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A STUDY OF SOME MECHANICAL DEVICES USED FOR THE PURPOSE OF APPLYING CHEMICALS TO SHEEP TO CONTROL INFESTATIONS OF EXTERNAL PARASITES

BY

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I N D E X

INTRODUCTION

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The Application of Chemicals to Sheep:

To control the effects of infestations of external parasites on sheep it is customary to apply a chemical poison to the sheep in such a manner that the external parasites are either completely eradicated or their numbers reduced and so that the sheep does not suffer ill effects from the reatment.

There are two major influences on the efficiency of control of an infestation of external parasites; firstly, there is the efficiency of the chemical poison, commonly known as the insecticide; secondly, there is the efficiency of the method of application with which problem this thesis is concerned.

To be efficient a method of application of an insecticide must enable the chemical to exert its effects upon the population of ectoparasites and further, as sheep are generally kept for profit, the method should not only be kept within economic reason, but should strive to be the most economical method available to apply the insecticide to sheep. The method may vary with circumstances and what may be the method of choice at one time could be supplanted by another method under different conditions. Accordingly, at any one time various methods may be available for use and under the circumstances prevailing one will probably be superior, yet may not always be used.

The Origin of Mechanical Methods of Application:

The treatment of sheep to control damage by external parasites is of great antiquity; a passage in the 23rd Psalm refers to annointing a sheep's head with oil, presumably for such a purpose. According to Duncan (1948) in early times the usual method of treatment was to "salve" or smear the sheep with tar or similar greasy compounds (a practice which may be noted in occasional use in the Cumberland Hills of Great Britain even in recent years). It was in the early 19th century that dipping, or immersing the sheep in a bath of insecticidal solution, was used to any extent.

The formulation of insecticides for such dipping baths was then adopted by industrial organisations, so that the insecticides used evolved from crude home remedies to standard formulations whose composition is now often subject to legislation.

Despite such improvements in insecticides over a long period, it is only in recent years that the method of application has received much attention. Even to-day a commonly used method is to immerse the sheep in a bath or vat of insecticidal solution, but such a practice (called "plunge dipping") has considerable disadvantages, which can be briefly described:

As sheep grow older in experience they become extremely reluctant to enter a plunge dip and it is often seen that a particularly obstinate sheep may have to be carried to a position from which it can be thrown into the dip. At its best plunge dipping is hard work for the operator; at its worst the operators and dogs may cause considerable injury to the sheep in their efforts to force them into the dip. Plunge dipping is often deleterious to the condition of the sheep, many graziers claim that the sheep lose "condition" after dipping and due to the rough handling they receive it is almost impossible to consider dipping ewes heavy in lamb.

Further losses in plunge dipping are due to drowning, inhalation or ingestion of the chemicals with resultant pneumonia or poisoning, or to infection, the latter being the most common source of loss.

A plunge dip is frequently used for several days before emptying so that, despite the addition of fresh wash and disinfectant during dipping, it becomes progressively more foul and has been likened to a "bacterial soup" (Edger, private communication). The sources of entry of infection are usually unhealed shearing cuts, or injuries received in bringing the sheep to the dipping bath - usually biting dogs, rough handling, sharp projections in the yards, or skin punctures by grass seeds.

To overcome these serious defects of the plunge dipping method workers have sought better ways of applying insecticides to sheep. It is generally noted that these improved methods incorporate a mechanical device and the insecticide is either pumped over the sheep in a watery mixture, or blown over them as a dust. In general, the improved methods seek to eradicate the obligate external parasites of sheep with a minimum effort of the operator and causing minimum damage to the sheep, at the same time being designed so that they can be easily operated and maintained by persons with limited mechanical knowledge and they must be of reasonable cost.

As the numbers of these devices have increased, their advantages have become more widely known and as a result their manufacture now involves an industry of increasing importance. In order to thrive, such industry must continually seek improvement and the work presented in this thesis was conducted to that end.

The improvement of existing devices, or the invention of new methods, aims to present to the flock manager a device whose use will lie within certain limits of efficiency, economy and convenience. These limits will be described in greater detail later in this introduction to the work.

As might be expected, it is in countries such as Australia, New Zealand and the western United States of America, with large flocks of sheep and a small but expensive labour force and without strongly established traditions of sheep husbandry, that labour saving devices which treat sheep rapidly and economically have received attention and encouragment.

The Form of Thesis:

The treatment of sheep for control of ectoparasites has been concerned with either traditional methods or with industrial organisations who frequently prefer to keep their information confidential, so that the published literature on the mechanical application of chemicals to sheep is small in volume and in the case of certain devices of very recent evolution is practically non-existent.

In such a case the introduction to this thesis does not devote attention to a general review of the previous literature on the subject and rather will be devoted to introducing the methods used in the work reported and in defining certain terms which may be as yet unfamiliar to those not immediately concerned with the practice.

Methods of Work:

In most of the work described below, field trials were the means of obtaining information, because it was thought that the most reliable assessment of a machine or method would be to use it in the environment of general use, namely the properties on which sheep are depastured. The use of field trials demands its own particular disciplines, which are different to those used for experimental procedure under rigidly controlled conditions. In a field trial, for example, the number of uncontrollable variables which may affect the result are often too numerous to allow statistical analysis of the data. The method used therefore, has been to include a small number of identified known infested sheep in a larger flock which may be infested and to subject the entire flock to the treatment. Following treatment the identified sheep or alternatively a random number of the entire flock, were examined rather than the entire flock, which procedure was often impossible or unnecessarily tedious and, as the assessment of the method of treatment was based on the presence or absence of ectoparasites, statistical analysis was not needed. Further importance was added to the result if the machine or method achieved the same degree of efficiency, such as the entire removal of a parasitic infestation, under a number of conditions of climate, topography and of flock management.

In most of the field trials conducted, untreated controls were not used for two reasons; firstly, in some regions the law does not permit a grazier to treat any but the entire flock if ectoparasitic infestation is found and reported and, also, in many cases, the flock manager could not safely retain untreated infested sheep where the proper facilities for the isolation of such a group did not exist. This being so, the experimenter assessed the efficiency of the mechanical devices without the aid of untreated controls.

Generally the method used to test the efficiency of a device was as follows: Small tests, called "pilot tests" with small numbers of sheep under close supervision, were conducted. In the event of success of these pilot tests the device was taken to a large flock in the country and further tests under field conditions were made. If possible, these conditions were varied and if, as a result, the device or method used managed to eradicate infestations of ectoparasites from sheep under varying conditions, then it was assessed to be efficient within the limits found by the experiments.

Presentation of the Thesis:

When presenting a short paper describing an experiment or experiments, it is orthodox to describe the materials and methods used in full detail so that there can be no room for doubt on the conduct of the trial, or on the basis for drawing conclusions. It was considered, however, that in the presentation of this thesis, consisting as it does of reports of many tests often using similar methods and materials, the constant repetition of details would, by becoming tedious, obscure rather than clarify the presentation. To avoid this, the writer has modified the normal methods of presentation by including detailed descriptions of materials and methods only when these are introduced for the first time and not when summaries of similar field trials are presented as additional evidence.

To further assist the presentation of this report the detailed description of mechanical devices has been included in the form of an Appendix A and the devices will be referred to as briefly as possible in the text. For a similar reason the common names of the four ectoparasites of economic importance are used, the full description of these being found in the section entitled "Definitions" in this introduction. Similarly chemical names used are the common names as described by Haler (1957) and the proper chemically descriptive names are given in Appendix B. Also, although the symbols w/v, indicating that the strength of a liquid has been calculated according to the method of weight by volume, are normally used, these symbols have been omitted for the reason that the strengths of all liquids used have been calculated on this basis and the symbols w/w, indication that the strength of a solid formulation such as a dust has been calculated according to the method of weight by weight, have also been omitted, as the strength of all the dusts used were calculated on such a basis.

As there is practically no authoritative literature on the subject of mechanical devices for applying chemicals to sheep other than the patented trade marks or names, which are numerous, some confusion may exist as to the devices used and their common names. The devices or techniques reported below have been divided into four major classifications and these will be defined in this introduction. This thesis is thus divided into four major sections, each dealing with the defined technique, followed by a general discussion of the results of all methods.

Definitions:

In these definitions, lacking published authority, the terms of common use are employed, except where it is thought that ambiguity may occur, in which case other terminology less common but more explicit is used.

Insecticide: Generally a chemical which kills ectoparasites of sheep has been termed an insecticide. Its general use and the simplicity resulting from a single term are the reasons for so defining the term, even though parasites such as "itch mite" are not insects.

Dusting: Dusting is the mechanical blowing of an insecticidal dust on to sheep.

Surface Spraying: Surface spraying is the application of an insecticidal solution to the surface of the fleece of a sheep in such a manner that there is no mechanical penetration of the fleece by the fluid. (This technique is commonly called "tip-spraying").

Jetting: Jetting is the application of an insecticidal wash at pressure through nozzles, the force of the jet permitting immediate penetration of the fleece at the site of application of the fluid.

Showering: Showering is the process of subjecting sheep to a large volume of insecticidal wash under a comparatively low pressure, so that the fleece is eventually soaked to the skin and retains a proportion of the wash to which it is subjected. (This technique has been described commonly as "spray-dipping").

Louse: The sheep body louse Damalinia ovis. (Linne, 1758.)

Ked: The sheep ked Melophagus ovinus. (Linne, 1758.)

Itch Mite: The sheep mite Psorergates ovis. (Wormersly, 1941.)

Blowfly: The common sheep blowfly Lucilia cuprina, (Robineau-Desvoidy, 1830,) was considered to be the main cause of blowfly strike (cutaneous myiasis) of the sheep examined, but no attempt was made to determine the classification of larvae when strikes were examined.

The Work Done by the Writer:

The design and manufacture of machinery, the detailed study of external parasites of sheep, the formulation and analysis of chemicals used as insecticides and the knowledge of the management of sheep flocks embrace too wide a field for any one worker to become expert in each phase of an investigation, so that, of necessity, much of the work has been done as a team of workers with the writer in some cases directing the activities of the team, or in others being a partner in the investigations. Throughout the text it is intended as far as possible to indicate which of the work was done by the writer.

Generally it is wished to acknowledge that unless purchased and described as such, the design and manufacture of machinery has been carried out by the staff of the Sunbeam Corporation Ltd. For chemical formulation and analysis the staff of Geigy (Australasia) Pty. Ltd. have been responsible for work on the chemical diazinon, the staff of the Imperial Chemical Industries of Australia and New Zealand Ltd., (ICIANZ) for the work on the chemical dieldrin and to Elliott's Rural Division of the Drug Houses of Australia Ltd. for various Arsenical formulations.

For the use of facilities, sheep and assistance the writer is indebted to many individuals and organisations and where results of tests were collected by other workers their name will be mentioned in the text.

Standards:-

It was mentioned above that the three primary characters of a method are efficiency, economy and convenience. Some remarks on these primary characters will help to explain the factors governing the design and use of mechanical devices.

Standards of Efficiency of a Treatment:

In the case of the obligate parasites, lice, keds or itch mite, the standard of efficiency required either by the law or by the flock manager are total eradication of the infestation. These standards may be modified in that although complete eradication is desirable, when sheep have fleeces several months in growth, but too short to consider immediate shearing, it may be economically advisable to only reduce the infestation, because methods of eradication may themselves cause considerable economic loss by damage to the fleece, or they may be too expensive, as large quantities of chemical are needed.

In the case of blowfly, if a sheep is already struck, complete eradication of larvae is needed; in the case of prevention of strike the flock manager desires as long a period of protection against strike as can be obtained within economic limits.

Standards of Economy:

As previously stated, sheep are run for profit; therefore costs of bringing the fleece of the sheep to market must be kept as low as possible. The amount of money that can be spent on sheep to eradicate obligate parasites, or to prevent blowfly strike, will vary according to the amount of money spent on other aspects of the husbandry. For example, more money is available to a grazier to combat external parasites if he does not have to combat internal parasites, or if he does not need to consider the costs of nutrition. In extensive areas, where large flocks are run with few labourers, a large capital outlay on devices which will treat sheep rapidly may be justifiable, but where flocks are small capital outlaid must likewise be small.

Apart from the initial purchase of a device the cost of insecticide must always be reckoned when considering the economy of use. In this regard many of the newer synthetic insecticides are expensive to purchase and much work lies ahead to find their most economical use. For example Skerman (1959) showed that dieldrin and diazinon could be used in extremely low concentrations, such as a dip of 0.0001%, yet effectively eradicate lice and Graham (unpublished) also showed that dieldrin could be efficient in similarly low concentrations. Although to eradicate lice insecticides such as dieldrin are used in dips at approximately 0.0125% (and the method of use should prevent this concentration falling much below 0.006%) with the continuous replenishment system described below a shower could be charged at 0.004%, which would ensure an application strength of approximately 0.002%. In terms of present prices this means that instead of the cost of insecticide for dipping in dieldrin being approximately 100 shillings per thousand sheep, this could be reduced to approximately 20 shillings per thousand sheep. These costs of insecticide can mount to alarmingly high proportions if graziers attempt to use a shower for blowfly control when costs of insecticide can rise above 200 shillings per thousand sheep, or using surface sprays at concentrations of 0.25% or higher, in which case it can cost approximately 250 shillings per thousand sheep. Other insecticides now available are often more costly than dieldrin (which has been used in the above example), so that more care has to be exercised in their use if the control of external parasites is to be kept within economic bounds. On the question of cost of insecticide, it is generally considered that the blowfly should be regarded as a separate problem to those parasites which live only on the sheep, namely lice, keds or itch mite, as the costs of eradicating these are usually less than the cost of preventive treatment for blowfly, which should only be used if the sheep in the area continually suffer a high rate of blowfly strike.

At present times it is thought that the cost of dipping sheep should not exceed approximately 100 shillings per thousand.

Standards of Convenience:

Generally it is desired that a device should be easy to use and that installation and maintenance should be reduced to a minimum. Many of the standards of convenience, however, are those dictated by local circumstances. For example, in certain zones it may be necessary to use devices such as the dusting machine, which was evolved in the western United States to treat sheep in arid areas and to avoid wetting them during the cold weather which usually prevails at the time of treatment. Portable devices may be of use to graziers whose mustering points are far apart, but of little consequence to those who can easily bring their sheep to a central treatment place. The use of off shears treatment is vital to graziers who bring their sheep long distances to shearing and whose pastures, or the lack of them, do not permit them to hold the sheep near the shearing point until their cuts have healed and they can be dipped with safety.

To an extent, also, the size of the flock determines the choice of a device or method of treatment. For example, it may require several hours to prepare a device which can then treat many thousands of sheep in a single day and so, for a large flock, such preparation is worth while; in a small flock, however, a more laborious method, requiring less preparation, may be better employed.

Design of Machinery.

The design of machinery is governed by the considerations listed above. The manufacture of machinery is further limited by industrial considerations which need not be extensively reported here, but which are an important influence on the machine presented to the flock manager. In general the device must be available at the lowest possible cost and may be capable of withstanding considerable neglect, hard use and should be as simple as possible to install and to operate

PART ONE. DUSTING

By definition dusting is the mechanical blowing of an insecticidal dust on to sheep.

INTRODUCTION:

Mechanical or power dusting of sheep appears to be of comparatively recent development and is mostly used in the western United States of America, where the technique was evolved to meet certain local conditions

In these areas sheep are shorn while the weather is still cold. The zone is comparatively arid and little water is available for the treatment of the large flocks or "bands" of sheep which are held in temporary enclosures for shearing and so must be treated rapidly, effectively and also must be kept as dry as possible.

Matthysse (1945) published a paper on power dusting sheep. These were run through a chute or race surrounded by nozzles connected by hose to a fan driven by a 5 horsepower engine which blew the dust on to the fleece as the sheep ran past the nozzles. He attempted to make the dust penetrate the fleece, but was not successful; however, under optimum conditions of short dry wool he could obtain a 90% kill of keds with a dust containing 0.5% rotenone His results were poor if sheep were treated with long wool and when the wool was wet.

Fiedler and du Toit (1953) showed that certain chemicals possessed a property which is now commonly known as "diffusion". Diffusing chemicals are those which apparently move from the site of application along the wool fibre towards the skin of the sheep and which reach the skin in sufficient quantity to kill parasites despite the movement in the opposite direction of the wool grease (Lennox 1938) The exact mechanism of the process is still under study, but it was surmised by Sinclair (1959) that the amount of insecticide reaching the ectoparasites is a fraction of that applied to the surface of the fleece and that the size of this fraction depends upon two major factors; firstly, the length of the fleece and secondly, the amount of insecticide applied. If such is the case it would be expected that the greatest degree of success of a surface application of insecticide, as occurs in dusting, would be achieved by the use of a highly concentrated insecticide applied to as short a wool as possible, that is, off shears.

To some extent this was confirmed by the work of Pfadt and de Foliart (1952) and (1957) who tested a series of insecticidal dusts and found that the most effective treatment they obtained was with the 1.5% dieldrin dust used soon after shearing Using less concentrated formulations of dieldrin, or using other compounds not known to have the property of "diffusion", or dusting in the autumn when wool was much longer, proved to be less efficient than the use of 1 5% dieldrin soon after shearing In their tests, however, complete eradication of keds was not always obtained Thomas (1958) obtained success with higher concentrations of insecticide in the dust and a series of tests carried out by Scott and Sinclair (1959) are described below, which trials tend to confirm the hypothesis of Sinclair (loc cit) that the efficiency is governed by the concentration of the applied insecticide and the length of wool at the time of treatment

TRIALS ON THE DUSTING OF SHEEP:

In the trials carried out by Scott and Sinclair the treatments were conducted by both writers and the post treatment observations in general made by Miss Scott

Pilot Test No 1·

Dusting to control lice Sheep treated off shears or with 5 months wool by a 3% dieldrin dust (Scott and Sinclair, (1959)

Summary

54 sheep, including 7 experimental identified sheep, off shears, 3 of which were heavily infested and 4 lightly infested with lice, together with 8 experimental identified sheep carrying 5 months growth of wool and heavily infested with lice, were dusted in 50 seconds with a machine delivering approximately 3 lb of a 3% dieldrin dust per minute Although heavy showers of rain fell on the sheep immediately after dusting within 3 weeks of treatment, live lice could not be found on any of the 7 sheep treated off shears, whereas live lice could be found in the 8 long-woolled sheep up to 10 weeks after treatment

Materials and Methods

Duster A "Howry-Berg" sheep duster, available commercially, was modified as described in Appendix A (i)

Dieldrin Dust: The dust was prepared to an experimental formulation containing 3% dieldrin by weight

Location of Test· The test was conducted at the ICIANZ Field Research Station at Croydon in Victoria and the sheep used were Merinos and Crossbreds of mixed ages and sexes Shearing was deliberately "rough" in that areas of comparatively long wool were left on the sheep after shearing Heavy showers of rain fell on the sheep immediately after dusting

Results of Dusting Sheep off Shears and with 5 months Wool with a 3% Dieldrin Dust on 7/11/57.

