Japan Servo Application Note on SF-01(Rev-1)

Silent Fans

or

SILENTornadoes

Tornadoes give such strong winds, but our tornadoes will do it in silence.

Naoya Ito
Head, Fan Engineering

Gene Takemura
Head, International Marketing

Maki Horikoshi
USA Sales

1. Background

Why SILENCE gets so much footlights now ?

There is a growing demand from equipment users for cutting down acoustic or audible noise and electro-mechanical vibration or resonance. We can summarize the background of such new demands as follows.

From performance demanding to user friendliness demanding

From large office use to small office use

From multi or general purpose use to specific use

The first reason is due to the change in the nature of the market requirement from performance focused to quality or human friendliness oriented requirement.

During the period of expanding economy or industry, people were looking for anything with more functions, higher performance, and so on for their money. As the industrial world has become saturated in size or a matured stage, however, user's eyes are more directed to look for quality of life or something cozier.

The second is; during early period of office equipment introduction into the market, majority of equipment were used in rather wide or large office spaces where noise or vibration are not raised as issues. These days, however, growing part of volume requirement is in personal use where noise or vibration will be a significant issue.

The third is; there are many equipment made available for specific use such as medical, security system, scientific instrumentation, broadcasting or recording studio and the like where noise or vibration will be a key element of the value of such equipment.

Based on our basic understanding of market trend as above, Japan Servo has refocused our business strategy to pursue Silent Motor Products to serve equipment manufacturers better so that they can serve their customers better with our products.

3. Design

How SILENCE is designed in ?

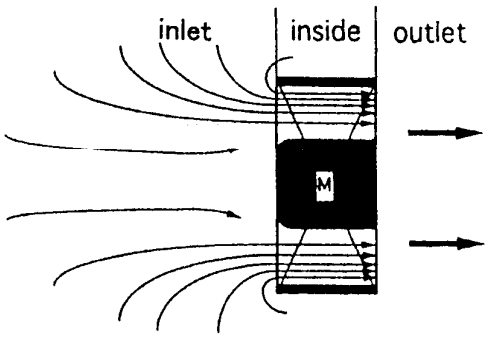

Fig. 1

We can generally call sounds that are unpleasant to us "Noise".

As we analyze source of fan noise, main cause is naturally understood to be with the blade rotation, but such noise will be further multiplied if there is some air turbulence within the in coming air flow.

We can discuss noise generating mechanism more analytically by splitting a fan into three areas in the side view, inlet, inside and outlet of a fan, as seen in Fig. 1.

1: Inlet area

The main source of fan noise is around the inlet area of venturi and there are three specific aspects to look into as follows.

A) Circular face rather than square face

As we look into the behavior of air flow coming into the venturi of a conventional box or square fan, there is a noticeable difference in the nature of air flow path, the one, 'A', taking a larger arc and the other, 'B', smaller arc which are giving different angles and speeds, as seen in Fig. 2 A. As these air flows hit head on when they come into the venturi, much noise will be generated at eight locations even when there is no blades rotating. As there will be blades chopping these air turbulence themselves in actual fan operation, we naturally have to expect much noise generated in a complicated mode due to this reason.

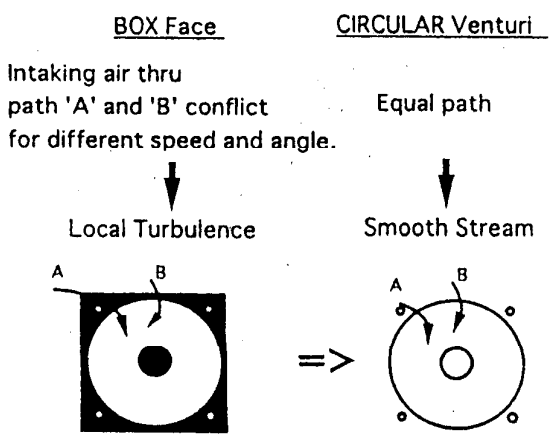

Fig. 2A

Fig. 2B

The way of reducing fan noise generated by this cause is quite clear, we can do it simply by cutting four corners off and making the face look circular, as seen in Fig. 2B, so that air comes into the venturi from any direction will have a uniform aspect, speed and direction.

