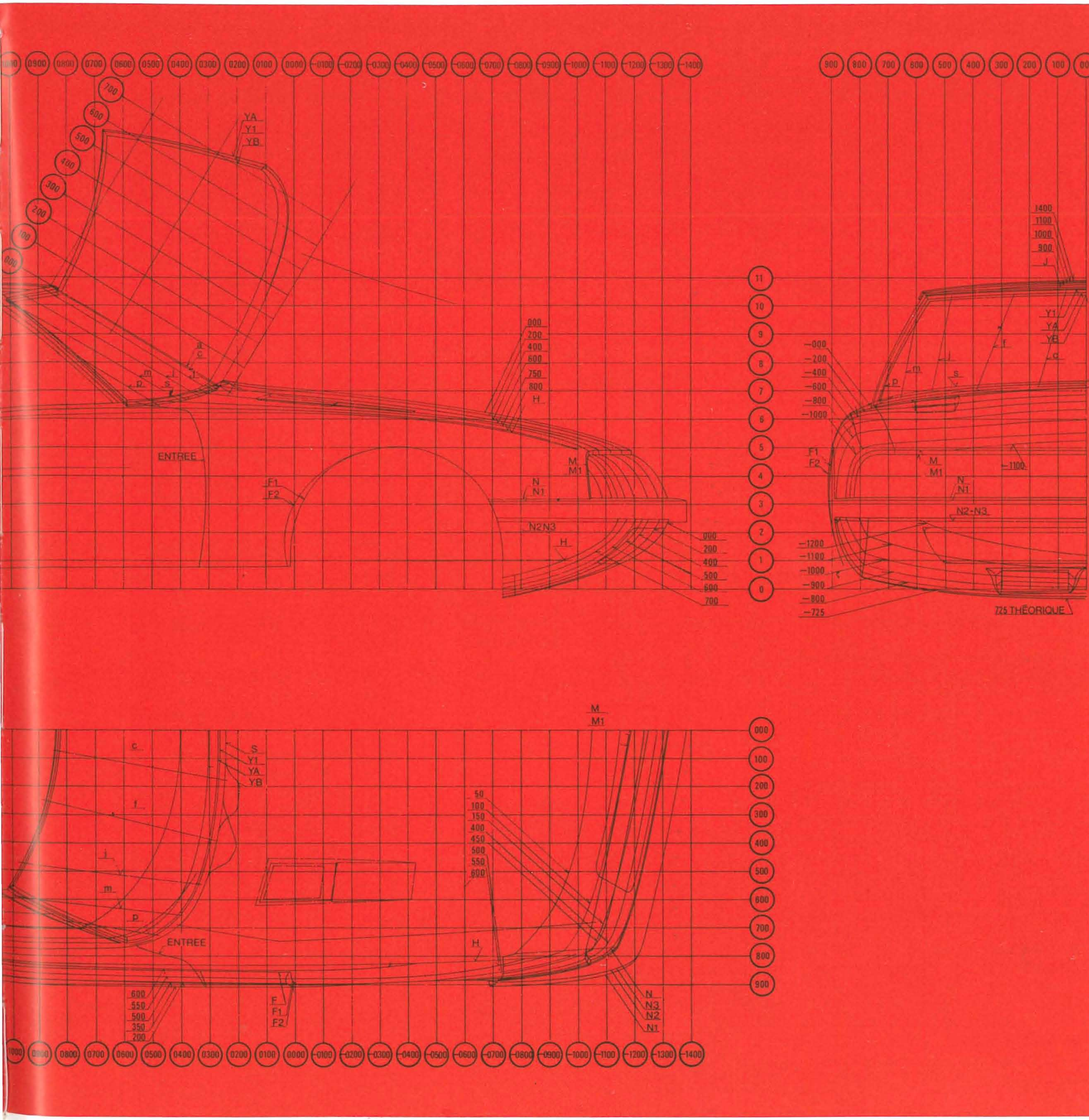
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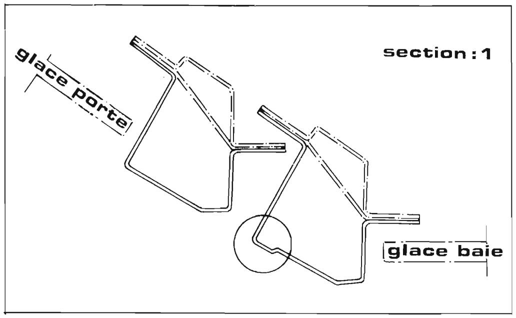
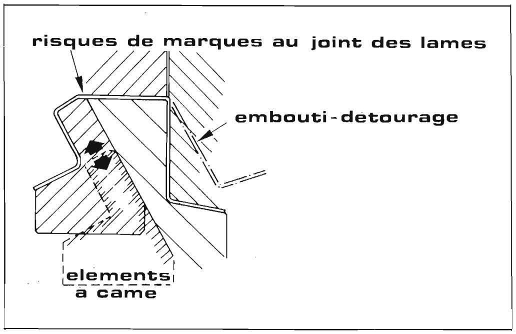
cowling and some ancillary parts such as, for instance, the cooling 'sleeves' of the front brakes, could be kept. Because of dish-out requirements the rear hatch (whose die is shown by the picture on pg. 59, at top left) and because of others of assembly the rear fenders, these had to be built in steel. Even the gas tank was initially foreseen in light alloy: still mounting it were the three experimental bodies (obviously built around an SM underbody and made in two-door 'coach' version) Chausson derived from the DS body shortened and lowered by 10 cm, to enable Citroën to carry out the testing of the mechanics of the future SM in the quietest way possible. For series production Chausson engineering has developed a tank in plastic material (anti-shock).
The first five prototype-bodies entirely done by hand, as well as the six pre-production assembled with dished out parts come out of the presses prior to production startup, were similarly built by Chausson.

