

WHY CITROËN



J-P CHASSIN

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by J. P. Chassin

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by John P. Chassin

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Editor's note:

The number of books printed was rather small and few books survive in good condition. My goal is to make this landmark book more widely available, in a portable format.

The book was originally printed in a more difficult to read 8-1/4x 5" size. This Adobe Acrobat version is done to make it possible to print it out on standard 8 1/2 x 11" paper. If you don't have Acrobat Reader, it is freely available on the Internet.

I have made every effort to retain the flavor and intention of John's work. John's second language was English, so the reader will be aware of his sometimes singular style, which includes a unique wit. Again, I made no attempt to make changes or "improve" on his work, unless they were to make the book more readable or easy to follow.

Remember that this was written before the Internet came along, and repairs were often done with the knowledge and materials at hand. Though the cars were newer, the availability of parts was, in many cases, more problematic than now. Thus, many of the procedures here will have been improved upon or may have been supplanted by better ones. Some may even have been proved to be not as beneficial as thought at the time. Many materials used have been improved or may not be available anymore. Many products described have changed or are no longer made.

With all of this in mind, it is still an educational and entertaining read. It has significant importance in the history of Citroen, particularly here in the U.S. Service, even in those days when dealerships still existed, was done in many cases by the owners themselves.

I have included the list of articles that were in the original book which were in the printed in the old Citroen Car Club newsletters. The articles themselves are not included and may be difficult to find. This section is included for completeness and may not be useful to you, but you can still get an idea how much was being done in those days to keep the cars in top condition. Let's be thankful for the work done by these people to allow these cars to survive these many years for our continued enjoyment.

To Ann,

My Wife

INTRODUCTION

This book is a recap of material published piecemeal in the past some 20 years. The purpose is to help and explain to the Citroën owner what, how and why his car (or his cars) did or did not behave as expected.

This book is not intended to cover each and every detail of every Citroën model that was ever produced. It is an eye opener expected to give you a better understanding of the Lefebvre design philosophy. Lefebvre was an aircraft designer who also designed racing cars. He designed the Traction Avant 15CV from the already revolutionary Traction 11CV. The 11CV was a 1935 design, using front wheel drive, unit body construction, large travel suspension and somewhat "modular construction", new techniques in large production models. The 15CV was a bit larger than the 11CV with the same body style. A six cylinder engine instead of a four powered the beast at speeds up to 100 mph. Lefebvre modified the 15CV by increasing the wheel travel, therefore increasing the comfort and stability, by increasing the accuracy of the steering, and by changing the overall balance of the car to improve its dynamic behavior. Finally, he added the famous hydropneumatic suspension to the rear axle of the venerable "Queen of the Road", making it the ultimate in comfort, speed and stability, even by today's practical standards.

The Citroën philosophy of large travel suspension was also applied in the A models with the 2CV, as far back as 1934. This model was not going to go into production for another 14 years due to World War 2.

As far back as 1938, Lefebvre had conceived a new vehicle using steel unit body on which the body could be "hung" and quickly replaced for model changes or repairs, in which the engine would be in the "midship" layout. Front wheel drive and trailing arm suspension were a must of the time (VW and Porsche were using the trailing arms but pushing the cars instead of pulling them). The chassis was designed in such a way that it would, in case of impact, collapse gradually, absorbing energy and relatively gently slowing the vehicle. The suspension had the large travel requirement and Lefebvre wanted it to be capable of following any road condition like a stylus follows a groove in a record . . . or better. The suspension had to be extremely soft and pliable and yet capable of rapid recovery. It had to be soft and yet not collapse the car to the ground when five passengers climbed into the car. A suspension capable of adapting automatically was designed and the hydropneumatic suspension born.

Such a vehicle, using the 11CV's engine could, with the aerodynamically clean body Lefebvre was to wrap the car in, go over 100 MPH on anything that was not sand, mud or water. Commensurate brakes had to be designed.

Lefebvre expected the car to be produced with the 11 CV's engine for a few years, later to be widened for a larger engine giving over twice the power, allowing for a theoretical top speed of 150 MPH. The chassis, the suspension and the brakes were designed for such a top speed, as far back as 1938 and are found in the SM model, driven by a Maserati engine. Since the front wheel bearings were enormous, almost a foot in diameter, and were heavy, the front brakes were installed INBOARD, next to the gear box. They were installed on F1 racing cars in the early 70's. Drum brakes could not dissipate enough heat and new types of brakes were designed: disc brakes.

Since the car ran on hydraulics, power brakes were easy to design into the system. A power steering was designed, that, unlike common power steerings, was able to "see" the angle errors of the front wheels caused by road irregularities, and able to correct them. Lefebvre also conceived the idea of adding the variable assist commensurate with the speed of the vehicle.

A vehicle was designed, far ahead of the technology of the day, with a soft suspension allowing for a light chassis, a nimble vehicle that ended up being capable of going through anything reliably comfortably and safely.

Later, the Citromatic was invented, followed by an automatic gear box on DS23 fuel injected models and SM models.

The GS model came out in 1971, using a simplified version of the suspension that would have horrified a purist like Lefebvre. The suspension was "tested" satisfactorily until 1974 when it was designed into the CX models, the SM models keeping the sophisticated early DS suspension until the end of run in 1973, when it was "killed" by the energy crunch.

A lot more can be said about these cars, and this would become an encyclopedia of auto design, should I be allowed to keep on rambling on the subject.

"MAY YOUR CITROËN RUN FOREVER!"

WHY FRONT WHEEL DRIVE?

Have you ever tried to push a wheel barrow up a curb? You surely found it easier to pull it over the edge. You discovered the advantages of front wheel drive and also of the trailing arm geometry.

I won't show the vectors to keep complicated explanations out of this work. The fact is that pulling is more efficient than pushing.

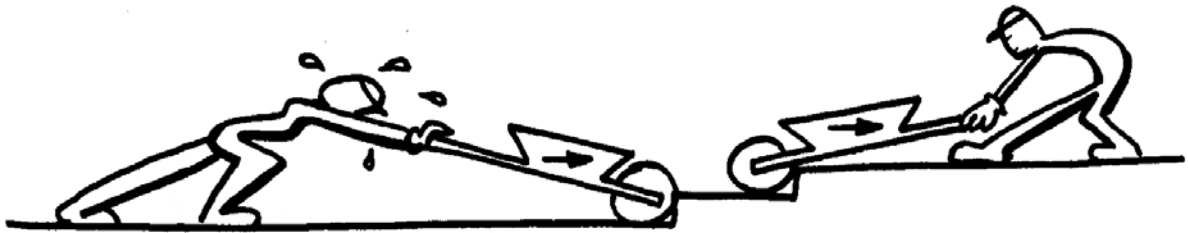
The result is that less energy is wasted climbing over bumps and more is refunded on the other side of the same bump. As a result, the suspension parts and the chassis do not have to be as heavy since they take less stress. It is possible to grossly overstress the above elements by, for instance, sliding into a sidewalk or braking into a pot hole. But such driving won't do any car much good.

While turning, a front wheel drive vehicle can start from "zero" speed to any given speed more efficiently and with more stability than a rear axle driven vehicle. We will have to use a diagram to show the transfer of force: D is a longer arm than d , therefore the same linear force applied along the perimeter will be, in fact a higher torque. The vehicle will accelerate faster, and since the rear of the vehicle is trailing the front, there is absolutely no reason for instability like in a rear axle driven vehicle where the front axle merely keeps the vehicle "ahead" of the rear axle, where it should be. The rear axle drive has some advantages. When one wants such instability of the vehicle, it is possible to "slide" the vehicle into a turn. One could make a complete U turn under power, or other tricks. Such tricks are difficult to do with a front wheel drive vehicle since the vehicle is too stable.

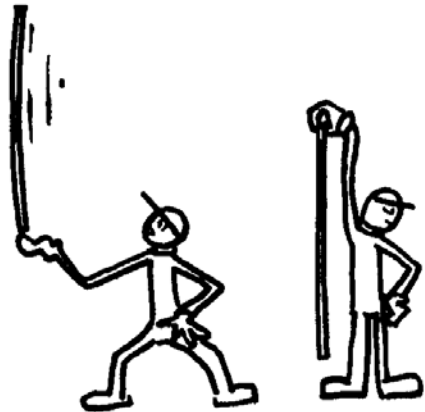
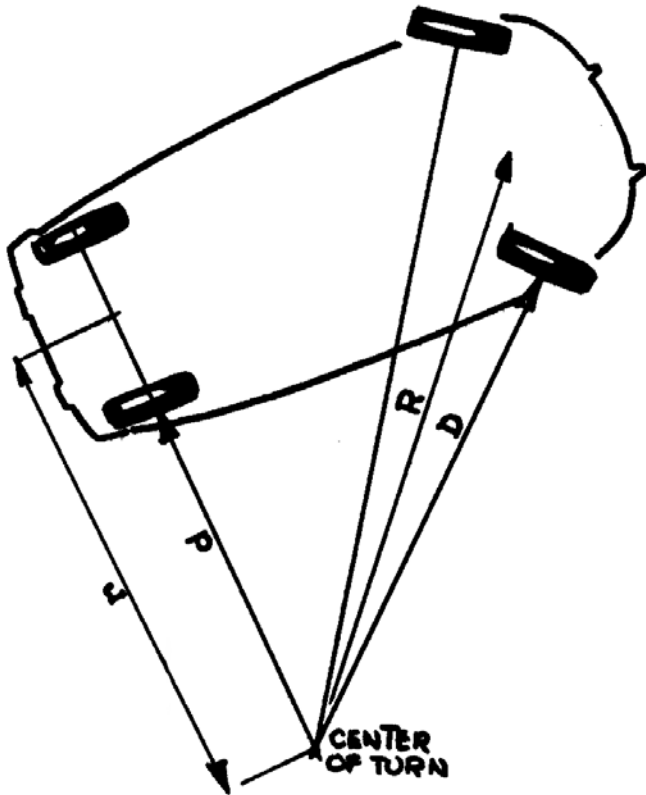
A result of the ability of the front wheel drive vehicle to take turns efficiently and with stability is that you do not have to slow down before the turn (not as much as conventional vehicles in extreme cases). You can drive into a turn by combining the properties of the steering and the torque applied to the front wheels, positive or negative, correctly modulated.

Going further on the stability chapter, you can do the following tests to show the advantages of front wheel drive:

Take a toy boat into a tub and try to push it. The boat will tend to turn right and left as long as no steering rudder has been installed in the front of the boat. Another test is the trick of holding a stick straight up on your finger. You will have to move the hand in the direction that the stick is falling to prevent it from doing so.



- IT IS EASIER TO PULL THAN TO PUSH OVER THE OBSTACLE.



THE BEST WAY TO HOLD A STICK STEADY?

The toy boat will be a lot more stable if it is towed from the front and the stick will definitely remain vertical if it is hung from one of its ends by a string. You have, here again, a trailing link and a front wheel drive in the front towed toy boat or in the "top hung" stick.

An exception, pusher tug boats are more efficient, for their thrust is not wasted on the front of the trailed barge. However, pusher tug boats can work only in relatively calm waters, since it is difficult for them to anticipate the motions of the load ahead and to take corrective measures in time.

Did you know that when Lefebvre designed the car, he offset the engine to the side so that the car would be perfectly balanced with the offset weight of the driver? Did you notice that the DS-I D has an offset engine, slightly moved to the right? The SM has its battery in front right for the same reason.

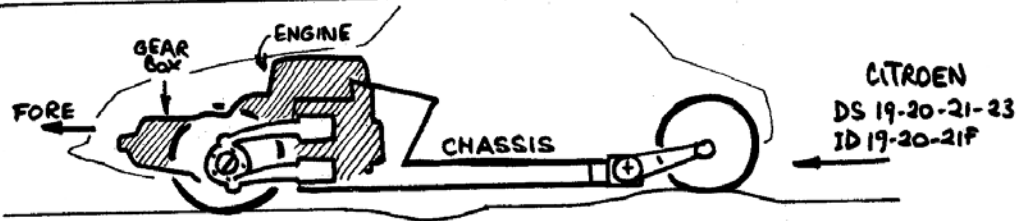
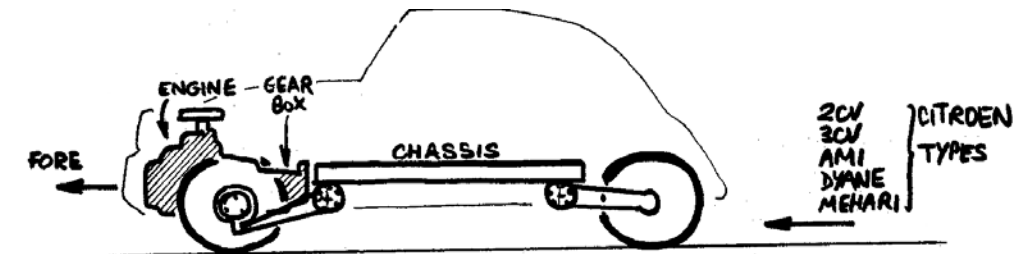
This will insure that the weight on each wheel is as evenly distributed as possible so that the car will behave identically in all turns. That is good automotive art design. Automobile designers should first be aircraft designers and not steam engine designers.

WHY TRAILING ARM SUSPENSION?

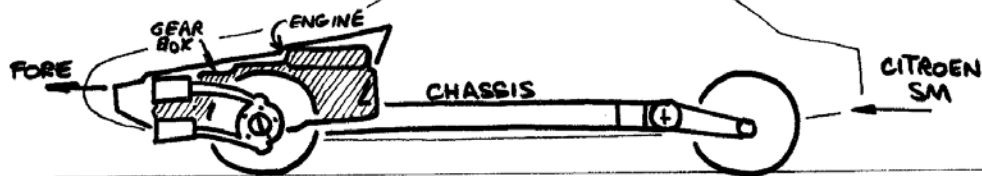
Referring to the wheel barrow experiment shown in the "Why Front Wheel Drive" chapter, the vectors can be shown and the result will prove that more of the energy is absorbed by the suspension spring in the trailing arm configuration. In the leading arm configuration, the energy is mostly transferred into the chassis and lost in heat.

It must be noted that the trailing arm is true only part of the time. The rear axles of all the Citroëns are true trailing arm suspensions except when the car is driven in reverse. The front axle of the Volkswagen is trailing at all times also with the same exception as above. The difference between the two is that the Citroën trailing arm is almost two feet long whereas the VW's is only 8 inches.

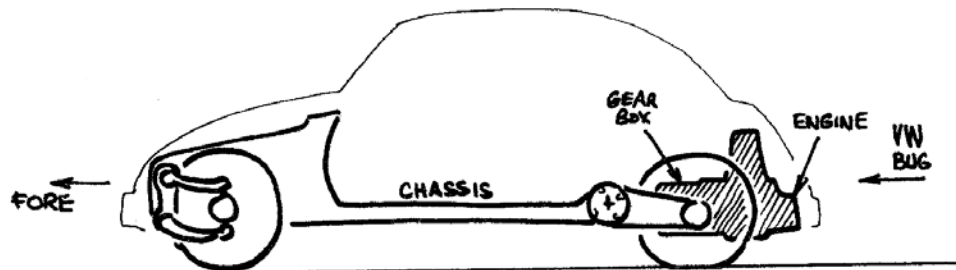
The front axle of the A models (2CV, AMI, etc.), the DS and ID models is trailing only when the vehicle is accelerating: the vehicle is stable and efficient. Only during braking is the vehicle inefficient or less stable. The SM models have their front axle actually "trailing" only during braking, therefore giving better stability during emergency slow downs while the "accelerating" geometry, not being trailing arm, is less efficient and less stable. In this model, the stability is already far superior to any other vehicle in mass production to date. The manufacturer accepted this design for safety and braking stability.



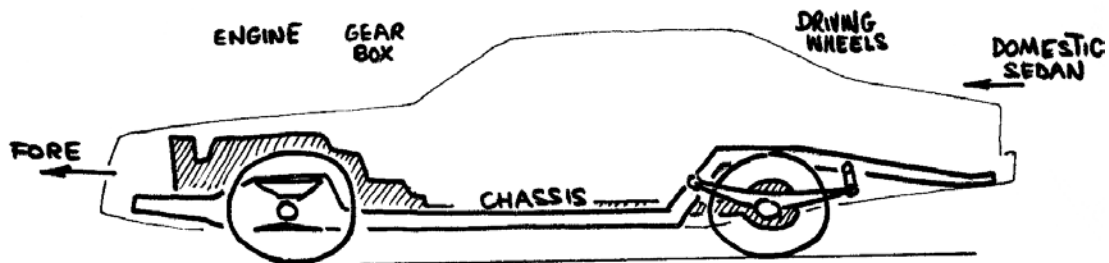
EXAMPLES OF FULLY TRAILING GEOMETRY: FRONT AXLE TOWS CHASSIS, CHASSIS TOWS REAR AXLE, DURING NORMAL DRIVING CONDITIONS.



IN THE CITROEN SM, THE FRONT AXLE IS NOT TRAILING EXCEPT WHILE DECELERATING. THIS GIVES BETTER STABILITY DURING BRAKING.



IN THE VW BUG, THE FRONT AXLE IS TRAILING WHILE THE REAR AXLE IS LEADING. THE VEHICLE IS STABLE DURING DECELERATION ONLY.



IN THE STANDARD US SEDAN, THE SUSPENSION IS DYNAMICALLY RIGID, SINCE IT IS NOT TRAILING NOR LEADING EXCEPT Laterally.

BRAKING

Braking ability is far more important than driving stability since a decent driver will not drive beyond the stability limits of his vehicle unless he knows the ways out, or intends to kill himself. One actually does not know the real limit of the braking stability of a vehicle without using it. The Citroëns can stop in a single lane, hands off the wheel, even with a flat in the front. Just do not try it with a car that has old brakes worn to the metal or on patchy ice and snow.

An underpowered car will behave better with the DS-ID suspension geometry since the vehicle was designed originally to be driven "flat out" all the time. It will be more stable most of the time, which is what most people want.

The SM was overpowered since front wheel drive does not work well above 130 h.p. and 1500 kg.'s (3300 lbs.), where tire limitation appears, no matter what tire width you mount. As a result, braking stability won in order to bring the vehicle safely to a stable speed without problems.

WHY THE COMFORT AND HANDLING TOGETHER?

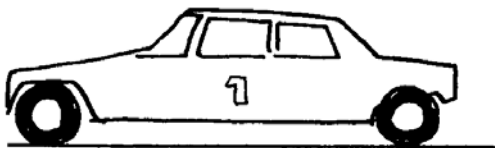
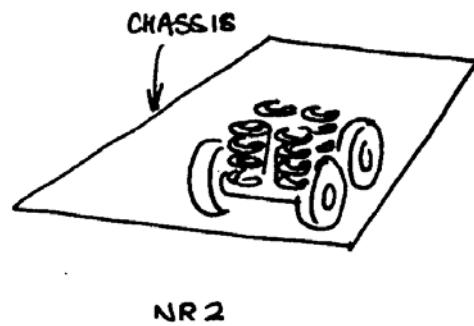
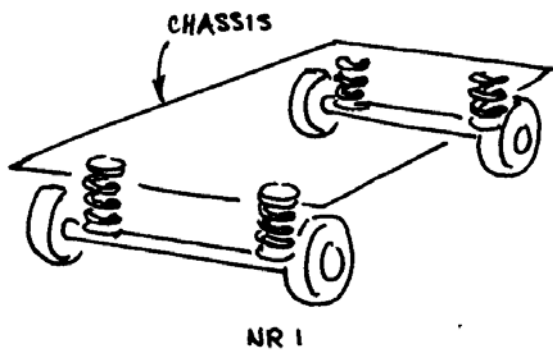
Look at the two figures: car number 1 has one wheel at each corner and car number 2 has all four wheels close together, near the center of gravity of the vehicle. These cases are extreme in order to better illustrate my point.

At first glance, it appears somewhat obvious that car number 2 would have a problem not flopping over side to side in turns or end to end while braking or accelerating. Car number 1 would be unflippable. This is stability. Good.

Now we have a comfort, or ride problem. Let us assume that each wheel of each car carries 25% of the weight, in order to simplify matters.

Upon hitting a bump, a wheel of car number 1 would squeeze a spring capable of holding 25% of the weight of the car. The same is true of car number 2. The problem is that the number 1 car's spring is actually lifting 25% of the car and the number 2 car's spring is so close to the center of gravity that it will lift almost 100% of the number 2 car's weight. The number 2 car's spring will definitely compress more readily and less of the bump will be felt by the driver. The car number 2 will "ride" better than car number 1 although with less stability.

Problem: car number 1 handles well since most of the car's mass is between the wheels, but it rides somewhat roughly unless one adds lead to each end. The lead will degrade the handling and cause the tires to wear fast. Car number 2 rides like a pillow and handles like a bar of wet soap.



STABILITY

AND

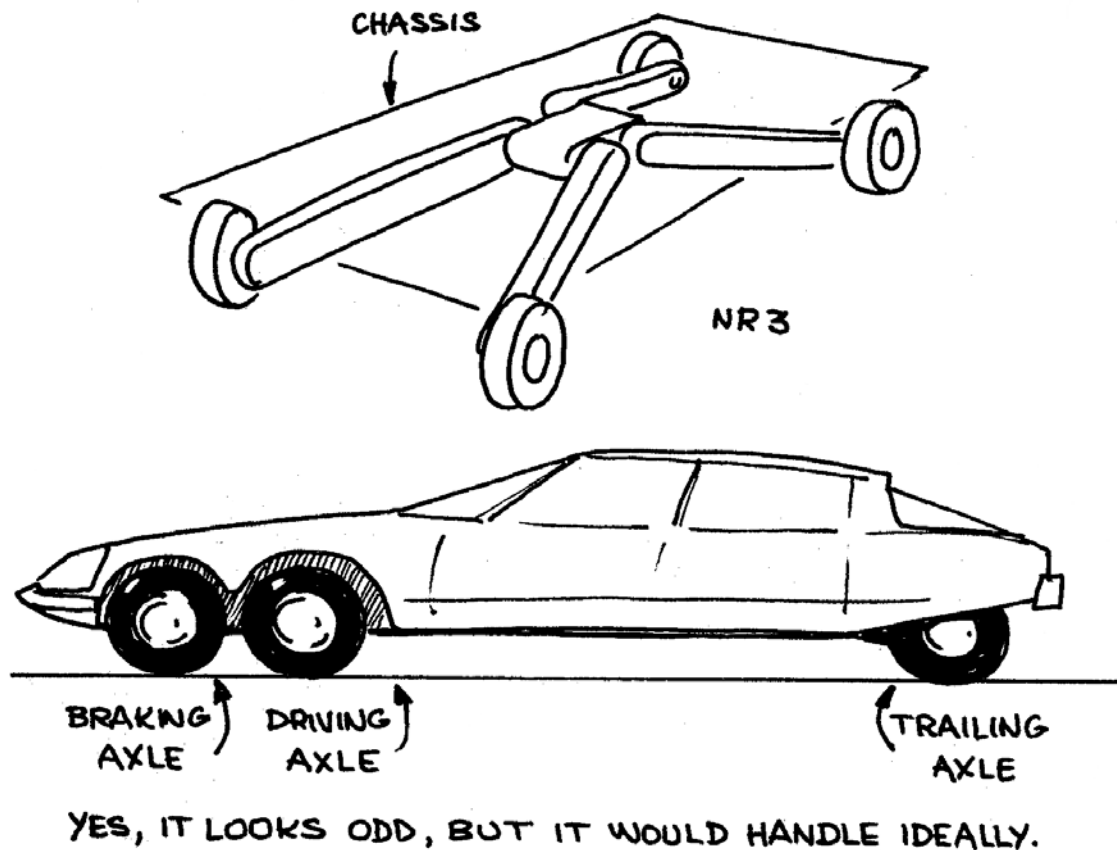
COMFORT

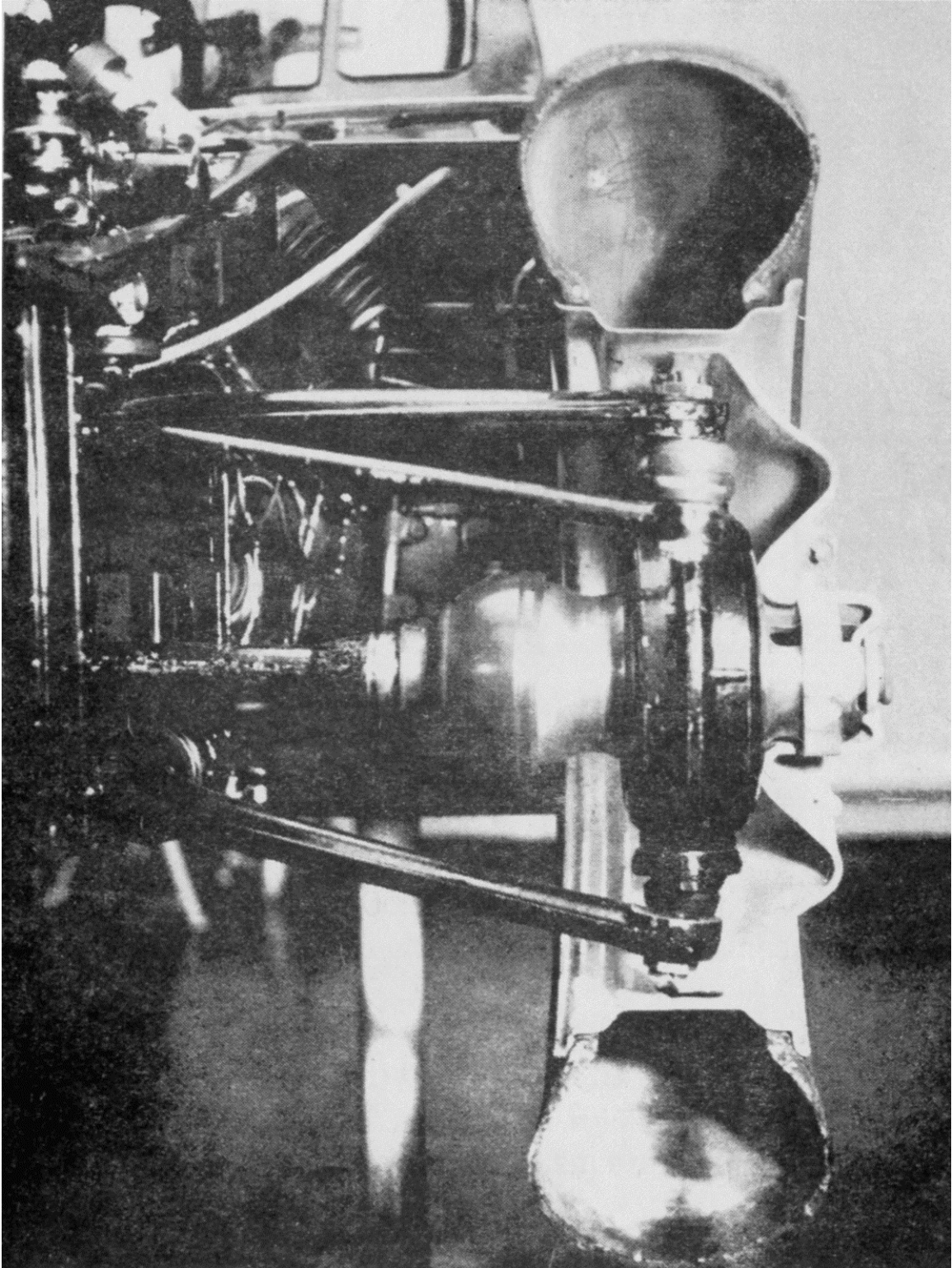
Compromise or solution: Car number 3. The suspension is attached close to center of gravity of the vehicle and the wheels are at each corner of the same vehicle. How do you do it? With long trailing arms.

Since it is not exactly economical nor practical to produce a vehicle that has 6 foot long suspension arms, Citroen has gone to the 2 to 3 feet long philosophy, close enough to the center of gravity for full control of the situation. We have a DS-ID or a 2CV-AMI.

The ultimate suspension? Take a look at the picture: two front axles. The first axle is used for braking only and the suspension pressure is "off" in normal driving. The second front axle is normally used as a front wheel drive axle and has no brakes except engine braking when releasing the accelerator. The second front axle is under pressure for suspension while accelerating, coasting would transfer the suspension pressure to the fore front axle, and braking would release all suspension pressure from the second front axle to transfer all suspension work to the fore front axle where the brakes are.

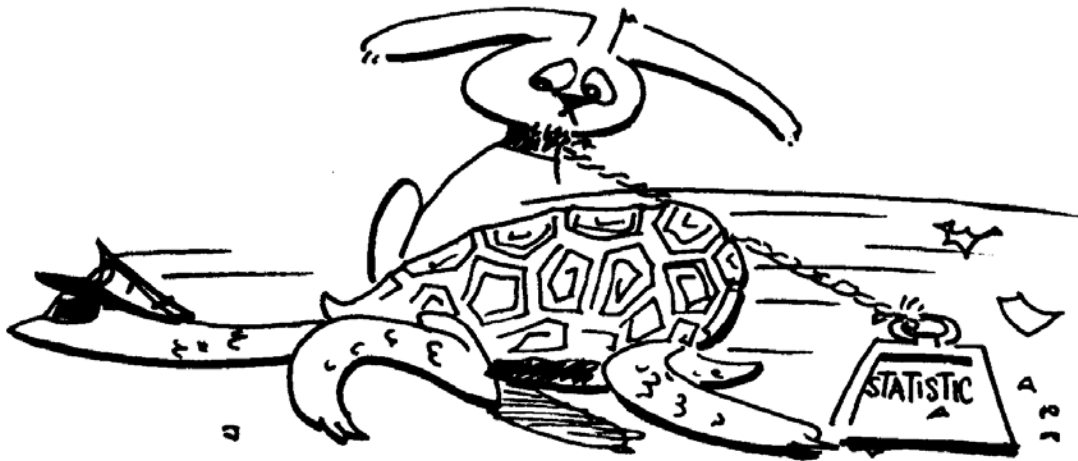
This solution gives a vehicle with absolutely flawless dynamic behavior, although a bit nose heavy.





DSI9 front axle. Similar design in the DS21, DS23 AND SM.

Centerpoint steering = the axis along which the wheel steers goes through the center of the tire/ground patch.

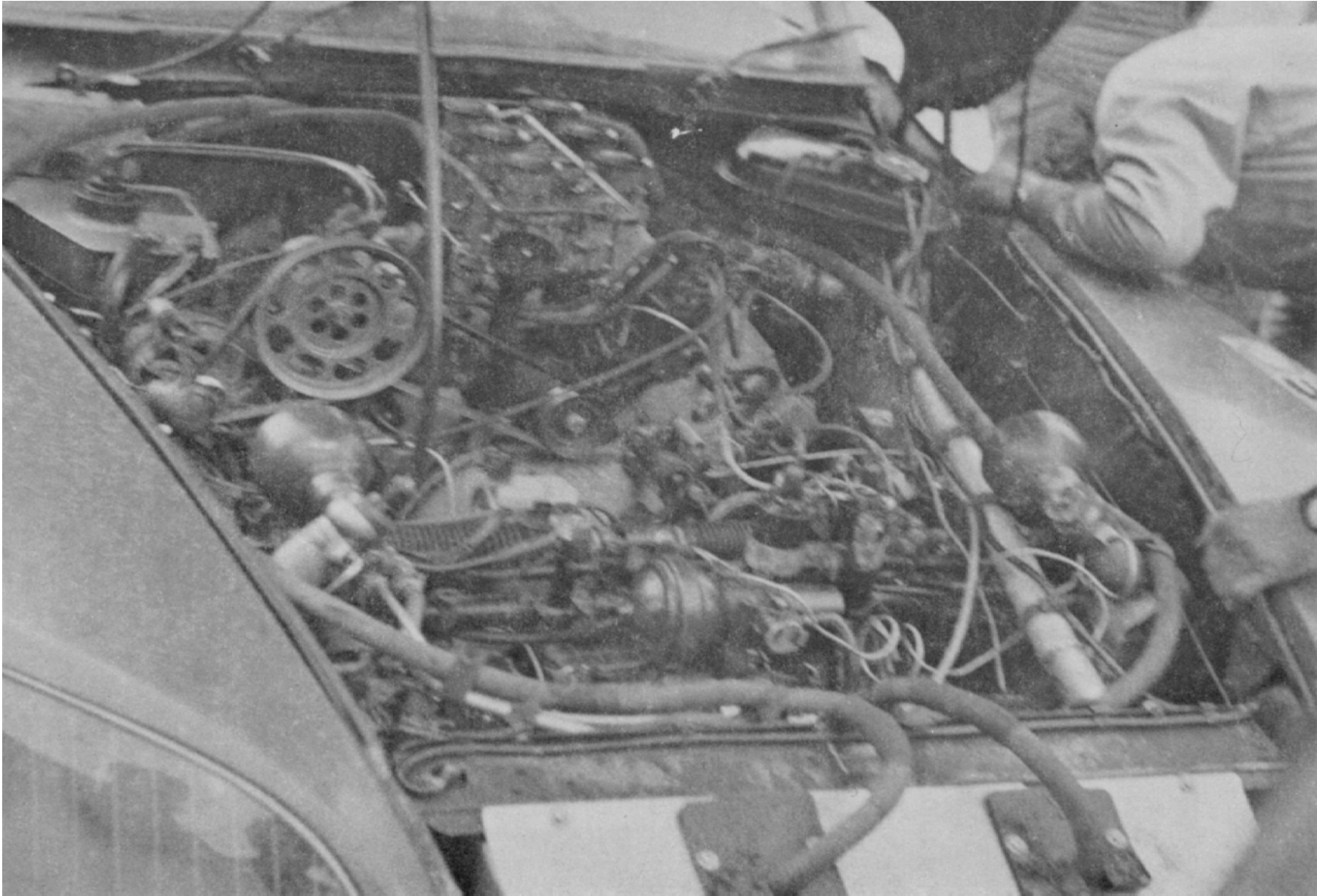


OF THE CRIMINALITY OF SPEED AND ITS PRACTICE

Upon reading an article written by a Citroen Car Club member about speed limits and their reductions, I have come to the conclusion that something ought to be said for and against speed limits.

Some time ago, upon entering the USA, I realized that the big domestic barge I was driving could not be driven above 55 MPH although it had some 300 HP under its hood. A few hours ago, a Citroen cabbie drove me to the Paris airport at some 85 m.p.h. with 85 hp. Paradoxical situation.

We are afflicted with the speed limits we know for the following reasons. Citizens' concern caused ordinances regulating the speed of the automobile as soon as it appeared that it could move at least as fast as the horse and buggy. Now the horse and buggy were never limited in speed because any damn fool who tried to go too fast severely damaged a horse and there was a lot of respect for horses at the time. So people did not abuse such transportation. The engine is a machine which does not feel nor complain in common everyday language. The engine can be abused and accidents occur, supporting the cause of the regulators and limitations.



SM prototype in DS body (1971)

What I am trying to convey is, that a moving violation should be handled as an administrative and not a criminal infraction, unless damage was actually caused.

An interesting result of the speed limit reduction of the early 70's is that the accident/m.p.h. curve proves that, if the speed limit is reduced to lower and lower values, the accident rate follows along to show zero casualty at zero speed. Then it would seem that the only safest speed limit would and should be zero. Or does one explain the reduced fatalities rate by the fact that cars were unsafe above 55 m.p.h.? Can the manufacturers justify this curve?

The speed limits are quite ingrained into the system for the following reasons:

Driver's education: "It is dangerous to drive fast".

Concern: "You are liable to kill yourself".

Guilt: "You are liable to kill somebody else". Greed: "It keeps the insurance premium low".

Convenience: "It is easier to sell a vehicle designed for top safe speed of say, 100 m.p.h. than to try to keep up with the other manufacturers' fast models".

Unimaginative: "How much earlier did you get there by going faster and what are you going to do with the time you gained".

Political: "I would not pass a bill that would cause good citizens to get killed".



Battered DS bodied SM after test run (1971)

For the above mentioned convenience reason, it is actually dangerous to drive a domestic product at high speed. Foreign products are designed for unlimited speed limit systems and are much safer. Of course, in order to be safer, they have to remain small and light. I will believe in a heavy, large vehicle's superiority when I see a fully loaded semi trailer beat the 1000 lb spiders on the Grand Prix tracks. Even a 10,000 h.p. engine will not keep it from arriving last.

In my opinion, a teenager driving a "slicked up" 'Vette at 45 MPH on wet pavement is going to hit something, unless he takes it very easy. On the same road, an experienced driver at the wheel of a full European standard regalia Citroen, can drive 100 m.p.h. without doing anything very much out of the ordinary for a Citroen.

The "You are going to kill somebody" statement is just as excessive as the following "Getting out of bed in the morning might be hazardous for your health". Where does the excess stop? A lost barge kills more reliably at 30 m.p.h. than a DS or SM at 60, even with new fangdangled safety regulations. Should cars be designed by engineers or by bureaucrats? The problem is that an honest statement is difficult to defend against an emotional opposition's abusive statement.

Driver education is also a problem: a conservative US driver will do everything in his power with his car to prevent the faster driver from overtaking him, thereby causing more danger to both of them and the rest of the traffic.

Have you wondered what would be the reaction of the guy going his safe minimum speed in the left lane when you are growing larger and larger in his rear view mirror? That is assuming he is looking at his rear view mirror.

I have seen one of them stop in the left lane. I have seen another one push the fast driver off the road. I have seen another one take a shot at the passing vehicle. No kidding. Such things do not happen in a system where there is no speed limit as the regulations are very strictly enforced to protect all drivers. The obstructor is at fault for obstructing traffic. Bald tires are not permitted and are checked by random stops of the Police. Bad headlights are causes for tickets and even impounding of vehicle. Lane switching without warning, or as much as rolling on the double yellow line is cause for license revocation. The enforcement is different and effective: at equal statistical propositions, the European expressways are safer than the U.S. ones. The Europeans are killing themselves on back roads and in town. At night with booze and in their forties.

After WW 2, superhighways were conceived. Take a look at your local public library's Popular Mechanics magazines of the early fifties. The superhighways were intended for speeds up to 90 m.p.h.

