Thesis for M.D. University of Glasgow.

X-RAY TREATMENT OF RINGWORM OF THE SCALP.

A survey of 2,200 cases.

by

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GENERAL.

The following is an account of the technique used and results obtained in a series of 2200 cases of ringworm of the scalp personally treated by the writer at the dermatological institution of the Metropolitan Asylums Board. Observation of the cases has been facilitated by the fact that all the cases, with very few exceptions, were in-patients, the institution combining the functions of treatment centre and Childrens' Home.

Despite the advent of thallium acetate, X-ray depilation still remains the main weapon in the armamentarium of the dermatologist in the treatment of tinea tonsurans, and seems likely to do so, in view of certain defects in the thallium acetate method——notably that of too early regrowth of the hair, and consequent re-infection from retained stumps.

The chief advantage claimed for thallium acetate is its practibility as a method in very young children. It is widely held that it is not possible to irradiate the scalps of children below three years of age.

Below will be found a description of the writer's method of restraint of young patients: a method by which the patient can be kept absolutely still during the exposures, and that without harm or discomfort. By this means it is also possible safely to restrain imbecile children of any age within the limits of the incidence of tinea tonsurans.

In the writer's view, X-rays should therefore be preferred to the thallium acetate method in all cases. It is possible through accidental overdosage to kill a patient with the latter: the worst that can happen with irradiation is an X-ray burn.

The chief disadvantage of the X-ray method is the difficulty of arriving at the required accuracy in dosage. The margin of safety is small. Irradiation of the scalp for tinea tonsurans is, in brief, by far the most critical of all X-ray therapy.

The percentage of accidents is fortunately small, but they do occur, and in fairness to the patient's parents, and as a safeguard to the operator, the parents should be warned of the risk.

HISTORICAL.

In 1904 Sabouraud and Noiré evolved their method——the first——of X-ray depilation as means of curing tinea tonsurans. It involved 10 to 12 exposures to successive portions of the scalp, in order to irradiate the whole, circular lead localisers being used. The procedure took from 3½ to 4 hours, allowing 15 minutes per exposure. It was a tedious process, and unsatisfactory because of the difficulty of obtaining uniform irradiation.

It was superseded by the Kienbock-Adamson technique, as described by the latter in 1909. (1.) In this method 5 exposures are given, the applications being so made that at those parts of the scalp where overlapping from two or more exposures occurs, the incidence of the rays is sufficiently oblique, and the skin sufficiently further away from the source, that no excessive dose is received at those points.

The Kienböck-Adamson technique was soon universally adopted, and was used, with certain modifications hereafter described, throughout the cases now reported.

APPARATUS.

Power unit. In the first 1921 cases a coil set was used. The department was then re-equipped, and a single valve transformer was used for the remaining.

The coil set consisted of a 12-inch coil, mercury jet interrupter with interruption-counter and high tension rectifier of the Morton type. Coolidge universal type tubes were used throughout almost the whole series, and with the coil set the filament current was supplied from accumulators. The line supply came from a gas engine dynamo set, delivering 100V D.C.

The determination of the correct exposure is always the most difficult problem in X-ray depilation, and an effort was made throughout the series to check

the pastille method with an electrical control. By keeping all the electrical factors constant and counting the number of impulses from the interrupter it was hoped to obtain an adequate check on pastille variations and errors in tint estimations. This was only moderately successful, because of inherent variations in the output of a coil set. The following factors with a coil set cause variations which it is impossible in practice to determine during a series of exposures.

1. Variation in speed of interrupter motor from dirt in commutator, brushes, etc.
2. Variation in the efficiency of the interrupter from oxidation of the mercury, temporary choking of the jets and impurities in the gas dielectric.
3. Variation in the efficiency of the high tension rectifier, from atmospheric changes.
4. Variation in the filament current from an accumulator source, from static stresses and sulphating of plates.

5. Diminution in the coil output as it heats up throughout a long series of exposures.

In view of the above varying factors, all of which were encountered in the coil set used, it was decided to replace the set with a single valve transformer set. This, which the writer considers to be the most stable and satisfactory type of unit so far made for this class of work, consists of the following components.

1. Petrol engine coupled to an A.C. generator delivering 200 volts A.C. (A company supply is unavailable).
2. A high tension oil-immersed transformer, with single valve rectification. The capacity and tension rating of the transformer are such that no overheating can occur with the output used for the treatment in question.

3. The control table includes the following controls.
    a. Autotransformer and rheostat controls.
    b. Fine and coarse tube filament controls.
    c. Kilovolt and milliampere meters.
    d. Time clock automatically cutting off current at zero setting.
4. Tube filament amperemeter.
5. Victor-Kearsley stabiliser. This maintains the milliamperage absolutely steady throughout the exposures.

The tube stand calls for no special mention except in the following details. The pastille holder is of the pencil type, and is radially disposed with reference to the target, in such a position that it is well in the field of radiation and yet does not obtrude into the beam falling on the skin. The radial disposition makes it easy to determine accurately the distance of the pastille from the glass of the tube bulb (and so from the target), and a locking sleeve on the stem of

the pastille holder renders it easy to reproduce that distance after changing the pastilles. The pastille holder has a lead backing, and is fitted with aluminium filter caps. The wooden tripod pegs are as thin as possible. The tube supports have a vertical adjustment, and provision is made for aluminium filters.

Tubes. For the first 245 cases water-cooled tungsten target gas tubes were used. These tubes emit a radiation that is more homogeneous and more suitable for depilation than a hot-cathode tube, but the impossibility of maintaining a uniform output from them over a long series of exposures —— say 20 exposures of five minutes each in a morning —— makes them unsuitable, in the writer's opinion, for this class of work. Neither the wave length nor the intensity of the radiation from a gas tube can be controlled accurately, and it is not possible with this type of tube to control the pastille estimates of

dosage by a time factor (transformer) or interruption counter (coil set).

For these reasons, and because of irregularity in the resulting defluvium, Coolidge tubes were used for the remaining series of 1944. The Metalix type of tube is unsuitable as it does not give a beam with a sufficiently wide angle for the overlapping areas, and in the other forms of line focus tubes the line focus might cause inequality of intensity in different parts of the field of radiation.

TECHNIQUE.

The Keinbock-Adamson technique is briefly as follows.

A Sabouraud pastille dose – B tint – is given to five areas of the scalp, the central ray falling perpendicularly to the tangent of the following five points.

1. Vertex. A point in the sagittal plane 1½ - 2 inches behind the anterior margin of the hairy scalp.

2. Crown. A point in the sagittal plane 5 inches behind 1.

3. Occiput. 5 inches behind 2.

4.& 5. Sides. Points just above and in front of each ear, 5 inches from points 1., 2., and 3.

