1953-1962 CORVETTE STEERING GEAR OVERHAUL

By Joe Calcagno

The steering gear assembly on the early Corvette is the source of grief to many a Co
can't tell you how many people I know who have major problems with their steering, and have been unable to successfully get them corrected. This is the result of several things. One is the mystique of the steering gear box. If you look in the ST-12 (1953-62 Corvette Servicing Guide) you will see that the steering is covered in great detail. It looks very complicated, with all the tests, adjustments, and special tools needed, it would scare the most capable mechanic.

Another problem is the fact many of the parts are made of that rare material... unobtainium.

Still other problems like the nature of the steering angles, the dirty and rusty conditions under which you will have to work, all join together to make this a particularly undesirable project.

I think we would all agree that the steering is one of the most important aspects of a desirable car. I'd say out of ten early Corvettes I drive, eight of them have deficient steering in one or more ways.

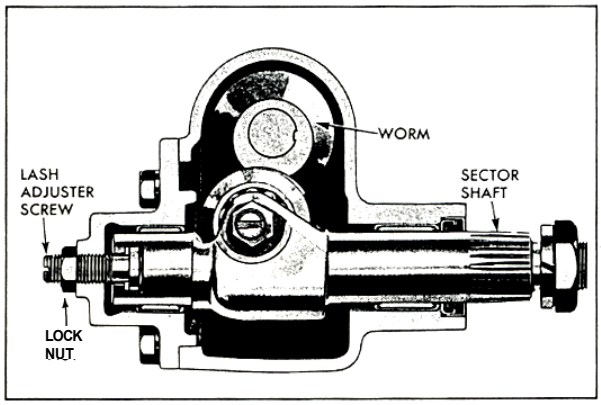
You might think the steering was a poor design. You may assume if the system was a good one, most would not be in the poor shape they are. I believe the design was actually very good considering the time it was done, and the objectives that were achieved.

This steering gear was designed to operate without power assist. The engineers came up with a low friction gear box that would be very efficient. In order to do this, they used high quality, specially designed gears with very precise fit of very hard materials. The large steering wheel was an important part of the overall design, because its large diameter helped to make the car easy to turn. Additionally, the front wheel geometry was a key factor in the success of the system. When all the parts are in good condition, and adjusted properly, the early Corvette is a surprisingly agile car.

Actually, I believe most of the failures in the steering boxes are caused by a failure of the owners to check and maintain the proper level of gear oil in the gear box. The Corvette Servicing Guide says the level should be checked every 1000 miles. While I believe this is unnecessary, it should be checked at least every 20,000 miles, or at least once a year. The gears need a hypoid lubricant commonly called E-P lubricant (Extreme Pressure) or what most of us call 90-weight gear oil.

Another thing which can cause a failure in the steering gear box is the use of oversize tires and reversed or otherwise improper wheels. Tires with wide treads have much more adhesion to the road surface, and therefore cause more forces to be transferred to the steering gears. Remember, back when these steering gears were designed, the tires were only four or five inches wide.

One of the most common problems I see is what I call a "catch" in the steering. This is where the steering wheel, as it is being turned, comes to a rough spot, or a "catch" which causes your turn to be interrupted. At this point, you must provide extra force to continue to turn the wheel. Suddenly, the wheel jumps past the hard spot, making the turn uneven, and in some cases dangerous. This type of a problem can be caused by many things. It is important to properly diagnose the cause before repairs are started for obvious reasons. I recommend you disconnect the drag link from the pitman arm or the third arm and then turn the steering wheel to see the steering gear box. If the problem ceases with the drag link disconnected, the



cause is somewhere in the steering linkage, and it must be located by visual inspection, or by disconnecting other parts until you are able to isolate the problem area.

I will concentrate on the problems with the steering box and how you can repair them.

Please take a look at the two cutaway drawings of the steering box. In figure 1 you can see the ball bearings in the sector roller. If you will notice, the sector roller is located just slightly to the left of the center of the worm gear. Looking to the the drawing, you will note the "lash adju As you turn this screw, you can move the complete sector shaft closer to or farther from the worm gear. This is how you adjust the lash, or play, in the steering gears. The lash is important. It allows for freedom of movement, without too much play. Note the way the lash adjuster screw fits into the slot in the end of the sector shaft. This fit is critical to the ti steering gears. This little item is often ignored. Later in this article I will show you how to check and adjust this important fit.

In figure 2 we are looking at the same assembly, but we have turned the gear box 90-degrees and we're looking at the end of the sector shaft. You can imagine how the sector roller will follow the screw shape of the worm gear as the worm gear is turned right and left. The sector roller is a precision hardened roller, and it never loses contact with the worm gear as it operates.

