Appendix D OPEN CHANNEL FLOW CHARTS

HDS-3, *Design Charts for Open Channel Flow* (FHWA, 1961) contains pipe design charts. Some of these charts have been reproduced in this appendix. An index of the design charts provided is given below, not all charts included in the FHWA manual are reproduced in this document.

This publication contains charts which provide direct solution of the Manning equation for uniform flow in open prismatic channels of various cross sections. The charts fall into two major groups: The first group, Nos. 1-51, consists of separate charts for various size channels of a given shape, with all functions on each chart; the second group, Nos. 52-82, has charts covering a wide range of sizes but with only one or two functions on each chart.

The open-channel flow charts in the first group give a direct and rapid determination of normal depth and normal velocity of flow in a channel of given cross section, roughness, and slope, carrying a known discharge. Values can be read to two significant figures, which is sufficiently accurate for ordinary design purposes. While the open-channel flow charts were drawn for a specific value of "n", they can also be used for any other value of "n" by following the instructions given. For circular sections, two other "n" values are provided by additional scales.

The second group of charts, Nos. 52-82, requires only five charts to cover the hydraulic functions of a wide range of sizes of channels of a given shape and roughness. They have some small disadvantage in that normal depth must be determined by three steps, involving two charts and a simple calculation. Determination of friction slope in part-full flow also requires three similar steps. On the other hand, critical depth, critical slope, and specific head at critical depth may be read directly from these charts, and probably more accurately, than from the open-channel flow charts. The latter actually give only critical depth, critical slope, and critical velocity but require computation of velocity head to obtain specific head at critical depth.

The designer is cautioned not to use the open-channel flow charts presented in this publication as a means of estimating the size of culvert required for a given discharge because the hydraulics of culverts is not simply uniform flow at normal depth. The head required to get flow into a culvert may be several times the head required to maintain uniform flow. Other publications proposed for the Bureau of Public Roads hydraulic design series will deal with the hydraulic design of culverts.

Charts 35-60 are designed for use in the solution of the Manning equation for circular-pipe channels which have sufficient length, on constant slope, to establish uniform flow at normal depth without backwater or pressure head. It is important to recognize that they are not suitable for use in connection with most types of culvert flow, since culvert flow is seldom uniform.

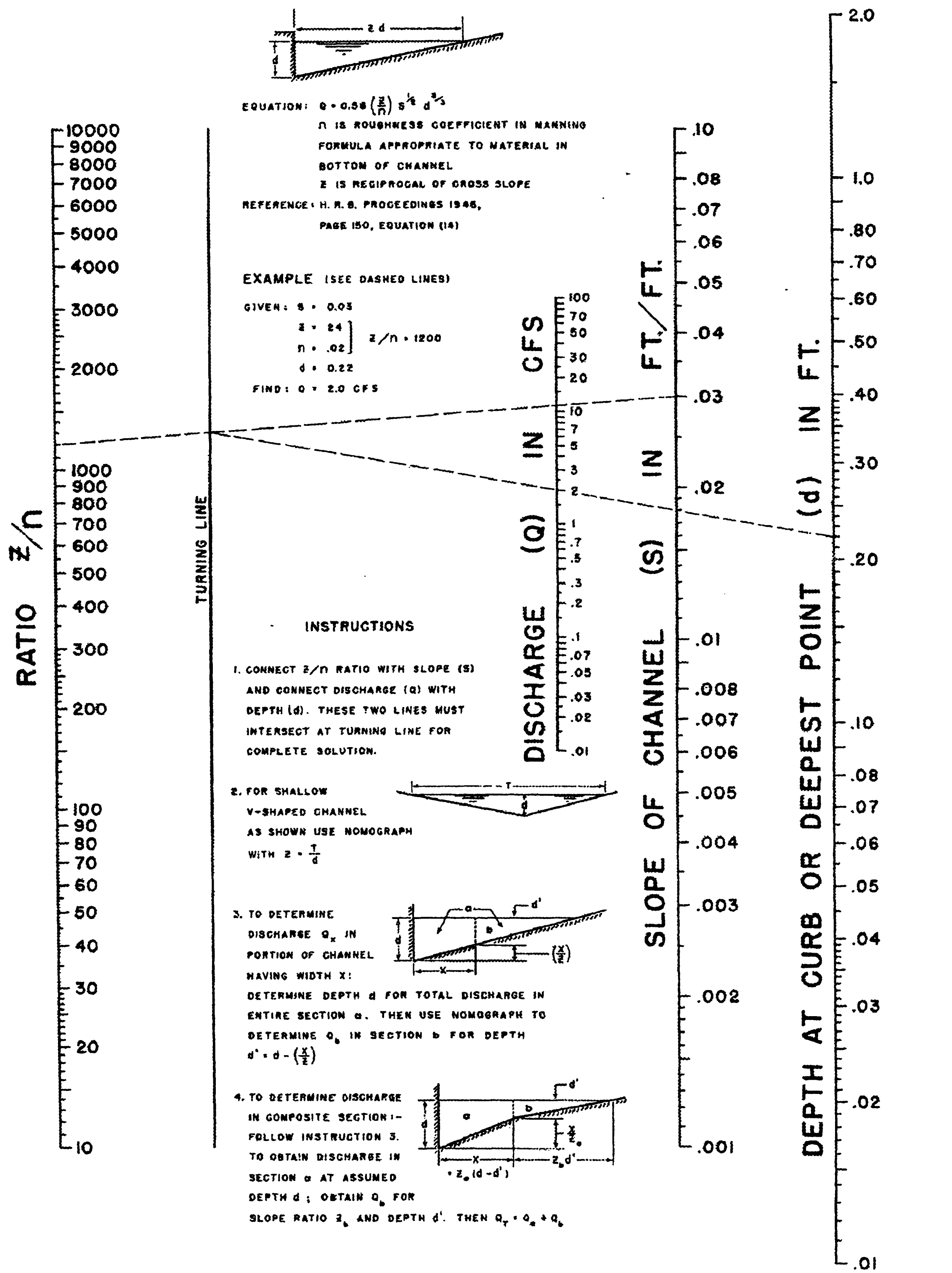
Charts 35-51 cover pipe sizes from 12 to 96 inches in diameter. It will be noted that each slope line has a hook at its right terminus. If d_n is greater than 0.82 diameter, two values of d_n will be shown by the slope line hook for a particular value of Q. In these cases, flow will occur at the lesser of the alternate depths. Interpolated slope lines follow the same pattern as those drawn on the charts. The maximum rate of uniform discharge in a circular pipe on a given slope, when not flowing under pressure, will occur with a depth of 0.94 diameter. This discharge can be determined by reading the highest Q, on the appropriate n scale, which can be read on the given slope line.

For a given discharge, slope, and pipe size, the depth and velocity of uniform flow may be read directly from the chart for that size pipe The initial step is to locate the intersection of a vertical line through the discharge (on the appropriate n scale) and the appropriate slope line. At this intersection, the depth of flow is read or interpolated from the depth lines; and the mean velocity is read opposite the intersection on the velocity scale for the n value of the pipe. The procedure is reversed to determine the discharge at a given depth of flow. If the discharge line passes to the right of the appropriate slope line, the pipe will flow full.

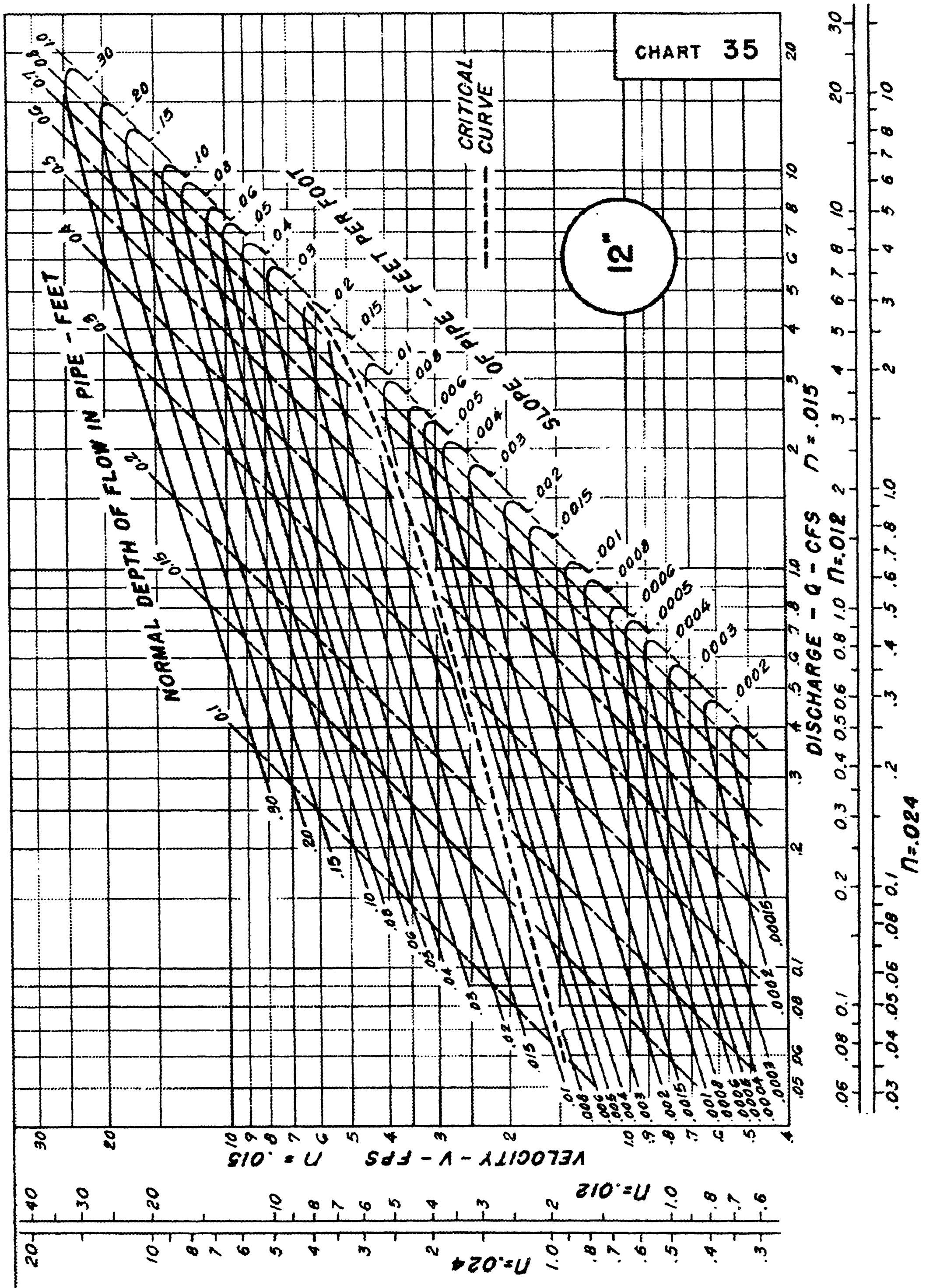
Critical depth and critical velocity are independent of the value of "n". They are read at the point where a vertical line through Q, on the scale n = 0.015, intersects the critical curve. Critical slope for n = 0.015 is also read or interpolated from the slope line at the same intersection. For "n" values of 0.012 and 0.024, critical slope is determined by first finding critical depth, using Q on the scale n = 0.015. Critical slope is then read or interpolated from the slope lines at the intersection of critical depth and the vertical line through Q on the appropriate n scale. Critical depths falling between the last two normal depth lines have little significance, since wave action may intermittently fill the pipe.

