POST GRADUATE SCHOOL (PGS)

FEDERAL UNIVERSITY OF TECHNOLOGY,

MINNA

DETERMINATION OF THERMAL CONDUCTIVITY OF YAM USING LINE HEAT SOURCE TECHNIQUE.

BY

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APPROVAL PAGE

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A PROJECT REPORT
SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF
POST-GRADUATE DIPLOMA(PGD) IN AGRICULTURAL ENGINEERING
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APPROVED BY

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PROJECT SUPERVISOR ____________________ SIGN/DATE

ENGR. DR M.G. YISA

HEAD OF DEPARTMENT ____________________ SIGN/DATE

CONTENTS

DEDICATION

This work is dedicated to my family and farmers

QUOTATION

Bestower, thou art my patron both in this life and hereafter and join me with the righteous.

Imran

ACKNOWLEDMENT

All gratitude belong to Allah , the all knower who taught mankind what he knew not. Then my sincere appreciation goes to the entire lecturers of the department of Agricultural Engineering F. U. T Minna, who saw me through the successful completion of my course and most especially my supervisor Engr. Onuochu Anthony Chukwunyere.

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A. B. MOHAMMED.

NOTATIONS

A	Cross-sectional area, m^2
Ar	Surface area, m^2
Bi	Biot number for heat transfer
C	Specific heat at constant pressure, J/kg^0C
D	Diameter of a material, mm, cm, m
h	Unit surface conductance
H	calorific value, KJ/Kg
K	Bulk or Particle thermal conductivity w/m^0c
Kp, Ku	Apparent thermal conductivity of yam for peeled and unpeeled.
L	Length of sample, cm
m	Mass of sample, kg
q	Constant strength line heat source or heat flux, w
q_1	Internally generated heat by a material, J
Q	Quantity of heat by energy, J
r	Radial distance, mm, cm or m
rp, ru, rw,	Radius of peeled, unpeeled and heater wires, mm
R	Thermal resistance, ok/w
R_1R_2,	Thermal resistance of peeled and unpeeled yam
R^2	Coefficient of determination, %
S	Slope
t_1	Observed initial temperature, ^0C
t_2	Observed final temperature, ^0C
t	Temperature ^0C
V	Volume, M^3
Z	Axial distance, mm, cm, m
θ	Time, min
θ_I	Time at point(i) on a plot
μ	Azimuth angle
P	Density, Kg/m^3

DETERMINATION OF THERMAL CONDUCTIVITY OF YAM USING LINE HEAT SOURCE TECHNIQUE

ABSTRACT

The thermal conductivity for yam was measured experimentally using line heat source technique. The apparatus was set up and test run for many replicates of yam samples and the mean K was found to be

0.9216 w/m^{0}c for peeled yam and 0.4546 w/m^{0}c for unpeeled samples as against 0.722 w/m^{0}c and 0.521 w/m^{0}c obtained from literature.

The line heat source technique consists of a 19mm thick ply wood box measuring 30cm and 15cm. One of the longitudinal inside faces carry centrally placed wooden battens projecting towards the centre by a length of yam. Each batten has a corresponding bolt on the other side spaced 4cm apart.

A michrome resistant wire of 48ohms per meter and 10 cm long was used as thermocouples.

Power supply was given by an accumulator of 12 voltage capacity. A variable resistor was used to control the current flow. A read out potentiometer was used to indicate the corresponding millivolt current through the samples. The yam samples used were from fresh yam tubers bought from the market.

CHAPTER ONE

INTRODUCTION

NATURE OF THE PROBLEM

It is a fact that researches were carried out in the areas of thermophysical properties of Engineering materials while that of Agricultural and food products were lagged behind, because of its variety nature anisotropy and heterogenity (Anazodo and Noris 1981).

In the design and analysis of machine for processing and systems involving processing and heat treatment, thermal conductivity of the material involved becomes very necessary as the design engineer needs to know more than the specific heat capacity of the material involved for proper designing.

However, (Ezeike 1984) determine the calorific value of some Biological materials including corn cobs, rice husk, kernel husk as a prelude to use this materials as solid fuels.

(Ijabo 1984) used line heat source method in determining thermal conductivity of corn cob and (Onuachu 1992) also used the same method of line heat source to determine thermal conductivity of plantain.

It is in line with these mentioned researchers that this project is being attempted to determine the thermal conductivity of yam using line heat source technique, so as to contribute to the thermal conductitivity data.

OBJECTIVES AND SCOPE

The objectives of this project are:-

To obtain by experiment the thermal conductivity of yam (peeled and unpeeled)

To determine the applicability of using line heat source technique in determining thermal conductivity of material.

To compare the thermal conductivities of peeled and unpeeled yam.

JUSTIFICATION

Yam (Diorscorea rotundata) one of the most important tuber crops grown for food in the west and central Africa. The yam zone in west-Africa streches from Cote de Ivoire to Cameroun along the costa areas, where some six hundred million people obtain more than two hundred dietary calories of energy per person per day from yam. (RCMRM NO 11) elasticity of demand for root and tuber-based food system.

West and central Africa produce 93% of the world's yam production, with Nigeria alone producing 75% of the total and south eastern Nigeria having a total of 42% of the world yam production. (F.O.S 1983, IITA 1988).

In Nigeria, yam is produced in commercial quantity in the following states: Benue, Imo, Enugu, Edo, Delta, Akwa Ibom, Cross River, Osun, Ogun part of Taraba and east of River Niger.

Yam is being used as a staple food by many both within and outside Nigeria. Yam is eaten in many forms as either boiled, roasted, fried, beaten(pounded yam) and yam chips. It is important to note that in whichever form yam is eaten it evolves a system of heat transfer.

Therefore, the knowledge of yam's thermal conductivity becomes necessary for Agricultural Engineer to adequately process or design a suitable processing equipment in the yam processing industry.

The specific heat of yam would have sufficed when estimating the total amount of heat to be added or removed during it's processing, but the Engineer must also know the rate of heat transfer for efficient design which depends on the thermal conductivity of the product.

Based on the Nigeria's contribution in the world yam production (up to 42%), there are abundant yam produce especially at the period of harvest which usually waste away, resulting in low income of the farmers by selling there produce at give away prices. But if these yam produce were to be processed into yam chips, yam flour and properly stored, it last longer and yet maintains it's palatability and would attract higher prices at the period of scarcity. (Dr Ajishegiri).

The processed food last longer than when left in it's original unprocessed condition (Dr. Ajishegiri). Therefore the knowledge of thermal conductivity of yam becomes inevitable by the design Engineer for efficient processing and designing of an equipment/machine for yam processing industry. Justifying the timeliness of this project for the yam producing areas.

CHAPTER TWO

THERMAL PROPERTIES OF BIOMATERIALS AND EXPLANATION OF TERMS:-

Some important theoretical and experimental researches have been carried out on thermal properties involving Agricultural and food processing materials, leading to a lot of literature in the area.

SPECIFIC HEAT:-

This is the quantity of heat required to change the temperature of a unit mass of material by $1^{o}c$.

$$C = \frac{Q}{(\rho V)\triangle t}$$

where C = Specific heat, J/kg

ρ = Density, kg/m^3

V = Volume, m^3

$\triangle t$ = Temperature rise, i.e. ^0C

This thermal property can be given either as specific heat at constant volume, CV or at constant pressure CP, depending on how heat is stored in the material.

Problems involving heat transfer in agricultural materials often occur at constant pressure since pressure dependence of specific heat is very little for solids and liquids at normal pressures.

THERMAL CONDUCTIVITY

When the temperature gradient, $\delta t/\delta x$, between two surfaces through which heat is flowing is unity, the quantity of heat q, that will flow in unit time across unit area, A, is called the thermal conductivity, K. The S.I unit is w/m^0k . The thermal conductivity , K, of solid engineering materials vary with the material temperature and moisture content. Hence, biological material known to be non-homogeneous and of varying cellular structure, composition, and air content will give greater variation in thermal conductivity than for non-biomaterials. This property plays a central role in heat propagation within a solid medium.

THERMAL DIFFUSIVITY

The rate at which heat is diffused in a material is termed thermal diffusivity. This is expressed in relation to the other thermal properties as:

$$\alpha_1 = \frac{K}{C_p\rho}$$

Where α = Thermal diffusivity m^2/s

K = Thermal conductivity w/m^0c

C_p = Specific heat at constant pressure, J/kg^0c

ρ = Density, kg/m^3

UNIT SURFACE CONDUCTIVITY, h

The unit surface conductance, h, can also be referred to as heat transfer coefficient . This term essentially refers to thermal conductivity of a relatively stagnant layer of fluid that is assumed to adhere to the surface of the solid during heating or cooling irrespective of the specific term used. Unit surface Conductance is the proportionality factor in the convection equation.

$$Q = h A \triangle t$$

Where q = Quantity of heat

h = Unit surface conductance

A = Surface area, m^2

$\triangle t$ = Temperature rise, ^0c

.5 BIOT NUMBER, Bi

Biot number is one of the dimensionless group of physical properties and engineering parameters used frequently in heat and mass transfer problems. The ratio of internal resistance to heat flow to external resistance is called the biot number. The equation normally used in evaluating it is given by

$$Bi = \frac{hl}{K}$$

h = Unit surface conductance

l = Length of material

K = Thermal conductivity.

2 SOME THERMAL PROPERTY VALUES OBTAINED FROM THE

EXPLANATION OF TERMS:

Summary of the values for some common agricultural and biomaterials obtained from various sources

literature, converted to S.I Units by Smith(1978)

Summary of values of thermal properties of some agricultural materials obtained literature an converted to S.I Units.