Note the worm bearings on the right and left of the worm gear. They are precision bearings. They

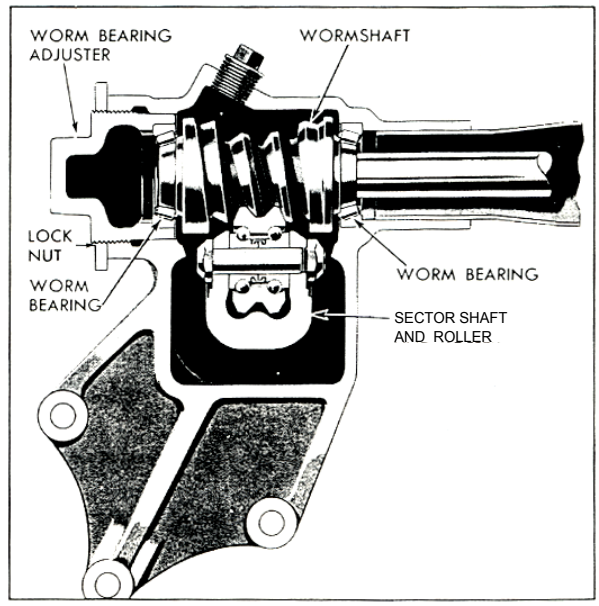


Figure 2

must hold the worm gear firmly, only allowing it to turn, never allowing it to move away from the sector roller. It is the bearings in this gear box which hold the parts in proper alignment, and provide for long life. If any of these bearings fail, it will lead to the failure of the whole assembly.

Now please look at figure 3. This shows how the whole gear box is put together. This is a blow up view and should show all of the parts. It fails to show some

items. Part No. 2, the worm bearing adjuster cap, has a race, exactly like part No. 6, pressed into it. I think this is important because that race needs to be changed when you overhaul the steering box.

Part No. 11, the sector shaft and roller assembly, has several parts installed in it. There are 22 ball bearings, each measuring .050-inches in diameter, two inner races, a retaining clip to hold the inner races together, and a hardened and ground shaft and lock nut to hold it all in the sector shaft.

Parts No. 8 and 9, are actually one part, the sector shaft seal.

This gear box uses four different types of bearings. It uses the 22 ball bearings in the sector roller, the two caged roller bearings on the worm gear, two different size caged needle bearings and a

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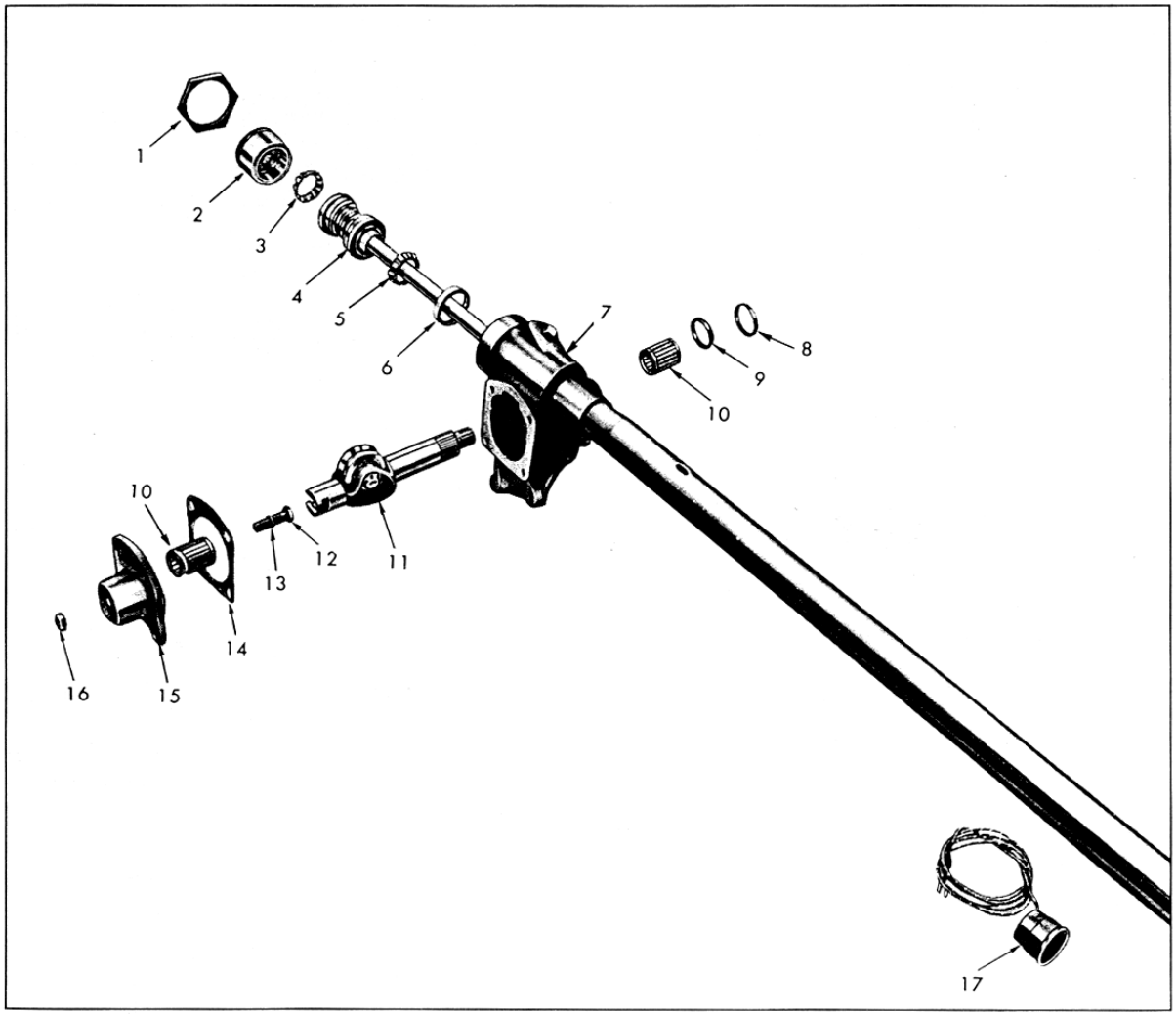

