Macmillan Motor Vehicle Craft Studies Series

Introduction to Motor Vehicle Craft

Student's Book

Editor R Brooks

Senior Lecturer in Motor Vehicle Subjects
Bolton Institute of Higher Education

Authors J Hirst

Lecturer in Motor Vehicle Subjects
Burnley College of Arts and Technology

J Whipp

Senior Lecturer in Motor Vehicle Subjects
North Manchester College

M
MACMILLAN

© R. Brooks, J. Hirst, J. Whipp 1981, 1984

All rights reserved. No reproduction, copy or transmission of this publication may be made without written permission.

No paragraph of this publication may be reproduced, copied or transmitted save with written permission or in accordance with the provisions of the Copyright Act 1956 (as amended), or under the terms of any licence permitting limited copying issued by the Copyright Licensing Agency, 33 – 4 Alfred Place, London WC1E 7DP.

Any person who does any unauthorised act in relation to this publication may be liable to criminal prosecution and civil claims for damages.

First published 1981
Reprinted 1981, 1984, 1988 (twice)

Published by
MACMILLAN EDUCATION LTD
Houndmills, Basingstoke, Hampshire RG21 2XS
and London
Companies and representatives
throughout the world

ISBN 978-0-333-36186-3 ISBN 978-1-349-06976-7 (eBook)
DOI 10.1007/978-1-349-06976-7

PREFACE

It is widely recognised that one of the prime aims of almost every young person is to own a motor-car, in so doing to achieve the mobility and freedom associated with it. This provides a powerful incentive to learn about motor vehicles, in fact often with far greater application than may be shown for more academic subjects. It was as a direct result of these very natural aspirations that this book was compiled.

The young people for whom the book is primarily intended are likely to be in their final year at school or taking part in a training programme prior to starting work. Importantly, it is intended to be of interest and value to everyone who uses it and not merely as a career introduction. However, any budding automobile engineer is certain to find it of especial benefit.

Arranged in workbook style on large (A4) pages, the student is able to complete the information presented and conclude the various investigations in note and sketch form. Sufficient guidance is given throughout so that the student is able to produce good-quality results without the need for either laborious note-taking or extensive sketching. This adds value and personality to the book and finally produces a useful work of reference.

Whilst it is clearly impossible to cover every aspect of the complex field of automotive work, the items selected form a sound basis for further study. The production team consists of practising teachers with a substantial series of popular motor vehicle books to their credit and extensive experience in the teaching of motor vehicle subjects.

To help teachers reduce preparation time, a completed 'answer book' (or Lecturer's Guide) is available. This has been carefully produced so that transparencies can easily be made from each page. This facility enables teachers, if they wish, to display completed drawings and text with the minimum of effort, thus enabling more time to be devoted to 'proper' teaching and student-based investigations. Much thought has also been given to conducting the work outlined in the books with only a minimum outlay of specialised equipment.

The authors and editor always welcome constructive comments from users of this book. Do not hesitate to contact us via the publishers.

R. Brooks
(*Editor*)

Austin mini Metro 1.3 HLS

With its transversely mounted engine driving the front wheels the mini Metro is typical of modern space-saving design.

Ford Sierra Ghia 2.3 litre

Ford retained the conventional in-line engine and rear-wheel drive for their highly successful Sierra. Its slightly unusual body styling makes it highly aerodynamic.

Contents

Glossary of technical abbreviations and terms	vi
Chassis layout and vehicle body	1
Spark-ignition engines: principles and construction	7
Cooling	18
Lubrication	27
Petrol fuel system	34
Transmission: clutch	42
Transmission: gearbox	48
Transmission: propellor shafts and drive shafts	53
Transmission: final drive	56
Suspension	59
Wheels and tyres	66
Brakes	73
Steering	80
Engine electrical system	84
Vehicle electrical systems	94
Electricity	106
Health and safety	112

Glossary of technical abbreviations and terms

As with any specialised subject, motor vehicle technology has its own 'language'. This glossary has been compiled to help you understand some of the more commonly used terms.

