Putting The Bite Into Weak Drum Brakes

by Tillmann Steckner

For a long time I have been puzzled why the wheel brakes of some gliders are next to useless when others are fairly effective. I finally decided to investigate this "pressing" issue when I recently got to fly a glider which is the favored choice of some of the best competition pilots. While I was greatly impressed by the performance of this ship, I felt rather embarrassed when I overshot my intended stopping point during the landing by what must have been 50 feet or even more. Good thing I did not head for the trailer as I often do, because I would have been "loading" the latter, wings and all, without ever getting out of the cockpit.

When I was doing the pre-flight check I was wondering how the original tire of the glider could look almost new after some 600 landings! I now knew why. As I could find nothing wrong with the brake adjustment or the external activating mechanism after my overshot landing, I decided to remove the entire wheel assembly for closer inspection. To my surprise, the brake linings had at most 1 mm wear on them. Given the known number of landings, this was clear evidence that these brakes were simply not doing their job.

Because most of the drum brakes which have been used on gliders of German origin in the last three or four decades, or even longer, are of a similar design (the wheel-brake assemblies are usually supplied by an outside source), it raises the question of why some are more efficient than others. Presently, I can think of only three reasons:

1. Differences in the drum diameter.
2. Differences in the brake lining compound.
3. Differences in the external activating mechanism (e.g. spoiler-coupled, stick-lever activated and heel brake).

In respect to item 1 above, it should be pointed out that the wheel, whose brake assembly will be the specific subject of our study, has a rim size of four inches. Obviously a rim size of say five inches, will allow for a larger and more powerful brake. But as I intend to demonstrate, wheel size alone cannot account fully for the deficiency of braking power I experienced in the above case. Furthermore, in the context of this article, it should be noted that the dimensions given here for the modification of a drum-type sailplane brake were based on the wheel already referred to. This means that if someone were to use the information provided by this article to modify a brake designed for a different rim diameter, he ought to exercise his own judgment as to whether dimensions other than those listed in the text are being called for.

My first step in solving the problem at hand was to inquire with the maker of the sailplane in question as to what could be done to increase the performance of the brake. (I now have good reason to believe that I am not the first pilot to have approached them with this request.) The reply I received was of no help. The engineer writing on behalf of the chief designer stated that:

a) He could only repeat what was already said on this score in the owner's manual, namely that the wheel brake was to be considered as a "Notbremse", i.e. an emergency brake.

b) The writer also claimed that the ratio between the glider's weight and the wheel size would preclude the design of a more powerful brake.

I had great difficulty in accepting either one of these statements. As to point (a), the term "emergency brake" is a misnomer in the present case, as it is normally applied to a back-up brake. Automobiles are required by law to have two independent hydraulic brake systems, plus an emergency brake, more commonly referred to as a "parking brake." Since a sailplane has only one braked wheel, there cannot be an "emergency brake" in the accepted sense. Furthermore, if one is really in "Not" (translated "dire need"), what is the use of an emergency brake which is inherently incapable of dealing effectively with an emergency? At its present performance, the brake in question would be totally useless in a downwind landing in a small field, let alone one inclined the wrong way. (I described such a hair-raising outlanding in my flight story, "An Unforgettable Day at the Ridge"," *Soaring*, August 1995.)

As to item (b) above, having had some professional experience with automotive and motorcycle brakes, I challenged the claim that the wheel size of gliders does not allow for a stronger brake. To begin with, hydraulically activated disc brakes should have been introduced as standard equipment decades ago on all sailplanes as they were on even medium-priced motorcycles. The cam-activated drum brake still used on most gliders today is automotive technology borrowed from the

1930s. The last one of its kind which I have personally encountered on a motorcar was in the early 1950s on a British Ford Prefect. It was a terrible brake and a nightmare to maintain and adjust.

In the last few months, I have had numerous discussions with fellow glider pilots and was astonished to find that many of them - owning sailplanes of various manufacture - very much shared my frustration in coping with totally inadequate braking forces. I also heard that some of them had tried their own modifications, but apparently only with limited success. This is how I came to write this article.

In the remainder of this text I shall show how even cam-activated drum brakes can be modified to produce some real bite. I do not take credit for discovering the basic principle involved because the system was introduced by the Bendix Corporation in the early 1950s. Both GM and Ford used this type of brake, which became known as the "self-energizing brake," on all of their passenger cars.

