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VEHICLE ANALYSIS

CHEVROLET CORVETTE SPORTS CAR

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CHEVROLET CORVETTE SPORTS CAR

by
M. R. HAYES and R. G. DARLINGTON

Approved for circulation,
July, 1962

A. FOGG,
Director.

CONTENTS

SUMMARY

The " Corvette " is a high performance two-seater car from the Chevrolet division of General Motors Corporation. With changes and additions, it has been in production for about eight years. One of the first cars to have a resin bonded glass fibre body, the model is now made at the rate of about ten thousand a year. It is thus an outstanding example of large scale production of this type of body and, mainly for this reason, the car was acquired for detailed study. Another feature of special interest was the sintered iron material used for brake linings—unorthodox for road vehicles.

Several small body cracks appeared, mainly in the vicinity of attachment points, at an early stage in the test programme, and, in consequence, no extended pavé endurance test was carried out on this vehicle.

The car was well equipped and provided comfortable accommodation, but routine maintenance could only be carried out with some difficulty. A maximum speed of at least 125 m.p.h. and acceleration from rest to 100 m.p.h. in 22 seconds were accompanied by a road fuel consumption of 18 m.p.g. The engine was extremely flexible, so that it was unnecessary to make frequent gear changes, although the precise gear change was a pleasure to use and the acceleration was excellent. The steering was accurate in all conditions, but became heavy at low speeds. Handling was good and a degree of control could be maintained even at the limit of tyre adhesion. The ride, although good at speed on smooth main roads, was uncomfortable at low speeds or on uneven surfaces. The brakes were very heavy to operate when cold, but less so when warm; they performed well from high speeds but harsh treatment could result, temporarily, in complete loss of braking power.

Dynamometer testing of the engine gave a corrected maximum power output of 185 b.h.p. at 4,600 r.p.m., together with a torque of 256 lb.-ft. at 3,600 r.p.m., compared with the maker's claims of 230 b.h.p. at 4,800 r.p.m. and 300 lb.-ft. torque at 3,000 r.p.m.

This was a well-equipped car, with excellent acceleration and a very flexible engine combined with good road holding, but was not very suitable for use on rough surfaces or on narrow country roads.

Fig. 1. Three-quarter front view.

SECTION 1
INTRODUCTION

THIS report describes the results of an examination of a new left-hand drive 1961 Chevrolet Corvette Sports Car. The vehicle, which was fitted with a four-speed synchromesh gearbox, was collected from the English distributor and was in no way specially selected or prepared.

The report includes a detailed description of the vehicle, and the conditions and results of a series of performance tests. At the conclusion of the tests, the vehicle was dismantled and an examination made of its design and the effects of the testing.

SECTION 2
SPECIFICATION AND DESCRIPTION

The vehicle examined had a resin bonded glass fibre body, produced in the U.S.A. at a rate of approximately ten thousand cars per year.

As can be seen from Figs. 1 to 8, the vehicle was a two-door sports car with a front-mounted engine, rear luggage compartment and a folding soft top. Detail views of the vehicle are presented in Figs. 9 to 14, the tool kit is illustrated in Fig. 15, and the arrangements within the passenger space are presented in Figs. 16 and 17.

2.1 Specification

ENGINE

The engine and gearbox were mounted as a single assembly at the front of the vehicle. Details of the engine specification, as quoted by the makers, are as follows:—

Capacity ...	283 cu. in.	4,640 c.c.
Bore	3·875 in.	98·4 mm.
Stroke	3·000 in.	76·1 mm.
Cylinders ...	8 arranged in 90 deg. V.	
Crankshaft ...	Forged steel, 5 bearings.	
Firing Order (to B.S.1599:1949)	B1, A4, A2, B2, A3, B3, B4, A1.	
Valve Gear ...	Inclined, in line overhead valves, rockers, pushrods and hydraulic tappets.	
Camshaft ...	Single, chain driven.	
Compression Ratio	9·5:1.	
Maximum Power	230 b.h.p. at 4,800 r.p.m.	
Maximum Torque	300 lb.-ft. at 3,000 r.p.m.	
Carburettor ...	Carter, type WCFB, No. 3779178, four-choke down-draught, with automatic choke.	
Petrol Pump	A.C., mechanical, with operating pressure of 5·25 to 6·5 lb. per sq. in. at 450 to 1,000 r.p.m.	

Fig. 2. Front view. Scale bars marked at 1 ft. intervals, camera 200 ft. from windscreen.

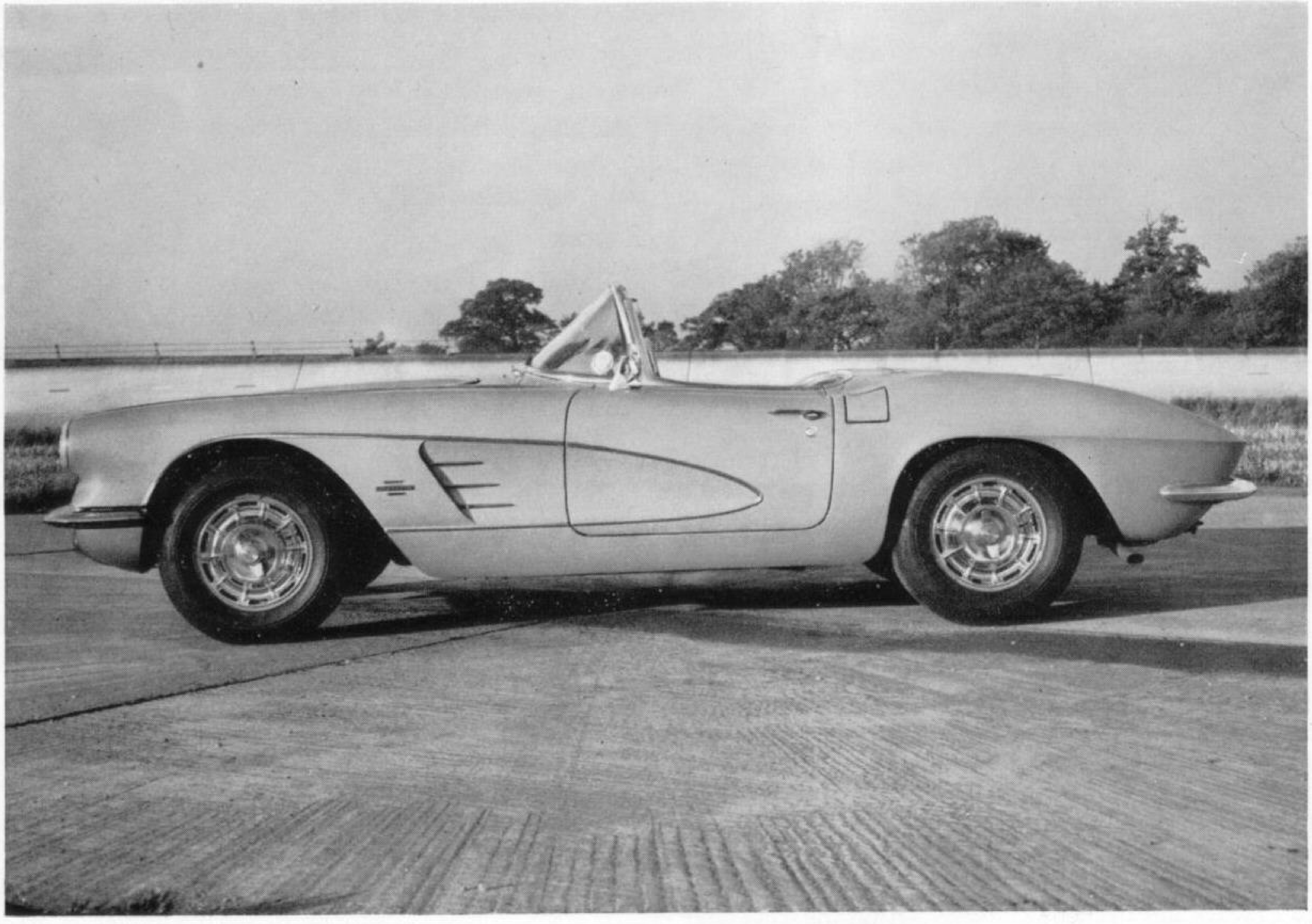

Fig. 3. Side view.

Fig. 4. Three-quarter rear view.

Fig. 5. Rear view.

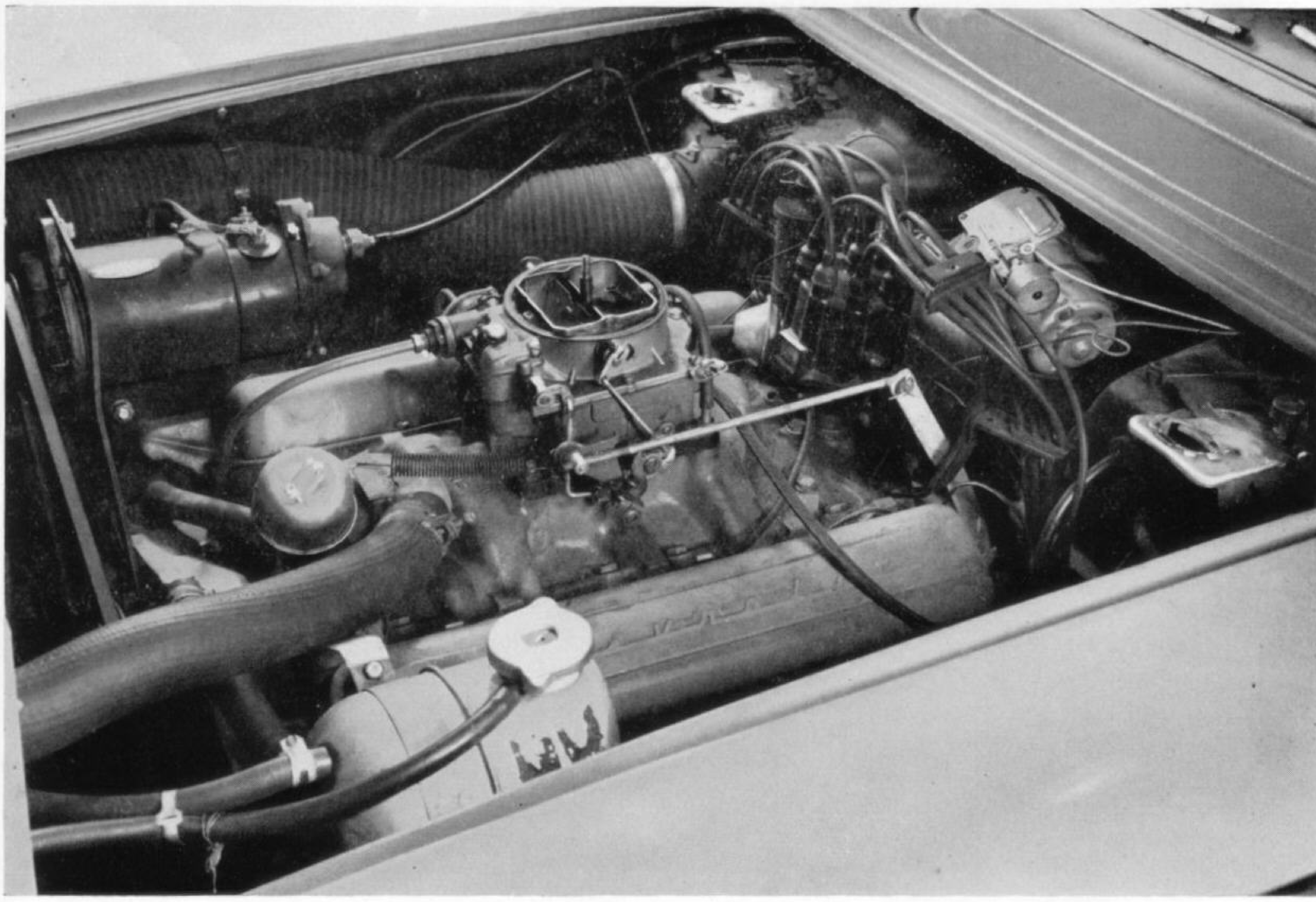

Fig. 6. Engine compartment, left side, with air filter removed.

Air Cleaner ...	A.C., type A98C, with washable polyurethane element.
Lubrication ...	Spur gear pump, with operating pressure of 45 lb. per sq. in. at 2,000 r.p.m.
Oil Filter ...	Full flow, A.C. type PM-16 with A.C. type PF-141 paper element.
Cooling System	Water cooled, Harrison aluminium radiator, No. 3150916, 16·62 in. high ×22·37 in. wide×2·87 in. thick, mounted in front of engine, pressurised at 13 lb. per sq. in.; system fitted with an aluminium alloy header tank, a water pump driven from the crankshaft at 0·95:1 ratio and an H.R.D. wax-pellet thermostat opening at 76°C. and fully open at 90°C.; aided by a five-bladed 17·12 in. dia. fan, with an Eaton viscous drive, temperature controlled to free wheel up to 54-65°C. radiator discharge air temperature, maximum speed restricted to 3,200 r.p.m.; the fan was driven by a G.M. belt having a measured outside length of 55·25 in., top width of 0·41 in. and included angle of 40 deg.

TRANSMISSION

The clutch and gearbox were in unit with the engine, driving the hypoid gears of the semi-floating rear axle through a single-piece open propeller shaft. Details of the transmission specification, as quoted by the makers, are as follows:—

Clutch	Single, dry plate, 10·0 in. dia., with mechanical control and two alternative pedal travels of 4·5 in. or 6·5 in.
4th Gear (Synchromesh)	1·00:1 (overall 3·70:1).
3rd Gear (Synchromesh)	1·31:1 (overall 4·84:1).
2nd Gear (Synchromesh)	1·66:1 (overall 6·14:1).
1st Gear (Synchromesh)	2·20:1 (overall 8·13:1).
Reverse Gear ...	2·25:1 (overall 8·34:1).
Propeller Shaft ...	Open, with needle roller universal joints at front and rear, together with sliding splines at the front.
Final Drive ...	Hypoid (37:10 teeth) 3·7:1.

CHASSIS

The main chassis structure was formed by two box-section longitudinal members and by " I " section members, in the shape of an " X ", comprising the centre portion.

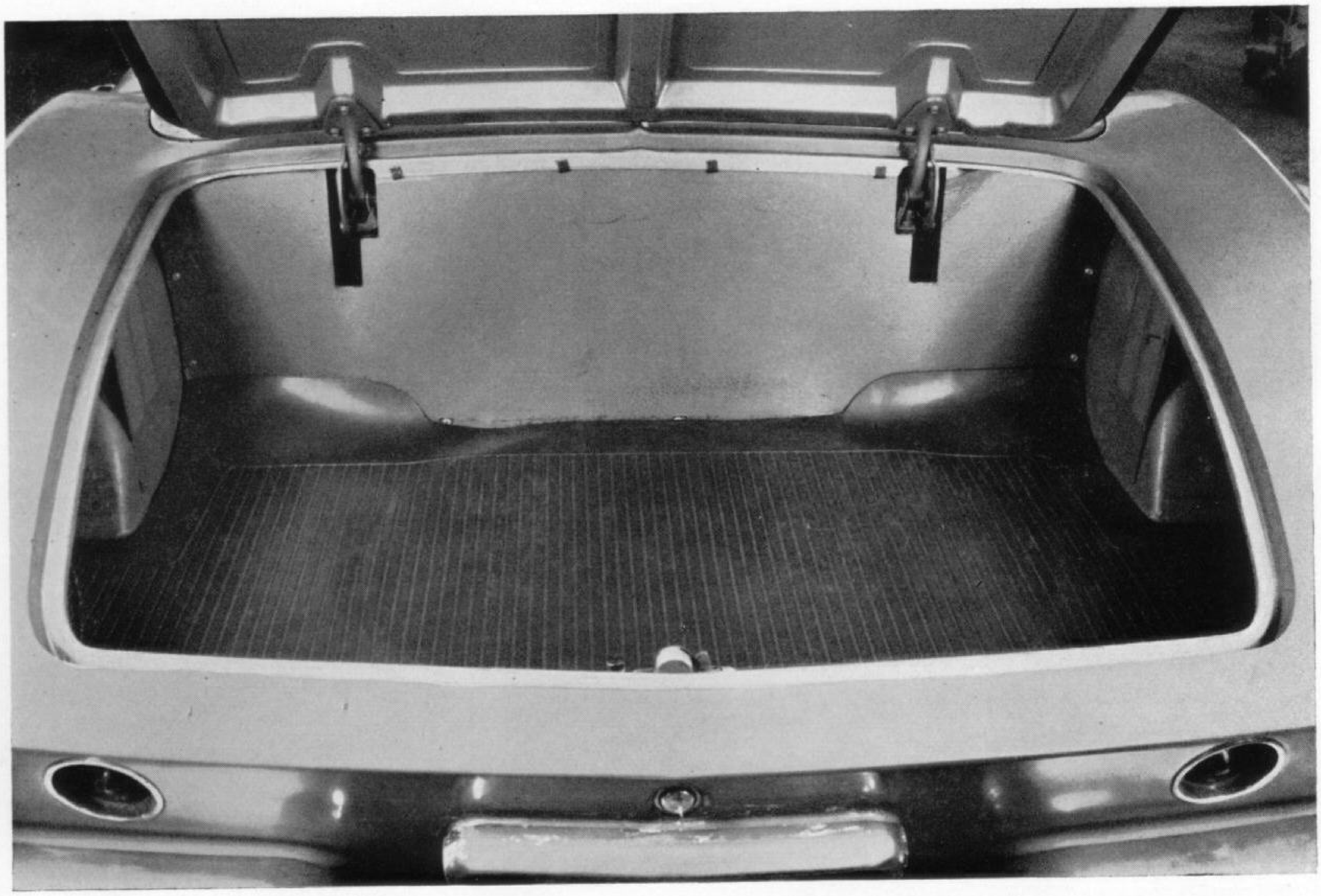

Fig. 7. Luggage compartment.

Fig. 8. Luggage compartment, floor covering removed.

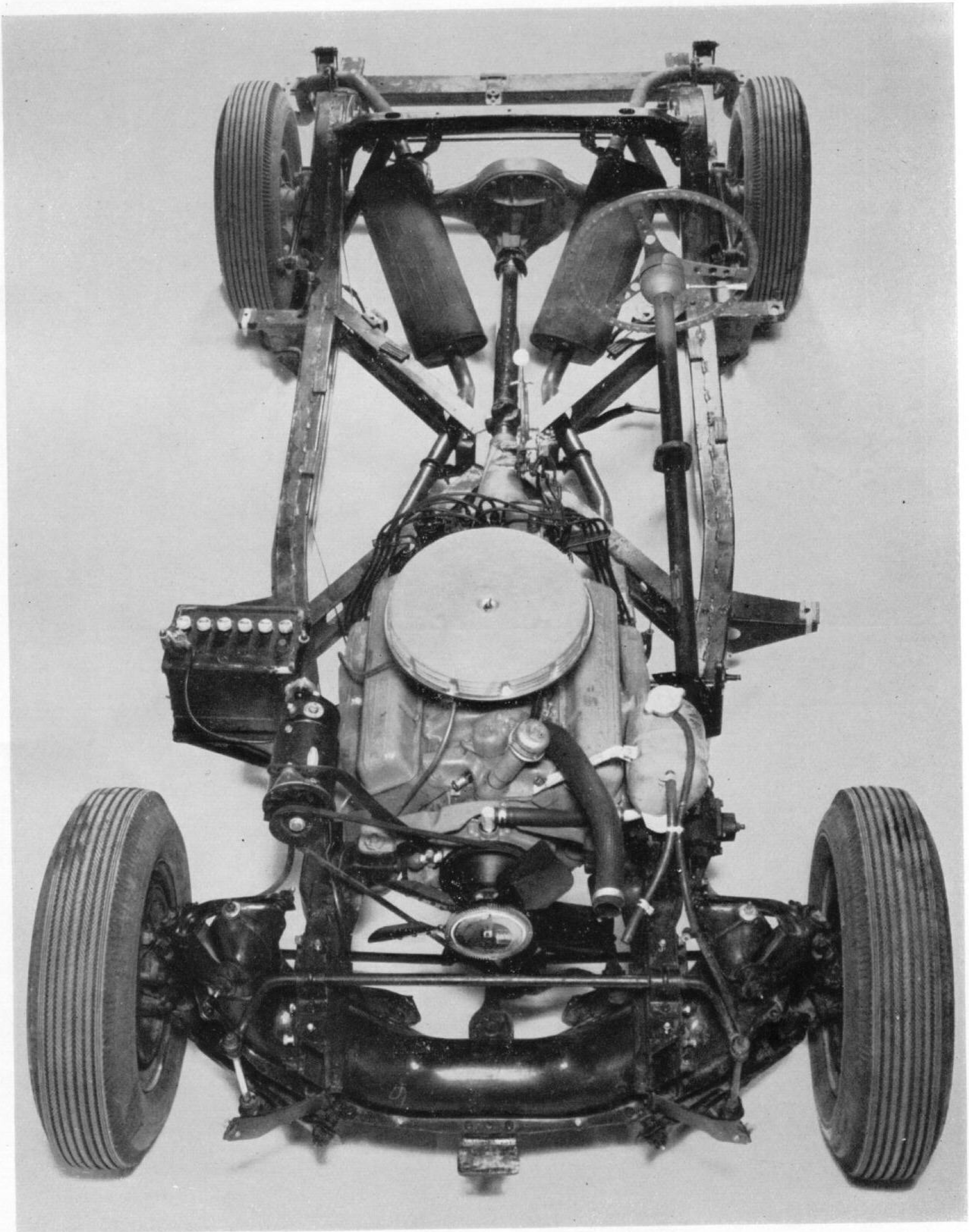

Fig. 9. Vehicle with body and radiator removed.

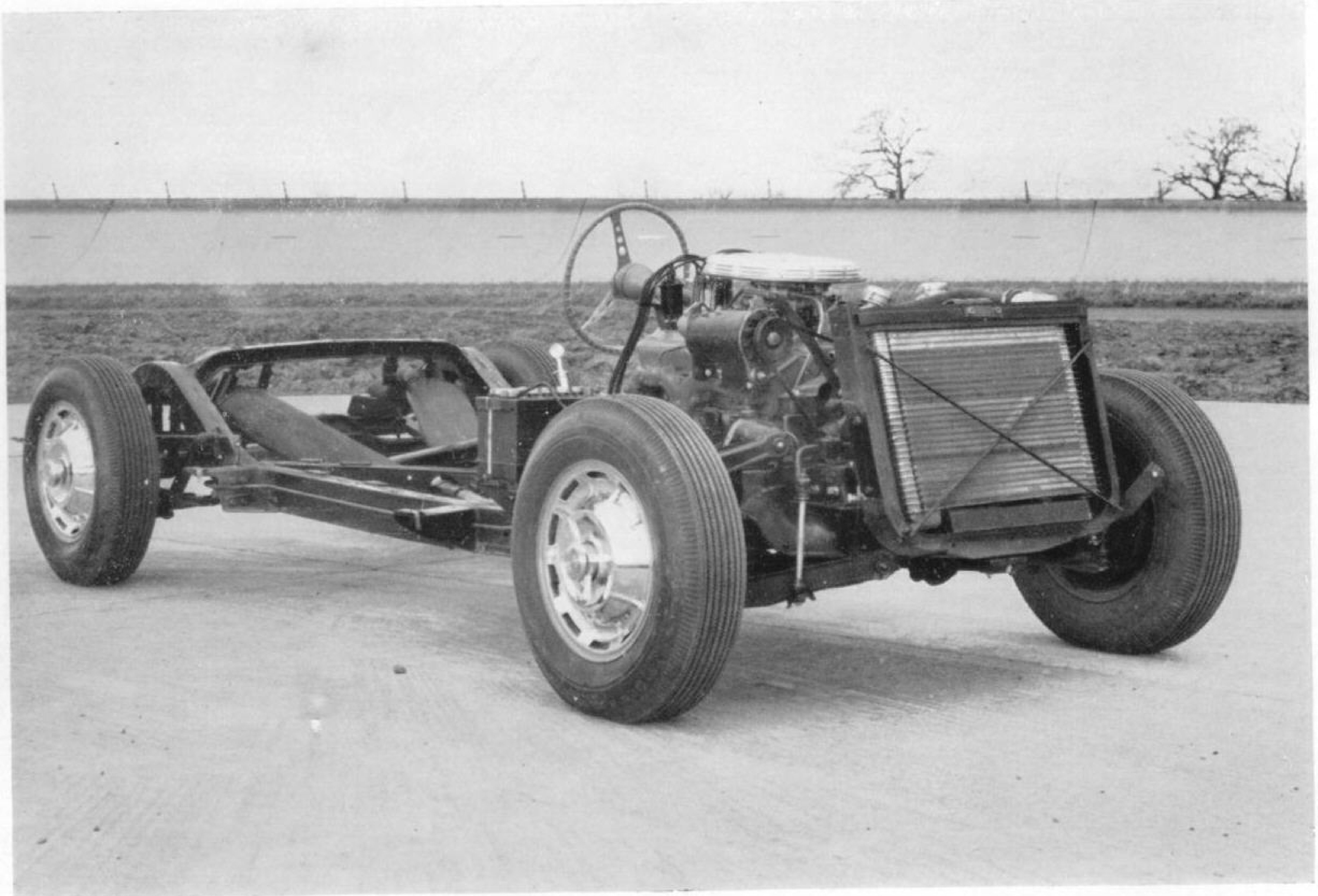

Fig. 10. Vehicle with body removed.

Two " U " section struts ran forward from the cruciform to join the longitudinal members rearward of a bolted-on front suspension cross-member. Two integral " top hat " section transverse stiffeners, one across the kick-up and one at the rear of the frame, together with four body support outriggers on the longitudinal members, completed the chassis structure. The body was bolted to the chassis through rubber insulators.

Details of the chassis specification, as quoted by the makers, are as follows:—

Suspension, Front	Independent, using unequal length wishbones and coil springs surrounding Delco telescopic dampers, with a torsional anti-roll bar.
Suspension, Rear	Two longitudinal semi-elliptic springs, two radius rods forward of a rigid axle casing and a torsional anti-roll bar with two inclined Delco telescopic dampers.
Dampers ...	Two Delco No. 5552796 front, two Delco No. 5554593 rear, all double-acting hydraulic with nitrogen bags and 1·0 in. dia. pistons.
Steering	Recirculating ball worm and nut steering gear with 16·0:1 ratio; overall ratio 21·1:1.
Brakes, Foot ...	Moraine four-drum 11·0 in. dia. hydraulic, duo-servo front and rear, with sintered-iron linings.
	Primary shoe 6 pads, secondary shoe 10 pads, all 0·875 in. wide × 2 in. long (identical shoes front and rear), 112 sq. in. total lining area.
Brakes, Auxiliary	Rear wheels, cable operation of the service brake shoes from a twist-to-release T-handle.
Wheels	Steel disc, five-point fixing by studs and nuts. Spare wheel held horizontally in a well in the luggage compartment floor.
Tyres	American made U.S. Royal Super Safety 8 low profile 4-ply tubeless, 7·3/6·70 × 15.

ELECTRICAL

Battery	Delco-Remy No. 458, 12 V., 54 plate, 53 A.-hr., mounted in engine compartment behind the right wheel arch.
Generator ...	Delco-Remy 1102043, OJ2.
Regulator ...	Delco-Remy 1119001D, with cut-out relay, current and voltage regulators.

Starter Motor ...	Delco-Remy 1107889, OL2, with solenoid 1119910.
Ignition Coil ...	Delco-Remy, with 1·8 ohm external ballast resistance.
Sparking Plugs ...	A.C. type 44, 14 mm.
Distributor ...	Delco-Remy, with centrifugal and vacuum advance.
Ignition/Starter Switch	Key-operated four positions, Lock-Off-On-Start (spring-loaded). Key could be withdrawn in all positions except Off and was only required when turning to or from Lock position.
Exterior Lamps...	Four 5·75-in. dia. headlamps, the outer pair being high and low beam, the inner pair high beam only; two 37·5/50 W. and two 37·5 W. Guide sealed beam units respectively. Two side lamps incorporating direction indicators and fitted with 4/32 W. bulbs. Four red stop/tail lamps incorporating direction indicators, fitted with 4/32 W. bulbs. One rear licence plate lamp fitted with a 3 W. bulb.
Dip Switch ...	On left side of toe-board.
Direction Indicators	Flashing type, controlled by a steering column-mounted lever, with steering cancellation.
Horns	Two Delco-Remy, controlled by push button in centre of steering wheel.
Panel Lamps ...	Five instrument panel lamps, rheostat controlled by road lamp switch, fitted with 2 W. bulbs and one clock-illuminating lamp fitted with 3 W. bulb.
Warning Lamps...	One for headlamp main beam, red, fitted with 1 W. bulb; one for parking brake, red, flashing, fitted with 2 W. bulb; two for direction indicators, green, with 2 W. bulbs.
Interior Lamp ...	One on lower facia above the centre panel, fitted with a 6 W. bulb, operated by rotation of road lamp switch or by door courtesy switches.
Windscreen Wipers	Two-blade, American made Trico, opposed motion with variable speed motor, self-parking, 12-in. blades on 11-in. arms, 14-oz. blade load.
Circuit Protection	Thermal circuit breaker for protection of headlamp circuit. Four fuses mounted in the car interior on the dash panel: 3 A. for instrument panel and clock lamps; 10 A for heater motor; 10 A. for parking brake lamp; 15 A. for stop/tail, licence, and courtesy lamps.

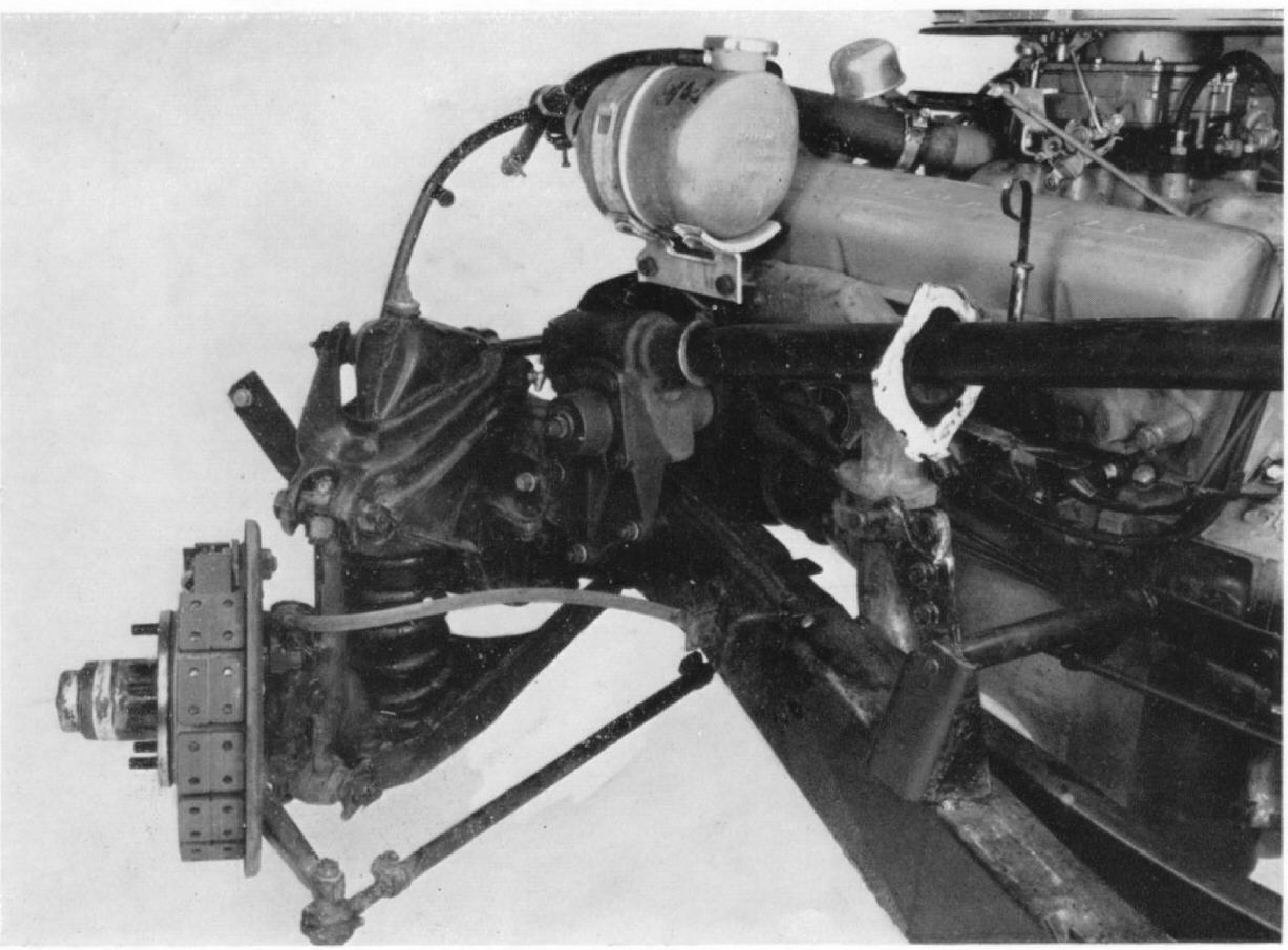

Fig. 11. Detailed view of left front of vehicle.

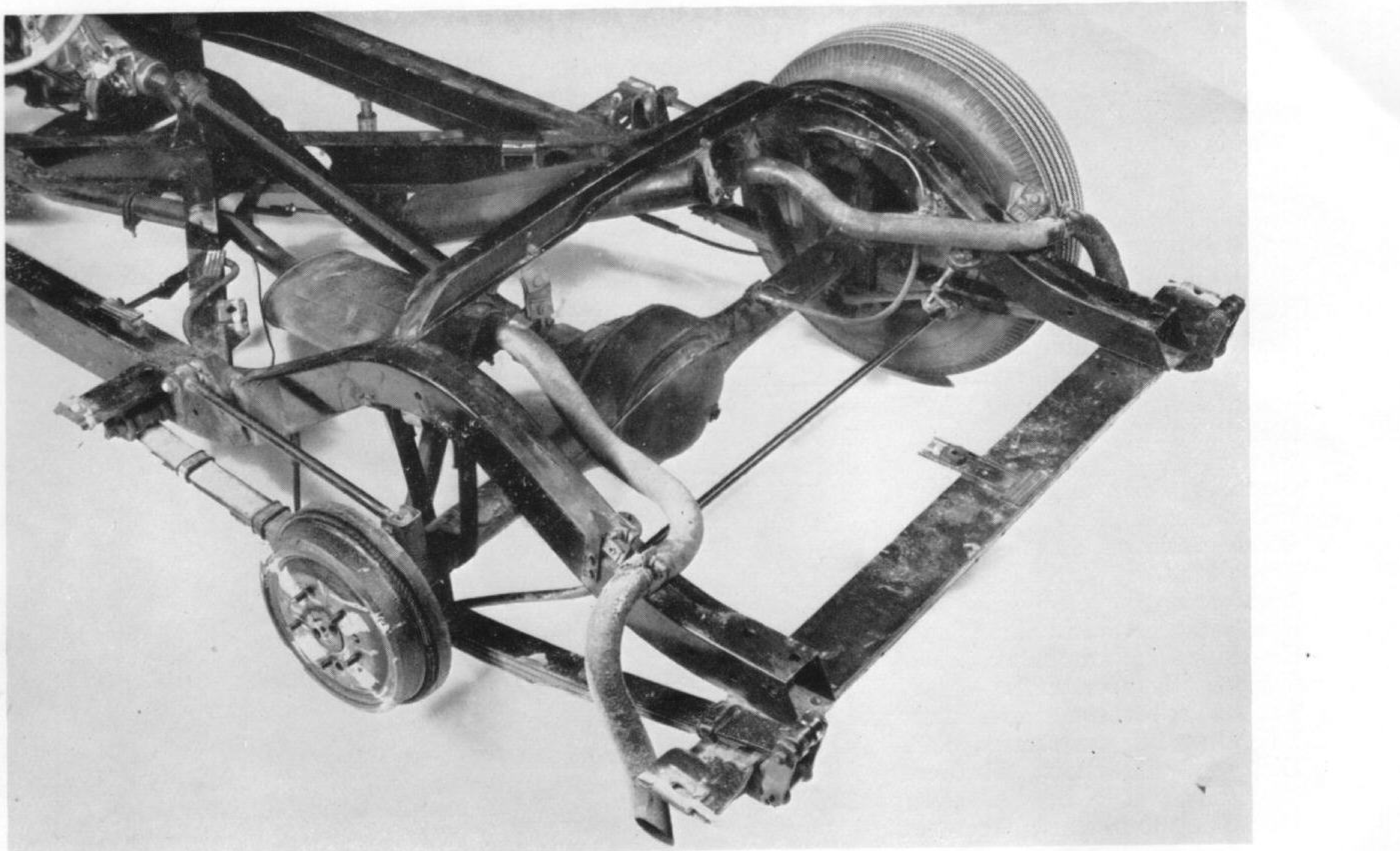

Fig. 12. Rear suspension.

2.2 Equipment

Bumpers, Front...	Three-piece with wrap-round ends, attached to structure and body at four points.
Bumpers, Rear ...	Two separate pieces with wrap-round ends, attached to structure and body at six points.
Jacking Points ...	Front suspension lower control arms and rear axle casing.
Tools and Accessories (see Fig. 15)	One jack and jack handle; one wheel nut spanner with flattened end. One pair of keys, for ignition switch, front doors, luggage compartment and parcel compartment locks.
Sun Visors ...	Two hardboard, padded and covered with plastic, for front use only.
Rear View Mirrors	Two; internal flat, ball-joint-mounted on the centre of the facia top; external flat, ball-joint-mounted on the driver's door.
Instruments ...	Speedometer with semicircular scale 0-160 m.p.h.; six-figure distance recorder in miles and tenths; tachometer with scale 0-70, r.p.m. in 100's; fuel gauge marked with five lines and E, $\frac{1}{2}$, F; temperature gauge with five lines and 100, 180, 220; ammeter with the heading " Battery " and with five lines and figures —30, 0, +30; oil pressure gauge marked with five lines and 0, 30, 60; electric Westclox clock.
Safety Belts ...	Two lap straps, American made Irving Air Chute.
Assist Bar ...	One, padded and covered with plastic, mounted across the front of the glove pocket, for passenger's use.
Locks	Ignition switch, both front doors, luggage compartment cover, parcel compartment, all using same key. Engine compartment cover had a release handle under the left facia.
Parcel Compartment	One, between the seats, with a lockable drop-down lid and painted interior.
Ash Trays ...	One, mounted in the transmission tunnel to the right of the gear lever, fitted with a hinged lid.
Door Reflectors...	Four, two on each door trailing edge, facing directly rearward when doors were fully open.
Heater	Fresh air, hot-water type with thermostatic control of water temperature. Three pull controls for :—two-speed fan, metering the water, air distribution. The air intake was on the right side of the car radiator.

Ventilator ...	Duct from hinged flap ahead of the windscreen, regulated by a lever under the facia to the left of the centre panel.
Windscreen Washer	Push-button vacuum operated, two separate jets just ahead of windscreen base, with American made Trico plastic container and vacuum pump.

2.3 Dimensions, Capacities and Weights

DIMENSIONS

Further information on the methods of obtaining dimensions is contained in the Appendix, Sections I to VII.

External

Length, overall	176·5 in.
Wheelbase	102·2 in.
*Overhang, front (dimension " a ")	31·7 in.
Width, overall	71·1 in.
Width, maximum, doors open ...	135·6 in.
Track, front...	57·1 in.
Track, rear	58·8 in.
Headlamps, between centres, inner	45·5 in.
Headlamps, between centres, outer	57·9 in.
Sidelamps, between centres ...	38·4 in.
Tail lamps, between centres, inner	37·8 in.
Tail lamps, between centres, outer	49·9 in.
Direction indicators, between centres, front	38·4 in.
Direction indicators, between centres, rear, inner	37·8 in.
Direction indicators, between centres, rear, outer	49·9 in.

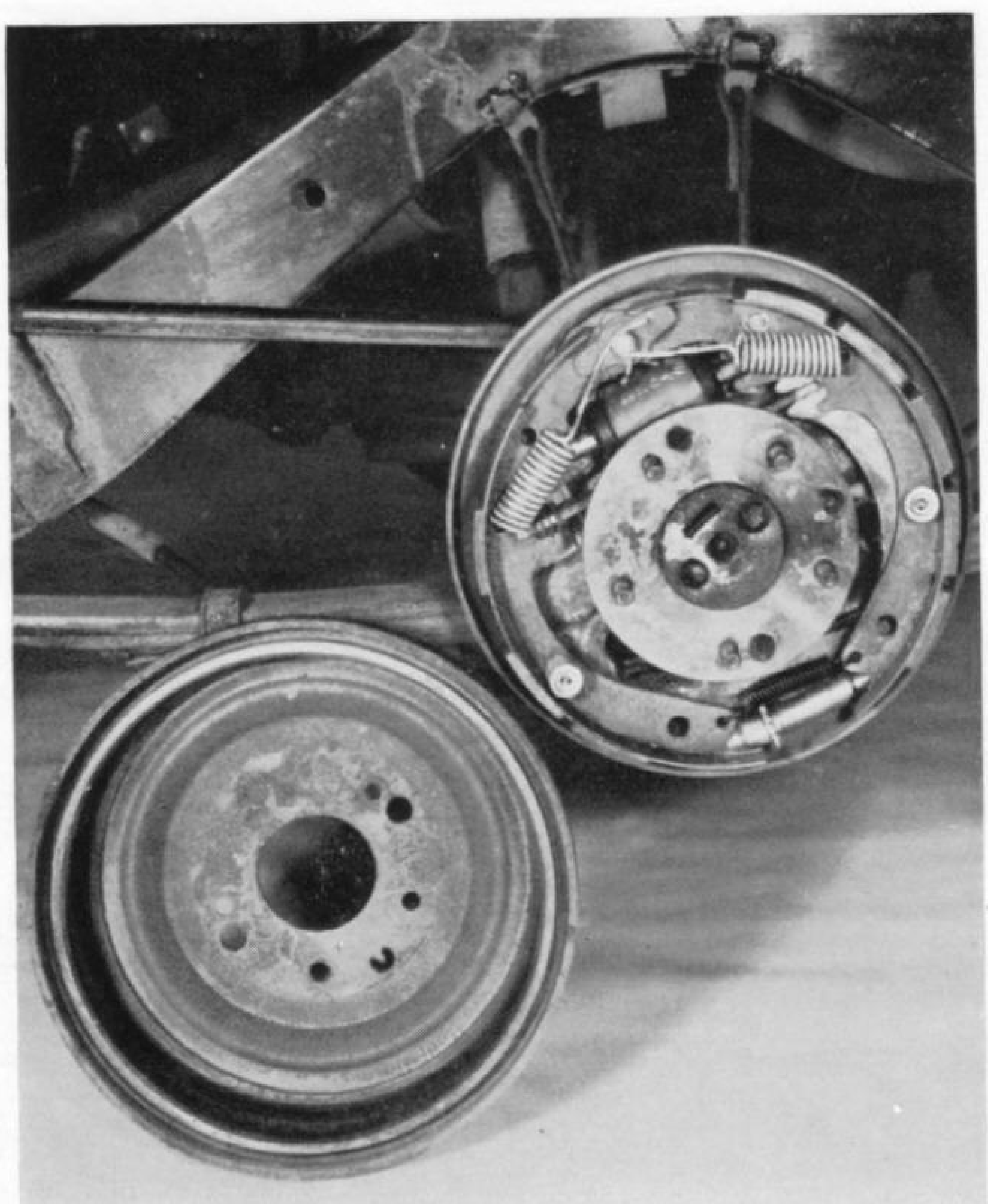

Fig. 14. Left rear brake assembly.