From past experience it is obvious that academic public interest quickly dwindled at the rate at which the legislators of the time knew where their votes were. No legislator in his right mind would push a bill favoring higher speed limits and, possibly, higher fatalities.

The speed limits remained the same until reduced to a comical 55 MPH. Nothing flattering as to the quality of the domestic hardware assembled in Michigan.

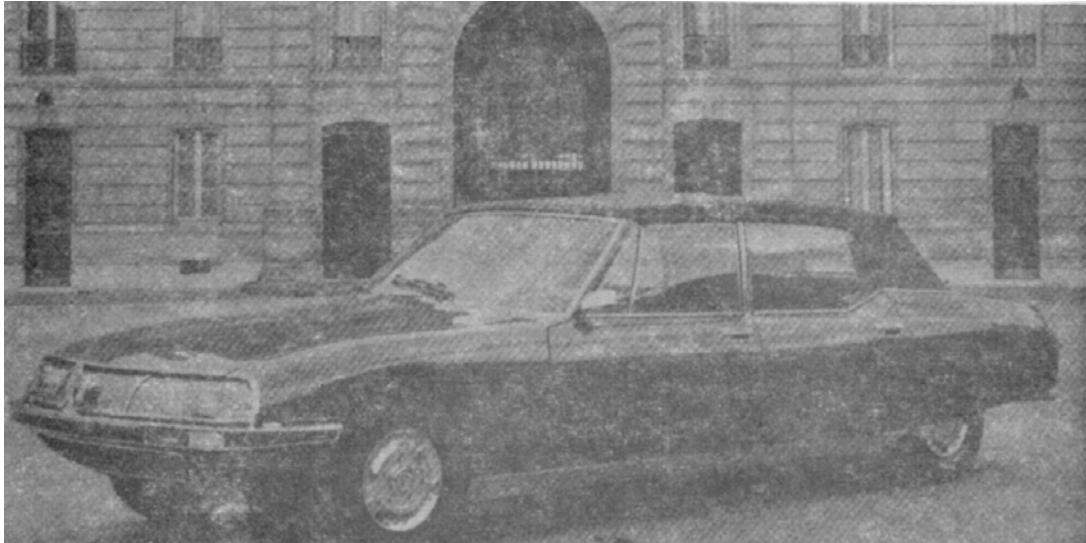
I personally support the unlimited speed limits on the superhighways for the following reasons:

1. That is what they were built for.
2. Conservative drivers will stay off of them.
3. Better design in cars will result.
4. Safer vehicles might actually be designed.
5. Truckers would earn more money and shipping costs would be reduced.
6. Road travel might actually be faster than air travel on distances up to 600 miles, door to door.
7. One does not fall asleep at 90 MPH. The scenery changes quickly enough so as to prevent the hypnotic effects of slow changing pictures. Truckers know all about this.
8. Cars are already designed for this kind of driving, already built. Tires are available that are good up to 180 MPH. Lights are available for this kind of speed.
9. Police work is reduced and allows for more effective service such as the search for stolen or unsafe vehicles, drunks, lane skippers, wrong side of the road drivers.

Speed limits are technological crimes since they allow the progressive degradation of design quality, to the most acceptable vehicle AT and NOT ABOVE the given speed limit. The paradox is that this is a nation of high speed technology, except in this respect. We have a clerotic system that is supporting this paradox. The paradox can be eliminated only from the driver's ed time where the student can learn and obtain a license as it is done now, only to carry a sticker on his car, or the car he happens to be driving. The sticker indicates that this is a learning driver and his speed is limited. England and France have this system. The learning driver keeps the hated sticker for a year. Any accident causes him to lose the license. Furthermore he must be of voting age to obtain his first license.

From the time a driver owns a vehicle that is capable of speed in excess of, say 60 MPH, he has to go to school again in order to learn to drive above 60 m.p.h. up to 100 m.p.h. He also gets afflicted with another sticker for another year.

This is not the kind of solution that will get universal acceptance or get us out of the rut quickly. Administrative measures are never instantaneous.

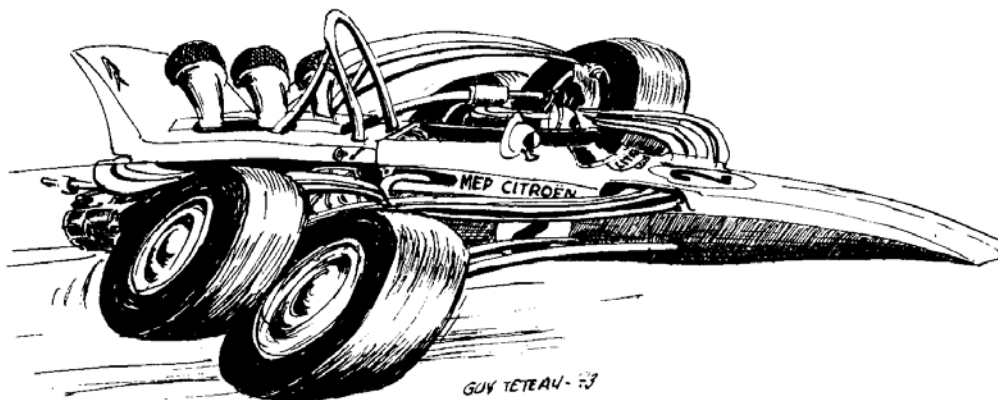


HOW TO BUY A USED CITROEN

This is valid for DS-ID and SM models only.

BODY Costly to repair or replace. Look for rust at door bottoms, front underpan around trunk lid's rear edge.

FRAME Difficult to get repaired. Check the alignment of hood with front fenders indicating front sub-frame distortion. Check for tags or brazing on front sub chassis indicating new sub chassis after accident.



Check for front door to front fender gap and alignment indicating a rusted frame or twisted frame at the firewall. Check that front doors actually shut and line up with rear door to "see" a twisted frame. Lift the rugs at the driver's foot rest area. Probably rusted floor. Any holes? Lift the rug at rear seat and ink the funk, look for rust and holes. Check that both rear wheels are actually vertical as seen from the rear. Bad angle indicates bent rear chassis. Check the top of the trunk walls on each side. Rust shows that water has been pouring from the roof into the trunk. Check for stains on the headliner indicating a leaky roof.

SUSPENSION Robust and reliable unless used with wrong fluid. Check that the fluid is the right one, color and smell. Check that there is enough of it. If you can raise the car, listen for knocks as the rear end gets up (bad rod), or groans as the front end gets up (bad ball joints). Grab front bumper firmly and lift and lower the car: 10 inches difference is excellent, no motion indicates bad spheres. Same test in the rear. Lift car all the way up and check fluid level in main tank: it will run out if there are bad spheres. Do not do this test if the spheres are bad, as indicated by lifting test. Look for puddles under the car, fluid, engine oil or water. Is the rear suspension clip in place on both sides?

STEERING OR POWER STEERING Move the steering wheel slowly right and left for smoothness. Any clacking noise indicates bad adjustment of valves. Hissing indicates leaky power steering. Short hissing noises are relatively insignificant, as long as they do not persist. Grab the front wheels (one at a time) and shake them right and left to check for loose tie rods. Grab the top of the front wheels and shake in and out for rattling and loose ball joints. Kicking the tires is of no use. Check the front tires for uneven wear, bad parallelism to be adjusted once for all. Check that both front wheels are vertical in straight line at normal height. On SM, check that the steering returns to mid position with engine just turned off. Failure to do so indicates bad main accumulator.

CITROMATIC Check that the lever actually can start the engine. Move the lever into each gear, engine off, any sustained hissing in gear indicates leaking selector dash pots. If the lever is hard to move, do not force it. The system can be checked by driving the car.

BRAKES Any hissing occurring when the brake pedal is depressed indicates air in the brake lines or badly adjusted rear brake shoes. Listen to the rear brake shoes moving in position or returning to rest.

HALF SHAFTS AND TRANSMISSION Lift front wheels off the ground, tighten hand brake if working and attempt to rotate front wheels. This is to check the axle wear. Check for improper level in gear box or seepage. Drive and see if gears do not crash together. Check where clutch pedal "grabs". This indicates age and wear of clutch. A worn clutch grabs near the end of it's release. Check where it's front adjustment is set.

ENGINE Check for oil leakage excluding normal seepage. Check oil at dipstick and check color and smell. After running the engine, check for particles of metal on dipstick (broken rings). Check pressure at engine head as engine is running by covering oil filler opening with the hand. This is the "blow by" caused by worn rings or pistons. Check that exhaust is gray and not black or oily. Water dripping at the exhaust end is O K. Blue smoke is indication of hole in piston or worn valve guide. Check for missing belts.

COOLING SYSTEM Check for right level in radiator. What is in it? Check front bearing at water pump by moving pulley right and left or attempting to do so. Any leaking or cracked hoses? Heater valve is working?

ELECTRICAL SYSTEM If possible, check for proper water level in battery. Check condition of battery connections. Alternator charges? Starter working? Headlights, horns, brake lights, dash lights warning lights, flashers, heater fans, air conditioner, defroster, radio, windows, windshield wipers and washer.

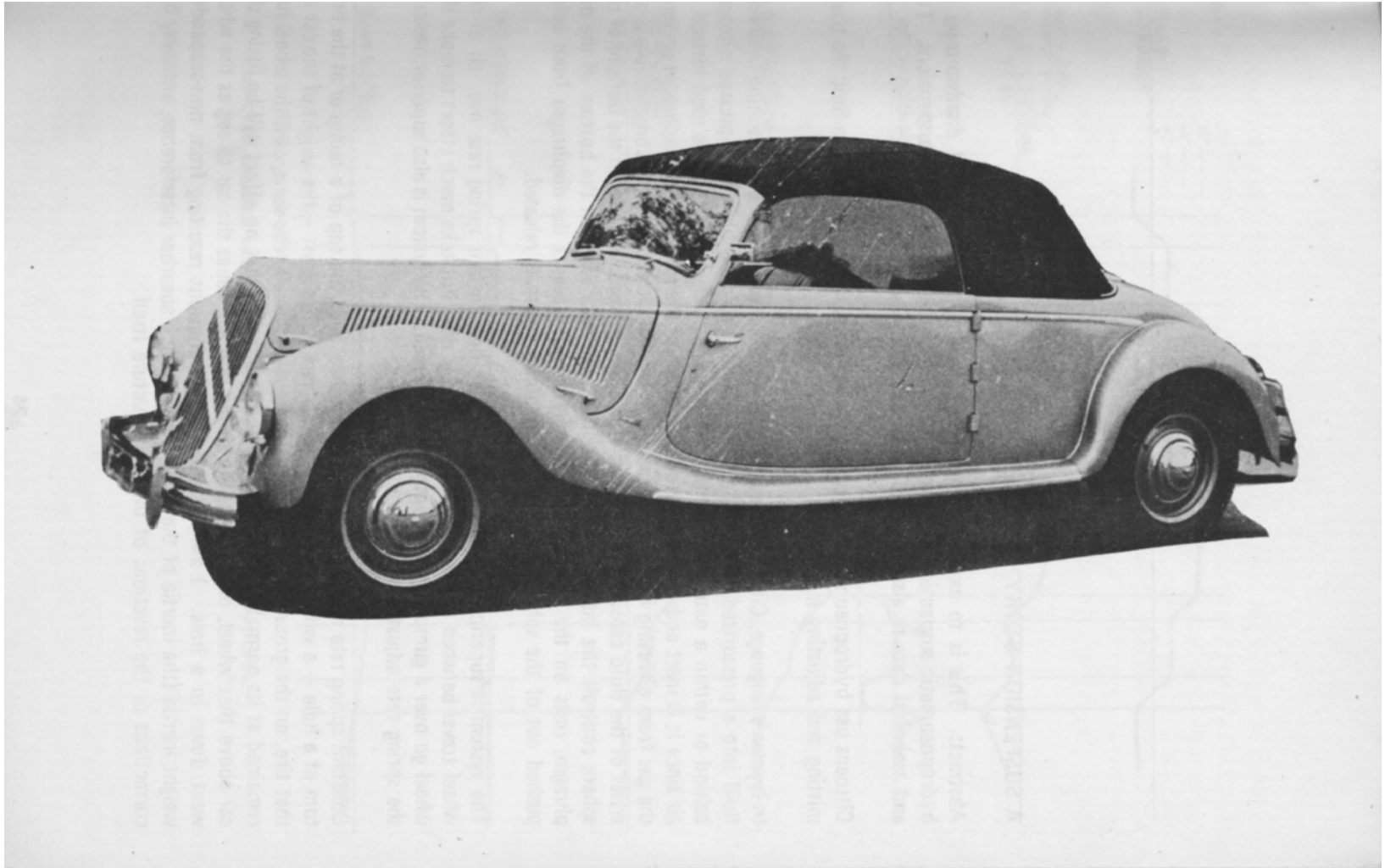
OTHERS Door latches, trunk lock, hood latches and releases, seat belts, exhaust, fuel system (smells), glass, mirrors, visors, speedometer and odometer.

Many more items could be checked into by spending more time with more equipment at hand.

TOWING RECOMMENDATIONS

REMEMBER THAT IT IS SAFER TO TRANSPORT A CITROEN THAN TO TOW IT. The cost might be higher but the damage caused by improper towing can cause it to be seriously damaged.

Hydraulically suspended vehicles can be towed only at reduced speed. Citroen recommends not to tow above 30 m.p.h. on smooth surfaces. It is possible to lift the suspension by rotating the high pressure pump with a speed wrench and extension. Some of the suspension will smooth out the bumps and will give a safer ride to the chassis.



Custom 11CV Convertible (1948)

A SUSPENSION STORY FOR DS, ID AND SM

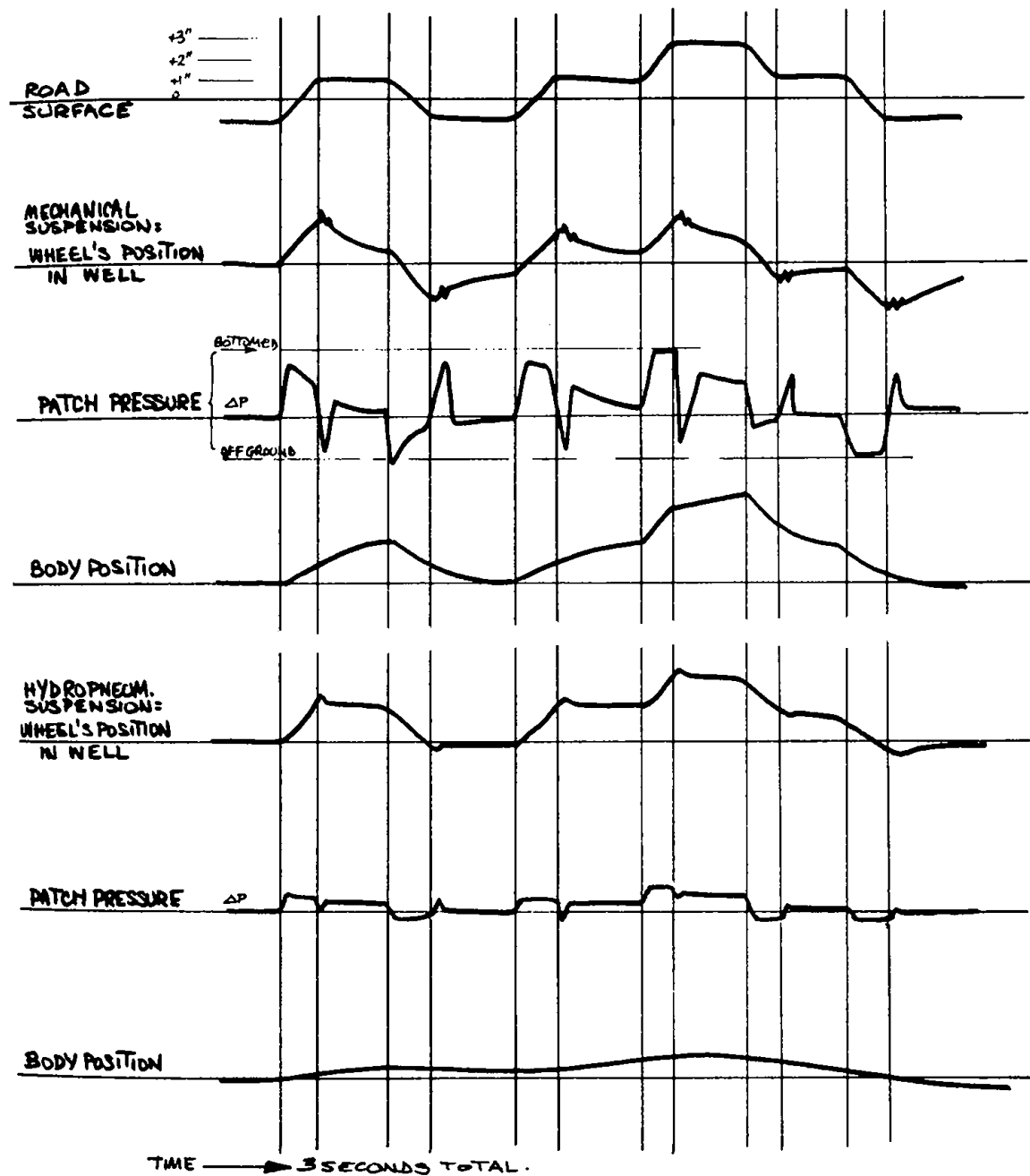
Abstract: This is to explain the purpose, reasons, advantages and disadvantage hydropneumatic suspension as compared to conventional mechanical suspensions. Technical data are also included in this chapter.

Citroens use hydropneumatic suspensions where a gas is the spring and a fluid the lifting and adjusting medium.

In layman's language, Citroens ride on a piston contained in a cylinder, pushing hydraulic fluid into a pressurized vessel (sphere) which contains a bubble of compressed nitrogen behind or within a natural or synthetic rubber diaphragm. Nitrogen is used instead of air since it is inert and will not corrode the inside of the sphere. The diaphragm prevents the gas from diffusing into the hydraulic oil, thereby degrading the incompressible properties of the fluid and causing the attrition of the gas in store. A valve on the bottom of the sphere controls the ins and outs of the fluid. Another valve on the bottom of the diaphragm rests on the opening of the sphere and prevents the diaphragm from being pushed out of the sphere when the hydraulic pressure is released.

The system is superior in that it has a practically constant spring rate over all of the wheel travel between stops. In clear language, it does not take much effort to make wheel go over a bump or retract into the wheel well. The system is also superior because the spring rate adjusts automatically.

Constant spring rate means that when your wheel is at the top of a bump or at the bottom of a hole - a whole seven and three quarters inches apart - the weight of the car that tire, on the ground (patch pressure) remains practically the same, as if the wheel remained at its normal mid-travel position. This means that no effort will be lifting the car above that wheel or no change in spring rate will cause the car to sag as the wheel went down in a hole. I am not considering variations resulting from non-suspended weight inertia (the inertia of the wheel itself), shock absorber interference, antiway bar corrections or the reactions of the tire structure itself.



PARAMETER CHANGES WITH TWO DIFFERENT TYPES OF SUSPENSIONS.

Constant spring rate also means "soft springing", since it takes little effort to retract wheels or to lower the car by such means as leaning on it. Soft springing is a problem, as any load put into the car will sag the suspension to finally "bottom" it. Therefore, adjustment must be done. Citroen checks the axle's position at all times with a valve which adds or removes hydraulic fluid from the axle's suspension elements. More fluid has been crammed into the same "space" since the vehicle has returned to the height. Something gets compressed in there. It is the nitrogen gas. Since the more compressed, its pressure is higher and therefore the spring rate is increased automatically. The system does not freeze, seize, leak, burst nor fail unless severely abused. I have seen several units that still behaved perfectly after 25 years on 15CV models.

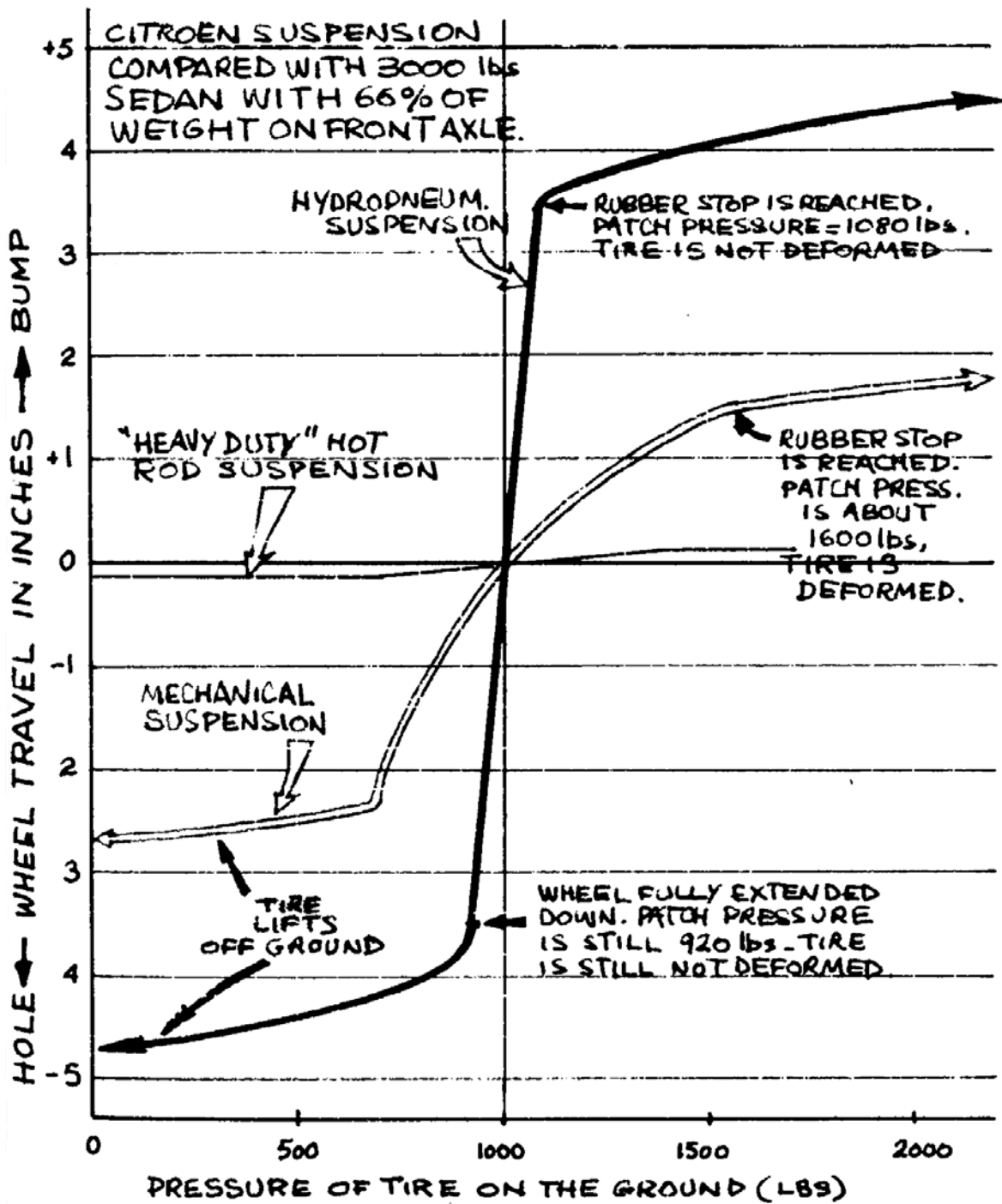
It is almost possible to do the same with a mechanical suspension, providing that long springs are used and that nothing is done that might change the weight of the vehicle more than, say, 80 lbs. on a 3000 lb. vehicle. Such a change would collapse the pension and a correction would have to be done. Mechanical suspensions with automatic correction have not been quite successful in the past since they were difficult make reliable at a reasonable cost. The only breed of designer capable to design such a suspension, in my opinion, would be an aircraft designer: They have the right understanding of dynamics of suspensions and of reliability demands.

As a result the mechanical suspensions have not evolved much in the past some hundred years. Stagecoaches had very sophisticated suspensions although bulky. The Model "T" Ford had a good suspension concept, which was reduced to standard capabilities by cost implementation. Mechanical suspensions were therefore reduced to the art of installing springs stiff enough to take the maximum rated load to prevent excessive sagging, excessive bulk and cost.

A standard mechanical suspension will see the "patch pressure" vary between zero (the tire is just about to lift off the ground) and extremely high values (when the tire is squashed by the bottoming suspension). The change is gradual over all of the wheel's travel up and down, and- not linear, which means that the patch pressure is constantly varying. As a result, the tire adhesion is also varying and so is the control this wheel is giving to the driver. Such a suspension will give completely different vehicle behavior on different grounds. It would tend to give good control on flat and smooth surface since the patch pressures are constant. It would be unpredictable on rough surfs

The 2CV type of suspension is good because it uses long springs (mechanically speaking) on interconnected axles. Any front wheel lifting will tend to push the corresponding rear wheel down, increasing the patch pressure on both wheels at once, and reducing the pressure variation to half of the value. Inertia dampers prevent wheel oscillations.

Adhesion to the ground is also affected by the tire's shape. When the suspension is bottomed by a bump, the tire is crushed and will definitely not do its job as expected.



PATCH PRESSURE VARIATIONS ON SUSPENSIONS

A tire that is about to lift off the ground assumes a rounded track and rides on some 25 of the effective track width. In this situation, the patch pressure is very low and the patch size is reduced to about 7% of the normal rated size. That tire is not to be expected to help control should you be turning, accelerating or braking. It will slip or spin.

On a mechanical suspension, a lot more effort is required to move the wheel into the wheel well (reasons given above). This effort will tend to lift the vehicle, rotate it and change the patch pressures on all the other axles or wheels. The pitch and yaw will change and the bump will be felt by the driver. Since the springs are stiff, and since their rates vary with their length, rapid oscillations of the wheel will occur. They will be damped by a shock absorber which will convert the energy into heat. Loss of energy. Since it is difficult to match a shock absorber to the period of the suspension under all situations, a soft shock will be designed and used to reasonably damp any bouncing. The result will be that the wheel will bounce and overshoot more than it should, degrading control.

So we go to the hydropneumatic suspension. The spring rate is practically constant along the whole travel of the wheel up and down between stops. The variation is about 80 lbs., plus or minus per front wheel on the DS, ID or SM corresponding to a plus or minus 3 1/2 inches change in height, providing you are shaking the car up and down fast enough for the correction valve not to have the time to "see" the motion. That is a plus or minus 8% weight change on that wheel, or about 2% of the full weight of the car

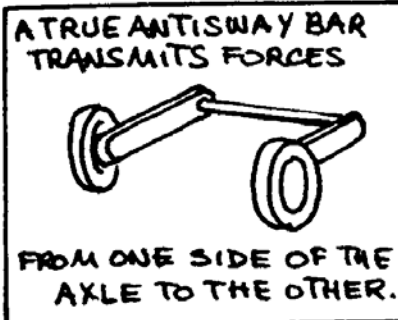
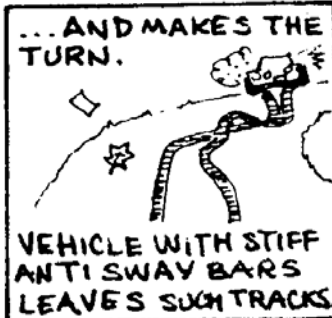
On a domestic sedan the figures are respectively, 600 lbs., 2 inches, 12% and 35%. Large percentages indicate rough ride or poor control. On the extreme side, a stiff-suspensioned hot rod will stay on the road only because it is in control between bounces, during the time the tire impacts the ground. Since their rubber is smooth, soft and overinflated, some positive results are to be expected although the vehicle is effectively off the ground up to 95% of the time on rough terrain.

As a result a Citroen will be able to go 35% faster on rough ground than any other vehicle, its wheels faithfully following the ground as the body remains level. The suspension will adapt rapidly to terrain changes without changes on the suspension level. A hot rod will merely hop from crest to crest, relying on its power to catch up. The hot rod, in this situation is merely following a ballistic trajectory, control being effective at lower speeds only, when the oscillation period of the vehicle is higher than the ground's variations' frequency. A "standard sedan" will somewhat behave better since its wheels are able to follow the ground better, only to be limited by the same frequency and oscillation period, when the chassis will plough into the ground.

It is true, Citroens can be driven across freshly ploughed fields at 60MPH and over. Just do not do it in second gear unless you are ready to replace the engine.

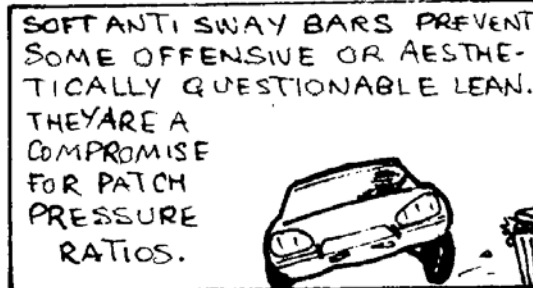
The shock absorber used in the hydropneumatic suspension is merely a damper.

ANTISWAY BARS (90 PROOF!)



THEY PREVENT DOUBLE
DECKER LONDON
BUSES FROM
FALLING OVER.

THAT IS: AS THE VEHICLE IS TURNING,
IT TENDS TO LEAN. THIS PUSHES ONE
SET OF WHEELS "UP". IF THE CAR TURNS
RIGHT, IT LEANS LEFT, THE WEIGHT
ON THE LEFT WHEELS IS INCREASED
AND SAGS THE SUSPENSION, THE
BAR ROTATES AND TENDS TO
LIFT THE RIGHT WHEEL. HOWE-
VER, THE RIGHT WHEEL IS ALREA-
DY STRETCHED OUT TO THE
GROUND AND TWISTS THE BAR
(HIPS!) THE OTHER WAY, IT WILL
PREVENT THE SAGGING OF THE
LEFT WHEEL AND MIGHT CAUSE
THE LIFTING OF THE RIGHT
WHEEL OFF THE GROUND.



AUTHOR RACING ON ICE AND MISSING GATE

The system is so efficient, "refunding" all energy absorbed on the up side of a bump when reaching the down side of the same bump, that some loss had to be introduced. Otherwise the car would swoop and rock to very large angles where the suspension might bottom up or down.

The fluid damper has been fastened into the suspension sphere's opening with a rivet since about 1971. The previous models had a removable damper which could be adjusted. Since these shock absorbers are completely contained, they never wear out.

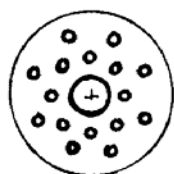
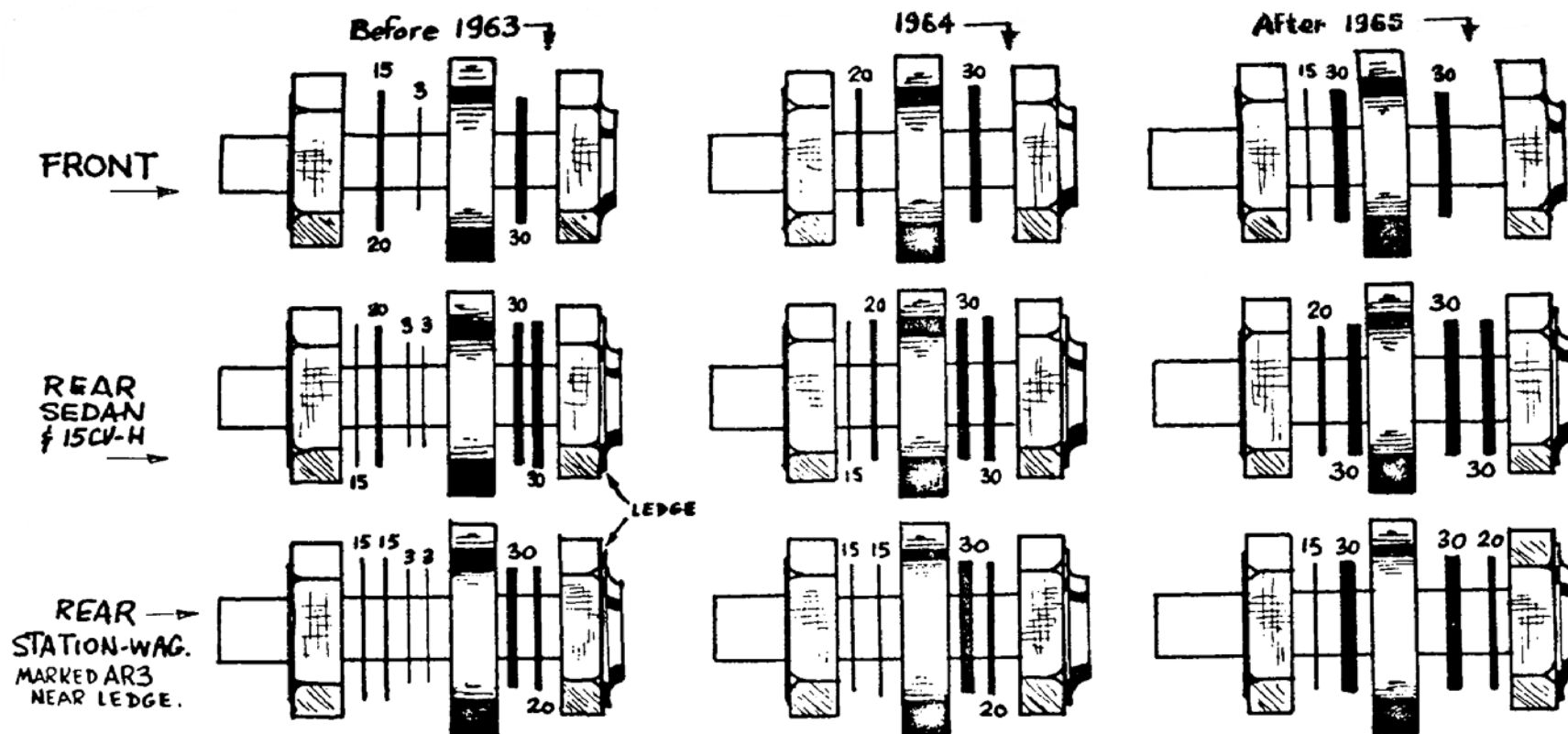
Their function is simple. The fluid enters a duct under a pressure commensurate with the weight on that wheel, and pushes a valve open. The valve is held by a spring that opens more or less. The higher the pressure, the more the valve opens. The larger the bumps, the less one feels them. The fluid flows back through another duct and another valve. The valve is simply a spring steel disc. Several thicknesses are available: The thickest is the stiffest. It is actually possible to set the damper to no resistance on impact and some resistance on recovery. Bumps would not be felt. However, since the vehicle wheel went up and it cannot come out as easily, the vehicle will have to settle and then would be felt by the car's contents.

As the years went by, the top speed of the DS and ID went up from some 80 MPH above 135 MPH. The dampers were stiffened and the ride suffered. Since it is illegal to drive above 55 MPH in the USA, the first settings used are perfectly good. The control remains excellent with old style soft dampers up to 100 MPH and the old cloud ride there.

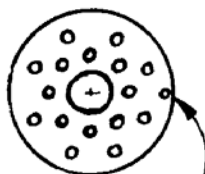
A "schedule" of the different settings is shown. All dimensions are in thousandths millimeters. Note that the bottoms of the rear shocks are different from the front on Note that the discs' bowing must be towards the cores. Note that pre 1963 cores do not have the small bypass hole in the core. At the time .003 mm shims were installed between the core and the discs and effectively and smoothly replaced the by-pass hole.

Make sure that the shocks are identical on the same axle, otherwise the vehicle will roll from side to side on bumps.

The curve indicates the pressure variations in the various cases described above. From this curve you can see that a standard sedan has as much control as a D or S model only when driving on a surface that has irregularities less than 1/2 inch plus or minus. The D or the S models equivalent will be a terrain with irregularities of plus or minus 3 inches. We will not even consider the "hot rod" for reasons explain above.



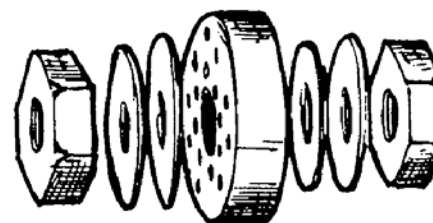
Pre 1963
core without
by pass hole



Post 1963
core with
by pass hole

THE SPHERE SIDE
IS TO THE LEFT
OF THE DRAWING

Numbers repre-
sent discs'
thicknesses in
1000th of mm.



We are not taking into consideration the resonance problems caused by oscillation period, which do not affect the hydropneumatic suspensions since the free oscillation period is so low. A hydropneumatic suspension will bottom only when landing after flying off the ground or on irregularities corresponding to the following formula:

$$V = L / 2.75 \text{ [L divided by 2.75]}$$

Where V is velocity in MPH, and L is length of irregularity's full wave.

The coefficient can be changed by changing the damper's stiffnesses. On standard sedans, the coefficient runs about 1.30 for luxury cars to .8 for so called compacts. Hot rods more in the .2 region.

The properties of the suspension can be used for off the road racing. A large position bump can be attacked with plenty of reserve in suspension travel by doing the follow:

1. Brake, so as to lower the nose of the car. The front suspension will correct and lift the nose up.
2. Accelerate hard just before the bump, so as to lift the nose further. The correction valve does not have the time to lower the suspension and you attack the bump, wheels fully extended, a full 7 1/2 inch wheel travel available to absorb the impact.

The same trick can be used the other way to depress the front axle, although not recommended.

Since the suspension will retract while the car is in mid air, after jumping off a bump, it is advisable to have the navigator control an extra suspension lever to prevent hitting the ground with the frame upon landing. This is in extreme off the road racing conditions. A sprung inertial control on the front valve can do the trick as well although difficult to set up reliably.



BRAKE STORY

HOW TO CARE FOR YOUR BRAKES, DS, ID, SM:

"Stuck", frozen or seized front brakes.

Leaky brakes, front or rear.

"Slow" brakes (delay).

Noisy brakes.

