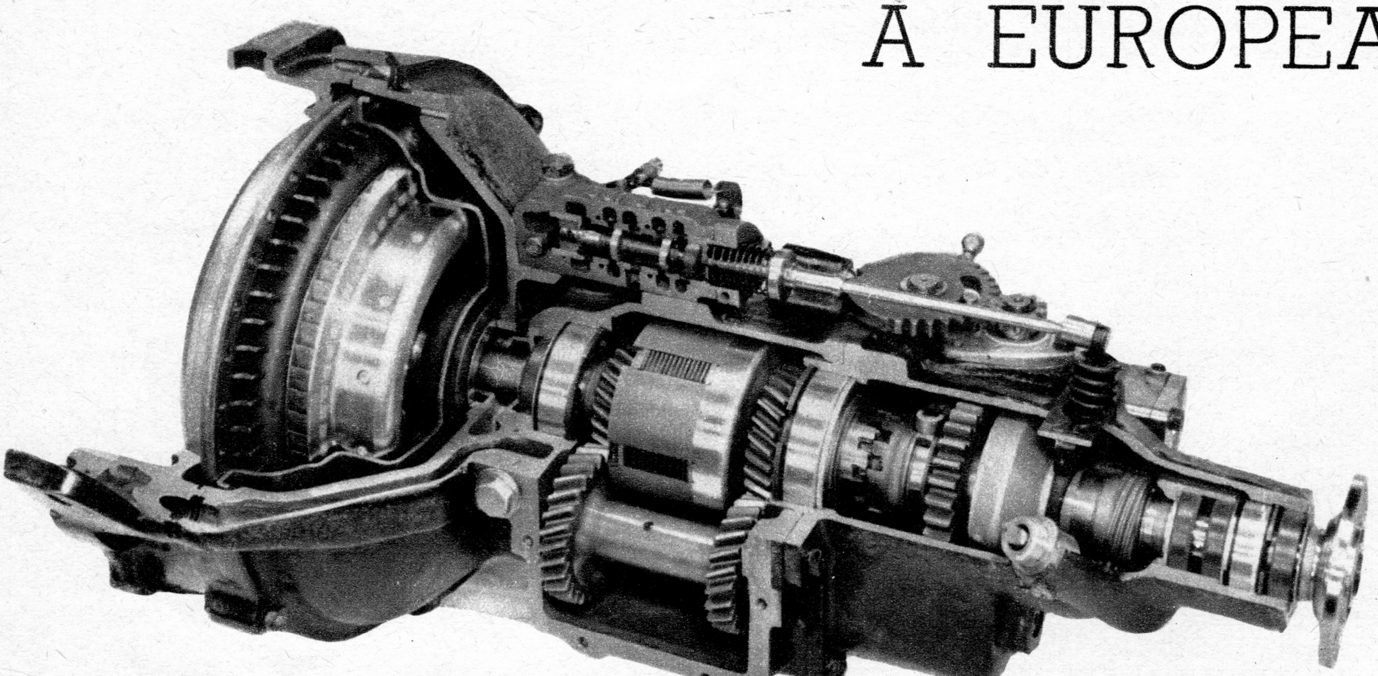
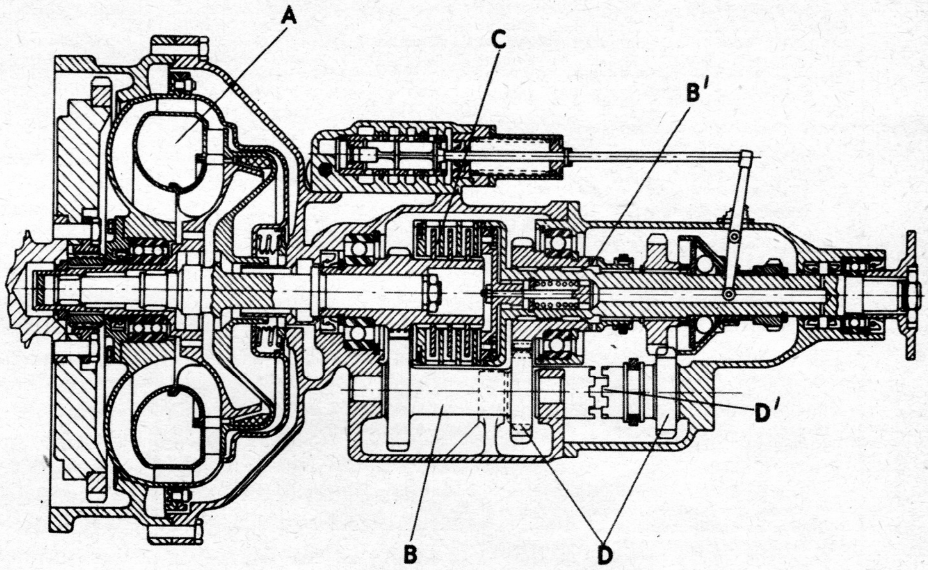
A EUROPEAN



