Bermudez—"The Good Roads Lake"

AN INVESTIGATION OF RELATIONSHIPS BETWEEN STANDARD PHYSICAL TESTS FOR A SERIES OF TRINIDAD AND BERMUDEZ LAKE ASPHALTIC MATERIALS

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OUTLINE OF THESIS

TITLE

An investigation to determine the existance of possible relationships between the results of standard tests of a physical nature on natural lake asphalts and lake asphalt cements.

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INTRODUCTION

A Statment of Object of Investigation

This investigation was made in an attempt to determine the existance of possible relations between the results of the standard tests of a physical nature proformed upon native asphaltic materials used in highway construction.

It will be noted that the second great class of such material, petroleum asphalts was not considered in this investigation and the conclusion reached is thus tenable only for native lake asphalts of Trinidad and Bermudez origin.

B Hitorical Data.

1. Production, Use, and Refinement.

The use of native asphalts for road building has been known and practiced almost from the dawn of history. One of the earliest incidents of which we have postive knowledge in which native asphalt were put to such use was in the Euphrates delta in the time of ancient Babylon. The ancient but highly civilized people of this district not only applied bitumen to many of its present day uses but also used it as a setting and as a laquer in fashoning artistic objects and mounting precious stones. Thus we learn from Herodotus that the city of Babylon was defended by a moat connected with the Euphrates, and by an immense wall surmounted by a roadway paralleling the moat and that these works were constructed of air and kiln dried brick bound together and waterproofed with bitumen by immersing the hot brick in a cauldron of the material and that the brick flags of the roadway had their intustices filled with bitumen so as to make,"A shining path".

This material was obtained from natural deposits in the vicinity and bitumen is still to be found in the locality.

In the western hemisphere the first anthenticated use of bitumen in highway construction seems to be that of the ancient Imcas of Peru who not only used a bituminous mortar in their stone buildings but also surfaced their military roads with a similar substance.

Returning to the eastern world, it is known that bitumen although put to uses too numerous to mention here did not play any considerable part as a constructional material in the time of the Roman Empire either as a binder or as a waterproofing agent. In fact writers on the subject point out that bitumen was unknown as a material for highway construction from a period antedating the Roman Empire until 1712 when a Greek Doctor, Eyrinis by name while journeying in the Val de Travers in Switzerland near the lake of Neufchatel found in the cliffs surrounding the lake a rock which not only burnt to a certain extent but could be easily worked with metal tools when heated. Dr. Eyrinis identified the basic material found in this rock as bitumen and being of a practical turn of mind set about to exploit his discovery. He found that the bitumen obtained by grinding this stone and heating to fluidity was suitable for waterproofing wooden and stone tanks and cisterns and that it gave a smooth surface to the rocky roads of his vicinity when mixed hot with small stone and spread and rammed into the surface of these rocky thorofares. This then may be called the re-discovery of the use of bitumen for road building.

Unfortunatly Dr. Eyrinis did not find sufficient market for his product, his business failed and he had to flee the country being arear in royalties to the government for his concession. Ninety years later Count Sassenay of France who deserves the title of first highway materials testing engineer, obtained a concession and started working deposits at Seyssel near Dr. Eyrinis' mine. The Count in order to study with care the peculiar substance erected a special laboratory at his mine in which he also trained his workmen in the practical carrying out of asphalt work of all classes. In this manner he soon found particular ways of refining and handling his product to give satisfactory results in many classes of work.

Its use was rapidly adopted in France where the open squares, market places, bridges, and military constructions were covered with a layer of mastic material composed of Count Sassenay's asphalt and broken stone. The Count discovered that Eyrinis' method of adding pitches to flux, the material although it facilitated the working, did not add to the quality of the finished road, also he discovered that the addition of pea gravel to the mastic rendered the finished surface more durable under heavy traffic. Perhaps the most important discovery that Count Sassenay made was that if his asphalt was fluxed with natural petroleum oil instead of pitch the mixture when applied to old and worn asphalt roads seemed to give them new life. Here we have the origin of asphaltic cement and, "Surface treatments."

In 1836 the first application of asphalt to road building in England was carried out in London. The industry began to grow in Germany and Italy about the same decade and slow progress was made in methods of building until in 1858, three sides of the square of the Palais Royale in Paris were laid with compressed asphalt mastic from Val de Franers on a six inch concrete base.

From this time until the present the extension of the technic of asphaltic road construction has been in the nature of refinements. Big strides, it is true, have been or are being made in this field but the principal of stone bound by solidified bitumenus material remains.

The use of native lake asphalts which term in this discussion takes into account only those materials taken from the Bermudez and Trinidad lakes of South America, dates from 1872 when a small ahipment was sent from Trinidad to the United States. These deposits have been worked exclusively for road building purposes, in gradualy increasing scope until the yearly production from these lakes now approaches two million tons.

~ THE TRINIDAD LAKE ~

2. Standards and tests.

From the viewpoint of the testing engineer it is a far cry from the present to the comparatively recent date (1893) when Delano, the foremost authority of the time wrote,"The best way to test the quality(of bitumenous road materials in general) is to draw it out into threads; the longer they stretch, the better the sample." and goes on to say, "Good bitumen should be free from dross, non-evaporative, perfectly black, not brilliant and at 21 degrees C., have a consistancy of beeswax." Such specifications would convey absolutly nothing to the modern technician and would even be shunned as sales talk by asphalt salesmen.

The first attempt at exact specifications were based on chemical determination of content in volitile elements, "petralenes" and non volitile elements,"malthenes", and were excellent examples of specifications that did not specify since it was at once found that any bitumenous material, natural or petroleum residual could be so fluxed as to show upon analysis the required proportions of petralenes and malthenes and further, that two different materials could be compounded so as to satisfy such specifications and yet one would be of brick like consistency while the second might be a semi-liquid. Hence the trend in specification writing began more and more to be based upon physical tests.

It is interesting to know too, in this connection that in the earlier days of the paving industry it became customary on account of this lack of exact determinants for specification writing to let paving contracts upon a differed payment plan or upon a maintainance plan under which the contractor became responsible for the behavior of the road. Under the first of these schemes ten to fifteen percent of the contract price was withheld upon completion of the work to defray maintainance costs, over a term of five years should such maintainance become necessary, under the second, the contractor engaged and was bonded to actually maintain the pavement over a term of five years, should such maintainance be necessary.

Such contracts, it is easily seen could only be the admission on the one hand that the engineer could not write specifications sufficiently definate to insure a good job and on the part of the contractor that he was willing to gamble on his past experience on similar jobs as to the correct materials and methods to use.

As must have been foreseen two very obvious difficulties arose to the satisfactory completion of such contracts. In the case where absolute maintenance was required the effect was to eliminate the function of the engineer since the contractor could with good show of reason, hold his contract as null and void as to the maintenance clause if the engineer so much as attempted to exercise his authority as to delineation of constructional methods. The contractor had to, in other words, work out his own solution and any assumption of authority by the engineer since it could not be proven to be of a helpful nature, could be construed as possibly harmful to the contractor's interests and the contractor could recover for such damage in court.

Under contracts of the differed payment class arguments always arose as, whether in the event the withheld money was spent in part or in full, the authority for such expenditure had been exercised in good faith. For instance the county, state or city paying for the pavement might decide within the time limit that a complete re-surfacing would be necessary to put the road in question in good shape while the contractor could not be made to see that a patching, involving a tenth of that expenditure would not serve equally as well. Both of these difficulties resulted in excessive contract prices, the contractor protecting himself by leaving a margin of profit, enough to nullify his possible maintenance losses.

These conditions were of course, intolerable and the different agencies such as the State Highway Department and Government Bureau of Roads set about the task of devising specifications and tests to put the purchase and use of asphaltic road materials on a scientific basis.

In the early days of the sheet asphalt paving industry, a few crude physical tests were developed, which, while reasonably satisfactory for the use of those versed in the use of the then limited number of available materials, were not based upon sound scientific principals. The gradual increase in the number of materials available for highway construction, the widely variant characteristics of different types and grades of these materials and the development of types of construction in common use necessitated improvement and expansion of the older tests. Today we have a full and practical series of tests for such materials at our disposal, thanks to the amount ofwork done on the subject by chemists and engineers toward the standardization of the methods involved. More complete standardization however, is needed in order to correlate and properly interpet the results these tests.

II PURPOSE AND SCOPE

A Need for Investigation

In all specifications for bitumenous materials at least one and usually three or more tests are specified with the limits that are allowed. These tests are included so that the material may be identified and the characteristics of the material recorded as well as the source itself. They also serve as a guide for selection of such material for future use. However, the kinds of tests called for in different specifications may have a wide variation. It is possible that some of these tests have no direct bearing on the suitability of the material for the purpose intended. In such cases of course, those tests are useless and should be replaced by tests that have some relation to the future use to which the material will be put. Then too, offtimes a large number of requirements are specified necessitating a test for each requirement. It is entirely possible that many of these tests may be eliminated if some inter-relationship could be found between the tests. That is if for a series of representative asphalts a relationship could be established between, say their softening point and their percent of total bitumen; or any two or three tests, then one or the other of these tests could be eliminated. Thus one would be able to characterize the material entirely by means of one, or possible two or three tests. This, of course, would greatly simplify the matter of identifying a bitumen and would do away with a number of standard tests that are very tedious, and probably inaccurateat best, tests that require elaborate apparatus and great care in manipulation.

Would it not be much saving in time, money and patience if, say the penetration test be made and from that one test the qualities shown at present only through other tests and examinations be deduced by knowledge of characteristic relations for such materials.

B Statement of Purpose of Investigation

It is with the above purpose in mind that this investigation was undertaken, namely, to investigate the possibility of there being an inter-relationship between two or more standard asphalt tests, with the end in view of eliminating some of them, and also to find if some of the tests are not superfluous and non indicative of the true characteristics of the asphalt.

C Method of Proceedure Outlined.

In order to further the investigation a series of fourteen asphalts were obtained from the Barber Asphalt Company. A detailed description of which is given in Part A of the Third division of this report covering Trinidad and Bermudez Lake Asphalt and Asphalt Cements. Four tests were made on each of these materials, namely; penetration, ductility, softening point and total bitumen determination. These tests were made possible by the splendid and up to date equipment available in the Washington and Lee University Road materials testing Laboratory, and the kindness of the Barber Asphalt Company in supplying samples of materials under investigation.

The results of these tests as may be found in Part 3, Section C were studied carefully in order to find any possible special relation that might exist between results of any of the four tests. When the possibility of such relations existed, curves were plotted in order that the relationship might be more clearly defined, and easier studied, and these curves in turn analysied to formulate in equational force the results of the investigation.

III MATERIALS INVESTIGATED

A Through the courtesy of Mr. C. N. Forrest, Manager of the technical department of the Barber Asphalt Company, a series of fourteen specimens of lake asphalt and cement covering, in the opinion of Barber organization, the total range of conditions, climatic and physical, presented by the needs of the American paving industry was secured. Seven of these materials were of Trinidad origin and the remaining seven were Bermudez products. Of each class four specimen were asphaltic cements and the other three were refined asphalts.