Chart Number	Type of Chart	Size or Shape
29	Flow Nomograph	Triangular Channels
35	Pipe Flow Chart	12-inch Diameter
36	Pipe Flow Chart	15-inch Diameter
37	Pipe Flow Chart	18-inch Diameter
38	Pipe Flow Chart	21-inch Diameter
39	Pipe Flow Chart	24-inch Diameter
40	Pipe Flow Chart	27-inch Diameter
41	Pipe Flow Chart	30-inch Diameter
42	Pipe Flow Chart	33-inch Diameter
43	Pipe Flow Chart	36-inch Diameter
44	Pipe Flow Chart	42-inch Diameter
45	Pipe Flow Chart	48-inch Diameter
46	Pipe Flow Chart	54-inch Diameter
47	Pipe Flow Chart	60-inch Diameter
48	Pipe Flow Chart	66-inch Diameter
49	Pipe Flow Chart	72-inch Diameter
50	Pipe Flow Chart	84-inch Diameter
51	Pipe Flow Chart	96-inch Diameter
55	Part Full Flow	Circular Pipe
56	Critical Depth	Circular Pipe
83	Manning's Equation	

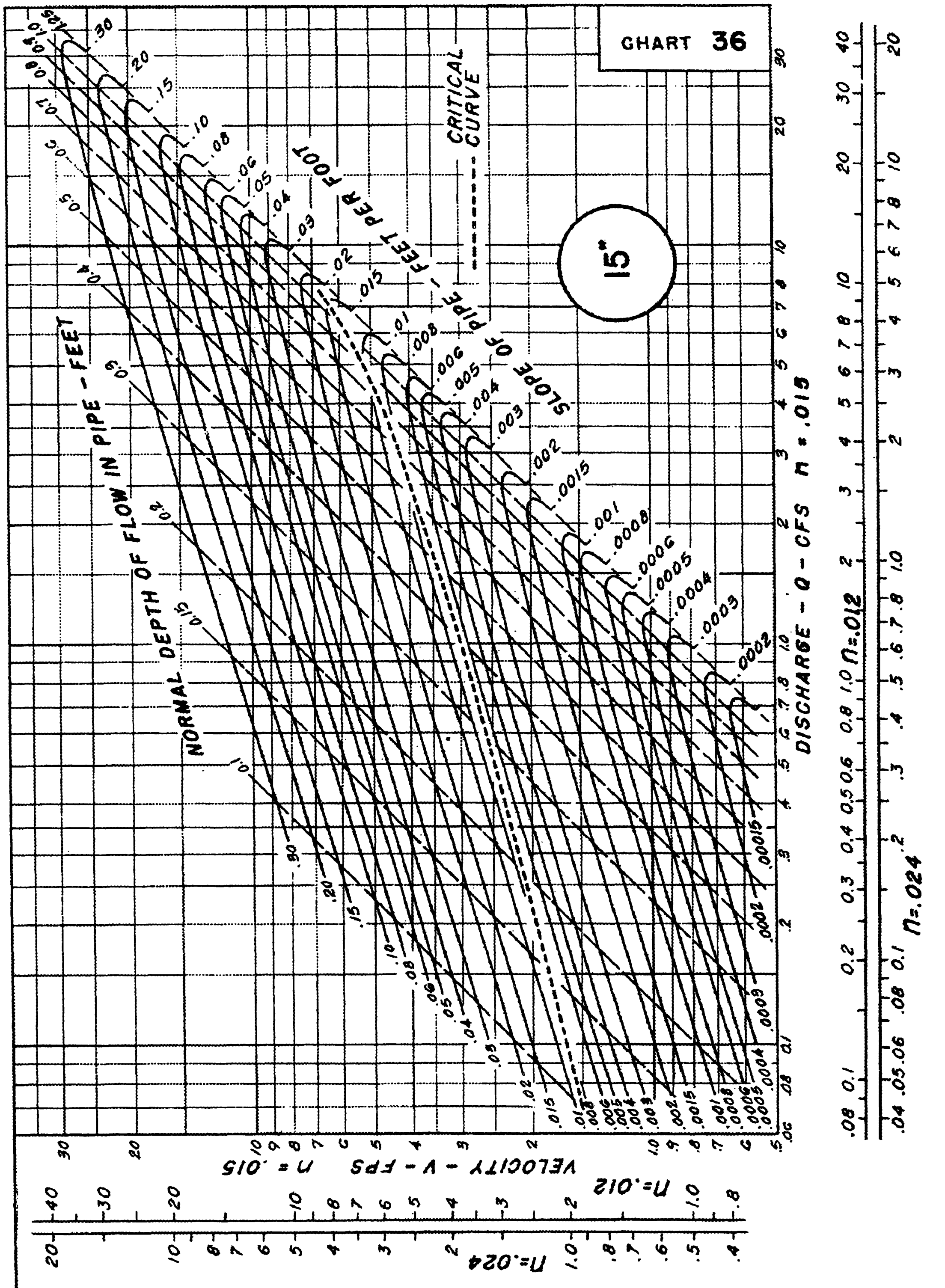
CHART 29



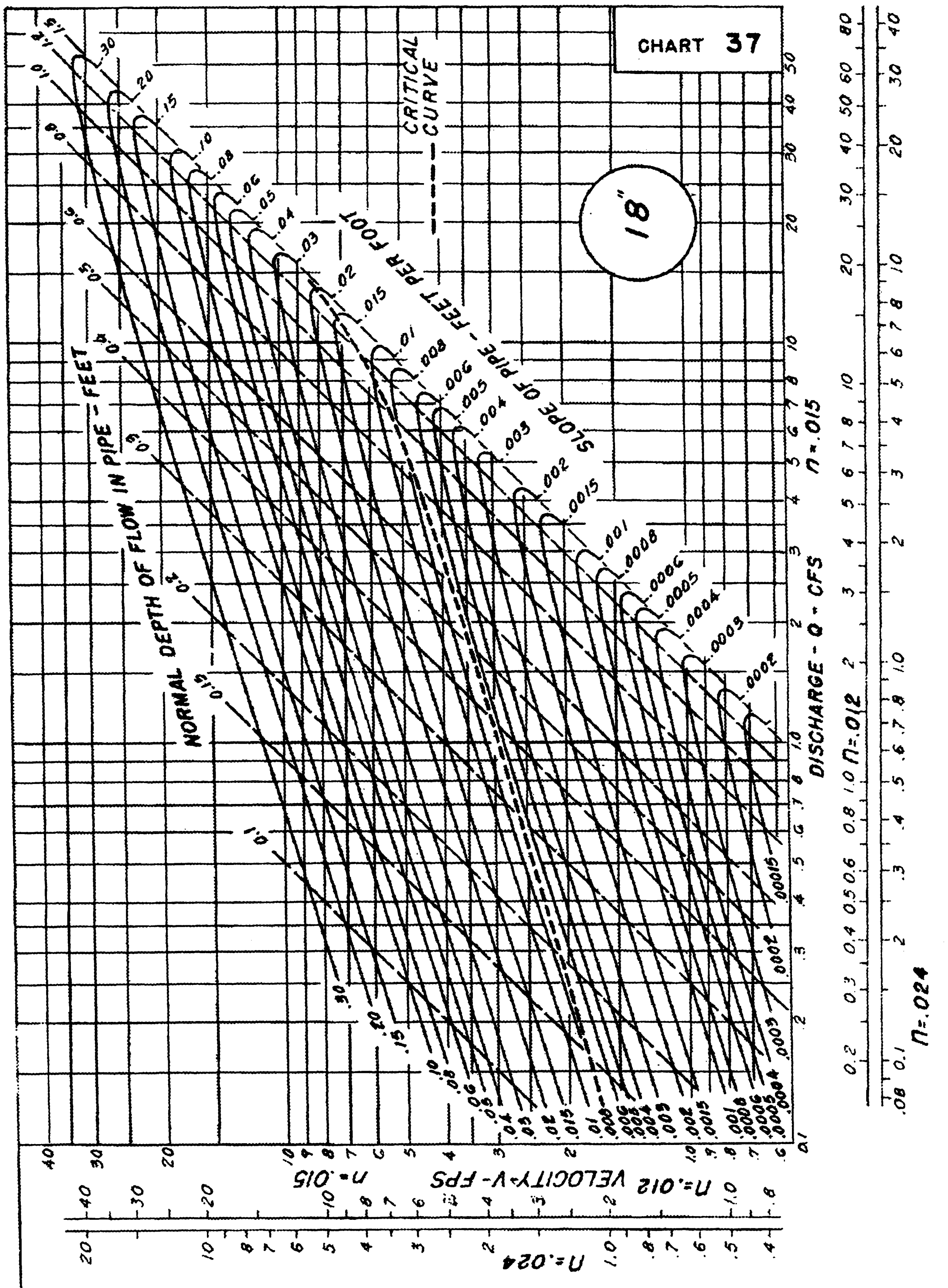
NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS



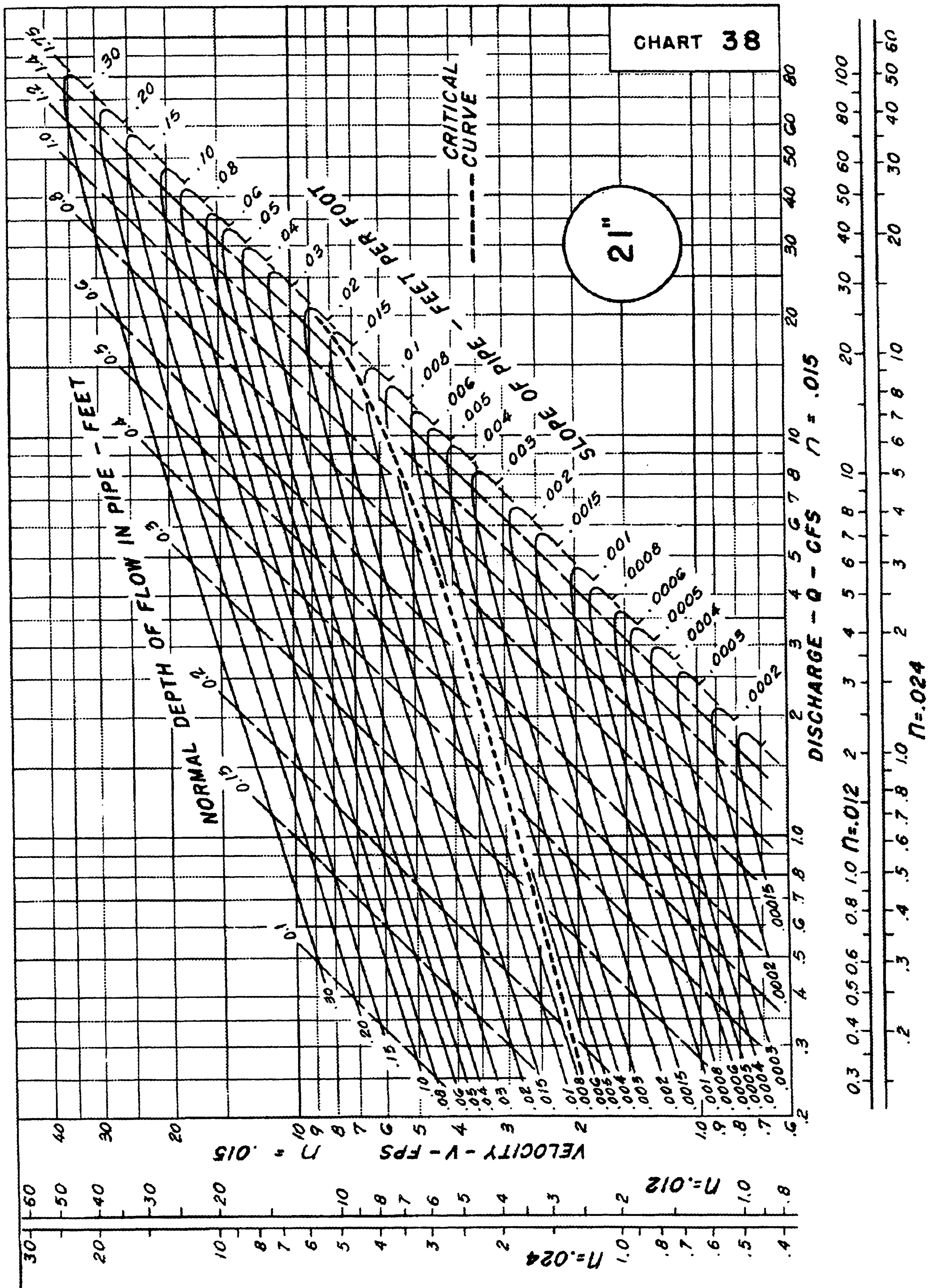
PIPE FLOW CHART
12-INCH DIAMETER



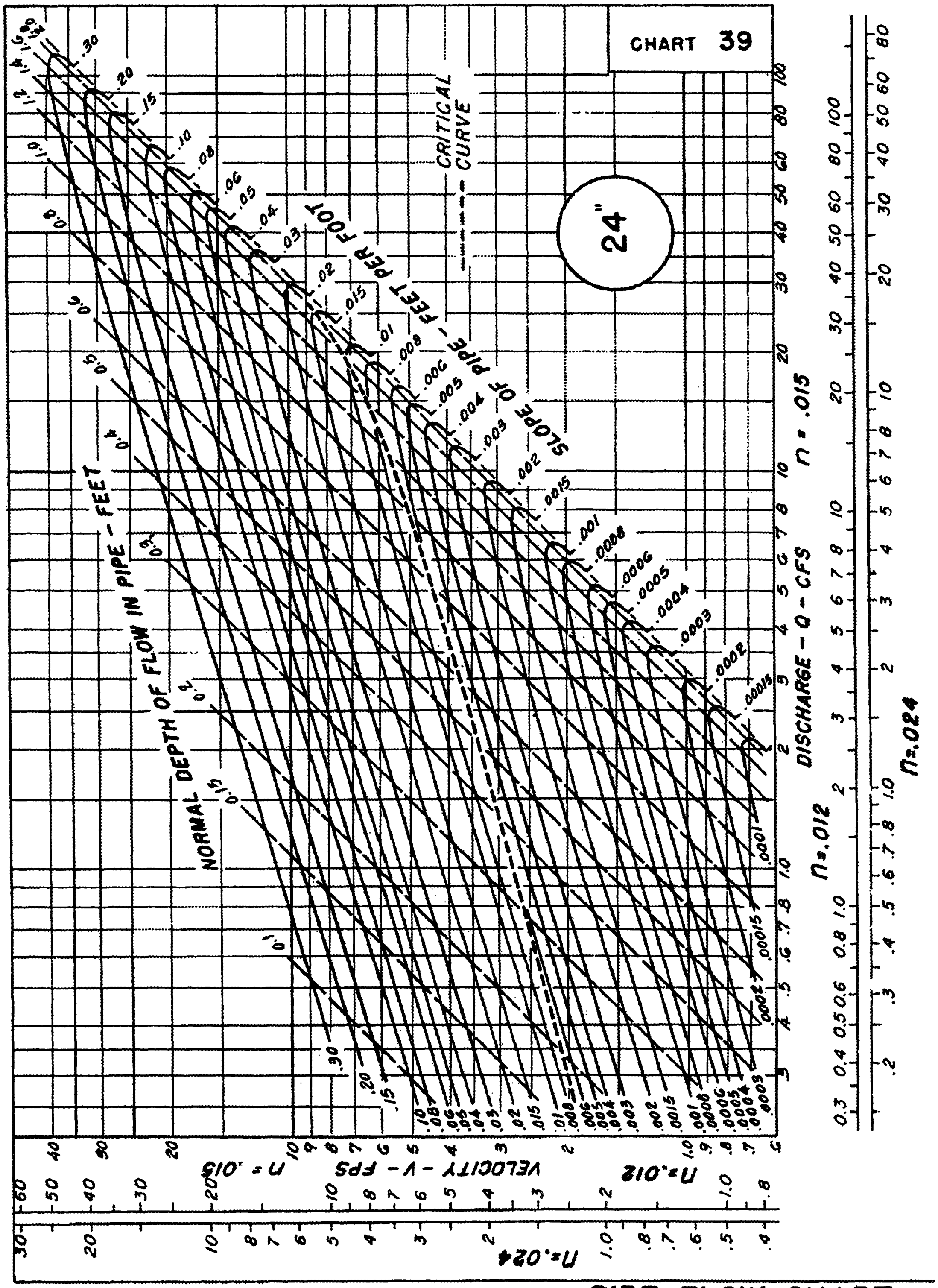
PIPE FLOW CHART
15-INCH DIAMETER



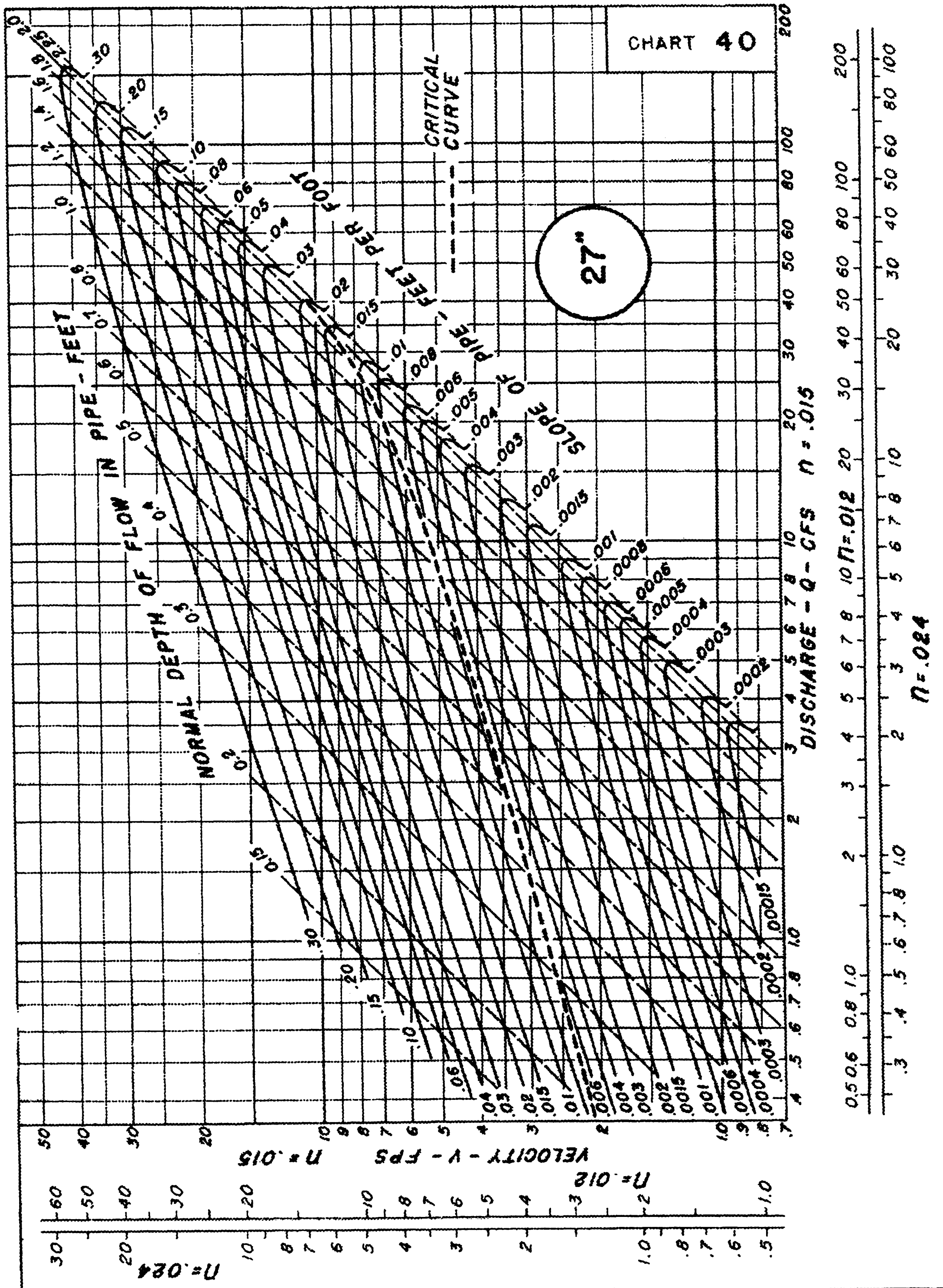
PIPE FLOW CHART
18-INCH DIAMETER



