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The items in this catalog are intended for use in motorsport competition, i.e. AUTO RACING. No warranty of these components, express or implied, is offered by Woodward Machine Corporation or its subsidiaries, for the following reasons, among others:

(1) Motorsport is inherently dangerous. The conditions of end use of the components are normally hazardous and unpredictable, and are entirely beyond our control; and

(2) The decision as to the suitability of said components for a particular manner of use, or in a particular installation, is made by the user and is likewise beyond our control; and

(3) The application of said components is therefore understood to be experimental.

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Warning: The approval of your state department of motor vehicles or your country's Ministry of Transport or other relevant authority, for the use of racing equipment on the public highways should not be assumed. Woodward Machine Corporation does not support nor participate in efforts to obtain such approval. The end user is reponsible for not utilizing Woodward racing components in any manner which may contravene local law.

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Returned parts may be subject to a charge of up to 20% to defray the cost of inspection, restocking, and repackaging. Returned merchandise must be unused, unmarked and not over 30 days old. We will make adjustment via exchange or credit only. Special order parts, damaged or rusted parts, or “basket cases” are not returnable except in connection with repair orders.

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Make absolutely sure to specify in the customs declaration that you are returning goods *manufactured in the U.S.* If this is not done and we receive a bill for import duties, it will be charged to your account.

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In this catalog, many categories of parts are only manufactured on a made-to-order basis. Please note that parts built or assembled to customer specifications are generally specialized enough to be otherwise unsalable, and consequently these are not returnable.

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WOODWARD Needle Bearing U-Joints

Since 1989, Woodward steering universal joints have been the preferred choice of race car builders everywhere, and have won every major race and series championship in North America many times over, including the NASCAR championship. Woodward pioneered the use of caged needle rollers with a slight preload to create a joint without backlash and with noticeably lower reversing inertia than conventional automotive designs. That means enhanced sensitivity at the steering wheel, and makes even the smallest steering input more effective—whether on a superspeedway at 200MPH or sideways on a dirt bull ring.

The bearing trunnion used in these U-joints is a single piece of hardened chrome-vanadium tool steel. The grease seals are high-durometer fluorocarbon o-rings in compression against the end surfaces of the needle bearing cups. These seals will resist sustained oven-level heat and will retain the bearing grease under severe conditions, including welding. Other design details include stainless steel truss-head screws overlapping the bearing cups, and a pair of fine-thread knurled set screws located at 90º, for highly positive and reliable retention on a splined shaft or steering gear.

Please note that the intended application of these u-joints and couplers is automobile racing, where low frictional resistance and low mass are the primary goals. Their dimensions are Woodward standards, shown in the drawing on the following page. Except for the spline sizes, which fit steering racks and gearboxes adapted from OEM automobiles, they do not conform to any automotive manufacturer's dimensions and are not OEM replacement parts.

PLATING: Splined Woodward U-joints are now available gold zinc plated in ALL SIZES. Plated joints are baked immediately after plating to prevent hydrogen embrittlement, and all dimensionally critical surfaces are corrected prior to final assembly. For gold zinc, add G to the part number. *To avoid possible contamination of the weld zone, plain-bore joints intended for welding are not plated.*

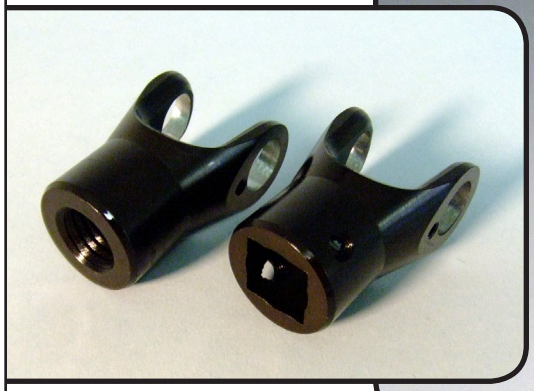
shown:
UAD1-201201

DOUBLE UNIVERSAL JOINTS: Double U-joints neatly solve problems of angular misalignment by providing a more constant rotational velocity than a single joint used at the same operating angle. These joints are available as short permanent-center units as shown, or assembled onto splined shafts at various center distances. On assembled units the Woodward "201" spline is timed with respect to the bearing axis to provide correct phasing and smooth and reliable operation.

INDUSTRIAL APPLICATIONS: Woodward can manufacture long or short runs for industrial uses such as machine tools, printing presses and assembly and packaging equipment.

MILITARY APPLICATIONS: As part of the defense procurement chain, Woodward supplies steering u-joints for combat vehicles in current production, as well as prototypes.

CUSTOM U-JOINTS: We can produce one-off splines for rare auto restorations, vintage race cars and retrofits. Alternatively, joints can be supplied unassembled for machining of special profiles by the customer via slotting or EDM.



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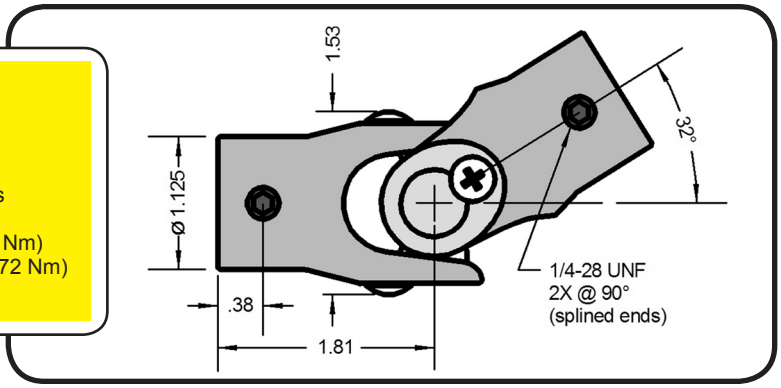
Mechanical Specifications