COMMON ABBREVIATIONS

Since public interest in motor vehicles is so widespread, quite a lot of the abbreviations are not so precise or standardised as those used in the strictly technical sense. However, the following will often be encountered in such as manufacturer's brochures, manuals and in general conversation.

A (amp)	Ampere
AC	Alternating current
AF	American Fine (thread)
Ah	Ampere hour
(amphr)	
b.d.c.	Bottom dead centre
bhp	Brake horsepower
BSF	British Standard Fine (thread)
BSW	British Standard Whitworth (thread)
cc	Cubic centimetre
c.b.	Contact breaker
d.c.	Direct current
DoT	Department of Transport
emf	Electromotive force
hp	Horsepower

HT	High tension
i.f.s.	Independent front suspension
i.r.s.	Independent rear suspension
k/h	Kilometres per hour
LT	Low tension
m.p.g.	Miles per gallon
mph	Miles per hour
o.h.c.	Overhead camshaft
o.h.v.	Overhead valve
psi	Pounds per square inch
rpm	Revolutions per minute
(rev/min)	
SW	Switch
t.d.c.	Top dead centre
UNC	Unified Course (thread)
UNF	Unified Fine (thread)

additives Chemicals added to oil and petrol to give them special properties.

air-cooled engine Engine cooled only by air which is blown over finned cylinder surfaces, usually by a fan.

air filter Usually found on top of the carburettor. It filters the air before it enters the engine.

air vent Small hole in the top of a fluid reservoir, float chamber or tank to allow atmospheric pressure to act on fluid.

alignment Usually describes adjustment of front wheels, also the setting of headlamp beams.

alternator Engine-driven electric generator which produces

alternating current, and is more efficient at low engine speeds than a dynamo.

ammeter Instrument that measures the amount of electric current passing to and from the car's battery. It is often marked with a + and – for charging or discharging.

automatic choke Device in the carburettor which controls the choke flap according to the engine temperature, to provide a rich mixture for starting and an increasingly weak mixture as the engine warms up.

automatic transmission Gearbox that alters the gear ratio automatically to suit car speed and load. It also eliminates the need for manual clutch and gear lever.

axle Transverse beam which carries the wheels and supports the body via springs.

ball joint Method of joining two components end to end so that they can pivot in any direction relative to each other.

beam axle Rigid transverse axle carrying wheels with no independent suspension.

bearing Device for supporting a rotating shaft or moving component with the minimum of friction and wear.

bevel gears Conical-shaped gears which permit transmission through 90°, as in the final drive.

big end Larger end of the connecting rod mounted on the crankpin of the crankshaft.

big-end bearing Material between the connecting rod big end and the crankpin.

bore Diameter of any hole, but especially used to describe internal diameter of a cylinder.

bottom dead centre Lowest point of the piston's travel in the cylinder, at the bottom of its stroke.

brake back plate Describes the plate of a drum-brake assembly which is fixed and which carries the brake shoes.

brake drums The drums are fixed to the road wheels and rotate with them. Shoes inside the drums are pressed against them, so that the friction slows and eventually stops the wheels.

brake fluid The hydraulic fluid used in the braking system in order to transfer energy from the pressing of the brake pedal to the operation of the discs or drums.

brake shoe Metal segmentally-shaped components with friction material on the outer face of the curve. Used inside the drum of a drum brake, they are forced apart to brake the wheel.

breather An opening or vent used to relieve internal pressure or to allow air to enter a space, e.g. gearboxes have breathers.

brushes Pads made of carbon that transfer the current from the rotating armature of an alternator or the rotating commutator of a dynamo.

bush A sleeve, usually of metal, rubber or plastic, which is fitted into a bore and acts as a bearing.