The converter turbine, multi-plate clutch for direct drive and intermediate "hill-climb" gear train with its separate dog clutch are visible in this cut-away picture. A key to the parts in the sectioned drawing (Fig. 1, *right*) is given in the text.



A detailed description of the Borgward fluid drive now fitted to the Hansa 2400 car

(Translated from an article first published in Motor-Rundschau and NKZ)

THE Borgward fully automatic fluid drive consists of a Föttinger-type hydraulic torque converter unit A (Fig. 1), hereafter referred to as the converter, a coupled reduction gear unit B, with dog clutch B1, for hill climbing; a hydraulically operated multi-disc clutch C, for direct drive; a train of gears D and a further dog clutch D1, for reversing.

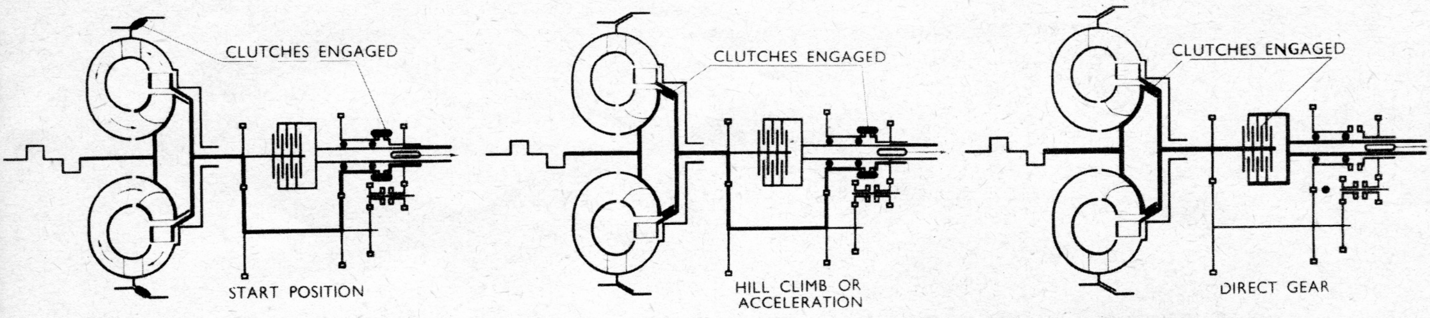
The individual ratio changes are made entirely automatically through a centrifugal governor, dependent on vehicle road speed and engine torque, so that the optimum driving ratio is always in engagement for any applicable running condition. No de-clutching or ratio selection is required on the driver's part when in motion, as he only needs to preselect the necessary (forward or reverse) direction, with a manual selector lever.

Starting off always takes place via the converter and its coupled reduction-gear unit. Then, according to the prevailing driving conditions, a change to second ratio occurs automatically between 10 and 30 m.p.h., followed by a change from second to direct drive at 25-55 m.p.h. Under full-throttle acceleration the individual gear changes, up to direct drive, take place at 30 and 55 m.p.h., whereas at part throttle, ratio changes occur earlier, at 15 and 25 m.p.h. This makes maximum acceleration on the open road just as feasible as picking up slowly, to the point of engagement, in town traffic. Should the car be running on part throttle below 55 m.p.h., opening the throttle wide engages second gear, which will remain engaged until the earlier mentioned, upper full-throttle ratio-change limit of 55 m.p.h. is attained, or until the driver ceases to accelerate. In either case direct drive will once again be selected. The conditions are exactly the same for changes involving second and first gears, though at the corresponding lower road speeds.

