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MARSHALL LABORATORY
November 23, 1953

MEMORANDUM REPORT #M-655

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INSTRUMENTAL METHOD FOR MEASURING INITIAL EASE
OF BRUSHING OF INTERIOR ENAMELS AND INTERIOR WATER
EMULSION PAINTS

INTRODUCTION:

Research Report No. 1252 and Memorandum Report #M-629 explain the details involved in the development of a new instrumental method for measuring the initial ease of brushing of exterior house paints and oil base flat wall paints, respectively. The method has now been adopted for interior enamels and interior water emulsion paints (wall paints). Separate rating charts are necessary for each class of paints.

In this report the term "initial ease of brushing" means ease of wetting and spreading. In the past, this rating was determined by the opinion of the painter making the brushouts. At its best, this opinion involved considerable error and was usually reported on a relative basis. The new instrumental method reported here eliminates this personal error and provides better precision.

SUMMARY:

(1) The initial ease of brushing of interior enamels and interior water emulsion paints (wall paints) can be determined by means of a recently developed instrumental method. The method is based on the use of plastic viscosity and yield value, as determined with the Interchemical Rotational Viscometer.

(2) Separate rating charts are required for the interior enamels (Fig. 4) and for water emulsion paints (Fig. 5). It should be noted that the limits of good, fair, and poor brushing

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vary for these two types of products.

(3) Test methods have been written to explain the details of the test. TD-508-H explains the method of obtaining plastic viscosity and yield value on the Interchemical Rotational Viscometer. TD-516-B and TD-516-C explain the methods of determining initial ease of brushing for interior enamels and interior water emulsion paints, respectively.

(4) TD-527-A covers the details for determining the "drag at lap" of architectural finishes. This term is defined as the resistance encountered in pulling a brush from an unpainted area to a freshly painted area. This value, plus the initial ease of brushing value, gives a more complete rating for "brushability".

STATUS:

In the past, ease of brushing ratings have been based almost entirely on the opinions of a master painter. The development of the instrumental method provides better precision and provides the formulator with a concrete "target area" for good initial ease of brushing.

ACTION TAKEN:

Test Methods (TD-508-H, TD-516-B, TD-516-C) have been issued, giving the procedures for determining initial ease of brushing instrumentally.

DISCUSSION AND EXPERIMENTAL:

In discussing initial ease of brushing with professional painters and in analyzing the problem from a theoretical aspect, it became apparent that at least two values were required from rheological measurements, namely one to measure the vehicle viscosity and one to measure the puffiness or structure of the paint. Plastic viscosity and yield value, respectively, as determined on the Interchemical Rotational Viscometer, met these requirements. Furthermore, it was believed that, besides the effects of temperature on ease of brushing, (Research Report #1252), penetration into the substrate and (in the case of water emulsion paints) surface tension might have some effects over porous substrates.

1. Plastic Viscosity and Yield Value:

By definition, yield value is the minimum force required to produce laminar flow in a plastic material, expressed in dynes/cm². Plastic viscosity is the resistance to flow of a non-Newtonian system in excess of its yield value, expressed in dynes sec./cm², or poises. These values are obtained by

measuring shearing stress as a function of shear rate on a rotational viscometer. Figure 1 shows the type of curve commonly found in interior enamels and in water emulsion paints. It is noted that, as is generally the case, the plastic viscosity of the enamel is greater than that of the water emulsion paint. This is evident from the difference observed in the slopes of the two curves. Actually the reciprocal of the slope of the straight portion of the down curve is a measure of the plastic viscosity, while the intercept of the extrapolation of this straight portion of the down curve to the shearing stress axis is a measure of the yield value. The yield value is a function of the structure or flocculation of the system.

The formulae for calculating plastic viscosity and yield value are as follows:

$$U = \frac{F - f}{S}$$

where F = shearing stress (dynes/cm²)
 S = rate of shear (sec.⁻¹)
 U = Plastic Viscosity (poises)
 f = Yield value (dynes/cm.²)

The size of the hysteresis loop formed between the up curve and the down curve is an indication of the degree of thixotropy.

