

THE PROVISION OF A SAFE AND SATISFACTORY  
MILK SUPPLY  
ON A NATIONAL BASIS  
WITH SPECIAL REFERENCE TO  
SOUTH AFRICAN CONDITIONS.

- by -

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## P R E F A C E .

In choosing the subject for this thesis the candidate has been impressed by the outstanding lack in the world literature of any single comprehensive outline of the problems involved in the provision of a satisfactory milk supply. Numerous books have been written, and scientific, Trade and popular journals carry innumerable articles, but always certain phases of the whole picture are emphasised, whilst others are ignored.

In the subsequent chapters an attempt has been made to set out a comprehensive, yet concise outline of the major problems of safe and satisfactory milk production, whilst a comprehensive solution to these problems is offered.

The writer has drawn extensively upon world literature, and where possible due acknowledgment has been made, but special reference should be made to the following publications that have been drawn upon exhaustively, viz:- "The Principles of Bacteriology and Immunity", Topley & Wilson (1936) "Dairy Bacteriology", Hammer (1938); "The Grading of Milk", Wilson et alia (1935); "The Pasturisation of Milk", Wilson (1942); and "The Secretion of Abnormal Milk by Quartus Free from known Pathogens", Van Rensburg (1944).

Undue emphasis has perhaps been laid upon the writer's own observations and publications, but in defence it is contended that few other investigators have covered so wide a field of milk studies with personal investigation and research. There has, moreover, been a logical sequence to these studies that should give them increased significance.

- THE PROVISION -

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## I N T R O D U C T I O N.

Milk coming from a healthy cow should be a safe and highly nutritious human food, but if it comes from cows that are diseased, or from cows that are improperly fed, then the milk may be extremely dangerous and totally unsuitable for consumption. Furthermore, milk that was absolutely safe when produced, may become highly dangerous if an opportunity is given for certain poisons to become added to the milk, or if the milk is subjected to contamination by disease-producing germs.

Even at a stage in history, when the subject of bacteriology was in its earliest infancy, it was already realised that milk might be an agent for spreading certain infectious diseases, and as long ago as 1857, Taylor (1870) advanced the hypothesis that an outbreak of typhoid fever and another of scarlet fever had been spread by milk. From this beginning, information has gradually accumulated until a stage has been reached when Public Health Authorities are forced to think in terms of :-

- (1) Milk that is safe.
- (2) Milk that is clean.
- (3) Milk that is both safe and clean.
- (4) Milk that is of a satisfactory nutritive quality.

The term safe is used to designate milk that will not cause any illness when drunk, whilst the term clean is used to designate milk that has been produced under satisfactory hygienic conditions, and which will, in consequence, stay sweet for a long time (i.e. has good keeping quality).

From the outset it must be appreciated that

- there -

there is very little connection between these factors of safety and cleanliness. Milk may have been excellently produced, have a very low bacterial plate count, be free of bacterium coli, and have excellent keeping quality. If, however, some carrier of diphtheria or scarlet fever infection has coughed over the milk, or if some of the milk has come from a cow suffering from a Salmonella dublin septicaemia, then it will be most dangerous to consume. Alternatively, milk which has been produced under filthy conditions will be perfectly harmless, provided it contains no pathogenic bacteria, or bacterial toxins. In actual practice, serious milk-borne epidemics have in the past been caused by milk produced under exceptionally clean circumstances - examples including the Brighton-Hove septic sore throat outbreak (vide Wilkenson 1931) and the Wilton epidemic of salmonella food-poisoning (vide Conybeare & Thornton, 1938). Other less wellknown epidemics include those recorded by Brooks (1930 b), Leeder (1932), Defries (1938), Harding (1939) and Faulds (1943).

It is comparatively easy to understand why high-grade milk should be responsible for epidemics. In the 1st place cleanliness of production is no guard against the danger of milk coming from diseased cows. For instance, Pullinger (1934) reported that in England 70% of samples of milk from tuberculin tested herds contained Brucella abortus, whilst only two out of 16 Certified herds were never shown to be excreting mastitis streptococci. In other words, the clean milk sold from these herds was not necessarily safe milk. Similarly Conybeare and Thornton (1938) reported that milk from an accredited herd became contaminated with Salmonella dublin, because one of the

cows in the herd was an active carrier of this infection, the ultimate result of this contamination being a serious epidemic of gastro-enteritis amongst school children. Furthermore, even though the methods of handling milk may be excellent, there is always a chance of a human carrier of disease accidentally contaminating the milk, though the likelihood of this happening increases as the standard of dairy hygiene decreases. Assuming that milk does become contaminated with pathogenic bacteria, the likelihood of them surviving and of actually multiplying is greater in clean than in dirty milk. Where the bacterial population of the milk is already high, pathogens are likely to be crowded out or destroyed by pH. changes, whereas clean milk offers a suitable culture medium for growth, and even for toxin production. These points are obvious just on general principles, but in addition, experimental data to this effect has been reported by Pullinger and Kemp (1937 and 1938). These workers showed that Strep. pyogenes multiplies readily in sterilised milk, but dies out in commercial grades of pasteurised milk, and similarly Bact. typhi multiplies rapidly in sterilised, and in pasteurised milk, but only slowly in ordinary quality raw milk. Finally, there is a greater likelihood of high grade milk being consumed in the raw state, rather than boiled or in hot drinks; and it is likely that such milk would be taken in large quantities by invalids, or by children, both classes of consumer being particularly susceptible.

From what has been written, it should be apparent that in planning a satisfactory milk supply (using the term milk to include milk products), it is necessary to consider these factors of cleanliness and safety independently in the first place.

## CHAPTER I.

COWS THAT MAY BE DANGEROUS AND BOVINE DISEASES  
OF ECONOMIC IMPORTANCE.

Milk can be dangerous for human consumption, if it contains mineral or vegetable poisons which have been excreted through <sup>the</sup> udder of a cow, or added to milk after milking. It is even more dangerous if it contains pathogenic bacteria, or their toxic products. Pathogenic bacteria may get into the milk directly from the udder of an infected cow, or indirectly by contamination with faeces or urine, or even by contamination with pus from open sores. On the other hand, milk which was quite safe as it came from the cow may be contaminated by flies or rodents, or by milk handlers who are themselves carriers of disease, and who contaminate the milk with their hands, or by droplet infection. The more important diseases that may be spread by milk are listed in Table 1.

A. Foods and Drugs that contaminate Milk.

In actual practice milk is rarely rendered dangerous as the result of food or drugs that are ingested by cows being subsequently excreted in the milk, though milk may become contaminated in this way. Trembles, or Milk Sickness is a classical example in this connection, this being a disease of cows and of humans, which is associated with certain plants. The condition has been described by Wolff, Curtis and Kaupp (1918), and by Marsh, Roe and Clawson (1926). According to Couch (1927) and (1928), the symptoms are caused by the toxic principle Tremetol, which is to be found in Eupatorium urtricaefolium, and also in Applopappus heterophyllus, two plants that grow in those areas of the U.S.A. where this disease

- occurs -

TABLE I.

SOURCES OF COMMON MILK-BORNE DISEASES.

Infections spread direct from Bovines to Man.	Infections spread by rodents, flies or water.	Infection introduced by human carriers.
Tuberculosis (bovine type)		
<u>Br. Abortus. Br. melitensis.</u> (Contagious abortion cattle) (Undulant fever man).		
<u>Strep. pyogenes.</u> (Mastitis of cattle occasionally). (Scarlet fever in man)		<u>Strep. pyogenes</u> (Scarlet fever & tonsillitis.)
<u>Staph. aureus.</u> (Mastitis in cattle. Enterotoxaemia in man.)		<u>Staph. aureus.</u> (Enterotoxaemia)
Salmonella species Paratyphoid in cattle. Gastro-enteritis in man.	Salmonella species.  Gastro-enteritis in man.	Salmonella species.  Gastro-enteritis.
	<u>Bact. typhi.</u> <u>Bact. paratyphi</u> A & B. (Typhoid & paratyphoid fever in man.)	<u>Bact. typhi.</u> <u>Bact. paratyphi</u> A & B. (Typhoid & paratyphoid fever).
	<u>Bact. flexneri,</u> <u>shigae &amp; sonnei.</u> (Bacillary dysentery in man.)	<u>Bact. flexneri,</u> <u>shigae &amp; sonnei.</u> (Bacillary dysentery.)
<u>Corynebact. diphtheriae.</u> (Ulcers in cattle Diphtheria in man.)		<u>Corynebact. diphtheriae.</u> (Diphtheria).

In addition to the above list, other diseases occur which are grave agricultural problems, These too will be discussed briefly in this chapter.

occurs. It is of interest to note that according to Couch (1927), this toxic principle is very heat resistant, and is not destroyed by pasteurisation, and is only destroyed slowly, when milk is boiled.

So far as the writer is aware, this is the only specific disease of man known to be caused in this manner, but there still exists a theoretical possibility that many other plant poisons might be excreted through the mammary gland. Similarly, certain inorganic poisons, picked up accidentally or administered therapeutically, might be excreted in the milk. Such possibilities have, however, but little practical importance.

B. Important Diseases of Dairy Cattle.

1. Bovine Tuberculosis. Incidence. In Great Britain, it has been estimated that about 40 per cent of dairy cows are infected with tuberculosis, whilst between 0.2 and 2.0 per cent of them suffer from tubercular mastitis. (vide Report 1931 and 1932 a). These figures are so high that it is obvious that in Great Britain at least, bovine tuberculosis is a major agricultural problem. Moreover, with so high an incidence of tubercular mastitis, there is every chance that market milk would often contain tubercle bacilli, because, as Osterman (1908) has shown, milk from a tuberculous cow can be diluted 50,000 times, and still remain infective for guinea pigs; whilst Pullinger (1934) diluted a tuberculous cow's milk one million-fold, AND STILL INFECTED GUINEA PIGS. According to Schwabacher and Wilson (1937), the minimal of infective dose of tubercle bacilli for guinea pigs is about 10 organisms, and this gives an indication of the enormous numbers of tubercle bacilli that were being excreted by



the cows that Pullinger had under test.

The extent to which market milk contains tubercle bacilli in Great Britain, has been studied by a large number of workers, some of their findings being quoted by Pullinger (1934). Summarising these records, it may be stated that according to Wilson and Nutt (1926), who worked in Manchester, 13 per cent of market milk samples were found to be contaminated, whilst Locke (1932) reported that 18 per cent of herd samples contained these organisms. In Scotland rail tanks were found to be contaminated in 37 per cent of instances (vide Report 1933 a); whilst in England 83 per cent of rail tanks were contaminated (vide Report 1933 B). Pullinger (1934) reported that from 2 to 23 per cent of herd samples were contaminated, depending upon the area where sampling was done; whilst, when testing large 3000-gallon rail tanks, the same worker found that all the 63 that were tested were contaminated with tubercle bacilli.

In South Africa, comparatively little is known of the extent of the bovine tuberculosis problem. Viljoen (1927) reported that only 0.05 per cent of 62,000 head of export cattle were infected, but this figure referred to slaughter, and not to dairy stock. De Kock (1932) reported a very low incidence of the disease in the State owned dairy herds, and in dairy herds that were in the process of becoming accredited. In the Durban area, on the other hand, during a disastrous anti-tuberculosis campaign, 38.8 per cent of all dairy stock, and 25.5 per cent of loose cattle reacted to the tuberculin test. Once again, from abattoir statistics quoted by De Kock, the following figures may be abstracted :-

- Bloemfontein -



Bloemfontein	0.33%	Pietermaritzburg	0.065%
Johannesburg	0.153%	Durban	0.053%
Capetown	0.8%	Port Elizabeth	0.046%
Pretoria	0.176%		

These figures refer to the percentages of slaughter cattle which showed lesions of tuberculosis, but no indication is available with regard to the proportion of dairy cows involved.

Apart from the foregoing figures, which probably bear very little relationship to the incidence of the disease in South African dairy stock as a whole, very little is known, and though it is assumed that the incidence is high in town dairy herds and low in country ones, there is no direct evidence to justify this belief. Similarly, there is a singular dearth of evidence with regard to the incidence of tubercle contamination of market milk. Small surveys have been reported upon by Pullinger (1941) working in the Transvaal, and by Horwitz (1944) from the Cape Peninsula. Pullinger found that only 2.5 per cent of 10-gallon can samples, and 2.5 per cent of large bulk samples contained tubercle bacilli. Calculating the number of cows contributing milk to these pooled samples, it would appear that in South Africa there is nothing like 0.2 per cent of tuberculous udders amongst our dairy herds. Over a ten year survey Horwitz only encountered tubercle contamination in 3.5 per cent of bulk samples, whilst routine examinations of random samples at the Government Veterinary Laboratory reveal a similar low figure (unpublished results), so that it seems likely that the low incidence of tubercular mastitis is not restricted to one area. With the data that is available, it is not possible to decide whether this low incidence of tubercular

mastitis is a reflection of a low incidence of all forms of tuberculosis, but there is some suggestion that another factor comes into play. Autopsi<sup>s</sup> of tuberculous dairy cows revealed that the udder only becomes involved, when infection is generalised throughout the body (vide Pullinger, 1941), and this suggests that dairy cows may usually be culled for general ill health, before tuberculosis has had time to spread to the udder.

The main point arising is that insufficient information is available regarding the incidence of this disease amongst South African dairy herds. The incidence encountered during the Durban campaign may be misleading, if applied to the country as a whole, whilst abattoir statistics make no distinction in regard to dairy stock. Before any serious attempt could be made to plan an eradication scheme, it is imperative that full information should be available regarding the magnitude of the task to be undertaken. This information can only be obtained by carrying out a country wide survey of the incidence of tuberculosis in dairy herds.

#### Antemortem Diagnosis of Tuberculosis.

From the point of view of the stock farmer, the question of the antemortem diagnosis of tuberculosis is of paramount importance. Diagnosis can be effected by means of the tuberculin test, by clinical examination confirmed by laboratory test, or by laboratory test alone, each of these procedures having its own particular uses.

#### Tuberculin Test.

This test is chiefly of value for detecting non-clinical cases in the early stages of infection, and also cases of latent infection, but it is less reliable in the

case of advanced or generalised disease. Much has been written regarding this test, and it is not possible to survey the literature here. Attention may, however, be called to the following reports that deal with various aspects of the intradermal tuberculin test.- Buxton and MacNalty (1928), Buxton & Glover (1933), Buxton & Glover (1939), and Glover (1941), whilst the application of the test under South African conditions has been considered by Canham (1944). Even to-day, the tuberculin test presents four basic difficulties which interfere with the diagnostic reliability, these being :-

- (1) The difficulty of preparing a highly purified tuberculin, free from all non-specific agents likely to interfere with the test, but retaining the specific extract in a highly concentrated and potent form.
- (2) The correct interpretation of borderline reactions.
- (3) Interferences with the test due to sensitisation by chemically similar substances, the classical examples being avian tubercle bacilli and Johnes bacilli (vide Minett 1932 b).
- (4) The difficulties arising because a positive reaction is sometimes given by a bovine which shows no lesions on slaughter, (i.e. non-lesion reactors). Where a campaign involving the slaughter of reactors is in progress such cases can represent a serious problem entailing the destruction of apparently healthy animals. During the U.S.A. eradication campaign 7 to 10 per cent of all reactors showed no lesions, whilst at Durban 4 per cent of non-lesion reactors were found (vide de Kock, 1932).

Three explanations are offered - firstly, small lesions may actually be missed at autopsy; secondly, sensitisation may occur, whilst lesions are still microscopic in dimensions; and thirdly, if the first two were the only causes, no problem would exist, but it is unfortunately known that organisms allied to the tubercle bacillus can sensitise bovines to the tubercle bacillus itself. Thus, it has been shown that both the avian tubercle bacillus and Johnes bacillus can produce such sensitisation (vide Minnett 1932b, Buxton & Glover 1939, and Glover 1941), and it is reasonable to suggest that other hitherto unidentified organisms might have a similar effect.

Whilst the factors mentioned above do introduce difficulties into the application of the tuberculin test, they do not invalidate the test for survey purposes, and the tuberculin test still remains the <sup>Most</sup> reliable way of identifying cases of latent infection.

#### Laboratory Diagnosis.

This may be done in confirmation, or independent of clinical diagnosis, and actually it offers the only convincing form of anti-mortem diagnosis

1. Microscopical diagnosis. This is usually applied to sputum, pus, or to milk. Sputum examination - though of vital importance in human medicine - has little veterinary application under South African conditions. For the rapid testing of pus collected by gland puncture, microscopical examination is invaluable, as it gives an immediate answer, and is reasonably accurate if sufficient time is given to examining the smear. If duplicate

- smears -

smears are prepared, the second one being stained by the gram method, the examination is facilitated, since any smear showing no organisms stained by gram should be specially carefully examined when stained by the acid-fast method. Generally speaking, a negative gram picture used to be highly suggestive of tuberculosis, but this generalisation no longer holds because of an epidemic of Lumpy Skin Disease (see later), which has left a trail of apparently sterile abscesses in its wake. If time is available a negative smear result should always be confirmed by biological test, which will show up tubercle organisms too small or too few to be seen, as well as filterable forms of tubercle bacilli (vide Walker & Sweeny 1934).

