

Homebuilt Stabilizers  
... things you should know before building a full rig  
stabilizer

By

Charles King

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Preparing for knowledge is only half the problem.  
Putting it to use is a whole different ball game.

## **Introduction**

I thought it useful to compile a summary of my experience and knowledge about this slowly growing genre to those who are interested or who are contemplating such an educational venture.

Due to all the interest and confusion I decided to sum up everything into one little book for those concerned. I hope it helps everyone.

I've decided to do this short book based on certain things that one should consider before building a full rig homebuilt stabilizer. It seems the craze for a lot of DIY'ers nowadays. One reason for this is that it is a cheaper method in getting the Hollywood feel of a high priced movie.

Now, people are becoming more adventurous, in producing similar moves or characteristics as that of the major film companies. Or maybe people just feel that because a movie as some kind of Steadicam involvement then it will ultimately fly well with the viewers. Well, whatever the reason make no mistake, the Steadicam device sure makes a movie stand out in all its glory.

So, I will attempt to explain certain things that are or might be important for someone building a full rig homebuilt stabilizer of their own. Now my thoughts should be used as a guide-line in building your dream stabilizer with the notion that fewer mistakes will be made along the way then finding out a minute too late.

So, let's get to the point...

## Arm Building Tips

1. One of the foremost decisions you'll have to make is to have a purpose of building a full rig stabilizer. No point in going through with a project of this size if there are no criteria. For example:

- What will you be achieving?
- Is it a must that you built a stabilizer?
- Will it be used often, seldom or once in a blue moon? In case of the latter it would rather be better to rent one then to purchase a unit.
- Is it worth it?
- How much are you willing to spend? Or simply put, what is your budget?
- Do you have the time?

The latter question is one of importance because it dictates whether or not your decision is, to make an *okay system* or an *outstanding system*. Nothing is ever easy is it?

2. What will be the purposed weight-bearing capacity of the arm in question?
3. What will be the ratio (3:1) or size of the configuration of the arm structural framework? A good example of a 3:1 arm ratio, roughly that is; is a section of my arm bone or shell which measures 26cm long, 50cm wide and 10cm high. Some arms are slightly shorter but 26cm was an ideal length to start with in terms of the type of construction I had in mind. So for you, this might be shorter than my specs.
4. What spring configuration will be used? There are different configurations to choose from depending on the complexity of the arm. They are as follows: *See diagram below.*

Looking at the diagram below, you can see the various spring configurations that one can setup. Please note that these three configurations are just one of many different setups available using the pulley/wire system. I'll just mention some of the most common ones used in a lot of stabilizers today.

Another configuration which is probably the simplest design is placing the spring across the diagonal of the arm like that of *fig 3* but without the wire and pulley system. By attaching one end of the spring directly to the upper axel of the arm and the other

end to the lower axel at the other end of the arm, this will provide the same function but without any iso-elastic characteristics. *See pic below.*

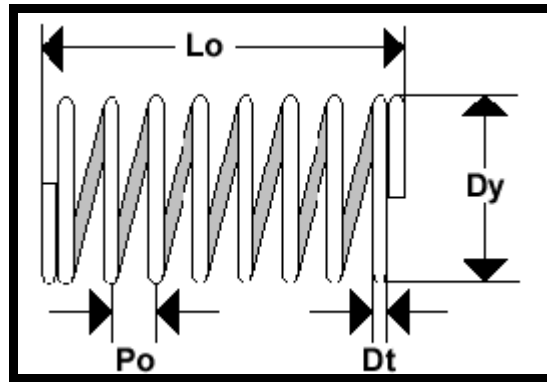


*The Glidecam® V-8 with a single spring across it's diagonal  
(courtesy of Taylor)*

You can see how simple the connection of the spring of the Glidecam® V-8 is placed in the arm. The spring can also be adjusted with a single bolt in the lower front to allow for different camera weights, which is one of the benefits of a multi functional arm.

If you are contemplating a less than complicated method then this design should be for you. You can practically use off-the shelf springs that will fit the bill according to the weight you will be flying.