Wool length:	Concentration of dieldrin:	Infestation before treatment:	No. of sheep in group:	No. of sheep infested at 4 days	2 weeks	3 weeks	4 weeks	6 weeks	8 weeks	10 weeks
Off shears	3% dust	Heavy	3	3	2	0	0	0	0	0
		Light	4	3	2	0	0	0	0	0
							5 weeks	7 weeks		10 weeks
Five months wool	3% dust	Heavy	8	8	-	8	8	7		6 *

- no examination
* One sheep missed inspection.

Three weeks after dusting live lice could not be found on the sheep treated off shears, but could be found on the long-woolled sheep up to 10 weeks after treatment.

Twelve weeks after treatment those sheep freed of lice were penned with heavily infested sheep and a transfer of infestation took place. This period of protection against re-infestation was not as long as that recorded in New Zealand by Thomas (loc cit) who obtained a period of 3 months protection against re-infestation, or that obtained from dipping by Skerman (1959) who obtained 16-20 weeks protection against re-infestation.

Further tests of the method were conducted by Sinclair.

Field Trial No. 1

Dusting to control lice. Sheep with various lengths of wool treated with a 3% dieldrin dust or a dust containing 1.8% diazinon. Sinclair (1959).

Summary:

360 lice infested sheep including 7 identified infested sheep were dusted with 3% dieldrin dust and 380 lice infested sheep including 9 identified infested sheep were dusted with 1.8% diazinon dust. On inspection 7 weeks after treatment

lice infestations were found to be eradicated from all sheep treated with the 3% dieldrin dust from sheep treated with 1.8% diazinon dust provided the wool length at time of treatment was not greater than two months growth.

Materials and Methods:

Duster: A Howry-Berg sheep duster already described in Pilot Test No. 1.

Dieldrin Dust: An experimental formulation containing 3% dieldrin by weight.

Diazinon Dust: An experimental formulation containing 1.8% diazinon by weight.

Location of Trial: The trial was conducted on the south-west slopes of N.S.W. The sheep were Merinos and Comebacks of mixed ages and sexes. Some had four months growth of fleece, some two months and some were within a few days after shearing at the time of treatment.

Results of Dusting Lice Infested Sheep with either 3% Dieldrin or 1.8% Diazinon Dust:

Dust used:	Sheep Ear Tag No:	Wool length at time of dusting:	Infestation before dusting:	Result of inspection 7 weeks after dusting:
3% dieldrin	37	Off Shears	Heavy	No live lice found
	39	" "	"	" " " "
	43	Two Months	Light	" " " "
	44	" "	Moderate	" " " "
	42	Four months	"	" " " "
	45	" "	Heavy	" " " "
	46	" "	"	" " " "
1.8% diazinon	26	Off Shears	Heavy	No live lice found
	27	" "	"	" " " "
	28	" "	"	" " " "
	30	" "	"	" " " "
	31	Two months	Moderate	" " " "
	33	" "	Light	" " " "
	32	Four months	Moderate	Live lice found
	34	" "	"	" " "
	35	" "	"	" " "

In this trial, although sheep dusted with 3% dieldrin were effectively treated for lice, the lower concentration of 1.8% diazinon failed to kill all the lice on the long-woolled sheep.

Field Trial No. 2:

Dusting to control keds. Sheep treated off shears with either 3% dieldrin or 1.8% diazinon dusts. Sinclair (1959).

Summary:

2,724 Merino sheep, including 8 identified sheep heavily infested with keds were dusted with a 3% dieldrin dust at a rate of 34 sheep per minute and 3,390 similar sheep, including 9 identified infested sheep were dusted with a 1.8% diazinon dust at rates varying from 32 to 73 sheep per minute through a machine delivering an average of 2.5 lb. to 3 lb. of dust per minute. All sheep were treated within a day of shearing and within 3 months of treatment live keds could not be found on the identified sheep.

Materials and Methods:

The duster, the dusts and the methods were similar to those described above. The trial was located onthe Monaro tablelands of southern N.S.W.

Results:

On inspection of the treated sheep at 24 hours after treatment, keds appeared dead or affected and at 48 hours only dead keds were seen on sheep treated with either dieldrin or diazinon dusts.

On inspection at one month after treatment, dead keds were seen and pupae found in the wool of sheep dusted with dieldrin, while on one sheep dusted with diazinon two live keds were seen. Dead keds were found on the remaining sheep in the diazinon dusted group and pupae were observed in the wool. Live keds were seen on the untreated sheep kept in isolation.

On inspection at three months after treatment neither keds nor pupae could be found in sheep dusted with either dieldrin or diazinon. The untreated sheep were not examined at this inspection.

It is of interest to record that a year later at the following shearing not a single ked infested sheep was observed on the property and further that shearers noticed a "chemical" smell in the fleece. Analyses of chemical content were made and wool samples taken at the auction store were found to contain up to 29 micrograms of diazinon per gram of wool (Cavey, unpublished) or up to 40 micrograms of dieldrin per gram of wool (Pryor, unpublished.)

DISCUSSION OF DUSTING TRIALS:

In these trials conducted under a wide range of topographical, climatic and flock management conditions. dusting off shears with either a 3% dieldrin dust or a 1 8% diazinon dust appeared to be successful in eradicating infestations of body lice or keds. With increasing wool length at time of treatment the weaker concentrations of insecticide, namely 1.8% diazinon, appeared to be inefficient when used on wool of more than 2 months growth at the time of treatment and the higher concentration, namely 3% dieldrin, was ineffecient when used on 5 months growth of wool As Pfadt and de Foliart (loc cit) found dieldrin to be better at 1 5% than 1% and their results were not as good as those obtained with 3% dieldrin (complete eradication), it would appear that the contention put forward in the introduction has been justified, that is, the amount of insecticide reaching the skin level (presumed to be the site of control of lice and keds) is a fraction of that deposited at the surface of the fleece and that the effect of the insecticide is enhanced by the use of relatively high concentrations of insecticide applied to the shortest possible length of wool

At this point it should be noted that our knowledge of the process known as "diffusion" is insufficient to be certain of what is really taking place. Most of the observations available are of a biological nature, that is, the assessment of the amount of chemical reaching the skin is made on the death of parasites such as lice or blowfly larvae feeding on the wool at skin level, which wool has been treated at the distal extremity with an insecticide. Brander (1957) assumed that the property of diffusion was possessed by only certain chemicals, whereas Graham (private communication) considers that most chemicals diffuse towards the skin, but only certain chemicals reach the skin at sufficient strength to kill ectoparasites

The dusting technique has certain advantages It can be the most rapid and easy method of treatment of sheep; rates of up to 70 sheep per minute were obtained by the writer with the aid of a dog and no other helpers In cold areas dusting has the advantage that the sheep are dry throughout the treatment, so are not likely to suffer if exposed to a cold wind and appear to be little affected by the treatment as they are usually observed to commence grazing within minutes of dusting. As there is no need for water the choice of treatment site is not limited and the machine is easily carried to temporary yards if these are needed Sheep can be safely treated immediately after shearing, so that untreated sheep seen in paddocks not completely mustered can be easily recognised over a considerable period and thus can be promptly shorn and treated. As was seen in the case of Field Trial No 2, there are appreciable and effective amounts of chemicals in the fleece for very long periods, so that accidental reinfestation is not a danger

With such advantages it might be conjectured why the method is not more widely used. At present it appears to be limited to certain areas of the United States of America and to a limited and decreasing extent in New Zealand. This might be understood if the disadvantages are considered The speed of the treatment and the ease with which it is carried out is dependent upon the direction and velocity of the wind. which, of course, is something beyond the control of the operator and is subject to wide variations within a single day If the wind changes during treatment and the dust is blown back towards the sheep entering the chute, instead of blowing away, as is normally desired, the sheep cannot see through the device and will not run The writer has found under these conditions that even with three helpers the work was extremely difficult. If there is little or no wind the dust settles over the working area in a thick pall and again the work is difficult.

There does not appear to be any hazard to the sheep apart from tissue involvement. Pfadt and Ryff (1955) found quantities of dieldrin in the tissues up to 86 days after dusting with a 1.5% dieldrin dust, but there is a distinct hazard to the operator, who is advised to wear protective clothing and a respiratory mask similar to those used by industrial spray painters. The clothes must be changed if impregnated with dust, otherwise insecticide poisoning may occur, as was observed by Patel and Rao (1958) who noted poisoning in Indian field workers who did not change clothing which had become impregnated with dieldrin.

The cost of the treatment can only be estimated, as it is limited by several factors, of which one of the most important is the efficiency of the operator. The dust is flowing continuously so that if sheep do not run continuously there is a degree of waste which could not be measured accurately. Calculations based on a dust cost of 3 shillings per pound, used in a machine delivering 3 lb. per minute and treating sheep at a rate of 40 per minute, show that the cost would be 80 shillings per thousand sheep. This, of course, can only be regarded as an estimate and would tend towards the minimum, but is still within the considered economic limit of 100 shillings per thousand sheep. The cost of freight on the dust is not taken into account here, but might be a large item, because whereas with watery solutions the diluent (water) is available on the property and only the concentrated active ingredient must be transported, in the case of a dust both active ingredient and diluent are subject to freight charges.

The above disadvantages have deterred would-be manufacturers of sheep dusters in Australia and it appears that in New Zealand the numbers of machines are decreasing in favour of the surface-spraying machines described below.

One possible disadvantage in Australia , which, although not seen, because of virtual absence of dusters, should be considered if dusters are brought into use, is the extremely long period after treatment when appreciable quantities of insecticide can be found in the fleece. At first sight this might be considered to be of advantage, particularly in the case of preventing reinfestation by obligate parasites, but there is a danger in the case of the blowfly that this long action, or "residual" effect of the insecticide, would subject the blowfly to a high "selection pressure" (Brown, private communication) and if the blowflies possessed the gene, or genes, conferring resistance to the chemical this high selection pressure could encourage the appearance of resistant insects.

If the technique of power dusting is examined according to the three criteria of efficiency, convenience and economy, it is seen that provided the length of wool is short and the concentration of a limited number of insecticides is high, the method is efficient, particularly in the control of lice and keds, but the convenience and economy are limited and the disadvantages in most cases appear to outweigh the advantages.

SUMMARY:

Published work and a series of tests and field trials showed that provided a sufficiently high concentration of certain insecticides was applied in sufficient quantity to a short fleece, such as immediately off shears, power dusting appeared to be a successful method of eradicating infestations of lice and keds from sheep and would give a considerable period of protection against reinfestation.

The method showed advantages; if conditions were right it could be easily applied and sheep were treated rapidly; it was used in cold weather without risk of shock or infection to the freshly shorn sheep and unless carelessly used could be maintained within economic limits, though not the cheapest method available. The device was easily carried to temporary facilities and did not require the erection of costly permanent yards.

The method also showed disadvantages; it was seriously handicapped by changes in wind direction or velocity, there was a hazard to the health of the operator and the choice of insecticides was limited to those which were relatively non-toxic and which showed the property of "diffusion". The device was considered to be comparatively costly to purchase, particularly when its limited use is taken into account.

It was thought that the disadvantages outweighed the advantages and that its use is not likely to increase beyond certain limited areas for which it was developed.

PART TWO SURFACE SPRAYING

DEFINITION:

Surface spraying is the application of an insecticidal solution as a fine spray to the surface of the fleece of a sheep in such a manner that there is no mechanical penetration of the fleece by the fluid.

INTRODUCTION:

A patent by Laws (1914) described a device which consisted of a plurality of arched pipes with nozzles through which animals walked and claimed a fine but penetrating spray which controlled the infestation of ectoparasites. The feat of achieving such a fine spray which will penetrate has yet to be satisfactorily peformed mechanically, but the property of chemicals called diffusion, described above, has led to the possibility of the useful application of certain insecticides to the surface of the fleece of the sheep as they pass through the sprays. As a result of this subject to the qualifications of concentration and wool length discussed above in Part One, infestations of ectoparasites can be controlled. In recent years numerous devices have been marketed which employ this principle and are known as "run-through spray races," the name being aptly descriptive of their function.

Essentially dusting and surface spraying function in a similar manner in that a concentrated form of insecticide is applied to the surface of the fleece, without mechanical penetration and it is the diffusing action of the chemical which enables the insecticide to reach and eradicate the external parasites. In such a case it might be expected that the hypothesis put forward for dusting should hold true for surface spraying. This hypothesis stated that the amount of insecticide reaching the ectoparasites is a fraction of that applied to the surface of the fleece and that the size of this fraction depends on two major factors; firstly, the length of the fleece and, secondly, the amount of insecticide applied. The hypothesis was again tested by the technique of surface spraying in a series of pilot tests and field trials described below.

TRIALS WITH SURFACE SPRAYING OF SHEEP:

Materials and Methods:

Spraying Device: Unless otherwise described in the text, the device used for surface spraying was a commercially available device patented by Bourke and Lander (1958) and improved by Sinclair and Hammond (1958), described in Appendix A (ii).

Pilot Test No 2

Surface Spraying to control lice Sheep treated in long wool with dieldrin or diazinon Sinclair (1957) unpublished

Summary

Two lice infested sheep in approximately 6 months growth of fleece were surface sprayed with dieldrin 0 125% and one similar sheep was surface sprayed with diazinon 0 125% After treatment the sheep were kept in isolation and examined periodically Within two weeks of treatment sheep were subjected to a period of very heavy rain but within 6 weeks of treatment live lice could not be found on the treated sheep and were not observed during a further four months of examination On lice infested sheep kept in the same environment live lice could be found throughout the period of examination

Materials and Methods

Spraying Device: Two sheep were surface sprayed by a nozzle attached to a stirrup pump with approximately one pint of an emulsion containing 0 125% dieldrin One sheep was sprayed in the device described in Appendix A (ii) with an emulsion containing 0 125% diazinon, the sheep being allowed to run through in the usual manner The sheep were Merinos or Crossbreds with wool of 58's to 64's quality with approximately 6 months growth of fleece and were depastured in the grounds of a factory in the suburbs of Sydney.

Dieldrin: A concentrated emulsion containing 24% dieldrin, available commercially, was diluted with water to a concentration of approximately 0.125%.

Diazinon: A concentrated emulsion containing 20% diazinon, available commercially, was diluted with water to a concentration of approximately 0 125%.

Results:

Each sheep was examined for lice infestation prior to treatment and the infestation was assessed subjectively at each examination by opening the fleece in at least 24 positions - 12 on each side.

Of the two sheep sprayed with dieldrin one was lightly infested and the other so heavily infested that the wool had to be torn apart to examine the skin. On the lightly infested sheep live lice could not be found within two weeks of spraying, but in the heavily infested sheep it was not until 5 weeks after spraying that live lice could not be found. On both these sheep live lice could not be found until the end of the experiment some four months after spraying. The sheep sprayed with diazinon was heavily infested with lice and live lice could not be found within ten weeks of treatment and live lice could not be found on this sheep for the remaining three weeks of the trial. During the entire period live lice could be found on two untreated sheep run in the same environment.

Despite the fact that the results of examination for lice at any time cannot be regarded as conclusively negative, due to the impractibility of examining the entire fleece, the continued negative findings are considered to be indicative of successful treatment and the complete eradication of infestation in long-woolled sheep appears to be slightly better than that reported by Brander (1957), although, due to the nature of the technique, it cannot be assumed that the deposits of insecticide were the same in both methods.

Pilot Test No. 3:

Surface spraying to control lice or itch mite. Sheep treated off shears with an Arsenical Solution. Murray and Sinclair (1959) unpublished.

In this trial the treatments were carried out by both writers and the assessments of infestation were carried out by staff of the McMaster Laboratory under the direction of Murray. The suggestion of the higher strength of Arsenical Solution was made by Graham.

Summary:-

Surface spraying with 1.0% Arsenical Solution apparently reduced the infestation of itch mite in one sheep and eradicated the infestation of lice in one sheep whilst infestations of these parasites continued to thrive on untreated sheep in the same environment. Surface spraying with 0.2% Arsenical Solution did not eradicate the infestation of lice in one sheep.

Materials and Methods:-

Spraying:- Adult Merino sheep were inspected for lice or itch mite and shorn within two days of inspection. Immediately after shearing the sheep were allowed to run freely through the surface spraying device in the usual manner. The sheep were treated on 4/12/58 and were kept in pens at a laboratory in Sydney.

Arsenic:- A commercial liquid, Arsenical Sheep Dip, containing 60% Arsenic as AS_2O_3 was diluted to make solutions containing 1.0% Arsenic and 0.2% as AS_2O_3.

Results:-

The sheep infested with itch mite was sprayed on the 4/12/58 and when examined a week later no live mites were found. Live mites were not found on subsequent examinations at four weeks and six weeks after treatment. The sheep was then examined at four months after treatment and live mites were found. Examination of untreated sheep kept in the same environment revealed live mites during the period of the trial.

Three sheep were heavily infested with lice. Of these two were treated, one with 0.2% Arsenic solution and one with 1.0% Arsenic solution. On the sheep treated with 0.2% Arsenic, although dead adult lice were observed soon after treatment, live nymphs were observed throughout the 6 weeks of examination and live adults were seen again within four weeks of treatment. On the sheep treated with 1.0% Arsenic a few live nymphs were observed up to four weeks post treatment, but for the remainder of the period of observation no live lice could be seen. On the sheep not treated, but kept in isolation in the same environment, numerous live lice could be seen throughout the test period.

The spraying with 1.0% Arsenical solution eradicated the infestation of lice and considerably reduced the infestation of itch mite, the latter result being somewhat unexpected, but the weaker solution of 0.2% Arsenic, though showing some insecticidal activity, did not eradicate the infestation of lice. Apparently all adult lice were killed, but eggs hatched out successfully and the nymphs grew to adult stage.

The results of this trial are considerable interest in that they tend to confirm the hypothesis that solutions used for surface spraying must carry comparatively high concentrations of insecticide if they are to be successful, presumably by allowing useful quantities of insecticide to reach skin level. Another point of considerable interest is that to date Arsenic has not been generally considered to be a diffusing insecticide, although its action here would tend to show that it probably does possess some diffusing activity. The work of Heath (1955) suggests that this might happen.

A further pilot test by Murray and Sinclair showed that surface spraying off shears with 1% Arsenical solutions again reduced infestations of itch mite, but did not eradicate all the mites.

Pilot Test No. 4:

Surface spraying to control lice. Sheep treated in various wool lengths with various concentrations and formulations of dieldrin. Scott and Sinclair (1959) and Scott and Sinclair (1958) unpublished.

In these tests the treatments were conducted by both writers and the post treatment examinations were conducted by Miss Scott.

Test A:

Summary:

Infestations of lice were successfully eradicated from a small group of sheep treated off shears by surface spraying with an 0.125% dieldrin emulsion. The same method failed to eradicate lice infestation from sheep carrying 5 months wool at the time of treatment, although the numbers of lice were considerably reduced. Lowering the concentration of the dieldrin used for surface spraying to 0.025% or 0.125% also reduced the numbers of lice, but failed to eradicate the infestation.

Treatments were not immediately effective in that eradication took place within four weeks after surface spraying.