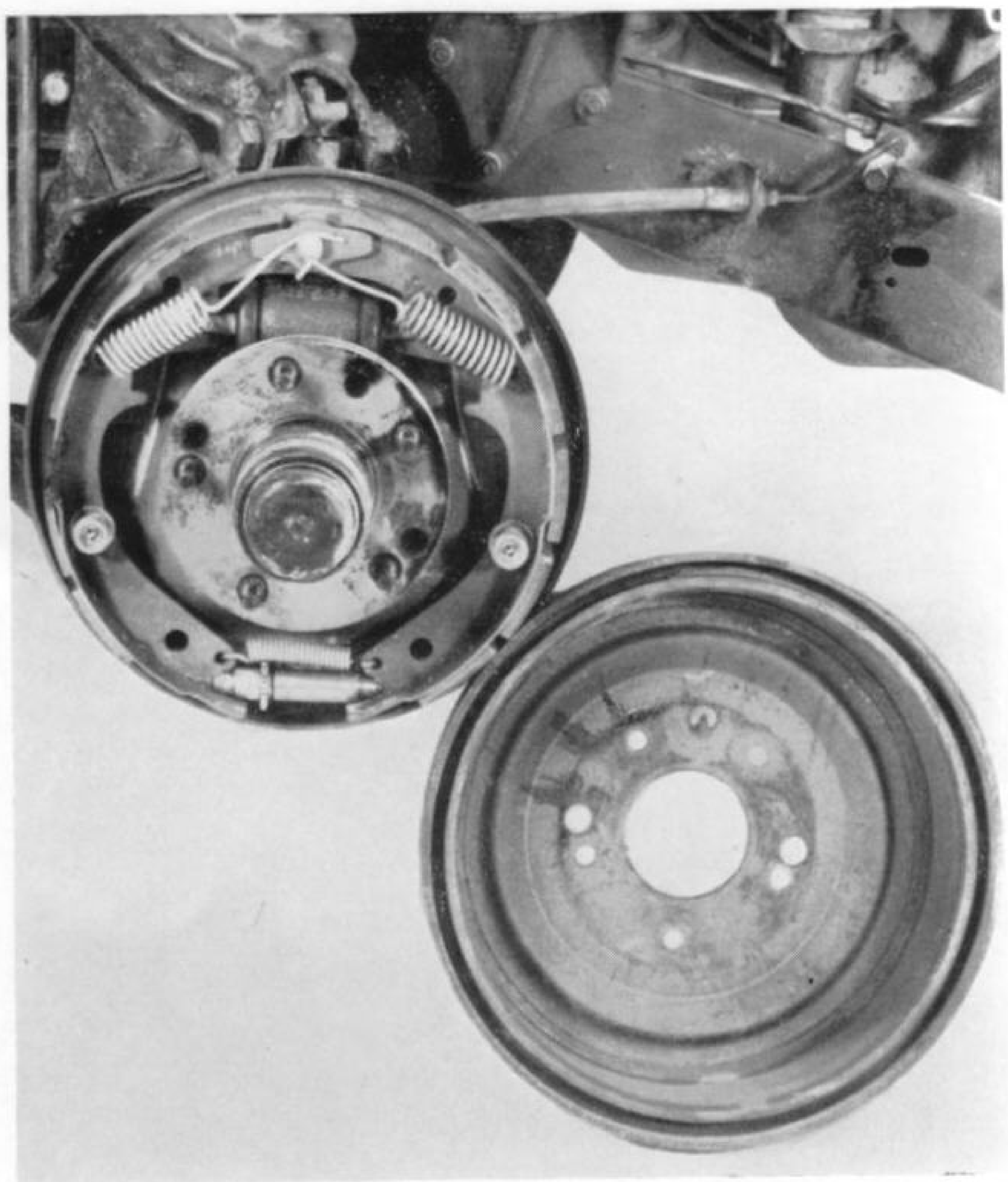

Fig. 13. Left front brake assembly.

Height overall, laden (hood up) ...	52·5 in.
Height overall, unladen (hood up)	53·5 in.
Front bumper to ground, top ...	19·3 in.
Front bumper to ground, bottom...	16·6 in.
Rear bumper to ground, top ...	18·1 in.
Rear bumper to ground, bottom ...	15·4 in.
Front licence-plate protectors to ground, top	17·5 in.
Front licence-plate protectors to ground, bottom	8·6 in.
Rear licence-plate protectors to ground, top	21·5 in.
Rear licence-plate protectors to ground, bottom	13·4 in.
Headlamps, centre height	28·1 in.
Sidelamps, centre height	12·6 in.
Tail lamps, centre height	21·6 in.
Direction indicators, centre height, front	12·6 in.
Direction indicators, centre height, rear	21·6 in.
*Sill to ground, ahead of seat, unladen (dimension " b ")	15·4 in.
Ground clearance, to sump ...	6·5 in.
Ground clearance, to clutch housing	7·7 in.
Ground clearance, to differential housing	7·5 in.
Ground clearance, to exhaust system	6·0 in.
Ground clearance, minimum, to exhaust system	6·0 in.
Ground clearance, minimum, unladen, to steering track rod ends	6·6 in.
Frontal area...	20·6 sq. ft.

Tyre size	7·3/6·70×15
Rolling radius of tyres (at very low speed)	13·1 in.
Turning circle, right lock, between kerbs	434·5 in.
Turning circle, right lock, between walls	459·0 in.
Turning circle, left lock, between kerbs	495·5 in.
Turning circle, left lock, between walls	520·0 in.
*Angle of approach (dimension " c ")	22 deg.
*Angle of departure (dimension " d ")	19 deg.

Internal

*Accelerator to driver's seat back rest (effective leg length) (dimension " e "). Nearest obtainable position to standard of 36·5 in. ...	39·0 in.
Maximum	41·5 in.
Minimum	39·0 in.
Note: There are 6 usable positions on each of the slides of the two separate seats. Dimensions refer to this standard position unless otherwise stated.	
*Height of " A " point (dimension " f ")	4·2 in.
Backrest angle to vertical	25 deg.
*Driver's backrest to steering wheel (dimension " g ")	13·5 in.
*Driver's seat to steering wheel (dimension " h ")	5·1 in.
Screen to rear window, top ...	36·5 in.
Screen to rear window, bottom ...	57·0 in.
Toe board to rear window, maximum	68·5 in.
*Centreline of rear wheels to front of seat backrest (dimension " k ")...	30·5 in.
Width through eye point (hat room)	45·7 in.
Width through shoulder point (shoulder room)	50·5 in.
Width through " A " point (hip room)	58·0 in.
Steering wheel centre to body centreline...	14·2 in.
*Headroom (dimension " l ")	35·0 in.
*Front seat height (dimension " m ")	8·0 in.
Seat length (front to rear), in line with " A " point...	18·6 in.
Seat width (through " A " point)....	20·5 in.
Backrest height (from seat over surface)	22·0 in.
Backrest width (on " A " point level)	19·5 in.
Windscreen, width between pillars	51·5 in.
Windscreen, vertical height ...	14·0 in.
Windscreen, slope to vertical ...	48 deg.
Rear window, width	33·8 in.
Rear window, vertical height ...	8·0 in.
Rear window, slope to vertical ...	45 deg.
Door windows, width	19·5 in.
Door windows, height	12·0 in.
Glove box, opening, width ...	19·5 in.
Glove box, depth	9·8 in.
Rear luggage compartment:	
Width, front	46·2 in.
Width, rear	66·5 in.
Length	37·0 in.
Height, maximum	13·5 in.
Height, minimum	5·7 in.
Steering wheel diameter (o/d) ...	17·0 in.
Driving mirror, width	8·0 in.
Driving mirror, height	2·2 in.
Exterior mirror, diameter	4·4 in.

STEERING GEOMETRY

Maker's Recommendations

Toe-in	0 to 0·125 in.
Camber	0 deg.±0·5 deg.
Caster	+2 deg.±0·5 deg.

Vehicle as Received

Toe-in	—0·06 in.
Camber, left side	+0·42 deg.
Camber, right side	—0·17 deg.
Caster, left side	+0·75 deg.
Caster, right side	+0·75 deg.
Kingpin inclination, left side ...	4·00 deg.
Kingpin inclination, right side ...	4·58 deg.

CAPACITIES

Fuel tank (no reserve)	13·8 Imp. gal.
Crankcase (total including filter) ...	9·0 pt.
Gearbox	2·0 pt.
Rear axle	3·5 pt.
Cooling and heating system complete	28·0 pt.
Radiator and engine	26·8 pt.
Radiator	5·8 pt.
Windscreen washer	3·0 pt.

WEIGHTS

Vehicle kerb, with full petrol tank, total	2,965 lb.
Vehicle kerb, with full petrol tank, front axle...	1,610 lb.
Vehicle kerb, with full petrol tank, rear axle	1,355 lb.
Vehicle loaded, total	3,415 lb.
Vehicle loaded, front axle	1,671 lb.
Vehicle loaded, rear axle	1,744 lb.
Engine, dry, with ancillaries, clutch and clutch housing	578 lb.
Gearbox, dry, with extension ...	87 lb.
Crown wheel, pinion and differential assembly	67 lb.
Radiator	12 lb.
Body less engine and luggage compartment lids	706 lb.
Engine compartment lid	23 lb.
Luggage compartment lid	21 lb.
Chassis frame	260 lb.
Front suspension cross-member ...	56 lb.
Windscreen and frame	36 lb.
Instrument panel and instruments	16 lb.
Seats (2)	64 lb.
Road wheel and tyre	40 lb.
Petrol tank	12 lb.

2.4 External Appearance

The general appearance of the vehicle is shown in Figs. 1 to 5. The car was finished in blue acrylic lacquer, and it

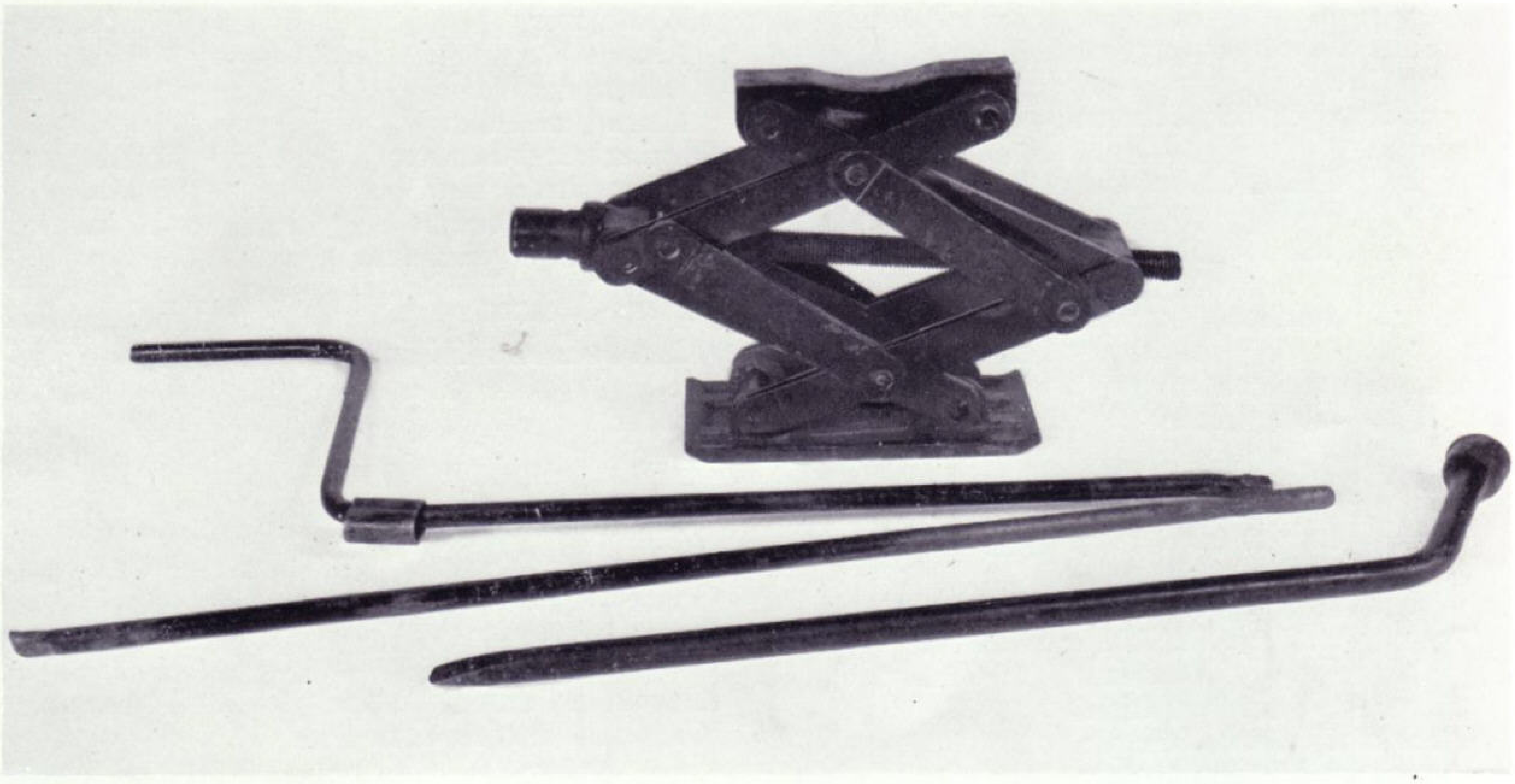

Fig. 15. Tool kit.

Fig. 16. Driver's access.

was not immediately obvious that the body was constructed in resin-bonded glass fibre until it was viewed along the length of its sides. The slight waviness then apparent showed that the body contours were inferior to those of good quality metal construction. The body was smoothly shaped with few flat areas and the only sharp corners were at the rear. The engine and luggage compartment covers were stiffened externally with two longitudinal ribs in the former and one in the latter; moulded reinforcements were also provided inside the covers.

The radiator grille carried a central horizontal bar in line with the corner bumpers, and the overriders were incorporated into a separate licence plate frame. Wrap-round corner bumpers and a licence plate surround incorporating overriders were also used at the rear. The grille was flanked by blanked-off air inlets, whilst the outlets behind the front wheel arches were also dummies. Behind these " outlets," the panel areas of the wings and doors, enclosed by a bright trim strip, were concave. Between the wheel arches and the " outlets " the name " Corvette " was emblazoned on plated castings. " Corvette " in stylised capitals was also spaced across the area above the radiator grille, over-topped by a crossed-flags emblem incorporating a red Chevrolet badge and a black and white chequered flag. The luggage compartment cover carried a large circular perspex panel incorporating the words " Chevrolet Corvette " surrounding the crossed-flags emblem, the whole having a plated rim and being protected internally by an aluminium dome. A device of similar pattern was inscribed in black in the centres of the dummy knock-off hubs incorporated in the pierced road wheel nave plates.

There were twin headlamps within blue-painted surrounds, and the front sidelights were deeply inset within plated surrounds, carried low down and well in from the vehicle side; they could not easily be seen from the side. The four red rear lamps had individual chrome plated surrounds, and their lenses were again inset so that they could not be seen from the side.

Push buttons were incorporated in the exterior door handles, and both doors had key-operated locks. The driver's door carried a circular mirror, ball-joint mounted on a chrome plated pillar. The black soft top was made of plastic coated canvas, and the Vinylite AS 6 rear window was stuck in position. After the release of four clamps, the top could be swung down out of sight and completely enclosed. With some difficulty, the windscreen assembly could be completely removed from the car. The glass was laminated, Libby-Owens-Ford Safety Plate AS 1 YU, 0·25 in. thick. The door windows were of the same make and thickness, but were laminated AS 2 YU material.

2.5 Internal Appearance

The internal appointments of the vehicle are shown in Figs. 7, 16 and 17, and supplementary information is given in the following paragraphs.

The instrument nacelles, the side panels forward of the doors, the glove box cover and soft top stowage compartment cover were blue-painted resin-bonded glass fibre

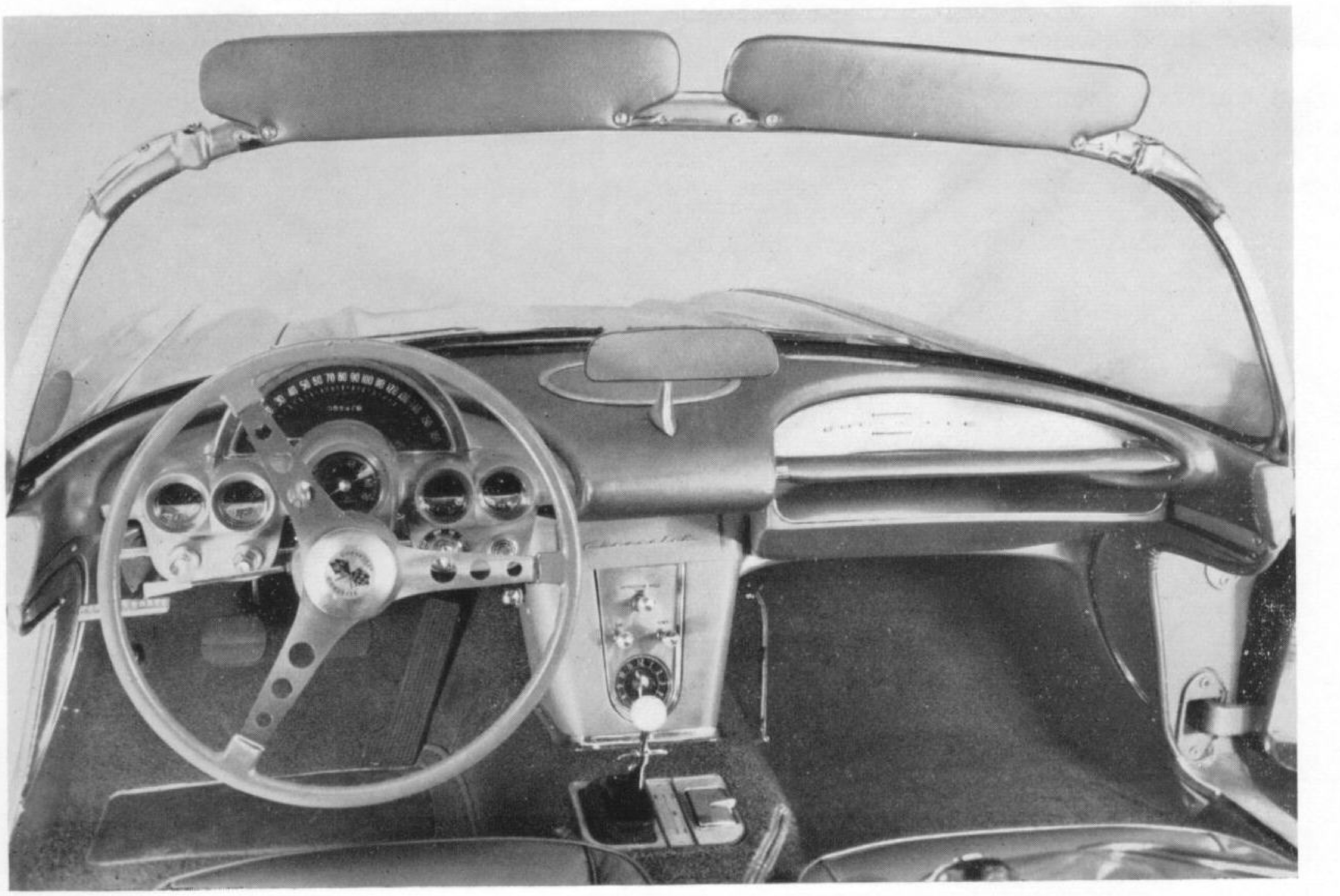

Fig. 17. Facia panel and controls.

mouldings. The floor and transmission tunnel were covered in rubber-backed blue carpeting, and the seats were upholstered in blue plastic, with the same material covering the top and front of the facia. The door trim panels and arm rests employed blue plastic, the panels also carrying patterned aluminium trims, and carpeted strips along their bases. Two red reflectors were mounted towards the trailing edges of each door, angled so that they faced towards the rear when the door was fully open.

A grille for use with a radio was mounted in the top of the facia, forward of the pillar supporting the internal mirror. Each instrument was separately recessed into the panel as seen in Figs. 16 and 17; the speedometer housing projected well above the rest of the facia, whilst the engine speed indicator was mounted above the steering column, closer to the driver than the rest of the instruments. The rim of the steering wheel was covered in plastic, with finger grips on the forward side; the three polished metal spokes each had three holes, whilst the chrome plated medallion at the centre formed the horn push. The right side of the facia was recessed and covered by an aluminium strip bearing the name " Corvette "; below was an angled parcel shelf, whilst a padded steel grab rail was bolted across the arc of the recess.

Further storage space was provided by a box with a lockable glass fibre lid, positioned between the backs of the two seats. Immediately above was the tongue of the lid of the soft-top compartment, with a press-button catch mounted on it. The fuel tank was strapped to the base of this compartment.

The heater controls were carried on a glass fibre plinth joining the centre of the facia to the gearbox cover. The short gear change lever projected through this cover, matched on the right side by a lidded ash tray.

The doors carried fixed front window pillars, and the framed windows dropped flush with the sills with 3·3 turns of the regulators.

The engine and luggage compartment covers were internally reinforced in glass fibre. The spare wheel was carried within a shaped recess in the base of the luggage compartment, the floor of which was covered by a blue rubber mat.

SECTION 3
PERFORMANCE DATA

All the testing described in this section of the report was carried out at M.I.R.A., with the exception of a one-day run on the public roads. The proving ground is approximately 320 ft. above mean sea level. Throughout the tests, the cold tyre pressures were maintained at 36 lb. per sq. in. at the front and rear. Premium grade fuel was used and the engine lubricating oil was of SAE 10W/30 viscosity, as recommended.

The methods used during these tests are presented in the Appendix.

3.1 Speedometer Calibration (Appendix VIII)

The results of the speedometer test are seen in Fig. 18 and calibration of the tachometer showed no significant error.

3.2 Distance Recorder Calibration (Appendix IX)

At 20 m.p.h., the instrument readings were 3·6% high.
At 40 m.p.h., the instrument readings were 3·1% high.
At 60 m.p.h., the instrument readings were 3·0% high.

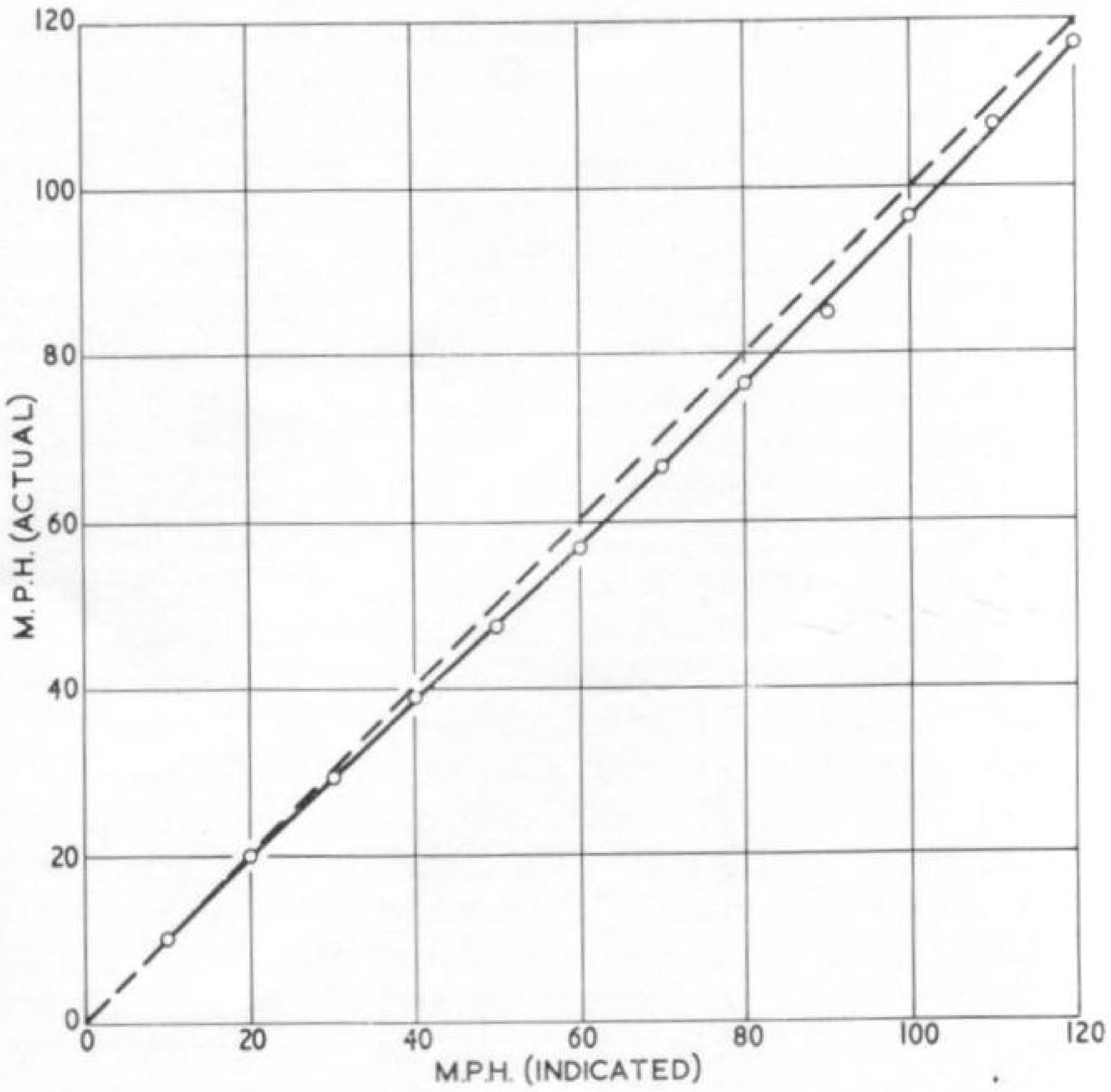

Fig. 18. Speedometer calibration.

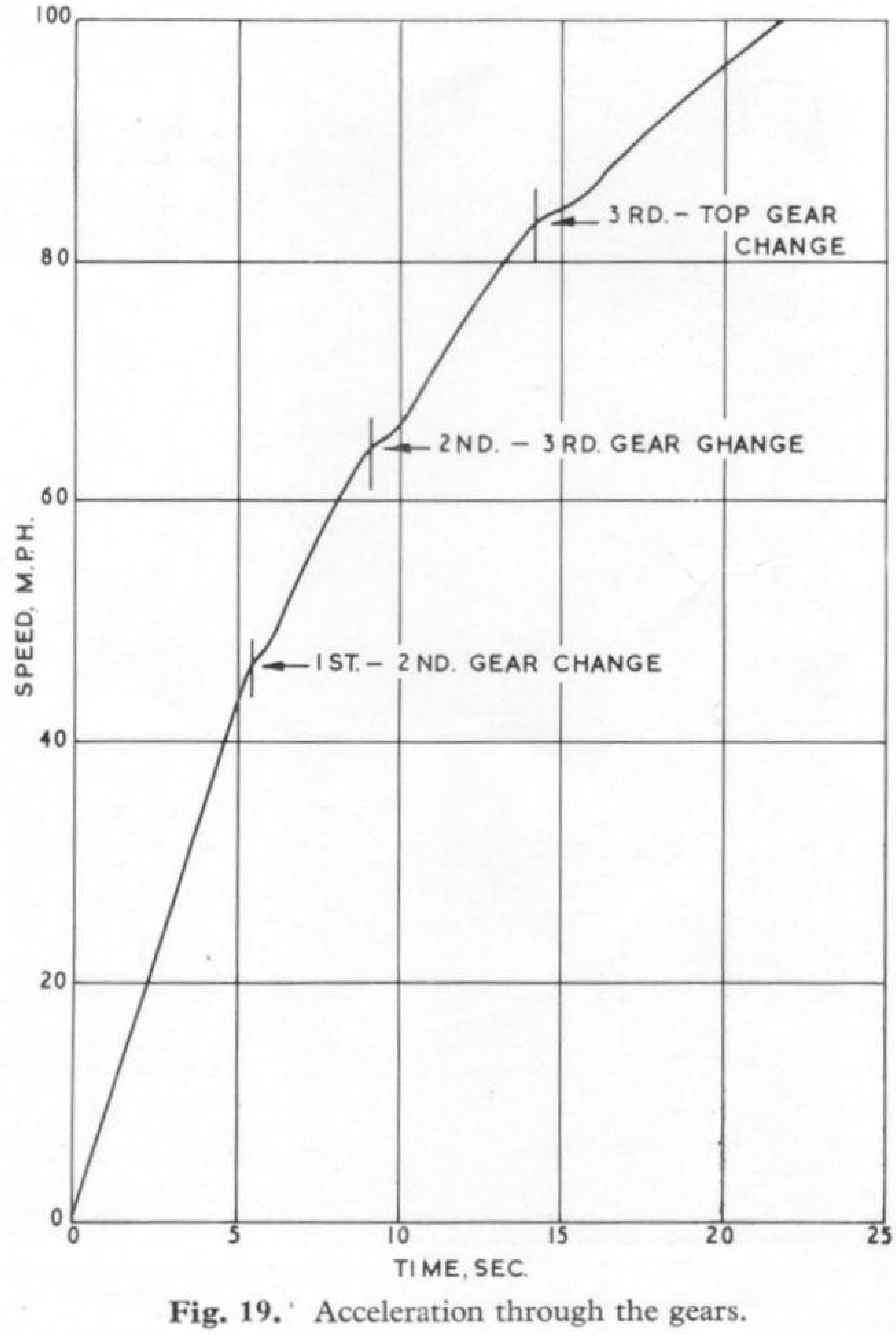

Fig. 19. Acceleration through the gears.

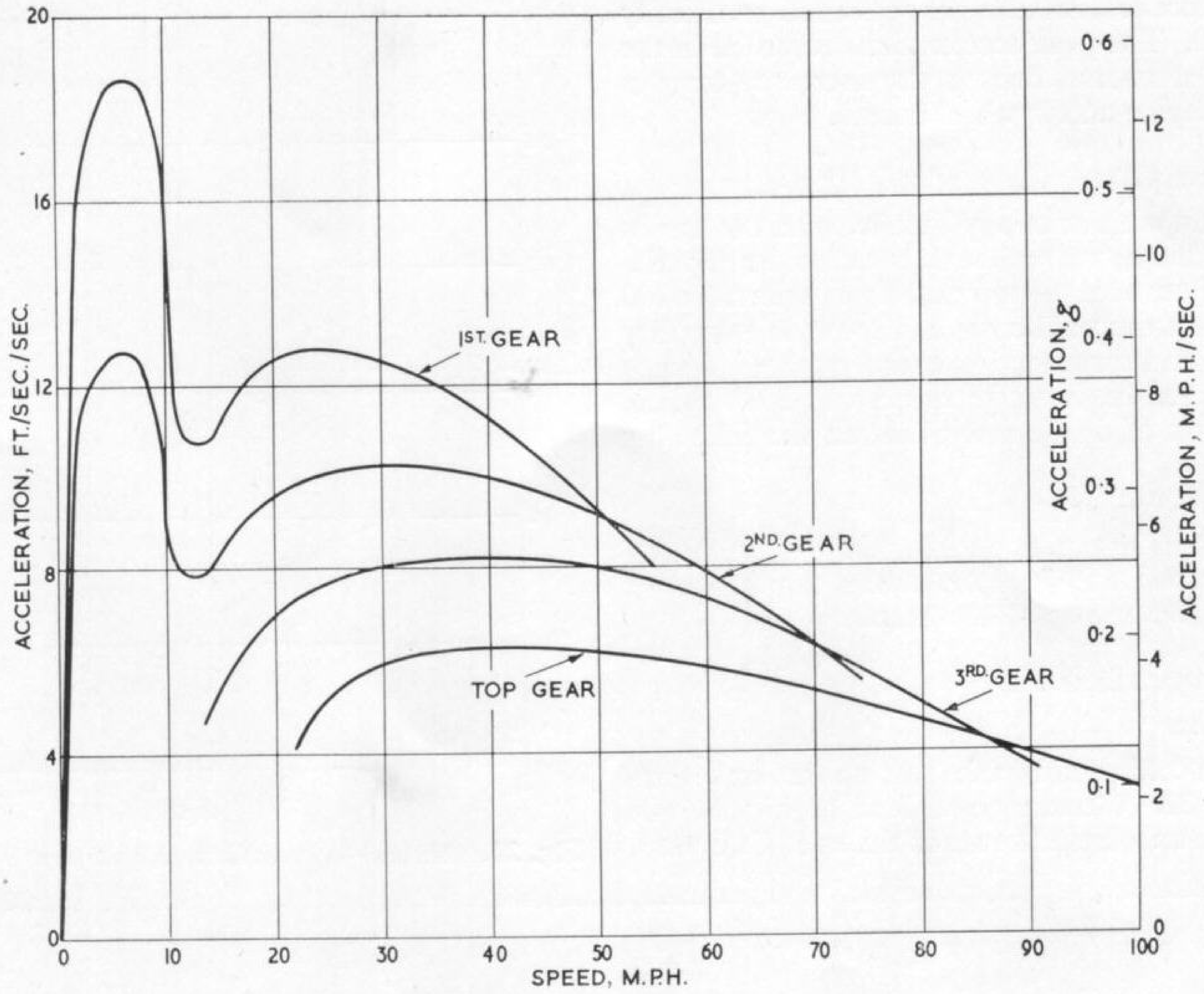

Fig. 20. Acceleration in the gears.

3.3 Maximum Speed (Appendix X)

The maximum lap speed was 115 m.p.h. It should be noted that this figure is above the neutral speed of the High Speed Circuit and that, due to a tendency for the car to climb the banking, it was unsafe to maintain full throttle at all times. Acceleration after leaving the bankings was delayed by fuel surge.

The car was electronically timed at 125 m.p.h. on one of the straights of the circuit.

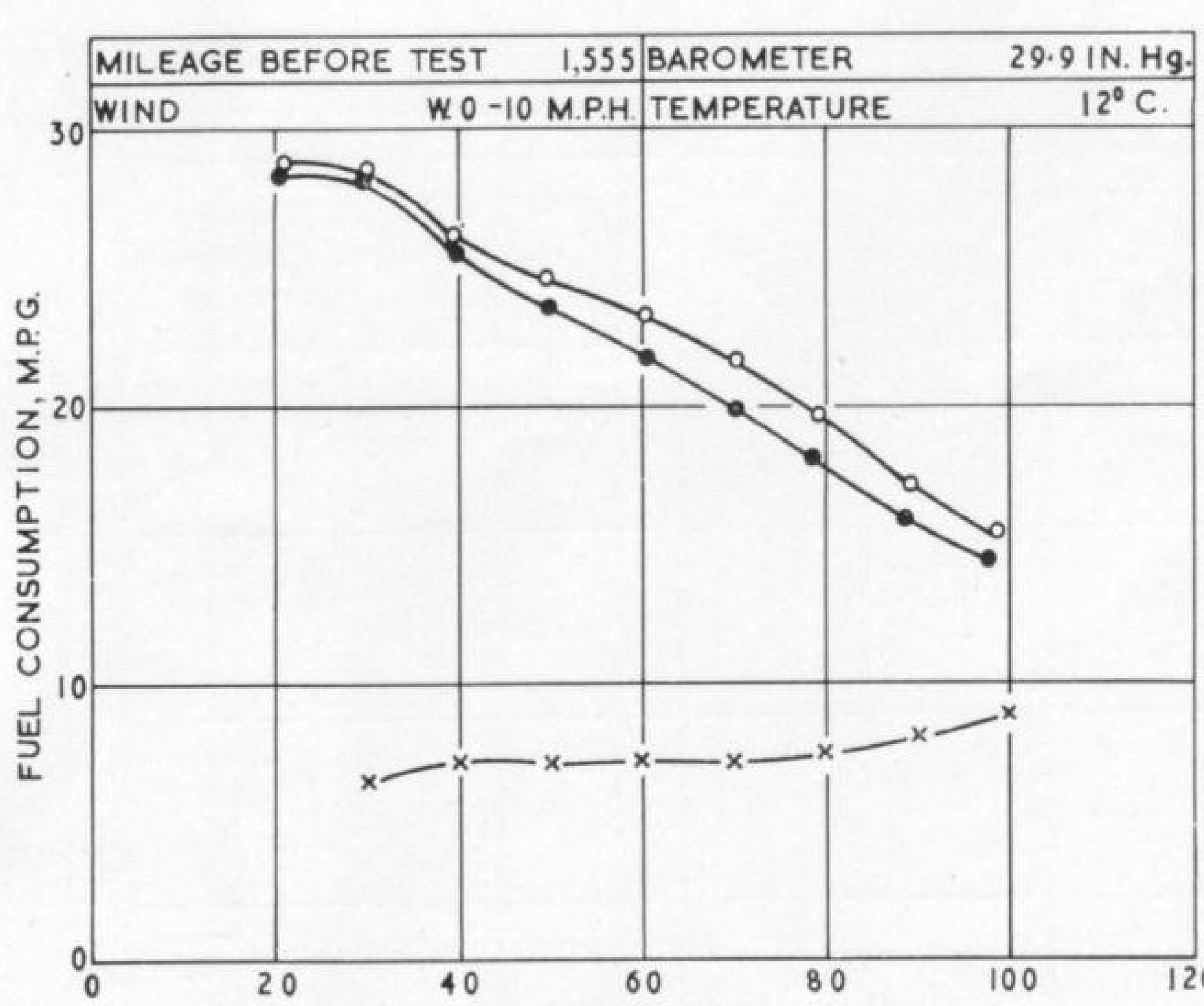

Fig. 21. Fuel consumption in top gear.

x—x—x Full throttle (maximum consumption).
o—o—o Part throttle, soft top up (minimum consumption).
•—•—• Part throttle, soft top down (minimum consumption).

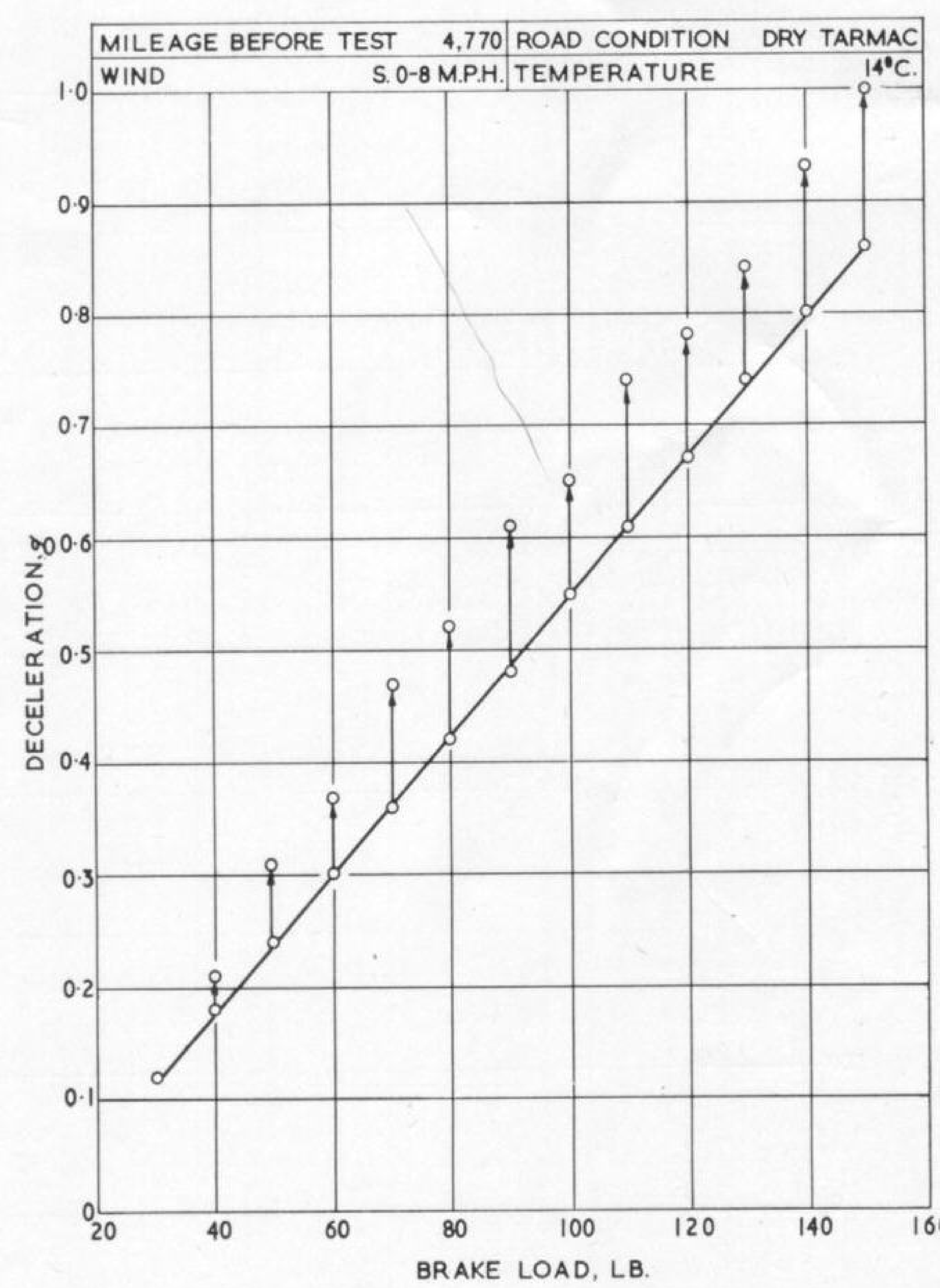

Fig. 22. Brakes—Cold performance. All stops from 30 m.p.h.