The refiners classification follows;

	Trinidad Lake			Bermudez Lake		
	Ash	Org. Insol.		Ash	Org. Insol.	
a. Refined Asphalt...........	36.0%	8.5%	(4)	3.6%	3.0%	(9)
b. Asp. Cement 25-30 Pen.....	28.1#	6.3"	(8)	3.1"	2.7"	(13)
c. " " 35-45 "	27.3"	6.1"	(7)	2.9"	2.1"	(12)
d. " " 50-60 "	26.3"	5.8"	(6)	2.7"	1.8"	(11)
e. Refined Asp.120-150"	23.4"	5.2"	(5)	2.3"	1.6"	(10)
f. " "			(1)	....		(3)
g. " "			(2)	....		(14)

the numbers suffixed being those used for reference in testing by the authors.

A comprehensive investigation of native asphalt and their cements as used in highway construction today was thus rendered possible.

B <u>Tests Performed</u>

1. Determination of total bitumen. (Filtration method)

This test consists in dissolving the bitumenous materals in carbon tetrachloride and recovering any insoluable matter by filtering the solution thru an asbestos felt.

From one to three grams of the material to be tested was put into a tared Erlenmeyer flask and weighed again. This was then dissolved by adding 100c.c. of carbon tetrachloride and shaking from time to time in order that no lumps might be left. It was then set aside for forty-eight hours to settle. At the end of this time the solution was poured off into another flask preciously weighed, in such a manner as not to disturb and residue that may be left. The contents of the first flask was again treated with 100 c.c of carbon tetrachloride and set aside for forty-eight hours to settle.

2. The solution in the second flask was then decanted thru a weighed Gooch crucible, about 3.2 cm, diameter at the bottom, and fitted with an asbestos filter. This was carried out carefully in order that the residue might not be disturbed. The solution in the first flask was treated similarly.

The crucible and both flasks were then dried in an oven at 125 degrees C. and weighed. The filtrate containing bitumen was evaporated in a previously weighed evaporating crucible, burned and weighed again. The sum of this ash and the weight of the residue left in the two flasks subtracted from the original weight of the specimen gives the amount of soluable bitumen.

This is the proceedure recommended by the American Society for testing materials.

3. Tests for penetration.

The consistancy of bitumenous materials is expressed as the distance that a standard needle will penetrate the substance under certain conditions.

These tests were carried out under the following conditions; (1) Standard needle No.35, 50.8 m.m. long and having a diameter of 1.016 m.m. and a taper of 6.35 m.m. (2) Needle carried a weight of 100 grams. (3) The time the needle was allowed to penetrate was 5 seconds. (4) The temperature was 25 degrees C. or 77 F.

The apparatus used was a New York Testing Laboratory Penetrometer and a container for holding specimen, 55m.m. in diameter and 35 m.m. deep.

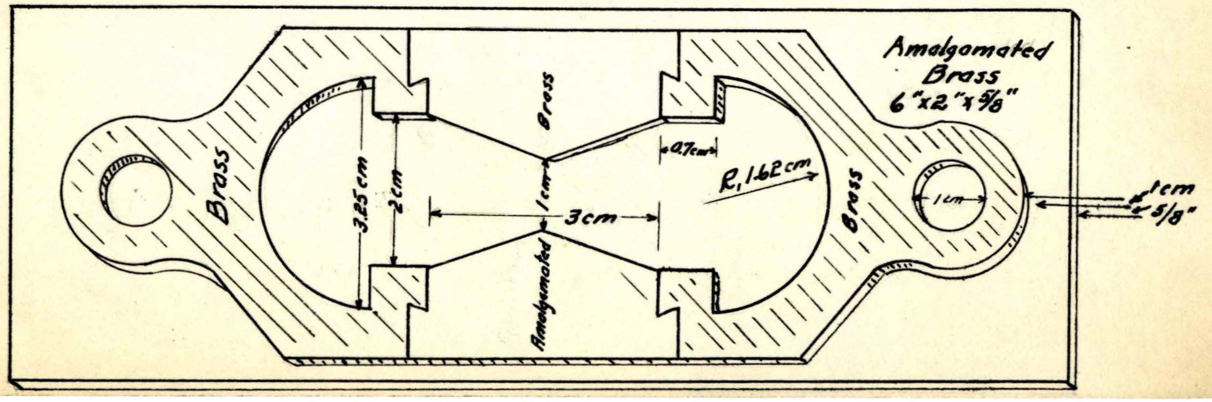
4. The material to be tested was melted and poured into the container, which was then allowed to cool for one hour. It was then placed in a water bath maintained at 25 degrees C. and allowed to remain for one hour, along with a transfer dish. The transfer dish containing the sample was then removed and placed upon the stand of the penetration machine. The needle loaded with the 100 gram weight was first brought flush with the surface of the smaple; and was then released and allowed to penetrate for five seconds into the sample. The depth that it penetrated was found by the use of circular micrometer scale graduated to read the penetration to 0.1 m.m. Several tests were made, each one being at a distance of 1 cm. from any other test. The average of these several tests was taken as the penetration.

Note: The above test has been adopted as standard by the American Society for Testing Materials.

5. Test for Ductility.

The ductility of a bitumenous material is tested by pulling apart a briquette of standard size, at a given rate until the specimen breaks.

The apparatus used in this test was a Smith Ductility Machine, and the briquette was of the size shown in the figure.



The hot material was poured into the briquette mould which was placed on an amalgamated brass plate in order that the material might not stick. When the material is nearly cold the excess was cut off with a warm knife. This briquette was then immersed for thirty minutes in water maintained at 25 degrees C. At the end of this time it was taken out of its bath and placed in the ductility machine. This machine consists of a rectangular stone box having a moveable block working on a worm gear from left to right. The left clip of the specimen was held firm by placing its ring over a peg in the left end of the box. The right clip was fixed to the moveable block by placing the ring over a peg in the block.

6. The box was filled with water maintained at 25 degrees C. and the briquette was placed in position. Power was applied so that the worm gear moved the block ahead at the rate of five cm. per minute. The distance the block had moved from the start of the test to the place where the specimen broke was considered the ductility of the substance.

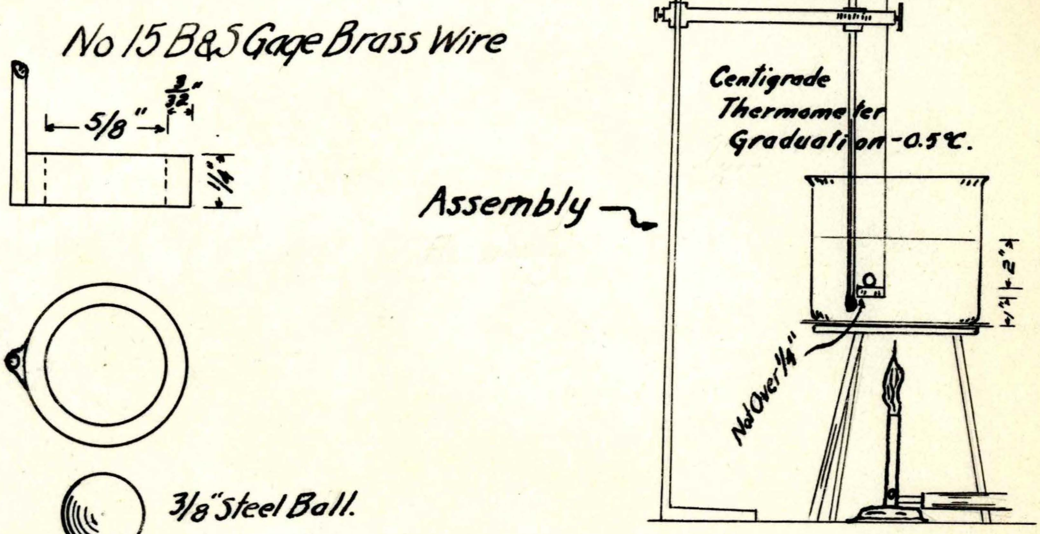
This method is recommended by the American Society for Testing Materials.

7. Test to find softening point.

Ring and Ball method.

Bitumenous materials are not definite chemical compounds but mixtures of a large number of compounds, And those that are termed solids are not true solids but solid solutions and hence they can have no true melting point. That is when heated they gradually become softer and softer until they become fluids and no critical temperature can be observed. For this reason any method to determine the softening point of bitumens is purely arbitrary.

The ring and ball method is one of these arbitrary standard tests recommended by the American Society for Testing Materials. This test was carried out by means of the apparatus shown in the figure.



8. The material to be tested was melted and poured into the ring shown in the figure. It was allowed to cool and the excess was shaved off with a warm knife. The ring containing the sample was then put in water whose temperature was about 5 degrees C. and allowed to remain for fifteen minutes. At the end of this time the apparatus was assembled as shown in figure. A 600 c.c. glass beaker was filled with water at about 5 degrees C. to a depth of 8.25 cm. The ring was then placed so that its bottom was 1" from the bottom of the beaker and the thermometer placed so that the bulb was at the same level as the ring and within 0.635 cm of it. Heat was then applied in such a manner that the temperature rose 5 degrees C. or 9 degrees F. every minute. These readings at the end of each minute were recorded to see that the temperature did not vary more than 0.5 degrees C.

9. As the material became soft the ball, which was placed in the center of the ring, sank down thru it and finally touched the bottom of the beaker. At the instant the ball touched the bottom the temperature was recorded and this was taken as the softening point.

For materials having a softening point above 80 degrees C. glycerine was used and the proceedure was the same as given above.

SECTION III C

TEST DATA- LABORATORY NOTES

Sample #1.

REFINED TRINIDAD LAKE ASPHALT--BARBER CO.

DUCTILITY

None — Fracture

PENETRATION

1.4

1.3
1.6
1.3
1.4

SOFTENING POINT
(Ring & Ball)

97 Degrees C.

Degrees F.

min.	deg.	ch'k
1	93	70
2	104	80
3	113	89
4	121	98
5	130	107
6	139	116
7	148	124
8	156	134
9	165	143
10	174	152
11	183	161
12	191	170
13	200	179
14	208	188--98C.
15		197
16	.	205--96.1C.

. . Softening Point-97C.

TOTAL BITUMEN**-58. 30/o
First charge Mar.2
WT Sample--5.367 gm.

5.367

Total WT	45.117
Tare Flask	39.75
Sample	5.367

FINAL WTS

Crucible	#1	75.78
"	#2	31.62
Flask	#2	41.72
"	#4	53.120
Ash Crucible		7.70/149.94

TARE

Crucible	#1	15.74
"	#2	31.44
" Ash		7.67
Flask	#2	39.75
"	#4	53.105/147.705

MINERAL*ASH — 2.235 — 2.235

TOTAL BITUMEN — 3.132

" " %

$\frac{3.132}{5.367}$ = 58.30%

MINERAL ASH% — 41.70%

Sample #2

TRINIDAD ASPHALT CEMENT*BARBER

DUCTILITY	23.6	23.6cm.	
PENETRATION	29.9	28.5	
		30.5	
		31.0	
		30.0	
		29.5	
		149.5	
			29.9

SOFTENING POINT
58.7C.

min.	Degs. C.	
1	8	
2	12.2	
3	17.0	
4	22.7	
5	28.0	
6	33.2	
7	38.5	
8	43.8	
9	49.4	
10	54.4	
	58.7 C.	58.7C.

