elimination. The metal duct connection to and from the furnace casing and fan housing should be broken by strips of fire resistant fabric. Motors and mountings must be carefully selected for quiet operation. Electrical conduit and water piping must not be fastened to, nor make contact with the fan housing. Installation of a fan directly under a return air grille is usually avoided.

SIMPLIFIED METHODS OF DESIGN

Simplified methods of design have been developed for several types of forced warm air heating systems. In general, the specific procedure chosen depends upon the type of system and the type of structure in which it is to be used. In most cases, more than one type of system may be used in a specific structure. It is therefore necessary to first choose the system desired and then determine the applicable design procedure. It is important that any simplified design method used take into account both the pressure loss and the air-temperature drop which occur within the duct system.

Perimeter-Loop Systems in Concrete Slab Construction

The perimeter-loop system,[4] shown in Fig. 4, conveys the warm air through embedded ducts to perimeter diffusers. The air is delivered from the furnace to *feeder ducts* which extend radially to the *loop duct*. The air flows through the loop duct to the diffusers. The ducts serve the dual purpose of conveying the warm air and of warming the floor. Although the design of the concrete slab is not specifically the concern of the mechanical engineer, it is absolutely necessary that he understand the considerations involved lest improper construction be used with consequent adverse effect on the performance of the heating system.

It should be understood that when air ducts are enclosed in concrete it is necessary to take certain precautions when putting the system into operation. The slab should be moist-cured for not less than seven days and a full 28 day aging period should elapse before heat is introduced into it. Once the concrete has been properly cured and attains its usual 28 day strength, it is not likely to be damaged by normal duct air temperatures provided the air temperature in the ducts is raised gradually during the first 96 hours of operation. With any type of heating (or with no heating system at all) rapid drying of a *green* slab may result in the development of cracks in the concrete. For information on slab construction, as well as duct placement, types of duct materials, perimeter edge insulation, etc., see Manual 4 of the National Warm Air Heating and Air Conditioning Association.[4] A section of typically installed loop duct is shown in Fig. 5.

Simplified design procedures are contained in Manual 4. One of these procedures subject to the following limitations: total heat loss 100,000 Btuh, maximum perimeter 210 ft, and maximum length of uninsulated feeder duct 30 ft for area served by one furnace; is the following:

1. Calculate the heat loss for each room using the methods explained in Chapter 25 of the 1961 Guide And Data Book. For subfloor and edge losses, see Manual J[5] of the National Warm Air Heating and Air Conditioning Association.
2. Determine the required furnace-bonnet capacity from the heat loss of the building.
3. Locate the diffusers on the plan. For best heating results, if a room has a heat loss of more than 8,000 Btuh or if it has two or more exposed walls, use two or more diffusers. Proportion the Btuh heat loss of each room among all diffusers in that room.

Table 2.... Diameter of Feeders in Perimeter-Loop System

Btuh per Feeder	Length of Feeder in Feet	
	0–15 Feet	16–30 Feet
	Inches	Inches
Up to 7,999	6	6
8,000 to 8,999	6	7
9,000 to 10,999	7	7
11,000 to 11,999	7	8
12,000 to 12,999	7	8
13,000 to 17,000	8	8

4. Locate the feeder ducts. First, divide the heat loss of the structure by 15,000 to determine the probable number of feeders. Second, locate the ducts so that they connect with the perimeter-loop at areas of greatest heat loss or in rooms where warm floors are particularly desirable. Third, locate the feeder ducts so that no more than 3 diffusers are in the section of loop duct between any two feeders. (The final number of feeder ducts may be larger than that originally estimated.)
5. Determine the size of feeder ducts using Table 2. Assume that the Btuh required by each diffuser will be supplied by the feeder nearest it. Determine the feeder duct diameter from its length and the total diffuser Btuh delivery carried by it.
6. Determine the total diffuser free area required in each room using Table 3. Measure the length of feeder duct under each room. Add to this *one-half* of the length of the loop duct, and determine the total diffuser free area required. Apportion this among all diffusers in the room.
7. The diameter of the loop duct should be uniform and equal to the diameter of the largest feeder duct. Where feeder ducts would be more than 30-ft long, they may be shortened by using a trunk-line distribution system with an insulated trunk supplying the feeders. The design procedure is similar to that used for a conventional trunk and branch system, and is given in Manual 4.[4]

Perimeter-Radial Systems in Concrete Slab Construction

The perimeter-radial system, Fig. 6, is similar to the perimeter-loop system in that the supply ducts are embedded in the concrete slab. The feeder ducts of the radial system extend directly from the subfloor plenum to the perimeter diffusers, and there is no loop duct around the perimeter of the floor. The feeders do provide floor-warming, but not to the same degree provided by the feeder and loop ducts of a perimeter-loop system. The same considerations of slab construction and edge insulation apply to both systems.