3.4 Acceleration (Appendix XI)

The results of acceleration tests are presented graphically in Figs. 19 and 20. The peak accelerations recorded in the lower gears are, of course, due to the increased torques obtainable from engine and flywheel inertia.

3.5 Fuel Consumption (Appendix XII)

The fuel consumption at steady speeds, with the top in the raised and folded down positions, is shown in Fig. 21.

In addition, the car with the top raised was driven for 180 miles in one day on the public roads, the roads being dry throughout. The fuel consumption over the whole journey was 18·6 m.p.g. and the average speed was 32·8 m.p.h. Analysis of sections of the journey showed the following average figures:—

Towns: 18·8 m.p.g. at 17·0 m.p.h.
Hilly roads: 16·5 m.p.g. at 34·8 m.p.h.
Heavy traffic roads: 19·7 m.p.g. at 31·3 m.p.h.
Open roads: 18·5 m.p.g. at 40·8 m.p.h.

3.6 Brakes (Appendix XIII)

(a) Cold Performance

The results of a cold performance test on the brakes are presented in Fig. 22. When a pedal load of 150 lb. was applied, the rear wheels locked towards the end of the stop.

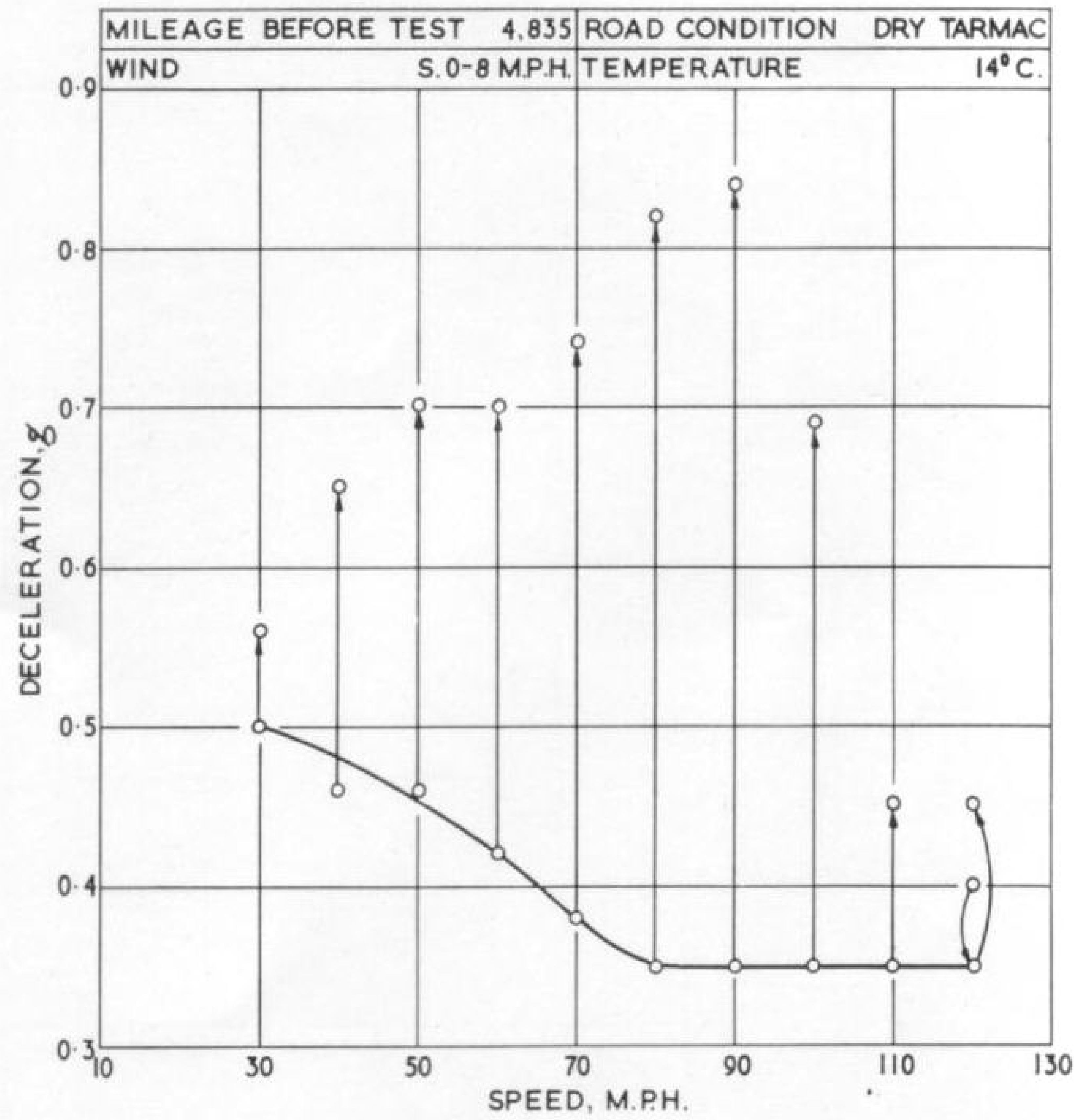

Fig. 23. Brakes—speed effect. All stops at 90 lb. pedal load.

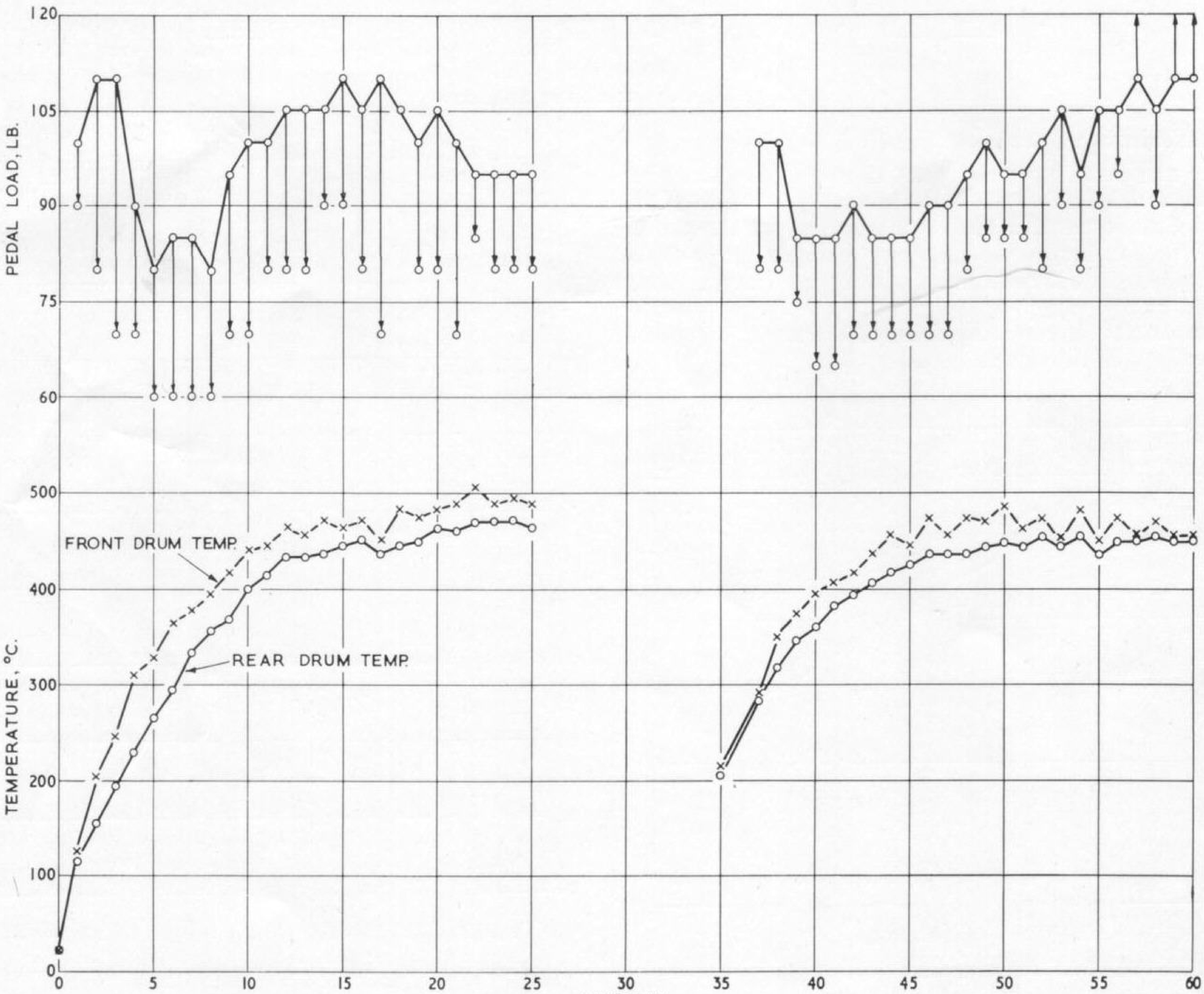

Fig. 24. Brakes—fade. All stops at 0·5 g deceleration from 90 m.p.h. (see text).

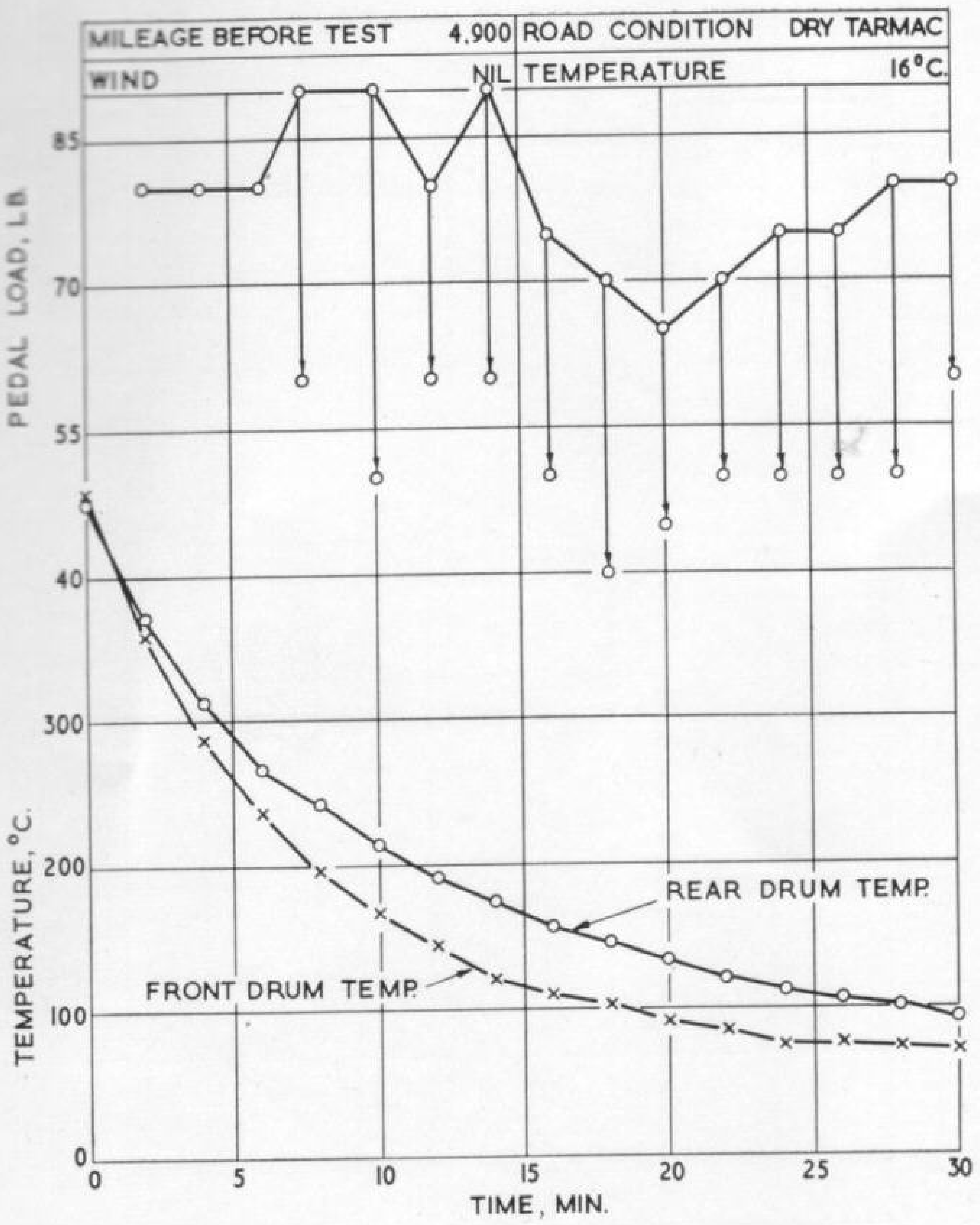

Fig. 25. Brakes—fade recovery. All stops at 0·5 *g* deceleration from 30 m.p.h. (see text).

(b) Brakes—Auxiliary Brake Performance

On this vehicle a T-handle, situated under the left of the facia, operated the rear wheel brakes through cables. It was not possible to lock the wheels from 30 m.p.h. using one hand only, but a very heavy pull with both hands on the handle locked the wheels, giving an initial vehicle deceleration of 0·4 *g* increasing to 0·46 *g* at the end of the stop. The auxiliary brake would hold the car facing up or down a slope of 1 in 3.

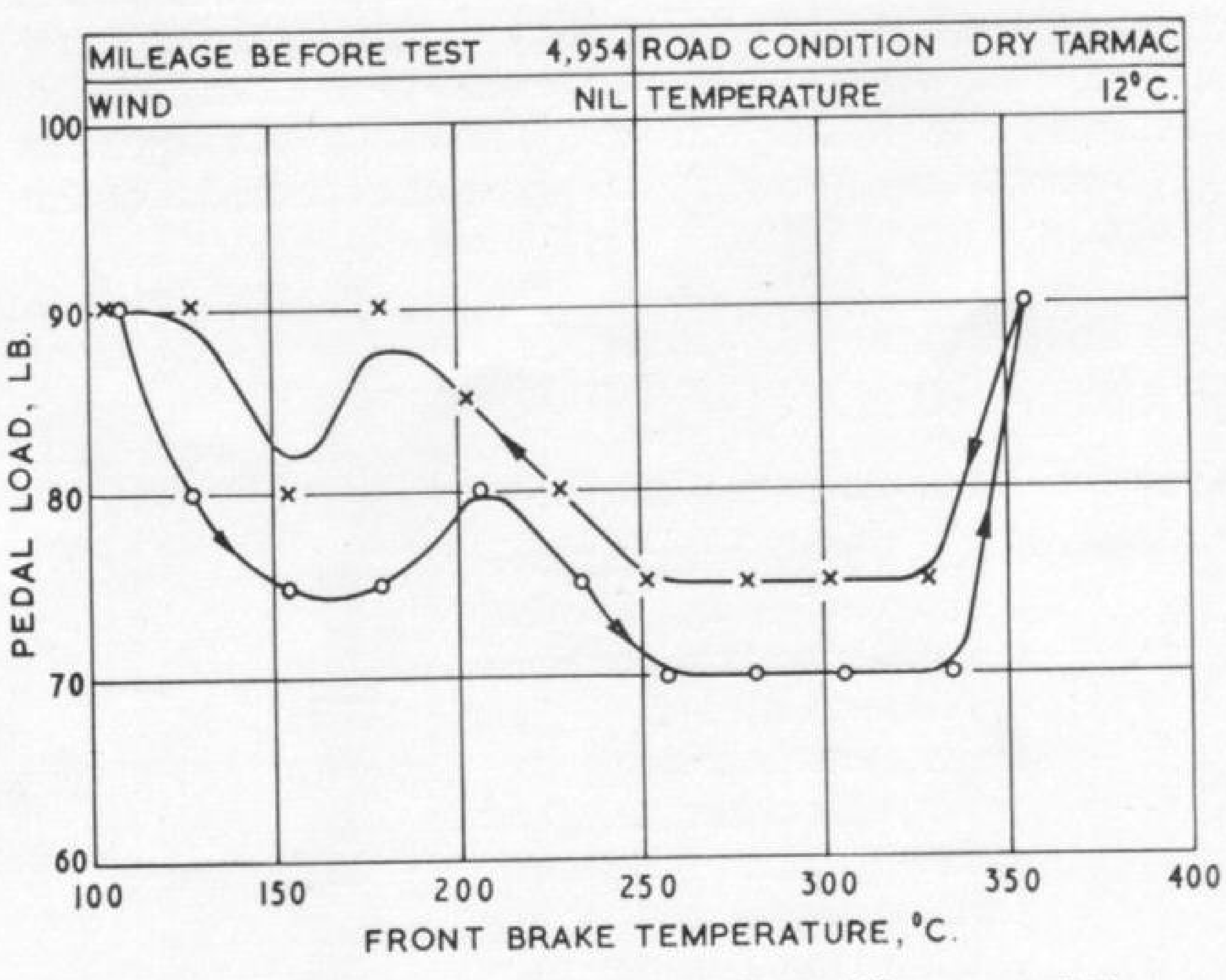

Fig. 26. Brakes—temperature effect. All stops at 0·4 *g* deceleration from 30 m.p.h.

o—o—o Brakes heating.
x—x—x Brakes cooling.

(c) Brakes—Speed Effect

The results of a speed effect test on the brakes are presented in Fig. 23. At speeds up to 100 m.p.h. the deceleration rose sharply during each stop. The deceleration tended to fall off during the last stop, with a recovery at the end.

(d) Brakes—Fade

The results of a brake fade test are presented in Fig. 24. On the first stop after the ten minute cooling interval the pedal reached the floorboards and, even with a further application, no deceleration at all could be obtained. On stops 47, 49 and 50 the pedal again reached the floorboards and an initial deceleration of 0·5 *g* could not be obtained.

(e) Brakes—Fade recovery

The results of the recovery test carried out immediately after the fade test are presented in Fig. 25. On the first five stops the first stroke of the pedal reached the floorboards with no deceleration and a second application was required to obtain a deceleration of 0·5 *g*. Subsequent stops gave no further troubles, and the car pulled up squarely on all stops.

It should be noted that although the manufacturers supply the sintered metallic linings separately, as fitted to this vehicle, extra equipment is available consisting of internally and externally finned drums, vented back plates and air scoops.

(f) Brakes—Temperature Effect

The results of a temperature effect test on the front brakes are presented in Fig. 26. The pedal loads shown in the graph are those initially used for braking; in every case it was necessary to reduce these loads by 15-20 lb. towards the end of the stop, in order to prevent the deceleration from increasing above 0·4 *g*.

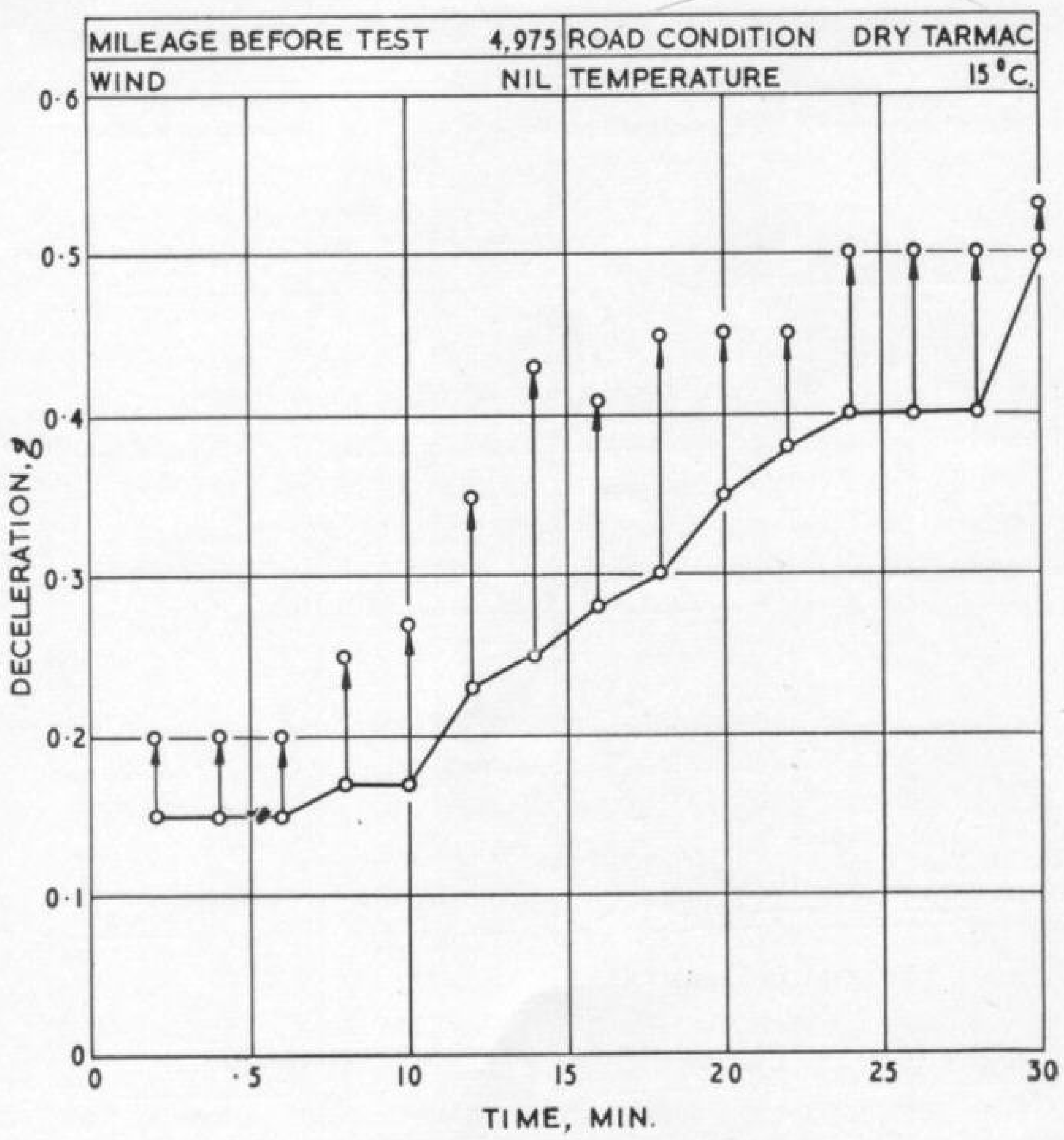

Fig. 27. Brakes—water recovery. All stops at 60 lb. pedal load from 30 m.p.h.

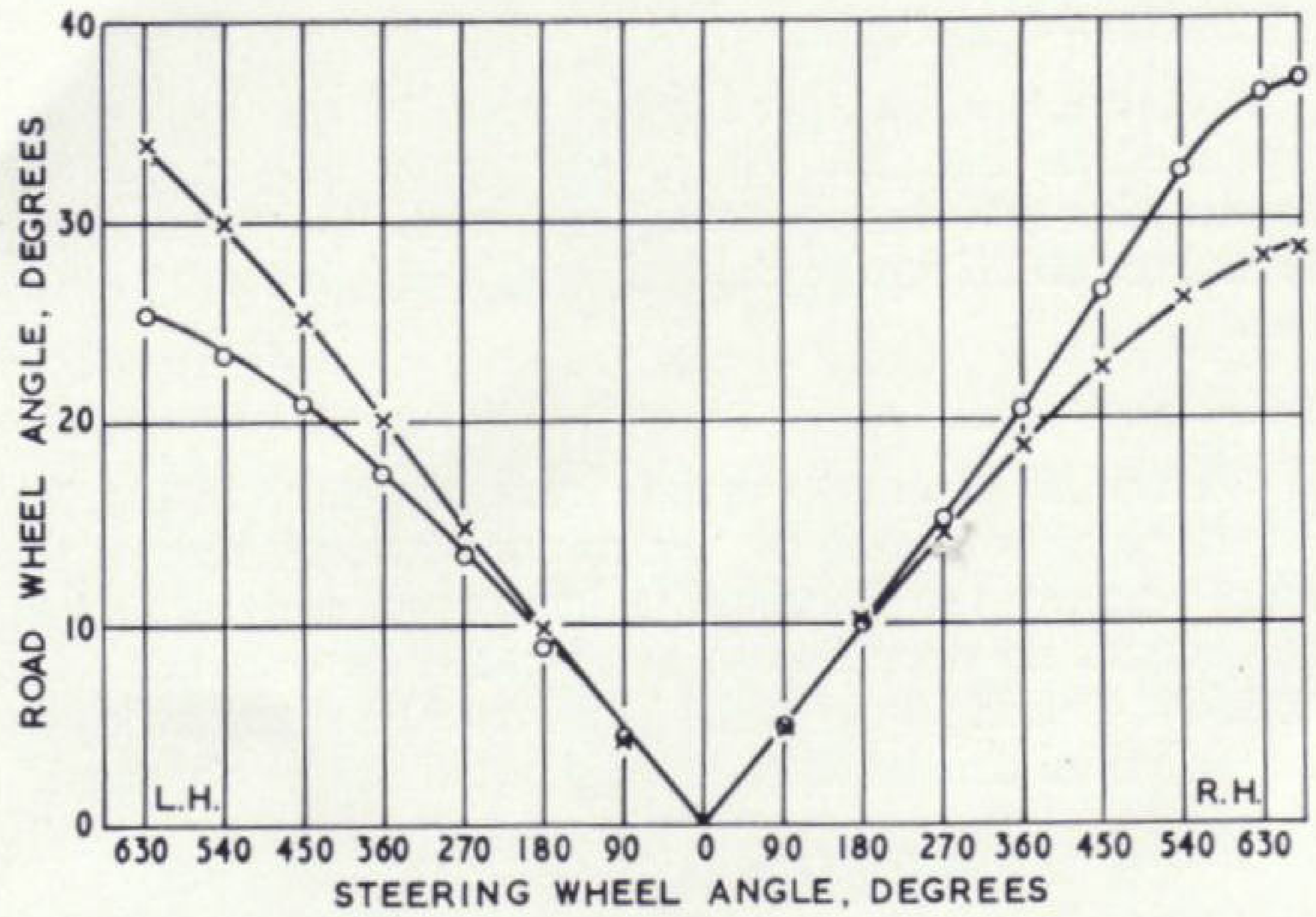

Fig. 28. Steering ratio.
o—o—o Right road wheel.
x—x—x Left road wheel.

(g) Brakes—Water Recovery

The results of a water recovery test on the brakes are presented in Fig. 27. It should be noted that, at the beginning of this test, it was only necessary to apply a pedal load of 60 lb. to obtain a deceleration of 0·5 *g* instead of the 90 lb. originally required. After the 26th and 28th minutes two stops at 0·5 *g* deceleration were completed from 70 m.p.h., and the braking then returned to its original standard.

3.7 **Steering** (Appendix XVI)

Measurements of the steering geometry of the unladen vehicle are included in Section 2.3 of this report. A graph of the steering ratio is shown in Fig. 28 and the static torque in Fig. 29. The results of the steering pad test are

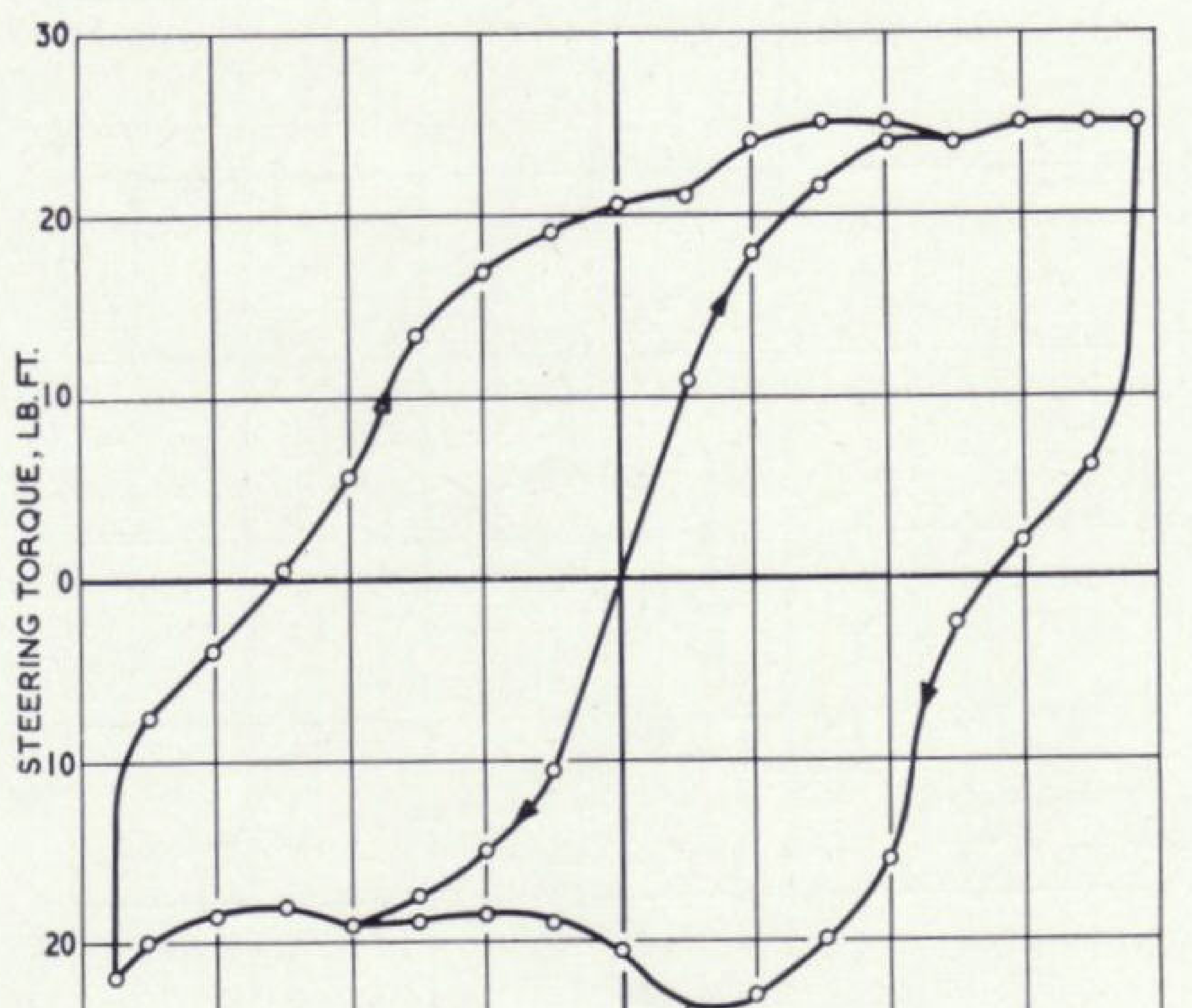

Fig. 29. Steering wheel torque—static.

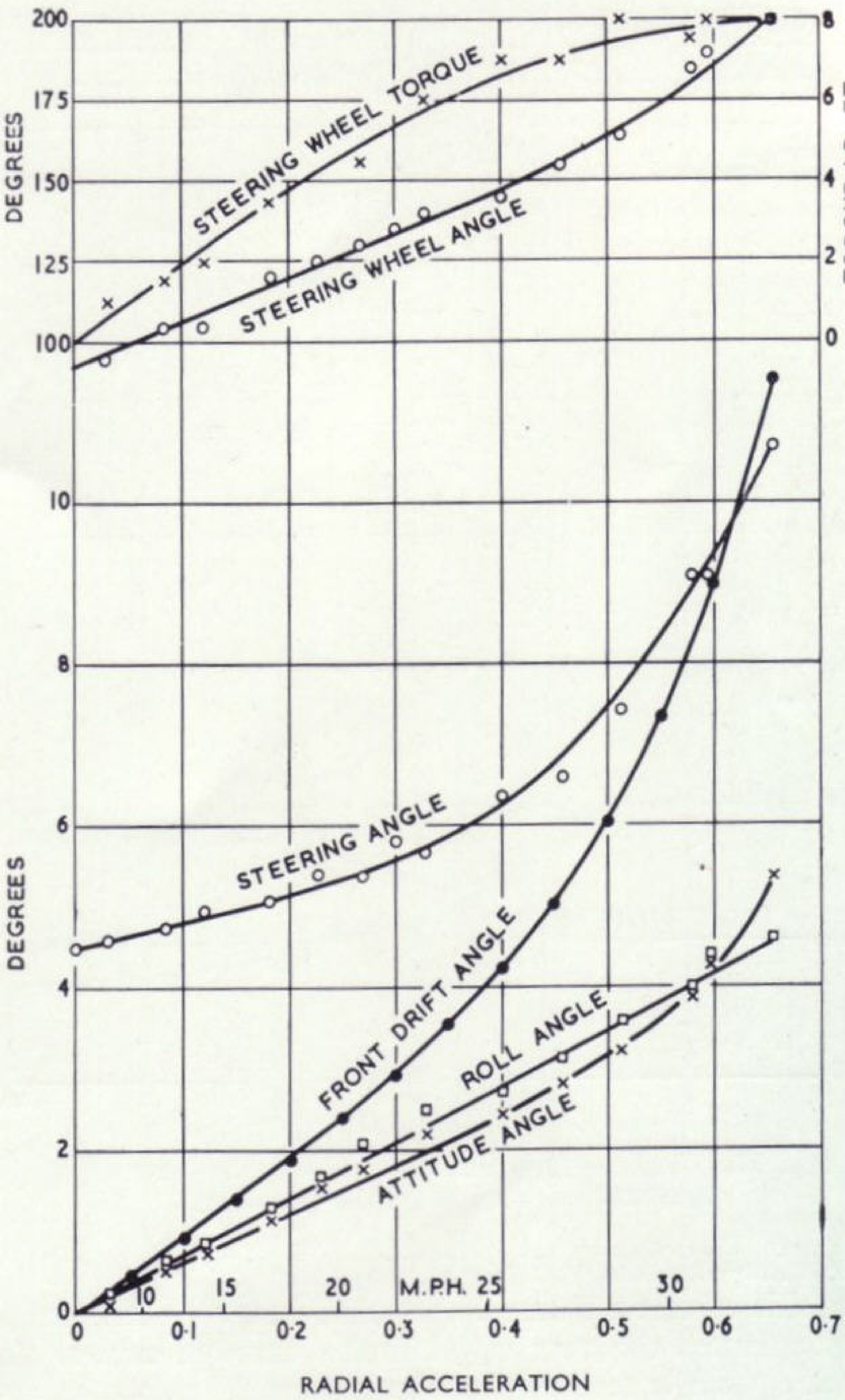

Fig. 30. Steering pad test, 108 ft. radius.

presented in Fig. 30. Fuel surge governed the maximum speed at which readings were attainable on the steering pad. The car was driven along the 5 and 10 deg. cambered straight on the Ride and Handling Circuit, and the measured steering wheel angles and torques were 12 and 22 deg. and 2 and 3 lb.-ft. respectively. The effects of suspension movement on the geometry are given in Section 3.8 of this report.

3.8 **Suspension** (Appendix XVII)

(a) Characteristics

VERTICAL MOVEMENT OF WHEELS:—

Front—from wheels hanging freely (controlled by rebound rubber) to uncompressed rebound rubber ...	1·0 in.
from uncompressed rebound rubber to static height	1·25 in.
from static height to uncompressed bump rubber	3·0 in.
rebound rubber depth ...	1·9 in.
bump rubber depth ...	1·9 in.

Rear—	from wheels hanging freely (controlled by check strap) to static height...	2·25 in.
	from static height to uncompressed bump rubber	3·75 in.
	bump rubber depth ...	1·2 in.
Wheel rate, front ...	... ...	105 lb. per in.
Wheel rate, rear ...	... ...	133 lb. per in.

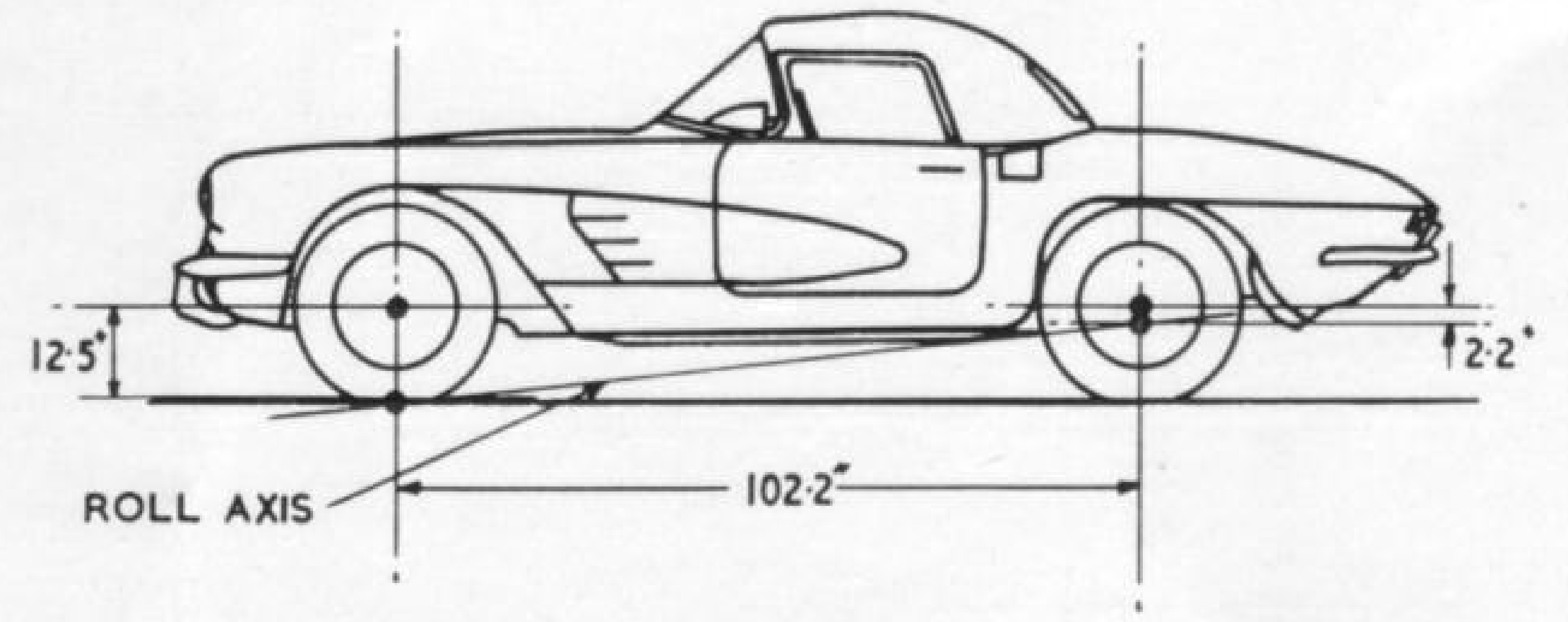

Fig. 31. Diagram of roll axis.

ROLL AXIS (Fig. 31)

Distance below hub centres in the plane of the front hubs ...	12·5 in.
Distance below hub centres in the plane of the rear axle	2·2 in.

CHANGES OF GEOMETRY WITH SUSPENSION MOVEMENT

The changes of geometry which accompanied front wheel travel were measured and the results are presented in Fig. 32.

Typical results of tests on front and rear suspension dampers are presented in Figs. 33 to 36.

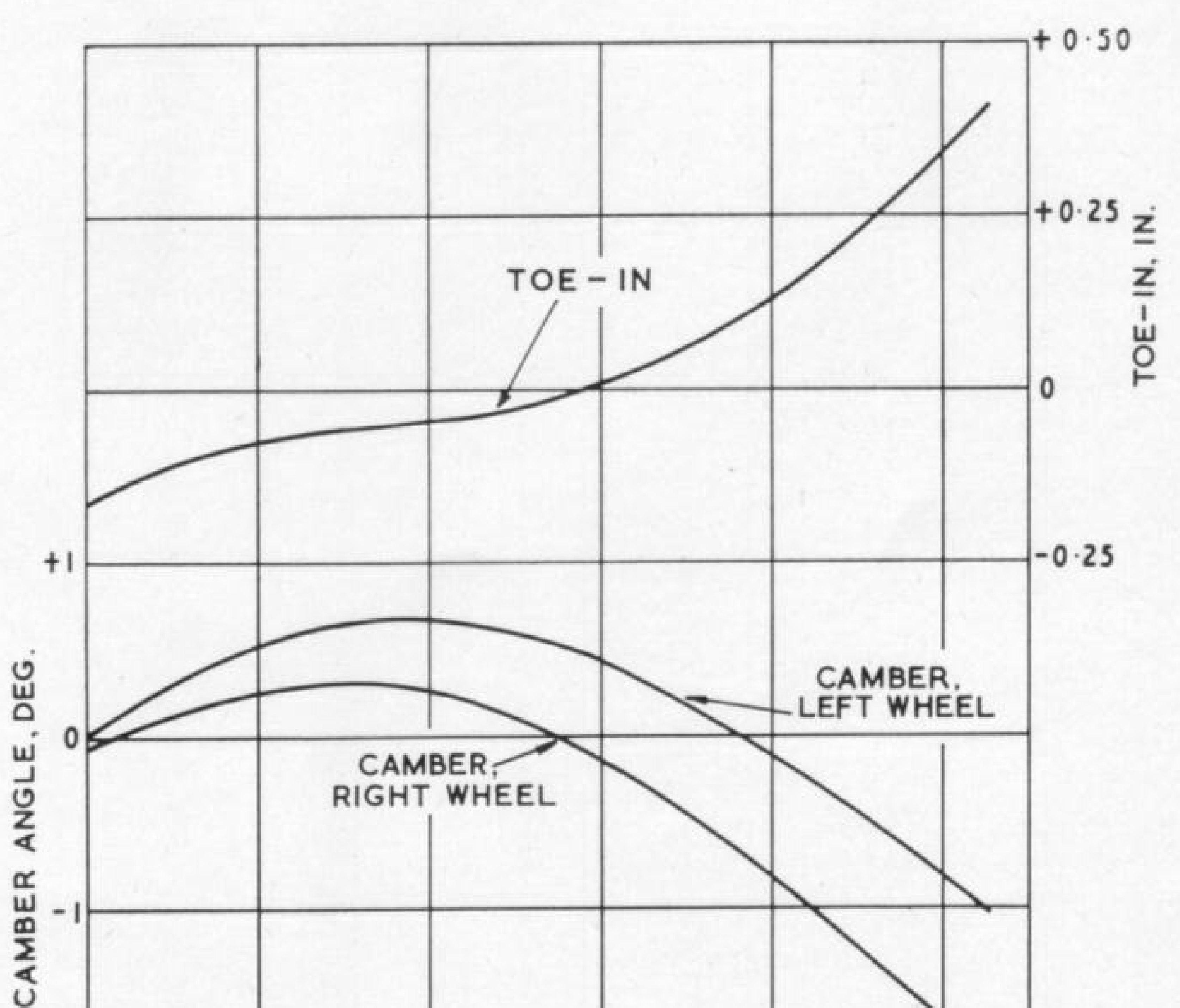

Fig. 32. Changes of steering geometry with wheel displacement—front. The changes shown are per wheel.