butterfly, or butterfly valve Used to describe the throttle valve in the main air vent of the carburettor, which is a disc of metal that can be rotated to control the air flow and so the speed of the engine.

by-pass filter A type of oil filter in the engine's lubricating system which receives some of the oil from the pump and filters it before it is pumped to the engine.

cam A rounded wedge, usually on a shaft, which will push and release another component as the shaft rotates, e.g. the engine camshaft which opens and closes the valves.

cam follower Any component that transmits the motion of the cam to the next component in line, like a push-rod or valve stem.

camber angle The angle by which wheels deviate from 90° to the road, looking from the front. Positive camber means that the wheels are further apart at the top; negative camber means they are further apart at the bottom.

camshaft The shaft which is rotated by the engine and actuates the valve gear. It may also drive the distributor and

fuel pump.

capacity Usually expressed in cubic centimetres, the capacity of an engine is the volume swept by all the pistons in the engine over the length of their travel.

carburettor A device to meter the amounts of fuel and air drawn into an engine, and mix them together.

clutch A part of the transmission which enables the driver to move the vehicle away smoothly from rest; disconnects engine from gearbox during gear changing, and gives temporary neutral.

clutch drag Inefficiency of clutch disengagement usually caused by faulty adjustment or mechanical wear.

clutch driven plate A metal disc mounted on the shaft leading to the gearbox. It has friction linings on its face which transmit drive from the flywheel.

clutch lining Friction material bonded or riveted to either side of the clutch driven plate.

clutch pressure plate Heavy metal disc which forces the clutch driven plate against the flywheel.

clutch slip Used to describe the effect of the failure of the pressure plate to grip the driven plate properly. Usually caused by oil contamination or excessive wear.

coil Two windings of copper wire housed together and providing the high voltage current necessary for causing a spark at the spark-plug gap. It does this by collapsing the magnetic field created by low-voltage current flowing through the outer (shorter) winding and so inducing high voltage from the inner (longer) winding.

coil ignition Describes an ignition system which employs a coil to induce high voltage.

compression-ignition engine An engine in which combustion is achieved by the heat generated by compressed air, such as a diesel engine. In this, a charge of atomised fuel is injected into the hot compressed air in the combustion chamber, so effecting ignition.

compression ratio The ratio of the volume of mixture above the piston at the bottom of its travel compared to the volume above it at the top. The higher the ratio, the more the power output of the engine. Averaged-sized car engines will have a compression ratio of 8.5:1 to 9.5:1.

connecting rod The forged steel component that joins the piston to the crankshaft, transferring the up-and-down

motion of the piston to the rotary motion of the crankshaft.

constant-mesh gears Describes gears on the gearbox which are always meshed together.

constant-velocity joint A type of universal joint which gives a smooth drive on front-wheel drive cars even when steering on full lock.

contact breaker A switch in the coil ignition system which constantly breaks and remakes the low-voltage current, so causing the current in the coil to collapse and provide high voltage current. It is operated mechanically, usually by a cam mounted on the distributor spindle. Also referred to as 'points'.

control box Part of the electrical system with three functions together in a sealed box; automatic cut-out, voltage regulator and current control.

crankpins Bearing surfaces of the crankshaft which carry the big-end bearings of the connecting rods.

cylinder block Iron or aluminium alloy cast block housing the cylinders and their water-cooling passages, or fins for air-cooled engines. On water-cooled engines it is usually one piece with the crankcase.

cylinder head Cast iron or aluminium piece which fits on the cylinder block and which contains the combustion chambers and the valve gear, as well as the continuation of water passages or finning.

cylinder-head gasket Thin layer, sometimes of metal with asbestos, used to prevent leakage of gas between the cylinder block and cylinder head. It also stops water from the water passages getting into the cylinders.

cylinder liners Usually cast-iron sleeves which fit inside the cylinder block where the piston does not run directly in the block itself, although they can be used to replace worn cylinder walls. Dry liners are surrounded by the metal of the block, whereas wet liners are exposed directly to the coolant.

