ALIGNING THE TR4A – TR6 REAR SUSPENSION

I recently upgraded some of the components of the driveline of my TR4A. I installed the Goodparts CV joint-type rear axles and the adjustable trailing arm brackets, as well as the springs. During this I found that one of my original springs had broken at the last turn at the top, and I didn't even know! I replaced the springs with the Suplex brand "standard rate" springs. Apparently the "stock" springs are not a perfect match to the stock springs as I had hoped. Initially I had NOT used new brackets, and I had hoped that the original brackets with "stock" springs would result in unchanged suspension geometery. But, after getting everything installed, I found I had about 1 degree of positive camber, so I had to go back and change the brackets to the Goodparts adjustable brackets so I could conveniently bring the camber to within specification on both sides.

I adjusted the toe-in before setting the camber. Changes to the toe-in will have a small effect on the camber, so it may be necessary to reset the camber after setting the toe-in. Probably it is best to adjust the camber to get it roughly correct and equal from side to side. Then set the toe-in, then go back and finally fine-tune the camber.

Setting the Camber

There are a number of good (and expensive) camber gauges for sale and these will work well. But for a small cost, you can get very good measurements with sufficient simplicity. All that is required is a 16 x 24" steel carpenter's square, a dial caliper, and a fairly level and flat surface to park the car.

Drive the car to settle the suspension. Park on the fairly level and flat area. Place the short arm of the square of the square on the ground and the long arm on a fixed spot on the wheel or tire, centered left-to-right on the wheel. Measure from the edge of the wheel rim to the edge of the square. Make the measurement at the top and bottom on the rim. Subtract the upper measurement from the lower. For the TR4A through TR6, the resulting value should be negative: the top of the wheel should be tilted a little toward the center of the car. This is called "negative camber". The camber for the TR4A – TR6 is specified as-1.0 degrees +/- 0.5. So the acceptable range is -0.5 to -0.15 degrees. Additionally, the camber is specified with equivalent of two "standard" people in the seats. Standard means 150 lb.

After my suspension upgrades, I measured the following camber:

Left: 3.942" – 4.282" = -0.340"
Right: 4.048" – 4.280" = -0.232"

I estimate the variability of my measurements from one try to the next to be no worse than about +/-0.030" which corresponds of about +/- 0.1 degree of camber.

In Table 1, these measurements equate to about -1.20 degrees and -0.81 degrees.

The Math

The camber angle is measured by taking the arcsine of the difference in the measurements divided by the diameter of the rim of the wheel. My wheel rim is 16.25".

Angle = ArcSine(Measurement / Wheel Diameter)

For example, given my measurement of -0.232" difference on the right, the precise camber angle is:

Angle = ArcSine (-0.232/16.25) = 0.8180, which when both the measurement and the result are rounded to two decimal places gives the reading in Table 1 of 0.81 degrees

CAMBER ADJUSTMENTS

I have installed the Goodparts adjustable trailing arm brackets which greatly simplify adjusting the camber. However, there is a webpage at www.buckeyetriumphs.org which gives a great table listing the camber angles for combinations of the stock fixed position brackets.

Richard Good said that his brackets change camber at about 0.25 degree for one turn of a bracket's adjuster nut, but let's do the math. The brackets of the trailing arm are about 13.5" apart, and one turn of the adjuster moves the pivot 1/20 of an inch. The math is: change = arcsine((1/20)/13.5) = 0.2122 degrees per turn. However, there is an additional complication: the axis of the trailing arm is oriented at 30 degrees from perpendicular to the center line of the car. Therefore, changes to the trailing arm angle will have less effect on the actual camber. The factor is Cosine(30).

Suppose the axis of the trailing arm were perfectly perpendicular to the center line of the car, then the angle difference would be zero. Cos(0) =1, so ALL of the change in the trailing arm angle would be reflected in the camber. Conversely, if the axis of the trailing arm were at 90 degrees to the perpendicular, NONE of the angle change would be reflected in the camber and cos(90)=0.

For our trailing arms, oriented at 30 degrees to the perpendicular, the camber change is:

change = cos(30) * arcsin((1/20)/13.5) = 0.1838 degrees per turn of the adjuster.

The measurements of -1.20 and -0.82 were taken WITHOUT the two 150 lb people in the seats. More weight in the seats will cause more negative camber, so for unladen measurements I want my settings to be on the more positive camber side of the acceptable range with no additional load other than a full tank of gas: I was looking for -0.5 to -0.6 degrees on the each side, so for the calculations I will use -0.55 as the desired final camber for each side. My correction should be +0.65 degrees on the left and +0.27 degrees on the left

So, I need to make the following adjustments:

Left: (0.65 degrees) / (0.1838 degrees per turn) = 3.5 turns.
Right: (0.27 degrees) / (0.1838 degrees per turn) = 1.5 turns.