SYMPTOMS, CAUSES AND CURES:

Most common of all diseases seems to be the "frozen" front brake.

a) *Symptoms:* Car slows down between gears . . . a lot, like on a ramp. Hot metal smell after a few minutes of driving. Long delay between the time when the pedal is pushed and the time when the brakes start braking (fluid is vaporizing, caused by heat released). Car jerks more or less when reaching full stop, without foot the brake pedal. More or less violent forward-backward oscillations as the car is gently accelerated or decelerated in 2nd or 3rd gear (only one brake piston locked in the front, causing warping of the disc). One brake pad wears faster than others.

b) *Causes:* brake pistons, generally on front axle, do not retract and keep the brake pad in contact with the discs. Since the brake piston is supposed to be "recalled" by the sealing O ring which rotated when it moved out, a little drag will prevent it from retracting. The disc then is in charge of the job, consuming a lot of energy in friction. When the assembly gets hot enough, the calipers expand faster than the steel piston, allowing it to move a little more freely. A little more heat will vaporize the fluid. The gas vapor so created will have to be compressed before the brakes start working, hence a delay.

c) *Cures:*

1. Extract the calipers and overhaul.
2. Repair on the spot.

DESCRIPTION OF THE CURES:

1. The extraction and overhaul are pretty standard. See brake maintenance chapter.
2. The on the spot repair is not described any place yet. Here it is:

TOOLS NEEDED:

Four screwdrivers or chisels.

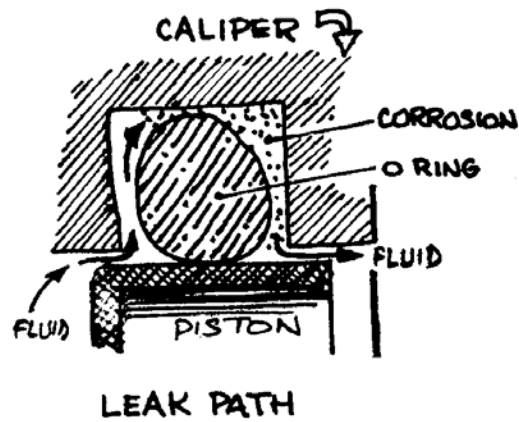
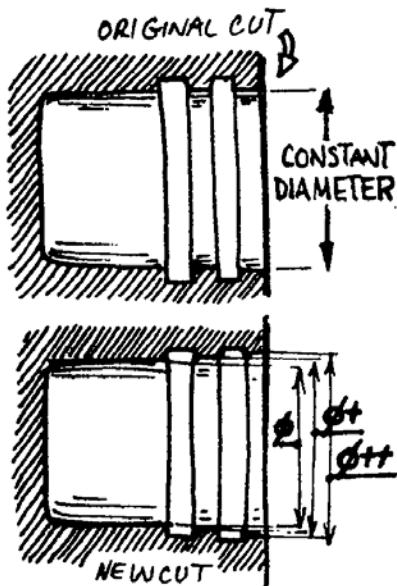
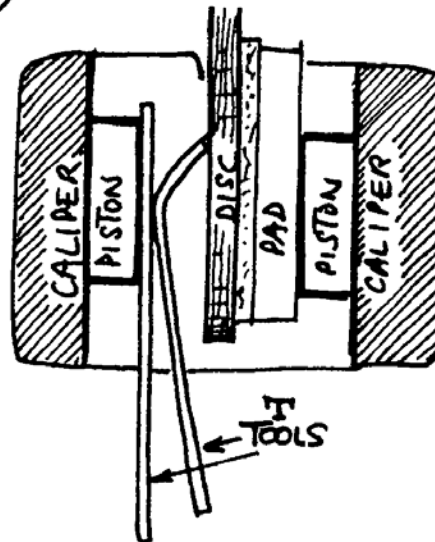
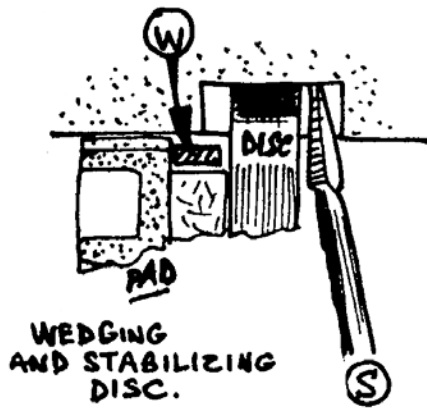
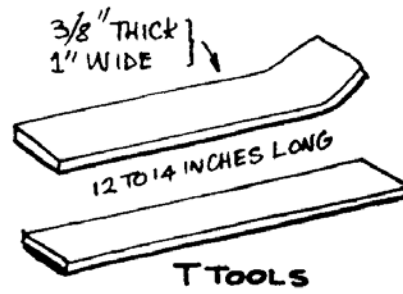
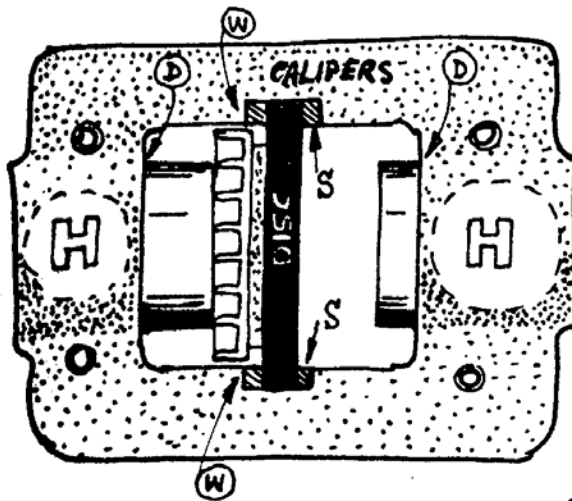
Butane or propane torch (no Oxy Acetylene - too hot too fast).

Two flat tools T as shown.

Pipette pipe for dropping fluid.

600 abrasive paper, use wet in fluid.

Gloves or rags. We are doing one pad at a time. No hammering or chiseling. Just steady pressure and clean shiny surfaces.

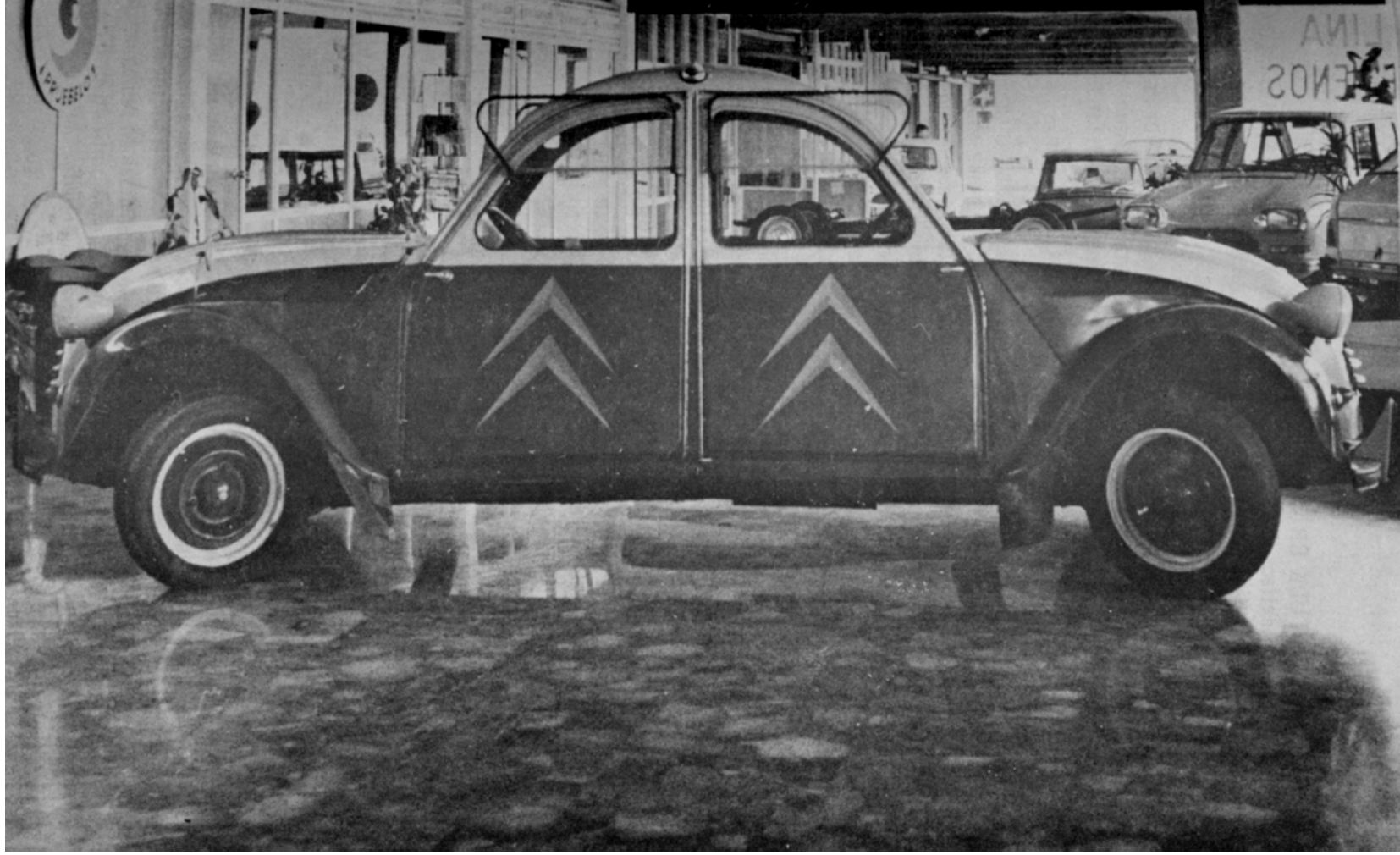


1. Heat caliper in H area until approximately 150° F. is reached, too hot to touch. No need to heat more: the piston will move then. Drop a few drips of fluid on each piston, in D.
2. Insert a screwdriver in each S area. They will prevent the disc's hub from warping and possibly breaking as we lean on it later.
3. Wedge two screwdrivers in W areas so as to move pad and piston back in. Give steady push rather than shakes.
4. Remove pad.
5. Install T tools as shown between disc and piston.
6. Have helper hold T tools in place. Push brake pedal GENTLY to extra piston. As a precaution, it might be advisable to move S screwdrivers to other side of disc, since the piston might be resisting extraction and the other piston, opposite, will bend the disc.
7. Leave T tools wedged between disc and piston. Clean and sand what shows of t piston with 600 paper soaked in fluid. Wipe clean. Drip fluid on piston and retract with T tools and S screwdrivers positioned so as to prevent disc bending.
8. Install pad.
9. Same treatment to other pistons. When all finished, push brake pedal and immediately check that pads are rattling after pedal release. If you cannot feel or hear any play, the corresponding piston is still "difficult". Do it over. One drop fluid a month keeps reoccurrence and leaks away. Just drop it in D.

The real cause is the fantastic Citroen accuracy requirements: 2/100th of a millimeter tolerance between piston and cylinder! Not really necessary since ten times that clearance once will still keep the O ring from "extruding" under pressure. Besides, the piston is so snug in the cylinder that any tilting or cocking will cause it to wedge and lock up. As a result, a disc that is not perfectly evenly thick will cause the pad to rotate as it climbs the bump on the disc. The pad's rotation will be imparted to the piston which will lock up and cause increased friction and braking during the "hill climb". The pad will ride true again once the "top of the hill" will have been reached: the piston will be relatively free to retract. The danger is to lock the wheel on water, snow or ice. Unless the brakes are immediately released, no braking effort is to be expected from that wheel. Releasing the brakes increases the stopping distance and the chances of collision.

The old DS19 brakes were better designed since the double piston set up permitted the pad to ride up and down irregularities on the disc without causing any binding. The Lefebvre original design was superior in that it incorporated the emergency brake and the wear adjustment mechanism. It was a watchmaker's delight and our nightmare.

The tight tolerances are also a cause for troubles when corrosion starts. The brake caliper has an excellent combination for acting as a battery: Steel (piston), aluminum caliper) and salt water impregnated felt (O ring and just plain dirty water from the road). The steel bubbles out and the aluminum pits. Same problem as on seagoing ships, where the propeller and the hull react with each other, causing hull degradation.



SOLUTION TO THE STUCK BRAKE PROBLEM

Extract the whole unit, extract the pistons and machine beyond O ring to an extra tenth of a millimeter larger. A slight taper is good, between both O rings. Pack felt ring with silicon grease before assembly.

LEAKY FRONT BRAKES are not caused by damaged O rings, but most of the time, by corrosion building up between the same O ring and its seat. If you cannot get a new ring, clean the groove, clean the ring, put fluid on both and reassemble **WITH THE RING TURNED AROUND**.

LEAKY REAR BRAKES are caused by worn O rings. The wear itself is caused by the fact that the play adjust cam has not been followed up as the brake shoe lining was wearing away and down. This causes the little piston's travel to increase to almost 1/4 inch every time the brake pedal is hit. No O ring can take this kind of punishment for too long, in the difficult environment of the rear brake cylinder. This excessive play also causes a delay in the braking. This can cause the driver to lock up the front axle while no braking is done on the rear yet. Then the rear catches up and squats.

Prevention: adjust the cams every 6 months or 10,000 Miles.

Cures: Replace the rear O rings. If you cannot get them fast enough, the old ones can be used again permanently as long as two or three turns of Teflon ribbon (plumbing supply or hardware store) are neatly wound in the groove. The O ring will seat itself on Teflon and be expanded enough to seal again.

OIL SOAKED BRAKES SHOES AND PADS CAN BE PUT TO USE AGAIN by baking the fluid away. Cook with a torch, evenly and gently to prevent explosions. Wipe what ever comes up to the surface, before it starts to burn. Clean the fluid off the drum and all accessories. When the shoes or pads have cooled off, clean with solvent lightly and quickly.

BRAKING DELAYS between the pushing of the brake pedal and the effective braking is usually caused by gas bubbles in the brake lines or cylinders. The system has to compress the bubbles before the right pressure is reached, allowing the pistons to move. A hiss is usually heard while the fluid is rushing to fill the void. Sometimes the effect is so severe that it will also cause a delay in the release of the brake, after the pedal has been released. This is a dangerous problem on wet, snowy or icy roads. The driver usual overbrakes to accelerate the braking delay. The result is that nothing much happens . . . suddenly the wheels are all locked. They will remain locked for a while although your foot is off the pedal. In the meantime, nothing much is to be expected from the steering since a sliding tire is rather symbolic in effectiveness. Another detail to remember on wet roads is that a tire that is sliding will not resume rotation again until 70 to 80% the braking effort is removed, unless a severe bump is encountered.

DS19 BRAKE CALIPER UNTIL 1966.

SOLUTION TO BRAKING DELAYS:

1. Bleed brakes.
2. Adjust rear cams. On the ID (manual), front axle's pet cocks are on the calipers. On the DS (semi automatic), front axle's pet cocks are: one on the govern top, one on the carburetor's side. On the SM, both located just behind the center plane of the radiator's fans. On DS, ID and SM's rear axles, the pet cocks located on the inside hub.
 - a) put the car in next to high position, stop engine.
 - b) open regulator till empty and close again. Leave engine off.
 - c) install plastic pipe from first pet cock to glass jar, open pet cock, about 1 turn counter clockwise.
 - d) put a brick on the brake pedal.
 - e) start engine. LEAVE AT IDLE.
 - f) wait till liquid coming out of pet cock is clear.
 - g) SIMULTANEOUSLY: close pet cock and stop engine.
 - h) get set for next pet cock and return to instruction C above.

WARNING: The rear axle will not bleed away as long as the wheels are not holding car up. Watch that the car does not come down on you as you are bleeding the rear axle. Only the early DS19s had a separate rear brake accumulator. The post 1963 models take their pressure from the rear spheres.

Finally, adjust the rear brake shoe cams so as to have just barely rub on the drum.

SQUEAKS, SQUEALS AND GROANS IN THE BRAKES:

Loud vibration in front brakes, near stop is caused by wet discs. Also can be caused by bad gear box mounts in before 1964 DS and ID models.

Squeaks or squeals in front or rear brakes are caused by interaction of brake material and metal disc or drum, obviously. Reason: the brakes were applied violently, repeatedly as the new pads were broken in. Citroen warns of this in Europe. The braking material has been matted to a polish and the metal has taken a pattern of ripples that will provoke the "ringing" when pressure is applied again. Braking hard will stop the ring and promote rear end collisions without erasing the ripples that cause the noise.

SOLUTIONS: Either remove shoes and pads and sand paper them or heat before reinstalling, or, rotate the front pads (left to right, etc. . .) and rotate the rear drums.



THE DS-ID-SM PROPORTIONING POWER BRAKES

WHAT DO THEY DO? THEIR PURPOSE:

The brakes' effort is proportional to the load on the rear axle. The more weight on this axle and the higher the braking effort for the same pedal pressure.

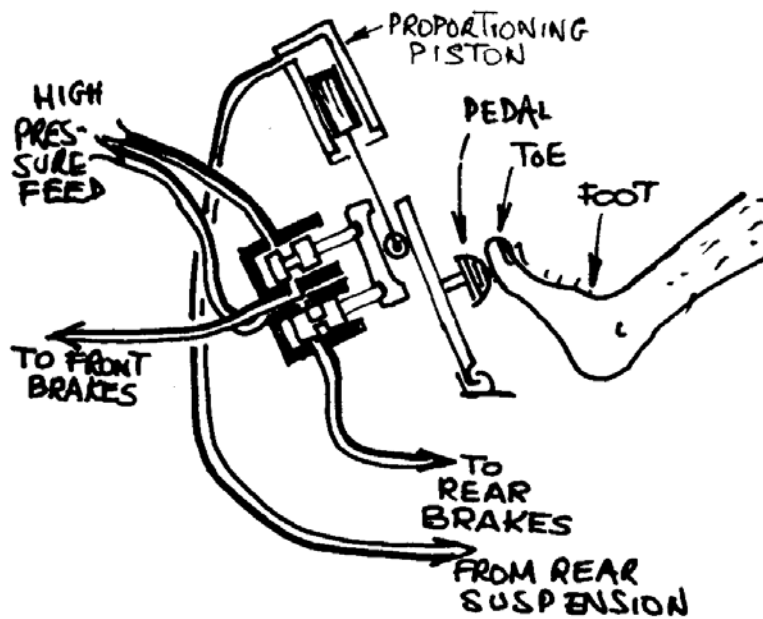
The system also helps prevent rear wheel slippage since it cuts off braking when the wheel is lifted off the ground or close to doing so (pot hole bottom). On a standard brake the effort remains constant and the wheel will stop rotating with no guarantee that it will rotate again when returning to the ground. Since a slipping tire has symbolic adhesion, the rear axle will slide . . . usually sideways, throwing the car in challenging positions not always desired. By the same token it gives more efficient braking when the passing of the same wheel on a bump: the patch pressure is increased and braking can be stronger with out slippage.

The braking is modulated at all times keeping the vehicle stable.

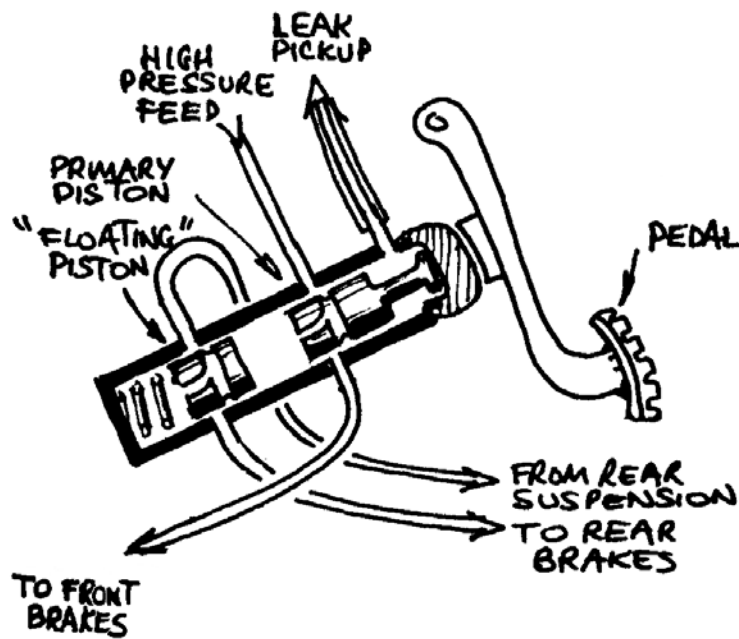
Several systems were used. We will consider two of them.

- The DS type measures the weight on the rear axle by picking up the sphere's pressure and sending it to a device that is actually installed between the brake "button" and the two master cylinders: one for the front and one for the rear. As the piston is pushed down and up by the pressure of the rear axle, the lever's ratio changes and more or less pressure is indirectly applied by the driver's foot to both master cylinders.
- The ID type actually uses the pressure from the rear spheres to power the rear brakes. It also uses a floating piston device in the master cylinder for proportioning

Both systems are reliable, being only sensitive to gases accidentally leaking into the fluid from punctured diaphragm in the spheres. This will cause braking delays. See Brake Story (p. 34).



DS19/DS21 BRAKE SYSTEM
BASIC LAYOUT



ID20/DS20 BRAKE SYSTEM
BASIC LAYOUT

STANDARD BRAKE MAINTENANCE

DS-ID-SM

Replacement of pads

D (early design):

Loosen screws holding locating pins out of pads. Remove pins. Extract pads. Using special tool, crank back the play mechanism, turning to the rear (CW on left CCW on right). Install pads and adjust play the mechanism to just barely tighten. You can also move the hand brake back and forth until brake handle feels normal again.

D (second design):

Remove clips in front of pads, extract pads and disconnect wires. Push pistons back with special tool described in brake story chapter (p.34). Install new pads, wire up and install clips.

Replacement of blocks.

D (early design):

Drain radiator. Remove radiator. Hold gear box assembly to prevent it from falling down as you remove the cross bar that holds the gear box. Remove (power) steering rack. Disconnect piping and cables on both brake calipers. Remove pads. Detach calipers from bell housing (make sure that the bell housing bolts are wired up again when installing overhauled calipers). Install pads. Connect cables and pipes. Do not over-tighten slide bar on rear of pads to allow caliper to move right and left. Press pedal to position caliper and adjust play mechanism.

Mount power steering. Install cross bar and front calipers' vertical adjustment so to have about 1 mm overlap of the front of the pads above the disc. Check all nuts and bolts tight. Bleed brakes.

D (second design):

Remove shroud and bar in front of radiator. Disconnect wires, remove pads, disconnect pipes and clamps. Hold gear box up from bottom (pan off) and remove large bolts. The calipers come off forward.

To install proceed in reverse. Precautions: before tightening calipers to gear box again, install piping and pads. Have a helper press on the brake pedal while you are tightening the calipers to the gear box. Bleed brakes.



Presidential SM



CITROEN POWER STEERINGS WHY DO THEY WORK BETTER?

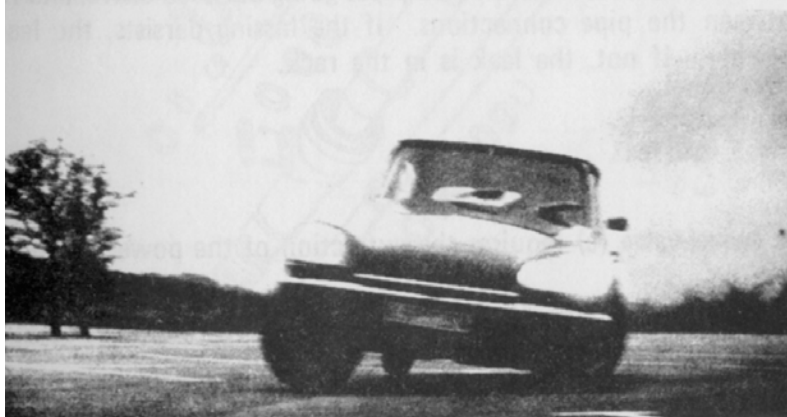
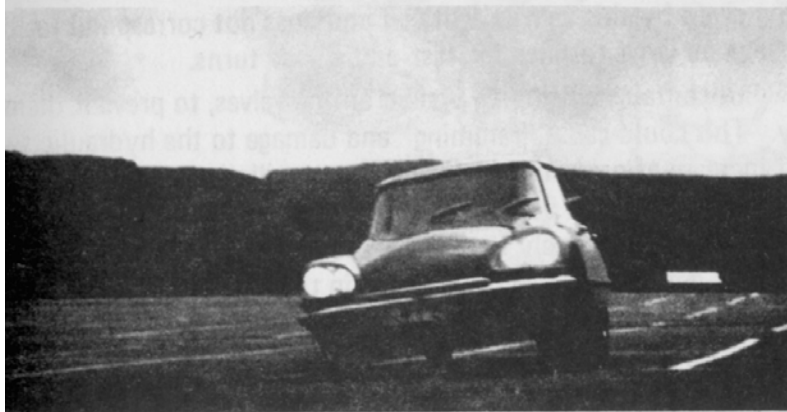
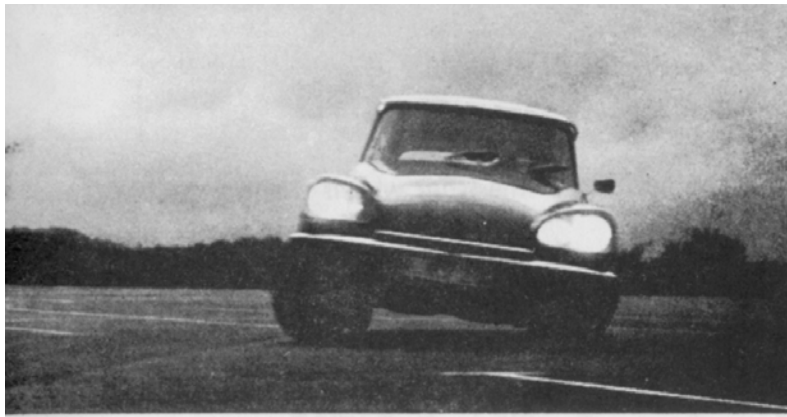
People have been raving about the "fantastic" accuracy of Citroen power steering. This will explain why they work so well and how.

At least 8 items contribute to the accuracy. They are the following:

1. Rack and pinion (since 1934).
2. Automatic track error correction (since 1955).
3. Nonsolidary steering wheel and rack mechanicals in non corrected position (since 1955).
4. Non-resilient connections and rigid class geometry (since 1934).
5. Feeling feedback at high torques.
6. Automatic "recall to zero" on SM and CX models (since 1971).
7. Variable power assistance on SM and CX models (since 1971).
8. Ball bearing equipped suspension (and not rubber bushings) for constant and reliable geometry (since 1938).

The basic system consists of the following units:

1. The rack and pinion unit, a gear rotating on a rack.
2. Attached to 1 is hydraulic piston and cylinder assembly.
3. Leading the above pinion is the rotating hydraulic distributor and valve assembly (swivel).
4. Attached to the end of the steering wheel's shaft is a "fork" that is not in contact with the above "C" unit except when a change of direction is requested by the driver.



5. A cam located on the steering wheel's shaft gives a "return to zero" feeling on DS/ID. On SM and CX models a similar cam arrangement rides on a piston system that actually has two functions. The first is to harden the steering with increasing speed. The second is to "push" the unit back to mid position after the steering wheel is free.

The feeling given by this cam is artificial and does not correspond to the road condition except at large torques, in fast and quick turns.

The above "C" unit contains a damping system on the valves, to prevent them from opening too rapidly. This could cause "ramming" and damage to the hydraulic system. Ramming is a rapid increase of pressure which can cause oscillations similar to faucets "groaning" in a house. This causes deterioration and fatigue of hydraulic lines and driven mechanical parts, leading ultimately to possible premature breakage. Note that the above D unit is capable of detecting errors in positions in the front wheels and to correct them. No other power steering actually does this since the linkage between the wheel and steering unit is "soft", using compliant materials instead of solid steel bushings and bearings. The geometry is unaffected by the road conditions since all suspension elements held in position by ball bearings instead of rubber bushings.

Since the linkages are accurate and do not vary in length, it is possible to accurately monitor the position of the front wheels.

FAILURES

Steering hisses all the time or in one direction only. Can leak in two areas:

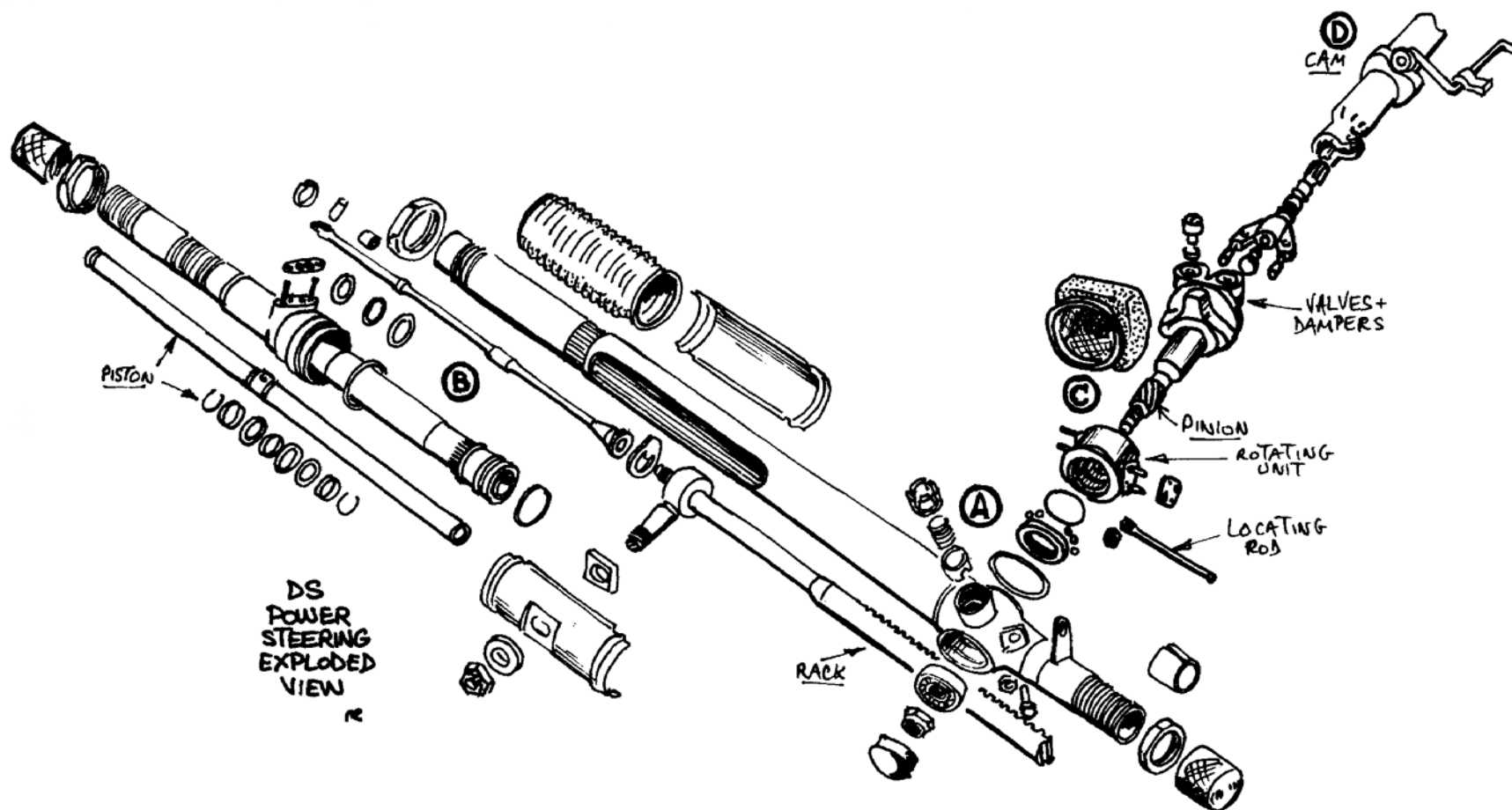
1. In swivel-valve area (c).
2. In rack assembly.

To determine where the leak is, close the two pipes going between swivel and rack by putting a plate between the pipe connections. If the hissing persists, the leak is in swivel-valve assembly. If not, the leak is in the rack.

REPAIRS

Repair of the swivel-valve (c) requires the extraction of the power steering unit from the patient.

Repair of the rack can be done on the car from the right side.



REMOVAL OF UNIT

- Remove spare tire, front left fender, battery and its brackets.
- Drop hydraulic pressure at the regulator.
- Disconnect steering shaft from valve assembly (C).
- Disconnect hydraulic lines from valve assembly (C) and close lines with plate to prevent main tank drainage.
- Disconnect steering levers from steering relays on each side (editor's note: make corresponding punch marks on the retaining caps and the rack to make accurate replacement possible before proceeding).
- Remove the two dampers holding steering unit to steering relays. Extract steering through left side of car.

REPAIRS

Swivel-valve unit (C):

- Disconnect pair of hydraulic lines from (C) to rack.
- Unscrew and remove positioning rod from (C).
- Keep sealing plates and 'O' rings clean.
- Remove cover cap on pinion bearing. Unscrew pinion from bearing.
- Remove pinion with rotating unit.
- Extract pinion from rotating unit.
- Remove old 'O' rings from rotating unit with dentist's claw.
- Install new 'O' rings, wet and clean.
- Tape pinion so as to prevent its teeth from damaging 'O' rings as it goes through the rotating unit.
- Insert pinion thru rotating unit wet and clean. DO NOT ROTATE the parts as they slip past the 'O' rings, as this will gouge the seals.
- Remove tape.
- Reassemble with same washers. Clean parts!

Rack piston assembly:

- Loosen the steering cap's nut and remove the cap from the extremity of the unit.
- Turn the steering fully to the right, the piston's end will appear.
- Remove the metal ring and the pin. Use special tools.
- Disconnect the hydraulic lines to the (C) unit and keep sealing plate clean.
- Loosen large nut locking cylinder, located inboard from rack power line's connection.
- Unscrew whole steering assembly off the right side. The piston and cylinders come on together.
- Dismantle and replace 'O' rings.
- Reassemble taking care to orientate parts correctly (lines' connections and pistons hole must match their mates).

NOTCHY POWER STEERINGS, HOW TO SMOOTH THEM OVER

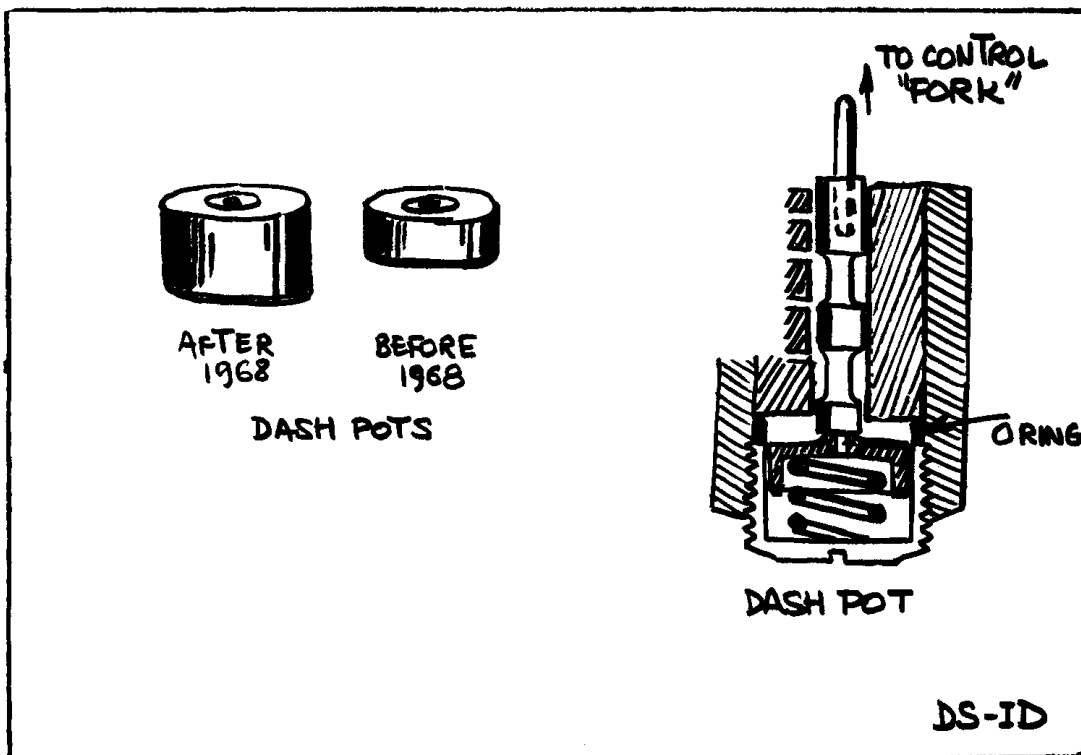
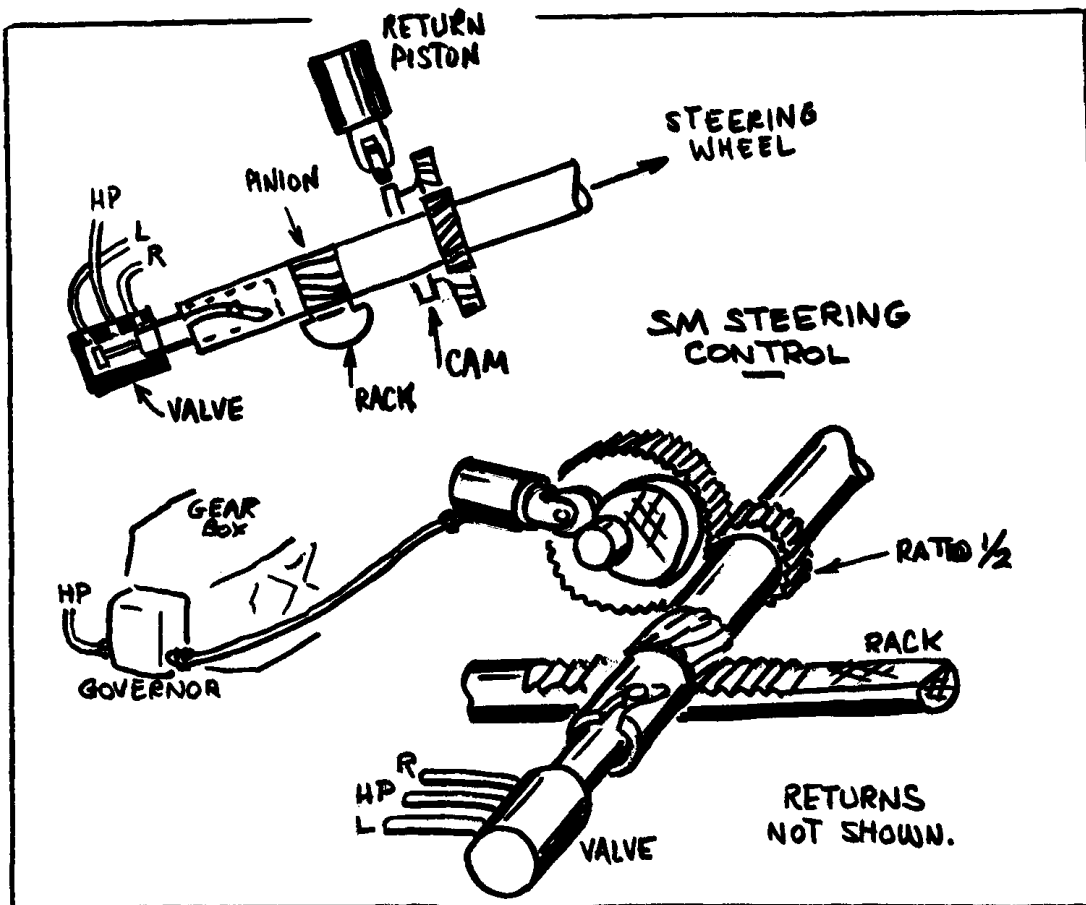
The new power steering units for LHM and LHS2, green and red fluids, have what feels like a "notch" in the center position. This is not the center cam since it still is felt when the cam is removed. The steering units produced since about mid 1968 develop this notch rather quickly and the use of fluids that are not preferred by Citroens will make it appear.