damper A device used to control the movement of the piston in a variable-jet carburettor, by damping the action smoothing out the response to the throttle. Also a term used to describe a shock-absorber in a suspension system.

decarbonising A process for removing the carbon deposits that can build up on piston crowns, valve ends and inside the combustion chamber.

detergent oil Specially formulated engine oil that has an additive to hold sludge-forming material in suspension, preventing it from settling, and so keeping the engine interior clean.

differential A set of gears (usually in a housing bolted to the crown wheel) which enables the driven wheels to rotate at different speeds (as when cornering) but still receive equal torque.

direct current Electric current which only flows in one direction, such as that produced by a battery or dynamo.

disc brakes A braking system which works by heavy metal discs being pinched by friction pads mounted in calipers that surround the disc. The disc is attached to the road wheel and rotates with it.

distilled water Purified water used for topping up the battery.

distributor cap Hard plastic moulding with connections which accept the high-voltage current from the coil, and subsequently pass it to each spark-plug lead by way of the rotor arm.

distributor drive shaft The shaft that rotates the rotor arm and the cams which operate the contact breaker. Driven by the engine camshaft, it is geared to rotate at half engine speed.

distributor rotor arm Resin-based plastic with a brass strip inlaid along the top. It rotates underneath the distributor cap and passes high-voltage current from the high-voltage input connection from the coil to the connectors leading to the spark plugs.

dog clutch As with all types of clutch, these are a means of transferring drive. Projections around the edge of one half of the clutch slide into corresponding indentations on the other. Usually found in gearboxes.

drag coefficients A measure of the resistance to air of a moving object, such as a car body.

drag-link The rod between the drop arm of a steering box and the linkage which controls the track-rod.

drain-plug A screw-in plug found at the bottom of a component for draining fluid. Typically found in the sump, gearbox, final drive or radiator.

drive-shafts Especially used where the shafts are not enclosed in the axle casing. They transmit the drive from

the final drive to the road wheels. Another name for half shafts.

drop arm Lever mounted on the steering box which is operated by the steering wheel pinion and which in turn controls the track-rod linkage.

drum brakes A method of braking in which drums attached to the wheels are slowed by internal convex shoes lined with friction material, forced outwards by hydraulic pressure from the brake pedal assembly.

dual-braking Two separate hydraulic braking systems working side by side to provide adequate braking if one circuit should fail. These can either duplicate the whole braking system, or one front and one rear brake, diagonally opposed.

dust excluder See 'gaiter'.

dynamic balance The balance of any rotating part, such as the wheels or crankshaft, while the component is revolving.

earth The connection from any electrical component which attaches to the chassis or body to effect a completed circuit.

east-west mounting Also known as transverse, this describes an engine mounted across the car instead of the more usual mounting in which the engine is in line with the car.

electrolyte A solution of distilled water and sulphuric acid in the battery.

electronic ignition A system of ignition in which an electronic unit triggers pulses of high-tension electrical energy to the spark plugs, so replacing the contact breaker assembly. More efficient than the mechanical method, especially in high performance engines.

ethylene glycol A chemical which prevents water from freezing at the usual temperature, and is thus used in most antifreeze compounds. It is mixed with corrosion-inhibiting chemicals so that it will not attack the metal of the coolant system.

exhaust gases The gases given off by the combustion of petrol and air. They include carbon monoxide, carbon dioxide, oxides of nitrogen, unburnt hydrocarbons and water vapour.

exhaust manifold Cast-iron pipework of various configurations which is bolted to the engine and which takes away the exhaust gases forced out of the cylinders.

feeler gauges A set of hardened metal strips of varying thickness used to measure clearances in components, e.g. the gap in a spark plug.

final drive The last phase of the transmission system. On a rear-wheel drive car this would be the crown wheel and pinion.