I already have my inner brackets almost completely adjusted DOWN to lower my rear ride height a little. So, I want to only change my outer bracket which is near the middle of its travel. To decrease the negative camber I need to tilt the top of the wheel out. This means that the outer bracket pivots need to be moved downward. The adjusters have a normal right hand thread, so that means I need to turn the adjusters clockwise as seen from the bottom to pull the pivot down.

Table 1.

Wheel diameter: 16.25
Increment: 0.010

Measurement	Degrees	Measurement	Degrees	Measurement	Degrees
0.000	0.00	0.340	1.20	0.680	2.40
0.010	0.04	0.350	1.23	0.690	2.43
0.020	0.07	0.360	1.27	0.700	2.47
0.030	0.11	0.370	1.30	0.710	2.50
0.040	0.14	0.380	1.34	0.720	2.54
0.050	0.18	0.390	1.38	0.730	2.57
0.060	0.21	0.400	1.41	0.740	2.61
0.070	0.25	0.410	1.45	0.750	2.65
0.080	0.28	0.420	1.48	0.760	2.68
0.090	0.32	0.430	1.52	0.770	2.72
0.100	0.35	0.440	1.55	0.780	2.75
0.110	0.39	0.450	1.59	0.790	2.79
0.120	0.42	0.460	1.62	0.800	2.82
0.130	0.46	0.470	1.66	0.810	2.86
0.140	0.49	0.480	1.69	0.820	2.89
0.150	0.53	0.490	1.73	0.830	2.93
0.160	0.56	0.500	1.76	0.840	2.96
0.170	0.60	0.510	1.80	0.850	3.00
0.180	0.63	0.520	1.83	0.860	3.03
0.190	0.67	0.530	1.87	0.870	3.07
0.200	0.71	0.540	1.90	0.880	3.10
0.210	0.74	0.550	1.94	0.890	3.14
0.220	0.78	0.560	1.97	0.900	3.17
0.230	0.81	0.570	2.01	0.910	3.21
0.240	0.85	0.580	2.05	0.920	3.25
0.250	0.88	0.590	2.08	0.930	3.28
0.260	0.92	0.600	2.12	0.940	3.32
0.270	0.95	0.610	2.15	0.950	3.35
0.280	0.99	0.620	2.19	0.960	3.39
0.290	1.02	0.630	2.22	0.970	3.42
0.300	1.06	0.640	2.26	0.980	3.46
0.310	1.09	0.650	2.29	0.990	3.49
0.320	1.13	0.660	2.33	1.000	3.53
0.330	1.16	0.670	2.36	1.010	3.56

RESULTS

I lowered the left outside bracket by 3.5 turns and the right outside bracket by 1.5 turns. I re-measured the camber and found the new camber to be:

Left: -0.160″ = -0.56 degrees
Right: -0.177″ = -0.63 degrees

These results are within the range I had intended. I do not mind having a little more negative camber on the passenger's side since there is likely to be less load on that side most of the time, so there will be less extra negative camber from loading.

SETTING THE REAR TOE-IN

I had used the original shims behind the trailing arm brackets and I was rather careful to preserve the correct number of shims with each bracket. However, a friend who was helping me, and who has a lot of experience with suspensions, looked at my left rear wheel and said "you have too much toe-in". Toe-in is the measurement of how much the front of the wheel is pointing toward the center line of the car at the front. The measurement is made by measuring from the center of the tread at the front of the tire to the center line of the car and then subtracting from that the same position on the tread on the back of the tire.

I eyeballed the left rear tire. With the front wheels pointing straight ahead, I looked at the rear tire from the rear and aligned the front and rear sides of the tire so I was looking tangentially at both toward the front tire. It appeared that this line pointed about 1" in from the outside edge of the front tire tread. I did the same eyeball check on the right side, and the line projected very close to the outer edge of the tread on the front tire. Clearly the toe-in settings were quite different, and the left side was likely to have too much toe-in.

I had previously used the "String Technique" to set the front wheel toe-in of my TR7. It was pretty easy and all I needed to do was to get the front aligned with reference to the rear because the TR7 has a solid rear axle and no rear adjustability. All I needed to do in that situation was to run a string along the side of the car and get the string perfectly parallel with the rear wheel rim (perpendicular to the axle). But in the TR4A, with independent rear suspension, it is more difficult because the rear wheels cannot give you a line parallel with the center line of the car the same way as the TR7.

So, how do I get a reliable method to use the string technique? In principle, all alignments of the wheels are supposed to be referenced to the front-to-back center line of the car. But it is inconvenient to have a reference line underneath the car, and there are no simple landmarks on the frame to give us that center line. So, what do we know about the car that will allow us to calculate the center line. Table 2 has some data that applies to the TR4A through TR6.