2. Effects of Surface Tension of Water Emulsion Paints on Ease of Brushing over Porous Substrates:

From the results shown in Table I, it is concluded that differences in surface tension do not affect the initial ease of brushing of water emulsion paints when brushed over porous substrates. The range of surface tensions studied is greater than that encountered in actual paints. It is seen that, in going from a sealed substrate to an unsealed substrate, the painter's rating decreases slightly in all but two cases. These two paints were too thin for a sealed substrate, but just right for unsealed surfaces. The slight reduction in initial ease of brushing of the majority of paints was attributed to loss of vehicle into the substrate. In each case, with one exception, the painter claimed the initial brushing over porous substrates was good, but that the paints needed water to speed up the work.

TABLE I

Code	Surface Tension	Plastic Visc.	Yield Value	Initial Ease of Brushing	
				Sealed Substrate	Porous Substrate
391-004	31	0.8	55	Ex. (thin, not sloppy)	Perfect, just right
391-019	31	1.1	138	Ex.	V.G.-Good; Slow, needs water
391-005	31	0.9	55	Thin	Perfect; not sloppy.
391-014	32	1.1	133	V. Good	V. Good; Needs a little water.
391-002	34	1.5	260	Ex.	V. Good; needs a little water.
389-001	48	2.8	166	Fair	Fair-Poor; needs water
P-100-U-63074A	51	0.7	39	Thin	Ex.; Not sloppy
P-100-U-63074	53	2.1	89	Ex.-V.Good	V.Good; needs water.
P-100-U-63095A	53	1.3	55	Ex.-V.Good	V.Good; needs water.
P-100-U-63072	55	1.7	89	Ex.-V.Good	V.Good; needs water.
P-100-U-63072A	59	2.0	116	Ex.	V. Good; needs water
P-100-U-63071	61	1.5	116	Ex.-V.Good	V.Good; needs water

3. Initial Ease of Brushing Charts:

Figure 4 shows the limits which have been set up for interior enamels. In general, an enamel with good initial ease of brushing has a plastic viscosity between 2.5 and 5.7 poises and a yield value in excess of 55 dynes/cm². Plastic viscosity and yield value data for 75 interior

enamels are plotted in Figure 2 together with their ease of brushing ratings. Classes of good, fair and poor are designated on this chart. An area marked too thin for trim work is also included. This means that, although the paint produces no drag under the brush, it is too sloppy to apply by brush on trim surfaces. In like manner, Figure 5 is a chart for determining the initial ease of brushing of interior water emulsion paints. These limits were determined from a plot of plastic viscosity and ease of brushing data for 70 water emulsion paints.

It may be possible to thin paints falling in the fair or poor range (marked with an asterisk) in Figure 4 and 5 so that they will fall in a better brushing area. This reduction test should be tried before a paint is condemned for initial ease of brushing for commercial sale.

A further interpretation of Figure 2 and 3 in terms of flow properties can be generalized; as the yield value increases from a low value to a high value, the false body increases and the overall effect is good slip under the brush, poor flow, and heavy brush marks. Below a minimum yield value (50-55 dynes/cm.²) brush marks are less pronounced, but sagging or running may result. Also, at a constant yield value, increasing the plastic viscosity above 5.7 poises for enamels and above 2.2 poises for water emulsion paints results in loss of ease of brushing; below 2.5 poises (enamels) and below 0.5 poise (water emulsion paints) there is a danger that the painter cannot apply the necessary film thickness for durability purposes, due to the thinners and sloppiness of the paints.