firing order The order in which the cylinders of an engine reach the 'firing' or 'power' stroke.

fluid reservoir This usually refers to a container which stores hydraulic fluid for the brake or clutch systems. (May also describe such as a container storing windscreen-washer fluid.)

flywheel Heavy metal disc bolted to the engine crankshaft. It smooths out the individual bursts of energy from the cylinders; forms a convenient mounting point for the clutch; and has the starter ring gear around its outer edge.

four-stroke cycle (Otto cycle) The basic sequence of operations of the internal combustion engine.

i.e. Induction
Compression
Power
Exhaust

Also known somewhat picturesquely as: 'suck', 'squeeze', 'bang', 'blow'.

free travel (free play) The amount of 'play' or free movement in such as a control lever or foot pedal before it begins to take effect.

friction pads Segments of friction material in a disc brake that are pressed on to the disc to effect braking.

front-wheel drive A transmission system in which the engine drives the front wheels of the car.

fuel pumps (petrol pump) A pump which draws fuel from the tank and delivers it to the engine.

full-flow filter A type of oil filter through which all the engine oil must pass before it reaches the engine bearings.

fuse A thin piece of wire of known electrical-carrying capacity which is incorporated in a circuit in order to protect it. It should be the first part of the circuit to break in the event of an overload.

gaiter (dust excluder) A synthetic rubber flexible shroud or cover used to keep out dust and grit from such as a steering ball joint.

gap This usually refers to such as the distance between the contact breaker points, or between the spark-plug electrodes.

gasket A thin sheet of material such as copper, cork, rubber or paper which is sandwiched between two close-fitting components so as to prevent leakage of any kind.

gearbox Can be applied to almost any housing (or box) containing gears. Usually it refers to the transmission gears which are controlled by the driver in accordance with conditions of load, speed and gradient. It then also provides a means of reverse and a permanent position of neutral.

gear ratio Relative speeds at which two gears revolve. If the input gear rotates twice as fast as the output one, the gear ratio is 2:1.

generator (dynamo) A device which converts mechanical energy into electrical energy. One of its prime functions is to charge the battery. An alternator performs the same function.

glass-reinforced plastic (glass-fibre) Often known simply as GRP, this is a laminated material used in the manufacture and repair of some car bodies.

independent suspension Each wheel has its own spring and linkage with car body, allowing it to move without influencing another wheel. Most cars have independent front suspension but fewer have it all round.

inlet manifold Pipework (often aluminium) which conducts petrol/air mixture from the carburettor to the engine.

jets Generally carburettor components with small-diameter holes drilled in them. They are used to control the amount of fuel that can pass through them.

Windscreen washers also have jets to control fluid flow.

king pin A hardened steel pin about which a front wheel pivots. On most modern cars it has been replaced by two ball joints which give the same steering effect but also allow for movement of the independent front suspension.

leaf spring A long, fairly narrow spring consisting of one, or more, flat blades (or leaves). Common on commercial vehicles and the rear suspension of many cars.

manifold See 'inlet' and 'exhaust' manifold.

master cylinder The main pressure pump of a hydraulic brake (or clutch) system.

oil seal A component used to prevent oil (or grease) leak-

ing out along a shaft protruding from a housing, e.g. a crankshaft where it passes through its crankcase. Usually made of synthetic rubber.

overall gear ratio Number of engine revolutions per single revolution of the driving wheels. (Gearbox ratio X final drive ratio.)

points See 'contact breaker' and 'spark plug'.

piston Forms a moveable gas and oil-tight seal in the engine cylinder. It transmits, via the gudgeon (or piston) pin, the force of the expanding gases to the small end of the connecting rod. Most pistons are made of aluminium. Pistons of different design are used in hydraulic braking systems.

pressure cap This is usually the radiator filler-cap. It also maintains the liquid in the cooling system under pressure and so raises the temperature at which it boils.

