How to Add Gas Spring Lift Assistance

(to the roof panels of an A-frame trailer)

Section I: Introduction

This article provides very detailed instructions for adding gas spring roof panel lift assistance to A-frame trailers. It presumes that the installer is skillful with tools *(or has the necessary help available)* and has personally decided to use this highly-effective *(inward-slanted)* installation method. Please note that an easy-to-follow *(abbreviated/three-page/non-technical)* summary article can be found at Attachment 2 when the reader is ready to install his/her new gas springs.

Gas spring lift assistance supplements the uplift force provided by the internal torsion springs or bars *(note that Forest River products use torsion bars)*. The structural areas for attaching the gas springs are presumed to be in good condition and undamaged. This article further presumes that the he/she *(hereinafter referred to as 'he')* has previously read my original article that evaluated several of the various methods commonly used for obtaining gas spring lift assistance *(see Attachment 3)* and two other installation articles *(at Attachments 4 and 5)*.

The photo to the right shows how low-pressure 26" long stainless-steel gas springs have been attached to my trailer. My installation method closely follows the procedures used by two other engineers who desired roof panel lifting assistance and therefore pioneered this innovative new installation method.

2005 Aliner Expedition Retrofitted with Gas Springs

This article is not intended to provide exact/precise installation details for every A-frame trailer. The installer will need to select the correct force springs and precise pivot placement locations because the requirements of each trailer are unique.

In 2019 Columbia Northwest *(i.e., the manufacturer of Aliner trailers)* began installing gas springs on some of their newer models using the method addressed within this article. To the right is an example photo acquired from their product website *(ref: https://aliner.com/)*.

Section II: Tools Associated with Installing Gas Springs

Mandatory Tools:	Highly Desirable Tools:
Drill and drill bits	Hand-held grinder
Center punch	Bench grinder
Measuring tape & ruler	Bench vice
Open-end wrenches	Tap and die set *(metric and/or SAE)*
Allen wrench*(es)*	Small wire brush
Metal file	Aluminum cutting device

A hand held grinder *(about $15 at: https://www.harborfreight.com/corded-4-12-in-43-amp-angle-grinder-69645.html)* will likely be needed if a Nylock nut *(a.k.a. nylon-insert locknut)* freezes/locks up and cannot be fully installed or removed. The head of the bolt will then need to be carefully ground off to remove it.


Nylock Nut

The installer is encouraged to: *1) pre-clean the bolt threads (see below photo) with an appropriately-sized die (about $17 at: https://www.harborfreight.com/carbon-steel-metric-tap-and-die-set-40-pc-62832.html) and 2) wire brush the threads after the bolts are pushed through the aluminum wall (to remove small acquired aluminum particles).* The likelihood of a nut freezing during installation will then be greatly reduced. It has happened to me a few times while attaching Nylock nuts associated with wind kits and gas spring brackets. It delays the installation process *(but only about 10 minutes)* if a hand-held grinder is available.
Without a grinder available a frozen Nylock nut is a disaster!

To easily accomplish the abovementioned deburring task related to the threads, I have supported the necessary die in a bench vice. I then used a cordless drill with a hex head drill bit to spin the end of the bolt in and out *(see photo to the right)*. Usually a very thin metal shaving will be trimmed off of each bolt which helps to ensure that a Nylock nut won't freeze when it is being installed.


Hex Head Drill Bits


Die & Hex Head Drill Bit Options

The abovementioned hand-held grinder also accommodates very thin blades for the next action. A thin-bladed grinder can be used to cut off any undesirable excess bolt length protruding into the trailer. The bench grinder can then be used to smooth the ends of the bolts.

The bench vice is also needed to help fashion/file any required spacers under the lower offset brackets *(as addressed later in Section V of this article)*. Offset brackets provide an additional rise of ¼".

The holes associated with offset brackets are 4.94 mm in diameter and accommodate U.S. No. 10 or metric 5 mm *(i.e., M5)* bolts. I would not recommend that installers attempt to enlarge the bracket holes to accommodate larger bolt sizes. The metal is very strong and enlarging


Stainless Steel Offset Bracket

the 4.96 mm diameter holes is a difficult task. Any drill bits used will likely be dulled very fast or just not be able to accomplish this task. If no shims are needed, then 1-3/4" or 40mm long bolts should be ideal for most trailer walls. I would recommend that an adequate supply of 2" or 45 mm and 50 mm long bolts be on hand to accommodate thicker walls and/or any needed spacers/shims *(see Table 1 in Attachment 2).*


5M Stainless-Steel Bolt Assortment

If metric bolts are preferred, a photo to the right *(linked below)* depicts a possible assortment of Stainless-Steel M5 bolts that would be ideal for attaching the lower offset brackets:

https://www.amazon.com/iExcell-Stainless-Internal-Drives-Threaded/dp/B07J2LRX16/ref=sr_1_11?keywords=M5+Stainless+Steel+Button+Head+Hex+Socket+Head&qid=1578098120&s=hi&sr=1-11

Regular nuts *(easier to install and remove)* are initially recommended *(temporarily)* until *(potential)* clearance issues have been resolved with any needed spacers/shims. The regular and Nylock nuts *(shown below)* will need also need to be ordered. Individual sizes of stainless-steel bolts can alternatively be obtained from this source in either U.S. or metric sizes:

https://www.boltdepot.com/

The method for cutting and fabricating any spacers potentially needed beneath the lower offset-brackets is optional. A band saw, reciprocating saw, saber saw, hack saw, blade runner, table saw, etc. are some of the possible tools to cut the desired spacers out of aluminum stock.

This installation method uses 10-mm ball studs *(see photos in Section III & V)* on the upper panels. Stainless steel washers *(to accommodate their 5/16" diameter base)* can be used to achieve any needed clearance. Ball studs are also available with a longer threaded base.


Gas Spring Hardware Kit

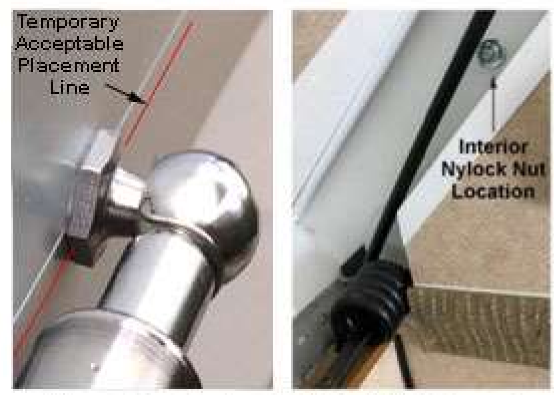
Section III: Determining the Required Gas Spring Sizes

Determining the required gas spring force rating is the most forgiving part of the entire process. If the wrong force gas springs are initially purchased, they can usually be exchanged for springs with larger or smaller force ratings.

David Hall *(the Australian Mechanical Engineer who developed this innovative method—see his article at Attachment 4)* used 26" long gas springs. His selected springs were 22 pounds for the rear and 33 pounds for the front panel. I also used 26" long gas springs. My springs were rated at 30 pounds on the rear and 40 pounds on the front. They were the maximum allowable for my requirement. My roof panels would separate when they are fully raised with higher force gas springs. My low-force gas springs are amazingly effective in assisting with fully raising the roof panels with very little added effort required. Using David's exact spring sizes would have been the minimum acceptable/desirable for my needed uplift assistance.

In my original article/review *(see Attachment 3)* I indicated that approximately 45 pounds of applied lifting force *(using a suspended pulley system and actual/precise iron barbell-type weight lifters' plates)* was needed to fully raise my roof panels to their peak position. That lifting force had to overcome: *1) the net weight of the roof panels, 2) the forces of the bungee cords, and 3) rubbing/friction in the hinges and torsion springs.* My selected combination of gas springs has made it very easy to overcome those obstacles that impede the raising of the roof panels.

I would strongly recommend that *(for uniformity)* all A-frame owners use the 10-mm ball size for gas spring pivot ball connections. There is no technical reason to use the next size up *(i.e., 13 mm).* I would also recommend that for uniformity a gas spring length of approximately 26" be used. If these sizes are used then owners can swap them in the future. An owner using 40-pound springs for several years might find that they have dropped to a 30-pound equivalent spring *(as the nitrogen gas leaks out over the years).* He could perhaps then sell or give the used springs to someone needing 30-pound springs and then buy new 40-pound springs.



Upper Gas Spring Ball Stud Attachment

Since most owners will likely need spring forces in the range of 30 to 40 pounds, my suggestion is for owners to purchase the eight needed mounting ball devices but only buy two gas springs with say a 30-pound rating. If both panels are exceedingly difficult to raise *(with two reasonably able persons),* then the owner might instead initially purchase two 40-pound springs.

After installing the eight pivot balls, the installer can then raise the roof panels *(with any needed help),* and sequentially install the initial pair of gas springs on the front panel and later on the rear panel to observe their effect. This allows the installer to determine if this initial test set is perfect for either or possibly both panels. The next two springs can then be ordered based on the initial test results. This two-step purchasing method minimizes/eliminates shipping charges. Shipping is free on orders of $75 or more from the supplier that I used *(indicated in Section IV).*

Section IV: Sources for Gas Springs and Related Hardware

Gas springs are available in a variety of lengths and forces. Dave Michaels used an excellent *(but rather expensive)* source for his shorter 24" long stainless-steel gas springs *(e.g., their length with add-on ends)*. His source *(McMaster-Carr)* sells springs of that length in a wide variety of rated forces *(at 15 pounds and then at 20 to 130 pounds in 10-pound increments).* My economical source for 26" stainless steel gas springs is only feasible if the owner desires them with a force rating of 30, 40 and/or 50 pounds *(when fully extended).*

The total cost for my four stainless-steel gas springs and all necessary hardware *(except bolts, washers, spacers & nuts)* was less than $200.00. My source is the world's largest gas spring supplier and at this link:

https://www.liftsupportsdepot.com/

David Hall used *(non-stainless-steel)* offset brackets for his lower pivot balls. I also used offset brackets to similarly reduce/eliminate the need for shims/spacers by ¼". The link for these highly beneficial *(and strongly recommended)* stainless-steel lower offset brackets is:

https://www.liftsupportsdepot.com/fp-ball-stud-joint-10mm-3-8-2-hole-offset-bracket-s316-stainless/

Most people should be able to easily attach or remove low-force gas springs. No spring compression is required to connect/attach gas springs when they are fully extended. Attaching and removing gas springs is fast and easy with the roof panels fully raised *(it takes but seconds when the safety clips are temporarily removed from the ball sockets)*.