Weight 310g
(smaller hole=heavier part; larger hole=lighter part)
Rotational clearance circle 1.75 (44 mm) diameter
Maximum possible angular misalignment 32 degrees
Recommended operating angle <20 degrees
Torque resulting in bearing damage >250 lb/ft (>339 Nm)
Torque resulting in plastic deformation >275 lb/ft (>372 Nm)
Ultimate breaking torque >300 lb/ft (>406 Nm)



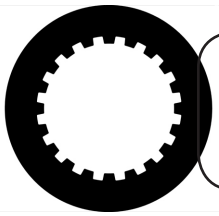
Operating Angle

Although the ears of the joint are contoured to prevent it from jamming, it will not operate beyond a 32 degree angle. Any universal joint will transmit rotary motion at constant velocity when straight, but when rotating through an angle it will develop a twice-per-revolution acceleration/deceleration cycle whose amplitude increases with the angle. To avoid variable velocity effects in the steering we strongly recommend that the total angular misalignment between steering column and pinion not exceed 20 degrees. Smoothness of operation can be further improved by subdividing the angle between two joints.

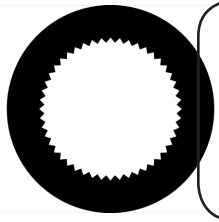
Spline Identification

The diameter shown after the three-digit identifying code is the nominal outside diameter of the male spline the u-joint is intended to fit, in decimal inches, and in millimeters where the profile was originally a metric design. In production, a spline is measured over wires of specified diameter which fit into the vees. Since it's seldom practical to do this in the field, we suggest you simply measure over the crests of the teeth. That measurement will usually correspond closely enough to one of the listed diameters to identify it. Keep in mind that splines fit on the flanks of the teeth, not the crests. Like screw threads, the crests of spline teeth can be truncated without affecting the fit, so an actual measurement of any of these examples might well be .015 (0.5mm) under the nominal sizes shown here. To aid identification, the vehicle origins of the various automotive splines are also listed below where known.

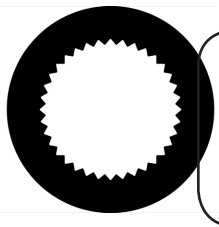
The "number of spline teeth" refers to the number of equally spaced divisions of the circle, whether or not they are used in the spline pattern. Flats or interruptions are ignored (e.g., a shaft with 36 teeth, 6 of which are missing, is NOT a 30-tooth spline). If interruptions make it impossible to get a reliable count all the way around the shaft, count halfway around and double it.



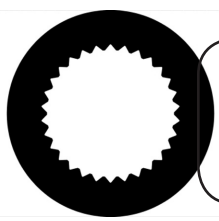
201 .750 diameter; 20 teeth
Used on all Woodward products since 1992; fits Woodward integral power racks, Woodward remote power racks, Woodward servos, and Woodward safety steering columns, weld-in stubs, and double u-joints. Also used on copies of Woodward columns. Not an automotive industry profile. The shaft spline OD is cylindrical and can run in a bearing.



101 .750 diameter; 48 teeth
Fits most US stock-car racks past and present (Sweet, Appleton, Speedway, SWS, Quick-trac, Wilwood, Coleman, BRT, RCP, and pre-1992 Woodward) and the output end of inline Sweet servos. Originally a British standard used on MG and Jaguar racks and Austin-Healey steering shaft, among others. Note: Over the years this profile has been applied to many products without reference to the original dimensional standard; a proper fit cannot be guaranteed on parts made by companies no longer in business.



102 .735 diameter; 36 teeth
Fits Mustang power rack and its clones, old manual Chevy and Ford box, Dodge truck power steering box, and most steering quickeners. Note: This is an automotive industry profile whose production tolerances varied during the half century it was in use. Some older aftermarket shafts and steering quickeners with a "3/4-36 spline" do not conform to this profile and may not work with this joint.



103 .720 diameter; 30 teeth
Introduced on 1980s GM power steering boxes and racks. Used on current Delphi 600 series boxes and on aftermarket servos using the Delphi 600 input shaft (Appleton, small style Sweet, etc.). Interchangeability of this profile is fairly reliable. Usually has a large flat on one side.

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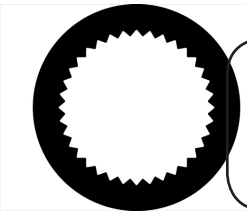
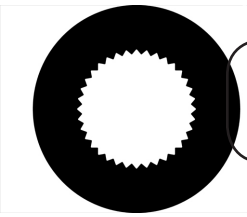
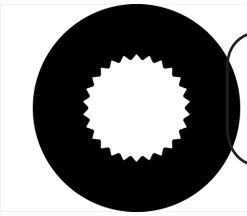


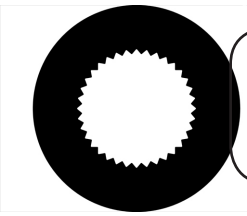
104 .820 diameter; 36 teeth
Used on older GM power steering (700 series boxes) and the input shaft of large style inline Sweet servos. The measured diameter varied considerably during the years of production of the steering box, from .812 as originally produced, to .820 on later units. Usually has a large flat on one side.



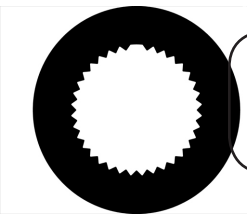
105 .620 diameter; 36 teeth
OEM Chevrolet Vega steering box (NOTE: may not fit "5/8-36" aftermarket copies of the Vega box).



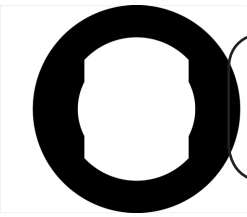
106 .565 diameter; 26 teeth
Fits Ford Pinto manual rack and pinion and most aftermarket copies.



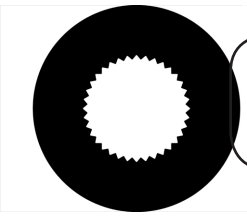
107 .625 diameter; 36 teeth
Made specifically for the Stiletto (Chassis Shop) manual rack. A special profile; not an automotive standard, and NOT for Vega steering boxes.