(b) Evaluation

LONG WAVE PITCHING

At speeds up to 25 m.p.h., the vehicle followed the contours, but from this speed up to about 33 m.p.h. there was increasing build-up of suspension movement over each successive wave. At 35 m.p.h., the front wheels left the ground after the first crest, and at 40 m.p.h. the rear wheels left the ground after the fourth crest. With further increases in speed the rear wheels left the ground earlier and vertical movement became extremely severe, with the peak at 45 m.p.h. The occupants were only retained in their seats by the safety belts provided and the rear of the car bounced violently on the crest of each wave. Increases in speed brought steady improvement, the front wheels remaining on the ground above 50 m.p.h.; at 57 m.p.h. the ride levelled out after the first wave and the wheels remained in contact with the road surface. At higher speeds up to 70 m.p.h., the highest attempted, the vehicle rode smoothly over all the crests.

SINGLE BUMP

Up to 25 m.p.h., the vertical movement of the vehicle increased until the rear wheels left the ground. A slight increase in speed to 28 m.p.h. had both the front and rear wheels leaving the road surface. At 35 m.p.h., movement at the rear had increased but the damping after landing was good. Further increases in speed up to 70 m.p.h., the highest attempted, improved the ride but all the wheels still left the ground after the bump.

CORRUGATED TRACK

With the corrugations in phase, the vehicle followed the contours at speeds up to 15 m.p.h., when the rear end began to hop. At 20 m.p.h., the rear-end hop was very bad and the steering was affected, but at 23 m.p.h. the rear adhesion was better though the front was moving laterally. There was considerable improvement from 25 m.p.h. upwards, right up to 80 m.p.h., the maximum reached, except for minor body vibration periods at 31 and 62 m.p.h.

With the corrugations out of phase, the car tended to yaw from side to side at 10 m.p.h. Rising speeds brought improvement, but at 17 m.p.h., front-end shake was noticeable. At 20 m.p.h., all wheels were pattering violently and the engine cover was fluttering, whilst at 23 m.p.h. a screw dropped out of the facia and at 25 m.p.h. the body seemed to be twisting across diagonally opposite corners. Further increases in speed brought improvement, but at 29 m.p.h. the doors were moving in their frames, and at 31 and 46 m.p.h. there was some vibration of the steering column. Thereafter, the car rode smoothly at speeds up to 80 m.p.h.

PAVÉ TRACK

At low speeds, the vehicle followed the contours of the surface, but showed some tendency to roll at about 10 m.p.h. Some pitching was noticeable at 17 m.p.h., but further rises in speed brought an improvement in ride until, at 32 m.p.h., there was occasional bottoming through at the rear. From this speed up to 50 m.p.h., the ride was acceptable though not particularly comfortable, and steering control was fully maintained, provided that the surface was dry. In wet conditions, 30 m.p.h. was the maximum speed that could safely be maintained through the S-bend.

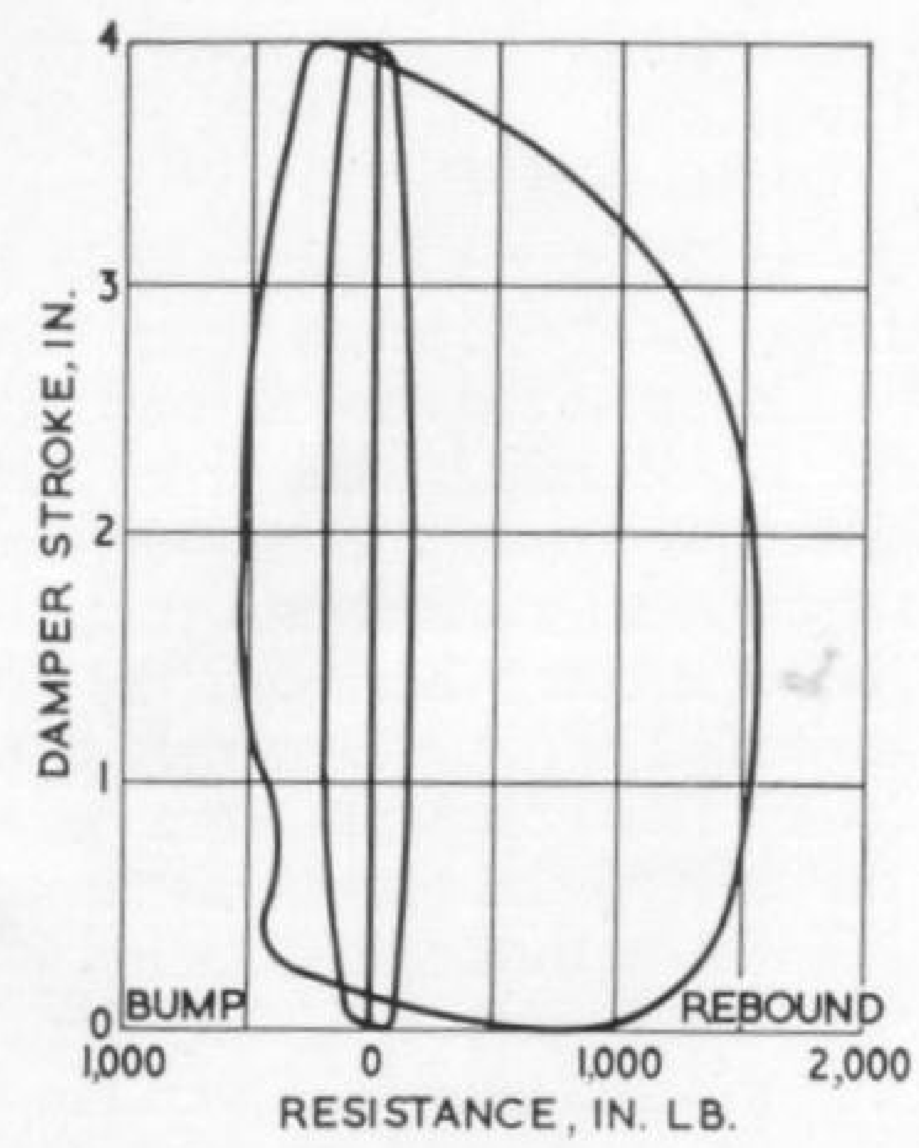

Fig. 33. Front suspension damper. 5 in. torque arm length, ambient temperature.

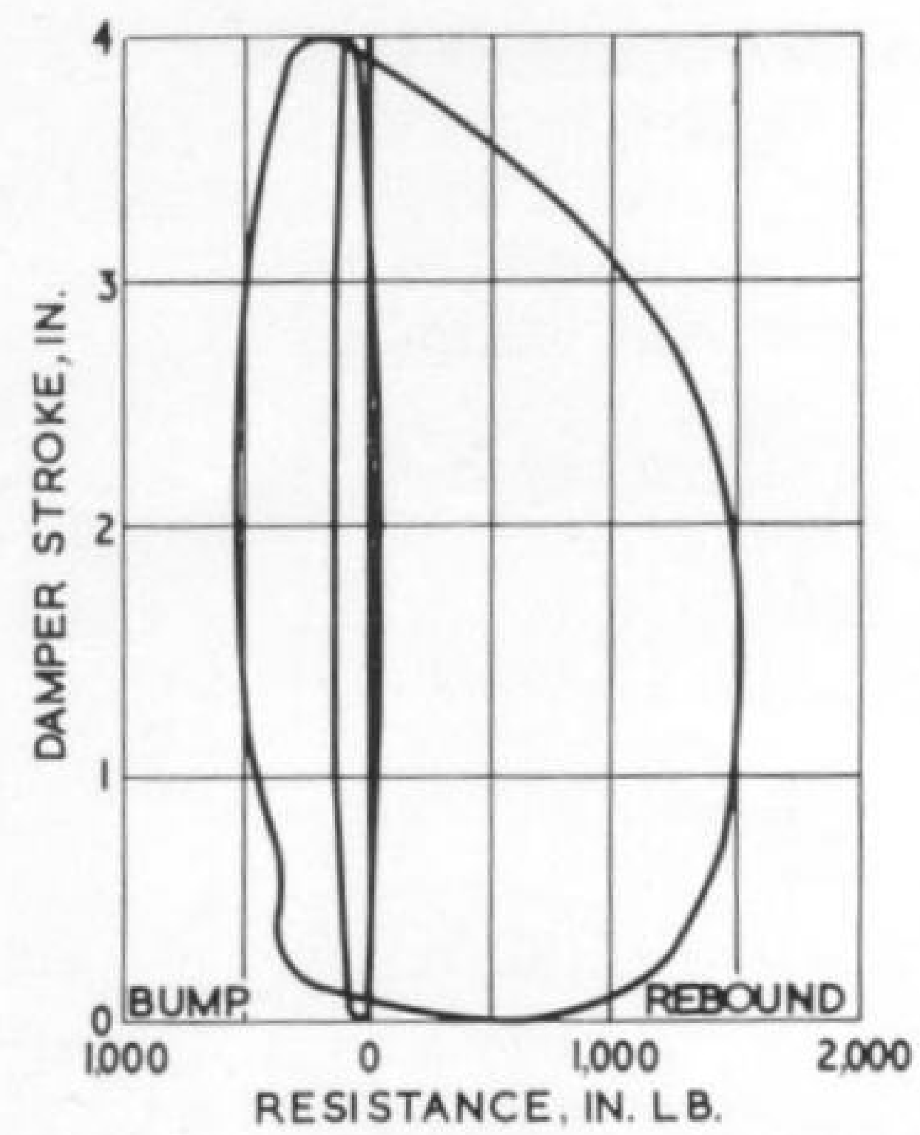

Fig. 34. Front suspension damper. 5 in. torque arm length, 100°C. case temperature.

RIDE AND HANDLING TRACK

At 30 m.p.h., the underfilled trenches, the pot holes and the 1·5-in. deep dip caused noticeable shock, whilst the effects of the tramline and the white lines were such that steering correction was required. At the level crossing and the road intersection, the occupants were flung sharply upwards against the safety belts. The 4 ft. and 5 ft. pitch corrugations, including those on the spiral bend, were all very noticeable. Some deviations from the intended course occurred when running with only one side of the vehicle on the varying wave pitches, but correction was easy.

At 35 m.p.h., there was a general improvement although all the features previously mentioned could still be detected. The 4 ft. pitch corrugations now produced a worse effect than those of any other pitch. At 38 m.p.h., there was a further improvement, except at the 4 ft. and 5 ft. pitch corrugations. At 43 m.p.h., behaviour was still good but the dip between the two slopes, the level crossing and th road intersection were making themselves felt, together wit all the 5 ft. pitch corrugations; the cambered bends wer easily negotiated, but changing sides across the width c the crowned bend required care.

At 47 m.p.h., the curved hill crest caused vagueness i the steering as the weight came off the front suspensio The dip between the slopes led to rear suspension bottomin but caused no steering difficulty. The 6 ft. pitch corrug tions, and those on the bend, were noticeable, whilst t cambered bends and the outside of the crowned ber caused tyre squeal.

52 m.p.h. was the highest speed attempted over t curved crest and around the spiral bend, as the limits control were then reached. This speed was not maintain around the cambered bends or the outside of the crown bend, as the carburation became upset, and the resulti

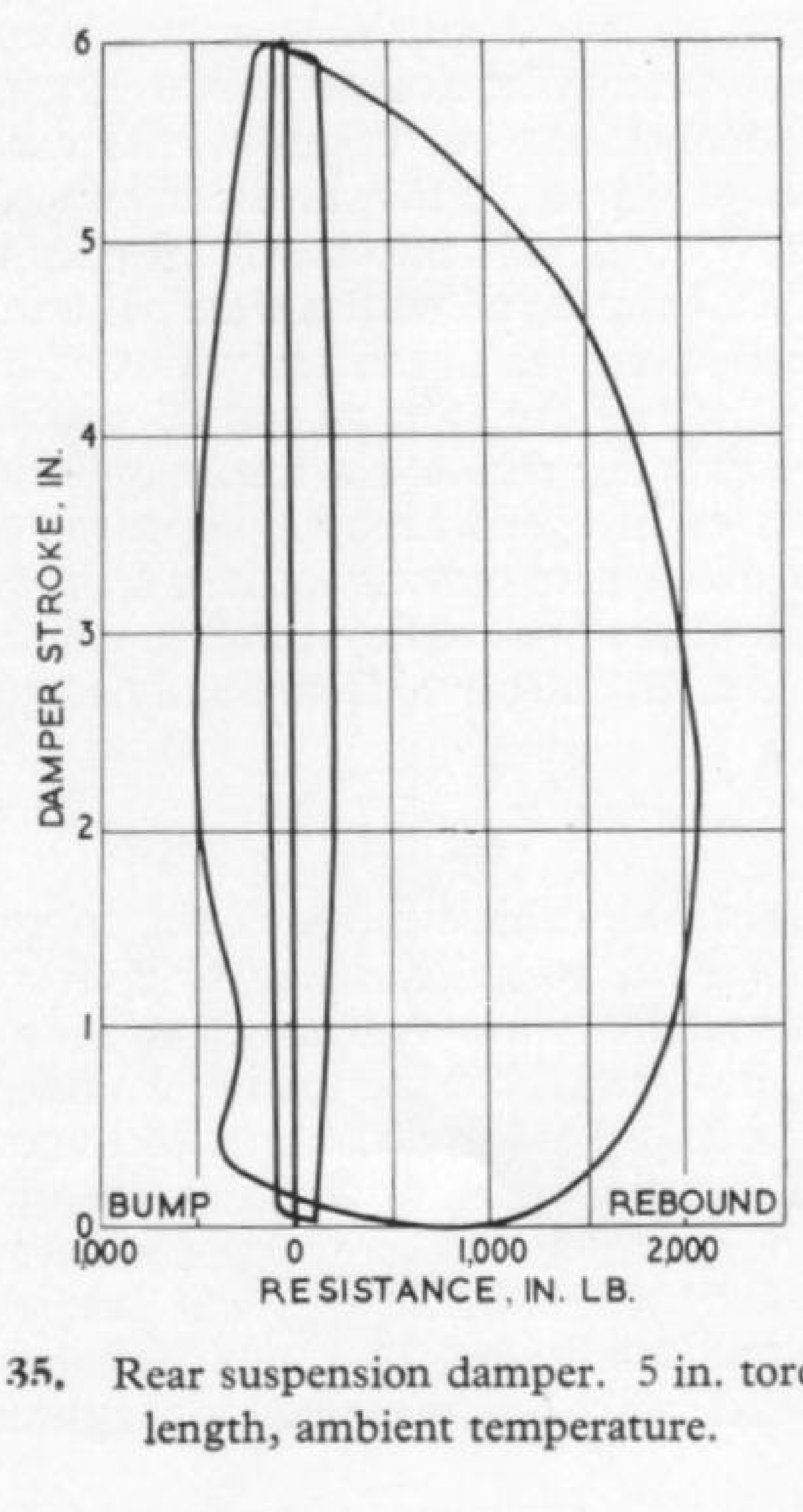

Fig. 35. Rear suspension damper. 5 in. torque arm length, ambient temperature.

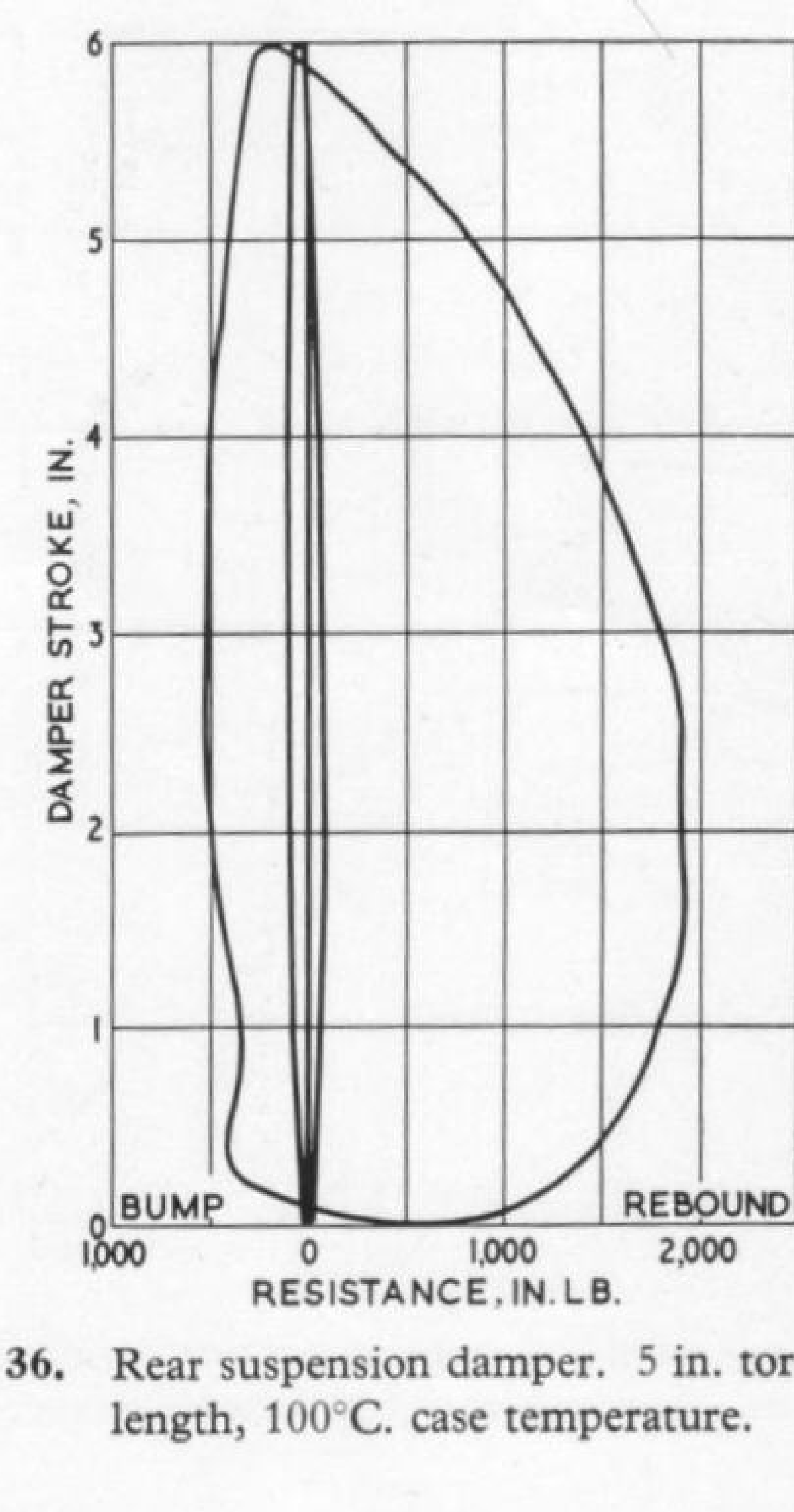

Fig. 36. Rear suspension damper. 5 in. torque arm length, 100°C. case temperature.

irregular torque impulses led to loss of control. In the clockwise direction, the car left the ground when negotiating the level crossing, but without any danger. The broken edges caused a little trouble, and the potholes and 1·5 in. dip could still be felt.

On all sections except the curved crest and the cambered and crowned bends, the car reached 57 m.p.h. The 6 ft. and 7 ft. pitch corrugations could be felt, but the corrugations on the spiral bend were less troublesome. Control was easily maintained on the remaining features, including the cambered straights.

Throughout the suspension evaluation, the firm suspension of this vehicle tended to give a harsh ride at low road speeds, accompanied by bodywork rattles, but control was well maintained at higher speeds.

3.9 Noise

Noise External to Vehicle (Appendix XIX (*c*))

(1) The noise levels were found to be 80 phons (DIN) with the vehicle stationary and 79 phons (DIN) with the vehicle moving.

(2) The vehicle's approach speed was 46 m.p.h. in second gear, and the resulting loudness figures are presented in the following table:—

Test No.	*Right hand side of vehicle, dB (A)*	*Left-hand side of vehicle, dB (A)*
1	84	86
2	85	86
3	85	86

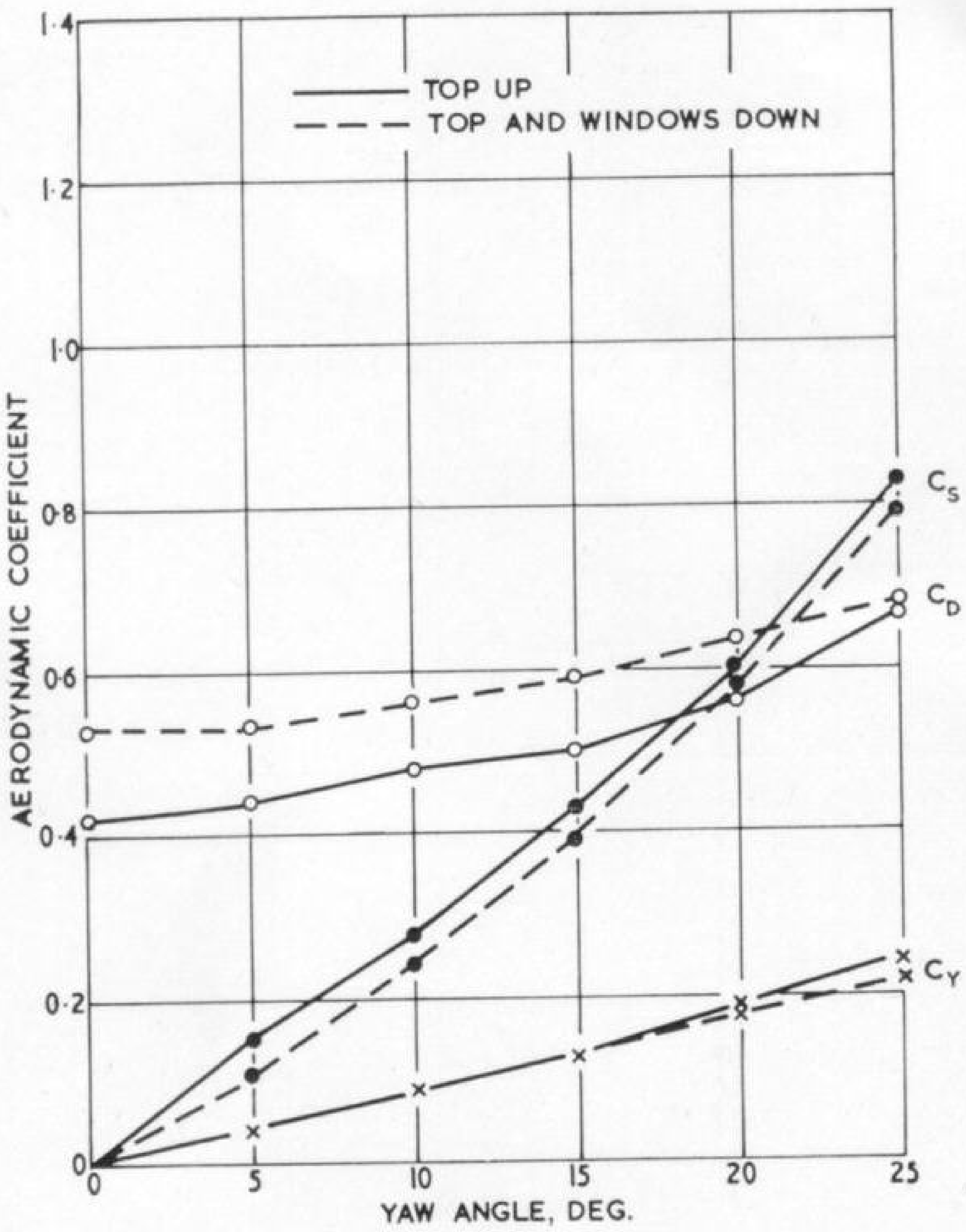

Fig. 37. Aerodynamic coefficients.
o—o—o Drag coefficient.
•—•—• Side force coefficient.
x—x—x Yawing moment coefficient.

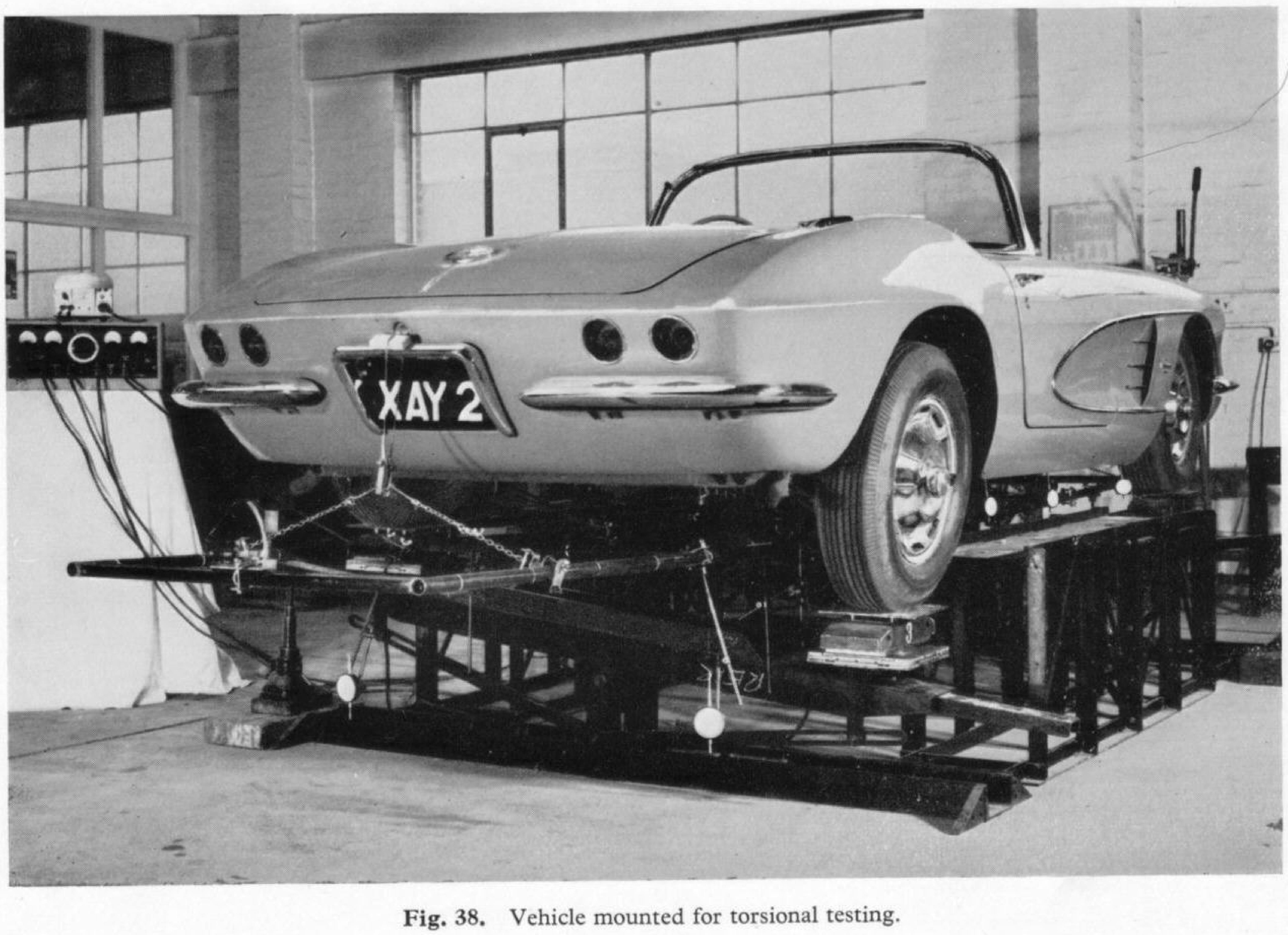

Fig. 38. Vehicle mounted for torsional testing.

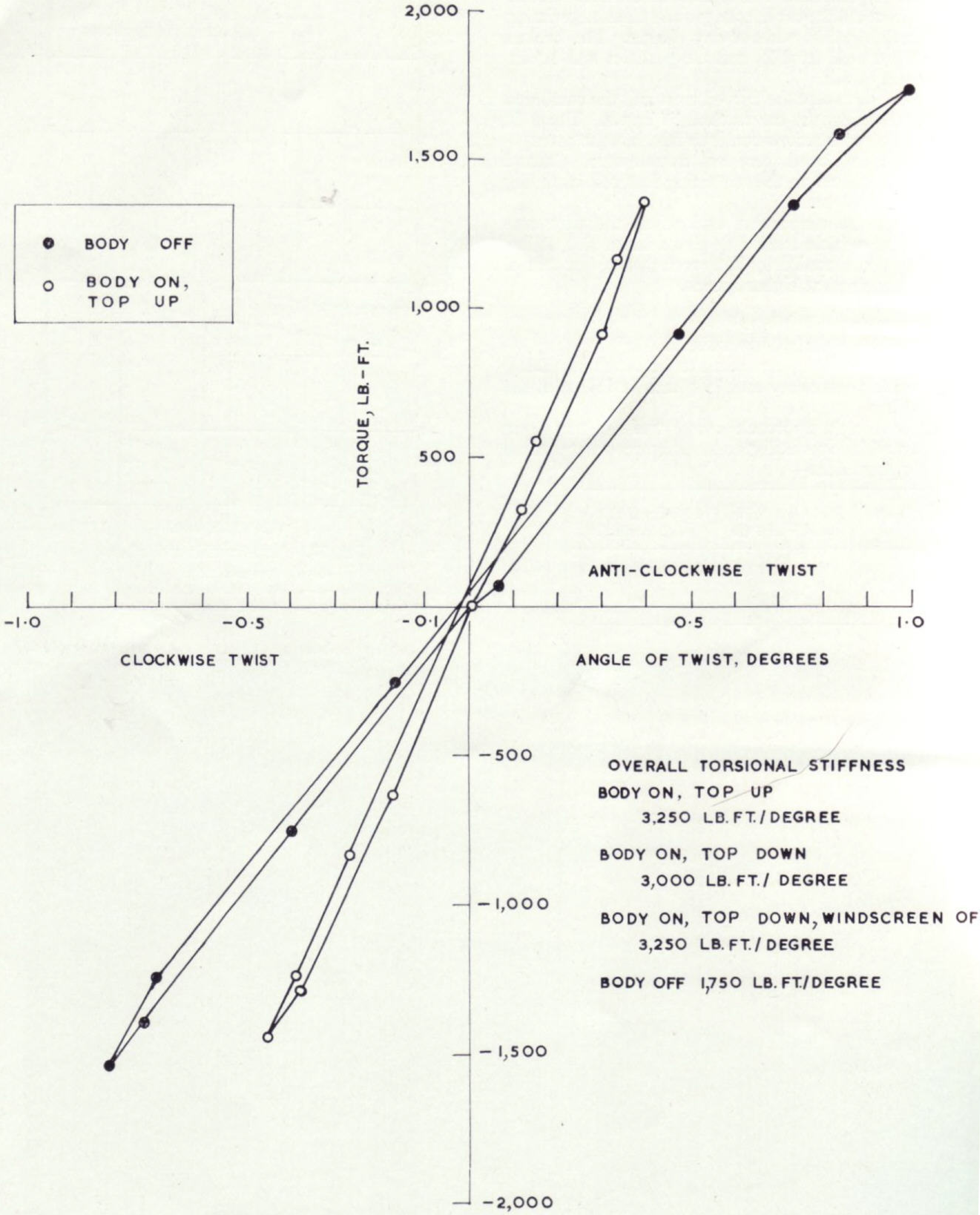

Fig. 39. Overall twist of the complete vehicle. Torque was applied at the front and rear wheels.

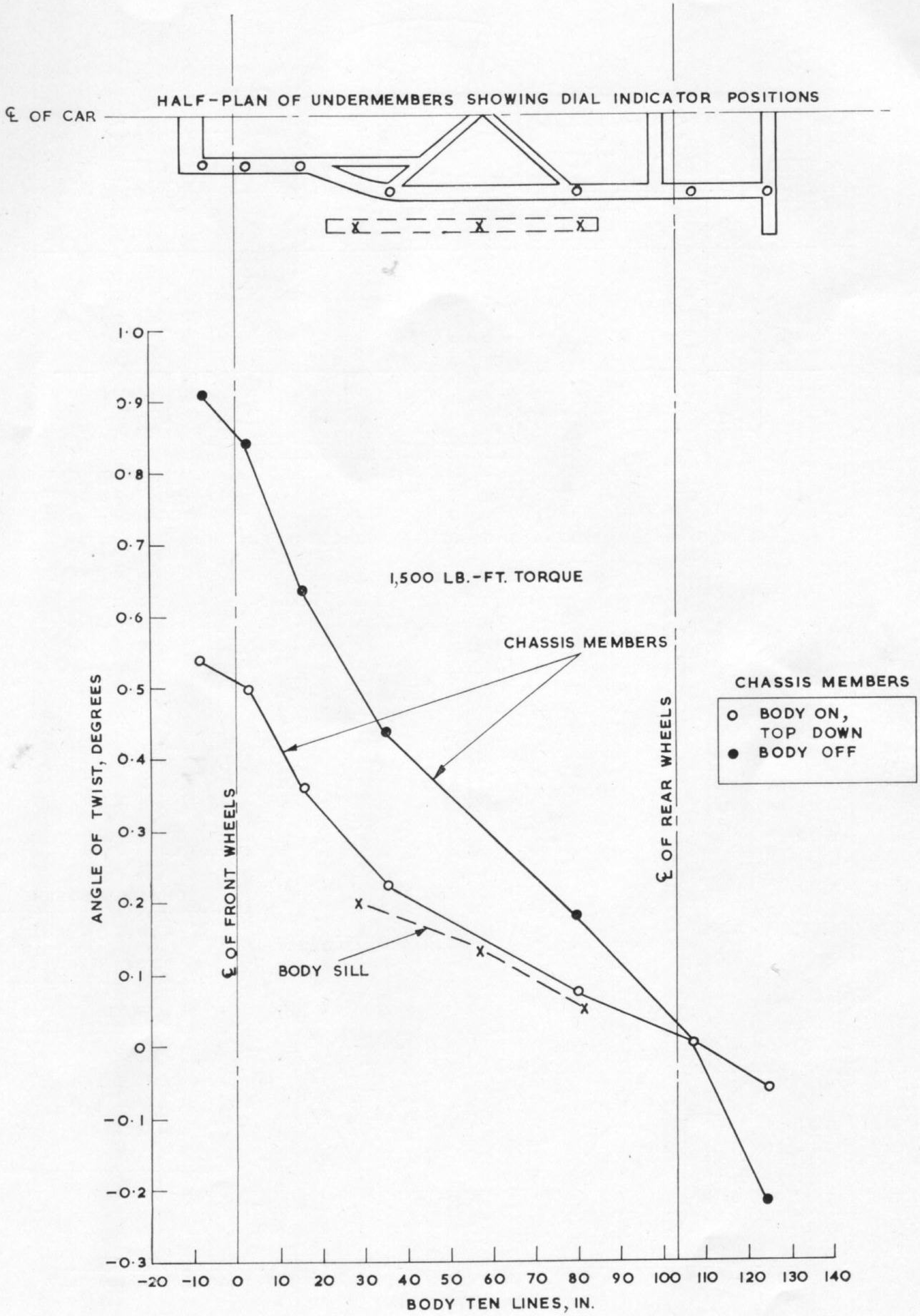

Fig. 40. Longitudinal distribution of twist.

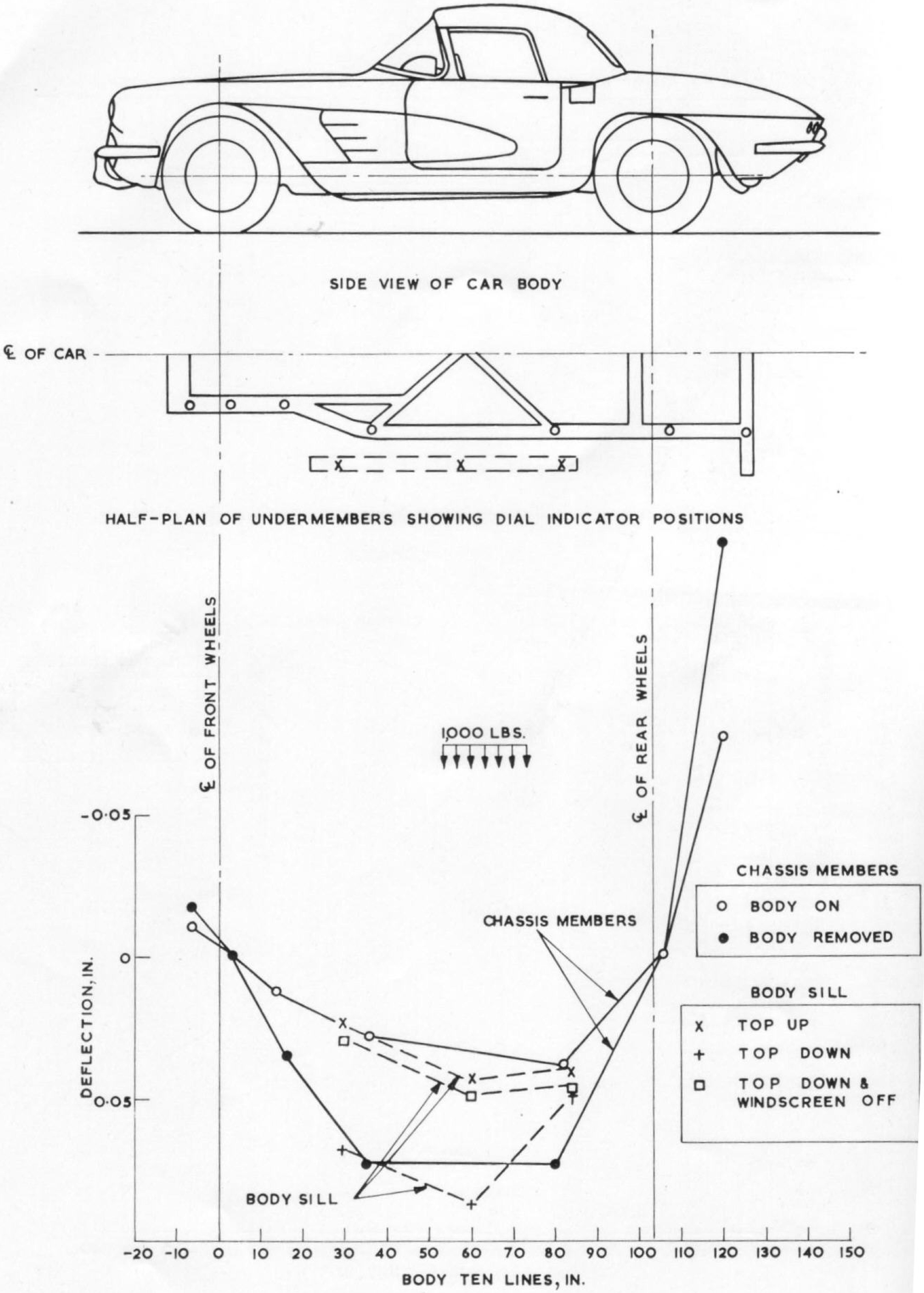

Fig. 41. Bending deflection of the complete vehicle.

3.10 Aerodynamic Coefficients (Appendix XXX)

The vehicle was subjected to wind tunnel testing at angles of yaw from 0 to 25 degrees, with the soft top up, and with the top and windows down, and the results are presented in Fig. 37.

3.11 Torsional and Bending Stiffnesses (Appendix XXIV)

The complete car was tested with the soft top up and down, and with the top down and windscreen removed. The body was then removed and the chassis was tested in the condition shown in Fig. 10. The complete vehicle mounted for testing is shown in Fig. 38.

After a period of six months, between February and September, during which the vehicle remained in the open air and was in regular use, a second set of tests was carried out in an identical manner to the first. No detectable change had taken place in either torsional or bending stiffnesses.

The overall twist at the axle positions is shown in Fig. 40. It should be noted that, as the torque was applied via the wheels and springs, full torque was not necessarily obtained over the whole length between the axles.

The bending stiffness results are shown in Fig. 41.

3.12 Electrical Equipment

Generator (Appendix XXVIII)

The results of tests carried out on the generator are presented in Figs. 42 to 44. The following results were also recorded:—

Field resistance, 18°C.	6·8 ohms
Pulley ratio	1·95:1
Weight...	22·7 lb.
Yoke diameter...	4·5 in.
Yoke length	5·0 in.
Temperature rise of casing after one hour at 30 A, and 6,500 r.p.m.	50·5°C.

