THE PROPER HANDLING OF CLUTCHES AND GEARS

BY

R. A. LEAVELL

ENGINEERING EXTENSION

Bulletin No. 26

AUTOMOBILE INSTITUTE

January 20, 1917

DEPARTMENT OF ENGINEERING EXTENSION
IOWA STATE COLLEGE
AMES, IOWA

CLUTCHES AND THE PROPER HANDLING OF GEARS

Nearly every motorist who purchases a new car is given two or three driving lessons by the agent from whom he buys it and is then left to his own devices to attain that stage of perfection which is acquired by persistent practice. Although an instruction book which contains very useful and definite information on the proper manipulation of clutch and gears is furnished with the car, it is more than likely that this will not be studied. Unless a service representative of the company, or some kind friend who is a really skilful driver gives him a few pointers he will, at the end of a few months, or even at the end of several years, be none too skilful in the control of his car, especially when it comes to changing from a higher into a lower gear half way up a long hill. This is sometimes partially explained by the fact that in the first two or three lessons he was taught to start out on low gear and get into intermediate, and finally into high gear, and how to release the clutch, apply the brakes and bring the car to a standstill, but there his lessons ended. When, some time later, in the middle of a hill, which is a little too long or a little too steep for him to "take on high" he attempts to shift from high gear into intermediate, he finds that his transmission is a little "cranky" and probably assumes that this is a characteristic of the car rather than the evidence of his lack of skill.

THE NEED OF A CLUTCH

Familiarity with the purposes for which a clutch and a transmission are designed will enable one to master the art of skilful gear shifting with very little practice. Some form of clutch is necessary on a motor vehicle in order that the engine may be started and afterward may be connected to the rear wheels without causing damage to the mechanism or discomfort to the occupants. A steam engine (or railroad locomotive) or an electric motor of the type that is used in electric street or railway cars or in electric automobiles is capable of pulling its full load from a standstill. The gasoline engine, on the other hand, must, nearly always, be turned by power from some outside source until the cylinders take up their regular cycle of operations, and whenever the load is great enough to bring its speed down too low it is liable to "stall." Since there is a very definite limit to the amount of explosive mixture which can be taken into each

cylinder, there is a limit to the amount of power which can be developed at a given speed. A greater amount of power can be obtained by turning the engine at a higher rate of speed, thereby securing a proportionally greater number of explosions in the same length of time.

GEARS NECESSARY FOR DIFFERENT LOADS

The need for a transmission can be illustrated by an example where two boys of approximately equal strength and skill buy two bicycles, one having a high gear ratio, the other a low gear ratio. On the smooth city pavement the boy on the high gear bicycle is able with very little effort, to maintain a pace which will soon tire his companion who has to peddle so much harder. When they come to a long hill, however, the boy on the low gear bicycle keeps right on riding while his friend is under the necessity of dismounting and pushing his wheel. Since the pulling power of the gasoline engine at a given speed is limited, and since it is not desirable to run the engine the greater part of the time at a speed many times as high as that necessary to produce sufficient power, a car is fitted with a set of gears to give two, three or even four different gear ratios corresponding to the high and the low gear bicycle. In addition a gasoline engine unlike the steam engine or the electric street car motor is generally not designed to run backward and, therefore, one set of gears for "reverse" is needed.

THE OPERATION OF THE CONE CLUTCH

The diagram, Fig. 1, represents a simple form of cone clutch. Although other types of clutch are in extensive use on motor vehicles, the purpose is identical and a discussion of their construction, their mechanical features, their care and the method of adjusting them is beyond the scope of this article. This information can be found in the instruction book and the driver should familiarize himself with it. Since the method of clutch control is practically the same on nearly all cars having a sliding gear transmission (this includes all gasoline cars of prominence except the Ford which has a planetary transmission, a new type of car employing a rather complicated electro-magnetic transmission and one or two cars not very well known which employ a friction type transmission) the statements here made can be applied just as well as if a disc or band type clutch were illustrated.

