DC Blower Motor Replacement

By ERIC WILDE

This article describes how to replace a direct-drive, DC blower motor, commonly found powering the main ceiling blower for the airconditioning and heating systems on older, DC railway cars.

Older, DC powered railway cars often had a ceiling mounted, direct-drive airconditioning and heating blower, consisting of one or two squirrel-cage blowers, directly driven by a DC motor. In addition to being direct-drive, the two-wheel blowers usually required a double-shaft motor.

The motors used to operate these ceiling blowers often ran at unusual speeds (mine was 1250 RPM) as well as being double-shaft. To find a replacement motor that will run on 240V AC, 60 cycles, is often difficult or expensive, if not impossible. Rewinding the existing motor for AC operation may be possible but is usually prohibitively expensive.

This article discusses how to replace such a motor with a commonly available, 1725 RPM, AC motor. The trick is to build an assembly that supports the blower wheel or wheels and the shaft that they are mounted to. The shaft is then driven by a pair of pulleys and a belt that are chosen to maintain the original speed when driven by a 1725 RPM motor.

Note that it is important not to change the speed of the blower because this has a dramatic effect on the horsepower required as well as the CFM produced. Since horsepower changes as the cube of the change in shaft speed, it is very easy to overload the motor by making small shaft speed changes.

Essentially, we will first work through an example that shows the technique used to figure out the replacement motor, pulleys and belts required. Then fabrication information will be presented for the motor/blower mounting assembly.

Original Motor

32V DC, 1250 RPM, 1 HP. 3/4” x 30” dual shaft. Odd frame (i.e. not NEMA) size.

Direct-Drive Replacement Motor

Assuming, for the sake of argument, we want to use a direct drive motor (if we can get a dual-shaft motor). We must pick a speed that is available in 60 cycle AC. This is either 1725 or 1150 RPM. The lower speed motor will probably not give enough air flow so the higher speed motor should be used. The calculations are:

$$\mathbf{RPM_{NEW}} = \frac{\mathbf{CFM_{NEW}}}{\mathbf{CFM_{OLD}}} \times \mathbf{RPM_{OLD}} \Rightarrow$$

$$\frac{\mathbf{RPM_{NEW}}}{\mathbf{RPM_{OLD}}} = \frac{\mathbf{CFM_{NEW}}}{\mathbf{CFM_{OLD}}} = \frac{1725}{1250} = 1.38$$

$$\mathbf{HP_{NEW}} = \left(\frac{\mathbf{CFM_{NEW}}}{\mathbf{CFM_{OLD}}}\right)^3 \times \mathbf{HP_{OLD}} \Rightarrow$$

$$\mathbf{HP_{NEW}} = 1.38^3 \times 1 = 2.628 \times 1 = 2.628\,\mathrm{HP}$$

It is probably impractical to purchase a 3 HP, dual-shaft motor. In addition, the air flow will increase by 1.38, as will the noise. A more practical solution is to replace the direct-drive blower with belt drive. This will allow the air flow and horsepower ratings to remain the same.

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Belt-Drive Replacement Motor

For the belt-drive replacement, we want to use the closest horsepower rated, capacitor start (squirrel cage fans require the high starting torque that only a capacitor start motor can supply), 60 cycle motor. The next, highest speed motor is 1725 RPM (it is better to reduce the speed than increase it) and 1 HP is readily available. The calculations are:

$$\text{Reduction} = \frac{\mathbf{RPM_{NEW}}}{\mathbf{RPM_{OLD}}} = \frac{1725}{1250} = 1.38$$

An "A" (a.k.a. "4L") vee-belt will suffice to transmit the 1 HP from the motor to the blower shaft. From a table of Browning "A" type cast iron sheaves (shown in Table 1), we find that the AK25 and AK34 sheaves will give the closest ratio to the one desired and, hence, the closest speed. The AK17 and AK22 sheaves would also have worked but I thought that the AK17 sheave was too small for my purposes.

$$\frac{3.2}{2.3} = 1.39 \Rightarrow \frac{1725}{1.39} = 1241\,\text{RPM}$$

The new speed of the blower, 1241 RPM, is almost exactly the original speed of the blower so that the airflow generated and horsepower requirements will be identical. In point of fact, the motor is slightly overrated, due to the reduction in shaft speed which will more than compensate for the friction of the drive belt.

