RESIDENTIAL AIR INFILTRATION

GARRY E. CAFFEY
Associate Member ASHRAE

INTRODUCTION

For many years the air change rate of a residential dwelling or home had been estimated to be in the area of 3/4 air change per hour, but experience has indicated that many homes were much higher. When attempting to determine a heating/cooling requirement of a home, a difference in infiltration can drastically effect the heating/cooling requirement imposed on a residential space conditioning system.

Measurement of air is one of the more difficult tasks in the heating/cooling industry. For this reason, in June of 1976, an air machine, "The Super Sucker," was built to depressurize homes so that infiltration could be measured under simulated wind conditions and each area of leakage isolated. Air should be pulled or extracted from the home so that individual leakages can be measured more accurately from the inner surface of the home.

After testing 30 homes (some were new construction and some were existing construction) a summary of data was compiled which indicated that infiltration could be effectively reduced by use of various caulking compounds. An additional 20 homes have been tested since the time when the summary of 30 homes was prepared, and the breakdown of leakages has remained the same. The results indicate that the average air change for the 50 homes is 1½ air changes per hour rather than the 3/4 air change per hour previously assumed.

DESIGN AND USE OF "THE SUPER SUCKER"

It was suspected that most homes would permit air infiltration in the range of 0.47 (1,000) to 1.42 cms (3,000 cfm). Therefore, an air machine, "The Super Sucker," was designed to move this quantity of air. Fig. 1 is a picture of the air machine under operating conditions and shows the physical size of the machine which measures 45.7 cm (18 in.) in diameter and 213.4 cm (84 in.) in length. See Fig. 2 for specific dimensions. The "Super Sucker" can be installed in any window opening of 50.8 cm (20 in.) square or larger. The air is drawn from the interior of the residence through a honeycomb air straightener for laminar flow. An accurate reading is obtained by a pitot grid having some 16 sensors. Immediately in front of a tube axial fan driven by a 3/4 hp, 115 volt motor, a 45.7 cm (18 in.) diameter butterfly damper regulates the pressure differential across the wall of the structure.

The air measuring section is connected by tubing to a cfm meter (Fig. 1) which has a scale of 0 to 6,000 cfm. The butterfly damper can be adjusted to obtain the desired vacuum within a home to simulate a comparable wind velocity. The pressure differential measuring device is a manometer which displays the difference in pressure in inches of water column. The pressure differential across the exterior envelope of the home can be related to a mile per hour wind velocity value as shown on Fig. 4, (page 21.1 of the ASHRAE HANDBOOK and Product Directory, 1977 Fundamentals Volume). Data were obtained at various simulated wind velocities of 16 km/h (10 mph) to approximately 48 km/h (30 mph) on most homes, and particularly at 24 km/h (15 mph) which is the average winter wind velocity in the Dallas area.

Garry E. Caffey, Technical Services Engineer, Texas Power & Light Company, Dallas, Texas.

THIS PREPRINT FOR DISCUSSION PURPOSES ONLY. FOR INCLUSION IN ASHRAE TRANSACTIONS 1979,Vol. 85, Part 1. Not to be reprinted in whole or in part without written permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 345 East 47th Street, New York, NY 10017. Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the author(s) and do not necessarily reflect the views of ASHRAE.

On June 4, 1976, the first of a series of 50 residential infiltration tests was conducted. The technique of calculating air change rate with the data available had not yet been determined. The test on the first home (data shown in Table 1) revealed 0.47 cms (1,000 cfm) or 1,800 m^3/hr (60,000 ft^3/hr) at 24.88 Pa (0.10 in.) static, a 24 km/h (15 mph) wind condition.

The number of air changes of a home is determined by dividing the measured cms (cfm) air flow rate at 24.88 Pa(0.10in.) water static pressure by 4. This number is converted to cubic feet per hour by using a 60 multiplier. The resultant is divided by the volume of the home expressed as cm (cf).

What is the reasoning for dividing the total leakage by the number "4"? Under a winter design wind condition, a home is affected by a positive pressure on the windward side, a negative pressure on the leeward side, and slight positive or negative pressures on the remainder of the surfaces depending upon the wind direction and the physical shape of the home. Tests on pier and beam, U-shaped construction seemed to indicate a number in the order of 4.5 would be necessary in order to correlate with previously assumed air infiltration data. Tests in conjunction with gas tracer devices indicated the number 3.5 for single-story, slab construction. The number 4 was used to represent a broad spectrum of home designs in the 50 home test sample. A sample calculation of determining air change rate on home #1 is shown in Table 2.

When the initial 3 homes had been tested, there was some concern that an air change of less than 1.0 could be obtained with a 24.88 Pa (0.10 in.) water column vacuum. After testing home #4 and finding an air change of 7/10 and realizing that this particular home had two or three infiltration areas which could be improved, an air change in the order of 1/2 appeared to be a realistic goal.

Infiltration tests were conducted in conjunction with two major universities in June, 1977. First, the accuracy of our machine was calibrated against a laboratory wind tunnel. Then data were correlated by operating the "Super Sucker" simultaneously with a gas tracer unit (Fig. 5), and the results were favorable. The "Super Sucker" values when divided by 4 were within 15% of the values obtained by the gas tracer technique.

As noted in Table 3, the leakage of an average home is generally broken down into 12 different areas. These measured values were obtained while imposing a 62.2 Pa (0.25 in.) static on the test homes. A higher static was used because small leakage areas can be more accurately measured with an anemometer or cfm hood when larger quantities of air are flowing. The cfm hood and anemometer air measuring devices are shown in Fig. 6. Pictorial applications of using these air measuring devices are shown in Fig. 7-10. The total leakages on the test homes were also measured at 62.2 Pa (0.25 in.) static, therefore allowing the 12 areas of leakage to be compared with the total home leakage.

WHERE IS THE LEAKAGE AND HOW DO YOU CORRECT IT?

The following data for the 12 major areas of leakages are the <u>average</u> of 50 test homes. Some cases will be worse and some will be better than the averages listed. During our tests, we found that the typical home had a large number of infiltration points. When we blocked a 0.142 cms (300 cfm) point of infiltration, the overall value was only effected by 0.47 cms (100cfm).

The first and largest area of leakage was found to be the soleplate, sometimes referred to as the bottom plate or base board area of the exterior wall. Measurements of 0 to 0.0025 cms (5.5 cfm) were obtained. Although several techniques have been tried, it appears that a caulking compound material is necessary to obtain a positive seal. This may be applied before or after the plate has been set in place. According to our tests, approximately 25% of the infiltration of the average home is through the soleplate area.

