Mr VC Campbell

INVESTIGATION OF ELECTROSTATIC LENSES

SUBJECT; Potential Field Plots for Three Different Electrostatic Focus Lens Assemblies

PURPOSE

To investigate the relative properties of a dumbbell type lens assembly as compared to the Dumont and General Electric gun assemblies.

PROPOSED ACTION TO BE TAKEN

In a discussion with Mr. R. T. McKenzie, it came to light that a major difficulty with the standard 17R focus assembly could be due to tilting of the focus cylinder with respect to the horizontal axis in assembly. Perhaps an investigation of this tilting aspect would reveal a major advantage of the special lens in that the potential distribution would be much more insensitive to such tilting. This also might be the advantage of the Dumont lens. It is proposed that such a program be carried out.

In view of the following discussion it is necessary to decide if the proposed configuration for the special lens offers a marked advantage over the standard lens production-wise, and if so, to carry out a program which would lead to the desired potential distributio which may or may not be exemplified by the Dumont construction.

PROCEDURE

It was hoped that the desirable focusing effect of the DuMont lens would be obtained without the critical features of the present General Electric 17R focus assembly. The assembly was designed such that its dimensions would closely approximate that of the DuMont lens. Its general configuration is as follows.

Specifications

Focus Cylinder	Length	.500"	
	Inside Dia.	.625"	(This is D' as referred to below)
Grids	Length	.375"	
	Inside Dia	.500"	
	Aperture	.120"	
	Radius (Inside)	.500"	
Separation of Grids	D =	.360"	

(D fixes all other dimensions with respect to the center of symmetry.)

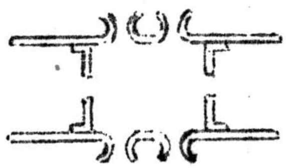
As compared to the DuMont Specifications.

Specifications

Focus Cylinder	Length	.375"
	Inside Dia.	.625" (This also D')
Grids	Length	.375" Indentation of aperture
	Inside Dia.	.500"
	Aperture	.120"
Separation of Grids	D =	.475"

(There results a difference in grid separation since my specifications were taken from a sketch which did not have the same separation as was used by Mr. A. Libenson in making the field plot for the DuMont lens.)

As compared also to the Standard 17R TV Focus Assembly.



Specifications

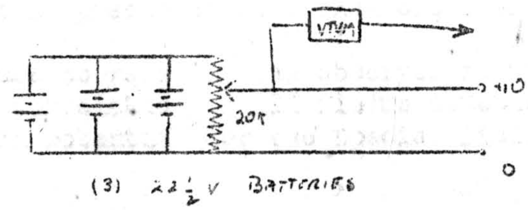
Focus Doughnut	Length	.115"
	Inside Dia.	.500"
	Radius	.0314"
Grids	Length	.500"
	Inside Dia.	.500"
	Radius	.0314"
	Aperture	.100"
	Aperture Recess	.115"
Aperture Separation		.502"

Since the DuMont configuration had already been plotted, it was not necessary to do so again. However, it was necessary to obtain comparable plots of the special and standard configurations. This was done as follows.

Method of Plotting Fields

The fields were plotted with the use of teledeltos paper which has the property of uniform resistance throughout. This lends itself quite readily to field plotting since Laplace's equation in two-dimensions is closely approximated by the field set up between electrode configurations.

All configurations were drawn on a scale of 20:1 and the following circuit was used to probe for the equipotentials.



Ideally, a null point method should have been used, however, the proper precision potentiometers were not available. It is felt that the results obtained from the above give sufficiently accurate results, since they are consistent from plot to plot and only comparison between plots is required.

Results of Investigation

Visual investigation of the field yields very little since very slight differences are observed and the major differences are outside the range of skew electrons for the beam width concerned. Therefore, three graphs were made in order that the fields might be more readily compared. These are attached.

Graph I

Axial potential as a function of the ratio of the distance from the center of symmetry to D, the total separation of the apertures.

This graph shows close correlation of the potential presented to an axial electron in the region close to the apertures. The Standard and DuMont guns continue in close correlation all along the axis, varying at most 1% of the total field. The special field is more constant over-all than the other fields varying 20%, while the variation is 30% for the other configurations.

