Differential failure 2018

by Tom Endy

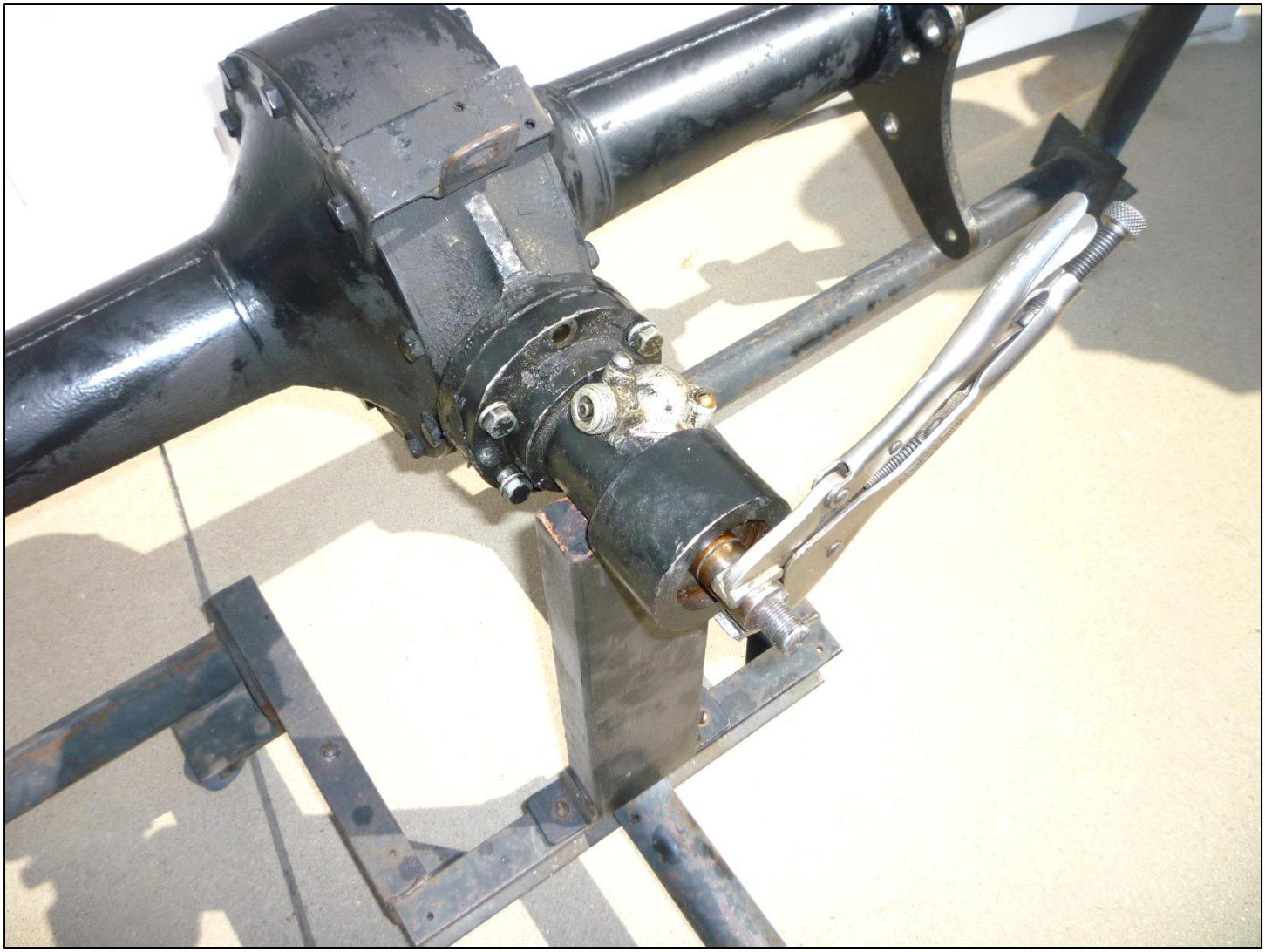
During the April 2018 CCRG meet in the Central California Town of Cambria, a member of the Santa Anita A's had a catastrophic failure of the rear axle assembly in his 1931 Town sedan. The car has a number of modifications such as a five-speed Borg Warner transmission from a modern car and hydraulic brakes. The actual cause of the failure is undetermined.

There were two separate failure modes, one occurring much earlier than the second and final failure. The first failure was the bearing hub sheared off the left side of the carrier. This failure was not a show stopper. The car would and did continue to run in this condition. However, the differential would not be running 100% on bearings. There would be an extreme amount of heat generated in the area of the sheared carrier hub and this affected the gear end of the left axle shaft. There would also be an unusual noise emanating from the differential. With the heat working on the gear end of the axle, which is right next to the sheared hub, the axle itself finally sheared and this was a show stopper. The car would not run with a sheared axle.

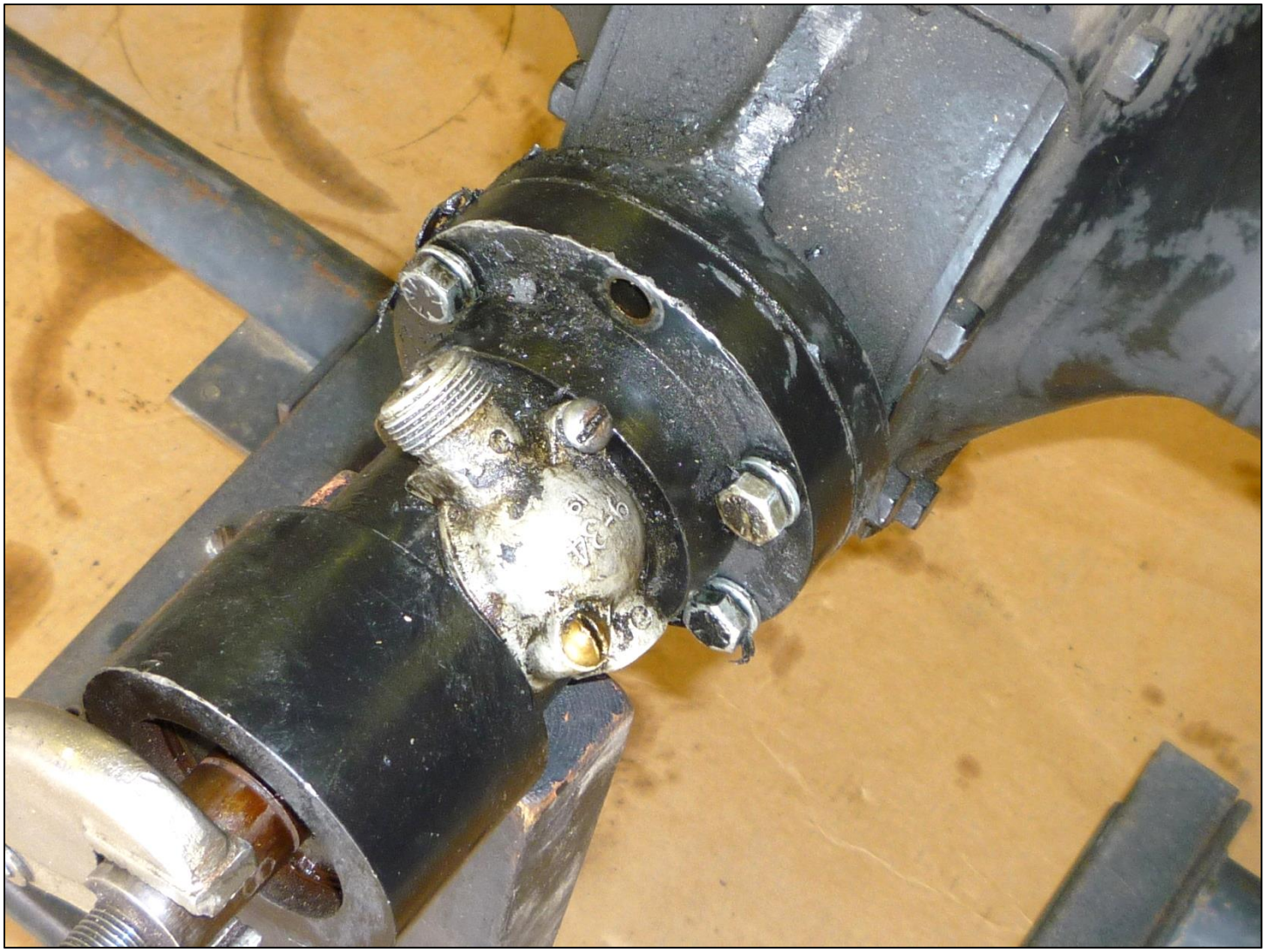
The rear axle assembly was brought to my shop after being removed from the car. Since the car has a modern five-speed transmission installed it does not have a normal Model A drive shaft and torque tube. There is a small housing attached to the banjo flange that houses the protruding pinion gear assembly and a short stub shaft that attaches to a U-joint and an open drive shaft. At the front end of the housing are two small ball bearings and an oil seal. The vice grips attached was used to rotate the assembly.

