JOHNSON CONTROL

AUTOMATIC CONTROL SYSTEMS

JOHNSON SERVICE COMPANY

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PREFACE

The scope of this manual is to provide new Engineering Data regarding damper performance, introduce a new damper product, guide the designing engineer in selecting dampers, and provide the installing mechanic with installation instructions.

Until now, Engineering Data regarding damper performance has been negligible. The purpose of this manual is to make the latest damper engineering and performance data available to you. Tests are still being conducted and information derived from them will be released for addition to this manual.

This manual introduces new concepts and a new high quality damper to the air conditioning industry. The new concepts apply to damper sizing, standard sizes and flow characteristics. The new damper is the Johnson Proportion/Aire* damper. Applying the Proportion/Aire and the new concepts outlined in this manual will provide an installation with the first major advance in the control of air flow.

The Design Engineer will be able to select the correct damper with the proper characteristics for all applications by applying the information contained in this manual. The installing mechanic will be able to use this manual as an effective tool for installing the Proportion/Aire damper.

*** Patent Pending**

CONTENTS

SECTION I – DAMPER THEORY

Damper Selection Compares to Valve Selection

A damper is a device that controls the flow of air in an air conditioning system. The damper accomplishes air flow control by varying the resistance to flow, just as a valve does in a liquid circuit. This manual deals with the multiple blade damper in its two basic design configurations, the parallel blade and the opposed blade. The same considerations that apply to valve selection, i.e., correct size, flow characteristics, rangeability and required pressure drop, also apply to damper selection.

Much has been published on the subject of valve selection and sizing. Instead of installing a valve the same size as the pipe, as was common practice not too many years ago, valves are now selected with regard to the function they are to perform. Manufacturers have given careful consideration to inner valve construction. Most of them now provide a choice of flow characteristics ranging from quick opening to linear to equal percentage, or modifications of these, to meet various application requirements. They have published data regarding these characteristics making it possible for the consulting engineer or the control engineer in the field to make the best valve selection.

This has not been true with dampers. Damper design has changed very little. Published data regarding their performance characteristics have been extremely meager. Dampers are almost always the same size as the duct in which they are installed. As a result, performance of air flow control systems often leaves much to be desired.

Present Damper Designs

Dampers are manufactured in two basic styles: with blades that rotate parallel to each other (Fig. 1) and those with blades which operate in an opposed manner (Fig. 2). Each has different characteristics. The application determines which should be used in each case for best control. Their design provides a very limited choice in characteristics.

The characteristic built into a damper is not necessarily the characteristic of the damper when installed in an actual system. The characteristic designed into the damper, here called the **inherent flow characteristic,** is represented by the curve "per cent flow versus operator travel" which is produced with a constant pressure drop maintained across the damper (Figs. 1 and 2). These are the basic characteristics designed into the dampers by virtue of the design of driving linkage, damper blade or leaf configuration and other factors.

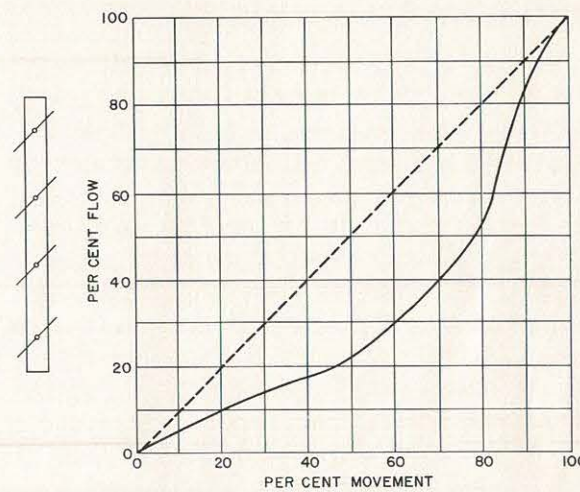

FIG. 1: PARALLEL BLADE DAMPER INHERENT CHARACTERISTIC CURVE (DASHED LINE IS HYPOTHETICAL LINEAR CHARACTERISTIC CURVE)

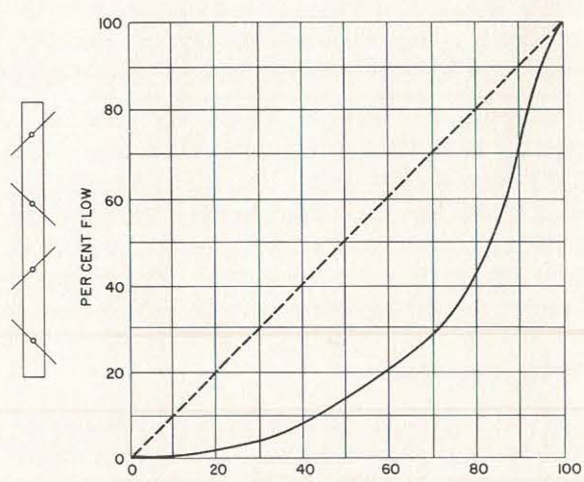

FIG. 2: OPPOSED BLADE DAMPER INHERENT CHARACTERISTIC CURVE (DASHED LINE IS HYPOTHETICAL LINEAR CHARACTERISTIC CURVE)

The **effective flow characteristic** is the actual flow characteristic of the damper obtained when the damper is applied to a given air handling system; that is, it is the inherent flow characteristic, as altered by the varying pressure conditions in the system and other considerations. To select the inherent characteristic best suited to a particular flow control application, it is important to first decide what effective characteristic is most desirable for good control. Then, knowing how the system pressure variations will alter the inherent characteristic to produce an effective characteristic, the proper selection can be made.

The Ideal Effective Characteristic

Maximum control stability in a system occurs when there is a nearly linear relationship between the change in the controlled variable (error) as measured by the controller and the corrective action produced by the controlled device (damper). If, for example, a thermostat controls the temperature of a space by varying the volume of warm air admitted, each equal increment of space temperature change should result in an equal increment of change in air volume admitted to the space. Figure 3 shows how a linear flow characteristic produces air flow control through the entire travel of the damper (from closed to 100% open), thus causing stable control.

Since the relationship between the controller and the damper operator, whether the system is pneumatic, electronic or electric, is essentially linear, it remains only to insure that the effective damper characteristic be relatively linear to have the entire control loop linear.

The way in which a damper is used in a system to a great extent determines how much the system will alter the inherent damper characteristic. It is this altered inherent characteristic, or effective characteristic, that is of importance to the end result. The following examples will illustrate why this is so.

Throttling Control

For purposes of explanation only, assume a system as shown in Fig. 3 wherein space temperature is controlled by varying the volume of constant temperature air admitted. Each equal increment in demand should result in equal increments of air volume change.

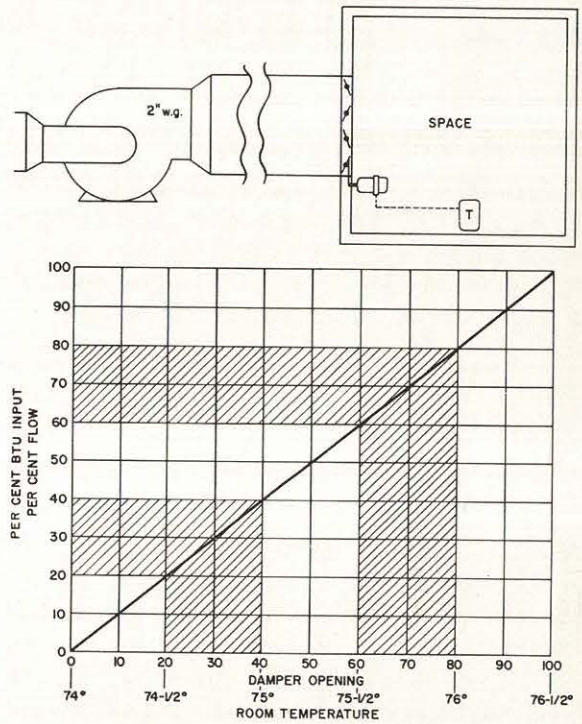

FIG. 3: VARIABLE VOLUME TEMPERATURE CONTROL SYSTEM

The relationship between room temperature change the damper operator movement is essentially linear, as was mentioned previously. It remains to be seen how the relationship between operator movement and flow of air through the damper can be made as nearly linear as possible.

At maximum flow, assume the fan pressure is 2" w.g. and pressure drop across the wide open damper is 1/4" w.g. Resistance of the duct system is then 1 3/4" w.g. At the other extreme, when the damper is completely closed, there is no flow and no duct loss, and the pressure drop across the damper is the full fan pressure of 2" w.g. or eight times what it was when wide open. (If the fan curve is taken into account this ratio will be greater than eight to one.) Thus, as the damper gradually moves from wide open to closed, pressure drop across the damper gradually increases. Closing the damper to reduce flow is partially offset by this increase in pressure drop. With the increasing pressure drop partially offsetting each increment of damper closing, the inherent characteristic curve will shift upward. Fig. 4 shows how a near linear inherent characteristic would shift upward in this application.

The damper characteristic curves of Figs. 1 and 2, however, are for a constant pressure drop. If a damper were constructed with an inherent linear characteristic, as shown by the dashed lines of Figs. 1 and 2, variable pressure drop would bend the curves upward and the effective characteristic would be far from linear in the system described (Fig. 4). Knowing this, it is best to select a damper with an inherent characteristic that falls well below the linear curve so that the increasing pressure drop, as the damper closes, will bend the curve upward toward linear rather than away from it.

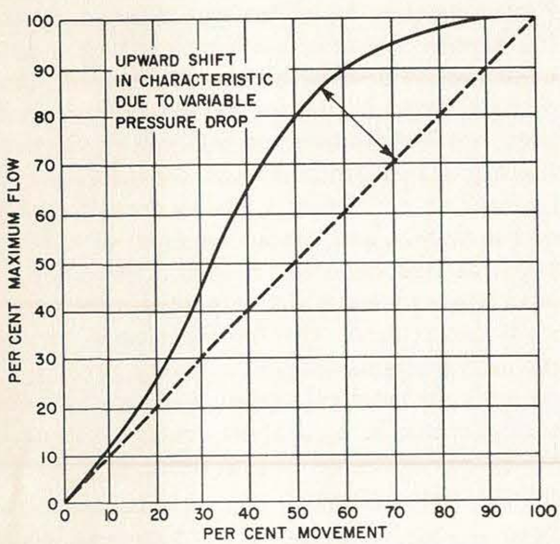

FIG. 4: SHIFT IN CHARACTERISTIC DUE TO INCREASING PRESSURE DROP

A system with several volume control dampers, instead of the single damper used in the example, would behave exactly the same as shown in Fig. 3. Whenever the volume of air handled by a duct system, or even a portion of a duct system, varies, a variable pressure drop across the dampers results unless the system is specifically designed and controlled to prevent it. Variation of pressure drop will usually be quite large, so that, normally, a damper with an inherent characteristic curve which is the farthest below the linear curve should normally be selected. This is the opposed blade damper shown in Fig. 2.

Face-and-Bypass Control

A face-and-bypass application must be treated much like the preceding example when dampers are applied. Although a constant pressure drop is maintained between points A and B of Fig. 5, causing it to resemble a mixing or con-

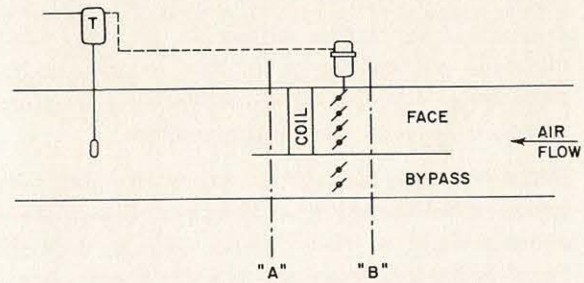

FIG. 5: FACE-AND-BYPASS SYSTEM

stant pressure drop application, other factors must be analyzed. Looking at the face section alone, assume a pressure drop through the coil of ¼" w.g. Also assume a 1/100" w.g. pressure drop through the face damper in the wide open position. When the face damper is wide open the majority of the pressure drop in the face section is across the coil. But, as the face damper closes, the pressure drop shifts from the coil to the damper. At the near closed position of the damper the majority of the pressure drop in the face section is across the face damper. In the preceding volume control example, the pressure drop shifted from the ductwork to the damper; in this example it shifts from the coil to the face damper. This shift in pressure drop makes the problem of selection of the face damper much like the variable volume damper.

When analyzing the bypass section by itself a study of Fig. 14 (pg. 1-10) should be made. Fig. 14 shows the resistance which is added by installing dampers smaller than duct size. When the face-and-bypass dampers are each in a 50% open position, air is flowing through both the face and bypass sections (air flow through 100% of duct area). When either damper is closed (100% face or 100% bypass) the pressure drop through the section is determined by the amount of total duct area being used for air flow. For example, with the face section closed, all the air must flow through the bypass section. The pressure drop added is that which is added by the blank-off section (closed face damper). Fig. 14 shows that blanking off 70% of the total duct area at an approach velocity of 500 fpm will add approximately .34" w.g. On the other hand, with the bypass closed, 30% of the total duct area is blanked off and .02" w.g. pressure drop is added. Although the pressure drop across the entire face-and-bypass section is relatively constant, the preceding example shows how the pressure drop varies within the section. This makes it impossible to consider a face-and-by-pass damper in the same manner as a constant pressure drop or mixing application.

Since the pressure drop across the dampers varies as the dampers are throttled, the inherent characteristic of the damper will be shifted. Truly linear dampers are therefore not necessarily the best choice. Fig. 6 shows the total flow variations which can be expected if the proper characteristic is selected.

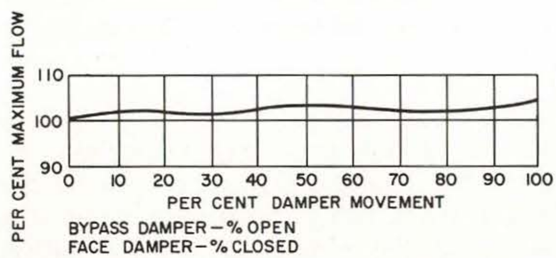

FIG. 6: FLOW THROUGH FACE-AND-BYPASS SYSTEM

Mixing Dampers

Application of mixing dampers presents a considerably different problem from that described in the previous section. An outdoor air, recirculated air and exhaust damper combination is typical and is shown in Fig. 7. The minimum outdoor quantity provides the required ventilation and keeps the building under a slightly positive pressure.

