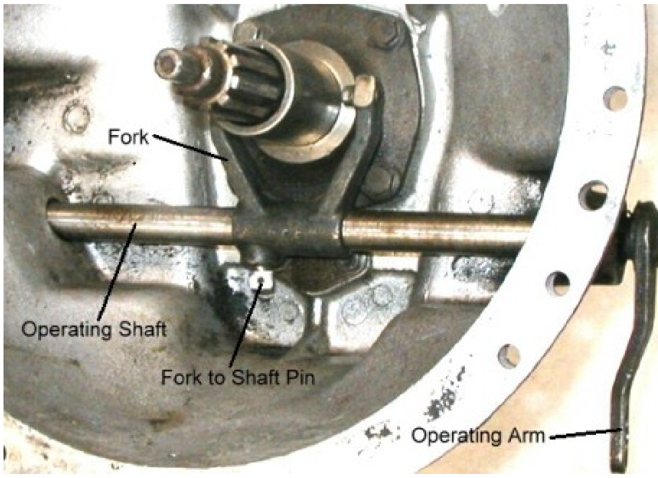
TR250/TR6 Clutch Operating Shaft Overhaul
(and that nasty pin)

The clutch operating shaft with associated parts has the function of transferring forces to release the clutch from the clutch slave cylinder via the operating arm and to the release bearing via the fork. The components are shown in the following photo. Not shown are the bushes inserted where the shaft passes through the gearbox. Overhaul involves replacement of worn bushes (if required), fork to release bearing pins in the fork (if required) and dealing with the fork to shaft pin, the weak point of the system.



Operating Shaft: Two versions of the operating shaft are shown in the photo below. The upper shaft is the TR250/TR6 version and the lower the earlier TR3/TR4 version. The earlier version has drillings in the end for grease fillings to grease the bushes. The earlier version also has a recess cut near the end for the locating bolt pictured on the right. The grease fittings and recess are not provided on the TR250/TR6 shaft. Each of the shafts are equipped with springs next to the operating arm. The earlier shaft can be used without the locating bolt in the TR250 and TR6 to provide a means to grease the bushes. Note that the later shaft (upper) in the photo is pretty chewed up. I don't know the history but it looks like there was a broken fork to shaft pin and also a cross drilling through the fork and shaft for a supplemental pin.

The major shaft wear points are where the back side of the shaft rubs against with the bushes. The photo below shows a heavily worn shaft that should be replaced.

Bushes: The bushes are shown in the left photo below. The upper two are original bushes for a TR3/TR4. The cutout section of the upper bush is for the locating bolt. Replacement TR3/TR4 bushes purchased a few months ago were shorter than those shown. The lower bush is a replacement for the TR250/TR6 bushes.

Many recommend that two of the short bushes be used on each side of the TR250/TR6 gearbox -- this is twice the original specification but seems like a very good idea that I will use in the future. The best arrangement seems to be to locate the two bushes with a short gap between.

I use a short piece of 1/2 inch steel plumbing pipe as shown in the middle photo below to drive out an old bush and drive in the new bush.

I recommend a shaft equipped with grease fittings for the TR250/TR6. The earlier shaft can be used directly or the later shaft can be equipped with grease fittings. To do this, drill a 7/32 inch hole in each end of shaft, about 1 1/4 inch deep on the operating arm side and about 3/4 inch deep on the other side. The end of the hole is then threaded 1/4 - 28TPI for the grease fitting. The shaft is then cross drilled 3/32 inch at a point on the shaft where the grease will exit the shaft into the gap between the double bushes on each side. The right photo shows how the shaft is drilled.

Forks: The photos below show different views of an unused fork purchased recently. Note that a hole has been drilled through the casting into the hole where the fork-to-shaft pin fits. This 3/16 inch hole allows one to use a punch through the hole to remove a broken pin. Refer to the accompanying note "Removing Broken Clutch Fork Pins" for more detail on this subject. It is my practice to drill such a hole before installing a fork. However, I'm pretty sure the fork shown in the photos came with the hole already drilled.

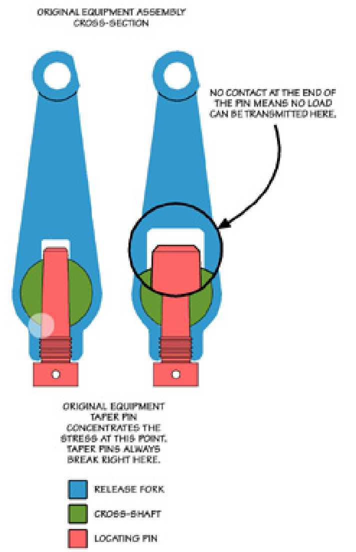
I have three other older forks laying around that are different from the one shown here in that they don't have the boss in the middle as shown under the thumb in the left photo.