4.1 - Pressing methods
The finalization of the Citroën SM - higher-quality car built on a small scale - to the Method service means reducing as much as possible the cost-quality relationship, which implies the search for rational and fully-reliable production technologies. To achieve these goals they have two ways at their disposal: to develop a specific tooling expressly conceived for a limited production and to intervene on the product through the interdependence between methods office and body design center. The comprehensive and competent collaboration of the latter enabled the former to obtain several worthy compromise solutions. By way of example, the following drawings show the modifications required by the Pressing Methods to windshield pillars and rear fenders, as well as the choice of the dies for fabrication of door outer panels and of the inner one of the engine lid.

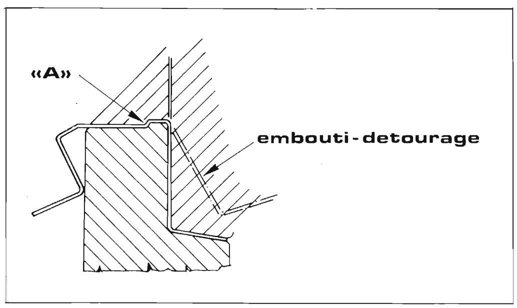
4.1.1 - Windshield pillar dishing. At left, section (1) of the windshield pillar (1 mm thick sheet steel) as it had been originally conceived by bodywork engineers; at right, the modification required by the Methods, regarding the exterior appearance alone.



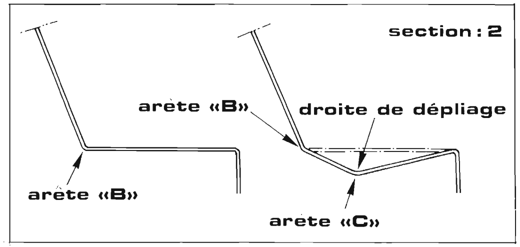
The windshield pillar is an 'appearance' element (that is, it must not show any surface flaw); the door opening restriking operation required the use of a cam-die to keep the piece in place.



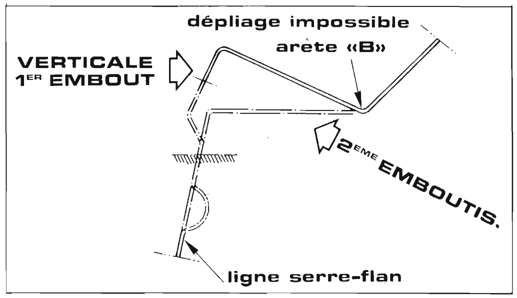
After the modification the sheet steel can be kept in the 'A' point and a traditional forming-restriking die is enough. Investments turn out to be reduced and quality of the piece improved.



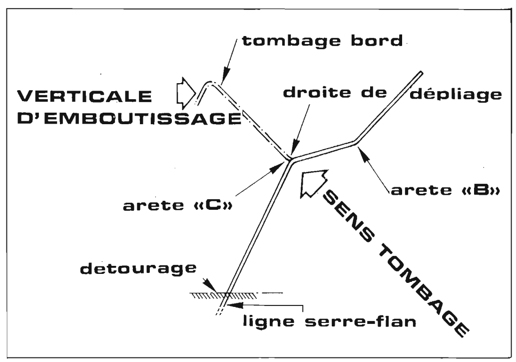
4.1.2 - Rear wing dishing. At bottom of the rear fenders, was originally foreseen only one crease as shown in the following cutaway drawing (section 2, at left) by the 'B' edge; being a line of style belonging to two non-square volumes, it is a curved profile. The modification required by the Methods (section at right) was the introduction of a straight dihedron 'C' to allow bending of sheet steel (0.7 mm thick) without rippling it.



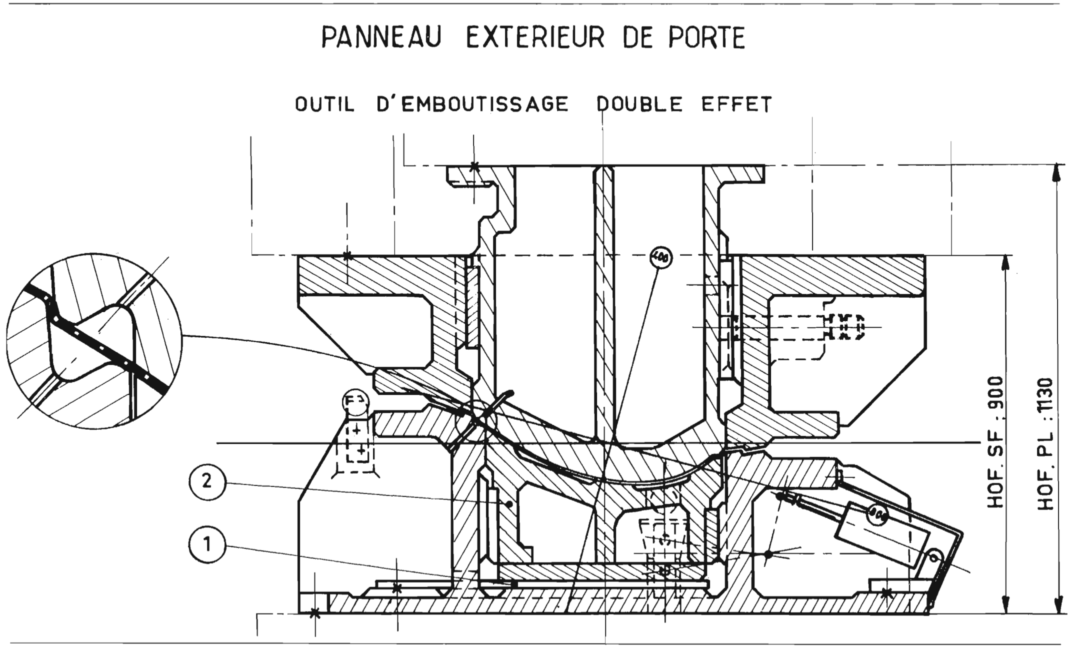
Before the modification, the appropriate dishing ways would not permit the obtainment of the lower edge without a complementary dishing-out operation due to the impossibility to bend the 'B' edge.