Fig. 12 - Layout of Steering Gear Parts

1. Worm Bearing Adjuster Lock Nut
2. Worm Bearing Adjuster Cup
3. Lower Worm Shaft Roller Bearing
4. Worm Shaft Assembly
5. Upper Worm Shaft Roller Bearing
6. Upper Worm Shaft Roller Bearing Race
7. Housing and Mast Jacket Assembly
8. Sector Shaft Packing Retainer
9. Sector Shaft Packing
10. Sector Shaft Needle Bearing
11. Sector Shaft a d Roller Assembly
12. Lash Adjuster
13. Lash Adjuster Shim
14. Housing Side Cover Gasket
15. Housing Side Cover
16. Check Nut
17. Mast Jacket Bearing Assembly

rubber mounted ball bearing assembly on the upper end of the steering shaft just below the steering wheel.

There is no need to rewrite the ST-12 Servicing Guide, so I will conclude with some photos of some of the wear and damage that I have found boxes. In the follow up article, I will attempt to show how to remove and replace the bearings and races that the ST-12 shows being changed by means of special tools. If you don't have an ST-12, you should get one before attempting any work on the steering assembly.

Photo 1 shows a worm gear removed from the steering shaft. Note the galling of the bearing surface on the right-hand end of the gear.

Photos 2 and 3 show severe galling on the cut portion of the gear where the sector roller rolls. It is easy to see how this type of damage will cause the

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PHOTO 1

PHOTO 2

PHOTO 3

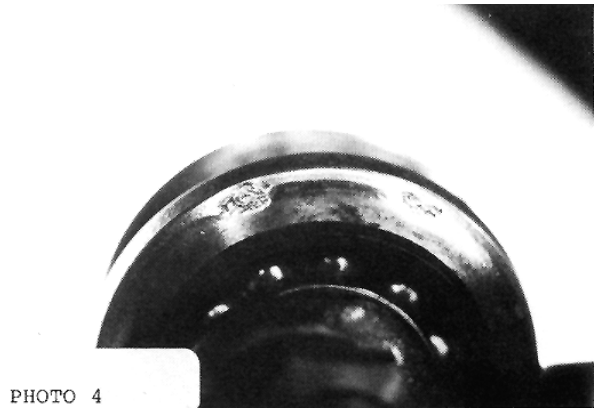

PHOTO 4

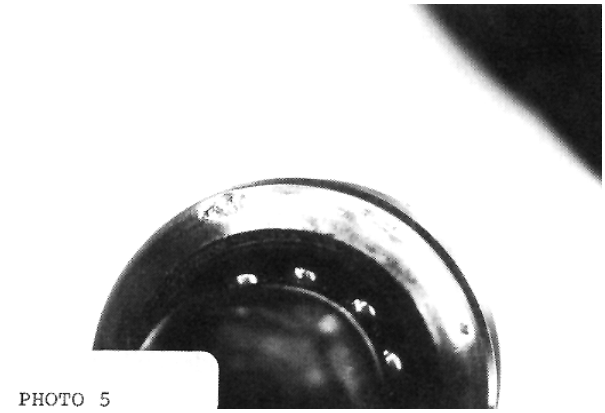

PHOTO 5

PHOTO 6

steering to catch as the roller moves through this area.

Photos 4, 5 and 6 show damage to sector rollers. Once again, these parts are precision manufactured to extremely close tolerances, and must be in good condition to maintain contact through the range of the turn. At any point, where there is roughness, you will be able to feel it in the steering wheel. When the system is in optimal condition, lubricated properly, and with the front suspension aligned correctly, you can expect very precise steering, with surprisingly little effort.