TOTAL BITUMEN--75.56%

WT Sample--5.727gm 5.727gm

	TOTAL	53.022			
	TARE	47.295			
	WT Sample	5.727			
FINAL WTS					
	Crucible		31.44		
	Ash "		10.345		
	Flask #1		48.456		
	" #2		50.585		
	TARE			140.826	
	Crucible		31.36		
	" Ash		10.200		
	Flask #1		47.285		
	" #2		50.571		
				139.426	
MINERAL & ASH				1.400	1.400

MINERAL & ASH%--24.44
TOTAL BITUMEN 4.237
" " %--75.56

Sample #3

REFINED BERMUDEY ASPHALT- BARBER

DUCTILITY	22.1		22.1cm.	
PENETRATION	14.2	14.0 14.5 12.5 15.5 14.5 71.0		14.2
SOFTENING POINT	69 degs. C.	min.	degs.C.	
		0	10	
		1	13.8	
		2	18.6	
		3	24.0	
		4	29.0	
		5	34.2	
		6	38.9	
		7	43.6	
		8	48.3	
		9	53.0	
		10	57.6	
		11	62.8	
		12	67.8	
			69.0	69.0

TOTAL BITUMEN --92.75

TOTAL WTS	52.570	
TARE	49.220	
WT Sample	3.050	3.050

FINAL WTS

Gooch Cr.	#1	15.84	
" "	#2	31.375	
Ash "		9.705	
Flask	#5	45.370	
"	#6	49.250	151.540

TARE

Gooch Cr.	#1	15.73	
" "	#2	31.37	
Ash "		9.635	
Flask	#5	45.365	
"	#6	49.220	
			151.320

MINERAL & ASH	0.220
TOTAL BITUMEN	2.830

∴ Mineral & Ash%--7.25%
Total Bitumen---92.75%

Sample #4

REFINED TRINIDAD LAKE ASPHALT- BARBER

DUCTILITY

None Fracture

PENETRATION---- 1.4

SOFTENING POINT

93 Degrees C.

min.	dgs.C.
1	64
1	76
2	84
3	94
4	104
5	115
6	123
7	130
8	140
9	150
10	161
11	170
12	178
13	188
14	197
	199.5---93 C.

TOTAL BITUMEN-- 54.1%

	Total Wt	52.965		
	Tare	51.940		
Wt. Sample		1.025		1.025
FINAL WTS	Gooch Cr,	15.895		
	Flask #4	52.295		
	" #24	47.255		
	Ash Cr.	9.715	125.160	
TARE	Flask #4	51.940		
	" 24	47.190		
	Gooch cr.	15.870		
	Ash Cr.	9.690		
			124.690	
MINERAL & ASH				0.470
TOTAL BITUMEN				0.555

Mineral & Ash % --45.9%
Total bitumen % --54.1%

Sample #5

REFINED TRINIDAD LAKE ASPHALT-BARBER

DUCTILITY 111 BEYOND LIMITS OF MACHINE

PENETRATION -- 110.5

110
111
109.5
111.5

110.5

SOFTENING POINT -- 42.4 C.

min.	Degs. C.
0	13.0
1	18.8
2	24.6
3	30.0
4	35.4
5	40.8
	42.4 C.

42.4 C.

TOTAL BITUMEN --72.5%

	Total WT	54.360		
	Tare	53.005	Flask #5	
WT. Sample		1.355		1.355
FINAL WT.	Flask #5	53.2875		
	Gooch Cr,	16.585		
	Flask 25	55.705		
	Ash Cr.	10.3325	135.9100	
TARE	Flask #5	53.005		
	" 25	55.670		
	Long Gooch	16.555		
	Ash Cr.	10.3075		
			135.5375	
MINERAL & ASH				0.3725
TOTAL BITUMEN				0.9825

Mineral & Ash -- 27.5%
Total Bitumen -- 72.5%

Sample #6

TRINIDAD LAKE ASPHALT CEMENT- BARBER

DUCTILITY	69.1		69.1	
PENETRATION	48.9		48.9 48.5 50.5 49.0	48.9
SOFTENING POINT	52.1 C.	min, 0 1 2 3 4 5 6 7 8	degs. C. 11.8 17.2 21.2 26.0 31.1 35.8 40.4 45.0 50.2 52.1 C.	52.1 C.

TOTAL BITUMEN --	64.8 o/o			
TOTAL WT	50.470			
TARE	47.175 Flask #7			
WT Sample	3.295			3.295
FINAL WT.	Gooch Cr. Flask #7 & #3 Ash Cr.	16.255 97.045 10.150	123.450	
TARE	Flask #7 " # 3 Gooch Medium Ash Cr.	47.175 49.055 15.950 10.115	122.295	
MINERAL & ASH			1.155	1.155
TOTAL BITUMEN				2.140
	Mineral & Ash%		35.2%	
	Total Bitumen%		64.8%	

Sample #7

TRINIDAD LAKE ASPHALT CEMENT

DUCTILITY	28.1		28.1
PENETRATION	33.2	32.5	
		34.5	
		32.5	
		34.0	
		30.5	
		34.5	
			33.2

SOFTENING POINT 60.0 Degrees C.

min,	degs. C.	
0	12.0	
1	16.2	
2	21.4	
3	26.2	
4	30.8	
5	35.8	
6	41.1	
7	46.0	
8	51.2	
9	56.4	
	60 C.	60.0 C.

TOTAL BITUMEN	70.0%		
TOTAL WT	42.485		
TARE	39.675 Flask #1		
WT Sample	2.610		2.610
FINAL WTS.			
Gooch Cr.	31.470		
Flask #1	40.160		
" #2	50.490		
Ash Cr.	9.822	131.942	
TARE Flask #1	39.675		
" #2	50.470		
Tall Gooch	31.360		
Ash Cr.	9.672		
		131.177	
MINERAL & ASH			0.765
TOTAL BITUMEN			1.845

Mineral & Ash	29.3%
Total Bitumen	70.7%

Sample #8

TRINIDAD LAKE ASPHALT CEMENT

DUCTILITY	32.4	32.4	
PENETRATION	27.8	27.5	
		28.5	
		27.5	
			27.8
SOFTENING POINT	58.9 Degrees C.		
	min.	Degrees C.	
	0	12.0	
	1	20.0	
	2	22.2	
	3	27.0	
	4	31.7	
	5	36.8	
	6	41.8	
	7	47.0	
	8	51.7	
	9	56.6	
		58,9 C.	
			58.9 C/

TOTAL BITUMEN		61.27%		
TOTAL WT.		40.250		
TARE		39.120		
WTSample		1.130		
FINAL WTS.				
	Gooch Cr.	15.775		
	Flask #8	39.460		
	" 28	50.105		
	Ash Cr.	10.340	115.680	
	Gooch Cr.	15.760		
	Ash Cr.	10.3125		
	Flask #8	39.120		
	" 28	50.050		
			115.2425	
MINERAL & ASH				.4375
TOTAL BITUMEN				0.6925

Mineral & Ash % 38.73%
Total Bitumen% 61.27%

Sample #9

BERMUDEZ LAKE REFINED ASPHALT

DUCTILITY	44.3	44.3	
PENETRATION	16.5	17	
		16.5	
		16.0	
			16.5

SOFTENING POINT 64.6 C.

min.	degs. C.
0	13.0
1	12.0
2	25.0
3	30.0
4	35.4
5	40.2
6	45.4
7	50.2
8	55.0
9	60.4
	64.6 C.

TOTAL BITUMEN	96.1 o/o			
TOTAL WT	47.120			
TARE	45.330			
WT Sample	1.790		1.790	
FINAL WTS.	Gooch Cr.	16.580		
	Flask #9	45.375		
	" 29	50.330		
	Ash Cr.	9.685	121.970	
	Gooch Cr.	16.5500		
	Ash Cr.	9.675		
	Flask #9	45.330		
	" 29	50.345	121.900	
MINERAL & ASH				0.07
TOTAL BITUMEN				1.72

Mineral & Ash %	3.9
Total bitumen %	96.1

Sample #10

BERMUDEZ LAKE REFINED ASPHALT

DUCTILITY	99.5	9915	
PENETRATION	117.0	136 - 16 -- 120	
		129.5 - 14.5 -115	
		138.5 - 20.5 -118	
		138.5 - 20.5 -118	
		135 - 20.5 -114.5	
		136 - 19.5 - 116.5	
		117.0	117.0

SOFTENING POINT 42.77 C.

min.	Degrees C.	
0	54.0	
1	64.0	
2	74.0	
3	81.0	
4	90.0	
5	100.0	
6	109.0	42.77 C.

TOTAL BITUMEN	95.0 o/o	
TOTAL WT	47.205	
TARE	46.150	
WT Sample	1.055	1.055

FINAL WTS.

Gooch Cr.	15.865		
Flask #10	46.150		
" #30	58.6225		
Ash Cr.	10.155		
		130.7825	

TARE

Gooch Cr.	15.860		
Ash Cr.	10.125		
Flask 10	46.150		
" 30	58.605	130.740	0.0525
			1.0025

MINERAL & ASH	0.0525
TOTAL BITUMEN	1.0025

Mineral & Ash %	5.0%
Total bitumen %	95.0%

Sample #11

BERMUDEZ LAKE ASPHALT CEMENT

DUCTILITY	53.8		53.8
PENETRATION	46.5	154 - 108 -- 46 156 - 109 -- 47 157 - 110.5 -46.5	46.5
SOFTENING POINT	53.2 C.		53.2

min.	Degrees C.
0	16.6
1	19.0
2	24.1
3	29.2
4	34.3
5	39.4
6	44.8
7	50.1
	53.2 C.

TOTAL BITUEMN	90.0%	
TOTAL WT	48.185	
TARE	47.020	
WT Sample	1.165	1.165

FINAL WTS.

Gooch Cr.	15.805	
Flask #11	47.040	
" #31	49.160	
Ash Cr.	10.375	122.380

TARE

Gooch Cr.	15.780	
Ash Cr.	10.313	
Flask #11	47.020	
" 31	49.150	122.263

MINERAL & ASH	0.117
TOTAL BITUMEN	1.048

Mineral & Ash %	10.0%
Total Bitumen %	90.0%

Sample #12

BERMUDEZ LAKE ASPHALT CEMENT

DUCTILITY	47.8		47.8
PENETRATION	39.0	147. - 107.5 -- 39.5 144.0- 104.0 -- 40.0 143.0- 104.5 -- 38.5 144.0- 106.0 -- 38.0	39.0
			55.5 C.
SOFTENING POINT	55.5 C.		

min.	Degs. C.
0	15.1
1	24.0
2	30.1
3	35.0
4	40.2
5	45.3
6	50.4
7	55.5

Note: The value 55.5 was checked twice.

TOTAL BITUMEN		91.7%		
TOTAL WT		52.865		
TARE		51.590		
WT Sample		1.275		1.275
FINAL WT				
	Gooch cr.	16.565		
	Flask #12	51.620		
	" #32	39.710		
	Ash Cr,	9.715	117.610	
TARE				
	Gooch cr.	16.535		
	Ash cr.	9.675		
	Flask #12	51.590		
	" 32	39.705	117.505	
MINERAL & ASH			0.105	0.105
TOTAL BITUMEN				1.17

Mineral & Ash %	8.3
Total Bitumen %	91.7

Sample #13

BERMUDEZ LAKE ASPHALT CEMENT

DUCTILITY	57	57.0 cm	
PENETRATION	26.3	131.0 - 104.0- 27.0	
		127.5 - 100.5 - 27.0	
		122 - 96.0 - 26.0	26.0

SOFTENING POINT 56.4 C.

min.	Degs. C.
0	54
1	62
2	70
3	80
4	89
5	98
6	106.5
7	115
8	123.5
9	132
	133.5

56.4 C.

TOTAL BITUMEN	79.7%	
TOTAL WT	46.335	
TARE	45.3175	
WT Ssmple	1.0175	1.0175

FINAL WTS.