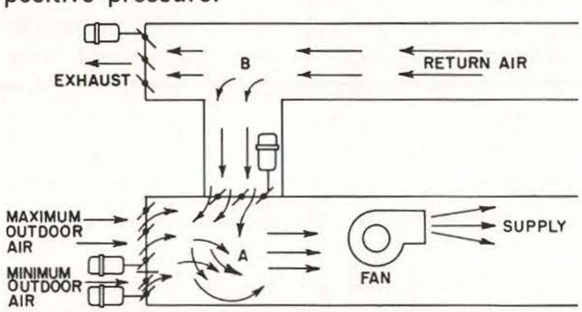

FIG. 7: TYPICAL OUTDOOR, RETURN AND EXHAUST AIR MIXING APPLICATION (PARALLEL BLADE DAMPER APPLICATION)

With the maximum outdoor air and exhaust dampers closed and the recirculated air damper open, assume pressure at A (mixing chamber) is −0.1″ w.g. and that system capacity is at the desired value of 10,000 cfm, of which 2500 cfm is minimum outdoor air and 7500 cfm is recirculated air. If the pressure at B is +0.1″ w.g., the pressure drop from B to A is 0.2″ w.g. When the maximum outdoor air and exhaust dampers are open and the recirculated air damper is closed, it is required that the system capacity remain at 10,000 cfm. It is then necessary to select the maximum outdoor air damper to handle 7500 cfm, with 0.1″ w.g. pressure drop, and the exhaust damper and duct to handle 7500 cfm, with 0.1″ w.g. presure drop, thus achieving the desired capacity. Knowing the pressure losses in ducts and dampers for various air velocities, it is possible to design a system that will essentially meet these constant volume requirements.

Proper functioning of this type of air conditioning system depends upon maintaining a constant rate of flow for all positions of the maximum outdoor air, return air and exhaust dampers, not just the extreme positions mentioned. If the pressure drops through the dampers can be held at a constant value by correct design of the system and proper selection of damper sizes, as described above, and if the dampers have linear inherent characteristics, nearly constant air volumes can be maintained for all damper positions. Hence a mixing application requires dampers of a relatively linear **inherent** characteristic because there are no appreciable changes in pressure drop to alter this inherent damper characteristic.

Referring again to Figs. 1 and 2, it is apparent that a parallel blade damper is more nearly linear than an opposed blade damper and should be selected for a mixing application.

New Characteristics Needed

The Johnson Service Company has tested various designs and makes of both parallel and opposed blade dampers and finds that, regardless of design details, they all conform, in general, to the curves of Figs. 1 and 2. Opposed blade dampers, having in general an **equal percentage** characteristic, are quite well suited to throttling control where the pressure drop increases materially as the damper closes. On the other hand, the inherent characteristic of parallel blade dampers for mixing applications, while considerably better than opposed blade dampers, is not ideal.

It is possible to characterize dampers. That is, by altering the relationship between operator movement and rotation of the damper, the curves of Figs. 1 and 2 can be changed.

For such mixing damper applications as outdoor and recirculated air, where linear inherent characteristics are required to maintain constant system air flow rate, dampers can be made to have relatively linear characteristics as shown in Fig. 8. While curves 1 and 2 are not strictly linear, they meet the objective of obtaining a relatively constant flow. Curve 3, which wavers slightly above and below the 100% flow line, shows total air flow through outdoor and return air dampers. At any percentage value of damper movement, such as A, B or C, total flow from both dampers adds up very close to 100%; the result is a relatively constant system volume even though the respective damper curves are not strictly linear.

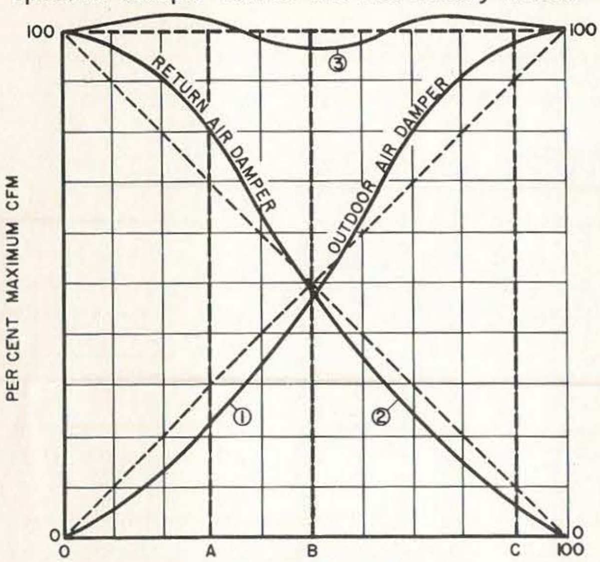

FIG. 8: DESIRED EFFECTIVE CHARACTERISTIC CURVES FOR MIXING DAMPER

Importance of Proper Damper Sizing

For many years it has been common practice to select the size of an automatic control valve to handle the required maximum flow at a pressure drop which will produce good controllability. An automatic damper is also a flow control device and, like a valve, it accomplishes its function by changing the flow area. It follows that it also should be sized for a pressure drop that will produce good controllability.

The damper, however, has not received this consideration. Much of this can be blamed on the fact that few manufacturers of dampers have had sufficient information about their damper characteristics and pressure drops to permit consulting engineers or control engineers to select dampers on this basis. For this reason it has been extremely unusual for dampers to be selected and sized with system controllability in mind. Instead, the damper is selected to fit the duct at a point where it is most convenient to install it. This has created serious problems because these dampers are usually oversized and overall system controllability suffers.

Why Size Dampers

It is important that the damper be sized to use a reasonable portion of the total system pressure drop in the open position so as to enable it to perform its control functions. If this is done, it is then possible to determine the change in pressure drop which will occur as the damper closes and thereby predict the shift in the inherent characteristics of the damper. Dampers with the proper characteristics can then be chosen so that the predictable change in pressure drop across the damper will shift the inherent characteristic curve to an effective characteristic curve which will prevent cycling and result in stable control.

To correctly size a damper, it is important to know the following information about the system in which it will be installed.

1. **Total pressure drop** in the portion of the system in which the damper is to be located or the total pressure drop which can be expected across the damper when in the closed position.
2. **The total volume** of air which the damper is expected to pass in the wide open position.
3. **The inherent characteristics** of the damper which is to be selected for this system.

Figures 9 and 10 show the effect of variable pressure drops on the damper characteristics. These are the variations in pressure drop which occur, for example, when a damper is modulated to its closed position and the system resistance decreases, thus increasing the pressure drop across the damper. A study of the tables and the accompanying curves indicates the need for selecting the "wide open" pressure drop by proper damper sizing. These curves are based on a particular range of damper sizes. As damper sizes change, these curves will vary slightly.

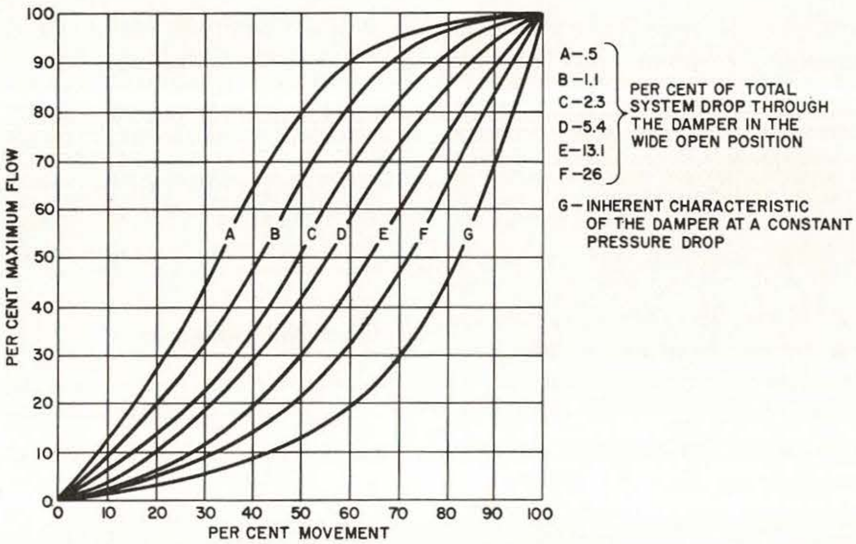

FIG. 9: CHARACTERISTICS OF AN OPPOSED BLADE DAMPER (SHOWING THE EFFECT OF VARYING PER CENT OF SYSTEM DROP ACROSS THE DAMPER)

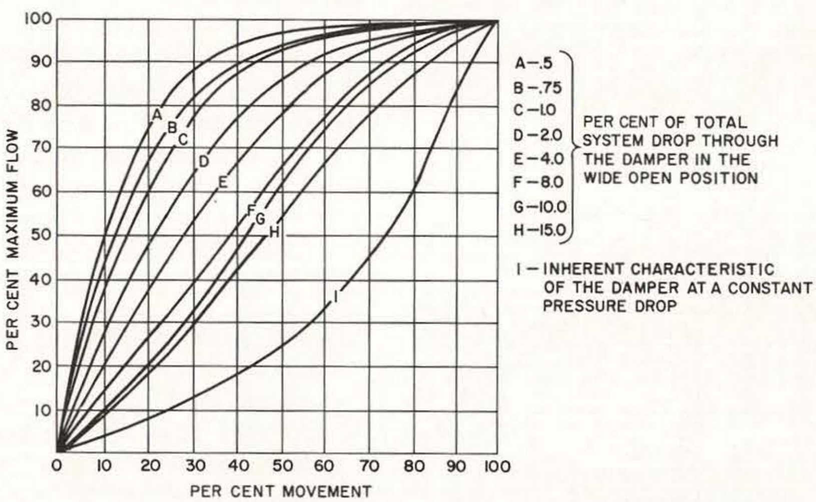

FIG. 10: CHARACTERISTICS OF A PARALLEL BLADE DAMPER (SHOWING THE EFFECT OF VARYING PER CENT OF SYSTEM DROP ACROSS THE DAMPER)

Curve G of Fig. 9 shows the inherent characteristic of an opposed blade damper. It is the curve that results when the pressure drop across the damper remains constant regardless of damper position. For a throttling control application, it was shown in Fig. 3 that the pressure drop across the damper increases from its wide open value, at full flow, to full fan pressure when the damper is closed. Thus, if the wide open pressure drop is 0.25" w.g. and the full fan pressure at no flow is 2" w.g., the open damper resistance in per cent of system resistance is 12.5%. Fig. 9 shows the effect on the damper characteristic for various values of open damper resistance in per cent of system resistance. Since a linear effective damper characteristic is desired for good control, curves C and D are best. Thus, a damper with an equal percentage inherent characteristic can be made essentially linear, in a modulating application, if it is sized so that its wide open resistance falls in the range of 3 to 6% of the total system resistance.

For example, curve A of Fig. 9 is decidedly non-linear. When 50% open, it has 80% of full open capacity. Most of its control is accomplished in less than one half of its travel. It would likely produce unstable control when near its closed position.

Figure 10 shows similar curves for a parallel blade damper. For a throttling application its wide open resistance would have to equal 10 to 15% of the total system resistance (curves G and H) to obtain a nearly linear effective characteristic. It is obvious that a damper with inherent equal percentage characteristics (opposed blade) requires less "wide open" pressure drop to produce the desired effective characteristic under actual operation. As mentioned previously, Fig. 9 indicates that its wide open resistance should be from 3 to 6% of the total system resistance. Although this is a small percentage of the total system resistance, and should not be objectionable from the standpoint of added fan horsepower, it is a great deal more than can normally be expected if dampers are the same size as the duct.

To obtain the wide open resistance required for proper control, the damper must usually be smaller than the duct. Correct damper sizing offers many advantages in addition to obtaining good control.

1. Initial Cost

Correct damper sizing will generally mean dampers smaller than the duct. Dampers are usually priced by the square foot. Thus the correctly sized damper will be less expensive. The smaller damper also requires less operating power and can reduce the cost of the damper operators.

2. Leakage

For a given damper construction and pressure drop, leakage is proportional to the damper area. A smaller damper will result in less leakage.

3. Rangeability

This is a term commonly applied to valves but is just as applicable to dampers. It is expressed as a ratio of maximum flow to minimum controllable flow. Reduced leakage decreases the uncontrollable flow and therefore increases the rangeability. This improves the controllability of the system.

Example of Poor Damper Selection

A look at Fig. 10 shows why a parallel blade damper is generally not suitable for throttling type applications where the pressure drop across the damper increases appreciably as the damper closes. The inherent characteristic of this damper (curve I) is more nearly linear than the inherent characteristics of an opposed blade damper. To obtain the most nearly linear curve D, the damper would have to be sized to use up approximately 15% of the total system pressure drop in its wide open position. If sized for one per cent of the system pressure drop, a common occurance, the damper would accomplish nearly 95% of its flow control in 50% of its travel (curve A). This would tend to produce unstable control and, since only about 50% of the total damper range is really effective, would multiply the effect of hysteresis and other losses.

Constant Pressure Drop Applications

If the damper selected above is applied to a system where the pressure drop across the damper remains constant, it can provide satisfactory control. Mixing dampers are for this type of application. Since the pressure drop across the damper does not change appreciably, its inherent characteristics and effective actual characteristic are essentially the same. Sizing the wide open damper to utilize a fair percentage of the total system pressure drop in this case is not as important as selecting the proper characteristic to produce constant total system flow.

Damper Sizing Methods

Figures 9 and 10 indicate the per cent of total system pressure which should be utilized by the damper in the wide open position, in order to avoid shifting the inherent characteristics to anything but the desired effective (near linear) characteristics. Figs. 11 and 12 show the approach velocities which produce the pressure drops illustrated by the curves in Figs. 9 and 10. The approach velocity information is easier to use since it can be directly related to the duct area and, therefore, duct size, if the cfm is known and no detailed pressure drop curves need be referred to.