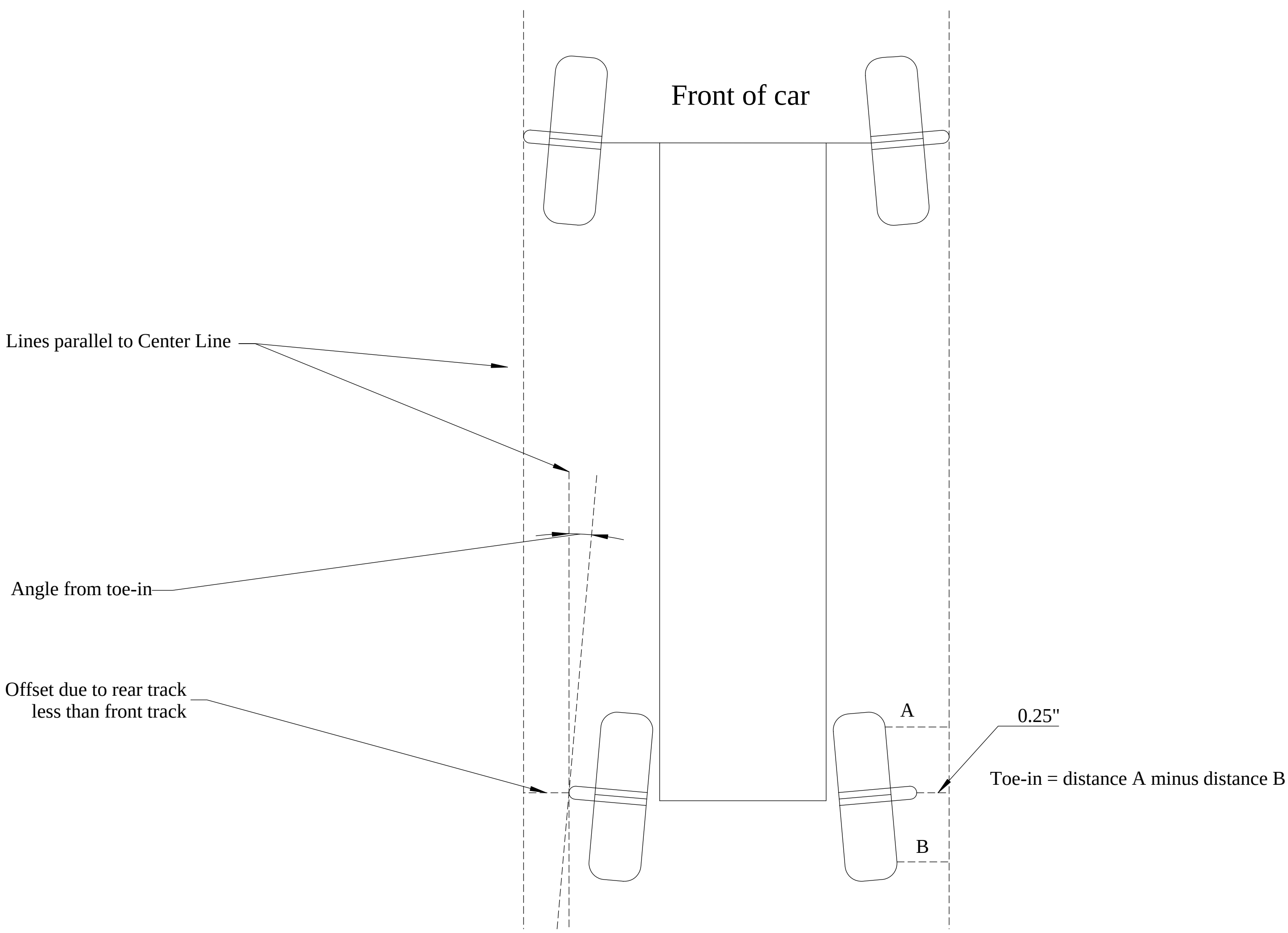
Table 2: Specifications:

Wheelbase	88″
Track (front)	50.25″
Track (rear)	49.75″
Toe-in	0 to 1/16″ (combined left + right)
Camber (rear)	-1.0 degree +/-0.5

The front and rear track data will allow us to determine where the rear wheel should be positioned in relation to the front wheel. The front track is 0.5″ wider than the rear track. So the edge of a front wheel should lie 0.25” farther away from the center of the car than the same point on a rear wheel. So, a string which is parallel with the center line of the car should be 0.25” further away from the rear wheel than the front. But what point should we use for this measurement? Both wheels have an unknown amount of toe-in, but if you average the distance from the string to the front and back edges of the rim, then you can calculate the distance of the string to the center of the wheel.

This requires placement of the string horizontally, crossing the center of each wheel, then taking precise measurements of the distance to the front and back rim of each wheel. Then the position of the string is moved in or out until the rear average distance is 0.25” greater than the front average distance. This is a bit tedious but feasible, and requires no special equipment other than whatever you use to hold the strings in position. Jackstands are commonly used for this purpose. One can make a special jig that has a 1” x 2” cross bar with two short dowel “legs” which are positioned on the front and back lip of the rim of the wheel, then take a measurement of the distance between the string and the center of the jig. The dowels do not need to be identically the same length as long as you always orient the jig the same for every measurement.