The ends of the fork are equipped with pins that fit into a slot on the release bearing sleeve. Severely worn pins can be drilled out and replaced. I don't recall ever finding pins that I felt needed replacing nor have I ever replaced these pins myself. Apparently it is standard practice to grind the front side of these pins flat as noted in the right photo. In this case the grinding on the two pins is to a different depth. This can cause a tilting force on the release bearing sleeve that might lead to a sleeve sticking. Before using this fork I'll file the pins to an equal depth.

The fork is is a pretty basic hunk of cast steel and not subject to wear except to the fork- to-sleeve pins noted above. New forks cost $40 or more so I don't jump at replacing an undamaged fork. The money is better spent on taking the spouse to dinner.

Clutch Fork Pin: The weak point of this system is the fork to shaft pin. Three of the five TRs I've purchased and most the used gearboxes I've purchased had broken pins. I've never had a pin break in over 200,000 mile use on my TRs. However, after pulling a gearbox a few weeks ago to fix a sticky clutch, I decided I'm too old for this crap and next time I pull a gearbox I'm going to reinforce the pin as a precaution. A number of methods to reinforce the pin have been suggested over the years. I've always used a new high strength pin, made sure it seated properly, and didn't over tighten the pin. This has worked for me and many others. On the other hand, many folks have suffered broken pins. From these data I conclude the pin is close to the shear point so doubling the cross-sectional area subject to the shear forces should provide adequate margin.

Improved Pin: Brian Schlorff (of Power British) suggests a custom made pin that more than doubles the pin area opposing the shear forces. Pete Chadwell made the really neat drawings and Brian provided the text to Pete who passed it on to me.



The fundamental engineering problem with the clutch fork is simply this:

The pin is tapered. The cross-shaft has a tapered hole to accept the tapered pin. The partially threaded bore in the fork IS NOT TAPERED!!!

What this means is that contact is made on only one end of the fork pin. (the end nearest the threaded portion just below the head) All the force is concentrated at that spot and the pin will ALWAYS break at this spot - never anywhere else. The best, albeit not so easy, solution is to ream the hole in the cross-shaft to the same diameter as the bore in the deepest part of the fork. Then fabricate a new pin, one with a straight shank of corresponding diameter + .001" for an interference fit that will tightly engage both sides of the fork. No modifications are made to the fork, but now the shear force is divided equally between the top and bottom of the new pin, which is also slightly larger in diameter than the original tapered pin.

The real benefit comes from the fact that the topmost portion of the pin extends directly up into the right-hand finger of the fork, thus there is no chance of overstressing or cracking the base of the fork around the shaft. I know it is not exactly a do-it-yourself prospect to make such a set up, but we feel this is the best way to insure never having to do that job twice! :-)

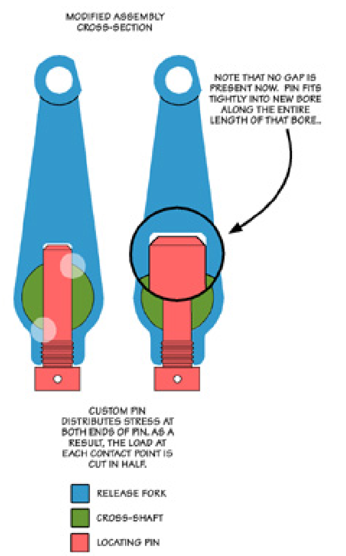
The pins we make are from a 7/16-20 x 1 3/8" socket head aircraft bolt. (Grade L9, which is higher than grade 8 - approx. 210,000 psi tensile.) Each one is a custom fit as the tolerances on the forks vary quite a bit.

To help you out, here are the specs we machine the bolts to start with, then hand-fit within the specified tolerance from there,

Shank diameter - 0.3375"/0.3380"
Shank length - 0.980"/1.000"
Length under head - 1.300"/1.312"
Length of 45 degree bevel (shank end) - 0.062"
Lock wire holes - 0.093" diameter

Pete said he had a machinist make his new pin from a grade 8 bolt as the aircraft bolt wasn't readily available.

I checked out the forks on hand and found all have a hole drilled in the upper part of the fork larger than the ~ 0.33 inches suggested above. In fact the hole is 25/64 or ~ 0.39 inches, the size drilled to tap the 7/16 -20TPI threads in the lower side of the fork --- they just ran the same drill through both sides. This scheme can still be used exactly as shown except make the pin diameter ~ 0.39 inches, the 7/16 inch bolt should accommodate this. Note that this scheme more than doubles the cross-sectional area opposing the shear force and should never break.



