D.1C18

D.

29 C10

The size and capacity of the kiln depends on the requirements. Namely all kilns are about 4.5 ms. high and hence their capacities vary with length and breadth. For example a kiln for 100,000 bricks will be 13.5 x 12 x 4.5 ms.

Bricks are stacked on edges in courses separated by layers of fine coal or coke of about one inch thich, and, at the bottom of the kiln, the courses are arranged to form narrow channels in the direction of prevailing wind in the time of firing. These are to be filled with wood, coarse coal, tree branches and cotton sticks, to which some kerosine is usually added. The kiln is surrounded by a temporary wall of green bricks or unfit bricks from previous kilns, and on the top is set a layer of clay 25 cm. thick. The outside surface is plastered with mud and left to dry.

Fuel required for burning 100,000 bricks are:

	Fire coal	6.5	tons
	Coarse coal	1.5	tons
	Wood	1.5	tons
OR :			
	Fine cinders coal(semi used)	9.0	tons
	Coarse coal	1.5	tons
	Wood	1.5	tons

b - CONTINUOUS KILNS

For the pursuit for economy in firing, the continuous kilns are used in brick industry in Egypt immediately after the second great War. The type greatly used is the open (archless) Hoffman kiln. This due to the following advantages :

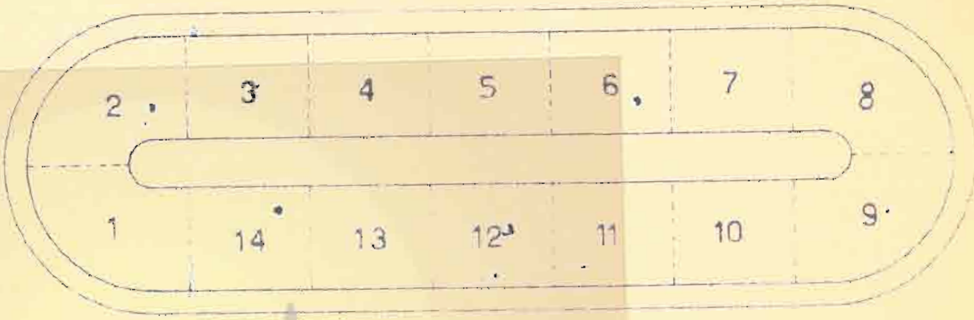
1 - Low cost of construction.
2 - Ease in controlling the progress of the fire.
3 - Great speed and comfort in filling and emptying, as, the top of the kiln being open, the chambers are cooler, and the setting can be done in a better light.

The usual form of the kiln is of two parallel walls terminated at each end by semicircular ones, with a central thick wall containing the main flue through which draughts pass from different chambers of the kiln to the chimney. The chambers are so connected to a system of flues that the heat from any one of them may be conveyed to the rest or not at pleasure.

1 - METHODS OF WORKING THE KILN

The method of working the kiln is briefly as follows:-

Fig. No.   shows a kiln of 14 chambers and it may be assumed that the kiln is in full working order.



Diagramatic Plan For Hoffman Kiln

a - Nos 14 is being filled with bricks.

b - A partition of paper separating No. 1 from the remainder of the kiln.

c - Nos. 2 to 6 are being slowly heated without the direct use of fuel , by passing the hot gases from Nos. 7 & 8 (which are being heated by oil) through them. In this way the heat from Nos. 7 & 8 is utilised in the preliminary heating of four chambers full of bricks, and as the gases pass from one chamber to another they gradually lose their heat, and are taken direct to the chimney stack.

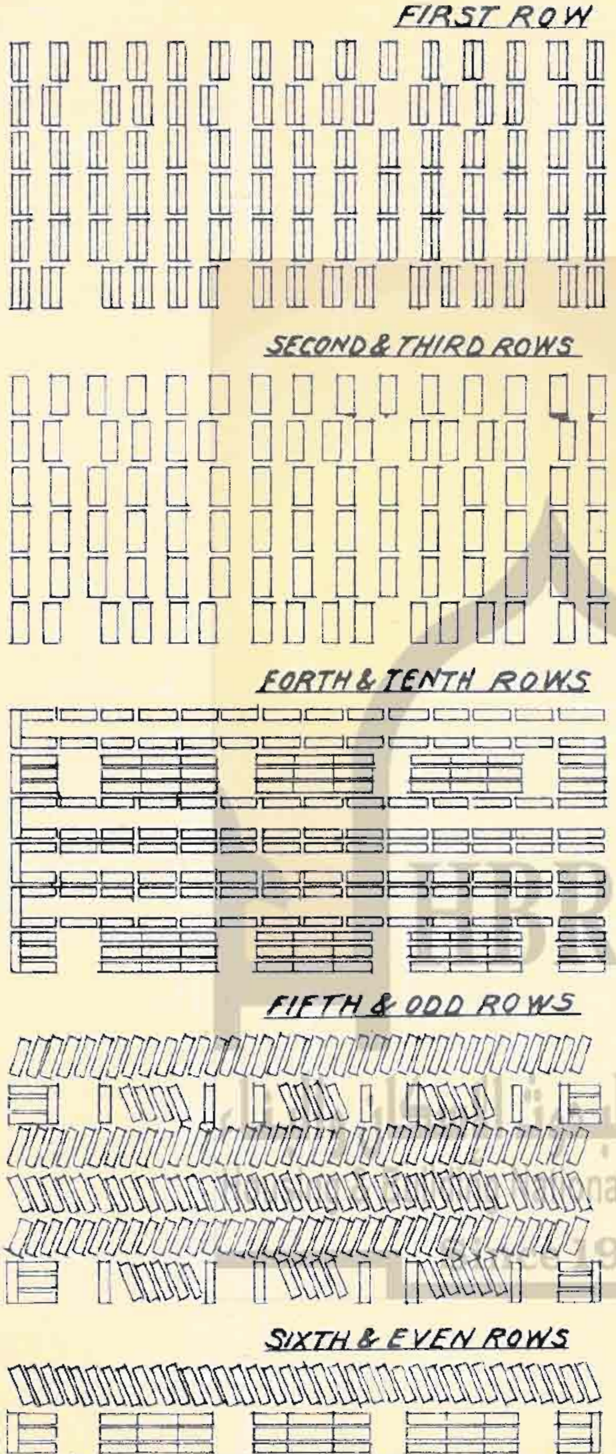
d - No. 8 is at such temperature that it constitutes the finishing point of the kiln.

e - Nos. 9 to 12 are containing the finished but hot bricks.

f - In order to cool these chambers (9 to 12), the air is admitted to pass through No. 12 (the last chamber).