The below chart includes the SKUs for the *(30 and 40-pound)* stainless-steel gas springs I purchased for my retrofit installation. Please verify/confirm the current accuracy/validity of all information in the below chart that lists the three sizes of stainless-steel gas springs available from this very economical source *(listed above)* that offers a limited lifetime warranty on many of their products. Note that their lengths are not identical, but they are very close. The stroke is the same for all of them. This slight variation is accommodated by using an extended and compressed length that accommodates all three sizes.

Table 1 - Stainless Steel Gas Spring Options

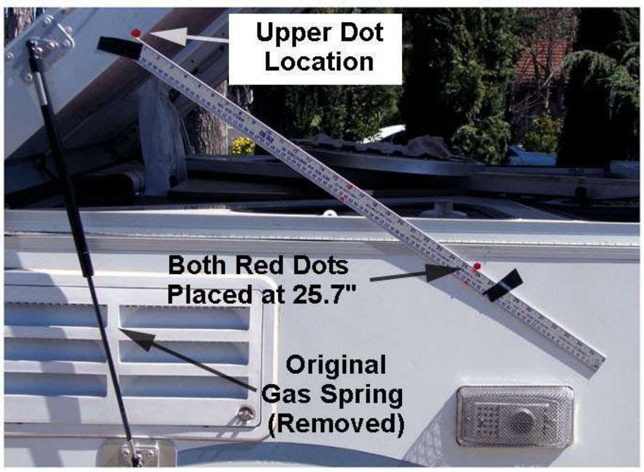
Dealer SKU	**Ext. Length *(in.)***	**Compr. Length *(in.)***	**Stroke *(in.)***	**Spring Force *(lbs.)***	**Price**
SE260PSS30M10	26.25	14.75	11.5	30	$37.95
SE263PSS40M10	26.65	15.15	11.5	40	$37.95
SE263PSS50M10	26.55	15.05	11.5	50	$37.95

Section V: Selecting the Required Hardware and Spacers

At the ideal placement location, the majority of the energy/travel of the gas springs can be captured. Also, maximum torque can be obtained with the lowest possible force gas springs. I designed around extending my springs to slightly less than their fully-extended lengths. This provided extra play at the end of the roof panel travel for raising the panels until they are latched in their fully-open position. Without extra play I wouldn't be able to raise my roof panels.

Note that the ruler/template shown in the below photo *(to aid in confirming correct placement of the red pivot ball dots)* is also shown in a larger scale in Section VIII.

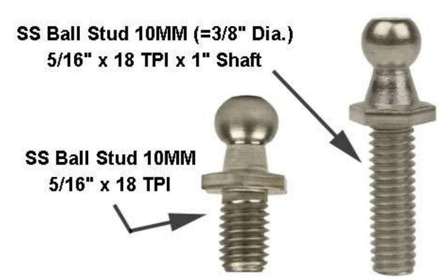
I used stainless-steel ball stud mounting brackets and attached them with stainless-steel bolts and Nylock nuts. If the owner lives in and/or envisions frequently camping in coastal locations, he might want to consider the effect of salty air. A salty air environment may accelerate galvanic corrosion issues between stainless-steel and aluminum *(especially aluminum rivets attached to stainless steel).* I live in a dry climate area where this is of negligible concern.



Ruler for Pivot Ball Placement Dots

New Gas Spring Installed!

This article recommends using four ball studs *($13.00/four-pack)* at the upper pivot locations since they only require the drilling of a single 5/16" diameter hole for each of them. These studs accommodate a box or open-end wrench for easily attaching and removing them. Here is the link:



https://www.liftsupportsdepot.com/ab-ball-stud-10mm-3-8-5-16-x-18-s316-stainless-4-pack/

I am switching to another (UV-resistant) sealant in the future. Formerly I used a white 3M 5200 fast cure adhesive sealant *(available at Lowe's hardware stores for about $26.00)* behind the lower offset brackets *(and spacers where necessary)* for leak *(and galvanic corrosion)* prevention through their eight drilled holes—something to not overlook in the installation. If this sealant is stored/protected in a frozen status between uses, it may last for many years. Here is the link:

https://www.lowes.com/pd/3M-Marine-Adhesive-Sealant-Pack-10-oz-White-Sanded-Caulk/3020020

Clearance problems will dictate any need for spacers under the ball studs and/or offset brackets. It may be necessary to fabricate one or more aluminum spacers for use under the *(lower)* offset brackets to increase the ¼" offset they provide. It will be up to the installer to determine the most feasible method of cutting the aluminum stock to size. Aluminum particles may quickly plug up the file being used *(to smooth the rough-cut surfaces)* and require periodic removal with a wire brush or possibly using a cordless drill with a rotary wire brush attached.

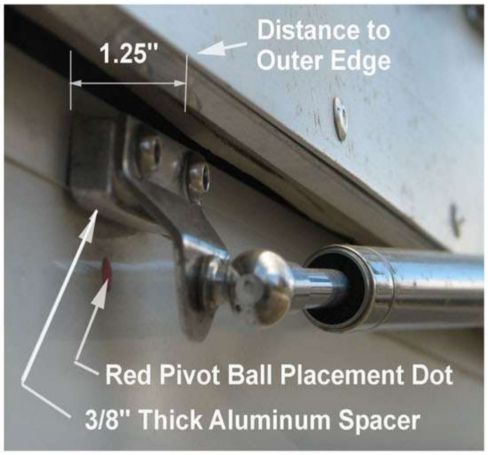
Purchasing flat bar aluminum stock that is ½" wide and of the required thickness will reduce the difficulty of fabricating any needed spacers *(for under the offset brackets)*. Home Depot stores stock an aluminum flat bar that is 1/8" thick by ½' wide by 4' long. The item sales receipt number is 887480002072, Internet #204604761, Model # 800207 and/or Store SKU #235295. The current price is $3.98. This bar could be used in the several layers to accommodate spacer thicknesses that exceed 1/8". Dave Michaels' retrofit used three 1/8" layers under his lower brackets since he did not use offset brackets. Should he have used the ¼" offset bracket recommended in this later article, he would have only needed one layer of this 1/8" thick flat bar aluminum *(cut to 2.25" in length)*.

Amazon.com sell bars of aluminum that are manufactured in the needed ½" width and in a variety of thicknesses. Perhaps you can find other sources for the spacers. For my needed spacer I could have: *1) purchased a foot-long bar that was ½" wide by the required ⅜" thickness, 2) cut off a piece that was just over 2-¼" long, 3) filed the rough-cut end to make it smooth, and then 4) drilled the two needed holes.* Many options are therefore available for consideration.

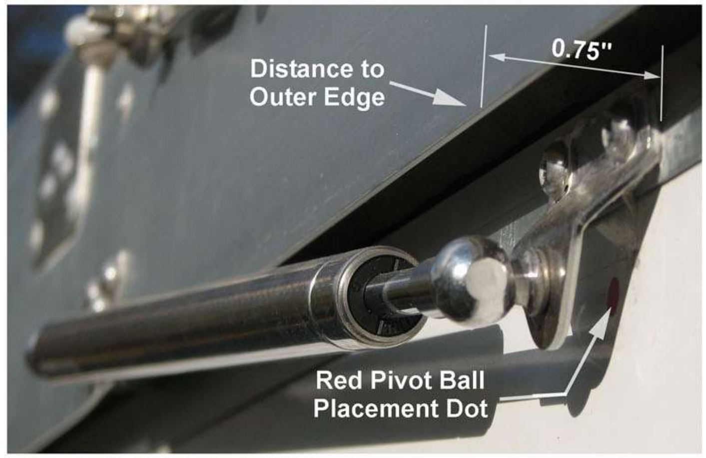
Here is a typical link to a bar that could have accommodated an easier spacer fabrication:

https://www.amazon.com/gp/product/B01M01DT6X/ref=ox_sc_saved_title_1?smid=ATVPDKIKX0DER&psc=1

When the roof panels are lowered/closed, installers can measure the distance between their "outer" edges and the offset bracket mounting surfaces *(see the below photos)*. If the distance exceeds 9/16", a spacer will most likely be required under one *(or potentially both)* of the ball units supporting the affected gas spring(s). The spacer*(s)* will be needed to prevent the body of the gas spring from contacting the lower edge of a roof panel when it is in the closed/lowered position. Note that the below photo was for a superseded method that used an upper mounting plate *(attached in a slightly lower position)*. The recommended newer method *(see Attachment 1)* places a ball stud at a higher location which slightly reduces the allowable clearance differential.



Spacer Due to Excessive Offset



No Required Spacer with Offset Less Than 0.75"

My use of offset brackets for the lower ball stud locations eliminated the need for spacers under either end of three of my four gas springs. The original manufacturing placement of my front panel resulted in an excessive separation distance of 1-¼" at the front right corner *(see above photo)*. I used a $^{3}/_{32}$" thick spacer under the top bracket and a ⅜" thick spacer under the lower offset bracket to obtain needed clearance for the right front corner gas spring. My spacers were hand made using tools mentioned in Section II above. For those opting to use a ball stud for the upper pivot, a stainless-steel washer is a better option because no fabrication is required! Ball studs with a longer base are also available *(as needed)* from the recommended supplier.

David Hall alternatively used taller ball studs that provided a very large extended distance from the edge of the trailer as shown at this link:

https://www.liftsupportsdepot.com/bc-ball-stud-10mm-3-8-hi-rise-m6-x-1-00-thread/

Upper pivot ball studs with longer 1" shafts are at this link:

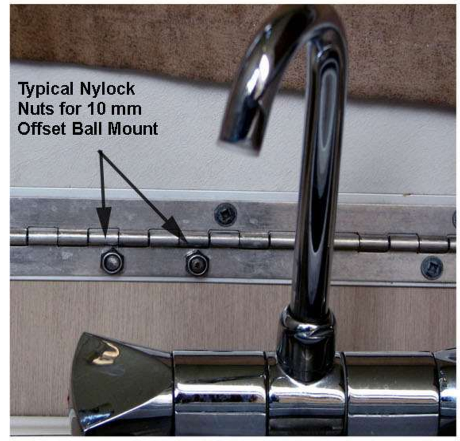
https://www.liftsupportsdepot.com/am-ball-stud-10mm-3-8-5-16-x-18-s316-stainless-1-shaft/

VERY IMPORTANT: I would strongly encourage the installer to use a small wire brush to clean the threads of the bolts after they are inserted through the wall. This is because they can easily acquire bits of aluminum that will interfere with the installation and/or removal of the interior Nylock nuts. Failure to remove the acquired aluminum could cause a need to grind the head off of a button-headed stainless-steel bolt to be able to remove it *(i.e., if it can't be fully tightened down)*. I would also recommend pre-cleaning **ALL** bolt threads with a die *(of a tap & die set)*. Some of them may not have completely clean threads which may occasionally causes problems when connecting them to a Nylock nut.