To carry out our modification - which can easily be performed with basic tools - we should first examine why the brake under study is so inefficient. For this purpose the reader is referred to Figure 1.

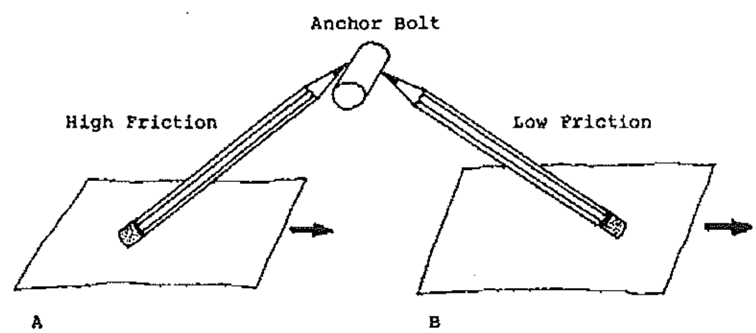

FIGURE 2. A simple demonstration how the direction of brake drum rotation in relation to a fixed locating point of the brake shoes (e.g. an anchor bolt and/or an activating cam) affects the effectiveness of the brake shoes in generating friction.
In the above diagram the pencil on the left (case A) represents the primary brake shoe, and the one on the right (case B), the secondary brake shoe. The two pieces of paper represent the inner surface of a brake drum.

When the brake is applied by means of the brake cable, the brake cam is rotated counter-clockwise by a few degrees. This forces the two brake shoes into the brake drum at the top, and to an increasingly diminishing degree at the bottom as well. The anchor bolt prevents the brake shoes from being taken around with the brake drum. The incremental reduction of braking force of the two brake shoes towards the anchor bolt is one of the shortcomings of this type of brake. Most importantly, though, the secondary brake shoe on the right tends to resist the outwardly directed pressure of the cam at the top, because the rotating brake drum (which turns counter-clockwise in the example chosen) tries to force the upper end of this brake shoe in the opposite direction of cam action. The converse applies to the primary brake shoe on the left as the rotation of the brake drum reinforces the pressure exerted by the cam as soon as the brake lining touches the drum. In fact, at that moment the entire brake shoe tries to rotate with the drum, and thus it is vigorously pushed against the anchor bolt at the bottom.

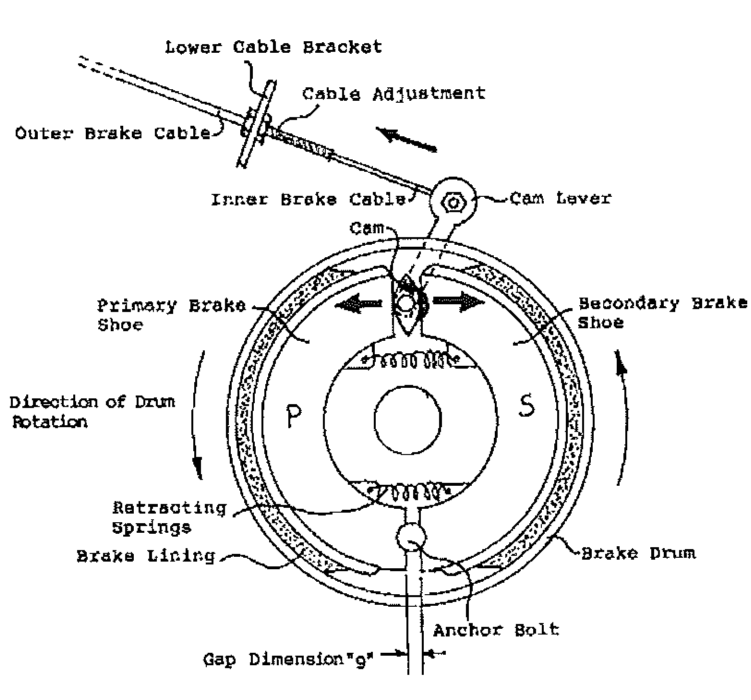

FIGURE 1. A schematic representation of a cam-activated drum brake with a fixed anchor bolt.
Note: The gap dimension "g" given above relates to the modification discussed later in the text.