Reductions in the concentration of insecticide were observed in emulsions collected after sheep had passed through the surface sprays.

Materials and Methods:

Spraying Device: The surface spraying device was that described in detail in Appendix A (ii).

Dieldrin Emulsion: A 24% concentrated emulsion, available commercially, was used to prepare dilutions of 0.125%, 0.025% and 0.0125% in water.

Dieldrin Wettable Powder: A 40% wettable powder, available commercially, was used to prepare a dilution of 0.0125% in water.

Spraying of sheep: At the ICIANZ Research Station in Victoria, Merinos and Crossbreds of mixed ages and sexes were inspected for lice infestation and shorn. Shearing was rough compared to that usually desired in the grazing industry, but this was deliberately done to increase the severity of the test. Within three days of shearing sheep were sprayed. The technique used was to mingle the sheep of each experimental group with a small flock of surplus sheep and to run this small flock through the sprays to simulate normal spraying conditions. This latter flock of surplus sheep, totalling 40, were immediately drafted off after each treatment and were mingled with the next experimental group and run through the device again. Thus the surplus sheep were actually treated by surface spraying four times with increasing concentrations of dieldrin and were also treated by dusting immediately after, thus giving a measure of the toxicity of the methods used. A total of 57 points of rain fell during the day of spraying; some sheep were wet before treatment and rain also fell during and after spraying.

Results:

Sheep were inspected after treatment by opening the fleece in numerous positions, particular attention being paid to the region under the neck. At least ten minutes were spent examining each sheep at any one inspection.

The results of the inspection are set out in the following table:

Results of surface spraying lice infested sheep both off shears and with 5 months wool with different concentrations and formulations of dieldrin on 7/11/57:

Wool length:	Concentration of dieldrin:	Infestation at treatment:	No. of sheep in group:	Results of examination after treatment: No. of sheep infested at - 4 days	2 wks.	3 wks.	4 wks.	6 wks.	8 wks.	10 wks.
Off shears	0.0125% emulsion	Heavy	6	6	6	5*	6	5	5	4
		Light	3	2	2	2	1	1	1	1
Off shears	0.0125% wettable powder	Heavy	6	6	6	4	2	2	2	2
		Light	3	1	0	0	0	0	0	0
Off shears	0.025% emulsion	Heavy	6	5	5	5	2	1	0	0
		Light	3	3	3	2*	2	1	0*	1*
Off shears	0.125% emulsion	Heavy	6	4*	4	3	0	0	0	0
		Light	2	0	0	0	0	0	0	0
							5 weeks	7 weeks		10 weeks
Five months wool	0.125% emulsion	Heavy	8	8	"	8	8	8		8

* One sheep missed inspection.

It was noted that the treatments were only effective in eradicating lice when applied to the sheep off shears Also the treatment was effective when applied at 0.125%, but infestations persisted when the concentration of the applied fluid fell to 0.025% or lower Generally the lighter infestations were more easily eradicated, but it should be noted that even when treatment was successful the infestation persisted for several weeks after spraying before eradication was achieved.

Although the surplus sheep had received, in one day, sprayings of 0.0125% dieldrin wettable powder and dieldrin emulsions of 0.0125%, 0.025% and 0.125%, together with a dusting of 3% dieldrin dust, none appeared to show clinical signs of illness.

Twelve weeks after treatment those sheep from which lice infestations had been eradicated were placed in a pen with heavily infested sheep. Transference of lice to the treated sheep occurred readily and the infestations persisted for a least one week.

From these findings it was noted that the period of protection against reinfestation by lice was not as long as that obtained by other workers. Anon (1957) in New Zealand obtained 6 months protection after dusting with 3% dieldrin, Thomas (1958) obtained 3 months protection by dipping in 0.0125% dieldrin and Skerman (1959) obtained 16 to 20 weeks protection by dipping in 0.01% diazinon and 32 weeks protection by dipping in 0.1% diazinon.

Test B:

This test was carried out at a later date, but in a similar manner to that described in detail in Test A.

Summary:

Lice infested sheep were surface sprayed off shears with emulsions containing 0.025% and 0.125% dieldrin. Lice infested sheep were also surface sprayed one month after shearing with an emulsion containing 0.125% dieldrin. The infestations of lice were eradicated from all sheep treated off shears, but were not eradicated from all sheep treated one month after shearing. Sheep freed of lice by the treatment were penned with heavily infested sheep 7 weeks after treatment and infestations were transferred and persisted in some cases for at least 3 weeks.

Materials and methods:

These were similar to those used in Test A.

Results:

After treatment periodical inspections of the treated sheep were made as described in Test A and the results of these inspections are presented below:

Results of surface spraying lice infested sheep in various wool lengths with various concentrations of dieldrin:

Wool length:	Treatment:	No. sheep infested/no. sheep examined: Results of inspection at - 4 weeks	6 weeks	10 weeks	11 weeks
Off shears	Dieldrin 0.025%	3/6	2/6	0/5	0/5
Off shears	Dieldrin 0.125%	0/8	0/8	0/4	0/4
One month	Dieldrin 0.125%	3/7	4/7	2/6	1/6

Lice were eradicated from all sheep treated off shears, but were not eradicated from all the sheep treated when carrying one month's growth of wool. It is of interest to observe the slower rate of eradication in the group treated with 0.025% dieldrin when compared with the group treated with 0.125% dieldrin. This would appear to provide additional evidence for the contention that the amount of insecticide reaching the skin after diffusion is governed by the concentration of the applied fluid as well as the length of wool at the time of treatment.

Field Trial No. 3:-

Surface spraying to control lice. Sheep treated off shears with either dieldrin or diazinon. Sinclair (1959).

Summary:

On a property on the southern slopes of N.S.W. 364 lice infested sheep were surface sprayed with an emulsion of 0.125% dieldrin and 437 similar sheep were surface sprayed with 0.125% diazinon. Identified sheep were examined at 4 weeks and 15 weeks after treatment and live lice could not be found. On an untreated group of lice infested sheep, shorn and kept in the same environment, live lice could be found at both examinations.

Materials and Methods:

Diazinon:: A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.125%.

The dieldrin emulsion, the spraying device and the techniques of experiment were similar to those described in Pilot Test No. 4 above.

Results:

Eight identified infested sheep sprayed with dieldrin 0.125% and 8 identified infested sheep sprayed with diazinon 0.125% were examined at 4 weeks and 15 weeks post treatment. No live lice could be found on these sheep and as they are included in the flocks of sprayed sheep it was concluded that the treatments had been efficient, particularly as a group of similar sheep, shorn but not sprayed and kept in isolation in the same environment, carried live lice throughout the period of the trial.

Field Trial No. 4:

Surface spraying for the control of lice. Sheep treated 6 weeks off shears with dieldrin. Sinclair (1959).

Treatments and inspections were made by Scott and Sinclair.

Summary:

On a property in Victoria, near Melbourne, 259 lice infested Cross-bred sheep of mixed ages and sexes were sprayed with an emulsion of 0.125% dieldrin 6 weeks after shearing. Inspection at 3 weeks after treatment revealed 7 sheep infested out of 50 selected at random; at subsequent inspections at 12 weeks and 18 weeks post treatment, live lice could not be found on random samples of sheep.

Materials and Methods:

The spraying device, dieldrin emulsion and techniques of experiment were similar to those described above.

Results:

In this trial the technique of assessment of efficiency was to take a random sample of at least 20 sheep from the flock and to examine these sheep thoroughly for the presence of live lice. At 3 weeks after treatment 7 sheep out of 50 showed live lice, but at 12 weeks and 18 weeks post treatment live lice could not be found.

Field Trial No. 5:

Surface spraying for the control of keds. Sheep treated off shears with either dieldrin or diazinon. Sinclair (1959).

Summary:

On a property on the far south coast of N.S.W. 449 ked infested

Merino sheep were surface sprayed off shears with an emulsion of dieldrin 0.25% and 800 similar sheep were similarly sprayed with an emulsion of diazinon 0.25%. Inspections of random samples of identified infested sheep from either the diazinon or dieldrin groups at 4 weeks, 8 weeks and 17 weeks post treatment did not reveal live keds. On a group of sheep not treated for four weeks after shearing live keds could be found. These sheep were then jetted with diazinon 0.05% and the infestations of keds were eradicated.

Materials and Methods:

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.25%.

The spraying device and techniques of experiment were similar to those described above.

Results:

Within two weeks of treatment a severe period of 6 inches of rain in two days resulted in the death of over 300 sheep. As a result of problems of flock management only random samples of sheep identified as infested at treatment could be inspected. Identified sheep were inspected at 4 weeks, 8 weeks and 17 weeks post treatment and also at the subsequent shearing 12 months later. On no occasion could live keds be found. A small group of sheep were left untreated and a few of these also were not shorn and these showed live keds 4 weeks after shearing. These sheep were then jetted with 0.05% diazinon and at the inspections at 8 weeks and 17 weeks post treatment live keds could not be found.

Field Trial No. 6:

Surface spraying for blowfly strike. Sheep surface sprayed or jetted in six months wool with dieldrin. Sinclair and Gibson (1959).

Summary:

On a property on the northern tablelands of N.S.W. a group of 200 Merino ewes and lambs were surface sprayed with 0.25% dieldrin and a group of 1400 similar sheep were jetted with approximately half a gallon of 0.025% dieldrin on body and crutch. These sheep were run in the same paddock and observations on the numbers of blowfly strikes occurring revealed that although there did not appear to be any difference in the period of complete protection against blowfly strike conferred by either method,

after this period of complete protection had passed the rate of blowfly strike was much higher in the surface sprayed sheep when compared with the jetted sheep.

Introduction:

The manufacturers of certain surface spraying devices have made claims that the technique can be used to prevent blowfly strike provided the concentration of the applied insecticide is 0.25% or higher. These claims are possibly based to some extent on the work of Graham (1957) who showed that surface spraying sheep with emulsions of up to 0.5% dieldrin conferred a protection against body strike similar to that obtained by jetting with dieldrin at 0.025%, but he pointed out that the deposit of insecticide per sheep by surface spraying was much higher than that from jetting and he questioned the economics of such a procedure. The efficiency of methods of prevention of blowfly strike can be assessed in two ways, either artificially or under field conditions. Hobson (1935), Stones (1954), Riches and O'Sullivan (1955) and Fielder and du Toit (1953) have described most of the artificial means which essentially can be either the exposure of sheep to abnormally high populations of flies, or the implantation of blowfly larvae in the fleece. Published literature by Wright, Payne and Shanahan (1957) using artificial flystrike to compare surface spraying and jetting, and Shanahan (1951) using field trials to compare fogging, surface spraying and jetting, indicated that surface spraying would be inferior to jetting under field conditions. Sinclair and Gibson (1959) thought that the speed with which a flock could be treated by surface spraying under severe fly wave conditions, justified a further attempt to assess the efficiency of surface spraying against blowfly in a field trial and this trial is now described.

Materials and Methods:

Dieldrin: A 20% concentrated emulsion, available commercially, was diluted to concentrations of approximately 0.025% and 0.25%.

Treatment of sheep: A commercially available device, described in Appendix A (ii) and (iii) was used for both surface spraying and jetting. Details of the jetting method will be described below in the section of the thesis dealing with this technique. The technique of surface spraying was as described above.

A flock of approximately 1600 Merino ewes and their lambs of at least 3 months of age were brought to the yards and a draft of approximately 200 were taken off at random. These were surface sprayed with dieldrin 0.25% and identified by paint brand. The remainder of the flock was jetted with approximately half a gallon of dieldrin 0.025% on body and crutch and were also identified by paint brand. The flock was united after treatment and run in the same paddock until crutching time when the experiment was concluded.

Results:

Until 18/3/58, approximately 7 weeks post treatment, flystrike was not recorded. On this date, as a result of a severe fly "wave", records of flystrike were kept until crutching time and are presented below:

Records of flystrike from 18/3/58 to 16/4/58:

Treatment:	No. sheep:	Period to first recorded flystrike:	Period 18/3/58 to crutching: No. strikes:	% sheep struck:
Surface spray dieldrin 0.25%	205	6 weeks 4 days	13	6%
Jetted dieldrin 0.025%	1,408	6 weeks 5 days	8	0.6%

The observers recorded that practically all flystrikes were crutch strikes.

These results do not show any difference in the period of complete protection against flystrike obtained by either method, but the considerably increased rate of crutch strike occurring in the surface sprayed group during the period of partial protection led the authors to consider that despite the slower rate of treatment, jetting was the superior method for prevention and treatment of blowfly strike.

BEHAVIOUR OF CHEMICAL EMULSIONS WHEN PASSED THROUGH THE SPRAYING DEVICE:

The description of the surface spraying device in Appendix A (ii) mentions that under the normal field conditions approximately one third of the spray misses the sheep and is collected in the waste tray. When considering the economy of the method it can be seen that, like the duster, the sprays function whether or not sheep are running through the device, so that means of collecting the wasted emulsions for further use could favourably affect the economy of the method to a considerable extent, as these highly concentrated emulsions are expensive to prepare.

Samples were taken from the device during the pilot tests and field trials described above and were also taken during a series of pilot tests by Sinclair and Cavey (1958) unpublished and Sinclair and White (1958) unpublished and the results of the analyses of these samples are presented in the table below:

Results of analyses of samples of emulsions taken whilst surface spraying:

Insecticide:	Analysis of sample of emulsion from: Supply:	Pump:	Nozzle:	Waste Tray:
Dieldrin	0.023%	-	0.021%	0.020%
	0.110%	-	0.108%	0.040%
	0.024%	-	-	0.023%
	0.102%	-	-	0.088%
	0.125%	-	-	0.110%
	0.25%	-	-	0.195%
Diazinon	0.188%	-	-	0.078%
	0.034%	-	0.030%	0.026%
	0.123%	0.122%	0.122%	0.119%

Chemists believe that the accuracy of the third decimal place of these analyses is open to doubt, due to the limitations of accuracy involved in the actual method of analysis. For any one test, therefore, one cannot state that anything has been definitely proven, yet when the results of all the tests are considered, it can be seen that there is a consistent picture of a slight reduction in concentration as the emulsions pass from the supply tank through the nozzles, the air and are collected in the waste tray.

Sheep do not normally remain in the device for more than a second, so that the wash collected as waste has not passed over, or through, the fleece and the reduction in concentration of insecticide is not thought to be due to the type of insecticide exhaustion found in dips or showers (Graham, 1959). Possible reasons for this fall in concentration of insecticide in the emulsions used in surface spraying have been considered, but no convincing explanation can be put forward.

If the reclamation of wasted emulsion is considered a further problem of considerable importance must be solved. When sheep are treated off shears it has been noted that appreciable quantities of short wool clippings, known as "second cuts", accumulate in the waste tray together with the inevitable debris of grass, seeds, silt, etc. These contaminants must be removed from the wash if reclamation is desired, because they can easily cause a blockage in the fine apertures of the nozzles used for surface spraying and these blockages can reduce the efficiency of the treatment in two ways; firstly, by reducing the amount of spray delivered on to the sheep and secondly, by the delays in treatment if nozzles have to be frequently cleaned.

To assess the technique of reclamation of wasted emulsion in surface spraying, therefore, it can be seen that whilst it might be considered to be of considerable economic advantage in the reduction of waste of expensive emulsions, the disadvantages of removal of debris to prevent clogging of nozzles and the uncertain nature of reduction of concentration of the insecticide appear to outweigh the advantages and so it has been recommended by the writer that the unused wash collected in the tray be allowed to go to waste.

DISCUSSION OF SURFACE SPRAYING TECHNIQUE:

As a means of removing infestations of lice or keds the technique of surface spraying appears to be efficient within certain limits and as observed in the introduction to this section of the thesis these limits are similar to those observed in the technique of power dusting, which employs a similar principle, namely the application of insecticide to the surface of the fleece without mechinical penetration of the wool and the reliance on the diffusion of the chemical to ensure that the insecticide reaches the external parasites.

The results of the tests described in this report are considered to bear out the hypothesis that the efficiency of the technique depends upon the amount of insecticide reaching the ectoparasites and that this is governed by two major factors; firstly, the length of the fleece at the time of treatment and secondly, the amount of insecticide applied to the surface of the fleece. It is concluded that the most efficient use of the technique is to apply it immediately after shearing, when the wool is shortest and that high concentrations of diffusing insecticides must be used. For example, dieldrin or diazinon should not be used below a strength of 0.125% and these emulsions should be freshly prepared for use and not reclaimed as waste from previous spraying, unless considerable care is used to remove debris capable of clogging the nozzles, and that the possibility of lowered strength of insecticide be considered and corrected if necessary.

It was not thought that the technique was of high efficiency when used for the prevention or treatment of blowfly strike, particularly of crutch strike.

When the economy of the method is considered it is calculated that if sheep can be sprayed at an average of 35 per minute with an emulsion of dieldrin 0.125% the cost of insecticide is approximately 90 shillings per thousand sheep. This is not excessive and lies within reasonable limits of economy, but the method can become extremely expensive if care is not taken to keep sheep running through the device while the sprays are turned on. Also the use of more highly concentrated emulsions is thought to bring the cost of surface spraying above reasonable economic levels.

When the convenience of the technique is examined it can be seen that this is probably the greatest advantage of the method and is possibly the reason for a relatively wide acceptance of the technique. It can be used immediately off shears with a minimum of labour and effort and although subject to a slight extent to direction of wind, or to the effect of direct sunlight shining on the sprays, it is much less affected by these conditions than the technique of power dusting. Apart from the ease of treatment the ready identification of treated sheep, if they are done immediately after shearing, makes the identification of untreated "stragglers" a simple task.

Soon after introduction the method was received with enthusiasm by many flock managers, but after several years use the technique is in an apparent decline. Even the grazier who has used the method correctly has found the problem of itch mite now overshadowing the advantages gained in the easy elimination of lice and keds and until a means of eradicating this parasite by surface spraying is found it is thought that this problem alone will serve to further limit the use of the technique. Despite the early promise of good fly control, this has not been seen to any extent and the technique has not been widely used for this purpose.

SUMMARY:

A series of tests showed that the technique of surface spraying was an efficient means of eradicating lice and keds if used immediately after shearing with relatively high concentrations of diffusing insecticides.

Infestations of lice were efficiently eradicated by surface spraying off shears in a described device with emulsions of dieldrin or diazinon at a concentration of approximately 0.125%, or a solution of Arsenic at a concentration of 1.0% Arsenic as As_2O_3. Infestations of keds were eradicated by surface spraying off shears in the same device with emulsions of dieldrin or diazinon at a concentration of approximately 0.25%. Infestations of itch mite were not eradicated, though considerably reduced, by surface spraying off shears with 1.0% Arsenical solution. Surface spraying lice infested sheep with concentrations of insecticide lower than those quoted above, or spraying at times when the wool length was greater than immediately after shearing was not consistently successful under all conditions and was not recommended. Surface spraying was not found to be of great use for the prevention or treatment of blowfly strike.