B) Round and smooth inlet edge rather than sharp edge

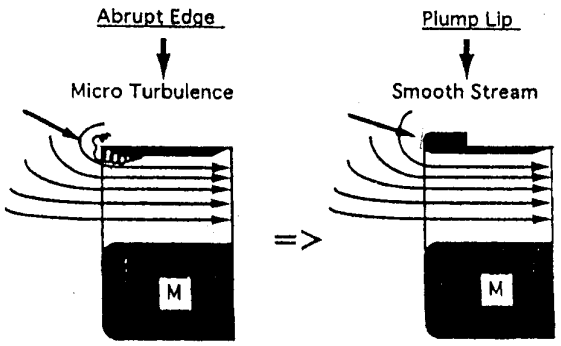

Fig. 3A Fig. 3B

When incoming air hit the sharp edge of the venturi, no matter if it's cross-sectional view has an acute angle or a square shaped, there will be some micro turbulence adding fan noise, see Fig. 3A. By changing the cross sectional shape to a smooth and round one, micro turbulence can be reduced to a good extent so as fan noise accordingly, see Fig. 3B.

C) Finger guard is another element to give a major effect to fan noise

As repeatedly mentioned in this material, any air turbulence will be a cause to increase fan noise.

As easily understood from Fig. 4A, finger guards of punched metal type will naturally generates more air turbulence compared to wire grid type, as seen in 4B.

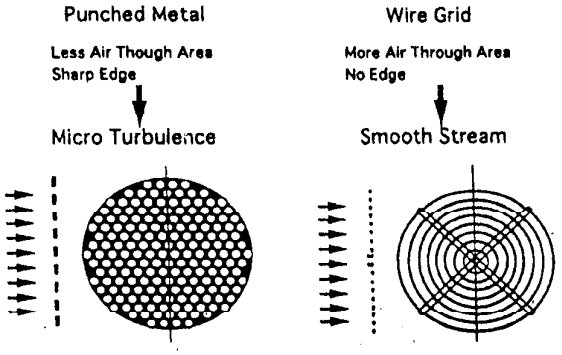

Fig. 4A Fig. 4B

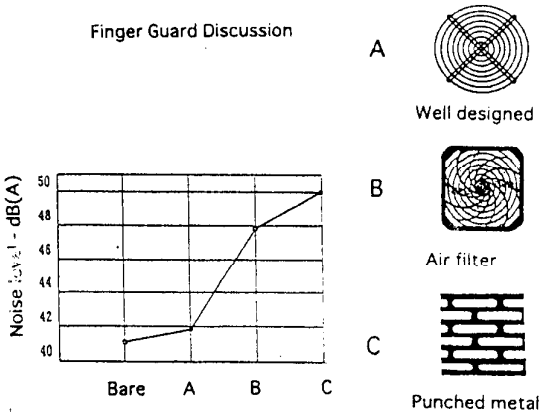

Fig. 5

Fig. 5 tells us how fan noise can easily be increased when a wrong type of finger guard is chosen.

Based on this fact, we have a line of wire grid type finger guards developed as standard accessories to go with our fan products.

2: Inside the fan

There are two aspects to talk about inside the fan. Air flow path or venturi and physical elements of blade are equally core elements when discussing how to cut down fan noise.

A) Air flow path need to be stream lined

The first and prime issue in this area is the shape of air flow path.

Very basic requirement is a gradual narrowing of air intake path and a gradual widening of air outlet path. This situation can be analogically compared to those of an ordinary tunnel for trains. When a train comes into a tunnel, the train, also passengers usually get some shock.

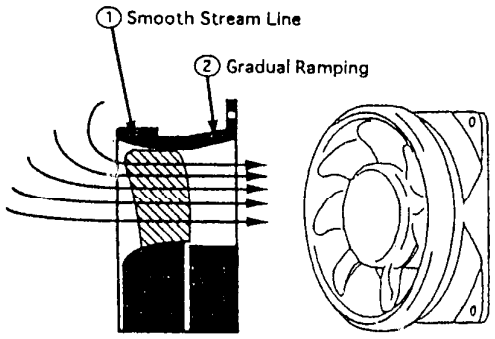

Fig. 6

This is because there is an abrupt change in the diameter of air flow path.