The target-skin used by Adamson was 6⅛ inches. This was maintained by a tripod: three slender wooden pegs fixed to the tube-box, and converging at their extremities to ⅛-inch of each other. When the tips of the pegs touch the scalp the target is at the desired distance from the skin. In each case the central ray should be in the same plane as the lines joining the centring point with the adjacent centre-points.

By the above method uniformity of dose is achieved over the whole scalp. The exact dose is received at the centring areas from one exposure, whilst the over-lapped areas receive a fraction of the doses from two or more exposures. This latter depends on two simple laws, viz:- that the intensity of a radiation incident on a surface varies inversely as the square of the distance from the source, and directly as the angle of

the incidence, the perpendicular being the maximum.

The above method of securing uniformity of irradiation was arrived at by calculations based on a 15 cm. target-skin distance. If a Coolidge tube be used, that target-skin distance is no longer possible because of the diameter of the bulb. A minimum distance of 8" is necessary, and even that distance brings the pastille undesirably close to the tube, unless a filter cap be used to shield the pastille from the heat of the tube and resulting heat-discoloration.

It will readily be seen that any increase in the target-skin distance alters the effect of the above two factors, as follows.

1. The intensity at the centring point and the overlapped areas is more nearly equal the farther away the source of the radiation is placed. (At, say, 3 feet away, the intensities would be equal, practically speaking).
2. The obliquity of the incidence of the radiation on the overlapped areas is lessened

by increasing the distance of the source.

Because of both 1. and 2, therefore, increasing the target-skin distance increases the amount of radiation falling on the overlapped areas, and this effect was illustrated in a disastrous way in a series of 10 cases of imperfect regrowth of hair reported below.

DOSAGE.

This is the crux of the whole business. The problem presenting itself is that of raising the dose over the threshold level necessary to cause defluvium, and yet keeping it below the upper danger limit beyond which imperfect regrowth results. Unfortunately that safety band which one must reach, and still more must not o'erstep, is narrow.

The writer has not been able to convince himself that variation in sensitivity on the part of the patient occurs to any marked degree. Variation does probably occur within narrow limits. It has been repeatedly observed during the series

under discussion that of four cases treated in a morning's work the first and fourth cases, say, depilated normally, whilst the second and third showed an incomplete defluvium, in spite of all the physical factors apparently being constant. Individual reaction may in part account for this, assuming that the dose given to all was near the threshold.

In the main, however, variation in end-results means variation in dosage, and unfortunately a really satisfactory method of dosage estimation is not yet available.

1. The Sabouraud Pastille and its modifications. The pastille, the sheet-anchor of X-ray depilation, has proved its value in hundreds of thousands of exposures: but in spite of this, X-ray burns occur with skilled technique.

The chief disadvantage of the pastille lies in the difficulty in estimating the gradations in the colour tints, even when a standard such as the

Lovibond tintometer is used.

In the series of cases under consideration a well-known brand of pastille carrying the certificate of the National Physical Laboratory was used, in conjunction with a Lovibond tintometer, and in repeated tests the writer's margin of error in estimating the tints was in the region of 10 - 15%. The margin of error given by the National Physical Laboratory expert examiner is 10%.

Another factor which causes uncertainty is a variation in the initial tint in pastilles, even when they are chosen from the same batch of 100. In this respect, the following results of tests made by the National Physical Laboratory on pastilles sent by the writer may be of interest.

Two unexposed pastilles were chosen from a batch of 100, one being deep in colour and the other pale. The pastilles were cut in half, and a pale and a deep half-pastille exposed together in a pastille holder. (Nos.1. & 2.) The process

was repeated with two further dissimilar pastilles (Nos.3. & 4.), and all four half-pastilles were sent in black paper to the National Physical Laboratory for report.

The N.P.L. kindly examined these pastilles and reported as follows.

a. Standard test. In the standard test applied to pastilles, the initial tint (usually tint A) is determined, and the pastilles are then exposed to unfiltered radiation from a tungsten anticathode, the tube being operated at 70 K.V. and 5 m.a. The pastille is then considered to be satisfactory if the doses received by the exposed pastilles, after allowing for the initial tints, are found to register within ± 10% of the provisional Laboratory tint. The tints are determined with the aid of a Cox-Cavendish tintometer.

b. The tints of the half-pastilles sent to them were first estimated, and found to be:-

	Pastille No.	Observed Tint.
1st. Pair	1.	0.420 B
	2.	0.50 B
2nd. Pair	3.	0.45 B
	4.	0.575 B

The pastilles were then bleached, and submitted to a seven-minute exposure.

State.	Pastille No.			
	1.	2.	3.	4.
Initial Tint.	-0.05 B	0.10 B	0.00 B	0.20 B
Final Tint.	1.00	1.20	1.10	1.325
Total Dose.	1.05	1.10	1.10	1.125

c. The pastilles were again bleached, and submitted to the Standard test (a).

State.	Pastille No.			
	1.	2.	3.	4.
Initial Tint.	-0.05 B	0.125 B	0.00 B	0.30
Final Tint.	1.00	1.10	1.075	1.25
Total Dose.	1.05	0.975	1.025	0.95
% Difference from standard.	+2.4%	-5.3%	-0.2%	-8.3%

It will be seen that the above pastilles conform to the standard with a variation within the ±10% limit if the initial tint be allowed for. This initial variation is a further disadvantage of the pastille method of dose-estimation, and only those with an exceptionally sensitive colour sense can acquire the degree of accuracy in tint estimation set out above.

2. Electrical constants in dosage. A useful check on the Sabouraud pastille method is afforded by maintaining the electrical and time factors constant. With a coil set this is done by maintaining the primary voltage, milliamperage, secondary voltage, interruption rate and time constant, or alternatively to use an interruption counter in place of the time factor. A hot-cathode tube is an essential for this. In the coil series of cases, this check was used, and proved of value, but inavoidable variations mentioned above with this apparatus lessen its usefulness. When a transformer set is used, an automatic time-clock is used, all the electrical

factors being kept constant. The Victor-Kearsley stabiliser is here of great value in controlling the milliamperage, the factor otherwise most liable to variation.

3. Ionisation methods. Hitherto the iontoquantimeters available have been too delicate and susceptible to atmospheric changes to be of much value in ringworm work, but there is no doubt that ultimately this method will supersede all others in dosage estimation. It is hoped shortly to test out the apparatus recently put on the market under the name of the Mekapion. The standard uranium cell, against which this apparatus may be calibrated as frequently as is desired, should make this an instrument of considerable precision.