propellor shaft (prop-shaft) The tubular shaft which in a front-engined, rear-drive vehicle transmits torque from the gearbox to the rear axle. It is usually fitted with two universal joints and a sliding joint.

radiator The device used for lowering the temperature of the coolant which has absorbed heat from the engine.

rocker cover A deeply-domed cover (or lid) which encloses the valve mechanism on top of an overhead valve engine.

seal See 'oil seal'. 'Seal' is sometimes used instead of the word 'gasket'.

servo (brake) A form of auxiliary power used to assist the driver when applying the brakes. In most cars the auxiliary power is provided via vacuum existing in the inlet manifold.

shock absorber Damper to control body movement in relation to the suspension, preventing continuous bouncing on the springs.

silencer The part of an exhaust system designed to reduce exhaust noise. It has a larger volume than the exhaust pipe and contains baffle plates and sound-deadening materials which reduce resonance. A faulty system, allowing carbon monoxide fumes into the car, can be lethal.

slave cylinder A cylinder at the end of the hydraulic brake or clutch system which converts the hydraulic pressure back into mechanical effort, and operates the brakes or clutch.

slow running Also called either 'tick-over' or 'idling', it is

the low speed at which the engine runs when the vehicle is not moving and the accelerator is not depressed.

small end The smaller end of the connecting rod which is connected to the piston by the gudgeon pin (piston pin).

solenoid A tightly wound coil of wire with a central, moveable iron core. When current is passed through the winding, the magnetic field produced causes the core to be pulled into the winding. The moving core can close large-area contacts (as in a starter solenoid).

spark plug The component providing the insulated spark gap within the combustion chamber. It has a metal body, which screws into the engine cylinder head, and a central electrode insulated by ceramic material, which carries the high-tension current to the gap. The gap between the spark plug's two electrodes is usually in the region of 0.025 in. (twenty-five 'thou') or 0.6 mm and this is where the high-tension current from the ignition coil must jump across, creating a spark and igniting the fuel/air mixture.

starter motor A small, but powerful, electric motor used to start the engine. When activated, it engages a small pinion gear with a toothed ring on the engine flywheel.

starter ring (ring gear) The toothed ring fitted to the outer edge of the flywheel with which the pinion of the starter motor engages.

stub axle A short fixed shaft on which the non-driven hub of a car wheel revolves on bearings.

synchromesh A component which causes two gears to revolve at the same speed before they are meshed together, in order to prevent clashing. The effect is achieved by using a cone clutch to synchronise the speed of rotation of one gear with the other.

tappet A colloquial term for a follower which bears on the engine camshaft. It is usually a short, bucket-shaped cylinder, the flat end of which bears against the cam. The open ends holds a push-rod or a valve stem (if an overhead camshaft system is fitted).

thermostat A temperature-sensitive valve placed in the cooling system between the top of the engine and the radiator. The thermostat is closed when the engine is cold, allowing the coolant in the engine to warm up quickly. As an operating temperature of about 85° is reached, it opens to allow the passage of coolant through the radiator.

torque A twisting or turning force. It can be applied in very many ways. For example, the firing strokes exert (via the pistons and connecting rods) a force to turn the engine camshaft so as to drive the car. Equally torque is applied when a nut is released (or tightened) by means of a spanner.

torsion bar Steel bar used in suspension system of some models instead of coil spring. The bar is fixed at one end and twisted at the other by means of a lever attached to the wheel.

universal joint A coupling between two shafts which provides a positive drive, while permitting some angular deflection between the shafts.

valves (engine) Flat-topped, mushroom-shaped devices which open and close the inlet and exhaust ports in the combustion chamber. They work in special bearings called valve guides.

wheel cylinder See 'slave cylinder'.

The Editor's thanks are extended to:

Automobile Association
Burmah-Castrol (UK) Ltd
Renault UK Ltd
Royal Automobile Club

for help in compiling the Glossary.