When the engine is started the clutch is engaged but the gears in the transmission, which are used to transmit the power to the rear axle, are not in mesh. When the driver depresses the left pedal with his foot the cone is withdrawn from the fly wheel to increase the speed of the car and to prevent danger of stalling the motor. If he opens the throttle before the clutch begins to take hold, the motor may race excessively and there will be either a jerk with resultant strain on the mechanism of the car or if the clutch action is sufficiently smooth a considerable wear on the clutch facing. Practice gives one the skill of being able to engage the clutch smoothly and without either stalling or racing the motor.

When the car has gained sufficient speed on low gear he depresses the clutch pedal and closes the throttle at the same time (to prevent racing of the engine while it is not connected with the rear wheels). He shifts the lever from low gear to neutral position, pauses just long enough for the clutch brake to slow the clutch down to about one-half of the speed it was turning at when he released it, moves the lever into second speed position, engages the clutch and then opens the throttle. This avoids racing the engine before the clutch takes hold, there being no especial danger of stalling the motor as the car has accumulated sufficient momentum while it was driven on low gear. Exactly the same procedure is followed when the shift is made from intermediate to high gear and from third to fourth in a four speed transmission.

THE THREE SPEED SLIDING GEAR TRANSMISSION

The diagram, Fig. 4, illustrates in a simple way the arrangement of the gears in a three-speed, sliding gear transmission. The power from the engine is applied through drive shaft D and gear M to gear G, which is securely mounted on one shaft in the transmission, known as the counter shaft or lay shaft. That the explanation may be simplified, an assumption may be made that gear M has eighteen teeth and gear G thirty-six teeth

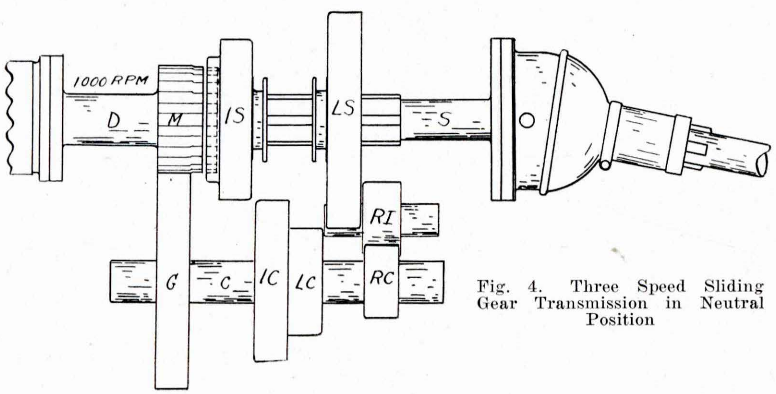
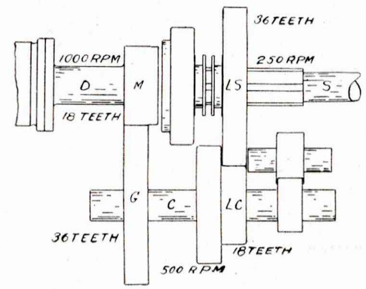
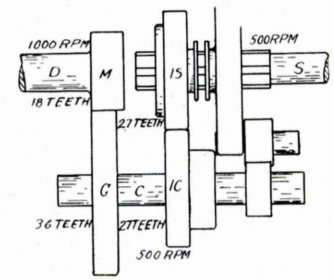


Fig. 4. Three Speed Sliding Gear Transmission in Neutral Position

so that when the engine which is connected through the clutch to D drives D at 1,000 Revolutions Per Minute gear G is driven at 500 R. P. M. and turns shaft C and the other three gears which are secured to it at that speed. Shaft S is placed exactly in line with shaft D and is supported at the rear by a ball bearing mounted in the case and at the front by an extension or pilot which slips inside of a ball or roller bearing or a plain bushing in gear M. The shaft S is made square or round with notches cut along it to leave four or six very strong, secure keys and has mounted upon it two gears which can be slid to different positions as indicated in the diagrams.