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In the first part of this article I outlined the general design and operational essentials of the early Corvette steering gear box. I mentioned some of the features of this design, and how they pertain to those of us who are involved with the restoration of these cars. I also mentioned that I would not be rewriting the *1953-62 Corvette Servicing Guide* (publication *ST-12).* It remains the premier source for information pertaining to this assembly.

In addition to the servicing guide, there have been other interesting and informative articles written in *The Corvette Restorer Magazine,* among which is a recent article by David Har-rington which appeared in the Spring 1993 issue (Volume 19, Number 4).

I hope to supplement the other writings by showing some workable methods for the actual replacement of some of the parts.

As you will see if you look *ST-12 Corvette Servicing Guide,* the need for special tools is clearly shown. I have tried to put together some ideas on how you could do this job without the need to buy or borrow these special tools.

The parts with which to overhaul this gear box are available in a kit from Corvette Central and other parts suppliers for about $54. They include all the bearings, seal and gasket.

As I see it, there are five areas where the average home restorer would have difficulty in completing the job:

- (1) Ball Bearings (22 ball bearings on the sector roller)
- (2) Roller Bearings (worm gear, one on each end)
- (3) Needle Bearings (sector shaft, two sizes and locations)
- (4) Lash Adjuster washer (maintains sector shaft end play)
- (5) Adjustment (pre-load of bearings, and gear lash or mesh)

I would like to treat these five subjects in the order shown above so as to keep them clear. I have, therefore, numbered the photos so as to relate to the these categories. All photos numbered with the number 1 will relate to the ball bearings in the sector roller assembly; the number 2 will relate to the roller bearings on the worm gear, etc.

Ball Bearings

These 22 ball bearings are used to support the sector roller with precision. There are two rows of 11 balls, one on each side of the roller. These ball bearings run on races which are a part of the roller, that is, the outer races are machined into the roller itself. The races are not separate, and therefore, not able to be changed separately if damage has occurred to them. In order to remove the inner races and the 22 ball bearings, you can pry with two screwdrivers as shown in photo 1-A. These small inner races will pop out as they are held in place by a simple stainless steel retainer which holds them when they are assembled. Use care as the balls will spill when the races are removed. I find it helpful to do this over a large cloth.

After the bearings have been removed, clean the races, both inner and outer, and look for any galling, roughness, discoloration or rust and determine if the original roller is usable again. If the roller is in good condition, and both the inner and outer races are smooth, you will be able to install the 22 new ball bearings by using a heavy grease to stick them to the inner, smaller races as shown in photo 1-B. After they are all stuck in place, use

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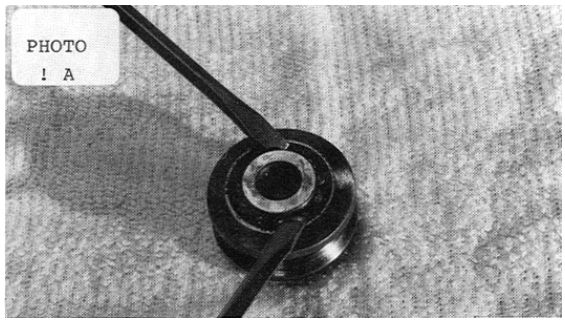