Property I	Material II	Range of property value III	Range of Moisture Content % wb IV	Range of values of Temperature °c V	Method VI	Sources VII
K	Spanish Peanuts	(w/°c)	-	-		
	(a) Pods	0.0450-0.0727	6.32	4.4-37.78	TCP	Sucter et al., 1975
	(b) Whole Kernels	0.1108-0.1693	6.00	25	TCP & Computer	Sucter et al., 1975
	(c) Ground kernels	0.1125-0.1284	6.00	4.4-37.78	TCP	" "
	(d) Ground hulls	0.0524-0.0611	4.30	4.4-37.78	TCP	" "
	Wheat	0.1184-0.1412	0-17	8.89-23.33	LHS	Kazarian & wall (1965)
	Corn kernels	0.1406-0.1766	0-23	20.55-53.22	LHS	" "
	White Garri	0.1490-0.1880	16-15	32-58	TCP	" "
	Oiled Garri	0.1940	16.4	62	TCP	Ezeima (1976), Odigboh ('78)
	Milled Rice	0.290-0.310	14.29	42-75	TCP	" " " " " " " "
	Milled Rice	0.069-0.302	14-29	12-97	FITCH	Babarinsa ('76) Odigboh('78)
	Meat perpendicular to fiber					
	(a) Raw	0.483-0.522	74	12-70	FITCH	Odighoh (1976)
	(b) Boiled	0.438-0.510	71	10-70	FITCH	" "
	Potatoes white	0.533-0.571	81-84	24-26	LHS	Rao et al. (1975)
	Squash citrus	0.500-0.533	87-94	24-26	LHS	" " " "
	Saw dust	0.0415	-	22.89	TCP	Mohsemin (1980)
	Butter	0.1973	-	3.56	TCP	" "
	Yam middle segment					
	(a) Ji Igwe	0.521-0.663	-59	42-64	TCP	Ezeima (76) Odigbo (78)
	(b) Ji Uturu	0.603	-59	60.5	TCP	" " " "
	(c) Ji Aga	0.722	-64	59.2	TCP	" " " "
	(d) Ji Obiora	0.445-0.637	-50.6	10.97	FITCH	Babarinsa (76) Odigooh (78
	(e) Ji Aga	0.547-0.714	-51	12-97	FITCH	" " " "

Property I	Material II	Range of property value III	Range of Moisture Content % wb IV	Range of values of Temperature ^{0}c V	Method VI	Sources VII
		(KJ/Kg^{0}c)				
	Peanut kernels	0-4.376	0-1	32-57	DSC	Young & Whitaker (1973)
	Peanut hulls	1.5497-4.326	0-1	32-57	DSC	" " " "
	Spanish peanut				Method	
	(a) Pods	2.301-3.974	23-48	4.4-37.78	of Mixture	Sucter et al., 1975
	(b) Kernels	2.719-3.346	23	"	"	" "
	(c) hulls	2.301-4.183	23	"	"	" "
	(c) Single whole	1.589-2.928	23-48	20-29.4	Calorimetr	" "
	Wheat	1.594-2.204	0-17	10.56-32.22	y	Wright & Poterfield('70)
	Corn kernels	1.447-2.459	0.23	12.22-28.89	Method Of	
	Corn kernels	1.447-2.459	0.23	12.22-28.89	Mixture	Kazarian & Hall(1965)
	Tobacco	1.428-4.112	0.80	40-75	"	Chakrabati & Johnson (1972)
					DSC	
		(x 10^{-7}(m^2/s)				
	Spanish peanuts					
	(a) Ground Hulls	1.1096-0.80	4.3	4.4-37.8	TCP	Sucter et al., 1975
	(b) Ground Hulls	1.4194-0.9032		"	TCP	" " " "
	(c) Whole peanuts	0.7226-0.5419	6	"	TCP	" " " "
	Wheat	0.929-16.28	0.17	8.8-23.3	LHS	kazarian & Hall (2975)
	"	18.58	-	22.8	TCP	Mohsenin (1988)
	Corn kernels	1.030-0.859	0-23	8,.8-23.3	LHS	Kazarian & Hall (1965)
	Squash citrus	1.47-1.63	87-94	24-26	LHS	Rao et al. (1975)

FACTORS AFFECTING THERMAL CONDUCTIVITY

There are many factors on which numerical values of thermal properties of agricultural biological materials could depend. These factors include: chemical composition, physical structure, the state of the substance, temperature, density, moisture content and genetic factors.

3.1 EFFECT OF TEMPERATURE

The effect of temperature on thermal conductivity and specific heat cannot be over-emphasized. For many structural materials particularly some metals, the relationship is well pronounced. Nevertheless, thermal properties of a limited number of biological materials follow a metallic pattern (Mohsenin, 1980).Under experimental conditions, the temperature effect could be considered by taking the mean property between available values at the extremes of the expected temperature range. In general thermal conductivity increases with the increase in temperature for food and Agricultural products.

3.2 EFFECT OF MOISTURE CONTENT

The effect of moisture content on k can be seen in two ways. One is to consider the bolstering effect, moisture has on k at given moisture contents due to Dufour effect. This coupling effect is brought about by moisture migration (mass transfer) which occurs only when a temperature difference exists in a permeable moist medium. This effect results in evaporation in the warm region, and transmission of vapour by diffusion to the cooler region, in most cases. Transmission by this mechanism, which is in addition to the heat transfer by conduction, is largely in the form of latent heat under such a condition. This phenomenon of moisture migration could result in an exaggerated value of k of the material under test. (Moole, 1953) and (Mohsenin, 1980).

Another way of viewing the effect of moisture content on the thermal property is in terms of pattern of variation for deliberately changed values of moisture content. In general, K and specific heat of biological materials have linear relationship with moisture content. (Mohsenin 1980). Indicated this linear regression of K on moisture content for oats and red delicious apples. Sweat (1974), however pointed out that k has a low linear co relation with moisture for apples because of the large amount of air space in it.

.3 DENSITY AND PARTICLE SIZE EFFECTS

The effect of bulk density on thermal conductivity of unconsolidated food materials like yam flour, and milled rice, and gari, as reported by Makinde (1977) indicated that K increases with increasing bulk density. Jasansky and Bilansky (1973) worked on the effect of bulk density and particle size on thermal properties of whole, crushed powdered soyabeans . They concluded that K increase with increase in dimension of the particle which agreed with Bilanski & Fisher, (1976).

3.4 OTHER FACTORS

There are variations of K with genetic factors deduced from the differences of K and other thermal properties values obtained for various varieties of the same crop. The different values or regression lines obtained for corn kernels and wheat (Kazarian Hall, 1965) ; potatoes (Rao, et, al 1975) confirmed this assertion.

.4 TECHNIQUES FOR DETERMINING THERMAL CONDUCTIVITY OF AGRICTULRAL PRODUCTS

Research has shown that there are about ten methods of measurements thermal conductivity employed by various researchers for agricultural and biomaterials (Mohsenin, 1980). Nevertheless, these can be divided into two categories: the steady state condition of heat transfer methods and unsteady state methods. Experimental techniques for measurement under each of the two categories are as follows:

1 **STEADY STATE, APPROXIMATION METHOD, STEADY STATE LONGITUDNAL HEAT FLOW METHODS**

The guarded hot plate which is widely used for the measurement of K of poor conductors of heat is typical of this class. Since the method is most suitable for dry homogeneous specimens in slab forms, it will be unsuitable for yam in this study;

STEADY STATE RADIAL HEAT FLOW METHODS

Where as the longitudinal heat flow methods are not suitable for slab specimen, the radial heat flow techniques are used for conductivity measurements of loosed, unconsolidated powder or granular materials. This is one of the easiest known methods used in the measurement of k of grains in a bid to understand the thermogenic process instored high moisture oats developing " heat pockets". (Mohseini, 1980)

4.2 **NON- STEADY STATE METHODS**

Transient methods for the measurement of K essentially make use of either a line heat source or one or more plane sources of heat. In either category the usual procedure is to apply a steady heat flux to the specimen which must have being in thermal equilibrium initially. Then the temperature rise at some points in the sample resulting from the applied flux is measured. The advantages acclaimed to this methods are that they are less complicated and much simpler than steady state ones. Another superiority is the reduction in moisture temperature coupling effects.

FITCH METHODS

Fitch methods is one of the most common transient methods applied to measurement of thermal conductivity of poor conductors. The apparatus is available in a commercial form. Essentially, it requires sandwiching a regular cross section of the test sample between the heat source and sink. Babarinsa (1976) used this technique to determine K of some Nigerian food materials like cassava and plantain and gari. Odigboh, (1977) compared Babarinsa's results with those obtained by Ezeima (1976) using thermal conductivity probe (TCP).

THERMAL CONDUCTIVITY PROBE

This method involves the use of a circular cylinder of a material which has a good thermal conductivity, which can be either solid with a small needle or hollow with a thick wall so that the radial temperature difference in the probe is provided with a heater wire insulated over its length and some means of measuring temperature at the centre of its length.

When measuring the thermal conductivity of a material, the probe is either buried in the external medium whose thermal conductivity is being measured, such as is the case of granular materials, or inserted in a long hole, in the case of solid materials.