A study of these curves indicates a "rule of thumb" method which will produce acceptable results for a large percentage of all applications. The total system pressure drop versus velocity curves show that to produce desirable (near linear) effective characteristics, dampers with system pressures of one inch or below

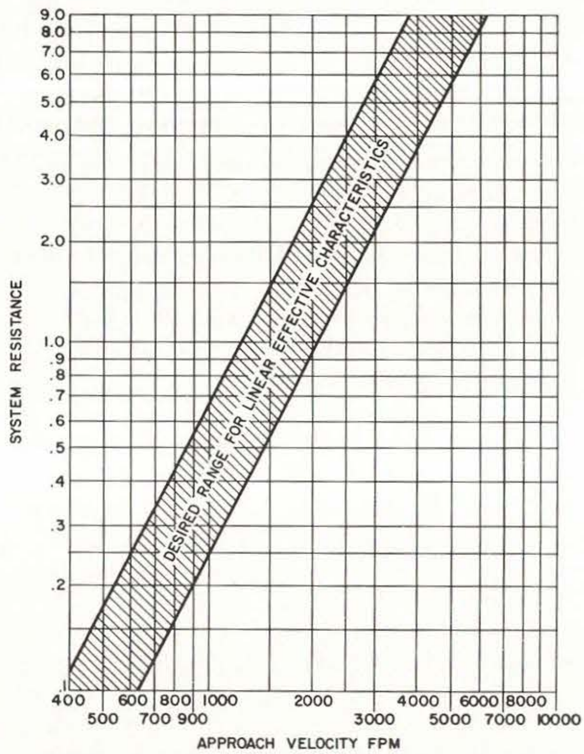

FIG. 11: DESIRED PRESSURE DROPS FOR OPPOSED BLADE DAMPER

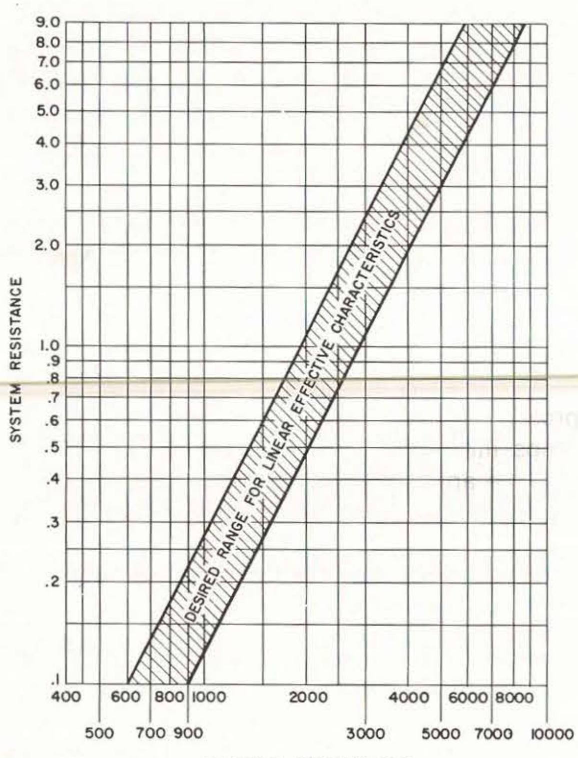

FIG. 12: DESIRED PRESSURE DROPS FOR PARALLEL BLADE DAMPER

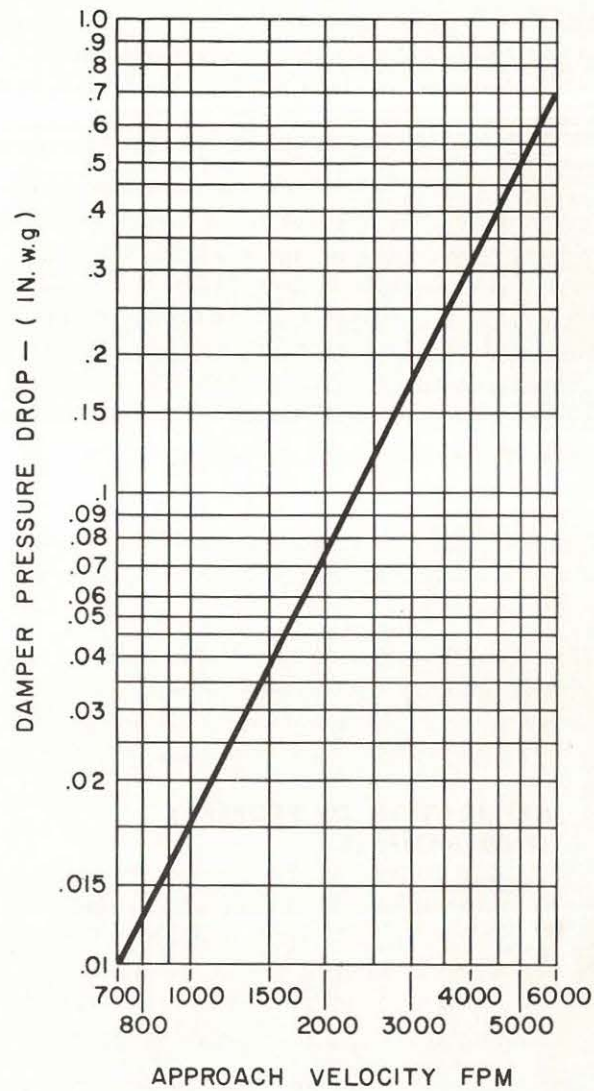

FIG. 13: PRESSURE DROP THROUGH WIDE OPEN DAMPER

should be sized for at least 1000 fpm approach velocity. For systems with pressures of approximately four inches, a minimum of 2000 fpm through the damper in the wide open position should produce satisfactory results. It must be remembered however, that a rule of thumb produces satisfactory results in most cases and should be used only if convenient, accurate, detailed information is not available from the damper manufacturers.

Do Properly Sized Dampers Create Excessive Pressure Drops?

Figure 13 shows the pressure drop we can expect through a damper in the wide open position at various approach velocities. From the information above, it is obvious that selecting dampers to produce the desired characteristics, in most cases, adds less than one tenth of an inch pressure drop to the entire system at design conditions. This drop should not be objectionable and will be offset by the superior system operation which can be expected.

If dampers are properly sized, a common question will be, "where can they be located?" In most cases, there is a conversion section within the duct system in which the properly sized damper could be located. In practically all cases, it will mean moving the damper away from the coil (velocities of 400 to 600 fpm) to a location in the system where the velocities are higher. Moving it away from the coil will also produce better distribution of air flow across the coil. A more controversial answer to the question might be that it is often possible to size the duct, or install conversion duct sections, to fit the damper. There are also inexpensive and convenient means for making the properly sized damper fit the duct while adding little pressure drop.

APPLICATION OF PROPERLY SIZED DAMPERS

Selecting the damper with proper characteristics to do a good control job is relatively easy if characteristic curves are published by the damper manufacturers. Selecting a damper of proper size to match the selected characteristic to the system in which it is to be installed, becomes feasible as damper manufacturers begin to take an engineering approach to the subject and publish the necessary test data. The only problem which remains is what to do if the properly sized damper is smaller than the duct in which it is to be installed. There are a number of approaches to this problem.

1. **Adapting The Duct To Fit The Damper**
   It is common practice for ducts to be designed to fit coils, filters, spray banks and even "bug screens." In many cases these components are of no more importance to the proper functioning of the system than the dampers. Realizing this, the designing engineer will find cases where the duct can be made to conform to the dimensions of a properly sized damper.

2. **Damper Location**
   The usual practice of locating a face damper near the coil has some disadvantages. Air distribution through the coil is poor. When the damper is throttling, there is a tendency to produce a number of relatively high velocity air jets through portions of the coil. This is a major cause of freezing of preheat coils. In many cases, there is a conversion section to reduce the duct size downstream from the coil. In this conversion section there is sometimes a location that provides the desired area for a correctly sized damper. If not, the damper may sometimes be located in the smaller distribution duct beyond the conversion section.

3. **Adapting The Damper To Fit The Duct**
   There will be a large number of cases where, regardless of the above suggestions, the properly sized damper will be smaller than the duct into which it is to be installed and some arrangements will be needed to accommodate the damper to the duct. In most installations it will be possible to make one dimension of the duct the same as that of the damper.
   A simple blank-off plate, Fig. 14, is an easy way of filling the duct. While this arrangement creates more turbulence, and therefore a greater pressure loss than more elaborate arrangements, it has the advantage of being inexpensive. As Fig 14 indicates, the pressure drops created by this arrangement are not excessive if the blank-off plate is less than 30% of the duct area. If greater reductions in duct area are required; more elaborate conversion sections must be used.

While adapting the damper to the duct system presents some problems, there are usually only a few dampers in even a fairly elaborate central air conditioning system. Most consulting engineers agree that coping with the problems of applying correctly sized dampers will not be difficult if proper engineering data is provided.

Advantages of Properly Sized Dampers

Properly sized dampers, separated as much as possible from dependence on duct sizes, offer many advantages aside from better control. Since they often will be smaller than those presently used, dampers of similar construction will cost less. The cost saved by reducing the area is greater than the cost of the blank-off plate sometimes required because of the dif-

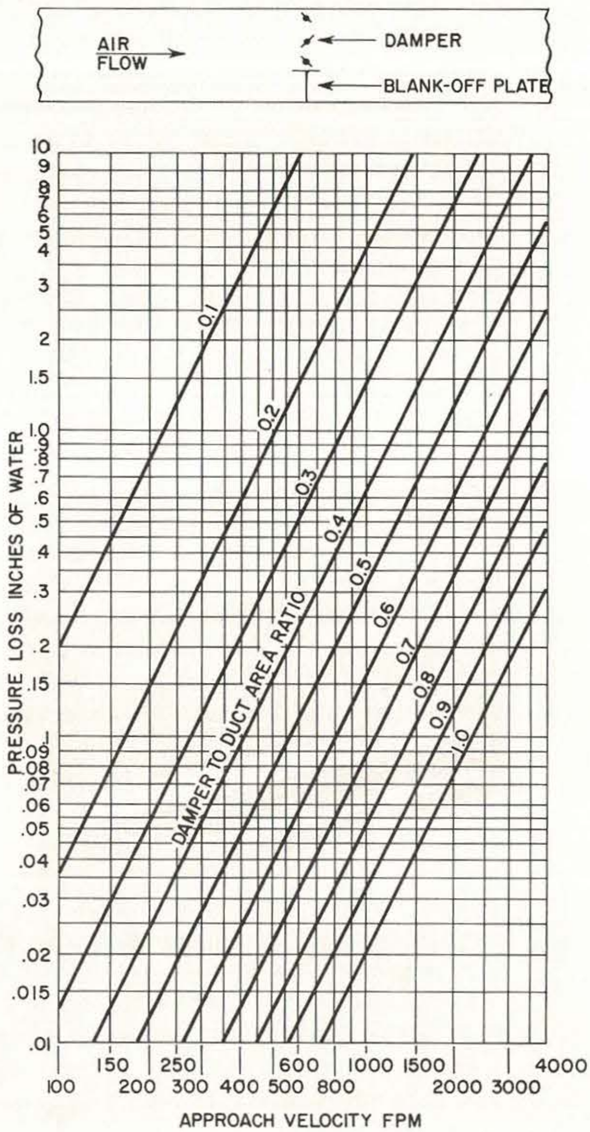

FIG. 14: EFFECT OF BLANK-OFF PLATE

ference in area. Leakage of dampers is related to damper size. Hence, a smaller damper will have less leakage.

Standard Size Dampers

The acceptance of the concept of proper damper sizing, where they are not necessarily related to the duct size, makes it possible to consider standard damper sizes. With a sufficient number of standard size increments, it will be just as easy to select a standard size damper as to specify a custom made size.

There are many advantages for standard size dampers. At present dampers are "tailor made" to any dimensions. The variety of blade lengths and widths, frame member dimensions and variations in other hardware preclude many possibilities of mass production. The use of standard sizes will reduce the number of variables sufficiently to open up opportunities for new design concepts, and permit mass production techniques. The result can be a far better damper in the same price range. Mass production techniques will permit closer tolerances, and hence less leakage. A more simplified linkage with fewer adjustments is possible. Characteristics will be more uniform thus allowing publication of performance data. More effective sealing methods can be employed. Special blade and frame shapes, not feasible in "tailor made" dampers but which best suit the purpose, become practical. Finally, the standardized parts can be made in quantity and stocked, ready for immediate assembly of any standard size damper, thus improving delivery time.

The next section of this manual introduces a new damper that has these features.

SECTION II – THE PROPORTION/AIRE DAMPER

The Proportion/Aire is a mass produced damper available in a variety of standard sizes. (Refer to Fig. 1 and Table 1.) This high quality damper, on which close manufacturing tolerances are maintained, provides uniform flow characteristics and low leakage values.

It is intended that the Proportion/Aire damper be applied in the same manner as a control valve. The dampers can be sized to the application by flow and pressure drop. In cases where the largest standard size available is too small, multiples of standard size dampers can be used. If a standard size damper or a multiple of them does not exactly fit the duct, a blank-off plate can be used to fill the rest of the duct.

CONSTRUCTION FEATURES

Frame

The damper frames are constructed of No. 13 gage galvanized sheet steel. The frame is constructed with "hatshaped" channels on both sides and No. 13 gage sheet steel channels on the top and bottom. The interconnecting blade linkage is housed in the side channels. The frame is braced at the corners to form a square, rigid assembly.