Rear Right Spring

Rear Right Spring

Rear Left Spring



Inside Mount Backing for Nuts

Section VI: Placement of the Pivot Balls

The lower pivot ball offset mounting brackets will be attached to the upper side wall aluminum extrusion. If the holes are carefully drilled then the Nylock nuts to be installed on the inside of the wall will align with the existing factory-installed screws on the wall hinge *(i.e., the hinge that supports the wall rotation—see the above photo with the sink faucet).* Some drills have a built-in leveling bubble to help drill a level hole through the wall. An economical drill with a built-in leveling bubble is at this link:

https://www.harborfreight.com/38-in-variable-speed-reversible-drill-60614.html

The initial upward angle of the gas springs can potentially be increased to provide some initial uplift force when the panels are lowered. However, clearance issues can be a limiting factor. Obstacles such as the storage location of the Aliner factory wind poles will limit the placement of the upper ball studs to a lower position *(i.e., below the interior torsion spring end enclosure).*

Each of the upper pivot ball mounting brackets I used required three holes. I would today recommend that installers alternatively use ball studs *(see photos in Attachment 1)* to reduce the number of necessary holes, hardware, cost and work. If I would have installed upper ball studs, **I could have reduced** the total number of required holes from 20 **to only 12**.

Placing the ball studs as high as feasible *(avoiding clearance issues such as any factory-installed Aliner wind poles)* is the recommended option for most trailers. It compares to the installation method used by the concept founder. The installer should draw a line *(avoiding clearance issues)* parallel to the roof panel edges in the vicinity where that ball stud is estimated to be mounted *(approximately 19" from the panel's hinge for 26" gas springs).* Then successive red sticky dots can be placed along this line until the ideal placement is determined *(as discussed later in Section VIII of this article)*. If there are no upper

Rivnut

obstructions the installer may desire to place the ball stud closer to the top of the panel sidewall *(to obtain greater initial uplift assistance).* A $^{5}/_{16}$" x 18 TPI Rivnut *(see photo above)* could be used instead of a Nylock nut if a higher connection point is desired and available. Sealant *(as previously addressed in Section V)* would need to be added between the Rivnut and the hole, etc. The Rivnuts would then be anchored into the holes needed to mount them. A variety of applicable rivet nut installing tools can be obtained on Amazon for approximately $40 to $50. These tools are also invaluable for many other A-frame requirements.

Special Note: If stainless-steel hardware is used, aluminum rivets are not recommended as a substitute for the bolts necessary to attach the lower offset brackets. Galvanic corrosion issues between the two metals could degrade the rivets the same as occurs to the sacrificial anode that is used inside A-frame trailer water heaters to extend their lives. Salty coastal air environments may also accelerate the aluminum rivet degradation process.

Section VII: Selecting the Compressed and Extended Lengths

The installer will need to select the appropriate compressed and extended lengths to be used as addressed in Attachment 2 *(a three-page simplified summary version).* This is a task that he alone must accomplish. This will affect the stroke that can be achieved as well as the energy storage capacity of the gas springs. I would recommend leaving at least ½" unused gas spring travel when compressed *(per the manufacturer's recommendations).* For the extended position, I would recommend not using the fully-extended *(potential)* distance because the roof panels normally need to open a few inches more than their raised position prior to retracting into their upper supporting slot. For an 8' roof panel like mine, a 2" extra potential rise of the roof panel equates to about 0.4" of gas spring travel.

By choosing to not compress my springs fully, I sacrificed a small amount of potential energy storage in order to have future flexibility that could *(potentially)* accommodate gas springs ranging from *(roughly)* 24" to 26" in overall length. Because 24" gas springs have a shorter stroke than my 26" gas springs, this reduced my allowable stroke. A 1.68" extension to the McMaster-Carr gas springs retrofit could be used *(i.e., using longer ball socket ends or 25M x 6M cylindrical nuts with 6M bolts)* should I need to switch to his source in the future.

One item to perhaps mention here is that with 26" gas springs the upper pivot ball connection point at the rear of the trailer will likely be around 19.0" from the hinge. Dave Michaels' retrofit A-frame trailer used shorter 24" long *(McMaster-Carr)* gas springs and had connection points at 16" from the trailer's rear hinge because shorter springs were used and as well as a higher upper pivot ball placement location. Note that the distance to a front upper ball stud connection to the hinge will likely be approximately 2" less than that of a rear ball stud connection due to the higher wall placement location. The resultant shorter lever arms will then affect the resultant torque.

Table 2 – Determining the Desired Range for Gas Spring Travel[1]

Spring Type	Stroke *(in.)*	Compressed Length *(in.)*	Extended Length *(in.)*
David Hall *(concept founder)*	295mm/11.4"	375mm/14.8"	670 mm/26.4"
McMaster-Carr Springs *(4175T150)*	9.84[2]	14.52	24.36
Above with 1.68" extension	*same*	*16.2*	*26.04*
Taylor Made 1870-30	10.2	16.1[2]	26.3
My 26" x 30 pound	11.5	14.75	26.25
My 26" x 40 pound	11.5	15	26.5
My Selected Range	9.5	**16.2**	**25.7**

Note 1 - This is intended to insure future compatibility with other gas spring sources
Note 2 - This measurement is a limiting factor for my installation parameters.

Section VIII: Determining the Pivot Ball Locations

Determining the pivot ball location is a key component of the entire task. Once this is accomplished for one gas spring location, the placement measurements can be transposed to the other three locations. For most installers, a trial and error installation method should provide a fast, easy and very satisfactory solution for pivot ball placement. For those who would like to utilize trigonometry, the following formula can be used for determining the upper pivot ball placement distance '**c**' *(i.e., to find point '**B**')*. Note that a sine value table is included within this article at the end of Attachment 3.

c = **a** x (sine **C** / sine **A**)	where **c**	=	distance between points '**A**' and '**B**'
	a	=	distance between points '**B**' and '**C**'
	A	=	roof panel angle at point '**A**'
	C	=	angle of the gas spring at point '**C**'

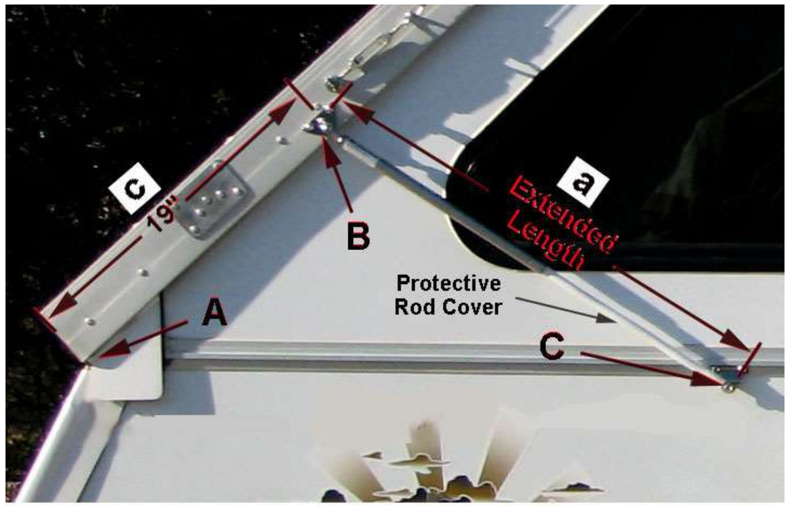
The owner doesn't need to use the above formula; however, he should realize that it does provide a valuable ratio between the distance '**c**' and '**a**' that is needed in the below example *(see "**Problem**" below on the next page)*.

On my trailer the estimated angle '**A**' *(43°)* has a sine value of 0.682 and the estimated angle '**C**' *(33.5°)* has a sine value of 0.508. Thus, for my trailer the ratio between distance '**c**' and distance '**a**' *(i.e., sine **C** / sine A)* is 0.745.

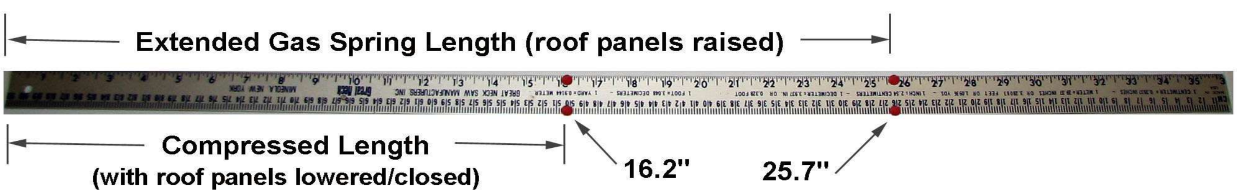
My desired extended gas spring length '**a**' is 25.7". Therefore, multiplying that distance by 0.745 *(i.e., the ratio between '**c**' and '**a**' for my trailer)* provides a theoretical length '**c**' of 19.1". Actual trial and error arrived at roughly 19" for this distance out from the hinge *(for my 26" gas springs)*.

A trial and error method *(as delineated below)* is much easier and doesn't require precisely measuring the applicable angles. The installer should not need to repeatedly raise and lower the roof panels to accomplish this task if the below procedure is followed.

In the next step the roof panels **must be initially down/closed** to make this task as easy and fast as possible *(i.e., two to five minutes)*. When using 26” long gas springs measure laterally 19” from the rear roof panel hinge *(i.e., point ‘A’ in the below photo)* and place a temporary sticky dot at point ‘**B**’ on the temporary line for this placement task *(see photo of this line in Section III)*. Now from the red dot at point ‘**B**’ measure the selected compressed length *(i.e. 16.2” in my scenario)* and place another red dot at point ‘**C**’.



