connecting of loads on the power line and they are likely to vary with different power companies.

**11 ● In controlling direct current motors what two methods are used, what speed ranges are obtained, and what is the relative efficiency of each method?**

In controlling direct current motors, resistance is placed in either the armature circuit or the field circuit. For armature control, the speed is reduced with the increase of resistance. With the field control, the speed is increased with the addition of resistance in the field circuit.

For most listed direct current motors, it is possible to obtain operation up to a speed ratio of two to one with field control equipment. This type of control is used in connection with shunt wound motors for best results.

For speed adjustment by resistance in series with the armature circuit, a reduction of 50 per cent in speed can generally be obtained. This control can be used with either shunt or compound wound motors.

The field control method of changing speeds on direct current motors is the most efficient. Due to the large current in the armature circuit, this method results in a high loss when the speed is reduced any appreciable amount. It is well to remember that with field control only constant horsepower output is obtained, therefore, care should be taken that the motor at normal speed is large enough to care for any increase in load as a result of speeding up the unit.

**12 ● What reduction in speed is possible and how is it obtained when alternating current slip ring motors are used?**

Speed variation in slip ring motors is obtained by inserting resistance in the secondary circuit. This generally allows for a 50 per cent speed reduction when it is fully loaded at normal speed.

From 20 to 30 per cent speed reduction can be obtained through the use of line voltage control of an adjustable varying speed motor with a fan closely motored (*i.e.*, the fan approximately fully loads the motor).



## Chapter 39

# *PIPING AND DUCT INSULATION*

**Heat Losses from Bare and Insulated Pipes, Heat Losses from Ducts, Low Temperature Insulation, Insulation of Pipes to Prevent Freezing, Economical Thickness of Pipe Insulation, Underground Pipe Insulation**

INSULATION reduces the flow of heat where it is desired to maintain a temperature higher or lower than that of the surroundings. Its use contributes to the most economical operation of heating and refrigerating systems.

### HEAT LOSSES FROM BARE PIPE

Heat losses from horizontal bare iron pipes, based on data obtained from tests conducted at the *Mellon Institute*, are given in Table 1. The

TABLE 1. HEAT LOSSES FROM HORIZONTAL BARE IRON PIPES

*Expressed in Btu per hour per linear foot per degree Fahrenheit difference in temperature between the pipe and surrounding still air at 70 F*

| Nominal Pipe Size (Inches) | Hot Water | | | | Steam | | |
|---|---|---|---|---|---|---|---|
| | 120 F | 150 F | 180 F | 210 F | 227.1 F (5 Lb) | 297.7 F (50 Lb) | 337.9 F (100 Lb) |
| | Temperature Difference | | | | | | |
| | 50 F | 80 F | 110 F | 140 F | 157.1 F | 227.7 F | 267.9 F |
| ½ | 0.543 | 0.573 | 0.605 | 0.638 | 0.656 | 0.742 | 0.796 |
| ¾ | 0.660 | 0.690 | 0.729 | 0.762 | 0.781 | 0.886 | 0.955 |
| 1 | 0.791 | 0.829 | 0.878 | 0.920 | 0.953 | 1.084 | 1.166 |
| 1¼ | 0.979 | 1.02 | 1.087 | 1.15 | 1.184 | 1.345 | 1.450 |
| 1½ | 1.09 | 1.15 | 1.220 | 1.29 | 1.335 | 1.520 | 1.640 |
| 2 | 1.34 | 1.40 | 1.491 | 1.58 | 1.637 | 1.866 | 2.015 |
| 2½ | 1.58 | 1.67 | 1.778 | 1.87 | 1.937 | 2.215 | 2.388 |
| 3 | 1.88 | 1.99 | 2.100 | 2.22 | 2.301 | 2.641 | 2.853 |
| 3½ | 2.13 | 2.24 | 2.380 | 2.51 | 2.585 | 2.972 | 3.215 |
| 4 | 2.36 | 2.50 | 2.650 | 2.78 | 2.873 | 3.312 | 3.582 |
| 4½ | 2.60 | 2.75 | 2.920 | 3.08 | 3.170 | 3.655 | 3.956 |
| 5 | 2.87 | 3.02 | 3.200 | 3.38 | 3.493 | 4.030 | 4.368 |
| 6 | 3.39 | 3.56 | 3.775 | 4.01 | 4.115 | 4.755 | 5.153 |
| 8 | 4.32 | 4.55 | 4.830 | 5.14 | 5.270 | 6.120 | 6.635 |
| 10 | 5.32 | 5.61 | 5.925 | 6.34 | 6.551 | 7.592 | 8.245 |
| 12 | 6.25 | 6.62 | 6.995 | 7.46 | 7.670 | 8.900 | 9.670 |