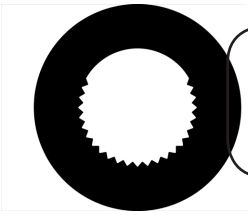
108 .688/17,5 mm diameter; 34 of 36 teeth)
Fits Toyota truck power steering with one filled spline for orientation, also other 17,5 x 36 splined shafts.



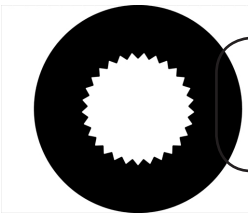
109 .750 diameter with two flats ("double D" shape)
Fits Ford style DD shaft and street-rod aftermarket DD shafting measuring .550 across the flats. *Does NOT fit the smaller 17 mm GM DD shaft.*



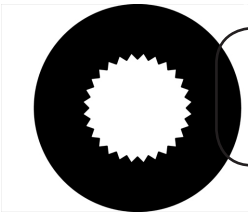
110 .563 diameter; 36 teeth
Fits Titan, Jack Knight and Miller racks, Ariel Atom steering shaft, also some dragster steering.



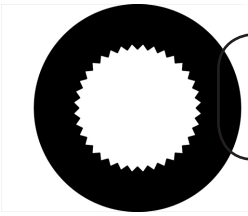
111 .625/16 mm diameter; 23 of 36 teeth
Originally made to fit the Australian TRW power rack with 13 blocked or filled splines, this also fits the 16 mm x 36 spline shaft used on various Japanese cars.



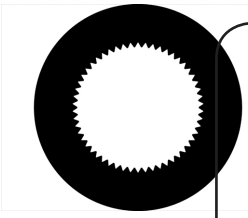
112 .590/15 mm diameter; 29 teeth
Fits Honda rack and pinion and steering column and some aftermarket midget racks.



113 .570/14,5 mm diameter; 28 teeth
Fits Datsun 240/260/280Z. The other end of this u-joint can be sized for welding onto the original steering shaft.



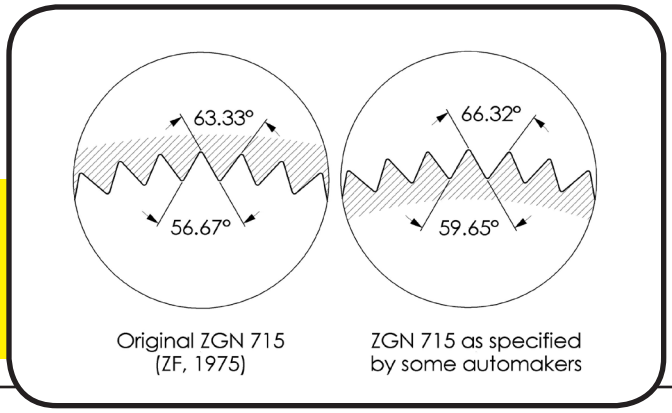
114 .669/17 mm diameter; 36 teeth
Fits Mitsubishi Starion, Chrysler Conquest and EPAS electric steering columns.

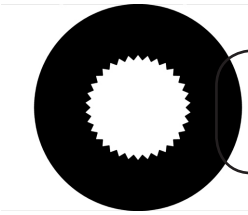


115 .688/17,5 mm diameter; 54 teeth
Fits ZF steering rack and splined shafts used on many European cars such as BMW, Mercedes, Ferrari, Maserati.

NOTE: On some recent steering racks, this spline does not conform to original spec. Referring to the drawing below, although both specifications show this spline as having the identical pitch diameter, the profile on the right has a 3° wider included angle.

We have resolved this conflict with special tooling. The #115 U-joint as currently produced will now fit all ZF pinions old and new. If in doubt, we suggest a trial fit using a C115 coupler.





116 .550/14 mm diameter; 34 teeth
Fits Toyota MR2 and Corolla steering rack and Quaife quicker-ratio replacement gearsets.

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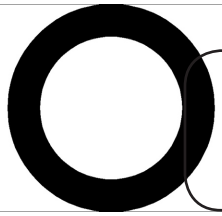
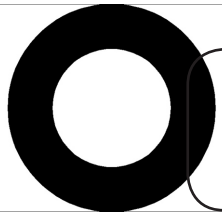
Plain bore sizes for welding onto steering shafts



100 .755/753 diameter
Sized for a close slip fit on 3/4 inch cold finished TUBING. Mills normally produce tubing to a PLUS tolerance.



150 .625 diameter
Sized for a close slip fit on 5/8 cold finished BAR STOCK. Mills normally produce round bar to a MINUS tolerance.

Notes on welding U-joints

While it has become obvious over many years that universal joints can be welded to shafts with a high degree of reliability, some procedures are detrimental to the U-joint and must be avoided. The joints are designed with sufficient mass and length to allow a full-circumference fillet weld without disassembly. NEVER add plug or rosette welds, as the additional contraction stresses will tend to misalign the bearing axes and/or distort the bearing bores.

(1) Plug or rosette welds on universal joints are virtually guaranteed to shorten the life of the bearings from both direct heat and the distortion resulting from weld contraction in proximity to the bearing bores.

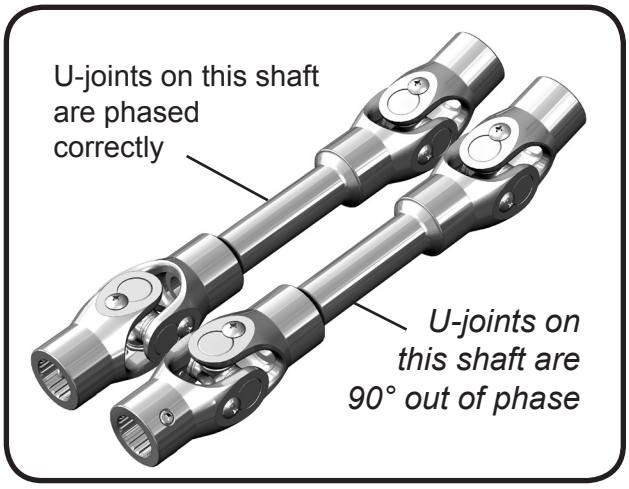
Even if the bearings are removed first (very difficult to do without damaging them) this distortion will cause enough ovality and misalignment to damage both the bearings and the trunnion journals when reinstalling. In any case, the diameter and total cross section of a circumferential weld is comfortably larger than that of a tubular steering shaft, and any additional welding in the form of plugs or rosettes would be entirely superfluous.

