Correspondence from Dr. E. I
Reports on Associated Ethyl Op
including analytical data on mer

No. D-1252½
Manufactured By
Browne-Morse Company
MUSKEGON, MICHIGAN

ASSOCIATED ETHYL COMPANY LIMITED
NORTHWICH CHESHIRE

Telephone: NORTHWICH 3241/7. Telegrams & Cables: ETHYLPORT, NORTHWICH.

Head Office:
ARTILLERY HOUSE,
ARTILLERY ROW,
LONDON, S.W.1.
ABBEY 3974

OUR REF. K.2.
YOUR REF.
DATE 14th December, 1950.

Dr. R.A. Kehoe,
Kettering Laboratory of Applied Physiology,
University of Cincinnati,
College of Medicine,
Cincinnati,
OHIO,
U.S.A.

Dear Dr. Kehoe,

I have been instructed by Mr. Bevan to give you the details of an incident which occurred here recently. We have no data of any value for comparative purposes, but are sure that you will have some in your possession, and will be able to advise Mr. Bevan on this matter. I understood from Mr. Bevan this morning that when the case is complete, so far as completion is possible, the Company will give the findings to H.M. Inspector of Factories (Alkali). We will forward the analysis of grass samples by cable when we finish them.

The incident is as follows:-

In the early afternoon of Tuesday, 28th November, I was informed by the Works' Manager that Mr. Wilson, Veterinary Surgeon, Northwich, had informed him that a colt foal had been found dead in a field adjacent to the Plant. I contacted Mr. Wilson, and arranged to be present at a post mortem on the animal on the morning of the following day. At the post mortem on the colt, on the morning of Wednesday, 29th November, it was estimated that the colt had been dead a little more than 24 hours. It was in good condition, and the immediate cause of death was pneumonia. A considerable part of the lung had progressed to the stage of hepatisation. I had a vague idea that in the Selby Smelter Commission report, the death of horses had been the subject of comment, and that pneumonia of inhalation or aspiration type was not uncommon in animals suffering from chronic lead poisoning, the result of paralysis of the muscles of deglutition. There was no evidence of any foreign bodies in the lung, and macroscopic examination of the trachea, which was full of fluid, appeared normal. There was also a slight excess of fluid in the abdominal cavity. The owner, a local farmer, had not noticed anything wrong with the animal, nor anything peculiar in its behaviour. The veterinary surgeon was satisfied as to the cause of death. I took the following samples as a precaution: liver, kidney, upper end of femur, tooth, lung and spleen. The colon was loaded,

KE 0010037

(Contd).

and some of the contents were stripped into a bottle.

The same afternoon, the veterinary surgeon phoned me, and stated that the mother of the colt, which had been lost, had been found dead, and that another grey horse was seriously ill. The latter was subsequently shot, and I attended the post mortem on both these animals the following morning. The mare was partially dismembered when I arrived. Most of the organs were in an advanced state of decomposition. This animal probably died at about the same time as the colt. There was no obvious cause of death. Samples of tissue were taken from the following organs: liver, kidney, femur, muscle and lung. The grey horse had an apical pneumonia, which the veterinary surgeon stated was not sufficient to account for the illness. Samples of the following organs were taken from this animal: liver, kidney, radius, heart blood, brain, muscle and lung. The veterinary surgeon took duplicate samples. Fortunately, another horse came in from a farm at Little Leigh, five miles from the Plant. This animal had died from a septic arthritis. To me, this seemed to be a synovitis of the joint between the hooves and the legs. Samples taken from this animal were liver, kidney, radius, heart blood and muscle. All samples of tissue were definitely from the animals described above, with the exception of the sample of the femur of the mare, which was taken from a bin containing dismembered parts of animals, and which was stated to belong to the mare.

The analysis was carried out by the method of Bambach and Burkey, and the results are shown on the attached table. During analysis, a little lead may have been lost, as some of the dishes cracked, and the samples had to be transferred.

The three animals, which had grazed in the fields near the Plant, had absorbed significant quantities of lead, and in the case of the colt, it would appear that the absorption had been going on for some considerable time. The colt was from 6 to 8 months old at the time of death. If the immediate cause of death was not directly the result of this lead absorption, it is not impossible for the terminal illness to have been aggravated by it.

As long as two years has elapsed between the bursting of autoclave discs. Of recent months, there has been a spate of these. So far as I am aware, four occurred during the month of November, and there were at least two in October, associated with fire, one of which lasted for 50 minutes. Some of the lead-bearing material from the autoclaves does find its way to the adjacent fields, but in my opinion not to any great concentration.

You will remember the lead recovery building; this has a reverberatory furnace, which deals with the dried sludge. The chimney from thi is 130 feet high, and the fumes from the furnace have direct access to the atmosphere through it. The estimated quantity of lead going up this chimney is 200 pounds per day, and as the furnace is in operation about 340 days a year, it would seem that approximately 30 tons of lead per annum are deposited over the countryside. The Pease-Anthony scrubber has never been satisfactory, and

KE 0010038

(Contd).

To: Dr. R.A. Kehoe. 14.12.50.

at best has only worked intermittently. Apart from technical difficulties in construction, there has never been enough water to operate it. At times, this chimney "snows" on to the surrounding ground, and has been a source of complaint on my part for years. I feel that it is the most likely source of lead contamination of the fields in the vicinity of the Plant.

The enclosed map shows the locations from which samples of various crops were obtained for analysis, and also the approximate areas from which grass samples were taken recently. The crop sample analysis has been accepted as correct after some discussion. The analysis for the first time was carried out by us by the Bambach and Burkey method. The grass samples, which were taken by the Plant Management subsequent to the death of the horses, have not yet been analysed, but we will cable these results, we hope, towards the end of next week.

The prevailing wind here is from the South-West.

We would all be most grateful for your opinion and comments on this matter.

With kindest personal regards to you all, and all best wishes for Christmas and the New Year.

Yours very sincerely,

E. Davison.

Encl.

HORSE SAMPLES. 7th Dece

SAMPLE.	FOAL.			MARE.			GREY HORSE.			CONTROL HORSE.			MA
	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	
Liver	100 g.	3.68	3.68	50 g.	1.519	3.04	100 g.	4.2	4.2	85 g.	.103	.12	
Kidney	150 g.	3.68	2.45	105 "	1.679	1.60	100 "	1.0	1.0	100 "	.031	.031	
Femur	50 "	11.4	22.8	50 "	.64	1.28 *							
Radius							47 "	.68	1.45	51.5 g.	.25	.48	
Tooth	13"	1.359	10.4										
Blood							50 "	.089	.178	100 g.	.0086	.0086	
Brain							100 "	1.24	1.24				
Muscle				100 g.	.094	.094	60 "	.021	.035	100 g.	.0106	.0106	
Lung	100 g.	.133	.133	100 "	.26	.26	50 "	.155	.31				
Spleen	100 "	.699	.70										

Foal.

Colonic Contents.

Pb. 7.7 mgm. per gramme ash.
Pb. 23 mg. per 100 grammes.

KE 0010040

HORSE SAMPLES. 7th December, 1950.

L.	MARE.			GREY HORSE.			CONTROL HORSE.			MAXIMUM OF HUMAN NORMAL. (R.A. KEHOE).
Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg/100 gms.	Mg/100 gms.
3.68	50 g.	1.519	3.04	100 g.	4.2	4.2	85 g.	.103	.12	.28
2.45	105 "	1.679	1.60	100 "	1.0	1.0	100 "	.031	.031	.16
22.8	50 "	.64	1.28 *							3.59
				47 "	.68	1.45	51.5 g.	.25	.48	3.59
10.4										
				50 "	.089	.178	100 g.	.0086	.0086	.06 - .07 (Circa)
				100 "	1.24	1.24				.09
	100 g.	.094	.094	60 "	.021	.035	100 g.	.0106	.0106	.17
.133	100 "	.26	.26	50 "	.155	.31				.06
.70										.07

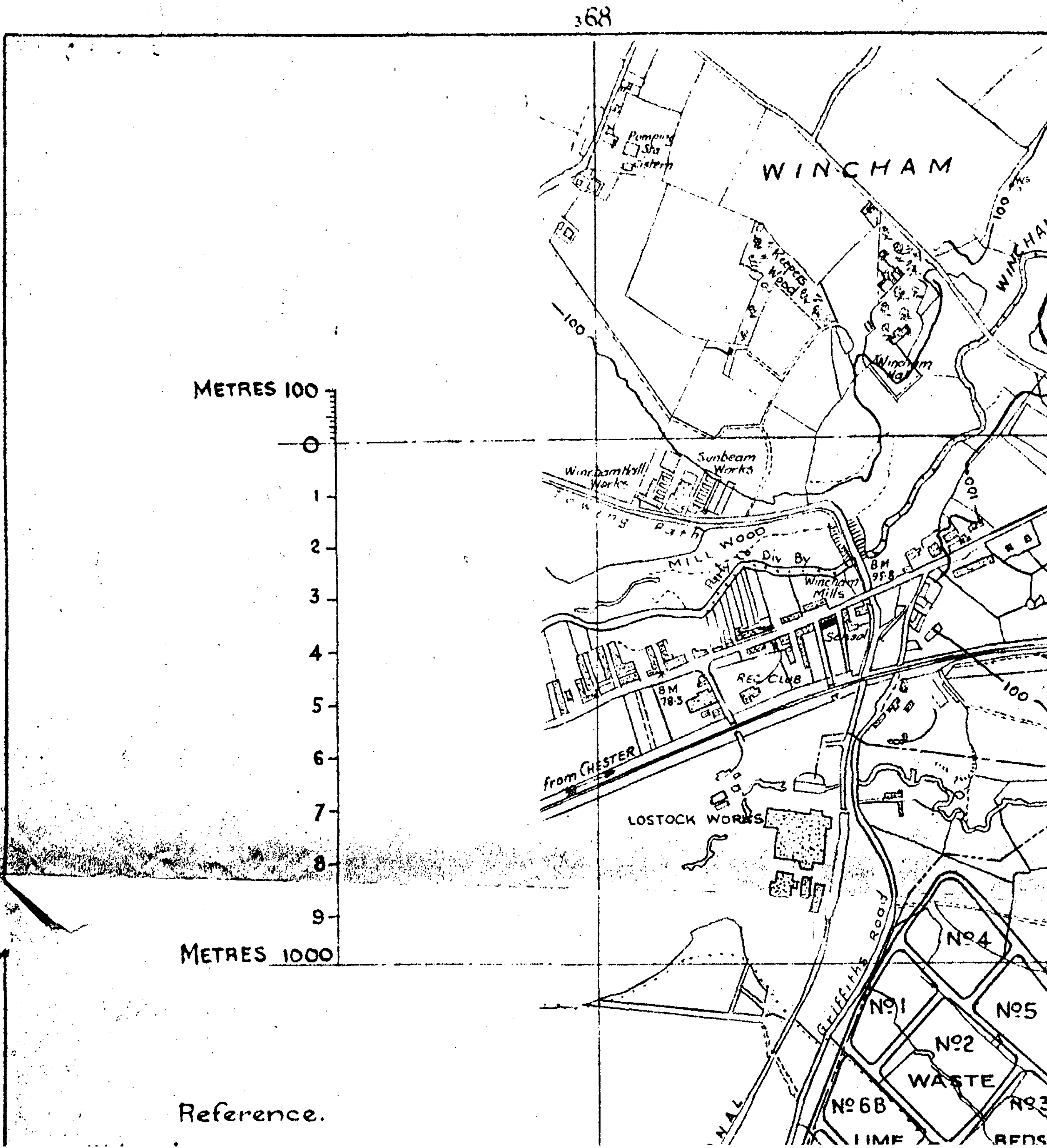
3.