Graph II

Cross Axial Potential (vertical axis of symmetry) as a function of the ratio of the distance from the center of symmetry to D', the inside diameter of the focus cylinder.

This graph shows a similar rather close correlation between the DuMont and Standard fields while the Special field varys more widely. A larger variation in cross axial potential is observed for the special field than for the other fields.

Graph III

Paraxial Potential plotted as in Graph I, in order to gain an approximate representation of the average potential presented to a skew electron.

Again, very close correlation was observed in the Standard and DuMont fields with the same "near aperture" correlation of all fields as observed in Graph I. Again, as in Graph I the total variation in potential for the special field is less than for the other two fields. (20% vs. 30%).

CONCLUSIONS

It is believed that the smaller variation in potential for the special field over other fields, as observed in Graphs I and III, and the greater variation in Graph II can be attributed to the considerably smaller D. If this distance were made greater, obviousl the potential drop to the center of symmetry would increase.

* From this consideration, it is concluded that nearly any axial potential distributio may be approximated as closely as desired within the limits of experimental technique. It follows that with the changes of axial distribution as stated, the cross-axial and para-axial distribution will receive inversely proportional or directly proportional (respectively) change. Hence, if the axial potential distribution, due to one set of electrodes, is made to approximate a given distribution due to another set of electrodes, the correspondence between the cross-axial and para-axial distributions will be closely approximated.

This corresponds to what would be expected by existing theory, which observes that given the axial potential, the potential distribution of the field may be closely approximated by

$$V(r,z) = V_0(z) - V_0''(z)\,\frac{r^2}{2^2} + \ldots\ldots\ldots + \frac{(-1)^n V_0^{(2n)}(z)}{(n!)^2}\left(\frac{r}{2}\right)^{2n} \qquad **$$

where $V_0(z)$ is the axial potential distribution, and r is the radial distance from the axis. Thus, if the axial potential may be approximated, then the field may be approximated independent of the electrode configuration.

From the above it is seen that what is now desired for an electrostatic focus lens is not what configuration of electrodes gives the best field, but what configuration allows us to most easily approximate a desired field. This involves choosing the simplest, most easily manufactured general configuration and then altering specific dimensions to give the desired distribution.

The above is somewhat over-simplified, in that the distribution is intimately tied up with the inside diameter D', of the focus cylinder. Thus, in order to approximate a given distribution, this dimension would also have to be altered. For the discussion in the first paragraph, it is assumed that optimum D' has been obtained.

The major argument in favor of this proposed lens design as seen by the author at this point, is the relatively non-critical dimensionality of the design, as compared to the Standard 17R lens having essentially three critical dimensions. Also, it should be remarked that due to its much simpler configuration it undoubtedly would increase the ease of fabrication.