In the case of milk, microscopical examination offers the only rapid method of diagnosing tubercular mastitis, and it can give extremely accurate results. Early reports by Wood (1931) and Pullinger (1934) were unfavourable to this test, but with the introduction of the "endotheloid cell-group" technique (vide Torrance 1932 and 1927, Matthews 1931, Davies 1933, and Cowan and Maddocks 1938) the whole position has changed. If tubercle bacilli in milk smears are sought in association with certain specific tissue cells, then the microscopical test is almost as sensitive as the biological one, if udder samples are being examined, but the technique has not proved to be satisfactory for the examination of pooled milk. When 120 herd samples were subjected to comparative tests, 41 showed up as containing tubercle bacilli under biological examination; whereas tubercle bacilli were only found in 11 samples during a search of 30 minutes per sample made under the microscope.

2. Biological -

2. Biological Test. The technique of this test is fairly well standardised, the aim being to collect the centrifuge deposit from as large a sample as circumstances will allow for inoculation into guinea pigs. Intra-muscular, or at least subcutaneous inoculation of guinea pigs is preferable to the intra-peritoneal route, because incidental contaminants cause less trouble if inoculated into a leg, whilst the tubercular lesions set up by such inoculation in no way resemble natural infection. The question of incidental losses arising from contaminants in the inoculum can become a matter of major importance, whilst incidental sporadic disease, or actual epidemics can ruin an investigation. In any case, certain losses from intercurrent infection must be anticipated, thus Pullinger (1934) reported the following losses amongst guinea pigs, when testing various grades of milk for tubercle contamination:-

Rail tank milk - raw	...	11.5 per cent.
"          - pasteurised		2.6 " "
Herd samples - raw	...	8.5 " "
Graded herd samples	... )	6.5 " "
(Certified T.T. & Grade A.T.T.)		

During the above tests, all guinea pigs were caged separately, but in the course of subsequent work, it was found that the losses from intercurrent infection were greatly increased if guinea pigs were caged in pairs, or in large groups. Thus in one experiment, 100 animals were equally divided between four paddocks, and of these 48 per cent died prematurely of causes listed below.

Haemolytic streptococci	8
Salmonella typhi-murium	32
Pasteurella pseudo-	
tuberculosis. ...	1
Unknown causes.	7

This subject of premature death of guinea pigs is also discussed by O'Brien.

A serious defect in the biological test is the length of time that must elapse before the result of a test can be known. According to figures given in the M.R.C. Report (1935c) tubercle bacilli would have been missed in 35 out of 47 instances, had the guinea pigs been killed after 4 weeks' incubation. Pullinger(1934), on the other hand, presented evidence to show that 4 weeks is sufficient time for incubation. Even four weeks, however, constitutes a long time, and attempts have been made to shorten this period by subjecting inoculated guinea pigs to a tuberculin test.

Coveney and Edington (1934) reported upon the tuberculin testing of guinea pigs, and according to their findings, after two weeks' incubation there was 32 per cent of agreement between the tuberculin test and macroscopic post mortem findings, whilst after three weeks there was 78 per cent of agreement. Working along similar lines the writer obtained results recorded in Table 2. All the guinea pigs in this test gave negative tuberculin reactions prior to inoculation with milk.

T A B L E 2.

Correlation between tuberculin tests and the post mortem examination of guinea pigs.

Period of incubation.	No. of G. pigs tested.	Times when both tests agreed.	Times when both tests disagreed.
15 days	8	3	5
19 - 24 days.	56	49	7
27 - 29 days	87	78	9

- These -



These findings agree sufficiently closely with those of Coveney and Edington, and they indicate that even after three weeks, infected guinea pigs may not yet be tuberculin sensitive. For routine purposes, therefore, the trouble of tuberculin-testing guinea pigs two to three weeks after inoculation with milk outweighs the advantages accruing from such a procedure. Working in South Africa, Lewin (private communication) considers that even six weeks may be too short an incubation period, and he considers that even eight weeks' incubation and a negative tuberculin test and a negative autopsy result may be necessary, before a negative biological test result can be recorded.

In theory at least, the whole biological test for tuberculosis might be invalidated, if it was found that guinea pigs are subject to the naturally contracted disease (and such spontaneous development of tuberculosis has been reported by Griffith 1930), for even the application of the tuberculin test to guinea pigs prior to use, would offer no absolute guarantee that animals were not already infected. In actual practice, the likelihood of spontaneous disease developing is remote, but even if it does occur it would never be confused with the inoculation infection, always provided that the inoculation is administered into some distal site, such as the thigh. Following upon such injection the route of the developing disease follows the chain of lymphatic glands, the oldest lesions appearing in the popliteal and femoral glands, and the infection spreading thence in sequence to the precrucial and internal illiacs, to those at the bifurcation



of the aorta, to those lying along the posterior aorta, and finally to the periportal lymphatic glands, whilst only later do the mesenteric and mediastinal glands, as well as the liver, lungs, and spleen become involved. With this type of distribution, the possibility of confusion with the spontaneously contracted disease can definitely be ruled out.

3. Clinical Examination. Used alone this can never be a reliable method of diagnosing tuberculosis, though a skilled clinical observer will be correct in a large proportion of instances, where active or advanced cases are being considered, but clinical examination is almost valueless against latent infection. The chief value of clinical examination lies in locating advanced cases, where desensitisation to tuberculin may already have occurred. In South Africa "piners" and advanced pulmonary cases are not often seen, and the majority of the so-called clinical cases show enlargement of superficial lymphatic glands, and particularly of the parotid lymphatic gland (vide Pullinger 1942), a good illustration of this type of lesion being given by Robinson (1944). A definite diagnosis of this glandular type of tuberculosis can seldom, if ever, be given, because it is only by laboratory test that Corynebacterium pyogenes infection can be excluded, and even in the case of apparent "pining", the symptoms may arise from the continual absorption of toxin from C. pyogenes abscesses situated in the internal organs, or even in the tissues of the foot. (vide Martignalia 1937-1938).

#### CONTROL OF TUBERCULOSIS IN DAIRY HERDS.

Under the Stock Diseases Act, Union of South

Africa (1911) tuberculosis is listed as a scheduled disease, and very extensive powers are given for its control, but unfortunately the powers that have been given are rarely used, with the result that control of tuberculosis is non-existent. The chief failures in the application of the Act to the control of this disease are:-

- (1) Where there are grounds for suspecting that the disease exists, instead of investigating the matter the State Department refuses to take any action to ascertain the grounds for this suspicion.
- (2) Where disease is known to exist, the State refuses to take any action with regard to "in contacts".
- (3) The state takes no steps whatsoever to stop the sale or other movement of animals suspected of being tuberculous.

Broadly speaking, the State Department concerned refuses to accept any responsibility for controlling this disease, the reason given being that the progress likely to be achieved in controlling the disease by applying the powers vested under the Stock Diseases Act would be small, in comparison to the cost. Put this way, the reason is plausible enough, if a short-term view is taken of the matter; but when nothing is done year after year, and decade after decade, whilst the disease position deteriorates more and more, then the fallacy of this argument is all too easily appreciated.

#### ORGANISED CONTROL SCHEMES.

Up to the present only one serious attempt has been made to control tuberculosis, namely an eradication campaign started in and around Durban. In this venture

- which -

which is described by de Kock (1932), the incidence of tuberculosis proved to be much higher than was anticipated, the figure working out at 38.8 per cent; moreover, no provision had been made whereby dairy farmers could replace culled tuberculous stock with healthy animals of similar milking capacity, and in consequence the whole scheme collapsed. This fiasco serves to stress the need for preparing a reasonably accurate survey of the incidence of disease before planning the details of any eradication scheme. Moreover, it also emphasises the necessity for first of all making provision for an adequate supply of healthy replacements.

In the Durban campaign, much misuse has been made of the fact that a certain proportion of non-lesion reactors were destroyed, and that, therefore, the tuberculin test was unreliable. In actual fact, only 4.0 per cent of such reactors were encountered, whereas in the U.S.A. eradication scheme from 7 to 10 per cent of such losses had to be accepted. Apart from the Durban campaign all other efforts to control the disease in South Africa have been confined to isolated herds, or to state controlled farm settlements, all of which have no bearing upon the general control problem.

In 1939 the Division of Veterinary Services, presented at the South African Medical Congress (vide Report 1939) a draft scheme for the control of bovine tuberculosis, but owing to the outbreak of war the scheme did not come into operation. Before considering the main provisions of this plan, it must be pointed out that under the existing laws any bovine that reacts to the tuberculin test must be slaughtered, and only under very exceptional

- circumstances -

circumstances can this provision be relaxed. It is the existence of this law which impedes all attempts to interest farmers as a whole in tuberculosis eradication schemes.

The scheme as presented in 1939 was in effect an attempt to simplify and to render more acceptable provisions that had been suggested some years earlier. Broadly speaking both the original and the amended schemes revealed the following weaknesses.

- (a) The scheme is a voluntary one, in which farmers are invited to participate, but no provision is made for the farmer to have a pilot test done, so that he can estimate the magnitude of the task that he is undertaking. Of his own free will, a farmer is asked to commit himself to an undertaking which may only amount to the slaughter of a small percentage of his herd with State compensation to assist him. Alternatively, it is just as likely that he is committing himself to having to slaughter out the bulk of his herd without financial assistance from the State.
- (b) If his test results fall between these two extremes, he may be faced with the problem of sub-dividing his farm and duplicating buildings and staff, in order to run several quarantine herds. Very often such separate herds cannot be run on one farm, but even where this is possible, it demands a further degree of capitalisation of the farm, and ~~SOME~~ <sup>SOME</sup> dairy farms are already over capitalised, owing to <sup>MISINTERPRETATION OF</sup> the sanitation demands of the local authorities.

c. - The -

- (c) The owner who has faced the risk of having his herd decimated, has met all the trouble and expenses of eliminating the disease, and at last has a tuberculosis free herd is offered recompense at the rate of one penny a gallon only.
- (d) No provision whatsoever is made for having available supplies of breeding stock free of tuberculosis, which can be purchased as replacements by farmers who are eradicating the disease. Consequently, the man who is eradicating will soon find that he is quite unable to replace his culls, and his milk output will dwindle.
- (e) Under the State scheme it is assumed that efficient pasteurising plants are available throughout the country, and that no difficulty will be encountered in diverting tuberculous milk to such plants. It cannot be too strongly stressed that there is a great dearth of efficient pasteurising plants. Moreover, it must be appreciated that to divert tuberculous milk into pasteurising plants as a set policy, would be a crippling blow to the whole pasteurisation movement. <sup>A PROPORTION OF THE</sup> South African milk consuming public is ~~averse~~ averse to pasteurisation, very largely on account of false propaganda that has been disseminated. If truth and colour could be lent to this false propaganda by a set practice of diverting tuberculous milk to pasteurising plants, then the whole movement to introduce compulsory pasteurisation would be set back by many years.

It may ~~be~~ seem that the foregoing comments are unnecessarily destructive, but it must be appreciated that,

for a control scheme to work, it must fit into the existing pattern of the dairy industry, unless the existing pattern can be altered to fit the proposed control scheme. A study of the report by Pullinger (1944a) shows all too clearly that the South African dairy industry is in dire need of reorganisation, but no one would seriously suggest that reorganisation should be patterned upon a tuberculosis eradication scheme, when this is one of the least important of the bovine diseases, and when bovine disease is only one facet of a problem which bristles with other shortcomings.

Turning to the question of constructive suggestions it must be stressed that it is most fallacious to plan to eradicate one bovine disease, whilst ignoring all others. Secondly, it is deadly dangerous to plan any control scheme without having available essential data regarding the distribution and incidence of the disease. Finally, it can be catastrophic to inaugurate a control scheme which involves the destruction of food producing animals, without first making provision for the replacement of at least a portion of such animals with healthy stock. Consequently, the establishment of big breeding farms must be considered an unavoidable pre-requisite to the inauguration of any eradication campaign that is likely to involve extensive slaughter of infected stock.

Bearing these points in mind, it will be realised that the following principles must be incorporated in the planning of an eradication scheme :-

- (1) The scheme must be comprehensive and be suitable to embrace all sections of the milk producing industry, and not be applicable only to one small section such as pedigree breeders or wealthy farmers.

- (2) It must cover all important diseases, and not be confined to one disease; furthermore, a survey must be made for each disease.
- (3) Preparations must be made in advance, to build up reservoirs of healthy stock to use as replacements.
- (4) The scheme must be a compulsory one.
- (5) It must fit into the existing pattern of the dairy industry, unless the pattern of the industry can in fact be altered to fit the scheme.
- (6) The scheme must be designed to attract and to meet the requirements of three sections of the "producing industry", these sections being the pedigree breeders, the heifer growers, and the milk producers. This involves creating a demand for milk from disease-free cows, either by offering the producers of such milk a worth while bonus, or by educating the public to demand, and to pay highly for such milk. Once the milk producer's interest is aroused, he, in turn, will interest the heifer grower and pedigree breeder by demanding disease free stock, and by being prepared to pay highly for such animals.

The fuller details of the comprehensive eradication scheme are discussed at the end of the next chapter.

2. Bovine Contagious Abortion. Contagious abortion is an infectious disease of cattle usually caused by Brucella abortus, but sometimes also by Brucella melitensis. The earliest progress in the investigation of Brucella infections was done by the Royal Commission on Malta Fever; Zammit (1906), and Horrocks and Kennedy (1906)

- showing -



showing conclusively that goats were the natural reservoir of Malta Fever infection, which generally spread to man through goats' milk. Meanwhile in Europe and America, a contagious form of cattle abortion was being investigated, and the causal organism was ultimately determined by Bang and Stribolt. Working in America Alice Evans noticed a striking similarity between the organism causing Malta Fever and the one causing bovine contagious abortion, and as a result of her work (vide Evans 1918) both organisms were included in the same genus. Traum (1914), studying a somewhat similar disease in pigs, isolated yet another organism similar to these two, and Meyer and Shaw (1920), correlating all the available evidence grouped all three organisms under the generic name of *Brucella*. It was at first thought that these three organisms were definitely species - specific as regards pathogenicity, but it gradually came to be realised that these differences in pathogenicity were differences of degree only, and that in any case all three species could become pathogenic to man. A useful review and bibliography, covering the foregoing ground is given by Smith (1934).

A stage had now been reached, when it was necessary to decide whether these so-called caprine, bovine and porcine strains are in fact different species, or mere varieties of a single species differing only in pathogenicity. Wilson (1933) correlated all the work done in the differentiating of these organisms, and worked out a set of criteria suitable for dividing the *Brucella* genus into three species, viz:- meletensis, abortus and suis.

#### INCIDENCE OF CONTAGIOUS ABORTION.

In England a fairly extensive review and survey



of the incidence of this disease was made by Priestley (1934), who concluded that 37 per cent of all cattle and 23 per cent of all cows slaughtered at the London Metropolitan Abattoir gave positive serological reactions to Br. abortus. In the U.S.A., Graham and Thorp (1930) reported that 20 per cent of all cattle gave positive reactions, a figure that was confirmed by other workers in a subsequent report (vide Report 1932b); whilst in yet a later report (Report 1938a) a lower figure of 15.4 per cent was given. From other parts of the world, higher percentages than these are given (vide Priestley 1934 for bibliography).

From the point of view of milk control, it is desirable to have some accurate information regarding the proportion of infected cows (i.e. cows giving positive serological reactions) that excrete Brucella abortus in their milk, since the chief public health significance of this disease lies in the fact that Br. abortus can attack man, producing a disease known as undulant fever. Runnels and Huddleson (1925), and Doyle (1935) drew attention to the fact that Br. abortus infection in the cow tends to localise in the udder, as well as in the uterus and certain lymphatic glands, but their work gives no indication of the proportion of infected cows that "carry" in the udder. Sheather (1923) reported that 34 per cent of cows giving positive serological reactions had infected udders, but apart from this one report very little direct evidence exists on the subject. Much work has been done upon the collection of indirect evidence, and a fairly extensive bibliography has been set out by Pullinger (1934), covering

work done in Great Britain. For instance, Gaiger and Davies (1933) reported that 43 per cent of herd samples contained Br. abortus, Beattie (1932) found 35 per cent of market milk samples to be thus contaminated, Pullinger (1934) found from 20 to 40 per cent of ordinary herd samples and 70 per cent of Certified and Grade A.T.T. herds to contain this organism, whilst the same worker reported that 85 per cent of rail tank samples showed Br. abortus.

As regards the incidence in South Africa, very little is known beyond the fact that the disease is widespread. The Division of Veterinary Services have an immense file of records of herd tests for this disease, but the records have never been analysed and the results made available for consideration. Working upon a small scale, the writer has attempted to fill this gap in the knowledge regarding the incidence. In the first study (vide Pullinger 1940), 38 herd bulk samples were examined by guinea pig inoculation, and only 4 were found to contain Br. abortus. For reasons that will be discussed later this figure was considered to be misleadingly low. In a subsequent survey composite herd samples were examined for the presence of Br. abortus antibodies in the milk whey. Using this test as an index of the potential Brucella contamination of the milk, it was found that 22 per cent of 154 composite herd samples showed milk whey agglutination in a dilution of 1:10, and this reaction can be taken as evidence of probable contamination. Even the figure of 22 per cent must be regarded as a minimal one representing the percentage of herds grossly infected with contagious abortion. From the foregoing, however, it is

very obvious that in South Africa, there is need of much information regarding the incidence of this disease amongst herds.