When the assembly was rotated with the vice grips both axles rotated in both directions giving an indication that all was well. Apparently there was enough friction at the axle shear to drive the left axle. Once the rear axle assembly was disassembled it was obvious that all was not well.

The two large brackets welded to the axle housings are part of the five-speed transmission modification. The bracket that is on top of the banjo supports the hydraulic brake line assembly.

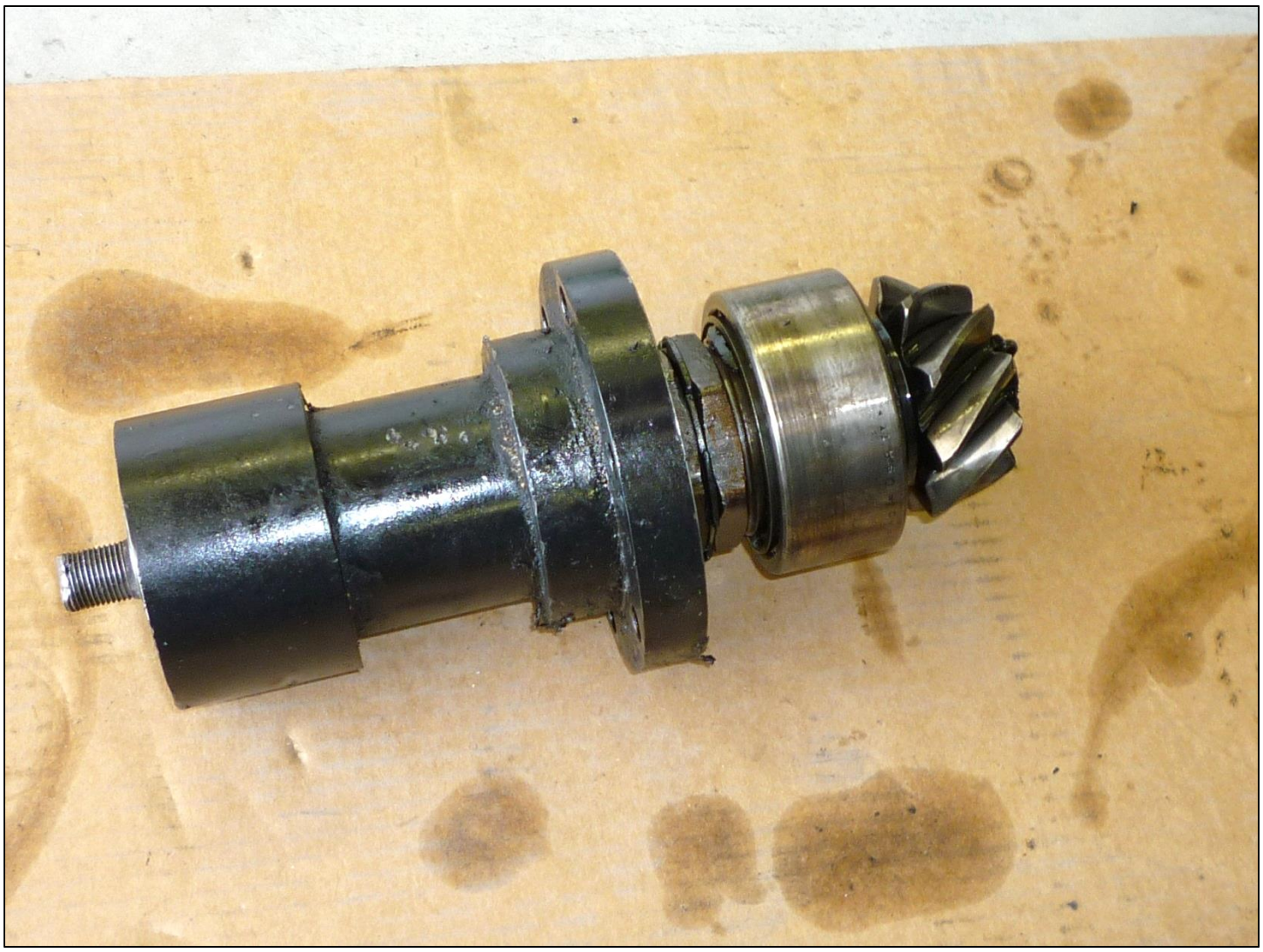


A close up look at what suffices as a torque tube: The short stub shaft can be seen protruding from the front of the housing. The end of the shaft is threaded where a U-joint attaches. The forward part of the housing directly behind the vice grips contains an oil seal and two small sealed ball bearings the shaft rides on. The next section of the housing has a standard Model A speedo housing attached. Directly under it inside the housing a speedo drive gear is attached to the stub shaft. The next section slides over the protruding end of the pinion assembly and has a flange that bolts to the banjo flange with six bolts.