W. H. Lake

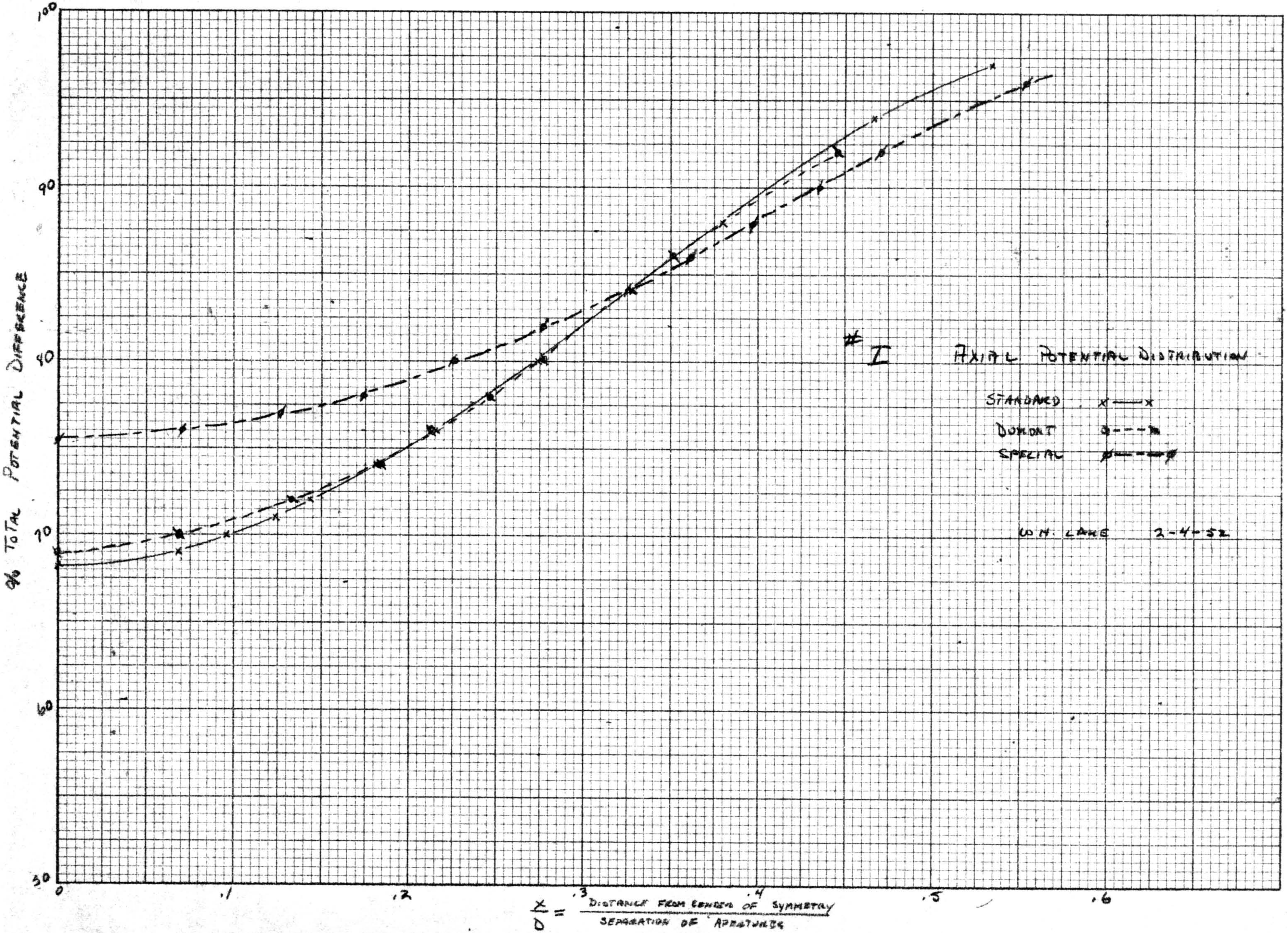
W. H. Lake
Engineering
CATHODE RAY TUBE

WHL/mb