This shock can be reduced if the diameter of tunnel entrance area is designed to be reudced gradually.

Taking the same concept into account, our deisign became a shape like shown in Fig. 6.

B) Blade

Front and cross-sectional views of the blades, angle of mounting them on a roter and number of blades are equally crucial elements to discuss.

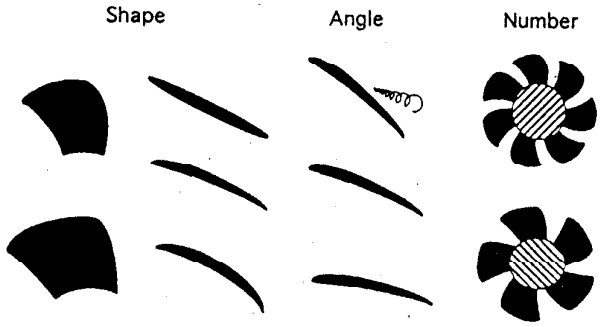

Fig. 7

Fig. 7 shows these elements.

As these four key factors are also function of fan size, face diameter and depth or thickness of a fan, and speed of a motor rotation, it has only been possible to come up with optimized dimensions utilizing computer simulation.

3: Outlet side of a fan

As far as the design of fan itself is concerned, there is no major issue to discuss in outlet area of a fan compared to those in inlet and inside the fan.

3. Data

How much noise was cut ?

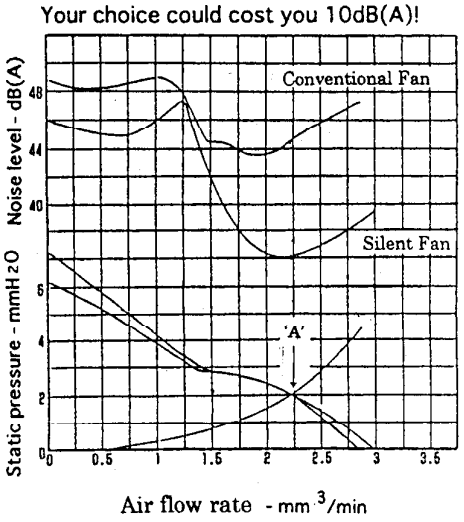

Fig.8

1: Noise vs. operating point, air flow rate

Fig. 8 shows typical operation characteristics vs. air flow rate.

The first aspect we can apparently notice here is the improvement in noise figure in higher air flow rate region, and this is the value ***SILENTornadoes*** provide equipment users and the heart of the matter of this whole development.

The second aspect to be noticed is the smoothness of noise figure curve of a ***SILENTornado***.

This is, we believe, one of the evidences that our design of ***SILENTornadoes*** is quite close to the theoretically ideal one.

2: Noise figure vs. frequency

Fig. 9 shows a typical comparison data of noise figure vs. frequency characteristics between a conventional box fan, 9A, and a ***SILENTornado,*** 9B, with the same size, 120mm dia.

This measurement was made at the operating point 'A' in Fig. 8, where the difference in noise figure was 8.x dB(A).

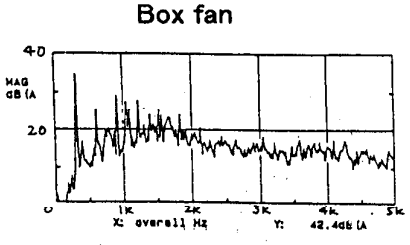

Fig. 9A

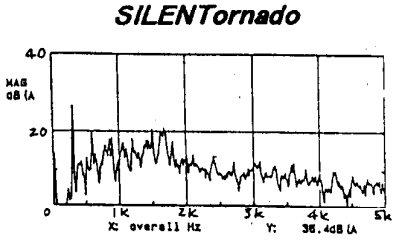

Fig. 9B

If we pay a little more attention to the frequency behavior of noise spectrum in Fig. 9,we can notice a larger difference in noise energy in higher frequency region.

This difference is more clearly recognized when these two data, 9A and 9B, are super-imposed to look like Fig. 10.