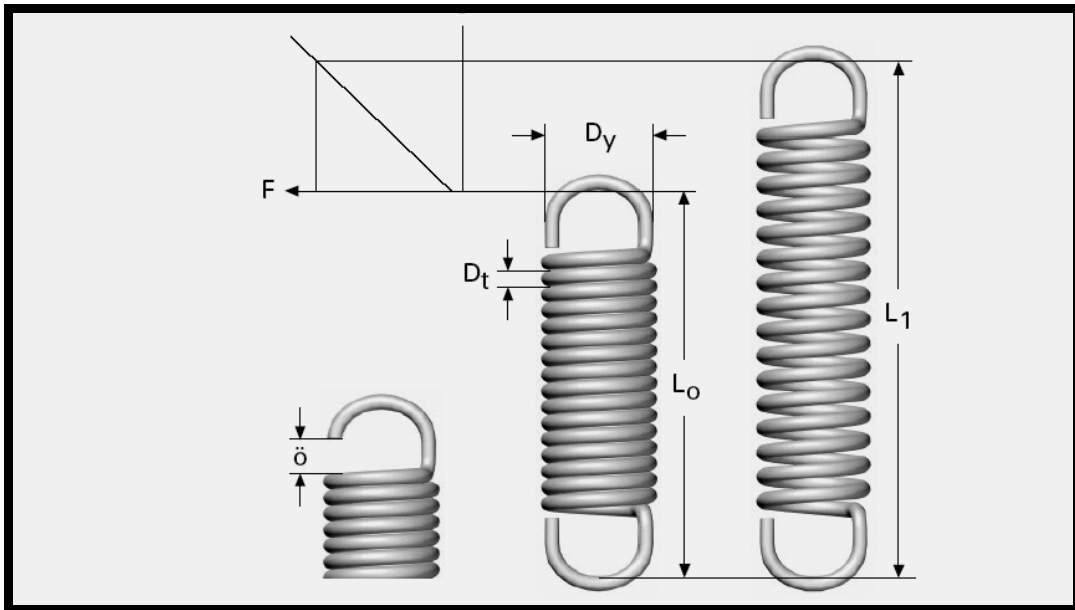
*Compression springs* on the other hand does the opposite of what extension spring does. They compress, which means they move inwards. Unlike their sister counter parts; they are less likely to fail over an extended period of time.



*Compression spring*

8. The Choice of springs. There are two types to choose from. *Titanium and Steel* springs are the ones available. The latter is the more common of the two. As always there are advantages and disadvantages with both.

*Titanium springs* are stronger and has a longer life span than their counter-parts. They are able to withstand larger stress endurance which makes them ideal for carry larger loads, like flying 35mm panavision film cameras. This is why most of the high-end arms use them. Could you imagine a fully loaded 35mm camera plus extra equipment failing on you,



*Springs dimensions*

*(Note the drawing above is for an extension spring)*

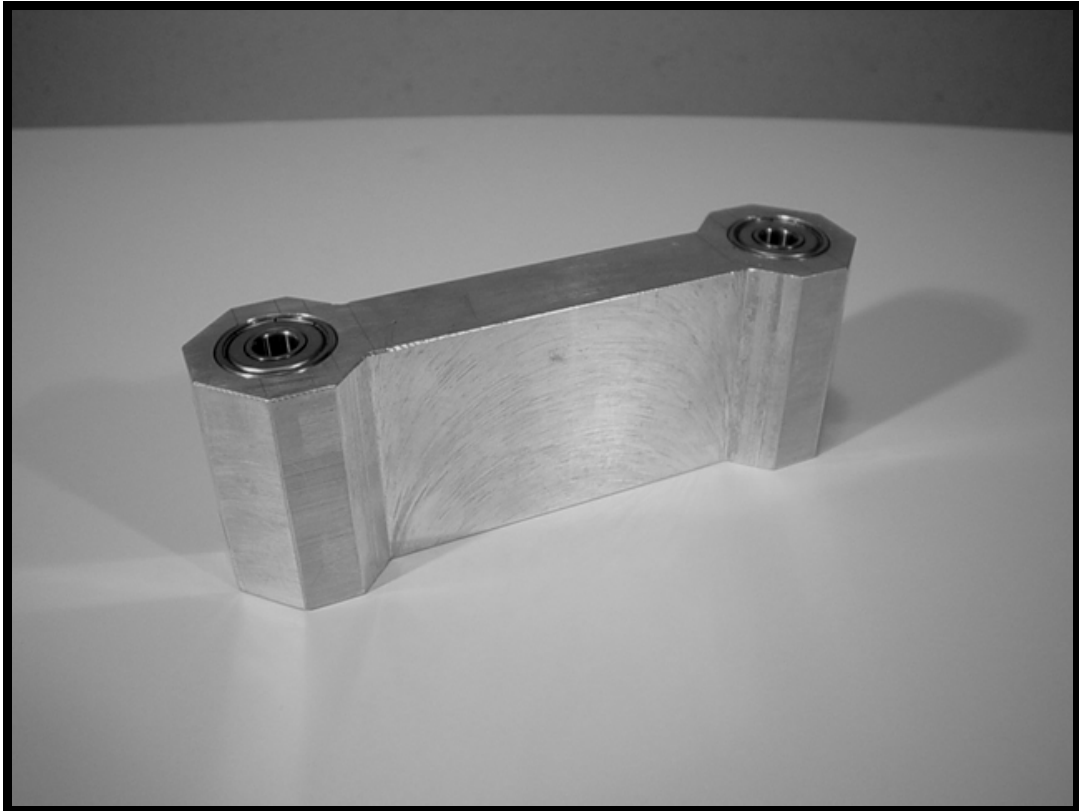
There are a couple of important things you need to know when purchasing a spring(s); *using the drawing above as an example*:

- $L1$  - the max recommended length for the spring to extend.
- $L_0$  - the length of the spring when not extended.

My preference of course is the dual arm. It may be a little more work involved but to me it gives a smoother ride and better stability than a single arm but in the end it's what you are comfortable with that makes the difference. Your decision to go

with a particular type of design will be based on what you will be flying. So take some time to think it over before venturing out into the machine room.

One thing to remember when building either dual or single arm, is that the elbow, that connects both arms in a dual arm or connects the arm to the vest bracket in both single and dual, is strong or thick enough to support both arm arms under load. Otherwise the arm will torque or twist under load. Something best avoided. See next page for the elbow I use to connect both arms in my dual design.



*This is the elbow that connects to both fore and aft arms. Notice the thickness.*

On the other side the smaller the lifting-triangle and with a strong spring, the less force is needed to boom.  
So using spring configuration 1 as in the drawing, little force is needed to boom.

Using spring configuration 2 will need more force to boom, although it still has the same spring rate.

By trying different variations of the available spring setups one can achieve a system that will suit one's criteria and at the same time maintain a safeguard against any spring failure.

Another design, which has been my personal choice, is the GPI® pro. This design excludes the pulley/wire configuration which is no way iso-elastic but instead as a smooth vertical movement throughout the entire boom range.

One particular feature with this design is the ability to exchange different set of springs or individual springs to suit different setups by simply just detaching the canisters that contain the springs. This is a real optional feature found on no other arm. This means you could fly the rig with one spring instead of two in each arm to compensate for the change-over to very light weight cameras.

The option to use lighter with heavy springs together or 2 sets of lighter springs or 2 sets heavy springs makes this arm an absolute exception over all other arms. See pic on next page for my version of the Pro GPI®.

Hopefully these tips can be used as a guide to help you achieve your dream setup.

On the following pages is an article that Bob Weber wrote to give beginners an easier understanding of how to work out spring specifications to accommodate any particular weight that builders might want to incorporate into their arms.

*N.B. Please note that this article was intended to assist homebuilders and is no way the official formula for finding out a spring specifications. I'm sure each manufacturer has a specific module to go follow or maybe all have the same or similar guidelines. Regardless this summation is Weber's own and stay true to the trigonometry and the mathematical equations that are all too similar to understanding the spring concept. So read and see how the spring concept in arms works for the majority of simple spring setups today.*

## **Bob Weber's spring formula – *Made simple***

This article was put together by Bob Weber who has been very gracious for lending us his time to writing this article. He has written a less complex formula for understanding how the spring system works and how to choose the right spring for the right system. The article might seem a little too daunting at first but don't worry, just read on and go over it several times if you have to. If you are still in doubt please visit the HBS forum at <http://homebuiltstabilizers.com>.