The "notch" feels like the steering is resisting at first solicitation and then suddenly taking over, pulling your hands away too far, causing the car to swerve.

The steering is damped by dashpots situated below the spool valves, located within the casting, wrapped up in a somewhat square boot or rubber dust cover. The same dashpots prevent the spool valves from opening too quickly, releasing pressure into the rack too brutally, ramming the rack's cylinder and possibly cracking it. They also prevent oscillations in the system, since they will correct errors in BOTH directions, unlike standard power steering units. The dashpots will correct errors in positions in the wheels caused by road irregularities and, of course, errors entered by a change only of the latter. As a matter of fact, the standard power steering units are only assisted power steerings, blindly helping along without knowing if the rack has reached the right position or not. The Citroen power steering is a servo system, fully aware of what is going on at all times. The only trouble is that this is true when the dashpots let the valves open in time: us say more than a few milliseconds and less than one second.

The dashpots are different before and after 1968. The old ones are about half as high as the new ones, that's all. Drop the pressure, remove the boot, unscrew the dashpot covers, mark them right and left (they are matched to the pistons), keep the springs and remove the pistons. Remember what side they were on. Do not try to file them down. They are made of hard steel. Grind them down to what you want. Clean them and assemble. If you do not have new 'O' rings, reuse the old ones after turning them upside down. Tighten the covers to 14 ft. lbs. The steering will have no more notch. However it might start twitching when you let go of the wheel, like the old ones did.

The big advantage will be that the steering will respond instantly and will not overshoot anymore.



HOW TO REMOVE SUSPENSION SPHERES

Obtain a strap wrench from your local hardware store. Chain wrenches cannot make around the rear suspension spheres without asking for a bend in the close by frame.

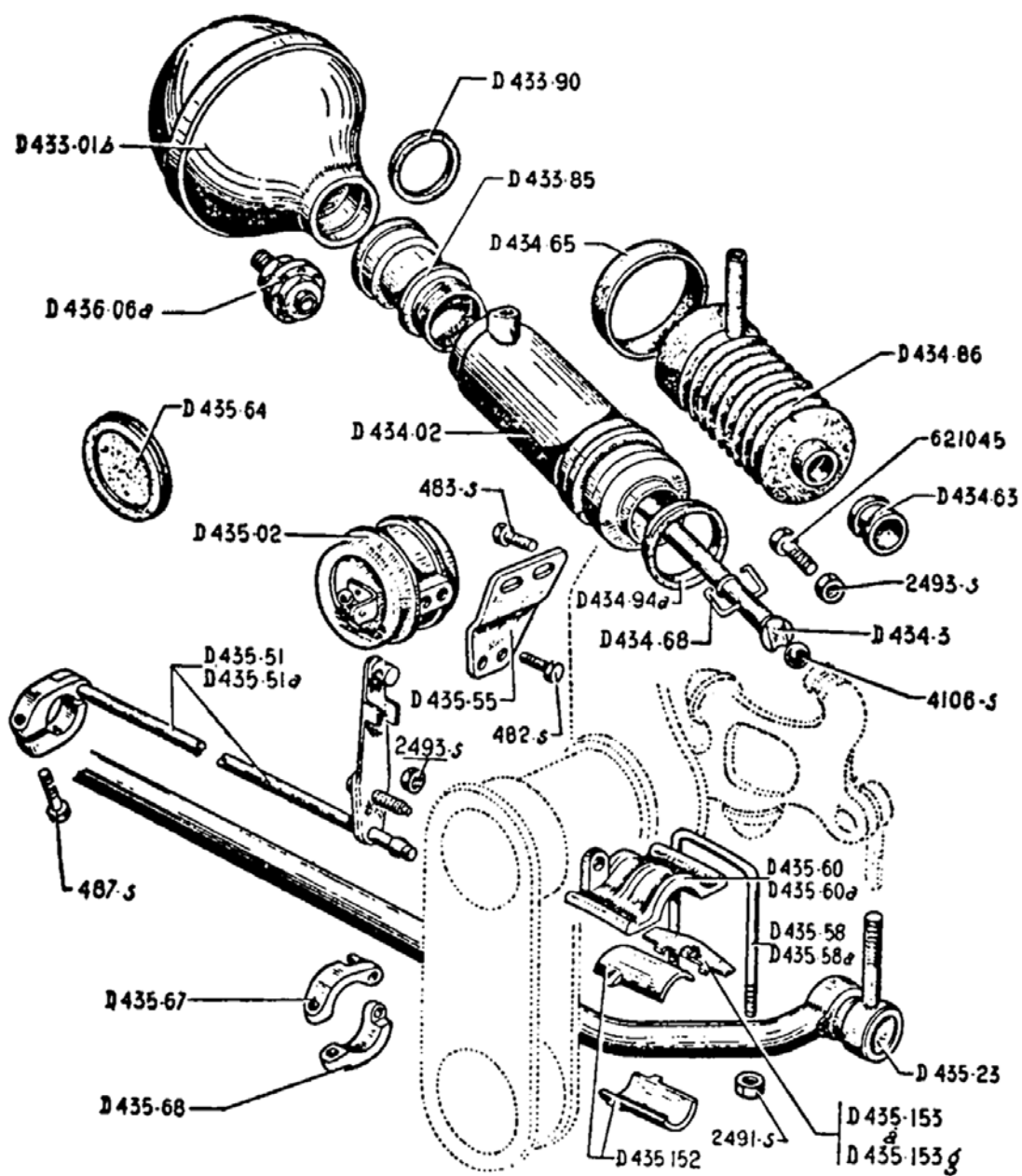
1. Put the car in high position, let it get up there and stop the engine.
2. Put a stand under the frame, in front of the rear wheels. A 2x4 between the stand and the frame is a plus.
3. Remove the rear fenders, the hub caps and loosen the rear wheel nuts.
4. Open main oil reservoir and leave the cap off.
5. Lower the car to its lowest position.
6. Wait till the sphere-cylinder assemblies are loose and can rattle in the frame of the car. In very old cars, they might be held up by accumulations of corrosion. At this point, the pressure is all but gone.
7. Wrap a rag around the suspension cylinder, below the sphere to prevent the little oil that will run out from spilling on the floor.
8. Wrap strap wrench around the sphere and give a sharp tug, counter clockwise. The sphere is loose and can be removed by hand.
9. Pick up the 'O' ring before it falls into the cavernous depths of the engine compartment.
10. Remove rear wheels and remove rear spheres.

SPHERES MUST BE INSTALLED HAND TIGHT ONLY. DO NOT USE TOOLS.

DIFFICULTIES IN REMOVING SPHERES:

- a) Sphere is not willing to turn: Clean area, lubricate with fluid, heat with torch about 200° F. and remove.
- b) Sphere turned a bit and is still resisting: There is still pressure in this cylinder, at the suspension corrector.
- c) A loud crack was heard as the car was settling down and a strong hiss could be heard from the main oil tank: one or more spheres blew its diaphragm and releasing the gas into the main tank. Check that the canister's (main tank) cap is removed. New spheres are available.
- d) The rear suspension cylinder rotates with the sphere: Go to above (b) as the cylinder is held in pliers.

DO NOT HAMMER OR CHISEL THE SPHERES SINCE COMPRESSED GAS IS IN SIDE AND COULD EXIT CATASTROPHICALLY THROUGH A FRACTURE.



HOW TO REPLACE SUSPENSION BOOTS OR HOW TO REPLACE SUSPENSION 'O' RINGS

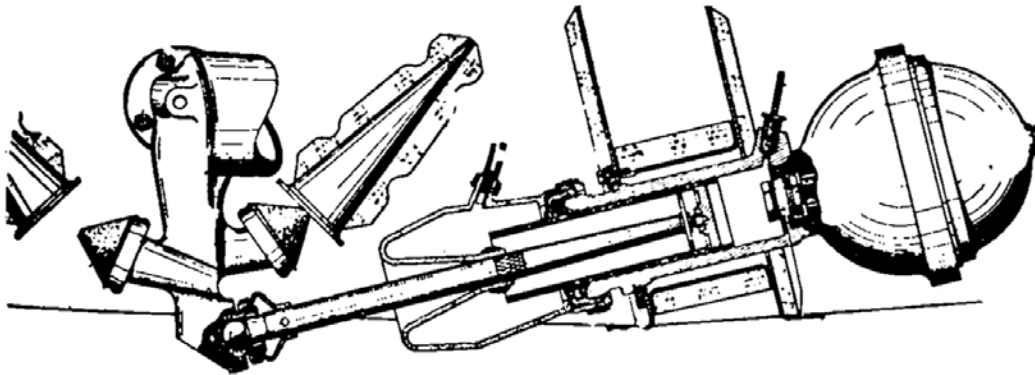
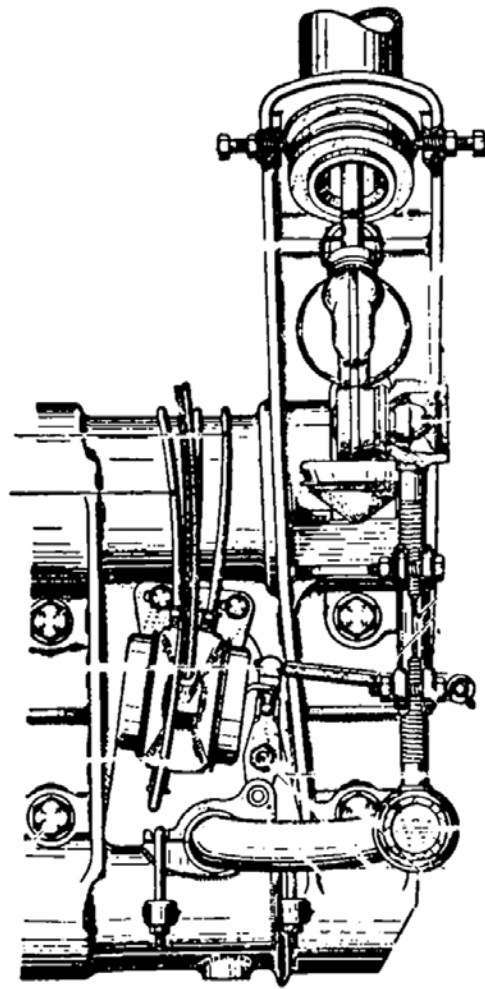
The procedure is almost the same for both operations, therefore the two titles.

The car must be lifted so as to have the wheels hanging "loose". It is preferable to lift the car by the frame as shown below: some cars are quite weakened by corrosion will not take too kindly to a jack under the sheet metal. Citroen recommends putting a wood item between the jack pad and the frame. In the US, we call the item a two-by-four.

Remove the fenders, the wheels, and the gravel shield on front axle. Detach the suspension boot (accordion on front and coffee pot on rear axle) on the suspension cylinder side.

Detach the metal clip from the suspension rod. Note that the rod will get out of cavity, only and only when the wheels are hanging and the rod is-correctly aligned. As the rod is out of the cavity, you might as well take a look at the steel ball that is supposed to be in the cavity. Make sure it is not cracked, chipped, galled, otherwise replace with a bearing supply house's steel ball. Grease the ball before dropping into the cavity again.

Should you be replacing the boot, turn it inside out and detach the clamp that holds it on the rod. When installing the new boot, use a local clamp, such as a nylon electronics type strap. Make sure the nylon strap is not against the boot's material by winding turns of tape against the "seat" of the strap. Use "air conditioning" tape if possible. Masking tape can do however. The same strap must not chafe the inside of the boot and cut it open and must therefore be covered with more tape, such as electrical or air conditioning tape. Masking tape will not hold there. Make sure everything is fluid free since any small quantity of fluid will destroy the adhesive capacity of the tape. Once the tape is installed, all the fluid in the world can pour on it without problems.



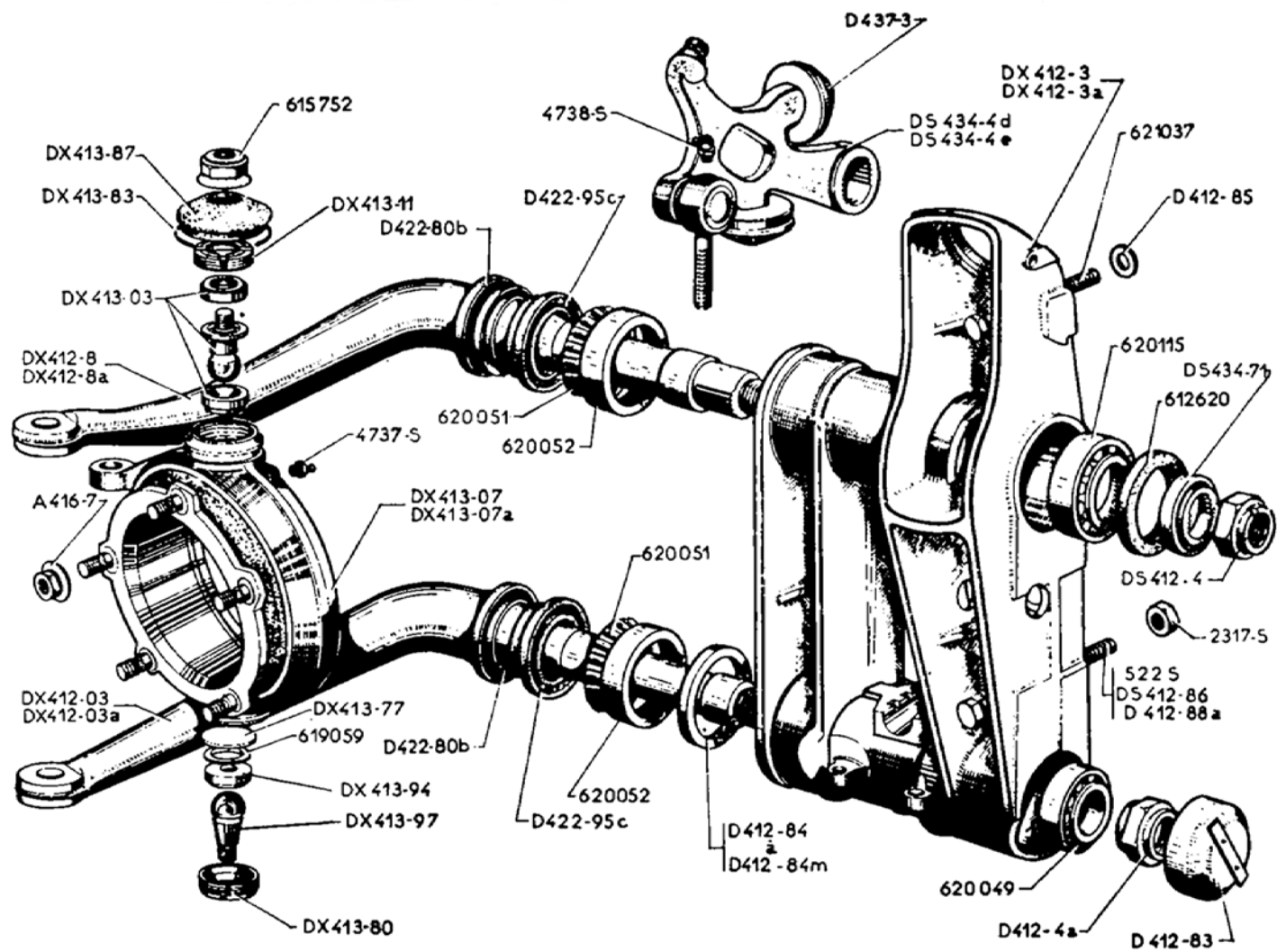
HOW TO REPAIR A BENT LOWER SUSPENSION ARM ON DS/ID

The lower arm is usually bent back by some form of impact such as a head-on or decelerating thru a large pot hole. The upper arms are not usually damaged. As a result the geometry is changed and the steering becomes unstable. The lower arms must be bent forward again. DO NOT USE HEAT, the arm's temper will change and make it behave like putty under stress, with permanent changes every time the stress direction changes, the ultimate result being arm's failure due to its fatigue: breakage. It can be repaired without removing the arm from the car (24 hours labor!).

1. Remove fender, wheel, mud cover over suspension casting, bottom mud shield under same casting.
2. Raise car on stands located under the frame about the brake's and half shaft's area.
3. Lower suspension.
4. Install rented PortaPower as shown on the picture. Use a hard wood block between the PortaPower and the frame. Respect alignments shown on pictures so as to prevent slippage of the PortaPower. Use a 2 ton or more PortaPower (capacity).
5. Install a jack under the lower suspension arm to prevent it from moving down the PortaPower pushes the arm forward. DO NOT USE THE SQUARE JACK STAND AS A REST POINT. DO NOT LEAN ON THE PIPING. LEAVE THE DOORS ON THE CAR CLOSED.
6. Measure the distance betwixt the square jack stud on the frame. It should be about 16 3/4 inches.
7. Make the difference between what you find and what the figure should be (16 3/4"). You must push the arm forward twice that difference and let the arm spring back to neutral.
8. Install a marker where the arm should go and jack the PortaPower slowly and smoothly. Do not jerk it. Listen for grunts and crunchings. The wood will crunch into the frame, it is OK. Release the PortaPower when the wood stops crunching and observe any motions in the doors or vertical motions in the suspension arm. If any, realign the PortaPower. The arm's motion must be strictly horizontal.

Should the PortaPower slip and hit you, stay out of its way. This means routing its hose under the car to its other side, where you cannot see it. Look at the marker's position with a mirror. The mirror is cheaper to replace than a broken jaw, should the jack slip out of its job.

When done the dimensions should show 25mm plus or minus /mm as shown on the drawing above.



FLUSHING OLD FLUID

HOW TO CHANGE THE FLUID IN YOUR DS-ID-SM GS-CX OR 15CV-H:

This is the operation commonly referred to as "flushing". It consists of removing old or noxious hydraulic fluid from a car and replacing it with good or new liquid.

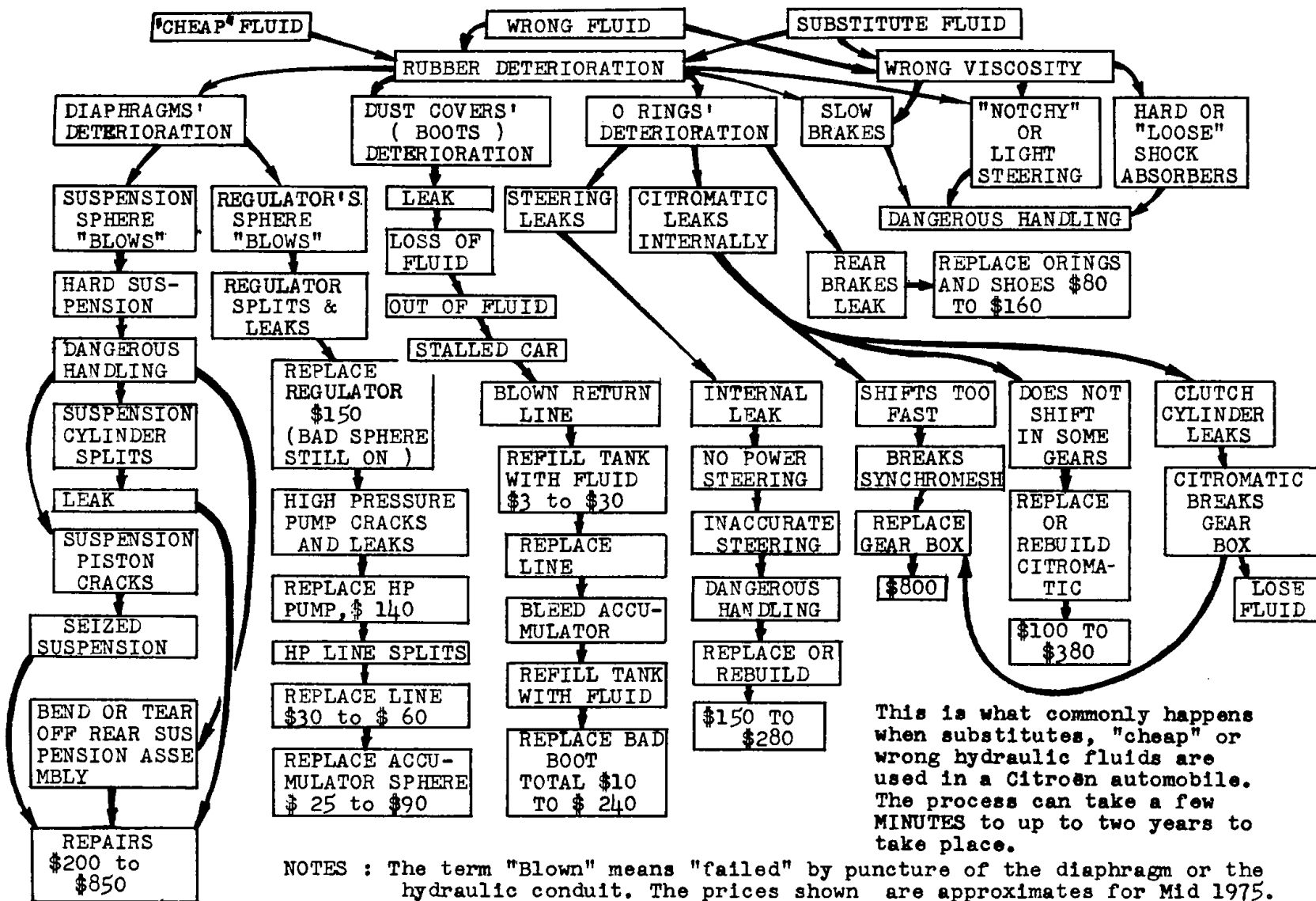
Tools needed:

1. 8mm wrench, for regulator.
2. 5 to 6 feet plastic tubing to siphon fluid out.
3. gallon container (old fluid).
4. gloves or rags (hands).

Operations:

- a) Open regulator's valve 1/4 turn counter clockwise.
- b) Lower suspension lever. Suspension empties into main canister. A bad sphere might rupture internally and cause damage to the canister, better open the canister's cover and cover the opening with a rag.
- c) Pump brake pedal until it "falls" to the floor. Even the button pedal will become limp.
- d) Have a helper press the rear suspension boot on one side while you press the other side's boot. Press as much fluid back into the piping as possible without damaging the boot against the piston or the rod's clamp.
- e) Siphon or empty fluid from canister. When canister is empty, run engine so as to pump whatever is left in pump and regulator back to canister. Empty that too. Stop the engine. Clean hydraulic filter.
- f) Pour new fluid into the canister. Use the top off a plastic bottle for funnel. Pour up to 1 inch from opening (top). Install filter.
- g) REGULATOR IS STILL OPEN. Start the engine. The pump will prime itself at idle. No need to rev up. . . unless you are doing this on a railroad crossing and a train is coming.
- h) Engine idling, look at the return from the regulator, through the canister's opening (top). As long as the return is milky or bubbly, wait.
- i) When return is clear, stop engine. Close regulator's valve with 8 mm wrench. Lift car. You are ready.

DO NOT FLUSH THE SYSTEM WITH ALCOHOL BASED FLUIDS ON GREEN FLUID CARS. MAKE SURE, SHOULD YOU ABSOLUTELY WANT TO FLUSH THE SYSTEM, TO LEAVE THE SOLVENT IN THE SAME SYSTEM THE SHORTEST TIME POSSIBLE.



HYDRAULIC PUMPS, FAILURES, CAUSES, REPAIR

The "seven piston pumps" are used in 15CV-H, DS and ID models, and SM models. They will be found in the CX models.

They usually fail by leaking externally, hemorrhaging more or less expensive hydraulic fluid. They do not leak internally unless they were used with the wrong fluid.

They can tolerate up to 4 times the maximum pressure, as found in the vehicles. That is about 6000 PSI. They will become rather noisy above 3000 PSI only.

They are capable of destroying accumulators or their regulators. We have seen cases where the steel regulator did not cut out, did not fail, and caused the explosion of the accumulator sphere. It just separated at the equator and made a large dent.

TO REMOVE PUMP FROM CAR, drop pressure at regulator, disconnect rubber feed hose from pump, loosen pump, unscrew the high pressure pipe, move belts out of the way and extract unit.

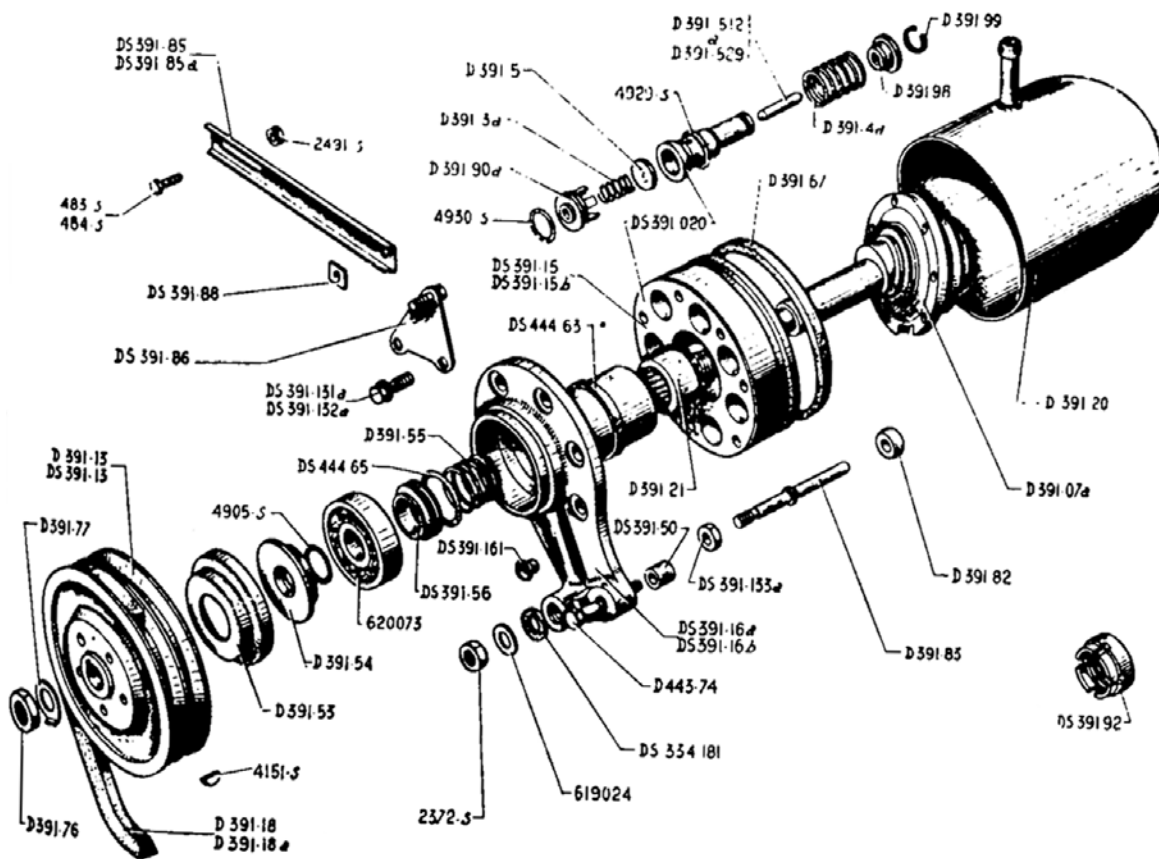
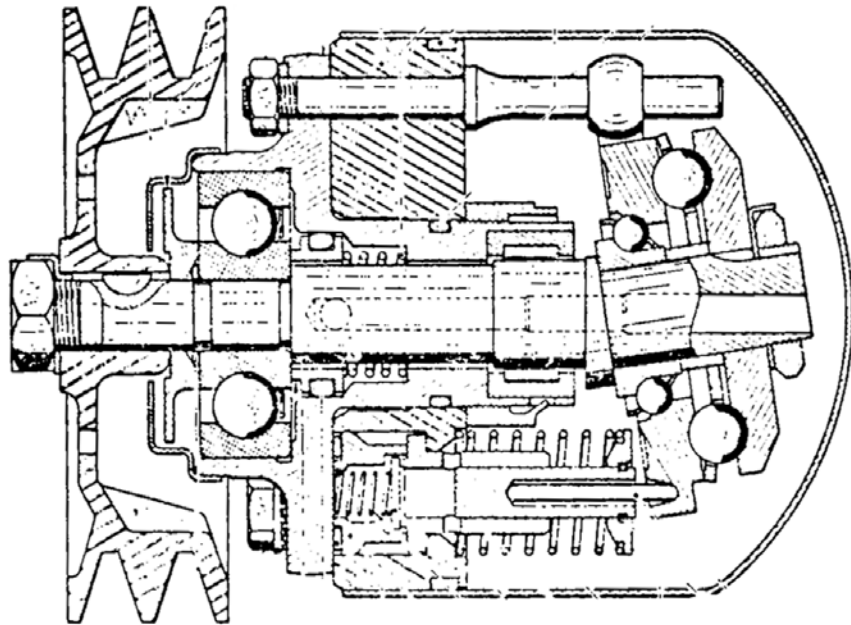
Empty the pump before working on it. Remove in sequence: pulley nut, washer, pulley, key on shaft. Close the pump's openings so as to prevent contamination.

Cover removal: lay pump on a piece of rug or rag and, using a large flat DULL chisel and a hammer, push the cover off. A few large blows well placed around the cover will work wonders. Many small blows will make lots of dents and not move the cover. DO NOT HOLD THE PUMP IN A VICE while removing the cover, unless you have a cover extra or. Hammering on the pump in a vice will bend or crack the block.

KEEP PISTONS AND CYLINDERS in order when removed; they are matched. Keep them absolutely clean with alcohol (LHS2) or kerosene (LHM). DO NOT FORCE THE PISTONS IN when reassembling the pump. Chips and disasters will result.

Dip all parts in fluid before reassembly.

THE PUMP LEAKS AT THE JUNCTION between the aluminum block and the steel block (slow drip): remove the wobbling plate, the bearing and the seven pistons' assemblies. Hold the steel block in a vice and loosen gradually the seven bolts holding the two blocks together. Follow the order 1.3.5.7.2.4.6.1.3.5.7. etc... Use the same procedure upon reassembly. As the blocks are separated, clean them with alcohol or kerosene and immediately dry them with air. Deposit a barely visible bead of epoxy glue mix, follow the pattern shown on the drawing. Assemble and hold in oven for 1 hour at 150 to 180 deg F. Serve warm without changing the O rings. The pump will come apart the next time with a tap on the block.



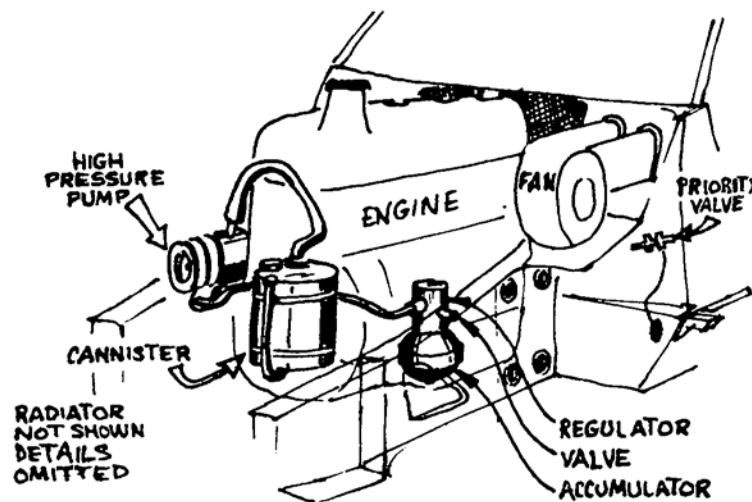
THE PUMP LEAKS AT THE PULLEY or does not prime: caused by bad 'O' ring on shaft's brass seal. This means removing the pump's shaft, the main bearing and replacing the ring. Very difficult to put together without special tool.

THE PUMP LEAKS AT THE ALUMINUM BLOCK, gushes or sprays: the block is cracked. The pump is lost unless a good local welding man can fill the void and a good machine shop can drill and tap the cylinder's seat again along with the bolt's threads. This is caused by overtightening of the belt or of the seven bolts. Cold weather helping along will cause the aluminum to crack between the tapped hole and the liner. A bad regulator's accumulator later can cause the same failure.

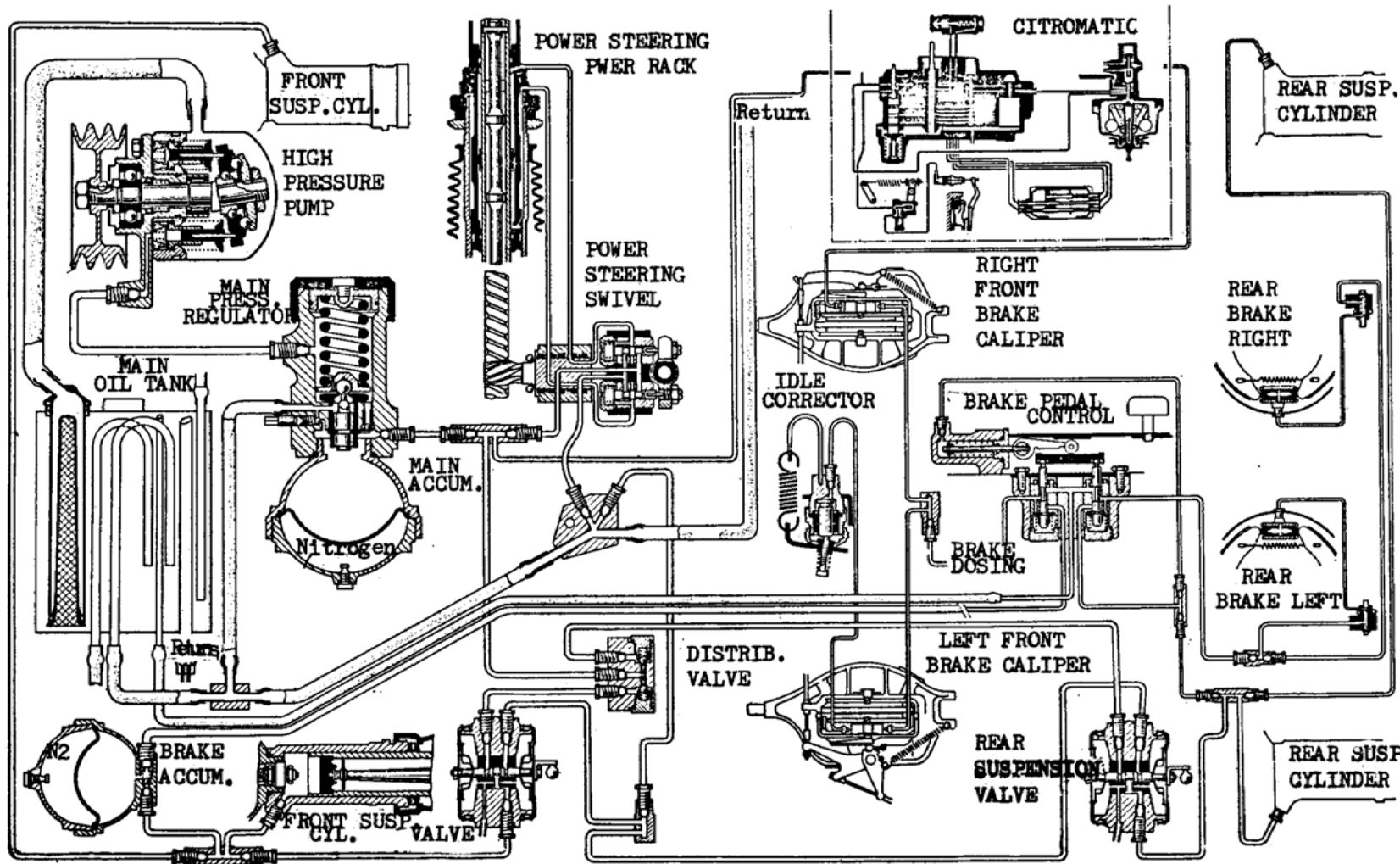
THE PUMP DOES NOT SUPPLY ENOUGH PRESSURE: turn it by hand, slowly enough to feel each piston "holding" the pressure. If one sector rotates very easily, the piston is damaged. A new one must be machined and case hardened. It is cheaper than buying new pump. Check the flapper valve's seats for cracks or corrosion (LHS2).