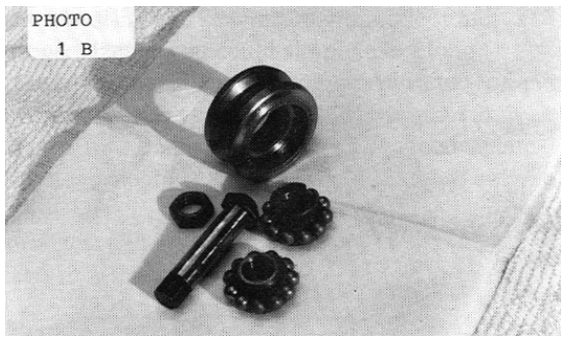

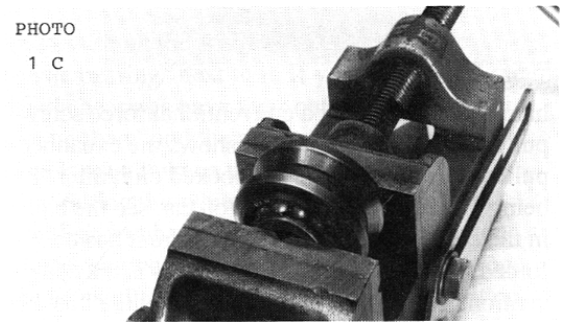

a vise to force the two small inner races straight together so the small stainless clip will snap them together as shown in photo 1-C. This roller is critical to the smooth operation of the steering gear. It is very important all the surfaces be smooth. It is the outside diameter of this roller which is in constant contact with the worm gear, and therefore, any roughness will be transmitted up the steering column to the driver. If you hold the roller in contact with the worm gear, you'll see it will touch in two places. It makes constant contact throughout the turn as it rolls. These two contact points carry the whole load of the steering effort. Look it over carefully to determine if there is any reason it would cause poor handling. The roller is mounted on a hardened and ground shaft, which fits into the sector shaft. It is designed to hold the roller bearing inner races, but should not show any signs of the races having turned on this shaft. This shaft has threads on the end, and after the nut is threaded onto the shaft, and tightened to 45 to 55 foot pounds of torque, the exposed threads are peened over with a hammer. This is done as a safety measure to be certain it will not loosen in service. The roller, shaft, inner races, and balls are all shown in photo 1.

Roller Bearings

The roller bearings support the worm gear and the lower end of the steering column in the steering gear box. Note the roller bearings have removable outer races which come with the kit, but the inner races for these bearings are machined onto the worm gear itself. (A condition similar to that of the roller mentioned in section one above.) Therefore, if the bearing races on the worm gear are damaged, the entire worm gear must be replaced.

The *ST-12 Corvette Servicing Guide* shows a special puller being used to remove the race in the bearing cup (Fig. 15, Pg. 9-B). This type of puller is available from the major tool companies in several forms. It is called a "Blind Bearing Puller" as it is designed to pull out of a blind, or closed bore. One of these pullers is shown in photo 2-A and 2-B. The pencil shaped pin fits down the center of the main barrel and, as it is

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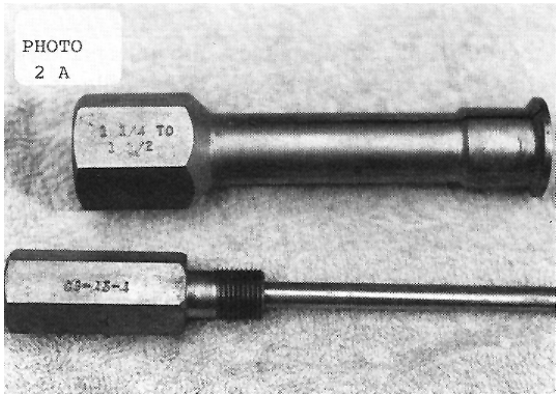

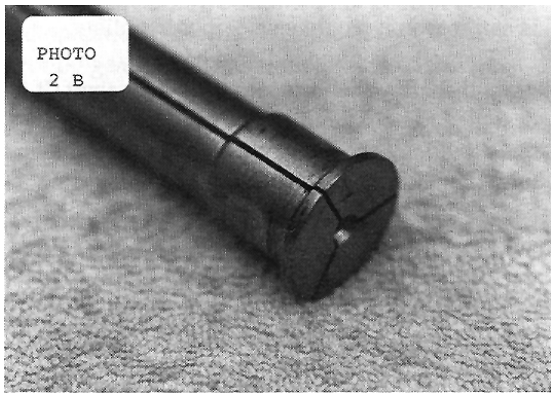

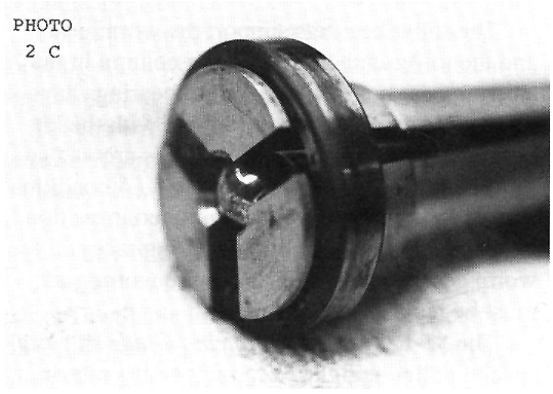

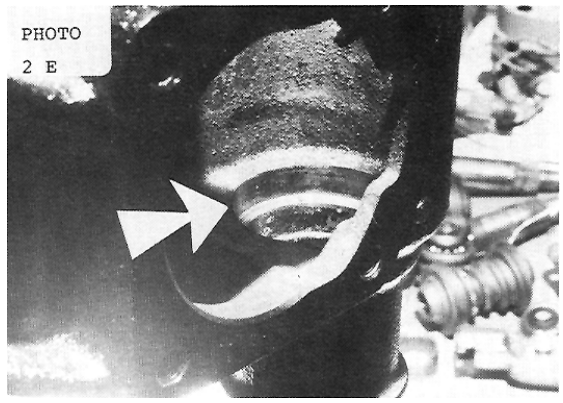

screwed into the threads, it forces against a ballbearing which is located inside of the barrel. The ball bearing forces the three legs of the barrel outward, expanding it to a larger size until it fits under the lip of the bearing race. After this has been done, the puller, along with the race, is drawn out of the bore by means of either a slide hammer puller, or by a conventional force screw puller. See photo 2-C which shows the expanded puller with the old race still locked on it after being pulled from the bore. You can see the ball in the center of the puller legs where it has been forced to expand the three legs. This is the conventional method of removing a race like this one.