The different forces acting on the primary and secondary brake shoes can be demonstrated by resting the rubber tip of a pencil on a piece of paper (Figure 2). The pencil represents the brake shoe and the paper takes the place of the brake drum. When the paper is pulled backwards against the extended rubber tip (case A), braking friction is high. However, when it is pulled in the opposite direction (case B), there is very little friction.

It is now clear why the primary shoe is much more effective with this type of brake than is the secondary brake shoe. Needless to say, if the rotation of the drum were reversed, so would be the roles and effectiveness of the primary and secondary brake shoes. (This explains why most parking brakes have very little braking force when the vehicle is moving backwards.)

Several decades ago someone rather clever came up with a very simple modification which almost doubled the performance of the drum brake without the use of a vacuum booster. That bright mind must have asked himself, "What if we flexibly join the two brake shoes at the bottom and allow them to shift, rather than holding them rigidly in position?" On the Bendix brake, this was done by discarding the anchor bolt and replacing it with a jointed link (Figure 3). This would permit the primary brake shoe to transfer the torque generated by the brake drum to the secondary brake shoe, and thereby cause it to be pushed against the brake drum with even greater force than the primary brake shoe. This principle is referred to as "servo-action" and the type of brake utilizing this principle became known as the "self-energizing brake." This leaves us to wonder why the human mind first thinks of complex solutions to eventually arrive at the simplest one only after the most concentrated effort.

The general approach to our modification is now clear. We must allow the brake shoes to float at the bottom, leaving the cam at the top to do double-duty as an anchor bolt, and permit the primary shoe to push the secondary shoe into the drum in order to convert our brake into a self- energizing one. There are two ways to accomplish this. At the time of writing this article, I learned that some pilots solved the problem by elongating the anchor bolt hole so the anchor bolt can shift sideways. There are several reasons, though, why this solution seems questionable:

1. It introduces a bending moment on the anchor bolt as it is supported only at one end by the brake backing plate.
2. The shifting of the anchor bolt will sooner or later cause some wear on the brake backing plate which is made of aluminum.
3. Items 1 and 2 above may make the operation of the brake unpredictable.
4. The elongated bolt hole could allow the entry of dirt and moisture, thereby causing corrosion and further wear.
5. It may require a longer anchor bolt for proper locking.
6. The alterations may be sufficiently invasive to require certification.

The modification outlined below would appear safer and easier to carry out. It requires relatively little skill and only basic tools. It has none of the shortcomings listed above. In fact, the proposed modification merely suggests the insertion of a small spacer between the anchor bolt shoulders of the two brake shoes and the removal of about .12 inches or .30 cm of material from the bolt groove at the lower end of the primary brake shoe. If I had to do the job a second time, I could probably complete it within two hours.

Here is how I proceeded:

1. Before I removed the primary and secondary shoes (which I inscribed "P" and "S" respectively), I measured the gap that separated them at the bottom. I also drew a reference line on the brake shoes around the anchor bolt (Figures 1 and 4).
2. I clamped the primary shoe in a vise with its two shoulders facing up. With a round file just slightly smaller in diameter than that of the semicircular groove which normally abuts the anchor bolt, I deepened this groove by about .12" or .30 cm (Figure 5). To ensure that the groove would remain perfectly perpendicular to the brake shoe as a whole, I frequently placed a suitably sized steel rod into the groove. To check on the correct depth of the groove, the brake shoe was put into position on the brake backing plate. The proper dimension is easily determined by drawing further scribe lines around the head of the anchor bolt (Figure 4).
3. The gap spacer shown in Figure 4 was prepared from two pieces of mild steel which were joined by means of silver-soldering. This technique, when applied to a straight butt joint, results in a stronger weld than arc-welding. As the silver flows between the joint on its own when it is brought up to the