When installing the pump, no priming is necessary. Just let the engine idle along until return to the main tank is clear. The regulator's bypass valve must be open until no more air is in the circuit.

The main bearing is made by SKF, is not available in the USA, nor in Canada, even from Citroen. The number is Citroen 89.475, SKF 431645A. You will find the same bearing in the early DS19 water pump and generator. The needle bearing is made by NADELLA and is sold by Bremen Bearing Co., Inc., Bremen IN 46506, ph# 219.546.2311. The main bearing size is 20x47x14 mm.



DS19 HYDRAULIC CIRCUITRY, 1961 to 1968. Basic for DS21 and ID models



CITROMATIC

HOW IT WORKS

It is basically a valve that sends fluid under pressure to some seven different locations takes and orders from some five sources. It can be compared to a logic matrix in computer language. The sources are the selector lever, the high pressure (power supply), the centrifugal governor, the brake pressure in the front brakes and the flow limiter. The "outputs are to five gear pistons (reverse, first to fourth), the clutch piston and the governor.

Added to this are two handy devices, a capacity stack of pistons of which the job is to delay the application of full pressure to the gear box pistons while the synchromeshes are synchronizing the gear velocities (grind!). The pistons move and drink up the juice while the gear box' pistons are going in at the same rate, although slower and carefulier. We have also an automatic stack of which the job is to open the flow to the clutch only and when in gear or under idle minimum so as to prevent stalling the engine. It is an OR in computers.

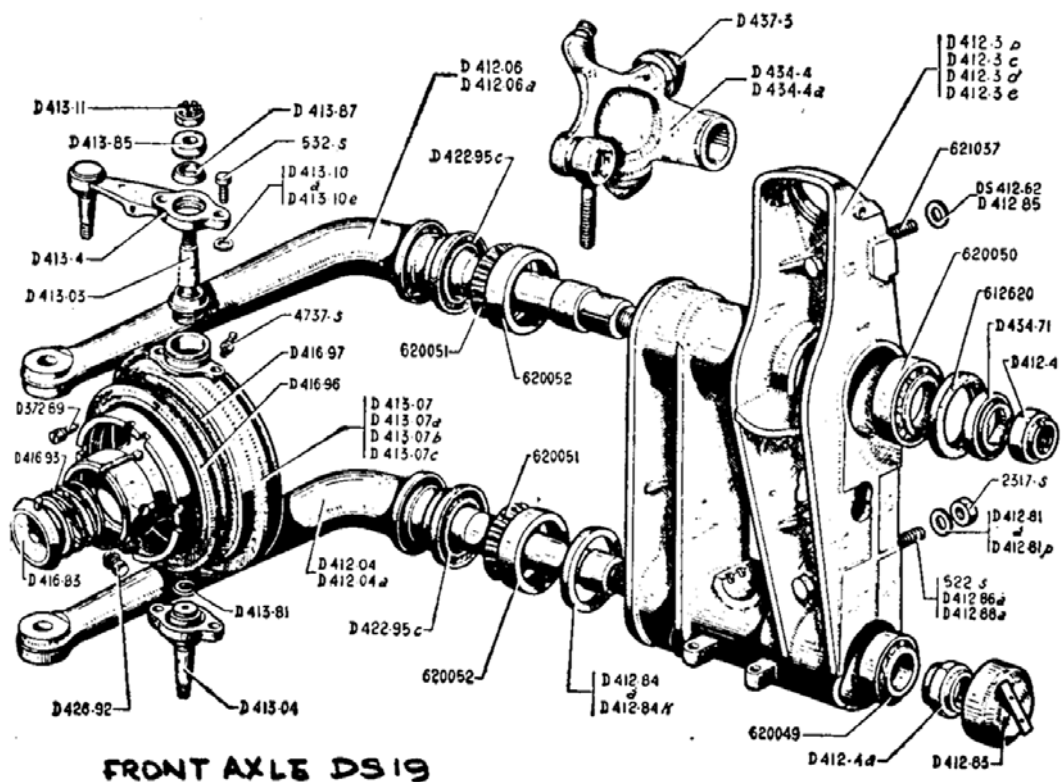
One last item is the flow limiter, which prevents the full force of the maximum pressure from rushing the gears together too eagerly. The faster the flow, the more its piston will slide and tend to obstruct the exit opening, therefore slowing down the flow. It can be heard rattling when air is in the system. It can be compared to a Zener diode in an electrical al system.

SELECTOR LEVER (SL); CAPACITY STACK (CS); FLOW LIMITER (FL);
AUTOMATIC STACK (AS); CENTRIFUGAL GOVERNOR CONTROL (CR)

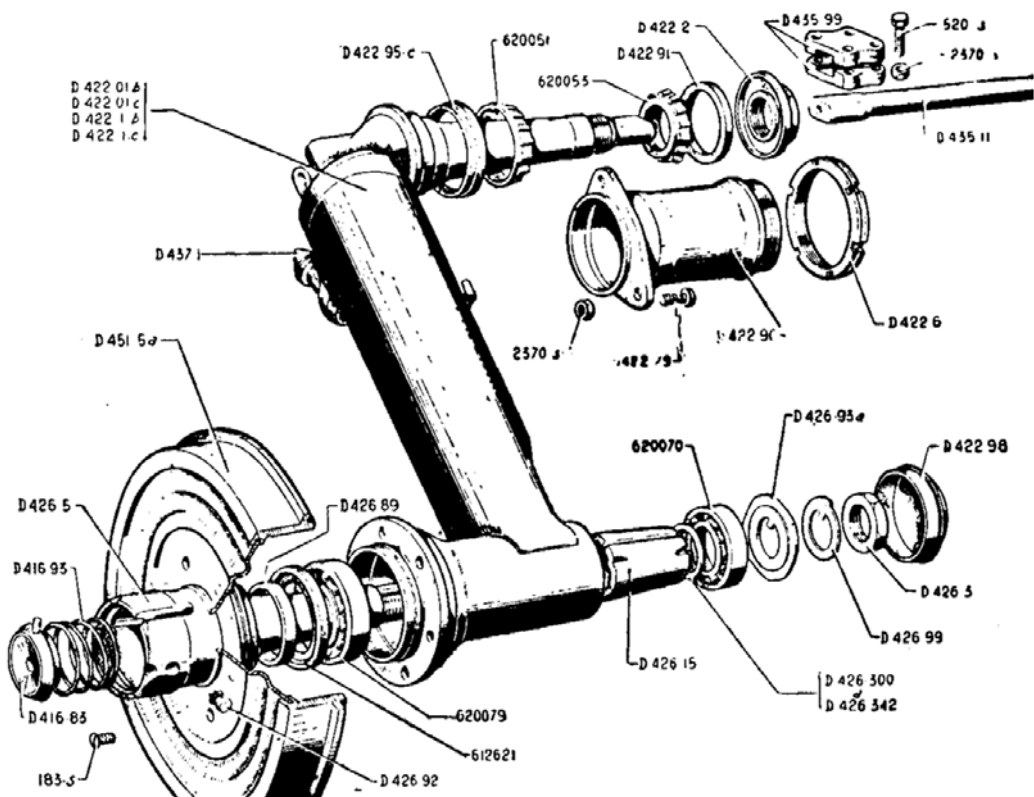
The centrifugal governor's control opens the block to high pressure as the engine reaches 850 to 1100 RPM according to conditions. The pressure goes in and flows to the clutch cylinder, releasing it.

At idle, in neutral, CR is open to high pressure and the clutch is held apart. In first gear, in idle, same situation, while the first gear gets engaged, no delay piston for first gear. As the engine gets revved up past, say, 1000 RPM, the CR moves to exhaust and allows clutch to contact. Brake pressure will push CR back to high pressure and will separate clutch again.

The rest is pretty evident from the above.



REAR AXLE DS19



FAILURES

Gears missing, do not engage, usually 2nd and 4th together or 3rd and 4th together. 3rd may miss alone but 2nd rarely gets lost alone unless a line broke.

Citromatic block pings, rattles, roars.

Lever is hard to move, sticky.

Lever is broken off the unit, loose.

Starter does not work.

CAUSES

"Missing gears" are caused by damaged 'O' rings in CS stack. The fluid leaks by the piston and prevents the gear box piston from getting enough pressure to move. Wrong fluid or dirty fluid can cause this. Old age can too, about ten years in LHS2 systems and five in LHM systems. All CS stack's 'O' rings will have to be replaced with Citroen's Nr 5032S or NORI kit X0017 or X0018.

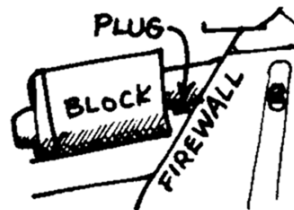
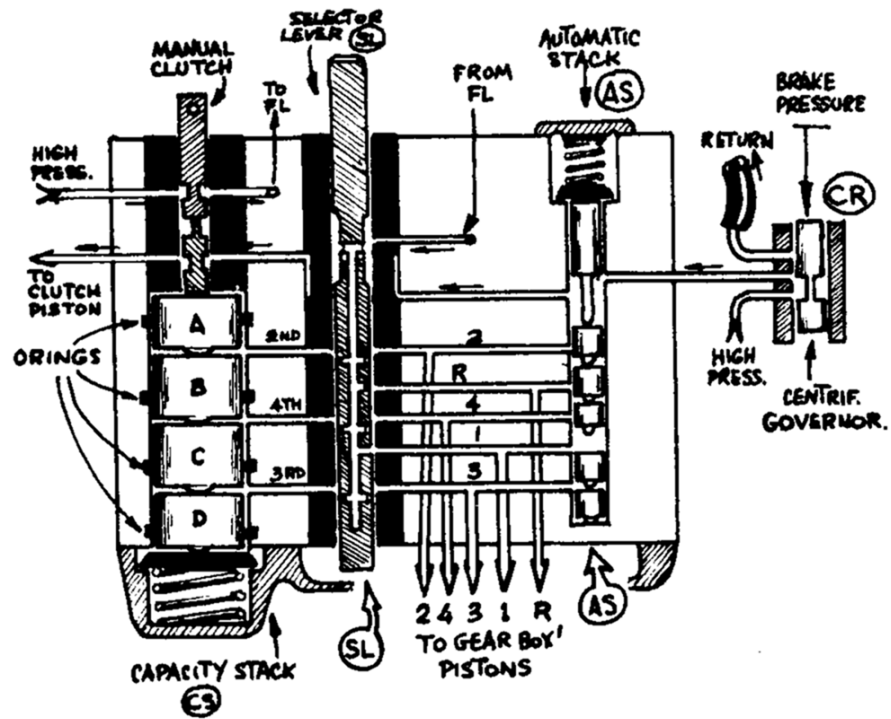
Noisy Citromatic is caused by air in system or bad 'O' rings in CS stack. An internally corroded flow limiter can cause this too, usually with LHS2 fluid.

Control lever hard to move: caused by dirt, hair, gummy deposit between SL's piston and its liner. Do not force it, as the lever link will break, and it is more difficult to repair than a dirty lever.

The starter switch does not work, providing all other starter elements are good. Replace the switch with a MILspec microswitch.

REPAIRS

The hardest repair is the replacement of the SC 'O' rings. Drop hydraulic pressure by opening the main regulator screw 1/2 turn CCW. Remove front left suspension sphere. Lay rag under the front of the Citromatic block. Slowly unscrew the front plate off the block. Avoid warping, since there is a beeg spring in dere. Pick up spring, gasket, discs and plate and remove CS piston with long nose pliers. Take long needle to remove old 'O' rings. Don't scratch the cylinder. Get new rings and install, wet with fluid. Insert pistons again WITHOUT ROTATING them, just push in. Clean gasket seat and reassemble with clean, wet parts. One to two hours' work.



The SL piston can be removed from the front, like the CS stack. It has to be disconnected from the control lever. However, remove the rubber plug (see picture) and, using 8mm socket, loosen the nut holding the clamp. The SL piston is free to move forward, providing it is not stuck. DO NOT GRAB IT WITH HARD TOOL but wrap aluminum around pliers. The liner can be cleaned with alcohol or kerosene on a Q-tip. Clean piston and blow out dust, dip again in cleaning liquid, dip in fluid and reinsert into block. Another rubber plug is located under the rear (firewall side) of the block. Remove it and insert a 1/8" pin into the hole until it fits into the SL piston's hole. This is the neutral position, no gear engaged. Tighten the 8mm nut on the clamp, remove the 1/8" pin, and replace both rubber plugs back in place. Close unit like for CS repair.

THE CITROMATIC GOVERNOR

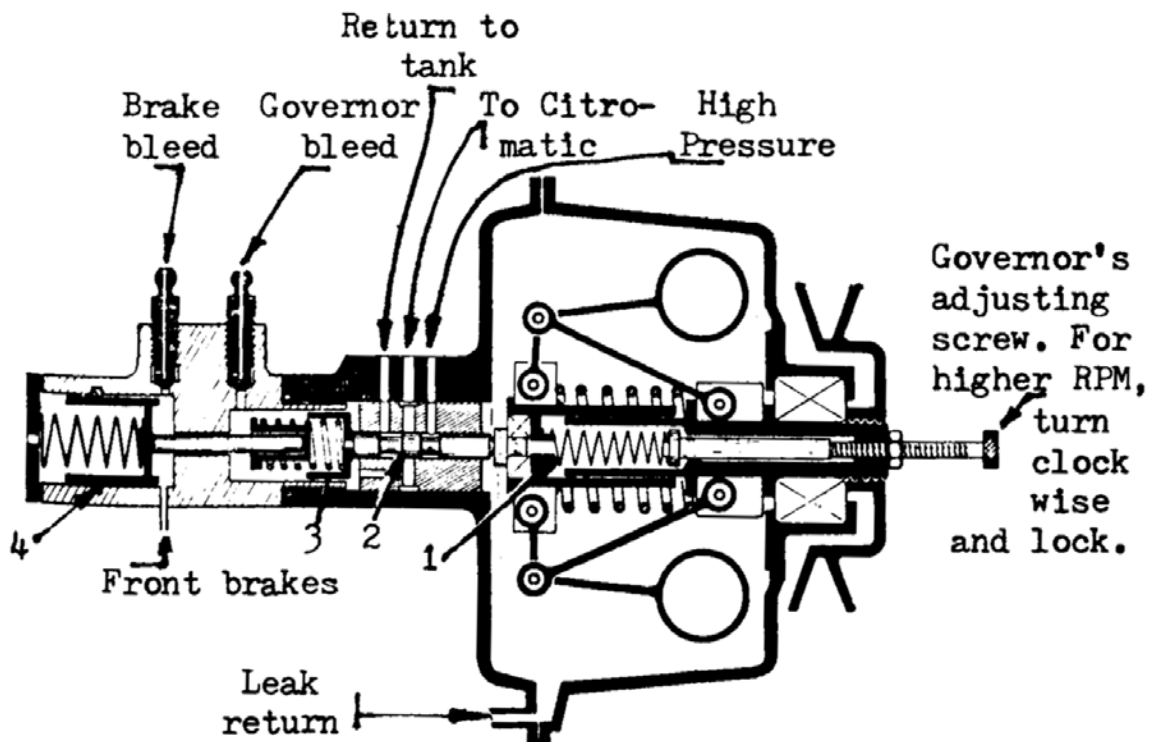
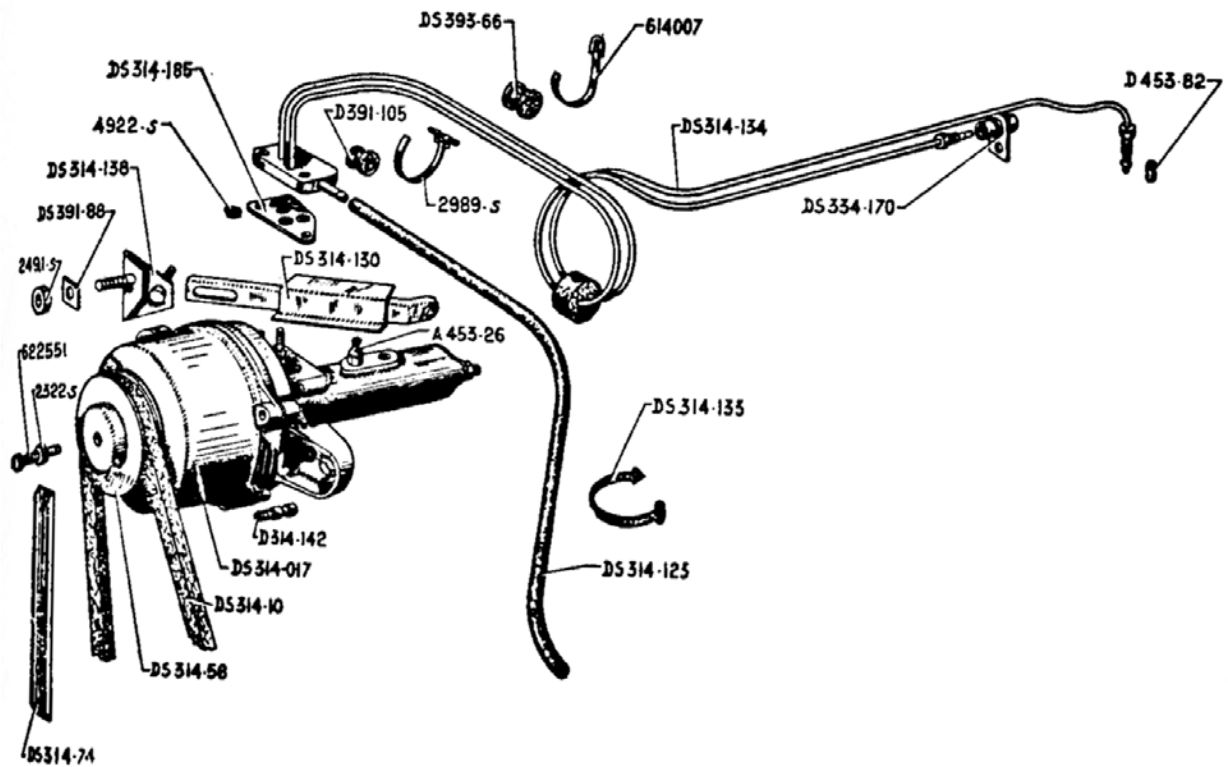
Its purpose is basically to decide when to engage the clutch in 1st gear and reverse. It also prematurely disengages the clutch near the set idle clutch engagement RPM so as not to "kill" the engine during quick decelerations in gear.

It is a very reliable unit - the failures are few, if any.

The front ball bearing's failure is rather noisy and obvious and necessitates the removal of the front cover and the ball assembly. No hydraulic difficulties other than necessary release of the pressure at the main regulator to avoid the loss of the piston. Two floating pistons are basically working with various springs.

From the front:

1. Spring, preload for clutch engagement RPM setting speed, can be adjusted by 8mm screw coming out of pulley. To increase the RPM at which the clutch engages, turn screw into the pulley. Spring can be "tired" and refuse to reach proper RPM.
2. Clutch piston is controlled by the centrifugal ball assembly "up front". It opens the Citromatic to either the high pressure side of the hydraulics or to return to main tank. It rides at the rear end of a dash pot that prevents quick motions of the piston and brutal clutchings.
3. The dash pot is loaded at its rear by a spring which is controlled in turn by:
4. The brake override piston. Any depression on the brake pedal will compress brakes and also push this piston towards the rear. This causes the spring above in (3) to release some of the load on the piston (2). The piston will then move back earlier and open the clutch cylinder to the high pressure side. The clutch will be pushed to release. Careless line swapping can do some very strange things with the brakes and the clutch. So check your lines carefully when assembling.



HOW TO RELOCATE A PRESSURE REGULATOR

PURPOSES, ADVANTAGES:

Ease of maintenance, access, protection from heat, better reliability.

DISADVANTAGES:

Two or three hours' work. The regulator can be heard clicking off at full load since it is attached to the frame and not to the engine.

PARTS NEEDED:

Rubber hose for return line; brake fluid resistant for LHS2 cars, gasoline resistant for LHM cars. Pressure is low: 1 PSI maximum.

US made steel brake line. Six feet of 3/16" diameter for main feed line from regulator to original main feed, near the brake master cylinder.

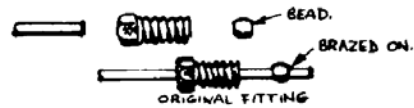
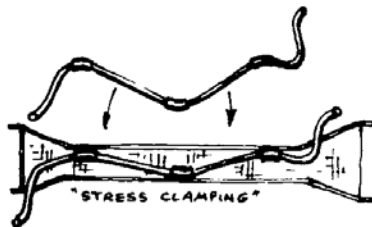
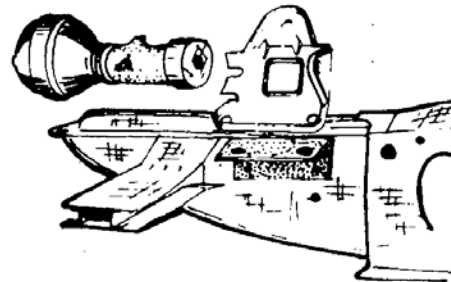
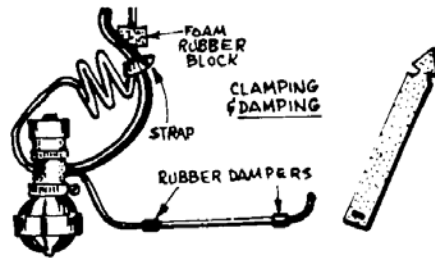
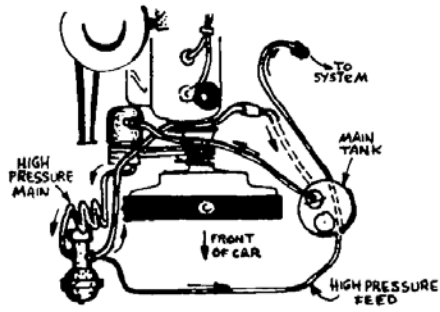
US made 1/4" diameter steel brake line, 6 feet long, for pump to regulator connection and coil.

HOW TO:

Take a look at the chapter on hydraulic piping repairs (Hydraulic line) before going into this.

Prepare the lines for installation as shown on drawing. Each item shown has a purpose and a reason for being, since the regulator will be fastened to the frame and the high pressure pump is still attached to the engine. The same engine is moving on its mounts. The regulator is not moving. Something will have to absorb the difference in motion.

The high pressure line, 1/4" diameter, will have to flex and, since it is too short on a straight line basis to take the bending safely, it will have to be coiled a minimum of 3 turns in a spot where there will be no mechanical interference with moving parts nearby. Since the coiling increases the resiliency of the line, it will tend to "sing", or "ring" at or near high pressure. This ringing fatigues the metal faster than relative engine to chassis motions will. As a matter of fact, a properly coiled line can take a couple of million flexions without failing, that is about 280,000 miles, while the ringing will fatigue the same line in less than 100 miles! The ringing can be prevented by wrapping the line at its most flexible point or nearby with a large foam rubber item, such as what is found on the line exiting the regulator on the original installation. This foam block, to be fully functional, should be leaning against something hard and steady such as the frame. The same block can be replaced by a rubber strap of the configuration shown above, installed by gently tying the line to the frame or the like. A piece of truck inner tube makes wonderful straps.



The regulator is to be fastened to the chassis of the car, ahead of the steering's right clamp-relay box. The original equipment can be used for either type of regulator with an extra bracket made out of a small piece of 20GA steel. Do not use aluminum since it fatigues and breaks 8 times faster than steel under vibration. Pop rivet the brackets to the chassis: four to six rivets are plenty. You do not want the regulator to faithfully follow the frame in case of accident, ripping and kinking hydraulic lines, but rather it come unhooked and stay loose. Four steel rivets will give a strength of about 800 lbs., which means that the regulator will come "unhooked" with any impact above 25 mph when this part of the frame goes haywire.

The main feed line can be routed from the regulator, down and fore to the rear inside of the front cross-beam, located under the radiator shroud. Then the line joins the brake lines, under the left half-shaft to come up again for connection to the main feed near the brake master cylinder unit. This line is the 3/16" diameter steel line and is quite flexible. It must therefore be clamped down by stress or physical means such as clamps or straps. However, the pipe must not chafe or be allowed to vibrate against anything hard, under penalty of quick failure. Therefore, the line must be "bundled" in a piece of rubber hose at each and every point where it might touch.

The rubber return line may be run along two different ways. I prefer the following: from the regulator, along the 1/4" steel line (bypass the coiling), to the high pressure pump area, up to above the water pump (behind it), and down between the engine and to the alternator or generator, back to the original return line. Since running out of will cause this line to blow apart, strap its junctions and wire them as shown. This will save you some fluid when you fill the system again.

GENERAL RECOMMENDATIONS FOR PREPARING HYDRAULIC LINES:

1/4" diameter lines, US made, match the original Citroen lines with a bit of play. No problem. On the other hand, the 3/16" US made lines do not fit into the corresponding Citroen fitting without drilling out the Citroen fitting to 3/16" diameter. No problem there either.

The lines can be prepared as shown below, using above described US made steel lines, brass compression fitting's beads and original Citroen fittings.

Do not use lines that have been kinked in bending. Do not bend the lines more twice FULLY. It badly fatigues the steel and can cause failure of the line.

Should you have no bending tool, use your thumbs as shown and apply more and force until the metal yields to where you want it. Do not apply any more force after the metal yielded, the pipe will kink.

Do not bend the pipe to less than

- 2 inches radius on 1/4 line
- 1 1/4 inch radius on 3/16 line.

Blow lines clean with compressed air after finished welding and clean with alcohol on LHS2 systems or kerosene/gasoline on LHM systems.

PRECAUTIONS FOR RELIABILITY:

The lines must be protected against excessive repeated motions, vibration, impacts and chafing. Any small such disturbance repeated a million times will shorten the life of the line by metal fatigue (the same that breaks the iron wire after bending it four or five times). The lines must be clamped and damped against something steady like the car's chassis or frame, or against other lines. They must never touch "a little" but squarely lean against straps or frame. Any shyness in contact will cause bouncing with vibration, resulting in fatigue and breakage.

Make sure the lines clear everything such as the transmission shaft, the fan, the belts, the steering arms.

Make sure the line does not block access to the brakes, the radiator draincock or any alignment to any nut or bolt you will have to reach in a later intervention on the car.

Wire up all the rubber hose connections since we are using straight piping and it can come apart should any air get trapped into the regulator. This air will occupy very little space in the regulator while under 2000 PSI. However, the same tiny volume of air will suddenly occupy a lot of space when the regulator cuts out and releases into the low pressure return pipe. As a matter of fact, it will occupy almost 2000 times the space it occupied under pressure. Should the rubber hose not be well attached, it will get torn off instead of slightly swelling, while the air rushes back to the main oil tank.

Please refer to the chapter on fluid replacement and the one on hydraulic line repair.



HYDRAULIC PIPING REPAIR

U.S. made steel brake lines can be purchased in most auto parts stores in two useful sizes for Citroens:

outside diameter 3/6" for the commonly referred to as the "skinny" line and outside diameter 1/4" or the "fat" line, such as the ones found between the high pressure pump and the regulator or on some main brake lines.

Copper tubing cannot be used, since vibration hardens the metal and ultimately causes bursting. The steel line can take the vibration quite steadily and not change properties as drastically as copper does. Steel lines do deteriorate with repeated bending caused by vibration, but the damage appears after a few million motions.

The skinny line will fit the Citroen fittings after reaming (drilling) the fitting with a 3/16" diameter drill bit. This will remove a few thousandths of an inch and allow the "domestic line" to pass through. The "fat" line will go through the original fitting no problems.

The difficulty of creating the bead near the end of the Citroen line is resolved by brazing a brass bead from a matching compression fitting (available from the local hard store) 3/16" or 1/4" respectively. Silver soldering is OK, providing it is not done on the line between the high pressure pump and the regulator. Tin soldering is OK on the suspension circuits as long as your spheres are in good condition and you do not drive in high position. Tin soldering is a definite no-no on the braking circuits.

The lines can be patched using the two following methods:

1. Slip a 2 to 3 inch length of 3/4" le over the two ends of skinny line. The two skinny lines must butt together. Braze, silver solder or last resort, tin solder, being careful that the metal "sweats" into the gaps.
2. Use a standard domestic compression fitting to match diameter. They will fit and close original equipment.

BENDING THE HYDRAULIC LINES:

You can use the special tool available from local stores. You can also use your thumbs, holding the line as shown below and applying more and more force until the metal yields. Do not apply any more force when the metal is yielding as this might cause a kink in the pipe.

A kinked pipe should not be used again since it will tend to be seriously weakened and will not stand any corrosion later. The kink will have created invisible cracks in the metal. These cracks will get corroded readily and deeply, therefore reducing the total wall thickness and promoting failure.

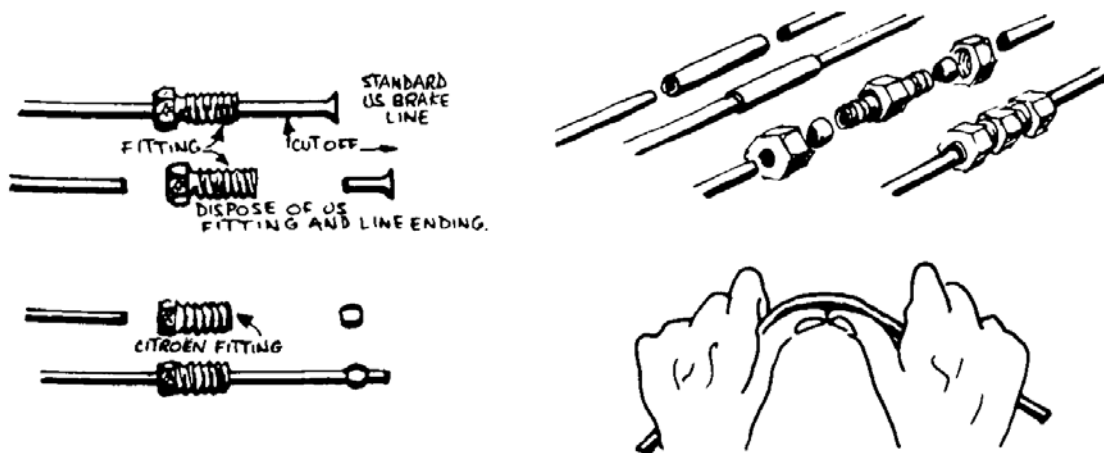
Do not bend the pipe fully more than twice since the metal will have fatigued and will not have the original strength.

The minimum bending that can be done safely is 2" radius for the fat line and 1 1/4" for the skinny line.

Do not use sharp tools to hold the pipe. They mark and "cut" the metal and may initiate cracks. If you want to use pliers anyhow, wrap them up in tape... generously.

When the line is ready, deburr the ends, blow the dirt and filings out with compressed air and wash with alcohol on LHS2 cars, or kerosene or gasoline on LHM cars. Watch for fire!

The above recommendations may be somewhat disregarded at the expense of reliability, that is expected life. It is possible to use tin solder, dirty pipes, kinked tubes and sharp bends, but you cannot expect a life above one or two years for the line you repaired. Corrosion will eat the metal away and failure will cause the painful sight of a squat Citroen by the side of the road.



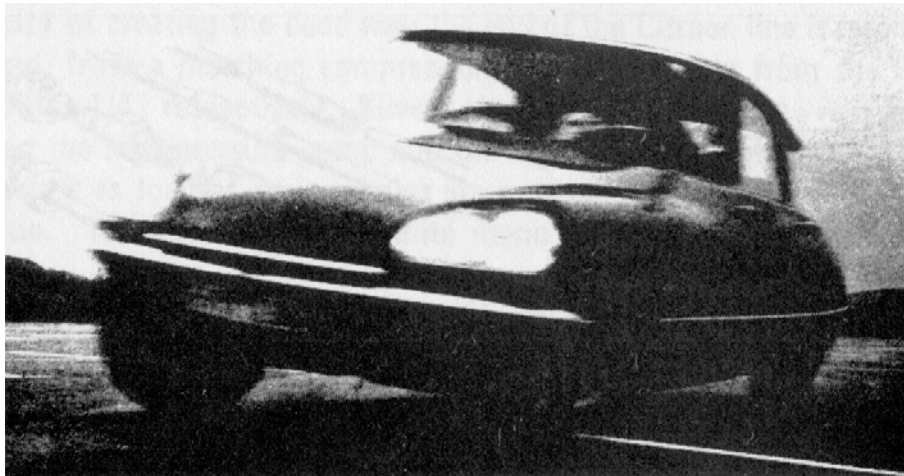
HOW TO CHECK YOUR MAIN ACCUMULATOR SPHERE

1. Run the engine until hydraulic pump stops rattling (regulator sphere is at pressure and pressure circuit is not connected to the pump).
2. Stop the engine.
3. It should be possible to make 32 quarter turns of the steering wheel, back and forth being two quarter turns. Some DSpecials will deliver 23 quarter turns. After the given number of motions, the accumulator sphere empties completely and the steering comes abruptly hard to move.

A reasonably worn main accumulator will give 16 to 20 quarter turns. Should one only 8 quarter turns or so, time to get a new sphere or get a nitrogen refill.

Some cars lose power steering as soon as the engine is turned off. The reason is that main accumulator does not accumulate any volume of oil, since it is probably punctured internally. In this particular case, the regulator will probably crack since the internal overload valve does not always react fast enough at the instant the maximum pressure is reached. The ramming will crack the aluminum casting of the regulator. This is caused by a casting flaw in the flow of the aluminum when the regulator's body is poured. The aluminum is poured from the "rear" of the regulator, in a cool spot, above the intake pipe. The aluminum is too cooled by then and the apparently good junction is not structurally sound. It will eventually separate under shock stress, causing the regulator to leak from an invisible crack, just above the intake from the high pressure pump.

The above test is not valid in a car affected with internal leaks in the power steering or in the suspension. The same internal leaks will rob fluid from the regulator and will of the readings.



BEFORE DOING ANY WORK ON THE HYDRAULIC SYSTEM

Stop the engine

Put the suspension lever at the lowest position

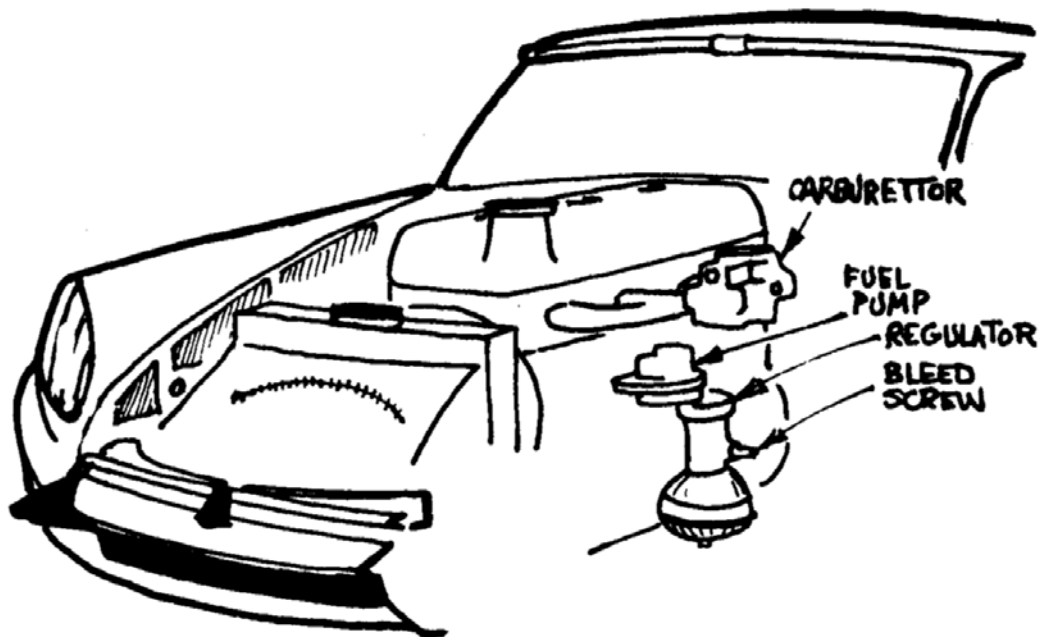
Turn the regulator's release screw 1/4 turn CCW, a hiss indicating the release of the pressure should be heard

Turn the steering wheel until it becomes stiff (it should already be stiff, but in certain failures, some back pressure may still power it).

Turn the ignition back on and watch the red light indicating low hydraulic pressure as you press on the brake pedal and release it repeatedly. When this red light goes on the whole system is down.

NEVER ATTEMPT TO STOP, DIVERT, TOUCH OR PLUG A HYDRAULIC LEAK UNDER PRESSURE. THE FLUID COMES OUT AT SUPERSONIC SPEED AND WILL PENETRATE THE SKIN. DO NOT WATCH THE LEAK AND DO NOT TOUCH EVEN WITH GLOVES ON. Let the leak exhaust itself. It will be easier and cheaper to mop up fluid off paint (should be done as soon as possible) and replace the fluid than a trip to the hospital can cost you.

NEVER DO ANY PIPING BENDING, TIGHTENING, LOOSENING ON THE HYDRAULIC SYSTEM WHILE IT IS UNDER PRESSURE.