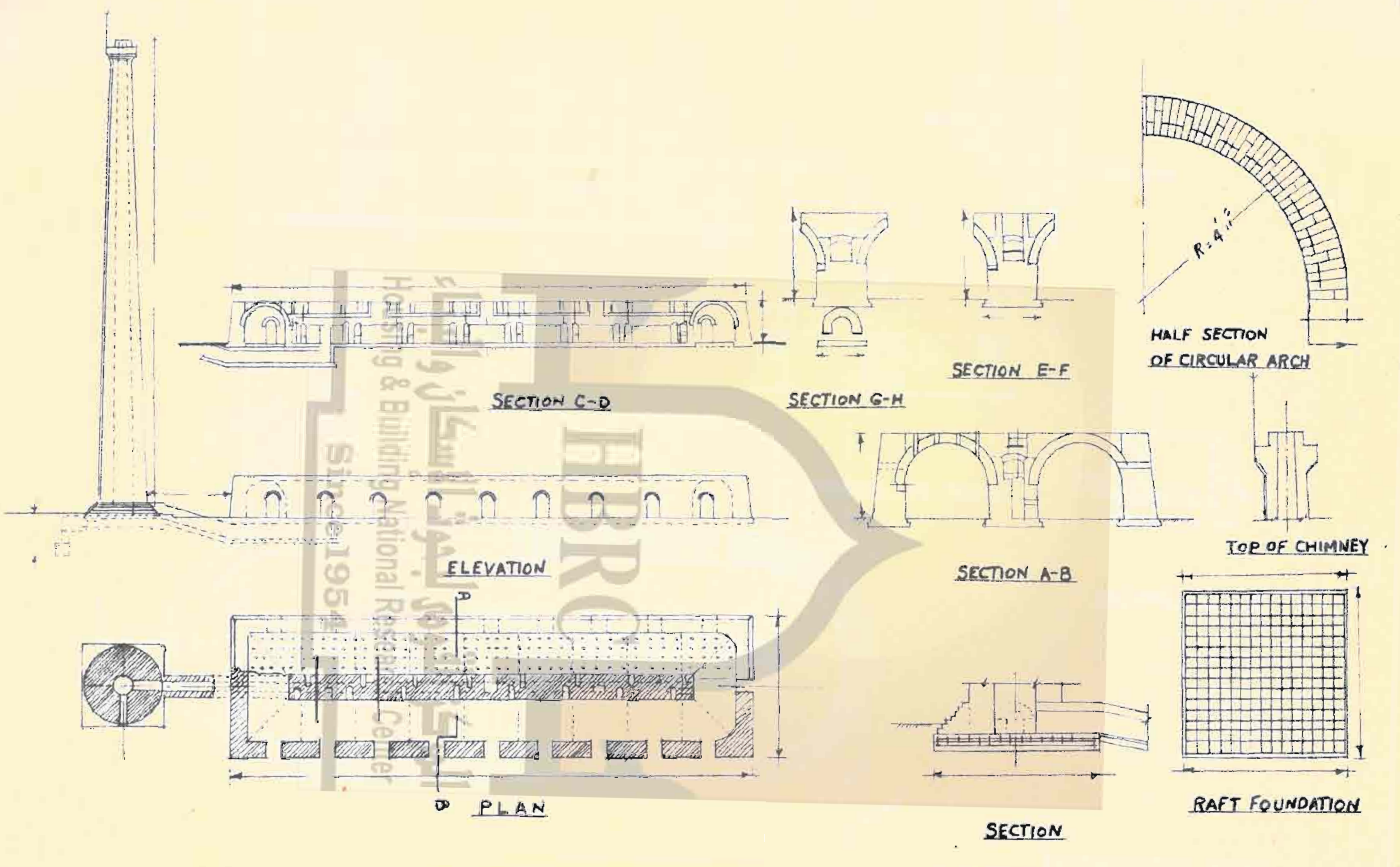
g - Air drawn from No. 12 to 9, becoming gradually hotter by contact with the bricks, so that it reaches No. 8, which is being fired, hot enough to assist greatly the combustion of the fuel. In this way the heat contained in the cooling bricks is used over again for heating of further lots.

h - Taking the chambers in the order given, it will be found that the temperature in each follows approximately the curve shown in fig. No.