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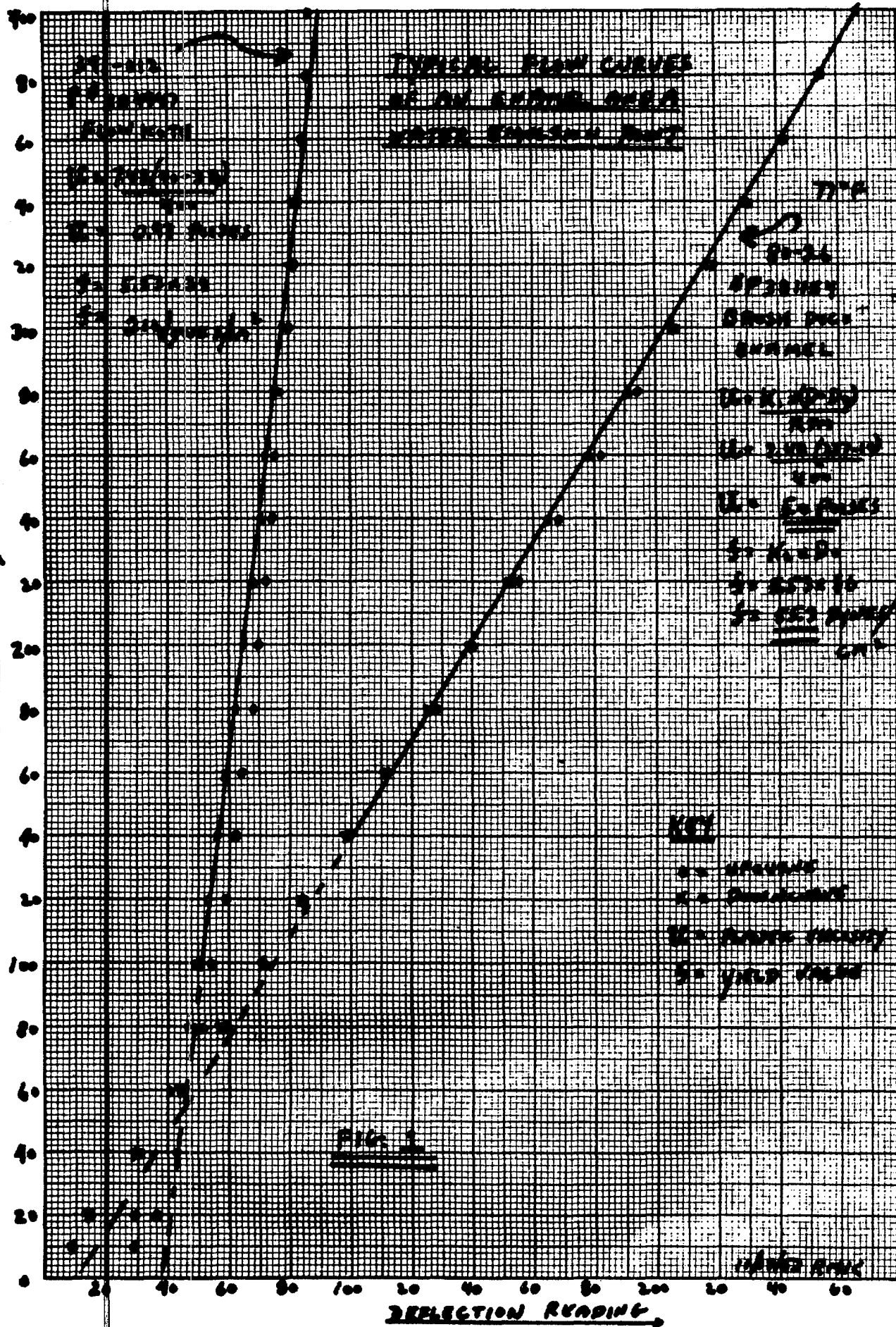