One thing I'm probably paranoid about is to make sure there is no slack or play in between the hole and pin. I can remember my Strength of Materials Professor droning on about the need to use taper pins, rivets, or other tight fitting devices to make multiple fastening devices effective in a shear situation. He ran a shear experiment with two plates fastened together by bolts in loose fitting holes. The result was that one bolt started to shear before the other bolt saw any shear forces due to the loose fitting holes. I also remember thinking at the time, why do Electrical Engineers have to study this crap? Maybe it was because several of the faculty that were in positions to influence the curriculum drove British cars. It's amazing that I remember any of this at all since I vividly remember the coeds walking past the open window on the hot spring afternoons.

Brian's scheme above uses an interference fit to make sure there is no slack or play in the joint. It would make that old Professor happy.

Additional Bolt: A common way to supplement the pin is to cross drill the fork and shaft and add a bolt as shown in the adjacent photo. Many use a 5/16 inch bolt. That triples the cross-sectional area opposing the shear force. It also might be overkill since the wall of the fork in the area of the bolt is pretty thin on those forks without the boss and might fail before the bolt shears. A 1/4 inch bolt more than doubles the area opposing the shear forces and is probably adequate. I would be sure the bolt is long enough so that no threaded part is in the area of fork-shaft joint. I would make sure the fit is a force fit by using an undersize drill such as a C (0.242) or D (0.246) drill, depending on the diameter of the bolt. I'd cut off the excess length and secure with a Nyloc nut. I would probably use a standard grade bolt. I wouldn't want to make the bolt much tougher than the shaft or fork; if something is going to break, I'd prefer it be the bolt rather than the shaft or fork.

Note that the main pin should be inserted and tightened and then the fork and shaft drilled at the same time. I've noticed in several cases including the shaft - fork combination in the photo that the pin seats against the fork casting before the pin seats in the shaft hole. This may be caused by wear in the hole. In this case several new pins were tried with the same result. The cure is to grind about 1/8 inch off the top of fork boss under the head of the pin.

Added Expansion Pin: Another alternative is to use an expansion pin, also known as a roll, tension and spring pin, instead of the bolt described above. These pins are made of spring steel and are a force fit. This was my preference rather than the bolt until I got to thinking about it. These pins solve the slack or play concern through their springiness. However, because of the springiness they will tend to give some before shearing. This flexing will could cause excess force to be applied to original pin, till it shears, then all the forces would be applied to the expansion pin. Now I don't think expansion pins are such a good idea for this application.

Added Taper Pin: Another alternative is to use a taper pin instead of a bolt or expansion pin. The standard taper is 1/4 inch per foot. I made a sample using a #5 taper pin. In this case one drills a 1/4 inch hole and then uses a reamer ($9.50) to shape the taper in the hole as shown in left photo below. Taper pins are sized by their large end diameter, 0.29 inches in the case of the # 5 pin. A 2 inch pin that has a small end diameter of about 0.25 inches was selected. The hole was reamed so that about 3/8 inches of the small end extended beyond the fork casting. That 3/8 inch length was threaded 1/4-28 TPI and the pin secured with a nyloc nut. The excess part of the larger end was cut off. The finished pin is shown installed in the right photo below. The taper pin has the obvious advantage of a very good fit and is easy to fabricate. This is probably my favorite choice at the moment.

Those who insist on a larger pin can select a # 6 pin that has a 0.34 inch big end diameter (and buy a #6 reamer). The hole should be drilled 5/16 inch and reamed so that the part of the small end of the pin where it exits the fork casting is just a few thousands larger than 5/16 inch. The small end can then be threaded 5/16 - 24 TPI and equipped with a 5/16 nyloc nut. In this case the big end of the pin will be nearly flush with the fork casting.

Welding the thing: Some of the accompanying notes mention Murry Mercier's sticky clutch. The mechanic that installed the previous clutch welded the fork to the shaft. Flux spatter is still visible on the front cover (see photo in the Sticky Clutch note). I thought at the time --- I understand why a guy would do it to avoid ever suffering a pin failure. I also thought I wouldn't do it because I didn't want to spend ~$75 to buy a new fork and shaft every time I overhaul a gearbox. More recently someone on one of the email lists mentioned a welded fork. Dave Massey responded that maybe it isn't such a bad idea, after all you can still do all gearbox and clutch overhaul except changing the left side clutch shaft bush. Dave is usually right on but I didn't think one could get the front cover or counter shaft out with the fork and shaft in place. I checked it out and found that Dave was right again. The fork can be slid to the left side making the components at the front of the gearbox accessible. This is probably my second choice close behind the taper pin. I have a small wire welder that makes for a quick weld and if I replace the shaft bushes using four bushes and have a shaft with grease fittings, then the shaft and bushes will outlast me. After that, I don't really care.