Figure 1



It is also a little inconvenience that the toe-in specifications are based on measurements on the TREAD of the tire. It is hard to measure to a reliable point of the front and back tread of the tire. It is much easier to measure to the edge of the rim of the wheel. So we need convert the measurements in the manuals to measurements we can make to the rim of the wheel.

Figure 1 shows a diagram of a car frame with front and rear wheels. In the diagram, the toe-in and difference in front and rear track are exaggerated for clarity. In real life the track difference is fractions of an inch, and the angles are fractions of a degree.
On my TR4A I have wire wheels with knock-off nuts. For simplicity I made a fairly dramatic assumption: The distance of the surface of the knock-off nut to the edge of the wheel is the same for all wheels. Therefore I can place the string in relation to the center of each nut and use that for my measurements. I confirmed by measurements that the center of the surface of the nut is identically the same for all of the wheels.

The Math

The recommended toe-in is zero to 1/16″ combined left plus right. This equates to zero to 1/32″ for each side measured from the center line of the car. The measurement is over a span of one tire diameter (25.25″ for a 165-15 tire). To convert this recommendation to measurements based on the rim of the wheel, we need to multiply the recommended values by the ratio of the wheel diameter to the tire diameter (16.25/25.25). This equates to 0″ to 0.0201″.

Table 2 shows the toe-in measurements for the two different reference points. The toe-in is measured by subtracting the distance from the string to the rear reference point from the same measurement on the front reference point. The reference points can be the edge of the rim of the wheel or the tread of the tire. The string is parallel with the center line of the car and includes a 0.25″ offset for the track difference.

Table 2 Toe-in measurements

Measured from tread:	
Zero toe-in:	0″
1/32″ toe-in:	0.0313″ (0.071 degrees)
Measured from rim:	
Zero toe-in:	0″
1/32″ toe-in:	0.0201″

RESULTS

All wheels can be out of true and have “run-out”. Run-out is the situation where the axis of the rim of the wheel is not perfectly perpendicular to the axle. This is seen a small “wobble” as the wheel turns. Run-out can be compensated by measuring the toe with the car rolled forward and backward by half a rotation, and averaging the two readings.

For my measurements, I made the string flush on the knock-off nut at the front and offset the string by 0.25″ away from the nut at the rear. On the left (driver’s side in the USA), my measurements when rolled forward were 2-12/32 and 2-9.75/32 for a difference of 2.25/32. When rolled backward, the measurements were 2-12.5/32 and 2-11.5/32 for a difference of 1/32. The average of these differences should eliminate the run-out and give us the real toe-in measurement of 1.625/32 or a decimal value of 0.0508". When measured on the rim, the toe settings should be 0 to 0.0201. So we are well outside the specified range.

SHIM ADJUSTMENT

My guess beforehand was that the addition or subtraction on one shim would change the toe by about the thickness of the shim. So, I wasn't sure I could make a small enough change by removing one shim since they seemed to be fairly thick. I decided to try removing one shim from the inner bracket to reduce the toe-in. I did this by placing a jack under the trailing arm as far forward as reasonably possible. I then jacked up the trailing arm enough to lift the body of the car about 1 inch.

I then loosened the bolts on the inner trailing arm bracket and also loosened the bolts on the outer trailing arm bracket a little. The shims were still pinned down strongly because the bracket wanted to tilt downward under the force of the spring. So, I jacked up the back of the trailing arm a little more until the bracket had little tendency to tilt downward. I was then easily able to extracted one shim. I measured the thickness of the shim and it was about 0.070".

I then tightened all the bracket bolts and removed the jack. I rolled the car back and forth to settle the suspension and re-measured the toe-in as described above. The new measurements gave a toe-in reading of 0.5/32 (0.0156) which is nicely within the range of 0 – 0.0201.

In addition, the change of toe caused by changing one shim was approximately 1.125/32 (0.0352) which is about half the change in shim thickness I am not sure why the change in toe was less than I expected, but the change was sufficient. Probably one needs to have on hand some custom made shims that are about 0.020" thick for a situation where you need to make a smaller change than I did. You can get galvanized sheet metal from the usual big box stores in 22 gauge (0.0299") and 26 gauge (0.0179"). You could also cut up a tin can and fabricate a thin shim at practically no cost at all. It **appears** that the rule of thumb is that you will change your toe-in by about half of the change in shim thickness, but I cannot verify this using geometry!

I also measured the right side toe-in and found it to be 0.25/32 (0.0078") which is within the specified range of 0 to 0.0201. The combined toe-in is 0.5/32 + 0.25/32, which adds up to 0.75/32. When converted to the toe-in listed in the books (referenced to the tread by multiplying my measurements on the rim by 25.25/16.25) the combined toe-in is 0.58/16. This is also nicely in the range of the specified 0 to 1/16 combined toe-in.