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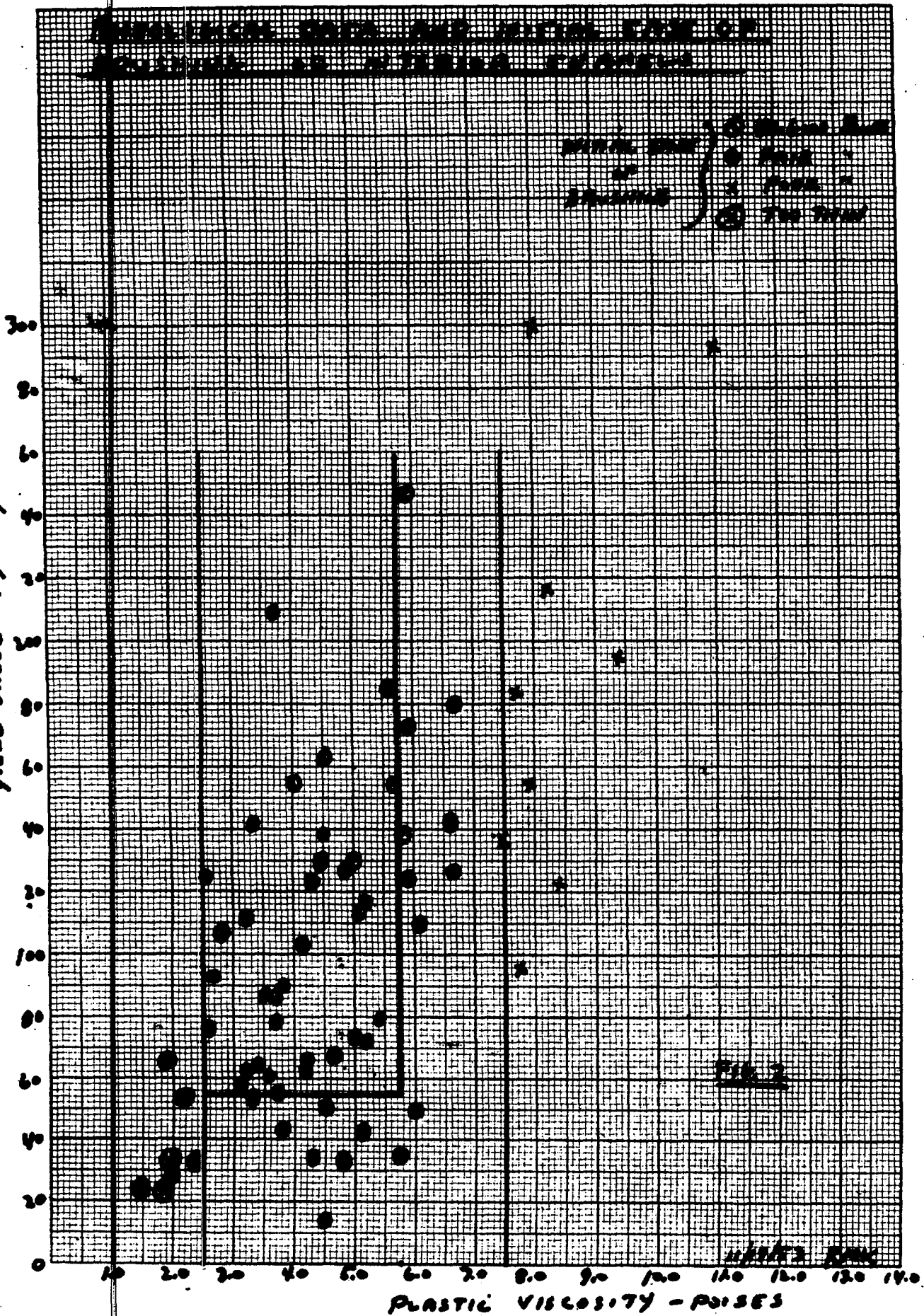