[illegible] ash.

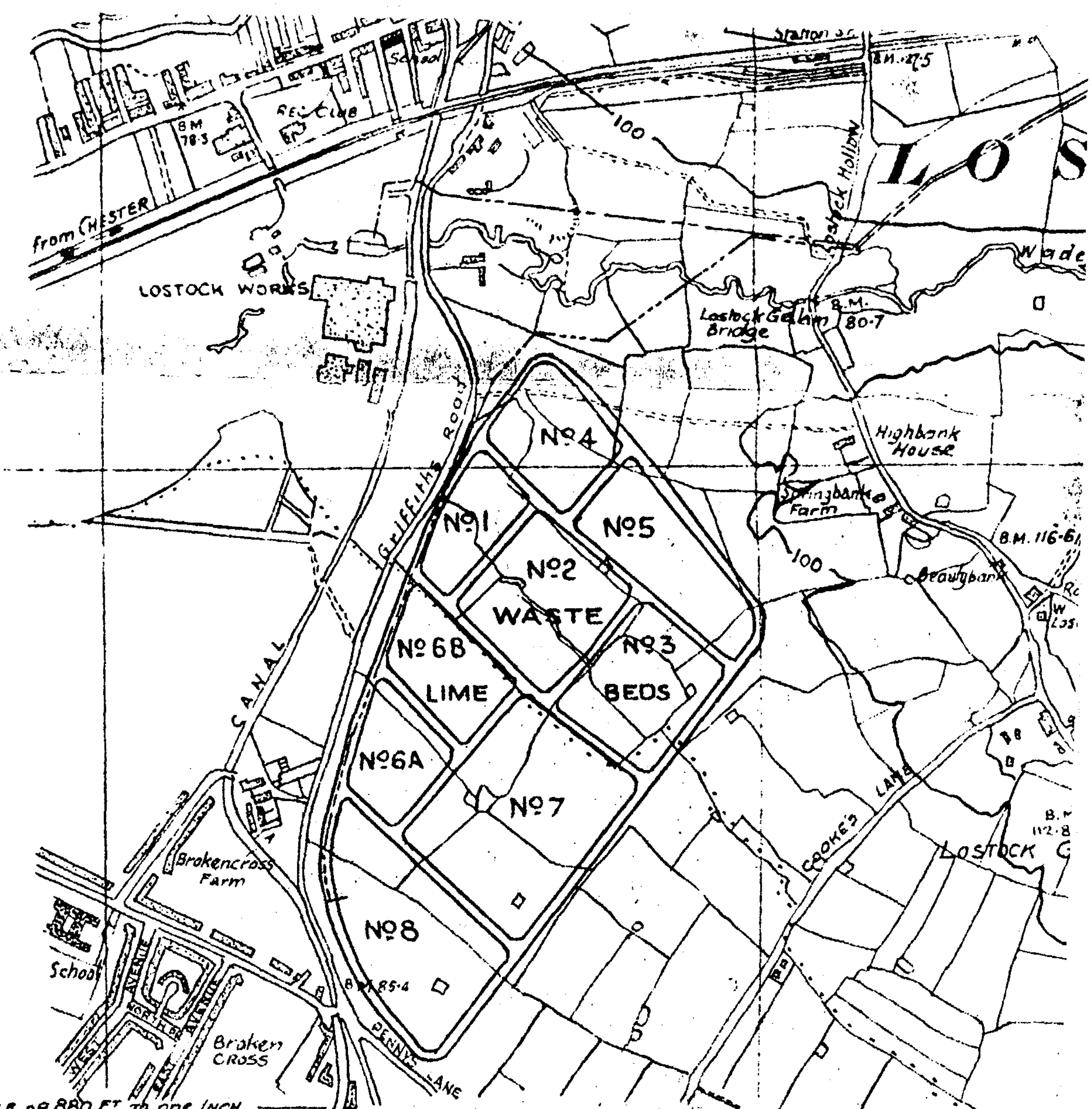
grammes.

KE 0010041

PLAN D



Reference.



3
4
5
6
7
8
9
METRES 1000

Reference.

Water pipes ——————————

Effluent pipes — — — — — —

SCALE 6 INCHES TO 1 STATUTE MILE OR 880 FT TO ONE INCH.

1000 FT. 500 0 1000 2000 3000 4000 5000 5280 FEET.

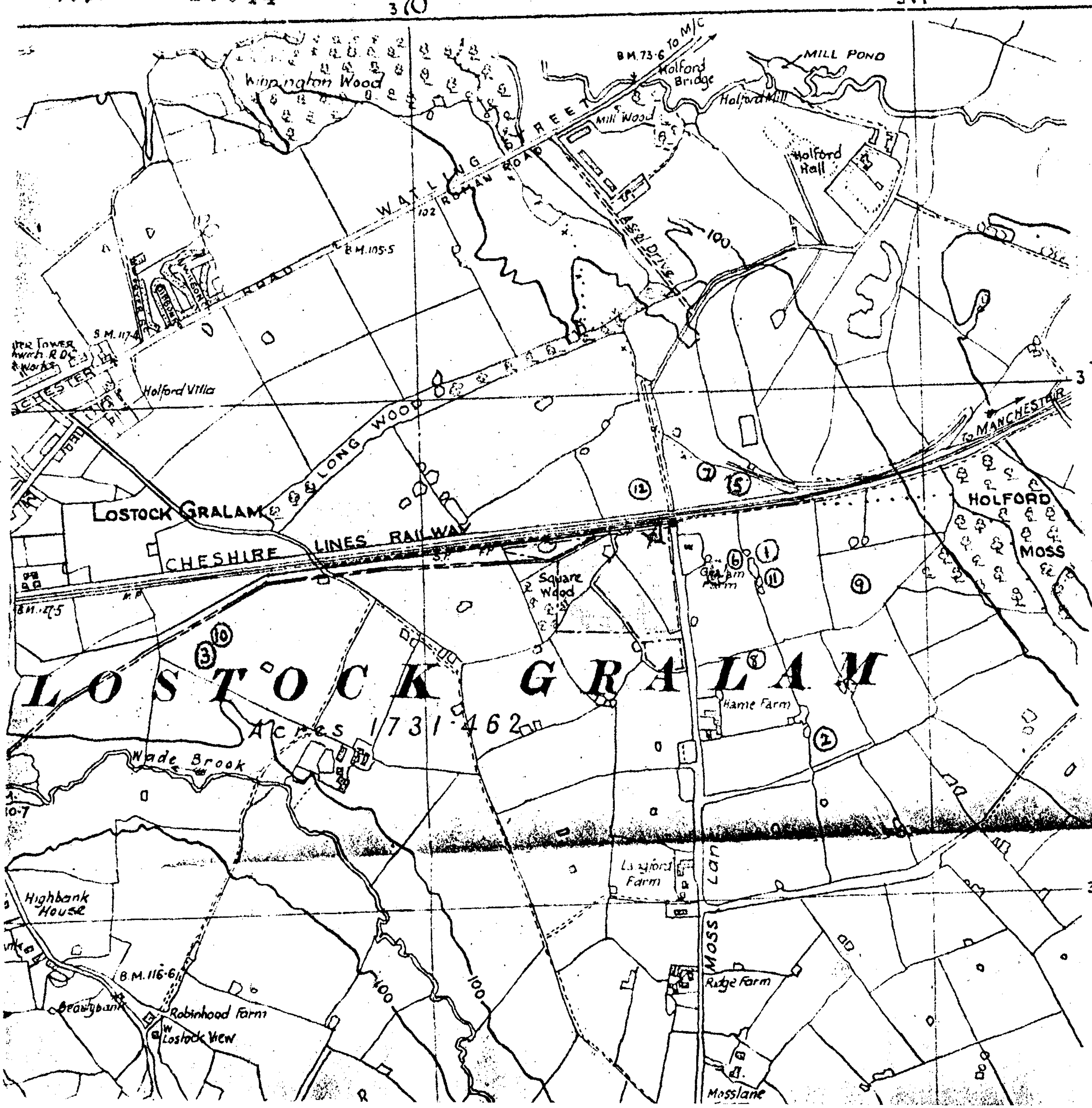
1/4 1/2 3/4 1 MILE

NATIONAL GRID REFERENCE.