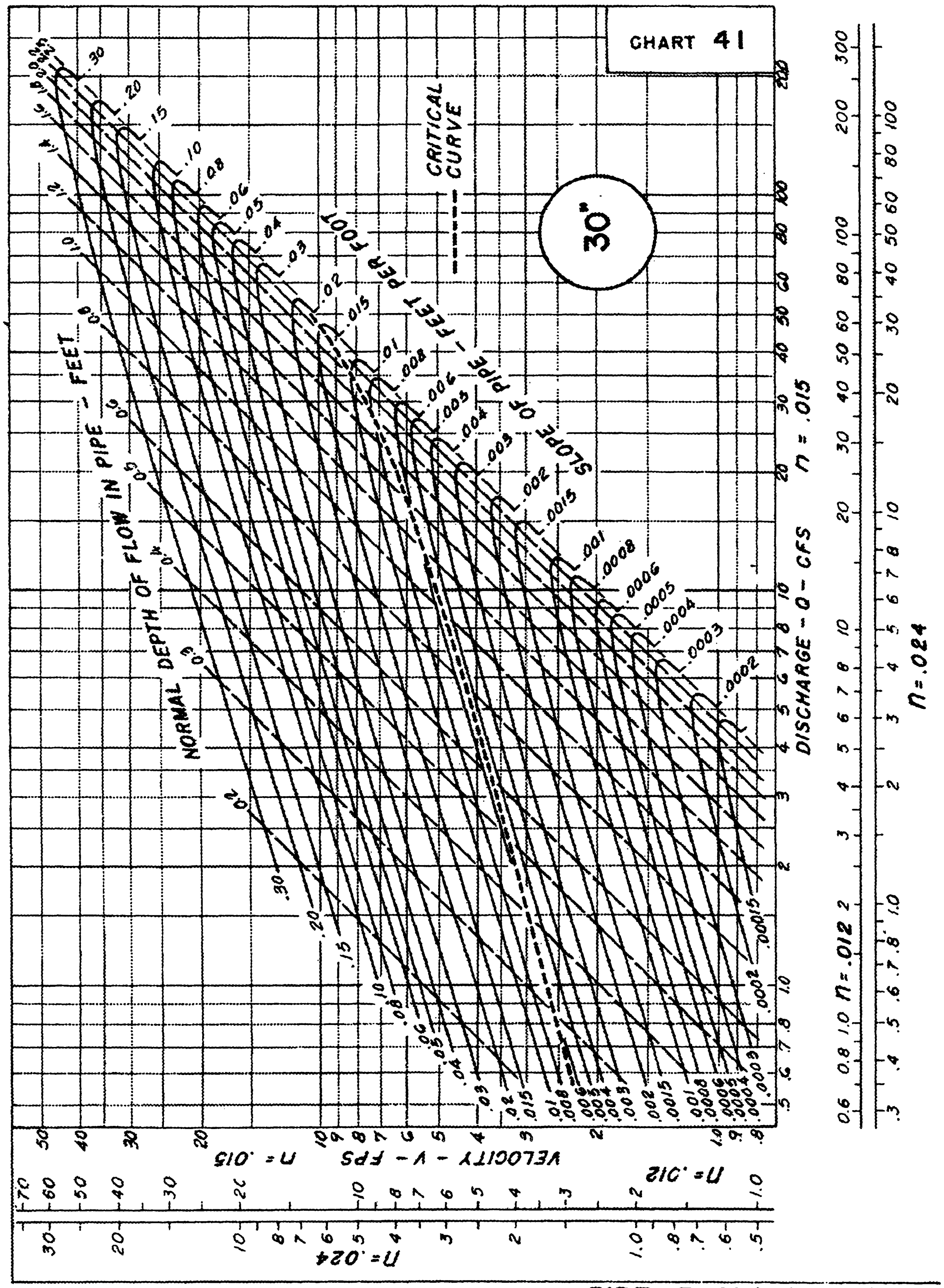
PIPE FLOW CHART
21-INCH DIAMETER



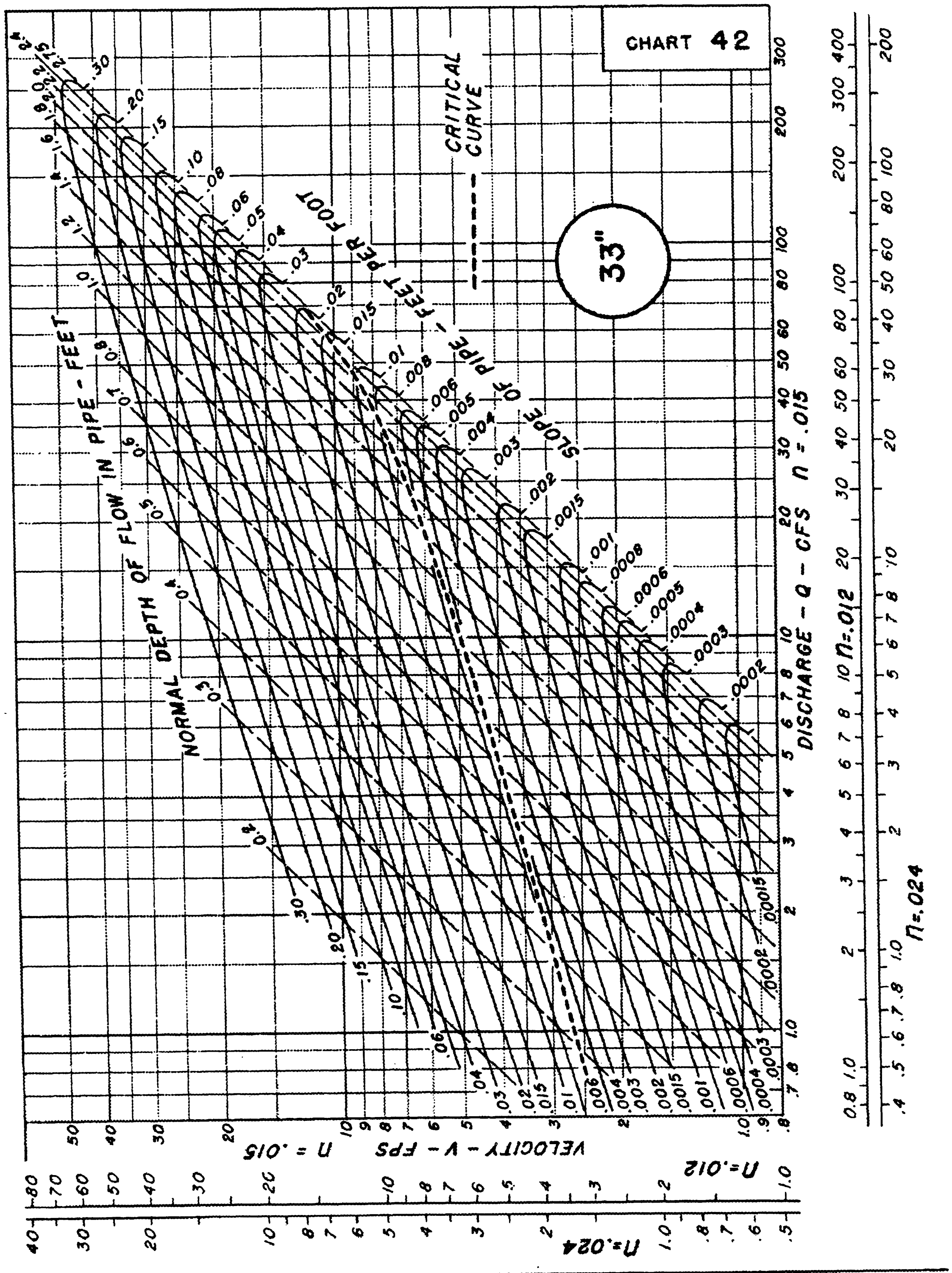
PIPE FLOW CHART
24-INCH DIAMETER



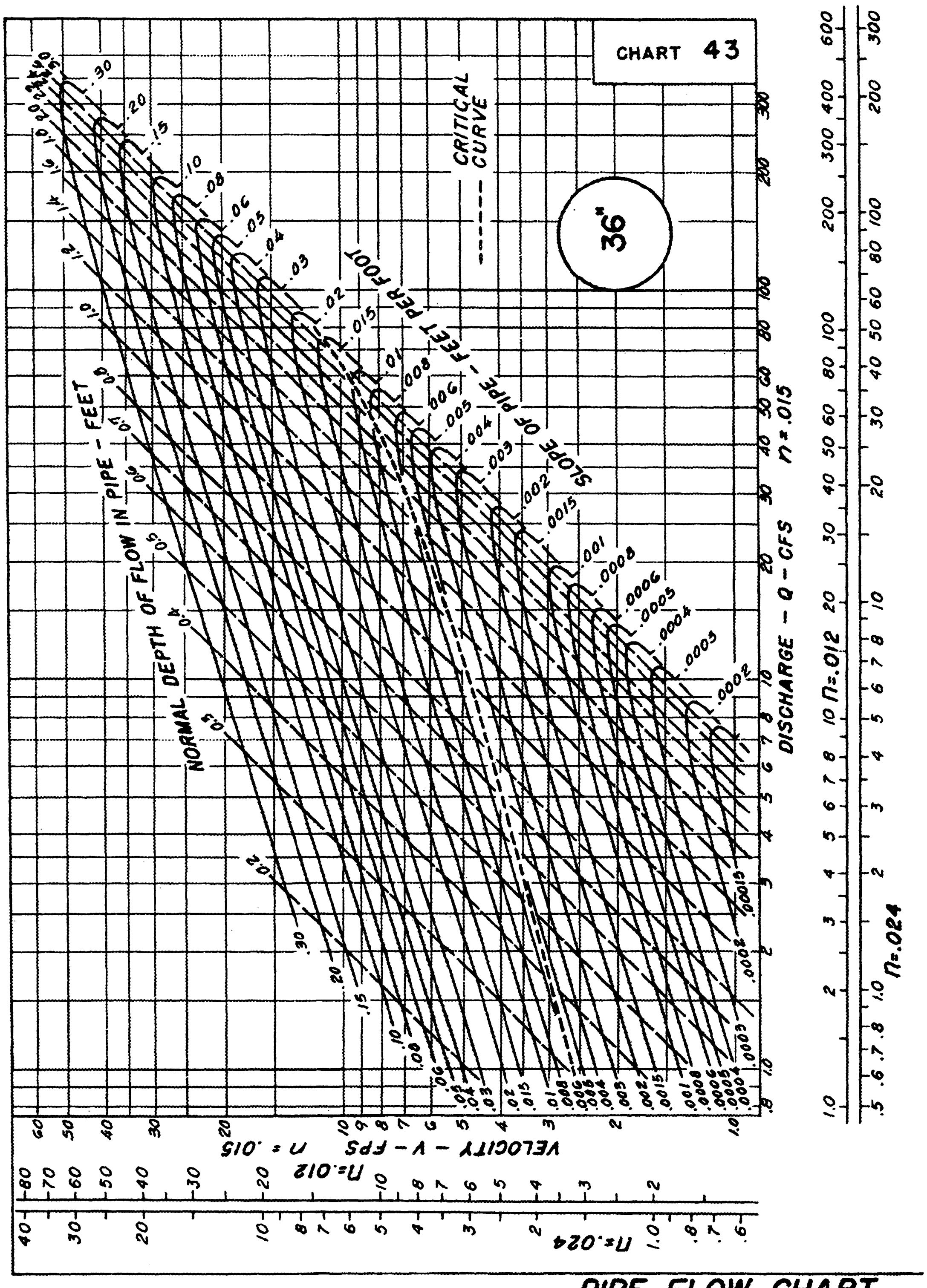
PIPE FLOW CHART
27-INCH DIAMETER