In this picture, we can identify that more improvement of noise has been made in higher frequency region by ***SILENTornadoes***.

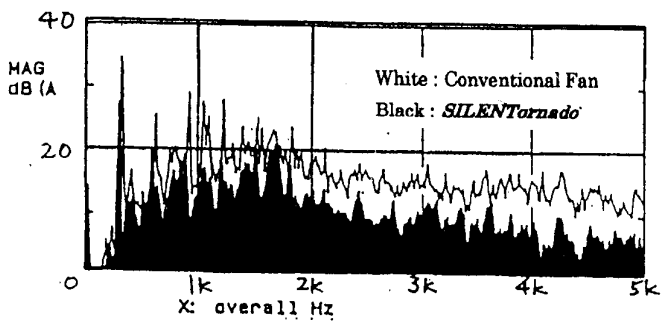

Fig. 10

As mentioned before, because the noise in higher frequency region gives more irritation to human ears, reduction of noise figure in this area will appeal more to equipment users over the top of the difference in noise figure, 8.x dB(A).

This is why we focus our effort so much to cut down fan noise over the top of reduction of motor noise.

5. Application clues

Do not misuse ***SILENTornadoes***, or their benefit will be lost.

This section lists collection of Do's and Don'ts in order not to damage such a constitutional low noise performance of ***SILENTornadoes*** in actual applications.

1: Choose the right operating condition

As seen in Fig. 8, the advantage of employing our ***SILENTornadoes*** will be eminent at higher air flow rate region. In other words, if the operating point is chosen wrongly to be in lower air flow rate or higher static pressure range, cost of noise figure to you could be as high as 10 dB(A), and you will see no difference in noise level from any of conventional box fans you have been employing.

2: Choose the right finger guard

The importance of choosing the right kind of a finger guard is discussed before referring to Fig. 5. Additionally, there are some aspects to talk about in the inlet area because this is the area where fan noise can be more easily increased unless proper care is taken.

Fig. 11 tells us how much noise is added on top of the original noise level depending on the kind of finger guard chosen and it's distance from the intake face of a fan.

Referring to Fig. 5 and 11, we are convinced that as much as 12 or more dB(A) of noise can be added unless the use of a finger guard is properly considered.

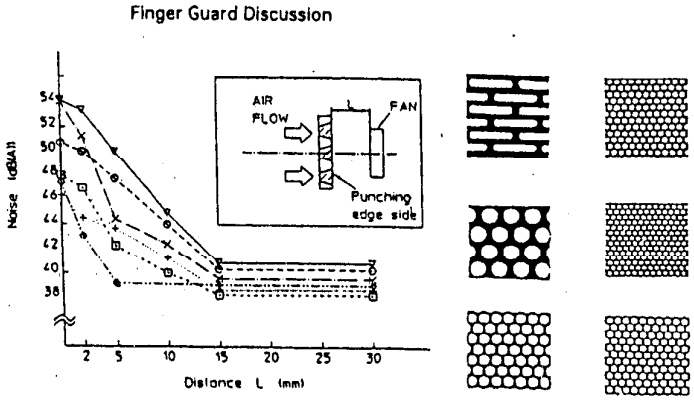

Fig. 11

3: Distance to/from cooling objects inside the equipment and obstacles outside

Fig 12A tells us how much noise is increased when an object is placed at inlet side of a fan as a function of it's size and distance.

Fig. 12B tells us the same when an object is at the outlet side of a fan.

These data confirms how much sensitively the air flow in inlet side is effected.