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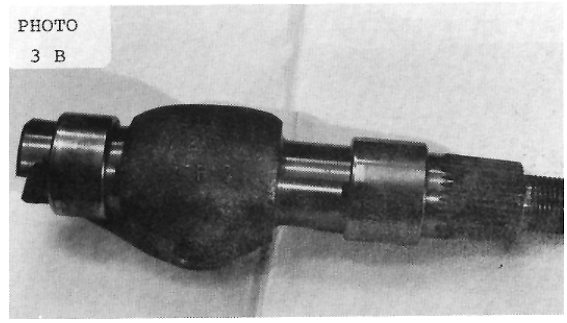
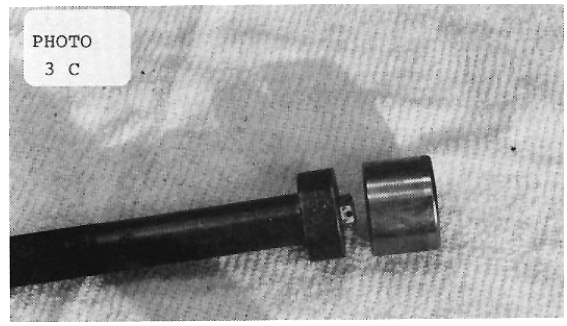
Another method is somewhat unconventional, but I have used it for many years with great success. It simply involves the application of an arc weld along the surfaces of the race, as shown in photo 2-D. I usually run two beads opposite one another as you can see. After a few minutes of cool-down time, the race will drop out of the housing. This will not harm the housing, but you have to be careful to not weld the race to the housing. The arc bead must be applied to the race only. It has never failed. I would recommend you use a MIG or wire-welder as it will cause little spatter. You can see in the photo how clean the area around the weld has remained. If necessary, however, I have used a DC arc welder and stick electrodes with success. As a matter of fact, the stick electrode makes it much easier to get into the gear box to remove the race on the upper end of the worm gear. Photo 2-E shows the empty gear box, and we are looking in through the side cover at the machined ledge where the race would normally be located. In photo 2-F, you will see the worm bearing adjuster cap with the race still installed. I would remove this one the same way.

In order to install the new races, you could use a bearing and seal installation tool of the proper size, or you could simply use a long punch, and tap alternately on opposite sides of the new race as you work it down into its cavity. If you use a punch, make sure it has good square shoulders so the punch will exert the force only upon the edge of the race, and not on the running surfaces. (A bearing installation tool is shown later in the article.)

Needle Bearings

These needle bearings are located on each end of the sector shaft. Photo 3-A shows the sector shaft, without the sector roller, and the two needle bearings next to it. If you will notice, the needle bearings have their outer races built right around them, and the races act as a cage also. A cage is used to keep the loose balls or rollers from falling out while the device is being assembled, and has no function during operation. Notice the two bearings are different. The longer one is installed closest to the spline. They fit on





the sector shaft as shown in photo 3-B. The sector shaft, being used as the inner race for these bearings, as well as the surface on which the seal will act, must be smooth and sound. The splines must be straight. I have seen at least one steering gear box where the sector shaft was so damaged the splines were spiraled like a barber pole.

Removal of the needle bearings is accomplished by driving the caged needles out of the housing with a bearing installer tool, as shown in photo 3-C. This is done after the seal