LINE HEAT SOURCE TECHNIQUE

This technique utilises a constant heat source on an infinite solid along a line with infinitesimal diameter, such as a thin resistance wire. In using this technique, subject to the sample diameter, it would be necessary to identify time and current values that allow for minimum heat loss to the surrounding. A maximum of ten minute is that recorded for most materials (Kazarian & Hall, 1965). Rao et al. (1973) worked with potato and recommended the cutting of such into halves before passing the wire and reclamping . This method is suitable for yam and hence is preferred to the other two methods in this study.

OTHER METHODS

There are many other methods including the plane heat source, statistical modeling (Mohsenin, 1980) frequency response (Otten, 1974) and packed Bed analysis (Luikov et al, 1968) that the length to diameter ratio of 25 % to 100 for the heater wire be used to allow for a negligible axial flow.

Some other basic assumptions include-:

(i) Thermal conductivity is constant within certain temperature range, i.e. room temperature.

(ii) Thermal conductivity is constant within each component when heat flow is radial.

(iii) Neglecting the effect of the three micro-structural component, an effective thermal conductivity could be found.

(iv) The Yam is not generating heat of it's own internally.

(v) The Yam is Opaque and temperature variation is minimal, so radiant heat transfer through the solid can be neglected.

(vi) Yam is of solid fact, hence mode of energy transfer is assumed to be by molecular transport only

(vii) There is symmetry with respect to geometric axis of the sample.

CHAPTER THREE

EXPERIMENTAL WORK

TEST APPARATUS:

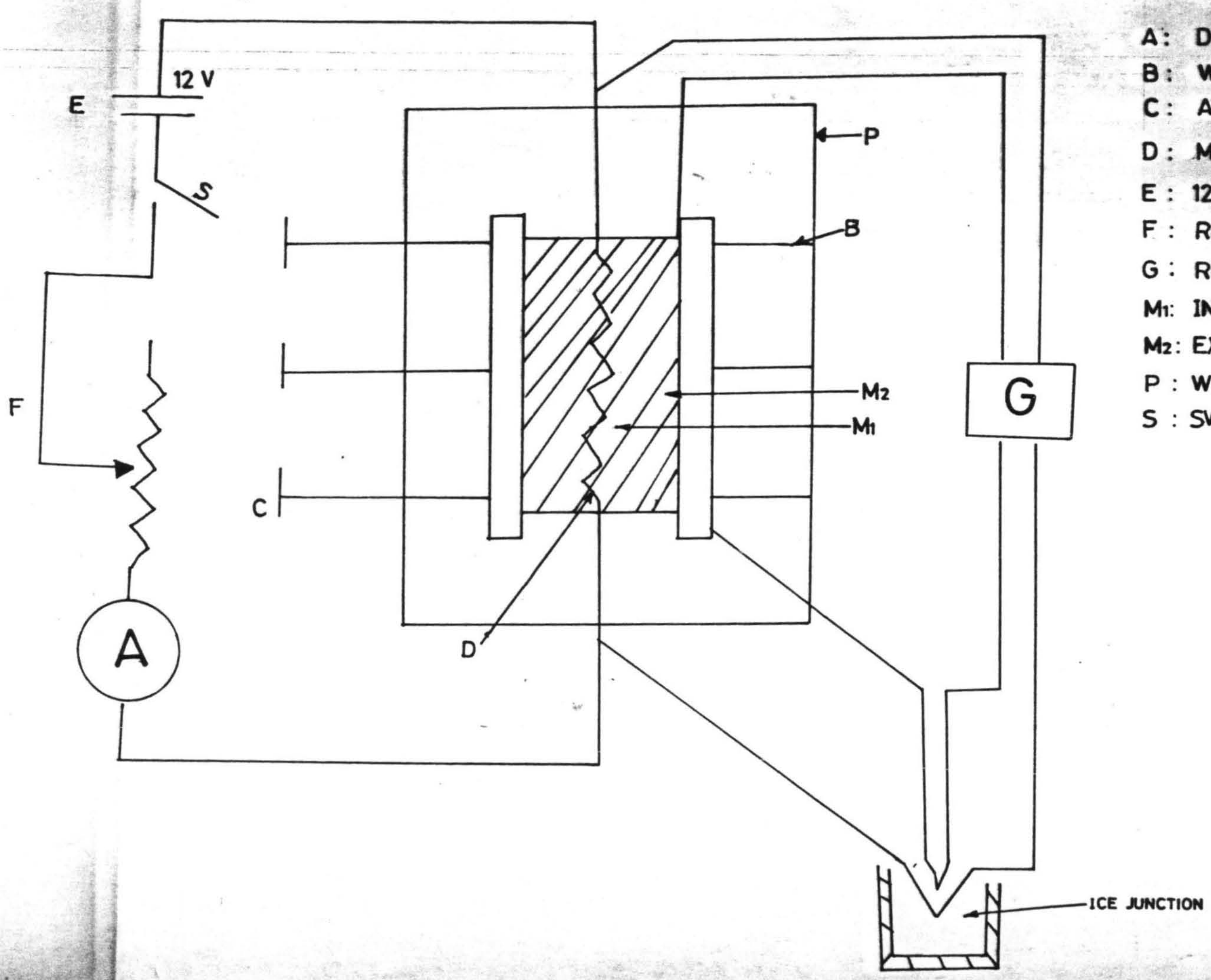
This consist of a 19mm thick ply wood box (p)

measuring 30cm x 15cm. One of the longitudinal inside faces carrying centrally placed wooden battens (B) projecting towards the centre of the box by a length of 7cm. Each Batten has a cross section of 2cm x 2cm. On the opposite side face are long screwing bolts (c) corresponding to each of the three batten figures, placed at 4cm intervals. At the centre of one of the faces of the box is a drilled hole of diameter 1cm which is for introducing the thermocouple wires and heater wire lead. A michrome resistant heater wire (D) with resistance of 48 ohms per meter and 10cm long was used.

The heater wire was completely embedded in the central length of the yam sample. A 12 Voltage accumulator (E) was used to supply power for the system. The current flow in the circuit was controlled using a variable rheostat (F) and a switch (S) The current across the load was read directly from an ammeter (A). Guaged copper thermocouple wires (M_1) & M_2 were used to measure the temperature. A direct current read out Potentiometer (G) was used for millivolt indications.

Below is the schematic diagram of the set up apparatus of line heat source determination of thermal conductivity.

SCHEMATIC DIAGRAM OF LINE HEAT SOURCE TECHNIQUE APPARATUS FOR THERMAL CONDUCTIVITY DETERMINATION



KEY

A: D.C. AMMETER
B: WOODEN BATTEN
C: ADJUSTABLE SCREW BOLT
D: MICHROME RESISTANT WIRE
E: 12 VOLTAGE ACCUMULATOR
F: RHEOSTAT
G: READ-OUT POTENTIOMETER
M_1: INTERNAL THERMOCOUPLE
M_2: EXTERNAL THERMOCOUPLE
P: WOODEN BOX
S: SWITCH

3.2 PRELIMINARY TESTS

The apparatus was run on preliminary test after been assembled to check the suitability of all connected wires and proper functioning of the potentiometer, Ammeter and the current flow. Other physical measurable properties of yam samples were taken including the size and weight.

3.3 EXPERIMENTAL PROCEDURE

Fresh yam tubers (Giwa) was bought from the local market and was used in the labouratory for experimental work.

Selected central portions of yam tubers were marked off using vernier caliper and cut into halves by means of a sharp knife, making sure that there were no grooves made on the cut surfaces.

In conducting the test for the peeled, the unpeeled yam was carefully peeled to separate the peeled yam and it's outer cover. The peeled yam was then cut into halves of cylindrical shapes of ten different sizes. The samples were clamped into position one after the other by the finger like batten and screw bolt, after having carefully pass through the thermocouple wire through the pith central portion of the yam sample, and this forms the hot junctions. The second thermocouple was placed between the cylindrical boundary so as to check any temperature rise at the boundary. About two minutes was allowed for the system to equilibrate before the box was closed, and the power switched on. The temperature of the thermocouple were first noted.

Then the potentiometer readings were taken at intervals of half a minute for 5 minutes. simultaneously, other physical properties of the yam samples were been determined by the helping hands. The same procedure was carried out for 10 samples of peeled and unpeeled yams.

CHAPTER FOUR

EXPERIMENTAL RESULTS

4.1 CALCULATION OF THERMAL CONDUCTIVITY BY USE OF POTENTIOMETER READINGS

Considering a material sample(sample A) with the following measured physical properties:-

Diameter of sample = 5cm

Length of the sample = 9cm

Weight of the sample = 192g

Current use = 2.2A

Condition of sample = (Peeled)

Potentiometer readings = 1.18(mv) at 1.5min

" = 1.197(mv) at 5min.

The potentiometer readings are converted to temperature with the relationship

$$T^0C = 2.16 + 23.2(mv)$$

Where T^0C = temperature in degree centigrade

2.16 = constant

23.2 = conversion factor

mv = potentiometer values (emf)

Then at 1.5th Min, $T^0C = 1.18 \times 23.2 + 2.16 = 43.456^0C$

at 5th Min , $T^0C = 1.97 \times 23.2 + 2.16 = 47.864^0C$

Introducing the working equation ie $K = (q/4\Pi) \ \dfrac{\ln(\theta_2 - \theta_1)/(\theta_1 - \theta_2)}{(t_2 - t_1)}$

The heat input $q = I^2 R$

Where I is the current used and R is the total resistance of the heater wire

$\therefore$ $R = (48 \times 0.1)$ ohm.

$I^2 = (2.2)^2$ Amps.