APPENDIX I

Factory Technical Document

LEYLAND-TRIUMPH SALES COMPANY, INC.

WESTERN ZONE

TO: ALL TRIUMPH DEALERS - WESTERN ZONE

DEPT: SERVICE DEPARTMENT

BULLETIN T-65-41

SUBJECT: REAR WHEEL ALIGNMENT
TRIUMPH 2000 AND TR-4A
I.R.S. MODELS

DATE: SEPTEMBER 30. 1965

When investigating complaints of excessive tire wear and/or alleged crabbing on the above models, the rear wheel alignment, i.e., the front to rear tracking may be carried out without recourse to expensive special equipment by adopting the following procedure. Where specialized equipment may be available the instructions on pages 4.204 through 4.212 would be found useful. (shop manual)

<u>NOTE:</u> Customer reports of alleged misalignment must not be confused with normal difference in track width between front and rear road wheels. Such an illusion may be formed when a narrower rear track model is viewed from the rear, i.e., by a following motorist.

Illustrations, Nos. 4 and 5, detail measurements for making up separate tracking boards for the above models. The two separate boards may be combined if desired by dimensioning both straight edges of one board, i.e., back to back.

<u>PROCEDURE FOR OTHER THAN SPECIAL EQUIPMENT</u>

1. Set front wheel track to parallel by adjusting tie rods equal amounts. Slacken off gaiter clips to prevent damage to gaiters when turning tie-rods.

2. Set rear wheel track to parallel by adding or subtracting shims from between trailing arm and cross-member.

3. Place car on a ramp and ensure front wheels are in a true straight-ahead position. This can be achieved by ensuring that the measurement "B" from each outer tie-rod ball joint stem to the center hole "A" in the front cross member are equal. Illustration 1.

LEYLAND-TRIUMPH SALES COMPANY, INC.
WESTERN ZONE

TO:	ALL TRIUMPH DEALERS - WESTERN ZONE		
DEPT:	SERVICE DEPARTMENT	BULLETIN	T-65-41
SUBJECT:	REAR WHEEL ALIGNMENT TRIUMPH 2000 AND TR-4A I.R.S. MODELS	DATE:	SEPTEMBER 30. 1965

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4. Apply tracking board, string or straight edge against front tire walls and if the geometry is correct the position shown in illustration 1 will be apparent. (The illustration shows use of tracking board or straight edge.)

   When using string or straight edge, half the difference in rear wheel track must be taken into account at point "C" which will be approximately equal at both rear wheels.

5. To allow for possible discrepancy in tire wall truth, 2nd and 3rd straight edge checks should be taken at 120 degree radical points about the tire, which positions should be achieved by rolling the car backwards and forwards from its first check position.

6. If misalignment, as shown exaggerated at points "X" in illustrations 2 and 3 is evident, the four attachment points of the rear sub-frame unit "E" must be slackened off and the sub-frame pivoted or moved sideways about these points until the correct condition is obtained. During this operation, the weight of the car should be taken off the rear suspension by means of jacks under the two rear jacking points on the body.

7. The front and rear wheel track setting may be left in the parallel condition.

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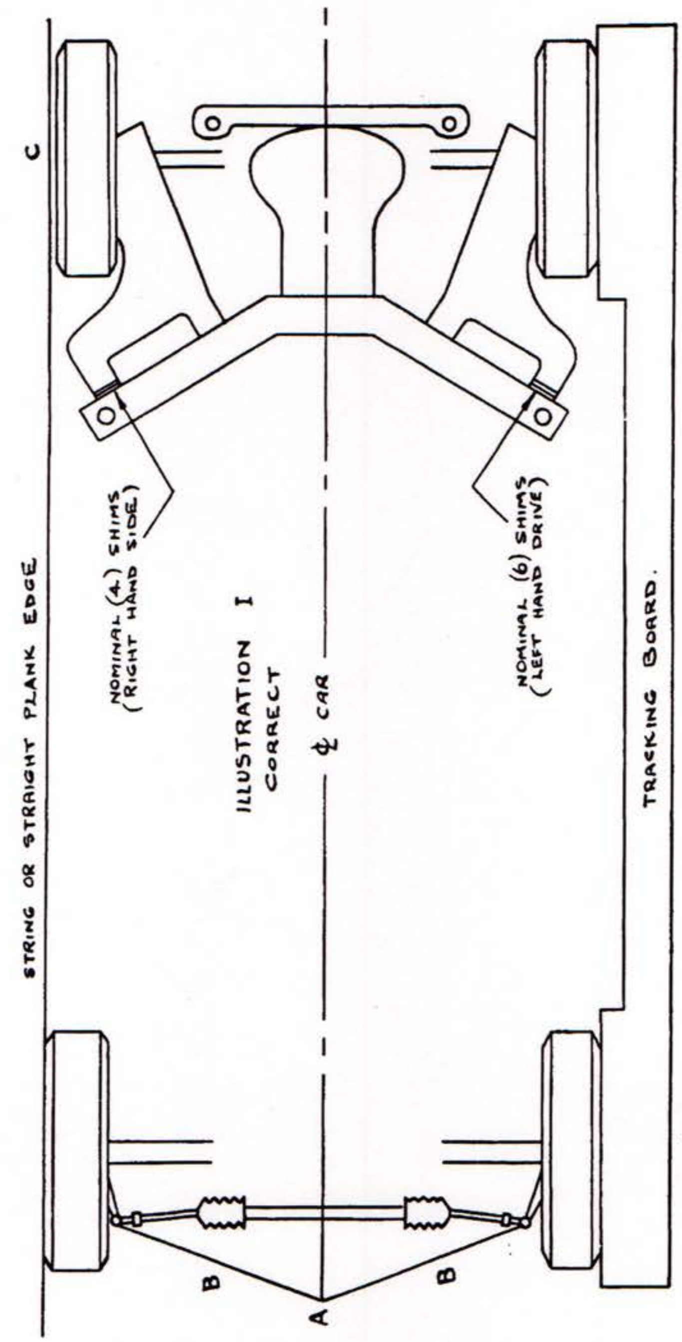