(2) Any welding procedure which consumes enough time to discolor the ears of the U-joint should be assumed to have drawn the temper of the bearings.

This does not necessarily disqualify the TIG process, but TIG is, unfortunately, fairly slow. To avoid heat-soaking the joint when TIG welding, use a high-strength, non-cracking filler rod such as 309 stainless and keep the cross-section small. People have successfully suspended the U-joint in water while welding around the exposed end, but this is a lot of trouble for no gain. The more practical method is MIG, as a comfortably large weld can be made in a few seconds, especially using a rolling fixture to support the shaft. ER80S-D2 wire using 25%CO2/75%Ar shielding gas will give excellent results for both strength and appearance.

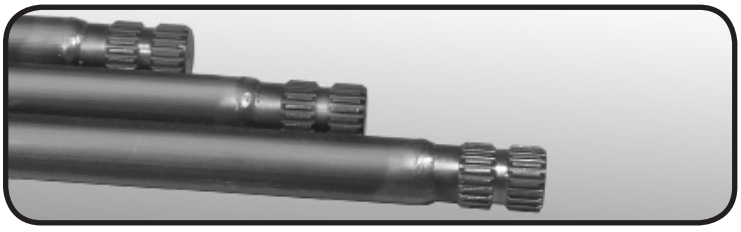
Phasing and clocking welded U-joints

Phasing or "clocking" of universal joints for smooth operation is especially critical when welding U-joints directly to the shaft, since it will be impossible to reposition them once you've done it. Assuming all sections of the steering shaft lie approximately in the same plane so that the only misalignment is angular (the most common condition), any back-to-back pair should be aligned like the ends of a driveshaft, as in the illustration at right. Please study it closely; the difference is not obvious unless you are looking for it. The greater the angular misalignment of the steering shaft, the more critical the phasing of the U-joints. For reference, most stock car steering layouts will tolerate joints 20 degrees out of phase, but 45 degrees out will cause a noticeable change in rotational velocity–the steering will actually speed up and slow down during half a turn of the steering wheel. Shafts with both angular and parallel misalignment may require special U-joint phasing which can only be found by trial and error. In the case of weld-on U-joints, this can be done by temporarily holding one of the joints onto the shaft or tube with a small tack weld, and welding it permanently in place only after you have determined its optimal position. The obvious disadvantage of welding U-joints directly to the shaft or tube is, of course, that once you've welded them they cannot be removed without resorting to a torch, saw, or angle grinder.



Using weld-in splined stubs

Welding a splined stub into the steering tube is no more work than welding a U-joint to it, and by confining the welding to the tube, potential heat damage to the U-joint bearings is eliminated. A full-penetration circumferential weld of the stub to the tube will transmit steering torque as effectively as the tube itself, and is not difficult.



.750-20 SPLINE
WELD-IN STUB

For 3/4 OD x .120 wall
ST201A 12.78
For 3/4 OD x .065 wall
ST201B 12.78
.660 diameter pilot
ST201C 12.78
.750 diameter pilot
ST201X..... 24.46
.875 diameter pilot
ST201GM 29.08

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Weld-in stubs contain no moving parts and are virtually immune to damage other than weld spatter. And, unlike a splined piece of tubing they are solid and cannot be crushed by the set screws of the U-joints. The relatively low extra cost of stubs and splined joints is almost insignificant compared with the time and effort which must otherwise be invested in directly welding U-joints to shafts, removing welded U-joints with a torch or hand grinder, or trying to modify a steering shaft whose joints have been welded.

Please note that we manuacture spline stubs *only* in the .750-20 (201) profile, which is universally used on our products. This spline develops a more positive grip when locked with set screws than any OEM automotive spline or serration. In Woodward U-joints the 201 spline is timed with respect to the bearing cross axis, to ensure that U-joints at opposite ends of a 201 splined shaft can always be installed correctly phased.

Prior to tacking the second stub, install a U-joint on it so you can visually orient it parallel to the U-joint at the other end of the shaft, as shown on the previous page and at the bottom of this page.

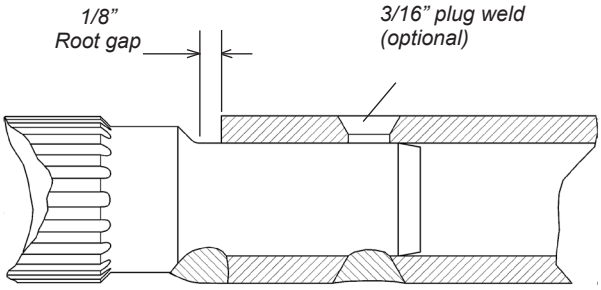
Welding technique for stubs

With a weld-in stub, plug or rosette welds can be added if desired. If so, use two; these should be as directly opposite each other as possible to equalize the inevitable distortion.

The pilot of the splined stub is made a few thousandths oversize to ensure a tight fit in the expected ID of a .120 wall tube. File the pilot if necessary until it fits the tube snugly. A heavy driven fit is unnecessary and will restrain the weld joint. **Leave a 1/8" gap at the root of the weld** to ensure penetration. For the circumferential weld, a couple of hot MIG passes (use a rolling fixture if you can) will get the job done before any significant distortion can set in. The recommended filler wire is ER80S-D2 with C-25 gas (Ar75%/$CO_2$25%), available from welding suppliers worldwide.