Substituting these values into the working equation

$$K = \frac{I^2 R}{4\Pi} \ \frac{\ln(\theta_2/\theta_1)}{(t_2 - t_1)}$$

$$= \frac{(2.2)^2(48 \times 0.1)}{4\Pi} \ \frac{\ln(5/1.5)}{(47.864 - 43.456)}$$

$$= \underline{\underline{0.7586 w/m^0c}}$$

Similar procedures were followed in calculating the thermal conductivities for the unpeeled samples.

4.2.1a POTENTIOMETER READINGS FOR THE PEELED YAM SAMPLES

SAMPLE 1

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.78
2	1	1.80
3	1.5	1.82
4	2	1.84
5	2.5	1.86
6	3	1.89
7	3.5	1.91
8	4	1.94
9	4.5	1.95
10	5	1.97

Sample Diameter = 5cm

Sample Length = 9cm

Sample Weight = 192g

Current used =2.2A

M.C = 71%wb

AMPLE 2

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.79
2	1	1.80
3	1.5	1.81
4	2	1.83
5	2.5	1.85
6	3	1.86
7	3.5	1.88
8	4	1.90
9	4.5	1.92
10	5	1.94

Sample Diameter = 4.5cm

Sample Length = 8cm

Sample Weight = 188g

Current used =2.2A

M.C = 74%wb

SAMPLE 3 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.80
2	1	1.82
3	1.5	1.84
4	2	1.86
5	2.5	1.87
6	3	1.88
7	3.5	1.90
8	4	1.91
9	4.5	1.93
10	5	1.95

Sample Diameter = 3.3cm

Sample Length = 8cm

Sample Weight = 162g

Current used =2.2A

M.C = 72%wb

SAMPLE 4 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.80
2	1	1.83
3	1.5	1.84
4	2	1.86
5	2.5	1.89
6	3	1.91
7	3.5	1.94
8	4	1.97
9	4.5	1.98
10	5	1.99

Sample Diameter = 5.0cm

Sample Length = 8.8cm

Sample Weight = 191g

Current used =2.2A

M.C = 75%wb

SAMPLE 5 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.77
2	1	1.78
3	1.5	1.79
4	2	1.81
5	2.5	1.83
6	3	1.84
7	3.5	1.86
8	4	1.88
9	4.5	1.89
10	5	1.91

Sample Diameter = 4.0cm

Sample Length = 9cm

Sample Weight = 184g

Current used =2.2A

M.C = 74%wb

SAMPLE 6 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.78
2	1	1.79
3	1.5	1.79
4	2	1.80
5	2.5	1.81
6	3	1.82
7	3.5	1.83
8	4	1.85
9	4.5	1.87
10	5	1.90

Sample Diameter = 3.5cm

Sample Length = 8cm

Sample Weight = 164g

Current used =2.2A

M.C = 72%wb

SAMPLE 7 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.78
2	1	1.79
3	1.5	1.81
4	2	1.82
5	2.5	1.84
6	3	1.86
7	3.5	1.87
8	4	1.89
9	4.5	1.91
10	5	1.92

Sample Diameter = 3.2cm

Sample Length = 8.2cm

Sample Weight = 160g

Current used =2.2A

M.C = 73%wb

SAMPLE 8 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.77
2	1	1.79
3	1.5	1.79
4	2	1.80
5	2.5	1.82
6	3	1.83
7	3.5	1.85
8	4	1.87
9	4.5	1.89
10	5	1.92

Sample Diameter = 4.0cm

Sample Length = 9cm

Sample Weight = 186g

Current used =2.2A

M.C = 72%wb

SAMPLE 9 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.80
2	1	1.81
3	1.5	1.83
4	2	1.85
5	2.5	1.86
6	3	1.88
7	3.5	1.89
8	4	1.91
9	4.5	1.93
10	5	1.95

Sample Diameter = 4.3cm

Sample Length = 8.6cm

Sample Weight = 183g

Current used =2.2A

M.C = 75%wb

SAMPLE 10 (PEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.79
2	1	1.80
3	1.5	1.80
4	2	1.81
5	2.5	1.83
6	3	1.85
7	3.5	1.86
8	4	1.88
9	4.5	1.90
10	5	1.92

Sample Diameter = 4cm

Sample Length = 8.8cm

Sample Weight = 182g

Current used =2.2A

M.C = 72%wb

4.2.1b POTENTIOMETER READINGS FOR UNPEELED YAM SAMPLES

SAMPLE 1(UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.01
2	1	1.04
3	1.5	1.06
4	2	1.06
5	2.5	1.08
6	3	1.08
7	3.5	1.09
8	4	1.09
9	4.5	1.10
10	5	1.14

Sample Diameter = 6cm

Sample Length = 8cm

Sample Weight = 190g

Current used =1.5A

M.C = 84%wb

SAMPLE 2 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1
2	1	1.01
3	1.5	1.02
4	2	1.04
5	2.5	1.05
6	3	1.06
7	3.5	1.08
8	4	1.09
9	4.5	1.10
10	5	1.12

Sample Diameter = 7cm

Sample Length = 9cm

Sample Weight = 205g

Current used =1.5A

M.C = 86%wb

SAMPLE 3 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.10
2	1	1.16
3	1.5	1.18
4	2	1.20
5	2.5	1.20
6	3	1.21
7	3.5	1.22
8	4	1.23
9	4.5	1.23
10	5	1.24

Sample Diameter = 5cm

Sample Length = 8cm

Sample Weight =166g

Current used =1.5A

M.C = 81%wb

SAMPLE 4 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.04
2	1	1.06
3	1.5	1.09
4	2	1.14
5	2.5	1.18
6	3	1.19
7	3.5	1.19
8	4	1.20
9	4.5	1.20
10	5	1.22

Sample Diameter = 7cm

Sample Length = 10cm

Sample Weight =240g

Current used =1.5A

M.C = 82%wb

SAMPLE 5 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.20
2	1	1.22
3	1.5	1.24
4	2	1.26
5	2.5	1.28
6	3	1.30
7	3.5	1.31
8	4	1.31
9	4.5	1.32
10	5	1.34

Sample Diameter = 5.5cm

Sample Length = 8cm

Sample Weight =185g

Current used =1.5A

M.C = 86%wb

SAMPLE 6 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.20
2	1	1.22
3	1.5	1.24
4	2	1.26
5	2.5	1.28
6	3	1.28
7	3.5	1.30
8	4	1.34
9	4.5	1.35
10	5	1.35

Sample Diameter = 6cm

Sample Length = 9cm

Sample Weight =220g

Current used =1.5A

M.C = 81%wb

SAMPLE 7 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.24
2	1	1.25
3	1.5	1.25
4	2	1.26
5	2.5	1.26
6	3	1.27
7	3.5	1.27
8	4	1.30
9	4.5	1.34
10	5	1.37

Sample Diameter = 6cm

Sample Length = 10cm

Sample Weight =235g

Current used =1.5A

M.C = 86%wb

SAMPLE 8 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.23
2	1	1.24
3	1.5	1.26
4	2	1.28
5	2.5	1.29
6	3	1.29
7	3.5	1.30
8	4	1.34
9	4.5	1.36
10	5	1.37

Sample Diameter = 5cm

Sample Length = 9.5cm

Sample Weight =230g

Current used =1.5A

M.C = 85%wb

SAMPLE 9 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.22
2	1	1.23
3	1.5	1.24
4	2	1.25
5	2.5	1.25
6	3	1.27
7	3.5	1.27
8	4	1.30
9	4.5	1.32
10	5	1.35

Sample Diameter = 6.5cm

Sample Length = 8cm

Sample Weight =195g

Current used =1.5A

M.C = 86%wb

SAMPLE 10 (UNPEELED)

S/N	CURRENT TIME (MIN)	POT READINGS(MV)
1	0	1.21
2	1	1.22
3	1.5	1.24
4	2	1.26
5	2.5	1.27
6	3	1.28
7	3.5	1.29
8	4	1.30
9	4.5	1.32
10	5	1.34

Sample Diameter = 7cm

Sample Length = 9cm

Sample Weight =228g

Current used =1.5A

M.C = 80%wb

4.2.2a CALCULATED THERMAL CONDUCTIVITIES FOR PEELED YAM SAMPLES

S/N	THERMAL CONDUCTIVITY (W/M^0C)
1	0.7586
2	0.8753
3	1.0344
4	0.7586
5	0.9483
6	1.0345
7	1.0344
8	0.8753
9	0.983
10	0.9482

TOTAL	**9.2159**
MEAN	**0.9216**
VARIANCE	**0.0108**

2.2b CALCULATED THERMAL CONDUCTIVITIES FOR UNPEELED YAM SAMPLES

S/N	THERMAL CONDUCTIVITY (W/M^0C)
1	0.5559
2	0.4447
3	0.7412
4	0.3421
5	0.4447
6	0.4042
7	0.3706
8	0.3935
9	0.4043
10	0.4447

TOTAL	**4.5459**
MEAN	**0.4546**
VARIANCE	**0.0135**

4.2.3 POTENTIOMETER READINGS FOR PEELED YAM SAMPLES

SAMPLE 1

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.78	2.16	41.296	43.456	0
2	1	1.8	2.16	41.76	43.92	0.464
3	1.5	1.82	2.16	42.224	44.384	0.928
4	2	1.84	2.16	42.688	44.848	1.392
5	2.5	1.86	2.16	43.152	45.312	1.856
6	3	1.89	2.16	43.848	46.008	2.552
7	3.5	1.91	2.16	44.312	46.472	3.016
8	4	1.94	2.16	45.008	47.168	3.712
9	4.5	1.95	2.16	45.24	47.4	3.944
10	5	1.97	2.16	45.704	47.864	4.408