Gooch cr.	15.805	
Flask #13	45.375	
" #33	50.505	
Ash cr.	9.750	121.435

TARE		121.435
long crucible		15.7675
Ash cr.	9.6750	
Flask #13	45.3175	
" #33	50.4675	121.2275

MINERAL & ASH	0.2075
TOTAL BITUMEN	0.8100

Mineral & Ash%	20.3%
Total Bitumen%	79.7%

Sample #14

BERMUDEZ LAKE ASPHALT CEMENT

DUCTILITY	140.3		140.3cm.
PENETRATION	199.8	324.0 - 121.0 -- 203.0	
		313.5 - 121.0 -- 182.5	
		237 - 119.0 -- 218.0	
		333 - 114.5 -- 218.5	
		318.5 - 116.0 -- 212.5	
		311 - 126.5 -- 184.5	199.8

SOFTENING POINT 37.5 C.

min.	Degs. F.	
0	56	
1	60	
2	69	
3	78	
4	87.2	
5	96	
drop	97.4	37.5 C.

TOTAL BITUMEN	99.76%	
TOTAL WT	51.730	
TARE	50.490	
WT Sample	1.240	1.240

FINAL WTS

	Gooch cr.	15.625		
	Flask #14	50.495		
	" 34	51.003		
	Ash cr.	9.690		
TARE			126.813	
	Short cr.	15.640		
	Ash "	9.680		
	Flask #14	50.490		
	" 34	51.000		
			126.810	
MINERAL & ASH				0.003
TOTAL BITUMEN				1.237

Mineral & Ash%	0.24%
Total Bitumen	99.76%

DATA SHEET

No	Kind	△ Penetration	○ Soft Pt.	□ Ductility	Total Bit.	x Ash	v Org. Insol.
1	RTLA	1.4	97.0 °C	0.0	58.3		
2	TLAC	29.9	58.7	23.6	75.56		
3	RBLA	14.2	69.0	22.1	93.11		
4	RTLA	1.4	93.0	0.0	54.1	36.0	8.5
5	TRA	110.5	42.4	111.0	72.5	23.4	5.2
6	TLAC	48.9	52.1	69.1	64.8	26.3	5.8
7	TLAC	33.2	60.0	28.1	70.7	27.3	6.1
8	TLAC	27.8	58.9	32.4	61.27	28.1	6.3
9	RBLA	16.5	64.6	44.3	96.1	3.6	3.0
10	BRA	117.0	42.7	99.5	95.0	2.3	1.6
11	BLAC	46.5	53.2	53.8	90.0	2.7	1.8
12	BLAC	39.0	55.5	47.8	91.7	2.9	2.1
13	BLAC	26.3	56.4	57.0	79.7	3.1	2.7
14	BLAC	199.8	37.4	140.3	99.76		

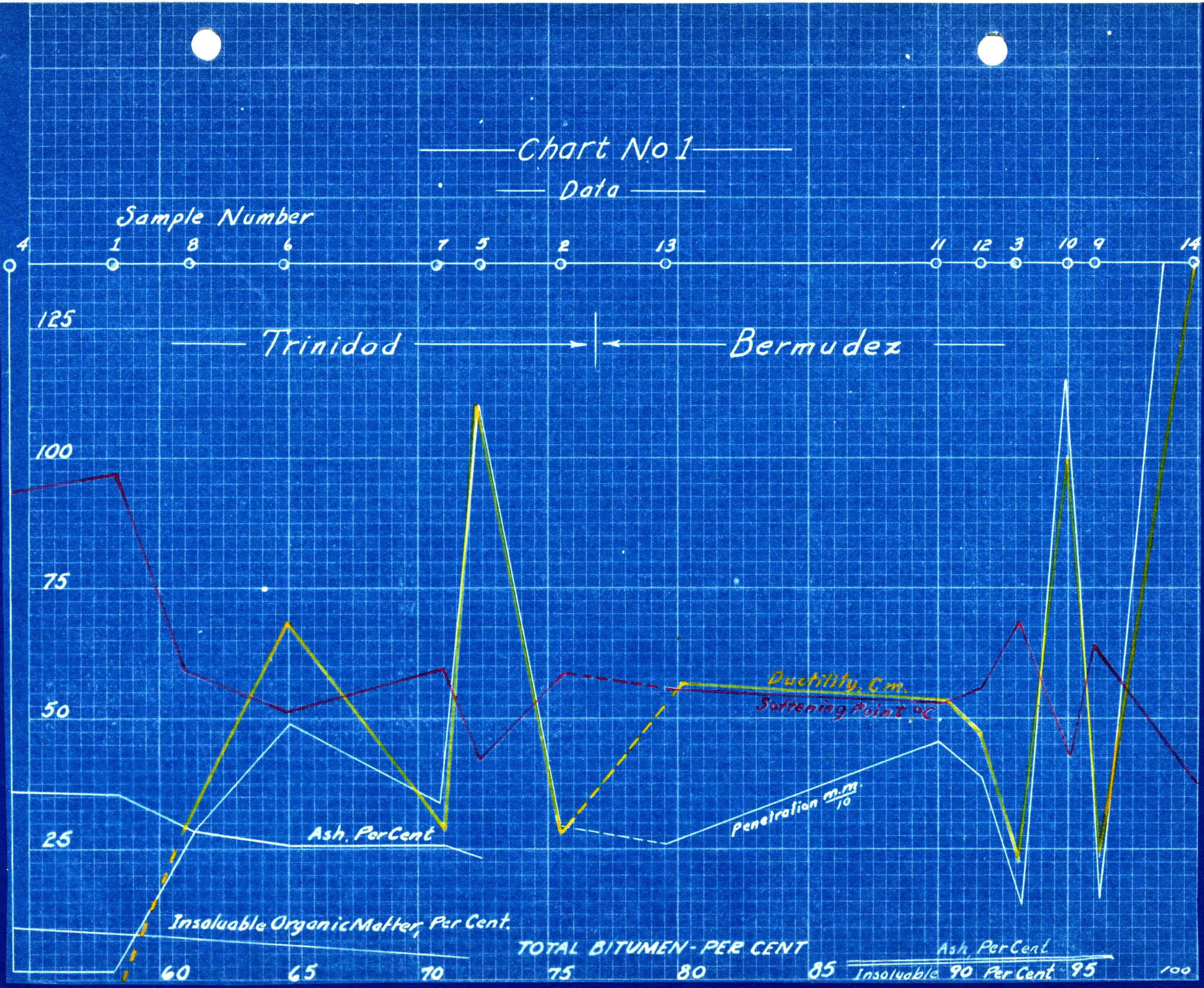


Chart No 1
Data
Sample Number
4
1
8
6
7
5
2
13
11
12
3
10
9
14
125
100
75
50
25
Trinidad
Bermudez
Ductility, Cm.
Softening Point °C
Penetration m.m./10
Ash, Per Cent
Insoluable Organic Matter, Per Cent.
TOTAL BITUMEN - PER CENT
Ash, Per Cent
Insoluable Per Cent
60
65
70
75
80
85
90
95
100

IV INTERPRETATION OF RESULTS.

A. Digest of data obtained.

For purposes of comparison all data resulting from the foregoing tests were collected on one data sheet included herewith. The labratory number given each sample as noted in Part III section A, was entered and opposite these key numbers the classification penetration, softening point, ductility, total bitumen and for the ten specimen for which the refiner furnished such impormation the content of ash and insoluable organic matter was entered.

Thus were obtained complete data for the four tests covering three degrees each of refinement of Trinidad and Bermudez lake asphalt and four degrees each of the respective cement of which the fluxing material was liquid petroleum.

1. Summation of data and preliminary discussion of same.

To facilitate comparisons and to furnish a starting point of the analysis of these results the values in per cent by weight of total bitumen, were plotted on coordinate paper and against this on the axis of Y were plotted the values of penetration, softening point, ductility, ash and insoluable organic matter on an arbitrary scale. Upon joining these points, certain general relations became at once apparent.

It was at once seen that the seven materials of Trinidad origin were of lower bitumen content than the Bermudez materials, the former ranging in the respect from 54 per cent to 76 per cent while the latter ranged from 80 to 100 per cent total bitumen and of it, six samples showed a total bitumen content in excess of 90 per cent.

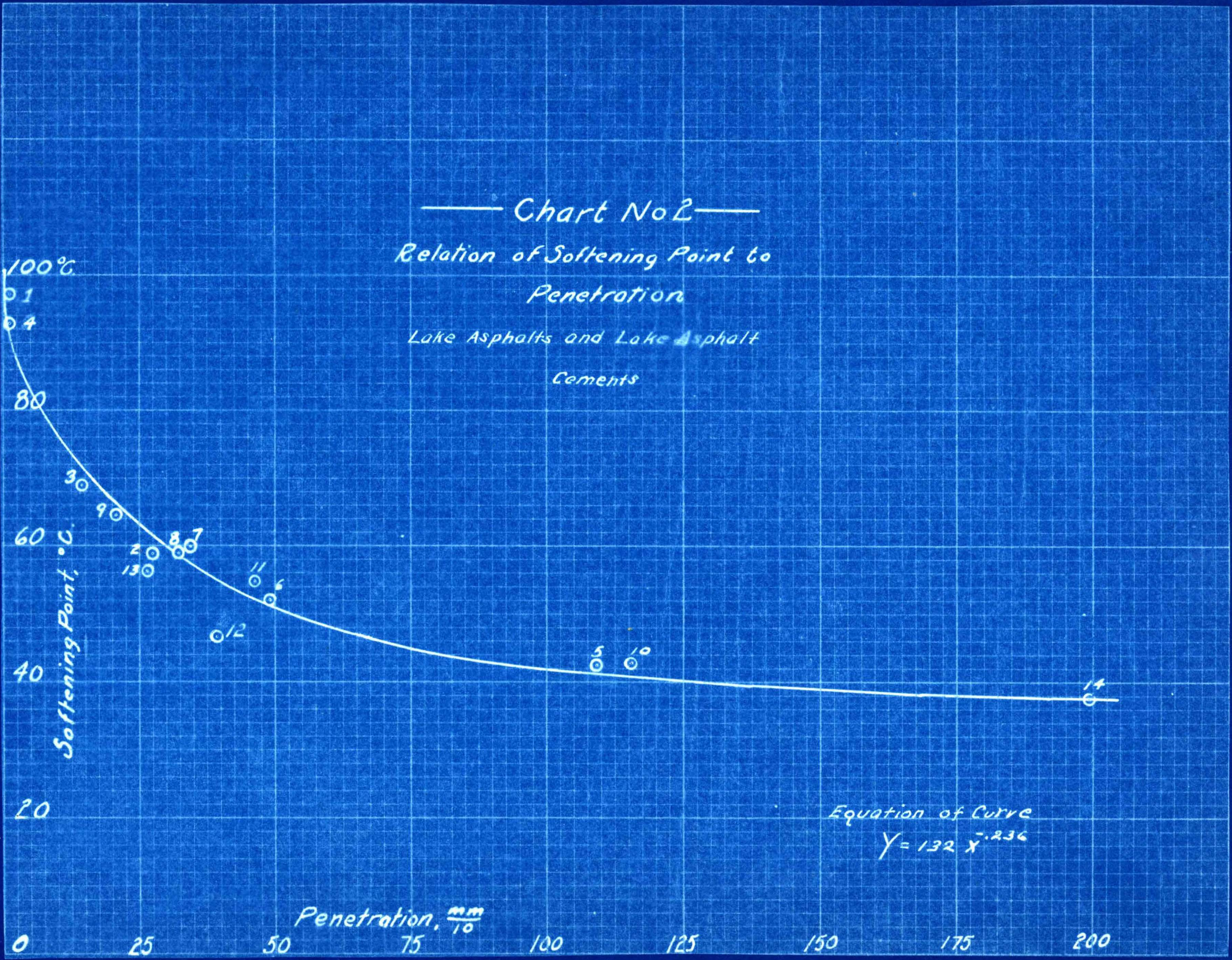


Chart No 2
Relation of Softening Point to
Penetration
Lake Asphalts and Lake Asphalt
Cements
100°C
80
60
40
20
0
25
50
75
100
125
150
175
200
Softening Point, °C.
Penetration, mm/10
1
4
3
9
2
13
8
7
11
6
12
5
10
14
Equation of Curve
$Y = 132\ X^{-.236}$

It appeared from the data diagram that as penetration increases ductility increases though not proportionally; that as penetration increases the softening point decreases though not directly proportionally nor in the same ratio as the ductility decreases; and hence obviously as borne out in the chart; as ductility increases the softening point decreases. It may also be noticed that for Trinidad products the softening point decreases with the percentage of ash altho in a much larger scale. Then obviously from the observations above the per cent of ash varies inversely as the penetration and ductility though in different proportions. Another peculiar observation made from the data diagram is the fact that in Bermudez products as the per cent of total Bitumen increases the per cent of ash remains almost constant.