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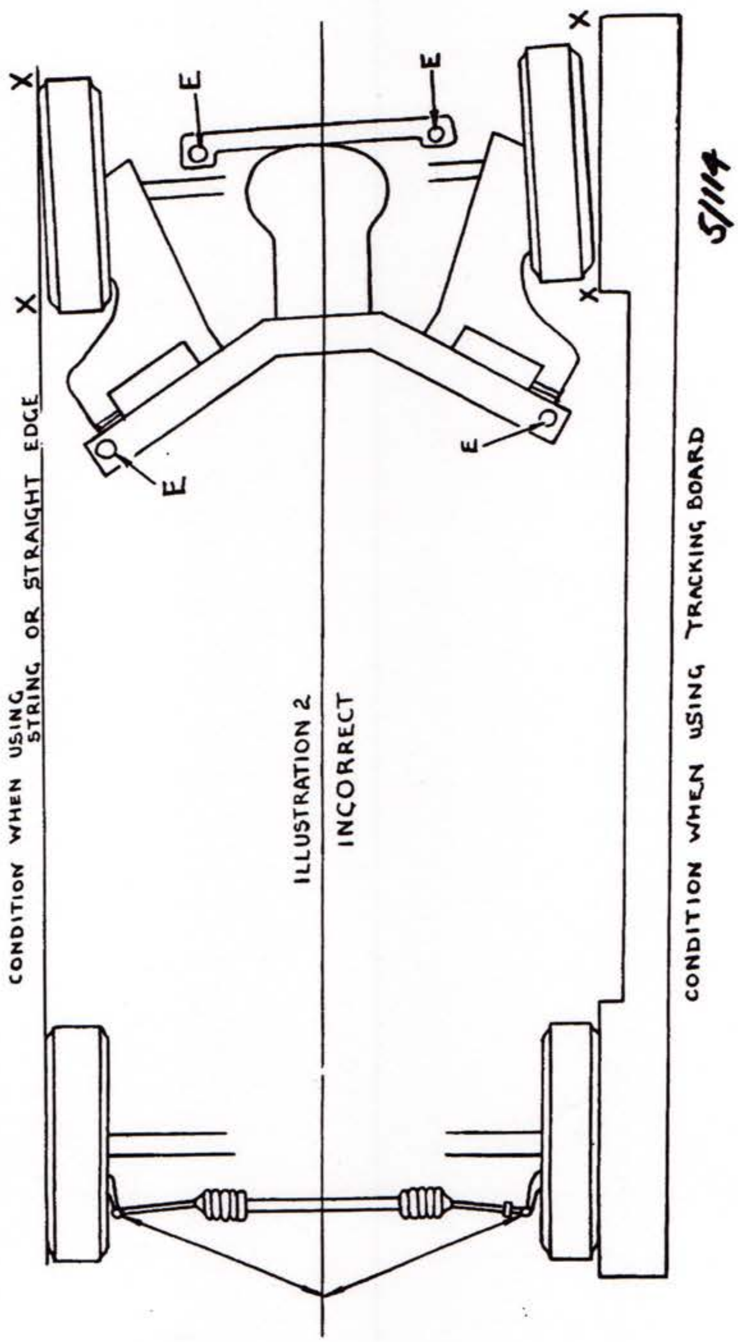