For first speed the gear LS is slid forward until it meshes with gear LC, Fig. 5. As LS has approximately twice as many teeth





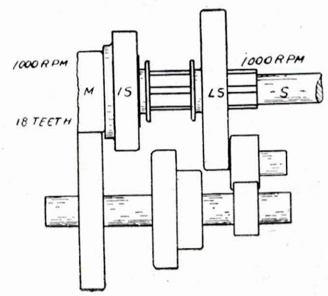


Fig. 5. Low Gear or First Speed

Fig. 6. Intermediate Gear or Second Speed

Fig. 7. High Gear or Third Speed. Direct Drive

as LC, when the engine travels 1,000 R. P. M. and the counter shaft 500 R. P. M., the splined shaft on which LS is mounted will be driven at 250 R. P. M. or at one-fourth engine speed.

For second speed, Fig. 6, the gears LS and LC must be out of mesh and the gears IS and IC, which have approximately the same number of teeth, must be slid into mesh. Now when the engine travels 1,000 R. P. M. both the counter shaft and the splined shaft travel at 500 R. P. M. and the car moves twice as fast on the road at the same engine speed as it did on low gear.

For third speed, Fig. 7, the gear IS is slid forward until the teeth or lugs on the face of gear M slide into mating depressions in the forward face of gear IS thus establishing a "direct drive." In this speed the splined shaft turns at the same speed as the engine and the car travels approximately twice as fast as it would in intermediate or four times as fast as it would in low for the same engine speed. Since the power of the engine is not being transmitted through gear teeth this is the quietest speed on the transmission. A four-speed transmission differs from a three speed only in that there must be an additional gear on each of the two shafts.

In order that a reverse combination can be provided, another gear, RC, which has a smaller number of teeth than LC is secured to shaft C, Fig. 8. When sliding gear LS is brought in line

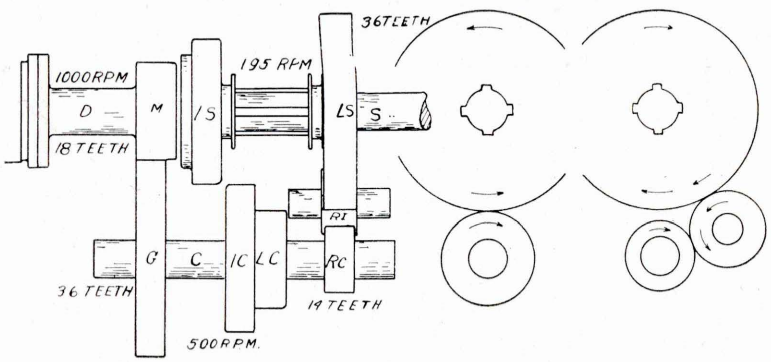


Fig. 8. Reverse Gear

with RC there is clearance between the teeth and still another gear RI is arranged so that it is in mesh with both of them. From the diagram it can be seen that when LC drives LS they turn in opposite directions but when RC drives RI and RI drives LS, RC and LS rotate in the same direction.

With these combinations, at a given motor speed the car would travel 40 miles per hour on high gear, 20 miles per hour on intermediate, 10 miles per hour on low gear or about 7.8 miles per hour on reverse.

SHIFTING FROM HIGH GEAR TO INTERMEDIATE OR LOW

If the speed of a car has fallen to 10 miles per hour on a hillside and it is necessary to shift to second speed the operator generally releases his clutch by pushing the clutch pedal clear down against the floor board, closes the throttle to prevent engine racing by taking his right foot off of the accelerator pedal, and attempts to move the gear shift lever from third speed to second speed position, but a loud grating noise indicates that the gears will not slide into mesh readily. This burring or clashing generally results in the breaking off or wearing off of small particles of metal which may remain in suspension in a transmission lubricant if it is too stiff and may cause noise, wear or breakage. If the clutch pedal is pushed clear down and the gear shift lever is thrown violently from third speed position to second speed position there is a possibility that the gears can be brought into mesh but the strain on them may be excessive, especially if the spinning portions of the clutch are too heavy. If the clutch pedal is pushed all the way down and the gears are slid from third into neutral and any pause is made before the attempt to move them into second, the clutch brake comes into action and brings the cone (or driven disc) to a standstill. It is then almost impossible to shift the gears into second, or even into first, until the car comes to a stop. Many accidents have happened when the driver was attempting to make such a shift on a steep hill because the car started to back up and he lost control of it.