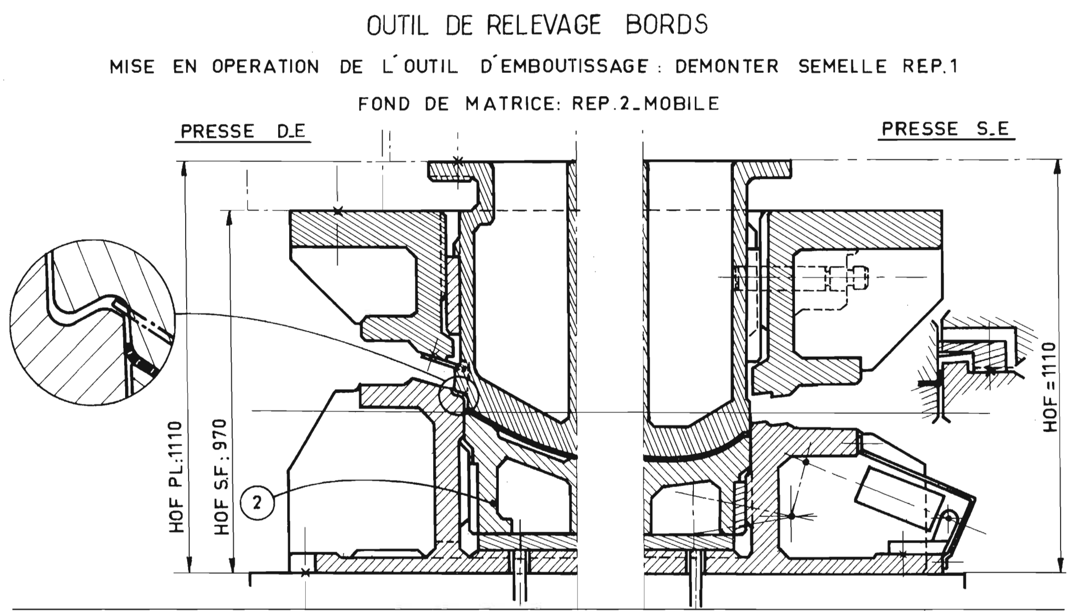
After the modification both dishing and the following operations are simplified; the lower edge is obtained through a simple bending operation around the 'C' edge, without resorting to supplementary dies; the cost/quality relationship appears to be ameliorated.

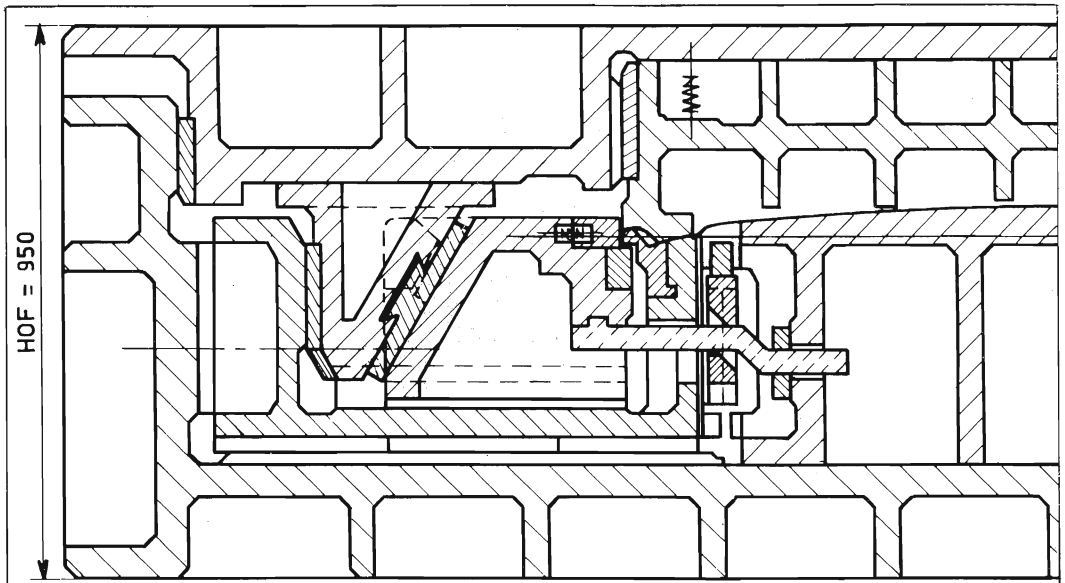


4.1.3 - Door outer panel dishing. The die (top picture) for the double-effect dishing of the door outer panel was conceived for use in the edge bending operation. The sequence of operations is as follows: dishing on 4500 kN (450 t) double-effect press; piece stocking; edge bending. Because of stocking after trimming, this solution is possible only in limited productions.