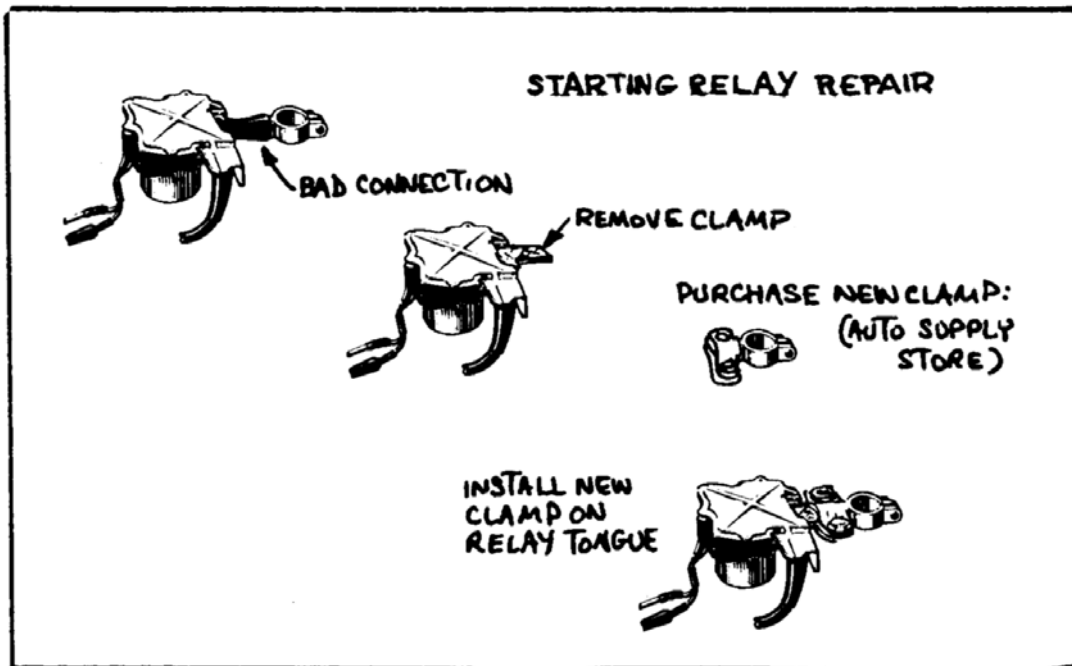


FOR RELIABLE STARTS WITH CITROENS

Whatever your routine is, just do not touch the accelerator until the engine is going by itself. Good battery contacts, distilled water in the battery, clean ignition insulation, all other parts good, along with synthetic oil in the engine, will get the old beast alive any morning below zero. This is true for SM, DS, ID, 2CV, AMI, and even 11CV and 15CV!

Make winter starting easier and more reliable:

- Tip up the battery with DISTILLED WATER only. Use your own supply from the local drug store.
- Keep the battery posts and contacts clean and shiny. Use antisulfate rings.
- Keep the ignition coil's top, the distributor cap and its rotor dry and clean.
- Avoid setting ignition timing too far advanced. The premature firing of the first cylinder will stop the rotation of the engine, cause increased drain on the battery, may damage the starting relay's contacts, may cause breakage of the starter's "bendix" spring, or, in severe cases, cause crankshaft warping.
- Avoid lugging the engine and
- Should you be used to revving-up the engine before shut off at night, do not cut the ignition off until the engine has reached normal idle again, since premature cut off promotes spark plug flooding or fouling.



DS21, ID20 AND DS23 ENGINE RELIABILITY

The above engines, like most Citroen designed engines, are reliable. One exception: the engine oil pressure sensor has been known to fail.

The sensor leaks oil to the outside, throwing all of the oil out. Without lubrication the engine is quickly destroyed at great cost.

One solution is to replace the sensor with a new one at or before the 50,000 mile mark. There is still no absolute guarantee that the sensor will be reliable.

The sensor is located under the fuel pump and can be reached from the top of the engine by removing the pump, the suspension sphere and the alternator. It can, in some cases, be replaced from the bottom of the engine.

Two solutions are available:

1. Cap the sensor so as to prevent loss of oil. The pressure indication will become erratic case of sensor failure.
2. Extract the sensor and plug the hole with a matching bolt. The engine is so reliable that there is no real need for the pressure indication as long as oil is present in the engine and one is aware of the rattling sound of low oil pressure upon hard acceleration.
3. Remove the sensor and plug its hole with a weld or epoxy. Install again into the engine and disconnect the lamp on the dash. Again, we have no indication of oil pressure loss other than the above described rattling.

As the sensor is failing, the dashboard light may flash on and off a few times. It may not remain ON, however, so beware of flashing engine oil pressure indicators.





SM ENGINE FAILURES

How, why, when, why not, and how not to have such failures.

USUAL SYMPTOMS: Engine purrs away smoothly, suddenly stops dead. Impossible turn it over with the starter, the crank or even in 5th gear while pushing the car...might turn a few degrees to get stuck again.

CAUSES: A valve was open while piston came up. Their meeting is cordial and their displays of rare violence are well concealed by the engine mass, however this causes the failure of one or several of the following parts:

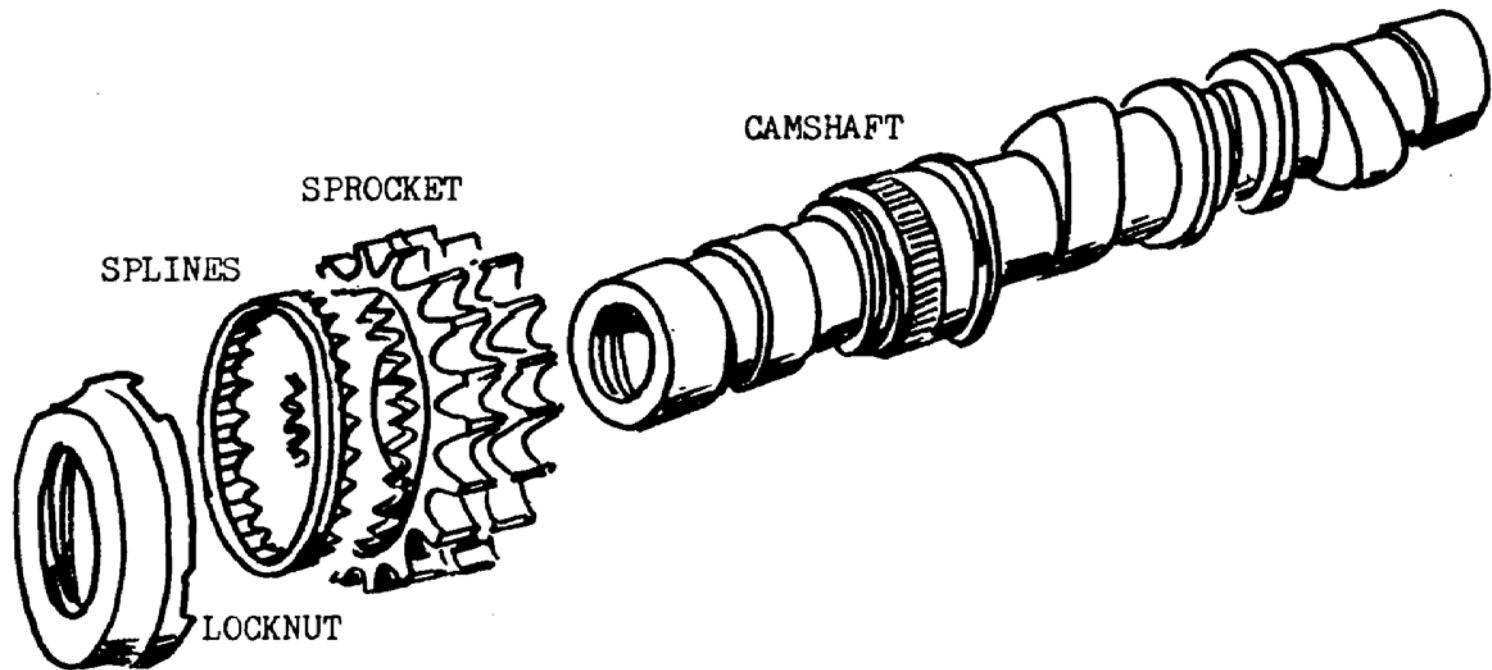
The piston, the liner, the engine block, the rod, the crankshaft, their bearings, the cam shaft, the cam shaft sprockets, the timing chains (any one of the two driving the out of place valve).

If car was in gear while the meeting of the two above parts occurred, the inertia the moving parts will definitely cause a lot of bending, shearing, tearing and destruction before the clutch decides to slip or the tire to slide, thus limiting (too late) the torque applied to the wedged parts.

If car was at idle and not in gear, you are in luck: Ha! Only the valve is bent.

REASON FOR FAILURE: The cam shaft angle changed as the sprocket became loose and slipped a few degrees, causing the valve to come out into the cylinder at the wrong time - when the cylinder should be up. Since our modest technological advances even Citroën's - have not yet permitted the fact that two different parts can occupy the same place in space at the same time, something has to yield.

The same sprocket has been known to skip a few splines and stay in a new location therefore reducing the compression on one bank. That engine was caught just in time.



SM CAM SHAFT

CURE: Remove engine and swap for a new one.

COST: High, considering the cost of the average powerplant. Low, considering what engine this is.

PREVENTION: Periodically open the top of the engine and tighten the sprocket nut again.

FINAL CURE AND PREVENTION MEASURE: Lock the nuts as follows: Drill through the nut and into the shaft (hard material) not more than 3/32 inch and install a piano wire clip as shown. The same piano wire will have to be wired down to prevent it from flying loose: good old aircraft technology.

Another solution is to bang the nut so as to deform it enough to prevent its loosening. Crude, effective and a one way solution.

OTHER PRECAUTIONS: Since the chain tensioner will reach its end stop at about 40,000 miles it would be a good idea to replace the top chains before such 40,000 mil mark, or 80,000, or 120,000 or whatever. The time to change has come when the chain keep rattling with an infinite torque applied to the tensioning tool.

Then, the SM engine should live, like most Citroen engines, "forever".





HOW TO RESTORE YOUR DS/ID FRAME

SAFETY

DO NOT

Crawl under a car held by hydraulic pressure or a hydraulic jack. Always install stands solid and stable. The same stands must be installed under the points shown on the bottom drawing of the DS. Install a wood board between the stands and the lifting points, avoid 4x4, they can "roll" and drop the car. Use 2x4 or larger ratio. Do not stack 2x4 so that they can slip, roll or shift in any way.

DO NOT work on hydraulic pipes under pressure. A leak might come out and hurt you.

DO NOT attempt to stop a hydraulic leak with your hand or fingers. Even with gloves on. You will get an injection of the fluid and will lose the body part that was injected with it.

DO NOT rock a car on stands.

AVOID sitting in a car after it has been aligned. Wait until the frame is closed or at least until the plate C is fastened to E and B. This is not dangerous, but you might warp the frame.

DO NOT lift the car from the side with a hydraulic jack. It might slip out.

DO NOT look at the drill bit as it is cutting a hole. Hide behind the drill's body. Broken drill bit might strike your eye. WEAR GOGGLES.

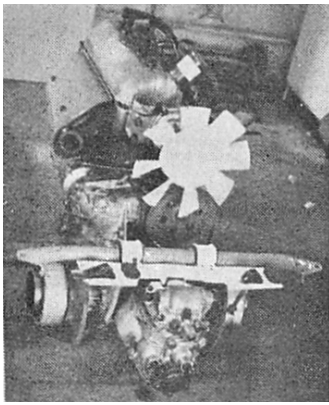
DO NOT look at the cutting disc on edge as it is cutting.

DO NOT work on sheet metal without gloves. You can get a nasty cut.

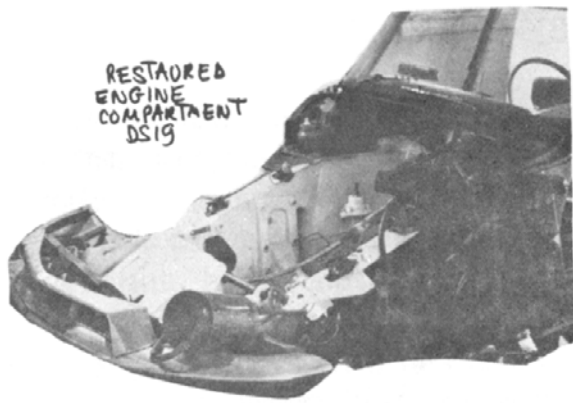
The assembly, fastening methods described in this paper, along with the precautions, cautions and warnings, are similar to the ones used by Citroen, as their prototypes are being built for track testing. Also similar to the technology used to build F 1 cars and commercial and military aircraft.

Welding on the frame is highly dangerous, since a fire might start rather easily, due to the proximity of conduits, fabrics and other flammable equipment. Welding is also dangerous in the long run, since the weld itself cannot be corrosion proof and tends to crack and tear off. It is also not possible to coat two plates to be assembled BEFORE assembly since the coating will ignite. In this case the metal would remain exposed to the air and therefore corrode.

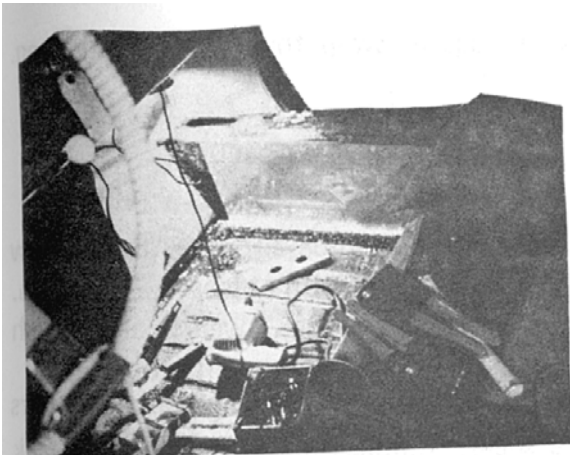
Aluminum rivets are used in the aircraft industry, since the ships are mostly made of light alloys. It is not possible to use aluminum rivets with steel since the corrosion rate is extremely high compared to the steel to steel method used in the present case. Aluminum rivets will shear, after several years exposed to the elements, at 200 lbs. (1/8" rivets). Steel rivets have at least twice this strength.



DS19
ENGINE
WITH
GEARBOX
AND
DISCS
(1959)



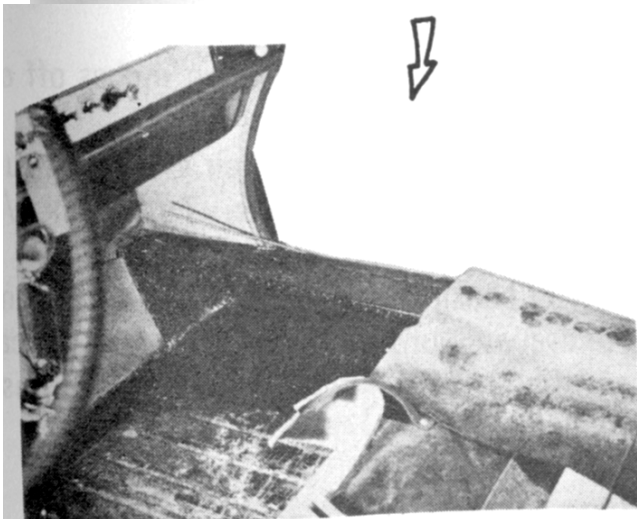
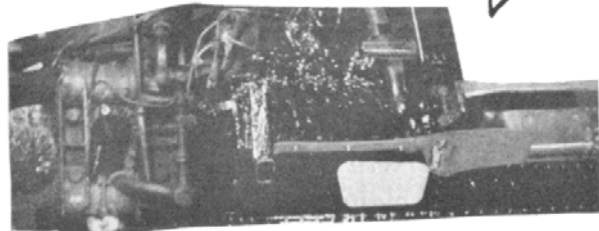
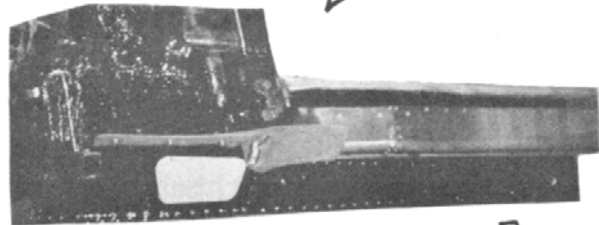
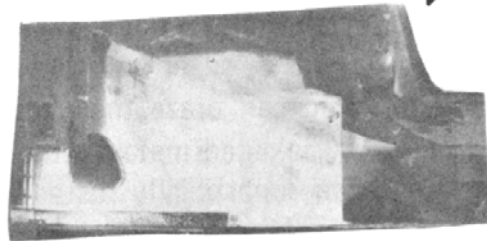
RESTORED
ENGINE
COMPARTMENT
DS19



INSIDE FRONT SPAR REPAIR



FRONT SPAR REPAIR



WORK SEQUENCE

Remove front fenders and front doors.

Remove the two plates located under the front suspension castings.

If possible, raise car to maximum height.

Install a 2x4 or a 4x8 between the two front suspension castings, and lift the car at least a foot off the ground. Install two safe stands, one under each end of the lumber. See drawing.

Install a 2x4 in the rear suspension box area. Must not touch the rear suspension arm mechanism. Lift at least a foot off the ground and install stands.

Align the frame true optically by altering the height of one of the stands. **ONE ONLY.** Use wedge between stand and lumber.

Remove front wheels. Cover front bearings with rags or wrap them into plastic bag.

Drop hydraulic pressure.

Remove front suspension mechanism's protection plates.

Mark hydraulic lines and replace them. Keep fittings for reuse.

Drain hydraulic system to rear.

NOTE: DO NOT saw hydraulic lines. Clip and round or use pipe cutter. Always blow lines before installing. Patch lines with larger diameter line with at least a 2" overlap. Solder with tin or silver and torch. Make sure the molten metal "sweats" all through the lap. You can braze the patches, but the "sweating" is more difficult.

Remove ALL weakened metal. This means all metal that is rusted through, as rust layers show. Clean superficially rusted metal. Use shears, nibbler, pliers, disc cutter, hack saw, etc. Wear gloves! Leave extreme front part, under lift stud. Be careful not to damage heater pipes nor electrical ducts.

Remove frame caulking, Ziebart or the like with putty knife, at least two inches off of where laps will be.

The front suspension's rear lower arms can now be reached. Remove their protective cup with a screw, drill out the dent in the nut and tighten it to 60ft/lbs. Turn back 1/8 turn and lock with a chisel whap on the nut. Install cup after greasing.

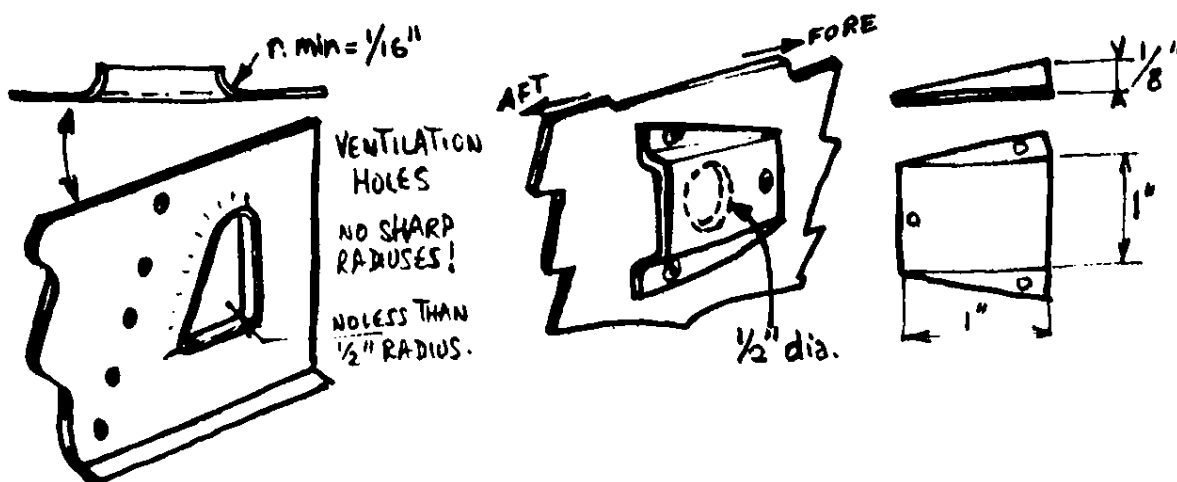
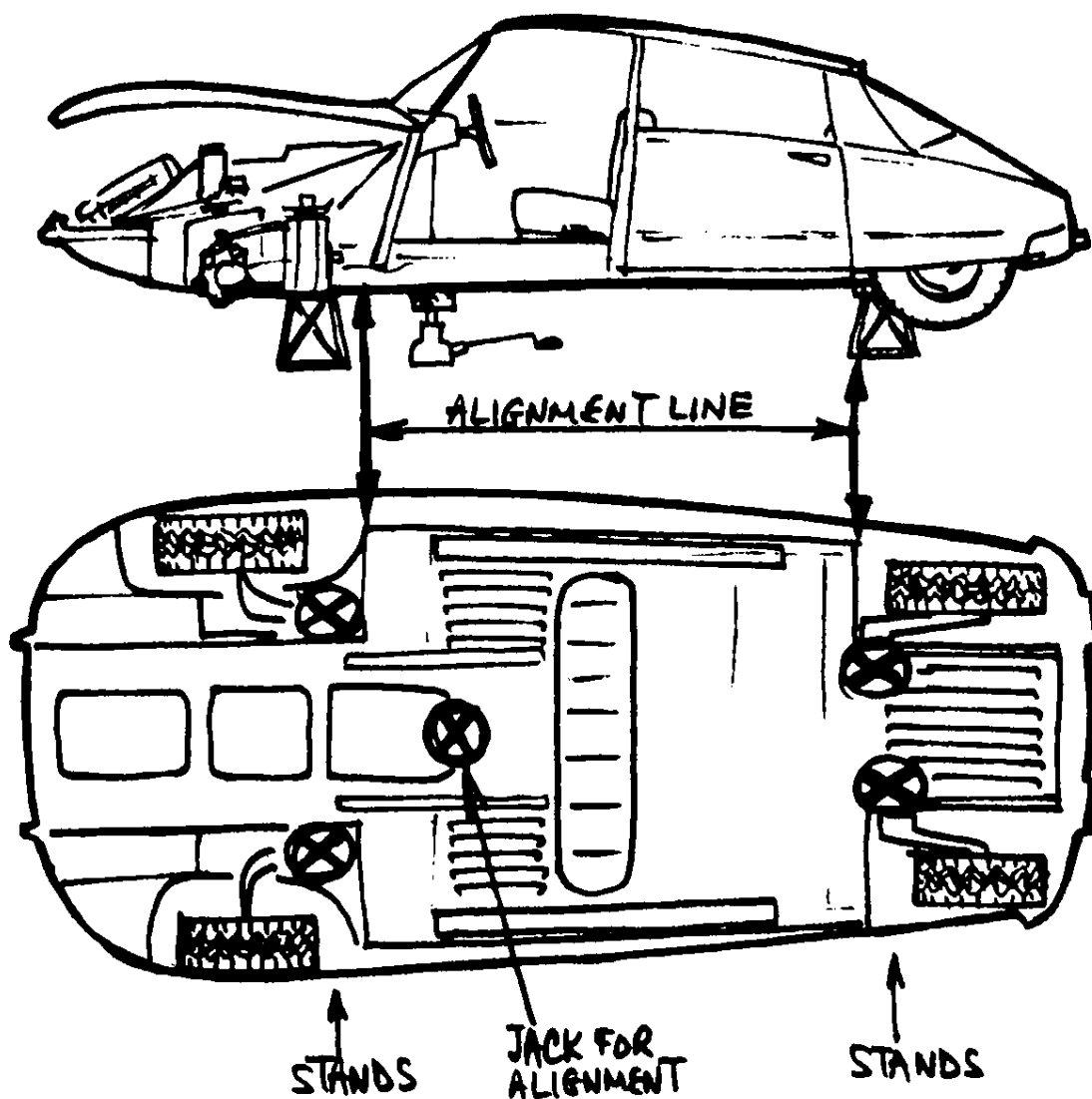
Alignment of frame. The frame has usually sagged causing difficult operation of front doors. Lift the firewall at the rear center, see drawing, until frame is straight. Optical alignment or ruler. When this is done, lift another 1/8" and hold it there.

Do not use a hydraulic jack as it will drop slowly down.

Remove remaining front frame under lift stud.

DO NOT SHAKE THE CAR SIDEWAYS FROM THEN ON. Wait till finished.

Install frame elements using alphabetic sequence or the following, whichever suits you best: G, BE, H, DF, J, K, L, M, N, C, S, P, V, X, W. Read the riveting procedure again.



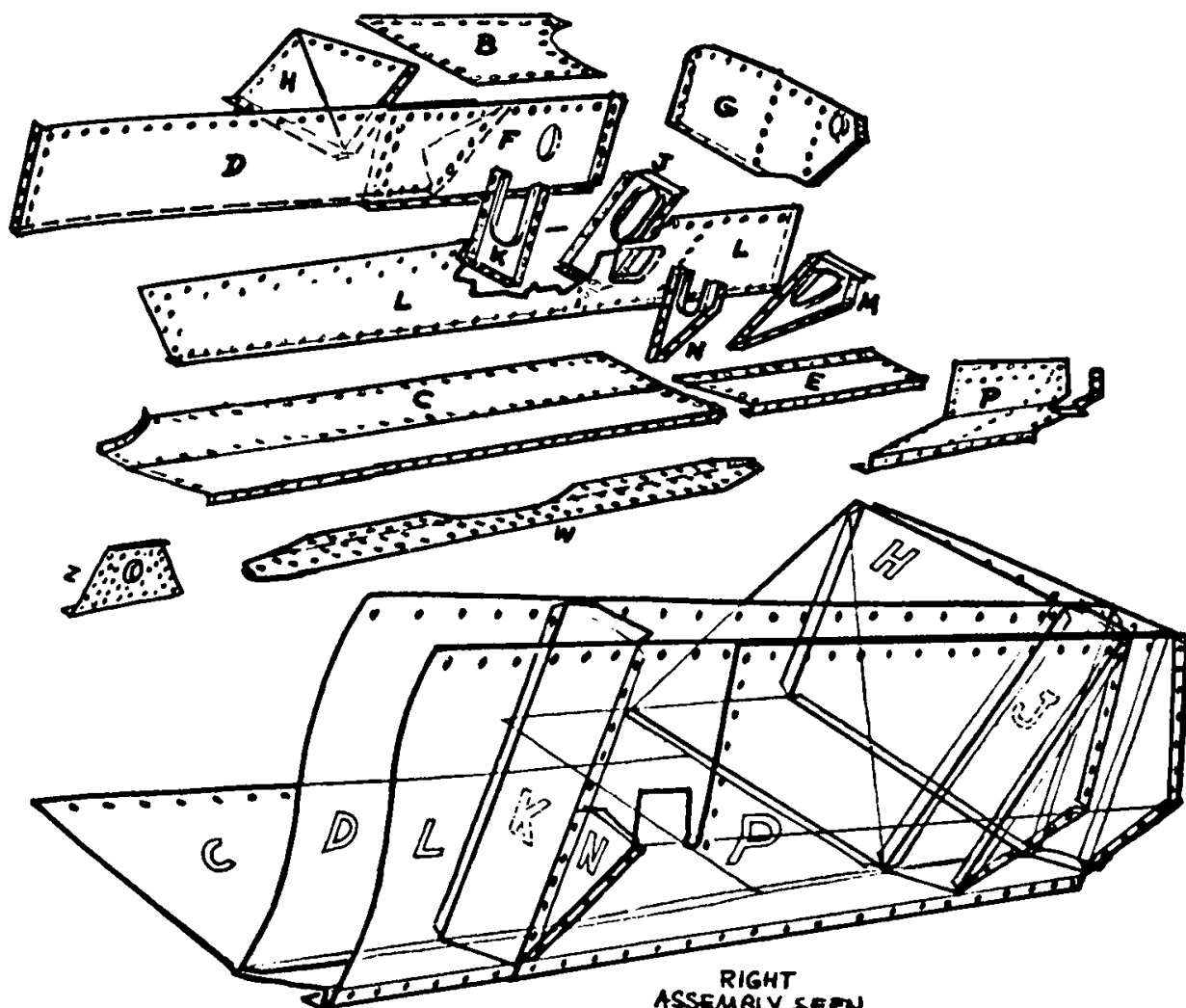
DO NOT install rivets closer than 3/4" from each other.
 Make sure the rivet head sticks out the other side.
 Make sure the plates are together before riveting.
 Do not use long rivets in the side beams unless you are sure they will not damage the water hose in it.
 Clamp the water hose, in the side beams, up close to the small diagonal brackets, so as not to damage it while drilling. Make sure the clamp will not cut or chafe the hose. Wrap the hose in electrical tape, or better, air conditioning tape. Make straps such as the ones used on the hydraulic rubber hoses, with a piece of truck tube.
 DO NOT drill closer than 3/16" from the edge of new metal.
 DO NOT drill closer than 1/2" from edge of original metal.
 DO NOT tar metal parts while fitting them: the tar will not be fluid enough during assembly.
 Insert rivets from outside so as to have only rivet heads exposed. Read riveting details further.
 Install hydraulic lines BEFORE closing frame.
 Tar each assembly just before assembly and right after again, on the laps only. When riveting across car, there must be at least one rivet per inch. If you will rough car up in cross country terrain, install two rows of rivets. Must be staggered.
 Do not let tar harden before assembly. This will prevent the plates from coming together and will expose the rivets to high shear forces, which might cause them to rupture. AVOID riveting too close to metal folds: 3/16" is OK. 1/16" is bad and can cause crack in the fold as the metal fatigues.

RIVET BE to frame from bottom.	RIVET J and K to floor from bottom.
RIVET C to floor from bottom.	RIVET L from outside.
RIVET DF to floor from bottom.	RIVET M and N same as J and K.
RIVET G to frame from inside.	RIVET P from outside.
RIVET G to BE from bottom.	RIVET X from outside.
RIVET G to F and L from front.	RIVET V from bottom.
RIVET H to floor from bottom.	RIVET W VERY CAREFULLY!
RIVET H to frame from inside.	Slight variations between production
RIVET J and K to DF from outside.	runs make for necessary trimming.

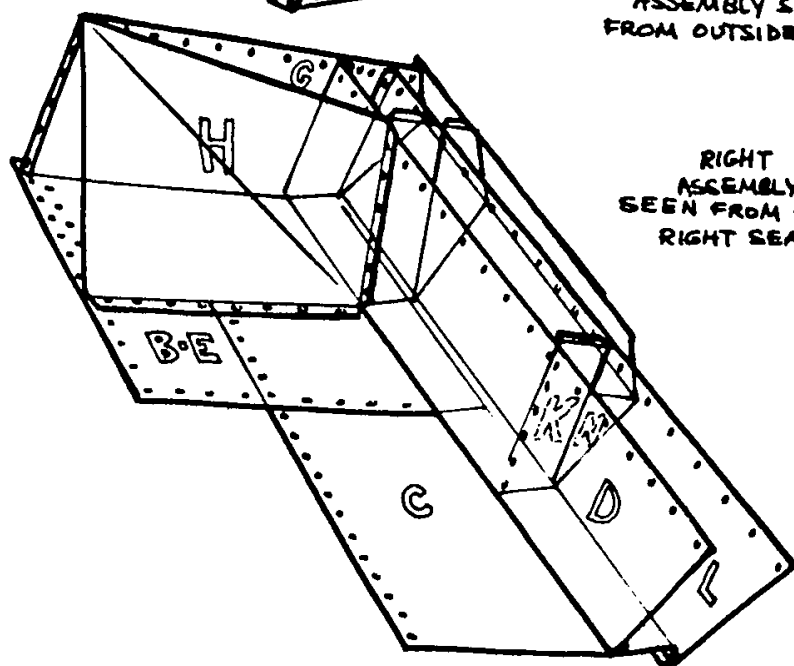
The parts that are to be assembled with the utmost care are BE, G, H, F, J, L, C and W.

You may open ventilation holes in H, F, L, provided the holes' edges do not come closer than 1 1/2" from any rivet row. The holes' edges must be rounded smooth and curved as shown on the drawing. Remove all burrs and all cracks as they may develop into splits and tears.

You may open one or several ventilation holes in the side of the frame, if you have an ID, or in the bottom of the same frame (outer side beam), providing you use reverse scoops. They will create a vacuum in the frame, which will bring air from the cabin. See drawing.



RIGHT
ASSEMBLY SEEN
FROM OUTSIDE RIGHT



RIGHT
ASSEMBLY
SEEN FROM FRONT
RIGHT SEAT

RIVETING PROCEDURES

DO NOT drill, full speed ahead, a whole row of holes. You will find that they will not match the rivets as you fit them. Start at one end, drill and rivet. Position the plate with the vice-grips, and then proceed to drill-rivet-drill-rivet. Use Cleco fasteners. Should the plates not be willing to come close together, you may use sheet metal screws to bring them along. Be careful, for the holes might not be aligned again, and the sheet metal screws will damage the bore of the hole, making cracks under stress.

Where the drill has reached, the rivet gun can reach too. USE STEEL RIVETS ONLY. Aluminum rivets have only half the strength and will corrode to powder rapidly due to galvanic action between the different metals. DIP THE HEADS OF THE RIVETS IN TAR before inserting them into their final location.

If possible, deburr holes on BOTH sides.

NEVER hammer fold angles to sharp angles. This will create a weak zone for a crack. Should you have a free edge, fold it with a 3/8" lip, so as to prevent its warping. All metal edges must be smooth and free of cracks or burrs, as they might provoke structural failures in time.

Keep plates together while drilling and riveting. This prevents metal chips coming between the two plates and separating them. The rivet would have to stretch between and would be severely overstressed. The two metal plates must be in contact as the rivet crushes the tar away.

TOOLS YOU WILL NEED

Pliers, long nose pliers, putty knife, cutting pliers, pipe cutters, soldering iron, solder (electronic silver), metric hex flat wrenches and/or sockets, body hammer, carpenter hammer, stiff paint brush, vice grips, sheet metal shears, mechanical jack or hydraulic jack (no scissors jacks, dangerous), nibbler, cutting disc, 20 drill bits 1/8" diameter, drill, small vice, two hands and lots of care and patience.

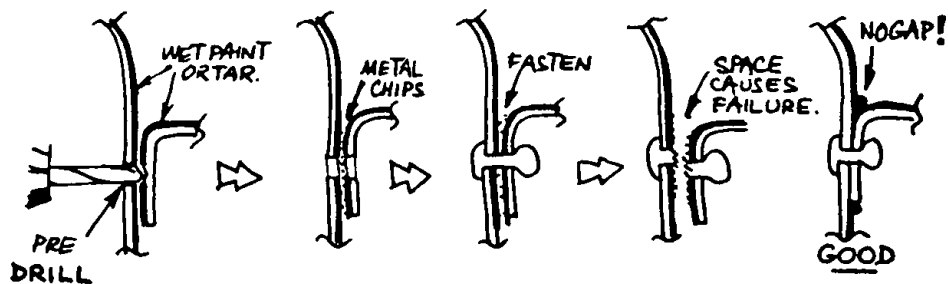
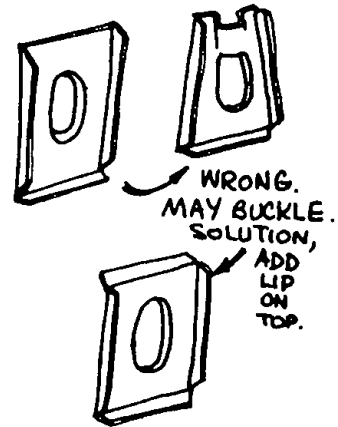
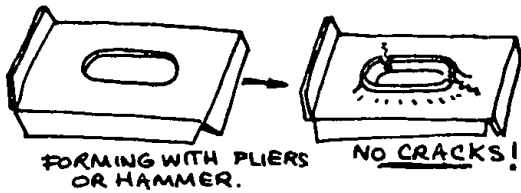
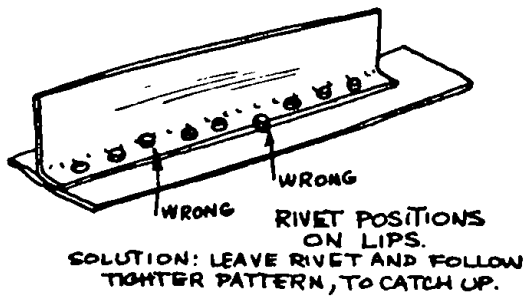
RIVETING

When riveting:

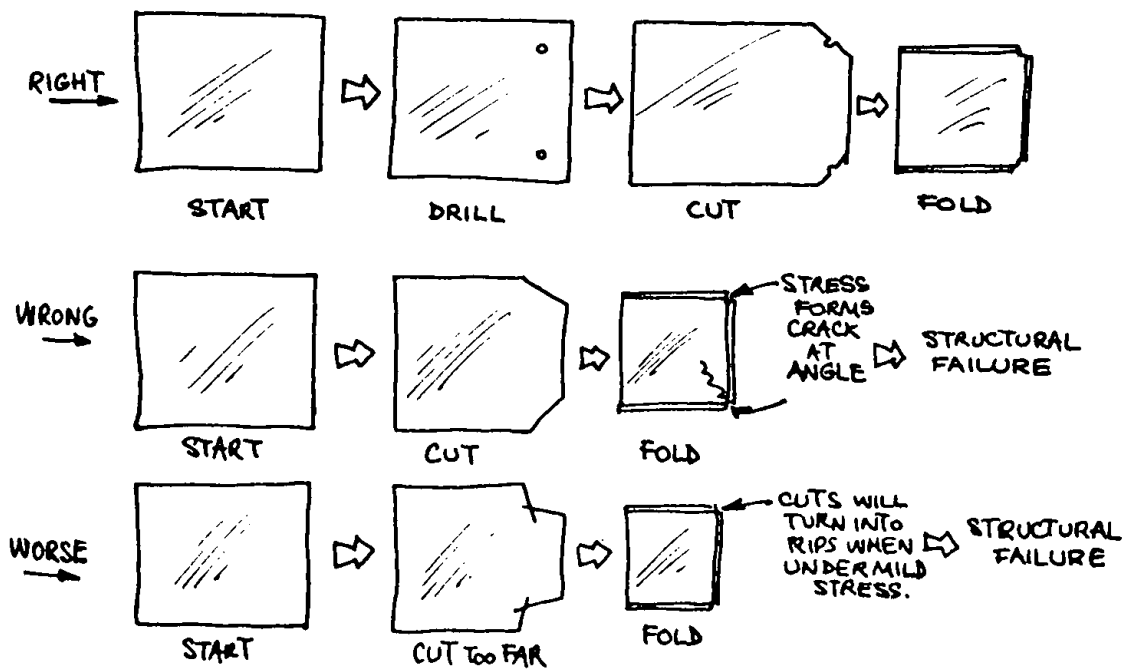
Drill one hole at a time, through pre-drilled part. Install one rivet at a time. Do not drill ahead and then try to match holes with rivets.