With these several similarities and dissimalarities in mind curves were drawn in each of the cases mentioned in order that the relationships might be carefully and exhaustibly studied.

B <u>Examination of data for special relationship</u>.

A careful consideration of the data sheet and data chart#1 confirmed the idea of the existance of the general relationship mentioned in the previous section and also brought to light several interesting relationships between the qualities of penetration, ductility and softening point regardless of the total bitumen content. All of these relationships will now be decussed in order.

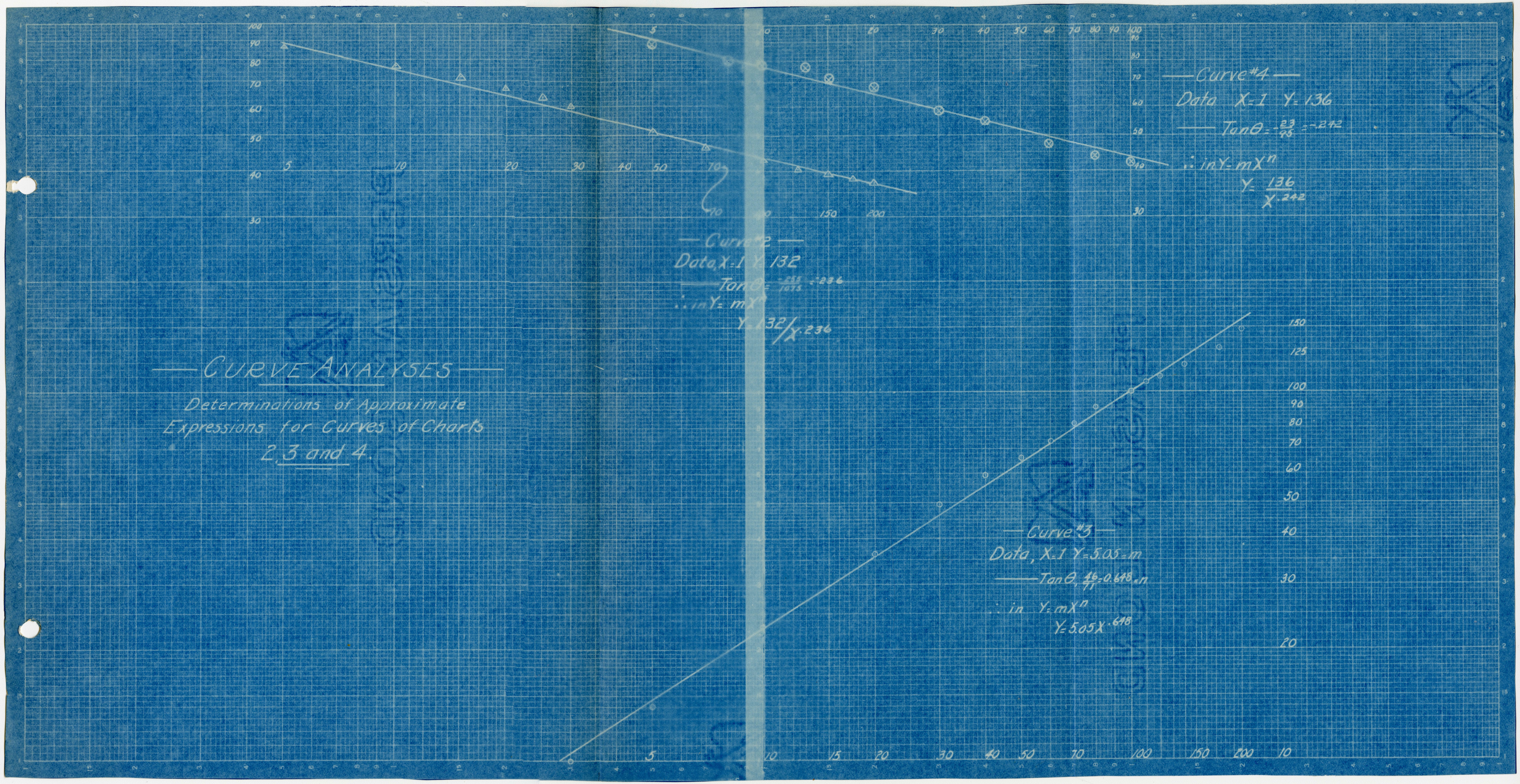
1. Plots and analysis of curves for such relationships.

Chart #2/ Relation of Softening Point and Penetration.

The most readily apparent possible relationship denoted by chart #1 was that of softening point to penetration. It was noted that the values for these tests as mentioned above varied inversely and it was apparent that in the majority of cases when lines were drawn joining the plotted values for such tests for specimens falling adjacent to each other in the scale of total bitumen that the slope of the line joining the values of penetration was as a rule roughly twice that of the line joining the co-ordinates of softening points. Here then was a problem, to reduce this general relation to an exact statement of relationship.

With this end in veiw the values of penetration for the whole series were plotted along a suitably co-ordinated axis of X against which were plotted the corresponding values of the softening point parallel to the axis of Y. The points thus obtained were found to delineate a rough parabolic curve and thru their region was drawn a smooth curve which apparently covered the plotted points. A curve was then drawn showing the relative variation of these two test values for the whole series of specimens varying in penetration from 0 to 200 and in softening point from 28 to 97 degrees C.

To obtain an approximate expression for this curve values of co-ordinates were chosen at random thruout its range and plotted on logrithemic graph paper which points were then seen to lie approximately in a straight line. This straight line was drawn and its slope which was negative, was measured in rectangular co-ordinates and its intercept on the Y axis of the absissa $X = 1$ was read in logrithemic co-ordinate. If then, M denotes the Y intercept and $N = \tan. \theta =$ slope of line, then if these values be substituted in the exponential equation $Y = -MX^n$ the resultant equation will be that of the parabolic


CURVE ANALYSES
Determinations of Approximate
Expressions for Curves of Charts
2, 3 and 4.
Curve #2
Data, X=1 Y=132
Tan θ = -.255/1.075 = -.236
∴ in Y = mX^n
Y = 132/X^.236
Curve #4
Data X=1 Y=136
Tan θ = -23/95 = -.242
∴ in Y = mX^n
Y = 136/X^.242
Curve #3
Data, X=1 Y=5.05=m
Tan θ, 46/71 = 0.648 = n
∴ in Y = mX^n
Y = 5.05X^.648

curve in its rectangular co-ordinates.

Thus in this case,

$$M = 132 \qquad N = -0.236$$

$$\therefore Y = 132X^{-0.236}$$

or

$$Y = 132/X^{-0.236}$$

The proof of the above method of analysis can be easily shown.

Given the general rectangular equation of the parabolic,

$$Y = MX^n$$

passing to logarithm

$$\log Y = \log M + N \log X \qquad (1)$$

Comparing this to the rectangular equation of the straight line,

$$Y = MX + b \qquad (2)$$

we see that;

N in (1) is analogus to M in (2)

log. M in (1) is analogus to b in (2)

Hence if we substitute;

N = slope of line

M = Y intercept when X = 1,

As found from the logarithmic diagram in the formula $Y = MX^n$ that expression becomes the rectangular expression of the parabola represented by the straight line of the logarithmic analysis.

Chart #3 Relation between ductility and penetration.

As mentioned in the perliminary descussion there is a relationship that exists between ductility and penetration for the series of fourteen specimens. Hence a curve was plotted as Penetration against Ductility, using ductility as ordinates.

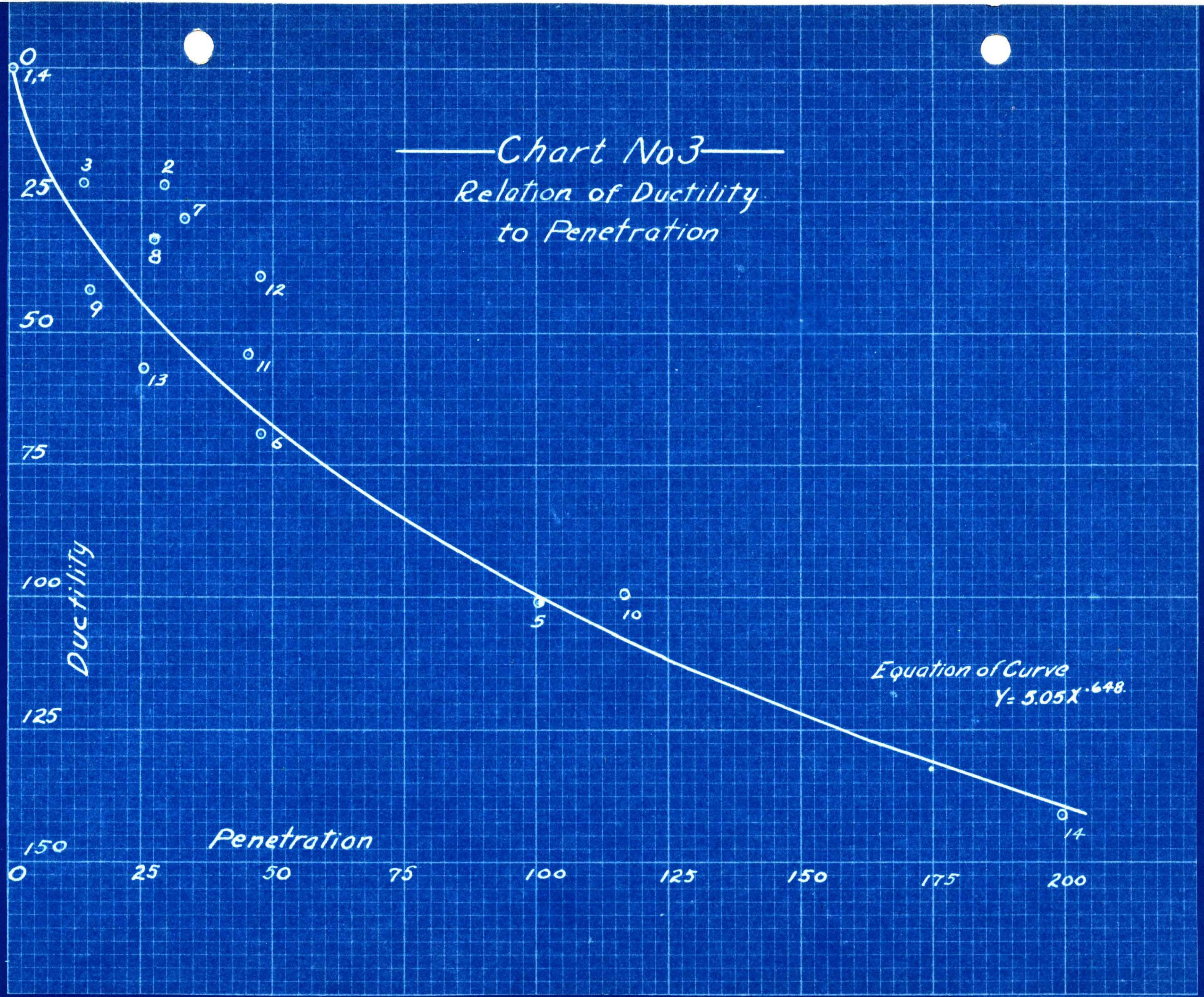


Chart No3
Relation of Ductility to Penetration
Ductility
Penetration
Equation of Curve
Y= 5.05X·648.
0
25
50
75
100
125
150
0
25
50
75
100
125
150
175
200
1,4
3
2
7
8
9
12
13
11
6
5
10
14