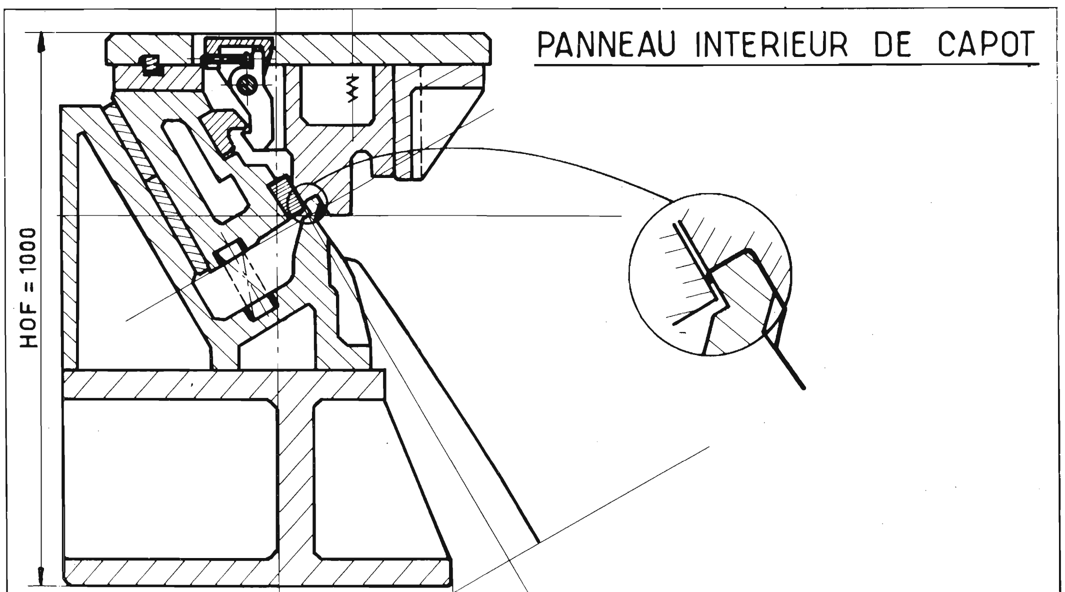


The left-hand cutaway (picture below) shows the dishing die transformed for the edge bending operation. The base (1) has been removed and the counterform (2) has become mobile. The die is mounted on a double-effect press.
The right-hand section shows the same die mounted on a single-effect press. Pins have been added to fix the blank holder, as well as the extractors to draw out the piece.