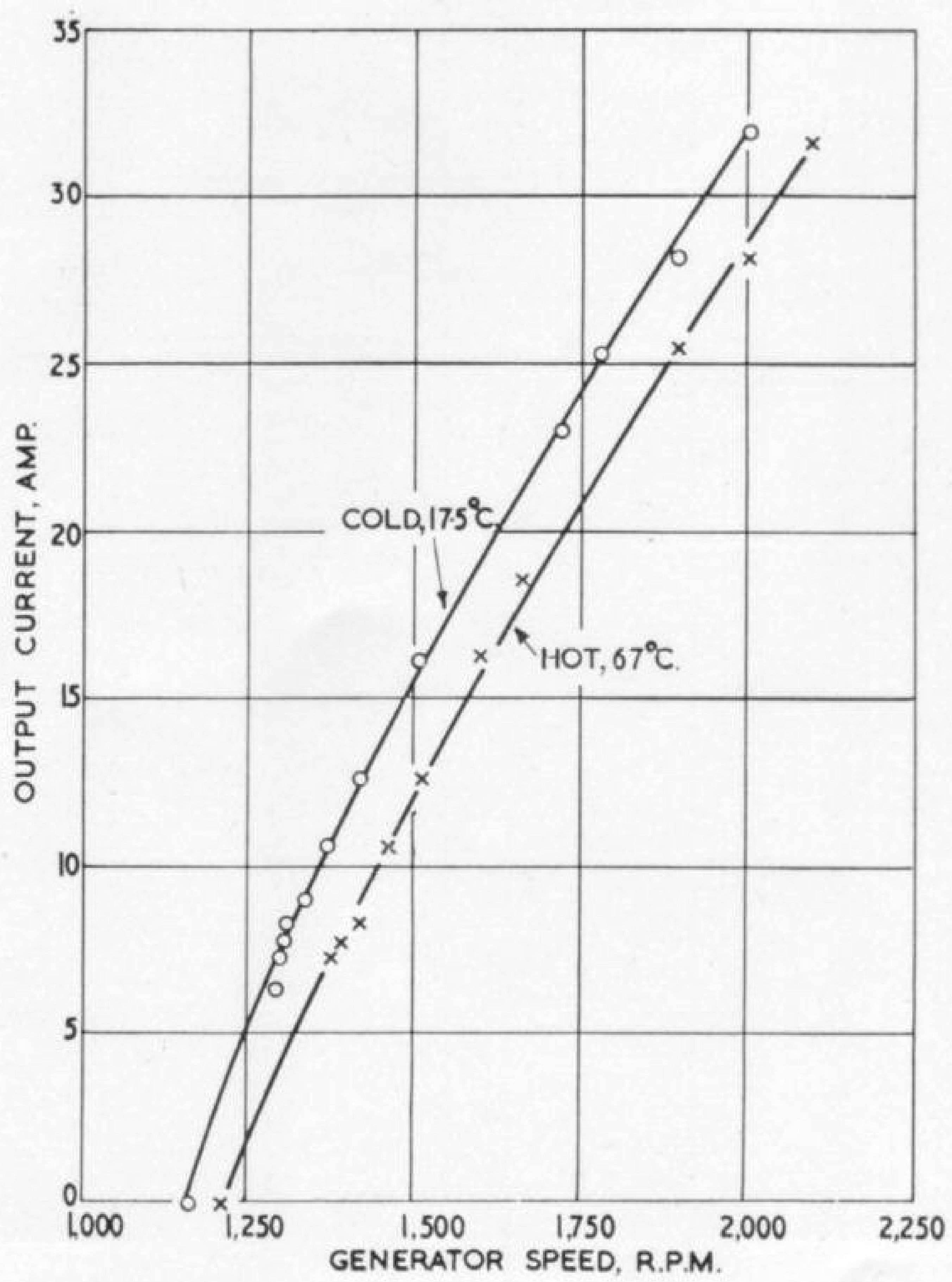

Fig. 42. Generator output characteristics.

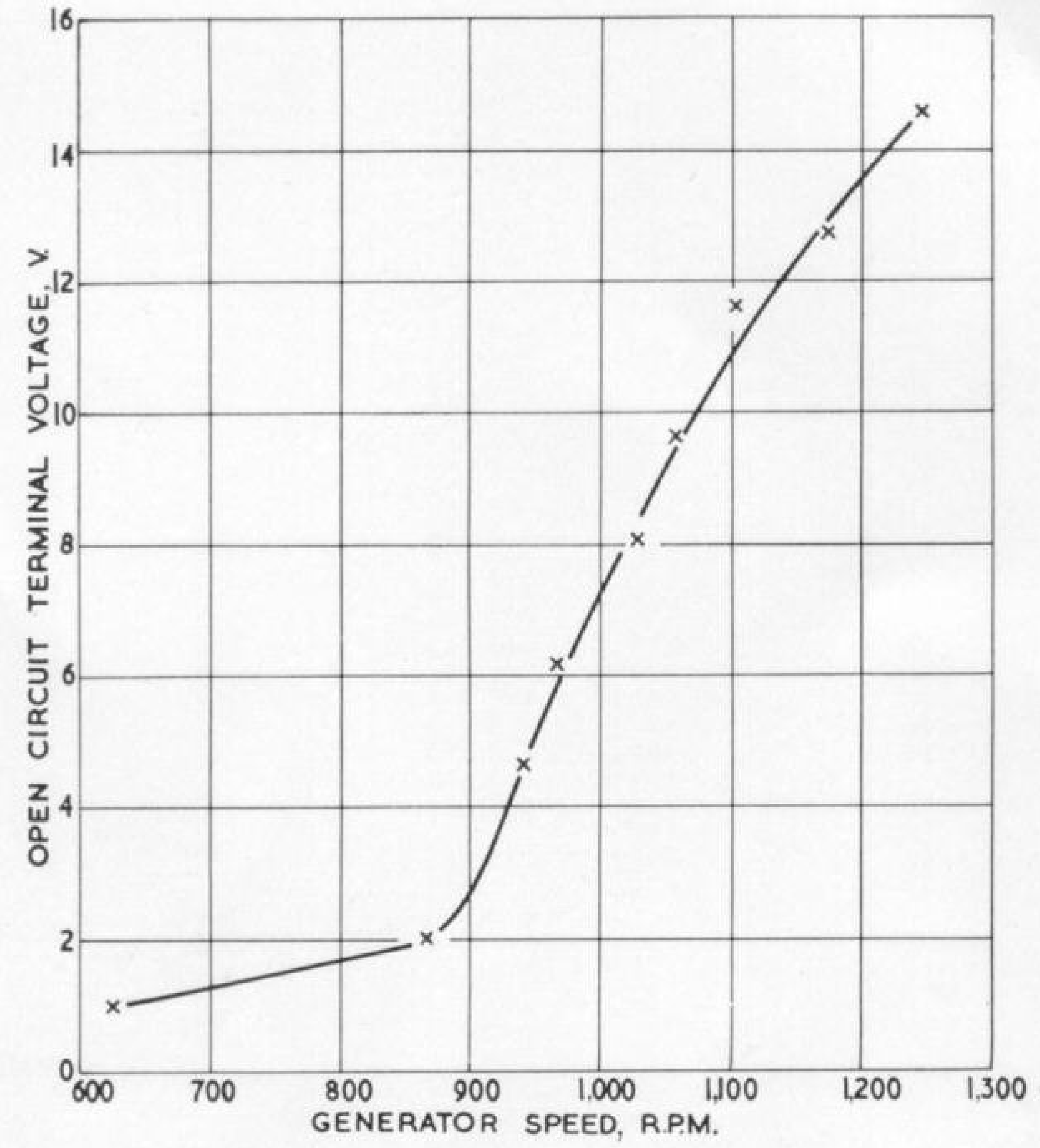

Fig. 43. Generator voltage build-up, hot.

3.13 Maintenance

The vehicle was delivered by a British distributor with 179 miles recorded. The car was clean and fully prepared on delivery. Slight scratches were visible on the paintwork and a small imperfection could be seen through the paintwork on top of the left front wing. The recommended lubrication and maintenance procedure was followed throughout. Access to the battery, sparking plugs and

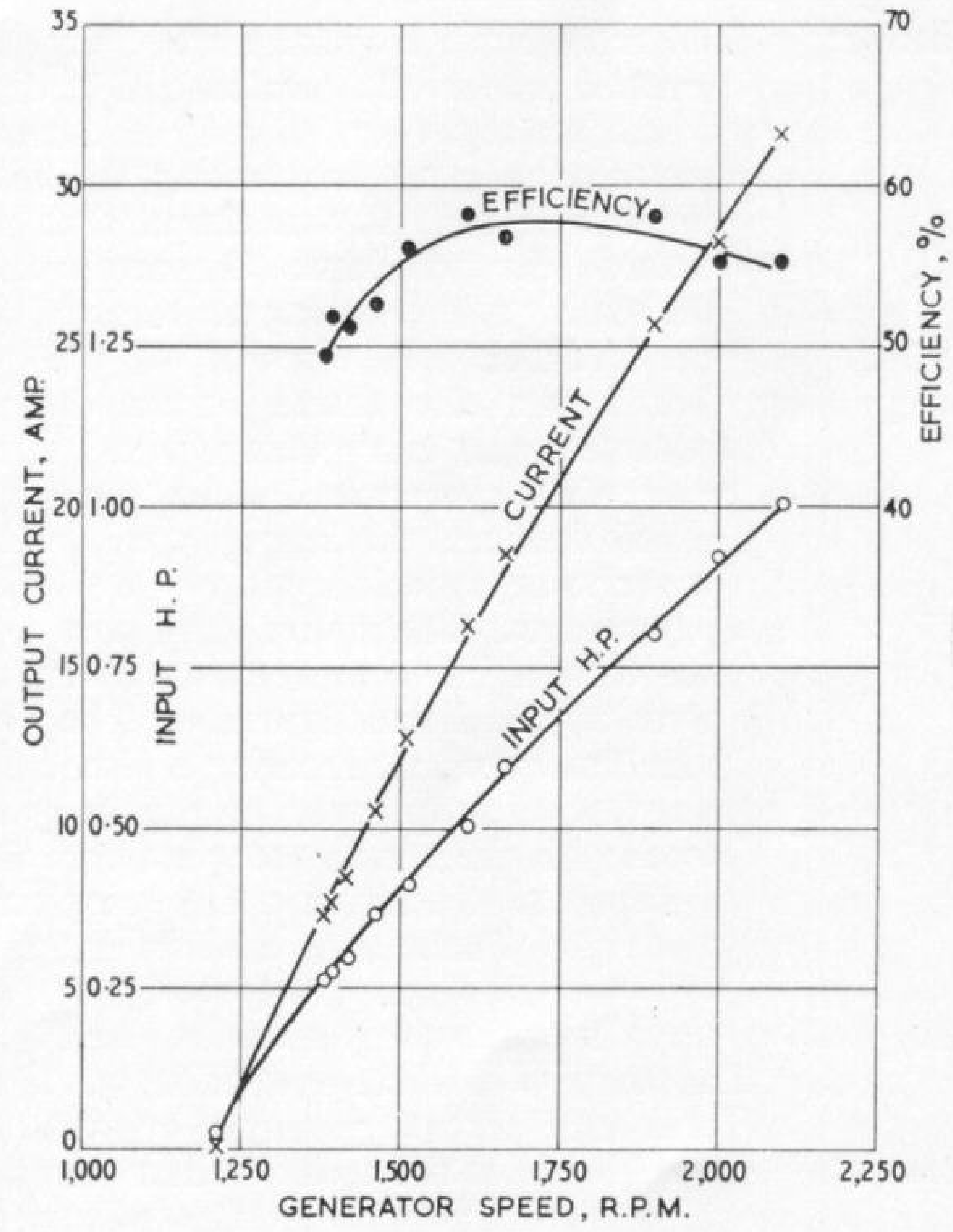

Fig. 44. Generator power input and efficiency.

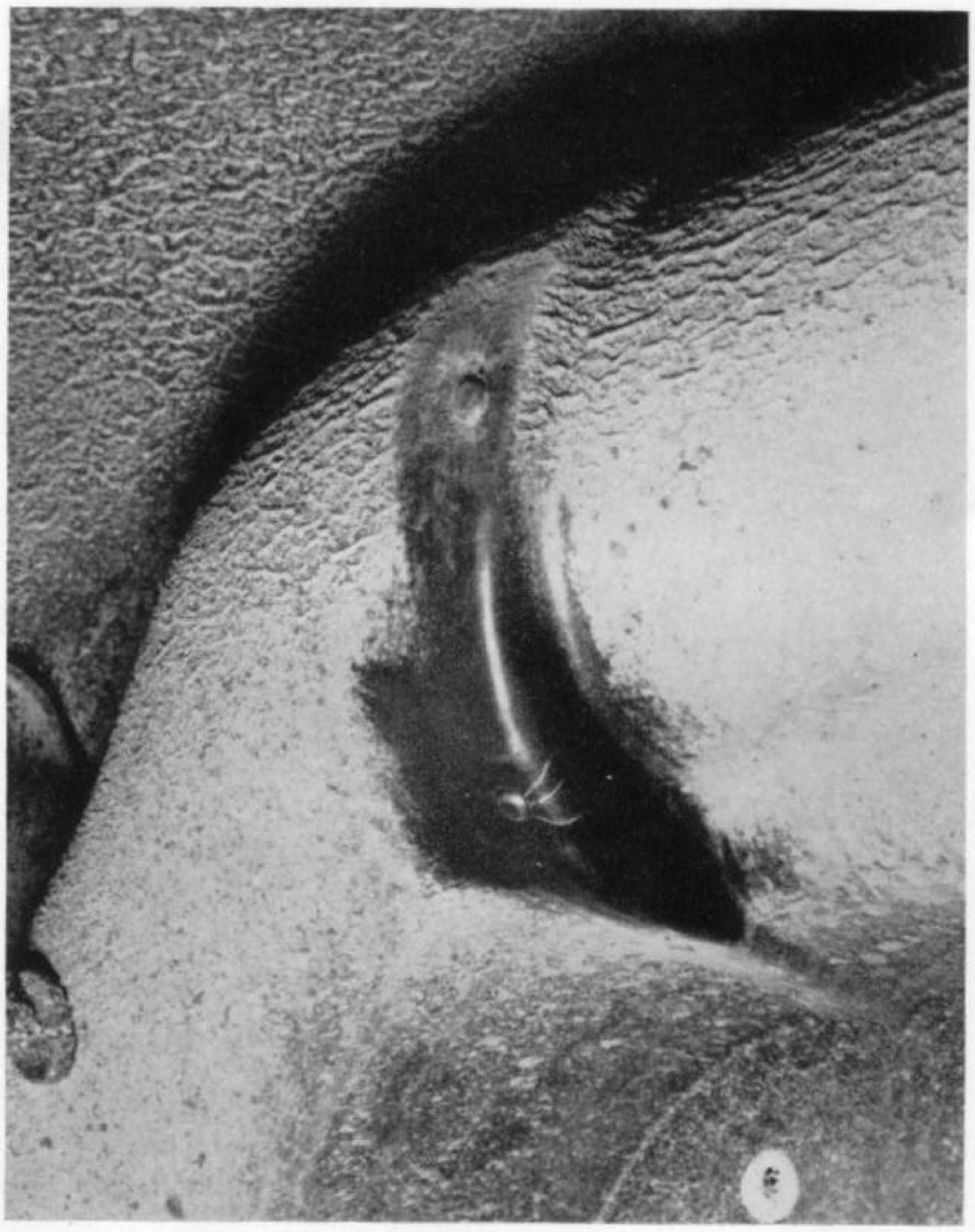

Fig. 45. Wing support, left front cracked on delivery.

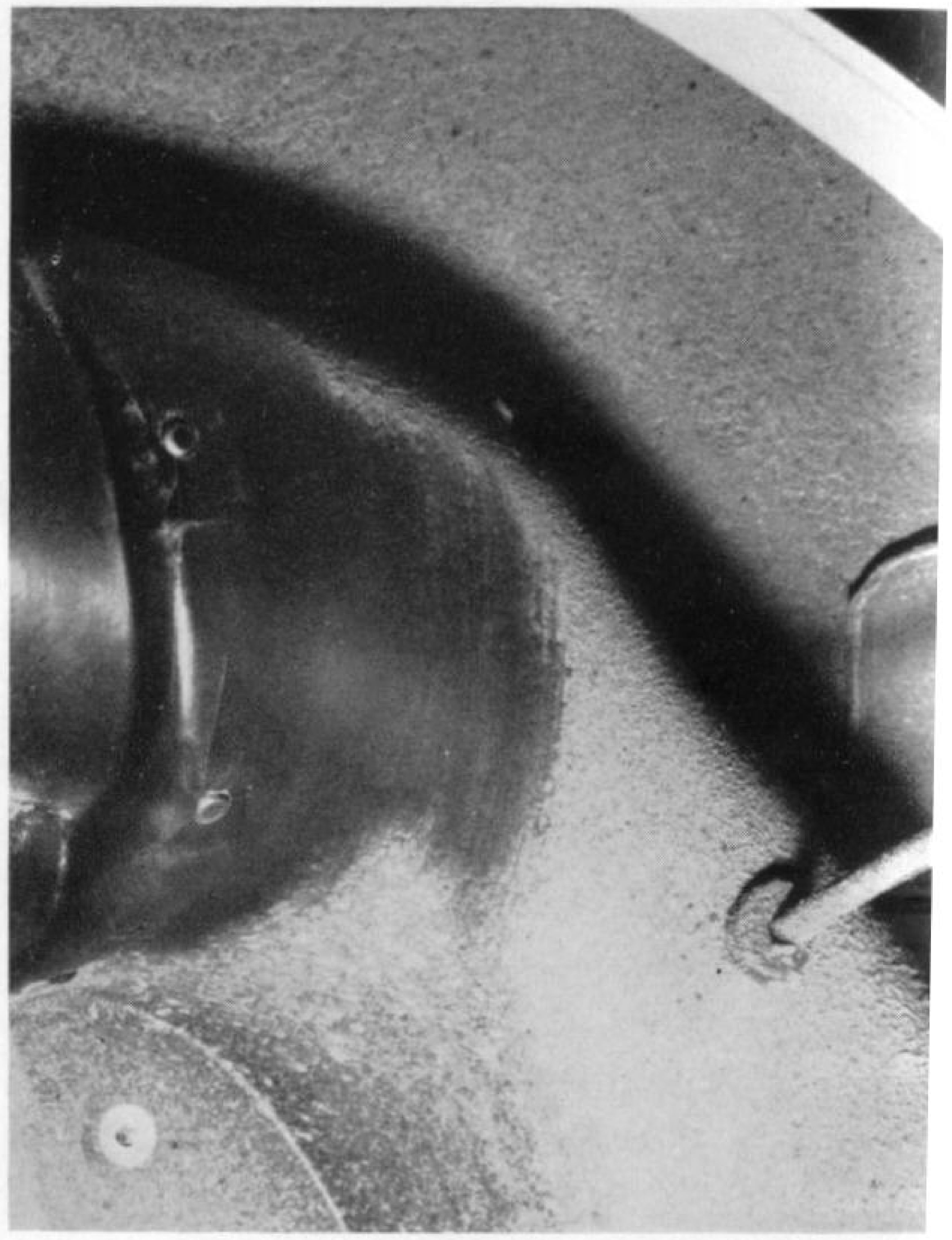

Fig. 46. Wing support, left front cracked on delivery.

windscreen washer reservoir was difficult, and 22 grease nipples required attention every 1,000 miles. Other items requiring attention are listed as follows:—

On delivery. The resin-bonded glass fibre body was cracked under the left and right front wings (see Fig. 45 and Fig. 46) in the areas around the rivets supporting the metal inner valances. It was found that rain entered the passenger compartment via the sealing rubbers along the edges of both the left and right sides of the soft top. Water was also found in the luggage compartment, entry being gained at the base of the spare wheel well.

The left door and the luggage compartment cover were difficult to close and required adjustment. The buffer nuts were loose on the engine compartment cover and were adjusted and tightened. The right side stud used for securing a plastic flap, on the soft top cover, to the body was loose; the threads in the glass fibre were stripped and a larger self tapping screw was fitted. The seam at the left edge of the left sun visor was split (see Fig. 47), and a replacement visor had to be fitted.

The battery was discharged, and it was found that one of the generator brushes was stuck so that the unit was not charging. The vacuum pipe to the windscreen washer reservoir was disconnected at the

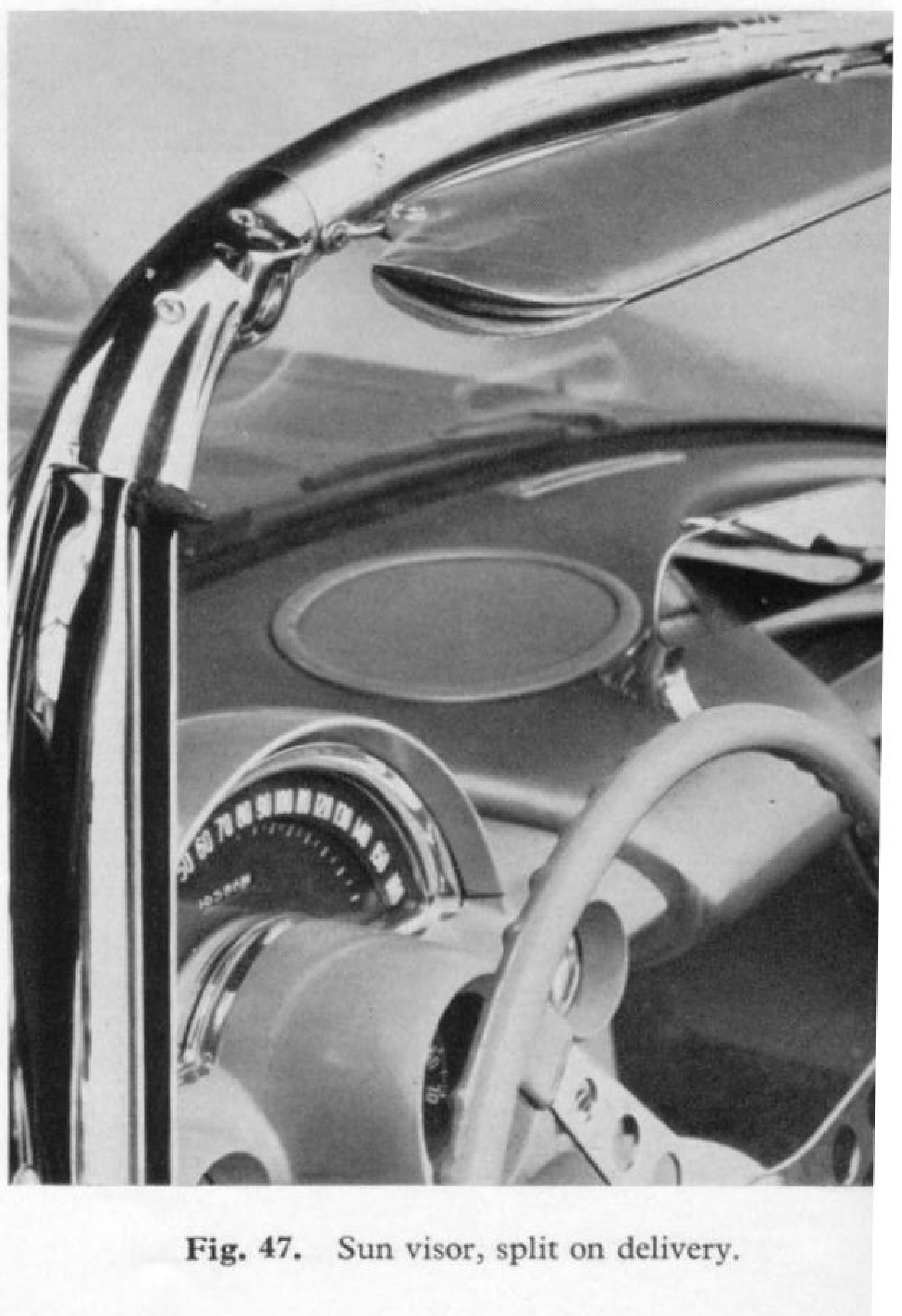

Fig. 47. Sun visor, split on delivery.

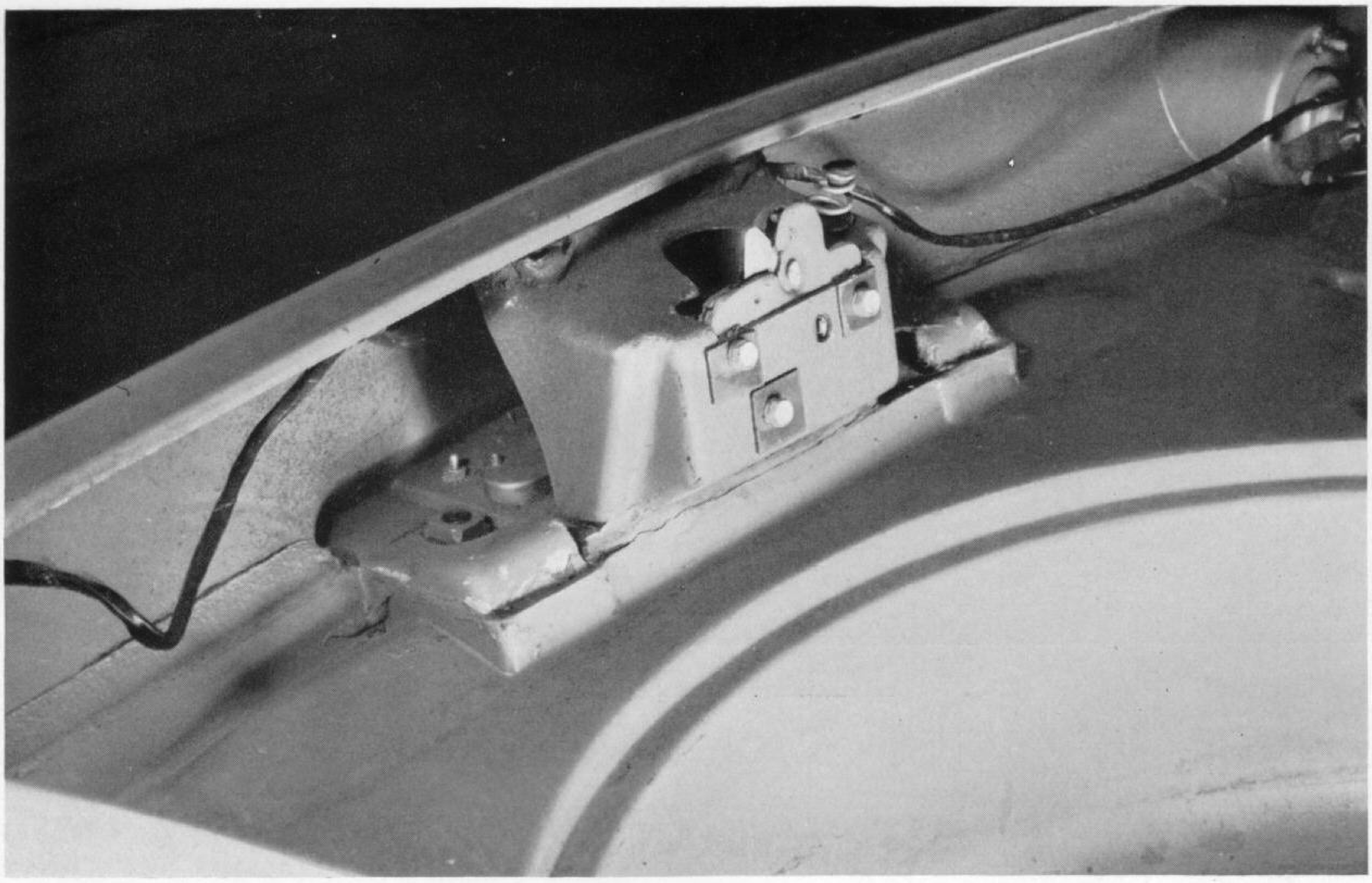

Fig. 48. Luggage compartment floor and repaired lock mounting after 5,210 miles

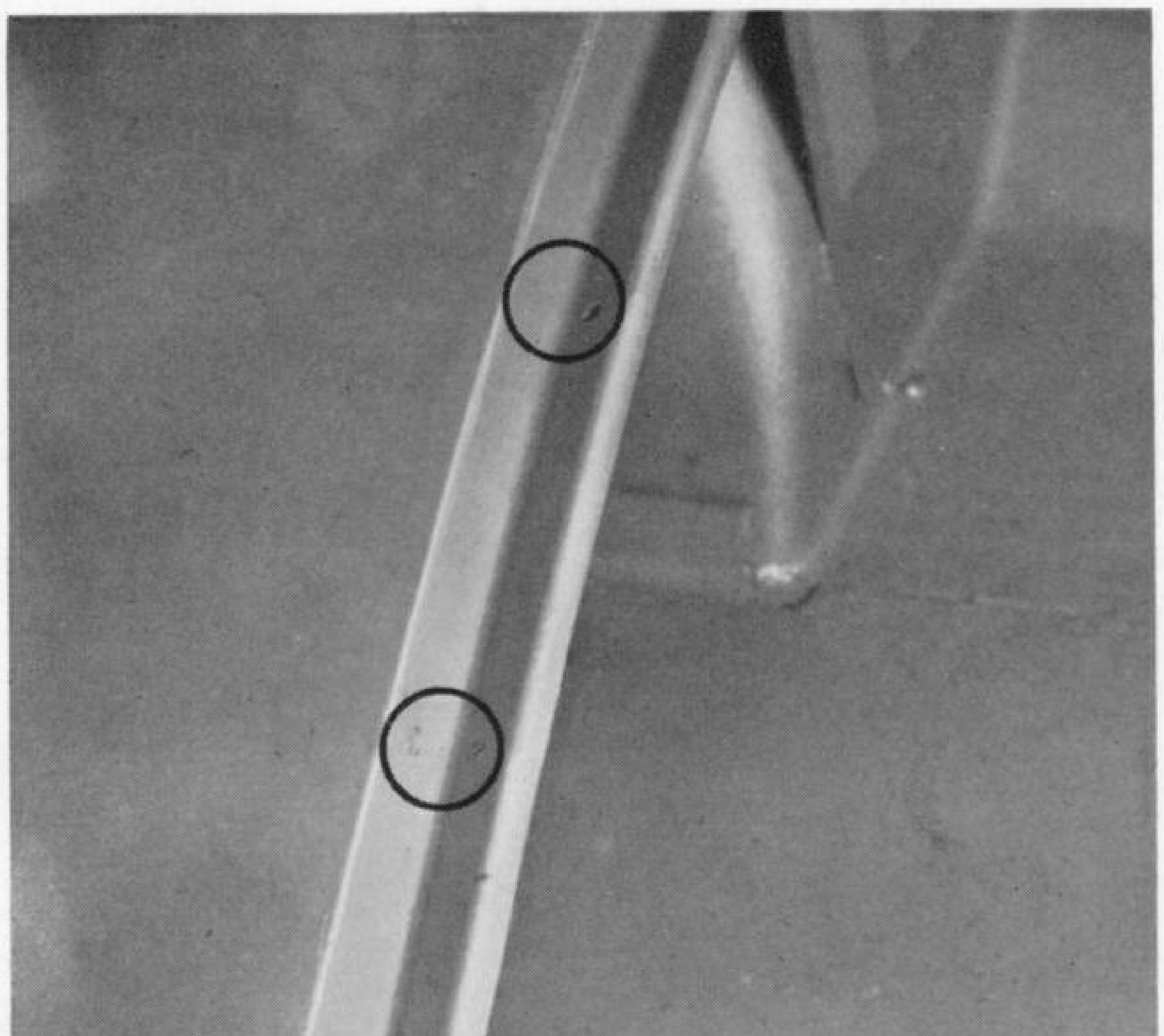

Fig. 49. Luggage compartment surround, left side, loose and missing rivets.

carburettor end. The engine idling speed was 700 r.p.m. instead of the recommended 500 r.p.m. The steering drop arm was jamming on the end of the chassis-mounted steering stop when full left lock was applied. The steering stop had to be bent considerably to correct the fault.

210 miles. The fuel gauge was found to read $\frac{3}{4}$ full when the tank was filled. The ignition timing was incorrect, being 6 deg. B.T.D.C. The timing was reset to the recommended figure of 4 deg. B.T.D.C.

350 miles. Difficulty was experienced with hot re-starting and the engine was using an excessive amount of fuel. The carburettor was dismantled and the float levels reset.

531 miles. On removal of the windscreen during torsional and bending stiffness tests, the lugs at the bases of both windscreen pillars fractured. The pillars were zinc-base die castings and had very small cross-sections across the lugs used for fixing the bottom rail of the windscreen. Both windscreen pillars were replaced.

1,247 miles. One of the nuts holding the right exhaust pipe to the manifold was missing and the other two were loose. The nut was replaced and the whole system was tightened.

1,858 miles. The right sidelamp bulb failed and was replaced.

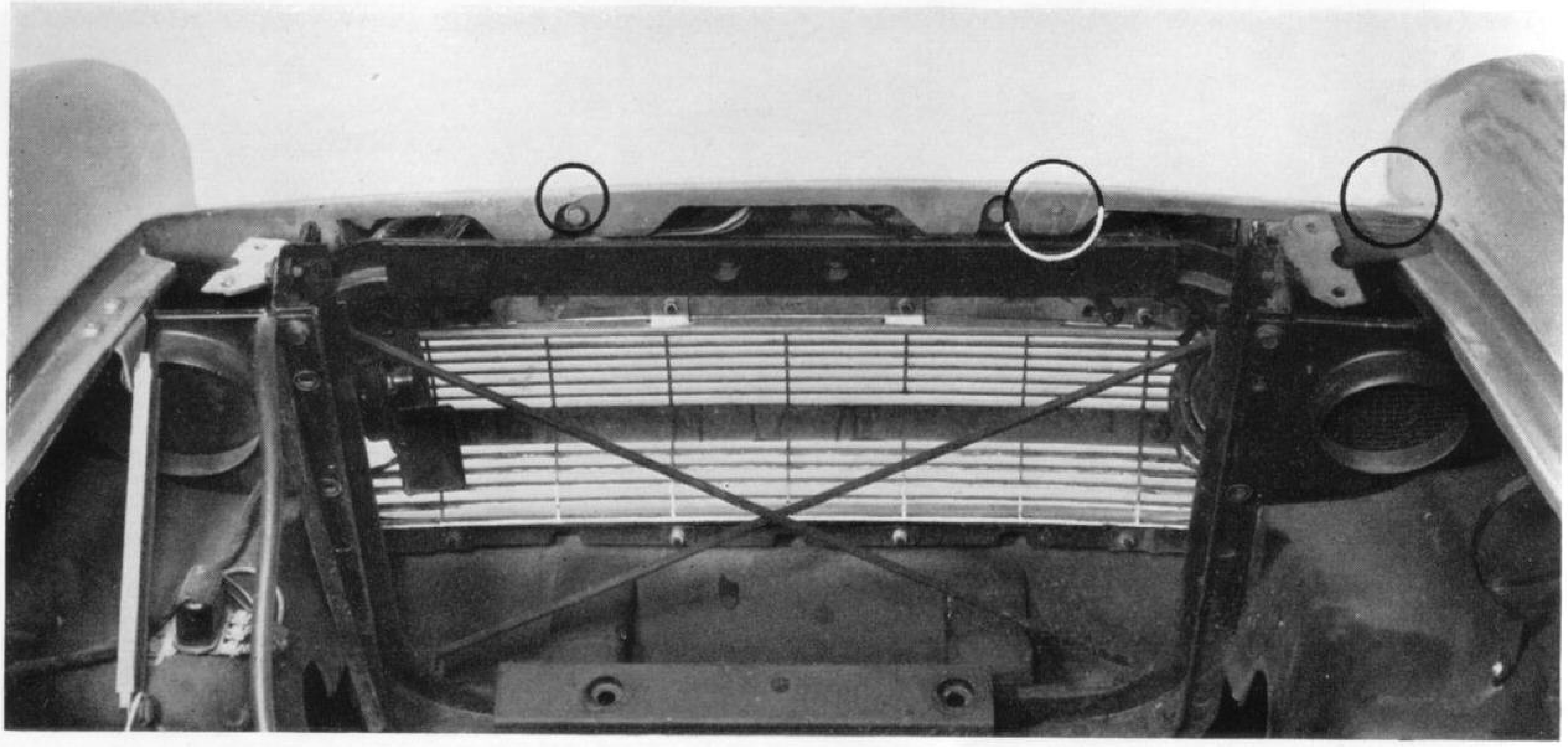

Fig. 50. Engine compartment, failures after 5,210 miles.

2,135 miles. Another nut was missing from the right side exhaust manifold as at 1,247 miles; this was replaced and the system tightened. The exterior mirror worked loose and was tightened.

2,988 miles. Flooding of the carburettor was noticed and it was dismantled and cleaned.

3,072 miles. The battery securing strap was corroding and required re-painting.

3,535 miles. There was a continual smell of fuel in the passenger compartment and the sealing of the filler cap was improved.

5,210 miles. After the Suspension Evaluation described in Section 3.8 of this report, examination of the vehicle revealed the following faults:— The luggage compartment lock broke out of its mounting, the screws pulling through the glass fibre, and strengthening plates had to be fitted behind the screwheads as seen in Fig. 48. The bonding cracked along the rear edge of the luggage compartment floor in the area of the lock as seen in Fig. 48. The metal rivets in the reinforcing struts on either side of the luggage compartment surround worked loose and one was missing (see Fig. 49). Several cracks appeared on the leading edge of the engine compartment surround, and the rivets joining the metal supports to the glass fibre worked loose (see Fig. 50). The fan shield attaching lugs broke at either side (see Fig. 51), and the shield became loose. Several self tapping screws threaded directly into the glass fibre, at various points in the body, worked loose or fell out completely. The spot welding holding the spare wheel securing nut broke away and required re-welding.

5,436 miles. A further nut was missing from the right side exhaust system as at 1,247 and 2,135 miles; this was replaced and the system tightened.

6,000 miles. The right outer headlamp unit failed and was replaced.

6,383 miles. The vehicle was dismantled.

3.14 General Impressions

The impressions of this car tended to be coloured by whether one regarded it as a sports car—in which it might be acceptable to subordinate some features to sheer performance—or as a comfortable and impressive fast tourer.

The appearance was generally thought to be attractive, but a width of six feet seemed unnecessary for a two-seater. Entry and exit were satisfactory for a sports car provided that the seats were not positioned too far forwards.

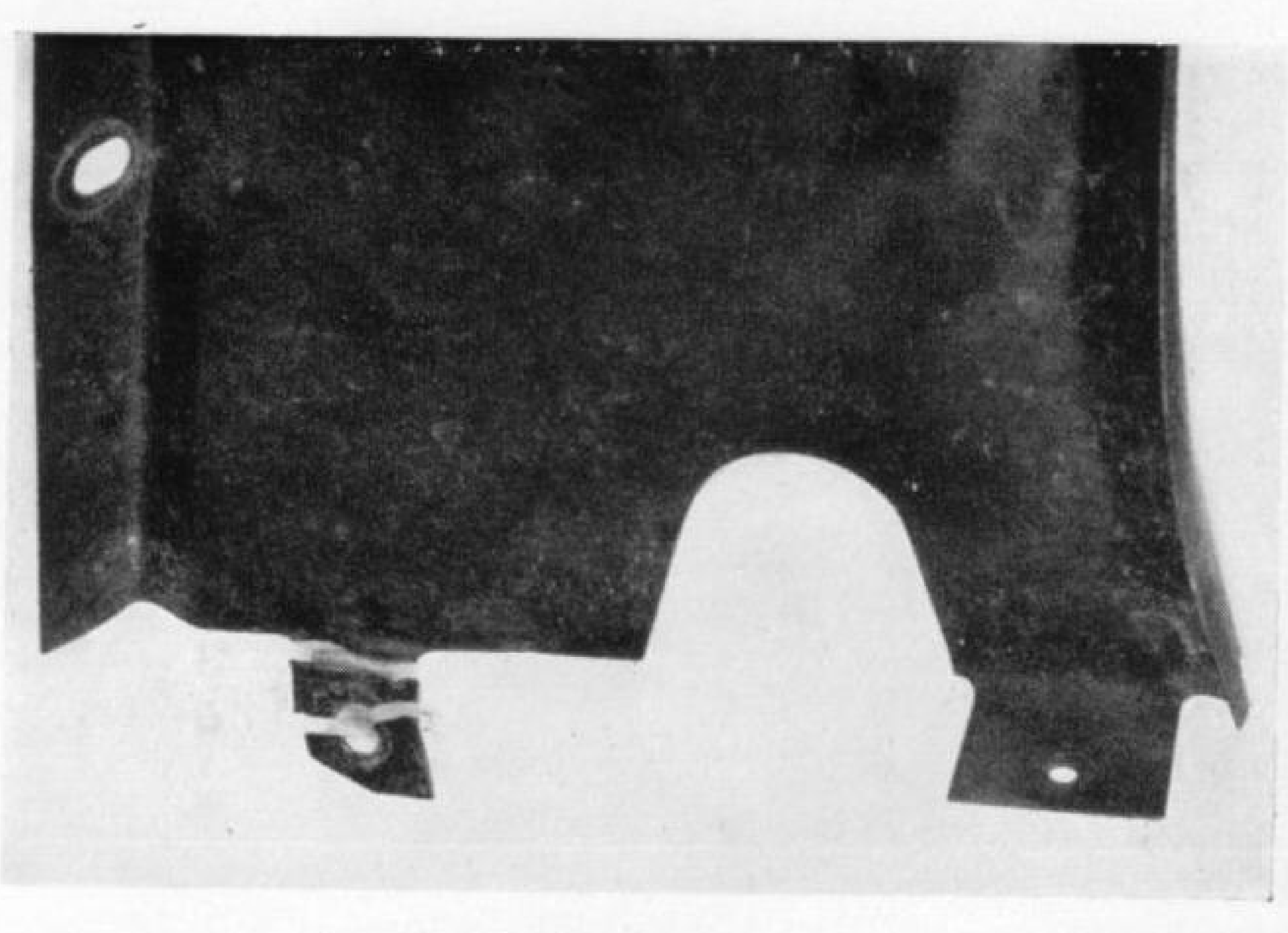

Fig. 51. Fan shield, cracked left side after 5,210 miles.