The second most important area of infiltration found during these tests was electrical wall outlet openings. The average leakage for an outlet opening is 0.0038 cms (8 cfm), and many homes have in the excess of 65 wall outlets. This leakage problem can be eliminated by caulking the holes where the electrical wiring, plumbing and refrigerant lines penetrate the upper and lower wall plates. In the case of an existing home where it is not feasible to caulk these holes, a gasket installed behind the receptical or switch plate was found to reduce the outlet leakage to 7% of its original value.

Of the 40 duct systems measured, 19 were in standard construction homes containing attic duct systems. These homes leaked 0.208 cms (441 cfm) on the average. The 10 attic duct systems of energy built homes leaked 0.156 cms (331 cfm). The 11 furrdown duct systems, which are physically located inside the conditioned area or insulated area of the homes, averaged only 0.082 cms (174 cfm). This indicates that the furrdown duct systems were more than twice as good as the attic duct systems. The leakage of most of these furrdown duct systems was further analyzed, and it was found that air was entering through holes where refrigerant lines, electrical wiring and plumbing entered the furrdown area. This allows attic or unconditioned air to enter the return air area of the duct system. In the case of two of these 11 homes, the leakages were only 0.01 cms (23 cfm) and 0.02 cms (45 cfm). These two leakages represented 1.8 and 3.5 % of the total home leakage indicating that the furrdown areas had been sealed extremely well.

After testing windows in several homes it was noted that the leakage was about the same whether they were sealed insulating glass, storm windows, or single glazed. After additional investigation, it was noted that the majority of a window's leakage appeared around the frame work or around the facing of the window. There were several instances where the leakage of the window was measured before and after the storm window was closed and there was very little change in leakage values, again indicating that a large amount of the leakage must be entering around the facing. In most instances, where the window facings had been adequately caulked, a reduction in infiltration of approximately 60% was noted.

For northern applications of secondary or storm windows, weepholes are required to allow moisture and/or ice build-up to evaporate from the enclosed area. These provide openings where air may move from the exterior of the home through the storm window and into the interior of the home by way of the window openings.

Of the 50 homes tested, 39 contained fireplaces, and these were measured with the damper in the closed position. Twenty-one of the fireplaces were located on an interior wall and leaked on the average 0.063 cms (133 cfm). The exterior wall fireplace leaked on the average 0.069 cms (147 cfm). The combined average was 0.066 cms (139 cfm) for all homes. Only 2 fireplaces had glass screens; one leaked 0.033 cms (70 cfm) and the other 0.026 cms (55 cfm).

At the present time, fireplaces are the most expensive luxury found in the home when they have been improperly designed. There are several design features which can be incorporated into a fireplace which will increase their heating efficiency and reduce infiltration losses.

First, every fireplace should have combustion air introduced directly into the hearth from the exterior of the home. Fig. 11 shows two methods of introducing outside air. A glass screen in front permits only outside combustion air. This reduces the infiltration normally caused by the fireplace getting its combustion air from inside a conditioned space.

Circulating fans moving air through shell heat exchangers may be used to draw heat from the inner walls of the firebox and exhaust it into the room area. This will increase the efficiency of a fireplace.

Most fireplace dampers fit very loosely, thus allowing infiltration and leakage when the fireplace is not in use. There are chimney dampers which can be located on the top of the chimney and glued in place. The chimney damper has a spring loaded door which can be opened and closed by way of a cable which is terminated inside the firebox of the fireplace. One particular chimney damper leaked only 0.038 cms (82 cfm) which is approximately 1/2 of the leakage of the typical cast-iron fireplace damper.

Therefore, a glass screen should be used as well as a chimney damper and both can be closed when the fireplace is not in use. For all practical purposes this limits the amount of air which escapes and enters the home during periods of non-use. When incorporated with the techniques mentioned previously, maximum efficiency of fireplace utilization can be obtained.

Kitchen range vents attributed to approximately 5% of the total leakage of the homes. In most instances, a vent fan was connected to a 15.24 cm (6 in.) round vent pipe which contained a butterfly damper, but was easily opened as wind passed through the attic or when the "Super Sucker" was used to create a vacuum in the home. Some builders have chosen ventless filter-type range hoods where no exterior vent pipes are involved.

Recessed light fixtures which protrude through the ceiling surface of a home attributed to approximately 5% of the overall leakage of the average home. Recessed light fixture manufacturers require that their fixture have a clearance of 7.62 cm (3 in.) from any combustible material. Because of this requirement, the fixture should not be caulked or insulation placed near the fixture since it must have ventilation to release excess heat from inside the fixture. Many builders are choosing exterior mounted fixtures in order to create spotlighting on fireplace mantles and other points of interest while avoiding infiltration problems.

Until infiltration tests had been conducted on these test homes, the major area of leakage of the home was assumed to be due to windows, doors, and sliding glass doors. As noted from the infiltration pie chart Fig. 12, only 19% of the overall leakage of the home is attributed to these three areas. It was found that by further separating the leakage of the exterior door area, approximately 37% of the leakage was passing by the weather stripping on the three edges of the door, 9% was passing by the threshold area and 54% was circumventing the door through the facing or framing area. Therefore, it is suggested that caulking or adequate sealing be done between the framing of the door and the opening of the wall in order to reduce a large portion of the overall leakage of the door. Although weather stripping itself is a necessary item in any energy designed home, these tests indicated that the difference in leakage between a standard metal weather stripping and other more expensive types of weather stripping is insignificant. The sliding glass door infiltration followed the same general pattern as that of the standard exterior door.

Other areas of leakage were found to be the dryer exhaust vent and the bath fan vent. In both cases the average vent has a very light damper which opens upon positive pressure from the fan itself. We have found that it also opens with very little change in pressure from natural wind velocities, either by opening the front door or from additional air received into the home from the fireplace or other leakage areas. In any case, these exhaust vent damper doors are easily opened and do so continually. The exhaust vent dampers must open whenever the equipment is energized, and would take an expensive control device to open these devices other than with positive pressure from the fan.

Finally, the 3.5% leakage which has been catagorized "Other" may be attributed to infiltration in and around the brick fireplace area in most homes. The leakage, as mentioned earlier, of a closed fireplace damper only considered the amount of air that entered the home through the actual opening of the firebox, and did not allow for leakage where brick contacts the interior wall finish.

DISCUSSION

Unnecessary infiltration can attribute up to 40% of the heating/cooling energy requirement of a typical home. Therefore, it is essential that every possible measure be taken to reduce infiltration. Of the 12 areas which are shown in Table 3, it is possible to caulk, tape and/or seal approximately 60% of the overall leakage of the home at a very reasonable cost (particularly on new construction).