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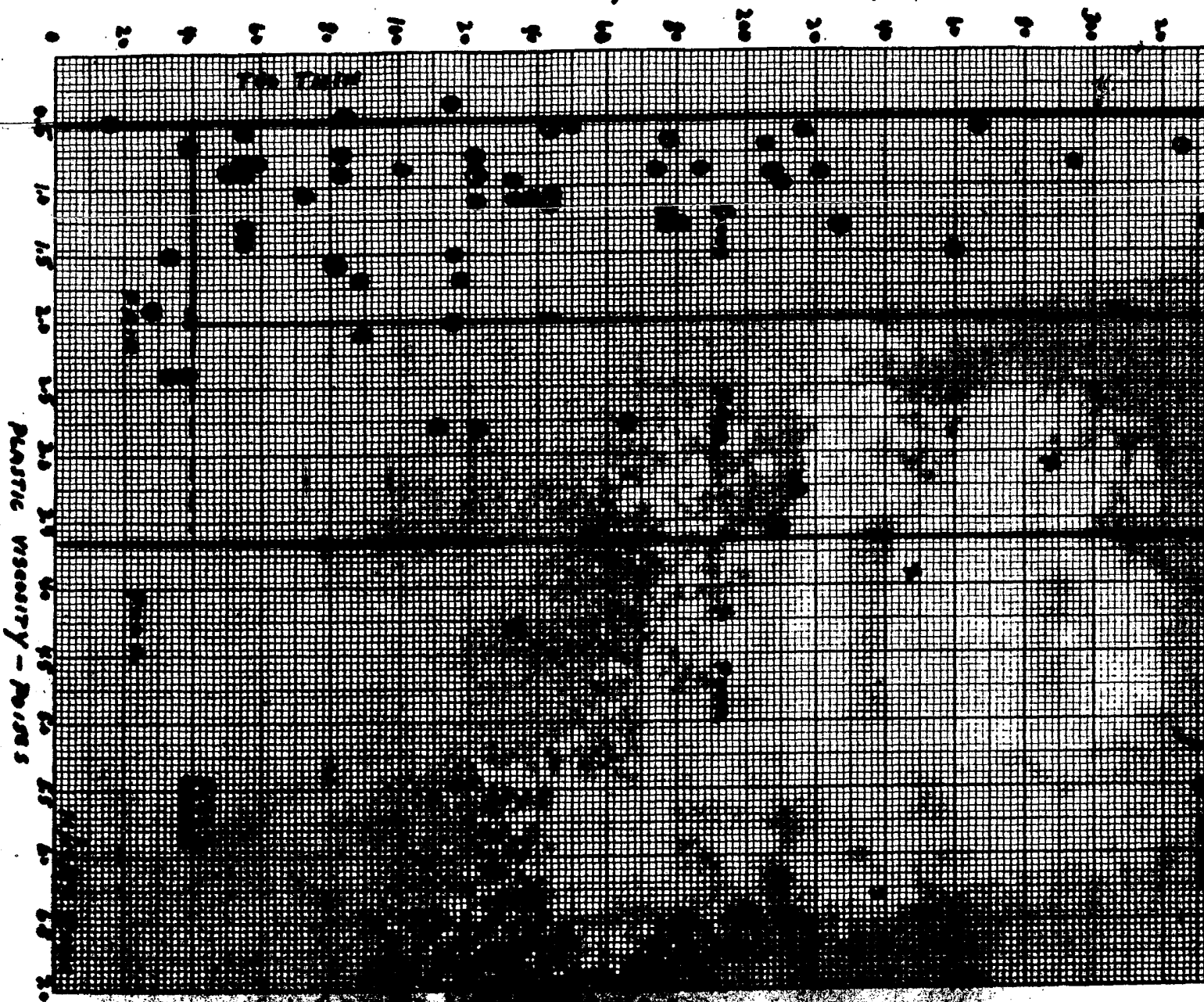
yield stress - dynes/cm²