4. Biological Effect. Finally there is the biological test. This is applicable only at a treatment centre where a steady sequence of cases is being dealt with. It consists in deliberately underexposing the first few cases, and gradually increasing the dose until normal defluvium is attained. What should be aimed

at is slight underexposure only: such a dose, estimated by the pastille tint, as makes one doubtful if defluvium will occur. The writer is of the firm opinion that this is the only safe procedure when commencing to use a new apparatus, or even a new Coolidge tube, for tinea treatment. It amounts to a biological calibration of the apparatus. A corollary of this view is that X-ray depilation of the scalp can be safely carried out only at centres where a considerable number of cases is being dealt with, and with an apparatus specially designed for the purpose. The occasional treatment of a case of ringworm in a small hospital department with apparatus designed for general radiographic work is to be deprecated.

MODIFICATION OF THE ORIGINAL TECHNIQUE USED IN THIS SERIES.

1. The dose given as a routine is 4/5 B tint.
2. An aluminium filter, ½ mm thick, is used.

3. A target-skin distance of 9" was used at first, to enable the pastille to be placed 1" from the glass of the Coolidge tube. After the series of 10 overexposures this distance was reduced to 8". In order to minimise the tendency of the increased distance to cause overexposure of the overlapped areas, the tube should, in the other four areas, be angled a little away from the crown area.

4. Restraint of the patient. About 25 % of the cases admitted are too young to keep still voluntarily during the exposures, and in addition a number of imbecile children of all ages up to 15 have been treated. If they were not treated by X-rays the institution would rapidly be full to overflowing. Manual restraint of the patient by the operator or nurses is so dangerous to the latter as to be out of the question. In order to deal with these cases, a restraining couch was devised by the writer, which efficiently and conveniently keeps the patient still.

Briefly, this means of restraint consists of strapping the child's trunk and limbs to the couch by quick-release webbing straps, and immobilising the head by a closely fitting calico cap, to which are attached tapes for fixation to the couch.

The Caps. These caps, of which several sizes are necessary, fit the head closely from the forehead to the nape of the neck. The ears are enclosed, and from the sides of the cap two flaps extend downwards and are tied together under the chin by a tape. Each cap has six tapes sewn on to it, two in front, close to the margin of the cap, and two on each side, above the ear flaps. (Fig.1.)

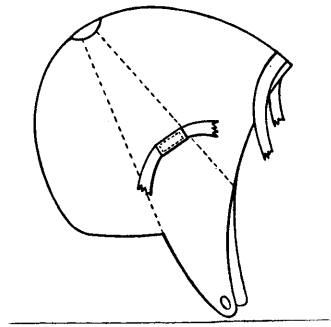


Fig.1.

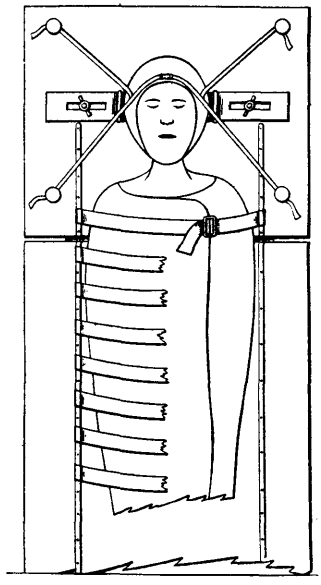
The Couch. This is a plain wooden-topped table, 5 ft. long and 18 ins. wide. At the head end of the top of the couch is a hinged flap. This flap is raised up for the first and fourth positions, forming then an angle with the fixed portion of the couch top of about 20 degrees. On the flap are two head-rests, adjustable laterally for the accomodation of the head in the sagittal and coronal planes respectively. In the particular couch in use these head-rests are not permanently padded, for reasons of asepsis, a pad of lint placed between them and the head affording the necessary comfort to the patient.

Close to the corners of the flap are four small brass binding posts, such as are used for window blind cords. On the immobile portion of the couch top are attached twelve webbing straps with quick-release buckles, such as are used on ordinary webbing book straps. (Fig.2.)

Fig.2.

Fixation of the trunk and limbs. After the cap has been fitted on the head, the patient is rolled tightly in a blanket, the legs extended and the arms by the side. For the first three positions, the supine position is used, and for the last two, the prone. By means of the webbing straps the trunk and limbs are then firmly but comfortably immobilised. The straps over the chest are so adjusted as not to impede respiration in any way. (Figs.3 to 6.)

Fig.7.



Fixation of the Head. The head, placed between the head-rests, is immobilised by the tapes, which are fixed taut by a couple of turns round the binding posts. They thus act as do the guy ropes of a tent.

Position 1. The two forehead tapes and one lateral tape on each side, are used. (Fig.7.)

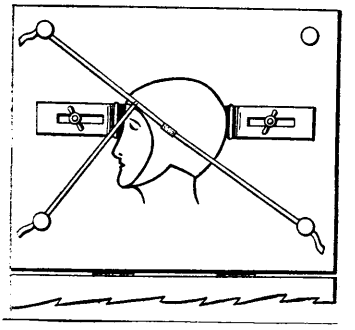


Fig..8.

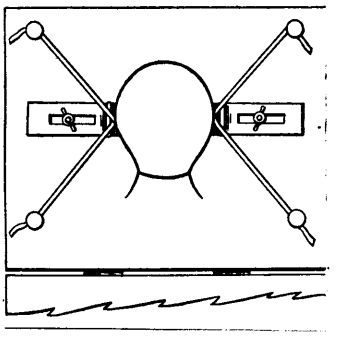


Fig..9.

Positions 2 and 3. The two upper lateral tapes, and one of the forehead tapes.(Fig.8.)

Positions 4 and 5. Both lateral tapes on each side. (Fig.9.)

Fig.3.

Fig.4.

Fig.5.

Fig.6.

As previously mentioned, the hinged flap is raised about 20 degrees for the first and fourth positions. It is sometimes necessary, in small dolichocephalic infants, to place a sand bag under the chest for the fifth position in order to obtain the proper angle for the occipital exposure.

Since this couch has been in use, restraint has been necessary in 862 cases, and in no case has satisfactory immobilisation not been obtained.

PRACTICAL DETAILS OF THE EXPOSURES.

The face, ears and nape of the neck should be protected by lead rubber masks, such as those illustrated in Fig. 10.

Fig. 10.

This is particularly important in the case of the ears, as they are nearer to the tube than the scalp in the lateral exposures. The patient should be observed throughout every exposure, to detect any change in the position of the head. A common occurence is a slight subsidence of the head when the child falls asleep (as they often do), in the first and fourth positions.

If an aluminium filter is used as a routine, it should be so attached by a cord to the tube-shield that when it is removed for any reason it hangs suspended from the shield. It cannot then be omitted in error.

If the child's head be very small, the lateral centring points may be less than 5 inches from the vertex and occiput. A mean should be struck between them, and the centre point moved a little down over the ear (the latter being protected by the mask).

The exposure should be slightly less in babes:

say, 20 seconds in a 5-minute exposure. The exposures should obviously be given all at one sitting, but if for any reason, such as breakdown of the apparatus, this is impossible, the exposures may be completed on the following day without upsetting the defluvium. This has happened on several occasions during the series under consideration. As long as four days has elapsed, and yet a satisfactory depilation has resulted.

p/o

CLINICAL CONSIDERATIONS.