If used correctly the method was reasonably economical, though was subject to the efficiency of the operator to keep the sheep running through the sprays to keep it within the bounds of economy. The use of higher concentrations than those recommended could bring the costs well above the considered maximum of 100 shillings per thousand sheep

The greatest advantage of the method was its convenience and it might be described as one of the most convenient methods available for the eradication of lice and keds off shears.

Investigations of the behaviour of emulsions passing through the device lead to the recommendation that the wash which has missed the sheep and collected in the waste tray should be discarded despite the apparent economic loss resulting from such a practice.

PART THREE: JETTING.

DEFINITION:

Jetting is the application of a wash at pressure through nozzles, the force of the jet of fluid permitting immediate penetration of the fleece at the site of application of the fluid.

INTRODUCTION:

According to Graham (private communication) the early jetting apparatus was evolved by modifying existing orchard spraying devices. Early patents of jetting devices were taken out by Dowling (1933) who used compressed air to force the fluid into the fleece, a technique rarely used to-day, and Bucknell (1934) who designed a series of boxes to hold sheep while they were being treated. The outstanding contribution, however, was that of McCulloch (1937) whose work on the mechanics of jetting sheep gave rise to a series of recommendations which are followed to this day. Although he spent some time with a perforated "saddle" placed against the crutch of the sheep and known as a "Spretter", Clapham and Moore (1944), most of his work was conducted with a piston type of pump connected by hose to a "handpiece" carrying three to five nozzles of approximately 0.060 to 0.070 inch orifice and he worked with pumps giving pressures of 40 to 90 lbs. per square inch (psi). McCulloch worked mainly with arsenical solutions and as a result of this work it was recommended that when a sheep is jetted the fleece should be saturated to the skin over the area to be protected, but the pressure should not be so high that the skin is damaged. He worked out a programme of preventive jetting as well as treatment during fly "waves" and such use of Arsenical solutions as jetting fluids continued to a varying extent throughout Australia for many years. Some graziers used a type of box to hold the sheep whilst being jetted, whilst others preferred to hold the sheep in a long race.

Since the work of McCulloch most workers appear to have devoted their time to the assessment of various chemicals and formulations of those chemicals and there is a considerable volume of literature on the subject of jetting as a means of prevention of flystrike. With the advent of the synthetic "residual" (or long acting) insecticides, graziers were quick to seize the advantage by jetting their sheep more than ever before. The result of this was first to see an apparent disappearance of the blowfly over a few years, resulting in relaxation of other fly control methods such as the Mules operation, careful selection of breeding stock, well-timed crutching or shearing and because of the efficiency of the insecticides the jetting technique was often very haphazard and not nearly as thorough as that recommended by McCulloch (loc cit). After several years of high selection pressure by the insecticides dieldrin and aldrin, it was noted that forms of the blowfly resistant to these chemicals had appeared, Shanahan (1958) and at present jetting has suffered a decline, despite its obvious advantages and despite the availability of other insecticides against which there is no known resistance.

The advantages of jetting for flystrike control has tended to obscure the use of the technique for any other external parasite and Belschner (1956) for example, defines jetting only in terms of blowfly control. A few workers have considered the technique in terms of other parasites; Anon (1951) jetted sheep with BHC and obtained a considerable reduction in the numbers of lice and keds in different infestations and Hoffman and Lindquist (1951) attempted to use jets in run-through races to control keds, but did not report successful eradication.

When the existing jetting machinery was examined with a view to improvement, it was thought that work would be necessary on both the technique itself and on the use of the technique to control all important external parasites of the sheep.

The Technique of Jetting:

Following the recommendations of McCulloch (loc cit) the common method of jetting used to-day and called in this report "Hand Jetting" (as a means of distinction from other methods) consists essentially of a pump driven by an engine, usually portable in nature; wash is drawn from a drum or portable reservoir and is pumped through hoses, usually one or two in number, to manually controlled valves on handpieces carrying three or five nozzles of approximately 0.050 inch orifice. The pump usually operates at pressures of 40 to 90 psi, although it is observed in the field that individual operators may work at pressures much higher than this, but they offset this higher pressure by holding the handpiece further than normal from the fleece, so that the nett result or jet impact is probably similar to that obtained with a lower pressure held close to the fleece.

The sheep to be treated are held either in long pens or races or in various designs of boxes and are jetted, or soaked to the skin, with insecticidal wash on areas of the fleece which give name to the jetting procedure. For example, if sheep are jetted on the crutch area it is called "crutch jetting", if jetted along the mid dorsal line in a band approximately 6 inches wide from poll to tail it is called "body jetting", around the horns is called "poll jetting" and around the preputial orifice is called "pizzle jetting"

The nozzle has also received apparently little attention. Knipe (1955) and Hall (1955) worked on the efficiency of output of cone or fan-type of nozzles used for spraying in malarial mosquito control, but these findings could not be applied to work on jetting, because the fan-type of spray will not penetrate a fleece.

McCulloch observed that with a piston type of pump the number of nozzles on the handpiece should be limited, as with numbers of jets greater than about five there is a considerable drop in pressure and so penetration of the fleece is reduced.

Type of Apparatus:

It was thus seen that if jetting apparatus was to be improved the first decision was to consider the type of apparatus to be made Work can be done on improved types of handpiece and the rate of jetting might be improved upon over the normal 250 to 400 per hour, or a device could be evolved which automatically jetted sheep and so reduced the errors due to individual operators. The latter was chosen because it has been noted that even good hand jetters become careless when fatigued and also the operator tends to be wetted by the jetting fluid, which is not desirable, particularly if the operator is sensitive to certain chemicals.

Having decided that an automatic type of device would be attempted, it was noted that if a piston type of pump were used the number of nozzles would have to be limited to about five, or else extremely large engines would be needed. Simple means of automatically jetting sheep of varying size with only five nozzles did not appear to be available and so the design. was considered to be best founded upon a device having a relatively large number of nozzles. Having thus decided upon the number of nozzles it was evident that the type of pump and engine would need serious consideration.

On many properties there are readily available small portable pumping plants known as "firefighters" which usually embody a centrifugal pump and a petrol engine of about 2 h.p. and which deliver about 1000 gallons of water per hour at a pressure of about 50 psi. These appeared to be the logical type of pump to power an automatic jetter for several reasons. Firstly, the pump is readily portable, it is usually kept in good condition and because the plant has alternative uses it means that the owner does not have capital tied up in a device which is not used frequently.

It is generally true that for any given power of engine a pump can do so much work. This is measured as the efficiency of the pump and is usually measured as the weight of water lifted to a certain height. It can be seen that if the "head" or pressure is increased, then the volume of water moved is decreased, or vice versa. Thus for any given power of engine a pump can put out so much fluid at a certain pressure and if the volume is to be increased the pressure must decrease, as McCulloch saw in the case of increased number of nozzles with piston types of pumps, whose pressure fell with the increase in volume.

The firefighter type of pump giving 1000 gallons per hour (gph) at 50 psi would give sufficient volume to supply a large number of nozzles, but the pressure would be limited to 50 psi at the pump and experience has shown that if such a pump be connected to a device with a series of valves, taps etc., then even with efficient design not much more than 30 psi at the nozzle can be expected.

Considering the existing apparatus, it appeared that such a pressure would be too low unless a nozzle were designed which would give a jet penetrating the fleece to the skin at a pressure of 30 psi or less.

Accordingly a series of tests were conducted firstly to design the nozzle and then to adapt this nozzle into a device which would automatically jet sheep rapidly and efficiently.

Tests on the design of an automatic jetting apparatus. Sinclair, Worrad, Payne and Cavey (1957-8) unpublished:

Summary:

A device was designed which would jet sheep efficiently on crutch, body, poll and pizzle, or any combination of these areas at rates of approximately 400 per hour. The areas jetted were soaked to the skin and efficiency of jetting did not vary to any extent with different operators. Observations with coloured jetting fluids revealed that if large volumes of fluid were jetted into the fleece along the mid dorsal line this fluid would move over considerable areas of the sheep's skin under the action of gravity and this movement could be assisted by the addition of surface active agents ("wetters") to the wash.

Materials and Methods:

Jetting Device: Various prototypes and designs were used until a final design was evolved and this is described in Appendix A (iii) and (iv) for which there are two patents, one by Bourke and Lander (1956) and one by Sinclair and Hammond (1958).

Pump: A commercially available Firefighter consisting of a one inch centrifugal pump directly coupled to a 1.3 h.p. petrol engine (air-cooled) running at 2000 revolutions per minute (rpm) with an output of 1250 gph at a pressure of 50 psi.

Jetting Fluids: Emulsions of dieldrin or diazinon at strengths of 0.02% up to 0.05% were prepared from commercially available concentrates. Dyes used were either Waxolene Blue (ICIANZ), an alcohol soluble dye, or Crystal Violet (Geigy), a water soluble dye.

Jetting of Sheep: In the initial stages and later when dyes were used, sheep were jetted either singly or in small groups. As the construction of the machine progressed it was taken to the field and used on larger flocks of sheep and at the time of writing it is estimated that the writer has either jetted or personally supervised the jetting of over 10,000 sheep in a period of approximately two years.

Results:

The use of coloured emulsions showed that if the jet from a nozzle of approximately 0.050 inch orifice was produced in such a manner that stream of fluid approximated the shape and size of the orifice for approximately 12 inches distance from that orifice and if that nozzle was held approximately 6 inches from the fleece of the sheep, it penetrated the fleece to the skin with nozzle pressures as low as 15 psi. The fleece of the sheep was judged to be of average Merino consistency or "density" and was of approximately 6 months in growth.

Observations showed that if a nozzle was held stationary over the fleece of a sheep which was also held immoveable, the jet of fluid penetrated the fleece to the skin at the site of impact, but tended to be reflected at the skin and an increased delivery of fluid did not result in wetting any increased area of fleece, but the fluid was reflected at the skin and returned to the surface of the fleece along a well defined tract of wool immediately surrounding the path of penetration of the jet. Thus, if a series of nozzles were held stationary above a sheep restrained from moving in a device and considerable volumes of dyed fluid pumped through these nozzles, the result was a series of small discrete and approximately circular areas of wetted wool corresponding to the nozzles and these areas were surrounded by dry wool.

The number of nozzles served efficiently by any pump is limited by its output; in the case of the pump used approximately 70 nozzles of approximately 0.050 inch orifice were the maximum number which could be used before loss in pressure was observed, so that all types of sheep could not be adequately jetted by stationary nozzles and so means were devised of moving the nozzles back and forth across the fleece in such a manner that the points of penetration of the jets were joined and formed a continuous line. In this way it was found that a sheep could be jetted on the crutch area with 10 to 16 nozzles and on the body with approximately 14 nozzles.

Observations with coloured solutions showed that if the fleece was soaked along the mid dorsal line the fluid tended to move around the body of the sheep on the surface of the skin until the wool pointed towards the ground and at this point the fluid then tended to flow along the wool staple and to drip off the dependent portions of the fleece. If the volume of the fluid was increased to approximately one gallon for an average sized sheep and if surface active agents or "wetters" were added, it was observed that considerable areas of the skin of the sheep could be covered by jetting fluids, but tests with other types of apparatus, including one device with 150 nozzles and powered by a one inch pump driven by a 5 h.p. engine, showed that complete cover of the entire skin area of all sheep could not be achieved by a simple apparatus if the jetting technique was used for such a purpose. This was achieved by Fitzpatrick (1959) unpublished, but the apparatus was considered to be of a nature unsuitable for general use.

Even though complete cover of the entire skin area of the sheep was not achieved, it was thought that the design of the apparatus was worthy of consideration both for the control of blowfly strike and for the control of parasites such as lice, keds or itch mite. In the case of treatment of sheep with cutaneous myiasis it was thought that the technique would be of value as it was observed that the flow of wash over the sheep, described above, tended to follow the natural contours of the body, particularly in the areas behind the shoulder and in front of the loins, which are both a common site of "body strike".

With the information obtained from these trials the device described in Appendix A (iii) and (iv) was constructed and made available commercially. It is described in detail in the Appendix and so will be described here briefly as a box which holds sheep whilst they are being jetted by a series of nozzles which can be selected at will to jet the various areas of the sheep's fleece.

Having studied the technique of jetting and its application to evolve a device the jetting techniques was then studied to determine its efficiency as a means of controlling the various ectoparasites of sheep.

TRIALS WITH THE JETTING TECHNIQUE TO CONTROL ECTOPARASITES OF SHEEP:

Unless specifically described, the technique of jetting in the following experimental work was done with the device described in the Appendix A (iii) or (iv).

Field Trial No. 7:

Hand jetting to control lice. Sheep treated in 3 months wool with dieldrin or diazinon. Sinclair and Scrivener (1956) unpublished.

Summary:

32 lice infested Corriedale lambs up to 3 months of age were each jetted along the back with 0.13 gallons of 0.02% diazinon and 30 similar lambs were jetted with 0.1 gallons of 0.02% dieldrin. The device used was a commercially available hand jetter. At two inspections within two weeks of treatment, although numerous dead lice were observed occasional live lice could be found in both groups..

Material and Methods:

Jetting Device: A commercially available hand jetter, driven by a piston type of pump and delivering wash at 100 psi through three nozzles of approximately 0.060 inch orifice.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a approximate concentration of 0.02%

Dieldrin: A 20% concentrated emulsion, available commercially, was diluted to an approximate concentration of 0.02%.

Jetting Technique: The lambs were jetted with approximately 0.1 gallons of fluid each in a line along the back from the head to the tail. The lambs were held in a race whilst being jetted and each lamb was identified with a coloured brand according to the insecticide used.

Results:

Lambs were inspected at one week and two weeks after treatment and on each occasion, although numerous dead lice were observed, it was always possible to find live lice on some of the lambs in each group. After this last inspection the entire flock was shorn and surface sprayed with dieldrin or diazinon and the infestation of lice was eradicated from the flock.

Pilot Test No. 5:

Jetting to control lice. Sheep jetted in the device with dieldrin when off shears or carrying 5 months wool. Scott and Sinclair (1959):

Summary:

Lice infested Merino sheep, either off shears or with 5 months growth of wool were jetted with approximately half a gallon of 0.025% dieldrin. Within 6 weeks of treatment the sheep jetted off shears were free of lice and remained free during a further 4 weeks of observation. Although the numbers of live lice were considerably reduced in the sheep with 5 months wool at the time of jetting, live lice could be observed in these sheep throughout the trial.

Materials and Methods:

Jetting Device: The patented device described in Appendix A(iii).

Dieldrin: A 24% concentrated emulsion, available commercially, was diluted to an approximate strength of 0.025%.

Jetting Technique: Sheep were held in the device for approximately four seconds, in which time an approximate half gallon of wash was delivered on to the back and crutch areas of the sheep.

Results:

Sheep were inspected thoroughly over most parts of the body for at least ten minutes on each occasion. The results of these inspections are set out in the following table

Results of jetting lice infested sheep with dieldrin:

Wool length:	Concentration of dieldrin:	Infestation at treatment:	No. of sheep in group:	Results of examination after treatment No. of sheep infested at - 4 days	2 weeks	3 wks.	4 wks.	6 wks.	8 wks.	10 wks
Off shears	0.025% emulsion	Heavy	6	4	3	2	2	0	0	0
		Light	3	0	0	0	1	0	0	0
								5 weeks	7 wks.	10 wks.
Five months wool	0.025% emulsion	Heavy	7	7		6	6	5		3 x

x One sheep missed inspection.

The results were considered interesting, because lice could be eradicated from sheep treated off shears, even though the insecticide could not cover all areas of the skin. It was also of interest to note that although the jetting fluid moves around the sheep within minutes of jetting, it was six weeks before eradication took place.

Pilot Test No. 6:

Jetting to control lice. Sheep jetted in the device with dieldrin when carrying various lengths of wool growth. Scott and Sinclair (1958) unpublished.

Summary:

Lice infested Merino or Crossbred sheep of mixed ages and sexes, carrying fleeces of up to 6 months growth, were jetted with approximately one gallon of dieldrin at concentrations of either 0.0125% or 0.025%. Within 9 weeks of treatment lice infestations were eradicated in sheep jetted off shears, or with one month's growth. In sheep with longer wool the infestation was not eradicated until 11 weeks after treatment.

Materials and Methods:

Jetting Device: The device described in Appendix A(iv) was used to jet sheep along the back and on the crutch area. This device carried 66 nozzles and in ten seconds two gallons of wash were delivered. of which volume approximately one gallon remained on the sheep, irrespective of the wool length and one gallon was collected as run-off.

Dieldrin A 24% concentrated emulsion, available commercially, was diluted to concentrations of approximately 0.0125% and 0.025%.

Results:

Sheep were inspected in the usual manner and the results of these inspections are set out in the table below.

Results of jetting lice infested sheep with dieldrin:

Concentration of dieldrin:	Wool length at treatment:	No. sheep infested/No. sheep examined at: 3 weeks	6 weeks	9 weeks	11 weeks
0 0125%	Off shears	0/8	0/8	0/3	0/3
0.0125%	One month	1/8	1/8	0/7	0/7
0.0125%	4 months plus	1/7	1/6	1/6	0/5
0.025%	" " "	3/7	1/6	1/6	0/5

The changes in numbers of sheep were due to deaths amongst the older sheep and were not considered to be due to the effects of the treatment. It is of interest to observe that with this method of treatment the principal limitation appears to be the length of wool rather than the concentration of insecticide used.

It was thought that the jetting technique transported the insecticide to the area of effect so that the property of diffusion was of little assistance

Pilot Test No 7:

Jetting to control lice. Sheep jetted in the device with diazinon when carrying 6 months growth of wool. Sinclair (1958) unpublished.

Summary:

Two lice infested Merino sheep carrying 6 months growth of fleece were jetted with approximately one gallon of 0 0125% diazinon Complete eradication of the infestations had not occurred within 9 weeks of treatment.

Materials and Methods:

Jetting Device: The mechanical device described in Appendix A (iv) was used to jet sheep along the back and on the crutch area with approximately half a gallon of wash.

Diazinon A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.0125%

Results:

Sheep were inspected in the usual manner and when the trial was terminated 9 weeks after treatment live lice could be found on one of the two sheep.

Field Trial No. 8:

Jetting to control lice. Sheep jetted in the device with dieldrin when carrying 2 months wool. Sinclair (1958) unpublished.

Summary:

On a property in central N.S.W. lice infested Merino ewes, carrying 2 months fleece, together with Border Leicester rams in 8 months fleece were jetted with one gallon of dieldrin 0.025%. Means were devised to collect the run-off wash for further use. At inspections up to 8 weeks after treatment infestations of lice had been eradicated from all but two of eight identified infested ewes.

Materials and Methods:

Jetting Device: The device described in Appendix A (iv) was used to jet the sheep along the back, on the neck and on the crutch areas with approximately one gallon of wash. To save the considerable volume of run-off wash a system of collection and continuous replenishment, described later in this section of the thesis, was used on some sheep to determine if this system of wash management could affect the efficiency of the treatment.

Dieldrin: A 24% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.025%.