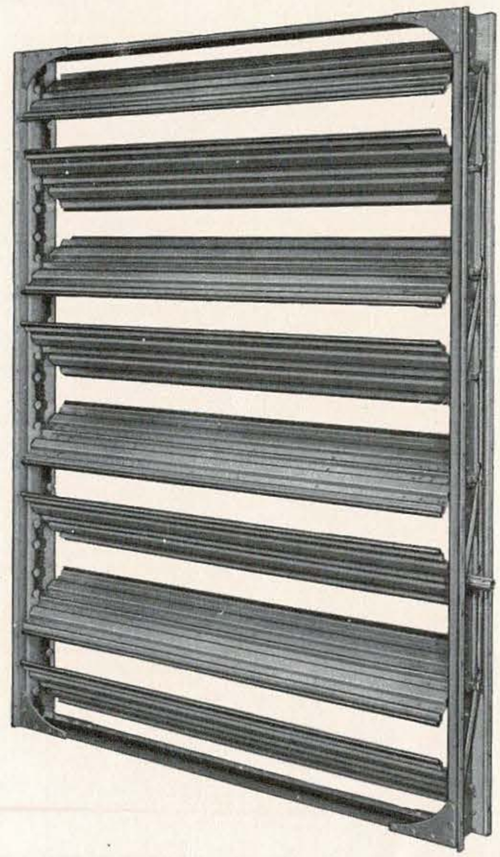

FIG. 2: THE PROPORTION/AIRE OPPOSED BLADE DAMPER

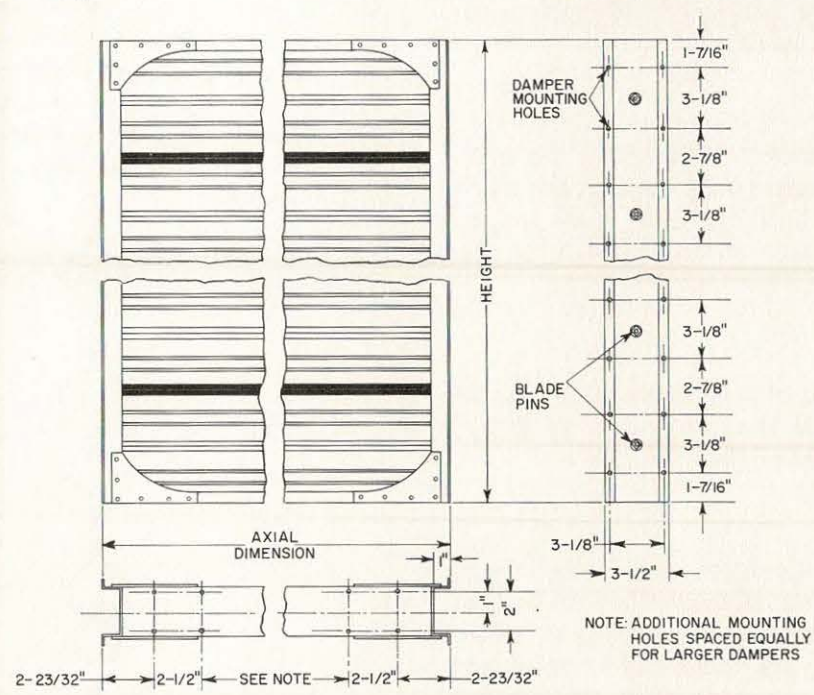

FIG. 1: DIMENSIONS OF THE PROPORTION/AIRE DAMPER

TABLE I

STANDARD DAMPER SIZES

HEIGHT DIMENSION

NO. OF BLADES	NOMINAL INCHES	ACTUAL INCHES
1	6"	5-31/32"
2	12"	11-15/16"
3	18"	17-29/32"
4	24"	23-7/8"
5	30"	29-27/32"
6	36"	35-13/16"
7	42"	41-25/32"
8	48"	47-3/4"

AXIAL DIMENSION

NOMINAL INCHES	ACTUAL INCHES
12"	11-15/16"
15"	14-59/64"
18"	17-29/32"
21"	20-57/64"
24"	23-7/8"
27"	26-55/64"
30"	29-27/32"
33"	32-53/64"
36"	35-13/16"
42"	41-25/32"
48"	47-3/4"

Blades

The damper blades are made of two formed sheets of No. 22 gage galvanized sheet steel, spot welded together, and are extremely rigid. Therefore, they are suitable for high velocities and static pressures (See Fig. 3). The corrugated type blade construction has two purposes; it holds the blade pins and blade seals, and it makes the blade rigid.

Bearings

For minimum friction and long life, the bearings of the Proportion/Aire damper are made of nylon. The bushings are made of oil impregnated sintered metal and turn in the nylon bearings.

Seals

All seals are made of butyl rubber, are capable of withstanding air temperatures up to 200 F, and are replaceable. (See Fig. 3.)

Linkage

With all of the interconnecting blade linkage housed in the frame channels there is no linkage in the airstream, thus reducing air noise. The linkage rods are fabricated of steel and the bearing pins are made of oil impregnated sintered metal.

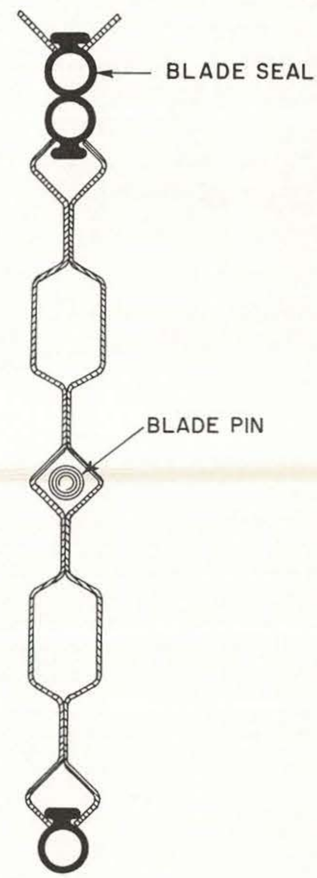

FIG. 3: CROSS SECTION VIEW OF THE PROPORTION/AIRE DAMPER BLADE

PERFORMANCE

Characteristics (Opposed Blade)

The flow characteristics of a damper depend not only on the construction of the damper, but also on the linkage between operator and blade pin.

Two linkage arrangements between operator and blade pin are available. One type is offered to provide an equal percentage characteristic for variable pressure drop applications, such as a throttling damper. The other linkage is offered to provide a near linear characteristic for mixing applications where the pressure drop is apt to be relatively constant.

Figure 4 shows the characteristics of the opposed blade Proportion/Aire damper. Curve A is the characteristic of the damper when it is provided with the linear linkage. This characteristic is intended for use on constant pressure drop applications.

Curve B is the characteristic of the damper when provided with an equal percentage linkage. This characteristic is intended for use on applications where the pressure drop increases as the damper throttles flow. The characteristic curves shown in Fig. 4 are the characteristics inherent in the construction of this damper and the operator linkage. These curves are the results of tests conducted at a constant pressure drop across the damper.

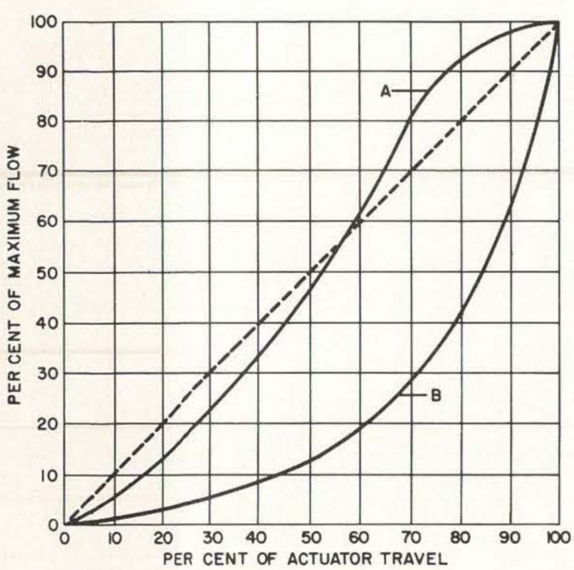

FIG. 4: CHARACTERISTICS OF THE PROPORTION/AIRE DAMPER

Sample Specification

The temperature control contractor will provide multiple blade dampers as indicated on the plans. All control dampers are to be the Johnson Service Company Proportion/Aire damper.

All dampers are to be sized to the application by the manufacturer using methods similar to control valve sizing. Dampers are to be installed by the sheet metal contractor under the supervision of the temperature control contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the sheet metal contractor.

The temperature control contractor shall submit a schedule of damper sizes to the sheet metal contractor with a copy to the engineer within ten (10) days after being awarded the contract.

All damper frames are to be constructed of No. 13 gage galvanized sheet metal and shall have flanges for duct mounting.

Damper blades shall not exceed six (6) inches in width. All blades are to be of corrugated type construction fabricated from two sheets of No. 22 gage galvanized sheet steel spot welded together. Blades are to be suitable for high velocity performance.

All damper bearings are to be made of nylon. Bushings that turn in the bearings are to be oil impregnated sintered metal. Replaceable butyl rubber seals are to be provided with the damper. Seals are to be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing low leakage damper.

Linkage which will provide a linear flow characteristic will be provided with the damper operator for all mixing damper applications (constant pressure drop).

Leakage and flow characteristic charts must be submitted to the engineer prior to approval of dampers.

SECTION III–PROPORTION/AIRE DAMPER APPLICATION

DAMPER SIZING

Throttling Application (Equal Percentage Linkage)

Figure 1 shows how the inherent characteristics are shifted upward when a damper is installed in a system where the pressure drop varies as the damper throttles air flow. In order to shift the inherent characteristic to the desired nearly linear effective characteristic, the damper must be sized so that its wide open pressure drop is a certain per cent of the system static pressure. It can be seen that curves C and D of Fig. 1 provide the most nearly linear effective characteristics. Fig. 2 shows the approach velocities which produce the wide open pressure drops necessary to create the curves illustrated in Fig. 1. This approach velocity information is to be used for sizing dampers for throttling applications. It can be directly related to the duct area and duct size, if the cfm is known, and no detailed pressure drop curves need be referred to.

When a damper is properly sized it will be smaller than duct size. A blank-off plate can be used in the majority of applications to adapt the smaller than duct size damper to the duct. Fig. 3 shows that when reducing the duct area by 30% or less, a blank-off plate can be used. If the duct area is to be reduced by more than 30%, a more elaborate gradual transition must be used to install the damper.

The information in Fig. 2 was derived from Fig. 1. The desired range band shows the approach velocities necessary to produce an effective characteristic curve which approaches curve C or D of Fig. 1. The total system pressure drop versus velocity curves show that to produce desirable (near linear) effective characteristics, dampers with system pressures

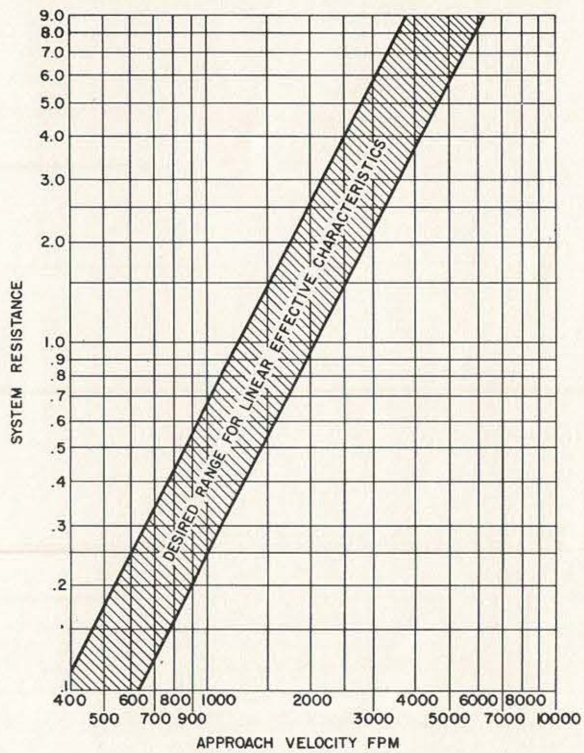

FIG. 2: DESIRED APPROACH VELOCITIES

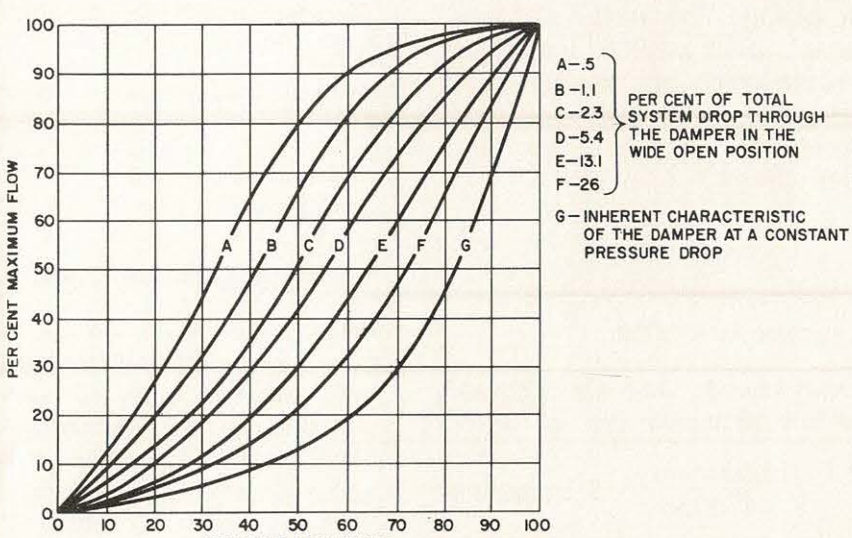

FIG. 1: EFFECT OF VARIABLE PRESSURE DROP ON DAMPER CHARACTERISTIC

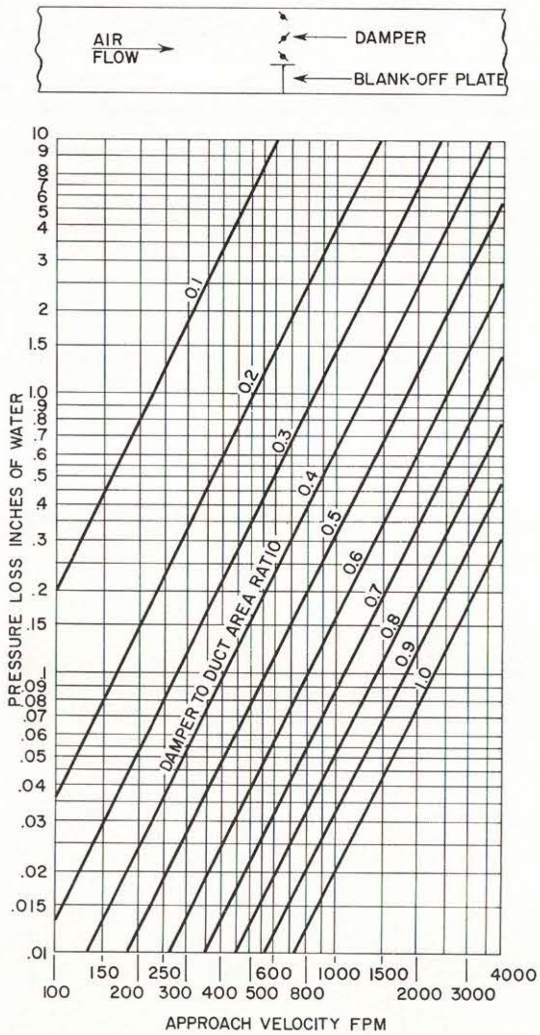

FIG. 3: EFFECT OF BLANK-OFF PLATES

of 1″ to 2″ should be sized for 1200 to 2800 fpm approach velocity. For systems with pressures of 2″ to 4″, 1800 to 4000 fpm through the damper in the wide open position should produce satisfactory results. With this information the correct damper size can be determined from the cfm.