From the room available in the blower compartment and the general layout of things, it was determined that the motor shaft should be offset from the blower shaft by approximately 7-1/2".

You will have to determine this offset empirically but it isn't too hard. You can set the blower up on the floor and take a few measurements using the motor, sheaves and shafting that you intend to use. The measurements don't have to be dead accurate. There is room for adjustment after the fact (there had better be because the belt will stretch a bit as it wears).

Motor Sheave			Blower Sheave	
Model #	A-belt Pitch Diameter	Pitch Dia. x 1.38	Nearest A-belt Pitch Diameter	Model #
AK17	1.5"	2.07"	2.0"	AK22
AK20	1.8"	2.484"	2.3"	AK25
AK22	2.0"	2.76"	2.6"	AK28
AK25	**2.3"**	**3.174"**	**3.2"**	**AK34**

Table 1: Browning "A" Sheaves Meeting Requirements

I constructed this table by perusing the Grainger catalog and selecting several candidate sheaves for the "Motor Sheave" column. I filled in the "Pitch Diameter" column from the catalog. Then, I calculated the values for the third column by multiplying each value in the second column by our calculated reduction value (1.38). Going back to the catalog, I picked sheaves for the "Blower Sheave" columns by selecting those that had a pitch diameter that was closest to the calculated value in the third column.

That's all there is to it. You can do the same for your calculated reduction value to arrive at the right sheaves for your application.

Using the two sheaves chosen, the actual blower speed is calculated from the motor speed by substituting the sheave pitch diameters:

From the motor shaft offset and the sheave information, we can now calculate the length of the belt required. First, look up the actual outside diameter of the two sheaves chosen. This information is shown in the catalog. For the sheaves chosen, the numbers are 2.5" and 3.45" (the actual diameter of sheaves is always slightly larger than their pitch diameters).

Using the sheave diameters, calculate the circumference of each of the sheaves:

$$\textbf{SHEAVE}_{\textbf{BLOWER}} = 3.45 \times \Pi$$
$$\approx 3.45 \times 3.14159$$
$$\approx 10.8\text{" circumference}$$

$$\textbf{SHEAVE}_{\textbf{MOTOR}} = 2.5 \times \Pi$$
$$\approx 2.5 \times 3.14159$$
$$\approx 7.9\text{" circumference}$$

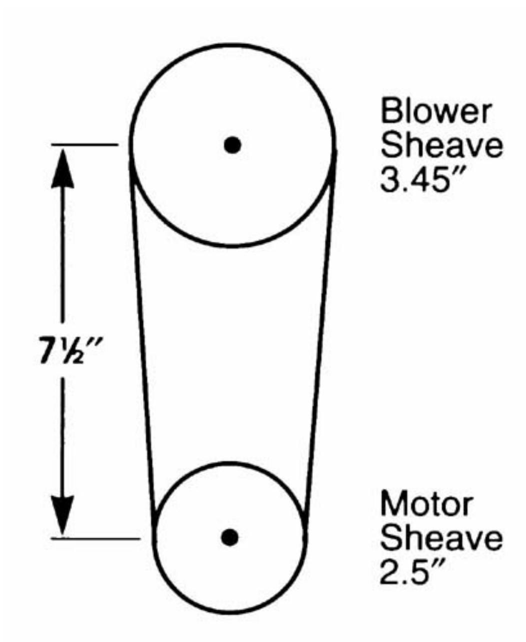


Figure 1: Sheave and belt arrangement

The sketch in Figure 1 shows the two sheaves, separated by the inter-shaft distance. From this sketch, it is evident that the belt length (given that the two sheaves are not too different in size) can be calculated approximately by:

$$\textbf{LENGTH}_{\textbf{BELT}} = \frac{\textbf{SHEAVE}_{\textbf{BLOWER}}}{2} + \frac{\textbf{SHEAVE}_{\textbf{MOTOR}}}{2} + (\textbf{OFFSET}_{\textbf{SHAFT}} \times 2)$$
$$\approx \frac{10.8}{2} + \frac{7.9}{2} + (7.5 \times 2) \approx 5.4 + 3.95 + 15$$
$$\approx 24.35\text{" length}$$

From these calculations, a 24” “A” (a.k.a. “4L”) belt was chosen.