ER80S-D2 wire is also available in 36" cut lengths for TIG welding.

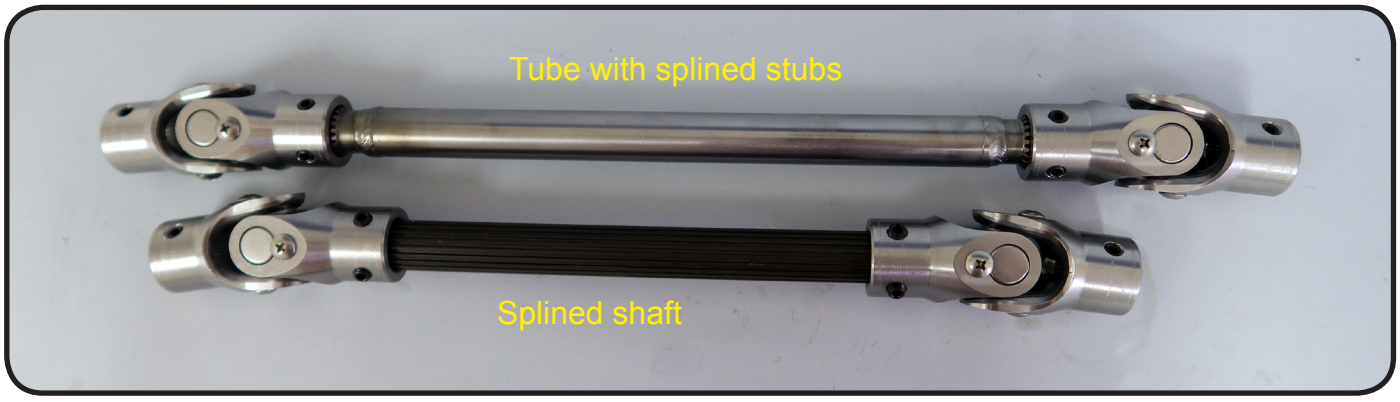
Although a steering shaft is not a high-speed rotating assembly, straightness is still a practical goal. Keep in mind that TIG is relatively slow and that *the slower the welding process, the more your finished job is likely to deviate from straight.*



ST201A into 3/4OD x .120W tubing

A welded intermediate shaft versus a solid splined shaft

Below (at top) is an example of 3/4 x .120 wall tubing with splined stubs welded into the ends. Although it is somewhat longer than the solid shaft (at bottom) it weighs slightly less because it is hollow except at the ends. Obviously, the longer the shaft the greater the weight saving.



Unless the lower weight of the tubular portion is of sufficient importance to justify the labor of fabrication, a one-piece splined shaft will be more convenient—particularly when the required shaft is fairly short, as is generally the case with the conversion of a modern automobile (that is, one originally manufactured with rack and pinion steering) into a race car or drift car.

Splined shafts are available from stock up to 16 inches long, with one end premachined with a locking groove 1/2 inch (12.7mm) from the end to accept the U-joint set screws. The other end is left blank for cutting to length (part numbers for this product are UADS-X-6 through UADS-X-16 and are listed on page 14). Once you have established the finished length, the groove can be turned in a lathe, or, in a pinch, notches can be hand-ground to accept the screws. Tightening the set screws will mark the location for the notches.

Reminder: Since the 201 spline is timed with respect to the bearing axes, U-joints at opposite ends of the solid splined shaft will automatically be aligned. When welding stubs into tubing, ensure parallel alignment by installing a U-joint at each end and squaring the U-joints against a straightedge or surface plate prior to tacking.

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Simplified U-joint Part Numbers

The new six-digit numbers are made up of the spline codes for each end. The numerically higher code appears first, e.g. UA201109, UA109102, UA110100 etc.

In addition to the common ones shown on the following pages, any combination of ends can be specified by composing an appropriate part number as above. All joints with splines at both ends (or bores other than the standard diameters) are priced the same; all joints with splines at one end are priced the same, etc.

Example:

UA201115

.750-20 SPLINE (201) x
3/4 WELD-ON (100)

Woodward spline one end; other end sized .755/.753 for welding onto 3/4 OD tubing

UA201100.....87.08

.750-20 SPLINE (201) x
.750-20 SPLINE (201)

Connects Woodward parts to any other Woodward parts (telescoping column, either end of Woodward servo, splined shaft sections, and all Woodward rack types).

UA201201 .....90.00

.750-48 SPLINE (101) x
3/4 WELD-ON (100)

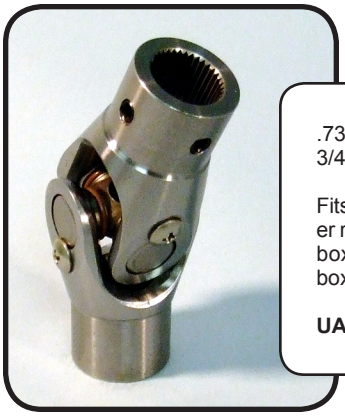
Fine-pitch serration fits Sweet manual rack and inline servo output shaft, several British racks such as MG and Jaguar, as well as the steering shaft on Austin-Healey. Also used on Woodward racks built before 1992.

UA101100..... 87.08

.750-20 SPLINE (201) x
.750-48 SPLINE (101)

Connects Woodward shaft to Sweet manual rack and inline servo output shaft, MG and Jaguar, racks as well as the steering shaft on Austin-Healey. Also adapts Woodward racks built before 1992.

UA201101.....90.00



.735-36 SPLINE (102) x
3/4 WELD-ON (100)

Fits Mustang power rack, AGR power rack, old manual Chevy and Ford box, Dodge truck power steering box, and most steering quickeners.

UA102100 ..... 87.08

.750-20 SPLINE (201) x
.735-36 SPLINE (102)

Adapts Woodward shaft to Mustang power rack, AGR power rack, old manual Chevy and Ford box, Dodge truck power steering box, and most steering quickeners.