Example:

Total system static pressure = 1″ w.g.

cfm through damper = 15,000

Desired approach velocity (from Fig. 2) equals 1200 to 2100 feet per minute (use 1670 fpm)

$$\text{Damper area} = \frac{15{,}000 \text{ cfm}}{1670 \text{ fpm}} = 9 \text{ square feet}$$

A damper of 36″ x 36″ in nominal size would be selected.

Face-and-Bypass Application (Equal Percentage Linkage)

A face-and-bypass application is handled much the same as the preceding example. The face-and-bypass damper is treated like a throttling application because of the internal pressure changes within the face-and-bypass section. As mentioned in a previous section, the pressure drop through the coil is transferred to the face damper as the face damper closes. The pressure drop across the bypass also changes due to the smaller than duct size effect. The face damper is sized for the velocity through the coil and the equal percentage linkage is used. The bypass damper must be sized using Fig. 4. By sizing the bypass damper from Fig. 4, 100% flow will be maintained through the bypass section for all positions of the face-and-bypass damper, as shown in Fig. 5. The equal percentage linkage is also to be used on the bypass damper.

Example: Assume a system of 5000 cfm total flow and a specified coil velocity of 600 fpm and a .25″ w.g. pressure drop through the coil.

The face damper will be coil size (or as close to coil size as possible) since we must size it for the specified velocity through the coil.

$$\text{Face area} = \frac{5000 \text{ cfm}}{600 \text{ fpm}} = 8.34 \text{ square feet}$$

Face damper size = 36″ x 36″ nominal (closest to 8.34 square feet available)

Bypass damper size = 35% of face damper area (refer to Fig. 4)

Bypass damper size = .35 x 9.0 sq. ft.
= 3.15 sq. ft.

Bypass damper size = 12″ high x 36″ nominal (closest to 3.15 sq. ft. available).

Mixing Application (Linear Linkage)

Mixing applications do not require as precise a sizing method as throttling applications since the pressure drop across mixing dampers remains relatively constant. As a general rule, dampers with the linear rather than the equal percentage linkage should be used. Mixing dampers, such as outdoor and return air dampers, should be sized for 1000 fpm or greater to aid in producing the desired mixing.

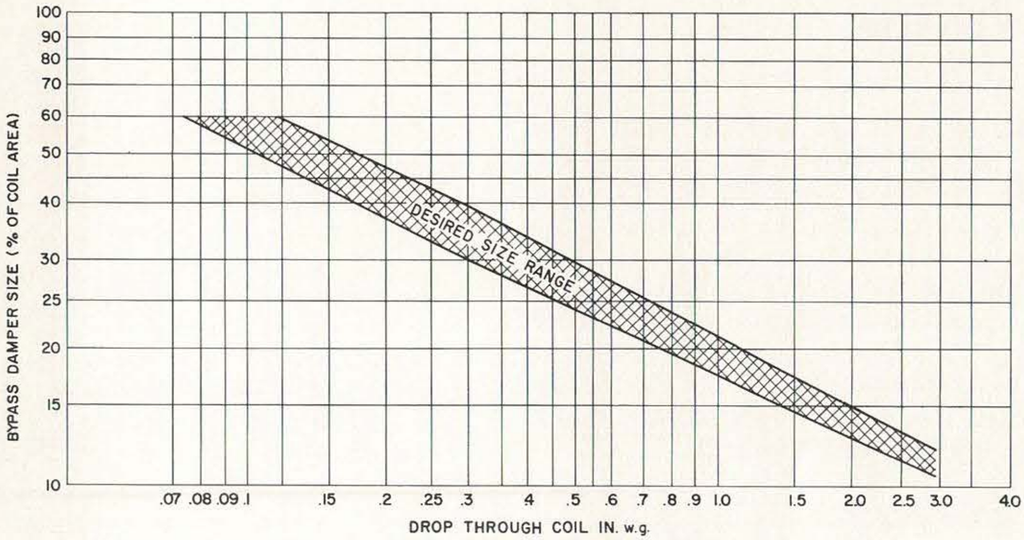

FIG. 4: BYPASS DAMPER SIZING CURVE

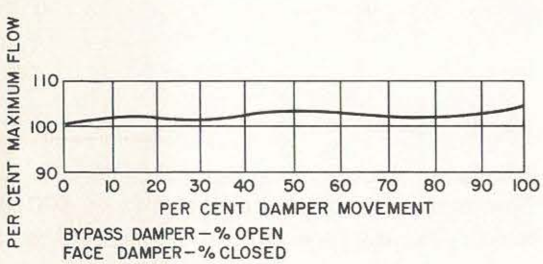

FIG. 5: PER CENT FLOW VERSUS DAMPER POSITION (FACE-AND-BYPASS SYSTEM)

Example: Assume a typical system like the one in Fig. 6. Total system cfm is 12,000. The minimum outside air requirement is 25% or 3000 cfm. Damper sizes are as follows:

Return air $= \dfrac{12{,}000 \text{ cfm}}{1000 \text{ fpm}} =$ 12 square feet

A damper of nominal dimsensions of 36" high x 48" wide could be used.

Maximum outdoor air = 75% x 12,000 cfm = 8000 cfm

$$\frac{8000 \text{ cfm}}{1000 \text{ fpm}} = 8 \text{ square feet}$$

A damper of nominal dimensions of 24" high x 48" wide could be used.

Minimum outdoor air = 25% x 12,000 cfm = 3000 cfm.

$$\frac{3000 \text{ cfm}}{1000 \text{ fpm}} = 3 \text{ square feet}$$

A damper of nominal dimensions of 24" high x 15" wide would be used.

The exhaust damper would be the same size as the return air damper since it will also handle 12,000 cfm at 1000 fpm.

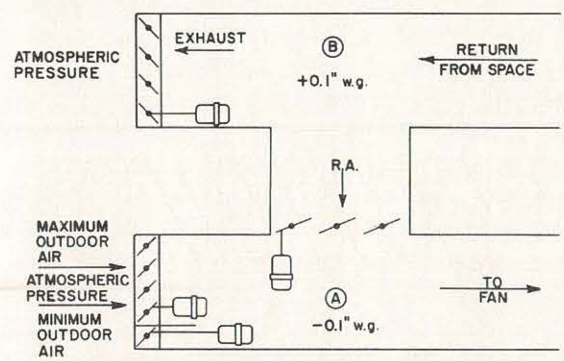

FIG. 6: TYPICAL CONSTANT PRESSURE DROP APPLICATION (MIXING DAMPERS)

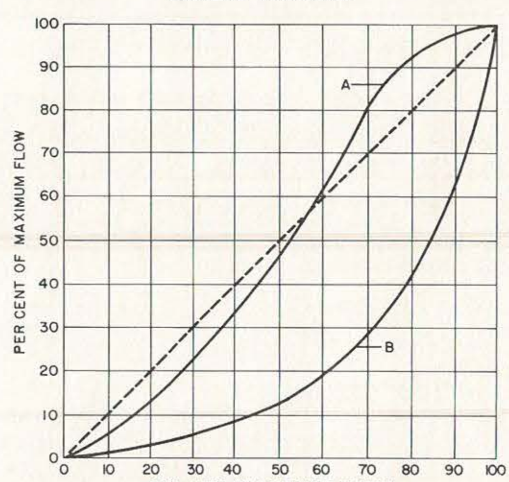

FIG. 7: INHERENT CHARACTERISTIC (CONSTANT PRESSURE DROP)

The damper operators must be ordered with the linear linkage for the above dampers so that a near linear flow characteristic is maintained. The flow characteristic produced will be the same as curve A of Fig. 7.

DAMPER LEAKAGE

Seals

The Proportion/Aire is provided with butyl rubber seals for tight shut-off. The seals are along the top, bottom, and sides of the frame and along each blade edge. The seals along the side of the frame are held in place by snaps and can be easily replaced by pulling off the snaps, and snapping in new seals. The remaining seals are in slots in the top and bottom of the frame and in slots on the blades. These seals can easily be replaced by sliding them out and sliding in new ones.

Per Cent Leakage

Tables 2 through 8 show leakage through the opposed blade dampers when closing off against 1" through 8" w.g. static pressure. If it is desired to relate these values as a per cent, the total flow at the wide open position must be known. For example, assume a damper which has nominal dimensions of four feet along the blade axis, by two feet in height, with a flow of 1500 fpm when wide open, and a maximum fan pressure of 1" w.g. This damper will then pass a volume of 12,000 cfm (8 sq. ft. x 1500 fpm). The leakage is found to be 47 cfm (from Table 2). The per cent leakage is:

$$\frac{47}{12{,}000} \times 100 = .39\%$$

Now assume the same damper in a system designed for a flow of 500 fpm, with other conditions being the same. Total fan pressure would still be 1" against the damper when closed and leakage would still be 47 cfm. This yields a percentage of:

$$\frac{47 \text{ cfm}}{4000 \text{ cfm}} \times 100 = 1.17\%$$

OPERATOR SIZING

Damper operator sizing tables are included in this manual. Using these tables in the following steps:

1. Determine the maximum static pressure against which the damper must operate. (This information is available from the plans or specifications.)
2. From the damper sizing calculations determine the square foot area of the damper.

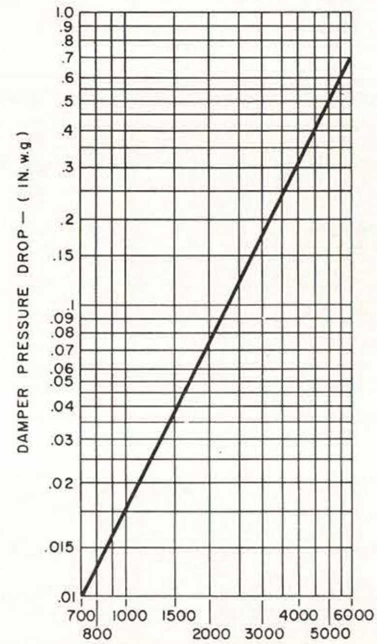

FIG. 8: PRESSURE DROP THROUGH WIDE OPEN DAMPER

3. From the damper sizing calculations determine the velocity of air through the damper in its wide open position (cfm/face area).
4. Select the operator spring range required for proper sequencing. Use as high a supply air pressure as is practical.
5. Using the proper table (9 through 12), select the columns for system pressure, velocity and spring range determined above. In the proper columns, locate the area next larger than that of the damper to be controlled. Find the proper operator size in the proper columns at the left of the table opposite the desired area figure. If the area of the damper exceeds the area shown in the table, divide by the necessary number of operators to decrease the damper area until it fits the table.

Example: Find the operator required for a normally open damper of 20 square feet. System pressure is 1" w.g. Velocity through the wide open damper is 2000 fpm. An operator with no pilot positioner and a 5-10 lb. spring range is desired.

From Table 9, in 2000 fpm column under 5-10 lb. spring range at 1" w.g. system pressure, one No. 4 operator will position 22 square feet of damper. A No. 4 operator would therefore be selected.

TABLE 1
STANDARD DAMPER SIZES
(SQ. FT. AREA)
(NOMINAL)

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	.5	.625	.75	.875	1.0	1.125	1.25	1.375	1.5	1.75	2.0
12"	1.0	1.25	1.5	1.75	2.0	2.25	2.5	2.75	3.0	3.5	4.0
18"	1.5	1.87	2.25	2.63	3.0	3.375	3.75	4.125	4.5	5.25	6.0
24"	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0
30"	2.5	3.12	3.75	4.38	5.0	5.625	6.25	6.675	7.5	8.75	10.0
36"	3.0	3.75	4.5	5.25	6.0	6.75	7.5	8.25	9.0	10.5	12.0
42"	3.5	4.38	5.25	6.13	7.0	7.875	8.75	9.625	10.5	12.25	14.0
48"	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	14.0	16.0

TABLE 2
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 1" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	11.8	12.4	13.0	13.6	14.4	14.9	15.5	16.1	17.0	18.3	19.6
12"	21.0	21.6	22.2	22.8	23.6	24.1	24.7	25.4	26.2	27.5	28.8
18"	30.2	30.8	31.4	32.0	32.8	33.4	34.0	34.6	35.4	36.7	38.0
24"	39.4	40.0	40.6	41.2	42.0	42.6	43.2	43.8	44.6	45.9	47.2
30"	48.6	49.2	49.8	50.4	51.2	51.8	52.5	53.0	53.8	55.1	56.4
36"	57.8	58.4	59.0	59.6	60.4	61.0	61.7	62.3	63.0	64.3	65.6
42"	67.0	67.6	68.2	68.8	69.6	70.3	70.9	71.5	72.2	73.5	74.8
48"	76.2	76.8	77.4	78.0	78.8	79.6	80.1	80.8	81.4	82.7	84.0

TABLE 3
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 2" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	15.3	16.1	16.9	17.7	18.6	19.4	20.3	21.1	21.9	23.5	25.2
12"	27.3	28.1	28.9	29.7	30.6	31.4	32.3	33.1	33.9	35.5	37.2
18"	39.3	40.1	40.9	41.7	42.6	43.4	44.3	45.1	45.9	47.5	49.2
24"	51.3	52.1	52.9	53.7	54.6	55.4	56.3	57.1	57.9	59.5	61.2
30"	63.3	64.1	64.9	65.7	66.6	67.4	68.3	69.1	69.9	71.5	73.2
36"	75.3	76.1	76.9	77.7	78.6	79.4	80.3	81.1	81.9	83.5	85.2
42"	87.3	88.1	88.9	89.7	90.6	91.4	92.3	93.1	93.9	95.5	97.2
48"	99.3	100.1	100.9	101.7	102.6	103.4	104.3	105.1	105.9	107.5	109.2

TABLE 4
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 3" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	19.2	20.2	21.2	22.3	23.3	24.3	25.3	26.4	27.4	29.5	31.5
12"	34.3	35.3	36.3	37.4	38.4	39.4	40.5	41.5	42.5	44.6	46.6
18"	49.4	50.4	51.4	52.5	53.5	54.5	55.6	56.6	57.6	59.7	61.7
24"	64.5	65.5	66.5	67.6	68.7	69.6	70.7	71.7	72.8	74.8	76.9
30"	79.6	80.6	81.6	82.7	83.8	84.7	87.8	86.8	87.9	89.9	92.0
36"	84.7	95.7	96.7	97.8	98.9	99.8	100.9	101.9	103.0	105.0	107.1
42"	99.8	110.8	111.8	112.9	114.0	114.9	116.0	117.0	118.1	120.1	122.2
48"	104.9	125.9	126.9	128.0	129.1	130.0	131.1	132.1	133.2	135.2	137.3