Just as the transmission automatically engages second and top ratio one after the other, after starting, so when the vehicle slows complementary downward changes occur. On braking or holding the vehicle, the engine runs at idling speed. The diagram at the top of page 55 clearly indicates the power path through the transmission system.

In the converter (Fig. 2) the impeller wheel P is in a rotationally fixed but axially free sliding contact with the cone clutch KP, on the engine crankshaft. Flanged to the output shaft and located axially with it in the housing is the turbine wheel T and the cone clutch KT. The guide vane casing with the guide vane wheel L and the cone clutch KL are mounted on the impeller wheel, able to rotate, but without end movement. A free-wheel device is inter-

AUTOMATIC TRANSMISSION



The path of the power through the transmission is shown diagrammatically. In the "start" position the guide-vane casing is fixed, so that the drive is transmitted via the impeller wheel, turbine, and intermediate gears. For hill climbing or acceleration the converter is out of action with the impeller and turbine locked together by a cone clutch, but the intermediate gear is still engaged. For the change to direct drive the converter remains idle, and the dog clutch is disengaged and the disc clutch engaged simultaneously.

posed between the impeller wheel and the turbine shaft, allowing the engine to keep pace with car speed on the over-run.

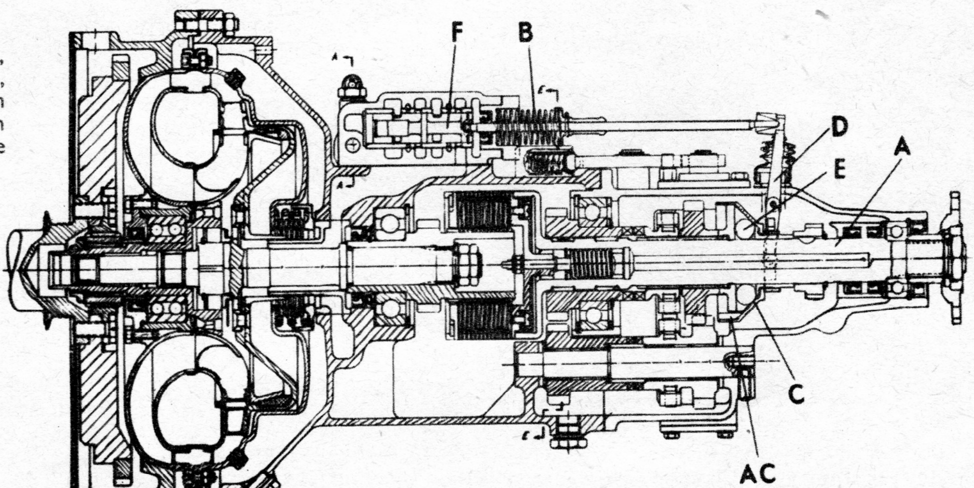
The converter is permanently filled with oil, and when in action is kept at a pressure of 70 lb. per sq. in. by means of an engine-driven gear pump. Oil is slung by the impeller-wheel blades into the circumferentially spaced hook-form vanes of the turbine wheel and thereby deflected through about 90 deg. The oil then leaves the turbine, entering the fixed guide vane casing, and on striking a screen of guide vanes situated at the point of greatest diameter is thereby redirected to assume the correct path for re-entry to the impeller blades. The static guide-vane annulus imparts the torque increase from the impeller wheel located on the output shaft to the reduction-gear unit.

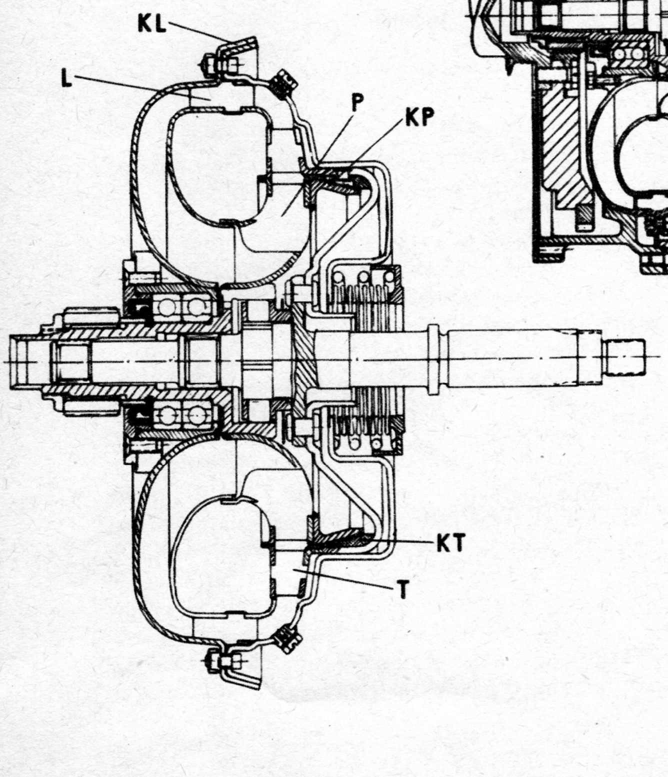
Rotation of the turbine wheel and movement of the vehicle begin the instant that the turbine torque has reached the necessary magnitude at the rear axle to start the vehicle, prior to stepping up into Hill-climb ratio.