Always deburr both sides of holes except when riveting per-se where it is not possible in blind spots.

Clamp parts together before drilling for rivet.



- HOW TO CUT (AND DRILL) FOLD CORNERS -



Any wrong hole must be closed with a rivet. The rivet's head must appear on the other side, so as to spread out there and not between the sheets. You are safer using a rivet that appears too long. Avoid drilling into frame's weld points.

HOLE SPACING

When part is riveted, tar the rivet heads.
Dip rivet in tar before inserting into part to be fastened.
Try to avoid factory welds as it is difficult to drill them.
Refer to "Green Sheet" nr. 67-74-1 for more data.
Clean area of frame to be fastened to, tar and assemble.

MODIFY YOUR DRILL BIT TO AVOID ACCIDENTS

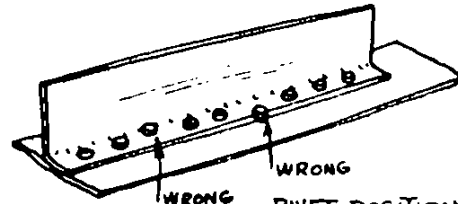
Do not drill into the frame without fitting over the drill bit a small length of old hydraulic tubing so as to have only about 3/8" sticking out. This helps avoid breakage of the bit and prevents it from plunging into the frame when the hole is finished, and eventually punching another hole in an electrical or water conduit.

HOW TO SHARPEN YOUR DRILL BITS

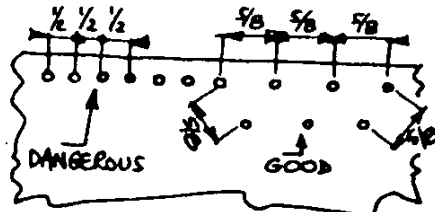
Use a small grinding wheel fitted on the drill. Present the drill bit as shown on the drawing and rotate the bit slowly while increasing the angle. Make sure both surfaces are equal, otherwise only one side will be cutting, which will fatigue the bit and ultimately cause breakage.

PREVENT WATER FROM ENTERING THE FRONT FRAME

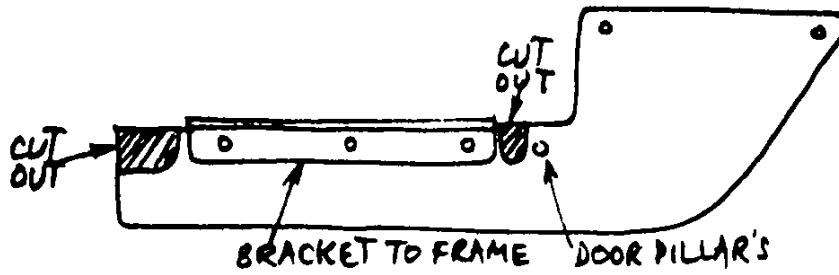
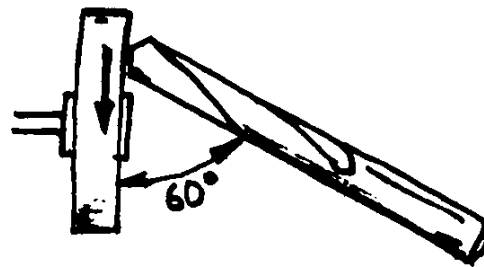
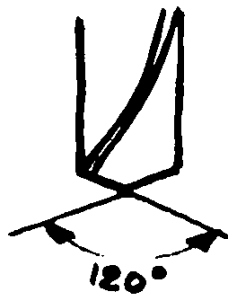
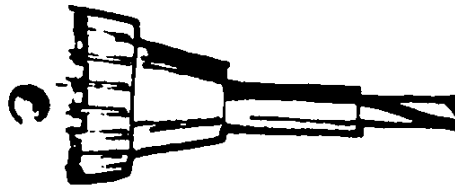
As the car is washed or during a rain, water runs in the gutter located in front of the windshield. From there, it runs into the hood hinge areas. The next place to go is along the sides of the frame, behind the rear of the front fenders. The water is stopped however, at about the level of the bottom of the door, by a rubber flap which extends from the back of the wheel well around to somewhere under the front door. As mud and decaying leaves accumulate in this flap, the water cannot run down anymore and seeps into the frame, right where the rot gets the worst. Cut the rubber flap as show and seal any cracks in the frame with caulking or tar.

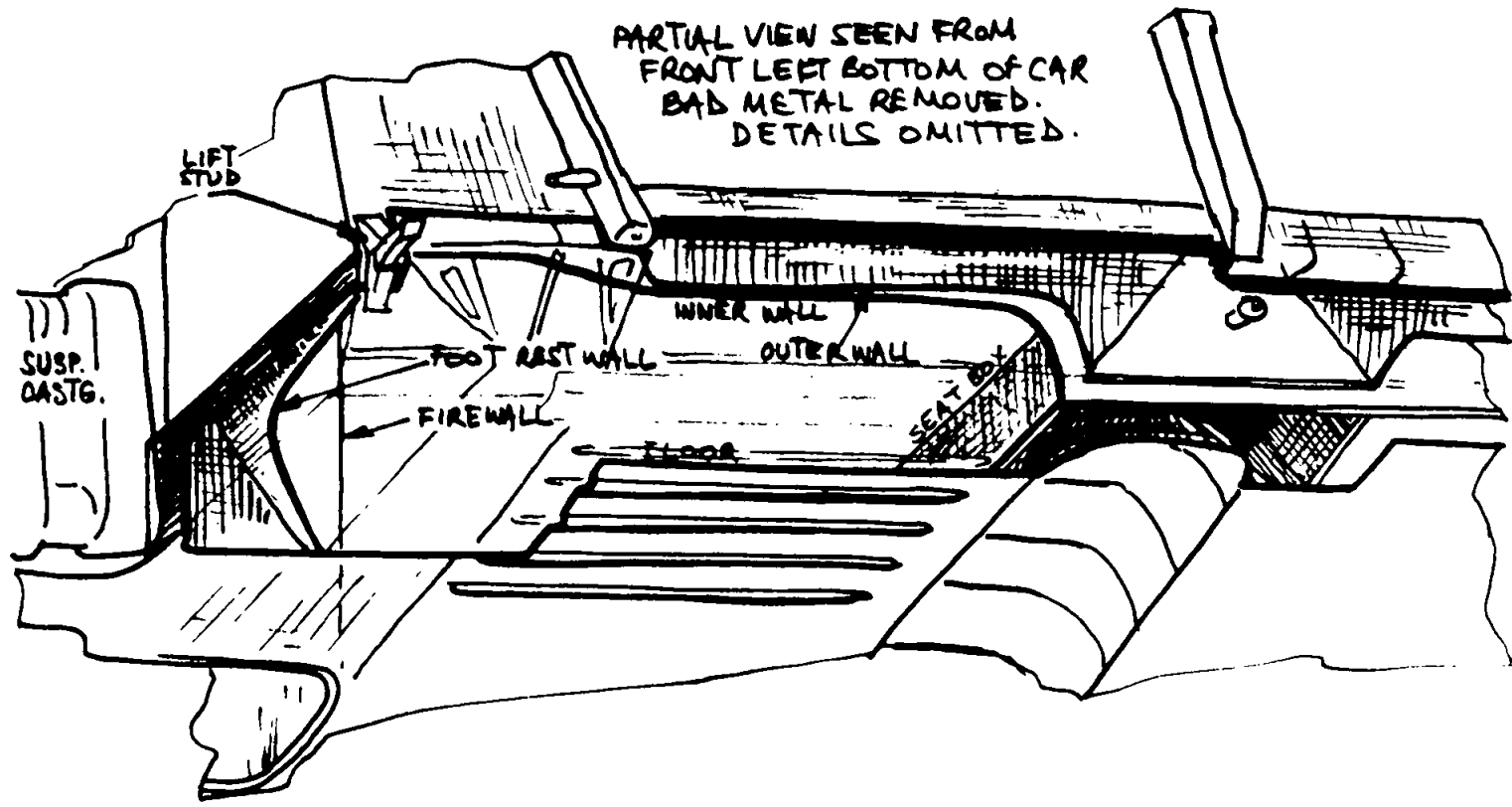


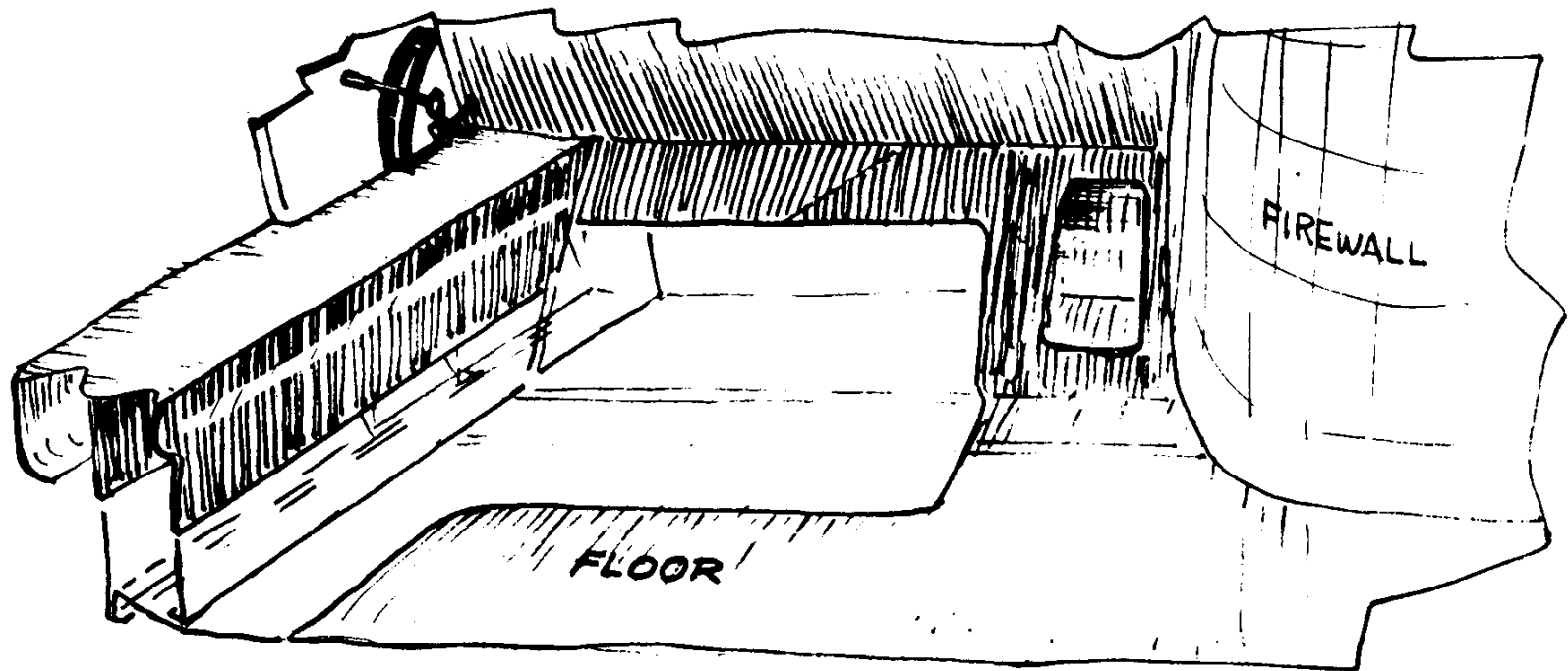
WRONG RIVET POSITIONS ON LIPS.
SOLUTION: LEAVE RIVET AND FOLLOW TIGHTER PATTERN, TO CATCH UP.



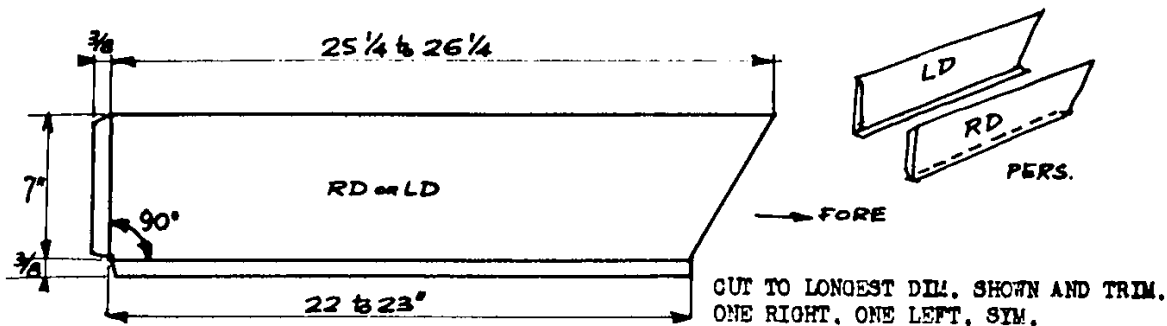
-HOLE SPACING-



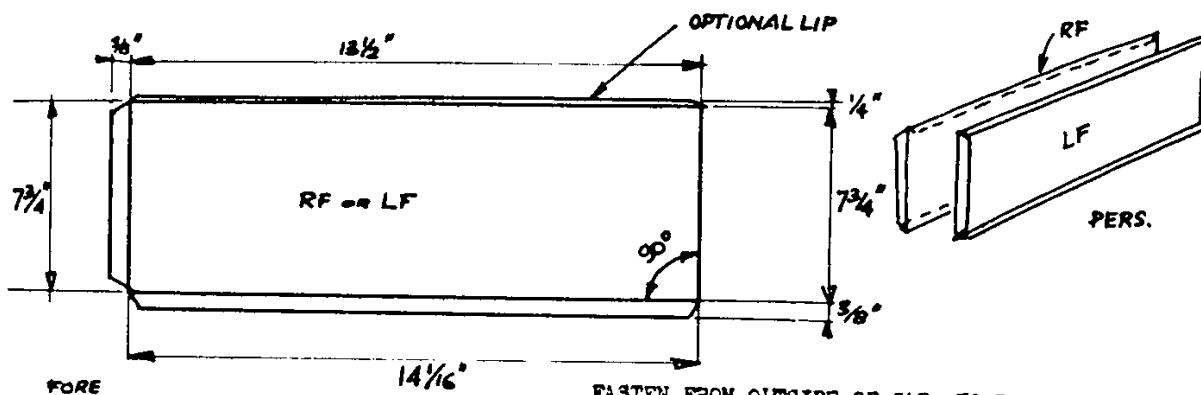




SECTION SEEN FROM INSIDE CABIN - DETAILS OMITTED.



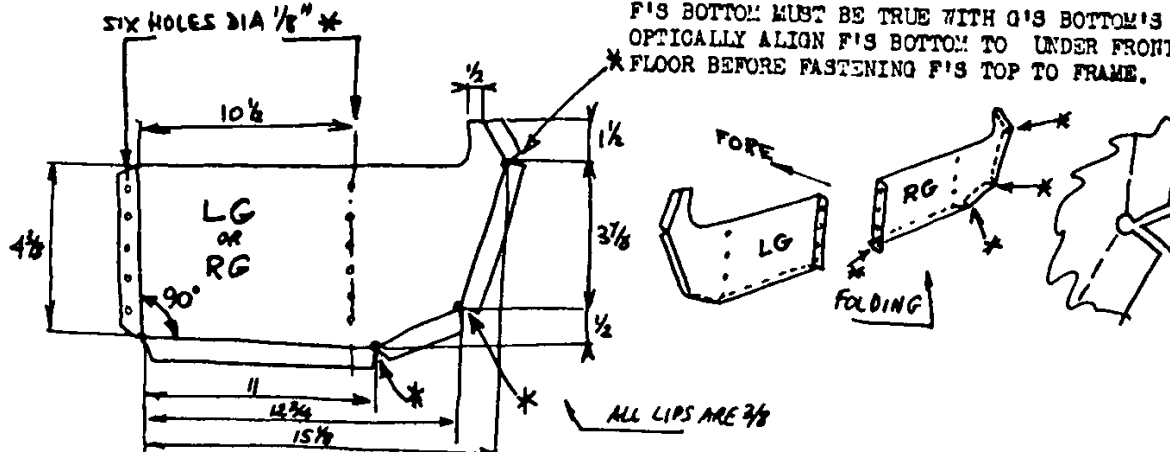
FASTEN TO, IN ORDER, C FROM BOTTOM OF CAR, REAR TO SEAT BOX FROM INSIDE CABIN, TOP TO FRAME FROM INSIDE CABIN (DO NOT DAMAGE LINES IN SPAR), DO NOT FASTEN TO F UNTIL H AND J ARE READY FOR FASTENING, SAME FOR K AND F REAR.



ONE RIGHT, ONE LEFT, SYM.
NO DRILLING BEFORE ASSEMBLY EXCEPT FOLD-CORNER HOLE

FASTEN FROM OUTSIDE OF CAR TO B, C, G, AND TOP TO FRAME. DO NOT FASTEN TO H PART YET. THIS PART WILL FASTEN TO D, J AND K LATER IN THE SEQUENCE.

F'S BOTTOM MUST BE TRUE WITH G'S BOTTOM'S PLANE. OPTICALLY ALIGN F'S BOTTOM TO UNDER FRONT SEAT FLOOR BEFORE FASTENING F'S TOP TO FRAME.

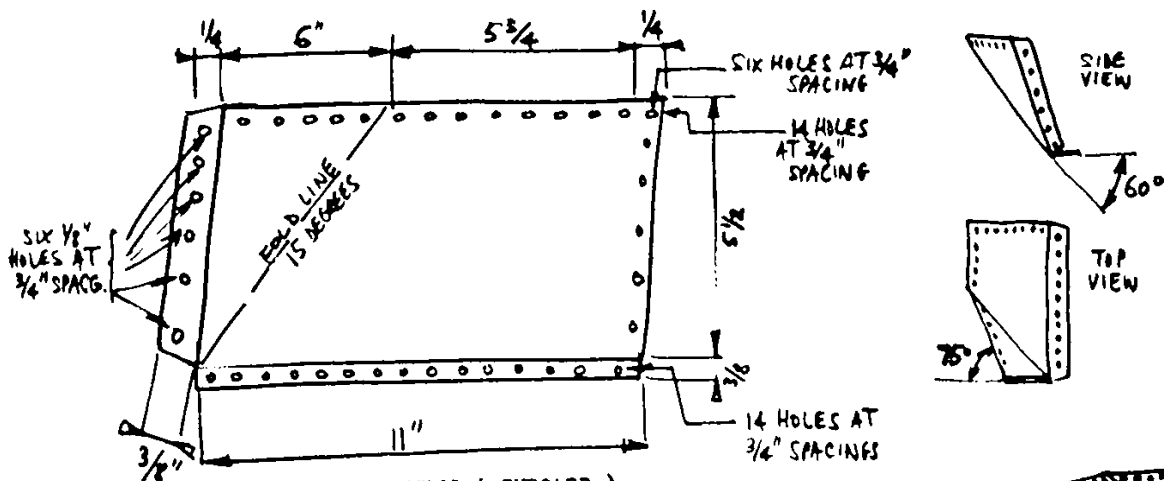


FASTEN FROM FOOT REST AREA TO FRONT HORN. FASTEN TO B-E PART FROM BOTTOM OF CAR, ALIGN, THEN FASTEN TO FIREWALL FROM FRONT WHEEL AREA.

F, L, AND P PARTS WILL FASTEN TO THIS PART LATER IN THE SEQUENCE. BEFORE ASSEMBLY : FOLD LIPS AND DRILL DIA $\frac{1}{8}$ ", 1 " APART IN VERTICAL LIP ONLY.

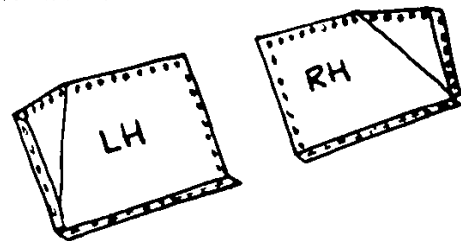
ONE PART RIGHT RG
ONE PART LEFT LG SYMETRICAL

All lips are $\frac{3}{8}$ " wide.



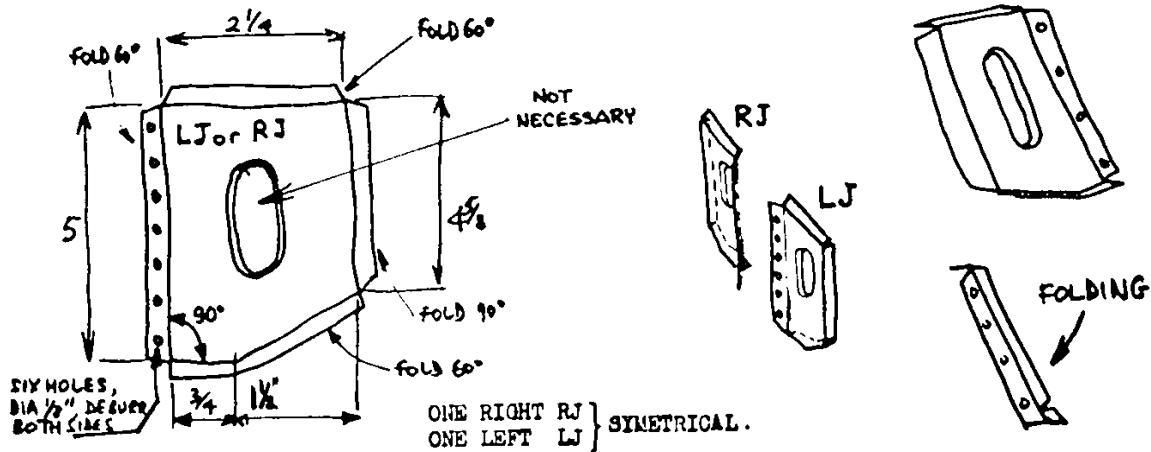
FASTEN IN ORDER TO INSIDE FIREWALL (INBOARD) FROM CABIN SIDE, TO FLOOR AND C AND E TOGETHER FROM THE BOTTOM OF THE CAR, TO THE TOP AND THE FRAME FROM THE CABIN SIDE. DO NOT RIVET TO D OR F YET.

SHOULD THE LIP OF THE B-E AND C OVERLAP BE MORE THAN 1 1/2" AWAY FROM THE H OVERLAP AND RIVET ROW, PUT AN EXTRA RIVET ROW FROM THE BOTTOM, NEXT THE EDGE OF THE B-E/C OVERLAP. IF NOT, SQUEEZE TWO ROWS AT 5/8" MINI SPACING ABOUT THE H LAP.



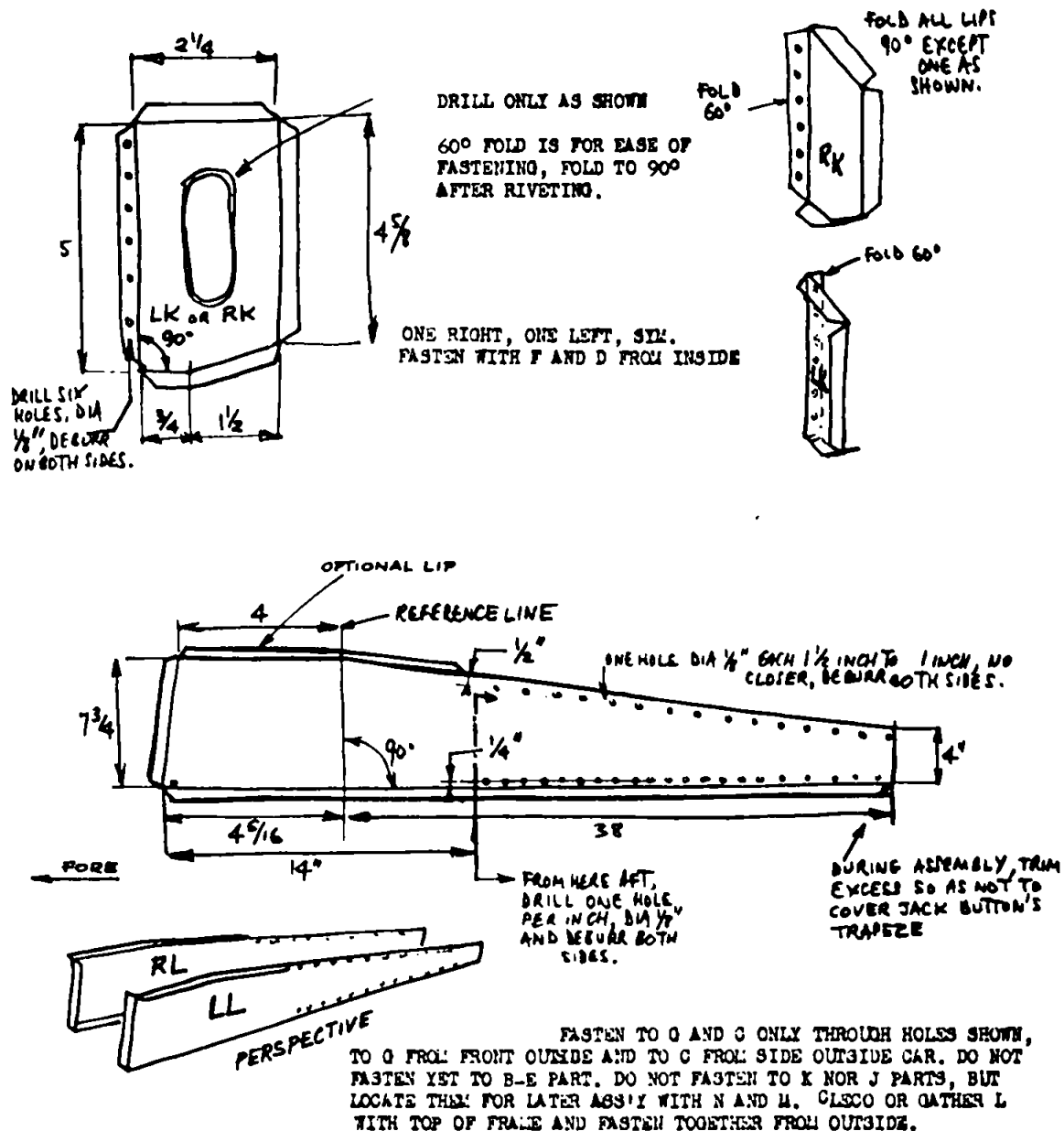
WARNING ! THIS PART IS NOT A RECTANGLE.

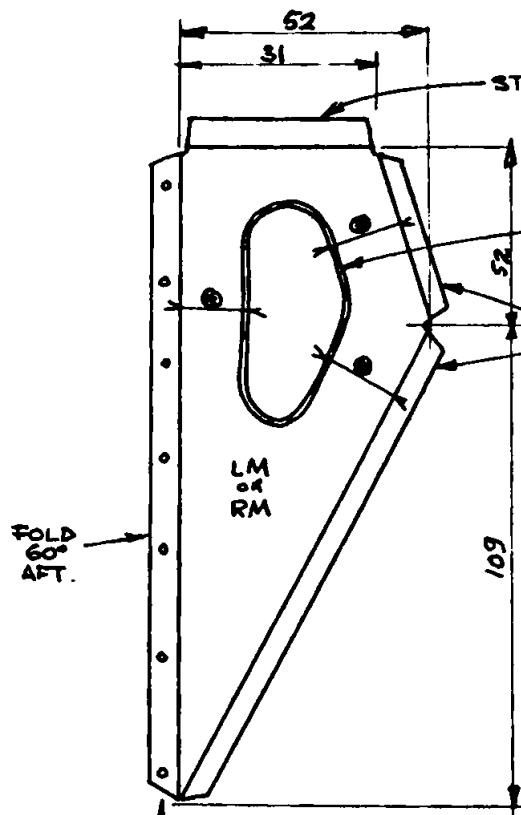
ONE RIGHT, ONE LEFT, SYM.



DRILL ONLY AS SHOWN.

DRILLED FROM INSIDE WITH H AND F AND D. FASTEN ALL FOUR (4) SHEETS FROM INSIDE OF CABIN. J WILL RECEIVE L AND M TOGETHER LATER IN THE SEQUENCE.

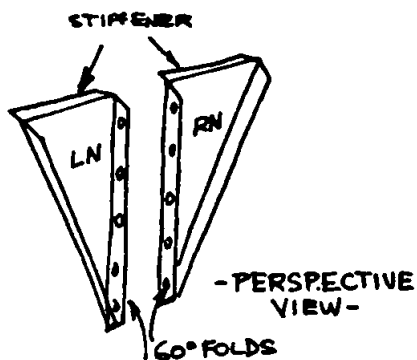




DRILL 7 HOLES
DIA 1/8".

⊗ NOT LESS THAN 1".

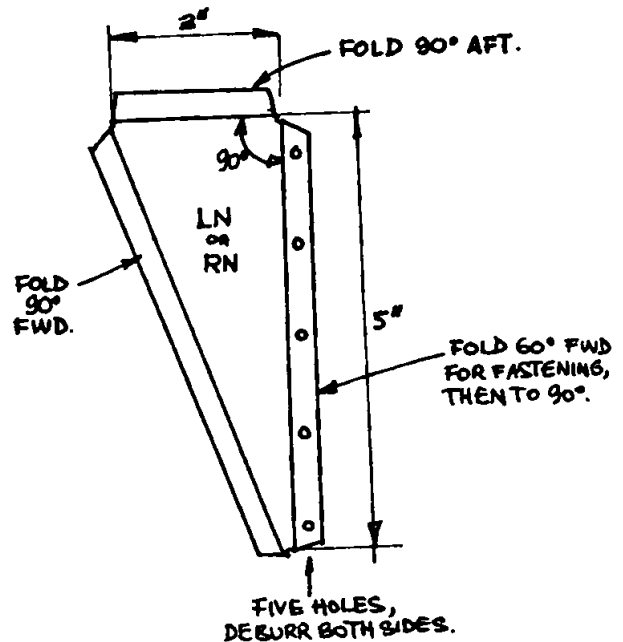
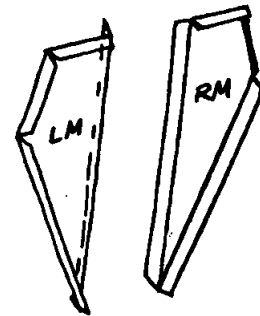
ONE RIGHT, ONE LEFT
SYMMETRICAL.
ALL LIPS 3/8" WIDE.



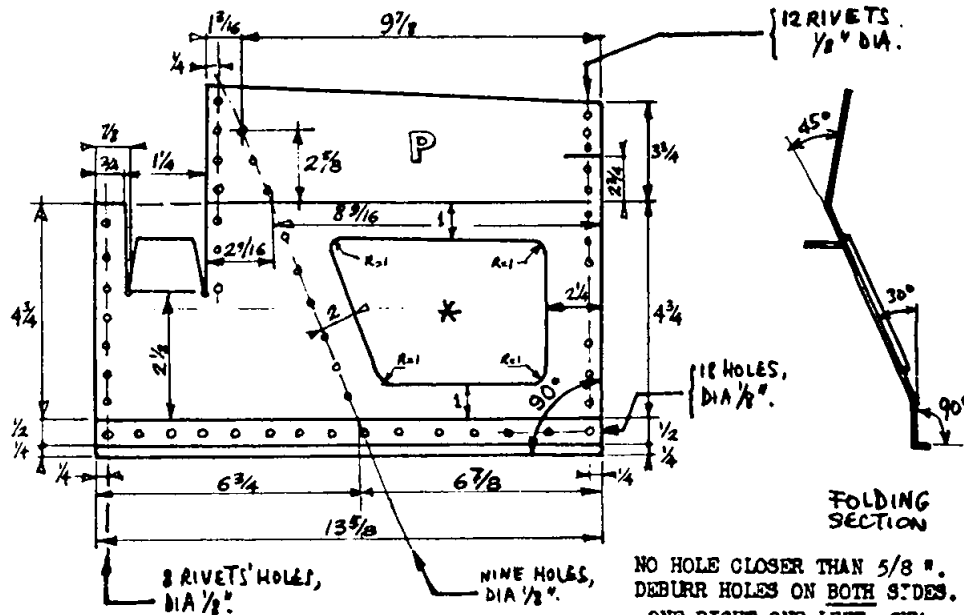
FASTEN TO L AND K PARTS FROM OUTSIDE OF CAR.
FOLD 60° ANGLE TO 90°.
THIS PART WILL RECEIVE THE REAR OF THE P PART
LATER IN SEQUENCE.

FASTEN TO L AND J PARTS TOGETHER FROM
OUTSIDE OF CAR, THEN FOLD 60° ANGLE TO
90°. THIS PART WILL LATER RECEIVE THE
P PART. DO NOT FASTEN TO FRAME TOP.

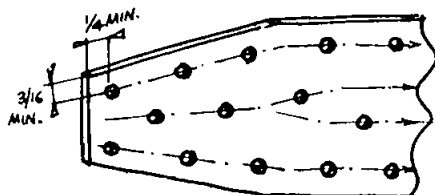
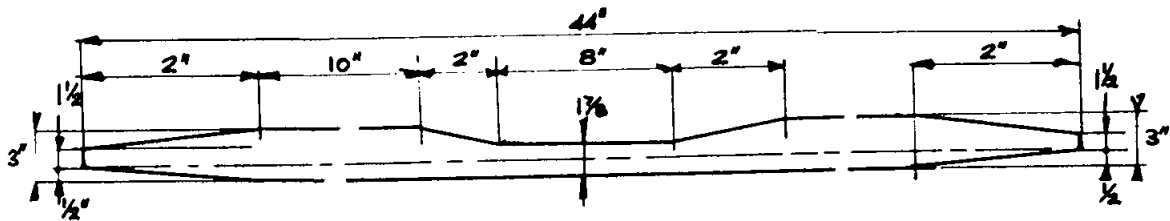
All dim. in mm.



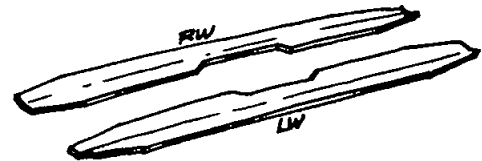
ALL LIPS ARE 3/8" WIDE.



ONE RIGHT ONE LEFT. SYM.
FASTEN FROM OUTSIDE, IN SEQUENCE, TO PARTS
B-E, Q, M, N AND JACK STUD ASSEMBLY. FASTEN
TO TOP OF ORIGINAL FRAME.



NO HOLE CAN BE
CLOSER THAN 5/8"
TO ANOTHER HOLE.



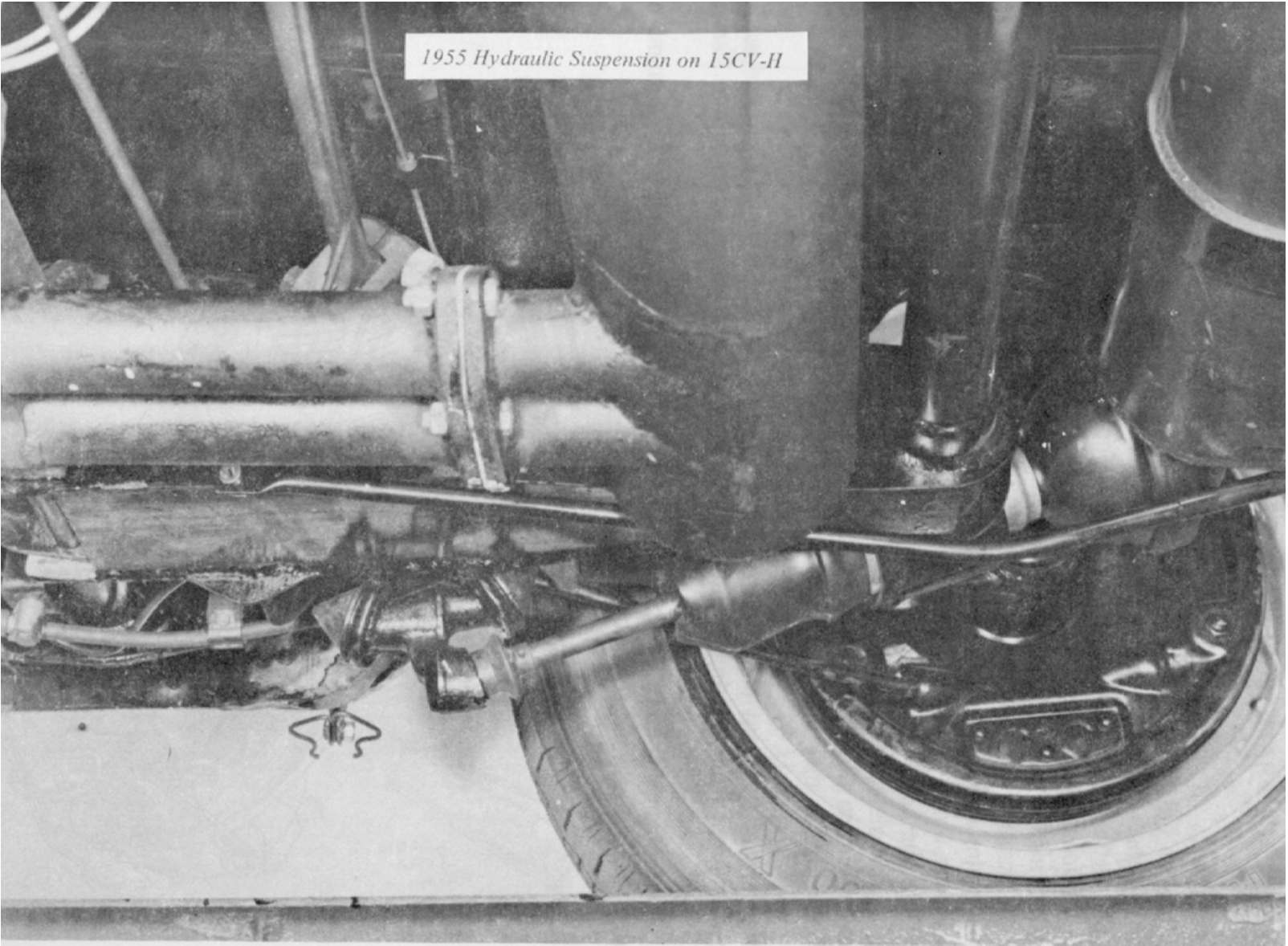
ONE RIGHT ONE LEFT } SYMMETRICAL
ALL HOLES 1/8" DIA, DEBURRED BOTH SIDES.
HOLE LOCATION TOLERANCES $\pm 1/16"$ IN ANY DIRECTION.
NO CRACK, NO BURRS IN NECK.
A MINIMUM OF 28 RIVETS MUST BE PROPERLY
INSTALLED ON EACH SIDE OF THE NECK.
ONLY ONE ROW OF RIVETS, IN CENTER LINE OF THE NECK.