PHOTO 3 D

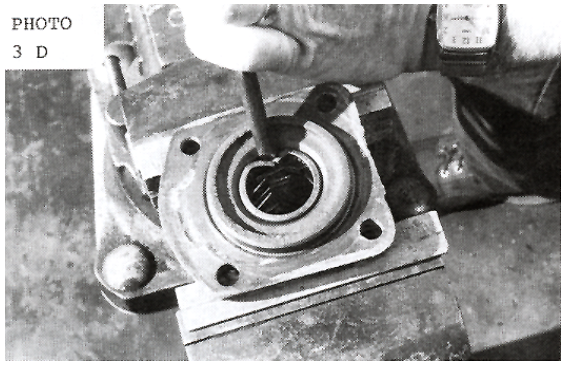


PHOTO 3 E

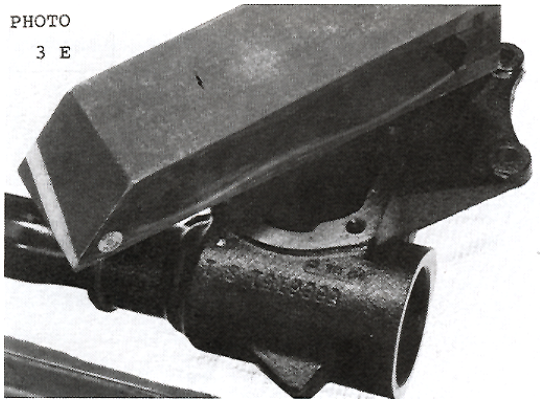
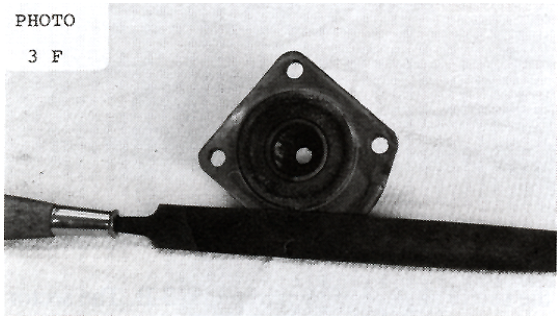


PHOTO 3 F



has been removed. The needle bearings in the side cover housing can be removed by using a cape chisel as shown in photo 3-D. This will distort the race and allow it to be pulled out with a pair of pliers.

I always dress the flat surface on the side of the gear box with a sanding block to remove any irregularities as in photo 3-E. The side cover housing should get the same treatment with a mill file as shown in photo 3-F.

Installation of the new needle bearings must be done by means of a device which will place the force on the entire circumference of the cage, like the one shown in photo 3-C. As you can see, the new bearing will be pushed straight into the bore, and no damage will come to the race. The use of a punch will always damage the outer race because it is made out of thin stainless steel only.

Lash Adjuster

This little button head bolt with a simple looking washer around its head is one of the most important parts in the assembly. This adjuster screw holds the sector shaft in place. You will remember that the sector roller must be held in contact with the worm gear at all times. This screw holds it.

In photo 4-A you will see the method of measuring the play in the head of the adjuster screw. You should not be able to get anything thicker than a .002" feeler gage into this space. I have never seen one with less than .006" of wear in a used gear set. The factory prescribed method of bringing this into specs was to buy a set of different thickness washers, and then selecting the correct thickness washer to bring the gap down to less than .002". Since that is no longer possible, and since just about every single one will need to be corrected, I have come up with a simple method of correcting the end play. I use a wave washer as shown in photo 4-B. The wave washer, or spring washer, is the thin one in the photo to the right of the selective fit washer (thick one). Photo 4-C shows both washers on the bolt ready for a trial fitting. The two washers together will be too thick to allow the button head to slip into the slot in the head of the sector shaft. I sand the head of the bolt with a sanding belt to reduce its thickness just a few thousandths at a time, photo 4-D. Each time I remove a small amount of metal, never allowing the bolt head to become very hot, I trial fit it into the slot. Soon I find I can just fit it in by hand, photo 4-E. This method will allow the freedom of movement necessary for the sector to turn, but it will not have any measurable end play. This has been a good alternative to some other methods involving such things as weld build up on the head of the bolt,

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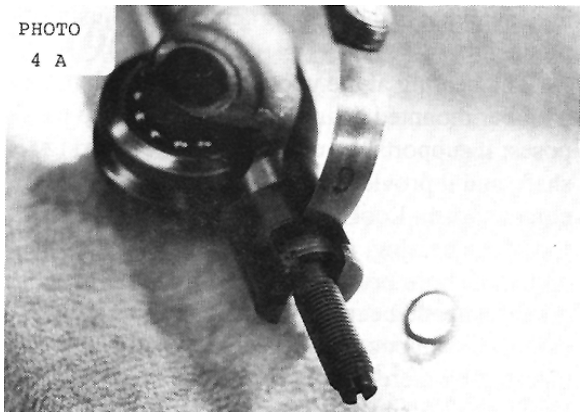
PHOTO 4 A