### ***Introduction***

*One of the more difficult tasks in the design of a stabilizer arm is determining the parameters of the spring(s) that are required to support the weight of the sled and camera. The Homebuilt Stabilizer web site has links to several good spreadsheet programs that can be used for this process but are most useful to users that have a good understanding of the principles involved. This paper is written to provide some background on the mathematics involved and to give the reader a better understanding of principles that apply to stabilizer arm design.*

*The mathematics used in this paper is primarily simple algebra with just a little trigonometry as required. In some cases, the reader is referred to the Appendices for more detailed explanations but these are not required for understanding of the fundamentals presented. All*

*of the intermediate steps in solving or manipulating the equations are included for those not familiar with the math even though it may be tedious for some to read.*

### **Basic Stabilizer Arm**

*The basic stabilizer arm consists of 4 elements arranged in the form of a parallelogram with a spring loaded diagonal element to support the weight of the camera and sled. Figure 1 shows a schematic of a stabilizer arm up at an angle ( $a$ ) with horizontal elements ( $X$ ), vertical elements ( $Y$ ), a diagonal ( $D$ ) and supported weight ( $W$ ) attached at the end. Two of the arm elements that are shown with dashed lines do not contribute to the support of  $W$ , hence, they are irrelevant to the analysis and are ignored.*

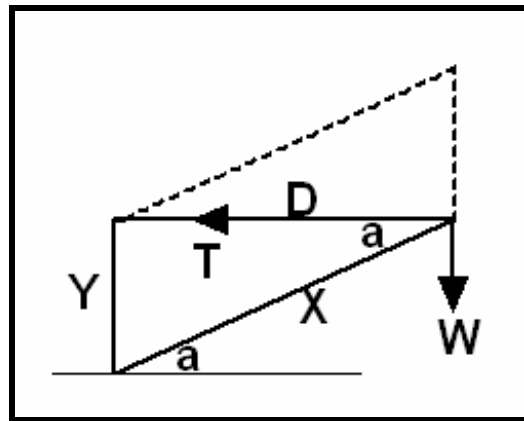


Figure 1

*The line marked  $X$  is the distance between the pivot points on the arm's horizontal element and  $Y$  is the distance between the pivot points on the arm's vertical element.  $D$  is the diagonal element that is under tension ( $T$ ) and that supports the weight  $W$ .*

*Static devices, devices that are not moving, can be analyzed by summing the moments, or torques, produced by all of the forces acting on the object and equating them to zero. In Figure 1, force T acts to the left pulling the arm in the counter clockwise direction. This force produces a torque, or moment, that is mathematically equal to T times Y. W is shown pulling down on the arm which produces a clockwise torque and is mathematically equal to W times D. Since the arm is not moving, these two opposing torques must be equal. In equation form this is:*

$$TY=WD$$

(1)

*Equation (1) was derived using Figure 1 which is drawn with the diagonal horizontal; however, it is equally true for any angle of the arm. Proof of this requires the use of slightly more complex math using trigonometry and is provided in Appendix B.*

*Dividing both sides by Y gives:*

$$T=WD/Y$$

(1a)

*Equation (1a) says that the tension in the diagonal due to the supported weight is equal to the weight multiplied by the ratio D/Y. This tension must be equalled by an opposite force that is provided by the tension in a stretched spring and can be expressed mathematically as:*

$$T=RS+P$$

(2)

where  $R$  is the spring rate,  $S$  is the amount the spring is stretched and  $P$  is the amount the spring is preloaded. Preload is produced by removing  $W$  and allowing the arm to move up to its maximum angle, then adjusting the spring mounting hardware to stretch the spring to produce the required preload tension. Preload should not be confused with the spring's initial tension which is one of the specified elements of a spring and will be discussed in Example 1.

When the arm is in the full up position the length of  $D$  is at a minimum,  $D_{min}$ . When  $W$  is applied the arm lowers to its equilibrium position and the diagonal will be at some length,  $D$ . The difference between these two lengths is the amount the spring stretches. Replacing  $S$  with  $D-D_{min}$ , equation (2) becomes:

$$T=R(D-D_{min})+P$$

(2a)

In order for the arm to be in equilibrium the tension due to the spring force must be equal to the tension due to the weight. This can be shown by setting equation (1a) equal to equation (2a).

$$R(D-D_{min})+P=WD/Y$$

(3)

These basic equations serve as the foundation for the applications which follow on the following page.