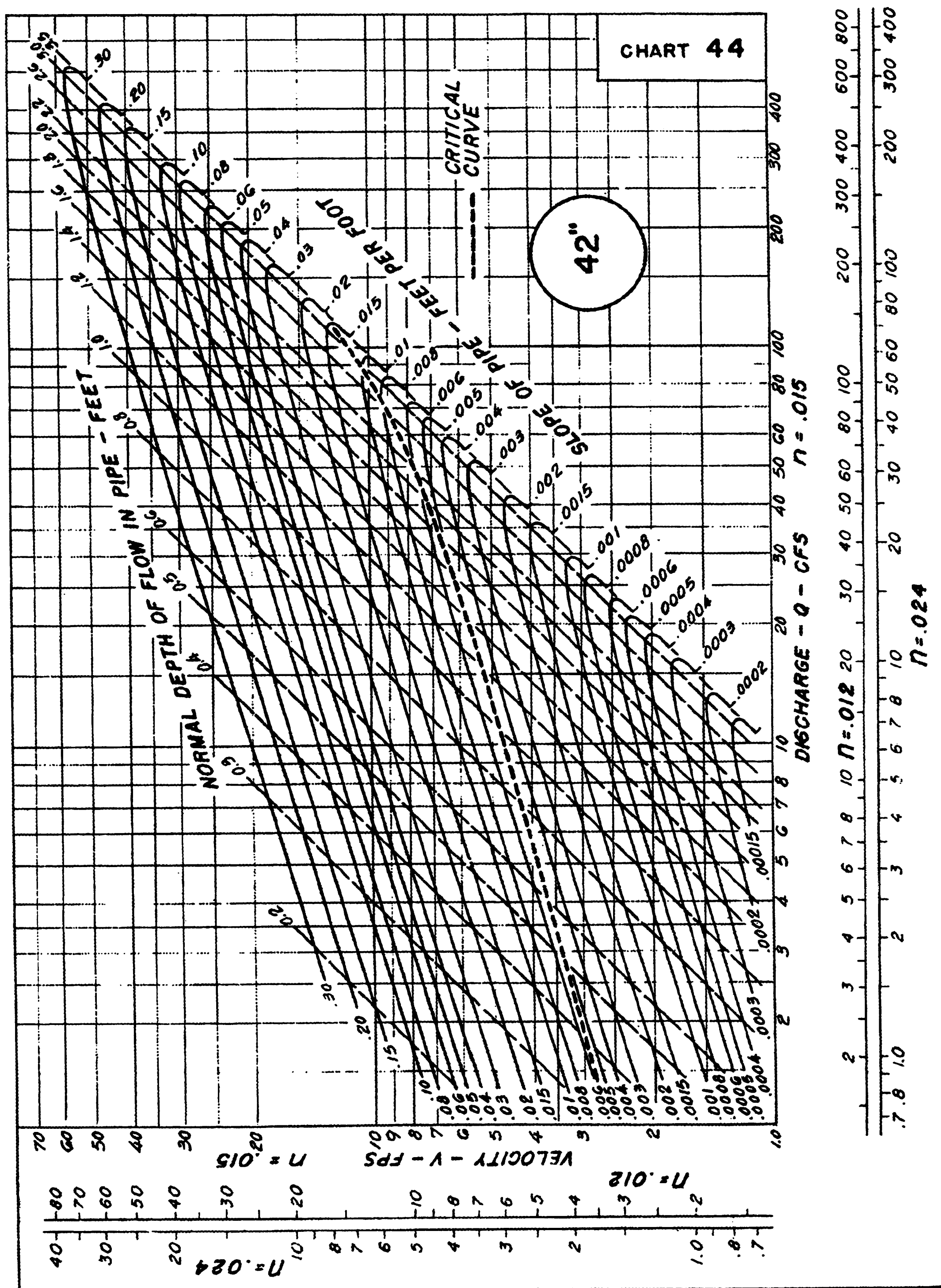
PIPE FLOW CHART
30-INCH DIAMETER



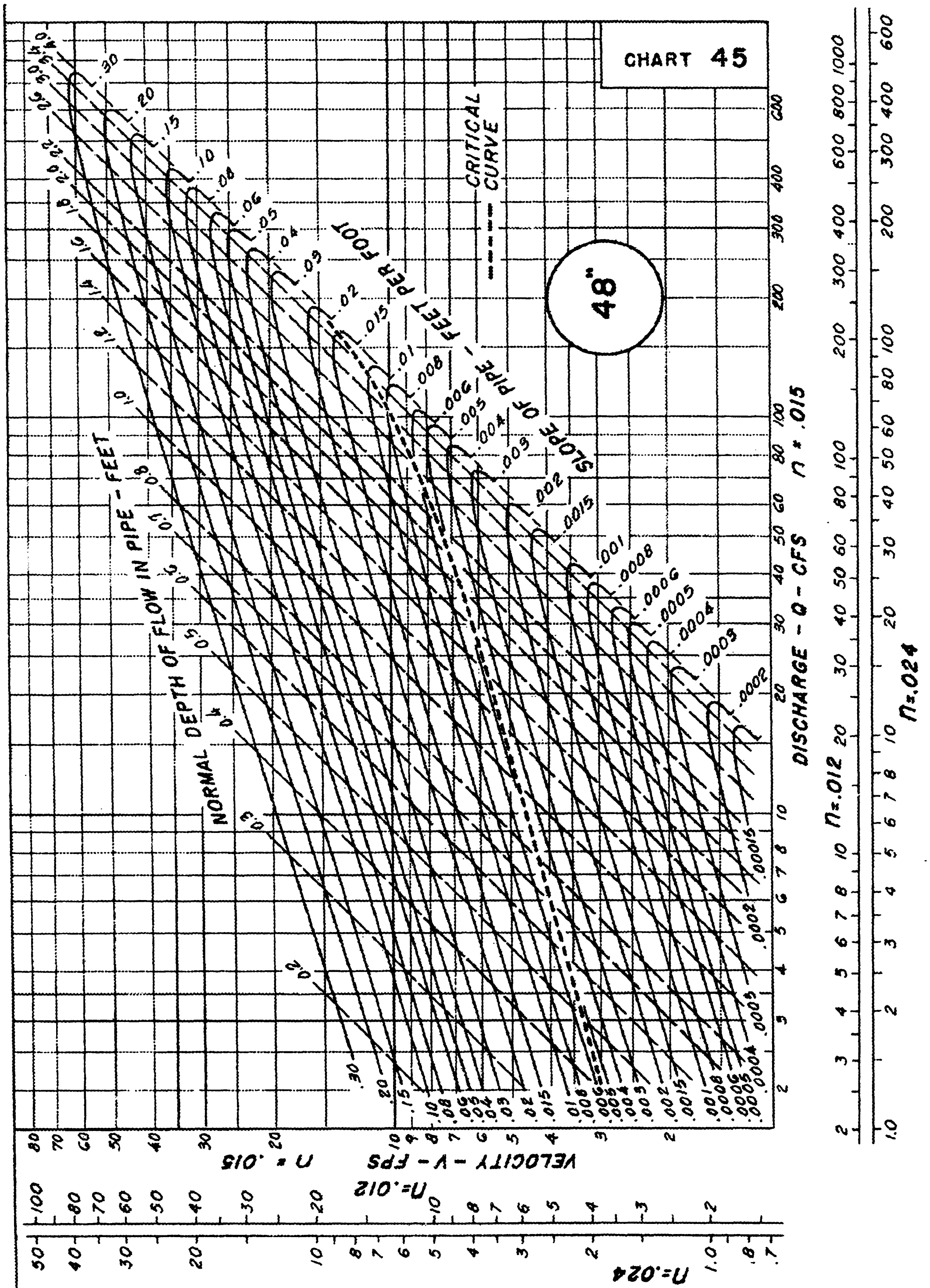
PIPE FLOW CHART
33-INCH DIAMETER



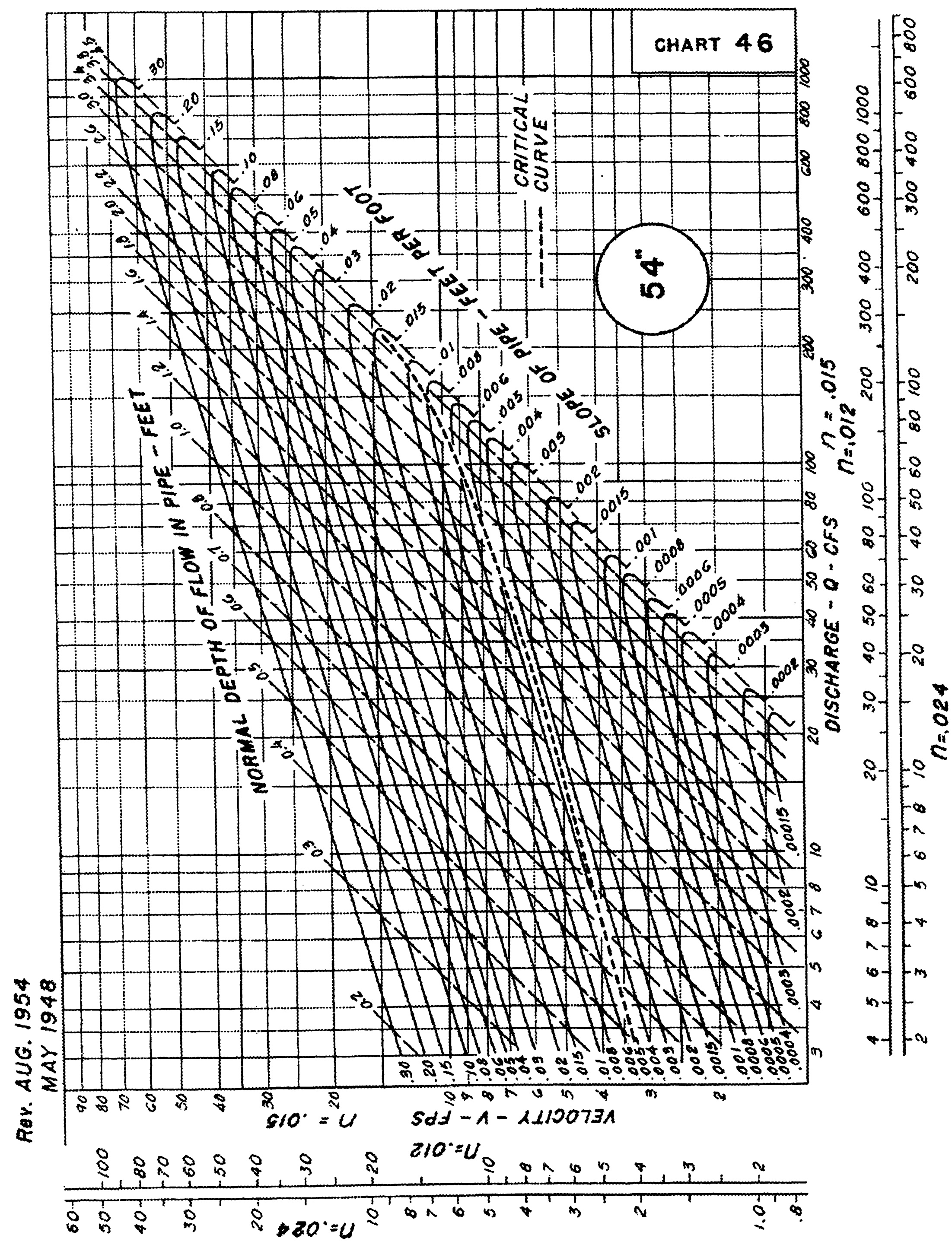
PIPE FLOW CHART
36-INCH DIAMETER