Type of infection. The vast majority of the cases in the series were microsporon infections. In only eight was the endothrix demonstrated microscopically. Only doubtful or atypical cases were, however, investigated microscopically, and doubtless a small number of endothrix cases were classed as microsporon. Since the Wood's glass lamp has been used in the department, the percentage of endothrix cases has not increased to any extent, and as this constitutes a ready method

of distinguishing between the two types, it is probable that few endothrix cases have been missed.

The type of infection is of little practical importance, as depilation is the routine for both, except in children of 15 years onwards. At that age microsporon infection tends to die a natural death; endothrix does not. One might be in doubt as to whether microsporon ringworm should be treated with X-rays in a patient of 15. With an endothrix case irradiation would be indicated.

Wood's Glass. It is convenient here to mention the Wood's glass lamp. This consists of an ordinary air-cooled mercury vapour ultra-violet lamp, enclosed in a light-proof metal hood. In the hood is fitted a filter made of Wood's glass (a nickel glass), which cuts off all the light rays, and allows to pass only the U.V.R. The apparatus is installed in a dark room.

Hairs infected with the microsporon show a

brilliant apple-green fluorescence under this radiation. Endothrix infection shows feeble fluorescence, or none at all, mainly because the fungus is so deeply situated in the hair follicles.

This apparatus has proved of inestimable value in the department, and it is not too much to say that no ringworm treatment centre can be regarded as properly equipped unless it possesses one.

The ordinary case of multiple microsporon infection of the scalp is so evident on mere inspection that no further proof is required, but if there is doubt as to the presence of the microsporon the Wood's glass lamp will provide an almost certain answer. If no fluorescence is visible, it is not a microsporon infection. So reliable is this test, and so easy of application, that it has replaced the microscope in routine work, and the latter is now reserved

for occasional doubtful and endothrix cases.

CONTRA-INDICATIONS TO X-RAY TREATMENT.

1. Age. It is widely held that children below the age of 3-4 years cannot be satisfactorily treated with X-rays. By the use of the couch above described, children below that age can be so treated with perfect safety. It has been the rule in the department not to treat patients younger than 1 year, for the hypothetic reason that damage might occur to the delicate scalp, and for the practical one that the smallness of the head upsets the principles governing the uniformity of the 5-area method of irradiation.

Whether or not deleterious effects on the scalp would result from irradiation at the age of 6 months has not been tested. Certainly no such effects have been caused in patients a year old.

Age incidence of cases irradiated.

Years.	-1	1	1½	2	3	4	5	6	7	8	9
No.	1	10	117	162	381	277	232	246	221	150	90

Years.	10	11	12	13	14	15	16
No.	85	62	40	38	26	5	3

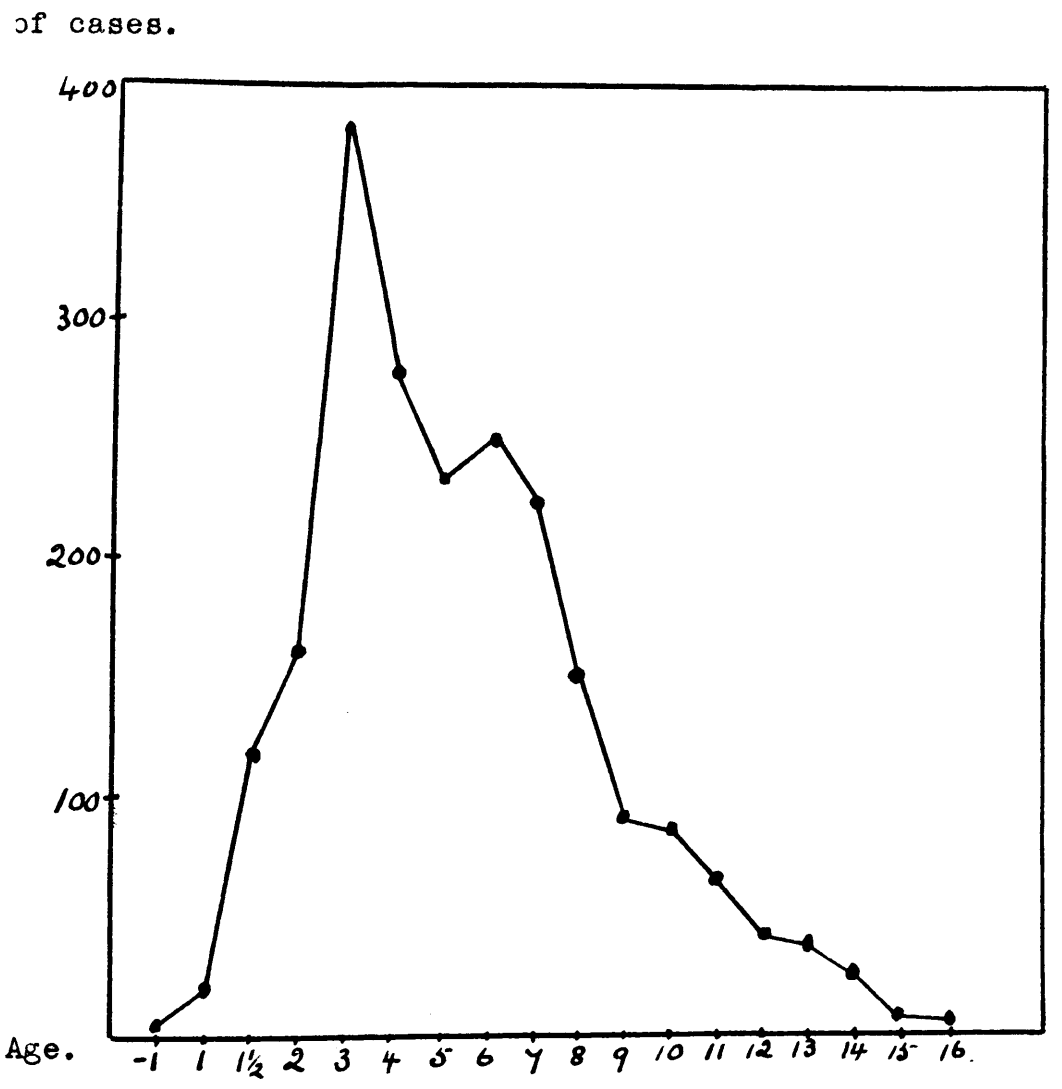


Fig. 11. Age incidence of cases treated.

2. Seborrhoea of the scalp. A mild dandruff of the scalp is no contra-indication, but it is unsafe to X-ray the scalp if any marked seborrhoea is present. In three such cases a violent dermatitis resulted 2-3 weeks after raying, fortunately without serious after-effects. If the seborrhoeic condition be quieted down first by suitable treatment, irradiation may then be used with safety.