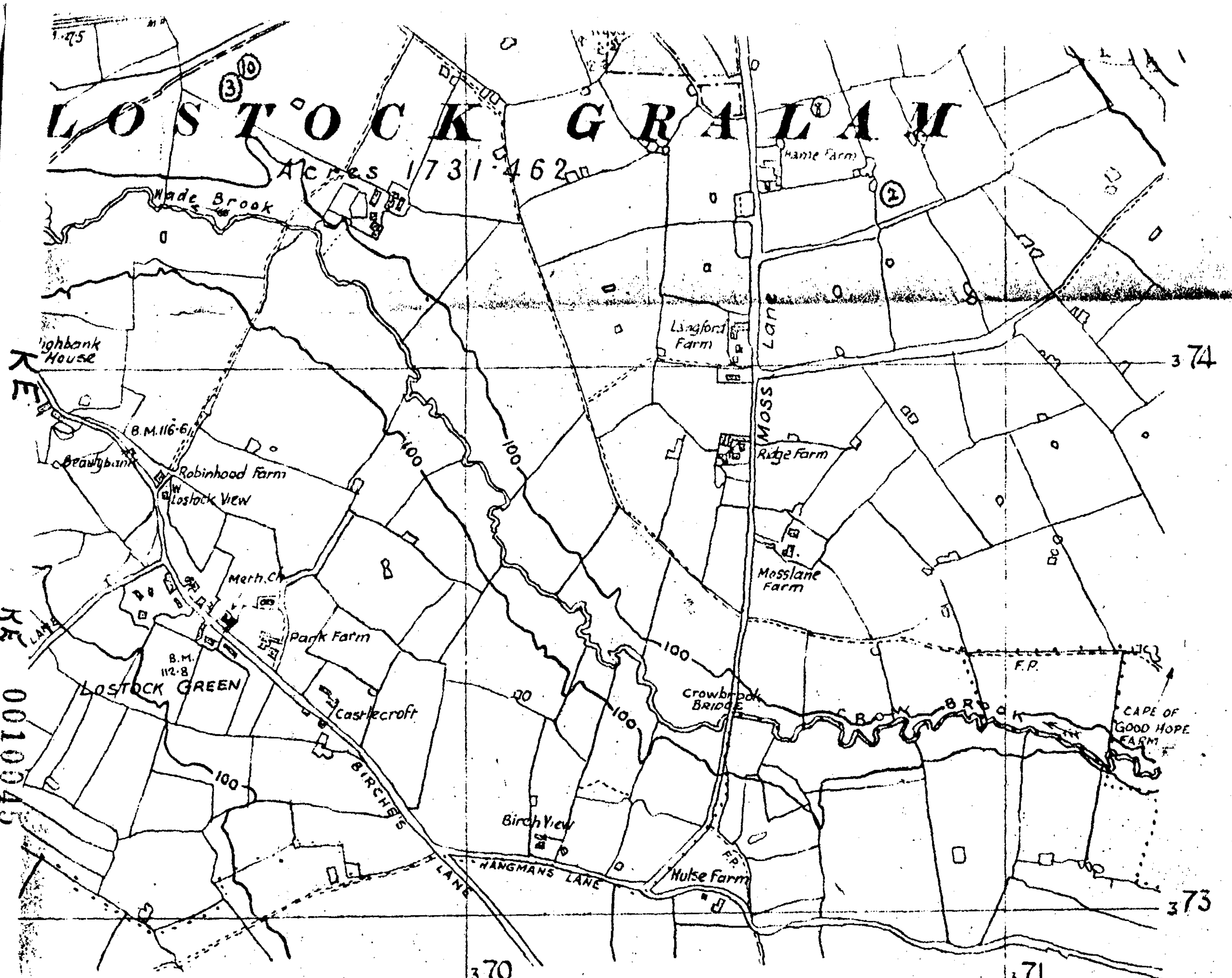
THE ASSOCIATED ETHYL CO. LTD. NORTHWICH CHESHIRE.	GENERAL PLAN OF ENVIRONS OF T.E.L. PL

KE 0010043

KE 0010044



* Furnace Chimney.
O Sample points.
(Samples 6 - 12 inclusive collected 30/11/50)
'Grass' in fallow.



DRAWN BY:-	
TRACED BY:-	
CHECKED BY:-	

T.E.L. PLANT, NORTHWICH, CHESHIRE.

JOB No.	ORDER No.	No. OF SETS REQD.

Traced from 6" Ordnance, Cheshire Sheets XXXIV. NW., NE., SW., SE. 1908 & 1938 Editi

ANALYSES OF LOCAL CROP SAMPLES - 1950.

23rd November 1950.

	Sample No.	Type.	National Grid Ref. ⊕	Wt. of Sample Taken.	Mgms.pb/ 100 gms.	Mgm. Pb/Kgm. or p.p.m.
22.8.50.	1.	Oats	7066-7465	50 gms.	2.24	22.4
		Chaff		45 gms.	133.2	1332.0
		Straw		50 gms.	160.0	1660.0
22.8.50.	2.	Wheat	7077-7430	100 gms.	1.22	12.2
		Chaff		25 gms.	11.28	112.8
		Straw		50 gms.	3.04	30.4
22.8.50.	3.	Oats, Barley	6960-7453	50 gms.	1.84	18.4
		Chaff		25 gms.	5.68	56.8
		Straw		50 gms.	4.84	48.4
22.8.50.	4.	Oats	7057-7463	50 gms.	2.84	28.4
		Chaff		25 gms.	51.2	512.0
		Straw		50 gms.	68.0	680.0
19.7.50.	5.	Hay	7063-7480	50 gms.	62.0	620.0

W. Trevor Marlam.
23.11.50.

⊕ 6" Ordnance Cheshire Sheets XXXIV. N.W., N.E., S.W., S.E., 1908 & 1938 Editions.

Location of Furnace Chimney - Grid Ref. 7045 - 7470.

KE 0010046

POTENTIAL SOURCES OF CONTAMINATION OF THE COUNTRYSIDE.

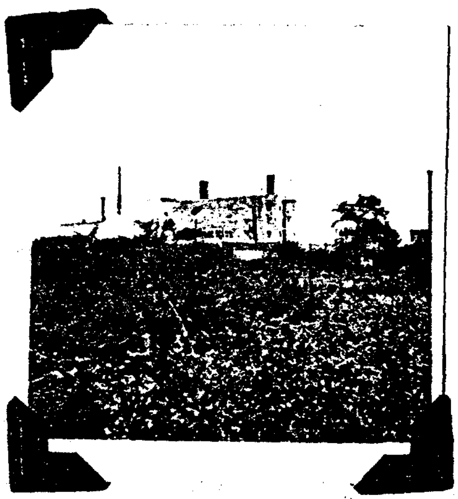
Summary.
Northwich Plant.

Main Source. - East side of Plant.

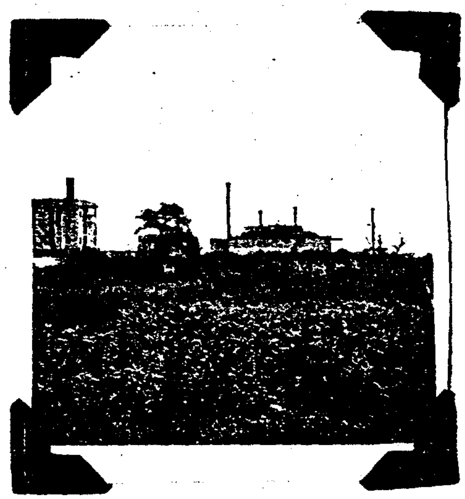
High Level.

	Inorganic	"B" Building.	) From chimney and exhaust sta
Constant	Organic	"A" and "G" Building.	) wastes. Dust deposited fr
			these on roofs, etc.

Occasional. Burst autoclave discs or venting of autoclave vapours and fumes to atmosphere.



1. August, 1950.

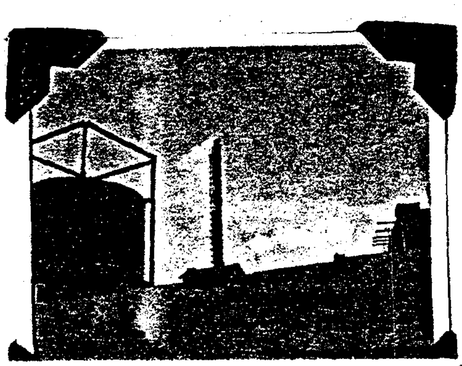


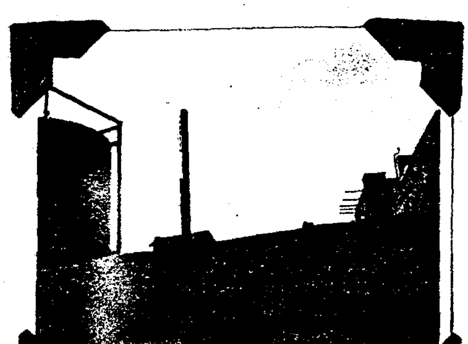
2. August, 1950.

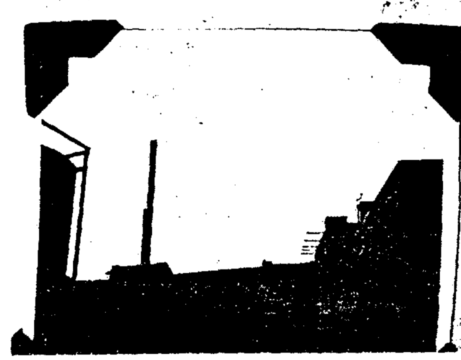
General view of exhaust stacks and chimneys from the S.W.

Main Source - Chimney of reverbatory furnace, "B" Bldg. Total lead liberated to atmosphere about 200 lbs. per day in 1950.

Size of Particles. Those causing heavy local deposition are the size of snow flakes, confetti, sand and pepper. Wind very variable, mainly S.W.







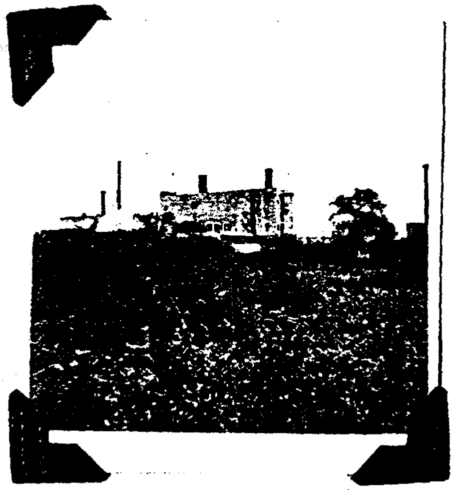
KE 0010047

Main Source. - East side of Plant.

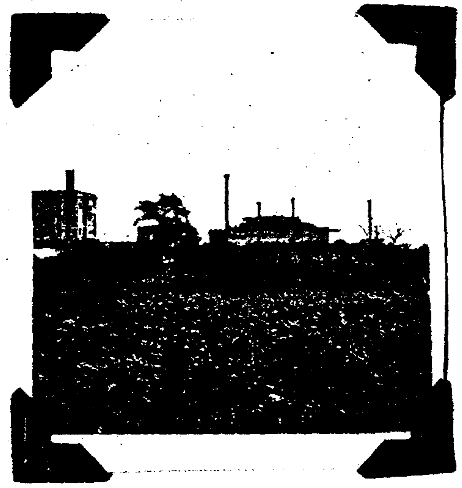
High Level.

Constant	Inorganic	"B" Building.	) From chimney and exhaust sta
	Organic	"A" and "G" Building.	) wastes. Dust deposited fr
			these on roofs, etc.

Occasional. Burst autoclave discs or venting of autoclave vapours and fumes to atmosphere.



1. August, 1950.



2. August, 1950.

General view of exhaust stacks and chimneys from the S.W.