UA201102.....90.00

.720-30 SPLINE (103) x
3/4 WELD-ON (100)

Fits current-model GM power steering including the 600 series box and all servos using 600 series parts (Appleton, small style Sweet, etc.).

UA103100 ..... 87.08

.750-20 SPLINE (201) x
.720-30 SPLINE (103)

Adapts Woodward shaft to current-model GM power steering including the 600 series box and all servos using 600 series parts (Appleton, small style Sweet, etc.).

UA201103.....90.00

.820-36 SPLINE (104) x
3/4 WELD-ON (100)

Fits older-model GM power steering (700 series box) and output shaft of large style Sweet servo.

UA104100.....87.08

.750-20 SPLINE (201) x
.820-36 SPLINE (104)

Adapts Woodward shaft to older-model GM power steering (700 series box) and large style Sweet servo.

UA201104..... 90.00

.620-36 SPLINE (105) x
3/4 WELD-ON (100)

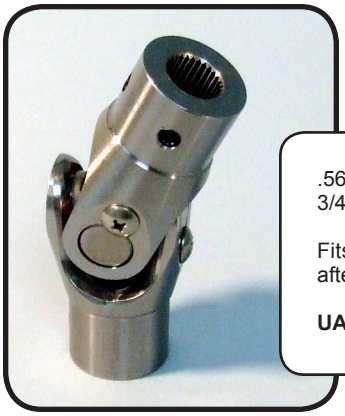
Fits OEM Vega steering box; may not fit aftermarket copies

UA105100 ..... 87.08

.750-20 SPLINE (201) x
.620-36 SPLINE (105)

Adapts Wooodward shaft to OEM Vega steering box; may not fit aftermarket copies

UA201105.....90.00



.565-26 SPLINE (106) x
3/4 WELD-ON (100)

Fits Pinto manual rack and most aftermarket copies.

UA106100 ..... 87.08

.750-20 SPLINE (201) x
.565-26 SPLINE (106)

Adapts Woodward shaft to Pinto manual rack and most aftermarket copies.

UA201106..... 90.00

.625-36 SPLINE (107) x
3/4 WELD-ON (100)

Fits Stilletto (Chassis Shop) rack and pinion.

UA107100 ..... 87.08

.750-20 SPLINE (201) x
.625-36 SPLINE (107)

Adapts Woodward shaft or slide yoke to Stilletto (Chassis Shop) rack and pinion.

UA201107..... 90.00

.688-34/36 SPLINE (108) x
3/4 WELD-ON (100)

Fits Delphi 600 series box used on Toyota truck. Has one filled or "block" spline; not indexable on the steering box.

UA108100 ..... 87.08

.750-20 SPLINE (201) x
.688-34/36 SPLINE (108)

Adapts Woodward shaft to the Toyota 600 box. Has one filled or "block" spline; not indexable on the steering box.

UA201108..... 90.00

3/4-DD (109) x
3/4 WELD-ON (100)

Fits Ford type DD and aftermarket DD shaft measuring .550 across the flats. *NOT for the smaller GM 17mm DD*.

UA109100 ..... 87.08

.750-20 SPLINE (201) x
3/4-DD (109)

Adapts Woooodward shaft to Ford type DD and aftermarket DD shaft measuring .550 across the flats.

UA201109..... 90.00
3/4-DD (109) x 3/4-DD (109)
UA109109 ..... 90.00

.563-36 SPLINE (110) x
3/4 WELD-ON (100)

Fits Titan, Jack Knight, Miller racks.

UA110100..... 87.08
73.86.563-36 SPLINE (110) x
.563-36 SPLINE (110)

UA110110..... 90.00

.750-20 SPLINE (201) x
.563-36 SPLINE (110)

Adapts Woodward shaft to Titan, Jack Knight and Miller open-wheel formula-car racks.

UA201110..... 90.00

Steering Universal Joints

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.625-23/36 SPLINE (111) x
3/4 WELD-ON (100)

Fits TRW power rack and pinion used in Australia and other right hand drive markets.
Uses 23 spaces out of 36; not indexable on the rack.

UA111100 ..... 87.08

.750-20 SPLINE (201) x
.625-23/36 SPLINE (111)

Adapts Woodward shaft to Australian TRW power rack. *Uses 23 spaces out of 36; not indexable on the rack.*

UA201111 ..... 90.00

.590-29 SPLINE (112) x
3/4 WELD-ON (100)

Fits Honda and aftermarket racks using Honda spline.

UA112100.....87.08

.750-20 SPLINE (201) x
.585-29 SPLINE (112)

Adapts Woodward shaft to Honda and aftermarket racks using Honda spline.

UA201112.....90.00

.570-28 SPLINE (113) x
3/4 WELD-ON (100)

Fits Datsun 240/260/280Z
UA113100..... 87.08
.
570-28 SPLINE x
14 mm (OEM shaft) WELD-ON
UA113100Z 87.08

.750-20 SPLINE (202) x
.570-28 SPLINE (113)

Adapts Woodward shaft to Datsun 240/260/280Z

UA201113..... 90.00

17 mm-36 SPLINE (114) x
3/4 WELD-ON (100)

Mitsubishi Starion and Chrysler Conquest steering rack, and EPAS electric steering column.

UA114100.....87.08

.750-20 SPLINE (202) x
17 mm-36 SPLINE (114)

Adapts Woodward shaft to Mitsubishi Starion, Chrysler Conquest steering rack, and EPAS electric steering column.

UA201114..... 90.00

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17,5 mm-54 SPLINE (115) x
3/4 WELD-ON (100)

ZF rack spline used on BMW
UA115100.....87.08

17,5 mm-54 SPLINE (115) x
3/4 DD shaft (109)
UA115109.....90.00

.750-20 SPLINE (201) x
17,5 mm-54 SPLINE (115)

Adapts Woodward shaft to ZF rack spline used on BMW, Mercedes, Ferrari, Maserati and other European cars

UA201115.....90.00

14 mm-34 SPLINE (116) x
3/4 WELD-ON (100)

Fits Toyota MR2 and Corolla, and Quaife quicker-ratio gearsets.