3. Eczema of the scalp. The above remarks apply equally to eczema. Irradiation of a dry eczema, even, is dangerous, and if X-rays were used on a scalp with an acute weeping eczema, disaster would almost certainly result.

4. Septic folliculitis and dermatitis of the scalp. Irradiation as a rule causes such conditions to flare up, and should not be applied until the

infection has been dealt with. Boro-starch compresses have been found most useful in the preliminary treatment of these cases. Alternative applications of value are mild antiseptic ointments containing boric acid, salicylic acid or ammoniated mercury.

5. Kerion. X-rays should not be used till this has subsided, not only because of the risk of exacerbation, but also because the onset of kerion on a single patch may automatically eradicate the ringworm infection.

6. Impetigo or eczema of the face or ears: otorrhoea: nasal discharge. These conditions should be corrected if possible before irradiation. Numerous cases have been observed in the above series where the depressant effect of X-rays on the scalp has

enabled these conditions to spread rather acutely over the latter.

7. Previous irradiation. An interval of 6 months should be allowed to elapse before re-raying.

8. Atrophic areas from previous irradiation should be protected with lead foil, if re-raying is deemed essential, but it is much wiser to avoid the further use of X-rays in such a case.

9. Bald patches from previous disease. These, if small, may be ignored. If large, or atrophic, they should be masked with lead, provided it is certain that they contain no infected stumps. The combination of alopecia areata and ringworm of the scalp has not been met with in the series. On general principles, it would appear to be unwise to X-ray such a case.

RESULTS.

Below is a tabulated analysis of the results of irradiation of the series. The cases are grouped according to the apparatus used.

Results of irradiation.

Result	Number				Percentage			
	A Coil and Gas Tube.	B Coil and Cool-idge.	C Trans-former and Coolidge.	Total	A	B	C	Total
Normal defluvium.	182	1419	235	1836	73.8	84.5	85.9	83.6
Underexposure.								
a) Slight imperfect defluvium, with cure of infection.	16	100	14	130	6.5	6.0	5.1	6.0
b) Severe imperfect defluvium, with cure of infection.	2	37	12	51	0.8	2.2	4.0	2.3
c) Imperfect defluvium with persistence of infection.	14	9	3	26	5.7	0.5	1.1	1.3
Overexposure.								
a) Slight erythema, with normal regrowth.	8	22	2	32	3.5	1.3	0.7	1.5
b) Severe erythema, with normal regrowth.	3	14	0	17	1.2	0.6	-	0.8
c) Overexposure with permanent alopecia.	0	10	0	10	-	0.6	-	0.5
Septic complications following irradiation.								
a) Septic dermatitis.	15	33	2	50	6.1	2.0	0.7	2.3
b) Septic folliculitis.	5	24	3	32	2.0	1.4	1.7	1.5
c) Septic dermatitis with incomplete defluvium.	0	8	4	12	-	.5	1.4	0.5
Totals.	245	1676	275	2196	100.	100	100	100

Reference to the percentages in the table will show that the most satisfactory results have been obtained with the transformer set, particularly if it be taken into account that the dose has been kept purposely as near the threshold for defluvium as possible. This has increased the percentage of incomplete defluvium, and has diminished the cases of erythema to practically nil. Imperfect defluvium is an inconvenience; imperfect regrowth is a disaster for patient, and it has been the writer's policy in the transformer cases to risk the former rather than the latter.

NORMAL DEFLUVIUM.

In the normal cases defluvium commenced about the eighteenth to twenty-first day, and was complete by the twenty-eighth day at latest.

In the great majority of cases, defluvium was complete by the twenty-first to twenty-third day after irradiation.

In a normal case the skin should show no erythema, bronzing or glazing. Very frequently, scattered downy hairs remain unfallen. A certain percentage of cases included in the normal group showed small retained "peg-tufts" of hair at the centring points: in others, a narrow sagittal strip was retained, a "line" of hairs joining the vertex and crown centring points. This is possibly due to peg shadows combined with the effect of the increased target-skin distance. Even if the retained hairs are infected, they can usually be dealt with by local applications, the treatment being controlled by inspection under the Wood's glass lamp.

Management of a normal case. Before X-raying the case, the hair should be clipped short with barber's clippers. Shaving is neither practicable nor desirable. It damages the skin in the infected areas, and hinders removal of the hair by massage, as the hairs are too short. No strong parasiticide should have been applied for some days prior to irradiation.

After exposure a cotton cap should be worn continuously, and the scalp anointed daily with a 1% ammoniated mercury ointment. On the fourteenth day the head should be washed with a non-irritating soap, and this repeated daily till the hair falls out. The hair should be washed before examination under the Wood's glass lamp, to remove any traces of ointment. The latter gives a brilliant purple fluorescence, which obscures the fluorescence of the stumps.

After defluvium has occurred the scalp should be washed and massaged daily with weak boric ointment, to promote regrowth of the hair.

ABNORMAL RESULTS.

INCOMPLETE DEFLUVIUM The commonest variation from the normal result is retention of some of the hair. This occurred in 9.6 % of the cases. The retained hair may or may not be infected. When infection persists vigorous local treatment should be adopted to remove the infected stumps. The following measures may be used for this purpose.

1. Parasiticides. The local application of croton oil, either by "needling" (introduction of a tiny droplet into the hair follicle with a needle) or by careful application to the infected patch, causes an intense localised dermatitis,

which culminates in the extrusion of the infected stumps. Virtually, an artificial kerion is produced. Croton oil must be used with caution; as it is apt to cause destruction of the hair follicles, it should be used only on small localised patches.

Other parasiticides which have been found of value are benzoic and salicylic acids. Mercurochrome and tinct. iodo. fort. have not proved of much value.

2. Physical measures. Massage of the scalp is often effective in removing loose stumps. Careful extraction with forceps is successful at times, but as a rule some of the stumps break, and remain in the follicles. Adhesive plaster has the some disadvantage.

3. Re-irradiation. If the above measures fail to get rid of the remaining infection, after treatment for some months, the case should be re-rayed, except in microsporon infections near the upper age limit of incidence. In

them the infection should be allowed to die a natural death.

In the series under consideration, 45 cases were rayed a second time, of which 26 were on account of persistent infection after previous irradiation, and 19 on account of re-infection after discharge. The percentage, therefore, in which irradiation failed to cure the infection in the series was 1.3 %, and these were all cured by subsequent X-raying. The rule now followed in the institution is never to re-ray a case until an interval of 6 months has elapsed. Some of the earlier cases were X-rayed again after 3 months, but this is probably rather close to the limit of safety. The practice of re-irradiating a localised patch that has not fallen is as a rule unsatisfactory. If done early, say a

month after, permanent damage may occur to the area irradiated, and if later, infection of the newly growing hair is apt to occur.

