register temperature is to be retained at the value of 175 F as recommended.

Registers used for discharging warm air into rooms should have a net area not less than the area of the leader pipe to which the register is attached. First story registers should be connected through boot and register box extensions having areas at least equal to leader areas. Upper story registers should be of the same width as the wall stack, and should be placed either in the baseboard or sidewall, preferably without offsets. First story registers may be of the baseboard or floor type, with the former location preferred. High sidewall locations for warm-air registers in gravity systems deliver a greater quantity of warm air into the room than do baseboard registers, but most of the additional air merely results in high temperatures at the ceiling.

RETURN AIR DUCTS, GRILLES, AND SHOE CONNECTIONS

The ducts through which air is returned to the furnace should be designed to minimize resistance to air flow. They should be of ample area, in excess of the total area of warm-air pipes, and should be streamlined. Horizontal ducts should pitch at least ½ in. per foot downward

TABLE 1. FORMER METHOD OF EXPRESSING LEADER PIPE CARRYING CAPACITIES

REGISTER LOCATION	CARRYING CAPACITY OF EACH SQUARE INCH OF LEADER PIPE FOR 175 F REGISTER TEMPERATURE, IN BTU PER HOUR	
First Story	105[a]	111[b]
Second Story	170[a]	166[b]
Third Story	208[a]	200[b]

[a]Actual capacity. [b]Used for average calculations.

toward the furnace, avoiding fittings which would require lifting of the return air after the duct has passed under some obstacle.

The return air grilles should have free areas at least equal to the ducts to which they connect. These return air grilles should be installed in the floor, or in the baseboard with the top edge of the grille not more than about 8 in. above the floor line. Frictional resistance in the return air system is as detrimental to proper performance as is resistance in the warm-air system, so that care should be exercised in locating return air grilles which require long return ducts.

The placement and number of return grilles will depend upon the size, details, and exposure of the house. Small compactly built houses may be adequately served by a single return grille effectively placed in the central hall. It is usually desirable to have two or more returns, provided that in two-story residences one return is placed to effectively receive the return air at the foot of the stairs. A return air connection must be carried to any heated room whose floor level is below that of adjacent rooms.

Where a divided system of two or more returns is used, the grilles must be placed to serve the maximum area of cold wall or windows. Thus, in rooms having only small windows the grille can be brought as close to the furnace as possible, but if the room has large window exposure the grille should be located near the exposure. If long ducts are used in parallel with short return ducts, the frictional resistance of the long ducts must be reduced to compensate for the length. Return ducts from upstairs rooms may be necessary in spaces which are closed off from the

rest of the house or which have much outdoor exposure. Return grilles on different floor levels should not be connected to the same vertical return duct.

Ducts returning air to the furnace should avoid heat sources which tend to reheat the return air. If the duct must be run over the top of the furnace, or above the vent pipe from the furnace, insulation should be interposed between the heat source and the duct.

Circulation of air is facilitated if the air can slide down a pipe inclined at approximately 45 deg and into a furnace shoe connection having a cross-sectional area equal to that of the pipe. The top of the return shoe should enter the casing below the level of the grate in the case of a coal furnace, and not more than 14 in. above the floor in the case of oil or gas furnaces. In order to accomplish this the shoe is made wide.

OUTLINE OF DESIGN PROCEDURE

The data underlying the design procedure are given in detail in a circular[2] issued by the University of Illinois. In this procedure the design of the warm-air duct system is considered as an entire unit, so that for a given heat loss the sizes of leaders, stacks, boots, stackheads, and registers are

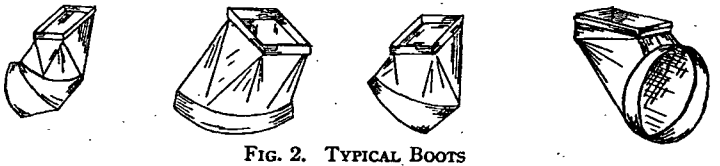

FIG. 2. TYPICAL BOOTS

all correlated. Similarly in the case of return ducts, the selection specifies a complete unit consisting of return grille, return duct, and shoe connection.

Recommended Standard Sizes

For the purpose of simplification and standardization, selected combinations of commercial sizes of warm air pipes, return air pipes, ducts, grilles, fittings, and registers are designated as *units*. The unit numbers assigned and the combinations selected as standard are listed in the following tables[3]:

Table 2—Units 1 to 5—First Story Warm Air Ducts and Registers.
Table 3—Units 11 to 16—Second Story Warm Air Ducts, Single Wall Stacks, Fittings, and Registers.
Table 4—Units 21 to 24—Second Story Warm Air Ducts, Double Wall Stacks, Fittings, and Registers.
Table 5—Units 31 to 38—Return Air Ducts, Fittings, and Grilles.

The selected types of boots are shown in Fig. 2. It is essential that free areas be maintained throughout fittings.

The selected types of return air ducts and fittings are shown in Fig. 3.

Carrying Capacity

The Btu carrying capacities of the selected units of warm air and return air combinations are shown in Tables 6, 7 and 8:

[2]Simplified Procedure for Selecting Capacities of Duct Systems for Gravity Warm-Air Heating Plants, by A. P. Kratz and S. Konzo (*University of Illinois, Engineering Experiment Station Circular* 45, Dec., 1942).

[3]Standard Code Application Manual for Gravity Warm Air Heating Systems, First Edition, 1941. *National Warm Air Heating and Air Conditioning Association.*