A simplified design procedure[4] using 6-in. diameter duct

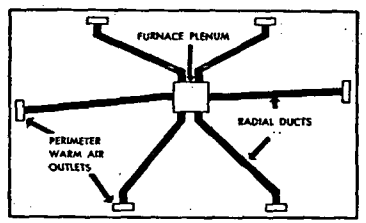

Fig. 6.... Perimeter-Radial System with Feeder Ducts in Concrete Slab or Crawl Space

Table 3.... Minimum Diffuser Free Area Required for Perimeter-Loop Systems

Section A. Use This Table if Length of Feeder which Delivers Major Portion of Warm Air to Room is from 2 to 10 Ft.

Heat Loss of Room Btuh	Length of Feeder Duct under Room Plus ½ Length of Perimeter Duct Under Room, Ft.						
	0–9 Ft.	10–19 Ft.	20–29 Ft.	30–39 Ft.	40–49 Ft.	50–59 Ft.	60–69 Ft.
	Total Diffuser Free Area Required for Room, Square Inches						
0 to 3,999	20						
4,000 to 5,999	32	27	23	18			
6,000 to 7,999	43	39	34	29	25	20	
8,000 to 9,999	55	50	45	41	36	32	27
10,000 to 11,999	66	61	57	52	48	43	38
12,000 to 13,999	77	72	68	63	59	54	50
14,000 to 15,999	88	84	79	75	70	66	61
16,000 to 17,999	100	95	91	86	82	77	72
18,000 to 19,999	111	106	102	97	93	88	84
20,000 to 21,999	122	118	113	109	104	100	95
22,000 to 23,999	134	129	125	120	116	111	106
24,000 to 25,999	145	140	136	131	127	122	118
26,000 to 27,999	156	151	147	142	138	133	129
28,000 to 29,999	168	163	159	154	150	145	141
30,000 to 31,999	179	174	170	165	161	156	152
32,000 to 34,000	190	185	182	176	173	167	164

Section B. Use this Table if Length of Feeder which Delivers Major Portion of Warm Air to Room is from 10 to 20 Ft.

0 to 3,999	23	18	18				
4,000 to 5,999	36	31	26	21	16	16	
6,000 to 7,999	49	44	39	34	29	24	19
8,000 to 9,999	61	56	51	46	41	36	31
10,000 to 11,999	73	68	63	58	53	48	43
12,000 to 13,999	86	81	76	71	66	61	56
14,000 to 15,999	99	94	89	84	79	74	69
16,000 to 17,999	111	106	101	96	91	86	81
18,000 to 19,999	123	118	113	108	103	98	93
20,000 to 21,999	135	130	125	120	115	110	105
22,000 to 23,999	148	143	138	133	128	123	118
24,000 to 25,999	161	156	151	146	141	136	131
26,000 to 27,999	174	168	164	158	154	148	144
28,000 to 29,999	186	181	176	171	166	161	156
30,000 to 31,999	198	194	188	184	178	174	168
32,000 to 34,000	211	206	201	196	191	186	181

Section C. Use This Table if Length of Feeder which Delivers Major Portion of Warm Air to Room is from 20 to 30 Ft.

0 to 3,999	27	21	21				
4,000 to 5,999	42	36	30	24	18		
6,000 to 7,999	57	51	45	39	33	27	21
8,000 to 9,999	72	66	60	54	48	42	36
10,000 to 11,999	86	80	74	68	62	56	50
12,000 to 13,999	101	95	89	83	77	71	65
14,000 to 15,999	116	110	104	98	92	86	80
16,000 to 17,999	131	125	119	113	107	101	95
18,000 to 19,999	145	139	133	127	121	115	109
20,000 to 21,999	160	154	148	142	136	130	124
22,000 to 23,999	175	169	163	157	151	145	139
24,000 to 25,999	190	184	178	172	166	160	154
26,000 to 27,999	205	199	193	187	181	175	169
28,000 to 29,999	220	214	208	202	196	190	184
30,000 to 31,999	234	228	222	216	210	204	198
32,000 to 34,000	249	243	237	231	225	219	213