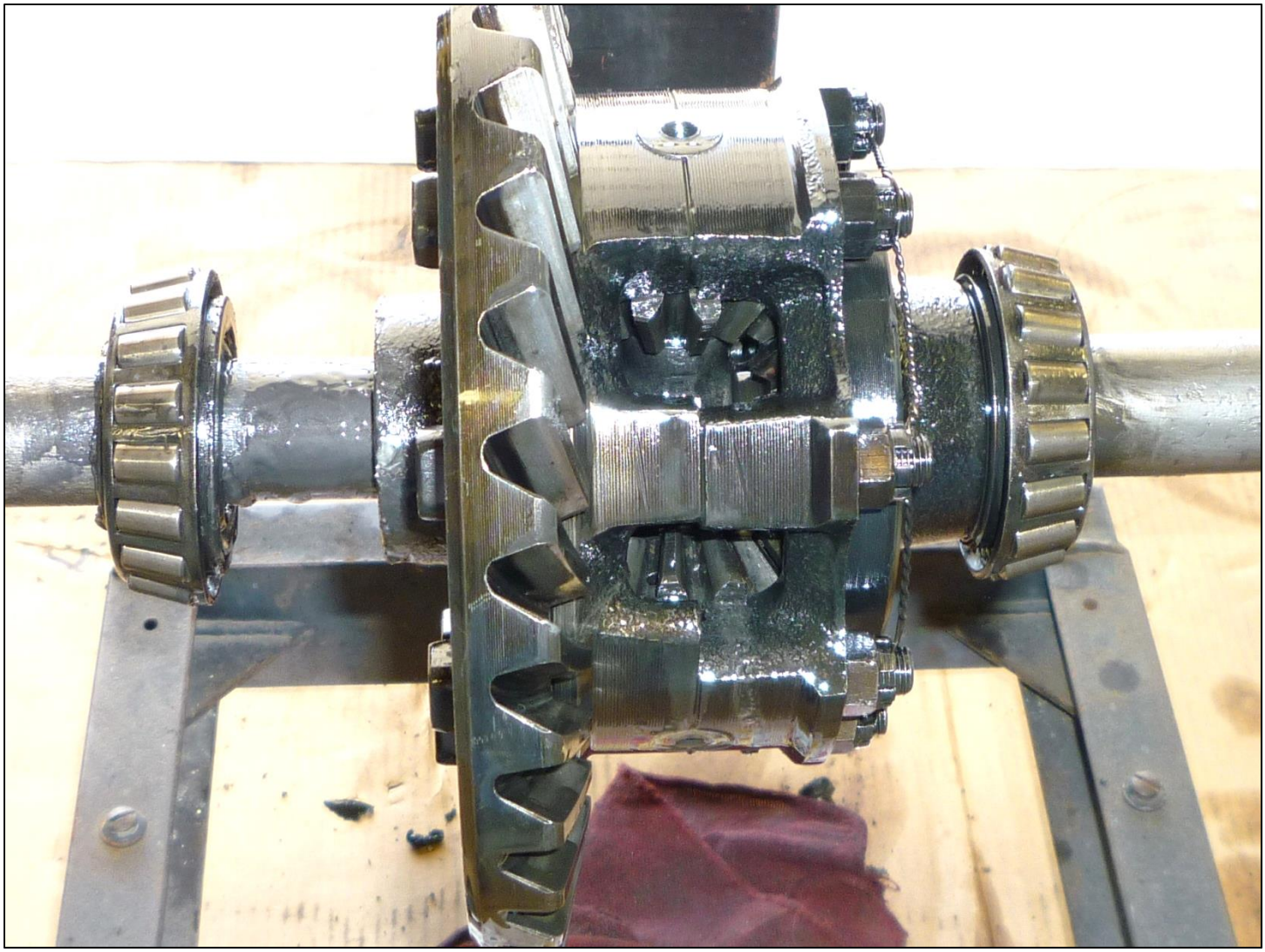


The speedo housing sits at the two o’clock position where the speedo cable attaches to it.

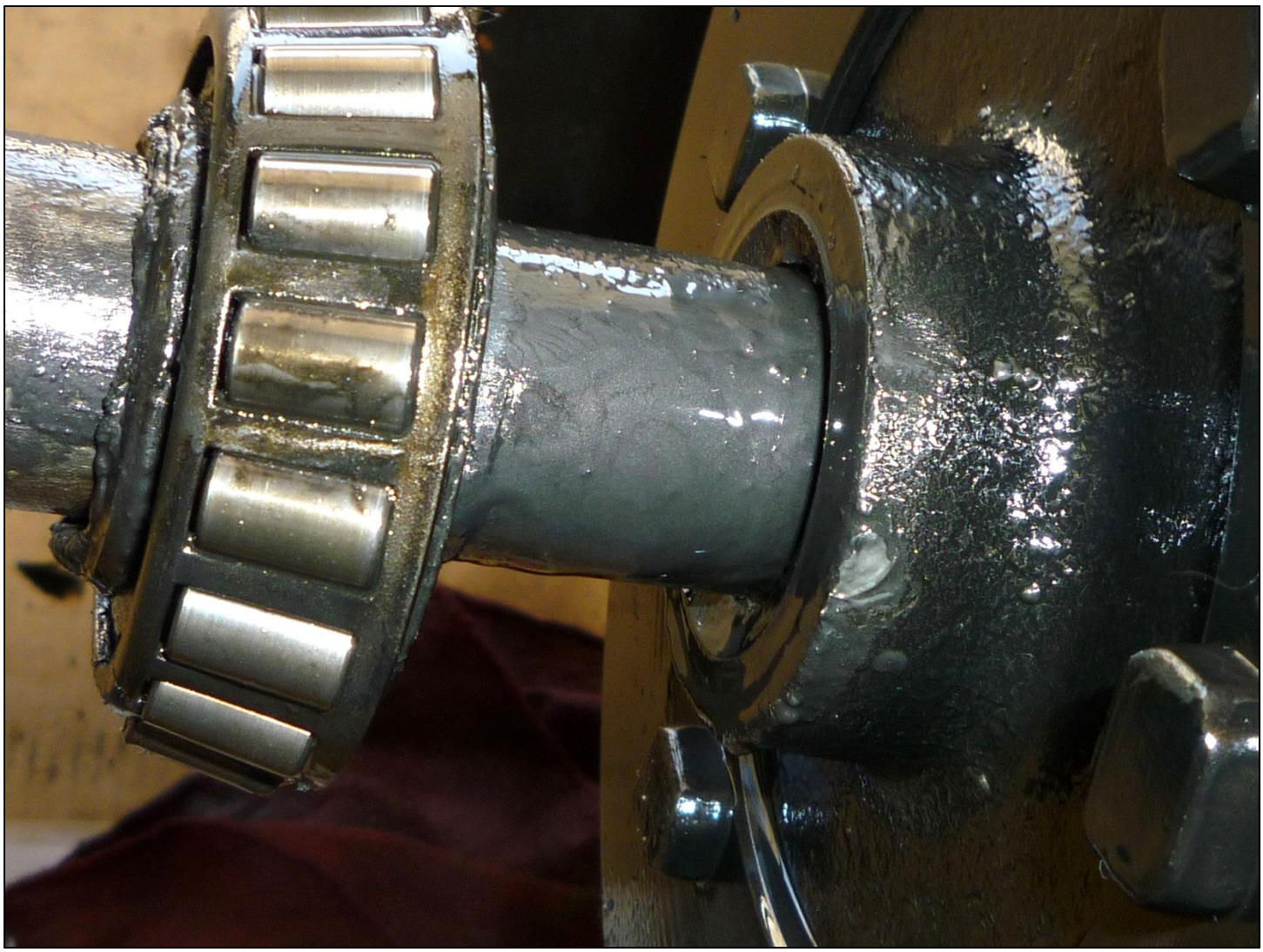
An additional failure mode was discovered: The double race that is part of the pinion gear assembly is supposed to mount inside the banjo flange opening with an interference press fit. This was not the case. The bearing assembly had spun the race in the banjo, machining metal away such that the assembly could easily be pulled out by hand. The race had about .005 slop in its fit. The banjo had to be replaced.



Another look at what suffices as a torque tube and drive shaft with the pinion assembly attached. This assembly was easily pulled out of the banjo. It should not have been the case. The bearing race is supposed to press into the banjo with an interference press fit. The race had apparently spun in its mount at some point.



The first failure: The left carrier hub has sheared from the carrier. The bearing is still pressed onto the sheared section of the carrier. This failure is not a show stopper; a car can continue to operate in this condition. However it will generate an extreme amount of heat that will affect the left axle. This first failure of the carrier could have occurred months or years before the axle sheared,



A close up look at the sheared area of the left carrier half:

The second failure was the gear end of the left axle sheared off the shaft. That was the show stopper; the car would no longer run with a sheared axle. Shown above the sheared axle shaft are both sides of the carrier. The left side sheared, the right side remained intact. The left side is where the ring gear mounts.

A close up look at the sheared left axle shaft: This is an original axle with the gear and the shaft being one piece. Reproduction axle shafts have the gear end welded to the shaft and there have been failures with the weld separating. This is not the case with this failure.

The damage caused by both failures will require the replacement of the carrier, the left axle shaft, and the banjo. All the bearings, races, seals, and gaskets will also be replaced. Both axle housing will require a thorough cleaning as they were both full of metal particles.

Fortunately the ring & pinion, spider gears, and the right axle shaft were not affected by the failures and are all serviceable and will be re-installed.