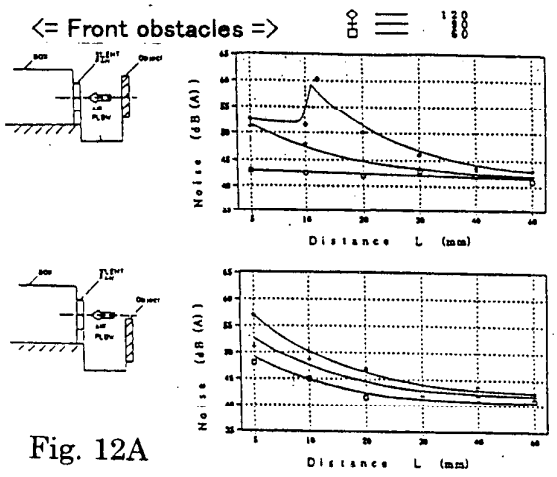

Fig. 12A

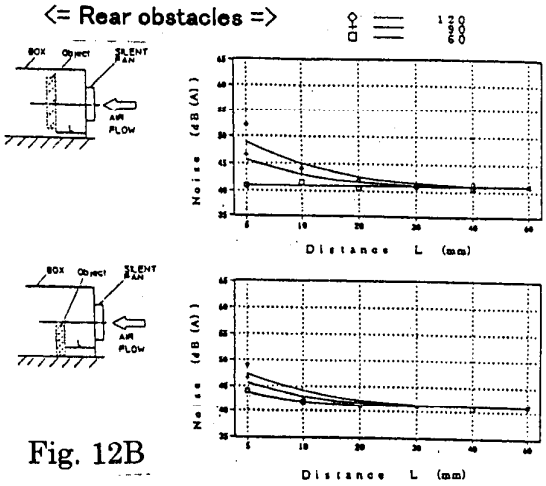

Fig. 12B

4: Choose whether to blow in or suck out

The same sets of data, Fig. 12, also tells us that the equipment manufacturer has to decide whether to blow air into an equipment box or to suck air out for cooling the circuit boards in a box when the fan noise is an important issue.

In order to accommodate versatile choice of mounting a fan on a wall of the equipment, our plastic version of ***SILENTornadoes*** have mounting rods at their four corners.

5: Choose a right mounting position

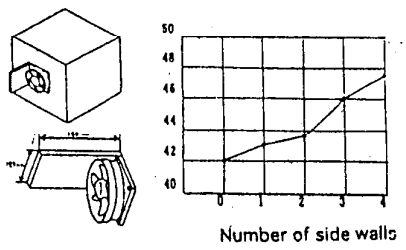

Fig. 13

Fig. 13 shows how much fan noise is increased when simple plates are placed right next to an intaking fan outside the box. With one plate, noise increase can be 1 dB(A), and two plates may add another 1 dB(A). This data is warning equipment manufacturer not to place a fan too close to the bottom and left or right edge of a side view of an equipment box.

As there are more application clues additional to above, in order not to degrade superior low noise performance of ***SILENTornadoes*** , please feel free to give us requests for more information on any of your particular cases.

6. Product lines

What's available now ?

The matrix below shows our full product lines currently available as standard as of September 1997.

As more types are in the development list, a close attention needs to be kept paying to the new development.

***Silentornados*-Silent Fan Series**

mm^3/min mmH_2O Japan Servo Co., Ltd

Dia. (mm)	Depth (mm)	Speed level	Max. air flow	Max. sta. pressure	Supply voltage 12 V	24 V	48 V	Model name	Venturi material
92	25	Half	1.0	2.2	●	●	–	SKUD	Plastic
		Full	1.3	3.6	●	●	–		
		High	1.5	4.6	●	●	–		
	32	Half	1.5	6.6	●	●	–	SKLD	Plastic
		Full	1.7	8.8	●	●	–		
120	25	Half	1.7	3.6	●	●	–	SCUDM	Plastic
		Full	2.4	6.3	●	●	–	~~SCUD~~	~~Metal~~
	38	Half	2.3	4.4	●	●	–	SCNDM	Plastic
		Full	3.0	6.0	●	●	●	~~SCND~~	~~Metal~~
		High	3.5	9.7	●	●	●		
172	51	Half	4.2	7.0	●	●	–	PADC	Metal
		Full	5.8	15.5	●	●	●	~~MADC*~~	
		High	6.8	18.0	–	●	●		
200	70	Half	6.2	12.2	●	–	–	SADC	Metal
		Full	7.7	16.1	–	●	●		
172	51	Half	5.5	15.5	AC 100, 115 and 200, 208/230, 220/240 V			PA	Metal
		Full	6.5	19.0				~~MA*~~	

Note 1 : MADC* and MA* have venturi fringe cut off.

Note 2 : Plastic versions have screw pins for reverse mounting.