Next raise the roof panels and measure the distance **‘a’** between the red dots at points ‘**B**’ and ‘**C**’. It needs to be 25.7” *(only for my desired extended length)*. If this is not the case, the below **example** template can be used to facilitate quickly finding the optimum placement of the two red sticky dots *(the future location of the pivot balls)*. With this template the installer can easily confirm the accuracy of the distance ‘**a**’ between points ‘**B**’ and ‘**C**’ when the roof panels are both raised and lowered.



Template Used For Gas Spring Pivot Ball Placement

Problem—The extended distance **‘a’** between the dots at points ‘**B**’ and ‘**C**’ *(with the roof panels in their raised position)* is *(say)* 1” short *(e.g., 24.7” for my scenario)*.

Solution—With the roof panels remaining in the raised position, the two red sticky dots must be moved **the <u>same</u> exact distance** to their right when increasing distance **‘a’**.

For simplification, we will use the ratio of ‘0.745’ between distances ‘**c**’ and ‘**a**’ from the trigonometric discussion above. So, if the owner needs to increase distance ‘**a**’ by one inch *(i.e., to achieve the desired extended length of the gas spring)* he merely moves both of the red sticky dots *(i.e., at points ‘B’ and ‘C’)* to their right approximately ¾ inch *(i.e., increasing distance ‘c’ by the 0.745 ratio found for my trailer angles)*.

The installer may still need to move the two dots a tiny bit left or right **the <u>same</u> exact distance** until the desired extended length *(i.e., 25.7" in this example)* is achieved. Then he needs to raise and lower the roof panels to confirm that the desired pivot ball mounting locations have been determined/located. The above template will aid in confirming that the extended and compressed *(gas spring)* distances between the two dots have been achieved.

Next these above pivot ball placement measurements can be transferred to the other rear corner. That placement can be confirmed *(using the above template/ruler)* with the roof panels in the raised and lowered positions. The front panel distances will be slightly different due to higher ball stud placement.

The next step is to drill the 12 needed holes! But wait, the carpenter's rule is to measure twice and cut once. Perhaps a friend can review and confirm all of the measurements. Maybe the installer should take a break and then remeasure everything later before drilling the holes.

To accurately drill the holes a center punch is recommended to make an indentation for a tiny pilot drill bit to follow *(see photo in Attachment 1)*. The tiny initial starter hole can then be followed by successively larger drill bits to create the 12 needed project holes *(at their desired locations)*.

Section IX: Gas Spring Maintenance

The stainless-steel rods of gas springs should never be lubricated *(as I understand it)*. I occasionally clean mine with 91% rubbing alcohol *(to remove any dust, pitch, grease, dirt, etc.)* and allow time for air drying prior to compressing them *(i.e., lowering the roof panels)*. I initially covered them *(whenever the roof panels are in their raised position)* with ⅜" white flex guard tubing *(as shown in the photo above in Section VIII)*. The tubing I used initially is found at:

https://www.frys.com/product/257177?site=sr:SEARCH:MAIN_RSLT_PG

I have more recently switched to an attractive chrome look with this protective tubing:

https://www.amazon.com/dp/B0006303BW/?coliid=I1J9ZY8E11MV3D&colid=3C8F1RMYWX5FA&psc=1&ref_=lv_ov_lig_dp_it

Section X: Summary and Conclusion

It is my sincere desire that other A-frame owners will also be able to easily, economically and satisfactorily retrofit their A-frame trailers with low-force gas springs. Perhaps they can find a skillful friend to help with this project, especially when attaching the lower offset pivot ball mounting brackets *(a two-person task)*.

It will be time consuming to install gas springs if this is the installer's first time. I would recommend that the installer not be in a hurry and perhaps split the work over two days. The total time estimated to make a first-time installation is estimated at around 4 to 6 labor hours. Note that it is critical that an installer have a second person to help *(temporarily)* attach the brackets for the initial clearance test as well as for the final attachment once clearance issues are accommodated with any needed spacers.

The time required to study this article *(and the attachments)* and order the required materials will hopefully be less than that required to install the gas springs.

For those persons discovering any new/innovative ideas for accomplishing this process, please share them with the rest of us. This is a continually-developing technical upgrade to our A-frame trailers. We are the pioneers in developing this very new retrofit process.

I have attached a series of photos immediately following this article *(see Attachment 1)* that depict the process of adding gas springs using the most recent method *(with upper ball studs).* Hopefully the pictures will help readers visually understand the process described in this article.

Attachments 4 and 5 provide gas spring installation articles that were written by the two engineers who preceded me in installing gas spring lift assistance using this very effective method. I carefully read and expanded upon/amplified their pioneering installation articles.

I wish to acknowledge the help and encouragement provided by Karen Greenwood. Her careful proofreading revealed areas where clarification was needed to make this retrofit process easier for others to comprehend and implement.

by Brian Hovander

4 Attachments:

1. Installation Photos for Double Dormer using Ball Studs *(next page)*
2. Simplified Version for Less-Technical Owners
3. Review of A-Frame Gas Spring Installation Methods
4. David Hall's *(Australian Concept Founder's)* Installation Procedure

The author is a licensed professional Civil Engineer in the State of California. During his *(pre-retirement)* career, he had the opportunity to work with a wide variety of technology development organizations including the Air Force Flight Test Center, NASA, the Air Force Rocket Propulsion Lab and the Jet Propulsion Lab. In this capacity he was associated with many scientific individuals who were not afraid to try new inventions despite the risk of venturing into the unknown. His objective in writing this article is that of sharing knowledge and furthering the technology regarding the subject matter. Hopefully the reader will be better prepared to make optimum design decisions.

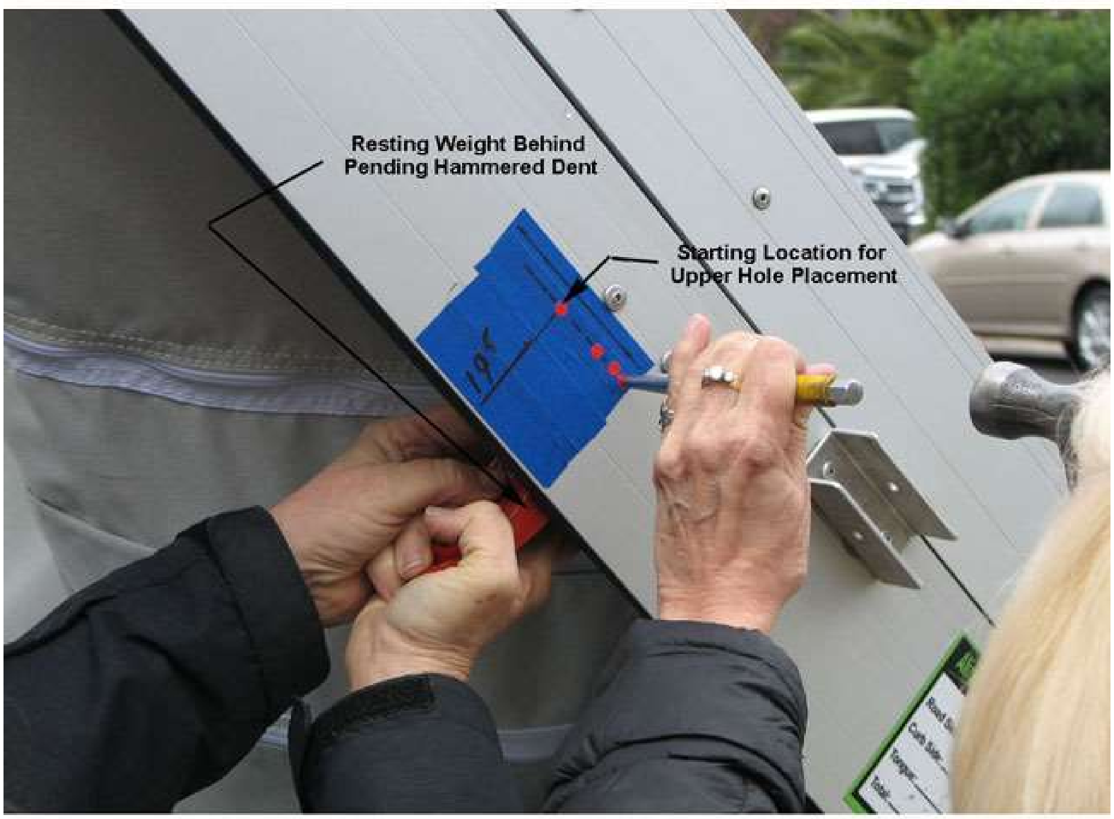
Marking Upper Obstruction Line & Starting Line (19" from Hinge)

Initial Pivot Ball Placement Locations (Roof Panels Lowered)

Initial Pivot Ball Placement (Roof Panels Lowered)

Checking for Proper Pivot Ball Placement (Roof Panels Raised)

Checking for Proper Pivot Ball Placement (Roof Panels Raised)