DIAGNOSIS OF CONTAGIOUS ABORTION IN BOVINES.

Agglutination Test.

The agglutination test of blood serum has long been the routine diagnostic procedure, but considerable mistrust of this test has been felt, particularly by German workers, so much so, in fact, that other serological tests have been developed, chief amongst these being the Meinicke-Klarungs-Reaktion (M.K.R. test), which is similar in principle to the Wasserman test. It would be quite impossible to survey the vast volume of experiments that have been used to compare the Agglutination with these other tests, but almost without exception, these experiments are worthless, because a carefully standardised M.K.R. test has been compared with an agglutination test that has been performed with unstandardised antigen. A standard agglutination technique has been laid down by the Agricultural Research Council of Great Britain (vide Stableforth 1936a), and if this procedure is adhered to, the test is quite as satisfactory as any of the substitutes. The lack of uniformity of technique is well shown by Stableforth (1936b), who compared the antigens and methods used in Europe. He found that a standard serum giving a titre of 1:20 with the A.R.C. procedure might give a result of anything from Nil to 1:200, when tested by different German investigators.

The agglutination test can be used for testing milk whey, as well as blood serum, in which case the presence of antibodies in a titre of 1:10, or more, indicates that

certain of the lactating cows have fairly high serum-antibody titres, and that sufficient serum is filtering through into the milk, to overcome the dilution effect in a composite milk sample. According to certain workers, including Cooleage (1916), Smith, Orcutt and Little (1923), and Gwatkin (1931), there is strong evidence to show that *Brucella* antibodies are actually produced locally in the udder. Jones (1926), on the other hand, has shown that :-

- (a) during normal lactation serum protein (containing the antibody fraction) filters through the udder tissue into the milk;
- (b) the rate of filtration increases at the beginning of lactation, or during an attack of mastitis.

Using the "optimal proportion" precipitin method of measurement, Pullinger (unpublished records) was able to show a definite correlation between the amount of undenatured serum protein in whey, and the presence or absence of streptococcal mastitis in the quarter of the udder under test. In a healthy udder filtration was slight, but increased in direct relation to the severity of the mastitis.

A positive whey agglutination titre shows that milk has come from infected cows, but it does not necessarily show that it contains *Brucella* organisms, and according to Sheather (1923), only 34 per cent of cows that give positive blood agglutination reactions actually do secrete contaminated milk. Pullinger (1934), dealing with pooled milk, found a close correlation, as is shown by the figures in Table 3 extracted from the report quoted.

- Table 3 -

T A B L E 3.

Comparison of biological and whey agglutination tests.

Class of Milk.	No. of samples.	Percent-	Percent-	Percent-
		age. Whey + G.Pig +	age. Whey - G.Pig. +	age. Whey + G.Pig. -
High Grade	70	67	24.3	8.7
Ordinary.	47	40.5	17.0	42.5
TOTAL	117	56.5	21.3	22.2

In high grade milk there is close correlation between a positive whey result and the development of infection in inoculated guinea pigs. In ordinary milk, on the other hand, there is no correlation at all, this being due to the unsuitability of the biological test for examining dirty milk, a point that will be discussed fully later.

Biological Test.

The inoculation of guinea pigs with supposedly contaminated material is a test that developed out of the findings of Schroeder and Cotton (1911), who reported that the inoculation of milk into guinea pigs for tuberculosis diagnosis sometimes resulted in the development of lesions due to Br. Abortus. The test came to be accepted as a routine procedure for isolating this organism, but in one series of tests Pullinger (1934) obtained the result recapitulated in Table "4"

T A B L E 4.
Biological testing of high grade & ordinary milk.

Class of milk.	No. of samples.	Per cent positive to Br. Abortus.
Certified.	44	63.3
Grade A.T.T.	57	73.6
Ordinary Herd Samples.	209	28.6

These figures suggested that in England the incidence of contagious abortion is much higher in good herds than in ordinary ones, a conclusion quite contrary to all available information, and it became necessary to explain these results.

It was at first thought that whereas with milk having a low bacterial count the biological test is sensitive, when Br. abortus is inoculated with many saprophytic milk-souring bacteria the Brucella might be destroyed by the strong tissue reaction set up by the mixed injection. This possibility was studied (vide Pullinger 1936), and it was concluded that dirty milk per se exerted no inhibitory action. The possibility still exists that certain special bacteria might have an inhibitory effect, one obvious possibility being the tubercle bacillus. According to Schroeder and Cotton (1911) and to Schoenfield and Cotton (1925) the tubercle and brucellar infections are mutually helpful, whereas Wilson and Nutt (1926) concluded that the two infections develop independently without interfering with one another. Working under experimental conditions Pullinger (1936) found that massive doses of Br. abortus had to be inoculated with virulent tubercle bacilli for the Brucella infection to become established. In a subsequent report (vide Pullinger 1938), it was shown that allied acid-fast bacilli, such as Johnes bacillus and B.C.G. had no such inhibiting effect. It was assumed, therefore, that the strong mononuclear reaction induced by the tubercle bacillus gave rise to the inhibition of the Brucella infection. To obtain confirmation of this hypothesis, the experiment was repeated, using Bact. Monocytogenes in place of the tubercle bacillus, and a similar type of inhibition was induced. It is reasonable to suppose, therefore, that other unidentified bacteria may

- have -

have a similar effect, and the possibility of such bacteria being in milk renders the biological test unreliable for identifying Brucella contamination of milk, though it remains a useful way of isolating this organism from post-mortem material. In spite of the unsatisfactory nature of the biological test, however, it is frequently the only one that can be used for locating Brucella contamination of milk, and for this reason certain aspects of the test deserve consideration.

1. The significant agglutinin titre in guinea pigs. It is necessary to determine the lowest guinea pig agglutination titre that may reasonably be considered to represent positive reactions as opposed to "normal agglutinins". To this end the serum titres of 123 guinea pigs have been analysed after the guinea pigs had been inoculated with Brucella contaminated milk, and after Br. abortus had been isolated culturally from all of them when killed four weeks later. The figures are extracted from a report by Pullinger (1934), and are set out in Table 5.

T A B L E 5.

Brucella agglutinin titres of 123 guinea pigs.

Serum titre.	1:10	1:20	1:40	1:80	1:80
No. of G.pigs.	2	2	15	11	93

N.B. A.R.C. standard agglutination technique used.

These figures show that in some infected guinea pigs the agglutinin titre may still be as low as 1:10 a month after inoculation, low titres such as these being due to the combined influence of low dosage, and the

- presence -



presence of some inhibitory agent. This point is dealt with more comprehensively by Pullinger (1936 and 1938). There still remains the possibility that in certain instances a low titre may sometime represent "normal agglutinins" (vide Lovell 1934), the fact that guinea pigs are encountered that are serologically infected and culturally uninfected lending colour to this idea. No convincing direct evidence exists on this subject, but a considerable volume/<sup>of</sup> indirect evidence suggests that guinea pigs do not show normal agglutinins to Br. abortus. Pullinger (1934) reported the testing of 63 samples of pasteurised milk, involving the use of 126 guinea pigs, but none of these animals showed any agglutinin titre at all. Similarly, Pullinger (1935a) reported upon the examination of 35 samples of pasteurised cream, and 89 samples of butter and cheese, and of all these only 6 guinea pigs showed agglutinin reactions. These six having been inculcated with unripened cheese extract, not only gave serological reactions, but also gave positive cultural results. These six definitely infected guinea pigs were the only ones out of a group of 350 to show positive agglutination reactions, and such evidence which is being duplicated all the world over indicates that healthy guinea pigs do not show such "normal agglutinins". The question of "normal agglutinins" must not, of course, be confused with that of natural infection, for it is well known that guinea pigs can contract infection naturally if suitably exposed. (vide Surface 1912)

2. The rate of development of Brucella antibodies in guinea pigs. Like the biological test for tuberculosis, this test for Br. abortus infection is a slow



one, and for milk control purposes it is desirable to shorten the duration, if this is possible. According to Smith (1932), out of a group of 123 pairs of guinea pigs under test, 53 gave negative agglutination results on the 28th day, whilst the duplicate mates which were allowed to survive 56 days, gave positive serological results. These findings suggest that it is necessary to run the biological test for 6 weeks, before negative results can be considered significant. To investigate this point more fully, guinea pigs have been inoculated with milk naturally contaminated with Br. abortus, and prior to inoculation they were bled from the heart, and were then rebled at various intervals after inoculations. The findings of this experiment are recorded in Table 6.

From the results recorded in this table, it is obvious that 3 weeks is the minimum incubation period, if reliance is to be placed upon serological diagnosis, but four weeks would constitute a safer average period for routine purposes. Bearing in mind the findings of Smith (1932), who was probably handling very lightly contaminated samples, or samples containing some Brucella inhibiting agent, it must be accepted that the incubation period may be long enough to detract seriously from the value of the biological test for routine diagnosis.

3. Relative value of serological and cultural testing of inoculated guinea pigs. Obviously it is important for routine purposes to ascertain whether either of these tests is the more reliable, and whether one or other may be omitted. The results bearing on this point are extracted from the previously quoted report, and are recorded in Table 7.

T A B L E 6.

Development rate of Br. abortus antibodies in artificially infected guinea pigs.

G. pig No.	Agglutinin titre of G. pig serum.										Incubation period in days.	Cultural Examination			
	7	14	21	28	35	42	49	56.	63.	72		post-mortem.			
188	0	1:40	1:160	1:2560	1:5120	Died							Br. abortus	positive.	
195	0	0	0	0	0	0	0	0	Q	killed			"	"	negative.
196	0	0	Died										"	"	negative.
199	0	1:20	1:40	1:320	1:160	Died							"	"	positive.
200	0	0	1:40	1:40	1:80	1:320	1:640	Died					"	"	positive.
206	0	0	1:80	1:320	1:320	1:320	1:640	-	-	1:20480			"	"	positive.
208	0	0	1:80	1:160	1:320	1:80	1:80	-	-	1:1280			"	"	positive.
212	0	Died											"	"	negative.
217	0	0	0	0	0	Died							"	"	negative.
218	0	0	0	0	0	0	0	killed.					"	"	negative.
220	0	1:40	1:80	1:320	1:640	1:1280	1:1280	-		1:81920			"	"	positive.
228	0	0	1:80	1:320	1:2560	1:5120	1:5120	-	-	1:5120			"	"	positive.
236	0	1:80	1:320	1:160	1:640	1:320			1:2560	killed			"	"	positive
239	0	0	1:20	1:80	1:2560	1:640	1:5120	killed.					"	"	positive

N.B. A.R.C. technique adopted.

- = No test made.

T A B L E 7.

Comparison of serological & cultural testing of inoculated guinea pigs.

Class of milk.	No. of guinea pigs.	Agg. + Cult. +	Agg. + Cult. -	Agg. - Cult. +
Graded milk	128	112	12	4
Ordinary milk.	40	11	26	3

From the figures in this table the following deductions can be made :-

- (1) With clean milk the serological and cultural tests agree closely, whereas with high count milk they do not agree.
- (2) Of the two tests the serological one is the more sensitive under practical conditions, particularly in the case of milk such as the ordinary market milk that contains *Brucella* inhibiting substances. Results recorded by Pullinger (1938) suggest that better cultural results might be obtained, if the local lymphatic glands were cultured a few days after inoculation, instead of many weeks later.

Direct Cultural Examination of Infected Material.

Direct culture may be done from the blood, uterine exudate, placental material, foetal material, milk, or pus. Blood culture, though commonly done in man is less often used in animals. Cultivation from the other materials almost invariably involves isolation from contaminated material, which is done on to solid medium. A number of different media have been recommended from time to time, including serum agar, potato extract agar, Huddleson's liver extract agar, etc., all of these being reasonably effective, if properly prepared. Primary cultures should

-- always -

always be put up in duplicate for incubation under normal atmosphere and under 10 per cent carbon dioxide. This is important, because primary culture under the wrong atmospheric conditions may induce a degree of gas tolerance, which can interfere with the subsequent <sup>SPECIFIC</sup> typing of a strain.

Influence of Concurrent tubercle and Brucella infection in Bovines.

In a report already referred to (vide Pullinger 1936), evidence was presented to show that in the case of guinea pigs tubercular infection definitely increases the resistance to Brucella infection, and it is of interest to know whether any similar increase of resistance occurs in cattle infected under natural conditions. Data has been collected in England of the incidence of Brucella infection in a group of cows known to be tuberculous, and in another group known to be free from tuberculosis, whilst these incidence figures have been compared with figures representing the normal distribution of Brucella infected cows, as given by Priestley (1934) and by Doyle (1937). The question of the presence or absence of tubercle infection was decided by abattoir findings. The relative figures are recorded in Table 8.

Commenting upon these figures it can be stated that no significant difference is shown between the tubercular, non-tubercular and control groups A to E, whilst the high percentage of Brucella reactors in the tuberculin tested groups was due, very likely, to the widespread use of living contagious abortion vaccine. It seems reasonable to assume, therefore, that with naturally infected cattle the two diseases develop concurrently, without interfering

TABLE 8.

 Influence of concurrent tuberculosis upon  
 Brucella infection of cattle.

Group.	Type of cow.	No. cows. Examined.	Percentage of cows with Brucella Agglutination titres as shown.			
			1:20	1:20	1:10	Nil.
A.	Tb. positive at P.M.	140	21.4	4.3	6.4	67.9
B.	Tb. negative at P.M.	92	10.9	2.2	6.5	80.4
C.	General slaughter.	100	14.0	7.0	11.0	68.0
D.	Ordinary Dairy herds.	884	22.8	4.2	13.8	59.2
E.	do.	311	34.7	2.9	7.7	54.7
F.	Tuberculin tested herds.	168	74.3	15.5	7.2	3.0
G.	do.	278	43.8	17.6	16.4	22.6
H.	Random selection.	684	35.0%	posi- tive)	65.0%	nega- tive.)

N.B. Group C represents figures given by Priestley (1934).

Group H " " " " Doyle (1937).

The remaining figures have been collected by the author.

with one another, and consequently there is little or no hope of developing a Bacterium monocytogenes vaccine for stimulating tissue resistance along the lines studied by Pullinger in a previous report (vide Pullinger 1938), when guinea pigs were used.

Legal aspects of control of contagious abortion.

Contagious abortion was formerly a scheduled disease under the Stock Diseases Act, and as such may be controlled as thoroughly as tuberculosis. As in the case of tuberculosis, however, the provisions of the Act were not enforced where this disease existed, or was suspected of existing, and finally this <sup>STATE OF INACTION RECEIVED OFFICIAL SANCTION</sup> ~~STATE OF INACTION RECEIVED OFFICIAL SANCTION~~ Schedule (vide Govt. Notice 870 of 1919). Suspected and actual cases of infection are now not reported, and the fact that the State may be aware of the outbreaks of disease is fortuitous, because the State laboratory does the diagnostic tests, but infected and in contact stock can be moved without permit, whilst stock sales and speculators' yards are hot-beds of infection.

Control of contagious abortion.

No definite control scheme exists in South Africa, but farmers are encouraged to blood test their herds. On the basis of these tests, and depending upon local circumstances, the farmer is subsequently advised to cull infected stock, or to vaccinate. Eradication by running infected and healthy herds is purely a voluntary measure, no bonus or other inducement being offered to the farmer who controls this disease, and it is not surprising, therefore, that only a few herds are subjected to regular testing. The farmer who is losing too heavily as a result

of abortion, usually resorts to vaccination, and by this means calf losses can usually be reduced to minimal proportions. From the public health point of view, vaccination is not without danger, this being a point that will be discussed more fully later.

Vaccination. Much work has been done in Britain and the United States on this subject, and it would be out of place to attempt to review the literature here, since recent comprehensive surveys have been prepared by Robinson (1941) and (1945). In finding a suitable vaccine, the following are important requirements :-

- (a) The vaccine should not interfere with serological diagnosis for any appreciable time after administration; moreover, it should not induce abortion, or active infection.
- (b) Nevertheless it should leave a strong immunity to natural infection, lasting at least a year, and preferably longer.
- (c) It must not leave behind a residual living infection in vaccinated animals, even though this particular strain of infection may appear to be apathogenic.