PRODUCTION: THIS PART MUST BE IN INTIMATE CONTACT WITH ALL CONCERNED
METAL PARTS. AS THE FASTENING PROGRESSES, USE CLECOS OR OTHER DEVICES
TO BRING THE SHEETS TOGETHER. SHOULD A SLIGHT DEPRESSION EXIST IN
THE METAL UNDER, HAMMER W INTO IT AND PRESS THE RIVETING TOOL SO AS
TO HAVE BOTH SHEETS AS CLOSE AS POSSIBLE.



1959 IDI9 restored in 1968. In January 1977, the chassis was still intact where rebuilt: shiny metal and dustless.

1975 DS23



1955 Hydraulic Suspension on 15CV-H

TO REPLACE FRAME COVERS ON DS MODELS

Installation:

Remove old plates. Keep washers, dispose of the old screws.

Keep the rubber anti rattles located on the bottom of the frame.

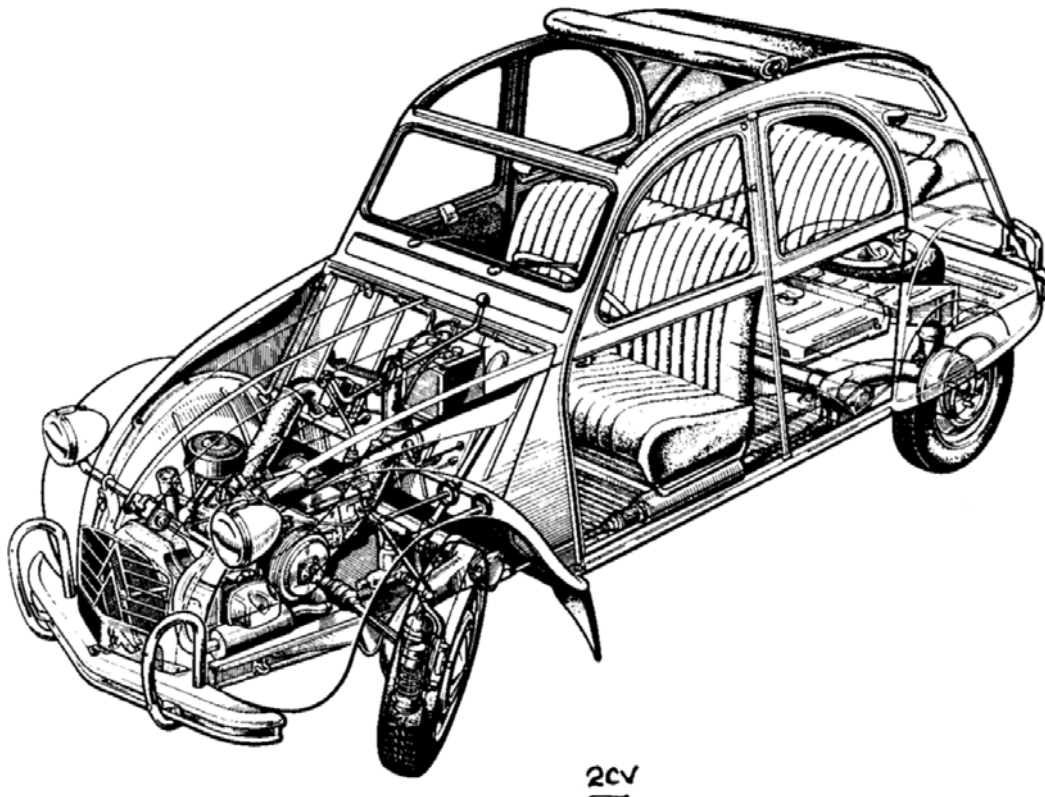
Screw the new plates starting by the rear ones, into the frame door bottoms, into the previous holes.

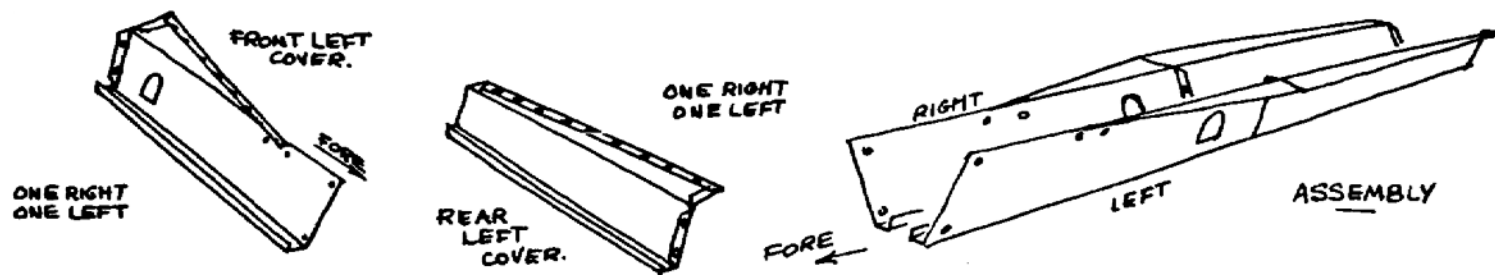
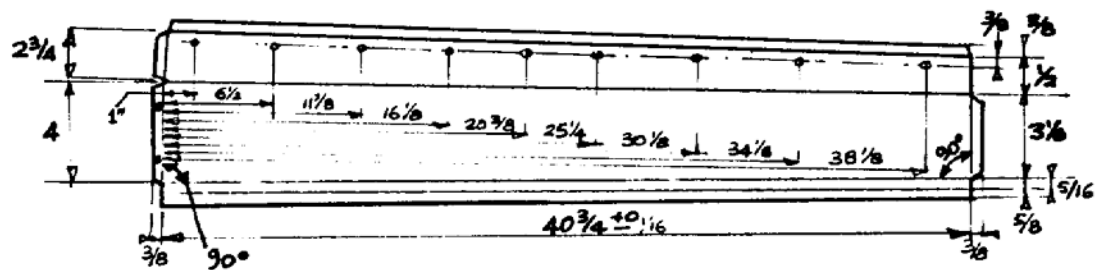
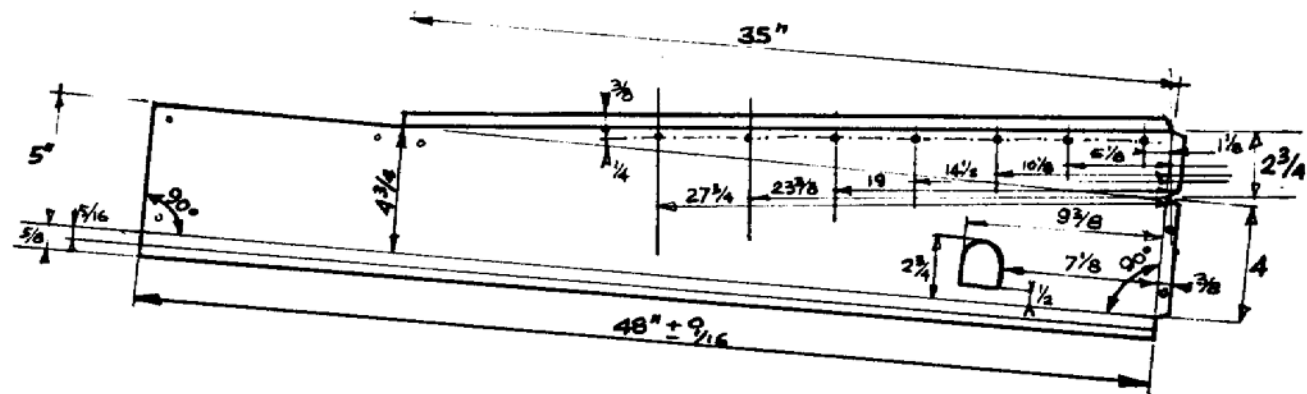
Once all the plates are fastened, clamp the bottoms of the plates around the bottoms of the frame. You may use the rubber anti rattles again. Should you not wish to use them again, weep holes must be punched on the bottom of the plates and the assembly should be tarred or the like before putting in contact.

Once the bottom of the plates are aligned with the bottom of the frame, pinch the lip of the plate that is overhanging inboard of the frame bottom. This lip must be pinched up, so as to provide a "hook" all along the frame. Do not use tools for this pinching, since they will damage the metal.

The front of the front plates must be carefully caulked in the front and top edges prevent water from entering. Caulking should be done just before screwing into frame.

It is recommended to caulk or tar the top lip in contact with the door frame bottoms order to slow galvanic corrosion.





REAR SUSPENSION FRAME REPAIR

Lift car's rear end, use rear trunk lower lip first. Then rest car's side members, near rear. Should the side members be weakened by corrosion, install a piece of 2x4 approximately 2 feet long between stand and frame.

Rear wheels must be hanging.

Remove fender and wheel on damaged side.

Open hydraulic tank's cap, and leave off until the suspension lever has been lowered and the suspension has lowered itself. Should a defective suspension sphere fail, the escaping nitrogen will not cause the rupture of the hydraulic tank.

See drawing no. 24004. Remove suspension sphere, two hydraulic lines, one on the suspension cylinder, one on the rubber boot.

Do not raise the suspension lever from now on.

Remove cylinder lock nut, lock clamp and rod-knuckle clip. In certain models, the knuckle will come apart.

Extract push rod from knuckle. Extract cylinder-piston-boot-pushrod assembly forward.

Remove boot from cylinder. Remove piston from cylinder. Examine piston and cylinder for cracks. Cylinder usually cracks near O ring seats. Replace the set if cracked. Check the new set for hard points. Use 600 paper to remove "high" spots. Clean with alcohol in red fluid cars, kerosene with green fluid cars. Blow air and insert careful

Keep all hydraulic parts clean.

Cut metal around bracket (shears or nibbler). No torch.

Remove bracket, straighten. Clean, deburr. Here is the only exception to the weld rule: the bracket may be welded where cracks have appeared. Make sure the flame is not oxidizing.

Make top plate and side curved plate.

See drawing. no. 24014. Clamp bracket to plates and plates to car's frame.

Align bracket as shown on drawing 24014.

Spray parts lightly with black lacquer when aligned properly.

Unclamp and rivet side curved plate to bracket following paint marks, follow schedule on drawing. no. 24004.

Fasten top plate on bracket. Follow paint marks.

Cut trunk's wall out.

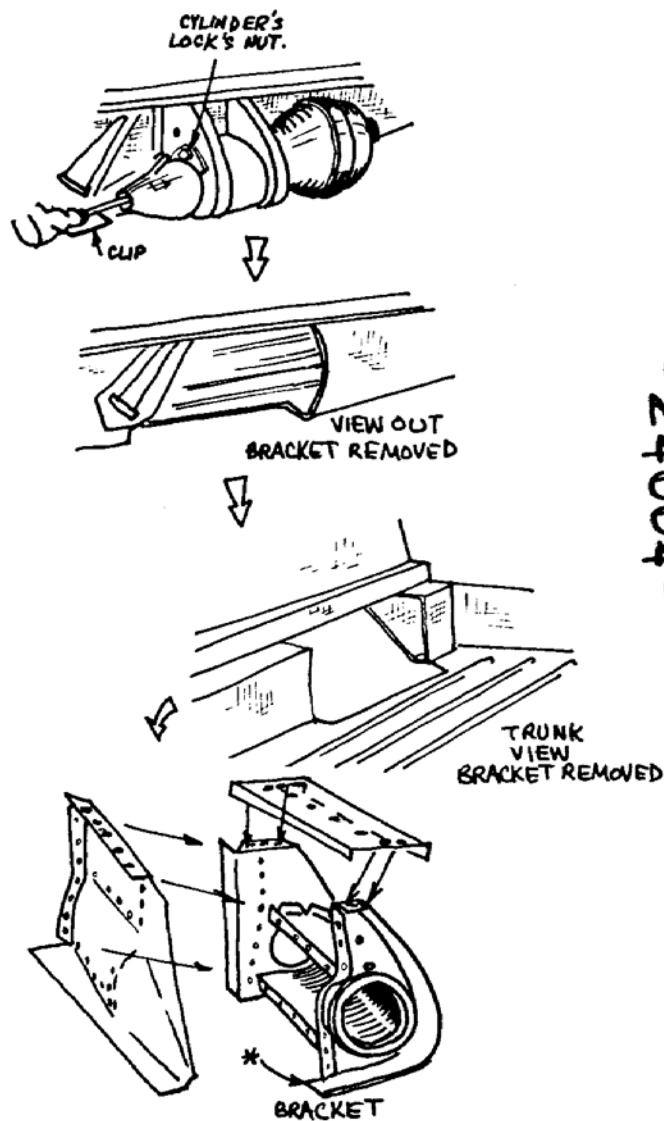
Clamp bracket assembly to car's frame, check alignment again.

Fasten assembly to frame, top plate first, front of side curved plate next.

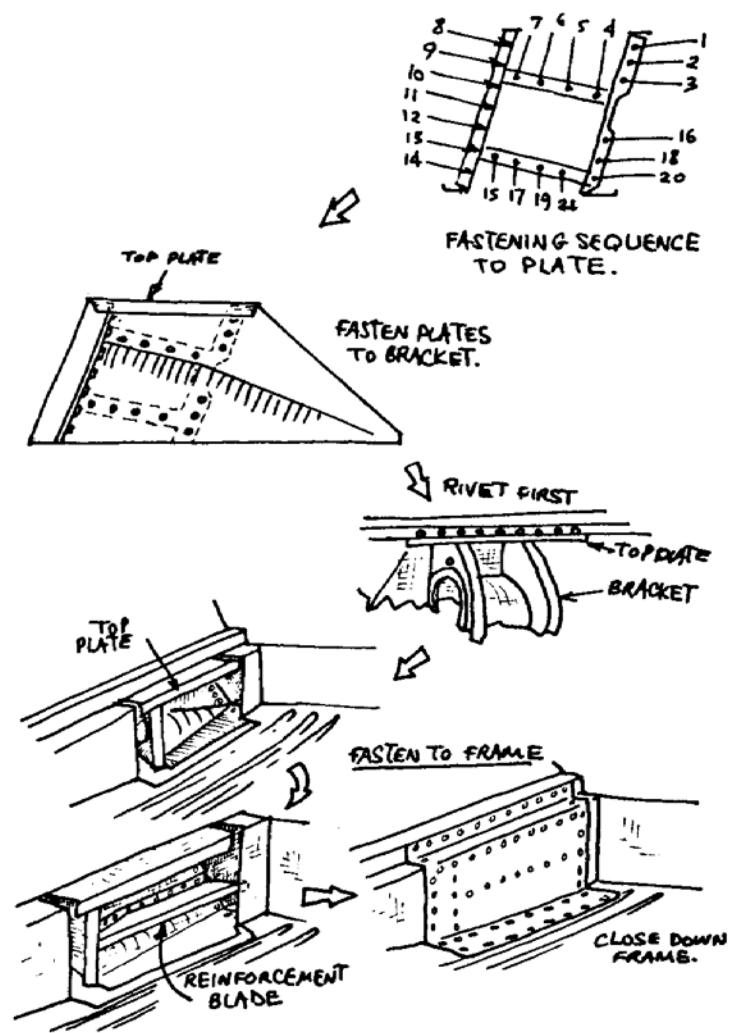
Fabricate reinforcement plate. This is optional and not really recommended since it gives too much strength to rear suspension and can cause a frame failure in the side member area, should another rear suspension failure recur (bad sphere or missing rubber stop).

Tar all parts just before assembly.

Fabricate trunk wall and fasten as shown.



-24004-



All plates must be in intimate contact. No gaps.

All laps and rivets must be tarred or the like.

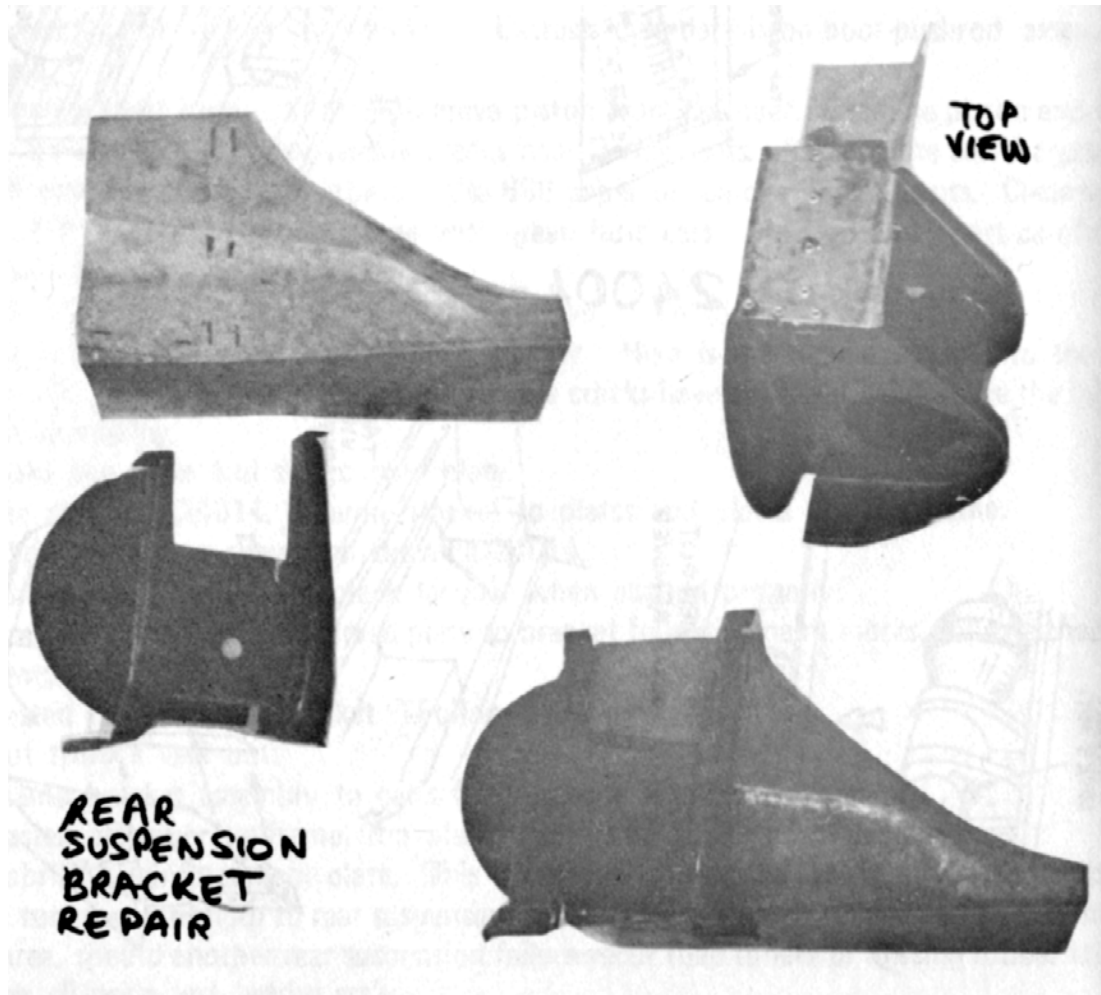
Install piston to boot. Insert boot-piston assembly into bracket. Lock with clamp and nut.

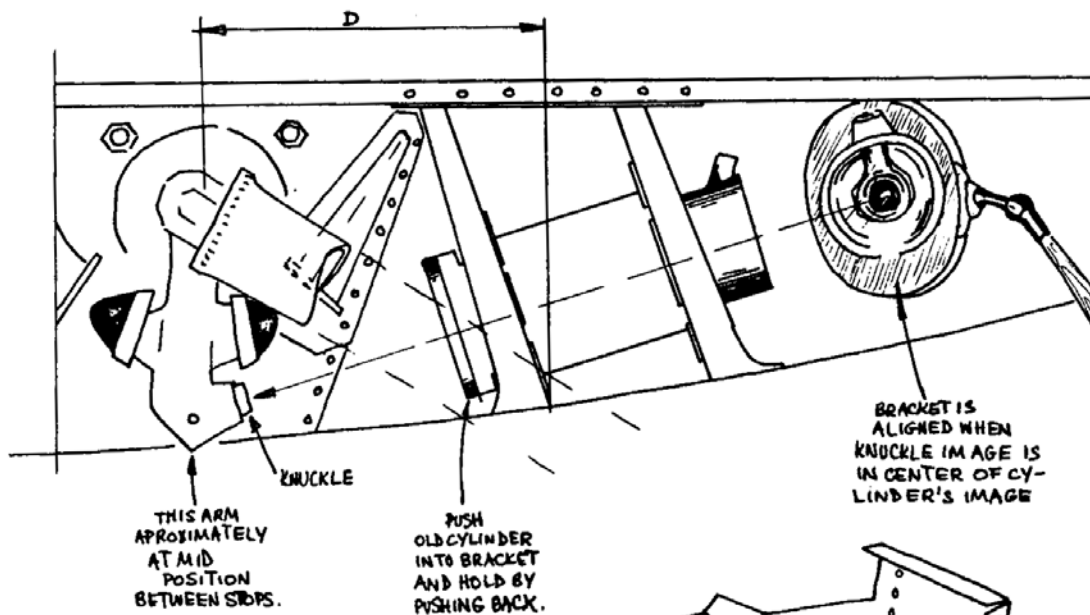
Grease ball in knuckle. Assemble rod to knuckle. Install clip into rod and knuckle and twist.

Connect hydraulic lines. Install sphere, hand tight only. Lift suspension lever now. Check for leaks. Do not attempt to stop leak with hand, even with gloves on. Throw rags on leak area, drop pressure, wipe and repair.

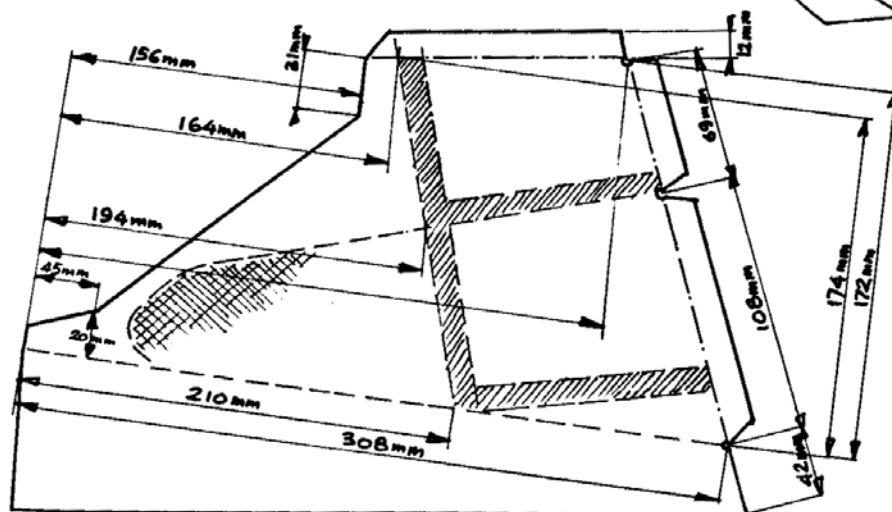
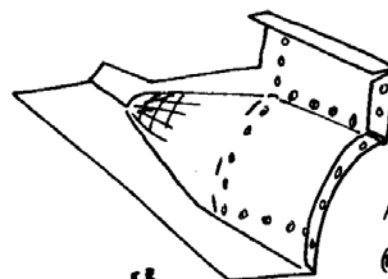
Do not release cars with missing rubber stop on suspension levers. Overtravel causes piston extraction or hammering and subsequent bracket failure. Bad spheres will have the same effect.

Avoid setting car in high position, engine running. The normal stress at the bracket area varies from 2000 to 2300 lbs. An old bracket not yet repaired cannot tolerate 3000 lbs.





- 24014 -



1. CLAMP CURVED PLATE IN POSITION
2. CLAMP BRACKET IN APPROXIMATE POSITION.
3. INSERT OLD CYLINDER AND SHIFT ELEMENTS UNTIL ALIGNMENT OK.
4. "D" DISTANCE FROM BRACKET'S HEEL TO ARM'S AXLE MUST BE THE SAME ON BOTH SIDES OF CAR $\pm \frac{1}{8}$ INCH.
5. CYLINDER MAY BE OFFSET BY ± 1.5 DEGREE. DO NOT SHIM CYLINDER!
AN IRREGULAR SHIM SUCH AS A PARTIAL WASHER WILL DESTROY THE CYLINDER'S SHOULDER. MARK ALIGNED PARTS WITH SPRAY.
6. DO NOT RELEASE CARS WITH MISSING RUBBER STOPS.

TRACTION AVANT FRONT AXLE FAILURES

FAILURE:

Drum is loose on shaft, rotates. Key is damaged and chewed up the keyways on both shaft and drum. Causes enormous shock loads on the transmission. Can lead to failure by breakage of a differential crown tooth or teeth. Every time the accelerator is pushed or released, the torque reverses and causes the slippage described above, loud banging and overloads on the front suspension, steering and transmission.

CAUSE:

The drum was installed on the shaft by some lubrication minded mechanic who grease the assembly before putting it together. Careful lubrication of parts before assembly is OK, but not in this case.

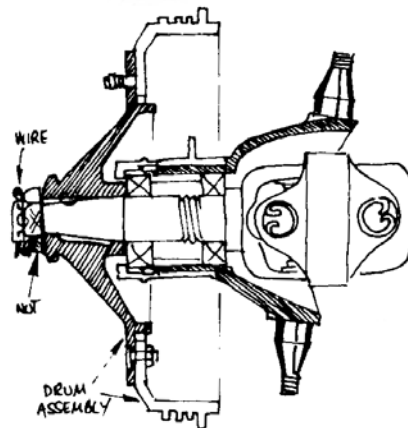
The shaft and drum are locked together by molecular adhesion. The two metal surfaces are prepared so accurately and are kept so clean that the molecules "get together" and actually bond the two parts. It does create problems when time comes to take it apart. That is when a puller is used along with a sharp tap of a ball peen.

The only purpose of the key is to keep the assembly together enough to get back home. It also to prevents free rotation of the two unlubricated surfaces, which can lead spindle failure, loss of wheel and usually disastrous consequences to both the car and the whatever it is that was hit by the loose wheel.

CURE AND SOLUTION:

Clean up drum's bore and spindle surface: no chips, no scratches, only true and clean surfaces. If not possible, have the surfaces refilled and machined again.

The tapers must match with priority to the larger diameter end. No deal on small end bearing and loose large end. The key must be installed without grease nor oil in a clean keyway, maximum play .02 mm (.008 inch). Assemble drum to shaft after cleaning both surfaces with alcohol. Put a little grease on the face of the big nut and tighten to 30MKG (198Ft.Lbs.).



11CV ENGINE STABILITY

11CV front end rattles and shakes. Solution.

Most 11CV and some 15CVs, upon engaging the clutch in 1st gear or in reverse, shake violently about the front axle. Most owners check their front axles, which are probably loose and hope not to have to buy new ones. Most owners just go around the problem by letting the clutch slip longer during the start. This causes more clutch wear and eventual headaches when comes time to replace the same clutch.

The rattle is caused by play in an area that is not too well known at the rear of the 11CV engine. There is an engine mount there! It is really a pivot, which allows the engine to rotate right and left as it idles and prevents the same engine from tilting up and down as the torque is applied on the front axle. This mount is a rubber block bolted on the rear of the engine, fitted into a box located in the firewall.

Inside the cabin, remove the fabric on the engine hump. The mount's box is visible and can be removed. No need to hold the engine up since it is balanced. The rubber block (damper) can then be unscrewed and replaced with a block of domestic rubber, properly cut to size, or built up with strips of rubber, glued with denatured alcohol or thinner. Fit the block back on the engine, fit the box and try a start. If you still have a rattle, better change the front axles before the differential's crown loses a tooth. If rattling persists, the gearbox casing is cracked or a bearing is loose.

TYPE 15-SIX					
Year	Type	Number	Year	Type	Number
1939	15-Six G	680.000 to 682.000	1951	15-Six D	701.601 to 713.100
1946	15-Six G	682.479 to 682.690	1952	15-Six D	713.101 to 721.650
1947	15-Six G	682.691 to 682.729	1953	15-Six D	721.651 to 723.710
1948	15-Six D	682.801 to 685.500	1954	15-Six D	723.711 to 724.950
1949	15-Six D	685.501 to 691.600	1954	15-Six H	726.001 to 727.680
1950	15-Six D	691.601 to 701.600			

TRACTION AVANT
Models Manufactured 1934 to 1954

TYPE 7			TYPE 11 NORMALE			TYPE 11 LEGERE		
Year	Type	Number	Year	Type	Number	Year	Type	Number
1934	7 A	0 to 7,000	1934	11 A	100,000 to 103,300	1934	11 AL	350,000 to 351,500
1934	7 B	10,000 to 30,620	1935	11 A	103,301 to 107,400	1935	11 AL	351,501 to 353,400
1934	7 C	50,000 to 56,700	1936	11 A	107,401 to 116,600	1936	11 AL	353,401 to 358,800
1934	7 S	20,000 to 21,500	1937	11 A	116,601 to 118,000	1937	11 AL	358,801 to 360,000
1935	7 C	71,400 to 80,000	1937	11 B	118,001 to 127,300	1937	11 BL	360,001 to 386,000
1936	7 C	80,331 to 93,000	1938	11 B	127,501 to 139,200	1938	11 BL	386,001 to 422,400
1937	7 C	93,000 to 100,000	1939	11 Cle	290,000 to 290,990	1939	11 BL	422,401 to 428,000
		and	1939	11 B	139,200 to 143,000	1939	Perf.	428,001 to 450,000
		200,001 to 204,300	1939	Perf.	143,001 to 152,350	1940	Perf.	450,001 to 454,500
1938	7 C	204,301 to 210,500	1940	11 Cle	291,200 to 293,500	1945	Perf.	456,600 to 457,600
1939	7 C	210,501 to 212,000	1940	Perf.	152,351 to 154,300	1946	Perf.	457,601 to 469,600
1939	7 C Eco.	212,001 to 218,600	1947	Perf.	154,770 to 156,600	1947	Perf.	469,601 to 488,200
1940	7 C Eco.	218,601 to 219,800	1948	Perf.	156,601 to 163,950	1948	Perf.	488,201 to 508,800
			1949	Perf.	163,951 to 177,700	1949	Perf.	508,801 to 531,500
			1950	Perf.	177,701 to 195,500	1950	Perf.	531,501 to 556,200
			1951	Perf.	195,501 to 212,100	1951	Perf.	556,201 to 582,200
			1952	Perf.	212,101 to 236,600	1952	Perf.	582,201 to 612,000
			1953	Perf.	236,001 to 270,800	1953	Perf.	612,001 to 636,900
			1954	Perf.	270,801 to 403,600	1954	Perf.	636,901 to 652,550
			1954	11 Cle	293,563 to 295,000			
					and			
					300,001 to 301,000			

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THE COSTLIEST TRAINWRECK IN EUROPEAN HISTORY

Gerard Gasson had spent the evening with friends; watching TV and drinking wine (less than half the amount allowable by law, 0.8 grams is the limit, Gerard had 0.3 grams as tested by the police). Two o'clock in the morning he left in his 20 year old Traction Avant with a friend to go back home. One rear tire was bald and one of the front tires was studded.

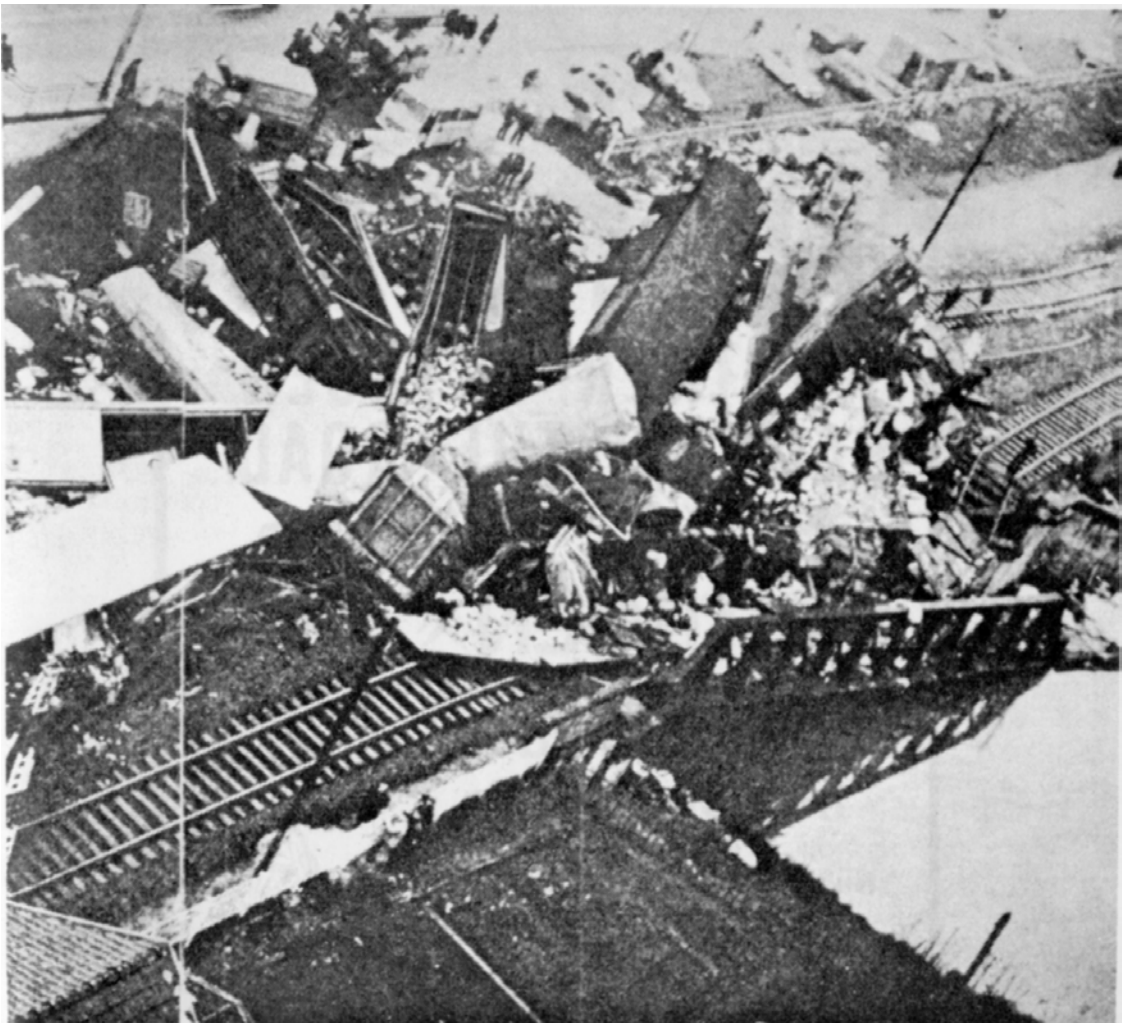
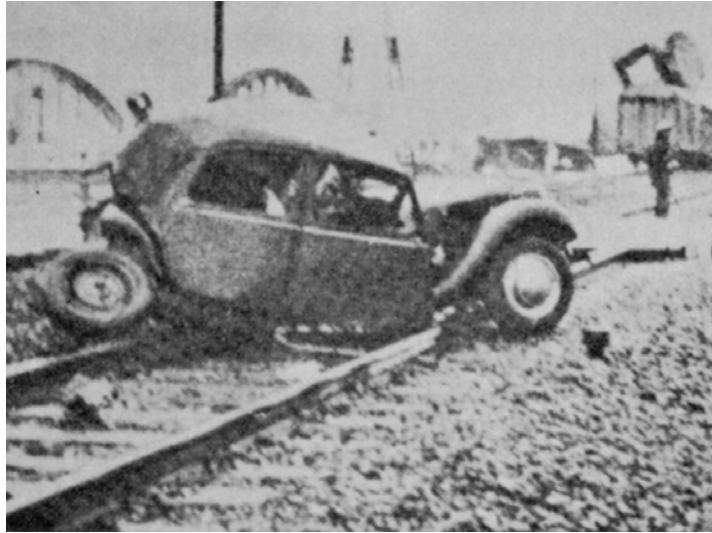
His car stalled on the railroad crossing with two rail sets, completely blocking one set of rails, so he had one chance in two that the oncoming train would miss the car.

He ran to the phone and yelled "this is post 110," but he was too late. The BB 15000 with 38 traincars slammed into his car at about 60 mph speed and threw his car 90 feet in the air and 150 feet down the tracks. The locomotive derailed and hit a bridge, which collapsed, and one after another the train cars fell into the Marne-Rijn canal. The engineer and fireman escaped with broken ribs and one had a broken arm.

Gerard was arrested and held for 36 hours. He was accused of driving under the influence, driving with bald tires, blocking railroad tracks, bringing injuries to other people, and driving an automobile with defective parts. The fish club of the canal also put in a claim against him for making the canal dirty with beer and packages of soup which the train was carrying.

The total damages from the train wreck were 30,000,000 New Francs, which was paid by his insurance company. Gerard paid 5,000 francs fine. He had paid 465 francs for his insurance policy, the cheapest one available in France. Gerard stated that if he had had to pay everything himself, he would need many, many lives to do it.

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