The generously proportioned seats were comfortable and provided some location, but the safety belts were needed to retain the occupants firmly. The seat adjustment slides could not be used in the extreme forward positions, because the seats fouled against the moulding around the gearbox. Very short drivers were in some difficulty when operating the pedals, and tall drivers' heads came very close to the steel soft top supports.

Forward visibility was reasonable, but the screen pillars were very thick, and short drivers had difficulty seeing over the steering wheel. With the soft top in position, rearward visibility was adequate whilst driving at speed, but manoeuvring in confined spaces was not so easy; the additional external mirror was rather close to the driver but was helpful under some conditions. The stowage tray to the right of the facia and the lockable container between the seats provided suitable accommodation for oddments, but the luggage compartment was shallow, although large in area.

With regard to the instruments, the fuel gauge readings were highly misleading, the tachometer dial was small and the speedometer housing projected well above the top of the scuttle, restricting the visibility of shorter drivers. Heating and ventilating provision was on a generous scale, but it was impossible to obtain demisting or defrosting without the accompaniment of a blast of air at foot level. With the soft top up, considerable gaps were visible at the tops of the door windows, and at high speeds very considerable noise was generated. With the top down, driver and passenger suffered from much air buffeting, whether or not the side windows were raised.

The brakes were very heavy in operation when cold, but less so when warm. They were neither completely quiet nor completely smooth, but never became strongly objectionable in these respects. Used frequently in fast main road driving, the brakes gave confidence, but really harsh treatment could result in a complete, but temporary, loss of braking power, probably caused by vaporised fluid. The clutch was smooth and positive, although some delicacy was required in moving away from rest with the close-ratio gearbox. The gear change mechanism was quick, precise and positive to use, and the synchromesh provision for all four gears was very effective. Acceleration and flexibility were both excellent, so that an outstandingly good performance was available even without full use of the gearbox.

Steering was heavy at low speeds, but accurate in all conditions. The road-holding was such that adequate warning was given of approaching limits, and a degree of control could be maintained even after the tyres had broken away. The suspension was stiff and inclined to be uncomfortable at low speeds, improving as the speed was raised; little roll was experienced.

In general, this car offered excellent sustained acceleration accompanied by a firm ride often associated with sports cars, together with a comfortable but rather wide body.

SECTION 4
DISMANTLING

After the completion of 6,380 miles, including the road testing previously described in this report, the vehicle was dismantled for further examination. This section is devoted to descriptions of some of the components, together with an account of any further faults found during dismantling.

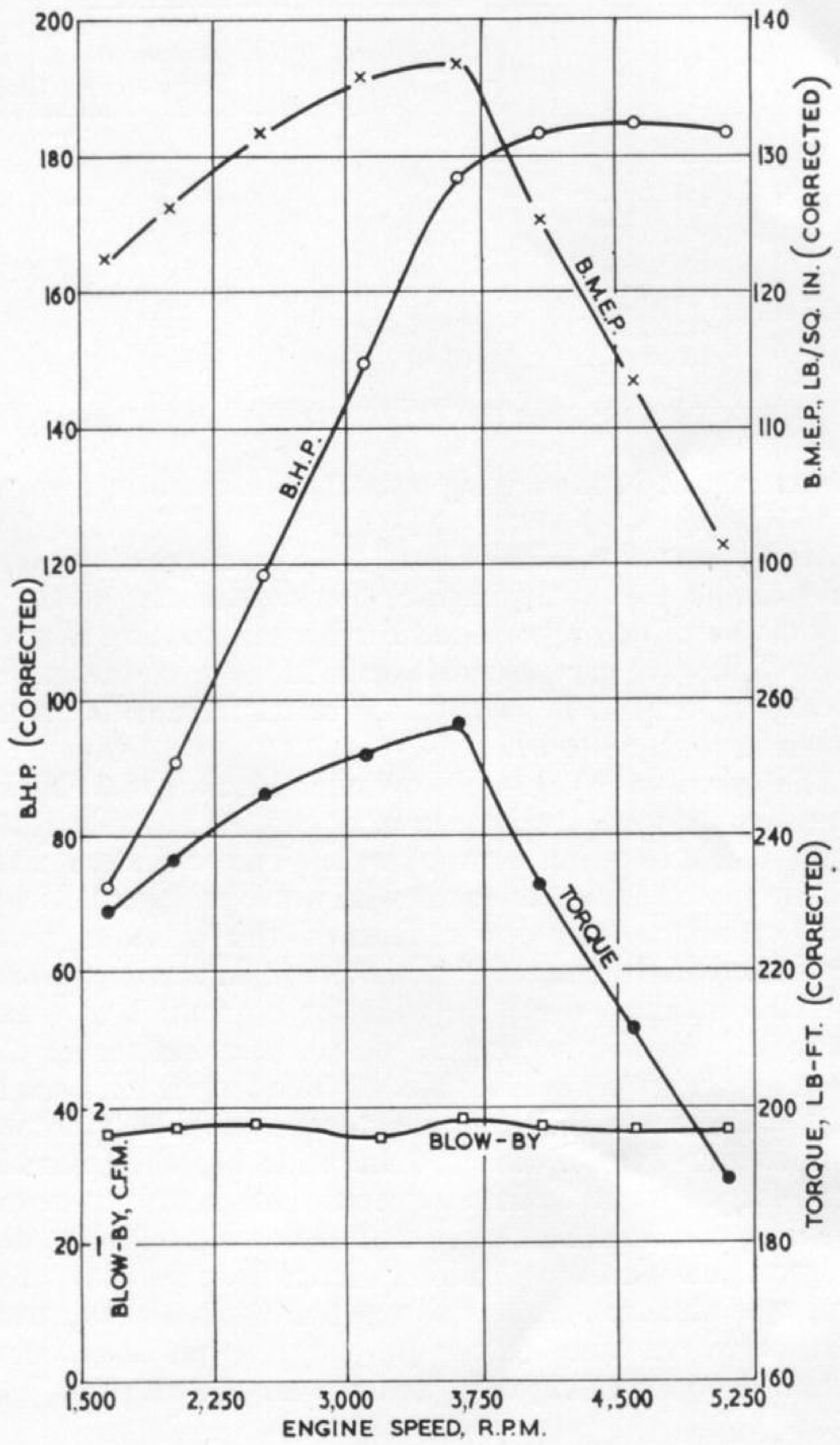

Fig. 52. Brake horse power, brake mean effective pressure, torque, and blow-by.

4.1 Engine

The removal of the engine was simplified by first disconnecting the gearbox. The engine could then be lifted fiom the vehicle. After removal, the engine was fitted with a new set of sparking plugs and dynamometer tested (see Appendix XXV). The vehicle exhaust system was used and the water pump and generator were driven, the latter at no load. The cooling fan was not fully engaged and free wheeled during testing, but the fan horsepower requirements are presented. The engine thermostat was removed and the cooling system temperature was controlled by a heat exchanger. The water temperature was measured at the jacket outlet and maintained at 78°C. throughout the tests. Oil pressure was measured at the main oil gallery and the oil temperature by a thermocouple in the dipstick tube. A set of observed values for oil pressure and temperature over a speed range at full throttle is given in the following table.

Engine Speed, r.p.m.	*Oil Pressure, lb. per sq. in.*	*Oil Temperature, °C.*
1,660	35	89
2,020	37	94
2,530	38	97
3,110	40	100
3,620	41	107
4,120	41	113
4,590	39	118
5,100	40	123

The results of the engine tests are presented in Figs. 52 to 55.

After completion of these tests, the engine was dismantled for examination. An engine specification is given in Section 2.1 of this report, and further information is given in the following paragraphs. Sectional views of the engine are shown in Figs. 56 and 57 and the engine ancillaries are shown in Figs. 58 to 61.

The cast iron 90 deg. V8 cylinder block was 21·75 in. long × 6·0 in. wide at the head faces and 9·5 in. wide at the sump face × 10·0 in. high overall. The cylinders were equally spaced along each bank with water passages between each cylinder. The lower face of the cylinder block terminated on the centreline of the five main bearings, which were 2·3 in. dia. × 0·762 in. wide for bearings 1 to 4 and 1·169 in. wide for bearing 5. Crankshaft end thrust was taken by flanges on bearing No. 5. The forged steel crankshaft had six integral balance weights, a detachable vibration damper and 2·0 in. dia. × 1·9 in. wide big end journals. Drop-forged steel connecting rods had centre-to-centre distances of 5·7 in. and carried semi-floating 0·927 in. dia. gudgeon pins which had an interference fit in the rods. The strut type aluminium alloy pistons had flat heads and their skirts were cut away below the gudgeon pin holes; each carried two gas sealing rings and one oil control ring. The

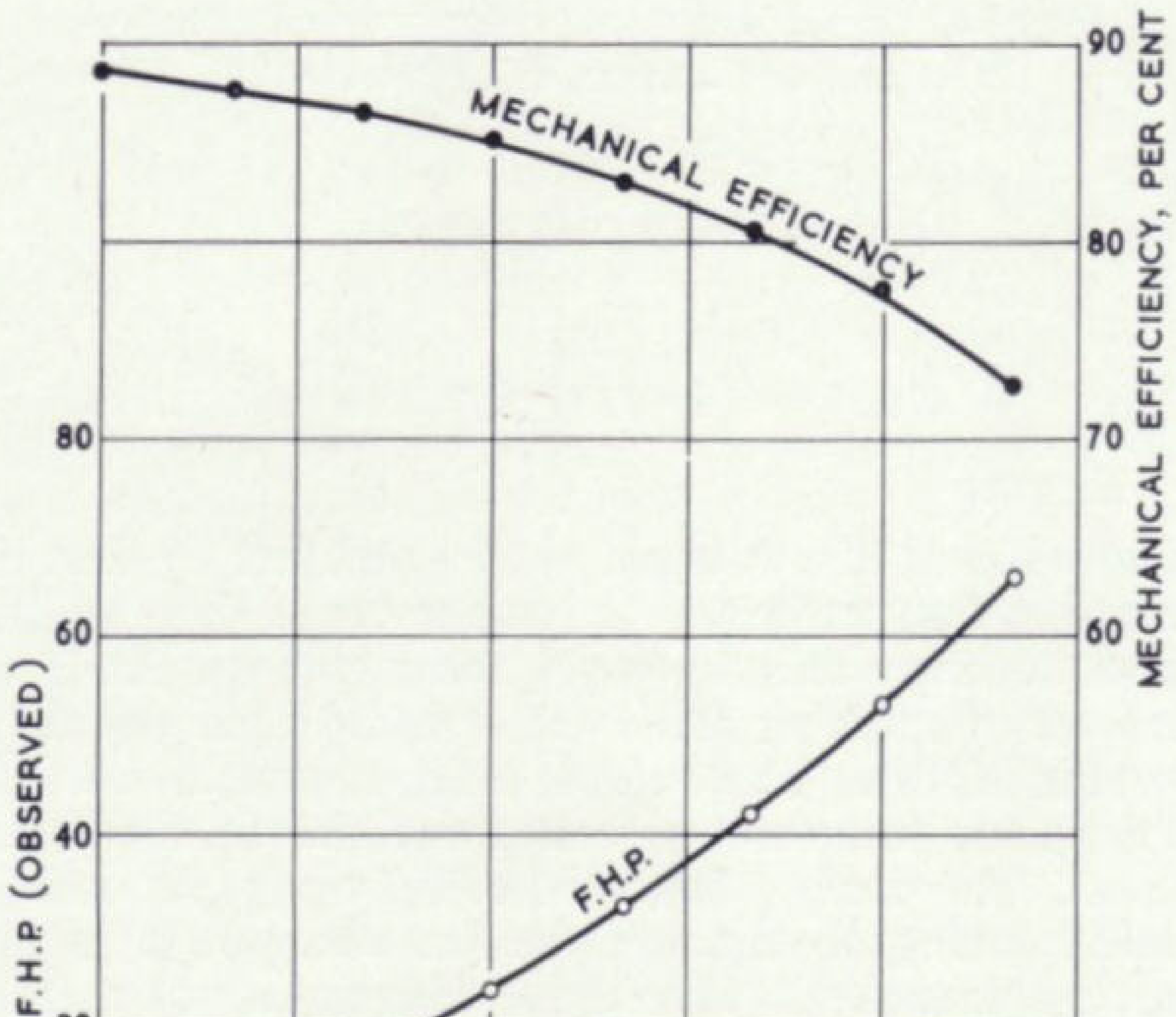

Fig. 53. Friction horse power and mechanical efficiency.

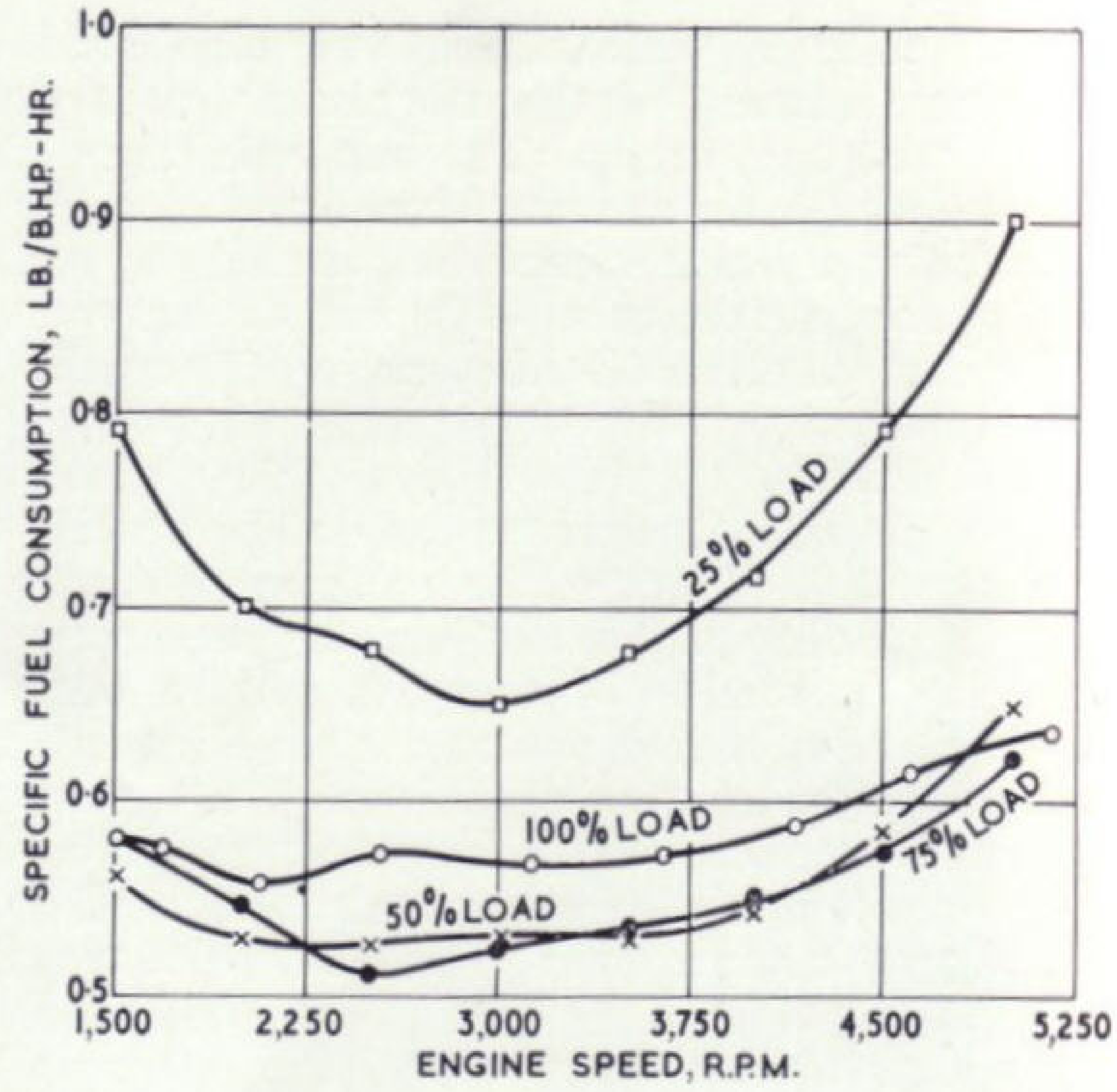

Fig. 54. Specific fuel consumptions.

gas sealing rings were of cast iron 0·078 in. wide and tapered, and the top rings were chromium plated. The three-part oil control rings were 0·184 in. wide assembled with chromium plated rails separated by hump type spacers.

The cast iron camshaft, located directly above the crank-shaft, ran in five shell bearings 1·87 in. dia. and was driven and located by a link belt chain of 46 links, 0·5 in. pitch × 0·875 in. width. 0·842 in. dia. hydraulic tappets operated the valves through 0·313 in. dia. × 7·9 in. long push rods. Pressed steel rockers, located by sintered iron washers were mounted on drilled steel pedestals pressed into th cylinder head. The inclined inlet and exhaust valves ha 1·72 in. dia. and 1·5 in. dia. heads respectively with 45 deg seat angles against 46 deg. in the cylinder heads. The valv springs were fitted with dampers, consisting of coiled stri steel 0·05 in. thick, fitting tightly onto the internal diamet of the valve spring. The valve springs had a free lengt of 2·03 in. and a fitted length of 1·75 in. with the valv closed, and the damper had a free length of 1·76 in.; eac valve stem was provided with a rubber oil seal ring fittir into a groove. The valve guides were integral with t cylinder heads and had bore diameters of 0·343 in. The ca iron cylinder heads had wedge shaped combustion chambe with the valves in line and separate inlet ports. Exhaust g hot-spot ports were incorporated in the heads. Cast ir was used for the two exhaust manifolds and for the inl manifold mounted within the Vee of the engine a incorporating an exhaust cross-over passage. A therm statically controlled valve was incorporated in the right si exhaust to regulate the amount of exhaust gas directed the carburettor hot spot. The gas from the hot spot w then led away through the left side exhaust. The front the inlet manifold casting was also used as a water passa between the cylinder heads and incorporated the cooli thermostat and temperature sensing unit; a by-pass out was provided at the bottom of the header tank to h radiator filling.

An aluminium alloy cross-flow radiator of tube a corrugated fin design was fitted, together with the alumini

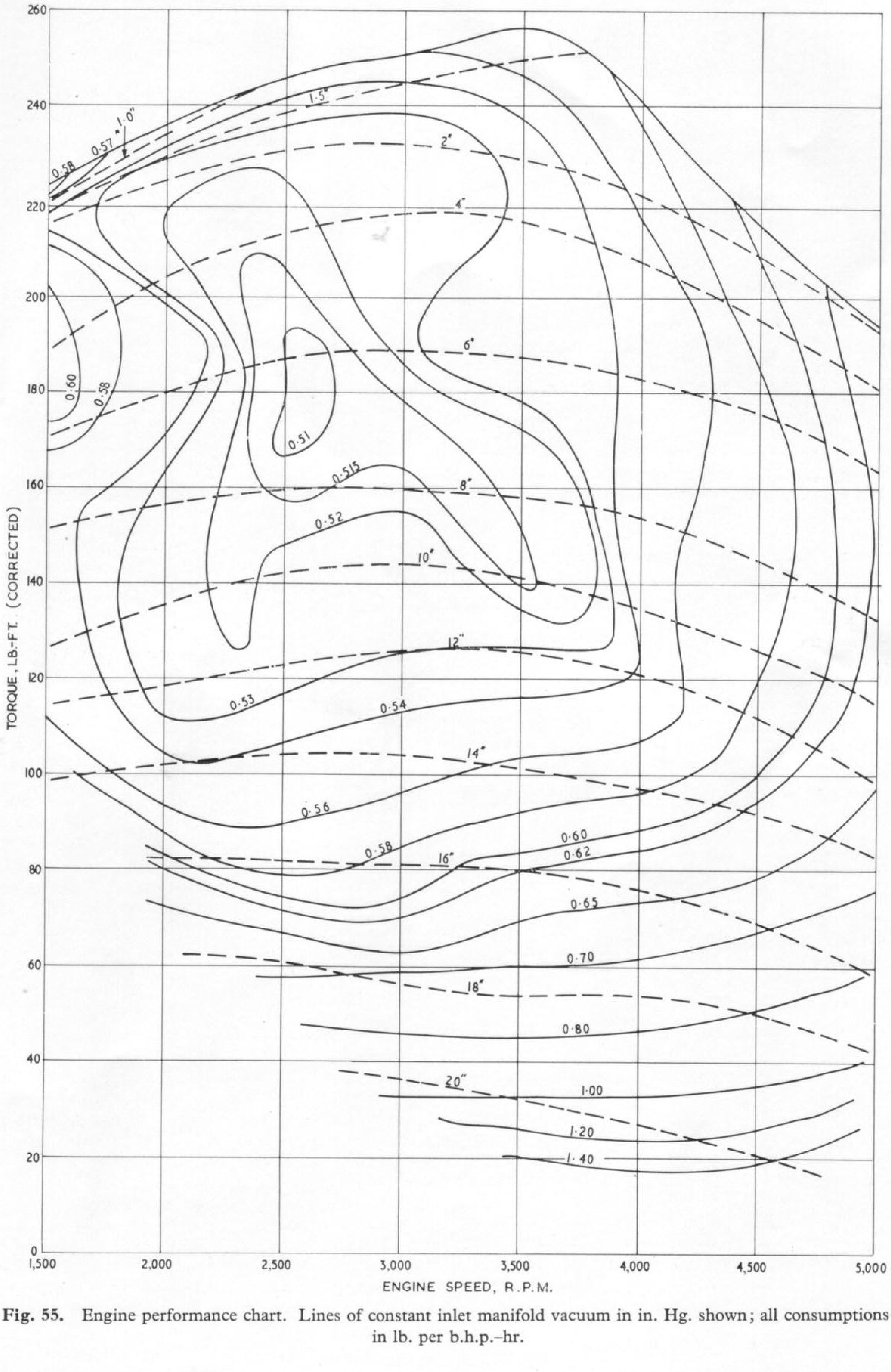

Fig. 55. Engine performance chart. Lines of constant inlet manifold vacuum in in. Hg. shown; all consumptions in lb. per b.h.p.–hr.

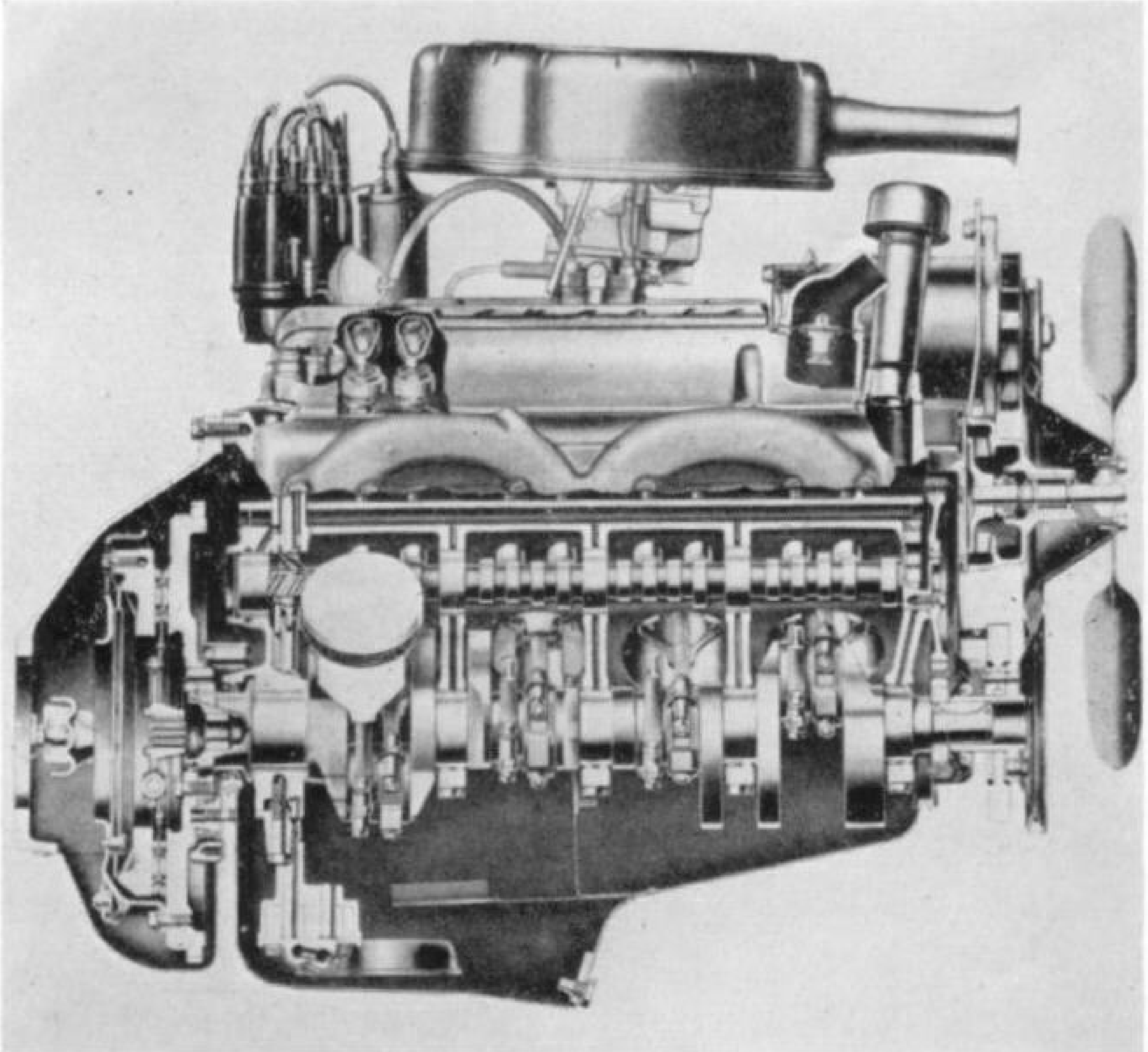

Fig. 56. Longitudinal cross-section of engine.

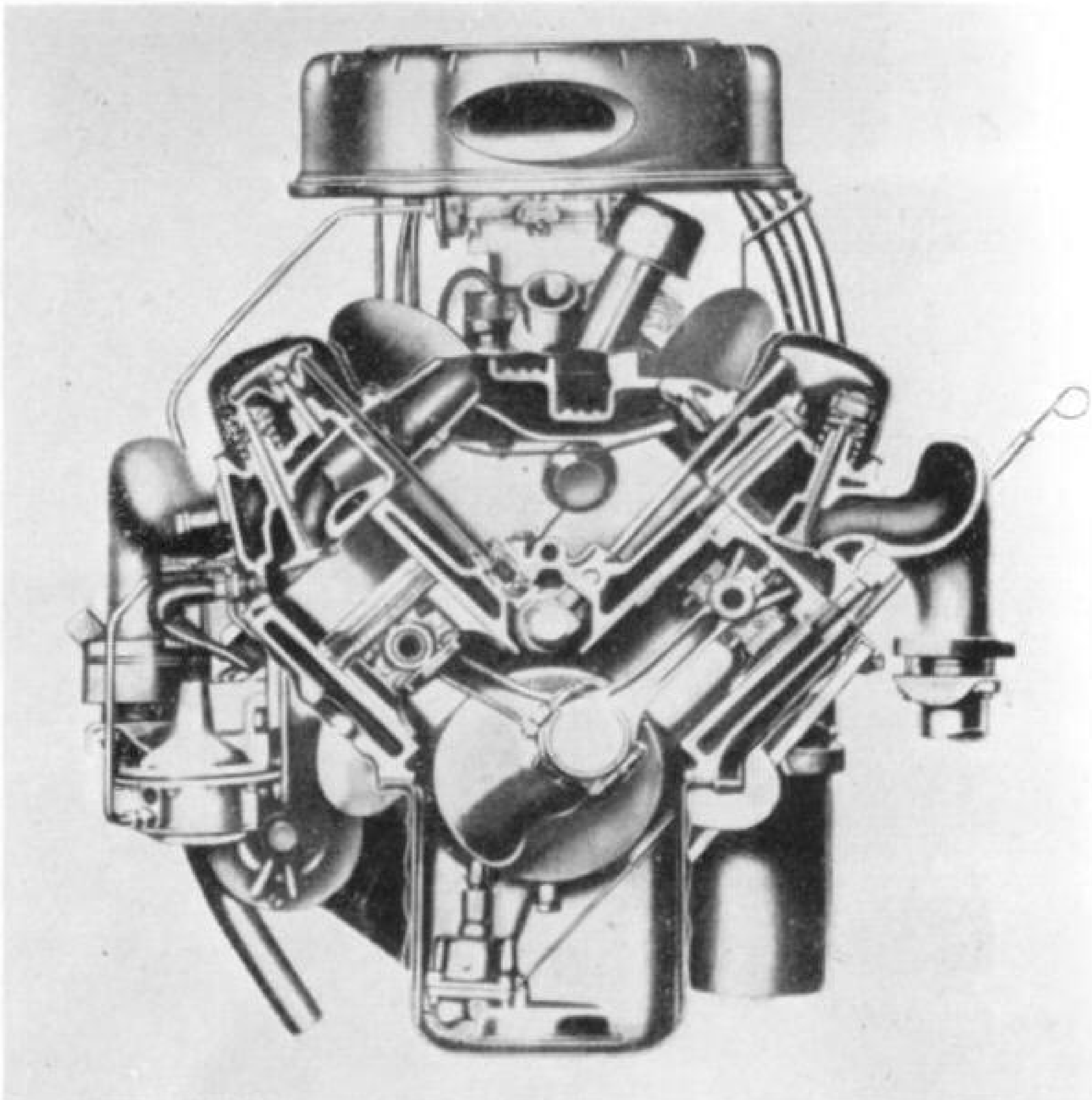

Fig. 57. Transverse cross-section of engine.

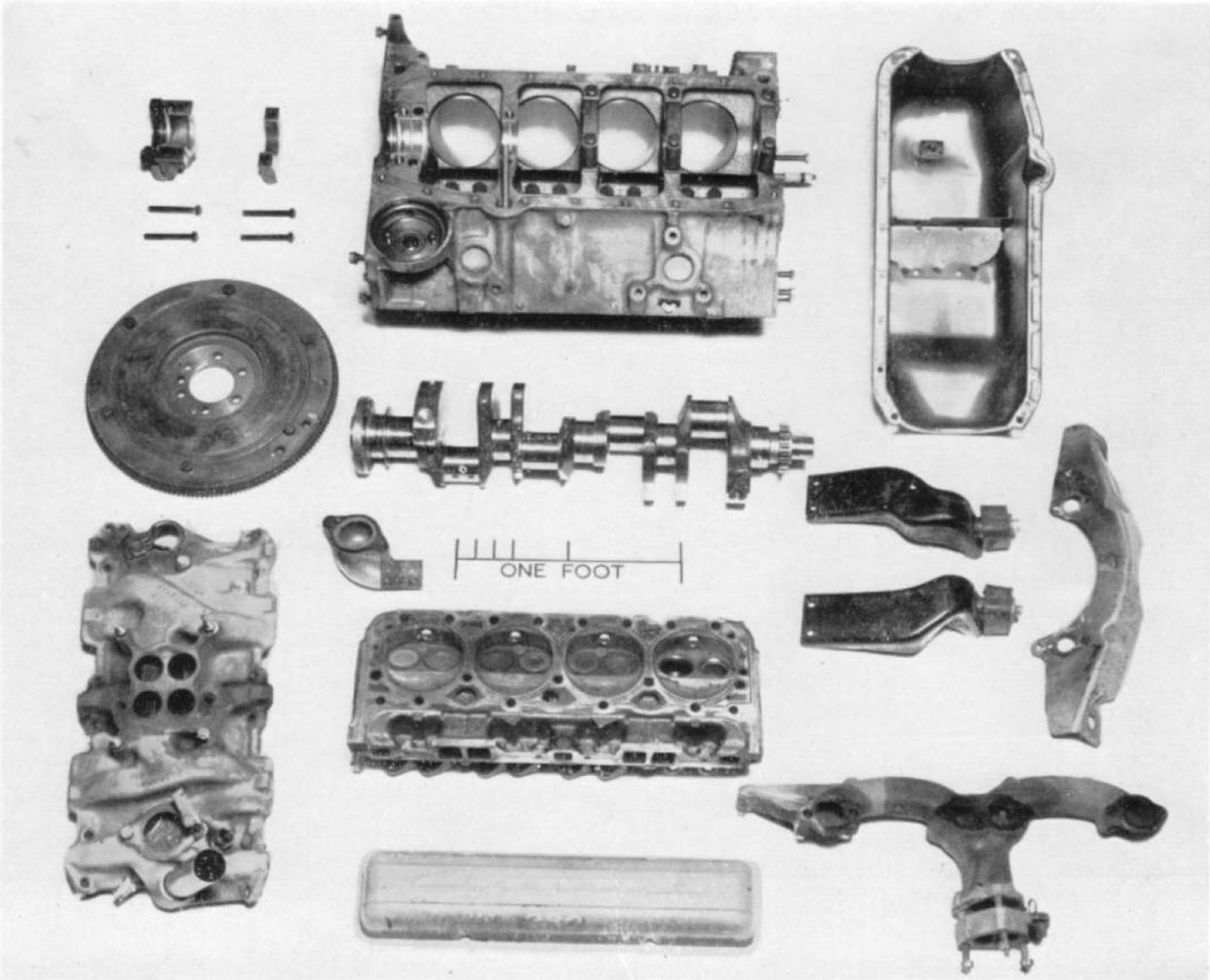

Fig. 58. Engine components.

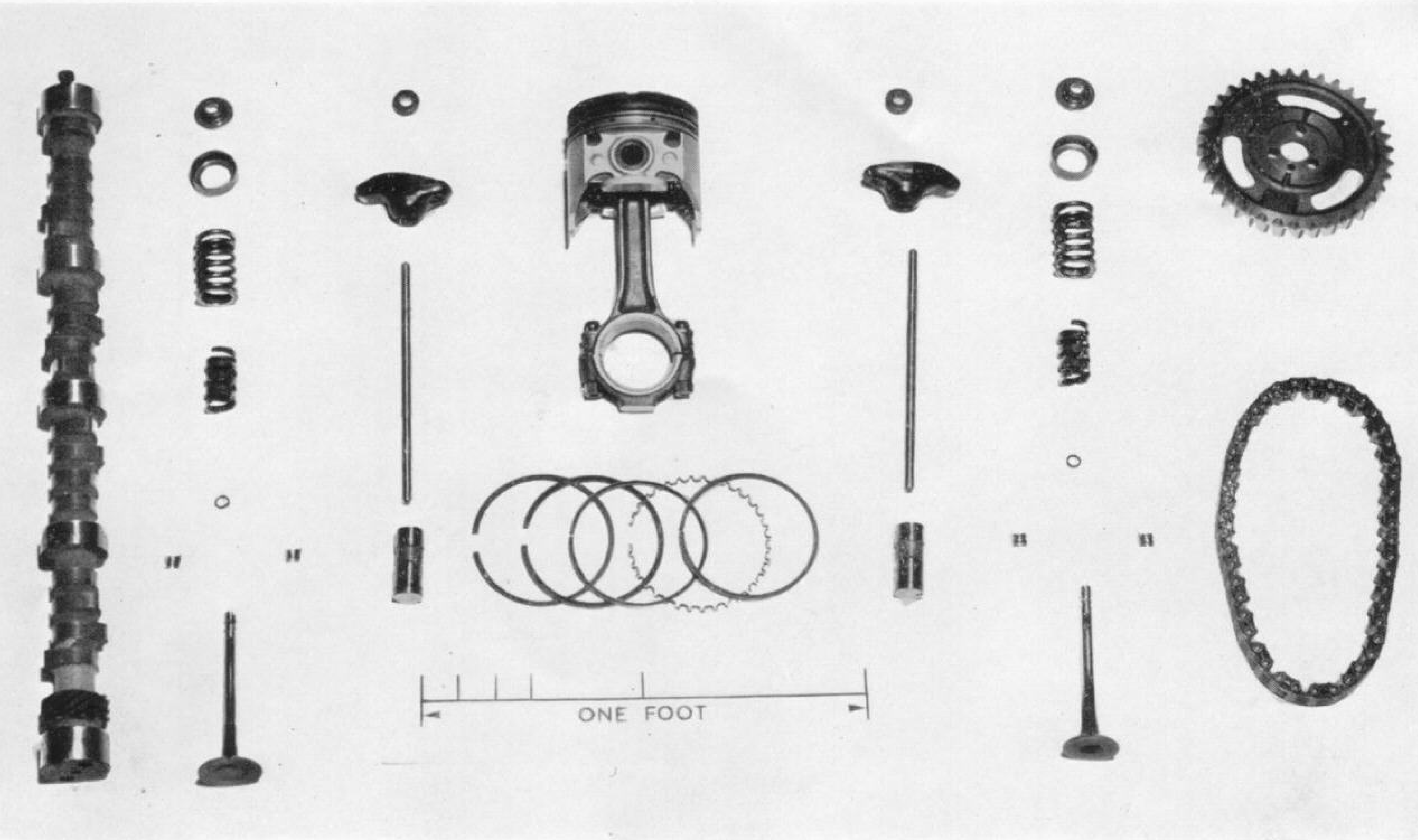

Fig. 59. Piston, connecting rod and valve gear.

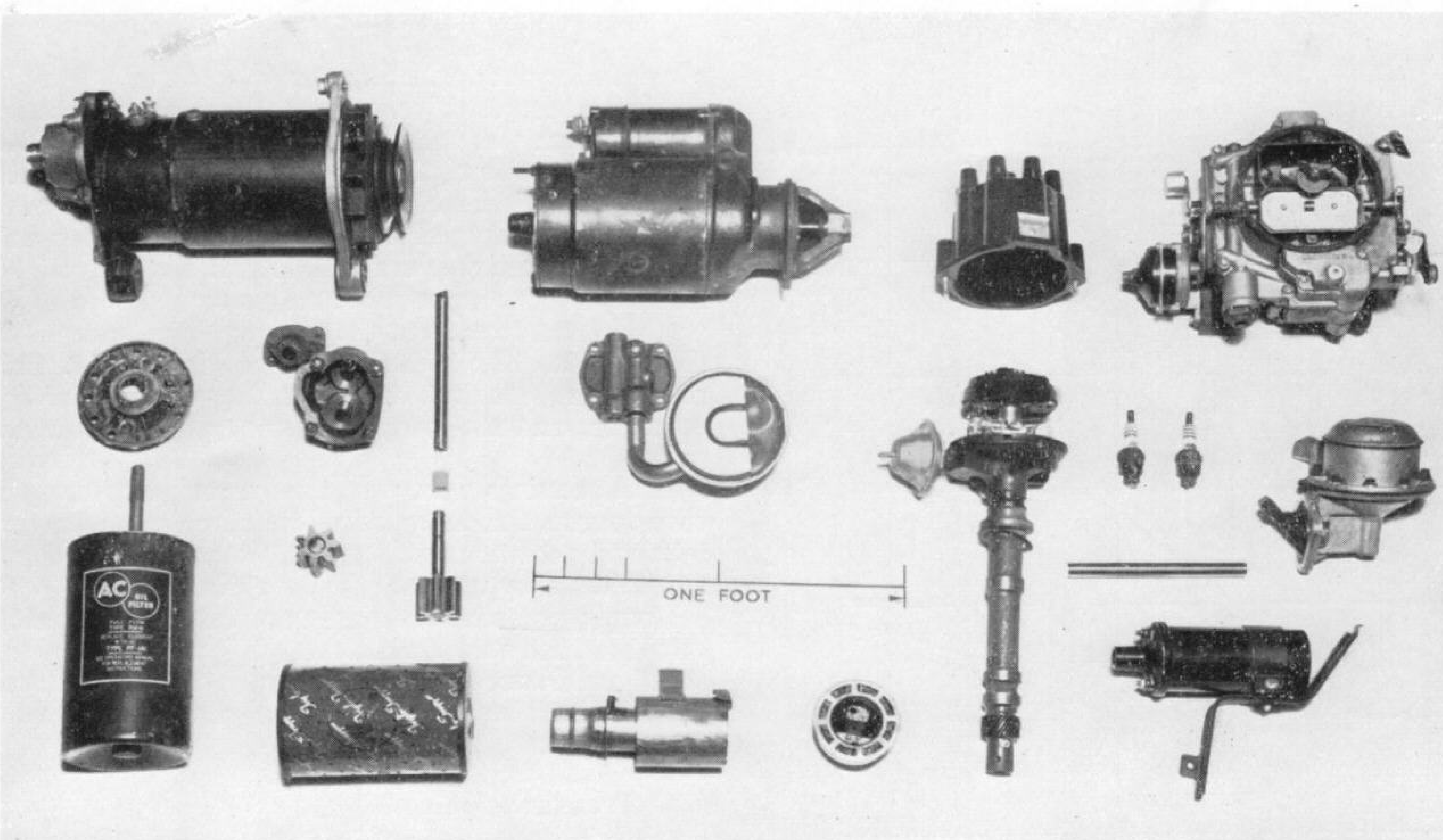

Fig. 60. Engine ancillaries.