Another look at the “torque tube”:

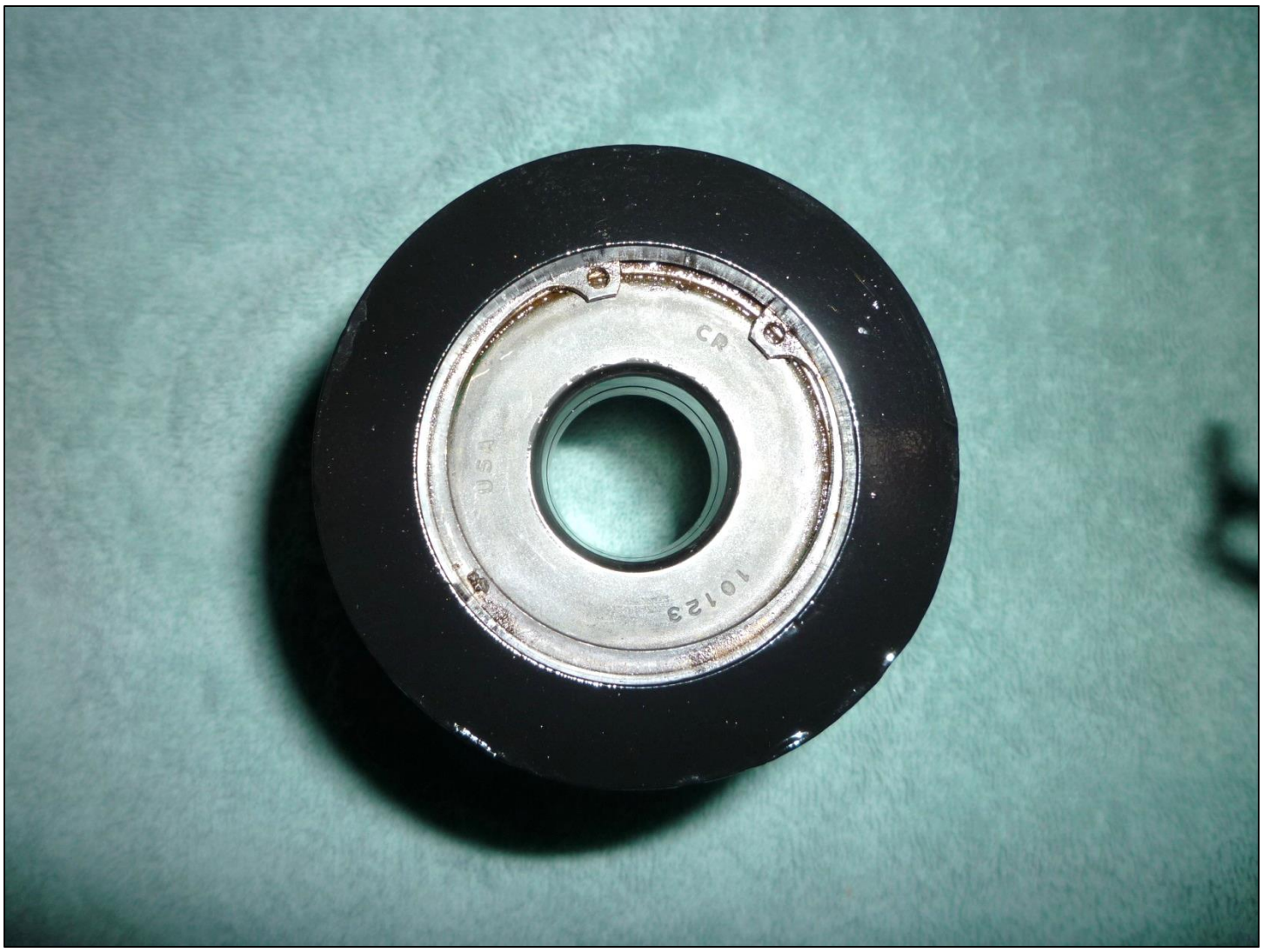
The sequence of the torque tube, drive shaft, and pinion gear:

The drive shaft (stub shaft): The left end of the shaft is where the U-joint is attached. The U-joint is locked to the shaft with a woodruff key and retained with the nut. The next section of the shaft rides on an oil seal and two small ball bearings inside the short torque tube housing.

The short section of shaft just to the right of the speedo drive gear is the only area of the shaft that can be held with a tool in order to put a hundred ft. lbs. torque on the pinion gear retaining nut at the right end of the shaft. This area is also held while setting the pre-load on the pinion bearings when adjusting the two large nuts and tightening the outer one. This makes this portion of the repair job very challenging.

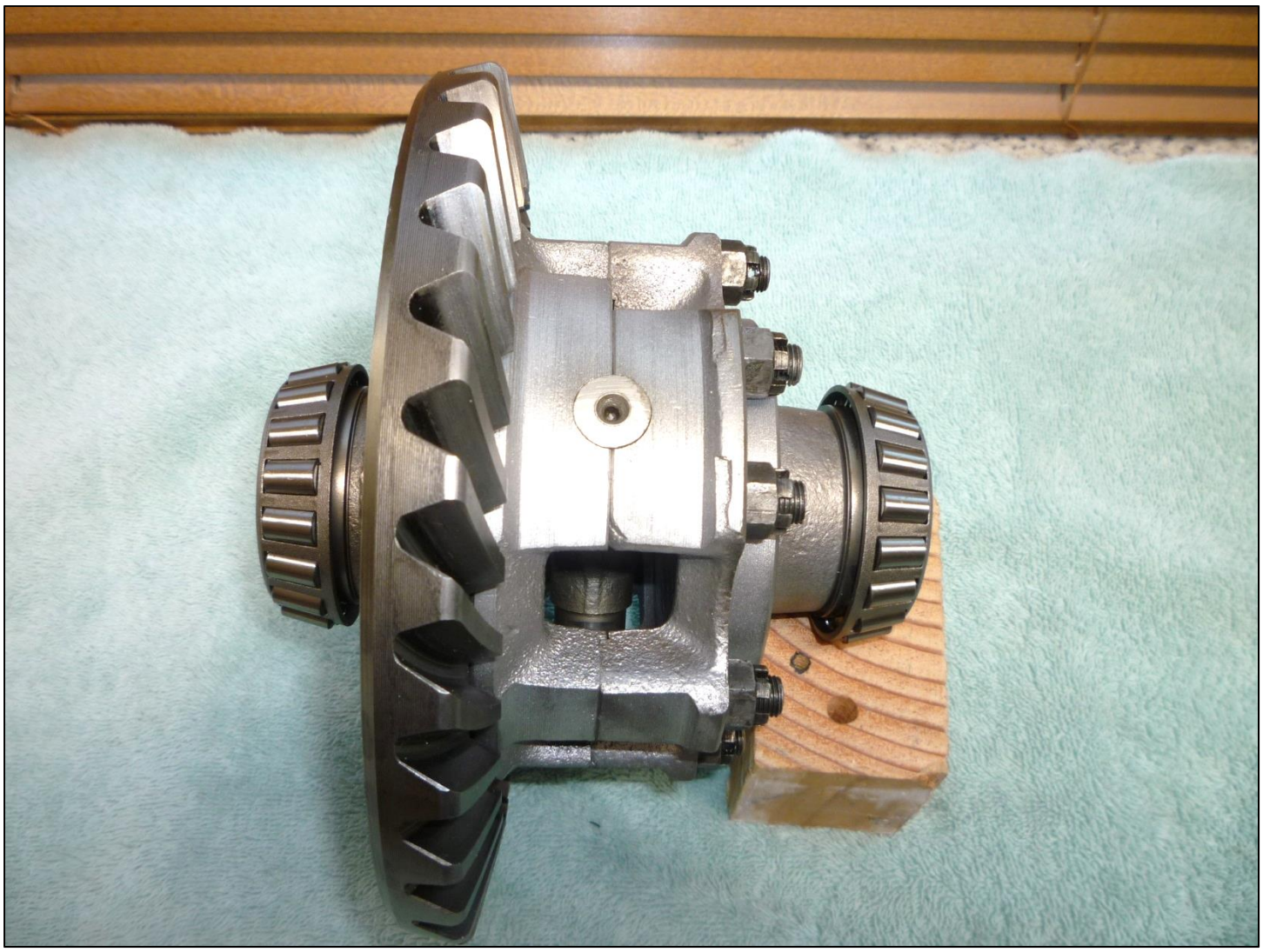
A look at the end of the torque tube housing that attaches to the banjo: The machined space on the flange end is to provide clearance for the end of the pinion assembly that protrudes from the banjo.