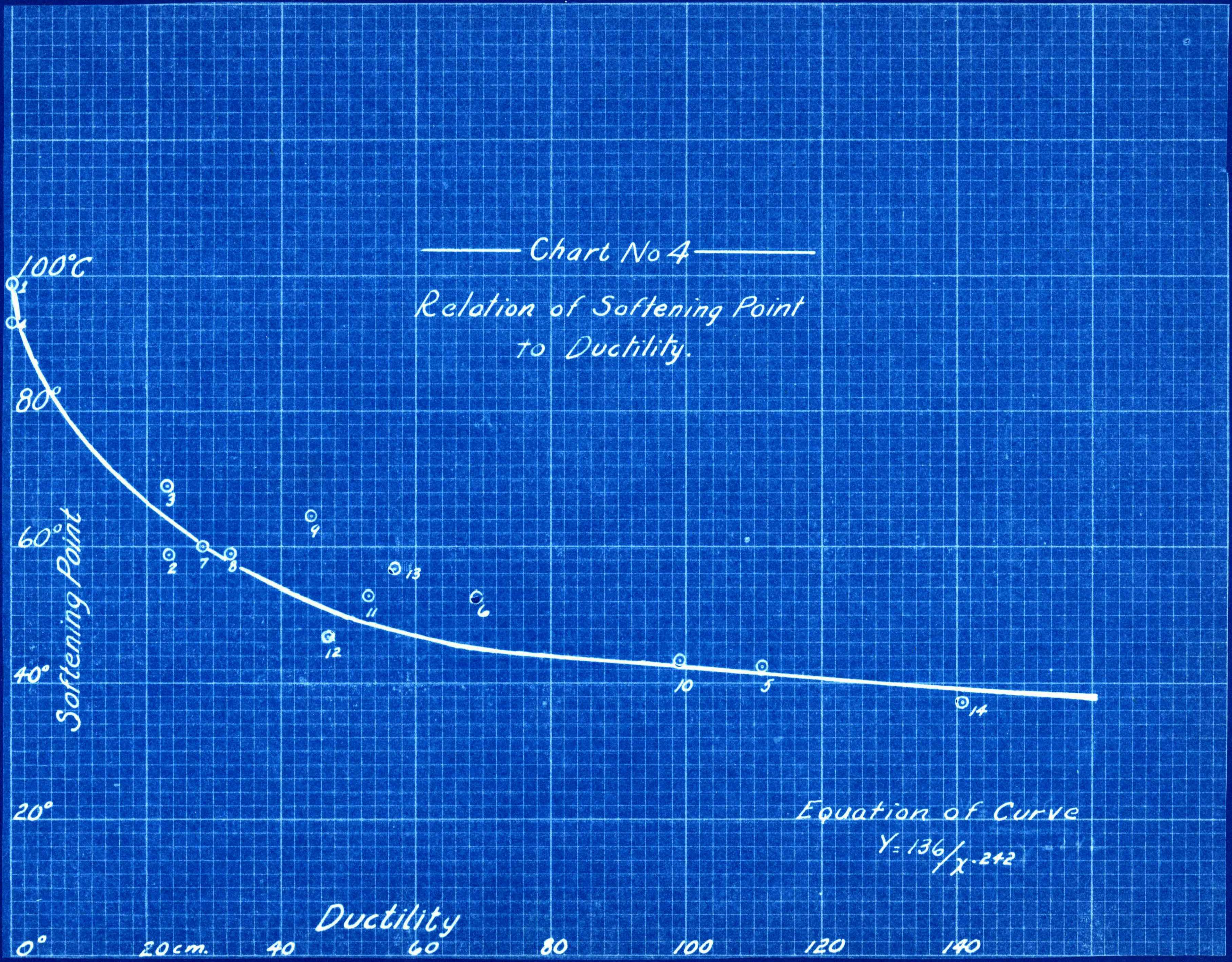


Chart No 4
Relation of Softening Point to Ductility.
100°C
80°
60°
40°
20°
0°
Softening Point
Ductility
20cm.
40
60
80
100
120
140
Equation of Curve
Y = 136/X^.242
1
2
3
4
5
6
7
8
10
11
12
13
14

It will be seen at once thru inspection of this chart that the values of both tests arrange themselves in a more or less regular fashion. Hence a curve was drawn involving as many of these points as possible. From this curve it is evident that as the values of ductility increase the values of penetration increase, but however, on a larger scale, the values of ductility ranging from 0 to 150 and those of penetration from 0 to 200.

As in the case of 1 (a) points were plotted on logarithmetic paper and were found to lie in very nearly a straight line. Then by the method previously given the equation of this curve was found to be in rectangular co-ordinates.

$Y = 5.05X^{.648}$

1. c.

Chart #4. Relation of softening point to ductility.

In the perliminary discussion, it was also found that there was an inverse relationship between softening point and ductility covering the entire series of specimens.

This relationship was more closely established by plotting values of ductility against corresponding values of softening point. The points thus plotted being in a more or less orderly arrangement. A curve was drawn thru joints seeming to lie in the most regular manner. This curve took, somewhat, the shape of a parabola in which it was seen that as the softening point decreased ductility increased the values plotted ranging between 0 and 140 cm. for ductility and 0 and 100 degrees for the softening point.

This curve as before was transferred to logarithmetic paper and came out nearly a straight line. The equation was then found to be: $Y = 136X^{-.242}$

Chart No5

Composite of Charts No's 2 and 4

Relations of

Softening Point to Penetration and Ductility

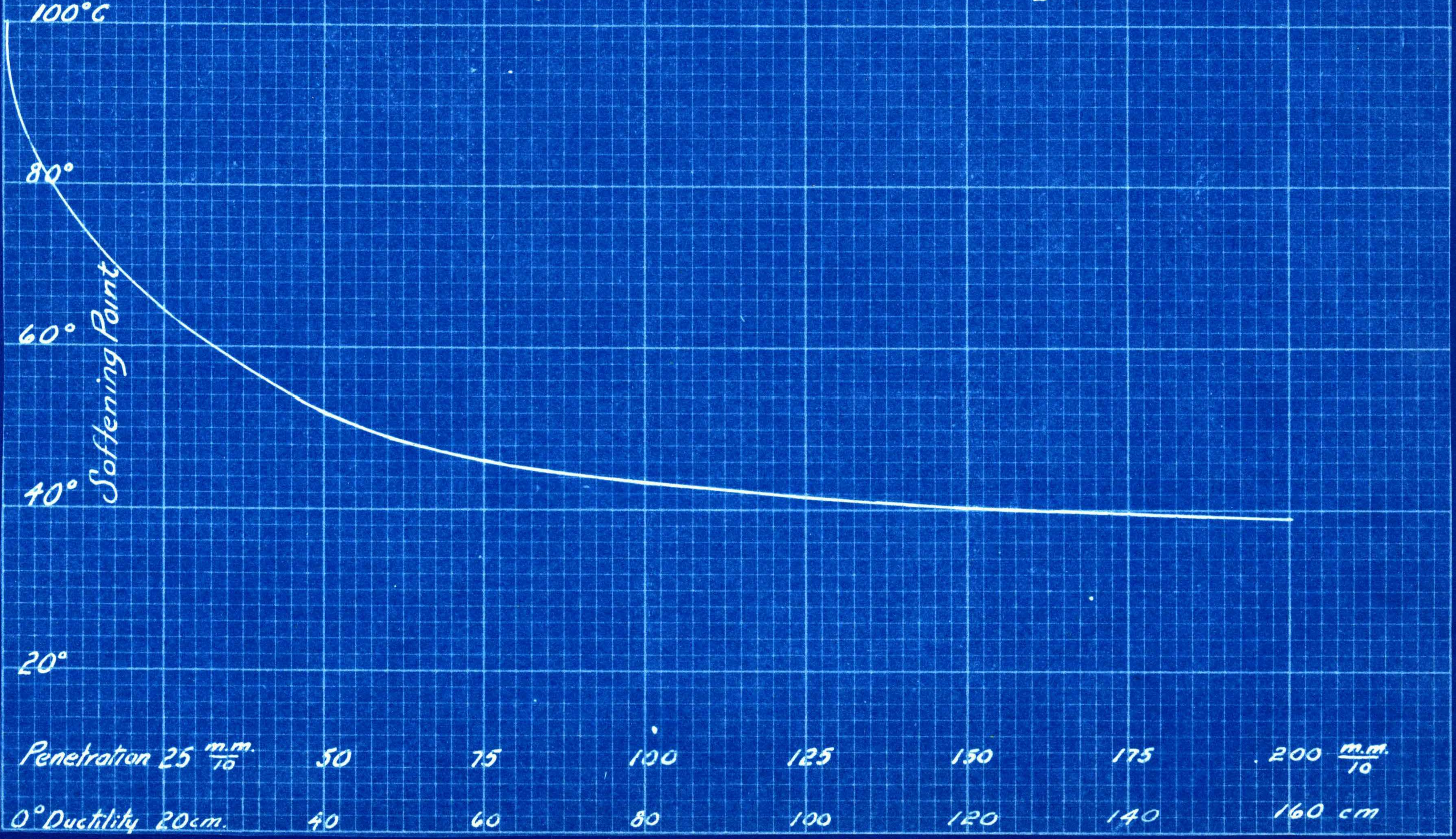
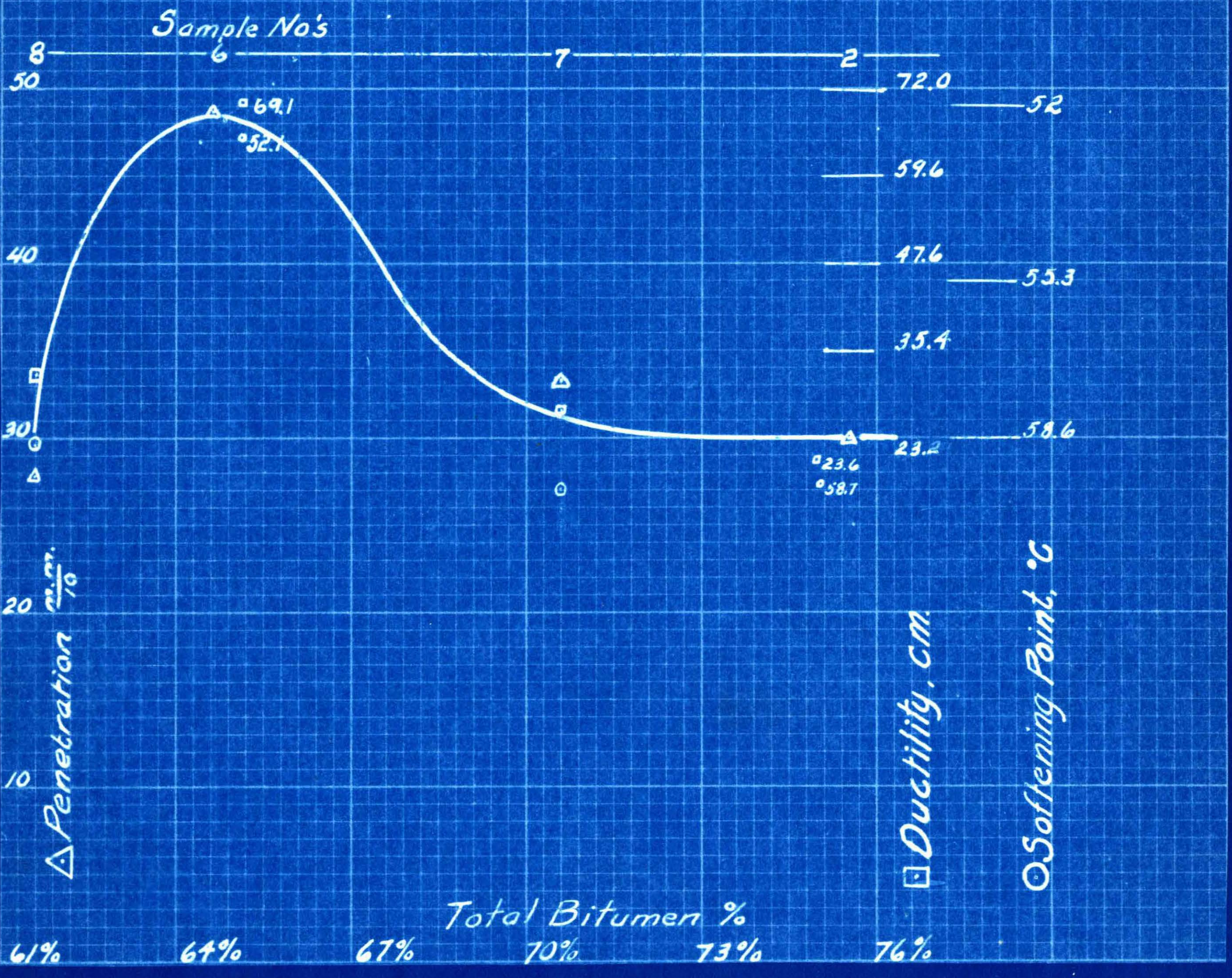


