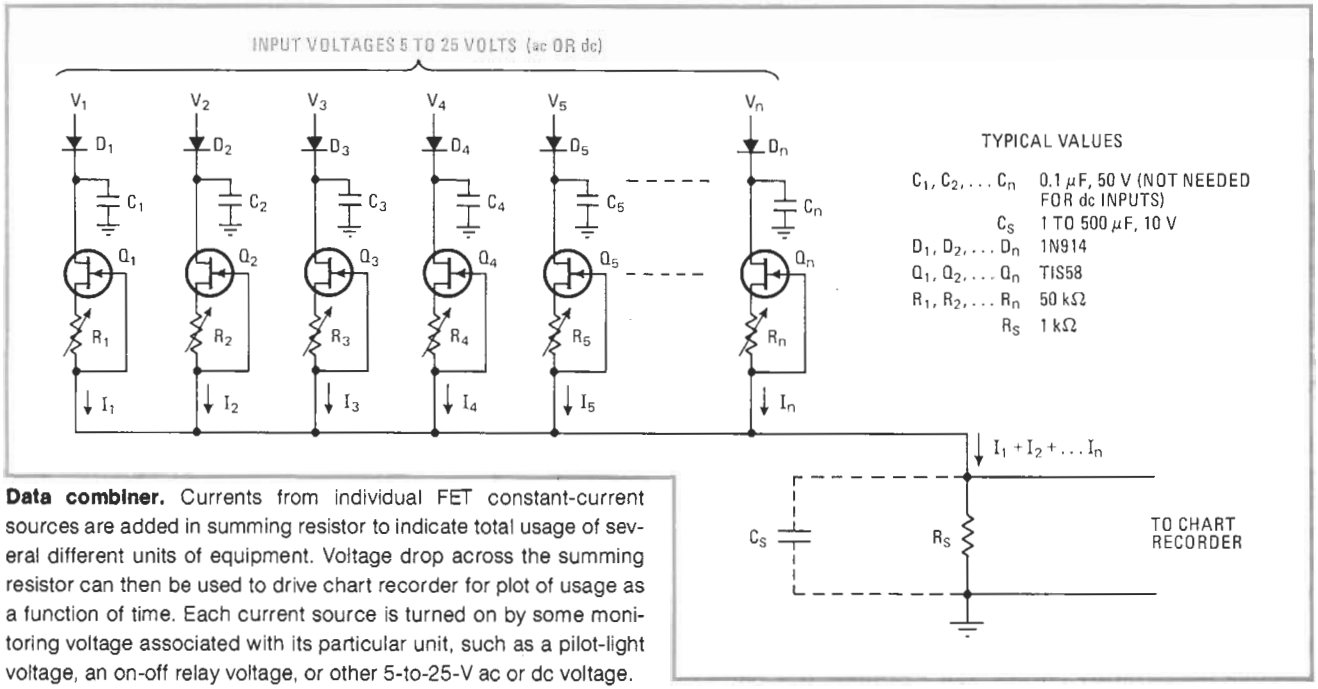
Chart recorder plots total of loads in several circuits

by L.W. Herring
LWHA, Dallas, Texas

Occasionally it is desirable to record the load requirements of an electrical distribution system or the total usage of a number of communications channels during some period of time. In determining ac distribution loads, a recording wattmeter can log the data, but plotting the total power consumption for several pieces of equipment fed from separate power mains or the traffic through a number of communications channels is more difficult. Still, if supervisory signals like pilot-light voltages are used to generate current in field-effect transistors, it is easy to develop a signal that can be plotted with any available chart recorder.

As shown in the figure, the currents from FETs used as constant-current sources are summed in a fixed resistor to obtain a voltage signal that indicates total usage rate. To provide equal weighting for each input, the current sources can be equal, or they can be set to various values to provide a scaling effect on the output voltage. Since the FETs are used as current sources, the input signals can be any convenient ac or dc voltages between 5 and 25 volts. The input signals are fed to the FETs through diodes that rectify ac and also protect against negative dc.

As an example, it might be desirable to plot the daily demand curve for five heat-treating furnaces. Two of



Data combiner. Currents from individual FET constant-current sources are added in summing resistor to indicate total usage of several different units of equipment. Voltage drop across the summing resistor can then be used to drive chart recorder for plot of usage as a function of time. Each current source is turned on by some monitoring voltage associated with its particular unit, such as a pilot-light voltage, an on-off relay voltage, or other 5-to-25-V ac or dc voltage.

the furnaces are 100-kilowatt/three-phase units, one is 50-kW/single-phase, and the remaining two are 25-kW/single-phase. All of the furnaces have 24-V dc indicator lamps that light on a control console when the furnaces are operating. The lamp voltages can excite FET constant-current sources that are proportional to the power ratings of their respective furnaces. The sum of these currents, passing through a common fixed resistor, produces a voltage that indicates the total power to the furnaces. This voltage drives the pen on the chart recorder.

The first FET, Q_1, is connected to the 24-V pilot light voltage for the first 25-kW furnace. Resistor R_1 is adjusted so that Q_1 delivers 100 microamperes to resistor R_S. The second 25-kW furnace pilot voltage is connected to FET Q_2, and R_2 is also adjusted for 100 μA into R_S. A resulting voltage of 0.1 V is produced across summing resistor R_S when either one of the 25-kW furnaces is on, and 0.2 V is produced when both are on.

The 50-kW pilot lead excites FET Q_3, which is set by means of R_3 to deliver 200 μA to R_S. Operation of the 50-kW furnace produces twice the voltage drop across R_S that either 25-kW unit does. Finally, the two 100-kW furnaces are connected to FETs Q_4 and Q_5, each adjusted to source 400 μA.

Each 25 kW of furnace load is represented by a constant current of 100 μA, which produces 0.1 V across summing resistor R_S. If the total current is 700 μA, the voltage is 0.7 V, indicating a 175-kW load, and this load can be recorded on any voltage-sensitive chart recorder.

This technique can also be used to plot the number of telephone lines in use at any time in an office or plant to determine whether or not a business is making effective use of its telephone service. In this example, the 10-V ac voltages that light line-button lamps are the input signals. The ac voltages are rectified by diodes D_1, D_2, and so forth before reaching the FETs. Each current source is adjusted for 100 μA so that whenever a line is in use, the voltage across the 1-kilohm summing resistor R_S increases by 0.1 V.

Any general-purpose depletion-mode junction FET with I_{DSS} of 1 to 15 milliamperes can be used for the FETs; the TIS58 has yielded excellent results. Dissipation and voltages are not critical if the input levels are kept under 30 V. A 1-kilohm value of R_S was used for convenience, but its resistance can be scaled along with the current sources to provide any desired output voltages. The maximum output voltage should not exceed 50% of the lowest input voltage. For example, if the inputs are 5, 5, 12, and 24 V, respectively, the maximum output voltage should not exceed 2.5 V. The standard input voltage for many chart recorders is 1 V, so that level is a desirable maximum output from this circuit.

Since the input voltages do not have to all be alike, 24-V dc relay levels, 5-V TTL levels, and 12-V ac signals can all be used as inputs in the same circuit. The input capacitors C_1–C_8 are required only for ac inputs, but diodes D_1–D_8 should be used with both ac and dc inputs to protect the FETs. On plots requiring long time periods with inputs that change rapidly, a capacitor C_S may be connected across summing resistor R_S to smooth the graph. □