Results:

The sheep were inspected in the usual manner and the results of these inspections are set out in the table following:

Results of jetting lice infested sheep with dieldrin:

Ear Tag No:	Infestation before treatment	Results of inspection at: 5 weeks	8 weeks
Sheep showered without replenishment of run-off wash:			
535	Moderate	Nil	Live lice
536	Light	Live lice	nil
Sheep showered with replenishment of run-off wash:			
537	Moderate	Live lice	Nil
538	Heavy	Nil	"
539	"	Live lice	"
540	"	" "	Live lice
541	Light	" "	Nil
542	Moderate	Nil	"

This trial had to be terminated, as the ewes had commenced to lamb and could not be conveniently inspected. The few remaining lice did not appear to be healthy and it was anticipated the infestations would die out. It was not thought that the use of wash replenishment technique was less efficient than the use of fresh wash.

Pilot Test No. 8:

Jetting to control lice. Sheep jetted in the device with Arsenic and a wetting agent. Sinclair and White (1958) unpublished.

Summary:

A lice infested Merino sheep carrying 8 months growth of wool was jetted with 0.2% Arsenical solution and a wetting agent. Live Lice could not be found within two weeks of treatment and could not be found for a further 4 weeks of examination.

Materials and Methods:

Jetting Device: The device described in Appendix A (iv) was used to jet the sheep along the back and on the crutch area with approximately one gallon of wash.

Arsenic: A 60% concentrated Arsenical solution, available commercially, was diluted to a concentration of approximately 0.2%.

Wetter: A surface active agent, Neofat 8, was used to increase the spread of the material within the fleece

Results:

The sheep was inspected in the usual manner and live lice could not be found from 2 weeks up to 6 weeks after treatment when the test was concluded.

Field Trial No. 9:

Jetting to control lice. Sheep jetted in the device with diazinon and a wetting agent when carrying 11 months wool. Sinclair and Cavey (1958) unpublished.

Summary:

On a property on the central tablelands of N.S.W. 198 Comeback wethers heavily infested with lice and carrying 11 months growth of fleece were jetted with approximately one gallon of 0.02% diazinon and a wetting agent, using the wash replenishment technique. Inspections up to 7 weeks after treatment revealed live lice on some identified infested sheep.

Materials and Methods:

Jetting Device: The device described in Appendix A (iv) was used to jet sheep.along the back, on the neck and on the crutch areas with approximately one gallon of wash, and the technique of continuous replenishment of the run-off wash was used.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.02%.

Wetter: A surface active agent, Geigy No. WAC 2/29/2, was used to increase the spread of the material within the fleece.

Results:

Sheep were inspected in the usual manner and up to 7 weeks after treatment live lice could be found on identified infested sheep. It appeared that the addition of wetting agent did not increase the speed of eradication of the infestation.

Field Trial No. 10:

Jetting to control lice. Sheep hand jetted with diazinon or Arsenic and wetters when carrying 5 months wool. Sinclair and Cavey (1959) unpublished.

Summary:

Lice infested Merino ewes and lambs, the ewes carrying 5 months growth of fleece, were hand jetted with approximately half a gallon of wash containing either 0.02% diazinon or 0.2% Arsenic and a wetting agent. Inspections up to 4 weeks after treatment revealed live lice on sheep from either group.

Materials and Methods:

Jetting Device: A hand jetter working at a pressure of 60 psi and delivering wash through three nozzles of approximately 0.060 inch orifice was used to deliver approximately half a gallon of wash along the backs of the sheep from head to tail.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.02%.

Arsenic: A 60% concentrated solution, available commercially, was diluted to a concentration of approximately 0.2%.

Wetter: A surface active agent, NW (Geigy), was used at a concentration of 0.02% to increase the spread of the material within the fleece.

Results:

Sheep were inspected in the usual manner at two weeks and four weeks after treatment and although there were numerous dead lice seen, live lice could be found on sheep in both groups at eigher inspection.

Field Trial No. 11:

Jetting to control keds. Sheep jetted in the device with dieldrin when carrying 6 months wool. Sinclair (1959) unpublished.

Summary:

70 Dorset Horn ewes and lambs heavily infested with keds and carrying up to 6 months growth of fleece were jetted in the device with approximately half a gallon of 0.025% dieldrin along the back and on the crutch. At inspection 6 weeks after treatment live keds could not be found on a random sample of sheep.

Materials and Methods:

Jetting Device: The device described in Appendix A(iv) was used to jet the sheep along the back only with approximately half a gallon of wash.

Dieldrin: A 24% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.025%.

Results:

A random sample of at least 15 sheep were inspected 6 weeks after treatment and live keds could not be found on any sheep inspected.

Field Trial No. 12:

Jetting to control itch mite. Sheep jetted in the device with Malathion or Lime Sulphur off shears. Sinclair (1958) unpublished. *

Summary:

On a property in southern Queensland adult Merino wethers, known to be infested with itch mite, were jetted in the device within a week of shearing with approximately 1½ gallons of 0.2% Malathion or the same quantity of 1% Lime Sulphur. The sheep were examined for 12 months after treatment and of three sheep treated with Malathion one sheep lost its infestation, but this could have been self-limiting. Of four sheep jetted with Lime Sulphur, two sheep lost their infestations, one of which appeared to be due to the treatment and one could have been self-limiting.

Materials and Methods:

Jetting Device: The device described in Appendix A (iv) was used to jet sheep along the back only with approximately 1½ gallons of wash. Fresh wash was used without any attempt at continuous replenishment of the run-off wash

Malathion: A 53% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.2%

Lime Sulphur: A 20% concentrated solution, available commercially, was diluted to a concentration of approximately 1% polysulphide sulphur.

Results:

Examinations by the normal skin scraping technique were conducted over a period of twelve months after treatment. Of the four sheep jetted with Lime Sulphur two did not show mites for a period of twelve months and of the three treated with Malathion one did not show mites during the same period. The results must be interpreted in the light of studies by

* Sinclair, A.N. (1961) - Aust. vet. J. 36: 211.

Sinclair (1958) and unpublished observations by the same author, and by Moule (1957), who both observed that mites tend to be absent from the sheep if skin scrapings are taken as a diagnosis, during the summer months in Queensland. The sheep were all treated during midsummer and so no mites could be found at this time. However, using the previous history of infestation, it was deduced that in certain cases it could not be demonstrated whether the loss of infestation was due to self-limiting infestations of mites or to the treatment. In the case of a sheep jetted with Lime Sulphur it was deduced that the treatment had removed the infestation. This efficiency of jetting with Lime Sulphur on infestations of itch mite has also been observed by Murch (private communication).

Field Trial No. 13:

Jetting to control itch mite. Sheep jetted in the device with Arsenic or Lime Sulphur and wetters one month after shearing. Scott and Sinclair (1958) unpublished. *

Summary:

On a property in central Victoria 118 Merino ewes and their Crossbred lambs, containing identified sheep known to be infested with itch mite, were jetted with approximately one gallon of 0.2% Arsenic and a wetter, and 600 similar sheep were jetted with one gallon of 1% Lime Sulphur. Continuous replenishment of the wash was used in all cases. At the time of treatment the ewes were carrying 3 weeks growth of fleece and the unshorn lambs were up to 3 months of age. Within 6 weeks of treatment examination revealed live mites on the sheep.

Materials and Methods:

Jetting Device: The device described in Appendix A (iv) was used to jet sheep along the back, on the neck and crutch areas with approximately one gallon of wash. The technique of continuous replenishment of the run-off wash was used.

Arsenic: A 60% concentrated solution, available commercially, was diluted to a concentration of approximately 0.2%.

Lime Sulphur: A 20% concentrated solution, available commercially, was diluted to a concentration of approximately 1.0% polysulphide sulphur.

Wetter: A wetting agent, Lissapol N (ICIANZ) was used at the rate of 3 fluid ounces per 50 gallons of wash to increase the spread of the material within the fleece.

* Sinclair, A.N. (1961) - Aust. vet. J. 36: 211.

Results:

Sheep were examined by Scott in the usual manner employing the skin scraping technique 6 weeks after treatment. Live mites were found on the identified sheep and Scott judged from the appearance and numbers of mites that the treatments had had little effect.

Field Trial No. 14:

Jetting to control blowfly larvae. Sheep jetted in the device with dieldrin when carrying 5 months wool. Sinclair (1957) unpublished.

Summary:

In central N.S.W. 12 Merino sheep infested with blowfly larvae over various areas of the body and carrying 5 months growth of fleece were jetted in the device with approximately one gallon of 0.05% dieldrin. Inspection on the following day revealed that 11 of the 12 sheep were rid of living larvae.

Materials and Methods:

Jetting Device: The device described in Appendix A (iii) was used to deliver approximately one gallon of wash along the midline of the back and on the crutch area.

Dieldrin: A 24% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0.05%.

Results:

Sheep were examined on the day following treatment and it was noted that in 11 of the 12 sheep the blowfly-struck areas were completely free of living larvae, even though some of these were considerable in extent, involving the body at the shoulders and loins. On one sheep which had an extensive crutch strike, living larvae were still present at the edge of the struck area.

Field Trial No. 15:

Jetting to control blowfly larvae. Sheep jetted in the device with diazinon when carrying 6 months wool. Sinclair (1959) unpublished.

Summary:

On the southern tablehands of N. S. W. 14 Merino wethers carrying 6 months growth of fleece and with extensive body strikes of numerous larvae were jetted in the device with approximately one gallon of 0. 05% diazinon. At inspection two days after treatment one live though moribund, larva was found on two sheep, but at inspection 6 days after treatment no live larvae could be found on any sheep.

Materials and Methods:

Jetting Device: The device described in Appendix A (iii) was used to deliver approximately one gallon of wash on to the body and crutch areas.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a concentration of approximately 0 05%

Results:

The sheep were inspected two days after treatment. On all sheep numerous dead larvae were seen and on two sheep one moribund though live larva was seen. On inspection 6 days after treatment neither live nor dead larvae could be recognised on any sheep.

Field Trial No. 16:

Jetting to prevent blowfly strike. Sheep jetted in the device with dieldrin, diazinon or diazinon and DDT with or without wetters and in various lengths of wool. Sinclair and Gibson (1959), Sinclair and Gibson (1959) unpublished and Sinclair and Cavey (1959) unpublished. *

Summary:

A series of three trials on the prevention of blowfly strike were conducted in various areas of N. S. W. As a result of these trials it appeared that the insecticide and its formulation had a considerable effect on the efficiency of the treatment. It was noted that the area of the sheep jetted could affect the efficiency of the prevention and that jetting appeared to be a more efficient method of prevention of blowfly-strike when compared with surface spraying.

* Gibson, A. J. F., Sinclair, A. N. and Cavey, W. A (1960) - Aust. vet. J 36: 372.

Materials and Methods:

Jetting Device: The device described in Appendix A (iii) was used to jet the sheep on either body and crutch, or on crutch area alone.

Surface Spray: The device described in Appendix A (ii) was used.

Dieldrin: A 20% concentrated emulsion, available commercially, was diluted to concentrations of 0.025% and 0.05%.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to a concentration of 0.02%.

DDT: A 20% emulsion, available commercially, was diluted to a concentration of 0.16%.

Wetter: A wetter, Geigy NW 0.02%, was used to aid the spread of the material within the fleece.

Results:

The detailed results of three separate field trials are thought to be too lengthy to present in this report. One set of results comparing surface spraying and jetting has been presented above in Field Trial No. 6 and further results of this trial were presented by Sinclair and Gibson (1959). In the unpublished data of Sinclair and Gibson (1959), it was seen that the addition of DDT to diazinon appeared to give a slight advantage over diazinon, but the economic advantages of this were doubted. These authors also found that blowflies had become resistant to dieldrin in the area where the trial was conducted. They found also that jetting on the crutch gave slightly inferior results to jetting on crutch and body in adult ewes, but the economic gain by the additional jetting was questioned. Jetting lambs on the body and crutch was of advantage, provided the insecticide was efficient, but an inefficient insecticide, such as dieldrin, used where resistant flies exist, could actually cause harm. Sinclair and Cavey found that the use of a wetting agent appeared to aid the action of diazinon in the prevention of flystrike.

It is not easy to determine the specific amount of protection obtained by jetting against the blowfly, as untreated controls are not usually kept on a property. Further to this, the incidence of fly and the type of chemical used influence the results considerably. As this thesis is concerned with methods of application rather than the inter-relationship of various chemicals and the environment, it is thought that these results should only be described briefly for the sake of clarity in the presentation and discussion of the technique of jetting.

BEHAVIOUR OF CHEMICAL EMULSIONS IN THE JETTING DEVICE:

Introduction:

It was observed above that when emulsions were passed through the surface sprays in the device there was a small but consistent trend of loss in concentration of insecticide in the wash if this was examined in the supply tank and compared with that collected as run-off. Further, though unexplained it was thought that this loss of strength was not the exhaustion due to passing an emulsion through the fleece, Graham (1959). Similarly the run-off wash collected after jetting had not passed through the fleece and it was thought that this should be investigated to see if a similar loss of concentration could be observed and further to see if means could be devised whereby the run-off wash from jetting could be saved and used again.

Materials and Methods:

Jetting Device: The jetting device was used as described in Appendix A (iii) and (iv). Samples of wash were collected at various points during jetting experiments and submitted to analysis. As a result of the findings of various trials a means of using this run-off wash was devised and was called "continuous replenishment of the run-off wash".

Continuous Replenishment of the run-off wash: Run-off wash was directed by means of lengths of guttering past several simple gauze strainers into a small sump or container in the ground. Into this container a fresh supply of wash was allowed to flow at a rate corresponding to the amount removed by the sheep. From this sump the suction hose of the pump drew wash through two strainers, a large strainer and a small strainer, and supplied the jetting device.

Chemical Analyses: The writer was indebted to Geigy (Australasia) Pty. Ltd. for analyses of diazinon and to The Imperial Chemical Industries of Australia and New Zealand Pty. Ltd. for the analyses of dieldrin.

Results:

Samples collected during a field trial were examined and the analyses presented as follows:

From supply tank	0.0155% diazinon
From nozzles	0.0150% "
From waste tray	0.0138% "

Attempts were made to ascertain the effects of fine filters on the run-off wash and a series of analyses showed the results as follows:

From supply tank	0.032% dieldrin
From waste tray (before filtration)	0.0316% "
From waste tray (after filtration)	0.0257% "

These results showed that there was a slight loss in concentration of insecticide in the jetting system and also the method of filtration of debris from the run-off wash could affect the concentration of the insecticide if the wash was to be used again.

As described in Appendix A (iv) the waste of wash can be considerable and so means of using this wash were considered to be necessary if the method was to be used economically.

The run-off wash had to be cleaned of its debris before further use if clogging of the nozzles was to be prevented. Further, it was noted that if a fine strainer was used on the suction hose of the pump this soon became clogged with silt and debris, as there was a considerable suction pressure on each unit area of the strainer. Filtration could not be carried to extremes because the results presented above showed that the filters themselves could remove appreciable amounts of insecticide. The method of removal of debris from the run-off wash would, therefore, be a compromise between complete removal and that necessary to leave most of the debris on the strainers. Acting on a suggestion by Brookes (private communication) a large strainer of fine gauze was used to enclose a small strainer of fine gauze on the suction hose of the pump. By this means most of the debris was left on the large strainer, but did not impede the action of the pump. As Graham (1959) had demonstrated theoretically that a continuous replenishment of the sump by fresh wash should keep the level of insecticide above the minimum effective level, this system was incorporated as described above and tests of the method were made by Sinclair, Cavey and Worrad (1958) unpublished.

Results of analyses of wash samples taken by these workers during two field trials using the jetting device and the system of continuous replenishment of the dip wash are shown as follows:

(a) Results of jetting sheep with continuous replenishment of a dieldrin wash:

From supply tank	0.020% dieldrin
From nozzles	0.027% "
From drain	0.027% "
From sump	0.021% "

(b) Results of jetting sheep with continuous replenishment of a diazinon wash:

From supply tank	0.018% diazinon
From nozzles	0.019% "
From drain	0.015% "
From sump	0.021% "

Until chemists have made detailed studies of the method of continuous replenishment of a dip wash the full implication of the various changes of concentration of insecticide within the system cannot be explained. It was thought sufficient for recommendation of the method that the concentration of insecticide in the sump was similar to that in the supply tank in both cases after the jetting of many sheep.

DISCUSSION OF THE JETTING TECHNIQUE:

The efficiency of the jetting technique appeared to be governed by a number of factors - those associated with the device and those associated with the use of the device.

Factors associated with the device were firstly, the formation of the jet of fluid and the impact of this jet upon the fleece. In the studies reported it was found that the desired effect of penetration of the fleece could be achieved with comparatively low pressure (such as 15 psi) provided the jet of fluid was restricted to a small area of impact and provided the fluid remained in a continuous stream and was not broken up into individual droplets and if it was desired to increase the area of wetting then the point of impact had to be moved. By incorporating these principles in the design a device was evolved which could efficiently jet sheep in a few seconds by making use of pumps which deliver large volumes of wash at pressure previously considered to be too low for jetting.

The efficiency of use of the device was governed by many factors, some of which were beyond the scope of the designer of machinery and which depended upon the insect parasite and the effect of certain chemicals on the parasite. Much of the work was done on infestations of lice and it appeared that jetting a sheep along the restricted area of the mid dorsal line from head to tail could eradicate or at least reduce the numbers of lice on an infested sheep. The reasons for the efficiency of the jetting technique were discussed by Scott and Sinclair (1959) and were thought to be due to the habit of the majority of lice living on the upper third of the sheep, Scott (1952) and also to the percolation of the jetting fluid on the skin round the body of the sheep from the site of application. Other explanations could not be found in the literature, but a commonly held theory amongst graziers and others is that lice pass frequently around the body of the sheep and so come into contact with the insecticide treated area of the fleece. The writer cannot subscribe to this theory and considers that despite its popularity it does not appear to be based on any known observations. Knapp, Farinacci and Herbert (1956) employed radio-active labels to follow the movements of cattle ticks on the body of the host, but as far as is known this has not been done with the louse of sheep. Further observations by the writer on lice infestations of sheep incline one to agree with the view of Scott (loc cit), who stated that lice tend to remain in colonies.

It was therefore considered that the reason for the efficiency of the technique of body jetting to control lice infestations was due to the movement of fluid around the skin of the sheep from the site of application and that this movement was presumed to be caused by the action of gravity on the fluid accumulated in the fleece at the site of jetting. Factors affecting this flow should therefore be factors affecting the efficiency and generally this was so. The major factor affecting the efficiency of body jetting sheep for the control of lice appeared to be the length of the wool at the time of treatment and in general the results showed that when the fleece was longer than 6 months growth the efficiency of the technique was not reliable. An unexpected result was the time taken for the effect of the treatment to be observed and despite the numerous dead lice observed soon after treatment up to 3 months elapsed before complete eradication was observed. Also, in the case of sheep jetted off shears, with practically no impediment to the flow of wash around the sheep, it was 6 weeks before eradication was observed

When coloured jetting washes were used it was noted that the spread of the materialwas irregular, particularly in long fleeces and not all of the skin was covered by the solution, even if wetters were used. These latter could increase the area covered, Cavey and Snelson (1959) unpublished, but at no time with the devices used could it be said that the body jetting technique resulted in complete cover of all areas of the sheep's skin In such a case it might be expected that lice would survive in these insecticide free areas and perhaps at a later date, due to their own small movements, or due to diffusion of the insecticide. the lice eventually were reached by the insecticide and so eradicated. In longer fleeces it was possible that these uncovered areas were more extensive than in sheep jetted in short wool and so it was possible that some lice were never reached by the insecticide

The concentration of the insecticide in the above experiments did not appear to be of importance and so it was thought that the efficiency of the technique of body jetting depended to a considerable degree upon the mechanical transport of the insecticide within the fleece.