Home #43 (Table 4) is a very good example of how tight a present day home can be built and still be financially feasible for the consumer. This home attained an air change of 0.58 per hour even though it contained 14.6% glass and two wood-buring fireplaces.

Home #50 had an air change of 0.35 per hour, (Table 5). The exterior walls of this home were filled with urea-formaldehyde foam and all exterior walls and ceilings were innerlined with polyplastic film. This is a big improvement over the 1½ air change rate of the average home in this study of 50 homes.

Areas of infiltration have been analyzed by various energy consultants and residential home builders to determine the most feasible corrective measures. Many of these leakage areas have caused design changes in the building industry.

One good example of design change is the furrdown duct system. Although the design of homes in the southern area of the United States may be somewhat different than those in the northern portion of the U.S., the average American home will have leakages similar to the ones mentioned. A large percentage of the homes built in Texas have their heating/cooling duct systems located in the attic. In the northern portion of the U.S., duct systems are normally located in the basement areas of the home. One would assume that the duct systems located in the northern homes would leak approximately the same as those located in the southern homes since the same type of materials are used. The overall effect in Btu/hr loss and gain, however, would be considerably different since basement mounted duct systems are in a semi-conditioned area while duct systems in the south are exposed to attic temperatures in the excess of 150 F on a 100 F ambient day. Again, the southern home duct system is exposed to temperatures near freezing in the attic on a 10 F day while the northern home has a semi-conditioned basement area often used as a laundry facility of useable living space. Use of the conditioned area duct system has essentially eliminated duct leakage and Btu/hr loss and gain from the system.

There are other areas listed in Table 3 which require more labor and larger expenditures to reduce their leakage, but would attribute to a much tighter home if corrected. Some of these items are: installing glass screens and chimney dampers on the fireplace system, storm windows on all exterior windows, storm doors on all exterior doors, and reducing the leakage circumventing recessed lighting.

SUMMARY

During initial stages of testing the 50 homes, it became apparent that an air change in the order of 1/2 per hour would be a realistic goal. Home #50 was tested and found to have an air change of 0.35 per hour which was achievable with a few changes in home building techniques. Regardless of the location where the structure is built, when the areas of infiltration are treated adequately, the American home should be a much more efficient and comfortable home than ever before. With the rising cost of energy, the additional expense incurred in reducing infiltration is minimal when compared to the long term savings.

The "Super Sucker" provides a simple and easy method to effectively isolate and identify areas of unnecessary infiltration. Correction of many problem areas is relatively inexpensive and cost effective for both the residential builder and the ultimate home owner.

NOMENCLATURE

Static - Static pressure across the exterior wall, Pascals of water column (inches of water column)

Pa - Pascals of water column

in. - Inches of water column (248.8 Pa = 1.0 in.)

cm - Centimeters of length (2.54 cm = 1.0 in.)

m^3 - Volume of home, cubic meters

ft^3 - Volume of home, cubic feet

cms - Rate of air flow, cubic meters per second

cfm - Rate of air flow, cubic feet per minute

One Air Change - One complete volume of air replaced in a structure per hour

REFERENCES

1. ASHRAE HANDBOOK and Product Directory, 1977 Fundamentals Volume, ASHRAE, Inc., N.Y., N.Y.

ACKNOWLEDGEMENTS

The author wishes to thank the 50 home owners and/or builders for their support during this study. Appreciation is also extended to Mr. Urban E. Gibson of TP&L, the 11 TP&L Service Coordinators, Mr. Walter Patterson of Texas A & M University, and Dr. David Harrje and Kenneth Gadsby of Princeton University. Appreciation is also extended to Mrs. Susan Bateman and Mrs. Janet Stovall for their efforts in preparing this paper.

It is unfortunate that we were unaware of Mr. Tamura's similar work on this subject during the summers of 1967 and 1968 and recorded in ASHRAE Transactions, Vol. 81, Part 1, 1975. This work would have been beneficial in conducting our studies.

GEC
RCC
UEG

Table 1 Test Home No. 1 - 1,560 Sq. Ft.

(INFILTRATION IN CFM)

(Standard Construction)

Stat. Pres.	Total CFM Exhausted	Supply Ducts	Return Ducts	Doors 2 ea.	Windows 2 ea.	Vent-a-Hood 6" Round	Vent-a-Hood Furrdown	Bath Vent Fan
0.25	1,700	122	38	23;46	25;25	130	210	30
0.25	*1,600	-	-	-	-	-	-	-
0.20	1,500							
0.15	1,250							
0.10	1,000							
0.05	500							

*Total CFM was reduced from 1,700 to <u>1,600</u> after a cap was placed on the Vent-a-Hood and the Vent-a-Hood was sealed.

Details: Standard Construction
Exterior Doors: 2 ea. - 3'0" x 6'8"; Total = 40 Sq. Ft.
Windows: 2 ea. - 4'0" x 5'0"; Total = 95.5 Sq. Ft.
2 ea. - 3'6" x 4'6"
2 ea. - 3'0" x 3'0"
1 ea. - 2'0" x 3'0"
Attic Duct System includes 6 supply grills and 2 floor level returns
Approximately 50 electrical wall outlets; switch over, 10 CFM; plugs over.
8 CFM Soleplate linear feet: Kev's Rm. - 20 ft., Kris' Rm. - 10 ft., Play Rm. - 30 ft.
Discharged Vol. @ 0.10: 15,000 ft.^{3}
Base Volume: 12,480 ft.^{3}
Air Change: 1.2
Leakage @ 0.25: 1.02 CFM/Sq. Ft.

Table 2 Method of Determining Air Change Rate

(Following is example for Home #1)

MEASURED:

Total Home Leakage = 30 CMM (1,000 CFM)

Volume of Home = 374.4 CM (12,480 CF)

CALCULATED:

$$\text{Air Change/hour} = \frac{\text{Discharged Volume}}{\text{Base Volume}}$$

Discharged Volume = 30 CMM (1,000 CFM) ÷ *4 X 60 min.

= 450 CM (15,000 CF)

Base Volume = Volume of Test Home

= 374.4 CM (12,480 CF)

$$\text{Air Change/hour} = \frac{450\text{ CM }(15{,}000\text{ CF})}{374.4\text{ CM }(12{,}480\text{ CF})}$$

Air Change/hour = <u>1.2</u>

*The number 4 is used to reduce the wind effect to one size of Test Home.