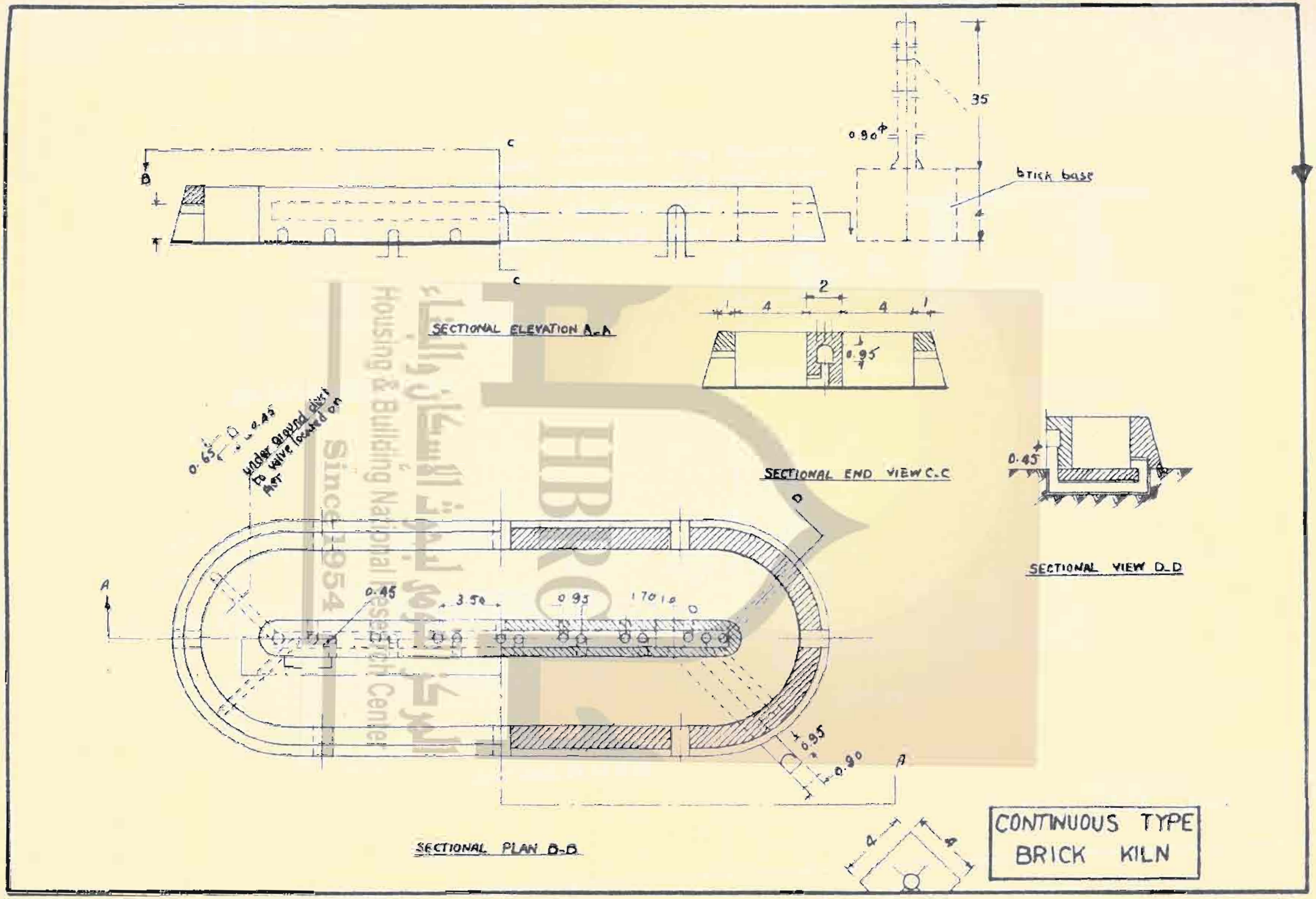


SETTING BRICKS IN

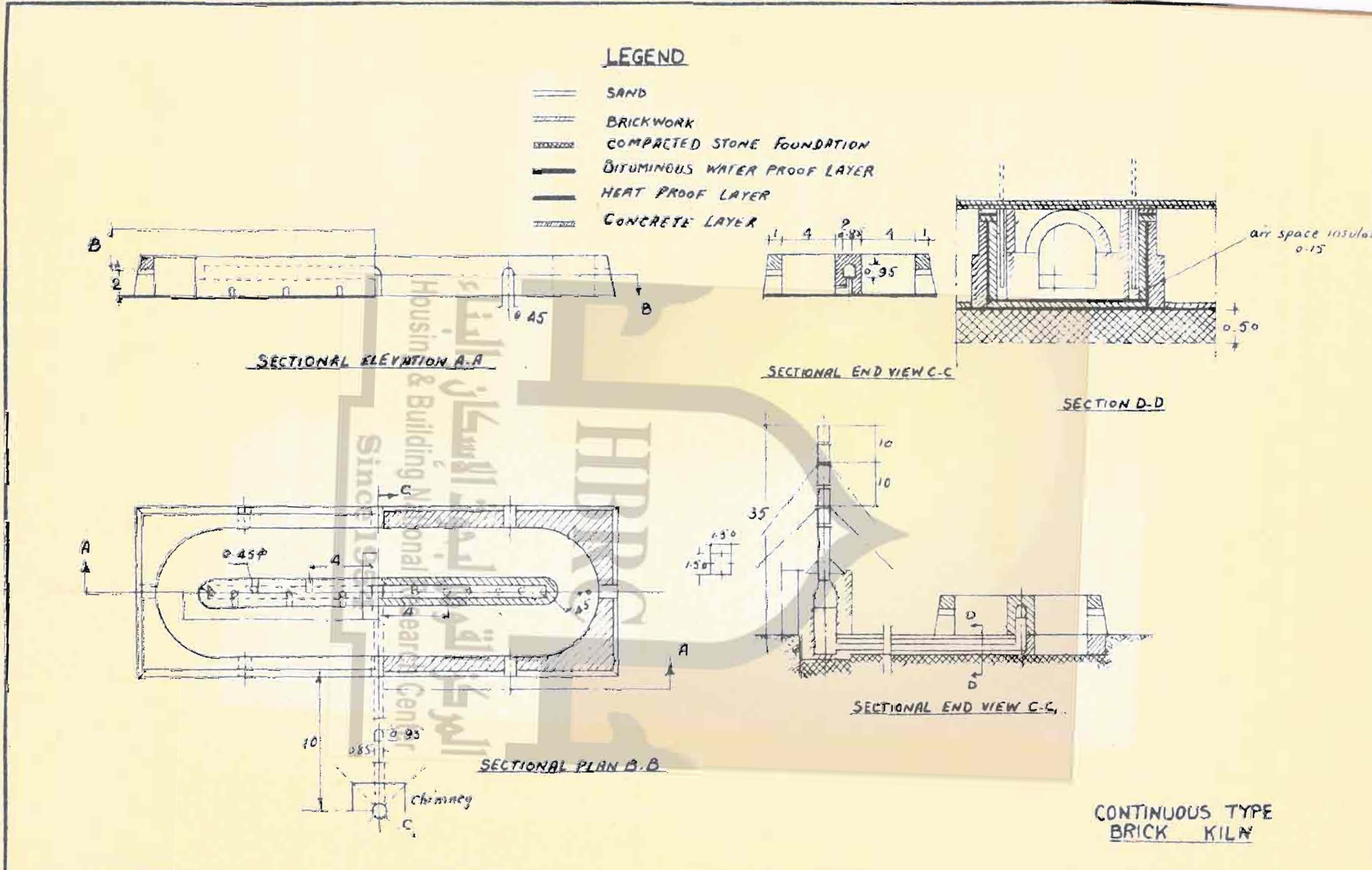
~~METHOD OF PACKING~~ CONTINUOUS ~~BRICK~~ KILNS