A pair of Browning flange mount pillow blocks were obtained (VFS2-112, 3/4”) along with a length of 3/4” drill rod which was cut down to 30”. The pillow blocks can be obtained from Grainger but the drill rod is something that you will have to get at the local steel supplier or perhaps a tool distributor. Drill rod is round steel bar that is fairly hard and straight, has been ground to an exact size and polished. Perfect for making a shaft.

A list of all of the parts used is shown in

Part	Description	Part #
Motor	1 HP, 1725 RPM, ball bearing, auto protect	6K237
Sheave	2.5” O.D.	3X766
Sheave	3.45” O.D.	3X775
Belt	24” “A” belt	4L240
Pillow Block	3/4” shaft size	5X707
Drill Rod	3/4” x 36” length	

Table 2: Parts list

Table 2. For convenience sake, the Grainger part numbers are shown.

Adapter Fabrication

The motor and blower wheels are mounted on a fabricated adapter that is bolted to the original motor mounts. Figure 2 shows the general arrangement of everything.

You will have to measure the original motor base and shaft location carefully to arrive at the correct dimensions for your adapter. The idea is that the adapter bolts onto the original motor mounts and thereby locates the blower shaft exactly where the original motor shaft was.

The adapter is fabricated from 1/4" x 8" steel flat stock and one small piece of 1/4" x 1" steel strip stock. All welds should be made with E7018 to ensure high quality and good strength.

Cut the two side brackets, per Drawing 1, and drill the holes for the pillow blocks (use the actual pillow blocks purchased to lay out the holes). Note that these holes must be laid out carefully because they determine the critical location of the blower shaft. If you wish, you may drill these holes after the adapter weldment is complete but the difficulty in setting the piece up in the drill press is increased. However, the result will be much more accurate.

Cut four angle braces. To do this, cut two squares, 3-1/4" on a side. Cut these two squares in half diagonally to give four angle braces, 3" on a side (the 3-1/4" dimension assumes that you will be using Mr. Torch for the cutting and allows for the waste of the cut so that the finished size will be 3").

Cut the bottom plate, per Drawing 2, and drill the main mounting holes to fit the original motor mounts. Once again, note that these holes must be laid out carefully because they determine the critical location of the blower shaft. If you wish, you may also drill these holes after the adapter weldment is complete.

Cut a 1" x 6-1/2" reinforcing strip to be welded to the bottom plate (your length may vary depending on how the original motor was mounted and how far your new motor is located away from the original motor location).

Weld everything together, taking great care to line up all of the parts and ensure that they are square and parallel. Flame straighten the side brackets, if necessary, before welding in the angle braces.

