Understanding Synchronizers

By Mike Weinberg
Contributing Editor

As far as I can remember the tech lines have handled calls every day of the year involving synchronizer problems. Grinding shifts, gear hop-out, gear block-out, high shift effort, and cold-shifting problems are the never-ending litany of calls that come in. This being the manual-transmission issue, it seems fitting to discuss again the fine points of synchronizer operation.

Synchronize means to coordinate or to happen simultaneously. In the war movies you have a squad of guys going out on a mission who synchronize their watches so that everyone will be on the exact same time. In making a shift in any standard transmission, the input and output shafts will be rotating at different speeds during a shift. The input shaft, driven by the engine through the clutch, will turn at engine speed as long as the clutch is engaged. The second the driver steps on the clutch and drops the throttle, engine speed drops and the input shaft will slow down under the engine compression. The output shaft is driven by the drive wheels (front or rear) and as long as the wheels are turning the output shaft will continue to rotate at road speed. When the driver makes a shift, the two shafts' speeds must be coordinated (synchronized) or a clash of gears will occur.

The speed gears of the transmission are equipped with cones and coupling teeth. The cone is a braking surface for the synchronizer ring, which is a wet clutch. The engagement teeth are used to bind the speed gear to the sliding sleeve of the synchronizer when the shift is completed. Since the speed gears freewheel on the main shaft and the synchronizer assembly is splined to the mainshaft, when the shift is completed and the sliding sleeve is engaged to the speed gear, the output shaft will transmit power to the rear wheels at the ratio of the speed gear in use. Sounds simple enough, but there are endless problems associated with the synchronizers, rings, speed gears and other transmission components that confuse the technician and waste a great deal of time (See diagnostic chart on page 48).

Inspection on teardown is the most critical aspect of beginning a successful repair. Start with a careful check of endplay in the unit. If the shafts or the speed gears have excessive endplay, the unit will jump out of gear and have grinding shifts. Examine the speed gears carefully. Are the points on the coupling teeth sharp and unbroken or chipped? Rounded or damaged pointing will create notchy, grinding shifts. Look at the sides of the coupling teeth for wear and relief. The sides of these teeth are cut at a back-taper angle, which helps hold the slider to the gear under changing throttle conditions. If the angles are worn out, the sleeve will pop off the gear.

Look at the fit of the synchro ring to the speed gear cone. It is my opinion to replace all the rings during an overhaul, but you still have to measure how much "grab" even new rings will have on the gear. Do this by using Prussian blue or machinists blue on the cone of the speed gear and twist a new good ring onto the cone. Now look at the pattern the ring made and make sure it is even all around the cone and from top to bottom.

Next look at the synchronizer keys. As the slider moves toward the gear the keys move with the slider to push the synchro ring onto the cone of the speed gear. Any wear in the keys or the steps in the ring in which they engage will create a comeback. Check the fit of the synchro sleeve to the hub. Are the splines worn, is there any side-to-side movement or radial play? This will allow the slider to cock on the hub and bind, causing draggy shifts or block-out. Fit the shift fork to the sleeve and make sure there is no excess wear on the fork or sleeve that can cause an incomplete shift, which will cause grinding or gear jump-out.

Synchronizer technology has advanced along with the sophistication of the transmissions. You now see many different types of synchronizer materials. Paper lined, sintered metal and carbon fiber ring linings have joined with the traditional brass and bronze rings of yesterday. These materials require specific properties in lubrication for a proper shift. There are at least 10 different lubricants found in standard transmissions and transfer cases that are specifically designed for the type of lining on the synchronizer materials. Choosing the wrong fluid will create shift problems and rapid failure of the synchronizer rings. Examing the lube chart on page 49 will help you to select the correct lube for the trans you are working

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Manual Transmission Shift Diagnosis

HARD SHIFT

Symptom: High, steady effort needed to move the shift lever into gear.
Steps Affected: 1 through 6
Parts Involved: • Synchronizer hub
• Synchronizer Sleeve
Condition: Poor fit between hub and sleeve (binding or cocking)

BLOCK-OUT

Symptom: Normal effort needed to move shift lever to a point then high effort needed to move lever further past a bump. Effort may be easy again, or another small bump may be encountered.
Steps Affected: 1 through 3
Parts Involved: • Synchronizer blocking ring
• Speed gear (Cone surface)
Condition: Cone clutch does not work well, but is forced to work by the driver. May be due to worn parts or improper shift speed.