The torque generated by the turbine wheel varies with the speed of the vehicle. At its greatest when the vehicle is at rest, it decreases with increasing speed and about approaches the efficiency of a manual transmission.

A spring-loaded centrifugal governor, mounted on the output shaft of the transmission, depends on engine revolutions and torque values to operate the ratio changes. On starting, i.e. when the output shaft A (Fig. 3) is still at rest, spring B pushes the governor housing C forwards by toggle lever D, and at the same time presses balls E inwards so that the rotary valve F is displaced to its rearmost position. On attaining a predetermined number of revolutions, the centrifugal force acting on the balls overcomes the tension of the governor spring, allowing them

Fig. 2 (*below*) shows the turbine, which is permanently filled with oil, and Fig. 3 (*right*) the transmission in the starting position, when both torque converter and intermediate gear are in action.



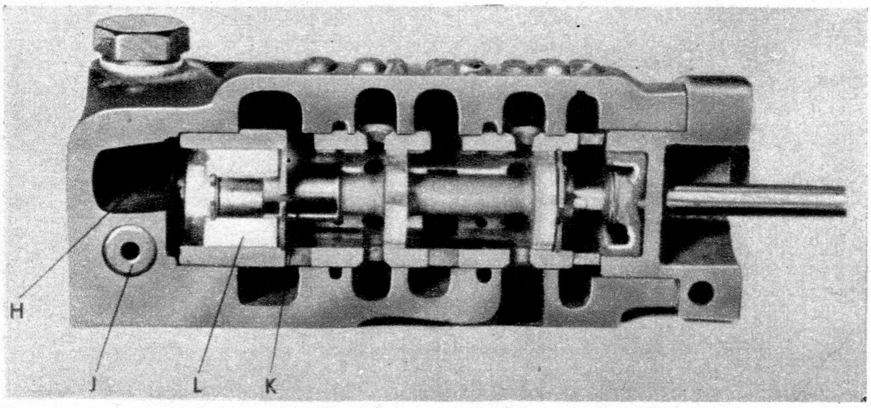


to move radially outwards until some of them strike against the abutments AC in the governor housing. Through this the governor housing is displaced backwards sufficiently to bring the regulator valve into its middle position. With increasing engine speed more centrifugal force acts on those balls, which are not yet stopped by the abutments and so continue to move outwards against the spring tension towards the peripheral housing collar. This is pushed back even more, so that the regulator valve F then takes up its forward end position.

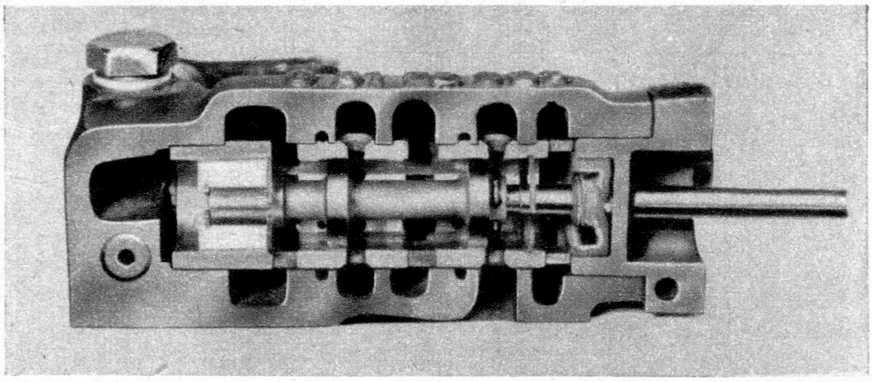
The regulator valve thus has three defined locations; that is to say the rear end position 1, the middle position 2, and the forward end position 3. The rear face of the regulator valve is permanently coupled to the return feed