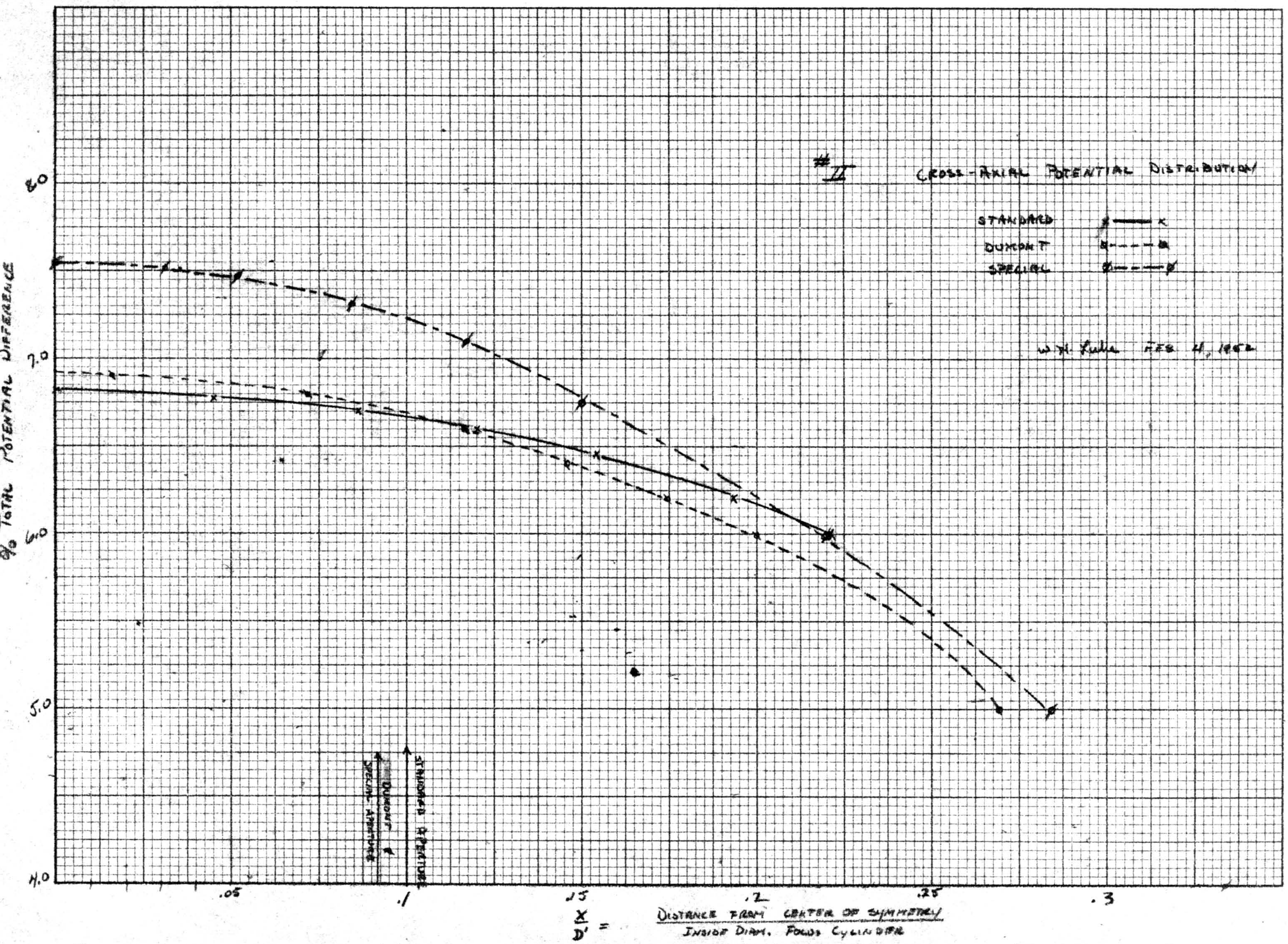
** Spangenberg, Vacuum Tubes, McGraw-Hill, New York, 1948.