The torque tube housing has been cleaned up and painted:



Shown here is the U-joint end of the torque tube housing where the oil seal and the two small ball bearings reside. The snap ring prevents the oil seal and bearing assembly from coming out, however the assembly appears to have been installed with an interference press fit.

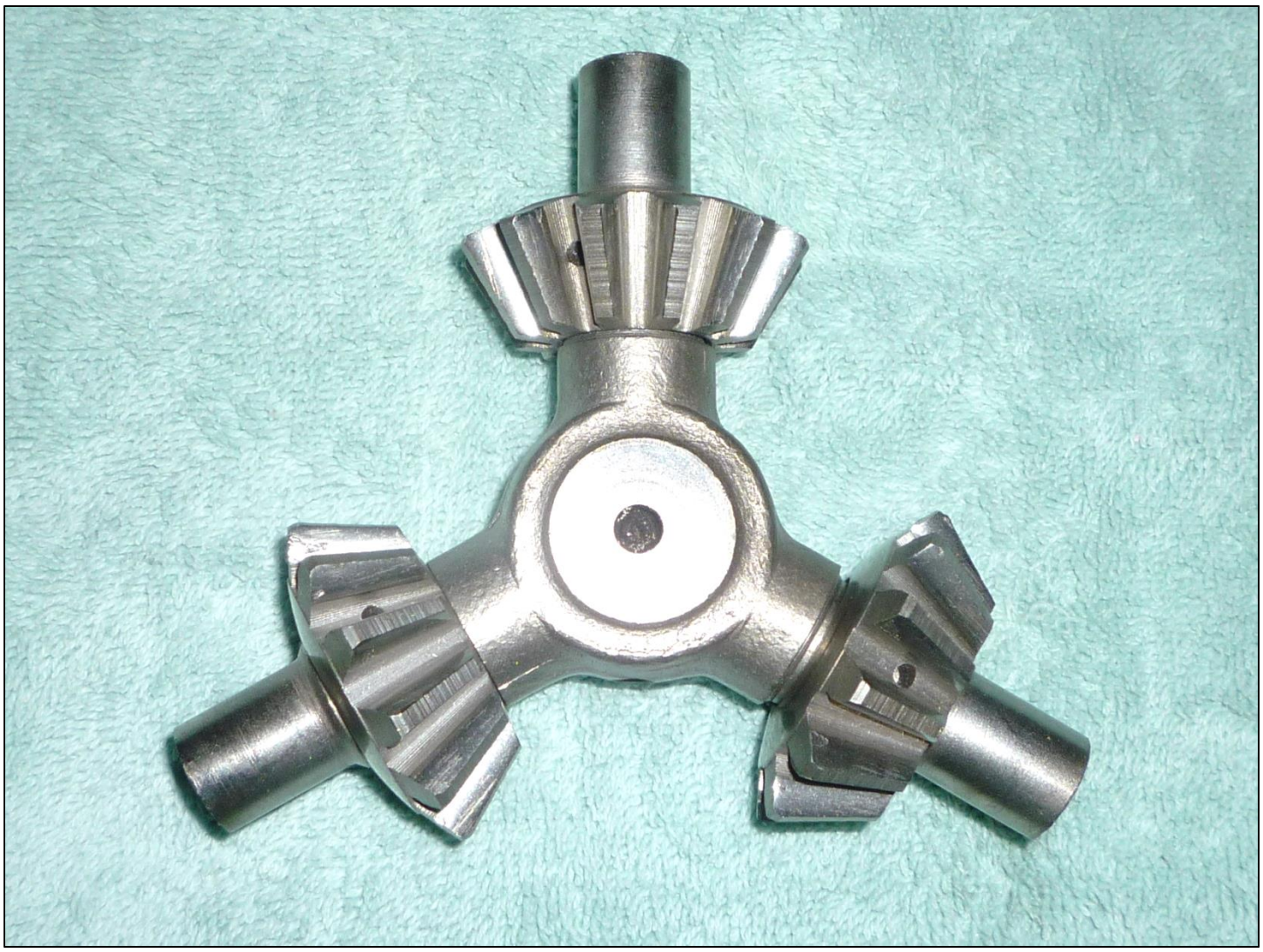
The banjo end of the torque tube housing is shown here. The two small sealed ball bearings can be seen at the bottom at the opposite end of the mounting flange.



The reassembly process begins: The replacement carrier has the undamaged ring gear attached along with two new bearings. Inside in place of the spider gears is the tool used in the pre-load setting process. When fully assembled the two axle shafts will protrude from each side.

Another view of the replacement carrier and the ring gear: The ring gear was undamaged and appears to be in excellent condition.

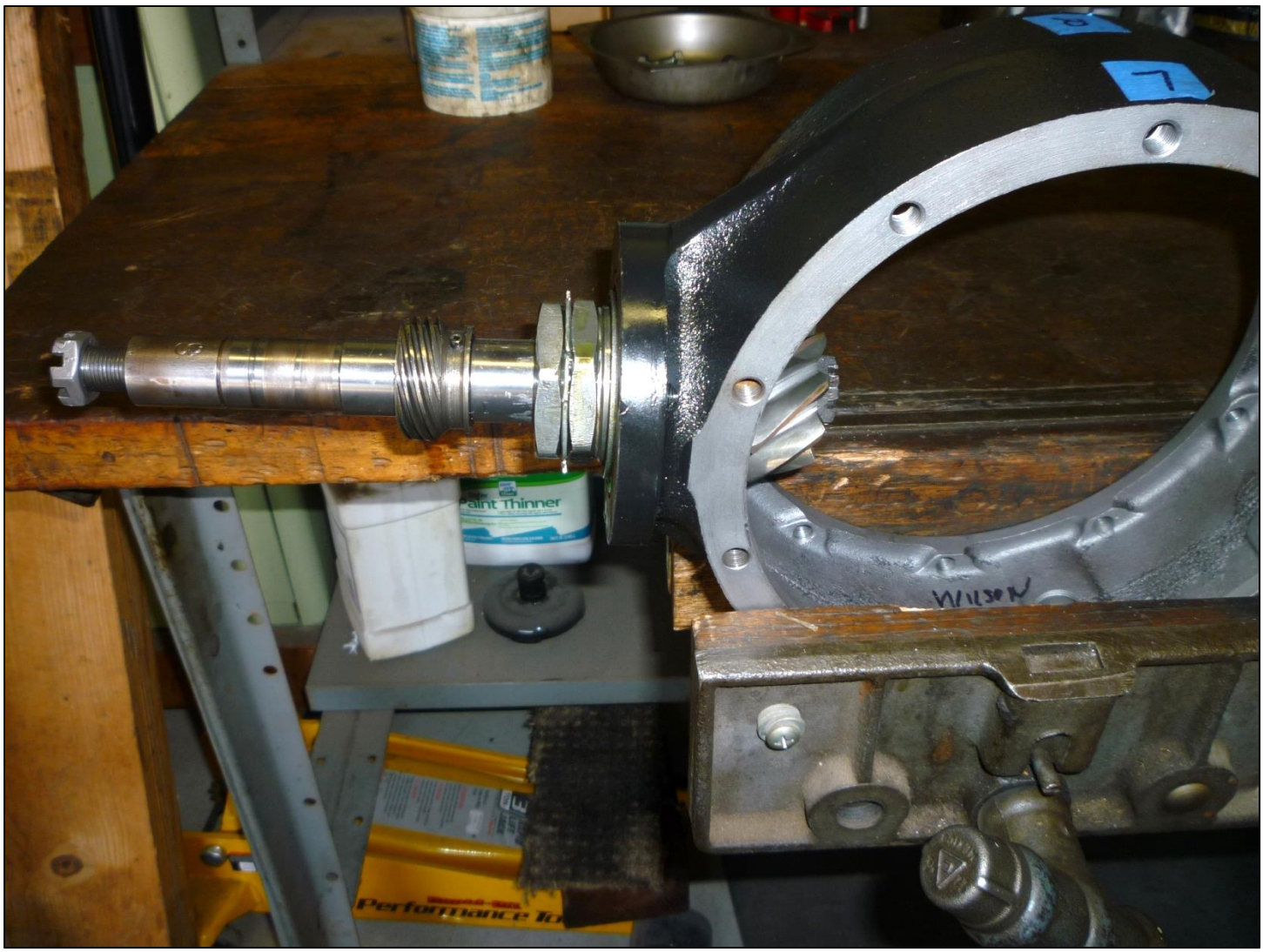
A view of the undamaged pinion gear with a new rear bearing installed:



The spider gear assembly was not damaged and appears to be in excellent condition: Note the holes in each gear. This was incorporated in 1931 to provide better oiling to the three shafts on the yoke.

A new race is being pressed into a replacement banjo.

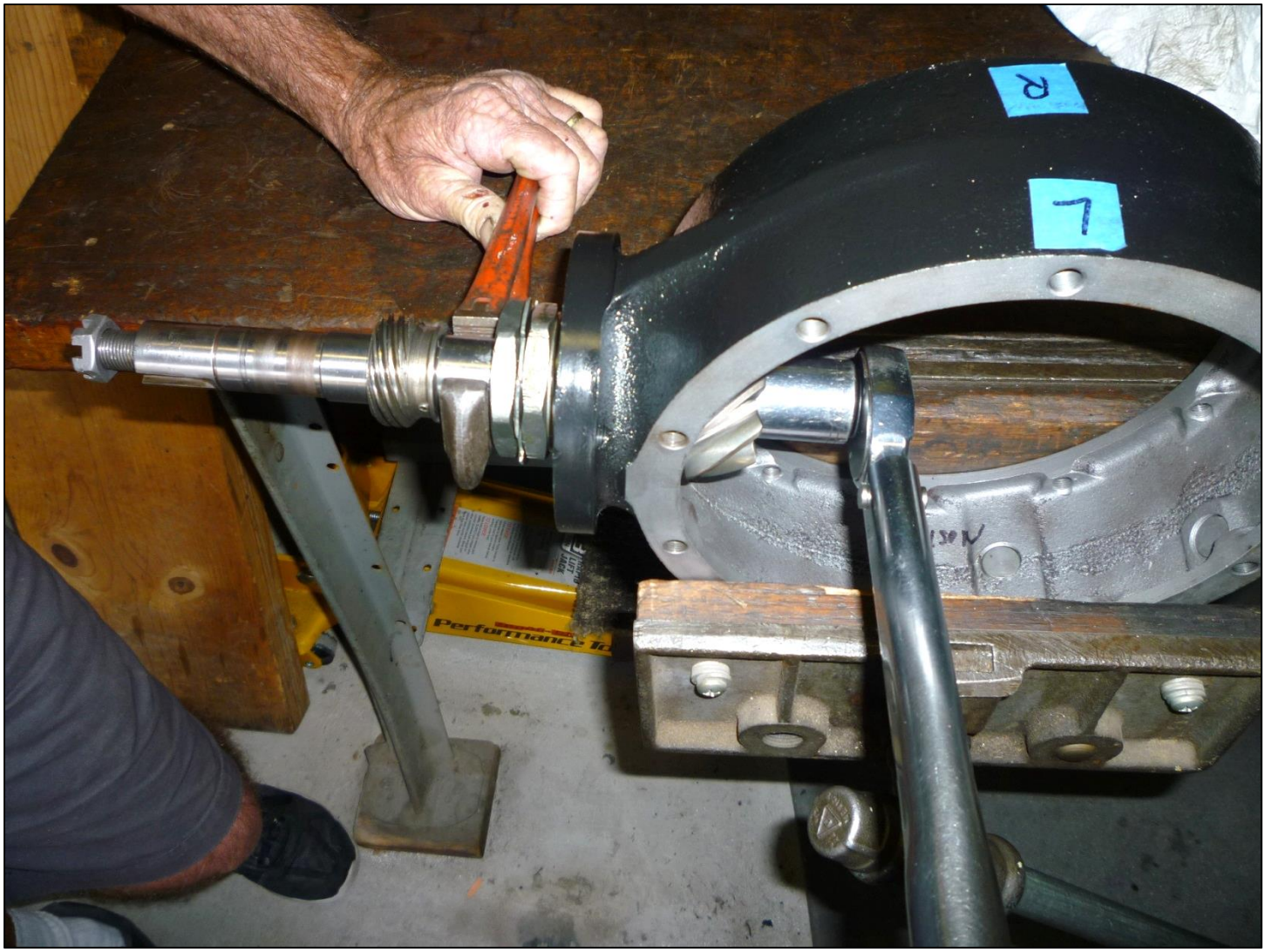
A view of the bracket that attaches to the top of the banjo to support the hydraulic brake line assembly: It has been bead blasted and painted.



The pinion gear has been installed in the replacement banjo. The preload setting of the pinion gear bearings is going to be more difficult because there is no lengthy drive shaft or overdrive stub shaft to grab hold of with a pipe wrench. The only area to grab hold of on this very short stub shaft is the space between the speedo drive gear and the two large pinion nuts. This is the only area of the stub shaft that is not critical and galling by pipe wrench jaws is of no consequence.