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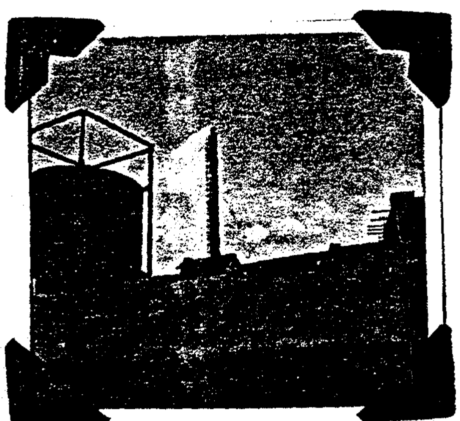
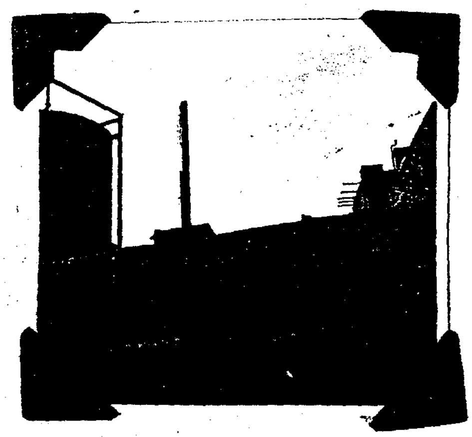
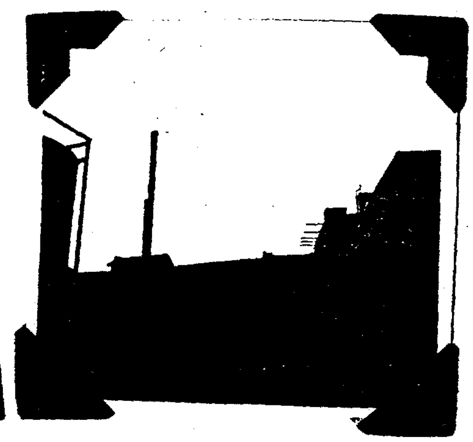
Size of Particles. Those causing heavy local deposition are the size of snow flakes, confetti, sand and pepper. Wind very variable, mainly S.W.



3. August, 1950.

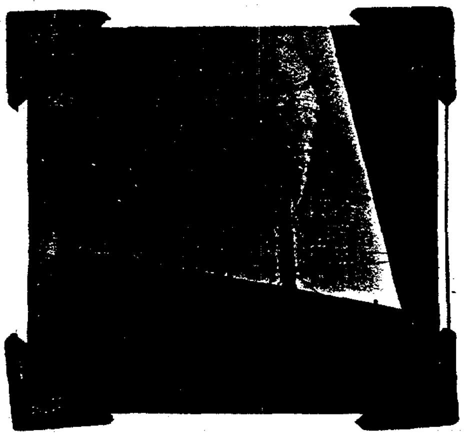


4. August, 1950.



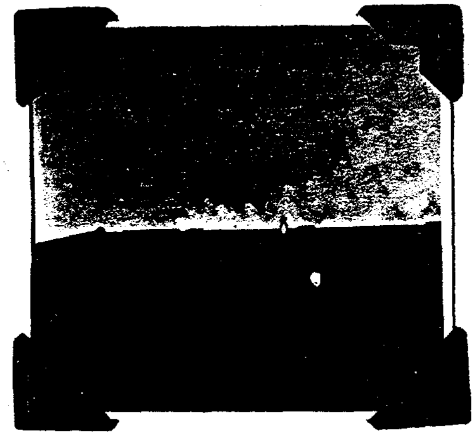
5. August, 1950.

Note variation in direction over a short period.
Taken from Consulting Room window.



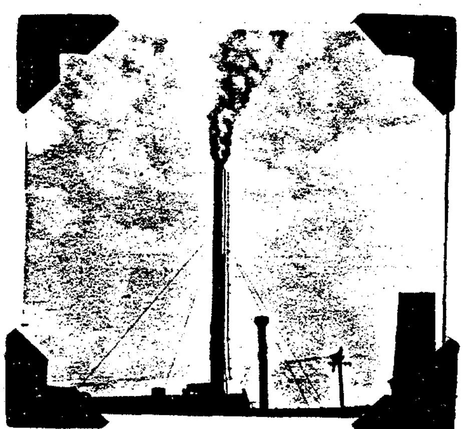
6. August, 1950.

Taken from N. door of input fan house, "A" Building.



7. August, 1950.

Same chimney waste as 6. This deposited a heavy deposit of sandy material on the floor of the fan house.

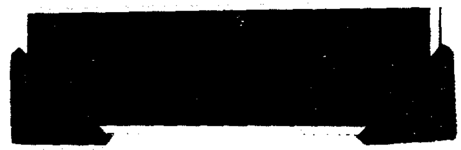


8. August, 1950.

Particles of confetti size were deposited on the farmyard from this.

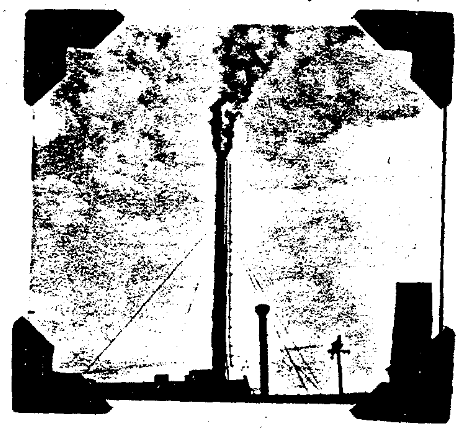
6. August, 1950.

Taken from N. door of input fan house, "A" Building.



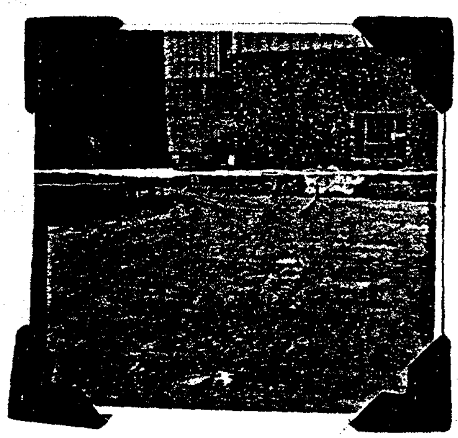
7. August, 1950.

Same chimney waste as 6. This deposited a heavy deposit of sandy material on the floor of the fan house.



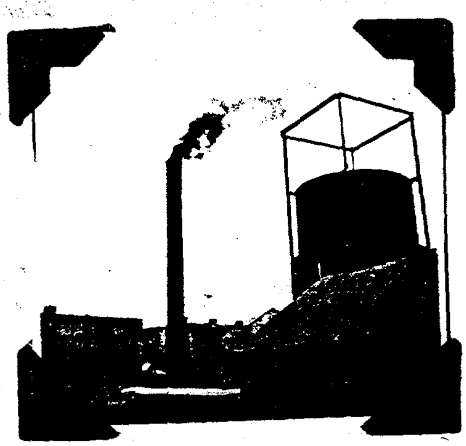
8. August, 1950.

Particles of confetti size were deposited on the farmyard from this.



9. 3.8.1950.

The white patches on the concrete at the East of "B" Building are from "snow flake" sized flocculations from "B" Building chimney.



9.(a)

Low Level Sources.

1. Drum graveyard - broken down scale, etc.
2. Dust from roadway on East side of Plant, including Farmyard dust and fumes.
3. Liquid contamination:
   Surface washings, "G" Building.
   Blocked chemical drains.
   Surface washings, "B" Building area, including overflows from "pad" of sludge water.

10. 31.8.1950.

Lead bearing material on concrete.

11. 18.8.1950.

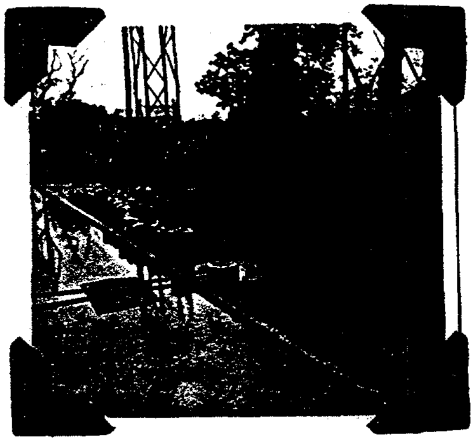
Close-up of 10. background, earlier date.

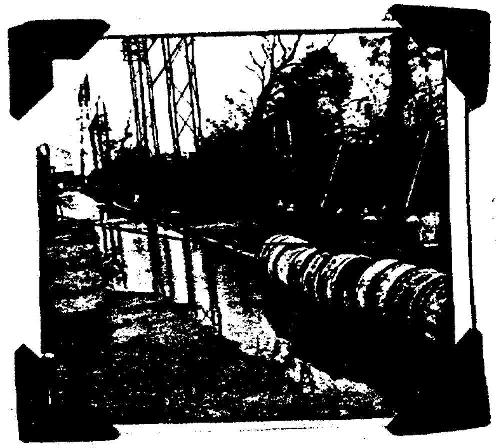
12. 31.8.1950.

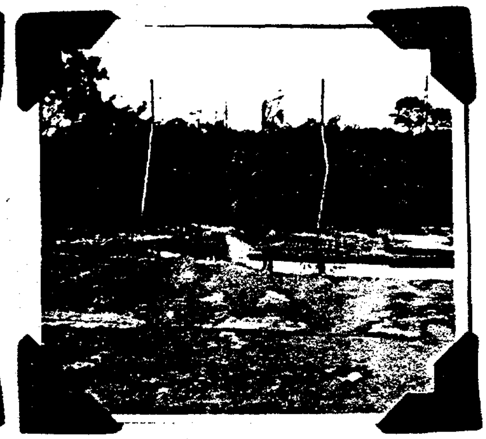
Heavy deposit.

10, 11 and 12 are intermittent.

KE 0010051





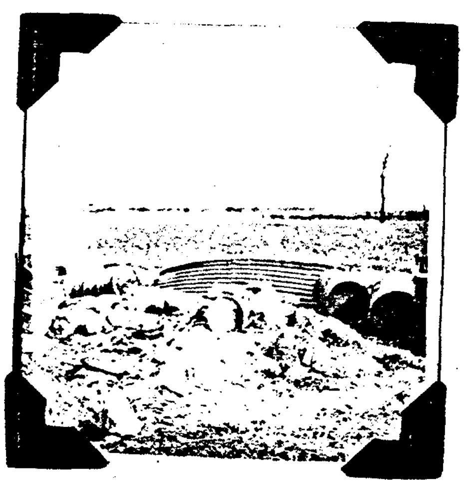


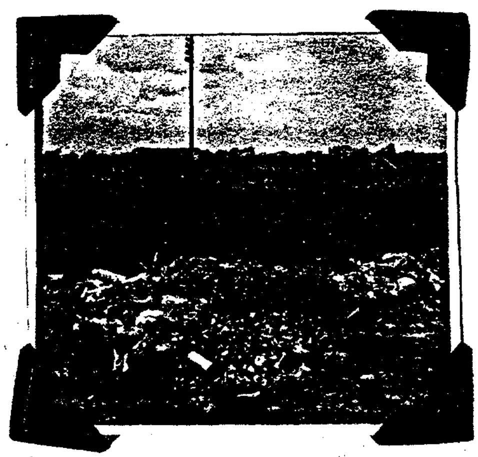
13. 11.8.50. 14. 11.8.50. 15. 11.8.1950.