It has been observed by Cavey (1958) unpublished, that with exhausting insecticides such as diazinon, the amount of chemical in the wool near the site of deposit was higher than that in the areas of wool reached by percolating fluid and so it would be expected that a non-exhausting insecticide such as Arsenic would be more efficient in eradicating lice by the body jetting technique. This was not observed to occur constantly in the trials conducted and so it did not appear from the work reported that a reliable method of eradicating infestations of lice from sheep with more than 6 months growth of fleece could be demonstrated.

This work was considered to be of importance, as it has been advocated by Sinclair (1958a) and others that jetting could be used as a means of reducing the damage due to lice infestation in long-woolled sheep, but could not be relied upon as a method of eradication. The cost of completely immersing long-woolled sheep in insecticidal dips is often too great to be worth consideration, so that a means of treating such sheep is worth finding. Unfortunately the results of the tests reported do not give any confidence in the jetting method as a means of eradicating such lice infestations and also, as jetting is not as convenient as surface spraying or showering for large numbers of sheep, it does not appear that it will be considered as a useful method for the eradication of lice in short-woolled sheep.

When body jetting was used for the control of keds, it appeared to be efficient and resulted in eradication of the infestation. This has also been observed in the field on more than one occasion, Smith (private communication) and it is thought that perhaps the ked is more mobile on the sheep than the louse and so has a better chance of coming into contact with the insecticide.

The efficiency of the jetting technique against itch mite does not appear to be great. The situation is somewhat complicated by our lack of knowledge of the bionomics of this parasite, although it was observed by Sinclair (1959b) that it is possible that this parasite can be more effectively removed during the summer period than during the winter when it appears to be more vigorous. Body jetting, therefore, could be recommended only in mid-summer on sheep after shearing and at present Lime Sulphur is the only insecticide known to be effective in its removal Graham (1943, 1959).

Concerning the blowfly, the jetting technique appeared to be a successful method of eradicating infestations of larvae on struck sheep. As a means of prevention of strike the efficiency appeared to be governed more by the insecticide, its formulation and perhaps concentration, than by the technique per se.

The convenience of the jetting technique again depended to a considerable degree upon the type of parasite to be controlled. For example, its convenience as a means of eradicating lice or keds appeared to be limited to the use in sheep whose fleeces were too long to consider dusting, surface spraying, or using total immersion methods. The convenience, however, was limited in the case of lice, even in long woolled sheep, because of the lack of reliable efficiency, so that it could be considered convenient only as an emergency measure. With the device described sheep were jetted at rates of 350 to 400 per hour in most instances and records of over 500 per hour have been obtained by the author and by others. The operator need not be wetted by the jetting fluids and so he could rapidly and comfortably jet sheep. It appeared that the most common use of the method would be in the treatment and control of blowfly strike and for this purpose the device described was of convenience, provided the operator could obtain some assistance to keep the sheep moving into the machine. It was not convenient if it had to be used by one man working alone.

The economy of the jetting technique, particularly in the device, depended to a considerable degree upon the cost of the insecticide and can only be estimated as a cost of jetting per head. Diazinon is now the material of choice for the treatment of blowfly and at a price of £12 per gallon of 20% emulsion, sheep can be jetted with half a gallon of wash of 0.02% concentration at a cost of approximately 120 shillings per thousand sheep, which is more expensive than the methods of surface spraying or dusting shown above.

SUMMARY:

Studies of the jetting technique showed that a nozzle could be designed which would deliver a jet of fluid capable of penetrating the fleece of a sheep with pressure as low as 15 psi, provided the nozzle was held within approximately 6 inches of the fleece. It was also demonstrated that if a series of nozzles were moved over the fleece, particularly along the mid dorsal line, the wool was soaked to the skin along the line of penetration of the jets and if sufficient fluid was applied to the mid dorsal line of a standing sheep this fluid would percolate through the fleece at the level of the skin and so would cover considerable areas of the skin of the sheep with insecticide.

A device was designed and constructed employing the above principles and this device was shown to be capable of jetting large flocks of sheep efficiently and conveniently at rates of 400 sheep per hour or better.

The jetting techqniue, particularly as applied in the device, was studied in its application to the control of lice, keds, itch mite and blowfly. In the case of lice the efficiency was limited to a considerable extent by the length of the fleece at the time of application and when used on sheep with more than 6 months growth of fleece eradication of infestations of lice was not reliable, despite the aid of wetting agents to spread the insecticide within the fleece.

It was concluded that the technique of body jetting for the control of lice would be limited to the emergency treatment of infestations in long woolled sheep as a means of reducing the wool damage, though not as a means of eradication. Body jetting appeared to be an efficient method of eradicating infestations of keds, even in long-woolled sheep, but was not a reliable method of eradicating infestations of itch mite, particularly if used in winter time.

The main use for jetting appeared to be for the prevention or treatment of blowfly-strike and provided the insecticide used was efficient the use of the device appeared to be an efficient and convenient method of treating sheep where some assistance was available. The method of jetting was not as economical as surface spraying or dusting when the cost of insecticide was calculated.

PART FOUR. SHOWERING

DEFINITION:

Showering is the process of subjecting sheep to a large volume of insecticidal wash under a comparatively low pressure so that the fleece is eventually soaked to the skin and thus retains a proportion of the wash to which it is subjected.

INTRODUCTION:

The first patent for a shower in Australia was issued to Seabury (1905), but apart from a few constructed to the patent of Wass (1929) and some of original design and construction, showers were not in common use until the decade commencing in 1940.

Findlay (1940) and Higgins (1940) and (1951) took out patents which had considerable influence on the practice of showering by introducing improvements and by stimulating other manufacturers to improve still further on the original designs, so that at the present time it is estimated that there are approximately 15,000 showers in Australia and New Zealand. Despite variety in design, most showers essentially consist of:

(a) An enclosure to hold sheep during treatment.
(b) Reservoirs to hold wash before being pumped over the sheep and to collect the run-off wash after it has passed over the sheep.
(c) A pumping system to circulate wash under pressure to the various nozzles which apply the wash to the sheep.

Showers were first used by flock managers who were dissatisfied with the method of immersing sheep in a dipping bath, known as "plunge dipping", because the latter method has exhibited many disadvantages. In the first place plunge dipping required a number of men or assistants to carry out this arduous task. Sheep become extremely wary of the dip and often have to be forced to the dip and may even have to be carried. The resulting struggle between operators and sheep can cause considerable bodily damage to the flock and most graziers find it unwise to plunge dip sheep which are weak, or ewes heavy in lamb. Others have observed that the ordeal to which sheep are subjected leaves them reluctant to graze for some time after plunge dipping and many fat lamb growers consider that the loss in condition of lambs is too great to even consider dipping them. Plunge dips are not usually cleaned out every day during dipping, because of the loss of dipping fluid involved and because of the amount of work necessary, so that infection such as post dipping lameness due to *Erysipelothrix* organisms, McLean (1948) and Whitten, Harbour and Allan (1948), can occur unless specific antiseptics are used and also general dipping infections particularly of freshly shorn sheep, are more likely to occur with plunge dips than with showers. Hart (private communication).

To overcome these disadvantages of the plunge dipping method the shower was evolved and in its earlier stages particularly was subject to much criticism generally by those who had not used it and noted the advantages. An early fault was the clogging of the nozzles by the inevitable debris, droppings, etc. which fall into the run-off wash. This problem was solved to a considerable extent by Hutchings (unpublished), who invented a nozzle with an aperture large enough to pass most of the debris and larger than the mesh of the gauze in the straining system. Most of the criticism has been directed towards the wetting of the sheep and in doing so the critics usually assume that the method of plunge dipping ensures perfect wetting, although the observations of Hill (1946b) and Murray (1955) lead one to question this assumption. Generally, showers were found to be more efficient for the control of lice than for keds in the early stages, but this was thought to be limited by the insecticide rather than the method of application, Hammond (unpublished) and the recent use of substances such as dieldrin or aldrin in showers with the successful eradication of keds shows that such an assumption was justified.

Published work on sheep showers is scarce. Hill (1945) showed that there could be an exhaustion of the active ingredient of a Lime Sulphur dip wash in a shower, but provided the volume of the sump was replenished frequently the method was efficient. Sinclair (1958b) showed that a Lime Sulphur wash containing 1% polysulphide sulphur mixed with dieldrin at an initial concentration of 0.0125% could eradicate concurrent infestations of both lice and itch mite, whilst showering with dieldrin at an initial concentration of 0.0125%, or diazinon at 0.02% could eradicate infestations of lice.

Davel (1958) reported the work of Bekker and Malan in South Africa, who found that the concentration of BHC in a wash was exhausted more rapidly from a shower than in a plunge dip and concluded that the plunge dip was therefore the better method. The conclusion can be questioned, because if methods can be devised to replace the exhausted chemical, then the shower would be a more efficient method of depositing chemical on the fleece from a wash of given strength The problem of exhaustion had been studied for a considerable period by other workers Addison and Furmidge (1956) studied the effect of formulation of the dip wash on the rate of exhaustion Graham (1959) studied the various methods of controlling exhaustion during dipping and Sinclair and Booth (1956) unpublished made a series of studies of the exhaustion of various formulations of aldrin, dieldrin and diazinon in sheep showers.

Until recently the majority of showers used as a reservoir a large pit usually of 500 gallons capacity from which the wash was drawn by the pump and into which the run-off wash was directed for further use. If an exhausting dip formulation was used it can be seen that unless specific precautions were taken the concentration of insecticide in the dipping fluid would continuously decrease until the sheep were being showered with a wash which contained practically no insecticide. The methods of preventing this were several. Addison and Furmidge (loc cit) showed that it might be possible to decrease the exhaustion rate by varying the formulation, whilst Graham (loc cit) defined two methods of adding insecticide during the dipping process. "Reinforcement" is the addition of amounts of concentrated insecticide at regular intervals, thus providing a fluctuation in concentration of insecticide, but whose lowest levels do not fall below a certain strength "Replenishment" is the addition of large volumes of freshly mixed wash at regular intervals and may be used in conjunction with the reinforcement technique For example, a shower sump might be reinforced with concentrated chemical at the 400 gallon and the 300 gallon levels, but then replenished with 300 gallons of fresh wash when the 200 gallon level is reached.

The methods of replenishment or reinforcement are in common use with exhausting insecticides, but suffer the disadvantage that they are subject to error in use Showering is a busy time and the operator may become distracted and forget to make regular additions of insecticide. Also, because the sheep treated immediately before addition of insecticide must receive an adequate deposit of chemical it stands to reason that all other sheep receive an excessive deposit

Theoretical considerations by Graham (loc cit) led to the deduction that a system of continuous replenishment of the run-off wash might eliminate most of the disadvantages of the systems of chemical use in showers and as the results of tests of such a method in the jetting device described above were encouraging, field tests with showers were devised.

Field Trial No 17:

Showering with continuous replenishment of wash to study the behaviour of chemicals in the wash. Graham, Sinclair and Cavey (1959).

Summary:

Two field trials showed that showering sheep using a system of continuous replenishment of the run-off wash resulted in an even deposit of insecticide per sheep When the replenishment wash was at a concentration of 0 023% diazinon the mean deposit per sheep was 0 67g and the sump wash was stable at 0 012%. When the replenishment wash at 0 037% the mean deposit per sheep was 1 15g and the sump wash was stable at a mean concentration of 0 013%

Materials and Methods:

Location of Trials: On the Monaro Tablelands of southern N. S. W. Merino ewes one week off shears and their unshorn lambs up to 3 months of age, Merino wethers, Corriedale hoggets and Crossbred hoggets approximately 3 months off shears were showered in two types of showers available commercially.

Diazinon: A 20% concentrated emulsion, available commercially, was diluted to the strengths described below.

Showering Technique: Standard commercially available sheep showers, both Cooper Model HH and a Buzacott were used. In these showers there was a concrete sump with a capacity of 500 gallons. In the sump a level of approximately 200 gallons was marked. A large reservoir tank, holding either 550 or 659 gallons was installed beside the sump and by means of a 1½" tap the flow of fresh replenishment wash into the sump was adjusted so that the level of 200 gallons was maintained throughout showering.

During showering the sump thus contained a mixture of run-off wash from the showering pen and fresh replenishment wash from the reservoir. In all other aspects the showering was done in the usual manner. Sheep were held in the enclosure for two to three minutes and were subjected to the sprays. They were then held in a draining pen whilst the next penful of sheep were showered and the drainings from the sheep ran back into the sump.

Duplicate samples of wash were collected at intervals from the sump and from the outlet tap of the reservoir and submitted to analysis. The results of these analyses are presented below as single figures representing the mean of duplicate samples.

Trial A:

A total of 875 sheep comprising Merino wethers, Corriedale hoggets and Crossbred hoggets, shorn in August, were showered on 24th October 1958 in a diazinon wash with an average consumption of approximately 3/4 of a gallon each. The system of continuous replenishment was used.

Results of analyses of diazinon content of samples of wash collected during showering of sheep with continuous replenishment of wash:

Trial A:

Concentration of diazinon in - Sump wash %w/v:	Fresh supply wash %w/v:	No. sheep showered:	Progressive total sheep showered:
0.011		Nil	
0.012	0.024	104	104
0.011	0.024	110	214
0.012	0.021	169	383
0.011	0.023	316	699
0.014	0.023	141	840
0.013		35	875
Mean 0.012	Mean 0.023		

Trial B:

A total of 942 sheep comprising Merino ewes one week off shears and their unshorn lambs up to 3 months of age were showered on 26th November, 1958 in a diazinon wash with an average consumption of approximately half a gallon of wash each. The system of continuous replenishment was used.

Concentration of diazinon in - Sump wash %w/v:	Fresh supply wash %w/v:	No. sheep showered:	Progressive total sheep showered:
0.043		Nil	
0.022	0.035	158	158
0.015	0.044	176	334
0.013	0.041	170	504
0.014	0.037	200	704
0.012	0.036	94	798
0.012	0.033	78	876
0.014	0.035	66	942
0.013			
Mean 0.013 x	Mean 0.037		

x Mean of last six (6) samples

In the first trial sheep were showered with an average removal of three-quarters of a gallon of wash per head and in the second trial with an average removal of half a gallon per head. During showering it was a simple matter to keep the volume of wash in the sump at a constant level by adjusting the flow with a tap from a reserve supply.

In Trial A it should be noted that the sump was charged at an initial concentration of 0.011%. The replenishment concentration was 0.023%, or approximately double the mean sump concentration, which represents the most economical method for the use of the insecticide. In Trial B the concentration of both sump and replenishment wash were similar, representing the most simple method of use. In this trial (B) the sump showed a higher concentration (for about 300 sheep) until the ephemeral effect of the unnecessarily high initial charging rate was dissipated.

It might be noted that whereas in Trial A the mean sump concentration was 0.012% when continuously replenished by a supply wash of 0.023%, increasing the supply wash concentration to 0.037%, in Trial B resulted in a very small rise of sump concentration to 0.013%. Calculations, however, show that in Trial A the mean deposit of insecticide was 0.67 grams of diazinon per sheep, whereas in Trial B this was increased to 1.15 grams of diazinon per sheep.

The results of these tests have led to the design of a new type of sheep shower. Whilst the showering mechanism has been left practically unaltered, the design of the sump and wash reservoirs has been altered with considerable effects on efficiency, convenience and economy.

In place of the expensive 500 gallon concrete well, the new design incorporates a small well of approximately 100 gallons capacity and as the run-off wash returns to this small well it is continuously replenished by fresh wash flowing from a reservoir placed above the ground. The efficiency of the showering method has been improved by reducing the errors of chemical use. The concentration of insecticide cannot fall to any extent, because the small well must be continuously replenished to keep the pump working. The convenience of installation of the new design is considerable when compared with the original well in the ground and the economy of the new installation, together with the elimination of waste of chemical is considerable.

DISCUSSION OF SHOWERING TECHNIQUE:

The work presented has opened new lines of investigation worthy of further attention, as it has led to questioning of the present accepted criteria of examination of the efficiency of the showering technique, which is to consider the efficiency of dipping sheep by examining the concentration of the wash and to determine the amount of "wetting" of the fleece. From the work presented it can be seen that the deposit of insecticide per sheep can be varied considerably without much change in the concentration of the insecticide in the sump wash and Graham, et al (loc cit) considered that the deposit of insecticide per sheep was the more important criterion. If this is so, then dipping emulsions of substances such as dieldrin and diazinon could be used at much greater dilutions than those defined by law or regulations at present, which would have considerable effect on the economy of the method. Graham (private communication) has estimated that dieldrin could be used in a continuous replenishment system at an initial concentration of 0.004%, which would result in a considerable saving of insecticide cost and would be as low as 20 shillings per thousand sheep. The work of Skerman (1959) also supports the feasibility of such a suggestion, as he obtained eradication of lice in field trials by dipping in emulsions of aldrin or diazinon with concentrations as low as 0.002%.

The criterion of "wetting" is also open to question. This is more of a subjective form of measurement most easily carried out by the use of an "indelible" pencil held against the skin of the sheep half an hour after showering. If the skin is wet the dye in the pencil will "run" showing that the area is wetted.

Even though complete wetting may be considered desirable it is thought that a much more real criterion would be to determine whether infestations of ectoparasites are eradicated with or without complete wetting. Unpublished observations by Sinclair, working with a standard Cooper Model HH Shower, described in Appendix A (v), showed that by the use of the top 8 nozzles all but a small area along the ventral surface of the sheep could be wetted and the work reported above in the section on jetting indicates that unless the fleece is extremely long, infestations of external parasites could be eradicated by the use of top nozzles alone. This could have a considerable bearing on the design and cost of a shower, because in the type referred to, 8 nozzles along the top can do most, if not all, of the work, whereas 16 nozzles are needed to wet this small and unimportant area on the ventral aspect of the sheep.

It is considered therefore that until the accepted criteria of assessing the efficiency of the shower are changed from the measurement of wash concentrations and the assessment of wetting to something more closely allied to the real purpose of showering sheep, which is surely the removal of external parasites, the further improvement in design of showers will be under a considerable handicap.

To discuss the showering technique from the viewpoint of efficiency, therefore, the work of Sinclair (1958b) showed that it could eradicate lice and itch mite infestations. The efficiency of the technique appears to be limited to a considerable extent by the efficiency of the chemical and the work reported above has led to a means of using exhausting insecticides in an efficient manner.