CONTINUOUS BRICK KILN_ OIL FIRED



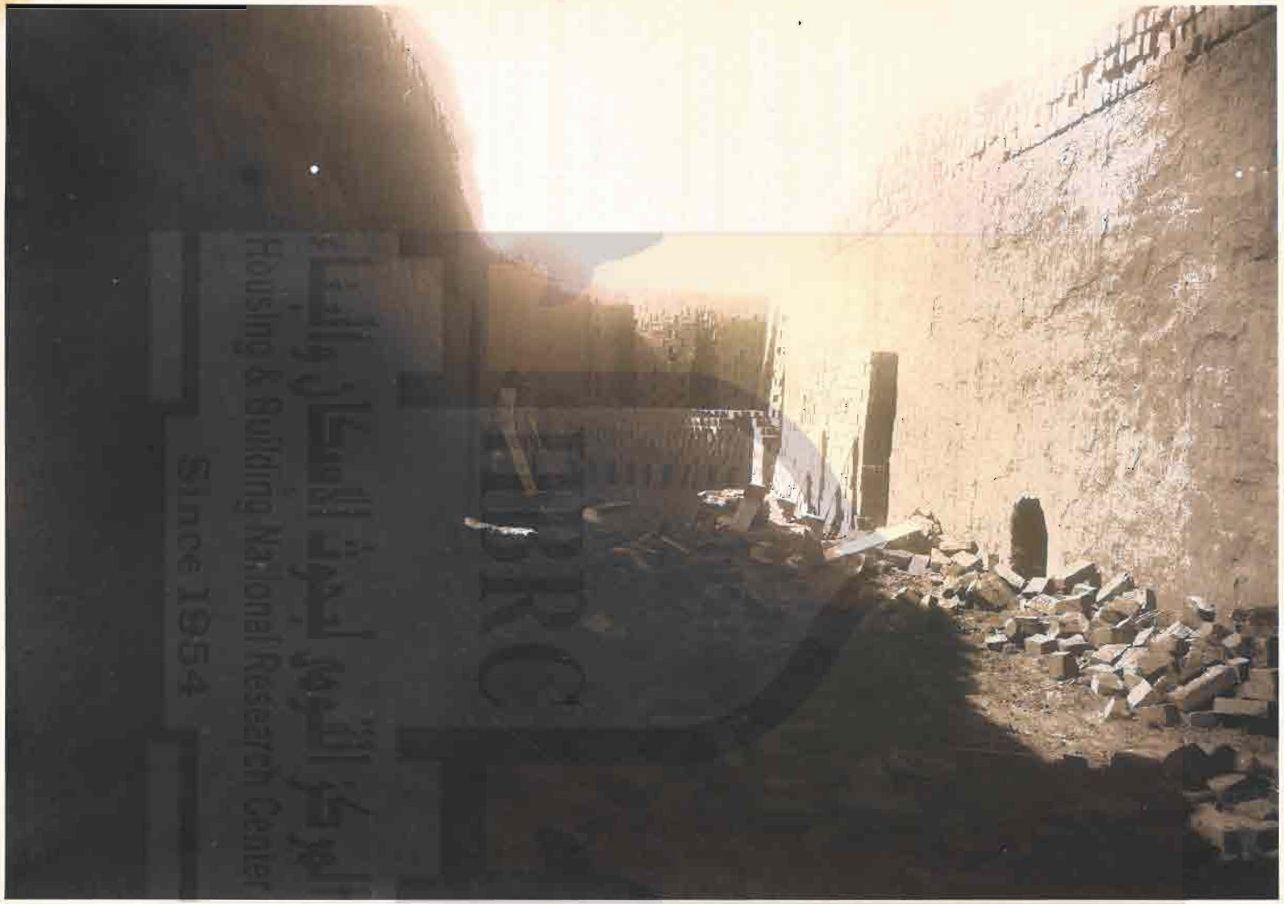
CONTINUOUS TYPE BRICK KILN



CONTINUOUS TYPE BRICK KILN

9 - TOP OF CONTINUOUS KILN SHOWING COMBUSTION

CHAMBERS, COVERS, AND FUEL CONTAINERS



4 - SETTING OF BRICKS

i - When No. 8 has been heated sufficiently the connection between No. 2 and No. 3 is removed so that the hot gases now enter No. 2.

j - Fuel is next fed into No. 6, but no more is added to No. 8, which therefore begins to cool. In this way the whole process of heating is moved on one chamber.

k - No. 12 will now be cool enough to be taken out and it is refilled.

l - In this way the action of the kiln is quite continuous so long as there is sufficient supply of bricks to be burned, as the fire travels forward, usually at the rate of two chamber per day.

2 - SETTING OR CHARGING

The arrangements for setting bricks in the continuous kiln are shown in Fig. No.   in such a way as to leave sufficient spaces between the bricks to secure a good as well as even draught in the different parts of the kiln. Fire boxes or chambers are formed with opening of 25 x 25 cms. at the top, and at about 1.0 metre apart. Each combustion chamber is fitted with a cast iron seat and a blind cap. When oil is to be fed, the blind cap should be replaced by another having a hole to receive the drip feed regulator.

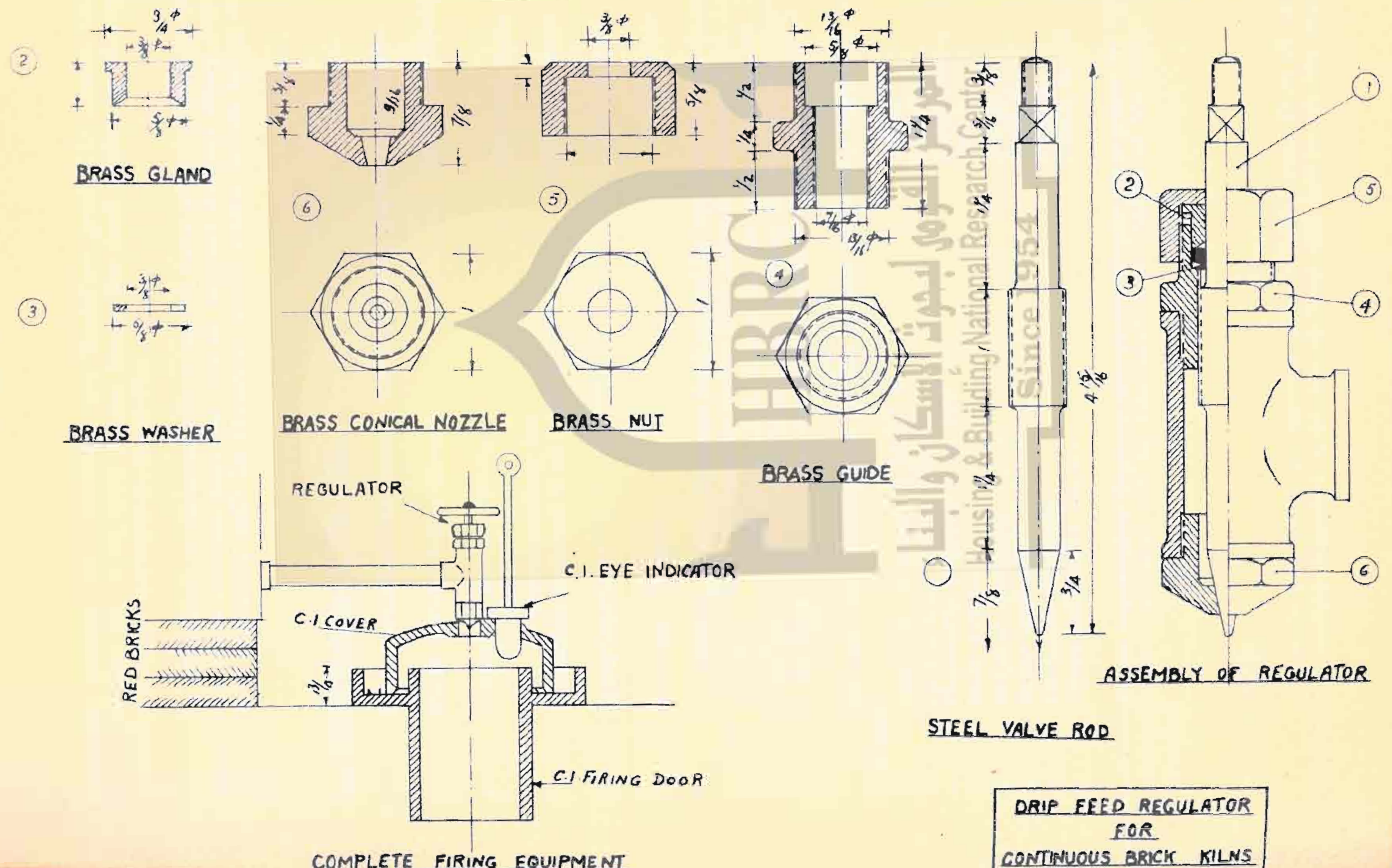
In case of archless kilns, bricks are covered by a layer of red bricks laid on their faces with the joints closed with clay, and by another layer of sand or red brick dust of about 20 cm. thick.