Chart No 6

Composite Curve of Relations for Penetration, Softening Point and Ductility to Total Bitumen for Trinidad Asphalt Cements.



1.d

Chart #5 Relations between softening point, penetration and ductility.

It will be noted that in chart #2, penetration was plotted against softening point while in chart #4 ductility was also plotted against softening point.

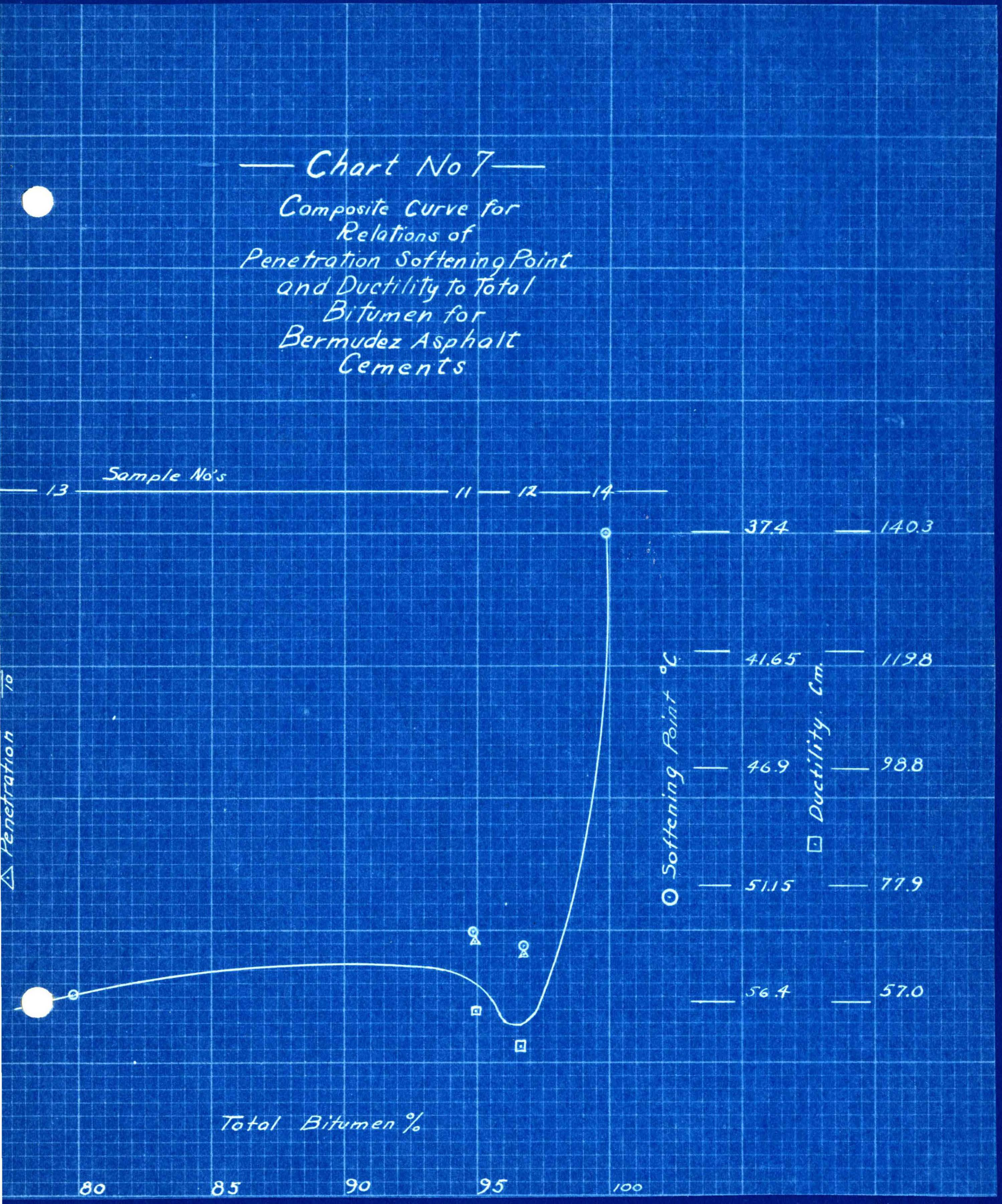
On a comparison of these two charts it was found that the two curves thus formed were almost exactly similar. Hence a composite chart #5, was made, being compounded by plotting penetration and ductility against softening point. The absissas being those taken from charts #2 and #4 and the ordinate being the common softening point. This curve was of course the same as both #2 and #4/

1. e.

Chart #6. Relation between penetration, softening point and ductility to total bitumen for Trinidad Lake Asphalt Cements fluxed with liquid petroleum.

From chart #1 a certain regularity was noted in the variation of the ordinates for the values of penetration, softening point and ductility for Trinidad Cements and for Bermudez cements also. In the consideration of this apparent relation, it seemed plausable that the variation of these results might be expressed as a function of the total bitumen content for the cement alone. This section deals with the investigation as to the Trinidad Cements.

On the axis of abscissas the range of values for the bitumen content was laid out, 60 to 75 per cent approximately. For the ordinates the co-efficients of penetration, ductility and softening point were used. The widest range in numerical coefficients were between #2 and #6 in all three cases and was greatest in



— Chart No 7 —
Composite Curve for
Relations of
Penetration Softening Point
and Ductility to Total
Bitumen for
Bermudez Asphalt
Cements
Sample No's
13
11
12
14
37.4
41.65
46.9
51.15
56.4
140.3
119.8
98.8
77.9
57.0
⊙ Softening Point °C
□ Ductility Cm.
△ Penetration 1/10
Total Bitumen %
80
85
90
95
100

the ductility test for which #2 showed 23.6 cm. and #6, 69.1 cm.

Specimens #2 and #6 were thus chosen as the criterions upon which to base the plotting of the curve. At the proper abscissas the ordinates of ductility were drawn for these two specimens and these points projected upon the scales of penetration and softening and given the values of each test corresponding with the specimen. Then by laying out the scale for penetration and softening, these two points having thus been determined the other points corresponding to the other cements of the series were plotted. A smooth curve was then drawn on the plot and by means of this deagram is made to expres by one line the variation of the results of the three tests with regard to total bitumen for Trinidad Lake Asphalt Cement.

The nature of this curve shows very conclusively that bitumen content is not a criterion of ductility, penetration, or softening point or vice versa and this throws light upon the basic idea of their work; the interrelation of physical tests and will be further discussed in drawing up conclusions in the final section of the investigation.

1. f

Chart #7 Relations of penetration, softening point, and ductility to total bitumen for Bermudez Lake Asphalt Cements.

In precisely the same manner as detailed in the last chapter, a regular variation of the values as shown by the data chart for penetration, softening point. and ductility was noted for Bermudez Asphalt Cement. As effort to correlate these variations with that of bitumen content was made as also detailed in the last section was made and the resultant curve #7 bears a marked similarity to and bears out the conclusion to be based on this curve and curve #6/

— Chart #8 —

Curves of Penetration
as Related to Softening
Point and Ductility
for
Lake Asphalts.