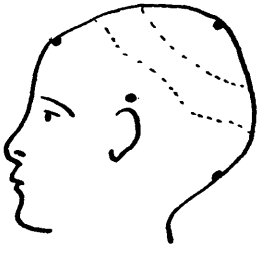
In all the above cases which were X-rayed a second time, the result was sudcessful, and no permanent alopecia resulted. One case was X-rayed a second time on account of persistent low-grade septic folliculitis, no fungus being detected either microscopically or under the Wood's glass. After the second irradiation the condition cleared up.

OVEREXPOSURE. The cases of overexposure fall into two categories: those in which erythema was produced, but with normal regrowth, and those in which permanent alopecia resulted. The former cases were scattered throughout the

series, but became progressively less frequent with each improvement in apparatus, until with the transformer set now in use only two cases of slight erythema occurred. With a mild overexposure the regrowth of the hair is retarded, and the overlapped areas regrow more slowly than the central areas. This affords a clinical proof of the effect of the increased target-skin distance in increasing the dose in the overlapped zones relative to the central. The cases of overexposure with imperfect regrowth of hair were all grouped closely together in the series, occurring in a period of two months, and being terminated by the puncture of the tube which had been used for them. During the period in which they occurred, 46 cases were irradiated. The rest of the 46 cases showed normal regrowth of hair.

Clinical Features. There was no obvious initial erythema, except slightly in one case. The overexposure and consequent permanent alopecia

conformed in each case to a definite type. The central areas receiving the direct rays from the tube were either normally exposed or under-exposed (the hair not falling), while those portions of the scalp receiving oblique rays from two or more exposures were overexposed. The result was roughly a band of alopecia encircling the head, with normal regrowth in the areas of centring (Fig.12).



The following are the details of the cases.

No.	INITIALS.	AGE when rayed.	SEX.	DOSE Interruption counter.	REMARKS.
1.	I.T.	1½	F.	14000	Incomplete defluvium in the central areas a month after. Imperfect regrowth in parietal and occipital overlapped areas.
2.	E.H.	2	F.	14000	Hair thin on right parietal region.
3.	D.K.	4	F	14500	Slight arythema 3 weeks after irradiation. 6 months later scanty regrowth and slight atrophy of skin over occiput.
4.	I.L.	8	F.	15000	No erythema 3 weeks after. Imperfect regrowth in parieto-occipital zone.
5.	R.J.	2½	M.	14300	Some bronzing a month after, with imperfect defluvium of the central areas. Imperfect regrowth in parieto-occipital zone with some skin atrophy.
6.	C.C.	2½	M.	14300	Imperfect regrowth in parieto-occipital zone.
7.	A.F.P.	8	F.	14500	Apparently normal defluvium a month after, but regrowth rather thin in parieto-occipital zone.
8.	K.G.	10	M.	14800	Apparently normal defluvium. Regrowth slightly below normal in parieto-occipital zone.
9.	E.G.D.	2	F.	14000	Incomplete regrowth in parieto-occipital zone.

A point of note in all the above cases is that the five centring areas always escaped damage, and that in two cases the hair did not even depilate over those areas. (Cases 1. and 5.)

In no case did the skin break down in the early stages. In two there was definite skin atrophy. In these two cases the damaged areas of skin showed 6 months later, a thin glazed appearance, with small telangiectases and a few scattered hairs, the latter being short, grey and curly. In each case there was a tendency on the part of the atrophic skin to crack and "weep" at points, after slight trauma.

X-ray aspect. The X-ray factors were kept the same, as far as was possible with the apparatus in use, as for the previous 1850 cases done, as follows:-

Coil. Primary 100 volts, 8 amperes.
Secondary. 110 kilovolts (sphere gap reading). 3.2 milliamps.

Coolidge tube filament. 4.2 amperes.

Target-skin distance. 9 inches.

Filter. ½ millimetre of aluminium (skin and pastille).

Dosage. Pastille and interruption counter were used to estimate this. Levy's pastilles, tested by the National Physical Laboratory, turned to 5/6ths of the full pastille dose. Tested against an 8 c.p. carbon filament lamp. From 14,000 to 15,000 interruptions were given, the number depending on the age of the child.

A universal type medium focus Coolidge tube was used, and this had been in use for about three years, during which time approximately 1,500 cases had been treated.

During the three years of use of this tube, the exposure had had to be increased gradually from 12,000 to 14,500 interruptions, in order to secure depilation. The pastille tint was not, however,

increased. This increase was held to be the result of lessened efficiency of the tube as it wore out.

On 30.11.27. the filament of this tube burned out, and it was returned to the makers, in exchange for a new one. The dose with the new tube was 1,000 to 1,100 indicating the lessened efficiency of the old one. During the last year of life of the old tube the inner surface of the glass bulb became increasingly coated with tungsten deposit, as a result of volatilisation of the target. With the existing arrangement of tube box and pastille holder those rays which the central areas of skin irradiated and also the pastille, would pass through the area of glass most heavily coated, whilst the overlapped areas would receive rays passing through more thinly coated glass.

Cause of the overexposure. This type of overexposure, marginal only, and with either normal exposure or underexposure of the central areas, has not been

encountered before by me, nor have I heard of its occurrence elsewhere. Possible factors in its causation are:-

1. Faulty centring and angling of the central ray. This would not explain whay the series was so closely grouped, and not spread over the five years during which I used the apparatus.
2. Increase in the target-skin distance compared with the original technique. This increase, necessitated by the size of the Coolidge tube bulb, diminishes the margin of safety in the overlapping areas, but the same objection obtains as in No.1.
3. Variation in the electrical factors, such as the primary voltage, diminution in coil output as it heats up during the morning's work, are subject to the same objections as a cause, as is:-

4. Error in reading the pastille.

5. Alteration in the tube characteristics.

Three experts have been consulted on this point. Mr.Burnside, of Messrs.Newton & Wright,Ltd.; Dr.Kaye, of the National Physical Laboratory; and Mr.Happe, of the Victor X-ray Corporation (British agents for the Coolidge tube.)

All three agree that a heavy deposit of tungsten on the inner surface of the bulb is a possible cause, although none of them had known it to cause a localised overexposure. Mr.Happe pointed out that such a deposit usually causes a puncture of the tube, putting it out of action before the deposit was sufficiently dense to cause much filtration. The combination of a heavy deposit with a pastille positioned as to receive rays passing through the densest portion of the deposit would explain

type of overexposure found in the above cases. The effect of bad pitting of the target was raised with the above authorities, but they were all of the opinion that this would be likely to have the reverse effect - that of concentrating the rays in a central bundle.

In this connection certain experiments by W.D.Coolidge and W.K.Kearsley are of interest. With a view to determining the filtration effect of a heavy tungsten deposit they made the following experiment.