Research into the question of vaccines has led to the search for non-virulent, immunity stimulating strains of Br. abortus and to the investigation of the best time for administration of the vaccine. Considerable success has been achieved by calfhood vaccination, but no finality has been reached in this connection; but a point that has so far received but scant attention is the Public Health significance of any vaccination policy. This aspect will be referred to again later. Probably one of



the chief obstacles to the production of an efficient vaccine is a lack of understanding of the true nature of the *Brucella* immunity. As the result of a chance observation regarding the isolation of Br. abortus from dirty milk (vide Pullinger 1934) a new line of approach was obtained for the study of the nature of this immunity, and from subsequent studies (vide Pullinger 1936 & 1938,) it became evident that in the very first stage of infection resistance depends entirely upon the mobilisation of cellular defences, and in particular mononuclear cells. It was found that by mobilising these cellular defences by means of some suitable stimulation (e.g. a local injection of tubercle bacilli or Bact. monocytogenes), the guinea pig could be made resistant to enormous doses of Brucella abortus. The experiments referred to showed very clearly that humoral antibodies played no part in the resistance in the early stages of infection, and in fact, the battle between the host and the parasite was already won or lost before humoral antibodies even appeared in the blood. The aim in vaccine production, therefore, seems to be to find a substance which will keep the mononuclear tissue cells (i.e. reticulo-endothelial system) in a constant state of mobilisation. This demand is only likely to be fulfilled by some vaccine which survives in some dormant but living condition in the animal body. If this supposition is correct, then it is improbable that *Brucella* infection could ever be eliminated by a vaccination policy (in the sense that smallpox can be eliminated), and the control of the symptoms of active infection is the best that can be achieved. From the agricultural point of view this is satisfactory enough, but from the Public Health viewpoint, it renders the disease a constant menace to safe milk production. A further difficulty caused by vaccination with

living vaccine which persists in the tissues, is that an interference of unknown magnitude is introduced into the question of using serological tests for identifying infected animals. The difficulties that can arise from this were realised all too clearly in the days when the Widal and complement fixation tests were the only ones available for identifying human typhoid carriers.

Control methods of the future.

As has already been stated it is, in the writer's opinion, useless to visualise any control scheme which does not include all important infectious diseases of dairy cattle, for it is worthless to build up a herd free from contagious abortion, but ~~is~~ riddled with tuberculosis, mastitis and salmonella infections. The best hope of controlling this particular disease would appear to be the introduction of a universal vaccination policy knit into a general control scheme such as is discussed at the end of the next chapter. If such a policy were adopted, it would have to be accepted as an unavoidable corollary that no milk is quite free from the danger of carrying undulant fever infection to man.

3. Mastitis.

Bovine mastitis may be caused by a number of different bacteria, chief amongst these being :-

Streptococci - usually Strep. agalactiae.

Staphylococci usually Staph. aureus.

Corynebacterium pyogenes,

Mycobacterium tuberculosis (This condition has already been discussed).

STREPTOCOCCAL MASTITIS.

Streptococcal mastitis is by far the commonest

udder infection of cows, representing the dairyman's major disease problem, and it is in the chronic form that the disease creates the greatest difficulties. According to the belief of the average farmer, the disease occurs only in acute or extreme forms when the udder is greatly charged, or the milk most unusual in appearance. The moment the udder and milk return more or less to normal, the farmer is apt to assume that recovery has occurred, and it is for this reason that many farmers firmly believe they have little or no mastitis infection in their herds. The farmer, however, who keeps accurate milk records, knows only too well that chronic mastitis is the greatest problem that he has to tackle.

#### INCIDENCE.

Chronic streptococcal mastitis is widespread throughout the world, but because diagnosis has in the past been a complex procedure, most surveys of incidence have been very restricted in scope. For instance, Davis (1918) reported that out of 45 samples from certified herds about half contained mastitis streptococci. Salter (1921) found mastitis streptococci in 35 samples of milk collected from 14 dairies, these samples including ordinary, certified and supposedly pasteurised milk. Frost Gunn and Thomas (1927) examined 1000 cows from 5 certified herds at monthly intervals for 18 months, bulk samples from 10 cows being subjected to test, and of these 28.6% contained haemolytic streptococci of mastitis type. Many such surveys could be quoted, none of which differ very greatly from the figures reported by Pullinger (1935b). In this report it is stated that when 96 samples collected from 39 certified and Grade A.T.T. herds were examined,

only 8 herds failed to show signs of haemolytic mastitis streptococci at any test. Of 26 of these herds which were subjected to 3 successive tests, only 4 were free from signs of mastitis on every occasion, and all these 4 herds had been subjected to laboratory testing and control of the disease for many months. Fifty-eight bulk samples of ordinary milk from large rail tanks all contained these haemolytic streptococci. It should be appreciated that far heavier infection would have been encountered, had it been possible to check up upon the non-haemolytic forms of mastitis streptococci, for according to Edwards (1932), the latter type is the commoner cause of chronic disease.

In South Africa but little is known beyond the fact that the disease is widespread, though Van Rensburg and Thorburn (1941) reported upon some preliminary work done on a very limited scale. To obtain more definite and extensive information regarding the incidence in commercial dairy herds (as opposed to pedigree ones), the writer has collected information during the course of routine milk testing, this data being reported by Pullinger (1944) and (1946a). A series of 435 herds situated in the Transvaal and Northern Free State were subjected to fairly regular examination, Breed smears of bulk milk being examined. The presence of definite evidence of the admixture of mastitis milk was recorded, definite evidence being taken as the presence of an abnormal number of pus cells with typical mastitis streptococci also present in the smear. It will be appreciated, therefore, that by adopting such severe criteria positive cases were missed, but in spite of this only 6.0 per cent of the herds never showed signs of mastitis milk, whilst of this

6.0 per cent only one of these herds was subjected to a reasonable number of tests. This survey gives a clear picture of the extreme gravity of the chronic mastitis position in South Africa.

As a corollary to the foregoing it seemed desirable to ascertain the extent to which individual herds are affected in South Africa, and for this purpose a small survey was made, using the direct microscopical examination of incubated samples (vide Van Rensburg 1941) as the diagnostic test. Actually it was found necessary to introduce small modifications to Van Rensburg's technique, to render the test suitable for use under field conditions, these modifications being reported upon by McLaughlan and Pullinger (1944). The results which were reported by Pullinger (1944) are reproduced in Table 9.

T A B L E 9.

Incidence of mastitis infection amongst  
lactating cows in 16 herds.

Number of herds with percentage of infected cows as shown.			
0 - 10%.	11 - 25%.	26 - 50%.	Over 50%
0	5	9	2

These figures speak for themselves, and there is no need to emphasise the gravity of the situation.

CONTROL.

It has been clearly shown by workers such as Minnett, Stableforth and Edwards, as well as by many others, that this disease can be eradicated, provided a herd is really self-contained, the herd is kept under continual test for the appearance of infection, and all infected cases are removed. At present it is quite unpractical

to apply such comprehensive measures to commercial dairy herds as a whole, and for this reason much attention has been given to therapeutic measures to combat the disease. It is not intended to review the therapeutic research that has been done, because the very nature of treatment at present precludes it from general use in South Africa. Successful treatment depends upon early diagnosis, for which facilities are usually lacking. Laboratory facilities are also required, to ascertain when treatment can safely be discontinued, the cost of treatment is apt to be prohibitive, and the therapeutic procedures are not readily mastered by farmers, whilst veterinarians are not available for such work.

At the present juncture it would seem that the average dairy farmer should aim at limiting the spread of mastitis, rather than attempting to eradicate the disease. Spread can largely be limited by regular supervision of the herd, coupled with milk-recording, and the regular use of the strip cup test. The farmer who is meticulous in these matters, and deals with infected animals along simple isolation and hygiene lines will not be troubled by an undue spread of infection. The heifer breeder and pedigree breeder should be more concerned with the complete elimination of infection, and such farmers are generally better situated to practise strict isolation of infected herds, but they too lack the necessary laboratory facilities, and veterinary assistance, which are essential to elimination of this disease. Probably the most useful measure that breeders can adopt is to dispose effectively of all infected milk, for it is not widely realised by farmers that the feeding of doubtful or unmarketable milk to calves may lead

to a calfhood infection that is never thrown off. Literary references to this problem of calfhood infection include McLean and Hewitt (1935), Stableforth, Edwards and Minett (1936); Minett (1939), and Van Rensburg (1942)<sup>1</sup>/<sub>2</sub>. These investigators all present circumstantial, but nevertheless very convincing evidence, of cases where virgin heifers, or heifers calving down for the first time, developed mastitis when the only contact with infection had been the feeding of mastitis milk during calfhood.

It is appropriate at this point to discuss the question of mastitis control from the point of view of the dairy industry. Leaders of the dairy industry have long realised that some form of control is necessary, if only to ensure that large pools of milk are not ruined by the admixture of milk too abnormal on account of mastitis infection, for mastitis milk will not boil, and begins to flocculate even when pasteurised. Attempts have, therefore, been made to evolve some test which would serve as a criterion of the degree of mastitis contamination to be permitted in the bulk supplies delivered by farmers. In one such survey Pullinger (1936) attempted to lay down a standard count for haemolytic streptococci of mastitis type above which milk should not be accepted as suitable for marketing. It was found, however, over a large series of tests that very striking variations in count might be expected in samples from any one herd, some of these changes being related to changes in the composition of the herd, whilst in other instances counts varied greatly whilst the composition of the herd remained static. Naturally, these variations in streptococcal count are due to variations in the numbers of organisms excreted by individual mastitis-

- infected -



infected cows, but it was thought that in pooled milk such variations would be smoothed out by dilution. This smoothing out of the variations did not occur, and it was concluded that no standard mastitis streptococcal count could be established.

Another method of tackling this problem has developed at the application of the Breed smear technique to mastitis investigations. This subject has been dealt with in some detail by Pullinger (1946a) in a report upon the examination of over 45,000 Breed smears collected from the repeated sampling of bulk milk from 435 producers over a space of three years. In the course of examining these Breed smears and recording the bacterial count, a note was made when definite evidence of mastitis contamination was seen. (Definite evidence consisted of the appearance of mastitis-type streptococci in conjunction with an abnormal Leucocyte picture). From a study of the data set out in the report quoted, it will be seen that as regards mastitis, producers fall into five main categories :-

- (a) No gross evidence of mastitis (Theoretical group usually).
- (b) Occasional evidence of mastitis.
- (c) Obvious but intermittent evidence of disease.
- (d) Persistent signs of mastitis.
- (e) Persistent signs of very severe mastitis.

T A B L E 10.

Percentage of 150 producers showing various degrees of mastitis contamination.

Group.	Extent of mastitis contamination of bulk milk.	Percentage of producers in each group.
a.	No gross evidence of mastitis.	18.4
b.	Occasional evidence.	46.1
c.	Obvious but intermittent evidence.	22.8
d.	Persistent signs of mastitis.	8.9
e.	Persistent signs of severe mastitis.	3.8

An analysis is given in Table 10 of the results shown by a group of 150 farmers during the months of April and May, 1942, these being months when the incidence of mastitis was high. It will be seen that 18.4% of producers showed no signs of mastitis, but in a later survey incorporating 435 herds the figure for Group a. dropped as low as 0.25%. Examining Table 10 it will be obvious that it would not be practical policy to exclude from market all milk falling into groups b. to e., involving, as it does, milk from 70 to 100 per cent of all producers. It is equally obvious that milk from a producer falling into Group e. should not be marketed. Under a properly regulated milk control scheme, farmers should never be allowed to sink into group d. or e. Under any scheme where milk is frequently tested, it would be possible to warn producers when the mastitis position deteriorates, and the farmer could then take the necessary action. Clearly too, the milk control organisation would also have to establish laboratory facilities adequate to test individual cows in all herds where trouble threatened, in order to assist farmers to control this scourge. Using the modified Van Rensburg technique (vide McLaughlan & Pullinger 1944), a comparatively small laboratory could serve a relatively large group of farmers.

As regards the question of the allowable degree of mastitis, it would seem reasonable from Table 10 that any farmer falling into groups d. or e. should be prevented from marketing his products until the mastitis position be improved. Farmers would quickly rise to group c. by dint of culling and practising mastitis control, but they would lack the incentive to improve above this level.

An alternative procedure was suggested by Pullinger (1945-46), as applicable to "high-grade" milk. In that report it was suggested that to qualify for a permit to sell "high-grade" milk at an enhanced price, it would be necessary, amongst other things, for a farmer to keep the percentage of cows in his herd suffering from chronic mastitis, below the level of 5.0 per cent. Obviously, this idea could be elaborated and less severe percentages introduced to cover the ordinary grade of milk. Once again, however, any such system presupposes the existence of adequate laboratory facilities, something woefully lacking at present.

A third possible method of attack would be to incorporate within any grading system a standard Breed count for leucocytes comparable to the bacterial Breed count. Counts of leucocytes would not be judged upon an absolute basis, but according to the Good : Bad ratio. system (vide Pullinger 1945-46, and also later in this thesis), bonuses being paid according to the Good : Bad leucocyte ratio achieved throughout the year.

Bovine mastitis due to human type of Streptococci.

This subject will be considered in some detail in the next chapter, and at this juncture it is sufficient to stress that several authentic cases are on record of cows developing active mastitis, due to infection with Strep. pyogenes (this general name includes Strep. epidemicus, haemolyticus, scarletinae, etc.) Without going too deeply into the literature at this juncture, reference can be made to the "Doncaster cow" and "Bendixen's cow" (Bendixen and Minett 1938), outbreaks of scarlet fever and septic sore throat being caused in England and Denmark by cows infected

with the human type Strep. pyogenes. From the veterinary point of view the infection is no different from ordinary acute streptococcal mastitis, except that infection does not seem to spread readily from cow to cow. Thus, in the Doncaster herd, only one cow had human<sup>type</sup> streptococci, though a number of cows suffered from ordinary bovine mastitis. It is always assumed that infection arises from the cow having contact with a human carrier of virulent streptococci.

#### STAPHYLOCOCCAL MASTITIS.

It has long been known that certain acute cases of bovine mastitis are caused by staphylococci, but it has always been thought that this infection is of but minor importance. Shattock and Mattick (1940), however, stressed that sub-clinical mastitis is frequently caused by staphylococci, and they pointed out that this had been overlooked in England, because of the practice of culturing milk for mastitis test in crystal violet agar (vide Edwards 1933), a procedure that automatically precludes the possibility of obtaining a satisfactory staphylococcal survey, since crystal violet inhibits the growth of these organisms. Plastridge et alia (1939) gave a very detailed description of the staphylococci that may be isolated from milk, including in their report an extensive bibliography.

From the public health aspect the importance of these staphylococci hinges around their ability to produce a soluble and filterable toxin. This problem will be discussed more fully in the next chapter, and at this juncture it is sufficient to refer to two publications by Minett (1936 and 1938). In these two articles the author describes the preparation, separation and titration of

- filterable -

filterable toxins from staphylococci responsible for bovine mastitis. Minett concludes that staphylococcal Enterotoxaemia in man may sometimes result from toxic products formed by bovine strains of staphylococci.

#### Control.

So little is known of the incidence of staphylococcal mastitis in South Africa, or elsewhere, that any consideration of eradication plans is somewhat pointless. At present, the only survey method is by cultivating samples in plain blood agar, or in aesculin blood agar (vide Shattock and Mattick 1940). Such plating methods are, however, too cumbersome for application to any extensive survey, whilst the identification of bovine strains of staphylococci by direct microscopical examination has not yet been placed upon a practical footing.

#### Corynebacterium pyogenes mastitis.

Mastitis due to this organism does occur, but only fairly infrequently, though more generalised C. pyogenes infection can become a major problem on some farms. As a pyogenic disease of cattle this condition was first described by Lucet (1893), and the literature dealing with this subject has grown enormously since then. (vide Lovell 1937). The organism invades the lymphatic glands, and even the internal organs, producing either large caseating cold abscesses, or else abscesses filled with immense quantities of creamy pus. Predelection sites of infection under South African conditions are the superficial glands in the perineal region, (vide Martignalia 1935), and the parotid lymphatic gland (vide Pullinger 1942). Lovell (1937) reported that this organism was a common cause of calf pneumonia in England, whilst in South

Africa Pullinger encountered two extensive epidemics of calf pneumonia, due primarily to this cause. Pododermatitis of cattle (i.e. the so-called "voet-siekte") has already been referred to in connection with the clinical diagnosis of Tuberculosis, and strong grounds exist for believing that this condition may primarily be due to C. pyogenes infection with secondary invaders such as Fusiformis necrophorus playing some part too. Martignalia (private communication) has reported upon the presence of C. Pyogenes in smears prepared from affected feet, whilst in herds where pododermatitis commonly occurs C. pyogenes abscesses are also frequently to be seen. As has already been stated, the pure udder infection (i.e. summer mastitis of England) is not sufficiently common to constitute an important problem in South Africa, but the foot condition, the general pyogenic condition, and straight calf pneumonia, due to C. pyogenes are major problems on certain farms. The most hopeful method of attack appears to be the immunisation of all stock on badly infected farms. Lovell (1937) reported that C. pyogenes produces a filterable toxin against which anti-toxin can be prepared. Following this lead the present writer has prepared carbolised alum-precipitated toxoid, and used it on a farm where for several years the calf crop had been practically annihilated by C. pyogenes pneumonia. When all newly-born calves were inoculated with three fortnightly doses of this toxoid the disease disappeared from the farm.

#### 4. BOVINE PARATYPHOID FEVER.

Paratyphoid infection of cattle is wellknown to all calf-growers, and is a disease that has been studied widely, particularly in Europe. The disease appears to be endemic throughout the world, but the incidence rate varies greatly from place to place. The earlier descriptions of the causal agent are confusing, because of a lack of understanding of the systematic bacteriology of the non-lactose fermenting gram-negative bacteria, but with the adoption and elaboration of the Bruce White-Kauffman system of recognising and typing these organisms (vide Report 1934), the identification of the Salmonella group has become an accurate procedure. Actually, a large number of Salmonella species can cause bovineparatyphoid fever, but those commonly encountered are S. dublin, enteritidis and Typhi-murium.