If the gears on the car are to be changed from third to second (or from second to first), it is necessary to turn the engine and the cone (or driven member) of the clutch at approximately twice as many revolutions per minute for the same number of miles per hour car speed. When the skilled driver finds that the car he is driving acts "cranky" on a shift from a higher to a lower speed, his procedure is as follows: Release clutch and at the same time hold throttle open wide enough so that the engine, freed from its load, will increase its speed to approximately twice that at which it was running, slide the gear shift lever from third to neutral, (while the lever is in neutral) engage clutch and immediately release it (to speed up the cone or driven member of the clutch) quickly slide the gears into second (or the next lower speed) and immediately engage the clutch. With practice this can be done in two or three seconds or just as quickly as a shift can be made into a higher speed, allowing the proper amount of time for the cone to be slowed down during the pause in neutral.

The skilled driver, who is well acquainted with his car, may be able to push the clutch pedal down far enough to release it but, to allow it to drag slightly, slide the gears into neutral, and then into the next lower speed with little, if any, pause, the throttle being open wide enough so that the engine will approximately double its speed while it is relieved of its load.

The manufacturers of one high grade pleasure car and some drivers preparing a car for road racing cut the end of every second tooth on one of each pair of gears which must be slid into mesh about one-sixteenth of an inch short so that the tooth on one gear, instead of sliding past the space between two teeth in its mating gear passes readily into the space approximately three times its width and slides immediately and with certainty into mesh. In a great many motor cars the driven member of the clutch is so light that gear shifting is easy even for the inexperienced and rather unskilled driver. Even on such a car, it is well to remember that when a shift is to be made from a lower into a higher gear ratio the throttle should be kept closed to prevent needless racing of the engine and wear on the clutch facing, and the clutch pedal should be pushed down far enough to bring the clutch brake into action and slow down the spinning cone and a slight pause should be made in neutral as the lever is being moved to the next speed. On the other hand, when a shift is to be made from a higher to a lower speed, the throttle should be left open wide enough so that the engine when it is freed of its load, due to the release of the clutch, will approximately double its speed, and the clutch pedal should be pushed down only far enough to disengage the clutch and not so far as to bring the clutch brake into action. The engaging and releasing of the clutch while the lever is in neutral may be found necessary only on cars which are especially stubborn. Whenever the action of the clutch becomes in any way unsatisfactory or the gear shifting becomes difficult, where before it was easy, it is well to consult the information book and examine the mechanism to ascertain that all of its parts are properly lubricated and in good mechanical condition.

DRIVING WITH DERANGED CLUTCH

If a clutch becomes so deranged that it cannot be released or so that it will not hold but can be adjusted or fastened so that it cannot slip the skilled driver may still be able to operate his car. The procedure is as follows: crank engine and throttle down to a very low speed, have car pushed by hand until a speed of two or three miles per hour is attained, slide gears into low speed. (One may also run motor until warm, turn switch off with throttle partially open in order that a start may be assured on the second or third compression, open throttle slightly, retard spark to regular starting position, slide into low gear, use electric starter to start both engine and car, which will probably be easy

if ignition is by battery system rather than by high tension magneto.) Open throttle until car speed reaches five or six miles per hour, close throttle and slide gears to neutral. Listen to motor until its speed has fallen off approximately fifty per cent, slide into second speed, open throttle till car speed reaches twelve or fifteen miles per hour, close throttle and shift to neutral. When motor speed has fallen off approximately fifty percent slide into high. If a shift is to be made to a lower speed close throttle just enough to relieve transmission of driving strains, slide to neutral, open throttle just enough so that engine speed will be practically doubled, slide into next lower speed, open throttle and proceed.