Table 3 Infiltration Test Results

(Data Averaged From 50 Homes as Related to 0.25 Static)

				For Average Home of 1,780 Sq. Ft.		
	Average	HI	Low	No. of Items	CFM	% of Total
Size of Home	1,780 sq. ft.	3,220	1,072			
Total Leakage	2,558 CFM	6,800	800		2,558	100
Leakage/sq. ft.	1.43 CFM/sq. ft.	2.75	0.56			
*Air Change @ 0.10	1.49	2.70	0.35			
Soleplate (lin. crack ft.)	3.6 CFM	5.5	0	175 ea.	630	24.6
Electrical Wall Outlet	8 CFM	15	0	65 ea.	520	20.3
A/C Duct System	345 CFM	1,328	23	1 ea.	345	13.5
Exterior Window	23 CFM	67	7	13 ea.	300	11.8
**Fireplace (Damper Closed)	139 CFM	300	32	1 ea.	139	5.5
Range Vent (dampered)	132 CFM	234	0	1 ea.	132	5.2
Recessed Spot Light	33 CFM	56	5	4 ea.	132	5.2
Exterior Door	39 CFM	80	8	3 ea.	117	4.6
Dryer Vent	71 CFM	112	38	1 ea.	71	2.8
Sliding Glass Door	43 CFM	75	10	1 ea.	43	1.7
Bath Vent	33 CFM	65	20	1 ea.	33	1.3
Other					96	3.5

*Only value related to 0.10 S.P. (15 MPH)
**40 Homes had Fireplaces

Table 4 Test Home No. 43 - 2,050 Sq. Ft.

Date: 6-21-77
Tested by: TDM
DH
DB
ABV
GEC

(INFILTRATION IN CFM)

(Super Energy Construction)

Stat. Pres.	Total CFM Exhausted	Duct System	Fireplace Damper Closed	Recessed Lights
0.44	1,900			
0.40	1,700			
0.35	1,550			
0.30	1,400			
0.25	1,250	45	2 ea. @ 120	25;52
0.20	1,100			
0.15	900			
0.10	700			
0.05	400			

Details: Energy Efficient Construction, Built June, 1977
Foundation: Slab R of ceiling, wall, floor, duct R-26; R-13; slab, furrdown ducts
Special Design Features: carpet turns up on walls
Exterior Doors: Thermalpane sliding glass door
Windows: All Thermalpane windows (14.6% glass as compared to floor living area)
Duct System: Total Furrdown Duct System
Discharged Vol. @ 0.10: 10,500 ft.^{3}
Base Volume: 17,880 ft.^{3}
Air Change: 0.58
Leakage @ 0.25: 0.61 CFM/Sq. Ft.

Table 5 Test Home No. 50 - 1,605 Sq. Ft.

(INFILTRATION IN CFM)

(Super Energy Efficient Construction)

Date: 10-11-77
Tested by: IJS
KF
GEC

Stat. Pres.	Total CFM Exhausted	Duct System
0.55+	1,550	
0.50	1,400	
0.45	1,300	
0.40	1,200	
0.35	1,050	
0.30	1,000	
0.25	900	90 CFM Duct System
0.20	700	
0.15	500	
0.10	300	
0.05	100	

Details: Energy Efficient Construction, built October, 1977
Foundation Slab-ceiling R-30, Wall R-24, Floor R-4, furrdown duct system
Special Design Features: Total urea-formaldehyde foam wall
Exterior Doors: 3 ea. exterior doors with rubber bead gasket
Windows: 8 windows but the storm windows were not installed
Duct System: Furrdown duct system but the heat pump air handler was located in an exterior room where the solar heating equipment was installed.
Discharged Vol. @ 0.10: 4,500 ft.
Base Volume: 12,840 ft.
Air Change: 0.35
Leakage @ 0.25: 0.56