Back flooding of chemical drains. Intermittent.

Contaminated water in 13 and 14 flowing through opening in fence into ditch in Moss Lane.

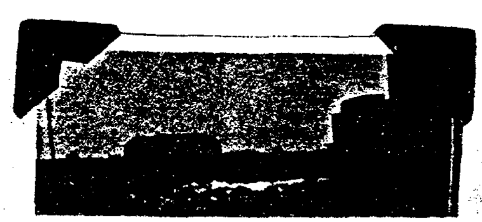
Farmyard.





16. March, 1950. 17. 3.8.1950.

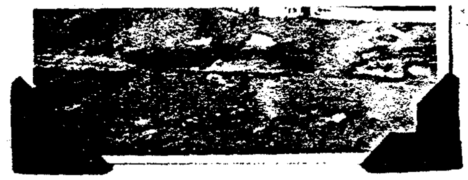
Incompleted incinerated material, some of which is lead bearing. Field beyond is the one in which the animals died.



13. 11.8.50.

Back flooding of chemical drains. Intermittent.

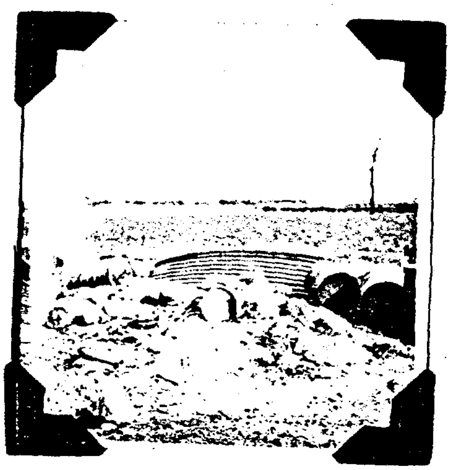
14. 11.8.50.



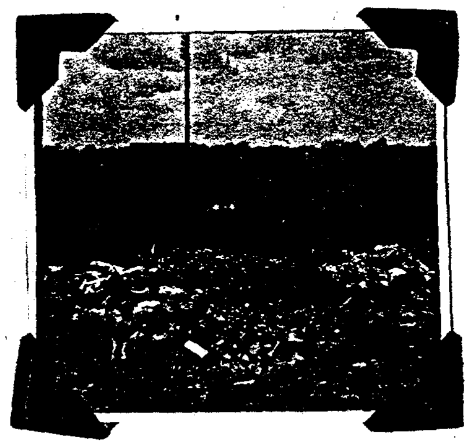
15. 11.8.1950.

Contaminated water in 13 and 14 flowing through opening in fence into ditch in Moss Lane.

Farmyard.

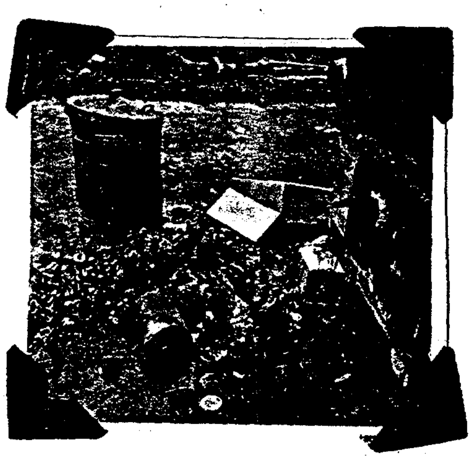


16. March, 1950.



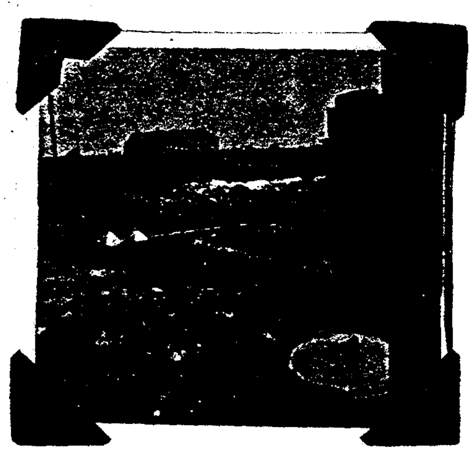
17. 3.8.1950.

Incompleted incinerated material, some of which is lead bearing. Field beyond is the one in which the animals died.



18. 18.8.1950.

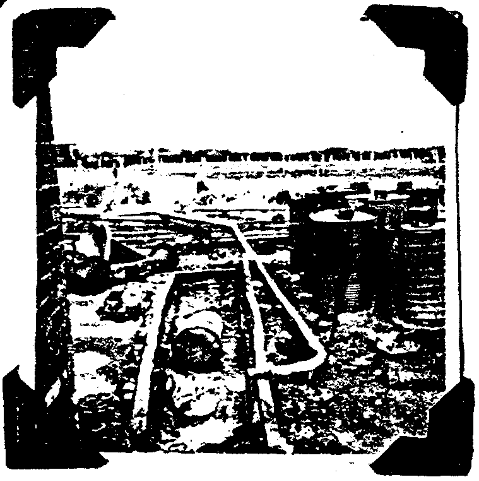
Incompletely incinerated organic lead bearing material at incinerator in farmyard.

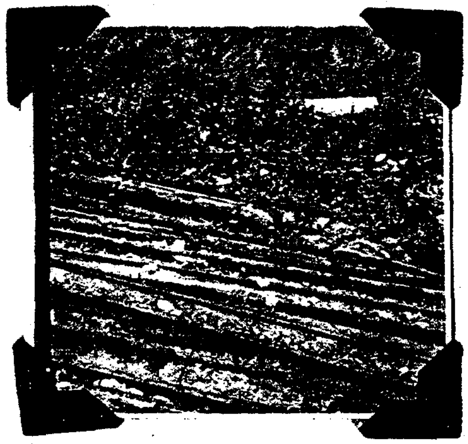


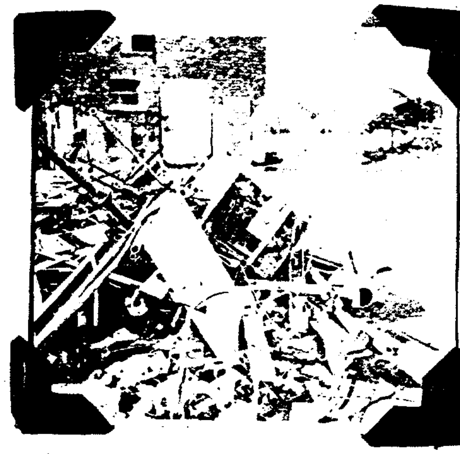
19. 3.8.1950.

Open hearth burning of lead bearing material.

Fumes from incinerator and hearth are at low level.







20. March, 1950.
Trench for decontamination of large parts of equipment. Note deposition of rubbish by wind. Note rails in background.

21. 3.8.1950.
Close-up of rails.
Note deposition of lead bearing material.

22. March, 1950.
Scrap metal. Rubbish in interstices on ground was blown there by wind.

All sources other than "B" Building chimney and bursting of autoclave discs are not by themselves of great importance.

The degree of contamination of vegetation by a burst autoclave disc under the worst known conditions gave rise to contamination of the following order: Samples were provided about a week after the incident.

<u>Deposition on Cabbage after Burst of Autoclave Disc.</u>

8.11.1950.	Size of sample 14 sq. inches. of heavily contaminated leaf.	Mg. Pb on 14 sq.in.	Mg per sq.in.
	Amount in water used for washing off surface contamination. Soluble in water.	0.85	0.061
	Amount in water used for washing off surface contamination. Insoluble in water.	47.0	3.55
	Soluble chloride as chlorine	0.5 mg. per sq. inch.	

10.11.1950.	Mg.Pb/14 sq. in.	Mg.Pb/ sq. in.	% wt.	p.p.m.	Mg./100 gm.
Cabbage leaf after washing. 14 sq. ins. Wt. 3.2 gms.	4.4	0.314	0.14	1400	140
Leaf of whole cabbage.					

20. March, 1950. Trench for decontamination of large parts of equipment. Note deposition of rubbish by wind. Note rails in background.

21. 3.8.1950. Close-up of rails. Note deposition of lead bearing material.

22. March, 1950. Scrap metal. Rubbish in interstices on ground was blown there by wind.

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Leaf of whole cabbage. 14 sq. ins. Wt. 3.8 gms.	3.8	0.271	0.15	1500	150

The photographs are not intended to indicate present conditions. A proper incinerator has been located elsewhere, and the farmyard is little used at the present time.

KE 0010055

Table 3 shows the degree of contamination of vegetation over a period of years. The figures for 1949 are excluded as the method of analysis was inaccurate.

Notes.

1. All samples were collected by the Management 1942 - 1950, with the exception of one water sample, (Point 5), which was taken by the Medical Department on 30.11.50. - Result, 0.29 p.p.m.

The vegetation analyses 1942 - 1947 inclusive were done in the Research Laboratories, I.C.I., Winnington. In 1948 and 1949 the Courtauld Institute methods were used. In 1950 the Bambach and Burkey method was used by us. Water samples have been done by the Northwich plant works laboratory with the exception noted.

2. Location of animals - see map.

January or February to end of August	Grey horse	)	A.B.C.
March to end of August	Mare and foal	)	
Late August - November.	Mare and foal.	)	D.E.
Late September - November.	Grey horse.	)	
November, for four days.	All three animals.		F.
November, seven days approximately before death.	All three animals.		G.

E. Davison.
5th January, 1951;

THE HARMFUL EFFECTS OF LEAD ON ANIMALS.

Review.

In the early part of the nineteenth century, it was not uncommon for cattle, grazing on the hillsides in part of Co. Durham, to die from a disease attributed to lead, which had been deposited on the herbage from the chimneys connected with local lead-smelting furnaces. In the early thirties of this century, similar deaths of livestock occurred in various districts of the same county, but all had the common factor in the presence of coke ovens adjacent to the grazing grounds implicated. Dunn and Bloxham (1, a and b) found lead (14 p.p.m.) and copper (4.7 p.p.m.) in herbage in one such area. One farmer lost about thirty animals which had grazed on such contaminated pastures, and had others ill. The water supply for the livestock was not involved. Lead was found in the organs of some poisoned animals to the concentrations:

concentrations:	Liver	2.6 p.p.m.
	Kidney	1.7 p.p.m.
	Stomach tissue	0.6 p.p.m.