SAMPLE 2

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.79	2.16	41.528	43.688	0
2	1	1.8	2.16	41.76	43.92	0.232
3	1.5	1.81	2.16	41.992	44.152	0.464
4	2	1.83	2.16	42.456	44.616	0.928
5	2.5	1.85	2.16	42.92	45.08	1.392
6	3	1.86	2.16	43.152	45.312	1.624
7	3.5	1.88	2.16	43.616	45.776	2.088
8	4	1.9	2.16	44.08	46.24	2.552
9	4.5	1.92	2.16	44.544	46.704	3.016
10	5	1.94	2.16	45.008	47.168	3.48

SAMPLE 3

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.8	2.16	41.76	43.92	0
2	1	1.82	2.16	42.224	44.384	0.464
3	1.5	1.84	2.16	42.688	44.848	0.928
4	2	1.86	2.16	43.152	45.312	1.392
5	2.5	1.87	2.16	43.384	45.544	1.624
6	3	1.88	2.16	43.616	45.776	1.856
7	3.5	1.9	2.16	44.08	46.24	2.32
8	4	1.91	2.16	44.312	46.472	2.552
9	4.5	1.93	2.16	44.776	46.936	3.016
10	5	1.95	2.16	45.24	47.4	3.48

SAMPLE 4

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.8	2.16	41.76	43.92	0
2	1	1.83	2.16	42.456	44.616	0.696
3	1.5	1.84	2.16	42.688	44.848	0.928
4	2	1.86	2.16	43.152	45.312	1.392
5	2.5	1.89	2.16	43.848	46.008	2.088
6	3	1.91	2.16	44.312	46.472	2.552
7	3.5	1.94	2.16	45.008	47.168	3.248
8	4	1.97	2.16	45.704	47.864	3.944
9	4.5	1.98	2.16	45.936	48.096	4.176
10	5	1.99	2.16	46.168	48.328	4.408

SAMPLE 5

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.77	2.16	41.064	43.224	0
2	1	1.78	2.16	41.296	43.456	0.232
3	1.5	1.79	2.16	41.528	43.688	0.464
4	2	1.81	2.16	41.992	44.152	0.928
5	2.5	1.83	2.16	42.456	44.616	1.392
6	3	1.84	2.16	42.688	44.848	1.624
7	3.5	1.86	2.16	43.152	45.312	2.088
8	4	1.88	2.16	43.616	45.776	2.552
9	4.5	1.89	2.16	43.848	46.008	2.784
10	5	1.91	2.16	44.312	46.472	3.248

SAMPLE 6

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.78	2.16	41.296	43.456	0
2	1	1.79	2.16	41.528	43.688	0.232
3	1.5	1.79	2.16	41.528	43.688	0.232
4	2	1.8	2.16	41.76	43.92	0.464
5	2.5	1.81	2.16	41.992	44.152	0.696
6	3	1.82	2.16	42.224	44.384	0.928
7	3.5	1.83	2.16	42.456	44.616	1.16
8	4	1.85	2.16	42.92	45.08	1.624
9	4.5	1.87	2.16	43.384	45.544	2.088
10	5	1.9	2.16	44.08	46.24	2.784

SAMPLE 7

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.78	2.16	41.296	43.456	0
2	1	1.79	2.16	41.528	43.688	0.232
3	1.5	1.81	2.16	41.992	44.152	0.696
4	2	1.82	2.16	42.224	44.384	0.928
5	2.5	1.84	2.16	42.688	44.848	1.392
6	3	1.86	2.16	43.152	45.312	1.856
7	3.5	1.87	2.16	43.384	45.544	2.088
8	4	1.89	2.16	43.848	46.008	2.552
9	4.5	1.91	2.16	44.312	46.472	3.016
10	5	1.92	2.16	44.544	46.704	3.248

SAMPLE 8

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.77	2.16	41.064	43.224	0
2	1	1.79	2.16	41.528	43.688	0.464
3	1.5	1.79	2.16	41.528	43.688	0.464
4	2	1.8	2.16	41.76	43.92	0.696
5	2.5	1.82	2.16	42.224	44.384	1.16
6	3	1.83	2.16	42.456	44.616	1.392
7	3.5	1.85	2.16	42.92	45.08	1.856
8	4	1.87	2.16	43.384	45.544	2.32
9	4.5	1.89	2.16	43.848	46.008	2.784
10	5	1.92	2.16	44.544	46.704	3.48

SAMPLE 9

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.8	2.16	41.76	43.92	0
2	1	1.81	2.16	41.992	44.152	0.232
3	1.5	1.83	2.16	42.456	44.616	0.696
4	2	1.85	2.16	42.92	45.08	1.16
5	2.5	1.86	2.16	43.152	45.312	1.392
6	3	1.88	2.16	43.616	45.776	1.856
7	3.5	1.89	2.16	43.848	46.008	2.088
8	4	1.91	2.16	44.312	46.472	2.552
9	4.5	1.93	2.16	44.776	46.936	3.016
10	5	1.95	2.16	45.24	47.4	3.48

SAMPLE 10

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.79	2.16	41.528	43.688	0
2	1	1.8	2.16	41.76	43.92	0.232
3	1.5	1.8	2.16	41.76	43.92	0.232
4	2	1.81	2.16	41.992	44.152	0.464
5	2.5	1.83	2.16	42.456	44.616	0.928
6	3	1.85	2.16	42.92	45.08	1.392
7	3.5	1.86	2.16	43.152	45.312	1.624
8	4	1.88	2.16	43.616	45.776	2.088
9	4.5	1.9	2.16	44.08	46.24	2.552
10	5	1.92	2.16	44.544	46.704	3.016

4.2.3b POTENTIOMETER READING FOR UNPEELED YAM SAMPLES

SAMPLE 1

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.01	2.16	23.432	25.592	0
2	1	1.04	2.16	24.128	26.288	0.696
3	1.5	1.06	2.16	24.592	26.752	1.16
4	2	1.06	2.16	24.592	26.752	1.16
5	2.5	1.08	2.16	25.056	27.216	1.624
6	3	1.08	2.16	25.056	27.216	1.624
7	3.5	1.09	2.16	25.288	27.448	1.856
8	4	1.09	2.16	25.288	27.448	1.856
9	4.5	1.1	2.16	25.52	27.68	2.088
10	5	1.14	2.16	26.448	28.608	3.016

SAMPLE 2

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1	2.16	23.2	25.36	0
2	1	1.01	2.16	23.432	25.592	0.232
3	1.5	1.02	2.16	23.664	25.824	0.464
4	2	1.04	2.16	24.128	26.288	0.928
5	2.5	1.05	2.16	24.36	26.52	1.16
6	3	1.06	2.16	24.592	26.752	1.392
7	3.5	1.08	2.16	25.056	27.216	1.856
8	4	1.09	2.16	25.288	27.448	2.088
9	4.5	1.1	2.16	25.52	27.68	2.32
10	5	1.12	2.16	25.984	28.144	2.784

SAMPLE 3

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.1	2.16	25.52	27.68	0
2	1	1.16	2.16	26.912	29.072	1.392
3	1.5	1.18	2.16	27.376	29.536	1.856
4	2	1.2	2.16	27.84	30	2.32
5	2.5	1.2	2.16	27.84	30	2.32
6	3	1.21	2.16	28.072	30.232	2.552
7	3.5	1.22	2.16	28.304	30.464	2.784
8	4	1.23	2.16	28.536	30.696	3.016
9	4.5	1.23	2.16	28.536	30.696	3.016
10	5	1.24	2.16	28.768	30.928	3.248

SAMPLE 4

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.04	2.16	24.128	26.288	0
2	1	1.06	2.16	24.592	26.752	0.464
3	1.5	1.09	2.16	25.288	27.448	1.16
4	2	1.14	2.16	26.448	28.608	2.32
5	2.5	1.18	2.16	27.376	29.536	3.248
6	3	1.19	2.16	27.608	29.768	3.48
7	3.5	1.19	2.16	27.608	29.768	3.48
8	4	1.2	2.16	27.84	30	3.712
9	4.5	1.2	2.16	27.84	30	3.712
10	5	1.22	2.16	28.304	30.464	4.176

SAMPLE 5

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.2	2.16	27.84	30	0
2	1	1.22	2.16	28.304	30.464	0.464
3	1.5	1.24	2.16	28.768	30.928	0.928
4	2	1.26	2.16	29.232	31.392	1.392
5	2.5	1.28	2.16	29.696	31.856	1.856
6	3	1.3	2.16	30.16	32.32	2.32
7	3.5	1.31	2.16	30.392	32.552	2.552
8	4	1.31	2.16	30.392	32.552	2.552
9	4.5	1.32	2.16	30.624	32.784	2.784
10	5	1.34	2.16	31.088	33.248	3.248

SAMPLE 6

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.2	2.16	27.84	30	0
2	1	1.22	2.16	28.304	30.464	0.464
3	1.5	1.24	2.16	28.768	30.928	0.928
4	2	1.26	2.16	29.232	31.392	1.392
5	2.5	1.28	2.16	29.696	31.856	1.856
6	3	1.28	2.16	29.696	31.856	1.856
7	3.5	1.3	2.16	30.16	32.32	2.32
8	4	1.34	2.16	31.088	33.248	3.248
9	4.5	1.35	2.16	31.32	33.48	3.48
10	5	1.35	2.16	31.32	33.48	3.48