## Single Diagonal Spring Design

Figure 2 shows a simple stabilizer arm in the normal horizontal position. The design of such an arm involves determining the length of the arm elements and selecting a suitable spring that will support the weight of the sled and camera.

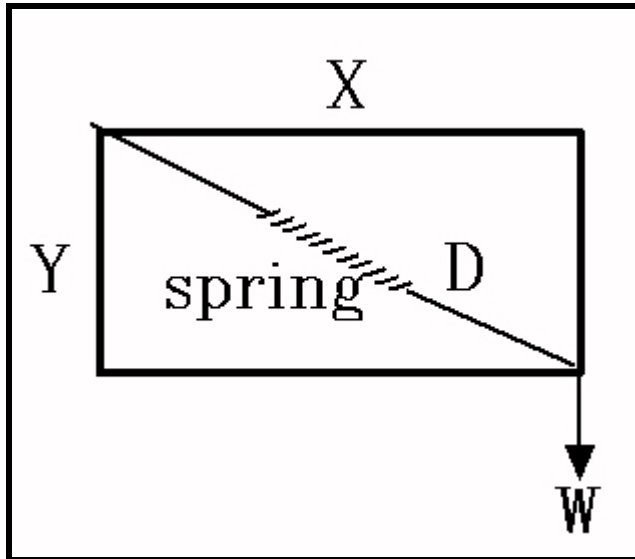


Figure 2

The length of the diagonal of a parallelogram at any angle is derived in Appendix A. The results are:

$$D = \sqrt{X^2 + Y^2 - 2XY \sin(a)} \quad (4)$$

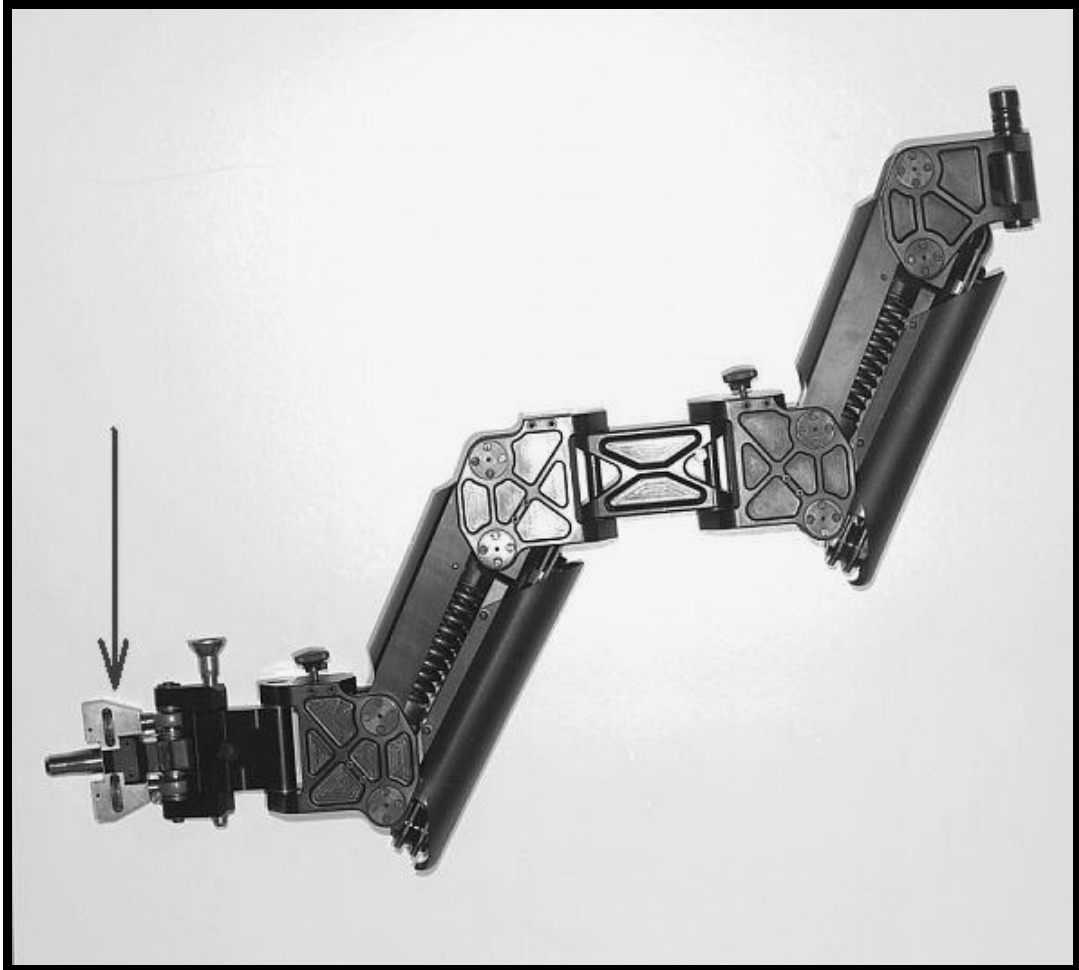
Where the angle ( $a$ ) is zero and the arm is in the horizontal position as shown in Figure 2. Setting ( $a$ )=0 gives the equation for  $D$  in Figure 2 as:

## Vest Building Tips

In keeping with the same profile we attack the vest with the same methods we use on the arm - *Solidity and stability*.

1. The vest has to be strong; yet light to fit the body like a piece of clothing and at the same time provide comfort to the operator.
2. The vest has to sit tightly; yet comfortably on the body while carrying the rig.
3. The purpose of the vest is to distribute the weight.
4. The rig has to remain steadfast at a fixed point on the arm bracket at the vest area while the operator is carrying the rig.
5. To provide the comfort needed to the operator, the combination of padding and light metal materials should be weighed so that both provide enough comfort and stability to succeed in doing its job. Remember comfort to the operator is essential as this will help prevent some of the quick fatigue associated with badly constructed vest when operating a rig for longer period of time.
6. Another thing to remember is that on the real Steadicam® vest there is an arm adjustment mechanism that determines the

This is half of the mechanism that makes up for part of the entire socket block. The other half of that block is on the arm. It is called the male socket block. *See pic below:*



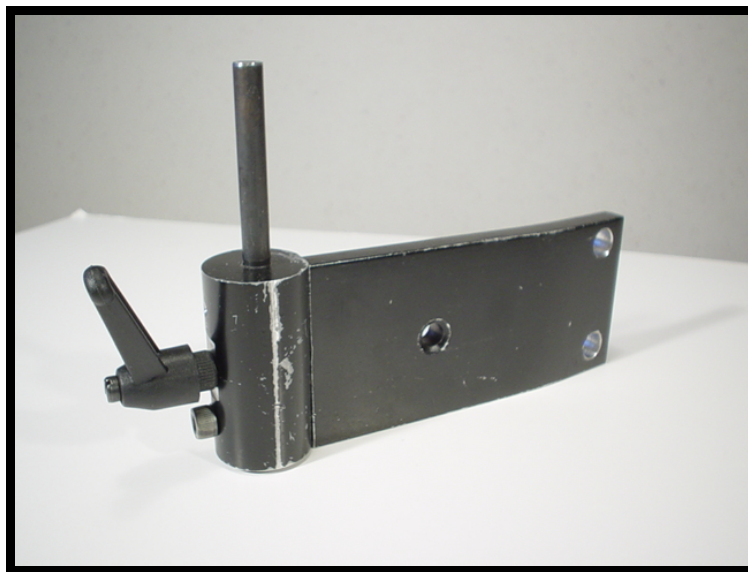
*The red arrow indicates the male part of the socket block*

*The Steadicam® Ultra arm*

*(Courtesy of Tiffen)*

Now when these two parts meet they can be adjusted by the operator to provide a stability point where the rig would seem to hover at a particular point in space. *Personal adjustment* is the key here for every operator and this makes it much easier to control the pitch of the arm. *See pages 58 & 59 for examples of the socket block.*

Being a very useful mechanism to have on your stabilizer vest, it also is one of the difficult parts to re-create. So if you decide you want these features, then you will have no choice but to have one probably machined for you, using very strong materials to overcome stress while operating the rig in real world instances. If this is not something that you might want to dive into then just go with the simple 'one-pin' adapter found on most low budget rigs. *See pic below:*



*A homebuilt arm adapter st*