Pyrites in coal may contain lead in varying proportions from 20 to 50 p.p.m., and it was inferred that this was the source of the contamination of the vegetation.

In continental countries and America, the problem of lead absorption in animals has been investigated from time to time, and some of the more recent work is included in this short review, although the value is not great for purposes of comparison with the problem at the manufacturing plant in Northwich.

Gabel (2) considered subacute lead poisoning a frequent disease in veterinary practice, and found the concentration of lead in liver tissue a useful guide when considered critically. He presumed lead could have been dangerous to life [illegible] excess of 0.2 mg. per 100 gms. of liver substance of horse or cow. In his experience the incidence of [illegible] for cattle, grazing on the hillsides in part of Co. Durham, to die from a disease attributed to lead, which had been deposited on the herbage from the chimneys connected with local lead-smelting furnaces. In the early thirties of this century, similar deaths of livestock occurred in various districts of the same county, but all had the common factor in the presence of coke ovens adjacent to the grazing grounds implicated. Dunn and Bloxham (1, a and b) found lead (14 p.p.m.) and copper (4.7 p.p.m.) in herbage in one such area. One farmer lost about thirty animals which had grazed on such contaminated pastures, and had others ill. The water supply for the livestock was not involved. Lead was found in the organs of some poisoned animals to the concentrations:

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Dankwortt and Holl (4) determined the lead content of cows, pigs and horses, which had been slaughtered in the municipal abattoir in Hanover, and also from material obtained in the open market. Three analytical procedures were used, including the electrolytic method of Schmidt and Weyrauch (5), whose work is considered subsequently. They considered the quantitative determination of lead with dithizone by the Fischer method unsatisfactory, as its accuracy is disturbed by organic material. Their findings by the electrolytic method used were:-

Tissue.	Concentration. Mg. Pb/100 gm.	P.p.m.
Liver	0.02	.2
Kidney	0.015	.15
Spleen	0.015	.15
Brain	0.015	.15
Bone	0.07	.7

Other investigators have had difficulty in finding any lead in brain, especially of smaller animals such as the rabbit, even when these had been given lead by various routes for significant periods.

In summarising their findings, Danckwortt and Holl (4) state that in cows, values of o.01 - 0.1 mg. Pb per 100 gm. of an organ is normal. In bones of cows, lead in concentrations of 1.15 mg. per 100 gm. is normal. The mean value of liver, kidney and spleen is 0.025 mg. per 100 gm. and 0.66 mg. for bone substance. In pigs the mean value for organic concentrations of lead is six times more than in cows, and for bones the concentration is double. This is probably due to a greater ingestion of lead by the omniverous pig than by the herbiverous cow. Weyrauch and Muller (6) state that allowance should be made for the state of the tissue being analysed, the fresh weight being approximately four times the dry weight.

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Pfrieme (7) considers that increase in lead absorption may be best determined from bone analysis, and next in the liver and kidneys. Traces are present also in the spleen, but the brain was always found lead free. He determined particularly the lead content of teeth, which should be relative to that of bone. Human and animal teeth frommany sources were analysed. He found lead in the teeth of normal individuals, and found more in individuals of older age groups. Lead is normally present in the teeth of carnivora, and herbivora, less in the latter. An omniverous animal, the pig, holds an intermediate position. The maximum normal concentration found in horse teeth was 0.04 mg. per 3 gm. of ash. Other investigators have found lead in higher and lower concentrations than in bone. The consensus of opinion appears to be that greater concentrations are to be found in teeth, and in the greatest concentration in the dentine of the teeth roots. In man, accumulation of lead in teeth as great as 7.9 mg. per 100 gm. ash has been found.

Weyrauch (8) considers that lead is present essentially in the bones, kidneys, liver and blood. He is also of the opinion of Barth (9) and Morris (10) that the lead value in bone increases with age, but does not run parallel to the age. Lehmann (11) found the goat relatively resistant to lead, and Weyrauch (8) has confirmed this. In the experiments of Lehmann, a goat was fed with 0.6 gm. of lead chromate daily for 91 days, without apparent ill effect. Weyrauch fed a goat with 180 gm. of lead acetate with 280 gm. of white lead, i.e. 330 gm. of lead over a period of ten months. The animal remained in good health and gained weight. On analysis of some tissues after slaughtering, considerable quantities of lead were found, especially in the bones, kidney, liver, brain, spleen and pancreas.

Goat. Mg. Pb/100 gm. dry tissue.

			P.p.m.
Liver		1.4	14
Kidney	Cortex	4.1	41
	Medulla	1.7	17
Lung		0	0
Spleen		0.53	5.3
Long bone		13.8	138
Brain		0.95	9.5

The distribution of lead in a calf and a mare whose decease was teeth was 0.04 mg. per 5 gm. of ash. Other investigators have found lead in higher and lower concentrations than in bone. The consensus of opinion appears to be that greater concentrations are to be found in teeth, and in the greatest concentration in the dentine of the teeth roots. In man, accumulation of lead in teeth as great as 7.9 mg. per 100 gm. ash has been found.

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Long bone		13.8	138
Brain		0.95	9.5

The distribution of lead in a calf and a mare whose decease was attributed to lead are shown in the following table. The immediate cause of death in the mare was apparently pneumonia, and the source of lead, dust from a foundry.

KE 0010062

Table 1.

SOLUBILITIES IN WATER OF LEAD COMPOUNDS.

The 1950 edition of Perry's Chemical Engineers' Handbook gives the following figures in gms./190 gm. water.

Temperature °C.	0°	10°	18°	20°	25°	30°
Lead acetate.					55.04	
Lead bromide.	0.4554			0.85		1.15
Lead carbonate.				0.00011		
Lead chloride.	0.6728			0.99		1.20
Lead sulphate.	0.0028	0.0035		0.0041		0.0049
Lead sulphide.			0.00009			
Lead Monoxide.			0.0068			

Tissue.	Mg. Pb per 100 gm. dry tissue.		
	Calf.	Mare.	Normal Horse.
Liver	5.0	1.5	Trace
Kidney	27.0	7.0	0
Lung	1.4	-	-
Spleen	2.4	2.5	0
Bone	7.7	4.0	0.5
Blood	1.0	0.13	0
Intestine (with contents)	7.8	-	-

Should these results be used for comparison with our investigations shown subsequently, allowance should be made for the possibly greater accuracy of the method used by us, and also for the fact that our results are calculated on the weight of fresh tissue, which is stated above to be four times as heavy as dry tissue. The method used by Weyrauch is probably not very inaccurate, which would permit the inference that, for purposes of comparison, our figures are low.

Weyrauch states that in human and animal lead poisoning, it is necessary to examine the liver, kidney, spleen, brain, bone and blood.

In children and young animals, there is good evidence that lead is deposited in the growing ends of bones in a selective manner. X-ray examinations have shown areas of increased density which in long bones appear as a series of transverse lines in the diaphysis (end of shaft) immediately below the epiphysis (growing end).

The relative toxicity of lead and lead compounds requires consideration as well as the distribution of leadin tissues, which has occupied most attention in this review. Fairhall and Sayers (12), from their experiments with guinea pigs, consider lead arsenate, carbonate, monoxide and sulphate to be more toxic than lead and other lead compounds when fed to animals, possibly due to their greater solubility in digestive juices. The solubilities of various lead compounds are shown on table 1, which was prepared by Dr. W.T. Earlam from recent literature. Fairhall and Sayers found lead in

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Consideration of the report of the Selby Smelter Commission has purposely been left to this stage. It should be appreciated that this admirable report was published in 1915, since which time the methods of analysis have greatly improved, and knowledge of lead from the medical point of view has made great advances. In fact, the entire problem of lead metabolism in the animal organism has been established in a very different light. The following points from the report are of interest. The amount of lead found in grass after a dry summer was 21 p.p.m. (maximum), which amounted to 0.9 gm. Pb per 100 lbs. of hay. There was no evidence that this degree of contamination, or that the ingestion of 0.25 gm. of lead per day by a horse would result in symptoms of chronic lead poisoning. The rate of discharge of lead fume up the chimney after passing through a bag filter was 96 - 113 lbs. in 24 hours. They considered that the amount of lead deposited on soil was so small that it would take many years to bring about an appreciable increase in the lead content of soil. It was estimated that lead would require to be present in a concentration of about 1200 parts per million before it would interfere with the growth of vegetation. The mean concentration on exposed surface soil in the smoke zone was 15.2 p.p.m. In the livestock survey, injury to horses is noted. No injury to cows, pigs and sheep is noted. Horses develop a paralysis of the throat muscles in chronic lead poisoning, and are more liable to pneumonia, possibly due to inhalation of food particles into the lungs owing to the paralysed condition.

Lead is present in the milk of human and animal females, and is increased under conditions of excessive lead absorption and lead poisoning.

The contamination of foodstuffs by lead deserves mention where relevant to this review. The lead in water in the Northwich area is about 0.03 p.p.m. It is considered by some authorities that potatoes and other vegetables, when boiled in water containing lead, take up much of the lead present. In this country, 0.3 p.p.m. of lead in water is considered safe, point of view has made great advances. In fact, the entire problem of lead metabolism in the animal organism has been established in a very different light. The following points from the report are of interest. The amount of lead found in grass after a dry summer was 21 p.p.m. (maximum), which amounted to 0.9 gm. Pb per 100 lbs. of hay. There was no evidence that this degree of contamination, or that the ingestion of 0.25 gm. of lead per day by a horse would result in symptoms of chronic lead poisoning. The rate of discharge of lead fume up the chimney after passing through a bag filter was 96 - 113 lbs. in 24 hours. They considered that the amount of lead deposited on soil was so small that it would take many years to bring about an appreciable increase in the lead content of soil. It was estimated that lead would require to be present in a concentration of about 1200 parts per million before it would interfere with the growth of vegetation. The mean concentration on exposed surface soil in the smoke zone was 15.2 p.p.m. In the livestock survey, injury to horses is noted. No injury to cows, pigs and sheep is noted. Horses develop a paralysis of the throat muscles in chronic lead poisoning, and are more liable to pneumonia, possibly due to inhalation of food particles into the lungs owing to the paralysed condition.

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Lead arsenate is used as an agricultural insecticide. The present United States limit is 7.2 p.p.m. It would appear that the natural lead content of wheat may be higher than was previously thought. Kent (14) found 0.9 p.p.m. in wheat flour, and 3 p.p.m. in the bran. The pericarp of wheat contained as much as 4.8 p.p.m.

Lead Metabolism.