SAMPLE 7

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.24	2.16	28.768	30.928	0
2	1	1.25	2.16	29	31.16	0.232
3	1.5	1.25	2.16	29	31.16	0.232
4	2	1.26	2.16	29.232	31.392	0.464
5	2.5	1.26	2.16	29.232	31.392	0.464
6	3	1.27	2.16	29.464	31.624	0.696
7	3.5	1.27	2.16	29.464	31.624	0.696
8	4	1.3	2.16	30.16	32.32	1.392
9	4.5	1.34	2.16	31.088	33.248	2.32
10	5	1.37	2.16	31.784	33.944	3.016

SAMPLE 8

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.23	2.16	28.536	30.696	0
2	1	1.24	2.16	28.768	30.928	0.232
3	1.5	1.26	2.16	29.232	31.392	0.696
4	2	1.28	2.16	29.696	31.856	1.16
5	2.5	1.29	2.16	29.928	32.088	1.392
6	3	1.29	2.16	29.928	32.088	1.392
7	3.5	1.3	2.16	30.16	32.32	1.624
8	4	1.34	2.16	31.088	33.248	2.552
9	4.5	1.36	2.16	31.552	33.712	3.016
10	5	1.37	2.16	31.784	33.944	3.248

SAMPLE 9

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.22	2.16	28.304	30.464	0
2	1	1.23	2.16	28.536	30.696	0.232
3	1.5	1.24	2.16	28.768	30.928	0.464
4	2	1.25	2.16	29	31.16	0.696
5	2.5	1.25	2.16	29	31.16	0.696
6	3	1.27	2.16	29.464	31.624	1.16
7	3.5	1.27	2.16	29.464	31.624	1.16
8	4	1.3	2.16	30.16	32.32	1.856
9	4.5	1.32	2.16	30.624	32.784	2.32
10	5	1.35	2.16	31.32	33.48	3.016

SAMPLE 10

S/N	CU. TIME	POT RD (MV)	CONST.	23.2MV	T0 C = 2.16 + 23.2MV	TEMP. RISE
1	0	1.21	2.16	28.072	30.232	0
2	1	1.22	2.16	28.304	30.464	0.232
3	1.5	1.24	2.16	28.768	30.928	0.696
4	2	1.26	2.16	29.232	31.392	1.16
5	2.5	1.27	2.16	29.464	31.624	1.392
6	3	1.28	2.16	29.696	31.856	1.624
7	3.5	1.29	2.16	29.928	32.088	1.856
8	4	1.3	2.16	30.16	32.32	2.088
9	4.5	1.32	2.16	30.624	32.784	2.552
10	5	1.34	2.16	31.088	33.248	3.016

4 POTENTIOMETER READINGS CONVERTED TO TEMPERATURE WITH THE RELATIONSHIP

T^0C =2.16 +23.mv FOR PEELED YAM SAMPLES.

E . REPLICATIONS

)	1	2	3	4	5	6	7	8	9	10
	43.456	43.688	43.92	43.92	43.224	43.456	43.456	43.22.4	43.92	43.688
	43.92	43.92	44.384	44.616	43.456	43.688	43.688	43.688	44.152	43.92
	44.484	44.152	44.848	44.848	43.688	43.688	44.152	43.688	44.616	43.92
	44.848	44.616	45.312	45.312	44.152	43.92	44.384	43.92	45.08	44.152
	45.312	45.08	45.544	46.008	44.616	44.152	44.848	44.384	45.312	44.616
	46.008	45.312	45.776	46.472	44.848	44.384	45.312	44.616	45.776	45.08
	46.472	45.776	46.42	47.168	45.312	44.616	45.544	45.08	46.008	45.312
	47.168	46.24	46.472	47.864	45.776	45.08	46.008	45.544	46.472	45.776
	47.4	46.704	46.936	48.096	46.008	45.544	46.472	46.008	46.936	46.24
	47.864	47.168	47.4	48.328	46.472	46.24	46.704	46.704	47.4	46.704

TENTIOMETER READINGS FOR PEELED YAM SAMPLES.

E REPLICATIONS

E)	1	2	3	4	5	6	7	8	9	10
	1.78	1.79	1.80	1.80	1.77	1.78	1.78	1.77	1.80	1.79
	1.80	1.80	1.82	1.83	1.78	1.79	1.79	1.79	1.81	1.80
	1.82	1.81	1.84	1.84	1.79	1.79	1.81	1.79	1.83	1.80
	1.84	1.83	1.86	1.86	1.81	1.80	1.82	1.80	1.85	1.81
	1.86	1.85	1.87	1.89	1.83	1.81	1.84	1.82	1.86	1.83
	1.86	1.86	1.88	1.91	1.84	1.82	1.86	1.83	1.88	1.85
	1.91	1.88	1.90	1.94	1.86	1.83	1.87	1.85	1.89	1.86
	1.94	1.90	1.91	1.97	1.88	1.85	1.89	1.87	1.91	1.88
	1.95	1.92	1.93	1.98	1.89	1.87	1.91	1.89	1.93	1.90
	1.97	1.94	1.95	1.99	1.91	1.90	1.92	1.92	1.95	1.92

POTENTIOMETER READING CONVERTED TO TEMPERATURE WITH THE RELATIONSHIP

$T^0C=2.16+23.2$ mv FOR UNPEELED YAM SAMPLES.

ME	REPLICATIONS									
IIN)	1	2	3	4	5	6	7	8	9	10
	25.592	25.36	27.68	26.288	30	.30	30.928	30.696	30.464	30.232
	26.288	25.592	29.072	26.752	30.464	30.464	31.16	30.928	30.696	30.464
.5	26.228	25.824	29.539	27.448	30.928	30.928	31.16	31.392	30.928	30.928
.0	26.752	26.288	.30	28.608	31.392	31.392	31.392	31.856	31.16	31.392
.5	27.216	26.52	.30	29.536	31.856	31.856	31.392	32.088	31.16	31.624
.0	27.216	26.752	30.232	29.768	32.32	31.856	31.624	32.088	31.624	31.856
.5	27.448	27.216	30.464	29.768	32.552	32.32	31.624	32.32	31.624	32.088
.0	27.448	27.448	30.696	30	32.552	33.248	32.32	33.248	32.32	32.32
.5	27.68	27.68	30.696	.30	32.784	33.48	33.248	33.712	32.784	32.784
.0	28.608	28.144	30.928	30.464	33.248	33.48	33.944	33.944	33.48	33.248

TENTIOMETER READINGS FOR UNPEELED YAM SAMPLE.

E REPLICATIONS

IN)	1	2	3	4	5	6	7	8	9	10
	1.01	1	1.1	1.04	1.2	1.2	1.24	1.23	1.22	1.21
	1.04	1.01	1.16	1.06	1.22	1.22	1.25	1.24	1.23	1.22
	1.06	1.02	1.18	1.09	1.24	1.24	1.25	1.26	1.24	1.24
	1.06	1.04	1.2	1.14	1.26	1.26	1.26	1.28	1.25	1.26
	1.08	1.05	1.2	1.18	1.28	1.28	1.26	1.29	1.25	1.27
	1.08	1.06	1.21	1.19	1.3	1.28	1.27	1.29	1.27	1.28
	1.09	1.08	1.22	1.19	1.31	1.3	1.27	1.3	1.27	1.29
	1.09	1.09	1.23	1.2	1.31	1.34	1.3	1.34	1.3	1.30
	1.1	1.1	1.23	1.2	1.32	1.35	1.34	1.36	1.32	1.32
	1.14	1.12	1.24	1.22	1.34	1.35	1.37	1.37	1.35	1.34

CHAPTER FIVE

GENERAL DISCUSSION OF THE RESULTS

The thermal conductivity for peeled and unpeeled yam samples were determined for different sizes. The average thermal conductivity for 10 samples of peeled yam gave 0.9216 w/m°c while the mean for the unpeeled sample gave 0.4546 w/m°c as against 0.722 w/m°c and

0.521 w/m°c respectively obtained from literature. (Ezeima 1976).

The thermal conductivity increases with increase in temperature and also varies with moisture content of the sample.

The data of the thermal conductivities (got from the experiment) when plotted on a graph against the rise in temperature seems to give a straight line with only few points falling out of line.

CONCLUSION

This project work of determination of thermal conductivity of yam using line heat source method has followed a practical procedure which is reproducible and can also be used to measure other thermophysical properties of other food and agricultural products. The average thermal conductivity for peeled yam is 0.9216 w/m°c and 0.4546 w/m°c for unpeeled yam.

The difference in the values of the thermal conductivity of peeled and unpeeled yam samples could be as a result of their moisture content difference and the conductive nature of the peeled cover.

RECOMMENDATION

Similar projects using line heat source technique could be under taken to verify the very result of this project and also to establish thermal conductivity values for other species of yam.

Further research could also be done to develop the relationship between the thermal conductivity of peeled and unpeeled yam samples and the peeled cover.