1 ère SOLUTION (NON RETENUE) : RENVOI BORDS LATERAUX A CAMES

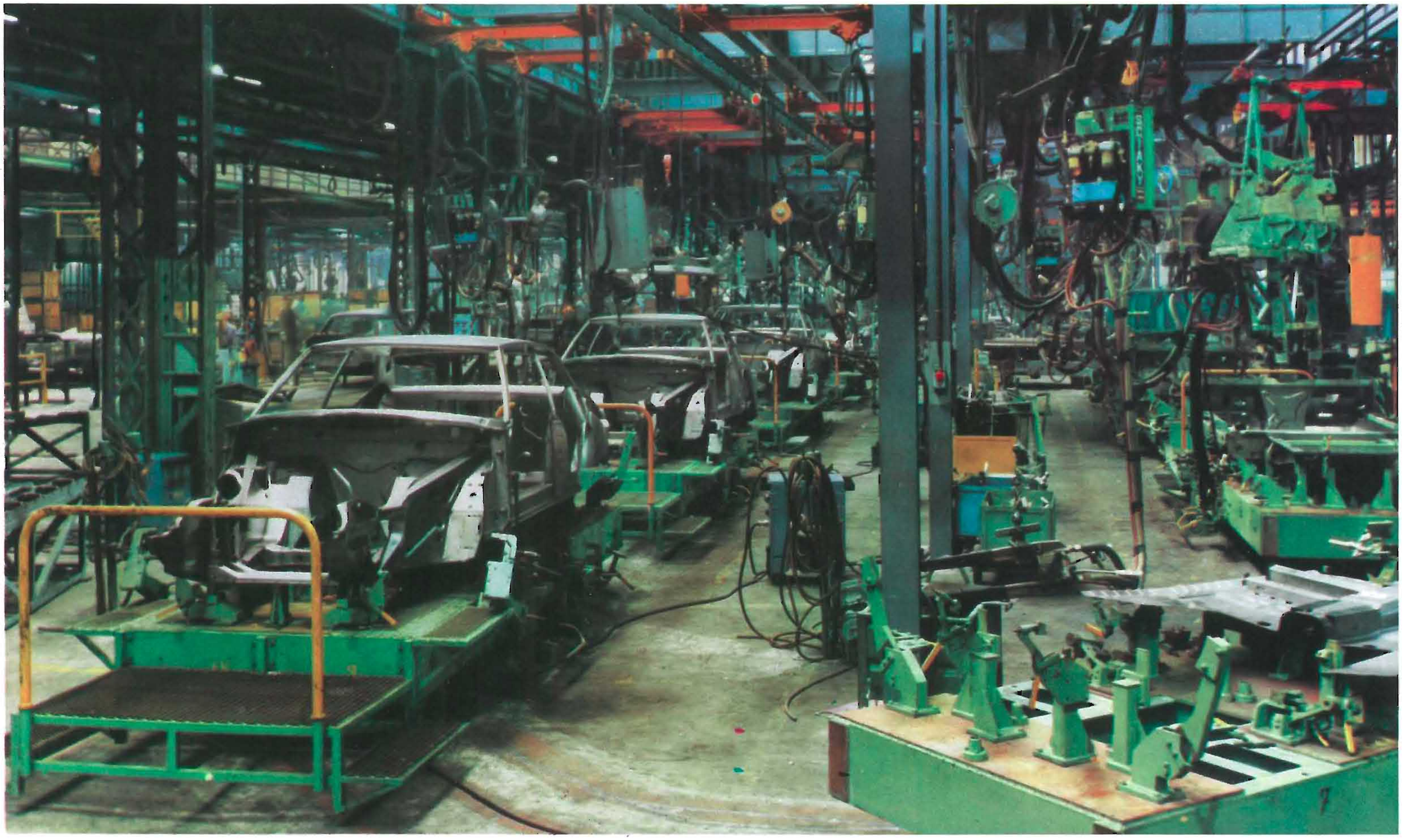


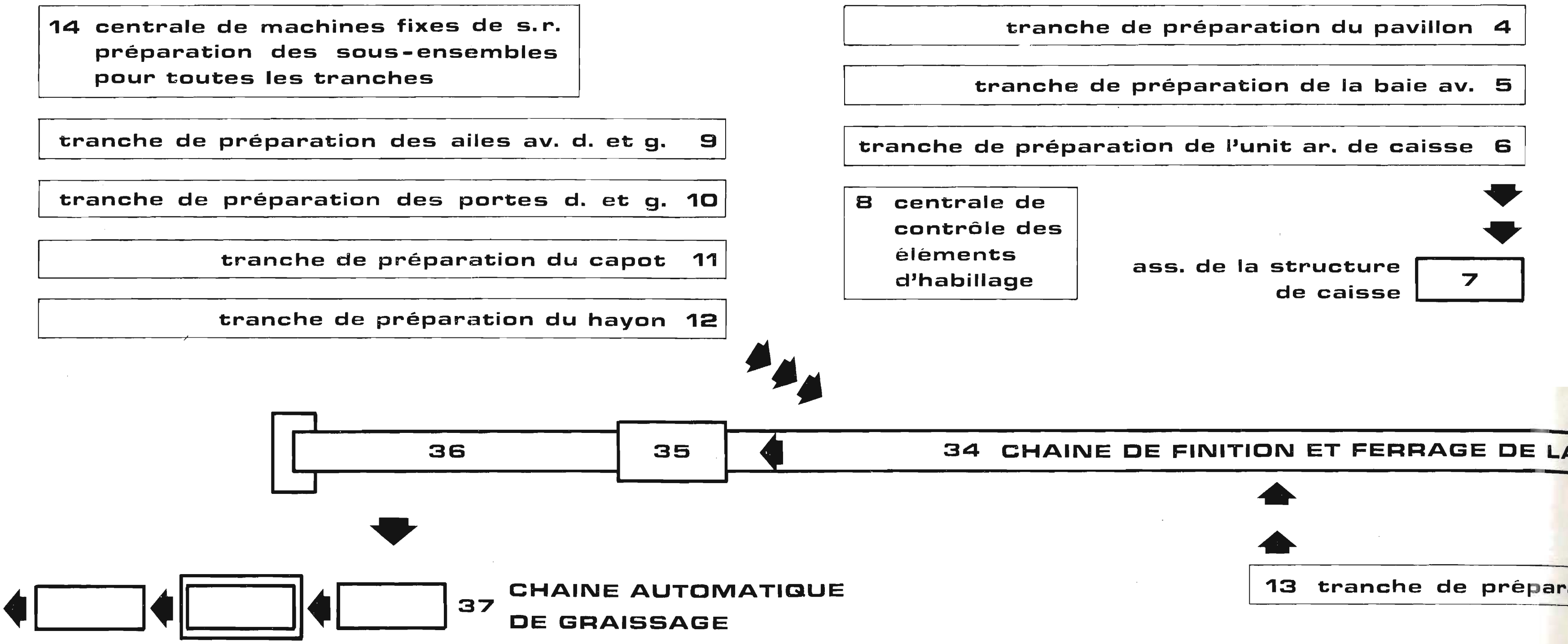
2 ème SOLUTION (RETENUE) : RENVOI BORDS LATERAUX, OUTIL BIGORNE

4.1.4 - Hood inner panel dishing. To fabricate the engine lid inner panel (A7U2G light-alloy sheet) the pressing methods required profound changes in function of the dishing characteristics of this kind of material.
The top picture shows the side edge flanging die, foreseen in an early solution. This cam die required mounting on a large press (4500 kN) and expensive automation for extraction of the piece and this solution was thus put aside.
The lower view shows the type of die finally adopted as best solution to the problem; this is mounted on a small eccentric press (1500 kN). To perform the edge-flanging operations two dies have been necessary but, despite it, such a solution turned out to be the most advantageous.

4.2 - Body assembly
This stage of production, tooled in view of an hourly output of 5 units, presents rather severe requirements, the main of which being:
1) high-precision machining on the assembled body-in-white, for subsequent attachment of some mechanical units;
2) particular assembly quality;
3) outstanding quality in the overall appearance of the above ensemble.
Point 1) demands the use of a very complex machine, whose main feature consists of a clamping of the body independently of possible costruction defects, so that when it is released, ripples in the sheet metal are not engendered such as to prejudice the exactness of the machining done; on the other hand, the bodywork must be built with very precise geometric qualities in view of further processing. This, led