A vast amount of work on lead metabolism, normal and abnormal, has been and continues to be published. Most of this is not directly applicable to the problem presently to be discussed, and our basis for this purpose is now given succinctly.

The earth is a lead-bearing planet, and therefore small quantities of lead are found normally in the soil, the flora that flourishes in this, the water draining it and the fauna which drink and feed on these, and in some cases on themselves. Lead does not play an essential part in the metabolism of vegetation, only minute amounts are to be found in the protoplasm. Excessive amounts of lead in vegetation are due to deposits on the surface through man made agencies, and such lead bearing material may adhere so firmly to vegetation that it may be considered part of the vegetation. Wind and rain may remove some of the deposited lead, but in most cases the reduction in concentration per unit of surface will not be sufficient to reduce to any material extent the superimposed lead.

Under normal conditions, all men and animals absorb most of the lead for their tissues from food and drink ingested. Under circumstances in which there is excessive exposure to lead, man usually inhales it, his food sources remaining normal, but in animals the main portal of entry remains the alimentary tract, as the source of lead is usually contaminated vegetation, and consequently animals most dependent upon this for nutrition, such as the herbivora, are likely to absorb most, although herbivora normally ingest and absorb least lead. No definite statement can be made on the relative susceptibility of animals. There may possibly be no such condition as relative susceptibility to lead poisoning. The result may depend upon the dose ingested and absorbed relative to the body weight, with due consideration of other possible variants, such as growth, age, storage and rates of excretion of lead.

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In animals, it is considered that most lead is absorbed into the portal blood stream from the alimentary tract, and carried by that system to the liver, which acts as a filter, barrier, and temporary store. The portal blood flow may be looked upon as passing through the liver, and connecting the intestine to that organ. From the liver, it will pass into the systemic circulation, and be carried to all tissues in that vehicle. The liver may pass a little via the bile back into the alimentary canal. The kidneys, being the main filter, will excrete the lead carried to them in the blood as a non-essential and inert substance. The amount found in the liver depends upon the quantity of lead ingested daily, and the period over which this dose is ingested. If large amounts are taken consistently, then the liver concentration will be high compared with other tissues. An exchange between the blood and tissues is a continuous process, and most will be passed from the former to bone for permanent storage. It may be anticipated that more will be stored in the more dense bone and at the growing end. In the presence of intense or high constant absorption, the power of excretion of the kidneys and rate of storage in bone may be incapable of keeping the concentration in blood and the tissues within a reasonable level, with the inevitable result that signs of intoxication will arise from the protoplasmic poison - lead.

The Present Problem.

The foregoing notes, we feel, present succinctly current views and findings on normal and abnormal lead metabolism in animals. Three horses died over a short period near the Northwich plant, and it was suggested by the local farmer that these animals might possibly have died as a result of lead poisoning. Our findings are presented in chronological form.

The owner of the three animals, the tenant of Langford Farm, stated that he purchased the grey horse or gelding at a fair in Wrexham in either January of February of last year. The mare, which was about five years old, was bought in foal from a farmer in the Mobberley area, which is about seven miles or so from the plant. The colt was born in Langford Farm in May. The gelding was worked intermittently and had additional feeding with purchased bran and chopped-up hay, which had been grown locally. All three animals had been in fields in the vicinity of Langford Farm until ingested daily, and the period over which this dose is ingested. If large amounts are taken consistently, then the liver concentration will be high compared with other tissues. An exchange between the blood and tissues is a continuous process, and most will be passed from the former to bone for permanent storage. It may be anticipated that more will be stored in the more dense bone and at the growing end. In the presence of intense or high constant absorption, the power of excretion of the kidneys and rate of storage in bone may be incapable of keeping the concentration in blood and the tissues within a reasonable level, with the inevitable result that signs of intoxication will arise from the protoplasmic poison - lead.

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x One of these was shot.

and new. Cows also grazed on these fields. There are a few surface collections of water on these fields. The main water supply for the horses and cattle is a trough, which fills from the town main supply. About a month later, that is about the end of September, the gelding was also put into this field, and thereafter its movements were similar to those of the mare and colt foal. All three remained in these two fields until some time in November, when they were removed some distance away, to a field South-East of the plant, the water supply of which was two ponds, supplied by surface water. They remained here for approximately four days. Someone is stated to have left the gate of this field open, and the horses found their way on to Moss Lane, and were found the following morning near the plant, and were placed in a field immediately East of the plant, in which Gralam farmstead is situated. This field had also had cereal crops. There are five ponds in this field, all filling from surface water, and one of these is adjacent to Moss Lane at the level of "G" Building. The others are approximately 200 yeard from the plant. About a week later, the foal was found dead, and the mare was stated to be missing. This was on the morning of Tuesday, 28th November. On the morning of the 29th November; one attended a post mortem on the colt, with the Veterinary Surgeon, Mr. W. Wilson, The Willows, Hartford, Northwich. The immediate cause of the death of the foal colt was obviously a massive pneumonic consolidation of the lungs, which must have commenced some days before death. There was a slight excess of free fluid in the abdominal cavity. Pneumonia in colts was stated to be very rare in this area. The colt was also stated to be in good condition. Samples of various tissues of this animal were taken. The same afternoon, the Veterinary Surgeon informed us that the mare had been found dead in the same field, and that the gelding was in a dying condition, and passing mucus in its stools. The post mortem of these two animals was attended by the Veterinary Surgeon and us the following morning, on which the gelding had been shot. The post mortems in all cases were performed at the yard of and thereafter its movements were similar to those of the mare and colt foal. All three remained in these two fields until some time in November, when they were removed some distance away, to a field South-East of the plant, the water supply of which was two ponds, supplied by surface water. They remained here for approximately four days. Someone is stated to have left the gate of this field open, and the horses found their way on to Moss Lane, and were found the following morning near the plant, and were placed in a field immediately East of the plant, in which Gralam farmstead is situated. This field had also had cereal crops. There are five ponds in this field, all filling from surface water, and one of these is adjacent to Moss Lane at the level of "G" Building. The others are approximately 200 yeard from the plant. About a week later, the foal was found dead, and the mare was stated to be missing. This was on the morning of Tuesday, 28th November. On the morning of the 29th November, one attended a post mortem on the colt, with the Veterinary Surgeon, Mr. W. Wilson, The Willows, Hartford, Northwich. The immediate cause of the death of the foal colt was obviously a massive pneumonic consolidation of the lungs, which must have commenced some days before death. There was a slight excess of free fluid in the abdominal cavity. Pneumonia in colts was stated to be very rare in this area. The colt was also stated to be in good condition. Samples of various tissues of this animal were taken. 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The Veterinary Surgeon obtained duplicate samples of the tissues of the gelding or grey horse. All samples of tissue were seen to come from the animals in question, with the exception of the sample of bone from the mare, and a limb stated to belong to this animal was taken from a bin, and a sample of bone taken from it. It was not possible to obtain samples of urine from these animals, as the bladders were empty. The blood samples were obtained from the heart, and consisted of blood clot, which was similar in condition in the two samples taken. The results of the analysis of these samples are shown in table 2. Further samples are being obtained and analysed to complete the control animal.

The farmer stated on the 29th December that he had had no cows or other animals ill with any condition similar to that from which the gelding suffered. The farmer deals in horses as a side line, and it was his opinion that adult animals would eat about 40 pounds of grass per day. The foal colt, he felt, would be suckled by its mother until about a year old, and as it was only seven months at the time of death, he felt that it would not be eating much grass. The Veterinary Surgeon's opinion on this is that the colt foal would eat grass to supplement its diet of milk, which would be failing in the mare at this time of the year.

A sample of water from the pond in the field East of the plant, near "G" Building,* was obtained on the 30th December, and contained .29 parts of lead per million. Samples of grass from some fields round the plant were obtained on the 30th November. In the fields North and North-East of the plant the lead concentrations were 1181 and 1921 parts of lead per million, and in the field East of the plant 1348 and 1350 parts of lead per million. All these samples were collected by the Works Management, and we had no knowledge of the locations from which they were collected during analysis.

In cases of reputed lead poisoning, it is necessary to establish or grey horse. All samples of tissue were seen to come from the animals in question, with the exception of the sample of bone from the mare, and a limb stated to belong to this animal was taken from a bin, and a sample of bone taken from it. It was not possible to obtain samples of urine from these animals, as the bladders were empty. The blood samples were obtained from the heart, and consisted of blood clot, which was similar in condition in the two samples taken. The results of the analysis of these samples are shown in table 2. Further samples are being obtained and analysed to complete the control animal.

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In cases of reputed lead poisoning, it is necessary to establish (1) that there has been significant exposure to lead, (2) that the symptoms and signs are those of lead poisoning, (3) that the tissues or other biological samples contain lead in concentrations greater than normal, when analysed by a

* Point 5 on map.

precise technique, with all due precautions and allowances being made for the possibility of contamination, and (4) that there is no other evident cause for the condition.

From the foregoing, it is obvious that the first condition is present, namely contamination of pasture by lead to a very considerable degree. The condition of the animals prior to death is not known, but what little is known of the gelding does conform to what may be anticipated in lead poisoning in horses. Some tissues of the animals had contained high concentrations of lead, and there is no evident cause of death other than the pneumonic conditions in the lungs of the colt and the gelding, which are considered to be due to intercurrent disease, which has been previously described as associated with lead poisoning in horses.

Consideration of the figures on table 2 shown a high concentration of lead in the liver of the foal, mare and grey horse compared with the control animal, and at a higher ratio than that found in the results for the kidney and bone. This, interpreted by us, means that there was very intensive and possibly prolonged absorption of lead from the alimentary tract prior to death. The kidney concentrations of lead are sufficiently high to warrant the conclusion that these animals were excreting lead via the kidneys in some considerable concentration. The findings in the bone of the colt indicate that this animal had been absorbing lead for some considerable time before death, and the concentration of lead in the colon contents of this animal, which to us seemed to consist of a grassy-looking material, when expressed either per 100 grammes of the sample or in terms of the ash, is also beyond normal limits. The bones of the mare and gelding contain lead in concentrations slightly in excess of normal. Nevertheless, we feel that these animals also had been ingesting lead bearing material for some considerable period before death.

The main source of the lead bearing material in the adult animals present, namely contamination of pasture by lead to a very considerable degree. The condition of the animals prior to death is not known, but what little is known of the gelding does conform to what may be anticipated in lead poisoning in horses. Some tissues of the animals had contained high concentrations of lead, and there is no evident cause of death other than the pneumonic conditions in the lungs of the colt and the gelding, which are considered to be due to intercurrent disease, which has been previously described as associated with lead poisoning in horses.