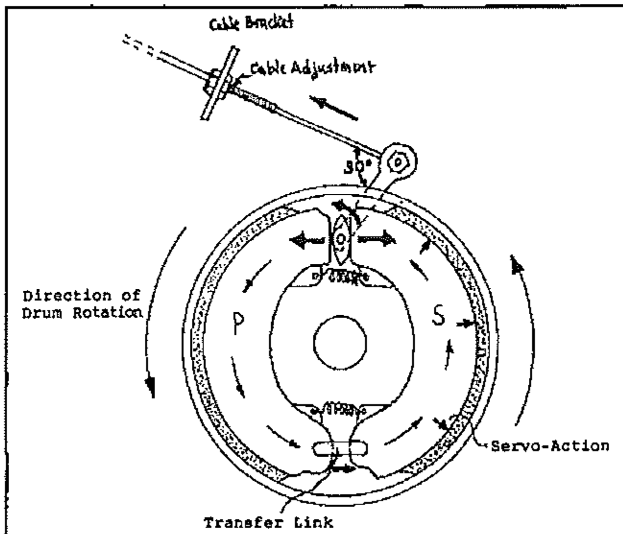

FIGURE 3. A schematic representation of a cam-activated self-energizing type drum brake employing a flexible transfer link in place of a rigid anchor bolt for the purpose of transmitting the braking torque of the primary brake shoe to the secondary brake shoe.

The transfer of the braking torque, referred to as "servo-action", almost doubles the performance of this type of brake over that of a brake using a rigidly fixed anchor bolt as illustrated in Figure1. The increase in friction generated by the secondary brake shoe is so high that brakes designed as self-energizing systems use a brake lining for the secondary shoe which is both longer and harder to ensure that the two linings wear at the same rate. This means that the modification described in this article will likely cause the lining of the secondary shoe to wear out well before its counterpart. In the event that the old brake linings need replacing anyway, one could have a qualified brake shop make the necessary adjustments in length and material of the linings at the same time as such a modification is undertaken.

N.B. With the brake applied and the wheel locked, the brake cable and the cam lever must be at a right angle as shown above. If this is not the case, disconnect the brake cable at the lever and reposition the lever on the splined shaft of the brake cam. After reconnecting the brake cable, adjust the latter for the new lever position.

right temperature, it also results in a very straight and clean corner of the L-shaped spacer. This is an important requirement if the spacer is to fit squarely against the respective shoulder of the secondary brake shoe.

4. The gap spacer is now brought down to the exact size and fitted to the secondary brake shoe (Figure 6). To determine the thickness of the actual spacer shim (i.e., the short leg of the L-shaped gap spacer), .002" (.005 cm) was added to the gap size measured in step 1 above. This addition in size was deemed sufficient to absorb the full thrust load transmitted by the primary brake shoe to the secondary brake shoe, while at the same time leaving the general geometry of the brake undisturbed. The same consideration was applied to deepening the anchor bolt groove of the primary brake shoe by only .12" (.30 cm). If the wear of the brake linings would reach a point where this would prove insufficient, the groove can easily be deepened further. From memory, I recall that the spacer shim ended up measuring around .070". The mounting plate - the long leg of the gap spacer - was roughly .080" thick. Given the shape of the lower end of the secondary brake shoe and the thickness of the brake linings, this was judged to give sufficient drum clearance, even in the event of lining wear to the permissible minimum tolerance. During the all-important fitting operation, close attention was given to the width of the spacer shim, as it must on no account touch or interfere with the anchor bolt. A clearance of about .002" or .005 cm would appear adequate (Figure 6).
5. The installation of the counter-sunk retainer screw also requires great care. If this step is carried out accurately, no shearing forces will be transmitted to it when the brake is applied. First, the center of the retainer screw hole was marked with a center punch. The hole should end up as much as possible in the middle of the gap spacer's mounting plate, but at the same time its extension into the brake shoe shoulder in the step described below, must bypass the semicircular anchor bolt groove by about 1/16" or 1.6 mm (Figure 6). This will allow sufficient "meat" in this critical area when a thread is cut into the brake shoe hole yet to be drilled. Second, a pilot hole was drilled into the spacer with a 1/16" drill bit. This should be done with a drill press equipped with a vise. Third, the secondary brake shoe was clamped upright into the vise of the drill press with its lower end pointing upwards. The flat surface of the brake shoe on which the gap spacer is to be mounted must be perfectly horizontal. Next, the gap spacer was put into position on top of the brake shoe. Using the pilot hole in the spacer as a guide, the 1/16" hole was extended all the way through the brake shoe (Figure 6).
6. With the gap spacer removed - but the brake shoe left undisturbed in the vise - the 1/16" hole drilled in the previous step was now enlarged to a diameter of 7/64". Again, the hole was drilled all the way through the brake shoe as this facilitates the ejection of metal chips during the tapping operation described below. (When using small tap sizes on aluminum, these chips can easily ruin the thread as they tend to stick to the tap when the latter is withdrawn from the hole.) To allay any fears regarding the long hole, it does not weaken the brake shoe in any significant way. This assumes that the brake shoe is made of a strong aluminum casting as is the case with the brake assembly shown in Figure 7.
7. The thread for the retainer screw was cut with a 6-32 tap. For the reasons already stated above, it is wise to reverse the tap by about half a turn for every two turns of newly cut thread. If the tap is long enough to come out at the other end of the hole, any aluminum chips stuck to its tip should be dislodged with a pointed tool before reversing the tap for extraction.
8. To receive the 6-32 retainer screw which will hold the gap spacer in position during assembly, the 1/16" pilot hole drilled in step 5 was enlarged with a 9/64" drill bit. This was followed up by beveling the hole with a chamfering bit to accommodate the head of the countersunk retainer screw.
9. To ensure a firm and foolproof attachment of the gap