An old Coolidge tube was chosen having a heavy deposit on the bulb, and a piece of glass having an area of 9.6 square centimetres was then cut from the region showing the maximum of deposit.

This piece of glass, with its tungsten deposit, was then placed before the ionisation chamber and,

with an X-ray tube operating at 127,000 volts, and 5 ma., the time of discharge of the electroscope was determined with and without filters.

The piece of glass with its deposit was then weighed. After this the tungsten deposit was removed chemically and the piece was again weighed. The difference between the two weighings gave the weight of the tungsten layer, and from the measured area of the surface in question and the known density of tungsten the thickness of the deposit was calculated.

The glass piece freed from its tungsten deposit was then again placed before the ionisation chamber and the previous measurements repeated.

It was found that the glass alone reduced the X-ray intensity by the same amount as a filter of 1 mm of aluminium.

The results are given in table.

Milli-metres Aluminium Filter	Time (Sec.) Glass	Time (Sec.) After Re-moval of Tungsten	X-ray Intensity $\frac{1000}{T}$ With Tung-sten	X-ray Intensity $\frac{1000}{T}$ With-out Tung-sten	Reduc-tion %
0	14.35	12.95	69.7	77.2	9.7
2	30.45	28.82	32.9	34.7	5.2
5	58.8	55.7	17.01	17.95	5.2

The last column of the table shows that when no external filter was used the tungsten deposit reduced the X-ray intensity, as measured by ionisation current, by 9.7 per cent. The glass was itself equivalent to a 1 mm. aluminium filter. If the support glass could have been removed the percentage reduction in intensity due to the tunhsten deposit alone would have been considerably greater.

The 2 mm. aluminium filter taken together with the piece of bulb glass was equivalent to 3 mm. of aluminium, and with this the tungsten deposit caused

a reduction in intensity of 5.2 per cent. The 5 mm. of aluminium together with the glass was equivalent to 6 mm. of aluminium and with this filtration also the reduction of intensity due to the tungsten deposit was 5.2 per cent.

The data relating to the thickness of the tungsten deposit were as follows:-

Area of deposit (sq. cm.)	9.6
Weight of glass plus deposit (grms.)	2.4817
Weight of glass	2.4620
Weight of tungsten, by difference	0.0197
Specific gravity of W	19.3
Thickness, calculated (in mm.)	0.00106

To return to the cases in question, the overexposure appears therefore to have been due to two factors in combination, the increased target-skin distance and the badly-coated Coolidge tube. Neither alone was sufficient to cause the trouble, but during the brief period when both factors were effective, the overexposures resulted. The lesson to be learnt is to keep as close to the

original distance as possible, and to discard a tube on the earliest sign of wear.

SEPTIC COMPLICATIONS FOLLOWING IRRADIATION.

Of these generalised septic dermatitis of the scalp was the most frequent, 62 cases occurring, or 2.8 %. In the majority of these the condition was mild, and subsided in a few days under treatment. In three cases it was severe, the scalp being acutely inflamed, with a reddened glazed or weeping surface. These three followed irradiation of scalps already affected by a fairly severe dry seborrhoea. The spread of such a dermatitis shows clearly that it is in no way the result of an overexposure. The condition commences in islands with normal areas of scalp between, and in 12 cases incomplete defluvium indicated that the head had been underexposed to X-rays. The condition is, however, resultant on irradiation in as much as the latter has a

depressant effect on the resistive powers of the scalp, and the onset of the dermatitis in an acute form is as a rule contemporary with that of defluvium. In two cases the dermatitis was sufficient to cause a general febrile disturbance, in another superficial ulceration of the scalp occurred, and in another marked exfoliation. In all four regrowth of hair was normal. In many of these cases the dermatitis tends to spread to the neck and trunk.

Septic folliculitis was a less common sequela, 32 cases occurring, or 1.5 %. Some of the cases grouped under the heading of generalised septic dermatitis of the scalp began as cases of folliculitis, the infection subsequently spreading over the scalp. A common exciting cause of both the above was scratching of the head by the child, and to

prevent this, and to prevent aggravation of the already established condition, it was found an efficient measure to splint the child's elbows with light padded cardboard splints. In the treatment of the above septic complications, the frequent application of boro-starch compresses is indicated in the acute stage: followed, when it is subsiding, by weak benzoic or ammoniated mercury ointments.

Septic dermatitis with incomplete defluvium occurred in 12 cases and indicates the tendency for septic complications to commence round retained stumps.

CONSTITUTIONAL EFFECTS OF IRRADIATION. Sickness after irradiation is the only disturbance that has been noted. It has been determined by careful

observation that about 40% of the children are sick a few hours after irradiation.

Etiology of the sickness.

1. Age. The age incidence in a series of 143 consecutive cases was as follows:-

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
Sick	0	0	11	11	7	2	9	6	1	5	4	3	1
Not sick	2	6	24	18	7	7	10	5	4	4	0	0	0

It will be seen from this table that the tendency to vomiting increases with the age.

2. Restraint of the patient is not a factor, as the phenomenon is more marked in those cases in which restraint is not necessary.

3. Noise. Plugging the ears makes no difference.

4. Irradiation of the medulla. Direct irradiation of the vomiting centre does not appear to be the cause, as in one case the occipital area was not X-rayed

until the following day. The child was sick in spite of this, and also on the following day after the occipital irradiation.

Presumably the vomiting is the same as occurs in deep X-ray therapy, and is not a specific effect on the medullary centres.

As a rule vomiting is slight and is not accompanied by any other constitutional disturbance. Food brings on or aggravates an attack. As a routine the children are allowed no lunch after being X-rayed in the morning. It was found that if lunch were allowed, nearly 100% were sick, instead of 40% if food is withheld for 4 or 5 hours.

In one child a prolonged attack was noted, vomiting occurring at two-hourly intervals for three days. The constitutional effects were small, normal temperature and pulse being maintained throughout.