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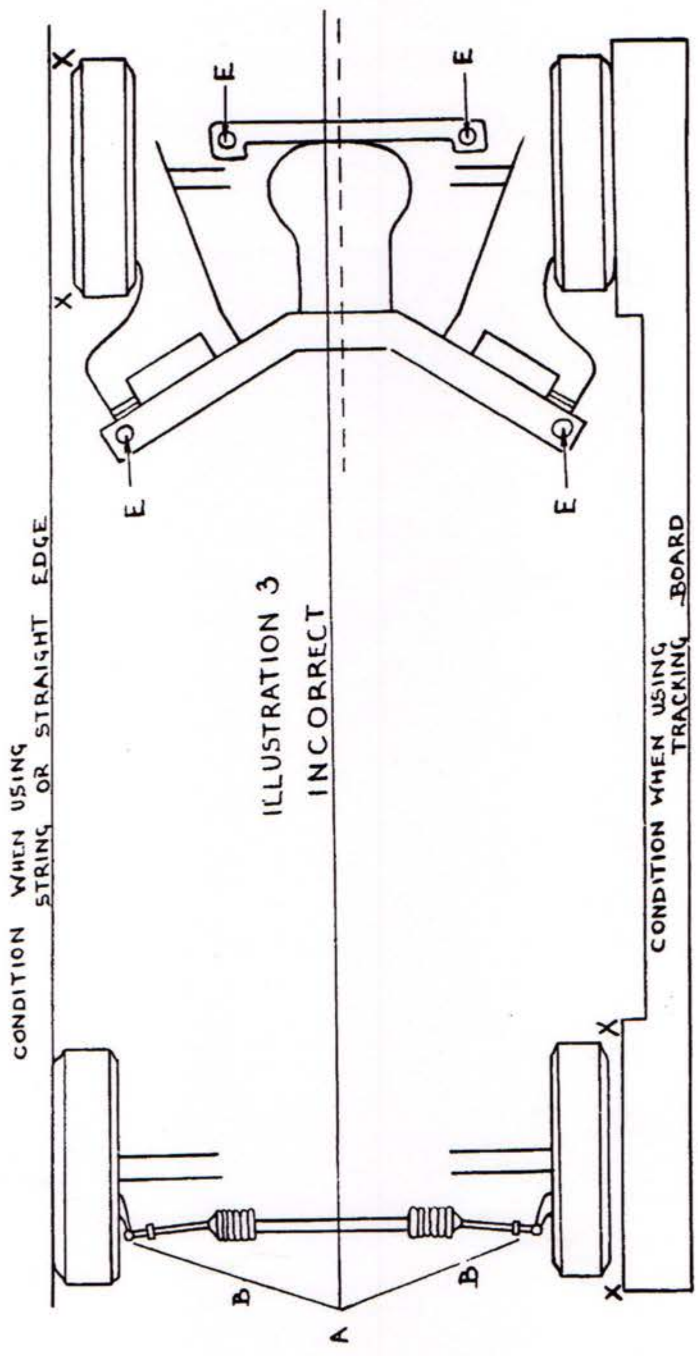

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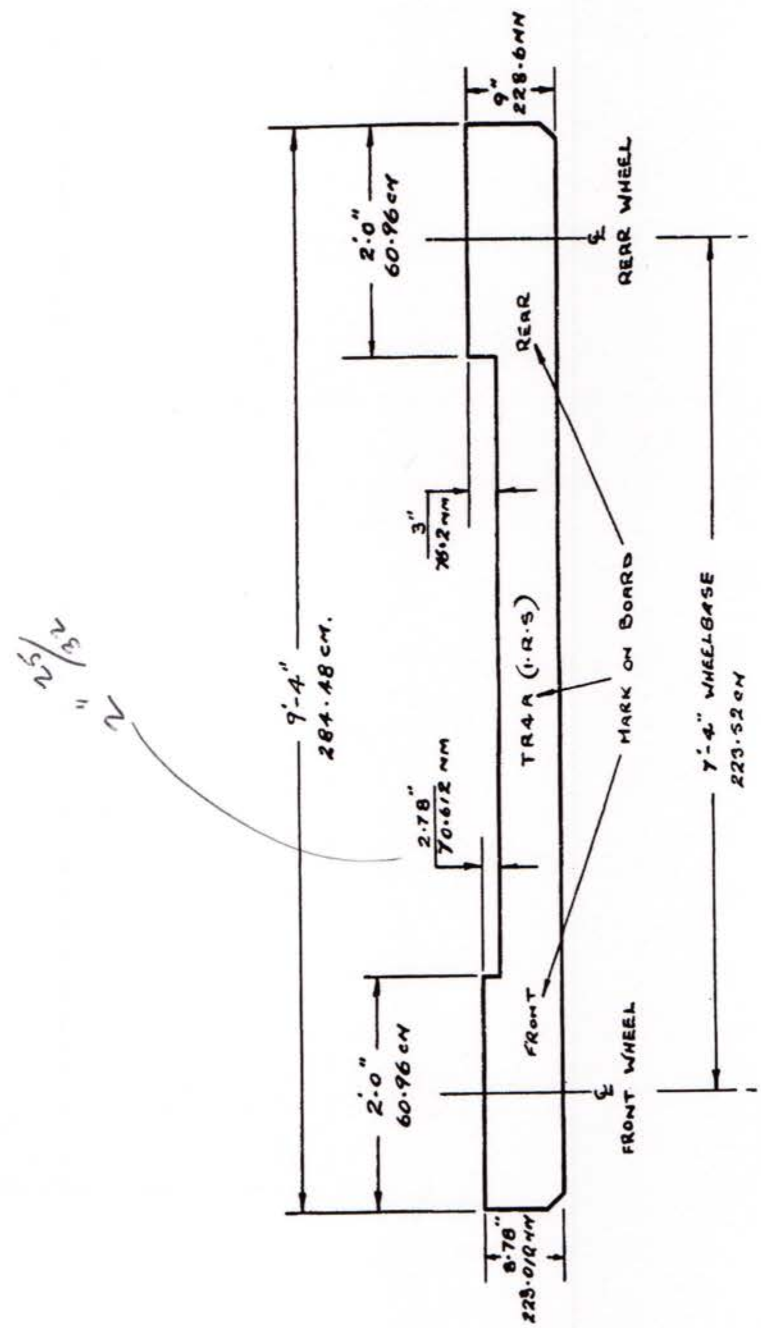