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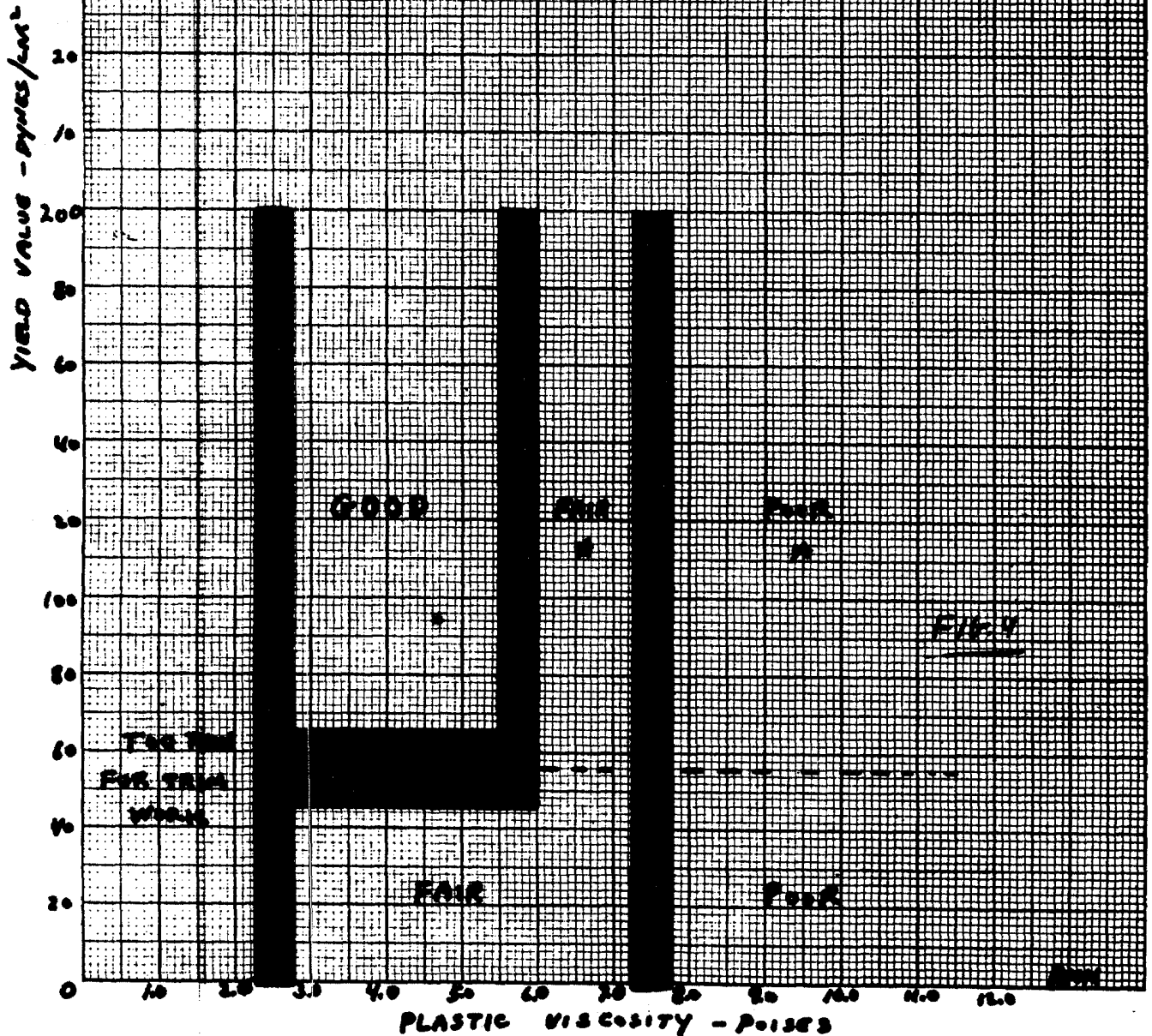
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YIELD VALUE - dynes/cm²



Initial Ease Of Breathing Of Various Examples

NOTE: IT MAY BE POSSIBLE TO IMPROVE THE QUALITY OF THE POINTS FALLING IN THE AREA BORDERED WITH AN ARROWHEAD (A) BY THINNING THESE POINTS SHOULD BE THINER AND REVERSED.



INITIAL TEST OF BRUSHING OF WATER EMULSION PAINTS

FOR INTERIOR USE

NOTE: IT MAY BE POSSIBLE TO IMPROVE THE BRUSHING OF THE PAINTS TAKING IN THE AREA STAINED WITH AN APPROXIMATELY 1/4 INCH. THESE PAINTS SHOULD BE THINNING AND RETESTED.