G, leading from the reduction unit to the pump, i.e. for all practical purposes it is not under pressure. Pressure from chamber H acts on the front face. This pressure is varied through a rotary valve J by movement from the accelerator pedal, so that it increases on opening up, but decreases on closing the throttle. The excess pressure on the front face, as opposed to that on the rear face, acts similarly to the function of the governor spring, i.e., it operates against the centrifugal force of the balls. This allows movement of the regulator valve to take place at increasing propeller-shaft revolutions, the more the accelerator pedal is depressed. So as to make the displacement of the two valves independent of each other, the front face is subdivided so that between the regulator valve positions 1 and 2 only the small area of piston K becomes effective, but between positions 2 and 3 this area is reinforced by that of the concentric ring piston L.

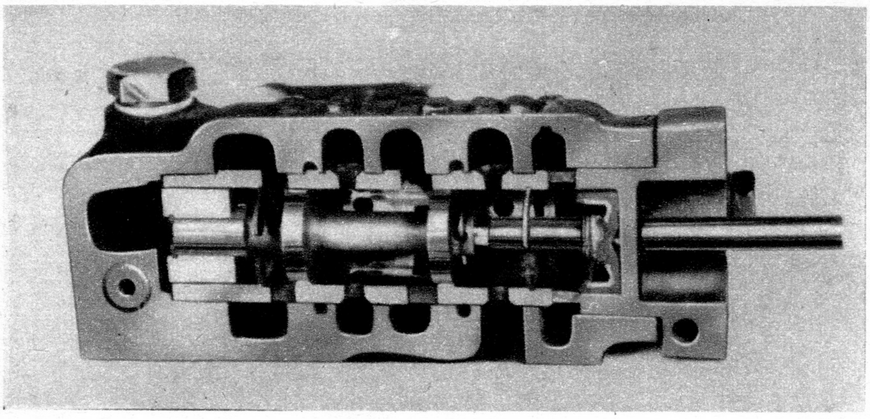
As already indicated above, the converter is permanently filled with oil from the engine-driven pump at 70 lb. per sq. in., which is fed into the regulator housing at point M (Fig. 4). When starting off, with regulator valve in position 1 connecting channel M with channel N, the



The control valve in position 1, for starting.



Position 2, locking the transmission in intermediate gear.



Position 3, for direct drive.

oil flows through this to the interior of the converter by way of O, after passing the throttling gap D. This throttling gap provides that oil pressure exists only on the converter side N of the turbine wheel. The chamber O behind the throttling gaps is pressureless for all practical purposes, as it is connected with the suction side of the pump via the regulator valve. The pressure difference between chambers N and O sees to it that the guide-vane casing, together with cone clutch KL, is firmly pressed and held into the cone face KG, of the static housing. Via the coupled reduction-gear unit (hill-climb ratio) the converter torque effect is mechanically increased.

When the regulator valve has reached position 2, through the increasing vehicle speed, it feeds the oil from channel M into the channel O, and at the same time connects channel N with a return line to the pump. With this the pressure condition in the converter alters so that chamber O now becomes pressurized as against chamber N The guide-vane casing now moves rearwards jointly with the impeller wheel, whereby the cone clutch KL is withdrawn from the cone face KG, and the guide-vane casing is freed. At the same moment the impeller wheel cone KP grips the turbine wheel cone KT, and pump and turbine shafts lock together. The converter is now out of action and so only runs on as a flywheel mass. The coupled reduction-gear unit remains in engagement after this change in the "hill-climb" (or second gear) position, increasing torque still further.

Second Speed Path

On second speed the engine torque effect is directly transmitted through clutch cones KP-KT, at a $1\frac{1}{2}$ ratio increase, to gear-wheel ZP which, lying concentrically with the transmission output shaft and running in needle rollers, is bedded in the transmission housing. The gear-wheel ZB carries the dog-clutch claws KZ; at their rear end these are engaged through claws KM with a coupling sleeve M, being on their part free to slide longitudinally, yet fixed rotationally on the transmission output shaft, and so transmitting the torque.