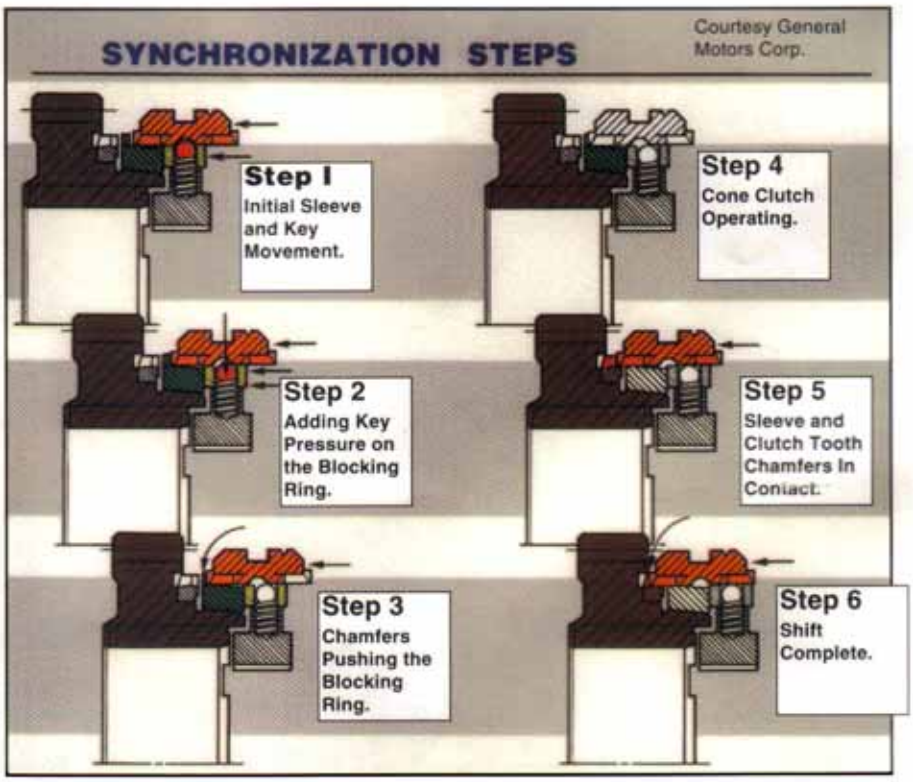
GEAR CLASH

Symptom: Normal effort needed to move shift lever until a grinding noise is heard. Increased effort needed to move lever into gear.
Steps Affected: 3, 4 and 5
Parts involved: • Synchronizer blocking ring
• Speed gear (Cone Surface)
Condition: Cone clutch does not work at all. The synchro-sleeve tooth chamfers push past the blocking ring teeth and meet the unsynchronized speed gear clutching teeth, causing grinding. Both the synchronizer sleeve and speed gear tooth chamfers should be checked for wear.

HOP-OUT

Symptom: After a normal shift, the shift lever jumps out of position and the transmission is in neutral.
Step Affected: 6
Parts Involved: • Synchronizer sleeve (tooth back-tapers
• Speed gear (clutching-tooth back-tapers)
Condition: The synchro sleeve is unlocked from the speed gear due to worn back-taper surfaces on either the sleeve or speed gear clutching teeth. Also, excessive runout of either the sleeve or speed gear will cause this.

Courtesy General Motors Corp.



RSG Lubrication Guide

BorgWarner Transfer Cases

Unit#	RSG Lube	Qts. Needed
1346	RSG-4001	4
1350	RSG-400+	2
1354	RSG-400+	2
1356	RSG-400+	4
1370	RSG-400+	4
4401	RSG-400+	4
4404	RSG-530GM	2
4405	RSG-400+	3
4406	RSG-400+	4
4407	RSG-400+	5
4472	RSG-530GM	3

New Process Transfer Cases

Unit #	RSG Lube	Qts. Needed
119	RSG-530GM	3
125/129	RSG-530GM	3
136	RSG-400+	4
203	RSG-150GM	5
205	RSG-150GM	3
207	RSG-530GM	3
208	RSG-530GM	S
219	RSG-530GM	3
228/229	RSG-530GM	3
231	RSG-530GM	2
233	RSG-530GM	2
236/246	RSG-400+	4
241	RSG-530GM	3
242	RSG-530GM	3
243	RSG-400+	3
247	RSG-400+	3
249	RSG-530GM	3
271/273	RSG-530GM	5

New Venture Transmissions

Unit #	RSG Lube	Qts. Needed
HM290/ 5LM60/3500	RSG-150GM	3
NV 3500	RSG-150GM	3
NV 4500	RSG-GL65	5
T350/A576/ F5MC1	RSG-9417	3

Various Transmissions

Unit #	RSG Lube	Qts. Needed
AX15	RSG-150GM	3
AX5	RSG-150GM	3
BA10	RSG-150GM	3
FM145/146	RSG-150GM	3
M5R1	RSG-400+	3
MSR2	RSG-400+	4
Nissan Truck	RSG-150GM	3
NP535	RSG-150GM	3
RUG/OD	RSG-150GM	3
SM465	RSG-150GM	5
T-18/19	RSG-150GM	4
T45	RSG 400+	3
T5	RSG-400+	3
T50	RSG-400*	5
Toyota	RSG-150GM	3
Toyota R150/150F	RSG-150GM	4

ZF Transmissions

Unit #	RSG Lube	Qts. Needed
S6-40	RSG-530GM	3
S5-42	RSG-400+	4
S5-47	RSG-400+	4
S6-50	RSG-400+	6

on. Many of the books do not have the right specs. These suggestions are all products of real-world testing and experience.

Study the synchronizer operation charts included here and you will gain a clearer understanding of the how all the components work together. Knowledge is the key to creating a properly shifting transmission and being able to diagnose some annoying shift problems. TD

THE BOTTOM LINE:

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Circle the corresponding number on the free information card.

87 Useful information.
88 Not useful information.
89 We need more information.