Indenting the Location for the Upper 5/16" Diameter Holes

Drilling the 5/16" Diameter Upper Holes for the 10 mm Ball Studs

Applying 3M Adhesive Sealant for Waterproofing

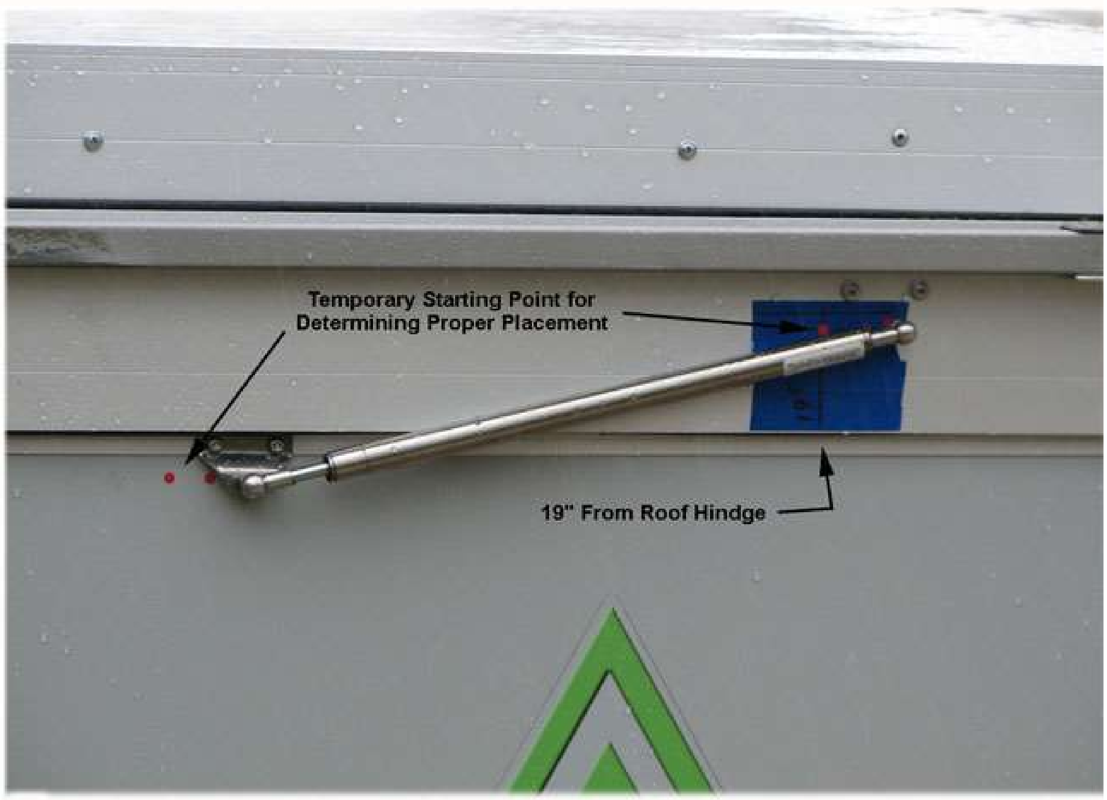
New 10 mm Stainless Steel Offset Bracket (no Shim Required)

New 10 mm Stainless Steel Ball Stud & 30 Pound Gas Spring

New 10 mm Stainless Steel Ball Stud Placement

New 26' Stainless Steel Gas Spring Alignment

New 10 mm Stainless Steel Ball Stud Placement Location



Red Sticky Dots for Bracket and Ball Stud Placement

Maximum Edge Spacing for Shim-free Installation


Nylock Nut on 5/16" x 18 TPI Stainless Steel Threads for Ball Stud

Nylock Nut on 5/16" x 18 TPI Stainless Steel Threads for Ball Stud

Nylock Nut on 5/16" x 18 TPI Stainless Steel Threads for Ball Stud

Nylock Nut on 5/16" x 18 TPI Stainless Steel Threads for Ball Stud

Nylock Nuts on 40 mm Stainless Steel bolts for Offset Brackets

2016 Aliner Classic Retrofitted with Low Force Gas Springs

Success! New Low Force Gas Springs Are Installed!

Atch 2 - How to Add Gas Spring Lift Assistance

(Simplified/Summary Version for Less-technical Owners)

Section I: Ordering the Springs and Hardware

Let's say you have a $200.00 budget and desires to purchase four each 26" long stainless-steel gas springs *(in the 30 to 50-pound range),* four pivot ball brackets and four ball studs from my suggested economical source: *(i.e., www.liftsupportsdepot.com).* From this source you will buy:

1) the initial two 26" long gas springs *(in likely the 30-pound size),*
2) a four-pack of ball studs for the upper connections, and
3) four offset brackets for the lower connections.

You will buy the appropriate stainless-steel nuts and bolts to attach the upper ball studs and the lower offset brackets, and any needed washers/spacers from other sources *(internet, hardware store, industrial supply, etc.)* as shown in Table 1 at the end of this Attachment *(see Section VI).*

Section II: Example Initial Gas Spring (etc.) Order

Here is your example initial order *(from the very economical supplier I used)* if you have one or two heavy roof panels. The below sample order presumes that your first order is for two 30-pound gas springs *(see Table 1 in Section IV on page 5):*

Item 1: Two each 30-pound stainless-steel gas springs at $37.95 each = **$75.90**
https://www.liftsupportsdepot.com/search/search-results/?search_query=SE260PSS30M10

Item 2: Four stainless-steel offset brackets at $6.25 each - **$25.00**
https://www.liftsupportsdepot.com/fp-ball-stud-joint-10mm-3-8-2-hole-offset-bracket-s316-stainless/

Item 3: Four-pack of stainless-steel ball studs - **$13.00**
https://www.liftsupportsdepot.com/ab-ball-stud-10mm-3-8-5-16-x-18-s316-stainless-4-pack/

Total cost for the first order - **$113.90** *(note that shipping is free on orders over $75.00)*

Important Warning:

Please note that if your order is alternatively for 40-pound gas springs your Item 1 link must be changed to:

https://www.liftsupportsdepot.com/search/search-results/?search_query=SE263PSS40M10

Section III: Determining the Dimensions to be Used

Next, use extended and compressed lengths that accommodate ALL three gas spring sizes as listed in Table 1 of Section IV *(see page 5),* and add/subtract approximately 0.5" *(unused spring travel)* at each end. The compressed length to be used will be the 15.15" of the 40-pound gas spring *(because it compresses the least of the three possible gas springs)* plus 0.5" or **15.65**". The extended length *(i.e., distance '**a**')* will be the 26.25" of the 30-pound gas spring *(because it extends the least of the three possible gas springs)* minus 0.5" or **25.75**". The usable stroke will be the difference between these values which is **10.1**".

The starting distance '**c**' for the upper pivot ball placement would be **19**" *(as addressed in Section VIII on page 11).* The starting distance '**a**' *(i.e., from point '**B**' to point '**C**')* would be the above **15.65**" *(i.e., the compressed length)* **with the roof panels lowered/closed**.

Next, raise the roof panels and again measure distance '**a**'. If it is **25.75**" *(i.e., the selected extended length)* then the pivot ball locations are placed correctly. If it is not **25.75**", then move the dots at points '**B**' and '**C**' an equal amount *(as suggested in Section VIII on page 11)* until distance '**a**' becomes **25.75**".

Section IV: Installing the Gas Springs

Next, use a template/ruler *(see Section VIII on page 11)* to confirm the locations selected for the upper and lower pivot ball locations. The red *(or other)* sticky dots will be placed at the compressed and extended lengths as indicated above *(i.e., **15.65**" and **25.75**").*

Because the smallest trailers have roof panel slopes greater than 43° *(e.g., my scenario)* and the longest/largest trailers have roof panel slopes much less than 43°, the amount to move the pivot ball location dots will vary *(as addressed in Section VIII on page 11)* to find their ideal placements.

After evaluating the effect of the first two purchased springs, another set *(of higher or lower force)* can be ordered. Shipping charges may then be eliminated using this two-step purchasing procedure.

Section V: Frequently Asked Questions:

The supplier that I recommend provides additional information about installing and operating gas springs at this link:

https://www.liftsupportsdepot.com/general-lift-support-faq/

Section VI: Other Ordering Options

Another source for obtaining gas springs is identified in Attachment 5 to the basic article. That source provides gas springs in a very wide range of force ratings. The end connectors must be ordered separately. That source does not sell the offset brackets that are invaluable in eliminating the need for spacers under the lower brackets. You must decide upon the optimum supplier for your gas springs and related hardware.

Table 1 - Required Hardware for the Off-set Brackets & Ball Studs

Required Bolt Lengths for the Offset Brackets

Shim Thickness Req'd.	#10 x 32 *(U.S.)*	5M x 0.8 *(Metric)*
Not Applicable	1-3/4"	40 mm
1/8"	1-3/4"	45 mm
1/4"	2"	50 mm
3/8"	2"	50 mm

Socket Button Head Stainless Steel 18-8 Offset Bracket Bolts and Nuts

	Item	Internet Link	Price	Req'd.
U.S.	1-3/4" x #10 bolt	https://www.boltdepot.com/Product-Details.aspx?product=4409	$0.34	8
U.S.	2" x #10 bolt	https://www.boltdepot.com/Product-Details.aspx?product=4410	$0.37	
U.S.	Basic #10 Nut*	https://www.boltdepot.com/Product-Details.aspx?product=2561	$0.06	8
U.S.	#10 Nylock Nut	https://www.boltdepot.com/Product-Details.aspx?product=2553	$0.08	8

(Note that the below is an option if metric bolts are preferred)

Metric	40 mm x 5M bolt	https://www.boltdepot.com/Product-Details.aspx?product=6639	$0.26	8
Metric	45 mm x 5M bolt	https://www.boltdepot.com/Product-Details.aspx?product=6640	$0.37	
Metric	50 mm x 5M bolt	https://www.boltdepot.com/Product-Details.aspx?product=6641	$0.42	
Metric	Basic 5M Nut*	https://www.boltdepot.com/Product-Details.aspx?product=4775	$0.05	8
Metric	Nylock 5M Nut	https://www.boltdepot.com/Product-Details.aspx?product=4794	$0.07	8

Nuts for the Four Upper Ball Studs

U.S.	5/16"x18 Basic Nut*	https://www.boltdepot.com/Product-Details.aspx?product=2564	$0.09	4
U.S.	5/16" x 18Nylock Nut	https://www.boltdepot.com/Product-Details.aspx?product=2555	$0.14	4

*Note - these nuts are only needed temporarily until the requirement for any shims/spacers has been investigated.

Atch 3 - Review of A-Frame Gas Spring Installation Methods

By Brian Hovander

Section I: Why A-Frame Roof Panels Become Difficult to Raise

A-frame trailers *(hereinafter referred to as trailers)* are manufactured with four internal torsion springs or bars *(i.e., one in each corner)* that assist in lifting their heavy folding roof panels. Unfortunately, these counterbalance/torsion springs/bars *(hereinafter referred to as springs)* slowly and continuously deform/weaken over time while they are compressed *(i.e., when the roof panels are closed/folded down)*. Since most trailers are stored in the closed position, this accelerates the deformation/deterioration of the torsion springs. Also, storage in a hot climate likely expedites the deterioration process. This natural phenomenon gradually increases the difficulty in raising the roof panels.

Until recently the only option available was that of replacing the internal torsion springs. Four of the large springs can be obtained from the applicable trailer manufacturer *(or Diamond Wire Spring Co. for around $120.00 plus shipping)*. A *"Do-It-Yourself" (or DIY)* torsion spring replacement article is posted on the Aliner Owners' Club website *(see link in Section II)*. In one known instance the new replacement springs installed on an older Chalet trailer destroyed the roof panels.

2005 Aliner Expedition Retrofitted with Gas Springs

Note - The owner of that Chalet trailer has now added gas springs to supplement the internal torsion springs.