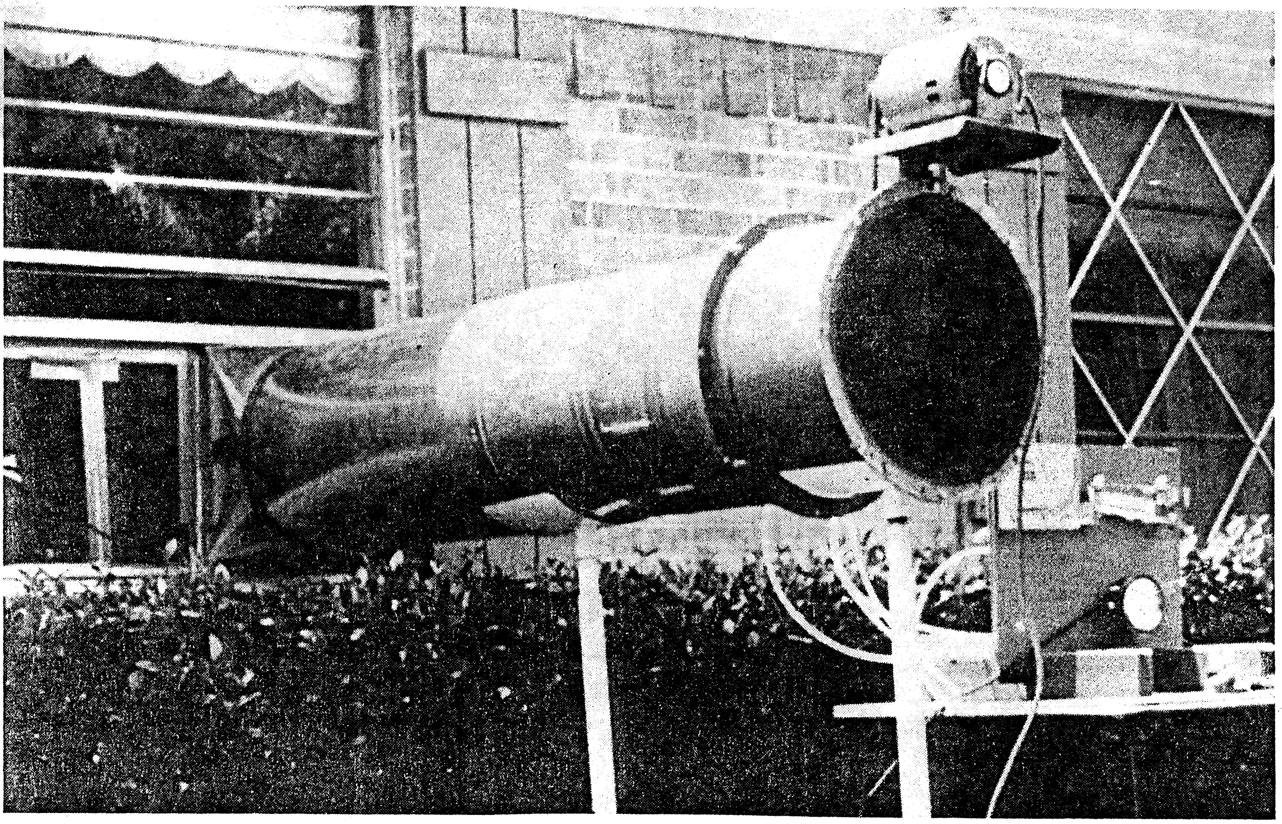


Fig. 1

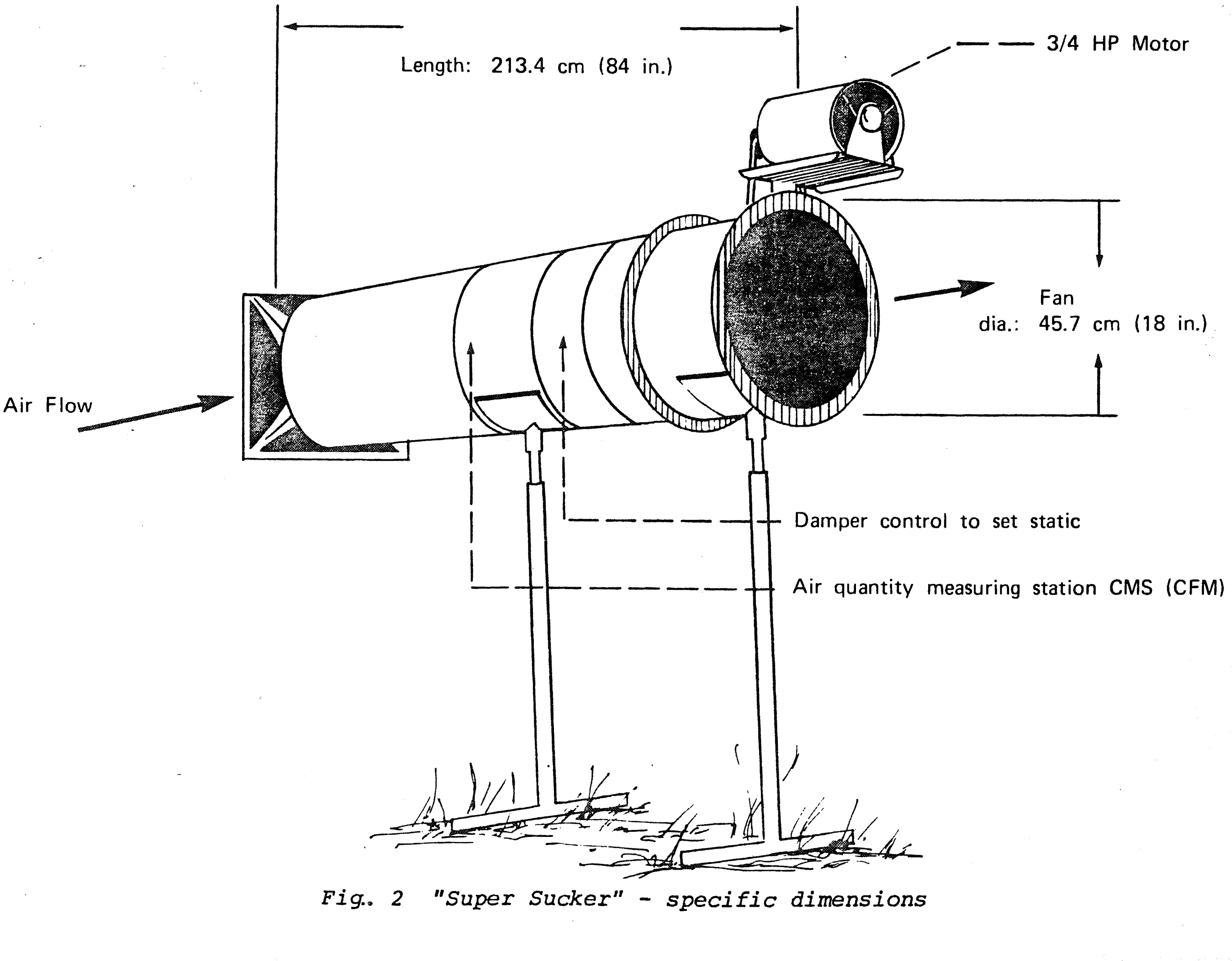


Fig. 2 "Super Sucker" - specific dimensions

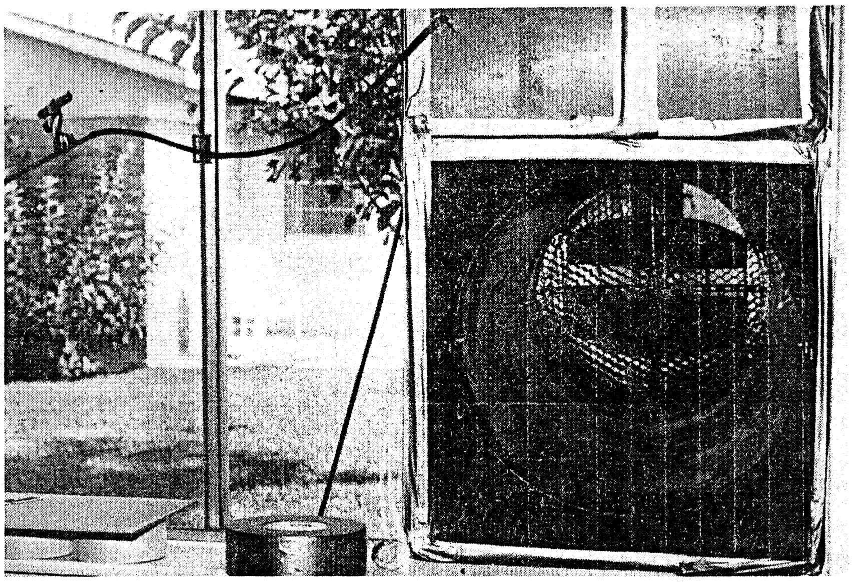
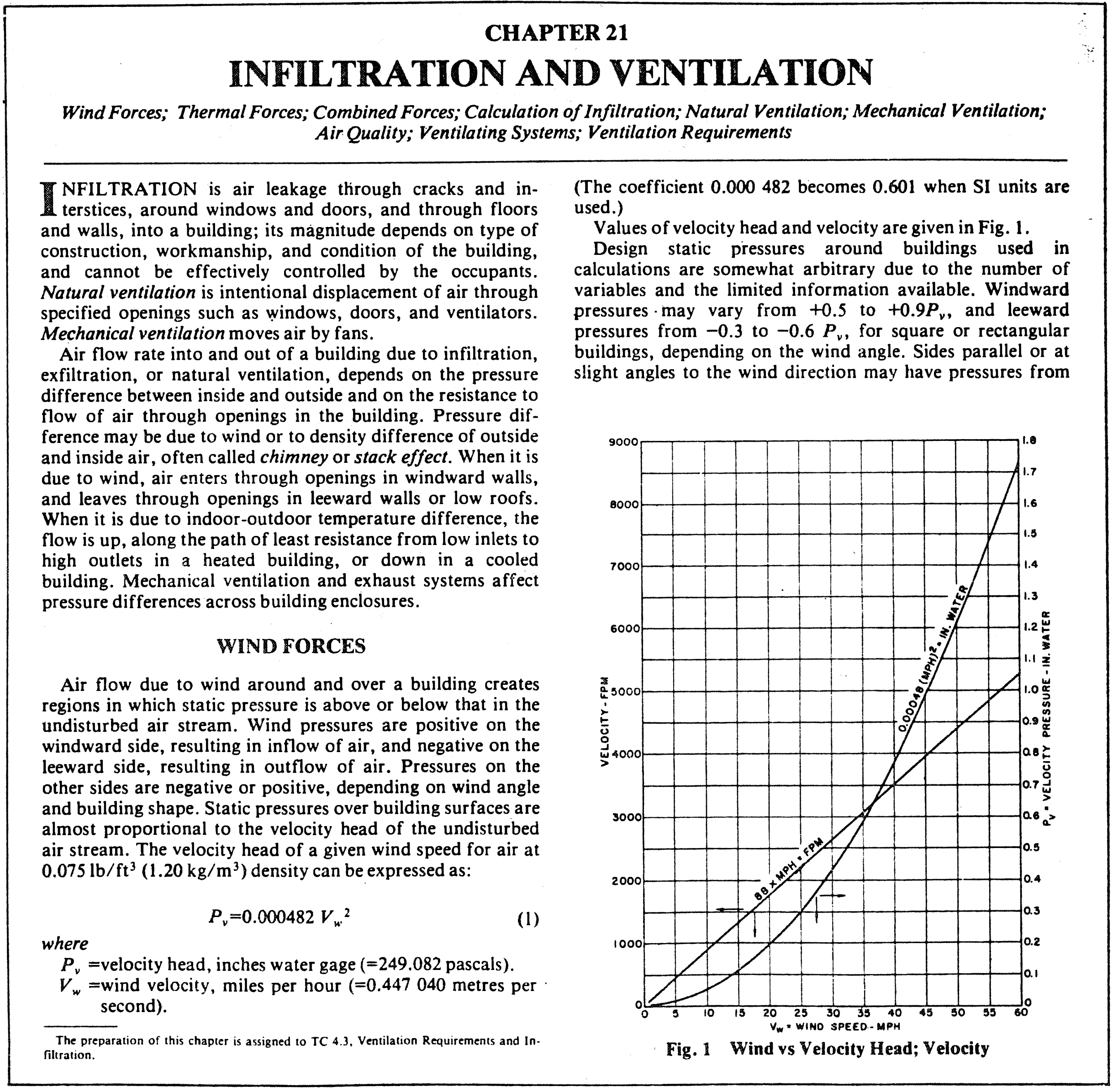


Fig. 3



CHAPTER 21

INFILTRATION AND VENTILATION

Wind Forces; Thermal Forces; Combined Forces; Calculation of Infiltration; Natural Ventilation; Mechanical Ventilation; Air Quality; Ventilating Systems; Ventilation Requirements

INFILTRATION is air leakage through cracks and interstices, around windows and doors, and through floors and walls, into a building; its magnitude depends on type of construction, workmanship, and condition of the building, and cannot be effectively controlled by the occupants. *Natural ventilation* is intentional displacement of air through specified openings such as windows, doors, and ventilators. *Mechanical ventilation* moves air by fans.

Air flow rate into and out of a building due to infiltration, exfiltration, or natural ventilation, depends on the pressure difference between inside and outside and on the resistance to flow of air through openings in the building. Pressure difference may be due to wind or to density difference of outside and inside air, often called *chimney* or *stack effect*. When it is due to wind, air enters through openings in windward walls, and leaves through openings in leeward walls or low roofs. When it is due to indoor-outdoor temperature difference, the flow is up, along the path of least resistance from low inlets to high outlets in a heated building, or down in a cooled building. Mechanical ventilation and exhaust systems affect pressure differences across building enclosures.