The convenience of the showering technique is worthy of mention. Experience has shown that if sheep are to be treated with any insecticide for any external parasite the shower presents a method which can be operated by one or two operators with little difficulty. Contrary to the plunge dipping method, where sheep do their best to escape from the treatment and may be only a short time in the wash, they can be held in the shower and treated for any desired period of time. The sheep can be treated even when heavy in lamb and although the manufacturers of showers do not recommend showering immediately off shears, frequent reports are received of this being successfully done and it is presumed that the frequent cleaning of the sump, which is easily done, renders the practice comparatively safe.

The economy of the method, apart from the initial installation, depends to a considerable extent on the cost of the insecticide. The cost of the initial installation is generally less than that of a plunge dip, but being permanent in nature is greater than the installation of surface sprays or dusters. The cost of insecticide varies with the chemical used and can vary from as low as 30 shillings per thousand with liquid Arsenical formulations to higher than 100 shillings per thousand for substances such as diazinon. If the suggestions of Graham mentioned above are taken, then the cost may be reduced to as little as 20 shillings per thousand.

SUMMARY:

The introduction of the showering technique was described and the advantages of the method were described. The problem of exhaustion of insecticides from dip washes was briefly introduced and a series of tests described, where the method of continuous replenishment of the run-off was used and examined.

The technique of showering was discussed and possible avenues of improvement described.

GENERAL DISCUSSION.

The manufacture of mechanical means of applying insecticides to sheep for the purpose of controlling infestations of external parasites is a commercial venture and for such industry to thrive these means of controlling the parasites must compete with the other methods available on the grounds of efficiency, convenience and economy.

Apart from the methods described above, external parasites of sheep can be controlled by plunge dipping or by the systemic application of insecticides, McCosker and Osborne (1957), both of which have been shown to be efficient in the literature cited in this thesis.

The efficiency of the various mechanical methods described is generally limited by the need to ensure that sufficient insecticide reaches the population of external parasites in order to cause their complete eradication, or to prevent them causing further damage. In the work reported a considerable effect was noted by the length of the fleece at the time of treatment. For the methods of surface spraying or dusting, which both rely on the diffusion of chemical along the wool fibre, it appeared that the best time for application was immediately off shears For the methods of showering or jetting which carry the insecticide through the fleece as a wash longer woolled sheep could be treated, but again there appear to be limits and for the sake of uniformity the manufacturers of the devices described have placed a limit of 3 months growth of fleece, despite the indications in the work of jetting that longer lengths of fleece could be successfully treated The amount of insecticide reaching the external parasites can also be affected by the method of use and means of keeping the amount of insecticide available as high as possible were evolved and tested. The continuous replenishment of used wash was shown to be efficient and has also opened up a new sphere of investigation for those equipped with the biological and chemical facilities to follow such work.

When a manufacturer designs a machine it is originally tested in ways reported above but if they are to be put into general use it must be remembered that the machines will not always be used by skilled persons and so the efficiency of the machine or method will be affected by its method of use, or abuse In recent years due to the characteristics of certain insecticides being efficient against lice, keds and blowflies, it has become the habit in many areas for flock managers to wait some 3 months or more after shearing to dip sheep to prevent blowfly-strike, Pryor and Skerman (1959) and Brander (1957), and to rely on this treatment to also eradicate lice or keds Whilst this may be a useful method under certain circumstances, it is thought that the work reported above. showing the effects of length of wool on the efficiency or treatment for lice, gives sufficient indication that it might be better to advocate treatment of sheep for the obligate parasites, lice, keds or itch mite as soon as possible after shearing and to consider the problem of the blowfly in a separate category. This is further strengthened by the observations of Shanahan (1958) on the resistant blowfly and on the work of McKerras (1936) and Weber (1958) which show that the blowfly can breed and develop without the sheep, so that whilst the obligate parasites can be eradicated from a flock of efficient methods of treatment, the presence of the blowfly must be regarded as inevitable and measures taken accordingly.

In the eradication of obligate parasites it is necessary for all sheep on the property to be brought to treatment and this is beyond the power of the designer of the device. The use of surface sprays immediately off shears makes it possible for easy identification of untreated (and unshorn) sheep, or when showering it is possible to recommend branding at showering rather than at shearing. It might be thought that the duster offers assistance to overcome this problem by leaving appreciable amounts of insecticide in the fleece for a period of 12 months, which would prevent reinfestation of treated sheep and at first sight appears to be an aid to efficiency. Against this, however, is the ever present thought of such a selection pressure soon producing resistant insects and so it is thought that a better method would be to aim at bringing all sheep to treatment and if possible to avoid methods which leave insecticides on the fleece for long periods.

The limits of efficiency of the mechanical methods are therefore those of length of wool at the time of treatment, off shears for surface spraying and dusting and up to 3 months for jetting and showering (for obligate parasites) and the insecticide. This latter must be of a diffusing type for surface spraying and dusting and must be applied at a reasonably high concentration such as 0.125% for surface spraying and 3% for dusting if dieldrin or diazinon are to be used. For jetting or showering there is a much wider choice of insecticides, but the strength of these must be kept within certain limits.

It can be seen that mechanical means of applying insecticides do not have any great advantage over other methods if efficiency per se is considered and therefore if they have a competitive place in the choice of treatments then their advantages must lie in the fields of convenience and economy.

If the aspect of convenience is considered, it can be seen that mechanical devices have their greatest advantage. As was noted in the introduction to the thesis, mechanical devices for the purpose of applying chemicals to sheep have developed to a considerable extent in areas of the world where flocks are large and labour is scarce. Primitive means of applying insecticide by either smearing, pouring out of small receptacles, or immersing the sheep in a bath, cannot be compared for convenience when one considers the ease with which sheep can be dusted, surface sprayed, jetted or showered. With these methods one or two men can deal with large flocks in a comparatively short space of time. The most rapid - dusting or surface spraying - can only be applied soon after shearing, so that despite the ease of application, their use is limited. Jetting or showering, on the other hand, can be applied in reasonable lengths of wool for the eradication of obligate parasites and there is practically no limit to the length of wool in which jetting can be used for the prevention of blowfly-strike.

When one considers the reason for purchase of a device, it can be seen that convenience, granted efficiency, is the main reason for the existence of appreciable numbers of these devices in the grazing industry. Convenience can also influence efficiency to the extent where an efficient method easily applied is more likely to be used properly than a laborious method which may not be used as carefully or as frequently as necessary.

Convenience is also bound to economy of use, firstly in the saving of labour, also in the fact that it may be used properly with ease, so that there is less chance of economic loss due to careless use.

The economy of the methods used is complicated to a considerable degree by the cost of the insecticide used and the method of use. It appears that showering can be favourably compared with plunge dipping, but surface spraying and dusting can be expensive if used carelessly. Jetting is probably the most expensive method in the use of chemicals, but it has special applications of use mainly for the treatment or control of blowfly-strike, It can be be regarded as a somewhat essential process and will often be used for this purpose despite the cost, whereas it may not be used to any extent for the control of lice, keds or itch mite, except in cases of emergency, when infestations are found in long-woolled sheep.

The studies have shown that devices can be designed which are original in concept, or improvements on existing designs, by a careful study of the fundamental principles of the techniques and extensive thorough testing in the field of use. As these devices are then manufactured and sold commercially, it is essential that they are efficient, convenient and economical, otherwise the industry concerned will fail, so the acceptance of these devices by the grazing industry is a measure of the success of the designer and the manufacturer As a result of these studies two devices have been submitted to this final test. One device is a mechanical jetter and the other is a sheep shower with a sump system which embodies the principle of continuous replenishment of the run-off wash.

GENERAL SUMMARY

The origin of mechanical means of applying insecticides to sheep was briefly described.

The methods of work and presentation of the report were described and reasons for the methods used were given.

Definitions were made of the common terms used and of the classifications of mechanical methods used

The thesis was divided into major sections dealing with each major classification, namely dusting, surface spraying, jetting and showering and in each section a series of experiments were reported which work lead to a greater understanding of the technique and to improvements in the design of the machinery used.

Dusting and surface spraying were found to be essentially similar and in each method a concentrated form of chemical poison, or insecticide, was deposited, either as a solid or a liquid, at the surface of the fleece without mechanical penetration of the fleece. A charateristic of insecticides, known as diffusion, was thought to permit the chemical to penetrate the fleece and reach the population of external parasites. From the evidence of the tests if was deduced that the amount of insecticide reaching the external parasites was influenced by the length of wool at the time of treatment and by the amount of the insecticide applied. It was concluded that surface spraying or dusting were best applied immediately after shearing and that the amounts of the insecticide used, dieldrin and diazinon, should be relatively high. The methods of surface spraying and dusting were efficient if applied as recommended, were convenient to apply, surface spraying being more so than dusting, but were not considered to be the most economical means available if insecticide costs were considered alone.

Studies of jetting showed that with certain designs of nozzle the fleece of the sheep could be penetrated from a distance of 6 inches with pressures as low as 15 psi previously thought to be too low to be efficient. It was also observed that if nozzles were moved across the surface of the fleece in a certain manner the fleece could be soaked to the skin and if sufficient volume of fluid was applied along the mid dorsal line of a standing sheep this fluid would percolate through the fleece around the skin of the sheep and would carry insecticide to a considerable proportion of the area of skin of the sheep.

Using these principles a device was designed which would jet sheep efficiently and conveniently. The economics of the process were generally determined by the cost of the insecticide and were considered to be high if compared with other methods of treatment for lice or keds, but the convenience of the method for emergency treatment of long-woolled sheep infested with these parasites made it worth consideration. Its use for blowfly

control was governed by the efficiency of the insecticide.

In the jetting technique the volume of applied fluid and the length of wool at the time of treatment appeared to be of more importance than the concentration of the insecticide used, as the method permitted the mechanical transport of the insecticide to most portions of the sheep.

Chemical investigations were made into the behaviour of emulsions of chemicals in surface sprays and jetters and a small but consistent loss of concentration of insecticide was observed. This was not thought to be due to exhaustion of insecticide from the solution on the fleece and was unexplained. Means of controlling this loss of strength were devised and means of removing debris from the run-off wash were also devised, so that the run-off wash could be used again if desired.

Investigations were made into means of controlling the exhaustion of insecticide from dip washes during showering and a system of continuous replenishment of the run-off wash was shown to be a major advance in the design of sheep showers.

The uses of mechanical devices and their limitations were discussed.

An appendix describing the various devices used and designed as a result of the studies was presented.

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APPENDIX A.

A description of the mechanical devices used in conducting the tests described in the above report.

Part One:

Technique: Power dusting.

Trade name: Howry-Berg Sheep Duster.

Manufacturers: The Howry-Berg Steel and Iron Works Inc. of Colarado, U.S.A.

A (i).

Description:- The device consists of essentially two components (a) a power unit and (b) the dusting chute.

(a) The power unit consists of a 5.5 h.p. engine (in this instance a Ronaldson Tippett 5.5 h.p. air-cooled engine) driving a fan at approximately 2800 revolutions per minute (rpm).

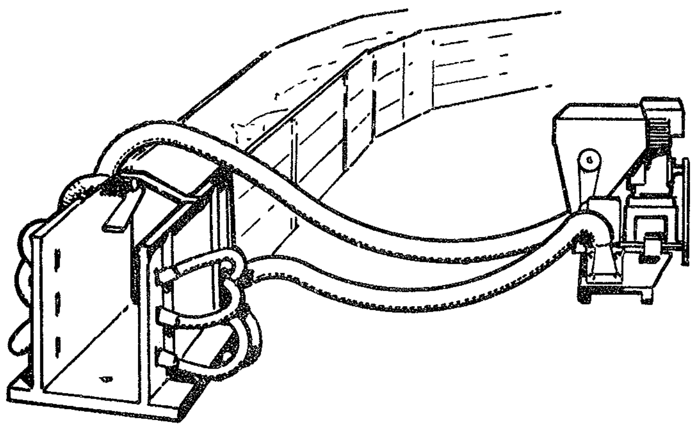
From a hopper above the fan the insecticidal dust is delivered by means of an Archimedes screw through an adjustable delivery port and falls on to the fan. The fan is running in an enclosed chamber from which lead two 3 inch hoses which deliver the air dust mixture to the second component.

(b) The dusting chute is a short length of steel race which can be placed at the end of a short sheep forcing race. On the dusting chute are a series of nozzles, as illustrated, three on each side and two on the floor.

Modifications: The device used in the tests described in the report above was modified by the writer so that the dust from one floor nozzle (the one at the entrance end of the chute) was diverted to a nozzle mounted on top of the machine so that the dust was directed on to the backs of the sheep as they passed through. Also, the dust delivery hoses were lengthened by approximately 15 feet, which allowed the motor and fan to be placed further back from the dusting chute.

Operation: The dusting chute was set at the end of a forcing race and pen. Sheep were then forced up the race to a small gate just before the dusting chute. The engine driving the duster was started and being situated behind the sheep near the dusting chute the noise tended to force the sheep to move towards the chute. The gate was opened and the dust flow started. It was found that provided the dust was of such a nature, and flowing in such a direction that the sheep could easily see through the dust and see other sheep and then they would readily run through the dusting device to a holding yard beyond. With good conditions it was found possible for one man, aided by a sheep dog, to dust flocks of three or four hundred at rates of up to 80 per minute. If conditions were such that the sheep could not see through the dust, then by extreme effort of at least two men, under trying conditions wearing face masks yet still suffering respiratory embarrassment, up to 30 sheep per minute could be dusted.

ILLUSTRATIONS:



Parts Two, Three and Four:

Technique: Surface spraying and jetting.

Trade Name: Sunbeam Cooper Automatic Multi-Spray Race, model BB and model NW.

Manufacturers: Sunbeam Corporation Limited, Sydney, Australia.

Description: Three models of this device have been manufactured and were used in the trials described above.

Model BB:

The device consists of a metal box or enclosure of sufficient size to hold one sheep. This box is installed at the end of a sheep forcing race, which is filled from the usual forcing pen. The device can be used for either surface spraying or jetting.

A (ii).

Surface Spraying: By means of pipes attached to the side walls of the box a total of 18 nozzles, 9 on each side, of 0.040 inch orifice, giving a fan-shaped spray covering an arc of approximately 90^{o}, are mounted in such a fashion that a sheep passing through the sprays receives a deposit on most parts of the body.

Operation: When properly installed, the sheep are forced up the race through the sprays at a rate of approximately 30 to 40 per minute. With the pump used delivering approximately 4 gallons of wash per minute through the sprays, sheep sprayed at the rate of 35 per minute receive a deposit of approximately 8 fluid ounces of wash. It has been observed that approximately one third of the wash misses the sheep and is collected in a waste tray underneath the box, from where it is lead to disposal.

A (iii).

Jetting: On the box are two gates, one at each end of the enclosure, these gates being connected by a linkage in such a fashion that the opening or closing of one gate results in a similar action of the other. Within the box is a set of sheep holding frames which are also connected to the gate mechanism and these frames are moved towards the sheep with the closing of the gates, the amount of movement of the frames being adjustable. The gate linkage is also connected to the main valve of the device, so that closing the gates opens the valve on the supply pipe from the pump and opening the gate closes the valve. Jetting nozzles of 0.052 inch orifice are arranged in certain areas of the machine and these banks of nozzles are carried on a pipe and are called "branches" Thus there are 14 nozzles, 7 pairs mounted on two connected pipes, on the top of the machine which will direct wash on to the dorsal area of the sheep. There are 11 nozzles on a pipe at the entrance end of the machine and direct wash on to the crutch area of a sheep standing in the box and there are 3 nozzles on the floor of the machine which direct wash on to the ventral aspect of the sheep being treated. Each of these branches is connected to the outlet of the main valve and controlled to a set position, or flow, of wash by a simple tap.

The top branch can be moved backwards and forwards and the extent of this movement is sufficient to join the penetration points of the nozzles on the fleece of the sheep being jetted. This movement of the top branch is also communicated to the crutch branch, which moves up and down.

Operation: With the gates held open, the frames are held against the side of the machine and the valve is closed. As a sheep enters the gates are closed; this brings the frames in to hold the sheep and simultaneously the valve is opened so that fluid commences to flow from the nozzles. The top bar is moved backwards and forwards, which ensures soaking of the fleece in the area desired.

When jetting is completed the gates are opened, which action closes the main valve and takes the frames back to the side of the machine and the treated sheep can leave. The entire operation takes two to four seconds and can be timed according to the amount of fluid the operator wishes to deposit on each sheep. With a pump delivering 1000 gph at 50 psi, four seconds will deliver approximately half a gallon of wash on to the body and crutch of each sheep.

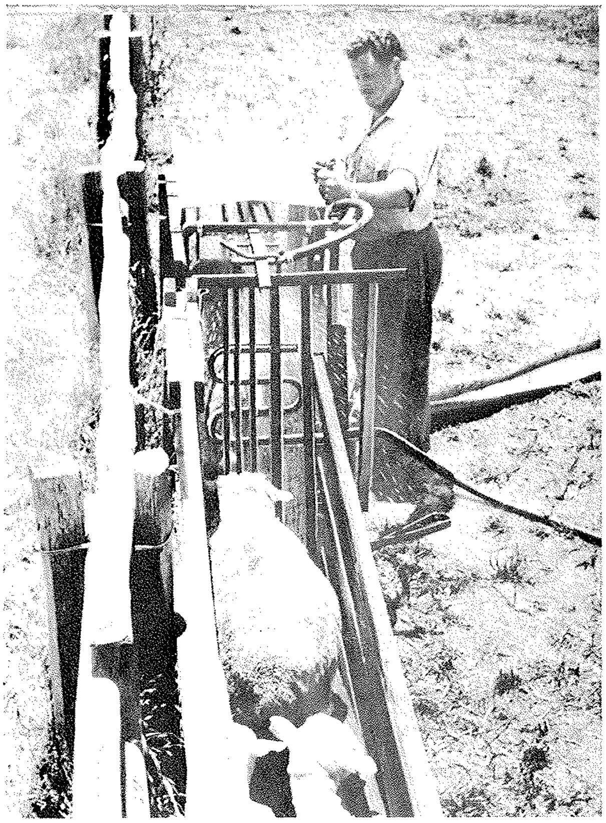
A (iv).

Model NW:

The device was modified to meet certain demands. In essentials it is constructed and operated in a similar fashion to the model BB described above. The main modification has been to increase the number of nozzles as follows: the top branch carries 28 nozzles on 4 pipes carrying 7 nozzles each (either 14 or 28 nozzles can be used); 16 nozzles on the crutch branch and in addition 16 nozzles on a branch at the front of the sheep which can direct wash on to the ventral aspect of the neck of the sheep; and six nozzles on the floor of the machine. The nozzles are reduced in size to 0.046 inch orifice. Using a standard pump of 1000 gph at 50 psi with all nozzles operating, the device delivers 2 gallons of wash in 10 seconds, of which approximately one gallon is collected in the waste tray and one gallon is retained by the sheep.