To obtain direct drive—in other words a straight-through connection between engine crankshaft and final-drive assembly whilst at the same time bypassing the layshaft—the disc clutch L must be in the engaged position. At the same moment second gear must be disengaged, i.e., the claw coupling KZ-KM be released. To prevent a break in tractive effort, the disc clutch is engaged at the very instant at which this dog clutch releases. The operation of the dog clutch is effected by an auxiliary piston having a selector fork S. A piston K1 (Fig. 5) is fitted at the front end of the piston rod K, which at its rear carries a disengaging piston K2, ending in the form of a control piston K3. The oil-feed line Z1 to this control piston is under constant pressure, whereas the oil-feed line Z2 is connected to the return lead of the pump and is therefore not under pressure. Lying in the position indicated is

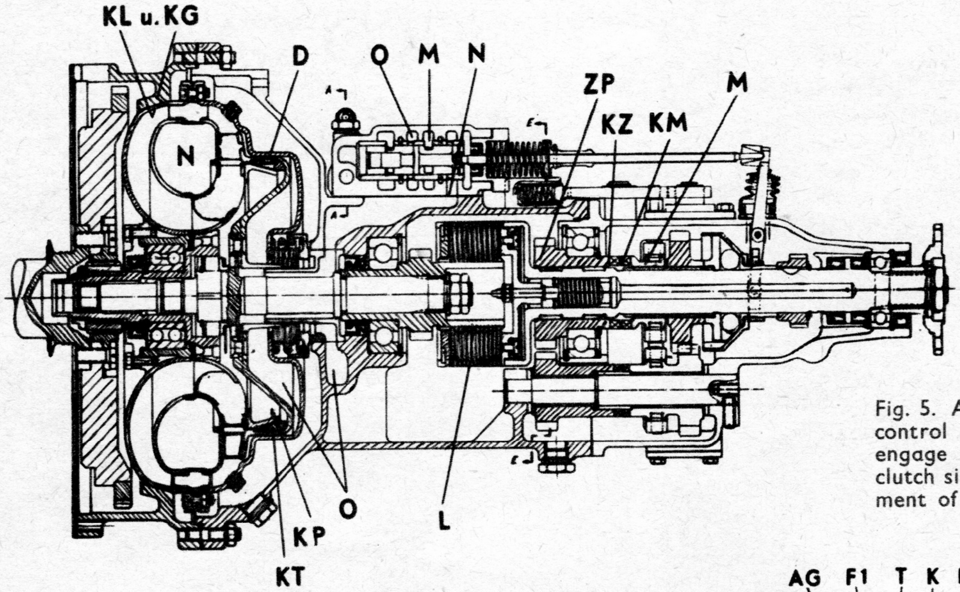
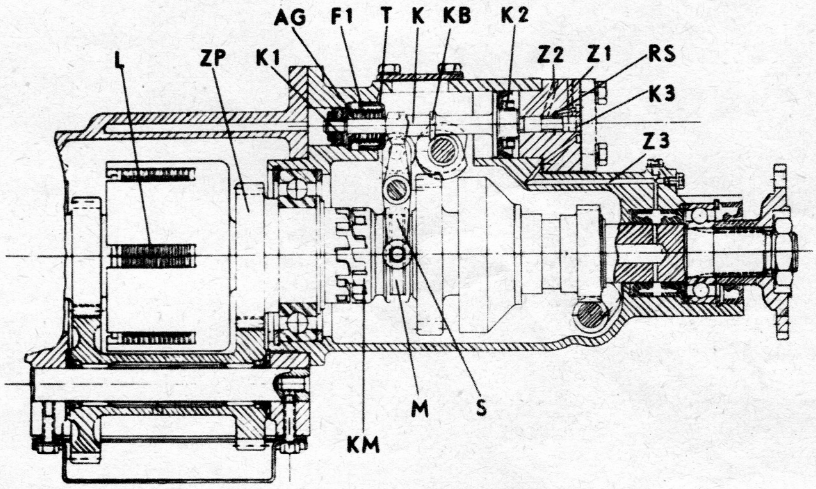


Fig. 4. The transmission in the starting position. Oil pressure keeps the guide vanes clamped by the cone clutch KL-KG; the disc clutch L free; and intermediate gear engaged by the dog-clutch KZ-KM.