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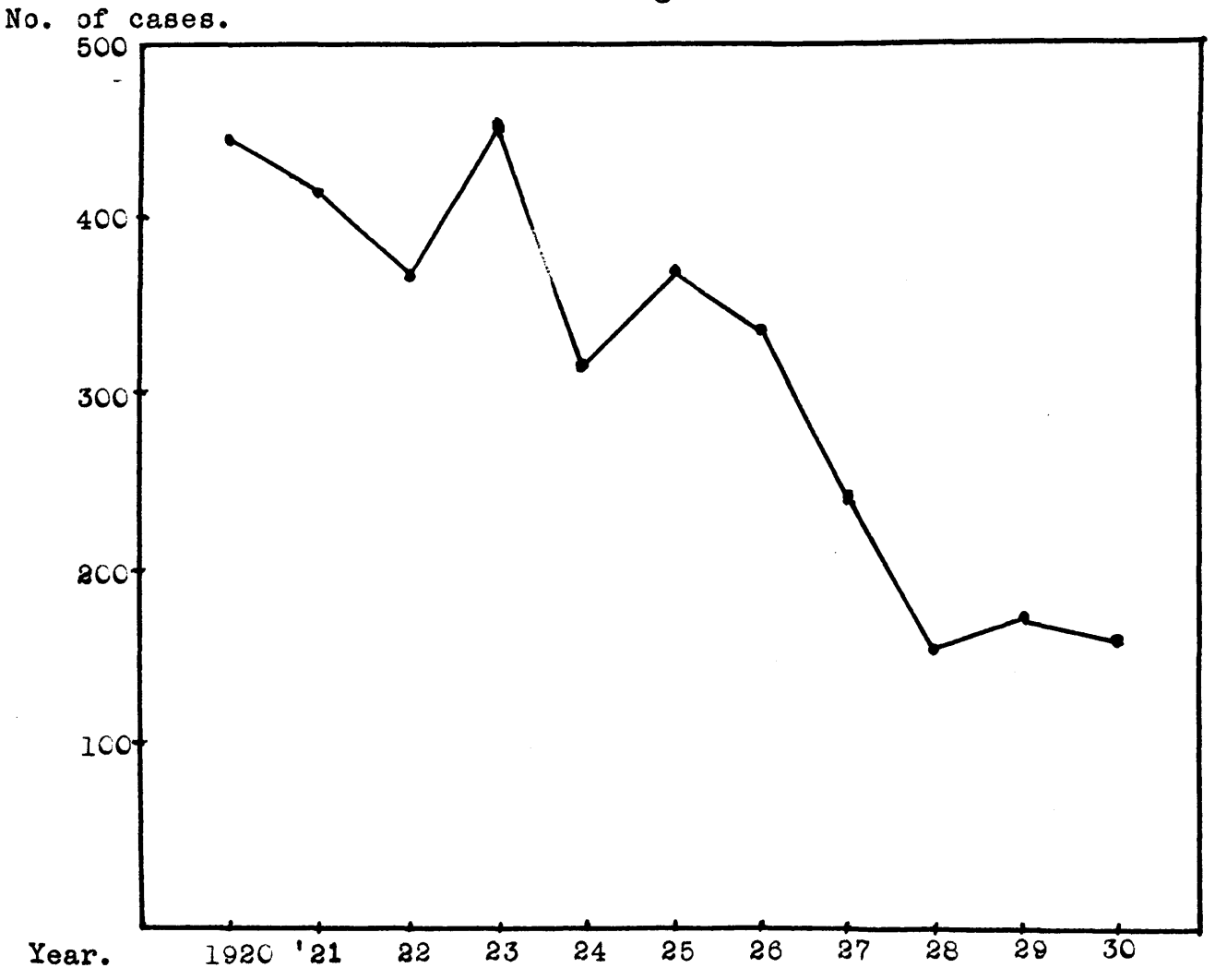
In conclusion, it is interesting to note the gradual diminution in the number of cases admitted to the Homes during the last decade.(Fig.13.)

Fig.13.



Yearly admissions during past decade.

As the Homes received all the ringworm cases from the old poor law institutions during that period, and as no change in the general arrangements governing the admissions to those institutions has been made, it is reasonable to accept this diminution as an index of a fall in the general incidence of ringworm in London. The figures of the L.C.C. ringworm clinics bear this out.

This fall in numbers is doubtless due to two factors. More efficient routine medical inspection of children, resulting in earlier diagnosis, and more efficient treatment. These two are combining to stamp out ringworm, and the Wood's glass method of examination, if used as a routine measure, should produce a still greater diminution in the number of cases of ringworm infection of the scalp.

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The recent literature on the subject of X-ray depilation is surprisingly scanty.

J.H.Sequeira (2) uses a target-skin distance of 15 cm. and estimates the dose by the Sabouraud pastille. He gives a dose of 4/5ths B, the tint being determined by the Corbett tintometer. He deprecates the use of X-rays in children under four years, and advises that no case should be re-rayed until at least a month has elapsed since the previous irradiation; a dangerously short interval, in the writer's opinion.

G.M.McKee (3) has written a full account of his technique. He uses 8" target-skin distance with all sizes of heads. He relies entirely on electrical control of dosage, which he agrees is possible only with a transformer set and hot cathode tubes. The pastille he does not regard as sufficiently sensitive for this work.

His unit is the skin unit, that amount of irradiation through a port of 1 square inch which will just cause an erythema on the flexor glabrous skin of a young blond adult. He takes the mean of several tests on different subjects. He holds that this dose will cause temporary epilation of the scalp in children without erythema. (E.D.) No filter is used.

The margin of safety he gives as follows.
3/4 skin unit occasionally causes defluvium.
1'/4 skin units may cause permanent alopecia.
More commonly 1½ units is required to cause this.

G.C.Andrews (4) employs McKee's constants as a guide to dosage, the pastille not being used. His epilating dose is as follows:-

Coolidge tube. 3 ma. at 100 K.V. for 2 minutes at 6".

" " " 1¼ " 6½".

He uses 8" target-skin distance for heads with a circumference of 20 inches or over.

For a head of 19" he uses a distance of 6½ inches, and for smaller heads he reduces the dose slightly.

He is at variance with the writer in recommending the immediate use of X-rays in kerion, and in holding that sepsis of the scalp, even to the extent of multiple abscesses, is not a contra-indication to X-ray treatment.

J.M.H.MacLeod (5. and 6.) outlines a technique closely similar to that embodied in this paper. Indeed, the technique used by the writer has been evolved with his close collaboration and advice, as consulting dermatologist to the institution, and to him the writer's grateful thanks are due for his unfailing help and encouragement.

The remaining references in the press during the past decade which the writer has been able to trace are brief, and give no precise details as to technique and results, while the classic works of Sabouraud (7) and Kienböck (8) in the first decade of this century are too wellknown to require feuther quotation here.

References.

1. Adamson (H.G.). X-ray treatment of ringworm of the scalp: Kienböck-Adamson method: Lancet 1909: I. p. 1378

2. Sequeira (J.H.) Diseases of the skin: 4th edit. 1927 pp. 177-9

3. McKee (G.M.) X-rays and radium in the treatment of the skin. 1927

4. Andrews (G.C.) Diseases of the skin. 1930. pp.556-564

5. MacLeod (J.M.H.) Diseases of the skin. 1920.p.409

6. " X-ray treatment of ringworm of scalp in children under 3 years of age. Brit. J. Dermat. 1926. pp.38, 492-501.

7. Sabouraud (R.) Maladies du cuir chevelu. Vol.III Maladies cryptogamiques: les teignes. 1910

8. Kienböck (R.) Radiotherapie. 1907.