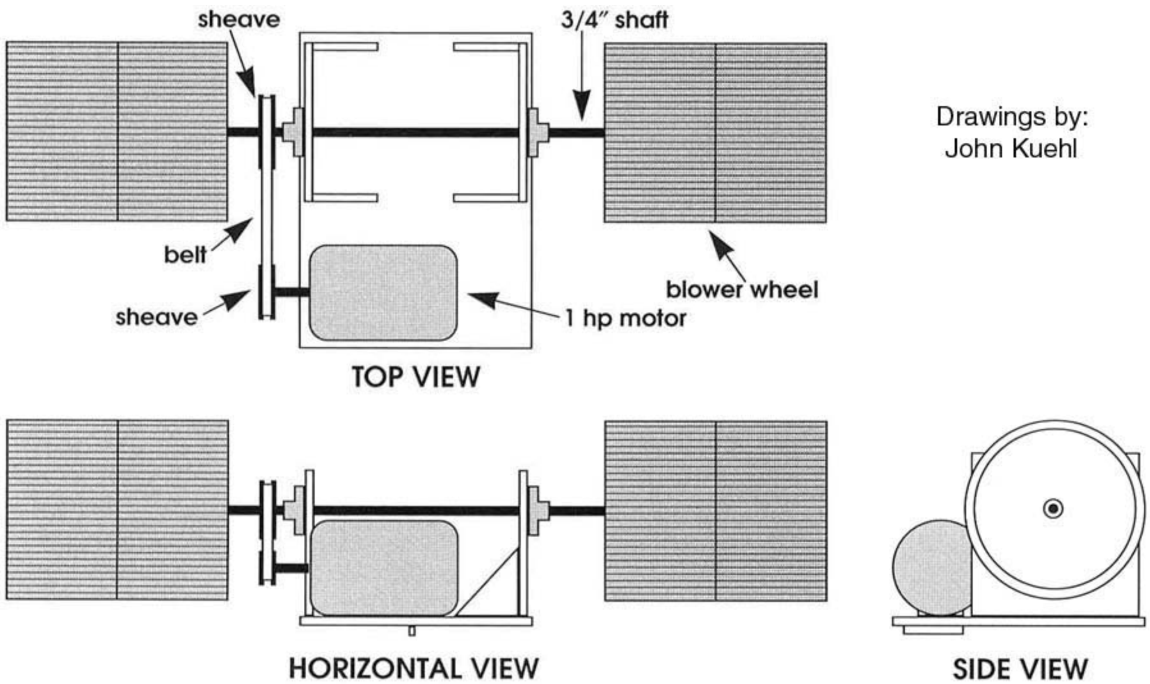


Figure 2: Motor adapter arrangement

Assembly

Bolt the pillow blocks to the two outside faces of the adapter using the correct size, Grade 5 bolts, nuts and lockwashers.

Since there is no key to transmit the power to the blower shaft, drill and tap a second set-screw hole in the blower sheave at 90° to the first.

Slide the shaft through one blower wheel and then the blower sheave. Slip the belt over the sheave now, since it may not clear the blower wheel. Continue to slide the shaft through the two pillow blocks and the second blower wheel.

Line everything up. It helps if you have the complete blower removed from the ceiling and lying on the floor (as I did) to make sure that everything is in the right place. If you don't, use the old motor as a pattern to show you where the blower wheels go and measure everything **very carefully**. Position the new motor in its correct location on the adapter with its sheave in place. Line up the belt with a straight edge.

Tighten all of the set screws well. We want them to leave their mark on the shaft.

Mark the motor mounting hole locations so that the motor may be adjusted to change the belt tension. The motor base will have long slots to allow adjustment. In general, a good location, with the new belt pulled tight, is about 1/4 to 1/3 of the way along the slot (i.e. 2/3 to 3/4 of the slot travel remains to take up belt wear).

Disassemble everything on the blower shaft. File flats on it everywhere that there is a set screw mark. A flat bastard file works well, giving a flat approximately 1" wide. A flat about 3/32" deep should do the trick.

Drill and tap the motor mounting holes for the appropriate bolts. A letter F drill and 5/16"-18 tap is suitable for a NEMA 56 frame motor (the most likely candidate).