Fig. 5. A detailed view of the auxiliary control piston and selector which disengage the intermediate gear dog-clutch simultaneously with the engagement of the disc clutch for the direct drive.



feed line Z3, for the disc clutch. It is connected with the non-pressure side of the control piston. Under these conditions the disc clutch is therefore not in engagement. When changing to direct ratio, the control valve takes up its forward end position 3, the oil being bypassed from piston K1 to piston K2, during which the pressure area in front of piston K1 is connected to the return lead and so loses its pressure. Piston K moves forward under thrust from piston K2 as far as the abutment AG in the housing. By means of a collar KB, and after a predetermined free movement has been taken up, it draws the selector fork into the hatched portion shown, its claws being extended in the overtaking position. Simultaneously the control piston K3 overruns the annular groove RS, and thereby directs oil under pressure into gallery Z3 for the disc clutch, being then shut off by piston LK. When the disc clutch starts gripping, the gear-wheel ZP is overtaken by the transmission output shaft and the coupling sleeve M, whereon the dog claws KM are thrust away backwards, and the selector fork S assumes its disengaging position.

Locked Solid

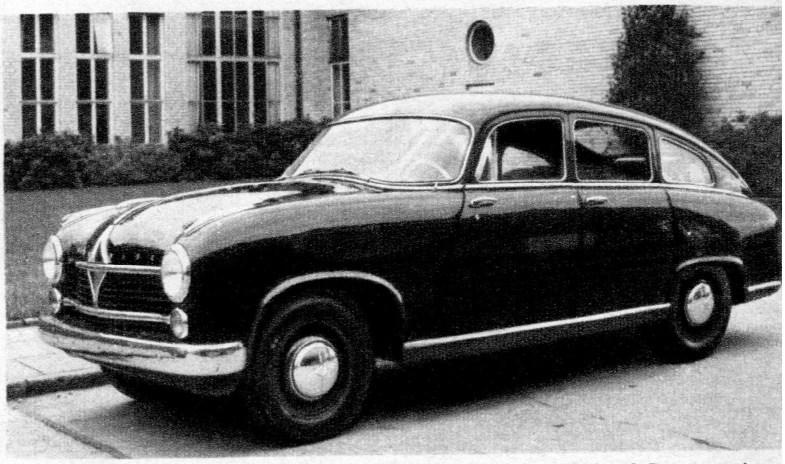
In direct-drive ratio the turbine shaft is solidly locked together with the rear transmission output shaft by means of the multi-disc clutch. The turbine shaft on its part is firmly coupled through the cone clutch, set between impeller and turbine wheel, with the impeller shaft, and by this with the engine crankshaft. The layshaft is now free to idle.

When the control valve changes back to the hill-climb ratio, the chamber in front of piston K1 is once more connected with oil under pressure, whilst the space behind piston K2 becomes non-pressurized. Because of this, the piston rod K moves back, the spring F1 loses tension and the spring plate T moves selector 2 towards the engaging position. At the same time the control piston K3 reconnects the oil lead to the disc clutch Z3, via the unpressurized lead Z1, and so disconnects the disc clutch. As the speed of the coupling sleeve is still greater than that of gear-wheel ZP and dog clutch KZ, after running in direct ratio, it is rejected until revolutions coincide and the spring F1 can enter the sleeve. This positively prevents the simultaneous engagement of two ratios. The more throttle is given, the quicker engagement takes place.

When the control valve reverts to the starting position, pressure oil is once more fed to chamber N, in front of throttling gap D, whilst chamber O behind the throttling gap becomes pressureless. This once more generates a force acting in a forward direction on the guide-vane casing, whereby cone clutch KP-KT is disengaged and cone clutch KL of the guide-vane wheel re-engages with cone face KG. The guide-vane wheel now again becomes static, causing an increase in turbine torque effect.

In reverse the converter is in the engaged position, because the control valve is in its starting location. The torque taken up by the turbine wheel is transmitted to the layshaft, from there to the reversing shaft, and then via the gear-wheel on the sleeve coupling to the transmission output shaft. The total mechanical advantage gained from the turbine torque effect is about 1.43.

Translated by R. E. P. SECRETAN



The automatic transmission is fitted to about 75% of Borgward Hansa 2400 models.