TABLE 5
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 4" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	22.1	23.2	24.4	25.6	26.8	28.0	29.2	30.3	31.5	33.8	36.2
12"	39.5	40.6	41.8	43.0	44.2	45.4	46.6	47.7	48.9	51.2	53.6
18"	56.9	58.0	59.2	60.4	61.6	62.8	64.0	65.1	66.3	68.6	71.0
24"	74.3	75.4	76.6	77.8	79.0	80.2	81.4	82.5	83.7	86.0	88.4
30"	91.7	92.8	94.0	95.2	96.4	97.6	98.8	99.9	101.1	103.4	105.8
36"	109.1	110.2	111.4	112.6	113.8	115.0	116.2	117.3	118.5	120.8	123.2
42"	126.5	127.6	128.8	130.0	131.2	132.4	133.6	134.7	135.9	138.2	140.6
48"	143.9	145.0	146.2	147.4	148.6	149.8	151.0	152.1	153.3	155.6	158.0

TABLE 6
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 5" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	24.3	25.6	26.9	28.2	29.6	30.9	32.3	33.6	34.9	37.5	40.2
12"	43.3	44.6	45.9	47.2	48.6	49.9	51.3	52.6	53.9	56.5	59.2
18"	62.3	63.6	64.9	66.2	67.6	68.9	70.3	71.6	72.9	75.5	78.2
24"	81.3	82.6	83.9	85.2	86.6	87.9	89.3	90.6	91.9	94.5	97.2
30"	100.3	101.6	102.9	104.2	105.6	106.9	108.3	109.6	110.9	113.5	116.2
36"	119.3	120.6	121.9	123.2	124.6	125.9	127.3	128.6	129.9	132.5	135.2
42"	138.3	139.6	140.9	142.2	143.6	144.9	146.3	147.6	148.9	151.5	154.2
48"	157.3	158.6	159.9	161.2	162.6	163.9	165.3	166.6	167.9	170.5	173.2

TABLE 7
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 6" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	27.3	28.8	30.3	31.8	33.3	34.8	36.3	37.8	39.3	42.3	45.3
12"	48.6	50.3	51.6	53.1	54.6	56.1	57.6	59.1	60.6	63.6	66.6
18"	69.9	71.6	72.9	74.4	75.9	77.4	78.9	80.4	81.9	84.9	87.9
24"	91.2	92.9	94.2	95.7	97.2	98.7	100.2	101.7	103.2	106.2	109.2
30"	112.5	114.2	115.5	117.0	118.5	120.0	121.5	123.0	124.5	127.5	130.5
36"	133.8	135.5	136.8	138.3	139.8	141.3	142.8	144.3	145.8	148.8	151.8
42"	155.1	156.8	158.1	159.6	161.1	162.6	164.1	165.6	167.1	170.1	173.1
48"	176.4	178.1	179.4	180.9	182.4	183.9	185.4	186.9	188.4	191.4	194.4

TABLE 8
LEAKAGE THROUGH OPPOSED BLADE DAMPERS (SCFM)
CLOSING AGAINST 8" w.g. STATIC PRESSURE

HEIGHT (PERPENDICULAR TO BLADE AXIS)	LENGTH (PARALLEL TO BLADE AXIS)										
	12"	15"	18"	21"	24"	27"	30"	33"	36"	42"	48"
6"	31.4	33.1	34.8	36.5	38.3	41.6	43.4	44.3	45.2	48.6	52.1
12"	55.9	57.8	59.4	61.1	62.8	66.8	68.6	69.0	69.7	73.1	76.5
18"	81.4	82.4	83.9	85.6	87.3	92.0	92.8	93.8	95.6	96.6	101.1
24"	104.4	106.8	108.3	110.1	111.7	117.2	118.0	119.0	120.9	122.2	125.6
30"	129.4	131.3	132.9	134.6	136.3	142.4	143.2	144.2	146.1	146.6	150.1
36"	153.8	155.9	157.3	159.1	160.8	167.6	168.0	169.4	170.0	171.2	174.6
42"	178.4	180.5	181.9	183.5	185.3	192.8	193.0	194.1	195.0	195.6	199.1
48"	203.0	204.8	206.3	208.0	209.8	218.0	219.0	219.5	220.0	221.1	223.4

TABLE 9
OPPOSED BLADE DAMPER AREA PER OPERATOR (NORMALLY OPEN DAMPERS)

Based on Standard Piston Operators without Pilot Positioners and 15 psi Air Supply

AREA IN SQUARE FEET FOR OPPOSED BLADE DAMPER																						
SYSTEM PRESSURE (IN. w.g.)	OPER-ATOR SIZE	SPRING RANGE 3–7 psi							SPRING RANGE 5–10 psi							SPRING RANGE 8–13 psi						
		VELOCITY (FPM)							VELOCITY (FPM)							VELOCITY (FPM)						
		UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2								3.4	3.4	3.4	2.7				1.36	1.36	1.36	1.36			
	3	14.5	11.1	10.3	7.2				9.1	9.1	9.1	7.2				3.64	3.64	3.64	3.64			
	4	35.2	26.6	25.0	17.3				22.0	22.0	22.0	17.3				8.80	8.80	8.80	8.80			
1.0	2								3.4	3.4	2.3	2.2				1.36	1.36	1.36	1.36			
	3	13.5	9.3	6.2	6.0				9.1	9.1	6.2	6.0				3.64	3.64	3.64	3.64			
	4	32.8	22.6	15.0	14.5				22.0	22.0	15.0	14.5				8.80	8.80	8.80	8.80			
1.5	2								3.4	3.1	2.1	1.6				1.36	1.36	1.36	1.36			
	3	13.4	8.3	5.8	4.4				9.1	8.3	5.8	4.4				3.64	3.64	3.64	3.64			
	4	32.4	20.0	14.0	10.7				22.0	20.0	14.0	10.7				8.80	8.80	8.80	8.80			
2.0	2								3.4	2.5	1.8	1.5				1.36	1.36	1.36	1.36			
	3	9.9	6.7	4.9	4.1				9.1	6.7	4.9	4.1				3.64	3.64	3.64	3.64			
	4	23.8	16.3	12.0	9.9				22.0	16.3	12.0	9.9				8.80	8.80	8.80	8.80			
2.5	2								3.3	2.2	1.7	1.4				1.36	1.36	1.36	1.36			
	3	8.7	5.9	4.6	3.8				8.7	5.9	4.6	3.8				3.64	3.64	3.64	3.64			
	4	21.2	14.3	11.0	9.3				21.2	14.3	11.0	9.3				8.80	8.80	8.80	8.80			
3.0	2								3.3	2.2	1.7	1.3	0.9	0.7	0.7	1.36	1.36	1.36	1.31	0.92	0.73	0.77
	3	8.7	5.9	4.6	3.5	2.4	1.9	2.0	8.7	5.9	4.6	3.5	2.4	1.9	2.0	3.64	3.64	3.64	3.52	2.46	1.95	2.06
	4	21.2	14.3	11.0	8.5	5.9	4.7	5.0	21.2	14.3	11.0	8.5	5.9	4.7	5.0	8.80	8.80	8.80	8.50	5.95	4.70	5.00
4.0	2								3.3	1.7	1.4	1.1	0.7	0.6	0.5	1.36	1.36	1.36	1.11	0.71	0.58	0.55
	3	8.7	4.6	3.9	2.9	1.9	1.5	1.4	8.7	4.6	3.9	2.9	1.9	1.5	1.4	3.64	3.64	3.64	2.96	1.91	1.58	1.48
	4	21.2	11.1	9.5	7.2	4.6	3.8	3.5	21.2	11.1	9.5	7.2	4.6	3.8	3.5	8.80	8.80	8.80	7.17	4.66	3.79	3.58
5.0	2								3.3	1.7	1.4	0.9	0.7	0.5	0.4	1.36	1.36	1.36	0.99	0.70	0.53	0.42
	3	8.7	4.6	3.9	2.6	1.8	1.4	1.1	8.7	4.6	3.9	2.6	1.8	1.4	1.1	3.64	3.64	3.64	2.68	1.93	1.43	1.13
	4	21.2	11.1	9.5	6.4	4.6	3.5	2.7	21.2	11.1	9.5	6.4	4.6	3.5	2.7	8.80	8.80	8.80	6.40	4.55	3.46	2.73
6.0	2								1.9	1.7	1.3	0.9	0.7	0.5	0.3	1.36	1.36	1.30	0.99	0.70	0.49	0.39
	3	5.2	4.6	3.5	2.6	1.8	1.3	1.0	5.2	4.6	3.5	2.6	1.8	1.3	1.0	3.64	3.64	3.48	2.68	1.93	1.33	1.04
	4	12.5	11.1	8.4	6.4	4.6	3.2	2.5	12.5	11.1	8.4	6.4	4.6	3.2	2.5	8.80	8.80	8.42	6.40	4.55	3.21	2.53
7.0	2								1.9	1.2	1.2	0.9	0.6	0.4	0.3	1.36	1.21	1.25	0.99	0.65	0.48	0.36
	3	5.2	3.3	3.4	2.6	1.7	1.2	0.9	5.2	3.3	3.4	2.6	1.7	1.2	0.9	3.64	3.25	3.35	2.68	1.75	1.29	0.96
	4	12.5	7.9	8.1	6.4	4.2	3.1	2.3	12.5	7.9	8.1	6.4	4.2	3.1	2.3	8.80	7.86	8.11	6.40	4.22	3.12	2.32
8.0	2								1.9	1.2	1.2	0.9	0.6	0.4	0.3	1.36	1.21	1.25	0.98	0.65	0.41	0.34
	3	5.2	3.3	3.4	2.6	1.7	1.1	0.9	5.2	3.3	3.4	2.6	1.7	1.1	0.9	3.64	3.25	3.35	2.62	1.75	1.11	0.93
	4	12.5	7.9	8.1	6.3	4.2	2.7	2.2	12.5	7.9	8.1	6.3	4.2	2.7	2.2	8.80	7.86	8.11	6.34	4.22	2.70	2.24

TABLE 10
OPPOSED BLADE DAMPER AREA PER OPERATOR (NORMALLY CLOSED DAMPERS)
Based on Standard Piston Operators without Pilot Positioners and 15 psi Air Supply

AREA IN SQUARE FEET FOR OPPOSED BLADE DAMPER

SYSTEM PRESSURE (IN. w.g.)	OPERATOR SIZE	SPRING RANGE 3–7 psi, VELOCITY (FPM) UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2							
	3	5.5	5.5	5.5	5.5			
	4	13.2	13.2	13.2	13.2			
1.0	2							
	3	5.5	5.5	5.5	5.5			
	4	13.2	13.2	13.2	13.2			
1.5	2							
	3	5.5	5.5	5.8	4.4			
	4	13.2	13.2	14.0	10.7			
2.0	2							
	3	5.5	5.5	4.9	4.1			
	4	13.2	13.2	12.0	9.9			
2.5	2							
	3	5.5	5.5	4.6	3.8			
	4	13.2	13.2	11.0	9.3			
3.0	2							
	3	5.5	5.5	4.6	3.5	2.4	1.9	2.0
	4	13.2	13.2	11.0	8.5	5.9	4.7	5.0
4.0	2							
	3	5.5	4.6	3.9	2.9	1.9	1.5	1.4
	4	13.2	11.1	9.5	7.2	4.6	3.8	3.5
5.0	2							
	3	5.5	4.6	3.9	2.6	1.8	1.4	1.1
	4	13.2	11.1	9.5	6.4	4.6	3.5	2.7
6.0	2							
	3	5.2	4.6	3.5	2.6	1.8	1.3	1.0
	4	12.5	11.1	8.4	6.4	4.6	3.2	2.5
7.0	2							
	3	5.2	3.3	4.4	2.6	1.7	1.2	0.9
	4	12.5	7.9	8.1	6.4	4.2	3.1	2.3
8.0	2							
	3	5.2	3.3	3.4	2.6	1.7	1.1	0.9
	4	12.5	7.9	8.1	6.3	4.2	2.7	2.2

SYSTEM PRESSURE (IN. w.g.)	OPERATOR SIZE	SPRING RANGE 5–10 psi, VELOCITY (FPM) UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2	3.4	3.4	3.4	2.7			
	3	9.1	9.1	9.1	7.2			
	4	22.0	22.0	22.0	17.3			
1.0	2	3.4	3.4	2.3	2.2			
	3	9.1	9.1	6.2	6.0			
	4	22.0	22.0	15.0	14.5			
1.5	2	3.4	3.1	2.1	1.6			
	3	9.1	8.3	5.8	4.4			
	4	22.0	20.0	14.0	10.7			
2.0	2	3.4	2.5	1.8	1.5			
	3	9.1	6.7	4.9	4.1			
	4	22.0	16.3	12.0	9.9			
2.5	2	3.3	2.2	1.7	1.4			
	3	8.7	5.9	4.6	3.8			
	4	21.2	14.3	11.0	9.3			
3.0	2	3.3	2.2	1.7	1.3	0.9	0.7	0.7
	3	8.7	5.9	4.6	3.5	2.4	1.9	2.0
	4	21.2	14.3	11.0	8.5	5.9	4.7	5.0
4.0	2	3.3	1.7	1.4	1.1	0.7	0.6	0.5
	3	8.7	4.6	3.9	2.9	1.9	1.5	1.4
	4	21.2	11.1	9.5	7.2	4.6	3.8	3.5
5.0	2	3.3	1.7	1.4	0.9	0.7	0.5	0.4
	3	8.7	4.6	3.9	2.6	1.8	1.4	1.1
	4	21.2	11.1	9.5	6.4	4.6	3.5	2.7
6.0	2	1.9	1.7	1.3	0.9	0.7	0.5	0.3
	3	5.2	4.6	3.5	2.6	1.8	1.3	1.0
	4	12.5	11.1	8.4	6.4	4.6	3.2	2.5
7.0	2	1.9	1.2	1.2	0.9	0.6	0.4	0.3
	3	5.2	3.3	3.4	2.6	1.7	1.2	0.9
	4	12.5	7.9	8.1	6.4	4.2	3.1	2.3
8.0	2	1.9	1.2	1.2	0.9	0.6	0.4	0.3
	3	5.2	3.3	3.4	2.6	1.7	1.1	0.9
	4	12.5	7.9	8.1	6.3	4.2	2.7	2.2