UA116100..... 87.08
14 mm-34 SPLINE (116) x
14 mm-34 SPLINE (116)
UA116116..... 90.00

.750-20 SPLINE (201) x
14 mm-34 SPLINE (116)

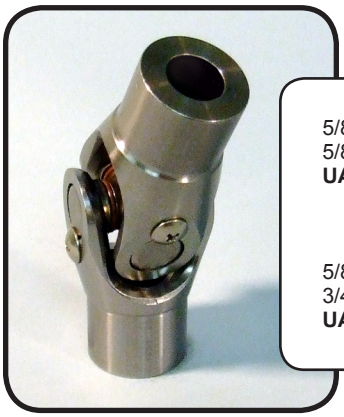
Adapts Woodward shaft to Toyota MR2, Corolla, and Quaife quicker-ratio gearsets.

UA201116..... 90.00

3/4 WELD-ON (100) x
3/4 WELD-ON (100)

Plain weld-on style steering joint; the actual bore diameter is .755/.753 so as to admit 3/4" OD tubing, which is typically oversize.

UA100100 .....83.97



5/8 WELD-ON (150) x
5/8 WELD-ON (150)
UA150150 ..... 83.97

5/8 WELD-ON (150) x
3/4 WELD-ON (100)
UA150100 ..... 83.97

Timing the Steering Wheel Position to the Rack Travel

When a universal joint operates at a zero angle, it rotates at a constant velocity like a solid shaft. As it is called upon to transmit rotation "around a corner," that is, through an operating angle, its velocity accelerates during a given quarter-turn and then decelerates during the subsequent quarter-turn. The greater the operating angle, the more this action speeds and slows the car's steering. This can be tested by measuring the travel of the rack at 45-degree intervals. For example, turn the steering wheel through some arbitrary angle (like 20 degrees; it doesn't matter how far, provided you turn it the same each time) and measure the rack travel. Reposition the wheel at 45 degrees, turn it 20 degrees and again measure the rack travel. Checking every 45 degrees will reveal a pattern. Note that a rack which travels 2.09 inches in 360 degrees should theoretically travel .116 inch in 20 degrees. If your u-joints operate through considerable angular misalignment you may discover your rack travels .180 inch when turned from the initial or twelve o'clock steering wheel position, but slows down to .050 inch from the nine o'clock position and speeds up again to .180 inch from the six o'clock position. This sort of thing can make high-speed cornering highly unpredictable. The classic example is a sudden spinout resulting from a small steering wheel input. The output at the rack at that point may be disproportionately large. Of course this is frustrating to the driver but virtually impossible to pin down without doing the above test. It's easier to blame the tires.

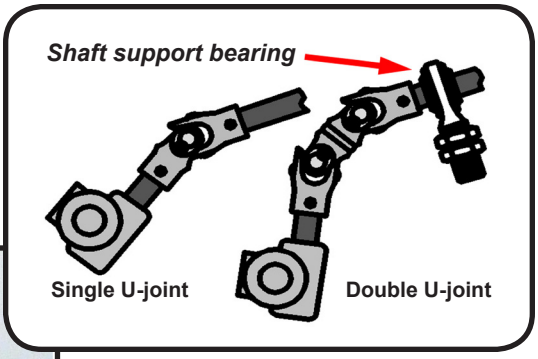
There are two ways to address the problem. As a quick partial fix, disconnect the steering shaft from the pinion and reconnect it so the speedup and slowdown is timed to occur symmetrically about center—or, on an oval track car, symmetrically about the most-used position of the steering wheel. Second, replace the most severely-angled U-joint (usually the one at the firewall) with a DOUBLE U-JOINT. The double joint will smooth out the rotation to practically constant velocity. Of course the best solution is to lay out the steering shaft so as to reduce all U-joint angles to the practical

minimum, and position other elements of the car so they won't interfere. This is an important enough in automotive engineering that OEMs frequently angle the steering wheel or offset the engine to avoid excessive U-joint angles, notable examples being the Lincoln Town Car and the big-block Corvette. However, real-world conditions don't often allow a wholesale redesign, especially if you're working on an existing race car that has nonconstant velocity in the steering.

Double Universal Joints

Double U-joints neatly solve problems that cannot be dealt with any other way. However, unlike a single U-joint, a double joint does not make a stable connection between two shafts because it essentially *adds* a shaft. Therefore the two shafts to be joined by a double U-joint must both be supported individually or the connection will wobble. A direct connection to a fixed component (such as a steering rack or gearbox) will support that end, while the other end will require a rod end or other bearing as shown at right.

The 20-tooth spline in the Woodward 201 U-joint is timed with respect to the bearing axis, so any two joints assembled back-to-back on a 20-spline shaft will have parallel axes and will be in phase for maximum efficiency. In certain cases where both angular and parallel misalignment are present it may be necessary to index one of the joints by one spline tooth (or more) relative to the other in order to improve the rotational smoothness. Although the maximum operating angle of a double U-joint is theoretically twice that of a single joint, it is always best to keep misalignment of the steering shaft to a minimum. Even where they are not absolutely necessary, double U-joints provide smoother rotation than a single joint used at the same operating angle.



SPLINED SHAFTS with one end machined with a locking groove for the set screws and the other end left blank for cutting to length and machining by user. *Last digit of part number is overall length in inches.*

UADS-X-6	**18.51**
UADS-X-8	**22.12**
UADS-X-10	**29.42**
UADS-X-12	**36.69**
UADS-X-14	**43.97**
UADS-X-16	**51.25**

DOUBLE UNIVERSAL JOINTS

UAD1 (2.18 inches bearing center-to-center)

.750-20 x .750-20 **UAD1-201201**	**167.51**
.750-20 x .750-48 **UAD1-201101**	**167.51**
.750-20 x .735-36 **UAD1-201102**	**167.51**
.750-20 x .720-30 **UAD1-201103**	**167.51**
.750-20 x 3/4-DD **UAD1-201109**	**167.51**
3/4 DD x 3/4-DD **UAD1-109109**	**167.51**

These part numbers are popular examples; ANY spline combination is available at no additional cost.