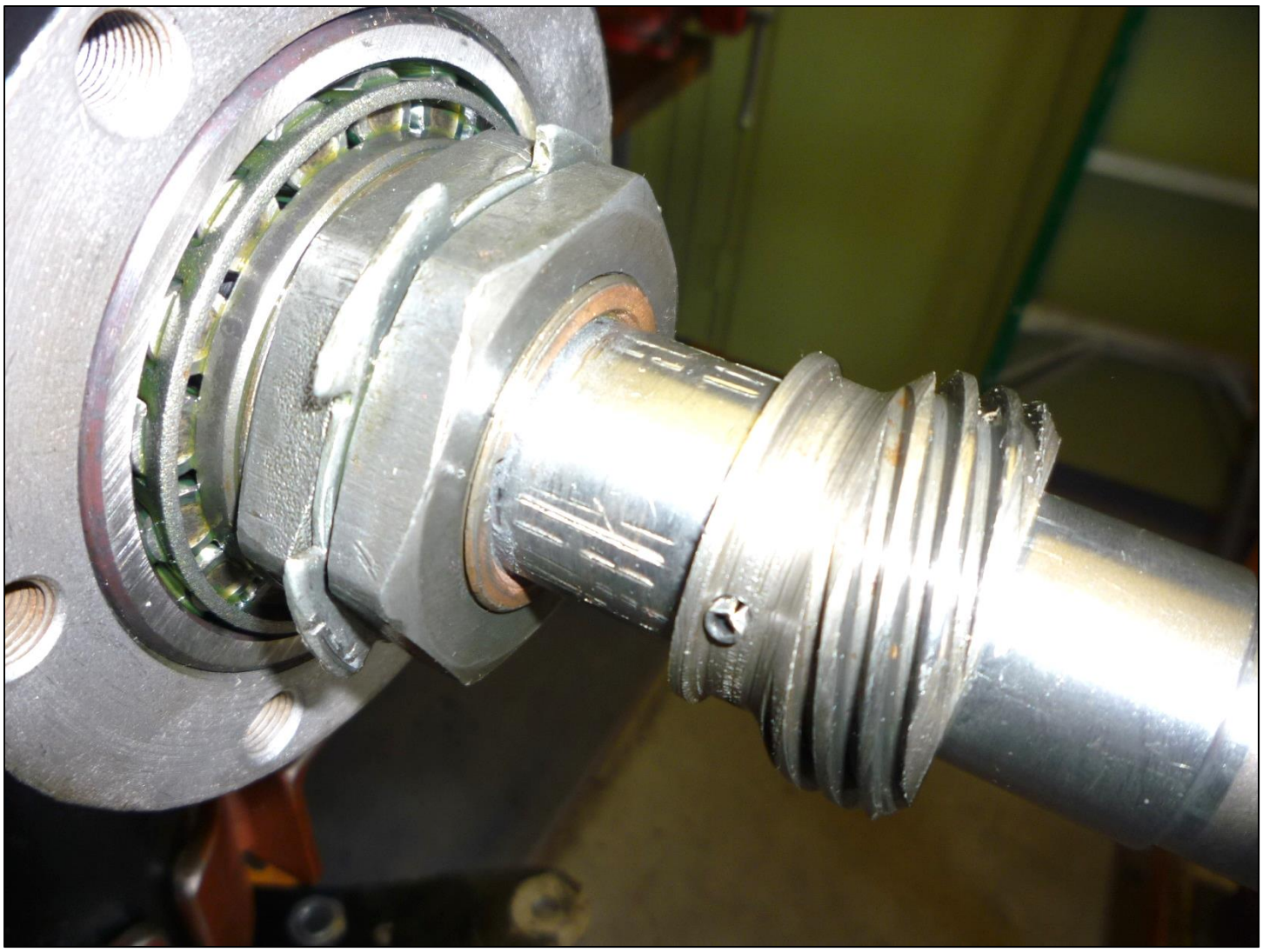
The photo shows assembly ready to have the nut on the end of the pinion gear torqued to 100 ft. lbs. and the bearing pre-load of 20 in. lbs. established with the two large pinion nuts.

The 20 in. lbs. pre-load on the carrier bearings has already been accomplished and was no different than a traditional differential overhaul.



The nut on the end of the pinion gear is being torqued to 100 ft. lbs. while the stub shaft is being held with a pipe wrench in the only area of the stub shaft available to place a pipe wrench.

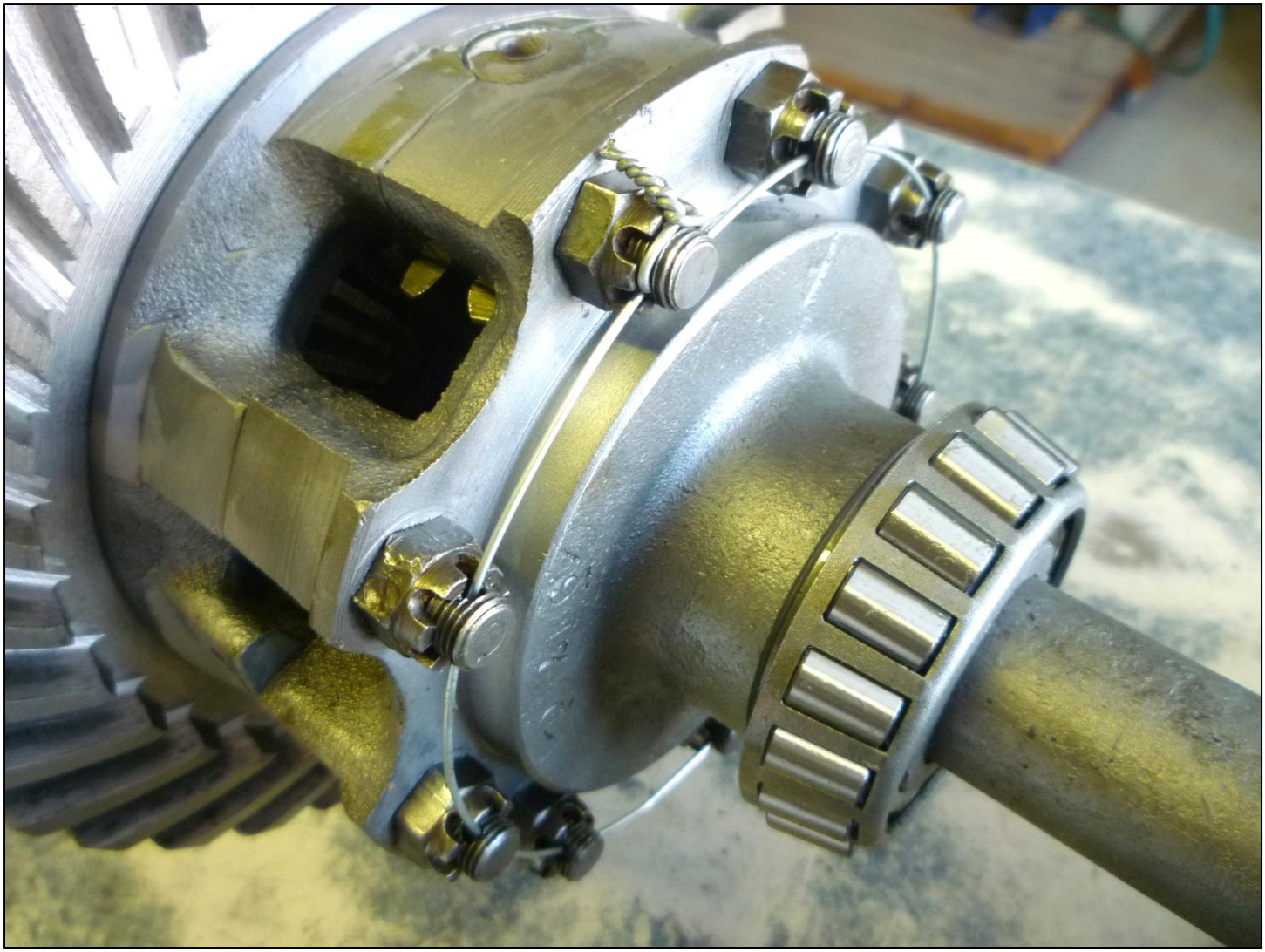
The pipe wrench is again being used to hold the stub shaft while the pre-load on the pinion bearings is being established. The large rear nut has been set and is being held with a pinion wrench. It can be seen braced against the work bench right below the shaft. The second pinion wrench is tightening the second large nut at front. This front nut has to be extremely tight and the wrench is struck with a hammer several times as directed in the Ford service bulletins.



The task of tightening the pinion nut to 100 ft. lbs. and establishing the pre-load on the pinion bearings has been accomplished. Note the galling that has occurred to the stub shaft in the area between the speedo drive gear and the two large nuts. This cannot be avoided if the task is to be done correctly. The galling is of no consequence as this section of the shaft is not critical.