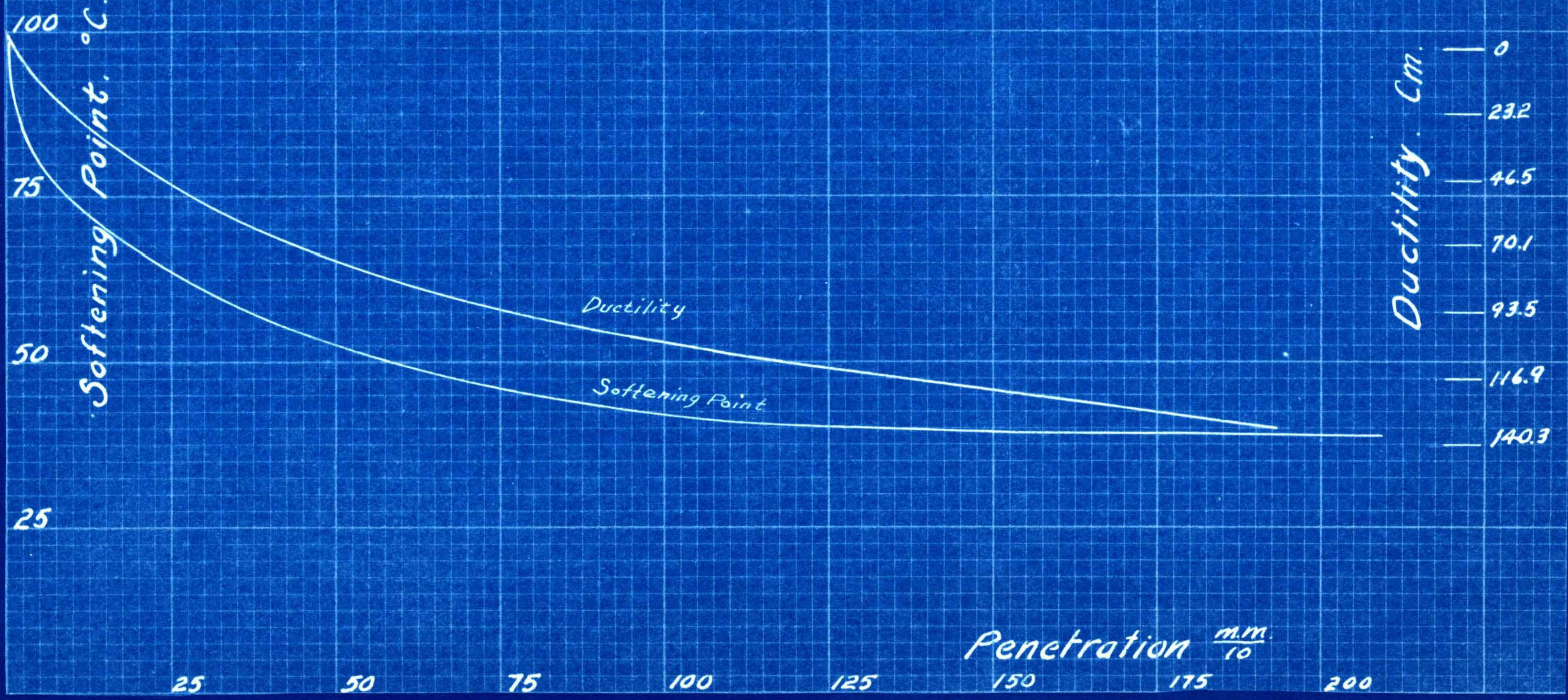
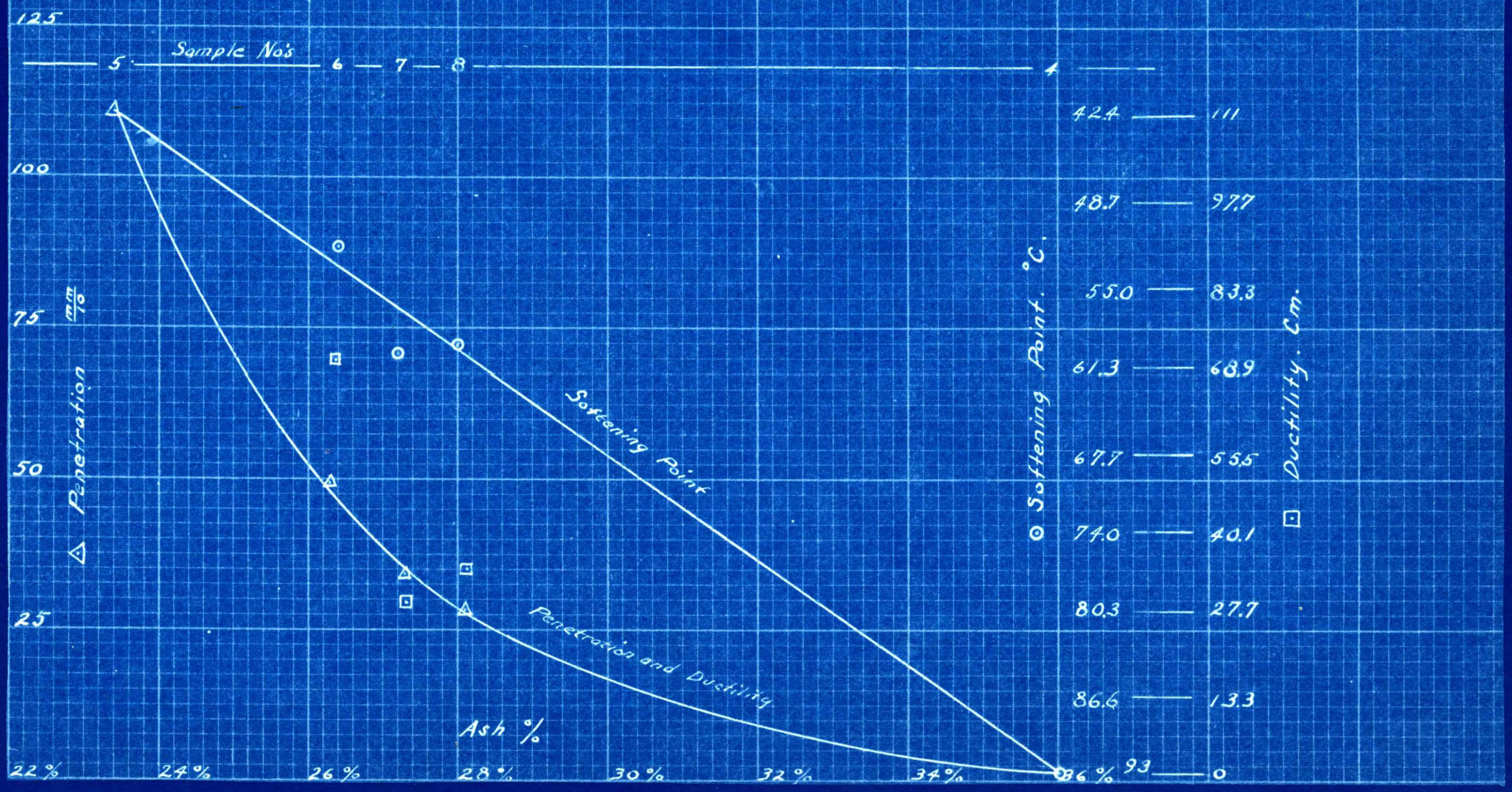


Chart No. 9

Relation of Softening Point
Ductility and Penetration
to Ash for
Trinidad Lake Asphalts and Trinidad Lake
Asphalt Cements



1.g

Chart #8 Relation of penetration to softening point and ductility for Lake Asphalts and Lake Asphalt Cements.

In the case of charts #1 and #4 it was found that a single curve represented the relationship of ductility and penetration to softening point. The purpose of chart #8 was to find some similar relation between ductility and softening point when plotted against penetration. To do this penetration values were plotted as abscissas and ductility and softening point as ordinates The ductility scale being laid out by taking the highest and lowest values of ductility and dividing the values between, into proportionate parts. The points plotted however, did not fall in the same curve as they did in chart # 5, but rather fell into two distinct curves, one of these being ductility against penetration and the other softening point against penetration.

1. h.

Chart #9. Relation of softening point, ductility and penetration to Ash for Trinidad Lake Asphalts and Trinidad Lake Asphalt Cements

On investigation of chart #1 it was found that there was a seeming relationship between ash content and softening point. hence since there was discovered a relation between softening point, ductility and penetration it was thought that there might be an interrelationship between the three just mentioned and the Ash content. To investigate this Ash content was plotted against penetration and the points fell in a fairly true curve as shown in chart #9. Then ductility was plotted against ash using the Y axis as the ductility ordinate and dividing the values between the high and low limits into proportionate parts. These points were found to fall very nearly on the curvedrawn for penetration.

However, when in the same manner, as for ductility, softening points were plotted against ash content these points took a seperate and distinct course of their own and hence a second curve was plotted accordingly.

V CONCLUSIONS DRAWN

We have indicated in the former section the relations arrived at from the consideration of the data and curves obtained in this investigation.

It now remains to discuss and digest and draw conclusions as to what light, if any this work has thrown upon the matter of the relation of physical tests upon native lake asphaltic materials.

A Digest of Conclusions.

The first and most striking conclusion that can be arrived at is that for the whole series of specimens ranging through the degrees of refinement of the unadulterated native asphalt and the cement formed from these materials by the admixture of liquid petroleum flux. A distinct relation was formed between the result of penetration and softening point tests, between ductility and penetration, and between softening point and ductility. Not only were we able to conclude the nature of these relations graphically, but we were also able to express those relations by formulae.

In order to show those relations in more comvenient form graphs were prepared to show the variation first of penetration and ductility with respect to softening point and second of softening point and ductility to penetration.

It was shown that a curve could be prepared to bring out the relations of softening point, penetration and ductility with respect to total bitumen content for each of the two series of cements which variation in bitumen content was due of course to variation in flux content. This flux which was added to soften the material containing no mineral matter itself and was by the limitation of the labratory and the writers necessarily included in the total bitumen content.

The chart of these two relations show very clearly that although any of the three qualities of penetration, softeness or ductility can remain unspecified and yet be automaticaly delimeated by the range of specifications of the other two; yet all three qualities might be specified for these cements and yet the bitumen content would be not delineated.

For example consulting chart#6 one can readily appreciate that a Trinidad Asphaltic cement could be specified for a penetration of 30-35, ductility 25-35 and softening point of 57- 59 degrees and the specification could be fulfilled by two distinct cements, one of which would have a bitumen content of about 62% while the second would have approximately 70% bitumen. It is logical to assume and as Privost Hubbard points our scientific investigation and the result of experience indicates that the assumption is the true criterion of the value of Asphaltic road materials, because it is the binding matter upon which the usefulness, in the final analysis of the material, depends.

In the light of the above consideration, it is then concluded that in specification writing for asphaltic cement total bitumen must be specified in order to protect the purchaser.

Parentheticaly it may be stated that it would be most interesting and instructive to obtain data of actual sources shown by two materials both of either Trinidad or Bermudez origin used in identical constructions and being identical in penetration, softness and ductility but having different bitumen content.

In considering the Trinidad materials a comparison of the ash content to the three qualities of penetration, ductility and softening point the only conclusion possible to draw was that for Trinidad materials as the ash content increases, softening point becomes higher, ductility increases and penetration decreases, and these relations amount only to a generality.

B Summary

From the results of these investigations we may summarize the following important conclusions,

(1) That for native lake asphalt paving materials in the sinse the term is herein used, it has been shown that relations exist between the values of softening point, penetration and ductility as shown by standard tests which may be expressed analytically as follows:

$Y = 132X^{-0.236}$ where Y = softening point degs. C.

X = penetration m.m. 10

$Y = 5.05X^{0.648}$ where Y = ductility cm. X = penetration

$Y = 136X^{-0.242}$ " Y = softening point degrees C.

X = ductility cm.

Hence for the purpose of rough tests usualy made in the field in which the material is only as a rule submitted to these three in addition to the specific gravity test any native lake asphaltic material could be submitted to only the penetration test, which is easily the most accurate and easily manipulated of the three and the other two values could be deduced from the formulas given with sufficient accuracy to determine whether or not the material should be accepted with certainity as to its passing specifications.

(2) That for cements of both Bermudez and Trinidad origin it is necessary to specify bitumen content to insure a satisfactory

material in all respects which will be uniform but it is necessary in addition to specify only specific gravity and penetration. The local origin of the material can be easily checked up when testing for total bitumen since the ash of Trinidad asphalts is of a salmon pink color while that from Bermudez is black.