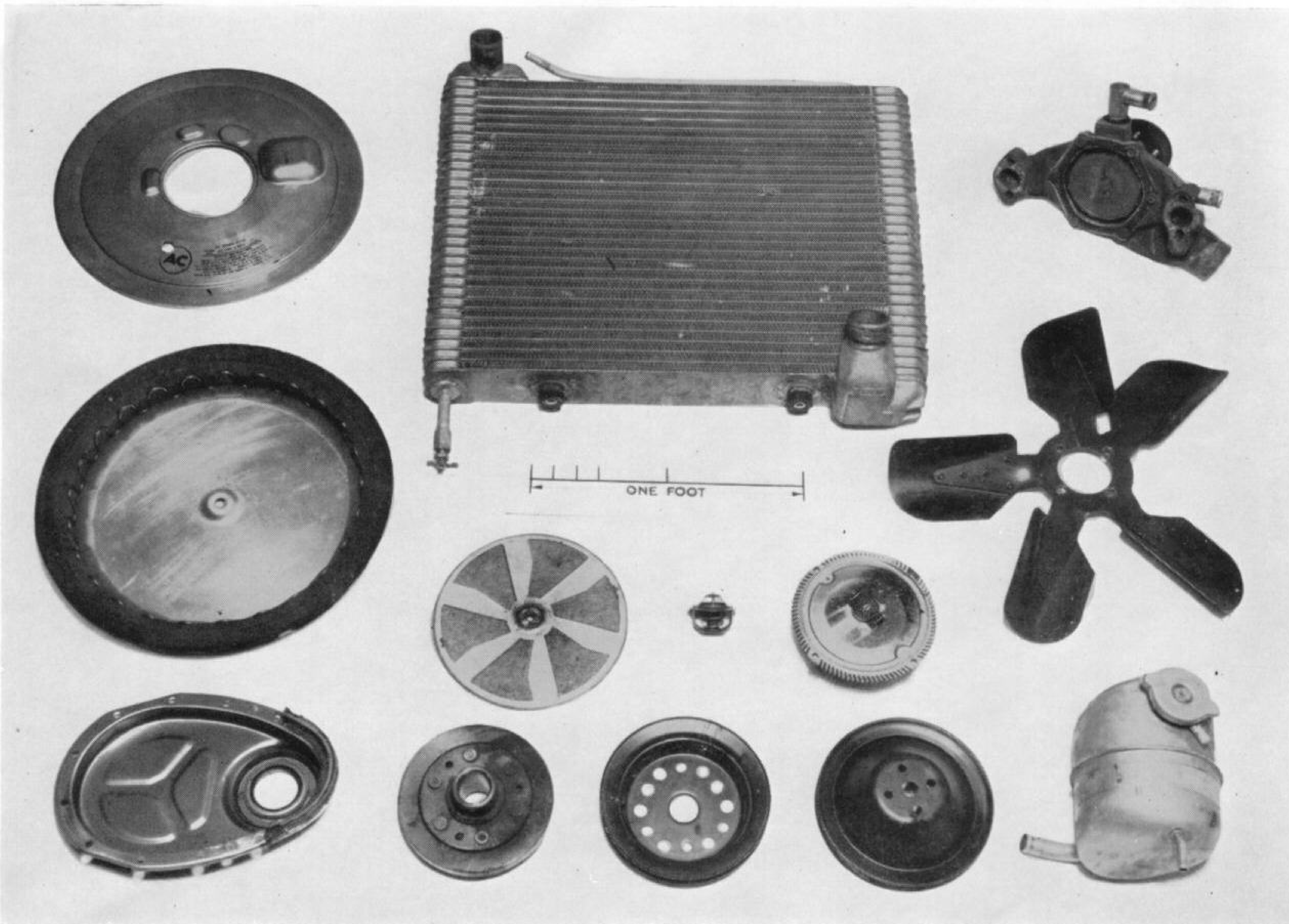

Fig. 61. Radiator, cooling and air-cleaner parts.

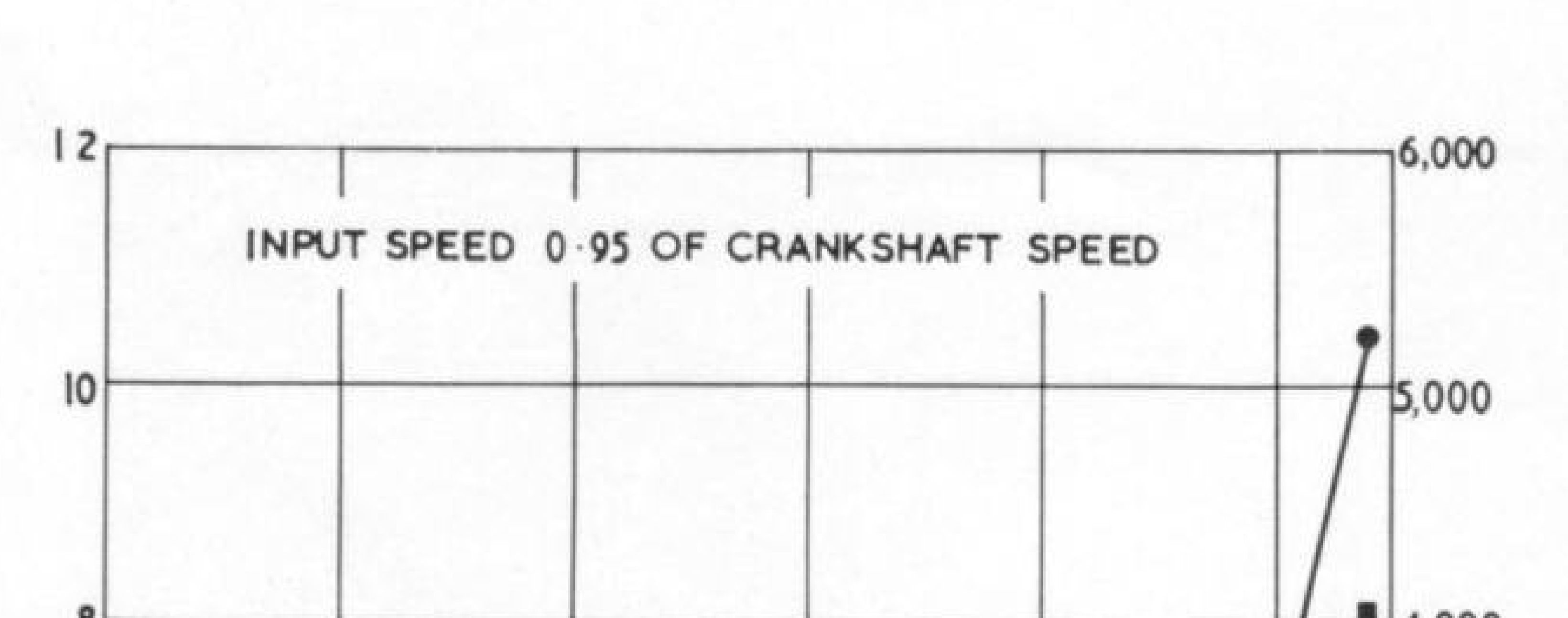

Fig. 62. Cooling fan tests.

alloy header tank. Cooling was assisted by a five-bladed fan with a viscous drive, controlled by means of a bi-metal spring which was sensitive to the temperature of the air leaving the radiator. The results of tests carried out on the fan are shown in Fig. 62, and it will be seen that even when nominally disengaged there was sufficient drag in the coupling to drive the fan at 1,800 r.p.m. and absorb 2 b.h.p. At 3,000 r.p.m. input speed an air temperature of 85°C. was required to engage the viscous drive, and 45°C. to disengage it. The higher the input speed, the higher the temperature required to bring the viscous drive into operation, and the lower the temperature for disengagement.

Steel pressings were used for the rocker covers, timing cover, sump, fan and pulleys. Cast iron was used for the inlet and exhaust manifolds and water pump casing, and aluminium alloy was used for the air intake case.

Examination after dismantling revealed that one exhaust valve head had a small radial crack in it and one valve spring shield had fractured circumferentially. All the valve spring dampers had been fouling on the valve spring retaining plates, fracturing two dampers.

4.2 Transmission

Power was transmitted from the engine through a rod-operated single dry plate clutch, a four-speed all-synchromesh gearbox and a single-piece open propeller shaft to a

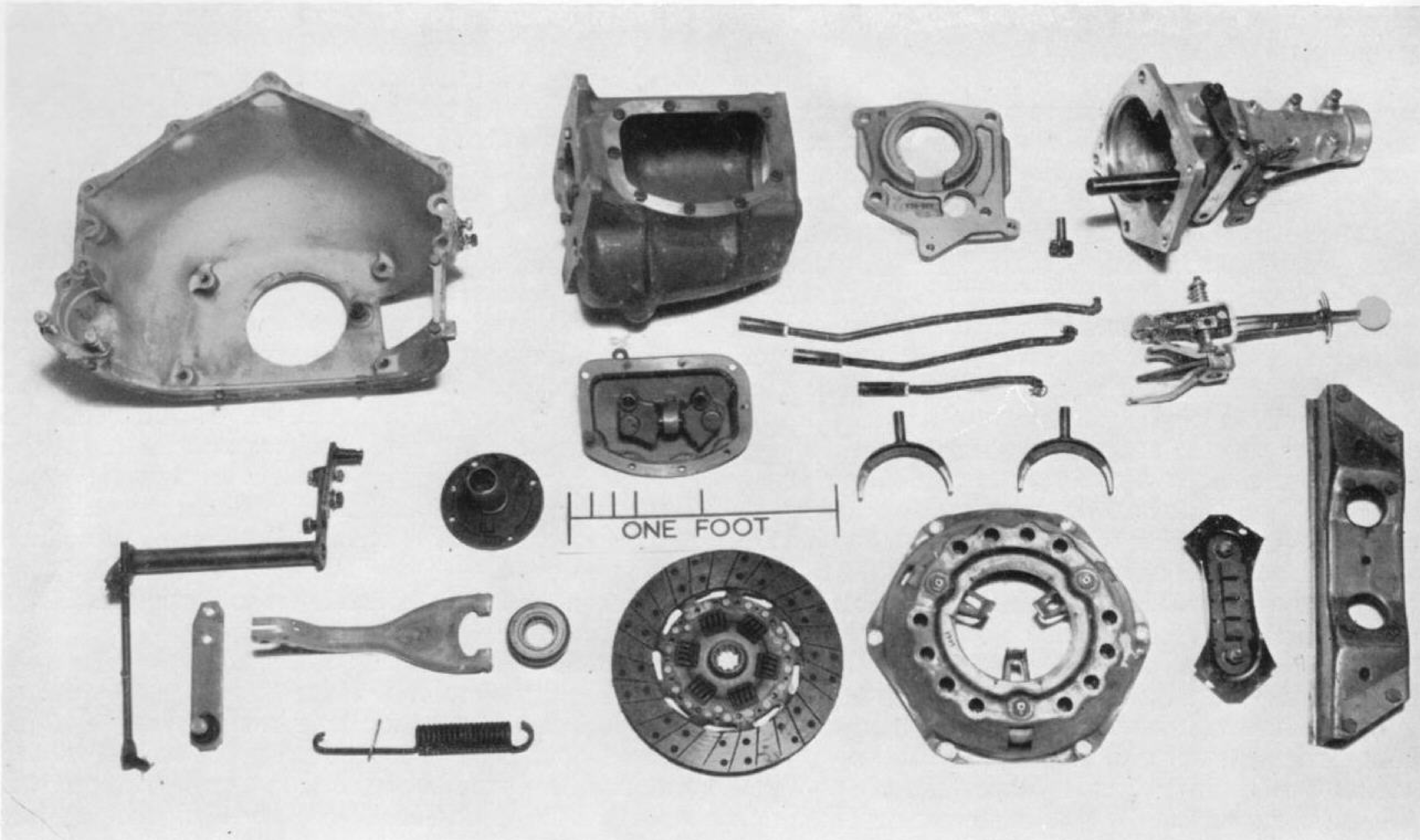

Fig. 63. Gearbox casing, clutch housing and clutch.

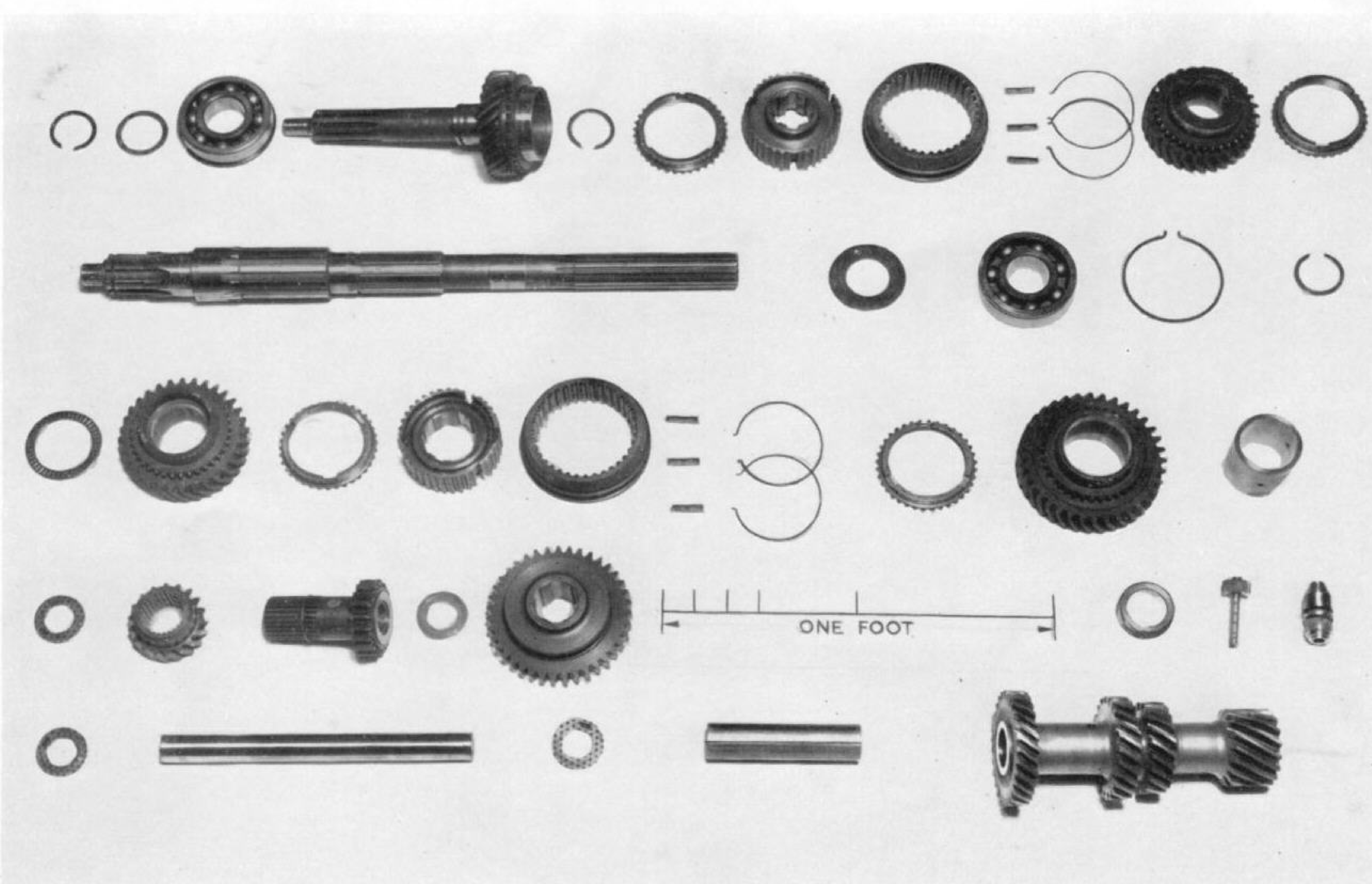

Fig. 64. Gearbox parts.

hypoid rear axle, with semi-floating half shafts. The component parts of the transmission are shown in Figs. 63 to 65.

The clutch housing, gearbox rear bearing carrier and gearbox extension were made of aluminium alloy, and the gearbox casing and cover were cast iron. The length of the gearbox casing was 9·5 in., and the mainshaft to layshaft centre distance was 3·25 in. Ball bearings supported the mainshaft, whilst the layshaft was carried in double row needle roller bearings. Baulking ring type synchromesh was provided on all four forward gears, all of which had helical teeth. Reverse gear was carried in the extension, which also formed the rear engine mounting. The gear change lever was floor-mounted, and was provided with a positive lock to prevent accidental engagement of reverse. Three rods were used, connected to two gear change-levers on the side of the gearbox casing and one on the extension.

The 2·5 in. dia. propeller shaft was 34·5 in. long between the centres of the Spicer needle roller universal joints. Fore and aft movement was accommodated by an internal spline on the front universal joint, sliding on the gearbox output shaft.

The rear axle pinion was offset 1·5 in. from the centreline of the 8·25 in. dia. crown wheel, which was mounted on a cast-iron carrier integral with the differential housing. The axle casing was fabricated from steel pressings.

It should be noted that the bracket supporting the clutch pedal arm was adjustable, allowing for short or long clutch pedal travel (nominally 4·5 and 6·5 in.). Experiment showed that the short travel position produced harsh clutch engagement, and also moved the pedal out of reach of shorter drivers, even with the driver's seat moved to the front of its adjustment. All testing was therefore carried out at the long travel position.

4.3 Rear Suspension

The assembled suspension is shown in Fig. 12 and the dismantled parts in Fig. 65.

The springs were attached to the axle casing by U-bolts; brackets and rubber bushes were used at the front ends, with shackles and rubber bushes at the rear. The four spring leaves were 2 in. wide, and full-length canvas interliners were used. Steel clamps with rubber washers enclosed both ends of the second leaf, whilst a similar clamp secured the front end of the third leaf to the main and second leaves. Axle movement was restrained by canvas check straps riveted to brackets welded to the chassis, and by bump rubbers on steel plates bolted to the underside of the chassis side-members.

An anti-roll bar was suspended from the chassis, with its ends secured to the spring-to-axle plates; the same plates also carried bolts for the eyes at the lower ends of the hydraulic dampers. The studded upper ends of the splay-mounted dampers were secured to a cross-member welded across the frame kick-up. Radius rods, with rubber-bushes at each eye, ran aft in line with the springs from brackets on the frame to brackets welded onto the axle tube.

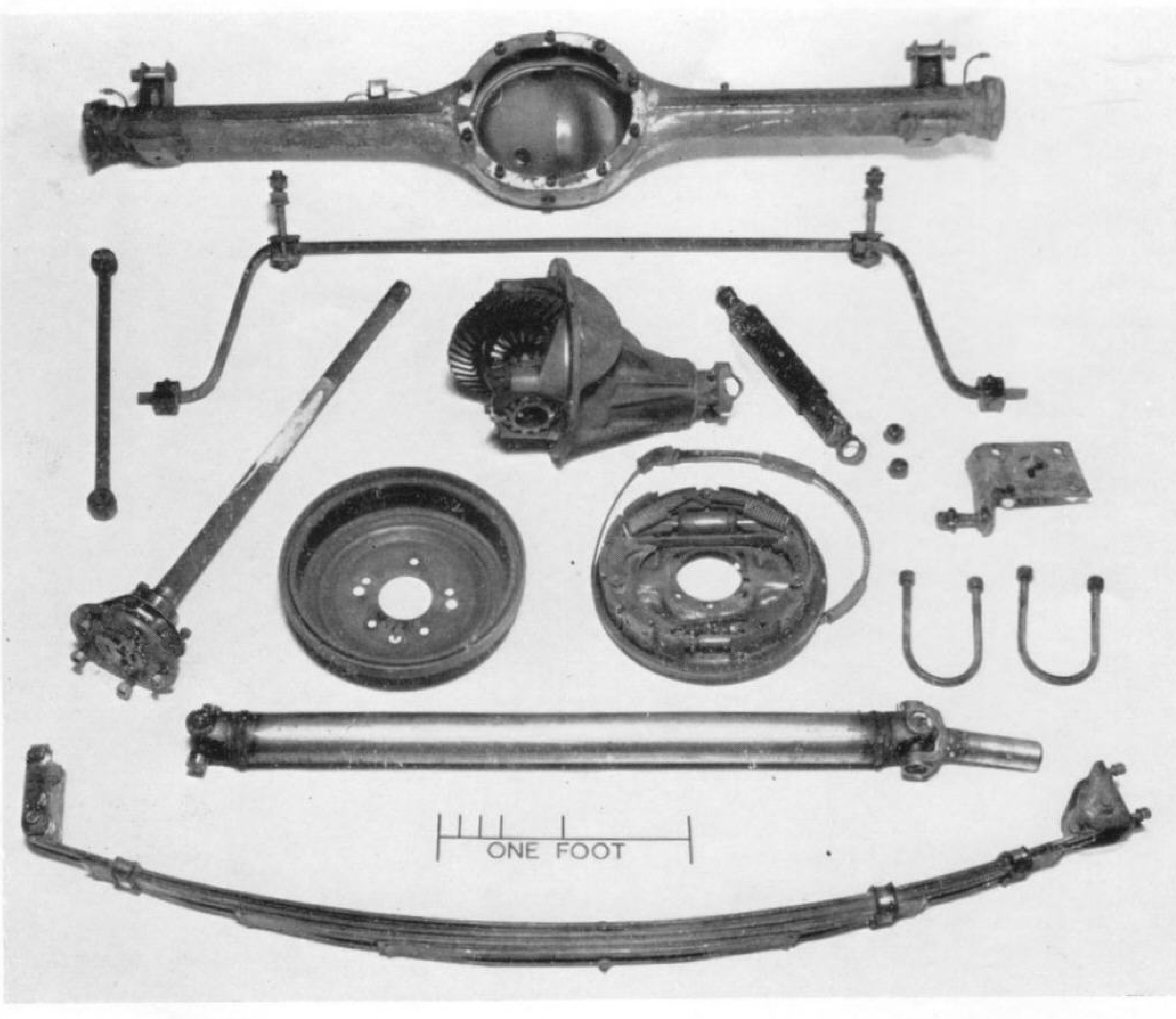

Fig. 65. Rear axle, suspension and brake parts.

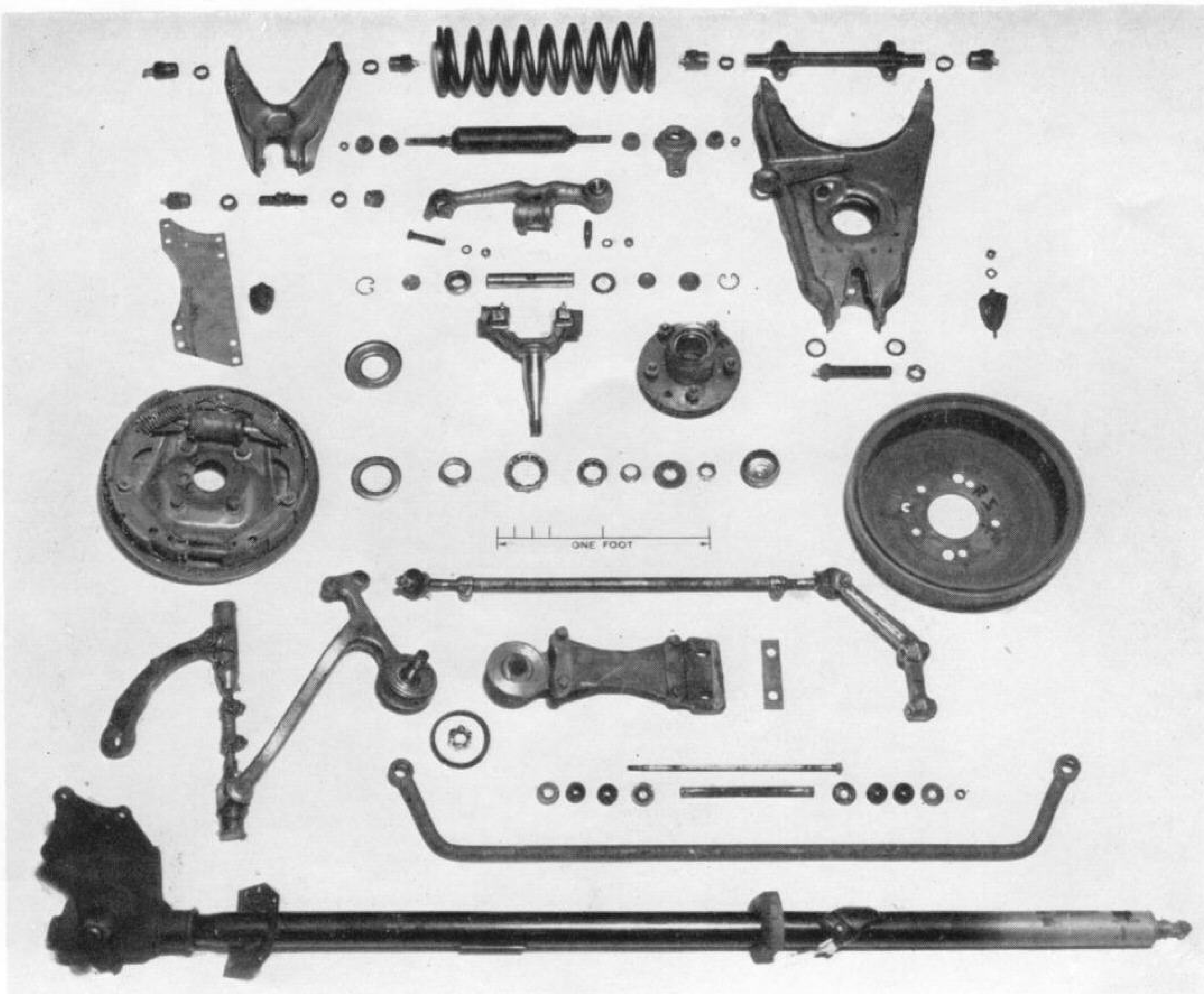

Fig. 66. Front suspension, steering and brake parts.

4.4 Front Suspension and Steering

The assembled suspension and steering is shown in Fig. 11, and the component parts and the cross-member appear in Figs. 66 and 67 respectively.

The independent front suspension was of the short upper arm, long lower arm design. Both arms were steel pressings of wishbone shape and were mounted in screwed bushes to a fabricated steel cross-member bolted to the chassis. The upper ends of the coil springs abutted on turrets integral with the cross-member, whilst the lower ends were located in the lower wishbones. Forgings carried in trunnions at the outer ends of the suspension arms supported pins on which the stub axles were pivoted.

Telescopic dampers with stud ends were carried in rubber bushes, passing through the coil springs, with plates attaching the lower ends of the dampers to the lower suspension arms. An extension was welded to the lower suspension arms for attachment of anti-roll bar links. The bar was supported in rubber bushes bracketed to the top of the chassis. Rubber bump stops were attached to the lower wishbones, and rubber rebound stops were fixed to the detachable cross-member, abutting on to the upper suspension arms.

A recirculating ball steering gear at the end of the steering column was connected to a pivoted link through a drop arm and tie rod. The ball bearing pivot for the link was on the longitudinal centre line of the car, with its support bolted to the detachable front cross-member. Equal length rods connected the link to the two steering arms through ball joints.

4.5 Brakes

The front and rear brake assemblies are shown in Figs. 11, 13 and 14, and the dismantled parts are seen in Figs. 65 and 66.

The hydraulic, duo-servo, single-pivot type brakes, operating on all four wheels, were actuated by a pendant pedal connected to a master cylinder mounted on the forward side of the bulkhead. The four brake drums were of the composite type, and each carried a coil spring wrapped around its periphery, presumably for anti-squeak purposes.

The linings were sintered metallic pads, each pad of rectangular shape, 2 in. long $\times$ 1 in. wide, held on the shoe by two semi-tubular brass rivets. The primary shoes at both front and rear carried six pads each, whilst the secondary shoes were fitted with ten pads. Microscopic examination showed the presence of iron and probably asbestos, together with a copper content which amounted to 3·3% by analysis.

A T-shaped twist-to-release parking brake handle was situated on the left side of the instrument panel, with a cable connection to a lever supported on the chassis cruciform member. Individual cables ran to each rear brake backplate from this lever, passing below the semi-elliptic springs.

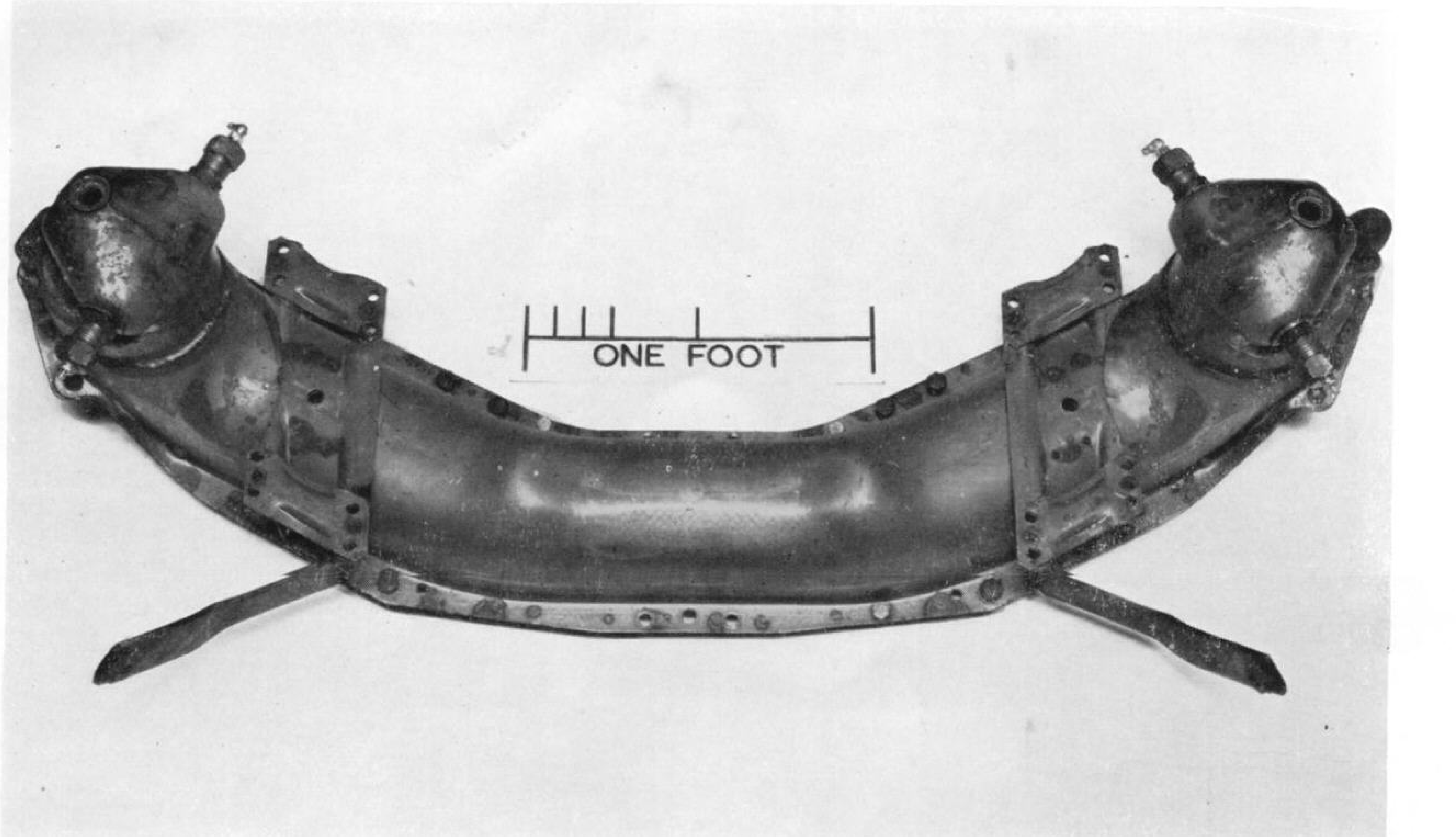

Fig. 67. Front suspension cross-member.

4.6 Chassis Frame

The frame is shown in Fig. 68.

The two side-members were of box-section throughout their length, fabricated from two channel sections in each case. An I-section cruciform was welded in position, with channel-section stiffeners running forward to the front of the frame side-members. The cross-member at the rear kick-up was of top hat section, and the rear cross-member was of inverted top hat section with a closing plate across the flanges. This rear member was extended to carry the rear ends of the semi-elliptic springs, whilst outrigged brackets were provided for body mountings and the front hangers for the rear springs.

A front cross-member, fabricated from steel pressings, was bolted in position to carry the front suspension (see Fig. 9). Tapered plates were inserted between cross-member and frame, arranged to lower the rear of the cross-member. The body was secured to the frame at twelve locations, whilst additional body supports were provided on the chassis-to-bumper mounting brackets at both front and rear.

On dismantling, one lug at the battery support tray was found to be fractured.

4.7 Body

All the body panels, apparently, are made by outside suppliers to Chevrolet specifications. The material for these panels is stated to consist of glass fibre chopped into half-inch strands (making up 40 per cent of the finished part, by volume), polyester resin, pulverised clay filler and a catalyst. A bonding mixture used for assembling the body employs the same materials except that powdered asbestos is substituted for glass fibre. Further bonding mixture contains promoter instead of catalyst, and the proportions of the two determine the curing time. Mixing is carried out in a paper cone, with added lamp-black to show the thoroughness of the mixing which is aided by an "egg-beater." The tip of the cone is cut off, the unmixed portion squeezed out, and the remainder of the mixture applied to the surface to be bonded. Some typical bonded joints are shown in Fig. 48.

Assembly of the panels is started from the underbody, extending from the toe-board to the rear of the body and incorporating the inner rear wheel arches—the largest single panel in the structure. Steel reinforcements are incorporated as shown in Fig. 69, but glass fibre is not bonded to the steel. Attachment is by aluminium rivets, or by riveting a bonding strip to the metal, then bonding the strip to the main panel.

The main panels are made in matched male and female dies, and the design thickness is generally 0·1 in., claimed to be roughly the equivalent of 0·036 in. steel. Measurements on the car showed thicknesses to be between 0·1 and 0·12 in. at most locations, but with isolated points varying from 0·08 to 0·15 in. These measurements were made without cutting the body, and it is possible that sections through the material would show greater variations.

A large panel such as the underbody is made in dies through which steam at 120°C. is circulated, with a curing time of approximately three minutes. For bonding the joints, the curing times are varied, but a typical time would be about five minutes. More than four gallons of bonding mixture are used on each vehicle.

After assembly, all the bonded joints and the panels are

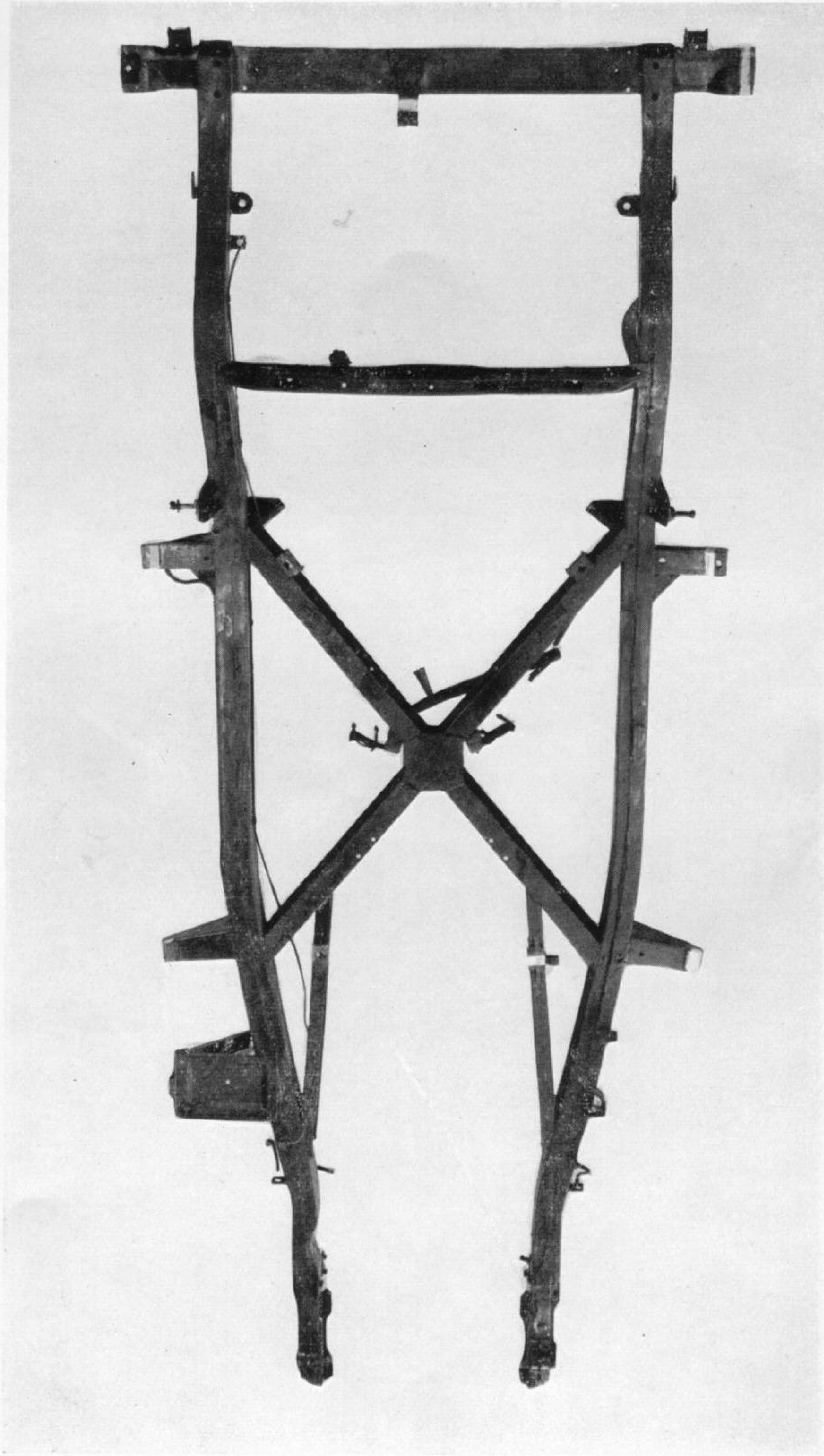

Fig. 68. Chassis frame.

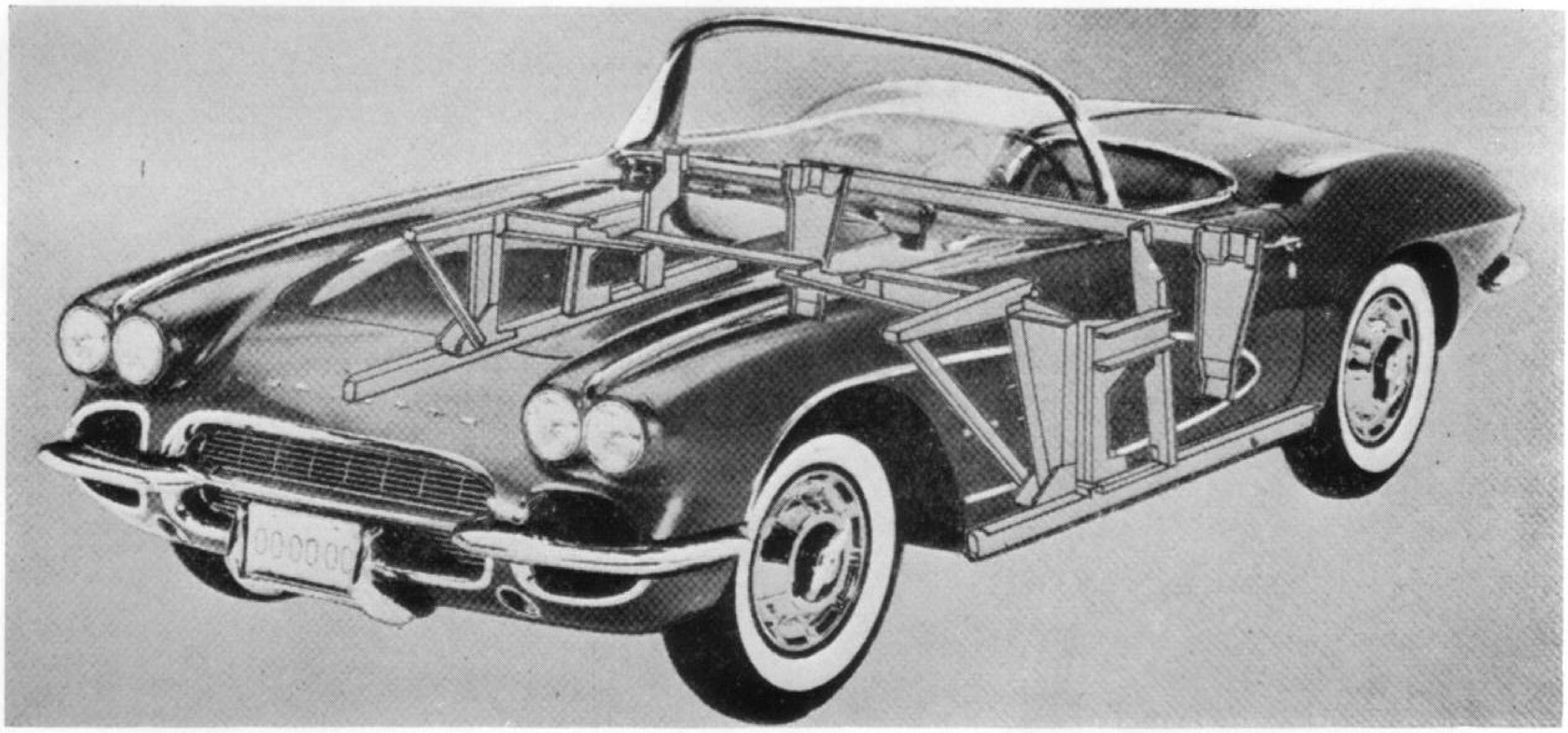

Fig. 69. Body showing steel reinforcements.

Fig. 70. Passenger compartment with trim removed.

sanded to a smooth surface. A putty rub is applied to cope with surface imperfections, and two coats of primer paint are applied before baking for 90 minutes at 88°C. After wet sanding and drying, a coat of sealer and the first coat of acrylic lacquer are applied and baked. Dry sanding is followed by application of the second and third coats of lacquer and baking at 77°C. for 30 minutes before the final polishing.

The windscreen assembly had die-cast side posts, and could be entirely removed from the body. The soft top was pivoted at each door lock pillar, and was secured in the " up " position by two clamps on the top of the windscreen frame and two more on the storage compartment lid. When out of use, the top folded down completely out of sight into the storage compartment above the fuel tank, and was covered by the fibre-glass lid. This lid was released by a push-button between the seats; lifting it when the luggage compartment cover was open caused the latter to close, and *vice versa*. Brackets and equipment were attached to the glass fibre by bolting through or by drive screws, the threads cut by these screws proving to lack endurance. Detail views of the construction of the passenger compartment and of the luggage and spare wheel compartments are shown in Figs. 70 and 71.