SYSTEM PRESSURE (IN. w.g.)	OPERATOR SIZE	SPRING RANGE 8–13 psi, VELOCITY (FPM) UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2	5.4	4.1	3.9	2.7			
	3	14.5	11.1	10.3	7.2			
	4	35.2	26.6	25.0	17.3			
1.0	2	5.1	3.5	2.3	2.2			
	3	13.5	9.3	6.2	6.0			
	4	32.8	22.6	15.0	14.5			
1.5	2	5.0	3.1	2.1	1.6			
	3	13.4	8.3	5.8	4.4			
	4	32.4	20.0	14.0	10.7			
2.0	2	3.7	2.5	1.8	1.5			
	3	9.9	6.7	4.9	4.1			
	4	23.8	16.3	12.0	9.9			
2.5	2	3.2	2.2	1.7	1.4			
	3	8.7	5.9	4.6	3.8			
	4	21.2	14.3	11.0	9.3			
3.0	2	3.2	2.2	1.7	1.3	0.9	0.7	0.7
	3	8.7	5.9	4.6	3.5	2.4	1.9	2.0
	4	21.2	14.3	11.0	8.5	5.9	4.7	5.0
4.0	2	3.2	1.7	1.4	1.1	0.7	0.6	0.5
	3	8.7	4.6	3.9	2.9	1.9	1.5	1.4
	4	21.2	11.1	9.5	7.2	4.6	3.8	3.5
5.0	2	3.2	1.7	1.4	0.9	0.7	0.5	0.4
	3	8.7	4.6	3.9	2.6	1.8	1.4	1.1
	4	21.2	11.1	9.5	6.4	4.6	3.5	2.7
6.0	2	1.9	1.7	1.3	0.9	0.7	0.5	0.4
	3	5.2	4.6	3.5	2.6	1.8	1.3	1.0
	4	12.5	11.1	8.4	6.4	4.6	3.2	2.5
7.0	2	1.9	1.2	1.2	0.9	0.6	0.5	0.3
	3	5.2	3.3	3.4	2.6	1.7	1.2	0.9
	4	12.5	7.9	8.1	6.4	4.2	3.1	2.3
8.0	2	1.9	1.2	1.2	0.9	0.6	0.4	0.3
	3	5.2	3.3	3.4	2.6	1.7	1.1	0.9
	4	12.5	7.9	8.1	6.3	4.2	2.7	2.2

TABLE 11
OPPOSED BLADE DAMPER AREA PER OPERATOR (NORMALLY OPEN DAMPERS)
Based on Standard Piston Operators with Pilot Positioners and 20 psi Air Supply

SYSTEM PRESSURE (IN. w.g.)	OPER-ATOR SIZE	AREA IN SQUARE FEET FOR OPPOSED BLADE DAMPER																				
		SPRING RANGE 3–7 psi							SPRING RANGE 5–10 psi							SPRING RANGE 8–13 psi						
		VELOCITY (FPM)							VELOCITY (FPM)							VELOCITY (FPM)						
		UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2								6.8	6.8	6.8	6.7				4.7	4.7	4.7	4.7			
	3	22.9	16.5	15.5	10.7				18.2	18.2	18.2	17.9				12.7	12.7	12.7	12.7			
	4	55.4	40.0	37.5	26.0				44.0	44.0	44.0	43.3				30.8	30.8	30.8	30.8			
1.0	2								6.8	6.8	5.8	5.6				4.7	4.7	4.7	4.7			
	3	20.4	14.0	9.3	9.0				18.2	18.2	15.5	15.0				12.7	12.7	12.7	12.7			
	4	49.2	33.9	22.5	21.8				44.0	44.0	37.6	36.3				30.8	30.8	30.8	30.8			
1.5	2								6.8	6.8	5.4	4.1				4.7	4.7	4.7	4.7			
	3	20.0	12.4	8.7	6.6				18.2	18.2	14.5	11.1				12.7	12.7	12.7	12.7			
	4	48.5	30.2	21.0	16.1				44.0	44.0	35.0	26.8				30.8	30.8	30.8	30.8			
2.0	2								6.8	6.3	4.6	3.8				4.7	4.7	4.7	4.7			
	3	14.8	10.1	7.4	6.2				18.2	16.8	12.4	10.3				12.7	12.7	12.7	12.7			
	4	35.8	24.4	18.0	14.9				44.0	40.7	30.0	24.9				30.8	30.8	30.8	30.8			
2.5	2								6.8	5.5	4.2	3.6				4.7	4.7	4.7	4.7			
	3	13.1	8.8	6.8	5.8				18.2	14.8	11.4	9.6				12.7	12.7	12.7	12.7			
	4	31.8	21.4	16.5	13.9				44.0	35.7	27.5	23.3				30.8	30.8	30.8	30.8			
3.0	2								6.8	5.5	4.2	3.3	2.3	1.8	1.9	4.7	4.7	4.7	4.6	3.2	2.6	2.7
	3	13.1	8.8	6.8	5.3	3.7	2.9	3.1	18.2	14.8	11.4	8.8	6.1	4.9	5.1	12.7	12.7	12.7	12.3	8.6	6.8	7.2
	4	31.8	21.4	16.5	12.7	8.9	7.0	7.5	44.0	35.7	27.5	21.2	14.9	11.8	12.5	30.8	30.8	30.8	29.9	20.8	16.5	17.5
4.0	2								6.8	4.3	3.7	2.8	1.8	1.4	1.3	4.7	4.7	4.7	3.9	2.5	2.0	1.9
	3	13.1	6.9	5.9	4.4	2.9	2.3	2.2	18.2	11.5	9.8	7.4	4.8	3.9	3.7	12.7	12.7	12.7	10.4	6.7	5.5	5.1
	4	31.8	16.6	14.2	10.7	6.9	5.7	5.3	44.0	27.7	23.8	18.0	11.5	9.5	8.9	30.8	30.8	30.8	25.2	16.2	13.3	12.5
5.0	2								6.8	4.3	3.7	2.5	1.7	1.3	1.0	4.7	4.7	4.7	3.5	2.4	1.8	1.4
	3	13.1	6.9	5.9	3.9	2.8	2.1	1.7	18.2	11.5	9.8	6.6	4.7	3.6	2.8	12.7	12.7	12.7	9.2	6.6	5.0	3.9
	4	31.8	16.6	14.2	9.6	6.7	5.2	4.1	44.0	27.7	23.8	16.0	11.4	8.6	6.8	30.8	30.8	30.8	22.4	15.9	12.1	9.5
6.0	2								6.8	4.3	3.2	2.5	1.7	1.2	0.9	4.7	4.7	4.5	3.5	2.4	1.7	1.3
	3	7.8	6.9	5.2	3.9	2.8	2.0	1.5	13.0	11.5	8.7	6.6	4.7	3.3	2.6	12.7	12.7	12.2	9.2	6.6	4.6	3.6
	4	18.8	16.6	12.6	9.6	6.7	4.8	3.8	31.4	27.7	21.0	16.0	11.4	8.0	6.3	30.8	30.8	29.5	22.4	15.9	11.2	8.8
7.0	2								6.8	3.0	3.1	2.5	1.6	1.2	0.9	4.7	4.2	4.4	3.5	2.3	1.6	1.2
	3	7.8	4.9	5.0	3.9	2.6	1.9	1.4	13.0	8.1	8.4	6.6	4.4	3.2	2.4	12.7	11.4	11.7	9.2	6.1	4.5	3.3
	4	18.8	11.8	12.1	9.6	6.3	4.7	3.5	31.4	19.6	20.0	16.0	10.6	7.8	5.8	30.8	27.5	28.4	22.4	14.8	10.9	8.1
8.0	2								6.8	3.0	3.1	2.4	1.6	1.0	0.8	4.7	4.2	4.4	3.4	2.3	1.4	1.2
	3	7.8	4.9	5.0	3.9	2.6	1.6	1.4	13.0	8.1	8.4	6.5	4.4	2.8	2.3	12.7	11.4	11.7	9.1	6.1	3.9	3.2
	4	18.8	11.8	12.1	9.5	6.3	4.0	3.4	31.4	19.6	20.0	15.8	10.6	6.8	5.6	30.8	27.5	28.4	22.2	14.8	9.4	7.9

TABLE 12
OPPOSED BLADE DAMPER AREA PER OPERATOR (NORMALLY CLOSED DAMPERS)

Based on Standard Piston Operators with Pilot Positioners and 20 psi Air Supply

SYSTEM PRESSURE (IN. w.g.)	OPER-ATOR SIZE	AREA IN SQUARE FEET FOR OPPOSED BLADE DAMPER																				
		SPRING RANGE 3–7 psi							SPRING RANGE 5–10 psi							SPRING RANGE 8–13 psi						
		VELOCITY (FPM)							VELOCITY (FPM)							VELOCITY (FPM)						
		UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000	UP TO 1500	2000	2500	3000	4000	5000	6000
0.5	2								3.4	3.4	3.4	3.4				4.7	4.7	4.7	4.7			
	3	5.4	5.4	5.4	5.4				9.1	9.1	9.1	9.1				12.7	12.7	12.7	12.7			
	4	13.2	13.2	13.2	13.2				22.0	22.0	22.0	22.0				30.8	30.8	30.8	30.8			
1.0	2								3.4	3.4	3.4	3.4				4.7	4.7	4.7	4.7			
	3	5.4	5.4	5.4	5.4				9.1	9.1	9.1	9.1				12.7	12.7	12.7	12.7			
	4	13.2	13.2	13.2	13.2				22.0	22.0	22.0	22.0				30.8	30.8	30.8	30.8			
1.5	2								3.4	3.4	3.4	3.4				4.7	4.7	4.7	4.7			
	3	5.4	5.4	5.4	5.4				9.1	9.1	9.1	9.1				12.7	12.7	12.7	12.7			
	4	13.2	13.2	13.2	13.2				22.0	22.0	22.0	22.0				30.8	30.8	30.8	30.8			
2.0	2								3.4	3.4	3.4	3.4				4.7	4.7	4.7	4.7			
	3	5.4	5.4	5.4	5.4				9.1	9.1	9.1	9.1				12.7	12.7	12.7	12.7			
	4	13.2	13.2	13.2	13.2				22.0	22.0	22.0	22.0				30.8	30.8	30.8	30.8			
2.5	2								3.4	3.4	3.4	3.4				4.7	4.7	4.7	4.7			
	3	5.4	5.4	5.4	5.4				9.1	9.1	9.1	9.1				12.7	12.7	12.7	12.7			
	4	13.2	13.2	13.2	13.2				22.0	22.0	22.0	22.0				30.8	30.8	30.8	30.8			
3.0	2								3.4	3.4	3.4	3.3	2.3	1.8	1.9	4.7	4.7	4.7	4.6	3.2	2.6	2.7
	3	5.4	5.4	5.4	5.3	3.7	2.9	3.1	9.1	9.1	9.1	8.8	6.1	4.9	5.1	12.7	12.7	12.7	12.3	8.6	6.8	7.2
	4	13.2	13.2	13.2	12.7	8.9	7.1	7.5	22.0	22.0	22.0	21.2	14.9	11.8	12.5	30.8	30.8	30.8	29.9	20.8	16.5	17.5
4.0	2								3.4	3.4	3.4	2.8	1.8	1.4	1.3	4.7	4.7	4.7	3.9	2.5	2.0	1.9
	3	5.4	5.4	5.4	4.4	2.8	2.3	2.2	9.1	9.1	9.1	7.4	4.8	3.9	3.7	12.7	12.7	12.7	10.4	6.7	5.5	5.1
	4	13.2	13.2	13.2	10.8	6.9	5.7	5.3	22.0	22.0	22.0	18.0	11.5	9.5	8.9	30.8	30.8	30.8	25.2	16.2	13.3	12.5
5.0	2								3.4	3.4	3.4	2.5	1.7	1.3	1.0	4.7	4.7	4.7	3.5	2.4	1.8	1.4
	3	5.4	5.4	5.4	4.0	2.8	2.1	1.7	9.1	9.1	9.1	6.6	4.7	3.6	2.8	12.7	12.7	12.7	9.2	6.6	5.0	3.9
	4	13.2	13.2	13.2	9.6	6.8	5.2	4.1	22.0	22.0	22.0	16.0	11.4	8.6	6.8	30.8	30.8	30.8	22.4	15.9	12.1	9.5
6.0	2								3.4	3.4	3.2	2.5	1.7	1.2	0.9	4.7	4.7	4.5	3.5	2.4	1.7	1.3
	3	5.4	5.4	5.2	4.0	2.8	2.0	1.5	9.1	9.1	8.7	6.6	4.7	3.3	2.6	12.7	12.7	12.2	9.2	6.6	4.6	3.6
	4	13.2	13.2	12.6	9.6	6.8	4.8	3.8	22.0	22.0	21.0	16.0	11.4	8.0	6.3	30.8	30.8	29.5	22.4	15.9	11.2	8.8
7.0	2								3.4	3.0	3.1	2.5	1.6	1.2	0.9	4.7	4.2	4.4	3.5	2.3	1.6	1.2
	3	5.4	4.9	5.0	4.0	2.6	1.9	1.4	9.1	8.1	8.4	6.6	4.4	3.2	2.4	12.7	11.4	11.7	9.2	6.1	4.5	3.3
	4	13.2	11.8	12.1	9.6	6.3	4.7	3.5	22.0	19.6	20.0	16.0	10.6	7.8	5.8	30.8	27.5	28.4	22.4	14.8	10.9	8.1
8.0	2								3.4	3.0	3.1	2.4	1.6	1.0	0.8	4.7	4.2	4.4	3.4	2.3	1.4	1.2
	3	5.4	4.9	5.0	3.9	2.6	1.6	1.4	9.1	8.1	8.4	6.5	4.4	2.8	2.3	12.7	11.4	11.7	9.1	6.1	3.9	3.2
	4	13.2	11.8	12.1	9.5	6.3	4.1	3.4	22.0	19.6	20.0	15.8	10.6	6.8	5.6	30.8	27.5	28.4	22.2	14.8	9.4	7.9

SECTION IV – INSTALLATION PROCEDURES

This section illustrates the recommended procedure for installing the Proportion/Aire damper and the available accessories. Figure 1 shows frame dimensions and mounting holes. To insure proper operation of the damper, the frame must be mounted squarely and securely. When using more than one section, the frames should be bolted tightly together to form a solid unit.

Figure 2 illustrates the recommended method of mounting a damper in a duct section. Either No. 12 self-tapping screws or No. 10-24 machine screws and nuts may be used. Self-tapping screws are recommended.