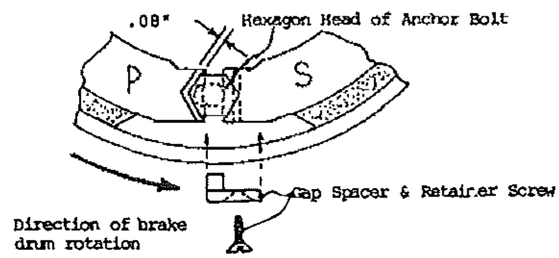

FIGURE 4. Detail of the modified anchor bolt area. Note the two scribe lines on the left side of the hexagon head of the anchor bolt. The first one, which was drawn around the bolt head before the material was removed from the shoulder groove, is barely seen at the 7 and 11 o'clock corners of the bolt head. The second parallel scribe line would also start to disappear if we took advantage of the now elongated shoulder groove (dotted semicircular line) and were to push the primary brake shoe against the shaft of the anchor bolt. The dimension .08" shows the amount of travel that the brake shoes can shift from left to right, thus permitting the transfer of brake torque from the primary brake shoe to the secondary brake shoe. The dimension of .08" (.20cm) was chosen to permit an equal amount of wear on the lining of the secondary brake shoe. In the event that the effective braking forces should suddenly deteriorate, or the pilot must apply a much greater effort to achieve tne same results, it is a sign that the secondary brake shoe lining has worn down. If inspection should reveal the secondary brake lining to be still thick enough to tolerate an additional wear of, say, .08", the groove can be elongated further by an equal amount. Given these considerations, the modification also provides a convenient means of monitoring brake lining wear, as any changes in the rate of deceleration during braking will alert the pilot to the fact that service is needed long before serious damage, such as scored brake drums, does occur.

In the above diagram the gap spacer was removed for reasons of clarity. The large hexagon head of the anchor bolt would otherwise obstruct a clear view of the constructive detail under discussion.

spacer to the secondary brake shoe, its inner surfaces facing the shoulder of the brake shoe was coated with an epoxy-like compound sold under the brand name "JB Weld." This compound has excellent bonding qualities (especially with metals) and its slow-curing variety can resist temperatures up to 300 degrees F (150°C). The compound will also serve to secure the retainer screw. When the retainer screw - which should be about 3/8" or 1 cm long - is tightened, the compound will ooze out all around the edges. It should be noted that both the screw and the bonding compound are merely used for retention of the gap spacer. If the latter is fitted properly, the thrust forces directed against it during braking will be transmitted directly to the shoulder of the secondary brake shoe without subjecting either the retainer screw or the bonding compound to any shearing forces.