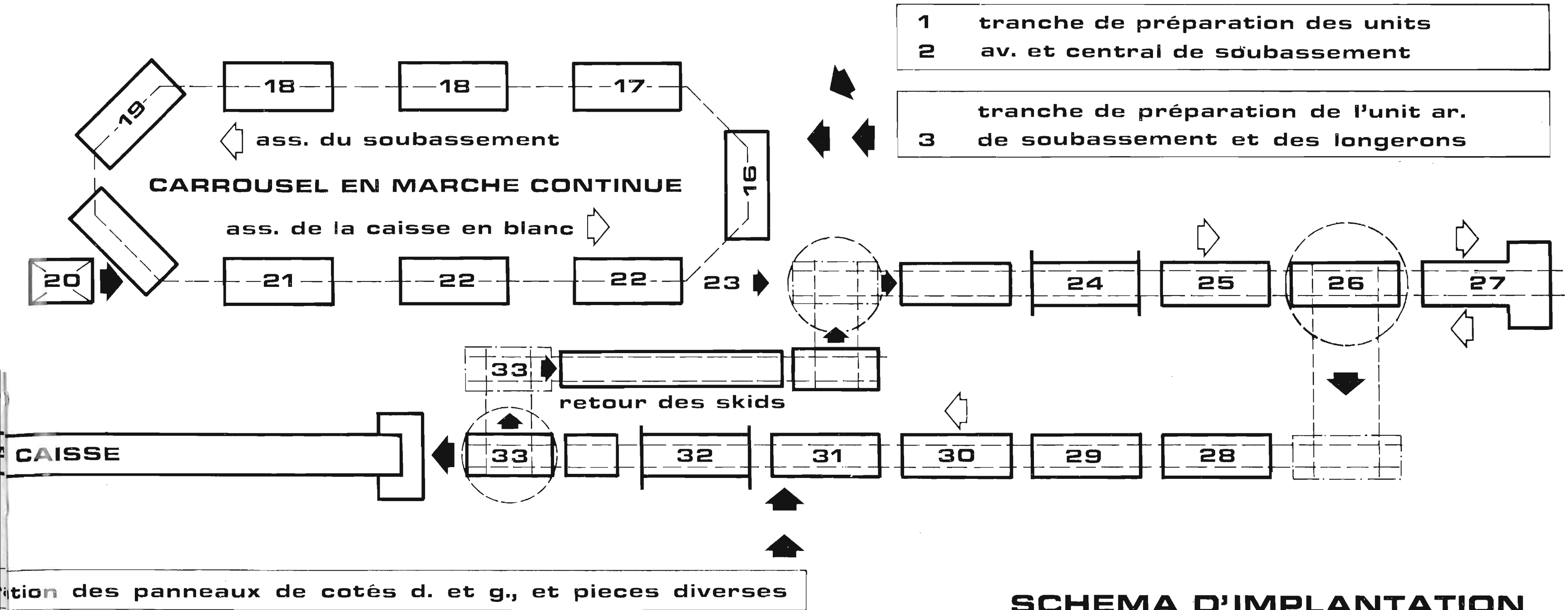






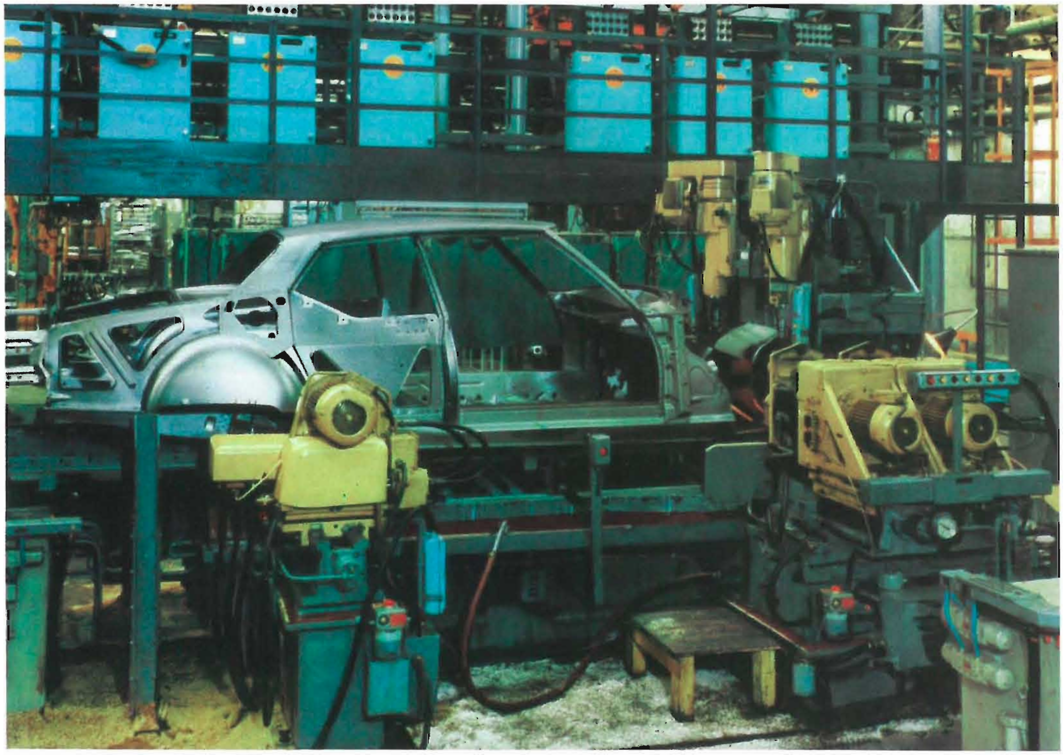
Chausson to develop technologies suitable for reducing to the minimum assembly deformations: the solution adopted in this case is that of a non-stop carrousel composed of a sequence of 9 tooled trucks, on which the underbody elements are clamped insuring dimensional constancy of the locators and correct positioning of the parts to be welded. The truck goes through all the stations of the carrousel, where various auxiliary hanging jigs insure loading and assembly of the successive elements until body-in-white completion, excepting the welds under the body which are done outside the carrousel on a turnover tooling. Also the body main subunits are assembled on precision fixtures and checked on reference samples prior to final assembly.
Point 2) calls for a steady checking of soldering materials and for a permanent testing of assemblies operated.
Point 3) requires a very high degree of body-in-white finishing, specially of its exterior surfaces (visible paneling, covering, etc.). To obtain this, the most appropriate means ought to be applied, such as for example the rear hatch seaming, done on a very complex hydraulic tool permitting to reach a quality otherwise impossible to obtain through a normal operation.