Normally bovines pick up infection during early calf-hood, and calf-paratyphoid is a disease dreaded by all calf-rearers,. Infection may, however, be picked up at any age. A large proportion of infected calves die from this disease, whilst of those that recover all remain stunted, whilst some become latent carriers of infection. What proportion of recovered calves completely throw off infection is not known, but it is known that in certain parts of the world, such as Central Europe, sufficient carriers survive to create a major problem to veterinary and to public health authorities, because in such areas human salmonella food-poisoning arising from salvaged meat (i.e. meat which in South Africa would be condemned as unfit for consumption) constitutes a grave menace to health. The full public health significance of this disease will be discussed later.



### Incidence.

The incidence and control of this disease in bovines has for many years been subject to considerable study in Europe, though in Great Britain, the U.S.A., and in the various Dominions, the disease has never been studied very seriously, largely because meat salvage has never been practised in the latter parts, and so no overwhelming public health problem has ever arisen. In Central Europe, the carrier-rate is definitely high, though no undisputable figures can be quoted. In South Africa the mortality from calf paratyphoid frequently reaches frightening proportions, but nothing is known as to the incidence of the "carrier" state in adult cattle.

### Control.

A vast volume of literature, emanating chiefly from Germany and Central and South East Europe, has been published upon the control of this condition, and no useful purpose would be served by attempting to review it all, and it will suffice to refer only to reports by Manninger (1939) and Meissner (1939), which give a fair review of the whole picture prior to the outbreak of World War II. Both these authorities urge the need for eradicating this disease, and they stress that the eradication should include "latent carriers", as well as active cases, whilst parallel with the elimination of infected cases, a vaccination campaign should be run to protect all healthy stock.

Actually, the biggest problem in this connection lies in the identification of the latent carrier, because differences of opinion exist with regard to the value of the serological test for identification purposes. Thus, Piening (1939) considers the agglutination test to be a waste of time, and that cultivation of Salmonella from the

secretions -

secretions, excretions, etc., represents the only reliable method of diagnosis, though how the "dormant carrier" can be recognised by this means is not made clear. Lutje (1940), on the other hand, considers that the agglutination test can be used for identifying carriers. Against the value of the agglutination test must be set the fact that healthy animals may show low "H" and "O" antibody titres to various Salmonella antigens, although they are not infected in any way, these being known as "Normal Agglutinins" (vide Lovell 1934). Incidentally, vaccination can raise the antibody level, particularly as regards the "O" factor, whilst cases are on record where proved carriers have shown no appreciable antibody titre. The problem, therefore, is comparable to the human typhoid fever one, except that up to the present no progress has been made in regard to "Vi" agglutination in connection with these bovine infections.

In the absence of more suitable tests, the serological one is of value at least for the identification of "probable carriers", whilst the cultural examinations give final proof with regard to active excretion of infection. Two fairly recent outbreaks of human salmonella food poisoning serve to illustrate that for the present both tests are complementary to each other. In an outbreak at Wilton in England (vide Conybeare & Thornton 1938), primary identification of carriers was effected by the serological test, whilst cultural examination gave the necessary confirmation. On the other hand, in an epidemic at Kensington, Johannesburg (vide Pullinger and Scott-Millar 1945), the serological results were quite ambiguous, whereas cultural examination immediately revealed the active carrier.

- Whatever -

Whatever may be the position elsewhere, in South Africa bovine paratyphoid is primarily a disease of calf-hood, and one associated with bad calf hygiene. Though definite figures are lacking, it can be stated that the calf losses on many farms are tremendous, whilst those calves that survive attacks of the disease are stunted, and possibly remain carriers. Obviously such farms are hot beds of infection, where no animal can be considered as being safe from attack. The routine method of control is to vaccinate all calves, and to improve the hygiene of calf rearing. Generally speaking, this procedure brings the calf mortality under control, but infection is not eradicated, and still smoulders on amongst the adult cattle.

To tackle the paratyphoid problem the first and essential requirement is the thorough cleaning up of farming methods with calves being reared in suitable accommodation, well segregated from other animal species. The proper composting of all manure should be considered under this heading. Secondly, all carriers - whether active or latent - should be identified, and this is the major problem, because of the lack of a suitable test. In a generalised disease eradication scheme, in which blood samples are regularly being collected for contagious abortion tests, these same samples could be used for a routine agglutination test for Salmonella. The precise technique of the test would have to be worked out during routine investigation. In the initial stages it would be necessary to do quantitative "O" & "H" agglutination tests, using a series of antigens sufficient to cover the whole series of Salmonella likely to be involved. As experience is gained, however, it would be possible to simplify this technique to the use of a composite "O" antigen, and a composite "H" antigen,

- containing -

containing all the expected factors. It might even be possible to work with a single mixed "O" and "H" antigen. Moreover, ultimately it would only be necessary to use at most two serum dilutions (probably 1:20 and 1:40 final). During the preliminary investigation, all animals showing standard agglutination at titres of 1:20 and 1:40 would have to be subjected to detailed cultural examination of all excretions and secretions. Furthermore, a large series of animals showing such titres would have to be subjected to post-mortem bacteriological investigation for foci of Salmonella infection. On the basis of such investigations, it would be possible to determine :-

- (a) The serological titre indicative of carrier state.  
This titre would give probable, but not absolute results.
- (b) Titres deserving more detailed cultural examination.
- (c) Titres to be regarded as representing "normal agglutinins". This, too, would be a probable figure only.

Having collected the fundamental data, it would then become possible to reduce paratyphoid carrier diagnosis to a routine basis in a comprehensive disease eradication scheme. In the long run diagnosis on a routine basis would have to depend solely upon serological results, with cultural investigation being confined to special cases. As a result, a proportion of faulty diagnoses would have to be anticipated, but these would not invalidate the eradication scheme as a whole.

Coincident with the hygienic measures and the eradication scheme, it would be desirable to enforce the routine vaccination of all calves. Such a procedure would

most probably interfere with subsequent serological diagnosis, so that the testing of a vaccinated animal would not be comparable to the testing of the unvaccinated subject. The extent to which this factor really would interfere could only be determined from the results of extensive surveying of the whole problem.

##### 5. THREE DAY STIFF SICKNESS.

This is an infectious disease of cattle which appears in epidemic form every summer, some years the outbreak being very severe, whilst in other years it is milder in character. A detailed description of the condition is given by Henning, but from the point of view of milk control, it is sufficient to say that like foot and mouth disease, three-day-stiff-sickness gains importance - not from the mortality that results, but from the tremendous economic loss that it can cause. As the name indicates, the duration of acute illness is a matter of days only, and except for occasional severe cases, or cases complicated by protozoal infection such as gall-sickness, no mortality results. Whilst cows are sick, however, they lose condition very rapidly, and the milk output drops almost to nothing. Many weeks elapse before cows recover anything like their normal milk output, and frequently animals never recover until the subsequent lactation. During a bad season farmers may have as many as 50% of their lactating cows affected at once, whilst up to 75% may be ill during the season. This state of affairs spread over practically all the dairy herds in a province, involves the country in milk losses that reach almost immeasurable proportions.

- Because -

Because mortality is so low, and bad seasons do not recur every year, little or no serious investigation of this disease has ever been carried out, but it cannot be too strongly stressed that as far as South Africa is concerned an expenditure of a million pounds would be a cheap price to pay for a successful means of eliminating the milk losses caused by this disease.

#### 6. LUMPY SKIN DISEASE.

This condition has only very recently become widely recognised in South Africa, though it appears to have existed in Central Africa in a mild endemic form for a long time. The first satisfactory report was given by Von Backström(1945), whilst a preliminary study of the pathology of the disease was given by Thomas and Mare(1945). Once again, the chief significance of this disease depends upon the loss of condition, loss of milk, and abortions, though in some cases the mortality may rise as high as 20 per cent. A further grave feature of the disease is that bulls are frequently rendered temporarily impotent, or even permanently sterile. It is as yet early to draw conclusions with regard to residual immunity following an attack of disease, but in the dairying areas of the Transvaal, where the infection has now been present for two seasons, during the second season the condition has not been serious, either in regard to incidence rate, or severity of symptoms. It seems likely, therefore, that lumpy skin disease will settle down in a mild endemic form, though only time will show whether severe waves of infection are to be expected every few years. During the first season of infection in the Transvaal, the losses experienced by dairy farmers

were immense, including a mortality rate rising occasionally to 20 per cent, the loss of many calves by abortion, loss of milk persisting for weeks and even months, residual mastitis and loss of fertility - particularly in bulls, with consequent derangement of calving cycles.

From the Public Health point of view, all evidence indicates that man is not susceptible to infection. During the season 1945-46 in the Transvaal, there was ample opportunity for humans to become infected, either through direct contact, or through the consumption of milk from diseased cows, but no untoward results were ever encountered.

#### 7. CONTAGIOUS VAGINITIS.

This disease, which is very well known, occurs uniformly throughout those areas where dairying is practised on any intensive scale. It causes considerable temporary and even permanent sterility, resulting in loss of calves and milk, to say nothing of wastage amongst the cows. Additional to the actual loss of milk, diseases such as this one interfere with breeding programmes, thus nullifying the dairy farmers' attempts to maintain a level output of milk throughout the year. Like so many of the cattle diseases, this one is fairly easily controlled in a self-contained herd, but runs rife where cattle graze on commonage, or where cattle continually change hands on auction sales.

The foregoing represent the main diseases of cattle which are likely to cause serious trouble to the dairy farmer in South Africa, and though other diseases,

- such -



such as red water, gall sickness, anthrax, etc. do occur, they present no serious problem. Three other causes of ill-health in cattle deserve mention, however, namely tick-infestation, malnutrition, and poisoning.

#### 8. TICK INFESTATION.

The danger of ticks as vectors of protozoal infections is obvious, and deserves no comment. Apart from this aspect, however, heavy tick infestation places a serious drain upon the constitution of the cows, and increases their nutritive requirements. This obviously has a grave effect upon their general health and milk producing ability. Treatment of the condition presents no difficulties, but the point to be stressed is that treatment must be carried out, and ticks must be kept under control by clipping and hand-dressing.

#### 9. MALNUTRITION.

This subject will be considered in greater detail in the chapter dealing with the chemical composition of the milk, and at this stage it is sufficient to stress the point that every year in South Africa a large number of dairy cows are expected to exist and produce milk under conditions of partial, and sometimes even absolute starvation. Quite apart from unavoidable reasons, such as prolonged drought conditions, there are other avoidable causes of malnutrition. Overstocking, in comparison to the grazing and feed supplies available is, of course, the major reason for this state of affairs, but other factors also come into play. Thus, a farmer who grows his own food may grow the wrong crop, or harvest it wrong. Maize cut for silage with the cob maturing makes an excellent feed,

but the farmer must not expect the same feed value from silage made of stalks only, after the cobs have been sold as green mealies. If it is desirable to sell the cobs, then the silage must be enriched with molasses, or even some leguminous crop. Then again, much veld grazing has high feed value when in full growth, but if left until mid-winter, the feed value is very different. Any given acreage of grassland will have a much higher carrying capacity, if veld hay is made, and the stock grazed upon the stubble, than if reliance is placed entirely upon grazing. These are but a few of the endless feed problems that the dairy farmer must face. The point to be stressed, however, is that malnutrition - whether relative or absolute - lowers the stamina of the cow, which is laid open to attacks of infectious disease and parasitism, and in South Africa mange is one of the first diseases to appear. Partial seasonal malnutrition is one of the first of the "hidden" failings requiring to be tackled on South African dairy farms, the method of attack consisting of educating the farmer in animal and field husbandry.

#### 10. POISONING.

Generally speaking, poisoning - whether organic or inorganic - occurs sporadically, but a few rather specific conditions are worthy of special consideration. Mention has already been made of "Milk Trembles" earlier in this chapter, but in addition, reference may be made to Chase Valley disease (vide Thorburn 1933), where poisoning is due to the "Inkberry" Cestrum Laevigatum, and also to the type of algal poisoning known as "Vaaldam Disease."

A further and rather specialised form of poisoning could very conveniently be called "Garbage Disease",

- which -

which occasionally occurs when Kitchen refuse from large catering establishments is allowed to putrefy, before it is fed. The bulk of evidence, including the symptomatology, suggests that the heavy death roll that sometimes follows the feeding of putrid garbage, is due to a form of botulism.

CHAPTER 2. IMPORTANT MILK-BORNE DISEASES OF MAN.  
 A. THE COW AS CHIEF RESERVOIR AND SPREADER OF INFECTION.

1. Tuberculosis.

It has long been recognised that man is susceptible to bovine tuberculosis, that infection with this organism generally occurs via the alimentary tract as a result of consuming milk from tuberculous udders, and that infants more often contract this condition than adults. In addition it has been reported by a number of investigators (vide Munro & Griffith 1928, and Griffith 1940), that as many as 10 per cent of all pulmonary cases of tuberculosis may be of bovine origin, it being conceded, however, that with the exception of specialised occupational groups (e.g. farm workers), the portal of entry is still usually via the alimentary tract. The incidence of the bovine infection in man has been extensively reviewed by Wilson (1942), but as a rough guide, it can be taken that in England and Wales, about 4,000 new cases developed annually (prior to World War II), whilst 2,000 deaths occurred - chiefly amongst children. Recent reports by Jensen (1935), and by Rhuys (1937) have shown that both in Denmark and the Netherlands, the disease was widespread, whilst Stahl (1939) has reported the occurrence in Scandinavia of an actual epidemic of bovine type tuberculosis in a small closed community, infection originating from tubercular cows. In this instance 57 people became infected, 47 of them being children.

In South Africa, on the other hand, there are grounds for believing that bovine infection rarely attacks man, <sup>THOUGH SOME BELIEVE THAT MAN IS INFECTED MORE OFTEN THAN IS REALISED.</sup> One definite case has been reported by Harrington & Emmerson (1939), and another by du Toit and Buchanan (1942), but for the rest all instances where the organism was typed, infection has proved to be the human variety.

Pullinger (1941) attempted to explain this low

- incidence -

incidence of bovine type tuberculosis in man on the grounds that in South Africa market milk rarely contains this infection. Up to a point this explanation is probable enough, since the writer found that only 2.5% of market milk samples in Johannesburg were contaminated with tubercle bacilli, whilst Horwitz (1944) gave a figure of 3.0% for Capetown. This, cannot, however, be the whole answer, because at a time when 38% of Durban cattle were giving positive tuberculin reactions (vide de Kock 1932), the probability is that a large number of cows had tubercular mastitis, and yet there is no record of human infection developing. Whatever the underlying reason may be, bovine tuberculosis in man is <sup>NOT AN URGENT</sup> public health problem in South Africa, and any plan to eradicate the disease from dairy herds must be tackled as an agricultural problem, pure and simple.

#### Sources of Infection.

The normal source of infection in man is through contaminated milk excreted by cows suffering from tubercular mastitis. It has been shown by various workers, including Osterman (1908) and Pullinger (1934), that milk of a single tuberculous cow can be diluted one million-fold, and still be infectious for guinea pigs. From this it is obvious how much good milk one single cow can spoil, and if it is appreciated that in England 3,000 gallon rail-tank milk samples can be diluted one hundred-fold, and still remain infective for guinea pigs (vide Pullinger 1934), the magnitude of the public health problem in that country will be understood.

Clearly the question also arises as to whether tuberculosis can be spread by milk products prepared from

- tuberculous -

tuberculous milk. Pullinger (1935a) isolated tubercle bacilli from 50% of raw cream samples, but never from pasteurised cream, or from factory made butter. Edington (1934) found tubercle bacilli in one out of forty samples of factory made butter; Smith (1934) found these organisms in 5 out of 51 locally made butter samples, whilst earlier on Briscoe and MacNeal (1911) reported that 13.2% of butter samples emanating from Europe were contaminated. As regards viability in storage, Schroeder and Cotton (1911) found virulent tubercle bacilli in salted butter after 160 days' storage at 60° F., whilst Briscoe (1912) recorded survival for even longer periods. As regards cheese, Kankoanpaa (1912) found 14% of Swiss cheeses to be contaminated, but Schroeder and Brett (1918), Harrison (1902), and Pullinger (1935) are all agreed that viable tubercle bacilli are only likely to be found in soft curd cheese, or in hard cheese that is not yet mature. In the case of ice-cream, it will be clear that the home-made variety is open to all the hazards that attend the consumption of unpasteurised cream, but factory made products are usually so strongly heated the contamination should inevitably be destroyed.

## 2. UNDULANT FEVER.

Undulant fever is the name given to the disease that Brucella abortus causes in man. Although this organism was first described by Bang and Stribolt in 1897, its relationship to the cause of Malta Fever was not recognised until twenty years later. (vide Evans 1918). Shortly after that it began to be realised that laboratory workers could be infected by Br. abortus, and finally

Bevan (1921-22) recorded a natural case of infection of a human being resulting from the consumption of milk contaminated with this organism. Because the disease occurs sporadically, because symptoms are indefinite, and because diagnosis can be difficult, the significance of Undulant Fever as a milk-borne disease has not been fully, or widely accepted, and it was only after the publication of reports by Madsen (1930) and Wilson (1932), that serious consideration was given to the subject. Although the disease usually appears sporadically, milk-borne epidemics have occurred (vide Engel 1938; Elkington et alia 1940; Cruikshank and Stevenson 1942).