WIND FORCES

Air flow due to wind around and over a building creates regions in which static pressure is above or below that in the undisturbed air stream. Wind pressures are positive on the windward side, resulting in inflow of air, and negative on the leeward side, resulting in outflow of air. Pressures on the other sides are negative or positive, depending on wind angle and building shape. Static pressures over building surfaces are almost proportional to the velocity head of the undisturbed air stream. The velocity head of a given wind speed for air at 0.075 lb/ft^3 (1.20 kg/m^3) density can be expressed as:

$$P_v = 0.000482\, V_w^{\,2} \qquad (1)$$

where

P_v =velocity head, inches water gage (=249.082 pascals).

V_w =wind velocity, miles per hour (=0.447 040 metres per second).

(The coefficient 0.000 482 becomes 0.601 when SI units are used.)

Values of velocity head and velocity are given in Fig. 1.

Design static pressures around buildings used in calculations are somewhat arbitrary due to the number of variables and the limited information available. Windward pressures may vary from +0.5 to +0.9P_v, and leeward pressures from −0.3 to −0.6 P_v, for square or rectangular buildings, depending on the wind angle. Sides parallel or at slight angles to the wind direction may have pressures from

Fig. 1 Wind vs Velocity Head; Velocity

The preparation of this chapter is assigned to TC 4.3, Ventilation Requirements and Infiltration.