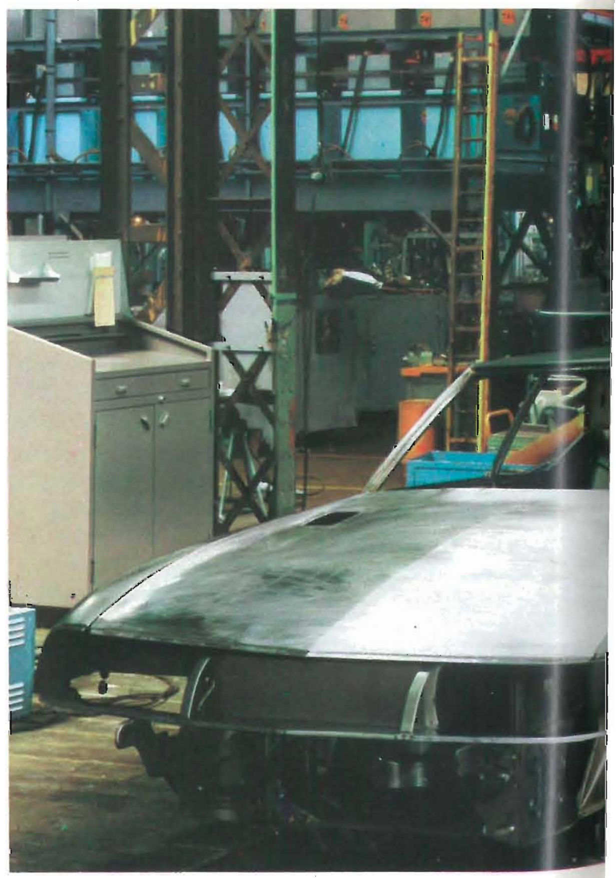
4.2.1 - Description of the assembly shop.
The numbers refer - in groups of logical sequence and in order of chronological development - to the operations schematically indicated in the above layout; from no. 1 to no. 14 they regard subassembly preparation, from no. 15 to 37 the carrousel and assembly line.
1) Preparation of the underbody front part in a sequence of fixed and revolving fixtures equipped with spot welding booths (that is with the usual hand-operated gun-welders) and others with semi-automatic gas arc-welding;
2/3) preparation of the underbody rear and center parts, spot-welded on fixed fixtures;
4) preparation of the greenhouse, on a sequence of fixtures comprising a trimming tool for the junction lines, one for the assembly equipped with arc-welders and touch-up booths for welds, which must be invisible; 5) preparation of the windshield frame, on fixed fixtures provided with protection copper to avoid spot marks; 6) preparation of the rear body structure, on fixed fixtures equipped with spot-welders;
7) mounting of the greenhouse/body structure assembly by spot-welding on a fixed tool of the interior mock-up type with hydraulic clamping, integrated by suspended plugs for windshield and rear hatch openings (see color pictures on previous page, at top right); 8) outer paneling control station, equipped with reference samples for each subassembly;
9) preparation of the front fenders, right and left, on a sequence of fixed assembly fixtures provided with gun-welders and hydraulic seaming tool, on which their rear edges are refined in only one pass; 10) preparation of the doors, right and left, on a series of fixed fixtures, equipped with spot and oxy-acetylene assembly booths, and on a seeming hydraulic press provided with