Dampers may be mounted with the blade axis either horizontal or vertical. Blade bearings are designed so they will accommodate either position with a minimum amount of friction.

On the individual damper, all interconnecting linkage between blades is within the channel frame. For connecting modules together, four linkage assemblies are available.

Figure 3 shows the pin-to-pin linkage which can be used to connect dampers which are to be mounted side by side. A coupling is fastened to any blade pin of one module with a set screw, which is in the coupling, and screwed into threads in the end of the pin. The modules are then put together, and the matching pin of the second module is pushed into the coupling.

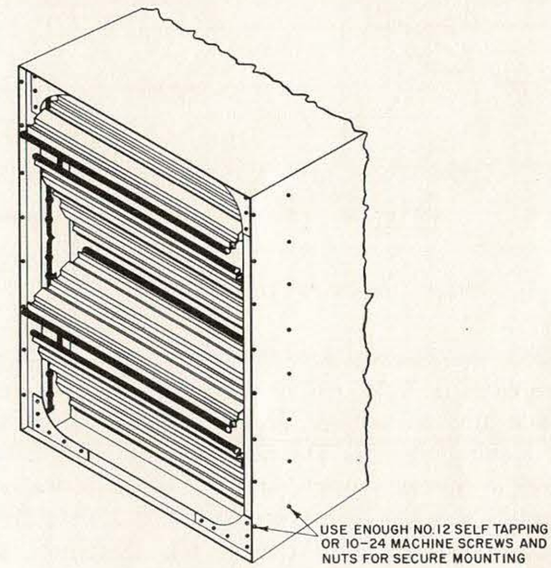

FIG. 2: DAMPER MOUNTED IN DUCT

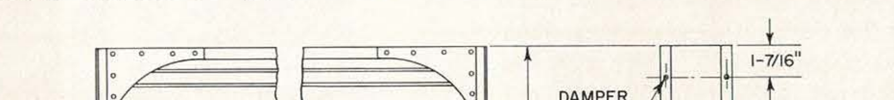

FIG. 1: FRAME DIMENSIONS AND MOUNTING HOLES

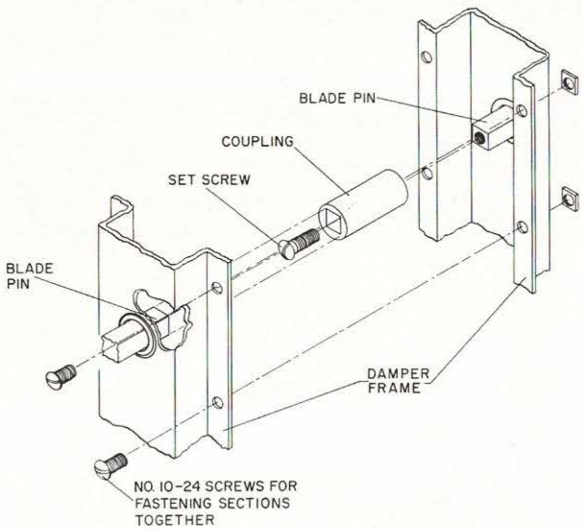

FIG. 3: PIN-TO-PIN LINKAGE ASSEMBLY

When the frames are fastened together, the coupling is held firmly in place. Since the blade pins are square, no additional set screws or locking devices are needed. To make one module normally open, and the other normally closed, the blades of one damper should be rotated 90 degrees before the coupling is engaged. Remember that this pin-to-pin coupling must be inserted before the dampers are installed in the duct. This is usually done by the sheet metal contractor. If the modules are to be connected after the dampers are installed, a blade-to-blade bracket assembly is available.

Figures 4a and 4b show a blade-to-blade bracket assembly which is used when modules are to be mounted side by side. This assembly consists of two brackets which are fastened to the blades to be connected, and a connection bar which is bolted to the brackets. The brackets are fastened to the blades with screws and nuts, using the knockouts provided in the blades for mounting holes. When both modules are to be normally open or normally closed, the assembly should be attached as shown in Fig. 4a. If one section is to be normally open and the other normally closed, the assembly is mounted as shown in Fig. 4b. One bracket assembly should be used for each operator applied to the damper.

Figures 5a and 5b show a blade-to-blade linkage assembly. This assembly is for use when modules are stacked one above the other, with blade axes parallel. In Fig. 5a, both dampers are either normally open or normally closed. In Fig. 5b, one damper is normally open, the other normally closed. To mount this linkage, the connectors are attached using the knockouts provided in the blades. The connecting rod is then attached to the connectors and adjusted. Any excess rod should be cut off. Use one blade-to-blade linkage assembly for every two modules.

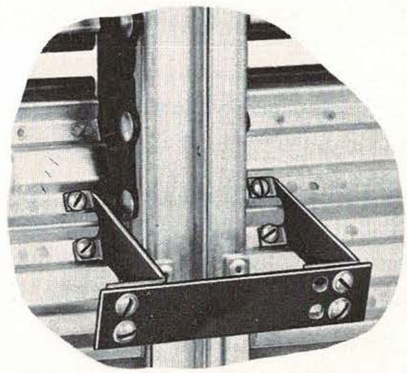

FIG. 4A

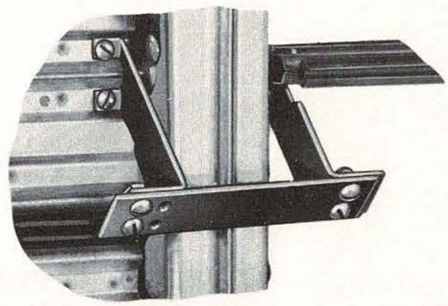

FIG. 4B
BLADE-TO-BLADE BRACKET ASSEMBLY

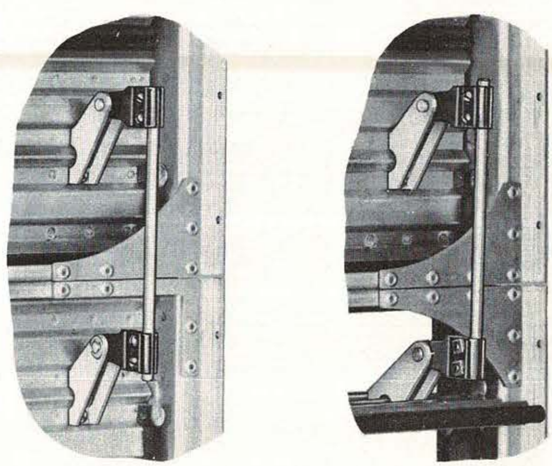

FIG. 5A **FIG. 5B**
BLADE-TO-BLADE LINKAGE ASSEMBLY

The assembly shown in Fig. 6 may be used where modules are to be connected outside a duct or enclosure. The assembly consists of two pin extensions, two crankarms with ball joint connectors, and a length of 5/16 inch connecting rod. For installation of the pin extension, see "Mounting the Operator." The crankarms are attached to the pin extensions with the damper blades in the proper positions.

The rod is put into the ball joint connectors, adjusted to the right length and tightened. Any excess rod may be cut off. The dampers may be adjusted for the same action, or the opposite action, depending on the adjustment of the crankarms with respect to the pins.

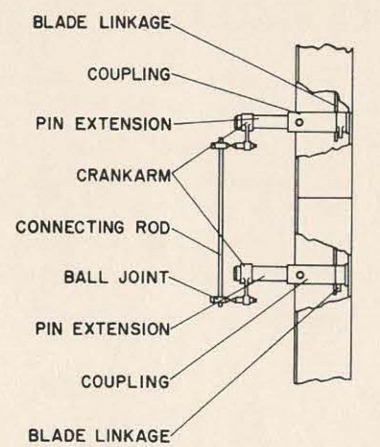

FIG. 6: EXTERNAL PIN-TO-PIN LINKAGE

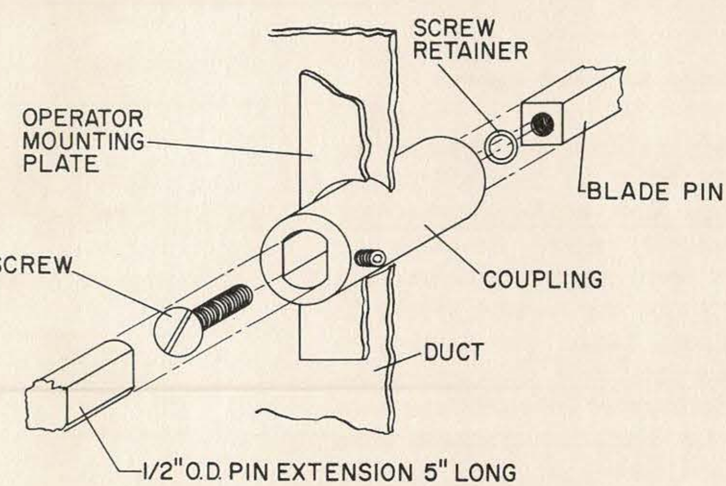

FIG. 7: EXPLODED VIEW OF BLADE PIN EXTENSION

MOUNTING THE OPERATOR

A Johnson D-251 Piston Operator may be mounted to the Proportion/Aire Damper using a mounting plate. This plate has two holes through which the pin extension coupling can extend. It may be mounted in any position around the pin, with the pin extending through either hole. Figure 7 is an exploded view of the blade pin extension assembly.

Figure 8 shows the position of the blade pin after the damper is installed in a duct. The exact center of the blade pin, inside the duct, is located by drawing lines from the center of the damper mounting screws to form a cross, as shown. The blade pin will be at the intersection of the two lines.

All blade pins, on both ends of the blades, are tapped to receive the coupling. The preferred operator location is at the side having the interconnecting blade linkage in the channel.

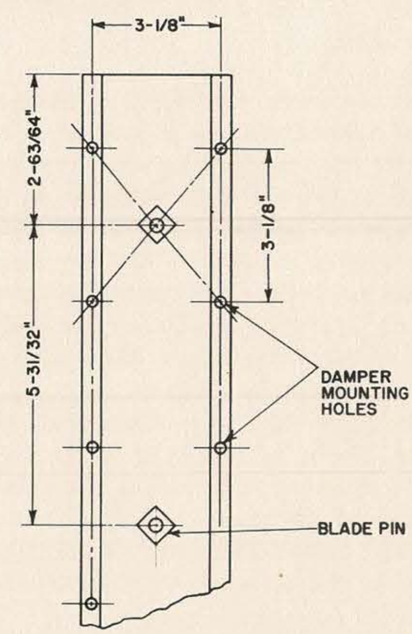

FIG. 8: FRAME HOLE DIMENSIONS AND BLADE PIN LOCATION

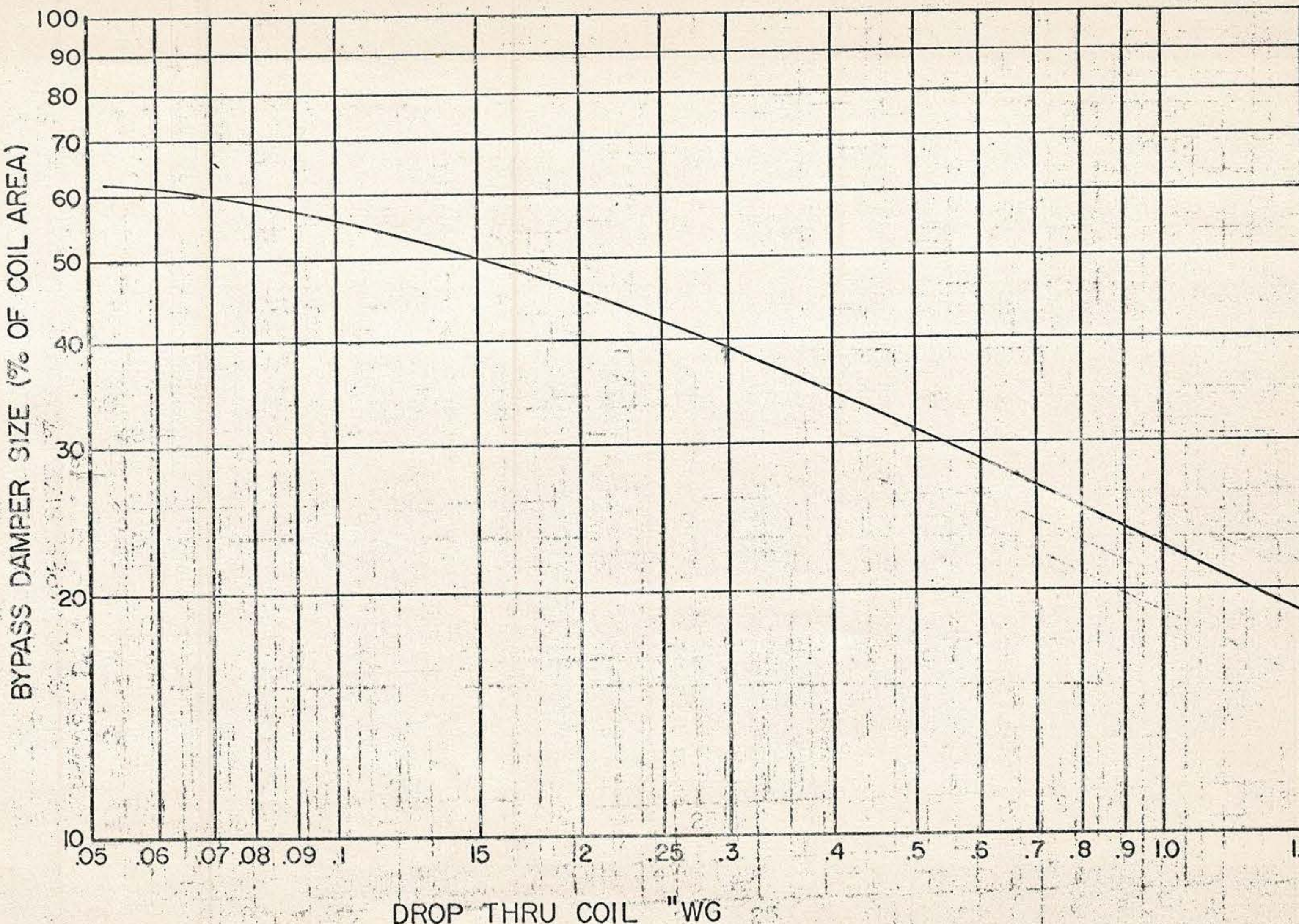

FIG. 14: FACE & BYPASS DAMPER RATIOS FOR VARIOUS COIL DROPS

REVISED

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DATE 8-18-63 DRWG.