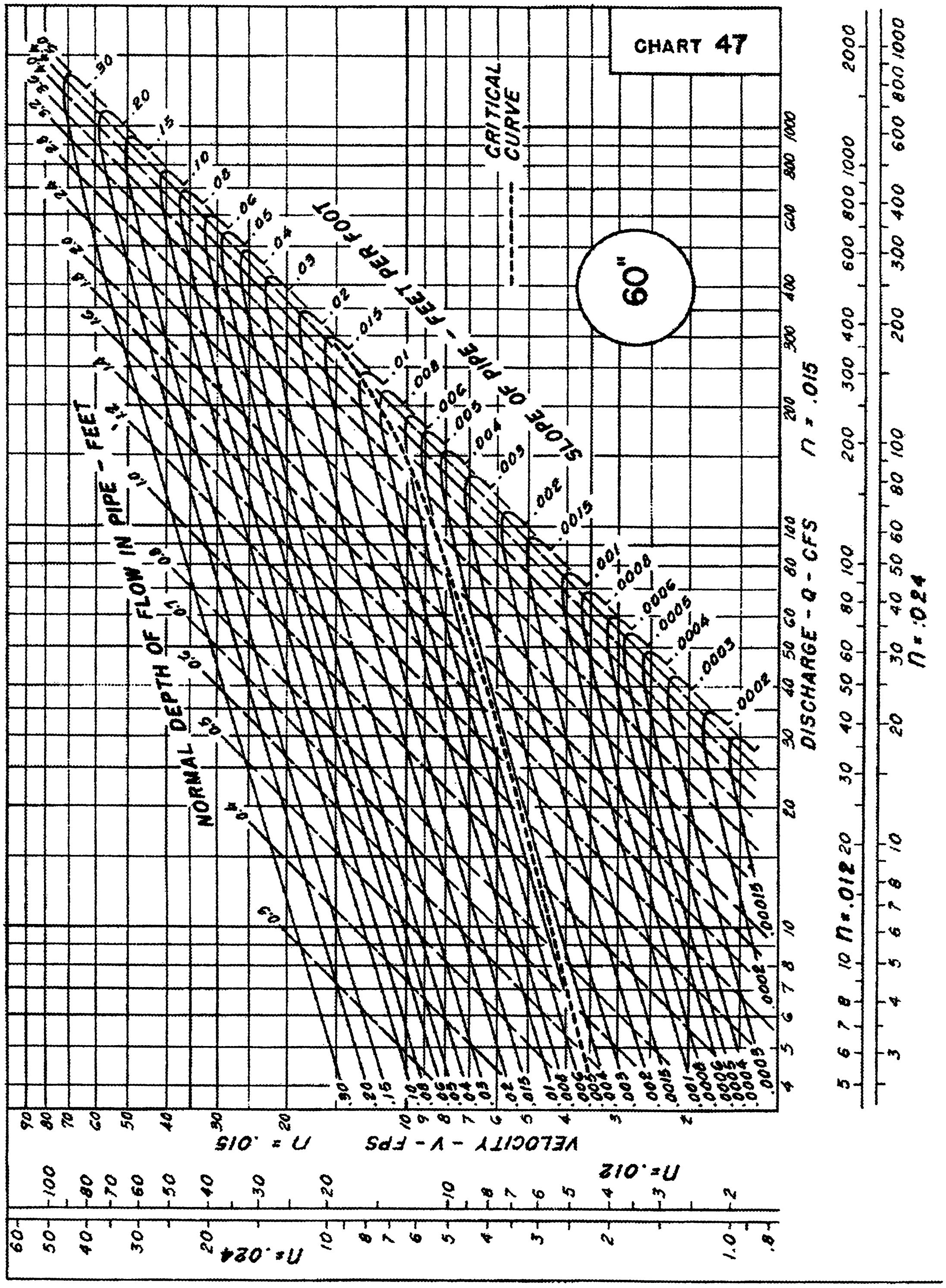
PIPE FLOW CHART
42-INCH DIAMETER



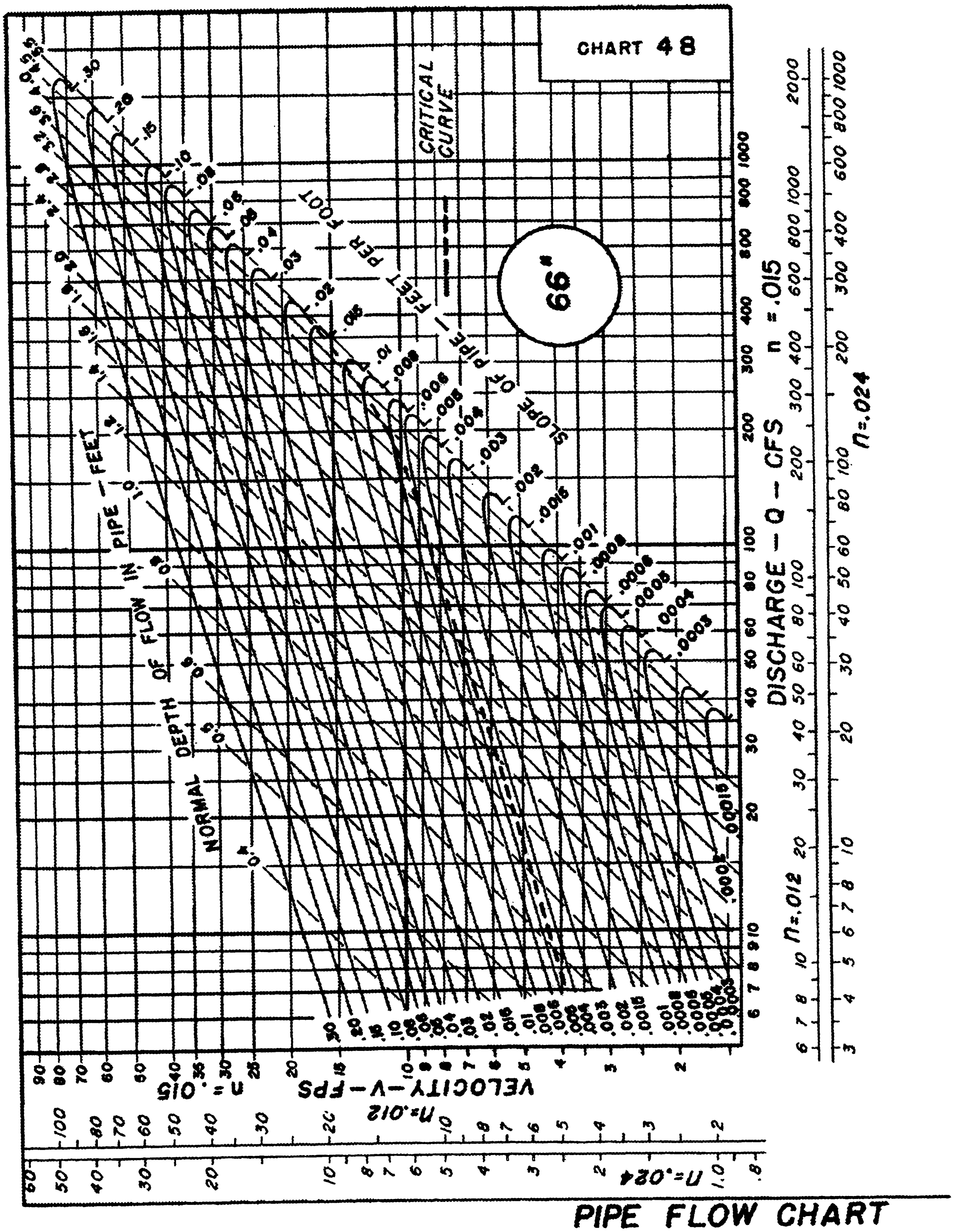
PIPE FLOW CHART
48-INCH DIAMETER



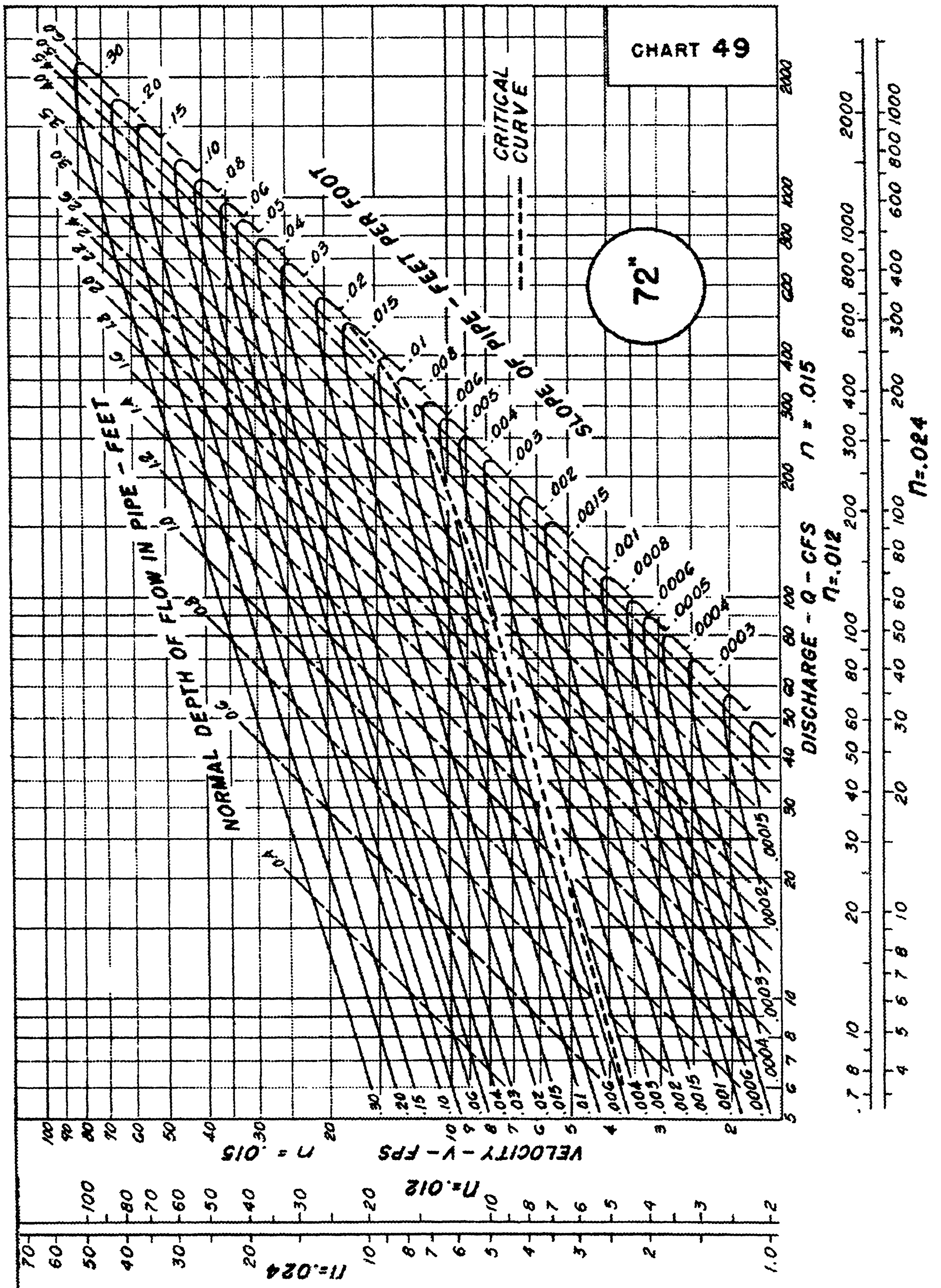
PIPE FLOW CHART
54-INCH DIAMETER