10. At this point the secondary brake shoe was held in position on the brake backing plate to check if any future wear of the brake linings could cause the gap spacer to come into contact with the brake drum. Although the photograph provided in Figure 7 is lacking in clarity, close examination of the area in question will show that this could not occur even if the linings would be worn right down to the metal of the brake shoe. If this cannot be seen clearly in the reproduction of the photograph, the reader should follow with his eyes the rear edge of the primary brake shoe along the wide groove of the brake backing plate. If this groove is used as a reference, it will confirm that there is indeed sufficient clearance. The reason the mounting plate of the gap spacer lies so far below the brake linings and well clear of the brake drum is the fact that the brake shoes themselves are flat in the area of the anchor bolt, rather than curved, as is the case with the surfaces to which the brake linings are bonded.
11. After completing the above check, all moving parts and sliding surfaces were lightly coated with white lithium grease and the brake shoes reinstalled. I then pushed the two brake shoes repeatedly from one side to the other by hand to see if they would shift freely in a straight line about the anchor bolt.

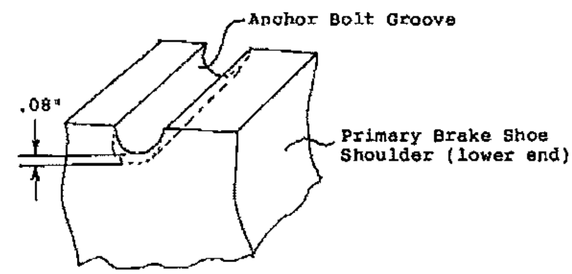

FIGURE 5. Detail of the primary brake shoe shoulder facing the anchor bolt (for reference see Figure 4). This diagram shows the semicircular anchor bolt groove and the amount of material which was removed from the primary brake shoe to carry out the modification. It is essential that the groove is filed at a uniform depth along its full length and that its diameter is not enlarged. To check on both, a steel rod of the same diameter was laid into the groove after every five file strokes or so. It should be noted that the deepening of the anchor bolt groove in the primary brake shoe by only .08" (2 mm) was based on the fact that the brake linings in question showed practically no wear, i.e., in the fully retracted position the diameter across the two brake shoes was about 1/16" or 1.6 mm less than the inside diameter of the brake drum. On brake shoes which have more drum clearance than this, but which still appear sufficiently thick, it may be necessary to deepen the groove by .12" (3 mm) or even more.

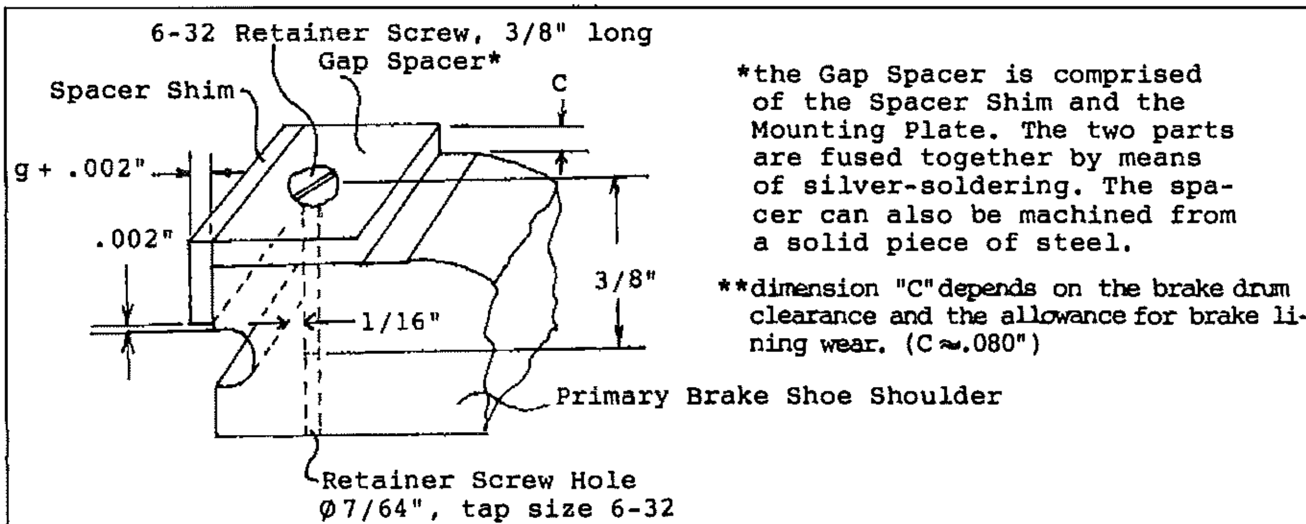

FIGURE 6. Detail of the primary brake shoe shoulder shown in Figure 5 with the gap spacer installed. The thickness of the spacer shim is g+.08" or g+.20cm, where dimension "g" is derived from the gap measurement which was taken in step 1 of the modification procedure. (For reference see Figure1.) Note that the free edge of the spacer shim is .002" (.005 cm) shy of the anchor bolt groove to avoid interference with the anchor bolt. Also note that the hole in the brake shoe shoulder for the retainer screw must clear the anchor bolt groove by a minimum of 1/16" or 1.6mm.