Many owners of A-frame trailers have tried a variety of alternatives to aid them in raising/lifting their heavy roof panels. For some owners, the chosen option has been to sell their trailers. The roof panel lifting problem was then transferred to the follow-on owner*(s)*.

Necessity Is the Mother of Invention!

Section II: A Solution Arrives from Australia

The use of nitrogen-filled high-pressure gas springs is a well-established technology that has been used for many years to provide extra lifting force for such things as the hatch of an SUV or a boat, vehicle hoods, tool boxes, truck bed Tonneau covers, trailer beds, etc. Now these are also being used to aid in lifting the roof panels of aging trailers thanks to a retired mechanical engineer in Australia named David Hall. David published his article *(see attached)* on how he added gas springs to his trailer on the exclusive members-only Australian Avan *(i.e., Aliner)* Owners' Club website. Someone must be a member of that club to access his published article at:

http://avanclubaust.org.au/members/modifications/gas-struts-installation/

David Hall says that the Aussie Avan Club had been around for a while and many of their members were feeling the effects of age. The roof springs on their aging trailers were also beginning to lose their spring. In 2015 David utilized his engineering experience to design and install these on his aging 2005 *(Cruiseliner model)* trailer. In his article he indicates that he used 26" gas springs. His front gas springs *(with solar panels added to that panel)* are rated at 33 pounds and his rear gas springs are rated at 22 pounds *(conversion values from metric ratings).*

Two of the American A-frame trailer manufacturers also began installing gas springs on some of their new trailers *(around 2015)* to supplement the internal torsion springs. Their installation techniques varied from the design that David introduced. His design parallels that used by the auto industry on SUV rear hatches to make it easier to close them. If automakers installed them at any other angle it would be extremely difficult to close the rear hatch of an SUV. David's placement methodology requires **significantly** lower force gas springs and applies maximum uplift force when needed *(as the panels rise)* and not when the panels are in the closed position.

Gas Spring Installation on an Aliner Trailer (pre-2019)

Gas Spring Installation on a Rockwood Trailer

When designing my first-generation retrofit solution *(erroneously copying the method used at that time by one of the A-frame manufacturing companies),* I was unfortunately unaware of the method developed by David Hall. In May 2016 I could not find any technical information for retrofitting gas springs on older A-frame trailers.

Section III: Adding Gas Springs vs. Replacing the Torsion Springs

The primary factors to consider include: 1) the ease of replacing *(lift-assisting)* gas springs, 2) their effectiveness *(using David Hall's method),* and 3) their affordability. They can be easily and economically replaced *(or possibly recharged)* should they lose pressure over time!

Section IV: Nitrogen-Filled High-Pressure Gas Springs

General information about the design, operation, functioning, installation and maintenance of gas springs is available on the web. Normally the rods of the springs should be placed in the downward position to allow the internal oil to lubricate and protect their seals.

One issue of potential concern relates to the variation between the compressed and extended forces of gas springs. The gas spring force *(normally)* increases by 20 to 50 percent when compressed based upon the characteristics of the particular gas spring *(i.e., the K-factor or gas spring rate).* The K-factor is inversely proportional to the ratio of the diameter of the spring rod to the diameter of the inner gas chamber. The higher fully-compressed spring force is continually applied to the structural components of the trailer when it is in the storage position. Gas springs rated at say 30 pounds *(when extended)* could actually be applying up to 45 pounds when the roof panels are closed.

The rated gas spring force is that of the internal gas pressure multiplied by the cross-sectional area of the rod *(when it is fully extended).* As the rod is pressed into the gas spring the internal pressure increases and so does the applied force of the gas spring. A larger outer chamber is sometimes used to reduce the K-factor to perhaps 10 percent.

The factory-publicized gas spring forces increase by the K-factor when they are fully compressed. A higher K-factor therefore increases the difficulty compressing the roof panels to their closed position when using the initially-vertical and/or the outward-slanted installation methods. This serious roof-closing problem has been overcome by using the inward-slanted method of the concept founder. His ingenious design places the lower ball stud mounting bracket at a location where the difficulty closing the roof panels can be greatly minimized or eliminated.

Section V: Design Considerations for Installing Gas Springs

Engineering principles can be used to determine the required gas spring forces. Unfortunately there are problematic variables in this dynamic situation *(for those without the tools to make necessary measurements)* which include*: 1) the unknown state of deterioration of the factory-original internal torsion springs (which will likely continue to deform with age), 2) the point at which the torsion springs no longer provide uplift force, 3) the variable force associated with the gas springs due to the K-factor (likely 1.4 to 1.5) for the selected gas springs, and 4) the varying lifting force required as the panels are raised.*

David Hall used engineering principles *(and a bathroom scale)* to calculate the required force of his gas springs *(see his attached article)*. I chose to use another method for measuring the varying force required to raise my roof panels throughout their rise *(see photos below)*.

Use of the lowest possible force gas springs is desirable for a variety of reasons. On some Aliner trailers the very high force gas springs that have been installed could potentially be applying a much greater force when the panels are compressed *(based on their K-factor as addressed previously)*. This constant high force level might not be structurally desirable in the long term.

The torque applied by the gas springs *(to help raise the roof panels)* is that of the *(right angle component)* **FORCE x DISTANCE**. Thus, to use a reduced force the lever-arm distance must be increased *(similar to using a cheater pipe extension on a pipe wrench)*. Also, to obtain maximum torque as the panels near their raised position *(i.e., when assistance is needed the most)* the force should be applied as close to being perpendicular as possible *(e.g., David Hall's method)*.

David Hall's *(inward-slanted)* method achieves an angle of 77° *(e.g., 90° being optimum)* whereas my *(initially-vertical)* former installation method *(on my trailer)* only achieved an angle of 61°. The outward-slanted method is very clearly the least effective at this position and only achieves an angle of 24° *(on a typical trailer using this method)*. Table 1 *(below)* shows the relative effectiveness of three of the various installation methods that have been used for gas springs. Note that the gas spring angles can also vary based on varying angles of the raised roof panels *(e.g., shorter trailers require much steeper roof angles)*. The Table 1 calculations are based on measurements of five different gas spring installations.

Table 1 indicates that the optimum solution for the installation of gas springs would be that of David Hall and Dave Michaels' retrofit. The applied force *(and resultant torque)* is highest in the raised roof position where maximum uplift force is required *(see Table 2 below)*. The applied force is similarly lowest when the roof panels are in the closed position and very little *(if any)* uplift force/torque is required. In the closed position there is still a 27% applied force for David Hall's method. This applied force will aid in raising heavy roof panels that require initial uplift force assistance. Note that I refined his method to reduce the *(undesirable)* initial uplift force to only12% with my new gas spring system *(see bottom row in Table 1)*.

To obtain the Table 1 spring angles for my first-generation and replacement systems, I directly measured them. To obtain the angles for other trailers I used available photos. To obtain the uplift torque our gas springs provide, the applied force *(percentage)* would be multiplied by the gas spring force rating *(e.g., 30 pounds for Dave Michaels' installation)* and also by the measured *(lever arm)* distance from the point of force application to the roof hinge *(e.g., 19-11/16" for David Hall's trailer and 19" for my trailer)*.

Table 1 - Installation Method Comparison Chart

	Roof Panels Down					Roof Panels Raised			
Installation Method	**Applied Angle**	**Spring Force[1]**	**Sine[2]**	**Applied Force[3]**		**Applied Angle**	**Spring Force[1]**	**Sine[2]**	**Applied Force[3]**
Slanted Outward	29	140%	0.485	68%		24	100%	0.407	41%
Initially Vertical[4]	90	140%	1	140%		61	100%	0.875	88%
David Hall	11	140%	0.191	27%		77	100%	0.974	97%
Dave Michaels	13	140%	0.225	32%		74	100%	0.961	96%
Brian Hovander	5	140%	0.087	12%		75	100%	0.966	97%

Note 1 - The K factor is assumed to be 1.4 for the gas springs. Their *(rated)* spring forces *(at their extended positions)* are known to increase by their K-factor amount when they are fully compressed.

Note 2 - The applied force is reduced by the sine value for the applied force angle *(see the attached trigonometric sine value table)* as it moves away from being applied in a perpendicular manner.

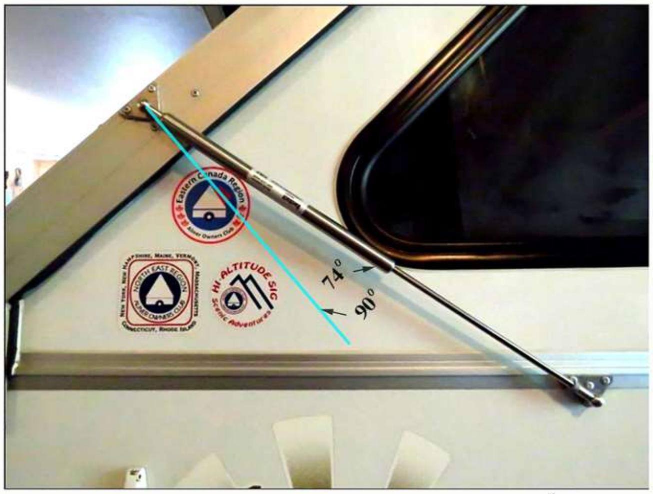
Note 3 - The applied force is the percentage spring force multiplied by the sine amount for the angle of which the force is applied. To obtain the torque applied one must multiply the force rating of the spring by the lever arm and the applied force *(percentage)*.

Note 4 - This is the method that I originally used for my gas spring system. It proved to be totally inferior to the method developed and used by the concept founder *(i.e., David Hall)* that I now am using.

Table 2 *(see below on page 22)* provides my measurements of upper roof panel rise verses the *(perpendicularly)* applied force *(using actual weight plates)*. Switching to David Hall's installation method has provided my trailer with significantly greater uplift assistance *(i.e., approximately twice as much)* as the panels near their fully-raised position. By changing to David Hall's more effective method, the installation dynamics now significantly reduce the applied torque/force when the roof panels reach their fully-closed position and very little *(if any)* uplift assistance is needed.

I used actual weight plates, pulleys, rope, a 12-foot tall stepladder, etc. to obtain fairly accurate measurements of the force required to raise my trailer roof panels *(see photos and procedures below)*. The point of my always perpendicularly-applied lifting force was at the very peak of my upper roof panel. Trying to separately measure the upper and lower roof panel resistive forces was not considered necessary and would have required extensive extra effort.