When the car was received, minor cracks were discovered in the resin-bonded glass fibre body at several places, almost invariably related to bracket attachment points, particularly where rivets had been used. During the early mileage, a few more such cracks became noticeable. No further deterioration was detected during smooth-road testing or after being left to weather out-of-doors in English summer and winter conditions. Evaluation of the vehicle's behaviour on various surfaces on the Proving Ground immediately caused further cracks to develop and drive screws and bolts to work loose; in view of this no pavé endurance test was attempted. Thus, the body was still in generally good order when the vehicle was dismantled, but a broken rivet was found at the internal mirror strengthening bracket and the bracket supporting the windscreen washer vacuum tank had fractured.

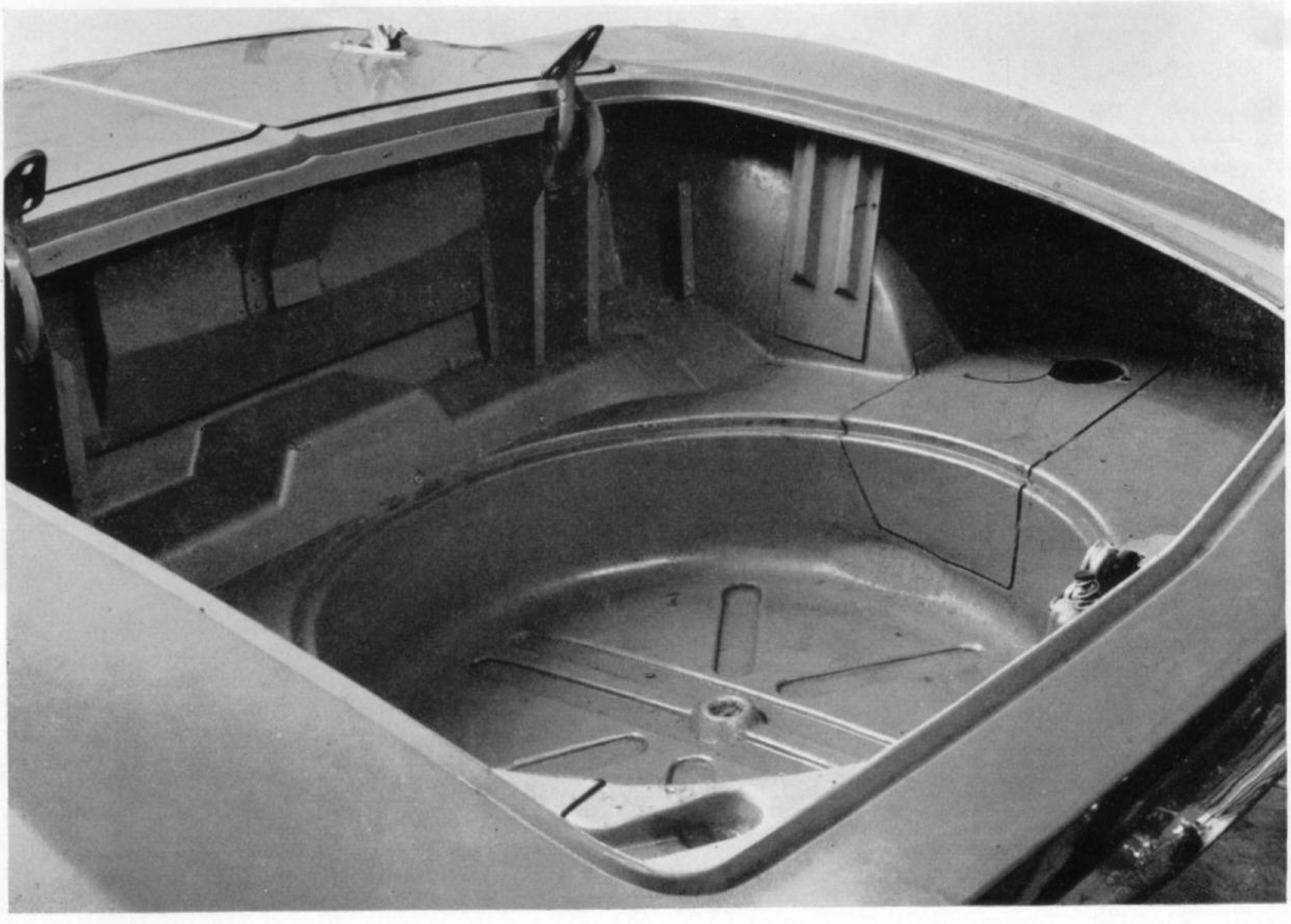

Fig. 71. Luggage compartment with trim removed.

APPENDIX

This Appendix is intended to supply details of the test methods used to obtain the results given in the report. The methods used are described in the following numbered sections of this Appendix, and references are made to these numbers in the related sections of the report. It is intended to adopt these methods as " standards " for future work, although they will be amended as a result of experience if and when improved methods of test are evolved.

A test load of 450 lb., including the driver, is carried throughout the measuring and testing unless otherwise stated. It would be desirable to specify " standard " conditions where test results may be affected by the road or weather but, as control is impracticable, the conditions at the times of making the tests are included with the results to which they refer. Such variations will need to be taken into account in making exact comparisons between different vehicles, but every effort will be made to reduce such variations to a minimum.

I. Dimensions

The terms " Left " and " Right " used throughout the report refer to the respective sides of the vehicle as viewed from the driving position. The system of measurement used for body internal dimensions is based on certain datum points as recommended in M.I.R.A. Report No. 1956/1, on visibility from vehicles. These points have been used as references for space dimensions, and the method of establishing them is shown in Fig. A. It will be noted that the longitudinal dimensions are referred to vertical tangents to the seat rests and the vertical dimensions are taken from undeflected seat cushions. In order to avoid lengthy descriptions of the method of obtaining dimensions, a letter key has been used in Fig. B. Where the dimensions shown on this diagram are presented in the body of the report they are marked with an asterisk.

II. Frontal Area

The frontal area is measured photographically. The plate camera is placed at half the height of the vehicle and 200 ft.

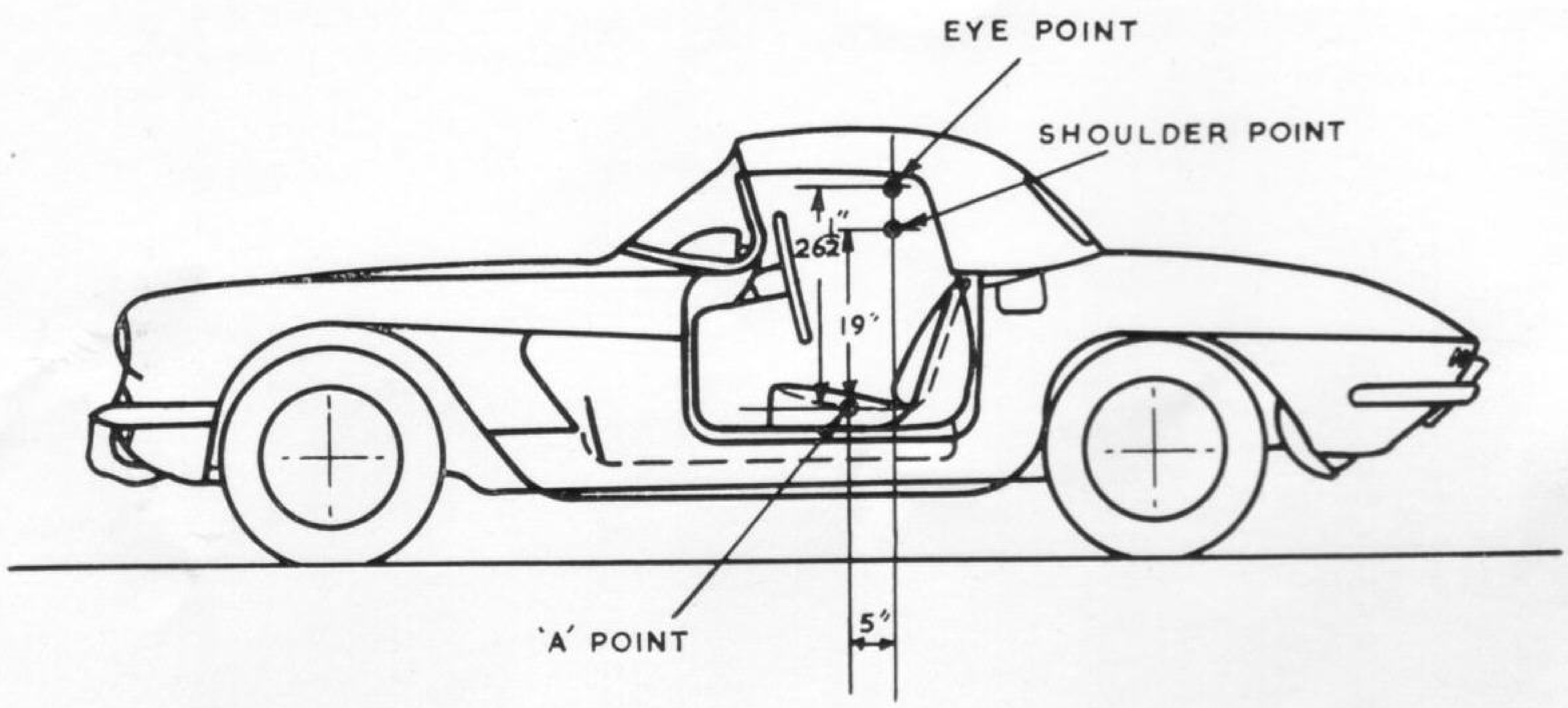

Fig. A. Illustration of " A ", shoulder and eye points. The tranverse position of the " A " point is in line with the steering wheel centreline.

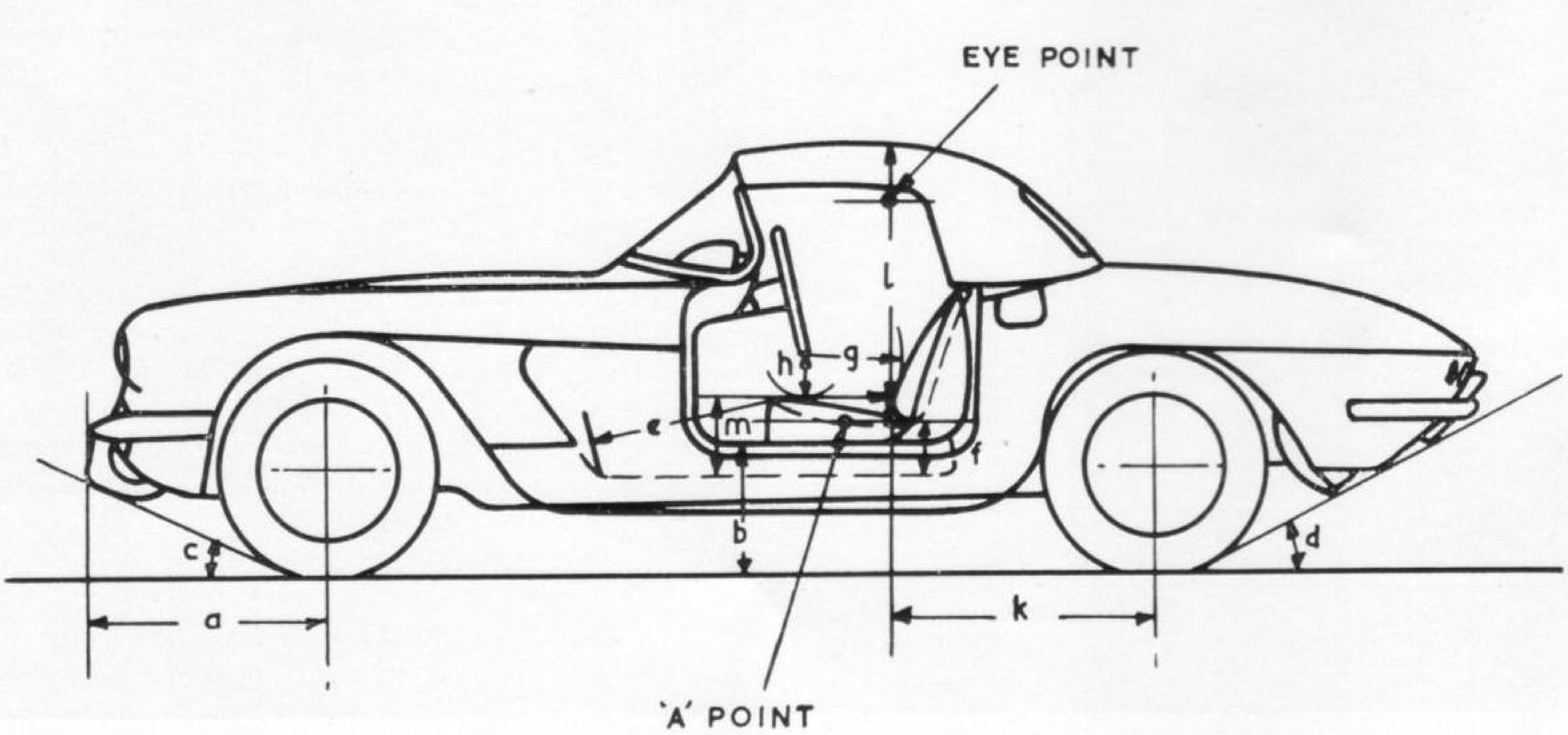

Fig. B. Dimension Key.

in front of it. The scale of the resultant photograph is established by means of the known dimensions of the vehicle and 6 ft. scale bars placed alongside. Planimeter measurements of the vehicle outline, including the underside, then establish the frontal area.

III. Tyre Rolling Radius

The rolling radius of the tyres is measured at pressures recommended by the manufacturer. A plumb line is suspended from the centre of each road wheel, and marks are made on the tyres and on the road surface vertically below the wheel centres. The vehicle is rolled slowly forwards, and further marks are made on the road surface to indicate the completion of 10 revolutions by each wheel. Rolling radii are calculated individually, and mean values for the front and rear wheels, or for all four wheels, are quoted.

IV. Turning Circles

Turning circles are measured with the vehicle rolled slowly forwards at full lock. The dimension " between kerbs " refers to the circle described by the outer sidewall of the outer front tyre, and the dimension " between walls " refers to the circle described by the outermost part of the vehicle.

V. Steering Geometry

Front wheel alignment, camber, castor and kingpin inclination are measured with standard Dunlop equipment.

VI. Weights

Vehicle weights and weight distribution are measured with the M.I.R.A. platform weighing cells (see M.I.R.A. Bulletin No. 2, 1958).

VII. Capacities

Fluid capacities are determined by direct measurement with calibrated containers.

VIII. Speedometer Calibration

The speedometer is calibrated, at indicated 10 m.p.h. increments, up to the maximum speed of the vehicle, by use of the M.I.R.A. Electronic Timing Equipment (see M.I.R.A. Bulletin No. 1, 1958). The errors in this method are governed by the accuracy of reading the vehicle speedometer.

IX. Distance Recorder Calibration

The recorder is calibrated by driving the vehicle at steady speeds of 20, 40 and 60 m.p.h. for 10 laps along the measured line of the High Speed Circuit. The errors in this method are governed by the accuracy of reading the vehicle distance recorder.

X. Maximum Speed

The vehicle is timed by stop watch over full laps of the High Speed Circuit until three successive laps are covered in times varying by less than 1 per cent. After an interval, this procedure is repeated and the result given is the mean of the three fastest recorded laps. The peak speed reached is invariably greater than the mean lap speed quoted; this is due to variations in weather conditions and in the level of the circuit. Determination of the speed reached is within 1 per cent, but variations due to differences in weather conditions, road conditions, individual cars, *etc.*, are not controlled.

XI. Acceleration

Accelerations are measured electronically, using the fifth wheel digital technique, similar to that used for measuring drag deceleration (M.I.R.A. Bulletin No. 1, 1959). For acceleration from a standstill, moving away from rest and gear changing are accomplished as rapidly as possible without abuse of the transmission. Preliminary tests are made to establish the most suitable road speeds for gear changes. The acceleration obtained in each gear is measured using the widest practicable range of engine speed, and the recorder is operated continuously.

The derived results from the tests enable a curve of speed against time to be drawn and from this curve a graph of acceleration against time is obtained.

All results quoted are obtained from a mean of measurements of at least one run in each direction. The digital counting technique is accurate to within ± 1 count.

XII. Fuel Consumption

Fuel consumption measurements are made under the following conditions:—

(*a*) At a series of steady speeds over the full speed range of the vehicle, using the minimum throttle opening required to maintain each steady speed over a complete lap of the High Speed Circuit. These results are referred to as " minimum consumption figures " and are the average of at least three tests.

(*b*) At the same series of steady speeds, and on the same circuit as (*a*), but at full throttle, speeds being controlled by brake application. These tests are made over shorter distances ($\frac{1}{2}$ mile when possible) to avoid overworking the brakes. These results are referred to as " maximum consumption figures " and are the average of at least three tests.

(*c*) On a selected public road route including towns with heavy traffic, hills, busy main roads and less frequented roads. Reasonably fast driving, consistent with the characteristics of the vehicle, is employed during such running, and the average speed is measured.

The amount of fuel consumed, under all the above conditions, is recorded by an instrument employing two measuring chambers each of 0·0005 gallon capacity, fitted in the fuel supply line. The instrument is operated by pressure from the fuel pump of the vehicle, the change over between the chambers being effected by a slide valve, the movement of which operates a counting unit. This instrument has been shown to have a maximum error of less than 1 per cent. Under condition (*c*), a check measurement is made of the amount of fuel used to replace the quantity consumed during the test.

For (*a*) and (*b*), speeds are indicated by calibrated fifth wheel over the measured distances, but the times taken to cover these distances are measured by stop watch to determine the speeds more accurately.

For (*c*), the distance covered is obtained from corrected readings of the vehicle's mileage recorder and the journey time is measured by stop watch.

XIII. Brake Tests

In all tests, deceleration of the vehicle is taken as a measure of brake performance and the results are presented as fractions of " g ", *i.e.*, acceleration due to gravity.

N.B. The presentation of results as a percentage of

" g " is deliberately avoided, since it is sometimes implied that 100 per cent " g " represents 100 per cent brake efficiency. This is a misleading and, perhaps, dangerous interpretation. Instruments used for measurement are the M.I.R.A. Multi-Channel Pen Recorder (see M.I.R.A. Bulletin, 1950, 4th Quarter), the M.I.R.A. Brake Pedal Load Indicator (see M.I.R.A. Bulletin, 1950, 3rd Quarter), and an indicating U-tube decelerometer.

In the graphical presentation of results, variations in deceleration or pedal load are shown by arrows.

(*a*) *Brakes—Cold performance*

With the gear lever in neutral the vehicle is repeatedly braked to a standstill from 30 m.p.h. at a range of steady pedal loads. Intervals of at least three minutes are allowed between stops to permit the brakes to cool. The results presented are the mean value of at least three tests at each pedal load.

(*b*) *Auxiliary Brake Performance*

The auxiliary brakes are subjected to a test procedure similar to that described above.

(*c*) *Brakes—Speed Effect*

With the gear lever in neutral, the vehicle is braked to a standstill from each of a range of speeds. For each stop the pedal load is that required to produce a deceleration of $0{\cdot}5g$ from 30 m.p.h.—a value determined from the results of the cold performance test. The brakes are allowed to cool between stops and the results given are mean values of at least three stops from each speed.

(*d*) *Brakes—Fade*

With the gear lever in neutral, the vehicle is braked to a standstill from 75 per cent of its maximum speed and a constant deceleration of $0{\cdot}5g$ is maintained throughout. The pedal load required is recorded and 25 stops are made with intervals of 60 seconds between successive brake applications. At the end of this period, the vehicle remains at rest for 10 minutes with the parking brake applied. A further 25 stops are then made in the same manner as before. During this test, brake drum temperatures are measured with calibrated thermocouples, arranged to rub lightly on the braking surfaces.

(*e*) *Brakes—Fade Recovery*

This test follows immediately after the fade test, and brake applications are made at intervals of two minutes. All stops are completed from 30 m.p.h. with the gear lever in neutral, and a constant deceleration of $0{\cdot}5g$ is maintained whilst readings of the pedal loads required are recorded. The test is continued until the deceleration stabilises, or for 30 minutes, and the brake temperatures are recorded.

(*f*) *Brakes—Temperature Effect*

This test is carried out using the front brakes only, and the rear brakes are entirely disconnected from the brake pedal. Measurement of front brake temperatures is by rubbing thermocouples, as already described for the brake fade test.

The temperature is controlled by brake application, and the first test stop is carried out by braking in neutral from 30 m.p.h. at a constant deceleration of $0{\cdot}4g$ starting when the indicated temperature is 100°C. The required pedal load is noted, and the temperature is again recorded after the stop. Further similar stops are completed at increments of 25°C. up to 350°C., or to the highest temperature recorded during the fade test, whichever is the lower. These are immediately followed by similar stops as the temperature falls back to 100°C.

The pedal load for each stop is taken as an indication of the coefficient of friction of the linings, and plotted against the mean temperature for the stop.

(*g*) *Brakes—Water Recovery*

The car is rocked slowly backwards and forwards for ten minutes in sufficient depth of water to ensure thorough soaking of the brake linings. Where this is not practicable, water is applied to the linings by hose-pipe. Stops are then made every 2 minutes from 30 m.p.h. at the pedal load required to produce a deceleration of $0{\cdot}5g$ during the cold performance test. The test is continued until the brakes have stabilised, or for 30 minutes.

(*h*) *Brakes—Delay*

This test is particularly applicable to brakes with power operation, or assistance. It is intended to show the delay period between the application of load to the pedal and the beginning of braking deceleration, and also the period during which deceleration builds up. Similarly, any tendency for the brakes to stay on after release of the pedal may be detected and measured.

Brake pedal operation is carried out as rapidly as possible, and the relevant Multi-Channel Pen Recorder traces of pedal load and deceleration are presented, together with figures for the measured delay times.

XIV. Dust Sealing

One hundred passes, with a minimum time interval between successive passes, are made through the M.I.R.A. 200 ft. Dust Tunnel (see M.I.R.A. Bulletin, 1950, 1st Quarter) with all vehicle windows and ventilators closed. A layer of fine kaolin clay dust on the floor of the tunnel is raised into a dense cloud by the passage of the vehicle, and more dust is raked into the wheel tracks after every 12 to 15 passes. Immediately after the test, any dust penetration is photographed, and the functioning of all components and accessories is checked.

XV. Water Sealing

Six runs are made, if possible, at each of the three speeds of 15, 30 and 45 m.p.h. through the M.I.R.A. Shallow Water Splash (see M.I.R.A. Bulletin No. 2, 1957), which is approximately 75 yds. long, 15 ft. wide and 3 in. in depth. On each occasion, the brakes are tested immediately after leaving the water. At the conclusion of the runs at each speed, an examination is made of water penetration.

XVI. Steering

The vehicle is driven around the M.I.R.A. Steering Pad in a clockwise direction on a constant radius of 108 ft. Complete laps of the pad are timed with a stop watch to determine the speed. The first run is made at approximately 10 m.p.h., and subsequent runs are made at speeds such that equal increments of lateral acceleration are produced, up to the maximum at which steady readings are obtainable.

The M.I.R.A. Steering Wheel Torquemeter and a protractor are attached to the vehicle's steering wheel and steering angle indicators are operated from the front road wheels. A cross-wire mounted in the centre of the rear passenger compartment is aligned with vertical and horizontal transparent scales fixed to the right side rear window. The cross-wire and scales are used in conjunction with the central sighting post on the steering pad for the determination of roll and attitude angles. Rear axle roll steer is also measured but is only recorded separately if it is of significant magnitude in relation to the limits of accuracy of determination of the attitude angle. Front drift angle is calculated from the steering and attitude angles and rear drift and roll steer angles are included in the attitude angle.

XVII. Suspension

(*a*) *Wheel Rate*

The vehicle is placed on the M.I.R.A. platform weighing cells (see M.I.R.A. Bulletin No. 2, 1958), and loaded until the maximum suspension deflection is obtained. Screw jacks are used to raise the structure in half-inch increments, until the wheels are clear of the cells. Measurements are taken at each point of the load on the cells and of the distances between the hubs and the chassis or body in the plane of the hubs. The jacks are then lowered, and measurements are taken at the same deflections as before. The wheel rates quoted are obtained from the mean of the two sets of readings, and a graph is plotted if the suspension has a varying rate.

(*b*) *Roll Axis*

For the determination of the heights of the roll centres, a board marked with a white line is fixed at each end of the vehicle so that each line is vertical and passes through the longitudinal axis of the vehicle. Photographs are taken of each of these boards, with the vehicle resting on a horizontal plane and with it tilted by loading first to one side and then to the other. The point of intersection of the lines on each photograph is taken as the height of the roll axis in the plane of the board concerned.

(*c*) *Suspension Damper Carding Test*

A proprietary carding machine provided with an adjustable stroke length and capable of operating at speeds of 9 or 104 cycles per minute is used.

The machine is allowed to operate for 30 minutes before results are taken, and the test damper is then fitted after being held in an extended position overnight. The damper is operated slowly through a few cycles, and a card is taken showing the resistance to motion of the damper throughout one complete cycle at both speeds. Further cards are taken in a similar manner after the damper has been cycled at high speed until the external temperature of the case is 100°C.

(*e*) *Suspension Evaluation*

Pending the development of suitable instrumentation, suspension characteristics are determined subjectively.

The vehicle is driven over the Long Wave Pitching, Corrugated, Pavé, and Ride and Handling surfaces (see M.I.R.A. Bulletin, 1951, 3rd Quarter, M.I.R.A. Bulletin, 1951, 1st Quarter, M.I.R.A. Bulletin, 1950, 2nd Quarter, and M.I.R.A. Bulletin No. 1, 1961, respectively), at a series of gradually increasing speeds, and notes are made of the effect on the vehicle. During the running on the pavé surface, a further object of the test is to establish a suitable speed for the vehicle during the subsequent pavé endurance test. For this purpose the suspension dampers are allowed to become hot, and particular notice is taken of any tendency to " bottom ". For evaluation on the two first-named surfaces the dampers are initially cool.

XVIII. Driver Visibility

Measurements of driver visibility are made in accordance with the detailed methods given in M.I.R.A. Report No. 1956/1. Briefly, this method employs two lamps, spaced 2·5 in. apart, with their mid-point in line with the centre of the steering wheel, 5 in. in front of a vertical tangent to the seat squab and 26·5 in. above the undeflected seat. The driver's seat is adjusted to a location giving an effective leg length (accelerator pedal to seat squab) of as nearly as possible 36·5 in. For forward visibility measurements the vehicle is unladen, but the normal test weight of 450 lb. is added before measuring rearward vision.

The lamps cast shadows on to a vertical semi-circular screen of 12 ft. radius, arranged so that the central axis of the screen is the vertical through the mid-point between the lamps. A development of these shadows to show the direct forward vision is presented, together with a ground plan prepared from the relationship between the areas of complete obscuration and the height of the lamps. Rearward visibility is determined in a similar manner from the images cast by the vehicle's mirror on to flat screens placed 10 ft. and 20 ft. behind the lamps, and the results are presented as a ground plan.

A table is also presented giving a comparison between the major visibility characteristics of the vehicle and the requirements recommended by M.I.R.A. to the S.M.M. & T. as a code of practice.

XIX. Noise

(*a*) *Road Excited Noise in Passenger Compartment*

The vehicle is driven over the noise generating surface on the M.I.R.A. Proving Ground at constant speeds of 15, 30, 45 and 60 m.p.h. in top gear with all windows closed. A microphone is placed successively in the positions normally occupied by the heads of front and rear seat passengers, and the road noise inside the vehicle is recorded on a M.I.R.A. Mark 3 magnetic tape recorder (see M.I.R.A. Report No. 1954/5). Fifteen-inch lengths of tape are removed from each recording and joined into loops, each of which is played back continuously and a frequency analysis made in one-third octave bands. The one-third octave band analyses are presented for front and rear mircophone positions.

The results are also shown tabulated as loudness figures, the summations being carried out according to the method of S. S. Stevens, as described in M.I.R.A. Bulletin No. 2, 1957.

Analyses of the results obtained on the quietest British vehicle yet tested by these methods are shown in Fig. C, and the loudness figures are tabulated below:—

Speed m.p.h.	*Front Microphone sones*	*Rear Microphone sones*
30	36	49
45	43	54
60	53	66

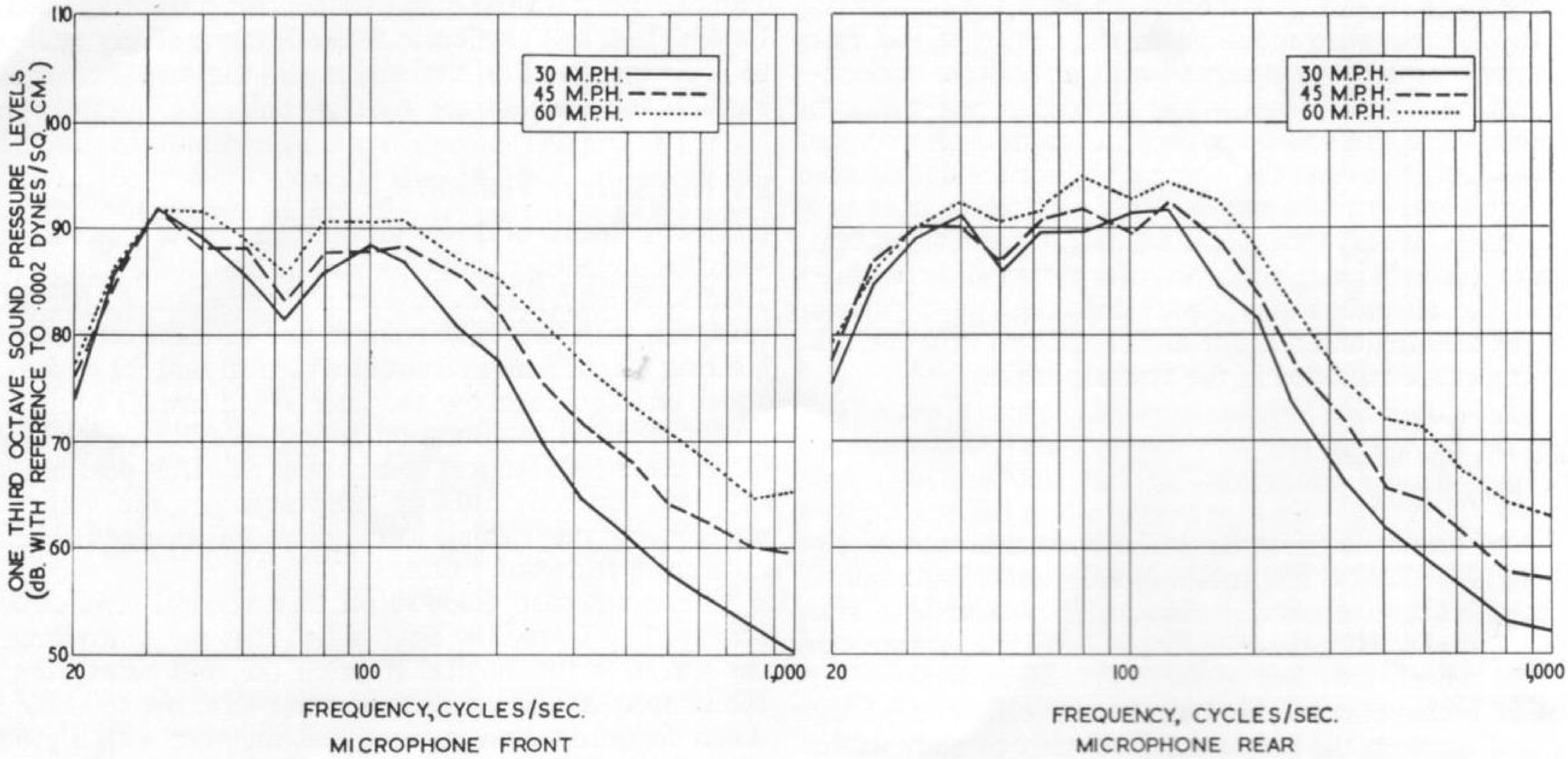

Fig. C. Road Noise—one-third octave band analyses. Reference graphs for the quietest British vehicle yet tested by the methods quoted.

(*b*) *Engine Noise in Passenger Compartment*

The vehicle is driven on the No. 2 Circuit at the M.I.R.A. Proving Ground at constant speeds of 15, 30, 45 and 60 m.p.h. in top gear and using full throttle. The speed is controlled by the vehicle's brakes. The recording and analysis of the noise inside the vehicle is completed by the methods already described for Road Noise, and the results are presented as one-third octave band analyses and tabulated loudness figures.

(*c*) *Noise—External to Vehicle*

(1) The microphone is suspended at a height of 1·25 m. (4 ft. 1 in.) above a level tarmac surface and at least 20 m. (66 ft.) from any object capable of causing an acoustic disturbance. The measurements are made with the M.I.R.A. Noisemeter, employing a 70 dB weighting network, and the results are quoted in sound level decibels. Measurements made on American and German meters with similar weighting networks would be numerically substantially identical.

For the stationary test, the vehicle is placed with the exhaust orifice 7 m. (22 ft. 9 in.) from the microphone and in line with it. The engine is operated under no load at the speed corresponding to the maximum speed of the vehicle. Three recordings are made, and the result quoted is an average of the three.

For the moving test, the microphone is placed 7 m. (22 ft. 9 in.) away from a straight line marked along the road and the vehicle is driven symmetrically astride this line, past the microphone position, at a steady speed of 40 Km.p.h. (25 m.p.h.). The vehicle is driven at full throttle in top gear, and the brakes are used to control the speed. Three runs are made in each direction and the result quoted is an average of the three.

(2) These tests are carried out in accordance with the recommendations of the International Standards Organisation (see M.I.R.A. Report No. 1960/3, Appendix II). The test area is a level tarmac surface in an area clear of objects capable of causing an acoustic disturbance for a radius of 50 m. (164 ft.). Measurements are made with the M.I.R.A. sound level meter employing the " A " (40 dB) weighting network. The frequency response of the " A " weighting network complies with the proposed I.E.C. standards for sound level meters. The measuring microphone is placed 1·2 m. (3 ft. 11 in.) above the road surface and 7·5 m. (24 ft. 7 in.) from the centreline of the test track.

The vehicle approaches the test area, along the centreline of the track, at a steady speed which corresponds to an engine speed of three-quarters of the r.p.m. at which it develops maximum power, and in such a gear (excluding 1st if the vehicle is fitted with 4 or more forward gears) that the road speed is as close as possible to 50 Km.p.h. (31 m.p.h.). If the vehicle is fitted with an automatic transmission it approaches the test area at a similar speed, using the normal drive setting of the transmission. At a line 10m. (33 ft.) before the microphone the throttle is fully opened as rapidly as is practicable and held open until the rear of the vehicle reaches a line 10 m. (33 ft.) past the microphone, when the throttle is rapidly closed. Three readings of the noise emitted are taken on each side of the vehicle as it passes the measuring microphone.

XX. Fuel Quality Requirements

(*a*) *Octane Requirement*

This test is carried out at the M.I.R.A. Proving Ground, using the C.R.C. E/1/748 method and primary reference fuels. The octane number requirement and the critical knock speed in top gear are given, at the maker's ignition setting.

(*b*) *Fuel Volatility Tolerance*

A full throttle/soak vapour lock test using single reference fuels is carried out at the M.I.R.A. Proving Ground. The results quoted are the ambient temperatures at which incipient and complete vapour lock will occur when using a typical British premium grade fuel.

XXI. Cold Starting

To determine the cold starting characteristics, the vehicle is " soaked " overnight in the M.I.R.A. Low Temperature Laboratory (see M.I.R.A. Bulletin No. 2, 1957) at a temperature of $-20°$C. An attempt is made to start the engine using normal starting procedure for a maximum of 60 seconds. Should this not be successful, the vehicle is tow-started and the test is subsequently repeated, raising the temperature by 10°C. increments until a normal start is obtained. The behaviour of all accessories is noted during the tests.

Prior to " soaking ", the battery is brought to the full-charged condition, the cooling system is filled with a 50 per cent anti-freeze mixture and, if necessary, the crankcase lubricant is changed to the viscosity recommended by the manufacturers for cold conditions.

XXII. Roller Dynamometer Test

The plant permits a pair of the vehicle's road wheels to be placed on rolls coupled to a dynamometer capable of absorbing power or motoring; cooling air is ducted to the radiator air intake, and further fans are available for tyre cooling.

Measurements are made of the full throttle power output at the road wheels and of fuel consumption throughout the speed range. Where possible, measurements are also made of the power absorbed in driving the wheels, but this is not practicable with many automatic transmissions. By placing the non-driving wheels on the rolls, figures are also obtained for the power absorbed in driving these wheels. During these tests the speeds of the engine, road wheels and rolls are independently checked.

XXIII. Drag Measurements

Total drag measurements are carried out by the coasting deceleration method described in M.I.R.A. Bulletin No. 1, 1959.

XXIV. Torsional and Bending Stiffness

Tests are carried out on the complete vehicle. Each wheel stands on a platform which is free to move in any direction in a horizontal plane. Load on each wheel is measured on a M.I.R.A. platform weighing cell (see M.I.R.A. Bulletin No. 2, 1958).

For torsional testing the load is applied through the wheels and the deflections of the front and rear suspensions are adjusted to keep the vehicle body horizontal. Deflections of the underbody members are measured by means of dial indicators mounted on a light reference frame, suspended from the vehicle body. Angles of twist are calculated from these readings.

For beam deflection tests, a sandbag load of 1,000 lb. is applied midway between the front and rear axles, and the dial indicators record the deflections of the underbody members.

XXV. Engine Test

A dynamometer test of the engine unit is completed in conditions similar to those specified in the S.A.E. Gasoline Engine Test Code. The engine is taken from the vehicle after the completion of all road testing. The cooling system temperatures are maintained with heat exchangers, and the lubricating oil temperature is measured with a thermocouple. As far as possible, the exhaust system is used, with its outlet coupled to the large-bore laboratory exhaust system. For measurements of friction horse power, the engine is motored in conditions as close as possible to those obtaining when the engine is running.

The results are presented as curves showing corrected brake horse power, torque, brake mean effective pressure and blow-by, observed friction horse power, mechanical efficiency and specific fuel consumption. The corrected values are obtained by the methods prescribed in the S.A.E. Test Code. Also the part throttle performance of the engine is determined by measuring torque output over a range of throttle angles and specific fuel consumptions at each condition. The results of these measurements are presented as curves of torque against speed, with superimposed lines of constant specific fuel consumption. In addition, a table of typical conditions for full throttle operation is given, covering engine speed, oil pressure and oil temperature.

XXVI. Pavé Test

After the completion of the road performance testing, the vehicle is submitted to an extended period of running on the M.I.R.A. pavé circuit. This is triangular in shape, two of the corners joining the straights having a smooth surface and the third junction consisting of a pavé-surface S-bend. The vehicle is driven throughout at the highest speed giving freedom from frequent " bumping through ", subject to a maximum of 25-30 m.p.h. Frequent inspections are made over a pit during the test period, and an attempt is made to rectify all faults as soon as they are observed. The full distance is 1,000 miles, but the test is abandoned at a shorter distance in the event of a major failure requiring extensive repair.

A tabulated summary of the test is presented, with details and photographs of the damage sustained.

XXVII. Corrosion Tests

(*a*) *Sulphur Dioxide*

This test is carried out in a 1 per cent sulphur dioxide atmosphere at a relative humidity of between 95 and 99·5 per cent at room temperature. The test period is 24 hours.

(*b*) *Acetic Acid-Salt Spray*

In this test the samples are subjected to a spray formed from a solution of 5 per cent sodium chloride with dilute acetic acid added to give a pH value of 3·2. The test is carried out at room temperature between 95 and 99·5 per cent relative humidity for 96 hours duration, with inspection at intervals of 24 hours. The condition of the samples after 96 hours is reported, unless otherwise stated.

XXVIII. Generator Tests

Three tests are conducted on the generator, using a test rig on which the generator is belt-driven as on the engine.

(1) *Output Characteristic Test—Cold*

A constant voltage of 13·5 volts is maintained across the load resistors and the output current is measured as quickly as possible over a suitable range of speeds until the maximum rated load is reached.

(2) *Output Characteristic Test—Hot*

The generator is run for one hour at its maximum rated load and at approximately two-thirds its maximum speed when installed in the vehicle. At the conclusion of this run the temperature of the generator casing is measured using a calibrated thermocouple attached to a field pole fixing screw. The output current over a range of speeds is then obtained as quickly as possible, as in the cold test. During this test the power input is also measured and hence the efficiency calculated.

(3) *Output Voltage Test—Hot*

This test follows immediately after the second output characteristic test and is conducted as quickly as possible. The generator is driven off load and the voltage build-up over a range of speeds is recorded.

XXIX. Heater Performance

Tests are carried out on the heater as installed in the vehicle, in dry conditions such that no radiant heat from the sun is being added and the ambient temperature is remaining sensibly constant. The schedule incorporates one hour of driving in top gear at a steady speed of 20 m.p.h. from a cold start, with the heater fan operating at its highest available speed; this is followed immediately by thirty minutes at 40 m.p.h. with the same fan speed, and then by a final thirty minutes at 40 m.p.h., but employing ram airflow only.

The quantity of water passing through the heater is measured by a flow meter. Temperatures at the air and water inlets and outlets and at the foot and head locations of four seating positions are plotted by a multi-point temperature recorder. A graph is plotted to show the variations in ambient and average interior temperatures throughout the test period. A table is also presented to show the stabilised temperatures attained during each portion of the test at each location, together with heater performance figures derived from these results.

XXX. Aerodynamic Coefficients

Aerodynamic coefficients are measured in accordance with the methods described in M.I.R.A. Reports Nos. 1961/8 and 1962/1. Briefly, the vehicle is tested as received, with the radiator air intake open and the engine stationary. It is placed in the M.I.R.A. full scale wind tunnel and measurements are made over a range of yaw angles from 0 to 25 degrees with the vehicle rotated to its left, whilst symmetry is checked at a yaw angle of 20 degrees in the opposite direction. Drag, side force and yawing moment coefficients are presented.

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