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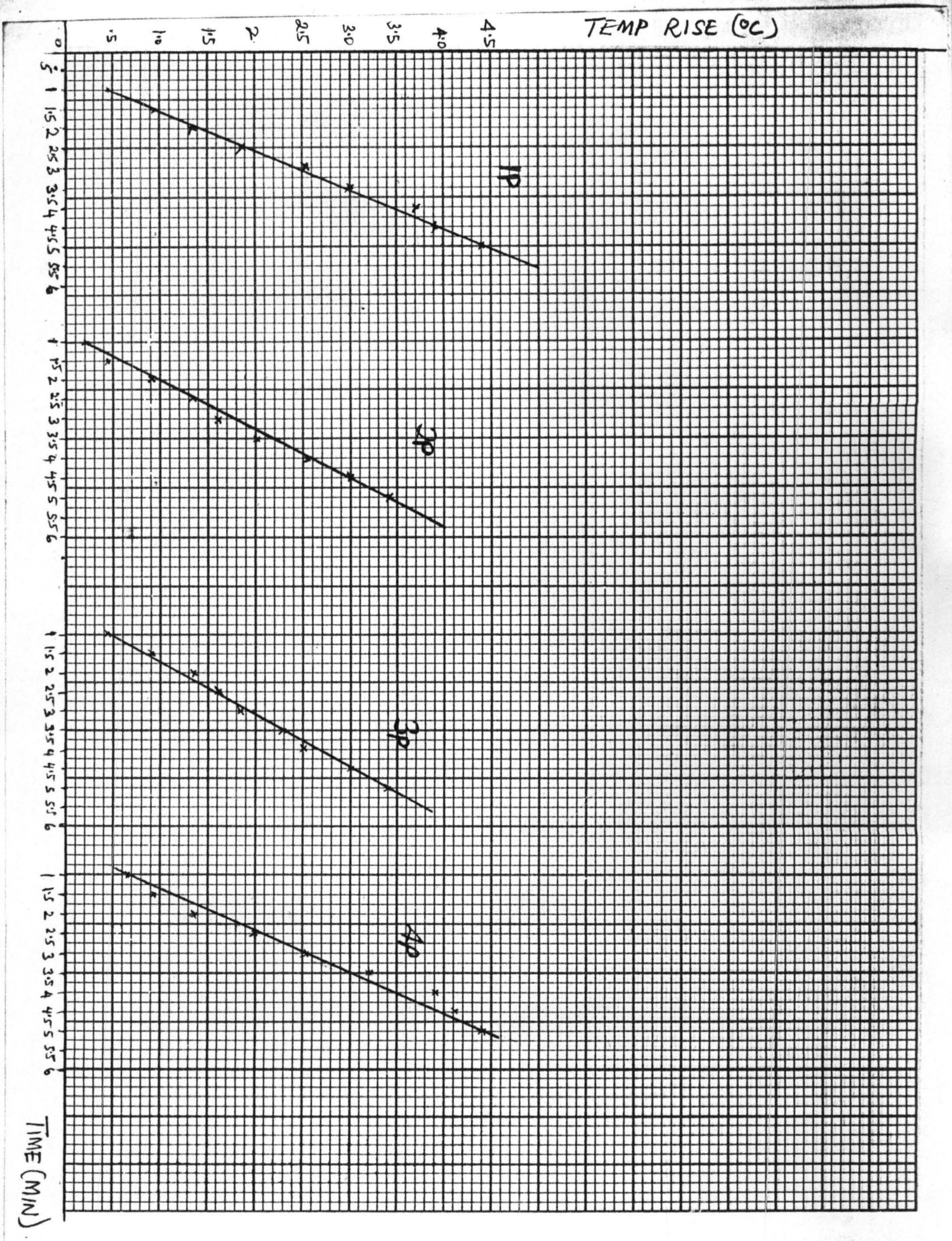
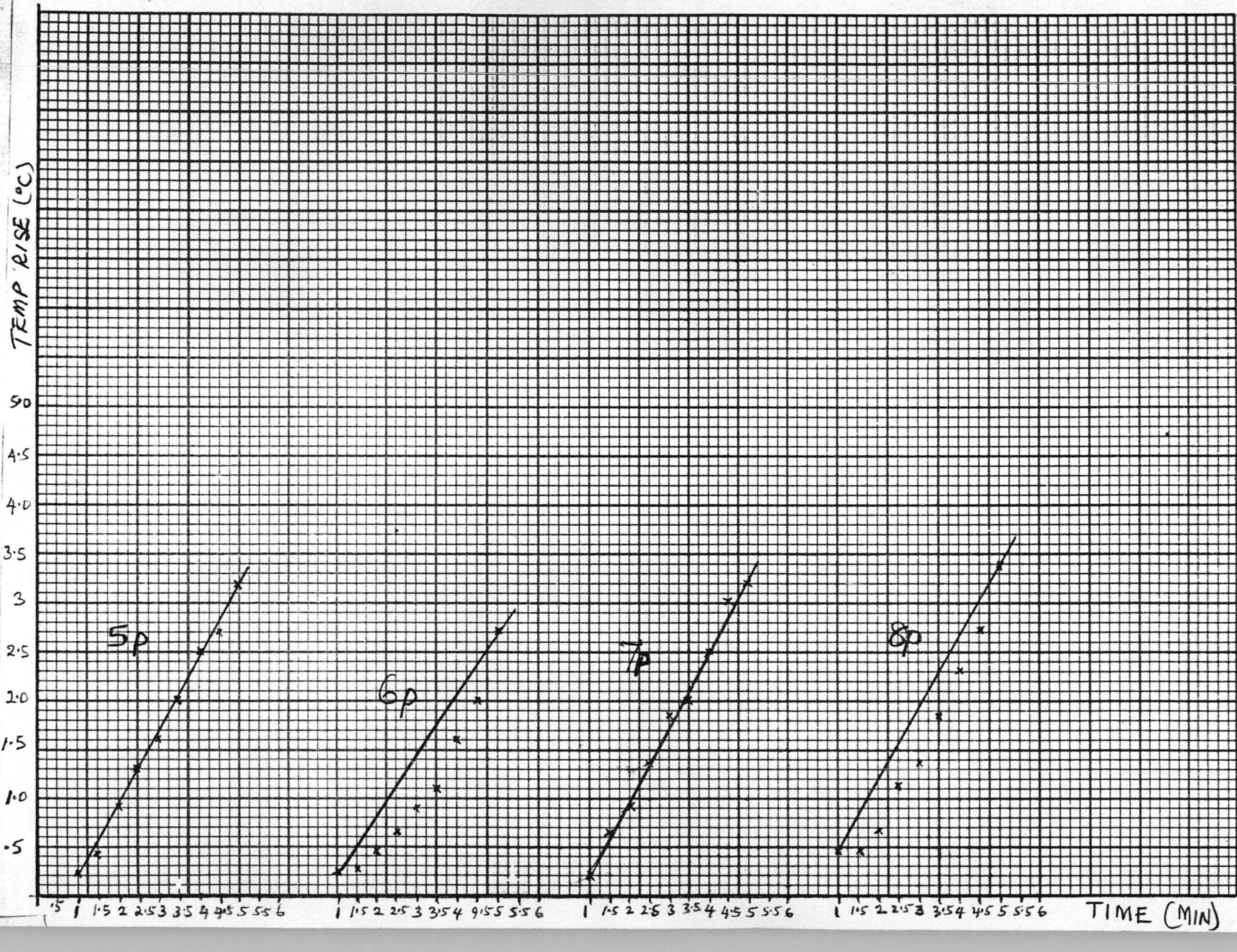
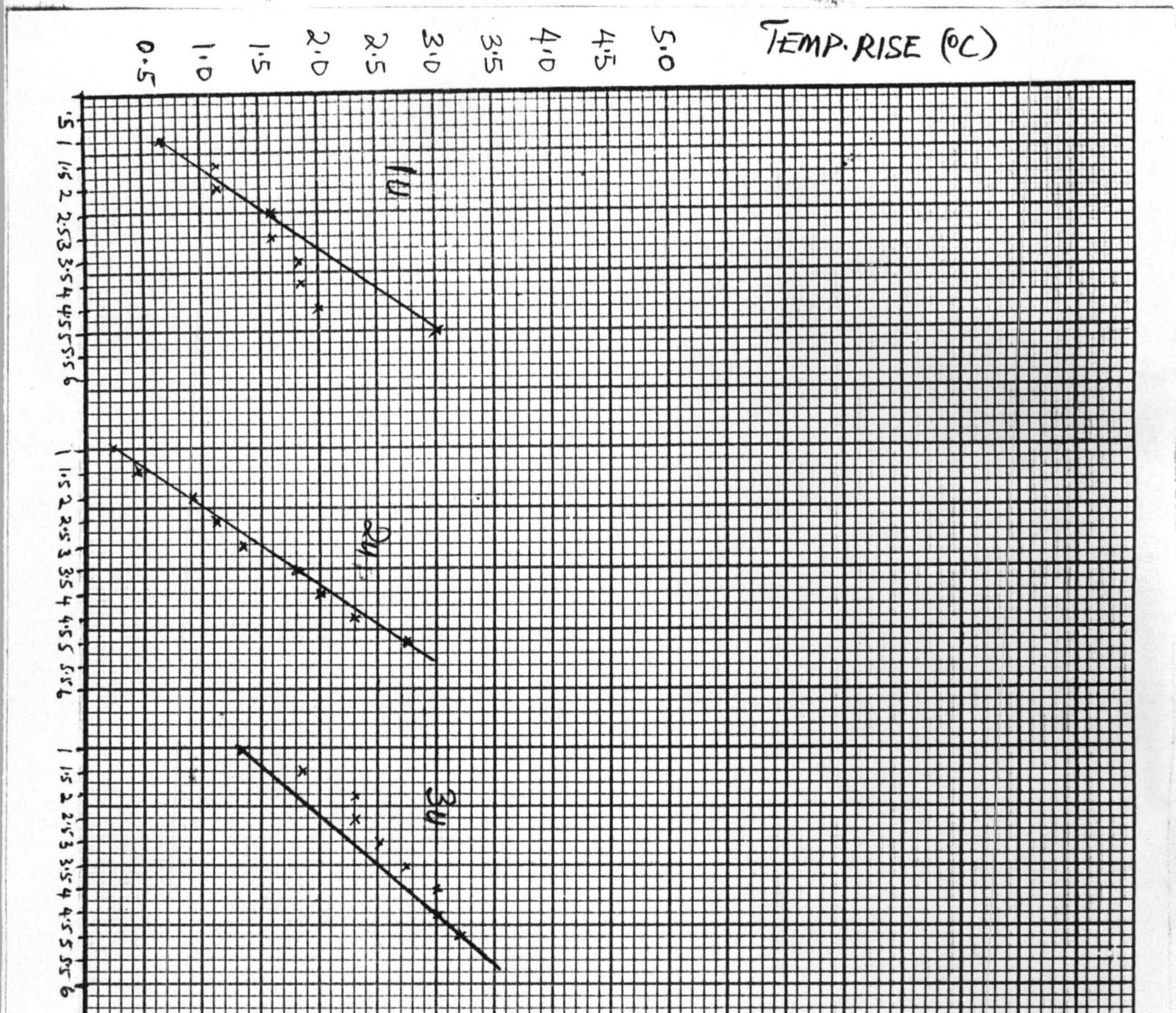
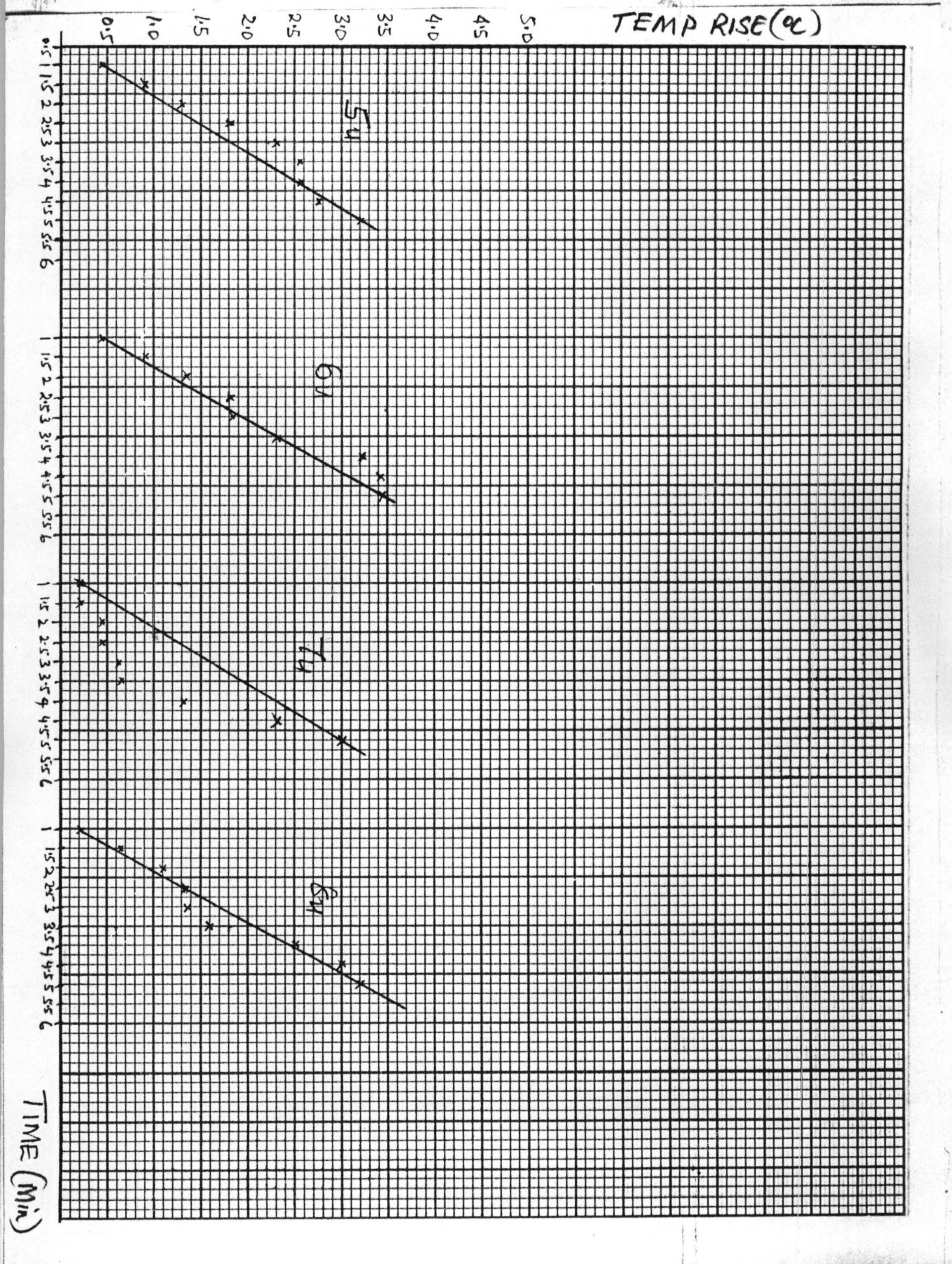
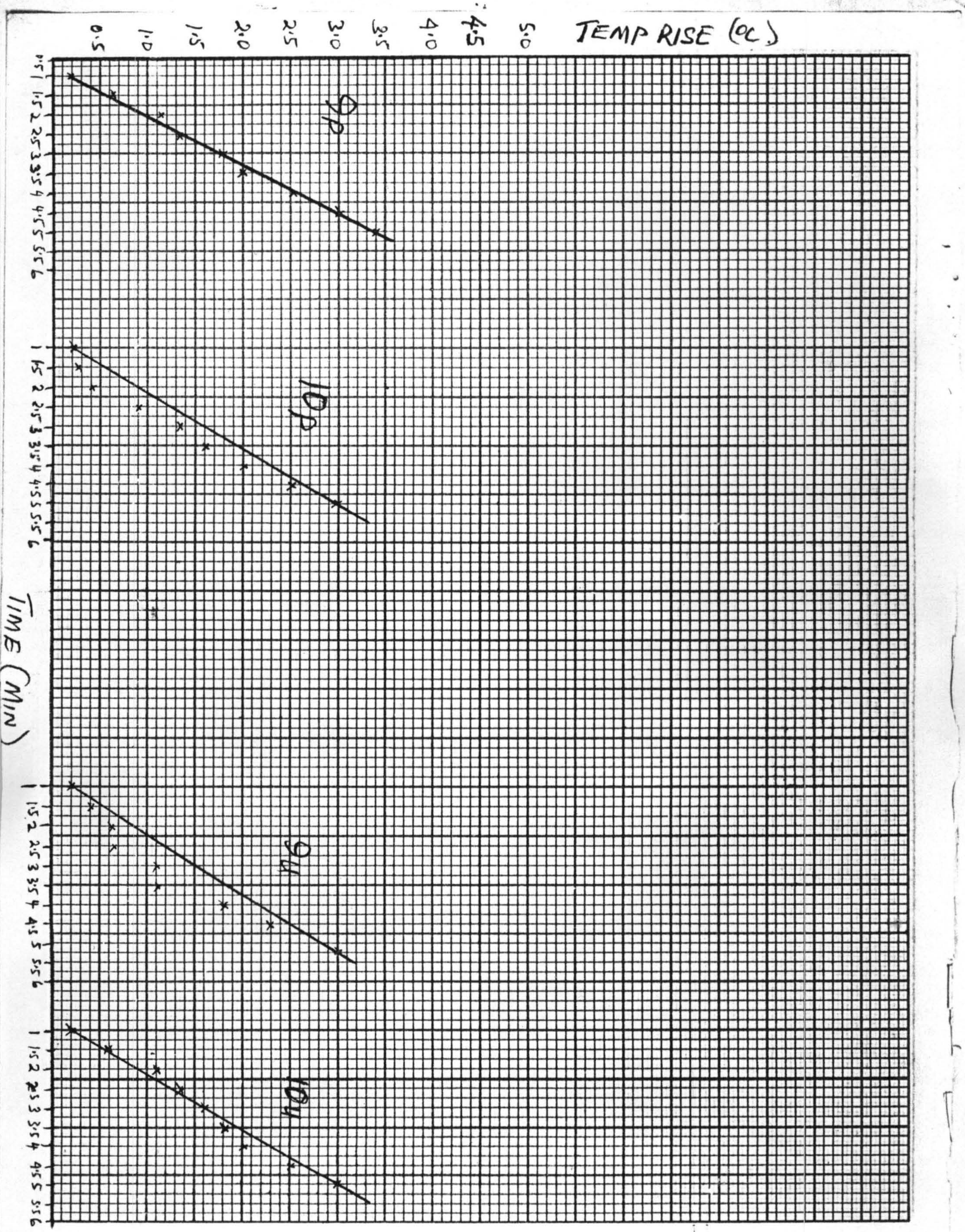

TEMP RISE (°C)
TIME (MIN)
1P
2P
3P
4P


TEMP RISE (°C)
TIME (MIN)
5p
6p
7p
8p


TEMP. RISE (°C)
0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0
TIME (Min)
1U
2U
3U
4U



TEMP RISE(°C)
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME (Min)


TEMP RISE (oC)
TIME (MIN)
9P
10P
9U
10U