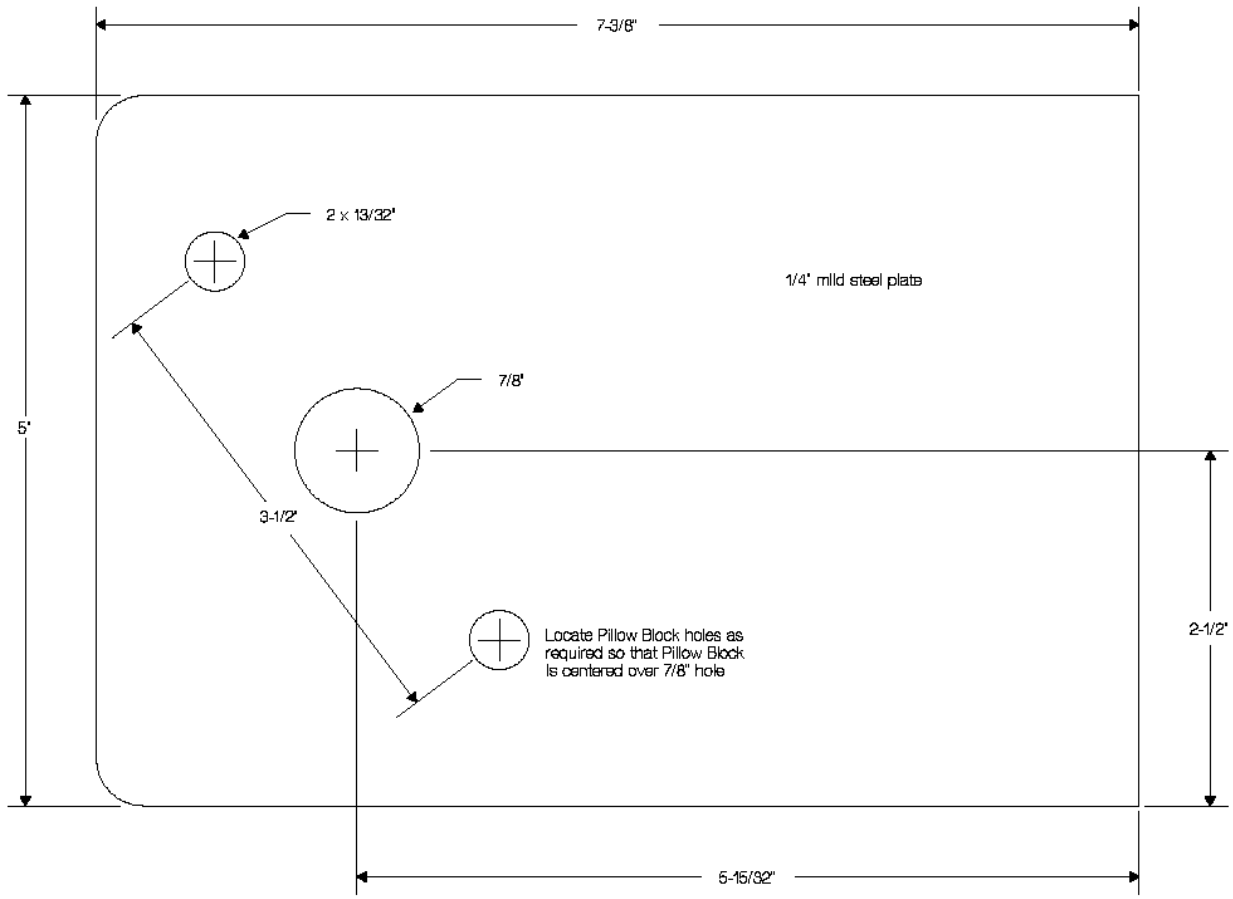
Reassemble all of the parts on the blower shaft, remembering to put the belt on at the right time. Use lock-tite on all of the set screws this time.

The blower adapter assembly may be bolted into the roof without the motor in place to reduce the risk of hernia (or brain damage, should you drop it). Once in place, the motor can be bolted to the adapter and the belt tightened. A belt stretcher helps assure the correct tension.

Maintenance

Shoot a little grease into the zerks on the pillow blocks once in a while. Oil the motor bearings, if they aren't sealed. Check the belt tension periodically or if you notice excessive belt squeal on starting and tighten as necessary.

Should the belt blow up, you can replace it, without disassembling the whole show, with a segmented belt. A 5' length of belting (will make two replacements) is available from Grainger (#5A547). A little more expensive but well worth the cost of the aggravation that would result from having to remove the blower wheels just to replace a belt.