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The main source of the lead bearing material in the adult animals is, in our opinion, the vegetation consumed. The amount contained in water compared with this is insignificant. The amounts found in water in the fields in the area are shown on the table overleaf, and of these points, 4 and 5 relate to the fields on the East of the plant, and 1,2 and 3 to the fields on the North and North-East.

The possibility of the inhalation of lead cannot be excluded, as frequently the smoke, fume, dust and mist from chimney wastes and inorganic lead vapours may cross the fields in which the horses have grazed at the level of the breathing zone of animals. It is understood that on the night of the 27th November or early morning of the 28th November, a considerable amount of organic lead was liberated to the atmosphere from an autoclave, and that no tetraethyl lead was obtained from the reaction mass remaining afterwards. There is the remote possibility that this may have had some detrimental effect on the gelding, but at the time of this occurrence, it is our opinion that the colt was already dying, and the mare already dead. The pneumonia in the colt at this time was, in our opinion, already advanced, and parts of the lung solid. The inhalation factor is, in our opinion, insignificant compared with that of ingestion of lead deposited on vegetation. We are not prepared to say definitely that the lead on the vegetation was due to either inorganic or organic lead, but we do feel that the evidence points to inorganic lead being the most likely form in which the deposition occurred. It is not inferred, from the concentrations of lead found on the grass after the event, that such concentrations existed for the some eighty days/ or more on which these animals grazed on these fields. In parts, the lead concentration was probably much less than that found, particularly after the crops had been removed. On the other hand, consideration of the findings indicate to us that it was very probable that a short time prior to death these animals had ingested vegetation containing lead at a much greater concentration than the findings for vegetation indicate.

It is not known, and can never now be determined, whether or not these animals ingested lead from the grass on the roadside on Moss Lane in the vicinity of the plant on the night on which they escaped from the field near Langford Farm. This area has been at times heavily contaminated by lead bearing materials, and no doubt that part of the field adjacent to Moss Lane has, at times, contained high concentrations of lead.

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There are several ways in which the amount of lead ingested by the adult animals over the period may be approached, and from our hyperthetical calculations over the time at which the adult animals were exposed, we feel it is possible that they had ingested one half to one kilogramme, perhaps more, of lead bearing material, in the vegetation consumed by them, and possibly 5% of

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this amount could be ingested from water.

It is therefore our opinion that, whilst the evidence is not unequivocal, there is more than presumptive evidence to indicate that these animals suffered from lead poisoning, the possible sources of which are discussed in the subsequent section.

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Table 2.

HORSE SAMPLES.

SAMPLE.	FOAL.			MARE.			GREY HORSE.			CONTROL HORSE.			M
	Wt. of Sample.	Mg. Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg. Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg. Pb/ Sample.	Mg./100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg./100 gms.	
Liver	100 g.	3.68	3.68	50 g.	1.519	3.04	100 g.	4.2	4.2	85 g.	0.103	0.12	
Kidney	150 g.	3.68	2.45	105 g.	1.679	1.60	100 g.	1,0	1.0	100 g.	0.031	0.031	
Femur	50 g.	11.4	22.8	50 g.	0.64	1.28 *							
Radius							47 g.	0.68	1.45	51.5 g.	0.25	0.48	
Tooth	13 g.	1.359	10.4										
Blood							50 g.	0.089	0.178	100 g.	0.0086	0.0086	
Brain							100 g.	1.24	1.24 +				
Muscle				100 g.	0.094	0.094	60 g.	0.021	0.035	100 g.	0.0106	0.0106	
Lung	100 g.	0.133	0.133	100 g.	0.26	0.26	50 g.	0.155	0.31				
Spleen	100 g.	0.699	0.70										

Colon Contents - Foal.

Wt. gms.	128.5
Mg.Pb. /Sample.	29.5
Mg.Pb. /100 gms.	23.0
Mg.Pb,/1gm. Ash	7.76

* Not observed to be from this animal. Taken from h

\+ This animal was killed with a lead bearing bullet. half of brain without evidence of trauma.

HORSE SAMPLES.

.	MARE.			GREY HORSE.			CONTROL HORSE.			MAXIMUM OF HUMAN NORMAL. (R.A. KEHOE).
Mg/100 gms.	Wt. of Sample.	Mg. Pb/ Sample.	Mg/100 gms.	Wt. of Sample.	Mg. Pb/ Sample.	Mg./100 gms.	Wt. of Sample.	Mg.Pb/ Sample.	Mg./100 gms.	Mg./100 gms.
3.68	50 g.	1.519	3.04	100 g.	4.2	4.2	85 g.	0.103	0.12	0.28
2.45	105 g.	1.679	1.60	100 g.	1.0	1.0	100 g.	0.031	0.031	0.16
22.8	50 g.	0.64	1.28 *							3.59
				47 g.	0.68	1.45	51.5 g.	0.25	0.48	3.59
10.4										
				50 g.	0.089	0.178	100 g.	0.0086	0.0086	0.06 - .07 (circa).
				100 g.	1.24	1.24 +				0.09
	100 g.	0.094	0.094	60 g.	0.021	0.035	100 g.	0.0106	0.0106	0.17
0.133	100 g.	0.26	0.26	50 g.	0.155	0.31				0.06
0.70										0.07

* Not observed to be from this animal. Taken from bin. (See notes).

\+ This animal was killed with a lead bearing bullet. Sample represented half of brain without evidence of trauma.

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Table 3.

VEGETATION ANALYSIS.

Point.	Year.		Grain.	Chaff.	Straw.	Hay.	Remarks.
2	1942.	Oats.	2.7	128	11	-	
	1943.	Oats.	6.9	123	11	-	
	1944	Wheat.	2.2	57	40	-	
	1945.	Hay.	-	-	-	71	No significant change except increase in wheat grain. and grass.
	1946.	Wheat.	4.3	211	39	-	
	1946.	Hay.	-	-	-	24	
	1947.	Oats.	2.0	71	18	-	
	1948.	Oats.		48	26	-	
	1949.		-	-	-	-	
	1950.	Wheat.	12.2	112.8	30.4	-	
		(Grass.	-	-	263.5)		
7	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.	Oats.	0.9	38	9.5	-	
	1945.		-	-	-	-	
	1946.	Oats.	1.9	104	23	-	High grass figures in 1950.
	1947.		-	-	-	-	
	1948.		-	-	-	-	
	1949.		-	-	-	-	
	1950.	(Grass.	-	-	292.8	-)	
1	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.	Oats.	5.8	607	90	-	
	1945.	Oats.	2.2	111	38	-	Marked and dangerous increase in 1950.
	1946.		-	-	-	-	
	1947.	Oats.	4.0	208	21		
		Hay.	-	-	-	78	
	1948.		-	-	-	-	
	1949.		-	-	-	-	
	1950.	Oats.	22.4	133.2	1660	-	
		(Grass.	-	-	1350	-)	
4	1942.		-	-	-	-	
	1943.	Hay.	-	-	-	139	
	1944.		-	-	-	-	
	1945.		-	-	-	-	High figures in 1950. Compare with point 5.
	1946.		-	-	-	-	
	1947.		-	-	-	-	
	1948.	Hay.	-	-	-	235	
	1949.		-	-	-	-	
	1950.	Oats.	28.4	512	680	-	
		(Grass.	-	-	1348-	-)	
5	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.		-	-	-	-	
	1945.		-	-	-	=	High figures
	1946.	Wheat.	7.4	270	56	-	in 1950

	1944	Wheat.	2.2	57	40	-	
	1945.	Hay.	-	-	-	71	No significant change except increase in wheat grain. and grass.
	1946.	Wheat.	4.3	211	39	-	
	1946.	Hay.	-	-	-	24	
	1947.	Oats.	2.0	71	13	-	
	1948.	Oats.		48	26	-	
	1949.		-	-	-	-	
	1950.	Wheat.	12.2	112.8	30.4	-	
		(Grass.	-	-	263.5)		
7	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.	Oats.	0.9	38	9.5	-	
	1945.		-	-	-	-	
	1946.	Oats.	1.9	104	23	-	High grass figures in 1950.
	1947.		-	-	-	-	
	1948.		-	-	-	-	
	1949.		-	-	-	-	
	1950.	(Grass.	-	-	292.8	-)	
1	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.	Oats.	5.8	607	90	-	
	1945.	Oats.	2.2	111	38	-	Marked and dangerous increase in 1950.
	1946.		-	-	-	-	
	1947.	Oats.	4.0	208	21		
		Hay.	-	-	-	78	
	1948.		-	-	-	-	
	1949.		-	-	-	-	
	1950.	Oats.	22.4	133.2	1660	-	
		(Grass.	-	-	1350	-)	
4	1942.		-	-	-	-	
	1943.	Hay.	-	-	-	139	
	1944.		-	-	-	-	
	1945.		-	-	-	-	High figures in 1950. Compare with point 5.
	1946.		-	-	-	-	
	1947.		-	-	-	-	
	1948.	Hay.	-	-	-	235	
	1949.		-	-	-	-	
	1950.	Oats.	28.4	512	680	-	
		(Grass.	-	-	1348-	-)	
5	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.		-	-	-	-	
	1945.		-	-	-	=	High figures in 1950. Compare with point 4.
	1946.	Wheat.	7.4	270	56	-	
	1947.		-	-	-	-	
	1948.	Oats.		39	31	-	
	1949.		-	-	-	-	
	1950.	Hay.	-	-	-	620	
		(Grass.	-	-	1921	-)	

Point.	Year.		Grain.	Chaff.	Straw.	Hay.	Remarks.
6	1942.		-	-	-	-	
	1943.		-	-	-	-	
	1944.		-	-	-	-	
	1945.		-	-	-	-	
	1946.		-	-	-	-	
	1947.		-	-	-	-	
	1948.		-	-	-	-	
	1949.		-	-	-	-	
	1950.	(Grass.			1181)		
3	1942.	Oats.	0.14	6.6	2.2	-	)
	1943.	Oats.	0.9	36.0	6.9	-	)
		Hay.	-	-	-	22.0	)
						31.0	)
	1944.	Oats.	0.4	14.0	2.4	-	)
		Wheat.	0.6	1.2	0.7	-	)
	1945.	Oats.	1.1	35.0	15.0	-	) A "control"
		Hay.	-	-	-	6.3	) point.
	1946.	Wheat.	0.9	18.0	3.4	-	)
		Hay.	-	-	-	2.3	)
	1947.	Oats.	0.6	35	4.9	-	)
		Hay.	-	-	-	-	)
	1948.	Hay.	-	-	-	7.6	)
	1949.		-	-	-	-	)
	1950.	Oats and Barley.	18.4	56.8	48.4	-	)
		(Grass.	-	-	-	55.3)	)

<u>Control</u>.

Grass sample with sooty deposit from lawn in Rudheath, Northwich.

8.9 p.p.m. lead.