In South Africa, whilst cases have been reported, little is known of the extent to which undulant fever does occur, *EXCEPT WHEN SPECIAL INVESTIGATIONS ARE DONE AS A ROUTINE THE CONDITION IS LIKELY TO BE OVERLOOKED.*

Owing to the fact that the disease produces no uniform train of symptoms, it cannot be recognised clinically, and according to Wilson (1942) "There is good reason to believe that the majority of cases are overlooked, or wrongly diagnosed." Certainly, the large numbers of cases recorded in South African hospitals as "pyrexia of unknown origin" lends colour to this belief. Even when bacteriological facilities are available, diagnosis may be difficult, depending as it does upon the summation of evidence collected by blood culture and serological and allergic tests. A review of the problems of diagnosis in men is given by Harris (1943). Reverting to the question of incidence in South Africa, Alves (1936) reported that 0.1% of Rhodesian natives showed titres of 1:50, or over (using the Oxford technique); whilst in the Port Elizabeth



area 0.33% of Widal samples gave positive reactions to Br. abortus (vide Report 1943a). In the same report it is stated that 2.7% of samples collected in Johannesburg were positive to Br. meletensis (the cause of Malta fever), whilst 4.5% were positive to Br. abortus. It is not clear whether these were random samples, or samples taken because undulant fever was anticipated.

Infection in the Cow.

In the normal course of events Br. abortus settles in the uterus of pregnant bovines, and in the various glands, if the animal is not pregnant, whilst amongst the glands likely to be invaded is included the udder. It is animals with udder infections that represent the chief public health risk. Once an udder is invaded Br. abortus organisms are excreted sporadically, and according to Karsten (1932), as many as 200,000 organisms per c.c. may be excreted. Some cows soon cease to discharge organisms, whilst others continue to do so indefinitely, and figures have been quoted in the previous chapter with regard to the incidence of Br. abortus contamination of market milk. With regard to milk products Pullinger (1935) found 35.5% of raw cream samples to contain this organism, but it was never found in mature butter or cheese. Considered as a whole, these findings indicate that though manufactured milk products play no important role, the average human being is frequently exposed to infection whenever raw milk or cream is provided for use. In South Africa at least, the other Brucella species, viz:- Br. suis and Br. meletensis play <sup>FLUSS</sup> ~~no~~ important role in infecting man THAN APPEARS TO BE THE CASE OVERSEAS IF ABSENCE OF REPORTS OF INFECTION IS A RELIABLE CRITERION.

Infectivity for man.

It is difficult for the unbiased observer to

- decide

decide whether the *Brucella* genus is classified upon sound criteria. The criteria used represent minor physiological differences and minor antigenic differences (vide Wilson 1933), which do not correlate satisfactorily with the pathogenicity of these strains for man. As a rule, Br. melitensis and Br. suis are extremely pathogenic for man, whilst Br. abortus is extremely non-pathogenic, but periodically an abortus strain is encountered that is highly pathogenic for man, whilst strains have been known to increase in infectivity for man by mutation, or by some process of selection. It might lead to a better understanding of the group as a whole, if they were regarded as all being of one species, and that strains developed differences in animal pathogenicity by natural passage. If this view is accepted, it becomes easy to explain the sudden appearance of undulant fever epidemics by postulating a sudden mutation of the abortus variety towards the melitensis variety, but it does not explain the sporadic cases of undulant fever that definitely occur. To explain why such cases do occur, it seems necessary to assume that the normal healthy human being is extremely resistant to cattle strains of *Brucella*, but that this resistance can be reduced by some change in the general state of health. Whilst stated in general terms this sounds quite feasible, it becomes less convincing when any attempt is made to define what constitutes a lowering of the state of health. One attempt has been made by the writer to obtain more precise information on this point, an effort being made to undermine the general health of guinea pigs by depriving them of fat-soluble vitamin. Vitamin starvation was applied, until the livers were free from demonstrable vitamin (as judged by the antimony

- trichloride -

trichloride test), and thereafter some were inoculated with Br. abortus, and others with Br. abortus mixed with a protecting dose of B.C.G. (vide Pullinger 1938). Groups of guinea pigs rich in vitamin were similarly inoculated. It was hoped that in the healthy vitamin-fed group B.C.G. would be strong enough to mobilise the tissue defences against the Brucella, whilst in the vitamin-free group these defences would not mobilise satisfactorily. Actually no differences developed in the incidence of Brucella infection in the various groups, indicating that vitamins A and D play little or no role in affecting the responsiveness of cellular defences. Endless opportunities exist for elaborating work along these lines, with a view to finding a reasonable explanation as to why man can come into endless contact with Br. abortus, and perhaps suddenly succumb to the disease.

In the meanwhile, it must be accepted that Brucella contamination of milk represents a grave potential danger to man, and from what is said in the previous chapter this danger is not likely to be removed by any simple control measures. This is in fact one of the diseases which will render heat-treatment of milk imperative in the long run.

### 3. SCARLET FEVER AND SEPTIC SORE THROAT.

Attention was first directed against milk as a vehicle for spreading scarlet fever by Taylor (1870), but this report was overlooked, and it was not until a series of extensive epidemics occurred around about 1912, that general attention was focussed upon milk. One of these outbreaks, described by Capps and Miller (1912), involved

- more -

more than 10,000 cases, but a full review of the epidemiology of scarlet fever during this phase is given by Armstrong and Parran (1927). At this stage it was almost universally believed that some human carrier of streptococci invariably contaminated the milk, but even at this early stage Savage (1911) advanced the hypothesis that scarlet fever streptococci might invade the cows udder, whilst Davis (1912) and Smith and Brown (1915) also favoured this view. The idea was reiterated by Savage in (1931), and again by Minett (1932a), but it was very generally rejected at this stage. The accurate streptococcal typing methods introduced by Lancefield paved the way for the final proving of the hypothesis in a joint report by Bendixen and Minett (1938) describing an outbreak in Denmark, and another at Doncaster in England, in which the scarlet fever epidemics were definitely caused by cows suffering from Strep. pyogenes mastitis.

In most of the earlier investigations very extensive efforts were made to find some human carrier, who had had direct or indirect contact with the milk. When it is remembered that the streptococcal carrier-rate can rise to as high as 25% of the population (vide Topley and Wilson 1936), it will be appreciated that a carrier can generally be found somewhere. In Table 11 is given a list of some of the main epidemics that have been reported fairly fully, the references being classified according to whether or not any serious effort was made to look for a cow carrying scarlet fever streptococci in the udder. From this table it is fairly clear that in the majority of extensive epidemics a cow will be found to be a carrier, if an immediate and a careful search is made.

T A B L E 11.

Bibliography referring to reports of milk-borne Strep. pyogenes epidemics.

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Cows examined and one incriminated.	Capps & Miller 1912; Krumweide & Valentine (1915); Rosenau & Hesse (1917); Smillie (1917); Brown & Orcutt (1920); Benson & Sears (1923); Frost & Carr (1927); Jones & Little (1928); Brookes (1930a); Golledge (1932); Archibald & Freemster (1932); Robinson & McComb (1932); Rambe & Hedstrom (1934); Stebbins <u>et alia</u> (1937); Report (1937); Bendixen & Minett (1938); Douglas <u>et alia</u> (1941); Dublin <u>et alia</u> (1943);
Cows not examined or none incriminated.	Report (1910); Winslow (1912); Rosenau & Moon (1915); Wilkenson (1931); Welch & Mickle (1933); Report (1935 b); Camps & Wood (1936); Sleigh (1936); Stebbins <u>et alia</u> (1937); Henningsen & Ernst (1939).

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Of the reports referred to in the lower section, with two exceptions only (viz:- Henningsen & Ernst 1939 and Stebbins et alia 1937) no serious attempt was made to incriminate a cow, or else any effort was made long after the epidemic had subsided.

With the weight of evidence set out by Pullinger and Kemp (1937), and by Bendixen & Minett (1939), it might be thought that the importance of the cow as the chief vehicle of spread of scarlet fever had been established. Nevertheless, on page 35 Wilson (1942) states "there is at present some doubt as to which is the commoner method of infection" (i.e. cow or man); so it seems necessary to clarify the position further. In connection with milk-borne

diphtheria Topley and Wilson (1936) state that diphtheria bacilli are rarely isolated from milk that is actually causing a milk-borne epidemic, because contamination from the human carrier is such a chance occurrence that gross spoilage of the milk could only occur, if the diphtheria bacillus could multiply in milk under ordinary conditions of storage. Applying this dictum to the scarlet fever problem, it is reasonable to argue that if the cow plays no major role in the spread of scarlet fever, then extensive and prolonged epidemics such as those described by Capps & Miller (1912), with 10,000 patients, and by Wilkensen (1931) with 1,000 patients, could only occur if Strep. pyogenes could multiply rapidly in milk. This point was fully investigated by Pullinger & Kemp (1937), and a clear-cut conclusion was reached that this organism does not multiply under normal conditions of storage. The only remaining explanation of extensive epidemics is that cows can become infected with Strep. pyogenes, and can excrete organisms in the milk. Since such excretion has been demonstrated on frequent occasions, and since counts of streptococci up to  $25 \times 10^8$  (vide Brown & Orcutt 1920) have been recorded, the writer cannot see where room for doubt exists in regard to the importance of the role played by the cow. The main point is that, in the case of every milk-borne epidemic of scarlet fever, immediate search should be made for a carrier cow. The fact that the cow originally was infected by a human carrier is incidental, for Bendixen & Minett (1939) recorded the case of a cow which remained infected for 13 months, including a dry period of 3 months. It must not, however, be thought that the human carrier is a negligible factor. Outbreaks

- recorded -

recorded by Henningsen & Ernst (1939) and by Stebbins et alia are clear cut examples of contamination by milk handlers, whilst the work of Pullinger & Kemp (1937) showed that multiplication of streptococci might easily occur, if a milk-handler contaminated pasteurised milk, an example of such an outbreak being given in Report (1938c).

#### 4. STAPHYLOCOCCAL FOOD-POISONING.

Since the first report made by Baber (1914), information has gradually been accumulated to show that certain staphylococci which are sometimes to be found in the cow's udder can produce a toxin which gives rise in man to symptoms of nausea, vomiting, diarrhoea, pyrexia, and prostration. The toxin is sometimes to be found in milk itself, but more often it is produced in cream, or cream derivatives, such as cake and pastry fillings. The toxogenic staphylococci may come from milk, or from other sources, such as the finger-nails of some "carrier", outbreaks definitely traced to milk being recorded by Crabtree & Litterer (1934); & Shaughnessy & Grubb (1936 & 1937). Minett (1938) made a careful survey of reputed human toxogenic strains, and compared them with strains causing staphylococcal mastitis, and he concluded that certain mastitis strains do produce sufficient toxin to cause food-poisoning epidemics. Hackler (1939) described an outbreak caused by milk, where the infection was introduced by a human carrier during bottle capping operations. He based this opinion chiefly upon the fact that the milk was pasteurised, but such evidence must be treated with reserve, because staphylococcal entero-toxin is relatively heat-resistant, and would not be entirely destroyed by pasteurisation.



### Control.

The task of carrying out routine tests for toxogenic strains of staphylococci is quite impractical, whilst straightforward pasteurisation does not provide adequate protection, once toxin has been formed. On the other hand, the mere presence of a toxogenic strain in milk is not of itself harmful, provided conditions are not favourable for toxin formation. In consequence, the important factor in the control of this condition is to ensure that milk is thoroughly cooled immediately after milking, and to ensure that it never warms up again until it is used, or is pasteurised. Similarly, after pasteurisation, if milk is never allowed to warm up, then any chance contamination with staphylococci will have no harmful results. Cake, pastry and meringue fillings, which have to be stored at atmospheric temperature, should only be made from pasteurised cream.

### 5. SALMONELLA FOOD-POISONING.

The species generally involved in milk-borne outbreaks of Salmonella food-poisoning are S. dublin, enteritidis, and Typhi-murium, though other members pathogenic for man would behave similarly after gaining access to milk.

#### Sources of Infection.

Contamination of milk may come directly from the cow, as a result of the existence of a septicaemic condition, with organisms filtering through the udder tissue into the milk; or, alternatively, the milk may become contaminated from urine, or faecal splashings from a carrier cow. Secondly, rodents, flies, or polluted water may

- cause -

cause the contamination, and finally it may come from the hands of a human carrier.

The relative importance of these modes of contamination is not known, but it seems likely that faulty conclusions have sometimes been reached in the investigation of epidemics. Investigators are all too prone to ignore the cow as a probable source of infection, and they concentrate rather upon seeking human, or rodent carriers. Chronically infected rodents are as a rule not difficult to find, though they may have played no part in causing an epidemic, whilst the human carrier is at times really an early victim of the outbreak. Faulty investigation was, of course, more common when the classification of this genus was but ill-understood, but even to this day difficulties are experienced in South Africa at least, in persuading those concerned with investigating epidemics that it is of vital importance to have *Salmonella* strains accurately identified from the very outset. Actually, those milk-borne *Salmonella* outbreaks that have been best reported have all been due to diseased cattle (vide Poppe 1931; Conybeare and Thornton 1938; Tulloch 1939; Sutherland & Berger 1944; and Pullinger & Scott-Millar 1945). The outbreaks reported by Conybeare & Thornton (1938) and by Pullinger & Scott-Millar (1945) are both noteworthy, because of the rapidity with which the responsible cows were identified, but this early identification was only possible because the cows were from the outset considered to be the probable cause of the epidemic.

#### Control.

Clearly, the major aspect of control consists of the elimination of the bovine carrier of paratyphoid, a

problem that is discussed elsewhere, and for the rest, control must depend upon the use of tested milk-handlers, who are free from this infection, and upon the practice of good dairy hygiene. Pasteurisation, per se, does not offer any guaranteed protection against this form of food-poisoning, because if these organisms gain access to milk, and multiply rapidly, subsequent pasteurisation - though killing the organisms - will not entirely destroy the toxic effects of their break-down products. Control must, therefore, be a combination of :-

- (a) Preventing the organism gaining access to milk by having healthy cattle and healthy milk handlers, and by practising strict milk hygiene, to avoid all chance contamination.
- (b) Preventing any organisms that may have gained access, from growing by storing milk cold at all times.
- (c) Destroying any organisms that may have gained access, by pasteurising the milk.

## 6. DIPHTHERIA.

### Source of Infection.

Under normal circumstances, this disease always arises from some human carrier, and cows do not develop infection in any more serious form than the colonisation of some local abscess with C. diphtheriae. Periodically, milk-borne diphtheria epidemics have been caused in this way, examples being the epidemics that were reported by Bowhill (1898-99); MacSweeney & Morgan (1928); and by Pfeiffer & Viljoen (1945), the last-mentioned outbreak being one that occurred in South Africa. A further list of reports is detailed by Wilson (1942).

### B. THE MILK -

B. THE MILK HANDLER AS THE CHIEF RESERVOIR AND SPREADER OF INFECTION.

Typhoid & paratyphoid fever.

In these diseases the essential reservoir is the human carrier, though contamination of the milk may be indirect via flies or polluted water. An almost unending series of epidemics have been quoted in the literature, but a clear-cut and particularly interesting record of a carrier transmitting contamination from dairy to dairy as he moved around is given by Laing (1934), whilst an interesting and unusual instance of a milk-borne epidemic caused by polluted water is recorded by Parry (1942). Normally the cow plays no part whatsoever in the spread of true typhoid fever, whilst rarely, if ever, in the spread of paratyphoid. In theory, however, a cow can play a major role as a passive carrier by conveying infection on the tail, coat and teats after grazing on pasture irrigated by unpurified sewage effluent; also a vague possibility exists of a cow becoming an active carrier of typhoid bacilli (vide Shaw 1937). It seems more likely that in the epidemic described by Shaw a cow or cows became passive intestinal carriers as a result of drinking contaminated river water.

Without attempting to set out a comprehensive bibliography a few key reports may be quoted. Thus, Armstrong & Parran (1927) reported upon 613 typhoid epidemics in the U.S.A., traceable to milk or milk-products, and of these milk was responsible for 444, butter for 2, cheese for 1, and ice-cream for 32. The remaining cases were not satisfactorily traced up. A very large outbreak in Montreal is recorded in Report (1927); Shaw (1937) reported upon an epidemic at Bournemouth; Wilson (1938 reviewed a

number of British epidemics, whilst Siroir (1942) recorded a **recent** epidemic in Canada. In South Africa milk-borne typhoid epidemics occur almost annually, but they are seldom adequately reported. Seven small epidemics in Johannesburg are on record in Report 1922-23), and an interesting series of epidemics already referred to is recorded by Laing (1934), but within recent years epidemics have occurred in Durban, Capetown, Johannesburg, Brakpan, Benoni, and Pretoria, but apart from Press accounts no satisfactory reports have been published, with the exception of the Report of the Departmental Committee, which investigated the Brakpan outbreak. This tendency to "hush-up" such unfortunate occurrences deprives the epidemiologist of much valuable data.