After filling each chamber with bricks, the charging door is bricked up and carefully plastered with mud, then left to dry for about three days.

3 - THE DRIP FEED APPARATUS:

This was designed by Shell Co. and comprises as illustrated in Fig. No.   , a 4 gallon steel container to which is welded a 1/2" steel pipe. A specially designed 1/2" oil regulator is screwed to the other end of this pipe. Furnace fuel leaves the regulator nozzle and falls by gravity into the combustion chamber where it burns. The regulator is designed in such a way as to discharge oil in the form of continuous stream of drops. In practice the adjustment of oil discharge can be easily obtained by these regulations.

When commencing firing, the blind, cover is removed and replaced by another having a 1" hole cut in its centre. A drip feed apparatus is then fitted and the regulator is operated at minimum discharge for about 4 hours after which the discharge is gradually increased to its maximum in about 12 hours and is then kept constant for four hours. The bricks are now at maximum burning temperature and heat is only required to replace convection and



DRIP FEED REGULATOR
FOR
CONTINUOUS BRICK KILNS

radiation losses. The regulators are therefore gradually closed down until they are shut off in 12 more hours, hence the feed system is dismounted to be used in other combustion chambers.

In oil fired continuous kilns, eight rows of drip feed system are used, four units in each row. One row is shifted forward every four hours and in this way every unit is employed for 32 hours before being shifted forward.

4 - SPECIFICATION OF THE FUEL:

This specification covers the following physical limits:-

• Flash point, P.M., closed	150° F minimum.
• Viscosity Sybolt Furol, at 122° F	300 sec. max.
corresponding to: Viscosity Redwood I at 100° F	6500 sec. max.
• Water content	1.0 % max.
• Sediment Content	0.25% max.

At present, Shell Furnace Fuel normally applied to the industrial market in Egypt has a viscosity under 2000 seconds Redwood I at 100° F. It is not anticipated that this will change in the near future, but it is not possible to guarantee it and future oil burning installations should be designed to cope with Fuel up to 3500 seconds Redwood I at 100° F.

Typical characteristics of the grades currently marketed are as follows:

• Specific gravity at 15/4° C	0.955
• Flaskpoint, P.M., closed	188° F.
• Viscosity Redwood I at 100° F.	1400/1900 sec. winter/summer
• Pour point.	60° F.
• Sulpher content.	2.7 %
• Water content.	0.05 %
• Sediment Content.	0.02 %
• Gross calorific Value.	18900 B. th. U. lb.

These inspection figures are given simply as a guide to the quality available now and must not be interpreted as limits of the properties indicated

5 - CHIMNEY:

Chimnies are built in masonry with heights vary from 37 to 45 metres, and with internal diameter 1.90 ms. at base and 1.0 m. at the top.

6 - KILN PERFORMANCE:

Kiln performance is measured by number of factors:

a - Fuel consumption on the kiln.
b - The output.
c - The quality of the fired product, including the propertion of saleable goods produced.
d - Properties of green bricks which influence the fire requirements.
e - Certain of the kiln and firing characteristics.
f - Other factors which have a bearing on the thermal and economic results obtained from the kiln.

Important performance factors including certain properties of the products for the average of the works surveyed are given in the following table:-

1	Fuel consumption kgs/1000 bricks	80 - 100 kgs.
2	Average firing-temperature	800 - 1000° C
3	Output of fired brick per day	20,000 - 25,000
4	Rate of firing per day	6 - 8 rows
5	Properties of fired bricks	
	- Average bulk density of bricks	
	✓ - Compressive strength	40 kg/cm²
	✓ - Liability to effloresce	slight
	✓ - Water absorption	21.3 %
6	✓ Average weight fired brick kgs.	3.35 kgs.
7	Kiln Feature	
	- Type of kiln	Hoffman
	- Number of chambers	14 - 16 - 20
	- Volume per chamber	24000

CHAPTER III

TESTS CARRIED ON CLAY AND BRICKS.

A - CLAY

Samples of clay has been taken from works surveyed as follows:

i - From silt trap of one of the works before the flood period.
ii - From ready mixed clay and sand before tempering.
iii - From crushing dried green bricks.
iv - From clay and sand carried to the works by boats during flood period.

The samples were the subject of the following tests:

1 - MECHANICAL ANALYSIS:

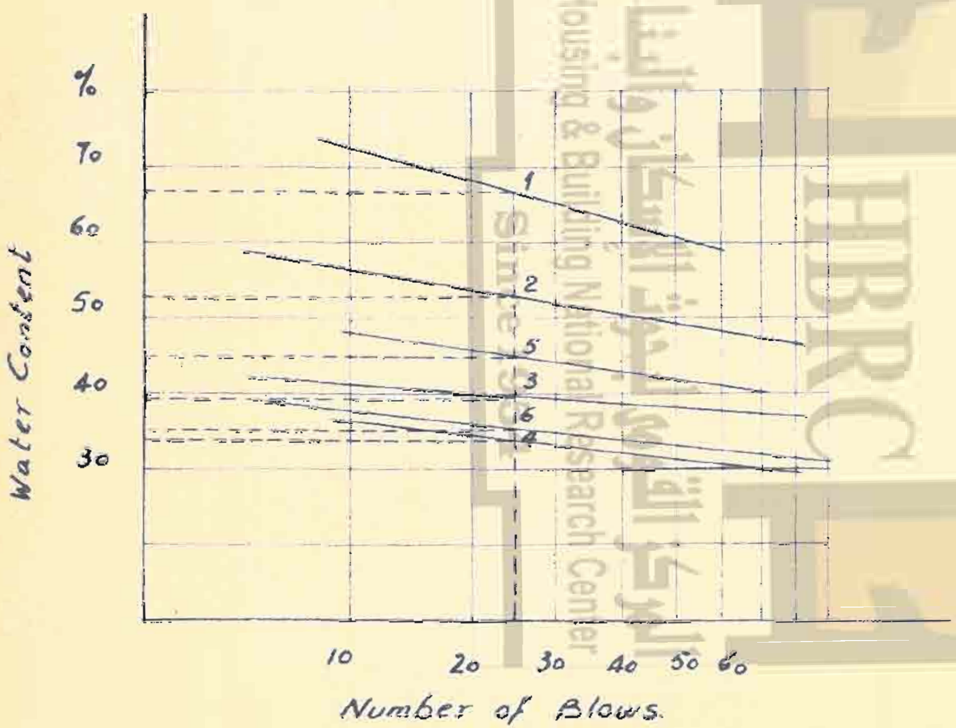
The purpose of mechanical analysis is to determine the size of the grains of clay and the percentage of the total weight represented by the grains in various size ranges.

Particles greater than 0.07 mm. are separated by using A.S.T.M. Standard Sieves. Smaller particles are subjected to wet mechanical analysis.

The method for performing wet machanical analysis are based on Stokes's low, which determined the velocity at which a spherical particle of given diameter settles in a quiet liquid. 50 gms of the size passed sieve No. 200 (0.07 mm.) are mixed with one litre of water, agitated and poured into a container. The density of the suspension is measured at various times by means of a hydrometer. At any given time, the size of the largest particles remaining in suspension at the level the hydrometer can be computed by means of Stokes's law, whereas the weight of the particles finer than that size are computed from the density of suspension at the same level. By this means clay fractions are separated down to a size of 0.002 mm.

Figure shows several grain-size curves for clay and sand taken from different parts of silt traps of one of the works.