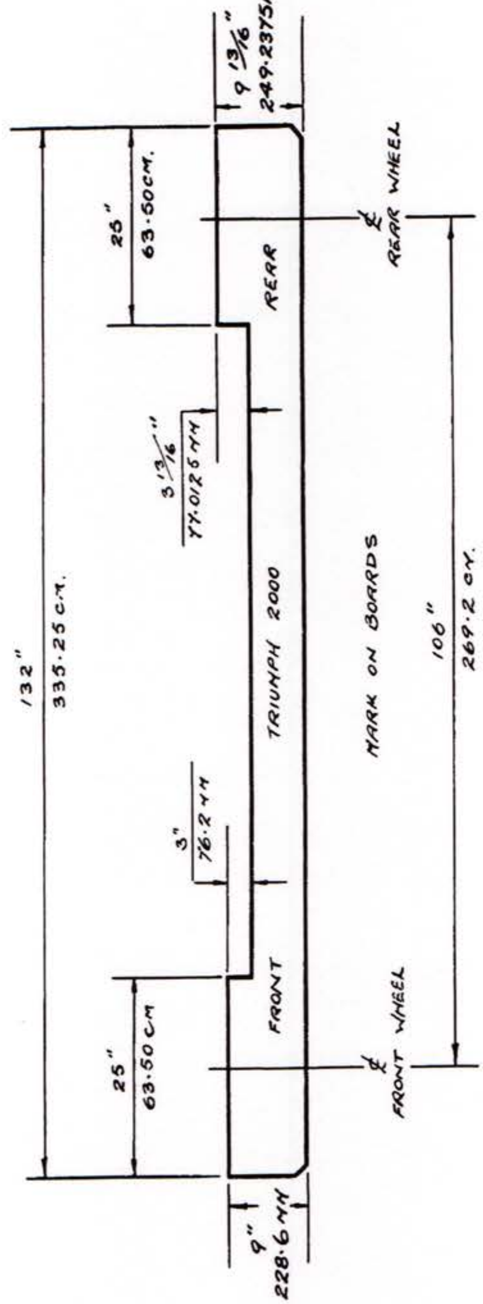
MATERIAL 1"(25.4 MM) HARDWOOD.

ILLUSTRATION 4

5/114

LEYLAND-TRIUMPH SALES COMPANY, INC.

WESTERN ZONE



MATERIAL 1"(25.4MM) HARDWOOD

ILLUSTRATION 5

LEYLAND-TRIUMPH SALES COMPANY, INC.
WESTERN ZONE

TO: ALL TRIUMPH DEALERS - WESTERN ZONE

BULLETIN T-65-42

DEPT: SERVICE

SUBJECT: I.R.S. AXLE LUBRICANTS

DATE: OCTOBER 14, 1965

The following lubricants or their equivalents should be used when reassembling the sliding joint of the I.R.S. rear axle on the TR-4A or Triumph 2000 model.

Esso/Enco	Esso Multi-Purpose Grease Beacon Q-2
Shell	Shell Lithall MDS Shellair Grease LG
Gulf	Gulflex Moly
Mobil	Mobil Grease Special

The following lubricants or their equivalents which are similar to current recommendations for front hubs and steering units may be used for lubrication of the rear hubs during assembly or repair operations.

Esso/Enco	Esso Multi-Purpose Grease
Gulf	Gulfcrown E.P. Special Grease Gulflex A
Mobil	Mobil Grease MP Mobil Grease Special