AC Blower Motor
Replacement Side
Brackets
(2 Required)

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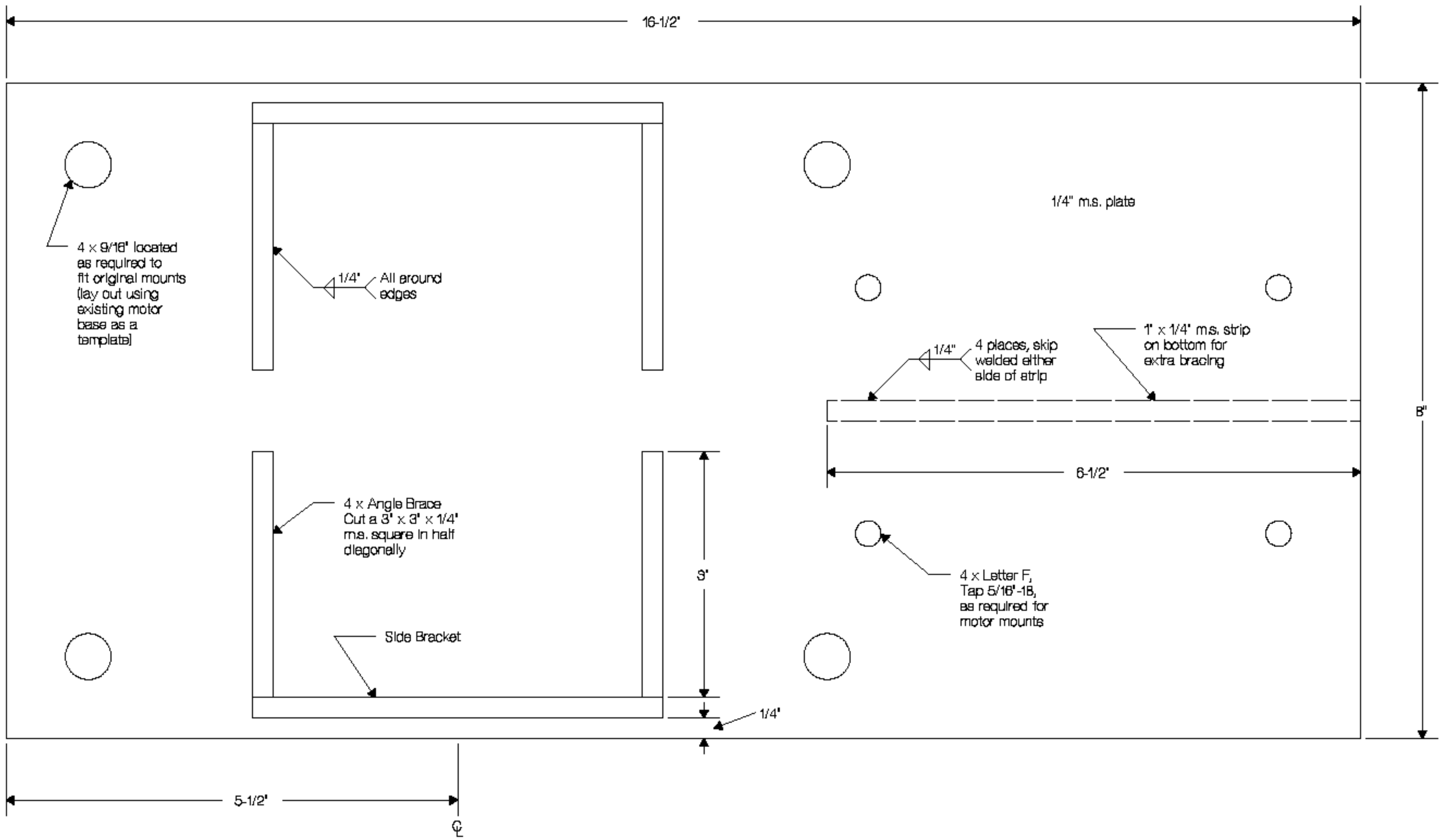

Top View

Position of Side Bracket (5-1/2") is typical. Locate bracket so that Blower Shaft is correctly placed relative to original mounting holes

New motor mounting holes are drilled so that motor sheave lines up with shaft sheave (usually motor is centered but watch for clearance of side brackets)

AC Blower Motor
Replacement
Bottom Plate

ENGINEER:	DRAWN BY:	
E. Wilde	E. Wilde	
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FILE: blower	TYPE: mech	
DATE: 98 Apr 29	REV: 1.0	