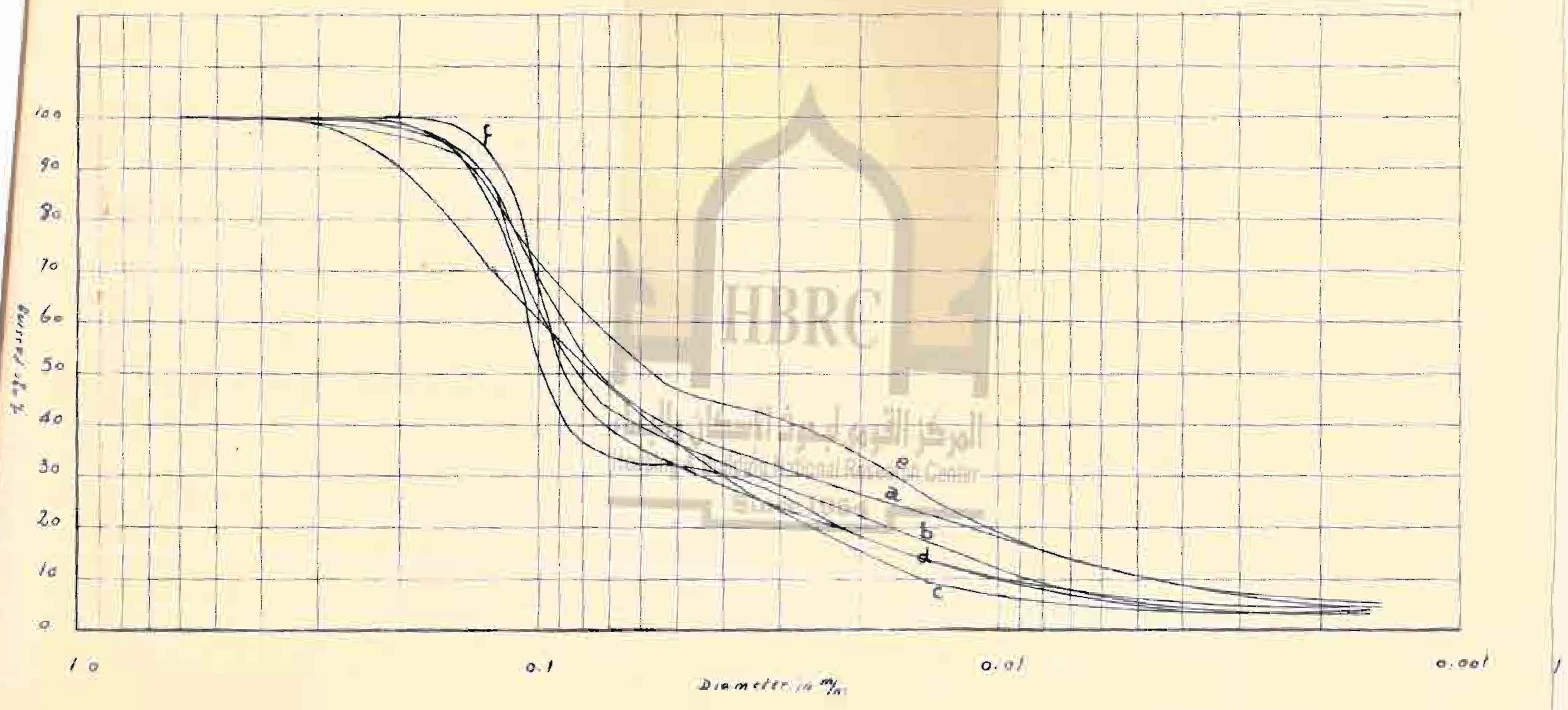
LIMITS OF CONSISTENCY FOR SAMPLES FROM VARIOUS PARTS OF A SILT TRAP



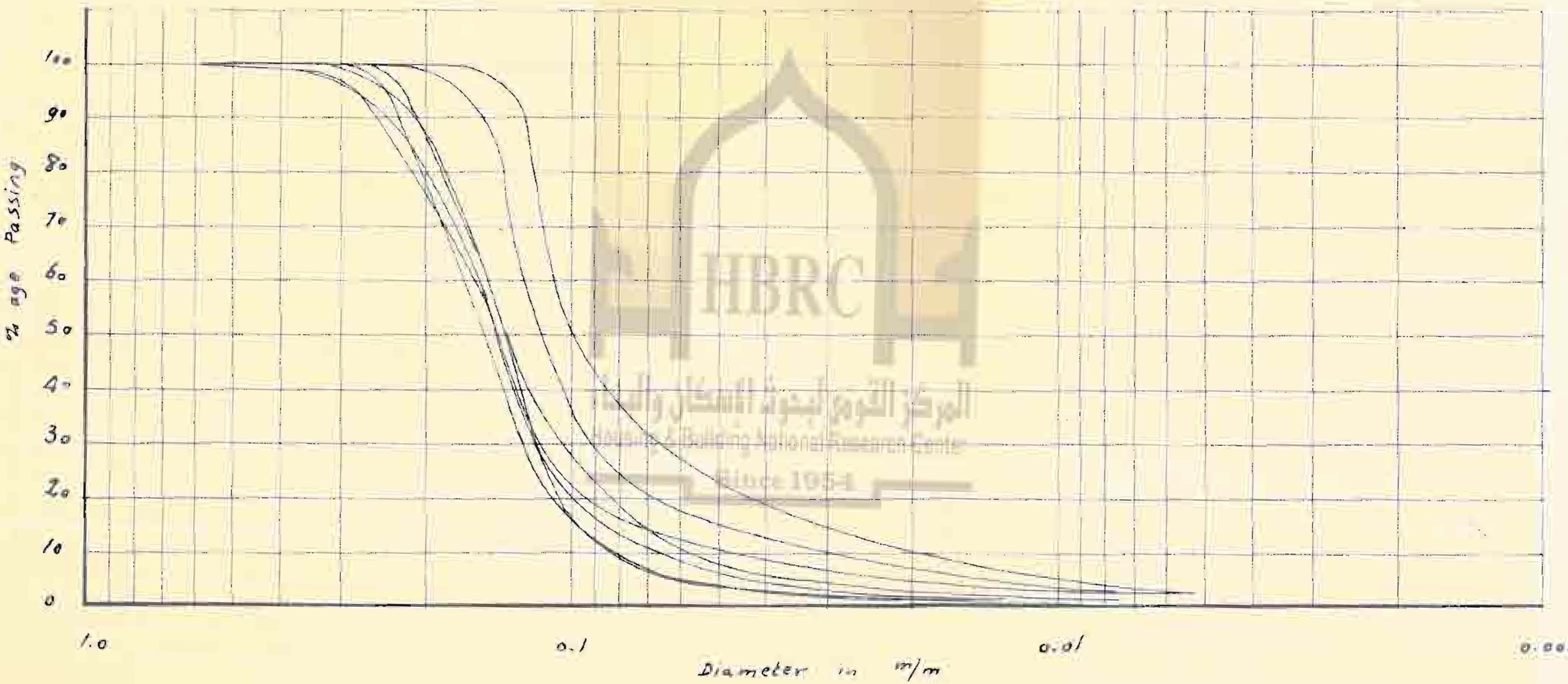
Limits of Consistency

Sample №	Liquid Limit	Plastic Limit	Shrinkage Limit
1	67.0 %	22.9 %	10.8 %
2	53.0 %	22.9 %	15.2 %
3	39.0 %	22.4 %	19.0 %
4	33.7 %	18.6 %	16.6 %
5	45.0 %	22.6 %	16.9 %
6	35.0 %	19.7 %	17.8 %

MIX OF CLAY AND SAND FROM VARIOUS WORKS USED IN BRICKWORKING



GRADING CURVES OF DIFFERENT SAND SAMPLES TO BE MIXED WITH CLAY FOR BRICKWORKING



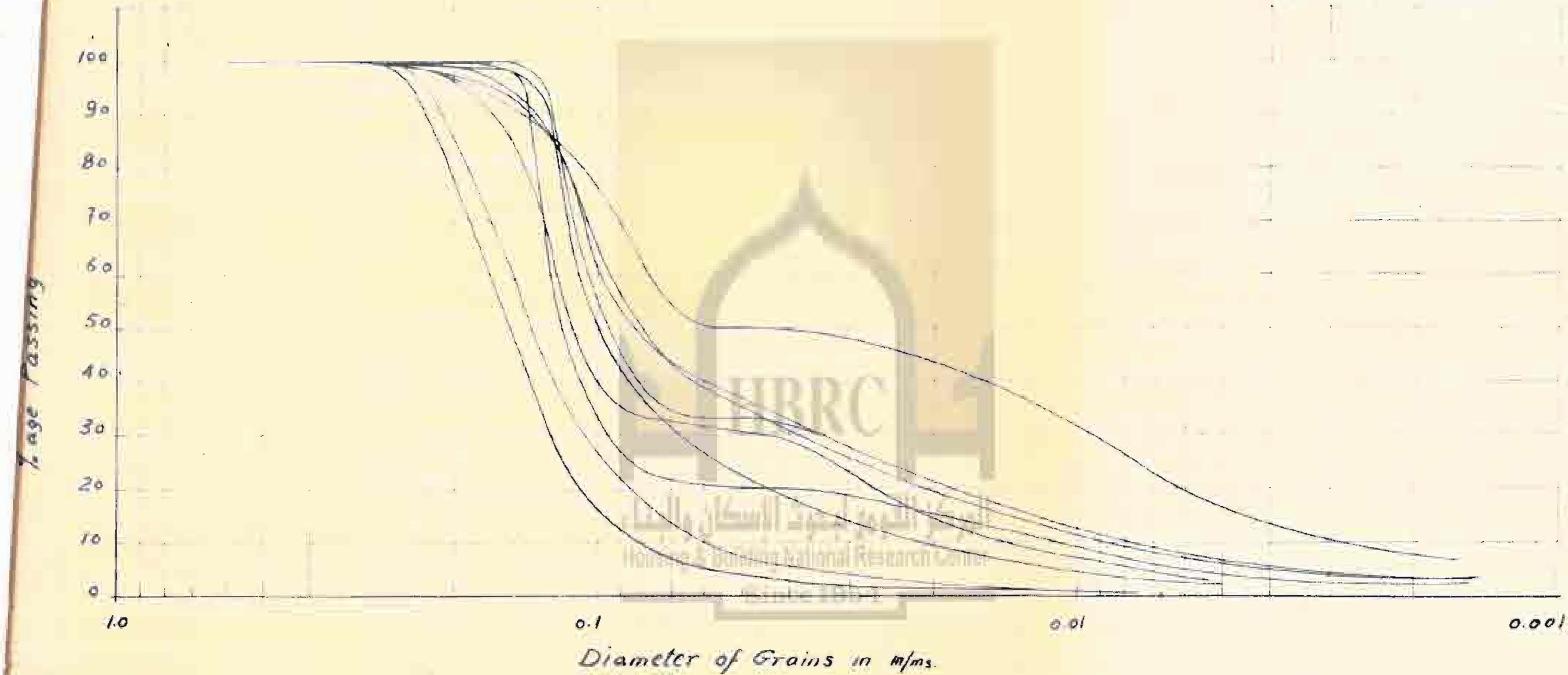

100
90
80
70
60
50
40
30
20
10
0
%age Passing
1.0
0.1
0.01
0.001
Diameter of Grains in m/ms.