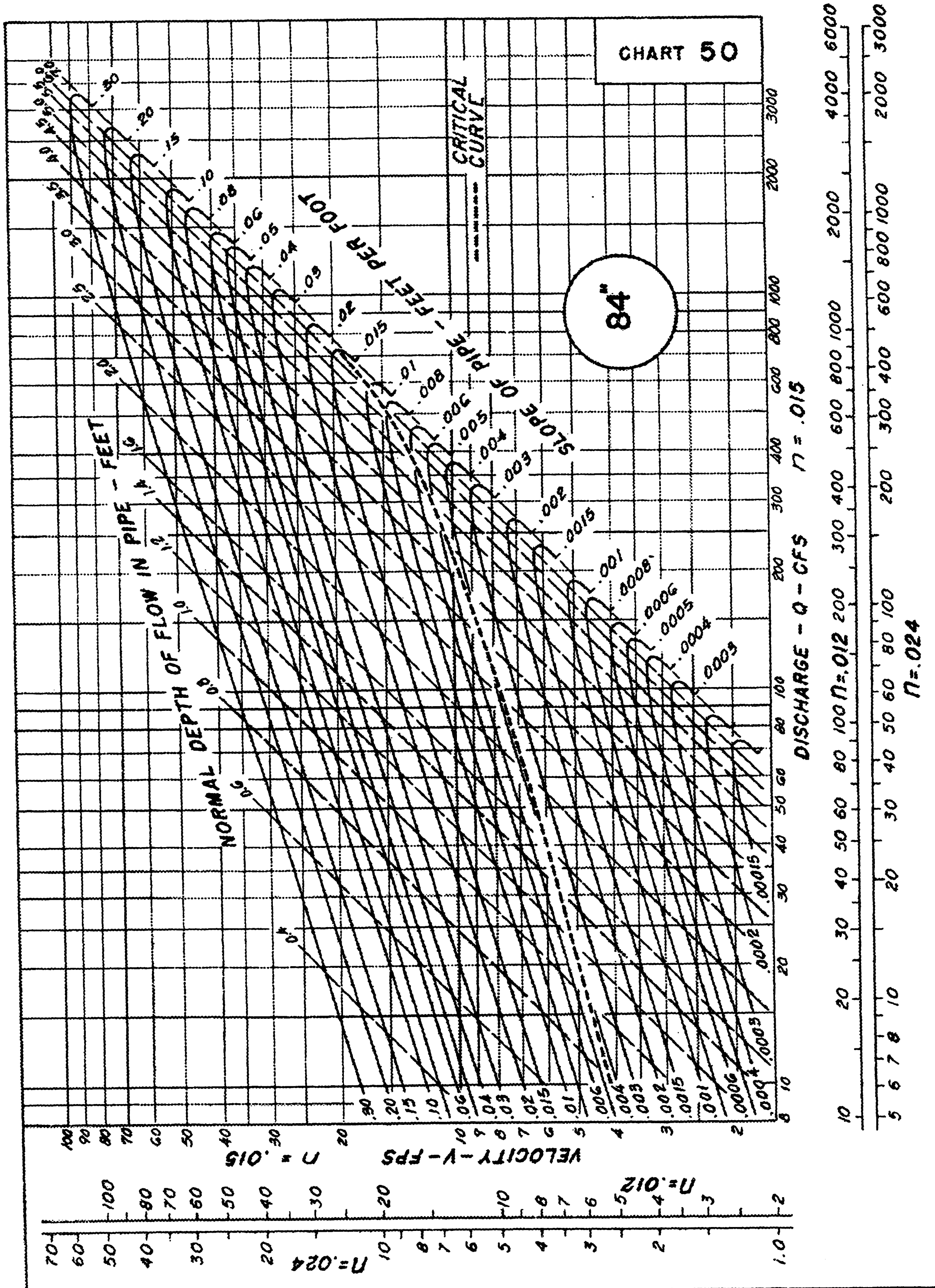
PIPE FLOW CHART
60-INCH DIAMETER



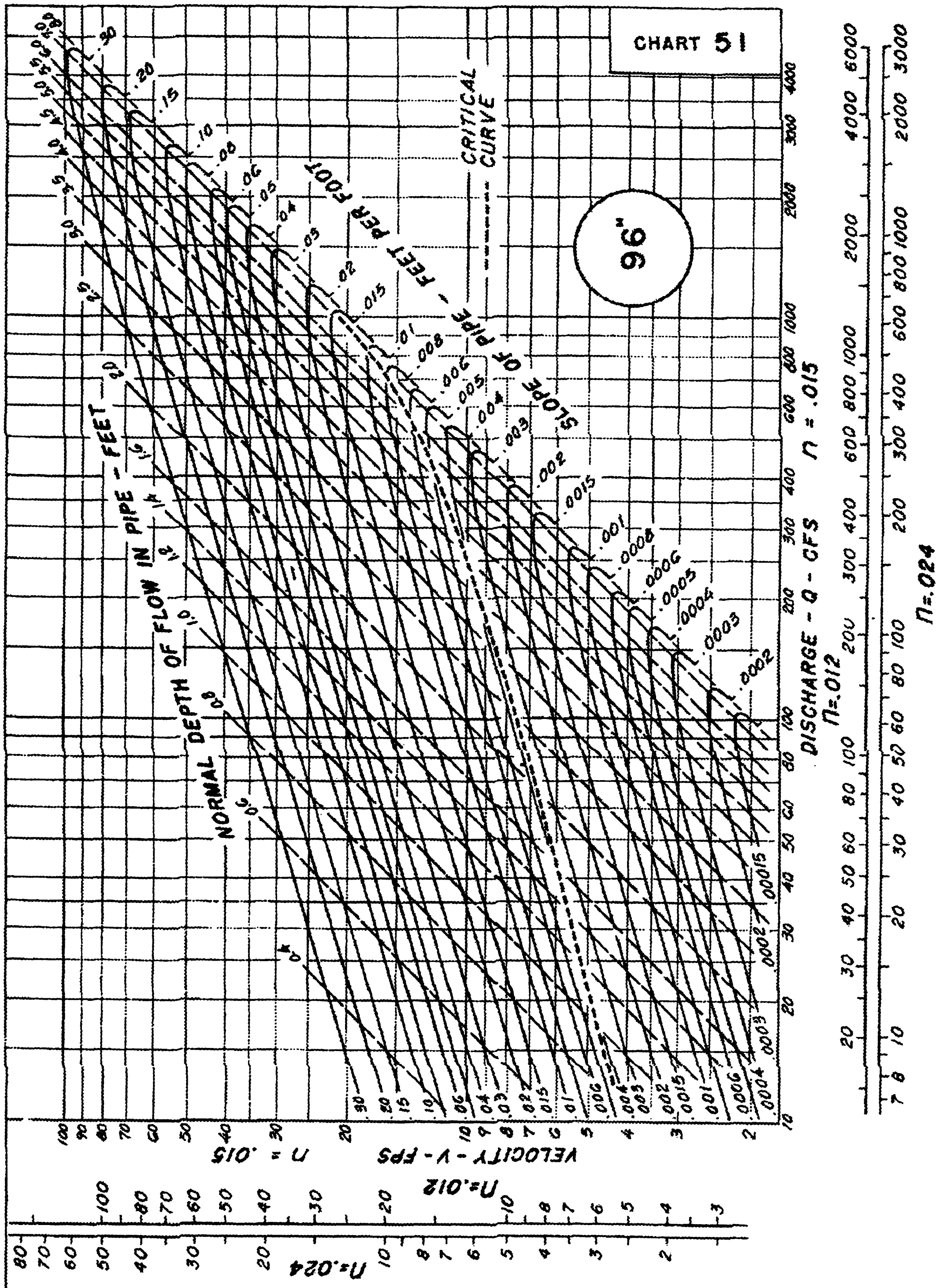
PIPE FLOW CHART
66-INCH DIAMETER



PIPE FLOW CHART
72-INCH DIAMETER

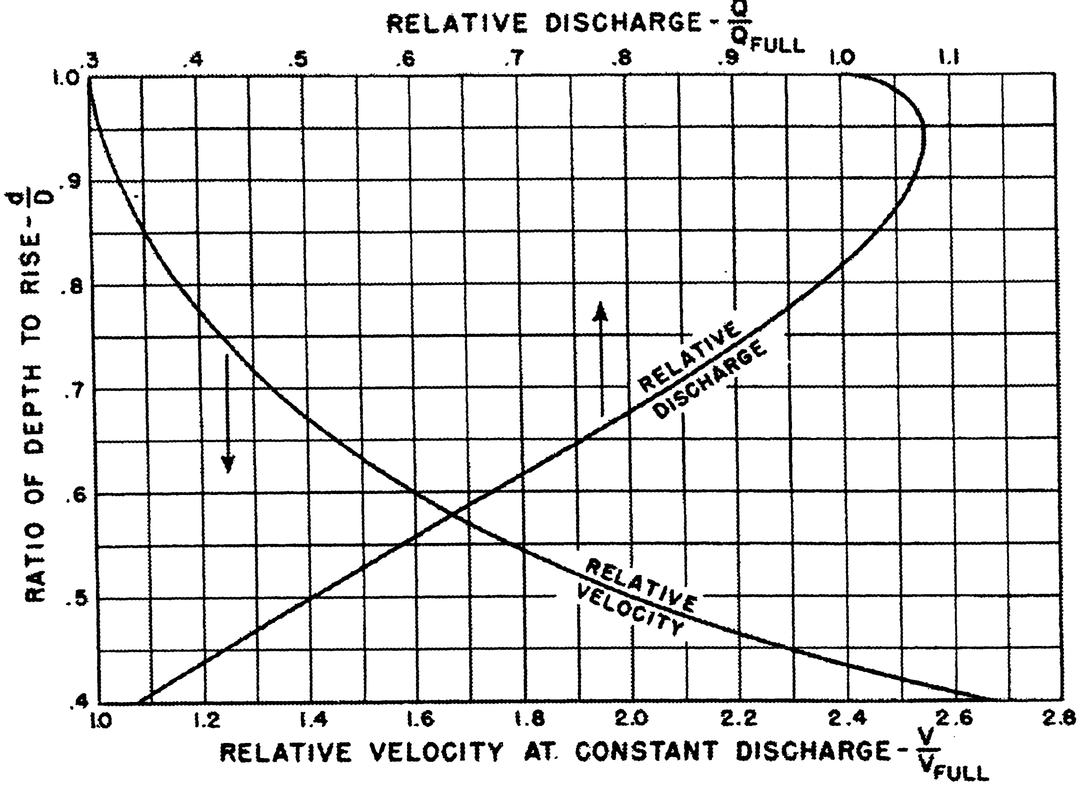