UAD3 (3.62 inches bearing center-to-center)

.750-20 x .750-20 **UAD3-201201**	**167.51**
.750-20 x .750-48 **UAD3-201101**	**167.51**
.750-20 x .735-36 **UAD3-201102**	**167.51**
.750-20 x .720-30 **UAD3-201103**	**167.51**
.750-20 x 3/4-DD **UAD3-201109**	**167.51**
3/4 DD x 3/4-DD **UAD3-109109**	**167.51**

UAD4 (4.62 inches bearing center-to-center)

.750-20 x .750-20 **UAD4-201201**	**170.80**
.750-20 x .750-48 **UAD4-201101**	**170.80**
.750-20 x .735-36 **UAD4-201102**	**170.80**
.750-20 x .720-30 **UAD4-201103**	**170.80**
.750-20 x 3/4-DD **UAD4-201109**	**170.80**
3/4 DD x 3/4-DD **UAD3-109109**	**170.80**

UAD5 (5.62 inches bearing center-to-center)

.750-20 x .750-20 **UAD5-201201**	**174.10**
.750-20 x .750-48 **UAD5-201101**	**174.10**
.750-20 x .735-36 **UAD5-201102**	**174.10**
.750-20 x .720-30 **UAD5-201103**	**174.10**
.750-20 x 3/4-DD **UAD5-201109**	**174.10**
3/4 DD x 3/4-DD **UAD3-109109**	**174.10**

Note that UAD3, -4 and -5 are assembled onto splined shafts and are removable. Longer assemblies (such as the connection between a Woodward safety steering column and the steering rack in a BMW) can be made using the UADS-X splined shafts at left.

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Weld-on splined couplers

Highly convenient for welding onto the steering shaft, these can replace universal joints in cases where a floating connection is not required. Unless otherwise specified, the coupler is counterbored 1 inch deep to accept 3/4 OD tubing. Couplers identified with a B in the part number are counterbored for 5/8 tubing. Please note that we cannot provide a counterbore smaller than the spline.

Couplers are useful for splicing a servo rigidly into a steering shaft, and also for connecting to a rack mounted in pillow blocks close to the driver (such as the Type MR or MC) provided it is possible to accurately align the steering shaft with the pinion spline. However, a coupler should never be used to connect to a rack where there is any likelihood of misalignment resulting from chassis flex. In such cases (which is to say most race cars larger than formula cars) the rack should always be connected with a universal joint.

.750-20

Fits all Woodward components (Pinion, servo input and output, safety steering columns, shaft kits, etc.)

C201 .....34.07

.750-48

Fine-pitch serration fits Sweet manual rack and inline servo output shaft, several British racks such as MG and Jaguar, as well as the steering shaft on Austin-Healey. Also used on Woodward racks built before 1992.

C101 .....34.07

.735-36

Fits Mustang power rack and most steering quickeners.

C102 ..... 34.07

.720-30

Fits current GM power steering boxes and the input shaft on servos using current GM parts such as Appleton and small style Sweet.

C103.....34.07

.820-36

Fits 4-bolt early GM power steering box and the input shaft on servos using early Saginaw valve parts such as large style Sweet. *Note: the spline ID is larger than 3/4 OD tubing; the coupler has extra set screws to align for welding.*

C104 ..... 34.07

.563-26

Fits Pinto racks and aftermarket copies.

C106 ..... 34.07

.625-36

Fits Stilletto (Chasis Shop) rack and pinion.

C107 ..... 34.07

.688-34/36

Has one spline tooth removed to fit Delphi-manufactured Toyota truck box. Not indexable on the steering box but works on other 17.5 mm shafts with base 36 spline.

C108 ..... 34.07

3/4 DD

Fits aftermarket DD shafting based on Ford dimensions of .75 diameter x .550 across the flats.
NOT for 17mm GM DD shafts.

C109 ..... 34.07

.563-36

Fits Jack Knight and Titan racks.

For welding to 3/4 tube:
C110A..... 34.07

For welding to 5/8 tube:
C110B..... 34.07

.625 (16 mm)-23/36

Fits Australian TRW power rack. Uses 23 spaces out of 36. Not indexable on the rack but works on other 16 mm shafts with base 36 spline.

C111 ..... 34.07

.585 (15 mm)-29

Fits Honda and aftermarket racks using Honda spline.

C112 ..... 34.07

.570 (14,5 mm)-28
Fits Datsun 240/260/280Z.

C113 ..... 34.07

.669 (17 mm)-36

Fits Mitsubishi Starion and Chrysler Conquest rack, and EPAS electric steering column.

C114 ..... 34.07

.688 (17,5 mm)-54

ZF 60 degree profile used on many European makes such as BMW, Mercedes, Ferrari, Maserati

C115 ..... 34.07

.550 (14mm)-34

Fits Toyota MR2 and Corolla manual rack and Quaife quicker-ratio Toyota gearsets.

For welding to 3/4 tube:
C116A..... 34.07
For welding to 5/8 tube:
C116B..... 34.07

.625 (16 mm)-23/36

Fits Australian TRW power rack. Uses 23 spaces out of 36. Not indexable on the rack but works on other 16 mm shafts with base 36 spline.

C111 ..... 34.07

.750-20 SPLINED THROUGH

Will couple any Woodward part to any other Woodward part without welding. Also useful in industrial applications. *NOTE: for HE racks, use part number VH201 at right.*

CD201 ..... 41.26

INTERNAL COUPLER for HE racks

Installs on the servo output spline and "plugs" the servo into the pinion. This coupler is smaller diameter to fit inside the servo adapter. *NOTE: the set screw spacing is special and will ONLY join the servo and pinion in a type HE rack.*
VHE201 ..... 45.60