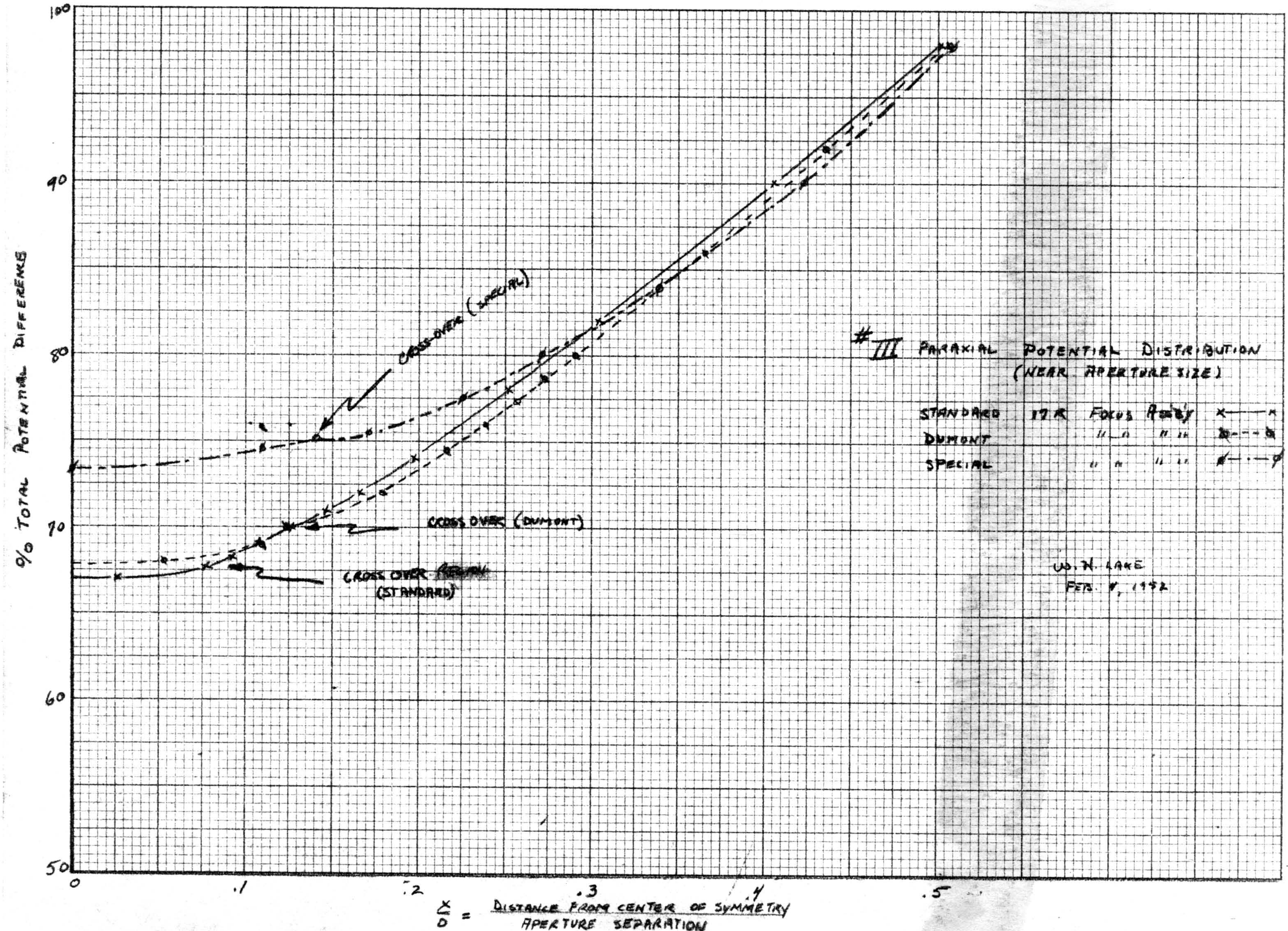
Distribution:

VC Campbell
KC DeWalt
RE Lee
CG Lob, Dr.
LE Record
GT Waugh
All Office Engineers



#I
AXIAL POTENTIAL DISTRIBUTION
STANDARD x——x
DUMONT
SPECIAL
W. H. LAKE 2-4-52
% TOTAL POTENTIAL DIFFERENCE
100
90
70
60
0
.1
.2
.3
.4
.5
.6
X/D = DISTANCE FROM CENTER OF SYMMETRY / SEPARATION OF APERTURES


#II
CROSS-AXIAL POTENTIAL DISTRIBUTION
STANDARD
DUMONT
SPECIAL
W. H. Kuhle FEB 4, 1952
8.0
7.0
6.0
5.0
4.0
% TOTAL POTENTIAL DIFFERENCE
.05
.1
.15
.2
.25
.3
STANDARD APERTURE
DUMONT
SPECIAL APERTURE
X/D' = DISTANCE FROM CENTER OF SYMMETRY / INSIDE DIAM. FOCUS CYLINDER


#III PARAXIAL POTENTIAL DISTRIBUTION
(NEAR APERTURE SIZE)
STANDARD 17R FOCUS ASS'Y
DUMONT " " " "
SPECIAL " " " "
W. N. LAKE
FEB. 4, 1952
CROSS-OVER (SPECIAL)
CROSS OVER (DUMONT)
CROSS OVER
(STANDARD)
% TOTAL POTENTIAL DIFFERENCE
100
90
80
70
60
50
0
.1
.2
.3
.4
.5
X/D = DISTANCE FROM CENTER OF SYMMETRY / APERTURE SEPARATION