Figure shows some grain - size curves for ready mixed clay and sand for use in brick making.

Figure shows some grain - size curves for sand to be mixed with clay.

2 - DETERMINATION OF LIQUID, PLASTIC AND SHRINKAGE LIMITS:

The knowledge of these limits helps to realise the characteristics of the clay.

The liquid limit is defined as the water content at which half an inch length of the groove in Casagrade Apparatus is closed at 25 blows.

The Plastic Limit or lower limit of the plastic state is the water content at which the clay begins to crumble when rolled into thin threads.

The Shrinkage Limit or lower limit of volume change, is the water content below which further loss of water by evaporation does not result in a reduction of volume.

Figure shows the above mentioned limits for the clay samples taken from the silt trap, while Fig. shows the limits for the ready mixed clay and sand.

3 - LINEAR SHRINKAGE:

In addition to the forgoing laboratory tests carried out on clay, other tests were made on site on view of measuring ~~linear on specimens of~~ drying and firing shrinkage of bricks under the actual condition of industry The specimens were full size bricks.

The size of the mould were measured to the nearest 0.10 mm. by a sliding caliber and these measurements were considered the dimensions of the green soft bricks. Measurement were taken on ten bricks after 24 hours, and also bricks dried white hand. The difference between the last and the first gave the total contraction on drying.

For getting firing shrinkage, measurements were taken on fired bricks and the difference between these and that of dried green bricks gave the linear shrinkage as shown on table:-

Linear shrinkage of green and fired bricks

No. of Survey	1				2				3			
dimensions of mould = that of soft green brick	length	breadth	depth	vol.	l	b	d	v	l	b	d	v
	27	13	8.25	2895	27	13	8.4	2948	27	13	8.3	2913
dim. after 24 hours	25.98	12.43	7.64	2467	26.10	12.6	7.79	2562	26.1	12.6	7.8	2565
% shrinkage.	3.77	4.38	7.39	14.8	3.148	3.076	7.26	13.2	3.33	3.07	6.02	11.8
dim. after drying	25.70	12.30	7.73	2443	25.83	12.22	7.46	2354	25.64	12.2	7.60	2377
% shrinkage	4.81	5.39	6.30	15.73	4.33	6.00	11.1	20.3	5.03	6.15	8.43	18.2
dim. after firing	25.36	11.93	7.55	2284	25.77	1217	7.4	2336	25.48	11.90	7.40	2243
% shrinkage.	6.07	8.23	8.47	21.2	4.55	6.38	10.1	21.0	5.62	8.46	10.84	23

4 - CHEMICAL ANALYSIS OF CLAY:

The samples taken from the silt trap were the subject of this analysis.

	Sand Samples			Clay samples					
No.	7	8	9	2	5	1	4	3	6
Moisture content.	0.74%	1.26%	0.63%	3.69%	4.01%	1.56%	2.41%	1.54%	1.75%
Loss due to ignition	3.13	6.16	2.93	11.26	13.22	8.33	8.38	10.19	9.66
Silica & unsolved oxides	87.52	77%	88.12	62.29	56.61	71.39	70.31	69.72	67.52
Iron & Aluminium "	7.49	13.52	6.80	23.35	25.55	16.46	18.43	15.85	19.34
Calcium oxides	1.14	2.50	1.05	2.56	4.14	3.04	2.25	3.47	2.98
Magnizium oxides	....	Neglegible	....	....	....	....	....	....	....
Total	99.19	99.18	98.99	99.46	99.51	99.22	99.37	99.23	99.50

N.B. 1 :

Mica is present in sand and can be seen by eye and percentage of Magnezium oxides is very small and it's estimation is neglected. All of these figures are without appoximation.

N.B. 2:
Qunatity of magnezium oxide is very small can be neglected.

B - BRICKS

The survey samples were taken in such a way that they were as representative as possible of the current output. They were submitted to the following available tests.

1 - Determination of compressive strength.
2 - Water absorption (5 - hours immersion).
3 - Measurement of linear drying and firing shrinkage.

Further tests shall be carried out in view of getting:

4 - Chemical analysis.
5 - Calculation of saturation coefficient.
6 - Analysis of soluble salts.
7 - Efflorescence test.
8 - Water absorption - 5 - hours in boiling water and after 24 hours in ordinary water.
9 - Changes in the porosity and compressive strength at different temperature of burning.

1 - COMPRESSIVE STRENGTH:

Five full size bricks with approximately plane and parallel ends are tested as follows:

i - The two flatawise faces of each brick are coated with a thin coat of neat paste of cement mortar (cement + sand with the ratio 1 : 1), that has been spread on an oiled nonabsorbent machined metal plate. 24 hours have been elapsed before testing.

ii - All specimens were tested flatawise.

iii - The upper bearing of the testing machine is a spherically seated, the centre of the sphere lies at the centre of the surface of the block in contact with the specimens.

iv - The load was applied at the rate of 140 kgs/cm^2 /minute, which conforms to B.S.S. (2000 lb/in/minute.)

v - The average compressive strength of all the specimens tested are reported as the compressive strength of the lot of bricks.

vi - The results are summeraised in the following table.

	1	2	3	4
Maximum Strength kg/cm^2	57.00	~~30.60~~ 41.5	45.50	53.00
Minimum " "	30.60	29.50	29.70	32.50
Average " "	45.50	35.00	38.2	44.20

2 - WATER ABSORPTION:

The tests were applied on 3 whole bricks for each of works surveyed.

Procedure for 5-hours immersion:

i - The bricks were dried to constant weight in an oven at 110° C.
ii - When cool, each specimen was weighed in a balance sensitive to within 0.5 gm.
iii - The dry bricks were completely immersed in clean water at 27° C for 5 hours.
iv - Each brick was removed, the surface water was wiped off with a damp cloth, and the brick was weighed.
v - The absorption results were reported in terms of weight, and calculated as follows:

Absorption per cent, by weight after 5 hours immersion

$$= \frac{100 (B - B_1)}{B}$$

Where B_1 = weight of dry brick.
B = weight of the brick after 5 hours' immersion in cold water.

vi - The average results are tabulated as follows:

	1	2	3
Max percent absorption	22	24	23.8
Min. per cent absorption	20.3	16.55	21.2
Aver. per cent absorption	21.33	19.70	22.9

3 - MEASUREMENT OF LINEAR DRYING AND FIRING SHRINKAGE:

See tests on clay.