Fig. 4

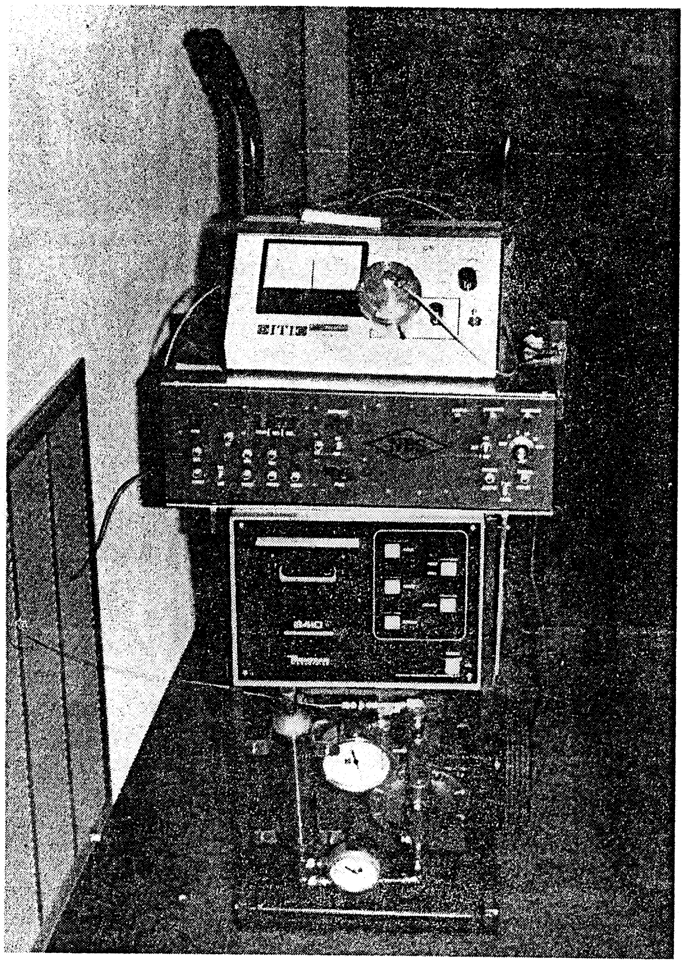


Fig. 5

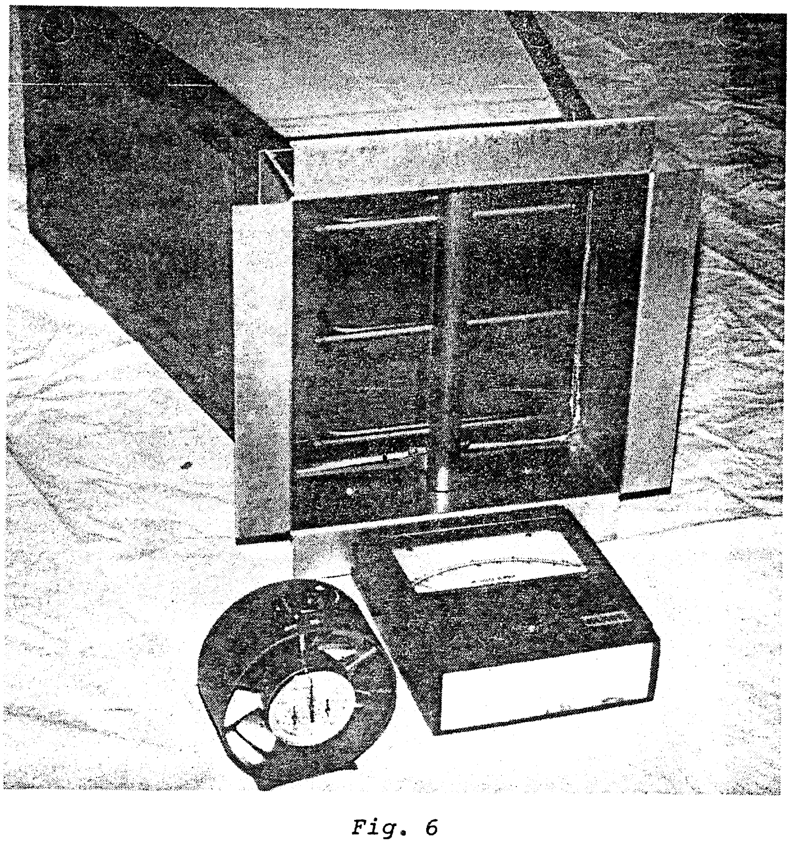


Fig. 6

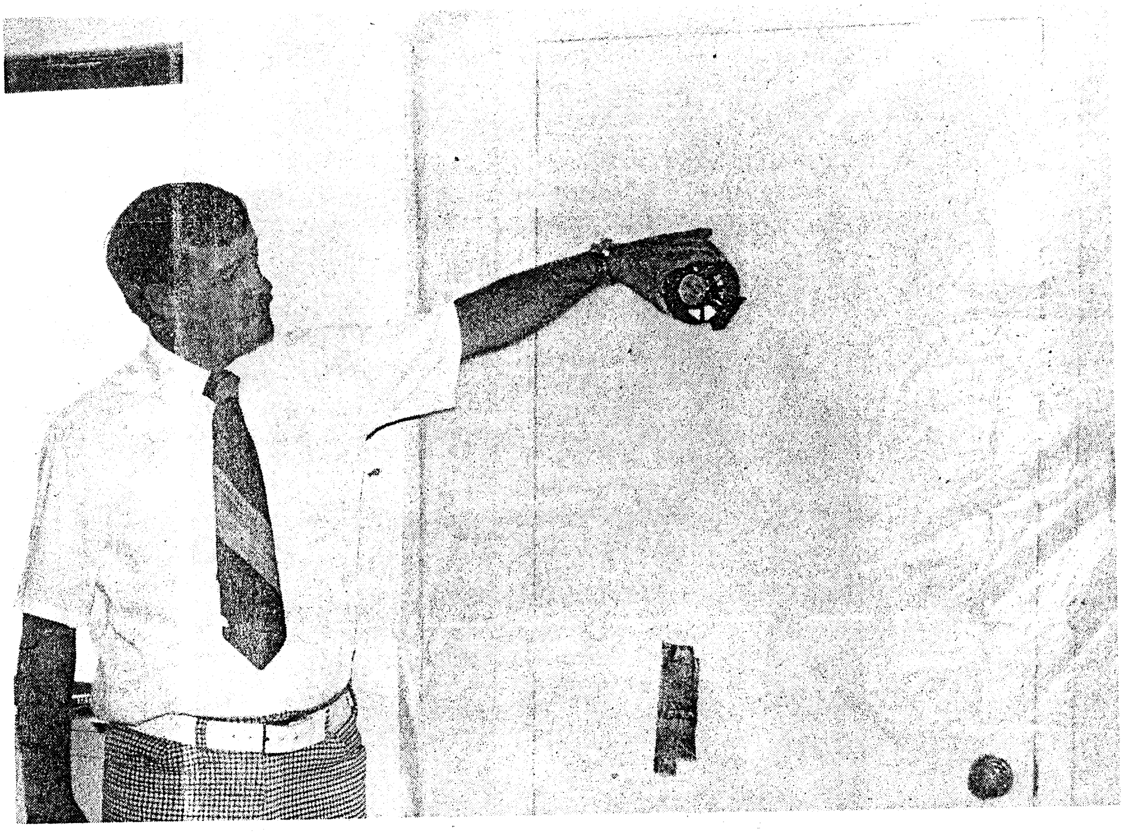


Fig. 7

Fig. 8

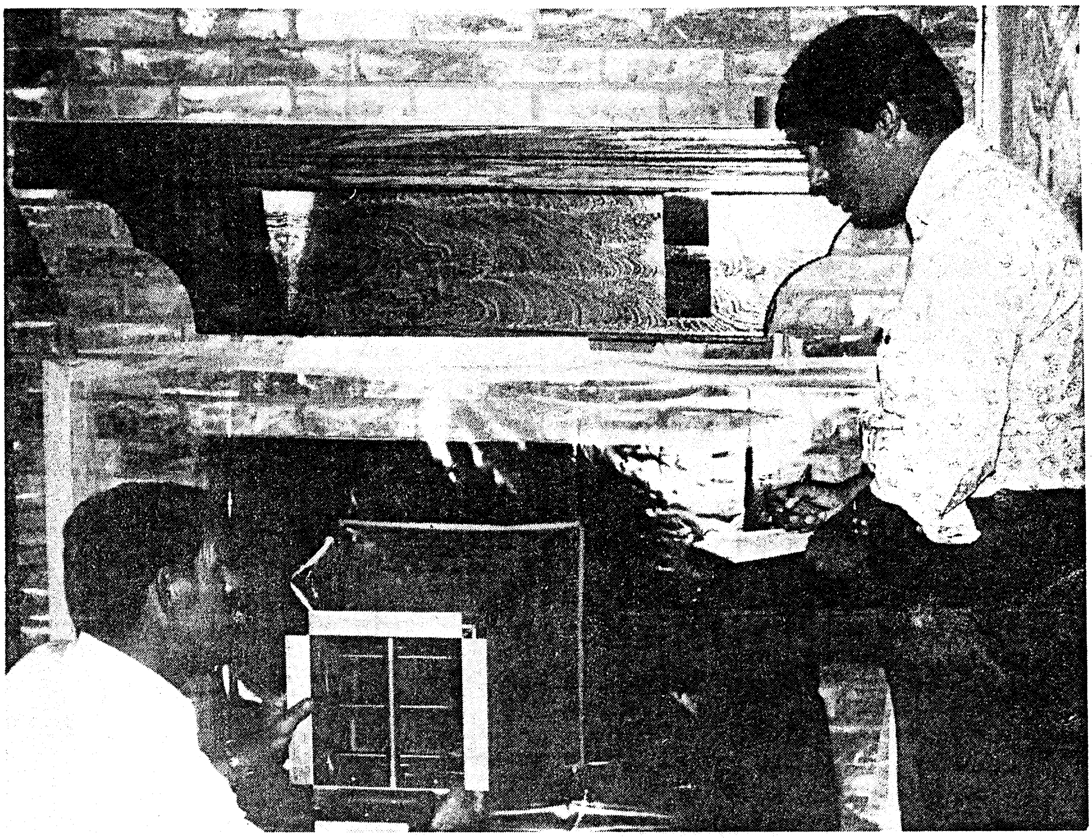


Fig. 9

Fig. 10

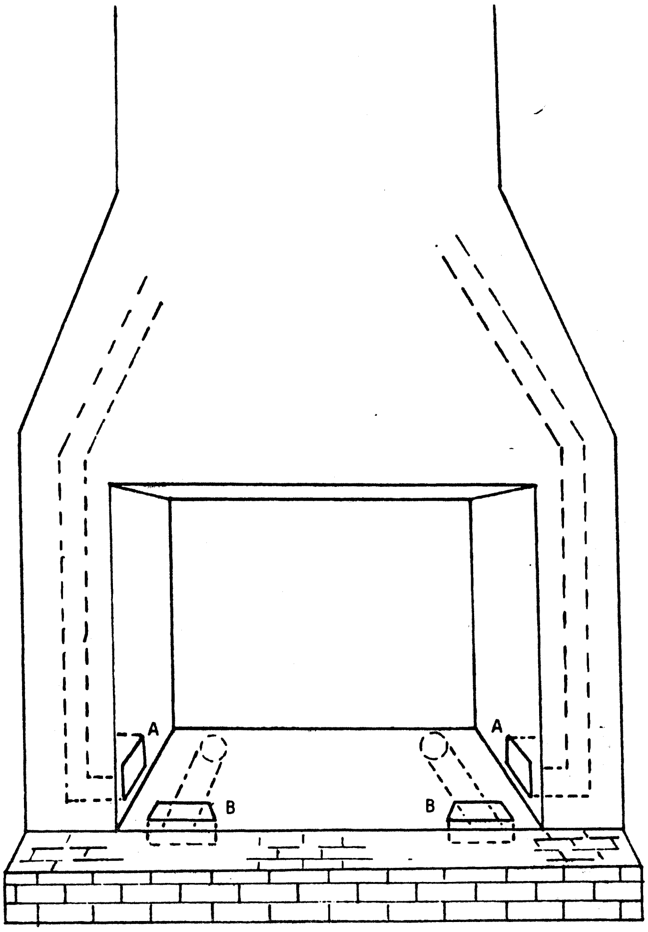