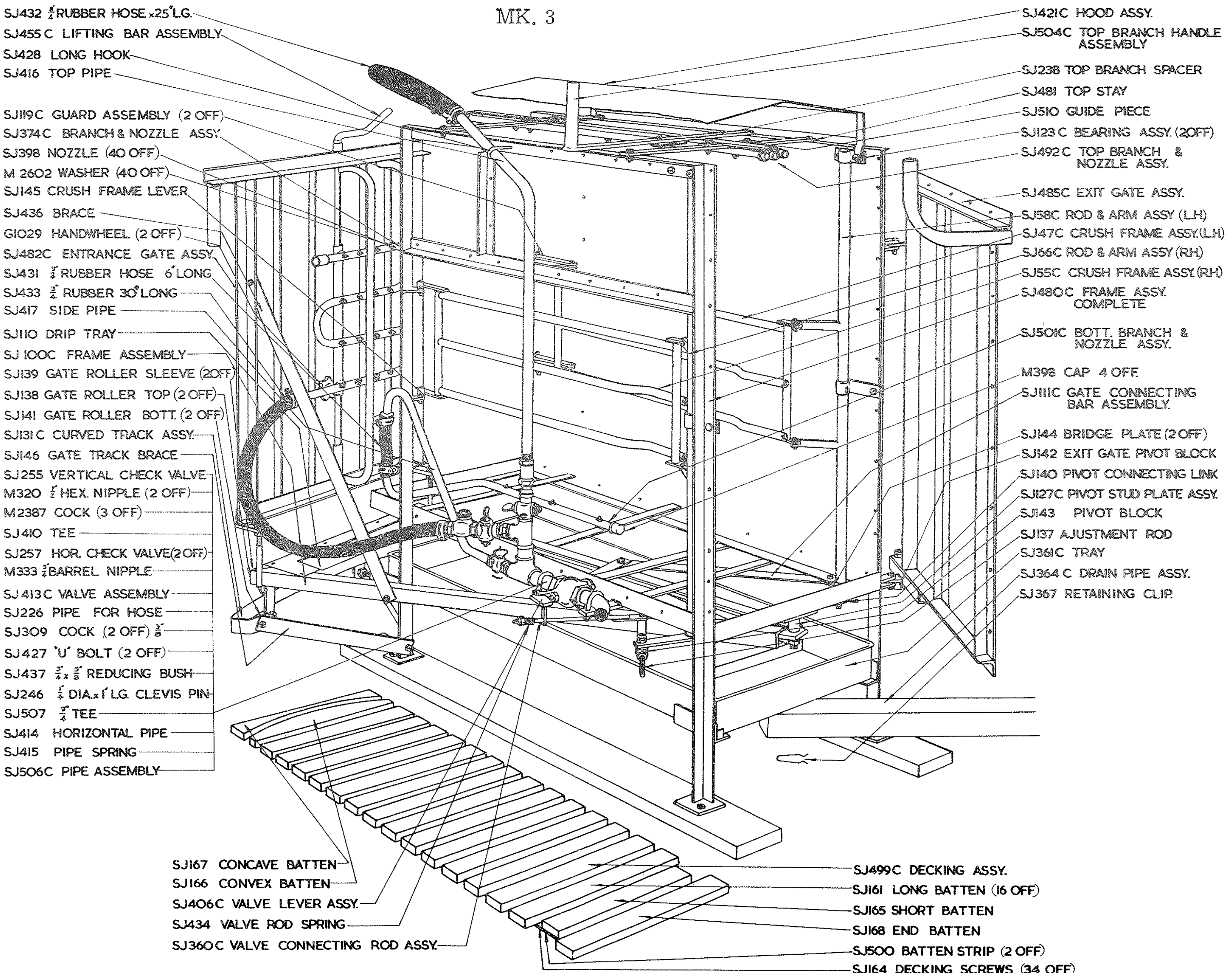
Model ME:

This is the more recent model of the jetting machine with minor modifications of the previous structures.



PARTS LIST AND DIAGRAM OF THE SUNBEAM AUTO-JETTER AND SPRAY RACE. MODEL M. E.

MK. 3



Part Five:

Technique: Sheep Showering.

Trade Name: Sunbeam Sheep Shower, Models HH, AS, SG and LR.

Manufacturers: Sunbeam Corporation Ltd., Sydney, Australia and
Sunbeam Corporation Ltd., Wellington, New Zealand.

A(v)

Description:

The showers consist of an enclosure in which sheep are held while being subject to a spray of dip wash from nozzles mounted above and beneath the sheep. The sides of the enclosure are of corrugated iron sheets mounted on upright pipes, while the floor is usually of concrete. Models HH and AS have a rectangular shaped enclosure, while models SG and LR have circular shaped enclosures.

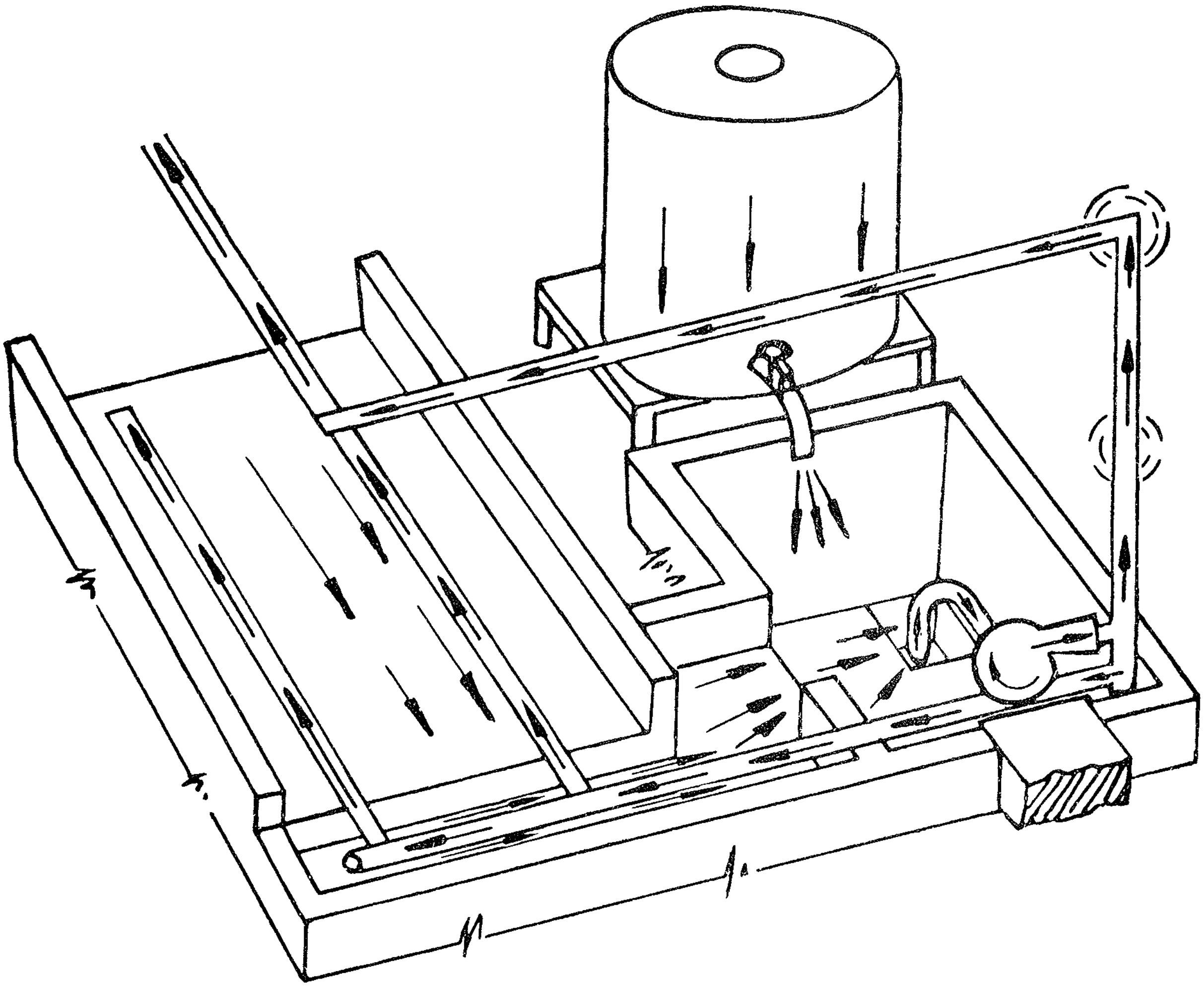
In the rectangular showers 8 nozzles are carried on a pipe which runs along the top of the enclosure and which sweeps back and forth in a "punkah" type of action directing wash onto the backs of sheep in all parts of the enclosure. On the floor of the enclosure are 16 nozzles arranged to direct wash onto the ventral aspects of sheep standing in the enclosure. The different models of rectangular shower refer to the type of sump used to catch the run-off wash. In the model HH the well is some 500 gallons capacity and there is a by-pass agitator which circulates wash in this large well when the wash is not being pumped over the sheep. In the model AS, designed as the result of work reported in this thesis there is no agitator and the sump has been reduced in volume to about 120 gallons capacity. The dip wash is mixed in a tank of about 500 gallons capacity standing beside this sump and is allowed to flow into the 120 gallon capacity sump through a regulating valve or tap at a rate sufficient to compensate for the amount taken out on the fleeces of the sheep. This method of continuous replenishment has the Trade Mark "Anti-Strip".

In the circular models, which hold either 30 average sized sheep (Model SG) or 60 averaged sized sheep (Model LR) the system is "Anti-Strip" i.e., one of continuous replenishment.

Operation: In all models the sheep are introduced into the shower enclosure and gates closed on them. The valves in the top nozzle pipes are opened and sheep subjected to these sprays for a minimum period of four minutes, but this may be longer according to length of wool on sheep being showered and according to the circumstances operating on the particular property. For the final minute of the showering period the bottom nozzles are turned on. In this period some 7 to 10 gallons of wash are pumped over each sheep in the enclosure and it retains from one half to one gallon according to length of fleece and time of showering.

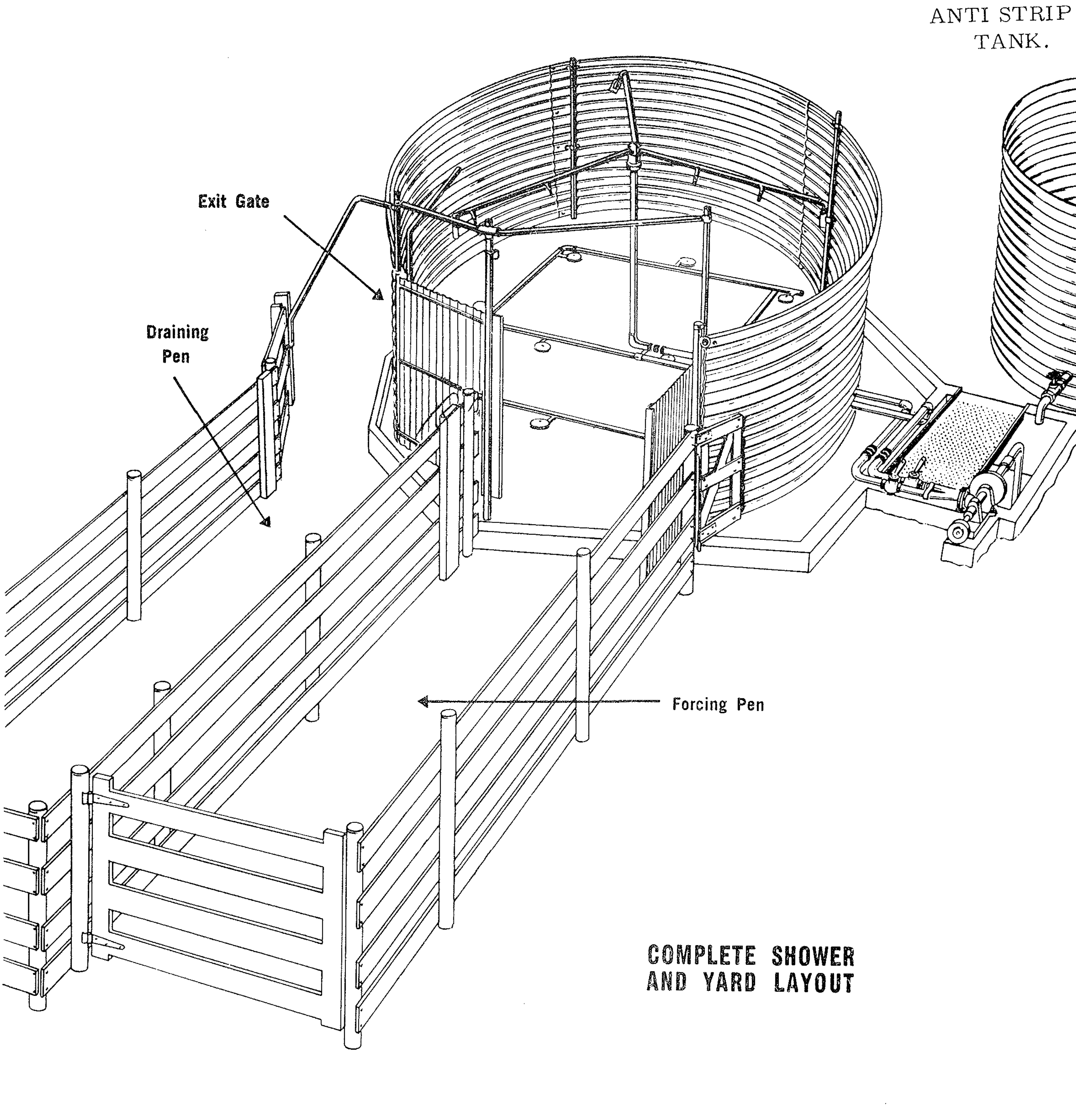
The wash not retained by the fleece runs through various shaped traps and filters to remove gross contamination and back through the pump. In "Anti-Strip" models this run-off wash is continuously replenished by fresh wash from the tank standing beside the sump.

Pump sizes and speeds of running vary according to model and according to the country of origin. Basically the 30 sheep models use a two inch centrifugal pump operating between 2000 and 2400 r.p.m. while the 60 sheep model uses slightly larger pumps operating at about 2500 r.p.m.



WASH CIRCULATION DIAGRAM

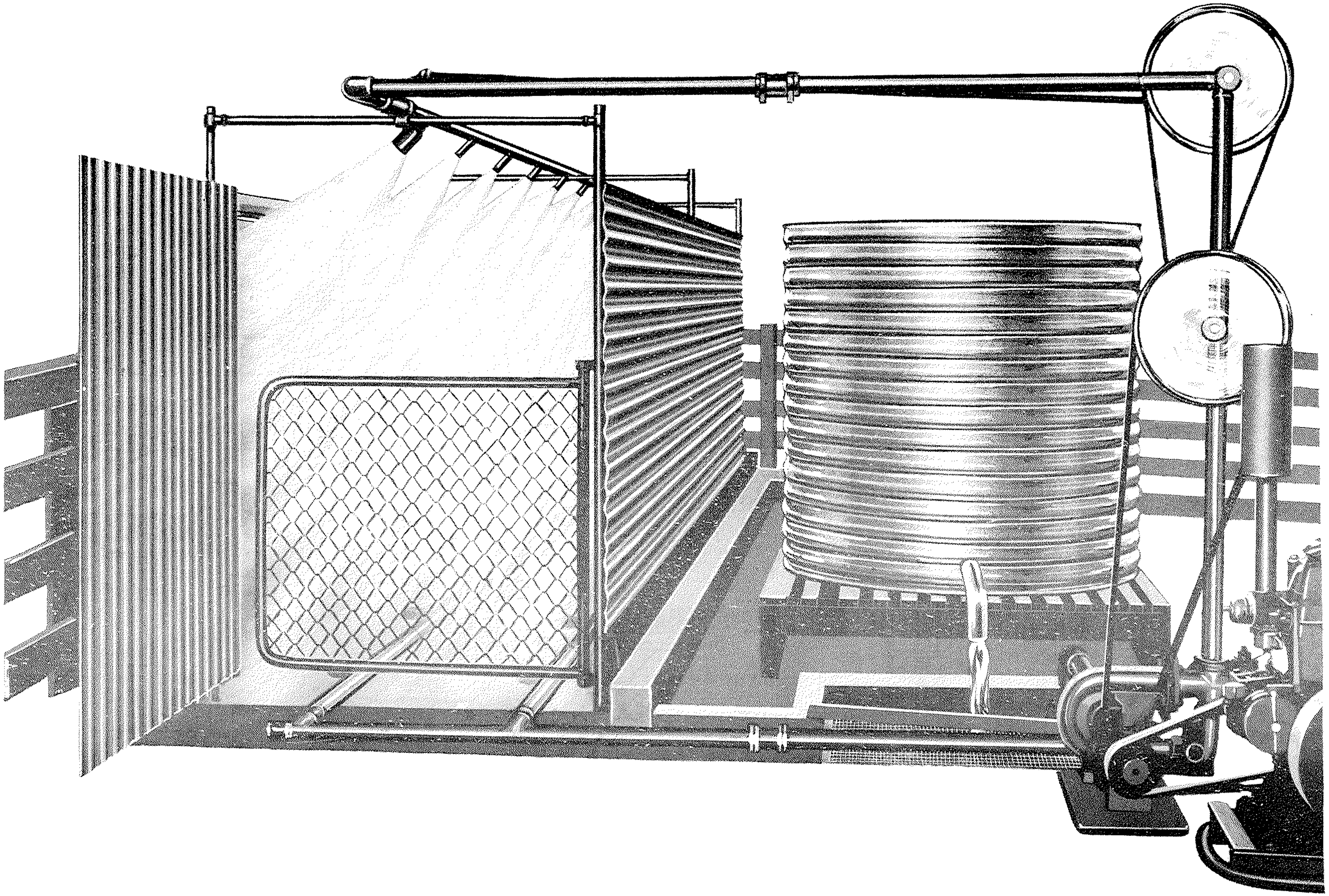
Illustrations of some of the treatment methods mentioned in the text.



COMPLETE SHOWER
AND YARD LAYOUT

"ANTI STRIP"
Trade Mark

RACE TYPE SHEEPSHOWER



APPENDIX B

Common names of Insecticides (Haler 1957).

Common Name:	Chemical Definition:
Aldrin	Not less than 95% of 1, 2, 3, 4, 10, 10 - hexachloro - 1 4, 4a, 5, 8 8a - hexahydro - 1, 4 - endo - exo - 5, 8 - dimethanonaphthalene.
B H C.	1, 2, 3, 4, 5, 6 - hexachlorocyclohexane, consisting of several isomers and containing a specified percentage of gamma
Diazinon	0, 0 - diethyl 0 - (2 - isopropyl - 4 - methyl - 6 - pyrimidinyl) phosphorothiate.
Dieldrin	Not less than 85% of 1, 2, 3, 4, 10, 10 - hexachloro - 6, 7 - epoxy - 1, 4, 4a, 5, 6, 7, 8, 8a - octohydro - endo - exo 5, 8 - dimethanonapthalene.

NOTE: This thesis was written before the current ban on the use of Chlorinated Hydrocarbon insecticides.

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