Records of Paratyphoid epidemics are much less numerous, but seven outbreaks have been recorded in the U.S.A. by Armstrong & Parran (1927), and a further small outbreak is recorded in Report (1935b); Madsen (1929) recorded two epidemics which occurred in Denmark; McKay et alia (1932) reported upon an outbreak in Canada; Parry (1942) gave details of an epidemic in which polluted water soiled milk utensils. Finally, in Report (1942a) there are details of a pig paratyphoid outbreak at Ely, Cambridge-shire, which was probably milk-borne in origin.

#### Control.

The isolation of typhoid or paratyphoid bacilli from milk is such a specialised procedure, that it is quite out of the question to undertake routine examination of milk samples. If such an examination were undertaken, the results would be unreliable and misleading, and even when such pathogens were identified, the time

lag would be so great that colossal damage could be done before diagnosis was achieved.

One obvious method of control is to take all possible steps to prevent milk from becoming contaminated, because once typhoid and paratyphoid bacilli gain access to milk, they are liable to multiply during storage (vide Pullinger & Kemp 1938). Unfortunately, it is very difficult to devise ways of safeguarding milk from contamination. Dairy cows can be kept away from sources of contamination, provided the South Africa practice of grazing dairy cattle on uncontrolled sewage farms is avoided. The second point is to ensure an unpolluted water supply for dairy purposes, and here the chief danger lies in the use of shallow well water, particularly in areas where the water-table has been raised very near the ground surface through extensive and excessive irrigation. Such a state of affairs can easily obtain on the lower ground in the neighbourhood of a big sewerage farm, whilst under natural conditions it can obtain on the lower side of irrigation furrows in certain areas such as Boskop, Transvaal, which is on the Mooi River - Wonderfontein series of perennial springs. Seepage from water furrows into shallow wells always presents a serious danger of pollution, a danger that becomes aggravated when seepage is assisted by driving a narrow bore pipe through the intervening wall between the water-furrow and the well. Thirdly, milk must be protected from chance contamination by flies, and more important, the flies must be prevented from becoming typhoid carriers by establishing proper latrines, and enforcing their proper use. Finally, and most important of all, the human carrier must be eliminated,

- and -

and it is this aspect of the problem that presents almost insuperable difficulties in South Africa.

According to Wilson (1942) there is approximately one typhoid carrier per 60,000 persons in England and Wales, though following upon an epidemic this carrier rate can rise to an extraordinary degree in the area where the epidemic occurs. No carrier rate for paratyphoid fever has been worked out. In South Africa no comprehensive survey of typhoid carriers has been made, but reports are available for certain selected areas. According to Pijper & Crocker (1943) 4.1% of apparently normal Europeans and 5.7% of apparently normal Non-Europeans are Vi positive. Lewin et alia (1945) on the other hand, found 16% of normal Europeans gave weak Vi positive reactions. Nelson (1946) gave figures of military personnel (food-handler survey) as varying from 5.0 to 25%, whilst in the same report he gave comparable figures from a Pretoria Municipal survey as 3.9%. Further references on this subject are quoted by Lewin et alia (1945). The different figures that have been quoted are hard to reconcile one with another, and it is difficult to escape the thought that variations in the Vi technique may play some part. Even taking the lower percentage (vide Pijper & Crocker) this carrier-rate is immensely higher than that of Britain, but since the mortality rate is eight times higher in S. Africa (vide Nelson : 1946), this high carrier rate could be anticipated.

When dealing with so high a carrier rate, the difficulty of ensuring that no carriers handle milk is obvious, because of the complexity of the machinery required to test milk handlers. The replacement of the Widal by



the Vi test for the identification of typhoid carriers has eased the position somewhat, but numerous factors do serve to interfere with the application of the Vi test on a country-wide scale. The following are some of the difficulties which are constantly quoted by those who oppose universal Vi testing :-

- (a) The Vi test is by no means infallible, and gives a proportion of faulty results. In addition it is so delicate a test that even slight haemolysis will interfere with the reading. Consequently, only highly skilled persons can be employed to collect blood samples, whilst ordinary methods of conveying blood samples to the laboratory are quite unsuitable, when the length of the journey is great. The haemolysis factor is a serious one, when it calls for the re-sampling on a farm perhaps 100 miles from the laboratory.
- (b) In the case of big cities the sources of supply of milk are so widely scattered, that the registration, testing, and "following up" of doubtful results becomes beset by immense administrative difficulties and expenses.
- (c) It is quite impossible for the controlling authority to ensure that only Vi negative personnel actually handle milk, because of constant changes in the native staff, and due to lack of co-operation and understanding on the part of the farmer. The best intentioned farmer would have to break the regulations continuously, because of staff difficulties.

(d) - At -

- (d) At best tests could only be repeated at infrequent intervals.
- (e) To any centre of population the cost of testing would be sufficiently high to call for special planning, which would draw Press and other attention to the service being undertaken. This in turn would give rise to a false sense of security with regard to the safety of the milk. That this is no trivial point can be seen from the attitude of the average dairyman, when the question of pasteurising is mooted. His automatic response is to clamour for "testing", instead of pasteurisation. By testing he thinks of tuberculin testing of the cows, and Vi testing of the personnel, as though tuberculosis and enteric fever were the only hazards to be avoided. It cannot be too strongly stressed that enteric fever is but one variety of the many diseases spread by milk.
- (f) Routine Vi testing engenders a quite unwarranted sense of security, even in the minds of professional men. This was well illustrated by a typhoid epidemic that occurred in Durban in 1941, when identification of the source of infection was seriously delayed by misleading Vi test results. Moreover, milk from untested sources was actually being smuggled into the dairy at the time of the outbreak. It cannot be over emphasised that Vi testing is only a real security factor,

when the dairyman co-operates fully; but if there is any suggestion of milk from unauthorised sources being introduced, then the sense of security engendered by the Vi test may have devastating results. In South Africa, it is an unfortunate thing that no effective machinery whatsoever exists to control the illegal introduction of milk under cover into consumer zones.

- (g) The question of finance is also raised, it being argued that country-wide Vi testing is a state service that should be financed by state, and not by local authority funds. Linked with this is also the question of the treatment of those Vi positive cases that are identified. Clearly, it is of little value to identify typhoid carriers, unless machinery exists for curing such carriers, or at least for ensuring that they are no longer employed by any of the food industries. This is undoubtedly a State, and not a Municipal responsibility, and in fact, subsequent identification of carriers is impossible, except in a country where the total population carries identification cards. In South Africa, all the African races are identifiable in this way, but under the existing laws the endorsement of the identification card with medical information is not permissible.

Reviewing the position with regard to Vi testing, it is probably reasonable to conclude that in a small town, with a limited milk supply coming from near at hand,

testing is a practical proposition likely to yield dividends in warding off occasional epidemics. In the case of a large city such as Johannesburg, with milk coming in over a radius of 300 miles, it becomes quite impractical to suggest that more than a fraction of the total milk handlers are tested personnel. It is even more impractical, under existing conditions, to suggest that milk smuggling can be eliminated. Stated concisely, the problem would resolve into :-

- (a) Primary visits to collect blood and check all identification cards.
- (b) Second and even third visits for re-sampling of all doubtful cases and spoiled samples.
- (c) Re-visits at frequent (probably monthly) <sup>INTERVALS</sup> ~~visits~~ to test newly engaged staff.
- (d) Re-visits in conjunction with the police to arrange for the isolation of proved carriers.
- (e) Frequent re-visits by other inspectors, to ensure that only tested personnel are handling milk, and to try and check up upon the probability of unauthorised milk being introduced under cover of the farmer's name and permit.

These services applied to upwards of 600 producers scattered over an area of 100,000 square miles, is what compulsory Vi testing would mean to the City of Johannesburg.

It must be appreciated that the foregoing remarks refer to Vi testing on the farm. In connection with the town milk distributing depot, however, the position is entirely different, and an indisputable case can be made for

the Vi testing of all milk-handlers employed in such concerns. Farm contamination is best combated by pasteurisation, but if milk is to be used raw, then all milk handlers on the farm must be Vi tested.

#### Bacillary Dysentery.

Under this heading are included infections of Bact. shigae, flexneri and sonnei, and all other allied bacterial strains. (Vibrio cholerae should be included in those countries where the infection occurs.) A number of outbreaks of milk-borne dysentery are on record, thus Armstrong & Parran (1927) quote six well authenticated epidemics in the U.S.A.; Sylvest (1933) records a small outbreak due to the Sonne bacillus, in which a milk handler was identified as the carrier; in Report (1937) there is the description of a large outbreak at St. Andrews, Scotland, involving 300 persons; Bowes (1938) reported upon a Sonne epidemic, the source of which was not identified, whilst Faulds (1942) recorded a similar outbreak involving 120 school children.

In these cases infection comes directly, or indirectly from human carriers, and control obviously comprises dairy hygiene and elimination of carriers. In this type of condition the carrier state is a temporary one as a rule, and somewhat transient in nature. Dairy farmers and dairymen should be impressed with the danger of allowing persons suffering from diarrhoea to handle milk, but pasteurisation offers the only real safeguard.

#### Summer Diarrhoea and Apricot Sickness.

Figures are given by Wilson (1942) of the high infant mortality experienced in England, due to so-called summer diarrhoea, but also a high sickness rate occurs amongst the older age groups. In South Africa the acute gastroenteritis that appears during early summer is commonly called

- Apricot -

"Apricot Sickness", but in symptomatology it differs but little from English Summer Diarrhoea. There is no single cause of the disease, and in all probability in both countries the symptom syndrome can be set up by any of the causes of bacillary dysentery, whilst in some of the more severe epidemics the cause is probably a Salmonella infection. Because gastro-enteritis is not a notifiable condition in South Africa, epidemics are usually on the wane before it is realised that the disease has reached epidemic proportions, but in three fairly recent outbreaks in South Africa, when some investigation was done, the cause in each case was found to be bacilliary intoxication. Two of ~~these~~ outbreaks reported by Pullinger & Scott-Millar (1945) were due to Salmonella dublin transmitted by the milk, definitely originating from a cow in one instance, and probably from a cow in another instance. The third epidemic, which was never reported upon, was also definitely milk-borne, the cause probably being Staphylococcal enterotoxaemia.

In addition to specific toxin producers and other recognised pathogens, it has been shown that common saprophytes such as Proteus vulgaris & morgani, and even Bact. coli, if present in sufficient numbers, give rise to breakdown products which are extremely toxic. (vide Park & Holt 1903).

In considering the epidemiology of Summer diarrhoea and Apricot sickness, it is necessary to consider the cow as a possible source of Salmonella infection, bad dairy hygiene as a cause of excessive saprophytic<sup>bacterial</sup>/growth, and the human carrier of the various dysentery causing organisms. In this latter connection Alves et alia(1937)

in Southern Rhodesia, found that 5.0% of 350 natives agglutinated Bact.shigae strongly, and a further 11.0% agglutinated it to a titre of 1:50. Out of 501 samples the same workers reported that 6.6% agglutinated Bact. flexneri to a titre of 1:50.

#### Scarlet Fever.

This disease has been fully discussed as one that may be spread by bovines, but epidemics can also result from direct contamination by human carriers. Generally speaking, it can be taken as correct that where contamination is direct from man, the epidemic will be restricted in extent.

#### Control.

The obvious method of control in this case is to exclude all human carriers from handling milk, but this is difficult - if not impossible - to bring into operation. According to Topley & Wilson (1936), the carrier rate for Strep.pyogenes rises from about 5% of the population to as high as 20%, when epidemics affecting the naso-pharynx are rife. To attempt to examine naso-pharyngeal swabs from all persons handling milk for a large city would in itself present an insuperable problem. But assuming that such an examination were possible, it would still be hopeless to try and take effective measures to deal with a temporary carrier rate of 20%.

#### Diphtheria.

This disease has already been referred to in connection with cows, but in this case the human carrier is the main source of contamination. Armstrong & Parran (1927) give records of 44 epidemics up to 1927, and from that time onwards about two outbreaks have been recorded



yearly (vide Report 1936). In Great Britain there were 20 recorded epidemics from 1912-1937 (vide Wilson 1942), whilst Goldie & Maddock (1943) reported another outbreak some years later.

### Control.

In this disease control hinges upon the removal of the human carrier, and the immunisation of the susceptible subject. The carrier problem is one which equals the streptococcal carrier problem in magnitude, and the whole present aim of the public health planner is towards the immunisation of the whole population. Those interested in the details of the problem of identifying human carriers are referred to a report by Borman et alia (1935), in which the whole matter - including the financial implications - are considered at some length. Foote et alia (1936) discusses the problem on similar lines, and Wilson (1942) concludes that "the economic and administrative difficulties of controlling milk-borne infection of human origin by medical and bacteriological supervision of milk handlers on the farm are too great to be practical."

### C. THE CONTROL OF MILK-BORNE DISEASE OF BOVINE ORIGIN.

From what has been written in the previous section with regard to typhoid fever, dysentery, scarlet fever and diphtheria, it is fairly evident that there is but little hope of eliminating the human carrier problem in the near future. The same may be said about the bovine carrier of disease, so long as the Dairy Industry and the Department of Agriculture carry on as heretofore. It is, however, quite possible to advance a reorientation of policy which would bring the eradication of certain cattle diseases within the bounds of practical policy, and reduce

the incidence of these diseases to a bare minimum. Before any eradication scheme could be developed, it would be necessary to stabilise the Dairy Industry, and the suggested method of stabilisation is discussed in the final chapter of this thesis. Assuming that such a state of stabilisation were established, it would then become possible to develop an eradication scheme, which would take from 10 to 20 years before it could bear substantial fruit. The scheme which is outlined for the eradication, or control of tuberculosis, contagious abortion, streptococcal mastitis, and paratyphoid fever has been planned to interlock with the sort of industrial reorganisation discussed in the final chapter.

#### National Scheme for the eradication of certain Bovine Diseases.

In the following description basic principles of an eradication scheme are discussed, but no attempt is made to present a scheme complete with all its detailed planning. The diseases to be considered are tuberculosis, contagious abortion, streptococcal mastitis, and paratyphoid fever; and it is taken as axiomatic that the control scheme must cover all these conditions, and not be confined to one only.

1. Stage 1. The first step in establishing the scheme would be to carry out a survey of the incidence of these diseases throughout the country. This would involve a systematic application of the tuberculin test in all districts with the branding of all reactors. A standstill order would be placed upon all reactors, but at this early stage no prohibition would be placed upon the movement of non-reacting in-contacts. Simultaneously with the

- tuberculin -

tuberculin test agglutination tests would be carried out on all herds, and using the same blood samples, some form of serological test for salmonella infection would also be done. At this juncture, it is not possible to lay down a standard test for salmonella, because there is room for much research in this direction (as has already been indicated), and as the scheme progressed improved methods of salmonella diagnosis would gradually be introduced. At the same time as the foregoing tests were in progress, a general mastitis survey would be done on all lactating cows, using the method of direct microscopical examination of incubated milk. An initial general survey of this type would provide the data necessary to visualise the scope of the task to be undertaken.

Coincident with beginning to plan the foregoing survey, it would be necessary for the state, or for some chartered corporation authorised by the State, to acquire large cattle ranches in strategic points throughout the country, and to get these ranches suitably staffed and equipped for cattle breeding on a large scale, the general idea being to run upon such ranches a general infected herd, and to breed from this herd disease free calves. In planning these farms, it would be necessary to provide accommodation for the various dairy breeds, and also for running pedigree and grade herds of the individual breeds. This would probably involve running pedigree ranches and grade ranches for the Friesland breed, and a joint pedigree and grade ranch for several of the less popular dairy breeds.

Stage 2. As soon as possible after a pilot tuberculin test had been completed in a district, reactors would be taken over by the State on the following terms :-

(a)

- (a) Any open cases of tuberculosis without compensation.
- (b) "Closed" reactors unfit for breeding purposes on 3/4 salvage valuation.
- (c) Reactors suitable for breeding on 3/4 market valuation. In the case of pedigree stock, it might prove desirable to place some maximum valuation for any single bull or cow, but in the case of grade stock cows could conveniently be valued on a "probable gallonage" basis, a system which dairy farmers generally use to judge prices worth paying at auction sales. Non-registered bulls of doubtful ancestry could be taken over at slaughter value, but some discretion would have to be allowed in the case of bulls of good known pedigree, which had not been registered in a stud-book.

In addition to all tuberculin test reactors being taken over, any animals giving definite positive paratyphoid reactions would be acquired by the State at <sup>COMPENSATION</sup> ~~the same rate as~~ ~~being paid for animals being destroyed unless a specially valuable blood-line is~~ ~~to be preserved.~~

In developing Stage 2 of the scheme, it would not be possible to operate simultaneously throughout the country, as this would result in too many cows being removed from private ownership simultaneously, with too great a drop in income to dairy-farmers as a class. It is suggested that teams of testers would gradually work their way through each district, and it might take two years before a complete survey had been made. Depending upon the number of reactors in a herd, a figure varying from all reactors to only 25% of them would be taken by the

State in the first instance. It is suggested that where the initial percentage of reactors is 10, or less, all should immediately be removed; whilst if the initial figure is 50%, then only one quarter of these should be removed in the first instance. In this way the State would immediately build up big breeding herds of tuberculous cattle, whilst no individual farmer would lose more than a fraction of his milk cows at one time.