Examples of other trailers that have been retrofitted with gas springs can be seen in the below photos. Note that in some examples the gas spring mounting bracket locations resulted in a failure of the springs to be fully compressed when the roof panels were in their closed position. Such *(erroneous)* placement will likely cause: *1) a failure to obtain adequate uplift force when the roof panels reach their nearly raised position and 2) excessive problematic uplift force in the closed roof position.* Dave Michaels' installation method is shown on the upper left photo below.



The above installation fails to compress the gas spring when the roof panels are closed.

The below left installation has the gas springs upside down and a very short moment arm.

Examples of Retrofit Gas Spring Installation Methods

Pulley System for Accurate Weighing

No Gas Springs--Rises 46" with 30 Pounds Force

No Gas Springs--Rises 26" with 20 Pounds Force

No Gas Springs--Rises 64" with 40 Pounds Force

Table 2 - Roof Panel Rise Versus Applied Force

Without Gas Springs

Weight *(lbs.)*	**Rise *(in.)***
0	1
10	6.5
20	26 1/4
30	45 3/4
35	60 3/4
40	64[2]
45	>69[4]

With Gas Springs[1]

Weight *(lbs.)*	**Rise *(in.)***
0	16.5
5	32
10	39
15	53
20	62
25	69[3]

Note 1 - These measurements were for my original *(superseded)* method using the initially-vertical gas spring installation method.

Note 2 - The roof panels separated about 4".

Note 3 - The fully open distance was 69" for my trailer.

Note 4 - The roof panels separated significantly.

My first-generation *(initially-vertical)* gas spring installation method provided excessive torque when the roof panels were in their lowered position. It also provided inadequate torque when they neared their fully-raised position *(as the above two tables indicate)*. When closing the roof panels, I needed considerable downward force *(i.e., 25 pounds of weight plates)* placed on the lowered peak to compress the upper panel to its ready to latch position *(for measurement only)*. My roof panels rose automatically to the 16.5” position *(see photo on the next page)* with the latches released due to excessive initial gas spring uplift force *(as depicted in the above table for the lowered position)*. Since the length of my upper roof panel is 8’ this equates to a torque requirement of 25 pounds x 8’ or 200 foot-pounds I *(unfortunately)* needed to close my roof panels. This *(unwanted)* resistive torque was primarily from the combined uplift torque caused by the internal torsion and the *(add-on)* gas springs.

Next, I will compare the *(unwanted)* 200 foot-pounds of torque measured above with the *(expanding spring)* initial uplift torque provided by my first-generation method when the panels were fully down. As previously mentioned, gas spring force ratings are measured at their fully-extended positions. I measured the expanding force and not the *(higher)* compressive/resistive force of each gas spring. The resulting measured gas spring *(expanding)* forces are as follows:

Rear *(two)* 30-pound 20” springs - 40 pounds *(each)*
Front right 40-pound 20” spring - 48 pounds
Front left 30-pound 26” spring - 36 pounds

The combined uplift torque that my former four gas springs originally provided at the fully closed position for the roof panels *(i.e., roof panels fully down and just beginning to rise)* is calculated as follows:

20" Springs	- Torque	= 11/12' x *(40 + 40 + 48)* pounds	=	117 ft. lbs.
26" Spring	- Torque	= 14/12' x 36 pounds	=	42 ft. lbs.
	Total Combined Gas Spring Torque		**=**	**159 ft. lbs**.

This above calculated initial roof panel lifting torque was unnecessary *(and very counterproductive)* at the start of the roof lifting process. It greatly compounded the difficulty related to closing the roof panels for storage or travel.

My 2005 Aliner Expedition Model as Originally Retrofitted with Initially-Vertical Gas Springs

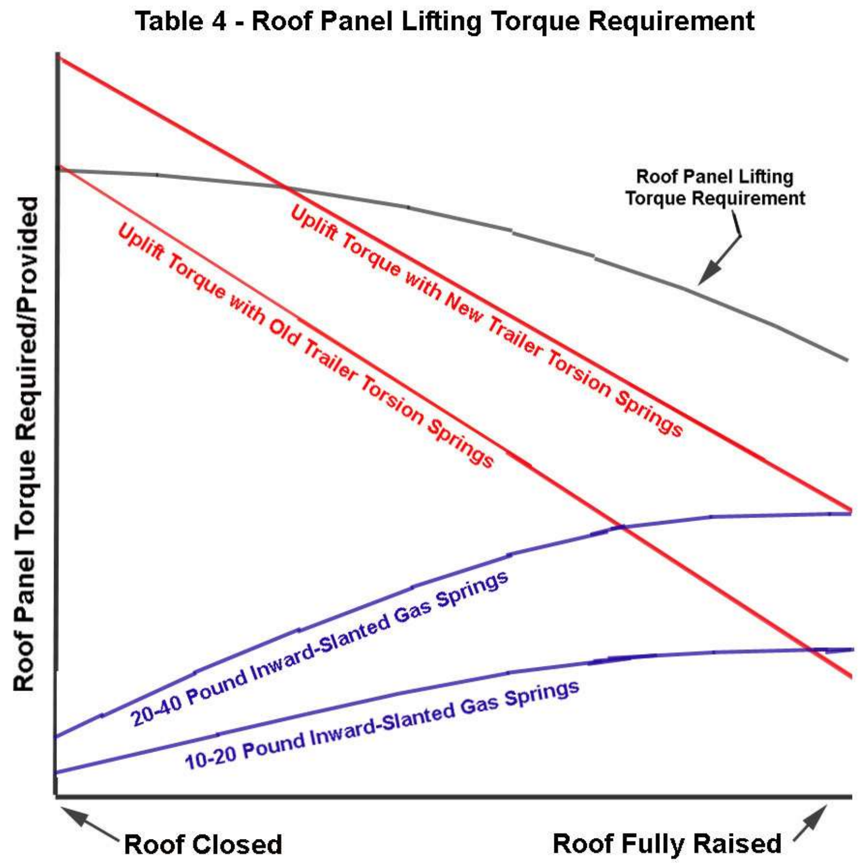
The above photo of my trailer depicts one of the two problems that resulted from my erroneously using the initially-vertical installation method. As previously mentioned, this method provided excessive initial uplift force/torque *(when none was needed)* and a serious deficiency of lift assisting torque as the panels reached their fully-raised position *(see Table 1 to understand this issue)*.

Section VI: My Personal Selection and Methodology

The gas spring installer will need to determine which pivot ball positions are appropriate for the specific installation. Varying the pivot ball placement changes the initial gas spring angle which affects: *1) the initially-applied uplift force (as shown in Table 1) and 2) the "lever-arm" distance for force application to the upper panel.*

Section VIII: Summary and Conclusions

My second-generation retrofit system follows and builds upon the installation methods of the concept founder, David Hall. As shown in Table 4 below, this method: *1) reduces the difficulty of closing the roof panels, and 2) provides greatly increased assistance in raising them to their fully-raised position.* Based on the significant deterioration of my torsion springs, I am now using 26" gas springs rated at 30 pounds for the lower/rear panel and 40 pounds for the upper/front panel of my trailer.



The factory-original torsion springs unfortunately provide their greatest amount of uplift torque when the roof panels are closed and very little additional gas spring lift assistance is needed. Therefore, the gas spring installation configuration method needs to provide minimal uplift assistance at the lowered position.

Note that the torque provided by the gas springs will vary between the compressed and the extended positions due to the K-factor previously addressed in Section IV.

The data in Table 1 shows that the *'Slanted Outward'* and *'Initially-Vertical'* solutions do not complement the torque of the internal torsion springs. To get a little help when the roof panels reach their nearly-raised position they erroneously add significant *(undesirable)* uplift force at the closed position making it very difficult to close the roof panels.

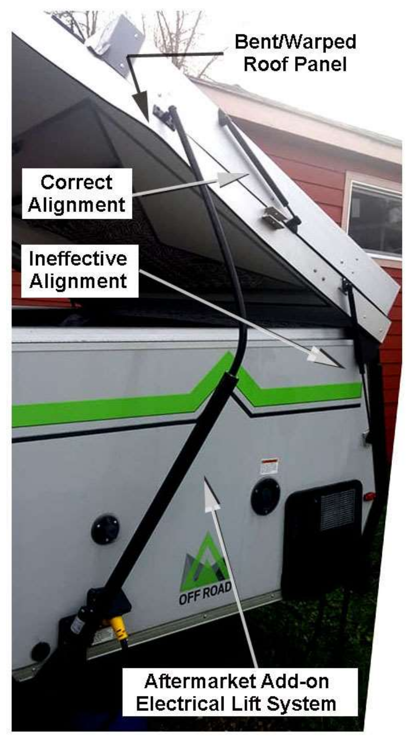
When using the *'Slanted-Inward'* method, the combined torque provided by the torsion springs and the add-on gas springs *(as shown in Table 4 above)* should more closely relate to the necessary total torque required while raising the roof panels. There may be slightly more torque than necessary during the middle of the roof panel lifting/lowering process.

Based on past experience and the information gleaned in Tables 1& 2 above, I was able to estimate the desired forces of my gas springs. My system works very well. With my selection I need to do a little bit of pulling of the panels down during the middle of the roof panel lowering process. This is my chosen trade-off in deciding which springs are optimum for my scenario.

With my new gas spring system, it is easy for me to raise my roof panels with very little added effort. I have documented my findings to aid other A-frame owners in resolving any roof panel lifting issues. Dave Michaels' installation caused me to thoroughly study the method designed by David Hall and conclude that it is the optimum method available for a retrofit installation on a trailer similar to mine.

Section IX: Epilogue

This article provides my review of several methods for adding gas springs to help lift the roof panels of A-frame trailers. I was looking for an easier solution than periodically replacing the internal torsion springs as they age/weaken and thereby fail to adequately assist in lifting A-frame roof panels. Replacing gas springs is inexpensive and easy. All four gas springs can be easily replaced by the trailer owner in less than 5 minutes. Replacing the internal torsion springs is expensive and beyond the capabilities of the average trailer owner.



Oops--Another Solution that Failed!

The photo to the right depicts what happened to a nearly new A-frame trailer when an electrical lift system was aftermarket-installed. It supplemented both the internal torsion springs and the factory-installed *(outward-slanted)* gas springs. Those gas springs were very powerful, but they were seriously deficient in providing adequate/effective uplift assistance for the owner.