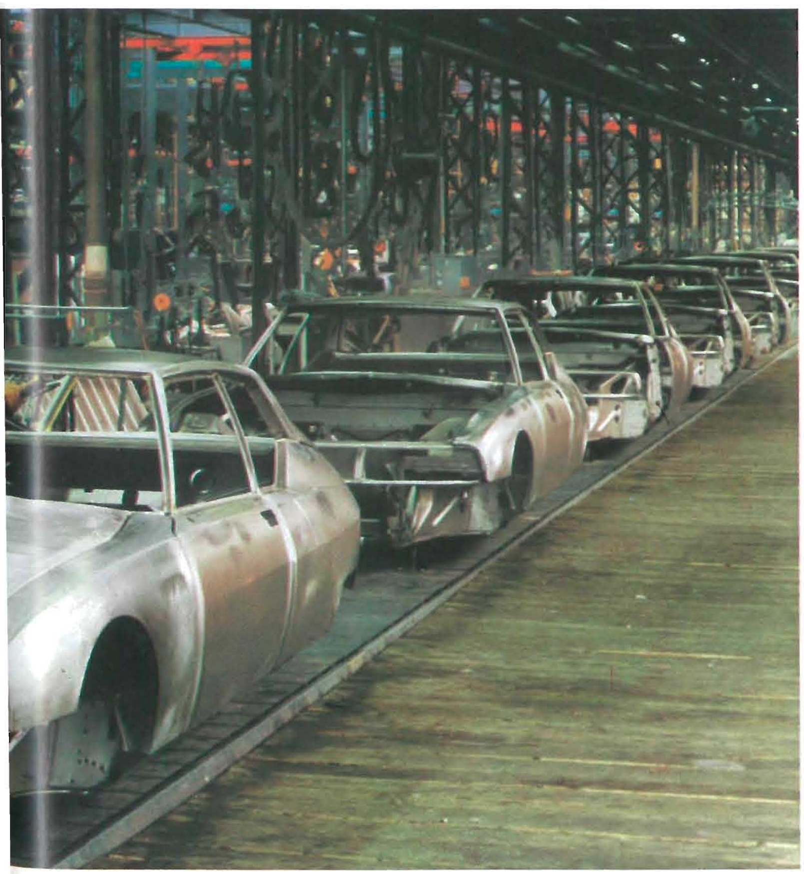
SCHEMA D'IMPLANTATION DE L'ATELIER D'ASSEMBLAGE

a four-tool automatic "tourniquet";
11) preparation of the rear hatch, on spot assembly and seaming fixtures in a single pass; 12) preparation of the engine lid, on fixed and revolving fixtures with spot-welding booths composed of high-power transformer-guns for welding of light alloy without pickling; 13) preparation of side panels and various items, spot and arc-welding on fixed tools; 14) welding station, to assemble the different subunits needed by various preparing depts;
15) continuous-run carrousel, made up of 9 identical trucks tooled for underbody and body-in-white assembly (photograph on previous page, below) in whose stations are carried out the operations of: 16) loading on the truck/fixture the three parts composing the underbody; 17) assembly of the aforesaid parts one to the other; 18) loading and assembly of subunits complementary to the underbody (long members, front posts, etc.) with the aid of hanging and portable jigs, as the truck passes by fixtures and spot-welding booths; 19) different arc weldings on the underbody; 20) traslation of the greenhouse/side structure toward the carrousel by hanging jig, studied in view of stiffening and retaining the structure during motion, in order to avoid whichever deformation; 21) loading of the same on the "chariot" already carrying the assembled underbody; 22) assembly of the greenhouse/side structure to the underbody, by means of spot & arc welding and overhead jigs synchronized with the underlying truck, comprising two side frameworks insuring the door openings, inserted on the platform and rigidly caged within them by means of the two windshield and rear window jigs;
23) picking of the assembled body from the carrousel and setting on a roller train for fixing the rolling sled; 24) completing of underbody welds on a turnover device equipped with arc and spot welders (color picture on following page, above); 25) checking model for dimensional control of the parts to be machine-tooled; 26) traveling lift for body raising to the height of the machine tool, re-descent to the lower level, and transfer to the second tract of line;
27) body readying for the mounting of mechanics - suspension and steering - through its processing on a mutliple automatic machine tool comprising (see color picture at left on the following page): a center section for body clamping, with relevant hydraulic dampers for vibrations; two front ensembles, right and left, each consisting of five-tool horizontal heads for the drilling-boring of the front suspension arms attachments; always in front a group with two vertical heads for boring of positioning holes of the steering relay supports; finally two rear ensembles, right and left, each with a boring head for the fixing of the relevant suspension arms; 28/29) two booths for completion of the aforesaid processes, tooled to make different threading, drilling, deburring and various finishing operations on the front and rear suspension attachments; 30) checking

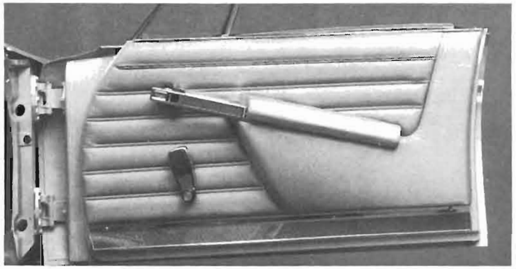


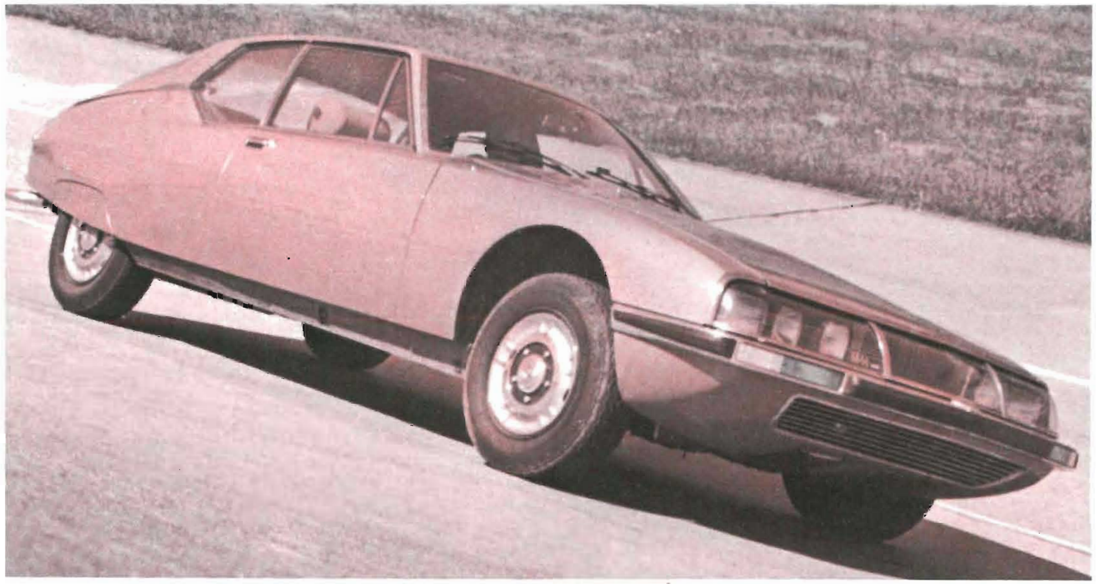


on elevator/fixture of previous operations and underbody welds; 31) assembly of the outer side paneling (rear fenders) on fixed fixtures equipped with spot-welders and one arc-welding booth; 32) finishing of previous welds and mounting of the steering relay supports on a turnover fixture equipped like the preceding one; 33) transfer of the body to the next line, release and return of the sled by means



of 2 translators and a ground conveyor; 34) body-in-white hardwaring and finishing line (color picture below) composed of 10 stations for various brazing and discing operations as well as for the mounting of doors and lids, headlight crosspiece and front fenders; among these stations we note that (35) of appearance control and the last two (36) meant for possible touch-ups after checking;
37) automatic greasing line - with electrostatic application on bodies-in-white - prior to their final buy-off from the Chausson plant.

On the previous pages we have aimed at emphasizing those information - regarding body design and production - our readers should be most interested in, rather than dealing again with subjects already exhaustively developed by the specialized international press. To the pictures of these last three pages of the article is therefore entrusted just a function of visual reminder of the aforesaid subjects: besides the most significant exterior views of the car (which underline a certain styling 'redundancy', incoherent with the 'scientific' essentiality of the shape design), a concise but adequate illustration of its interior as well as some particulars worth noting, complete the presentation in Style Auto of the Citroën SM.