Fig. 11 Fireplace combustion air dampers (Use option A or B; either option should be covered with a glass screen)

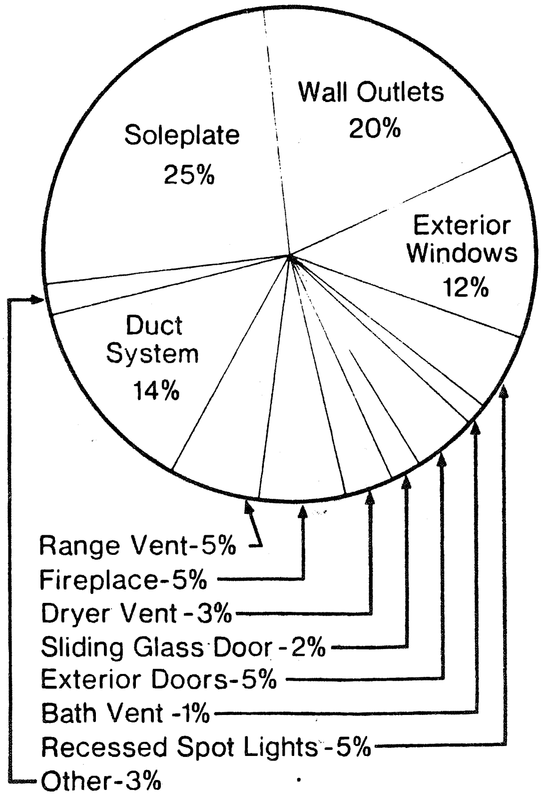


Fig. 12 Air leakage test results for average home of 1,780 sq. ft. (50 homes tested by Texas Power & Light Co.)