Electrical lift systems have: *1) been known to cause roof panel damage, 2) failed to operate, and 3) may be incompatible with an automatic wind protection system some owners may desire to utilize.*

It is possible that the gas spring roof panel-lifting method evaluated in this study could make most *(if not all)* electrically-powered lift systems obsolete.

For those considering purchasing a trailer *(new or used)* that has an electrical roof panel lifting system, they might want to investigate their potential problems *(see below comment)*.

> Related to your problems, if it any consolation, the electric roof actuators on one of the A-frame trailer brands *(name withheld)* are of low quality and problematic. Owners with these actuators are continually replacing them. Also, a number of roofs of those trailers with these actuators have suffered interior creases in the aluminum skin and bent outside aluminum roof edges. Manual is better… The manufacturers need to stick to the KISS principle. *(comment contributed by a fellow A-frame owner on a major A-frame chat site)*

Table 5 - Trigonometric Sine Value Table

Angle	Sine		Angle	Sine		Angle	Sine
0°	0						
1°	0.01745		31°	0.51504		61°	0.87462
2°	0.0349		32°	0.52992		62°	0.88295
3°	0.05234		33°	0.54464		63°	0.89101
4°	0.06976		34°	0.55919		64°	0.89879
5°	0.08716		35°	0.57358		65°	0.90631
6°	0.10453		36°	0.58779		66°	0.91355
7°	0.12187		37°	0.60182		67°	0.9205
8°	0.13917		38°	0.61566		68°	0.92718
9°	0.15643		39°	0.62932		69°	0.93358
10°	0.17365		40°	0.64279		70°	0.93969
11°	0.19081		41°	0.65606		71°	0.94552
12°	0.20791		42°	0.66913		72°	0.95106
13°	0.22495		43°	0.682		73°	0.9563
14°	0.24192		44°	0.69466		74°	0.96126
15°	0.25882		45°	0.70711		75°	0.96593
16°	0.27564		46°	0.71934		76°	0.9703
17°	0.29237		47°	0.73135		77°	0.97437
18°	0.30902		48°	0.74314		78°	0.97815
19°	0.32557		49°	0.75471		79°	0.98163
20°	0.34202		50°	0.76604		80°	0.98481
21°	0.35837		51°	0.77715		81°	0.98769
22°	0.37461		52°	0.78801		82°	0.99027
23°	0.39073		53°	0.79864		83°	0.99255
24°	0.40674		54°	0.80902		84°	0.99452
25°	0.42262		55°	0.81915		85°	0.99619
26°	0.43837		56°	0.82904		86°	0.99756
27°	0.45399		57°	0.83867		87°	0.99863
28°	0.46947		58°	0.84805		88°	0.99939
29°	0.48481		59°	0.85717		89°	0.99985
30°	0.5		60°	0.86603		90°	1

Atch 4 - Gas Struts for Lifting Avan Roofs

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Rev 1 24/08/2016

Introduction

When our Cruiseliner was new the roof sprang up about 30cm *(12")* if the catches were released, but later the springs sagged and it only lifted a little, so we had to do most of the lifting ourselves. On the trip to the Longreach AGM we will make camp about 40 times, and raise the roof for as many daytime stops. Wow, about 80 in all! We enquired about replacing the springs or having them re-tempered, but Avan recommended against it, as it is quite a job.

Gas struts are reliable and are fitted to the tailgates of most cars. How are the tailgate struts of your SUV lasting?

The best feature of gas struts is that once installed, they just happen. They do not need to be set up each time they are used, like a winch, and they need no regular maintenance. They do however lose gas very slowly, and need recharging after many years of service.

I have just designed and installed 4 gas struts to help the sagging springs on the Avan. They work very well.

Now, when the catches are released the roof springs up about halfway, and stays there, and either of us can easily open or close the Cruiseliner unaided. Our latest camping routine is for Joyce to erect the Avan while I disconnect it from the car and level it up.

The struts and end fittings cost $A175 *(added note by B. H. - about $125 US)* and fitting them is an easy job that a handy person can do with a measuring tape, 3/16 inch and 8mm drills, spanners and a pop-riveter. See below.

You will notice that I have also installed handles on the sides of the roof panels about 700mm *(28")* from the hinges to make it easier to erect the roof.

Gas Struts

Suppliers charge struts with nitrogen gas to deliver a particular force when extended. As they have one-way seals, they can be charged up with nitrogen, but not discharged, so their force can be increased later, but not lowered. The clue is to begin with a low pressure and if this is not enough to return them and get the supplier to raise the pressure, probably at no charge.

When struts are compressed the force they deliver rises about a third as the shaft is pushed in.

Design and Installation

There are two elements to the design, the lifting force needed, and the selection and location of the struts.

Lifting Force

A compromise must be found between the force needed to lift the roof and that needed to close it, the aim being to make the effort of lifting the roof about equal to the effort of closing it. If the struts are too strong then it is harder to pull the roof down and hook it down.

I weighed each panel in turn by supporting it with a pole at the peak and resting it on bathroom scales on the floor. The hinges were lubricated, the shock cords were loose and there was no friction between the panels at the top.

Strut Selection

I chose one from Struts Australia's standard 8/18 range, model K670-18-295, which has 670mm extended length, 295mm stroke, and is 375mm long fully compressed. It has an 8mm Ø shaft and 10mm Ø ball connections.

http://www.strutsaustralia.com.au/

Struts Australia
1/16 Fitzgerald Rd.
Laverton North. Victoria 3026.

Even though we keep the Cruiseliner outside, I selected a standard strut because stainless struts are very much more expensive.

The front pair were set to deliver 150 Newton *(about 15 kg or 33 lbs.)* each, and the rear pair 100 Newton *(about 10 kg or 22 lbs.)* each. The front pair is stronger to push the panels apart a little to reduce the friction between the panels, and as we have the weight of a small solar panel on the front roof.

The upper pivot is an 8mm stud at right angles to the shaft, KBSH1030M8 stud hex 30mm L M8x1.25 with 10mm ball

The lower pivot is a KB105 bracket offset black with 10mm ball.

The front roof is wider than the rear roof, so a 3mm *(1/8")* thick spacer is needed under each lower pivot at the front. I made them from aluminum bar, but they could be thick washers.

Differing Models of Avan

There are numerous models of Australian Avans. Recent models include Sportliners, Aliners, Cruisers, Cruiseliners, and Adventure Packs to mention a few. Later models have fibreglass ends and pre-2005 models have sandwich end panels. There are quite a variety of early models with a variety of wall heights etc.

Aliner bodies are 30cm *(1 foot)* shorter than Cruiser and Cruiseliner bodies, which are similar. This affects the roof angle.

Ours is one of the first Cruiseliners built in 2005 with fibreglass ends, and the dimensions given in this article are for that model.

It is likely that the gas struts specified here will suit all but Sportliners, which are too small to need roof lifters anyway.

The variations in body dimensions should be able to be accommodated by repositioning the lower pivot point horizontally, by swinging arcs as described under Locating the Lower Pivot. It is best to check and recheck these dimensions before drilling any holes.

Strut Position

The wall panels of the Avan are of lightweight foam sandwich construction that is unable to support heavy point loads, so I have kept away from anchoring the struts to the wall panels.

Instead the ball joints are supported on the extruded aluminum framing of the roof and wall panels.

The original roof springs are adequate for lifting the roof partway, but then run out of steam, so the trick is to have the roof springs do the first part of the lift, and then have the gas struts cut in for the rest of the lift.

The characteristic of a gas strut is that it delivers its maximum force when it is fully compressed and its least when it is extended, which is exactly opposite to what we want. But we can overcome this by design of the mechanism and by carefully positioning the pivots.

The lower pivot is mounted on a bracket fixed to the aluminum extrusion running along the top of the side wall panel, arranged so that the roof will close without contacting it.

The upper pivot is a stud in the vertical side of the extruded angle along the edge of the roof.

The pivots are arranged so that when the roof is closed, they are roughly in line with the roof hinge pin, which means that when the roof is closed the gas strut is delivering its maximum force, but in this position the strut is horizontal so the force is horizontal and there is no lifting component. The strut is nullified so the springs do all the work at the beginning of the lift.

The upper pivot is mounted on the side of the roof so that when the roof is up the strut is about at right angles to a line from the upper pivot to the centre pin of the hinge. This achieves the maximum lifting force, even though the strut is delivering its minimum output at the end of its stroke.

Upper Pivot

The strut should not obstruct the small side window, and to minimise forces on the pivot support it should be away from the hinge point. A suitable spot is 500mm *(19 11/16")* from the end of the roof at each end of the Avan, and 40 mm *(1 9/16")* above the lower edge of the roof frame. I drilled 8mm *(5/16")* holes in the frame at these 4 points.

Lower Pivot

The following factors have been allowed for in locating the Lower Pivot

- The working stroke has been reduced 5mm to 290mm to allow space for its hydraulic damping as the strut approaches full compression. Matching this, the working compressed length increases to 380mm
- As the front roof panel nears full height it needs to open 30mm too far, before dropping back when the rear panel engages the groove at the ridge of the front panel. This requires the front struts to extend 8mm too far before falling back. This reduces the available extended length of the strut by 8mm to 662mm

Locating the Lower Pivot

- Raise the roof. With the upper pivot as its centre, mark an arc of 662mm radius on the lower wall just below the aluminum extrusion running along the top of the wall
- Lower and lock down the roof. Now with the upper pivot as its centre, mark another arc of 380mm radius to cross the first arc
- These arcs form a triangular shape below the top of the wall within which the lower pivot must be located. The final position of our lower ball was 890mm *(35 1/32")* from the end of the roof and 37mm *(1 15/32")* below the top of the sidewall
- The brackets are mounted on the lower half of the aluminum section running along the top of the wall, so that they clear the flashing overhang of the upper wall when it is erected.
- I mounted each bracket with 2 pop rivets, 4.8mm *(3/16")* dia. and grips of 4.8mm *(3/16")* rear and 9.6mm *(3/8")* front roofs.

Installing the Struts

- Raise the roof and with the tube end upwards connect the upper pivot by punching it onto the ball
- Compress the strut so that the lower pivot can also be punched on
- A strut can be removed with the roof up by prising back the lower circlip with a narrow screwdriver in the slot while compressing the strut a little to get it off the ball