PHOTO 4 B


PHOTO 4 C

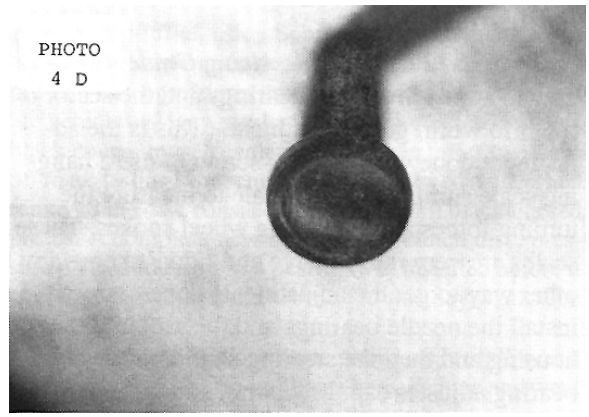
PHOTO 4 D

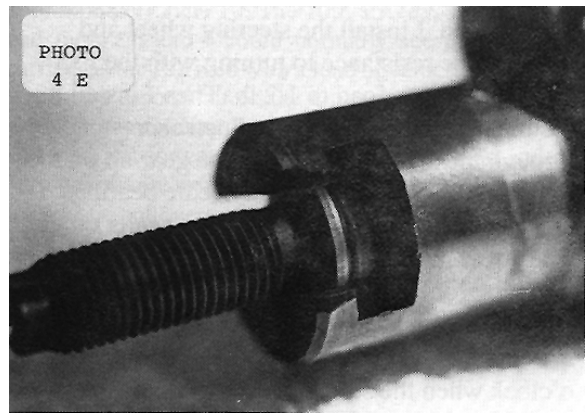
PHOTO 4 E


PHOTO 5 A

and I have quite a few of these steering gears in service with excellent results. The washer measures .470" (15/32") I.D. by .665" (21/32") O.D., with a thickness of .018". I buy them from clutch and brake houses or friction material supply houses. On trucks with drum brakes, they are used where the emergency brake lever attaches to the brake shoe web.

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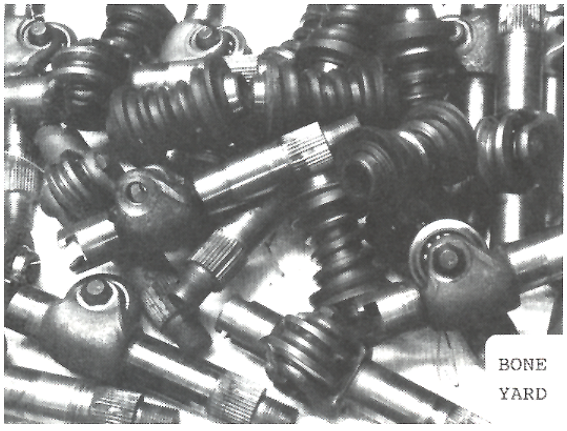
Adjustments

The *ST-12 Corvette Servicing Guide* shows how to adjust the worm bearings and the sector roller to worm gear adjustment. (This is the adjustment done with the lash screw.) I use a hanging scale similar to a fish scale to measure the turning forces at the steering wheel spokes. These scales are very inexpensive and I don't know any other way to get the adjustments done correctly. I install the needle bearings and the seal into the housing and then the steering shaft and the worm bearing adjuster cap. I recommend you coat the threads of the cap with "Never Seize". I do this to prevent the possibility of a leak at these threads. At this point, photo 5-A, I adjust the worm bearing pre-load. I install the steering wheel and measure the resistance to turning with the fish scale and set the load to 1/2 Ib. Then I install the sector shaft and fit the lash adjuster screw through the sidecover. I use some gear oil on the shaft to lubricate the seal and needle bearings. I use a good grade of silicone gasket sealer on the side cover gasket. I don't want any leaks.

Look for the mark on the top of the steering shaft. This is a small hash mark which looks like the hands of a clock. It should be pointing to 12 o'clock when the steering sector shaft is in the center of its movement.

Following the *ST-12 Corvette Servicing Guide,* adjust the lash as the steering wheel is turned through the center point. There is extra force required to turn the wheel through the center, and this extra force is what you are measuring, and what is most important in the adjustment procedure.



The bearing at the upper end of the column is a rubber mounted bearing which serves two purposes: It supports the upper end of the steering shaft, and it provides a ground track for the horn contact brush. Look for a brass track around the top of the bearing. It will tie the surface upon which the horn brush rotates. Clean it off with a wirebrush, and be aware it must be kept clean inside. If it is in poor condition, it can be easily changed by merely prying upward on the horn contact track, and the entire bearing will come up out of the mast jacket. The installation of the new one is just as simple.

The steering wheel goes onto the steering shaft in the following way: First, be sure the upper bearing is complete. It has a small curved washer which goes over the bearing for the spring to push against. Next, the spring goes over the steering shaft, and then the steering wheel. When the steering shaft is at the 12 o'clock position, the steering wheel should be mounted so that the two pins (turn signal cancelling pins) are closest to the driver's door. That is, one spoke will be pointing straight down when the two pins, which are away from you, pointing into the turn signal housing will be at the 8 and the 10 o'clock position. This is the correct way to install the steering wheel. The nut has a flat washer under it and it should be tightened to about 30 foot pounds torque.

The success of the steering box overhaul will depend upon the condition of the rest of the front steering linkage and the suspension. The third arm bearing, drag link, tie rod ends, king pins and wheel bearings will all affect the steering, as will the front end alignment angles. If you follow up on all these items, and make sure that they are all in good operating condition (including frequent lubrication of the 22 grease fittings), you will be surprised at how easily and responsively the car will handle.

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DATE	REVISION	AUTH	DR
07/28/05			

INSTALLATION INSTRUCTIONS

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