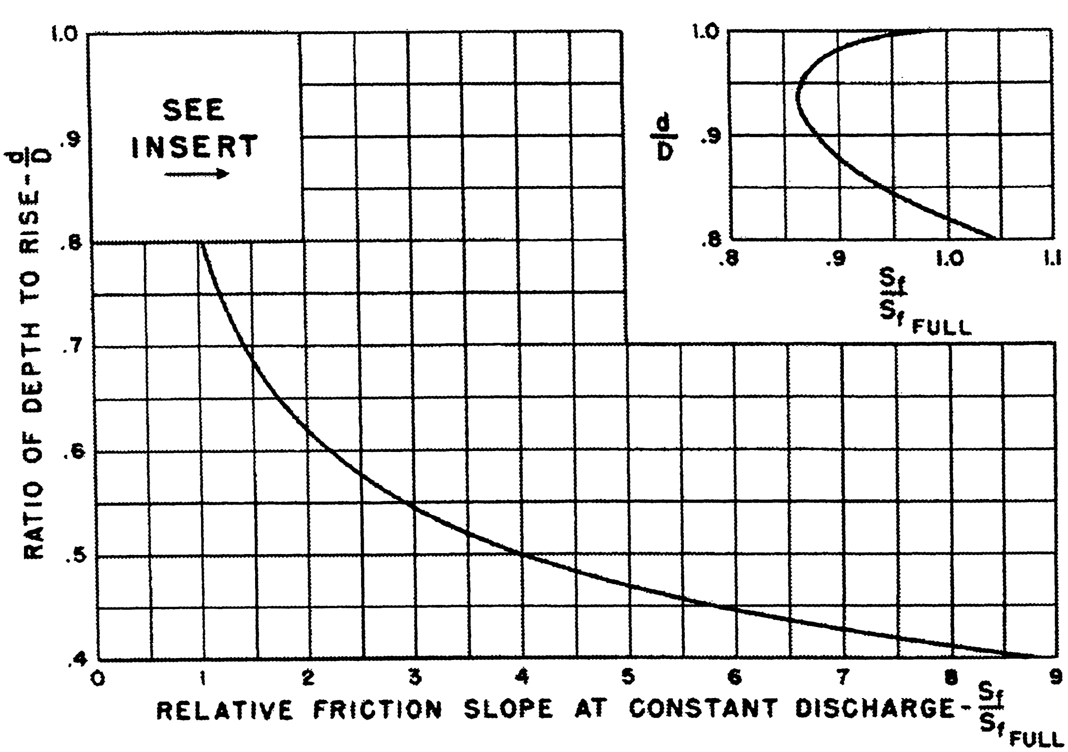
PIPE FLOW CHART
84-INCH DIAMETER



PIPE FLOW CHART
96-INCH DIAMETER

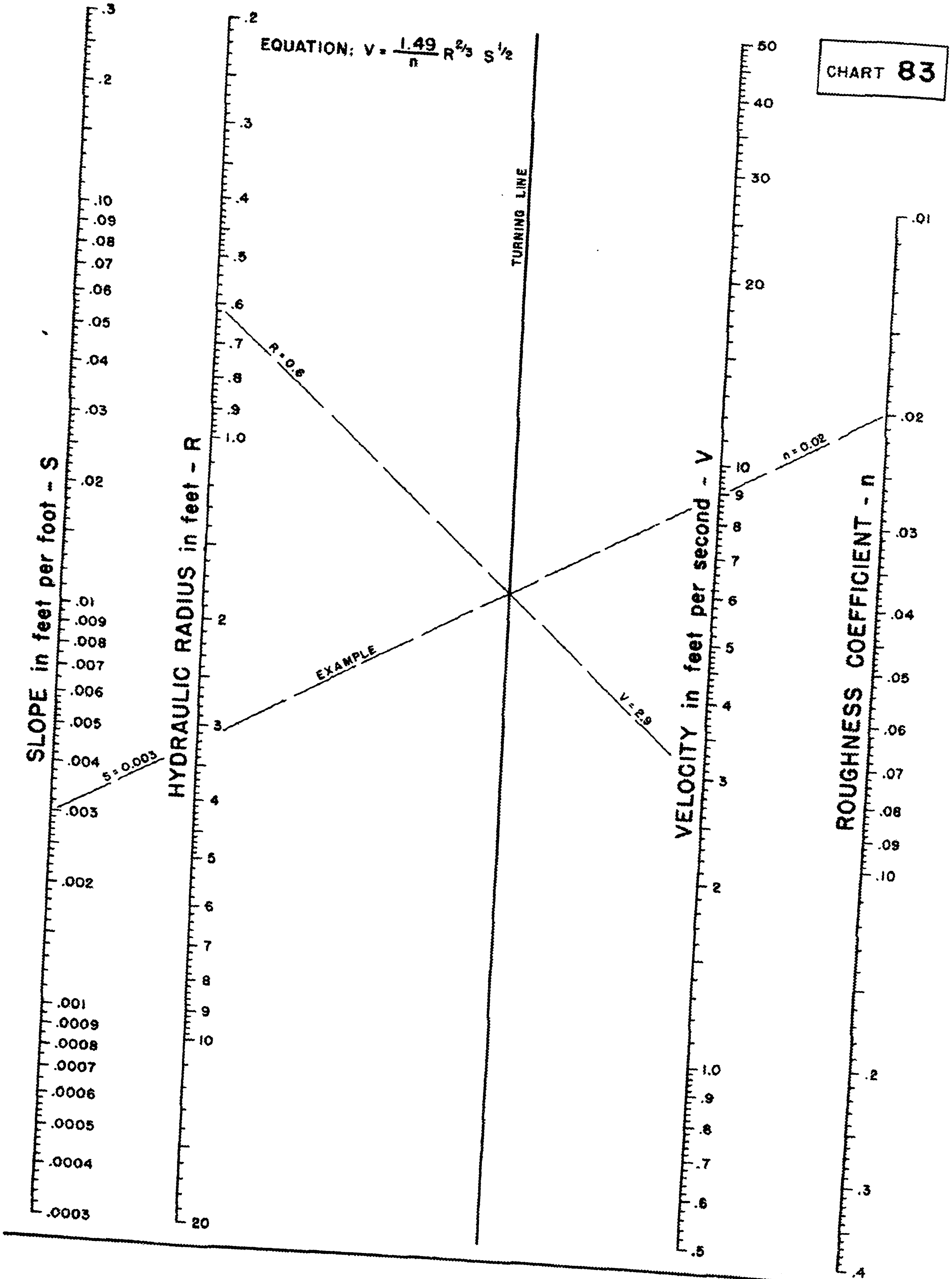
CHART 55





CIRCULAR PIPE

PART FULL FLOW



NOMOGRAPH FOR SOLUTION OF MANNING EQUATION