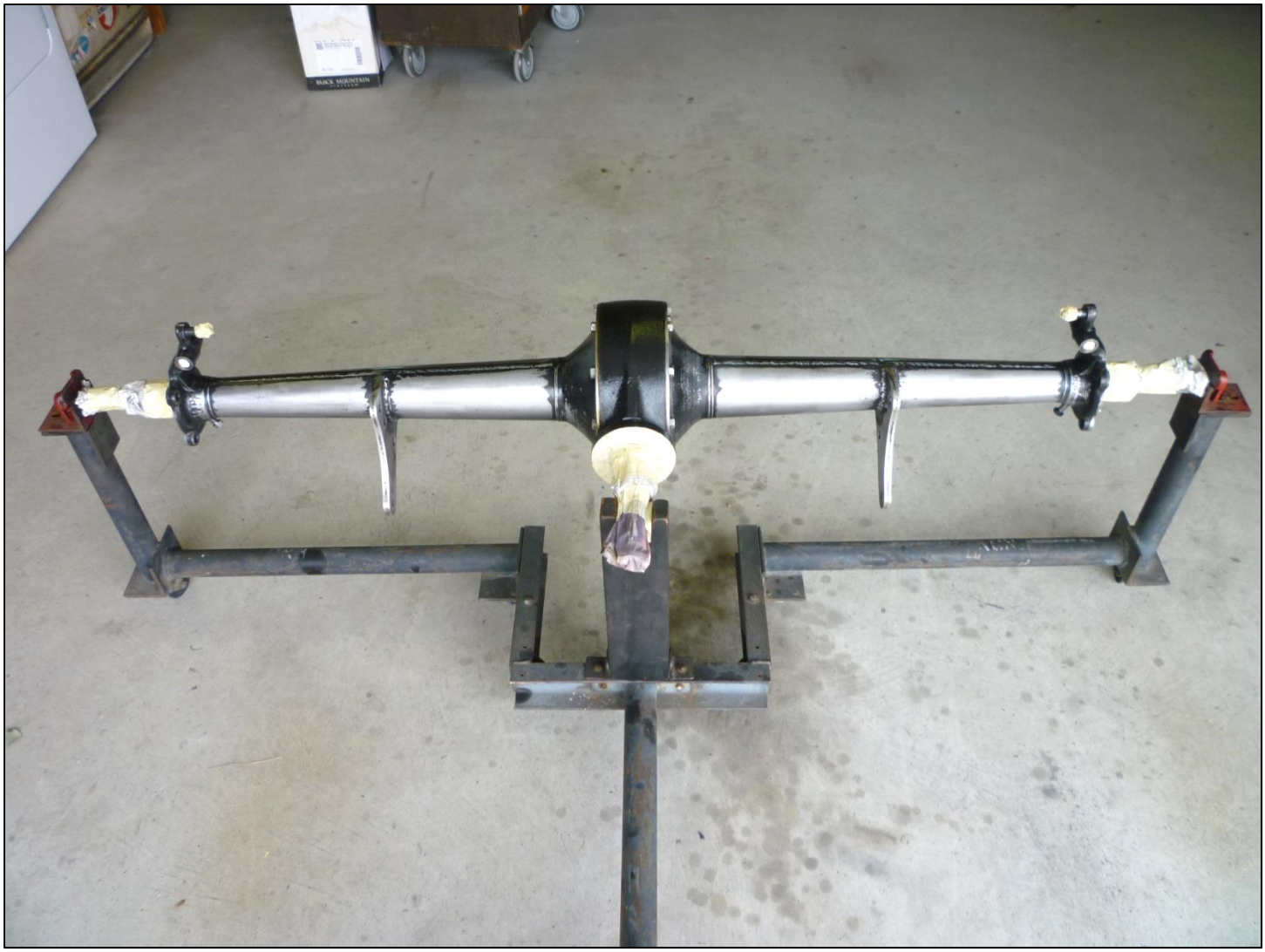
Note the speedo drive gear is attached to the shaft with a roll pin inserted through a hole drilled in both the gear and the shaft.

The replacement carrier assembly, including the spider gears and both axles has been assembled and is ready to be installed in the rear axle assembly housings. The sheared left axle has been replaced with a serviceable original.

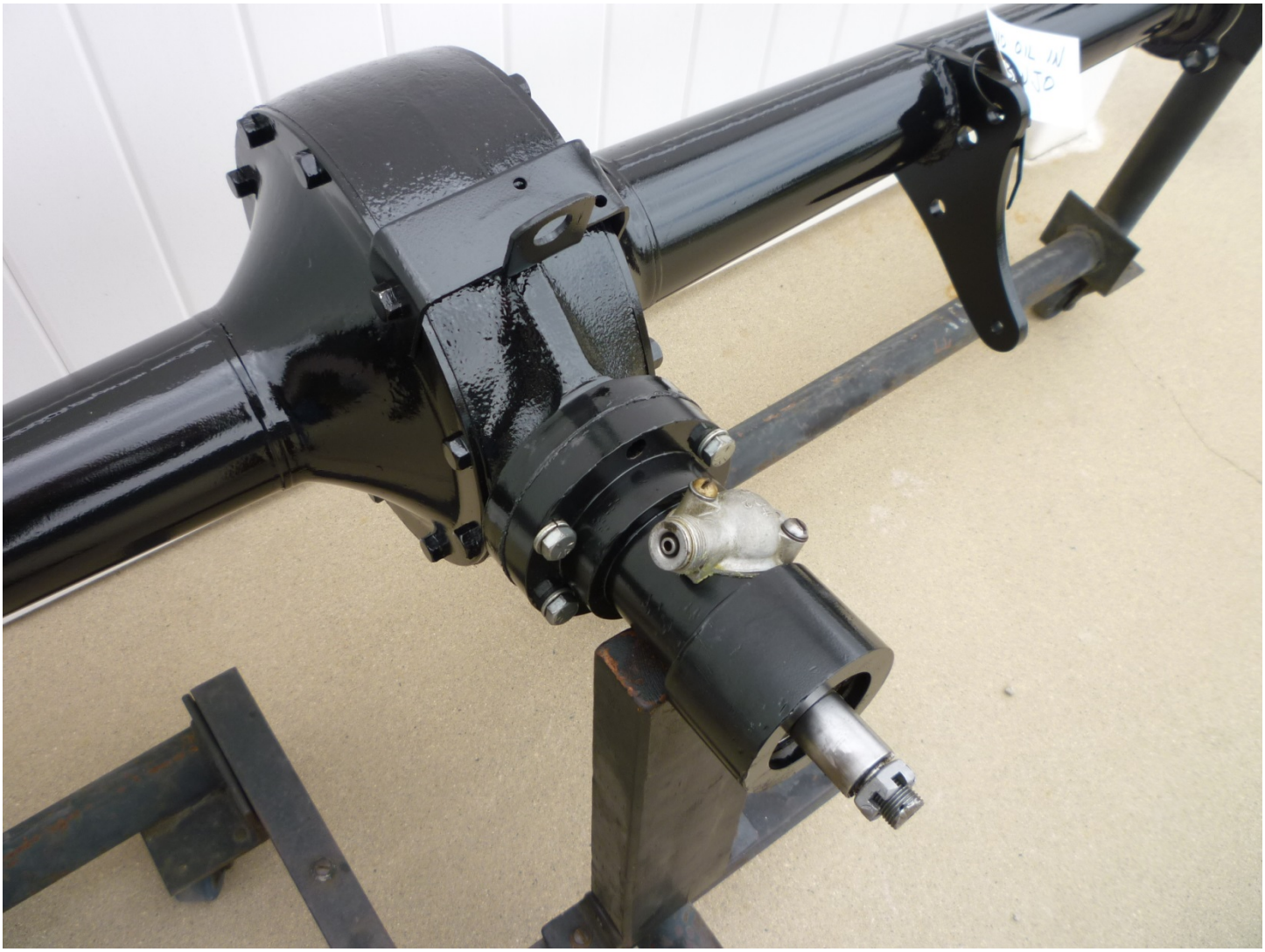


The carrier bolts are safety wired.

The completed rear axle assembly is shown sitting in the repair jig. The pre-loads have all been established and the carrier assembly, with both axle shafts and spider gears installed.



The completed rear axle assembly has been sanded, masked off and ready for painting.



The “torque tube” and the hydraulic line support have been installed.

The finished product:

Don’t forget to put oil in the banjo!