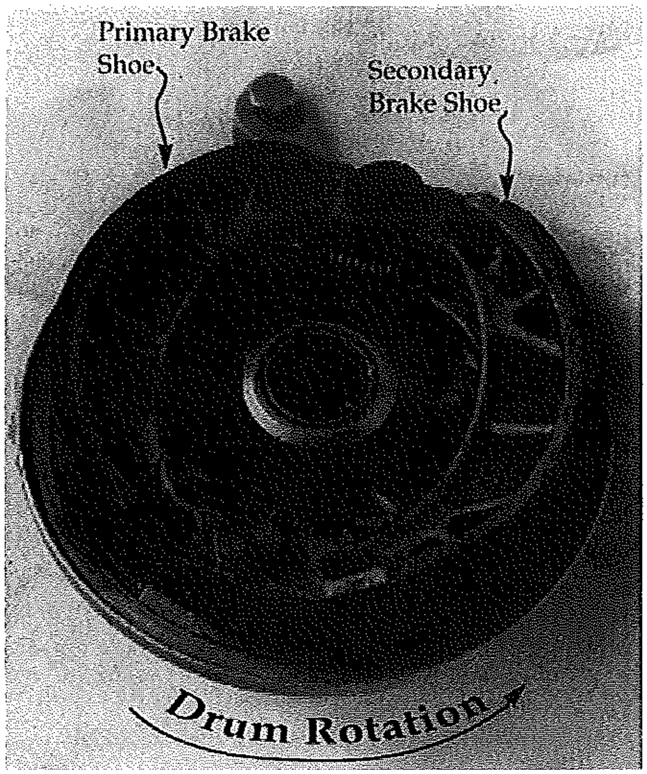

FIGURE 7. The brake assembly discussed in this article after the completion of the modification
The gap spacer can be seen at the right of the anchor bolt at the bottom of this picture.

They did so with very little resistance within the range of the two parallel scribe lines I had drawn around the head of the anchor bolt earlier in order to measure the planned 2 mm shift(Figure 4).

Needless to say, by now I had become quite anxious to find out if the modification would indeed bring the expected results, and do so without any undue grabbing. I took the glider up for a spin – not a literal one, though – and carefully planned my landing. I decided it would be best to first let the ship settle down nicely and then work the wheel brake with gradually increasing pressure, building up to a real emergency stop as if I was in dire "Not". There was no grabbing, just smooth and effective deceleration, and when I really stomped on it, the tail came up and the nose of the plane went right into the grass.

Recently, I talked to the pilot who flew the ship since it was new and who had just come back from a competition. When I asked him if my efforts had done any good, he replied, "Super! Just as you told me. When I used full brakes the tail came up, and the nose went down."

Of course normally no one would brake that hard, but if you found yourself staring at a tree, a wire fence or a downhill run, I'll bet you'd be apt to find yourself saying, "Give me a "break!" ■

***About the author:** Tillmann immigrated with his wife Marianne from Germany to Canada in 1953. He eventually became an automotive instructor and he holds a patent on a rotary engine design. He has a B.A. in English and Psychology, and has published several books, shortstories and articles. His fl;ying career started in 1987 and he completed his three diamonds four years later.*

An Update:

I only recently learned from an American airframe mechanic that a number of glider pilots tried to solve the problem of weak wheel brakes by cutting off the threaded shank of the anchor bolt altogether, thereby allowing the latter to shift in any direction. He showed me a whole handful of botched parts, among them an anchor bolt cut in half and a brake on which the lower lobe of the brake cam was completely filed off!

These ill-conceived alterations show how desperately some pilots sought to improve their wheel brake. These brakes had to be restored to their standard configuration because they did not allow for a gradual application of braking forces; they would typically grab and sometimes not release until the aircraft came to a complete stop.