It is fully realised that to leave reactors behind in a herd is in theory, at least, a fallacious procedure, but it must be appreciated that in stages 1 and 2 of the scheme, the main object would be to obtain an initial survey, and to build up the initial breeding herds necessary for the production of disease free calves. Moreover, it is only by avoiding penalising the individual farmer too heavily, or too suddenly, that his goodwill can be retained.

During these initial stages no particular attention would be paid to contagious abortion and mastitis, beyond collecting data, but naturally the results of all tests would be made available to farmers, who would be encouraged to begin the vaccination of calves and heifers in the case of contagious abortion, and in the case of mastitis, to eliminate those cows which were uneconomical to retain (i.e. two and three nipple cows, those giving milk consistently sub-standard in chemical composition, and those excreting too much pus). Such stock could be purchased by the State (not under compulsion at this stage) on the following terms :-

(a) Grade cows unsuitable for breeding on  
3/4 slaughter valuation.

(b) Grade

- (b) Grade cows suitable for breeding on terms as above, or half the market valuation had the udder been sound. (the larger sum to be paid in every case.
- (c) Pedigree cows unsuitable for breeding on 3/4 slaughter valuation.
- (d) Pedigree cows suitable for breeding on 3/4 market valuation, had the udder been sound.

Stage 3. This stage really would consist of building up State-owned herds of disease free calves. The animals acquired under compulsion during the initial survey (because of tuberculosis or salmonella infection), and those acquired as a result of voluntary sale (because of udder troubles) would be collected on the breeding farms according to breed, quality, etc., and a policy of breeding would be commenced. All calves would be removed from their dams at birth, and would be hand fed with pasteurised milk prepared on the farm. Whilst on the infected breeding farm, calves would remain in strict quarantine, and as soon as they had passed the stage of requiring milk, they would be drafted elsewhere to uninfected farms. Transfer to the clean farm would occur subject to a negative tuberculin test, a negative paratyphoid test, and in the case of heifers, only after vaccination against contagious abortion. SINCE THERE IS LITTLE HOPE OF ANY OTHER SATISFACTORY FORM OF CONTROL On the clean farms these healthy calves would be reared and made available for distribution as young bulls, heifers ready for breeding, and as heifers in calf. On the infected farms carrying the parent stock, all milk not required for calf rearing, would be pasteurised under strict supervision, and then made available for manufacturing purposes OF NON-EDIBLE PRODUCTS

- Stage 4. -

Stage 4. This stage represents the eradication and control scheme getting into full stride, and would be reached in 4 to 5 years after starting. By this time a constant and ever-growing supply of healthy heifers would be available, and it would now be possible to remove all remaining branded tuberculosis reactors from the herds, and instead of paying compensation they would be replaced by healthy stock of approximately equivalent value. From this stage onwards, routine testing of all herds would proceed automatically, new reactors to tuberculosis being replaced, paratyphoid reactors being replaced, a more severe interpretation being placed upon what constitutes cows uneconomical from the mastitis viewpoint. Since all replacements would be received from the State immunised against contagious abortion, it would only be necessary to introduce the compulsory immunisation of all calves against contagious abortion to put this problem on a sound agricultural footing. As regards mastitis; it is very much an open question as to what extent it would be possible, or even desirable, to attempt complete eradication. As has been stated, in the initial stages attention could be confined to the elimination of the worst cases, those definitely damaging the quality of the bulk milk, and as time progressed and replacements became available, the definition of worst cases could be rendered more severe, but it is difficult to visualise any complete eradication scheme for the elimination of this disease. The duty of the State would seem to be :-

- (a) To provide mastitis-free replacements for any farmer wanting them.
- (b) To provide all necessary testing facilities for farmers.

(c) To introduce -



- (c) To introduce a bonus system to encourage farmers to reduce their mastitis incidence to a minimum. This last aspect will be discussed in a later chapter in connection with other bonuses.

It is hardly necessary to point out that a scheme such as that outlined would take many years to get into full operation, and in the early stages would cost large sums of money. Initially, it would be necessary to collect together all necessary personnel, in order to train them for the work to be taken in hand. At the same time ranches would have to be purchased and all the necessary fencing, buildings, water supplies, etc., installed. Crop production would have to be taken in hand, in order to guarantee adequate food supplies for the cattle at reasonable cost. Then, and only then, would it be possible to start testing and collecting infected stock. Once a reasonable number of cows had been collected together, a small income would begin to be derived from surplus milk. This source of income would grow as the scheme developed, and in due course would become a major source of funds. In the meanwhile, the finest pedigree stock would by degrees be collected on the infected farms, and if properly used the State would in time become the biggest seller of first class pedigree stock - not only for the local market, but also for export. Finally, as producers of grade dairy stock of a guaranteed standard of health, the State would in time become practically the only supplier of grade dairy heifers. It is clear, therefore, that though the initial outlay would be very heavy, in the long run, the eradication scheme would develop into a sound business proposition paying reasonable and possibly generous dividends.

### CHAPTER 3. CLEAN AND DIRTY MILK.

The terms clean and dirty are used in connection with milk, for want of better words to describe milk which has been produced under good or bad sanitary conditions, and which has, in consequence, good or poor keeping quality. It has already been stated in the introduction, that there is not necessarily any connection between clean milk and safe milk, or between dirty milk and unsafe milk. On general grounds, however, it would <sup>be</sup> reasonable to contend that milk which is dirtily produced (i.e. withdrawn from dirty cows, by dirty hands, into dirty receptacles, in a dirty and fly-infested atmosphere) is more likely to be contaminated by bacteria, including pathogenic types, than milk handled under highly sanitary conditions. Up to a point this is quite true, but as has already been stressed, the safety of milk depends so largely upon the health of the cow, and to this extent sanitation per se does not enter the picture. Moreover, even where sanitation is of a high order, a human carrier of disease may inadvertently contaminate milk by droplet means. Once disease germs have found their way into milk, then the very cleanliness of the milk is an adverse factor, because in germ free milk the relatively delicate pathogens can multiply, where they would have been swamped by the heavy saprophytic flora of dirty milk. As a practical example of this, reference may be made to the work of Pullinger & Kemp (1937), where it was shown that Strep. pyogenes could multiply in commercially sterilised milk stored at 22° C., whereas they died out in the commercially pasteurised milk because of the denser bacterial population. Not only are bacteria more likely to multiply in clean milk, but there

is a far greater likelihood of milk being consumed raw, if it is of particularly high quality, and there is a greater likelihood of such milk being consumed by highly susceptible subjects, such as babies and invalids. Actually, a review of the literature shows that the dangers of very clean milk spreading disease is no idle fear. In Great Britain, prior to World War II, all milk from tuberculin tested herds was produced under highly sanitary conditions. Nevertheless, Brooks (1930a), Leeder (1932), Harding (1939) all described epidemics of scarlet fever due to certified milk, whilst the Wilton milk-borne salmonella epidemic (vide Conybeare & Thornton 1938) was caused by a diseased cow in an accredited herd. Faulds (1943) described a milk-borne Bact. sonnei dysentery epidemic caused by tuberculin tested milk, and Pullinger (1934 & 1935) showed that certified and grade "A" milk frequently was contaminated with Br. abortus & haemolytic streptococci. These are but a few of the many examples that could be cited to show that clean milk is not necessarily safe milk.

It is nevertheless very important that milk should be clean - not only from the economic viewpoint of reducing milk souring to a minimum - but also from the aesthetic viewpoint of not having to consume milk that is full of filth. There is, moreover, a growing volume of evidence to suggest that milk contaminants (with the exception of souring types such as Strep. lactis & Lactobacilli) may have toxic effects, if consumed in too high a concentration. The key investigations in this connection are reports by Park & Holt (1903), a long series of publications by Boivin & Mesrobianu (for full bibliography see Topley & Wilson 1936, page 800), and Topley & Raistrick (1934). Some of

these reports are ~~and~~ somewhat academic in nature, but additional to the practical observations of Park & Holt on the probable toxicity of Proteus vulgaris & morgani, Brooks (1932b) recorded six outbreaks of acute gastro-enteritis resulting apparently from the consumption of mastitis milk. Actually, the possibility of staphylococcal enterotoxaemia was not entirely excluded from certain observations, because, following upon the initial report by Baber (1914), the possibility of staphylococcal toxins was forgotten until the subject was re-opened by Crabtree & Litterer (1934), Shaughnessy & Grubb (1936 to/37), Minett (1938), and Burnet (1929 and onwards).

#### PRODUCTION OF CLEAN MILK.

The production of clean milk covers so vast a field that it could not be handled in this report, but attention may be drawn to a bulletin published by Mattick (1937). Although only published in bulletin form, this work is, in fact, a classic, which covers the production and handling of milk very adequately, but unfortunately the grading of milk receives scant attention.

The successful production of clean milk depends upon certain salient factors :-

1. The site of production.

Excessive attention has been paid by public health authorities to the elaboration of buildings to be used as milking sheds and milkrooms, the underlying idea being a sort of dairy slum-clearance campaign. This campaign, though most worthily conceived, has been carried to such excess in South Africa, that dairy buildings are demanded to-day so elaborate and costly, as hopelessly to over

- capitalise -

capitalise the business they are intended to accommodate. In the comparatively mild South African climate, few farmers let their cows sleep in the stable, and it is, therefore, totally unnecessary to build cow byres upon a scale which allows for sleeping accommodation. All that is required is the provision of a milking shed which offers a modicum of protection from wind and rain. Actually, the whole outlook of the milk hygienist in South Africa is at fault, because it has always been assumed that if a dairy farmer starts off with elaborate accommodation, and if he is given the benefit of a monthly visit from an inspector, then everything must be all right. In actual fact, there is no reason why under such conditions anything should be right, and bitter experience has shown that much of the milk with poorest keeping quality comes from the most elaborate stables. The point to be made here is that with regard to actual cow-byres, the barest minimum that will offer protection from the weather is all that should be demanded. Anything in excess of this bare minimum represents over capitalisation, and an interest charge that must be compensated for by excessive economy in some other direction.

In regard to milk rooms, the South African regulations are, if anything, insufficiently exacting. Great play is made of what is required in the complete dairy block, but all too frequently it is found that though all the necessary facilities are provided (i.e. cooling apparatus, hot water, milk storage space, etc), the provision made is quite inadequate for the volume of milk to be handled. This comment applies particularly to the provision of a hot water supply adequate for proper cleansing. Too little attention is paid to boiler capacity - a matter that is fully considered in Report (1936).

South Africa, and other countries too would be well advised to make less exacting demands with regard to capitalisation, and to reduce expenditure upon casual visual inspection, and to place far more reliance upon the very frequent testing of all milk supplies. What really matters is the daily quality of the milk, and not the appearance of the place from which it has come. Hoy et alia (1921) showed all too clearly what excellent milk can be produced under unfavourable conditions, provided the actual methods are sound, and it is as well to bear this in mind, even though admitting the axiom that a clean environment is likely to encourage clean handling. The point is that the clean environment may be "window dressing", which has no influence upon the handling methods, and it is only by daily laboratory testing that such "window dressing" is shown up for its true worth.

## 2. Methods of Production.

Satisfactory methods of production depend upon three simple criteria :-

- (a) Cleanliness.
- (b) Temperature.
- (c) Age (i.e. length of carry, and duration of storage.)

### CLEANLINESS.

Cleanliness of the Byre. The question of design of the byre has already been considered, and the only point to be made here is that it is the cleanliness that matters, whilst the design only serves to simplify cleaning. It is better to milk in a crude shed that is clean and airy, rather than in a tiled stable that is dirty and stuffy. Similarly, an open shed in the middle of a grassy patch is better than an elaborate edifice surrounded by an expanse of pulverised manure.

- Cleanliness -

Cleanliness of the Milker. Obviously, the process of clean milking can easily be hindered by a dirty milker. If his hands are soiled, he must inevitably dirty the teats and the milk, whilst if his milking methods are dirty or clumsy, or if he practises the dangerous and filthy habit of using saliva as a lubricant, there will be a similar result. When the dirty milker is also a carrier of disease, grave trouble is apt to arise, because then his dirty hands are almost sure to carry the pathogenic bacteria that he is excreting. It is not out of place at this juncture to refer to milking methods which have a very direct bearing upon cleanliness. If a man milks by pressure on the teat, the teat canal being occluded at the top, and then squeezed until empty, there is virtually no disturbance to the udder, and dirt adhering to the udder is likely to remain there. Moreover, working in this way, the milk can be directed in a straight stream to one point, and no splashing occurs. In South Africa, it is exceptional to see pressure milking done even by dairy college graduates, and the usual method of milking is by traction. Traction involves a continual stretching of the teats and udder, which disturbs dust and hair; at the end of the pull the milker's hand frequently gets splashed with milk; the milk stream is erratic, and splashes against the side of the vessel; the udder gets tender, which makes the cow restless, so that yet more disturbance is created. Finally, traction milking favours the spread of mastitis by injuring the udder. It is of great importance that a campaign should be initiated for educating dairy farmers in the art of milking. Unfortunately, the only officials frequently seen on dairy farms are sanitary inspectors, who

- have -



have neither the experience, nor the training to handle this matter.

Reverting to the primary question of cleanliness, the clothing of the milker can be important, particularly in a country where the average milkers normal garb is dirty rags. The usual recommendation is white overalls, which must be clean and in good condition. Unfortunately, even these do not always offer an ideal solution to the problem, because for utility reasons, overalls must be made of heavy material, and milking in such overalls on a hot day can, and actually does, induce such a heavy perspiration, that a steady trickle of drops runs down from the face and arms into the milk. During hot weather there is much in favour of milking being done in shorts only, or at most singlet and shorts. One item of clothing which should never be omitted is a clean cap that covers the whole head, and is made of white, easily washable material. The average farm worker's hair gets very full of dust, hay particles, etc., and every time the milker's head touches the flank of the cow, a shower of particles falls into the milk bucket.

Cleanliness of the Cow. Theoretically, cows should be cleaned prior to milking, but certainly under South African conditions, this is a Utopian ideal. It should, however, be a minimum requirement to keep the udder and flank hair clipped short, and to ensure that the hind-quarters and tails of the cows are well groomed, and then damped down with a wet rag. The damping down is to stop any dust flying during milking. When, as is so often the case, a cow comes in with her legs and flanks and tail heavily encrusted with mud and manure, it is then imperative that the parts adjacent to the udder should be washed

or groomed until clean, and dried until just damp. Udders and teats that are dripping dirty water are a source of contamination, and so is an udder that is bone dry.

As regards the actual milking, if this is done by pressure, lubrication of the teats is unnecessary, but if by traction the teats must be lubricated. The practice of lubricating with saliva is a filthy and highly dangerous practice, which cannot be too strongly condemned; lubrication with milk froth is most unsatisfactory, since the hands come in direct contact with the milk, contaminating it with dirt, including any pathogenic bacteria which may be on the hands. The alternative is the use of a greasy lubricant, such as vaseline. Numerous proprietary preparations are available for this purpose, most of which have some disinfectant incorporated, with the ostensible object of controlling mastitis. A large volume of work was done during the 1930.s by Seeleman and other notable German workers, on the value of the so-called preventive applications, and the general conclusion reached was that they are all equally worthless, and can become a medium for the spread of mastitis. Plain vaseline, kept in a tooth paste tube is a satisfactory lubricant. A proprietary preparation stored in an open tin can become a source of contamination, because of the filth which collects on the uncovered grease, and because a milker can milk a mastitis cow, and by returning to the grease pot he can render the grease itself a source of subsequent infection. This has actually been proved to have occurred. For more detailed information on the advantages of dry milking, reference may be made to a report by Boyes and McClemon (1932).

Milking Paraphernalia. In this term is included the milking-stool, the hock strap, and the grease pot, (the bucket will be considered under utensils), all of which are carried round from cow to cow. Obviously these items should be kept scrupulously clean, since they are inevitably handled after the final hand-wash which should precede milking. Furthermore, it is imperative that milkers should be taught a definite sequence in the handling of these items. On too many farms is it commonplace to see a makeshift stool, and leather strap slimy with grease, dung, and stable dust being adjusted without any re-cleansing of the hands before milking is begun. Stools should be of an easily cleanable design; where possible hock-straps should be dispensed with, and otherwise chains should be used; grease pots should be small enough only to contain grease for one milking, or the tooth paste tube system should be adopted. Prior to each milking, all these contrivances should be absolutely clean, and all milkers should parade in front of their foreman for inspection for general cleanliness. Additional to routine cleaning, milkers should be trained as follows :-

- (a) Adjust the position of stool and hock strap.
- (b) Secure the tail.
- (c) Have final hand wash in chlorine disinfectant.
- (d) Dry the hands on a clean towel.
- (e) Collect the milking bucket.
- (f) Milk the cow (with or without discarding of the fore milk, a practice that will inevitably vary from farm to farm).
- (g) Take the milk to the cooling room.
- (h) Return and check the stripping of the udder.
- (i) Remove hock strap, and proceed to secure the next cow.

- This -

This sequence should be repeated for every cow, it being assumed that the cleaning of the cows has been done prior to milking. On no account should concentrate feed be served out to cows whilst milking is in progress. Any accidental messing of apparatus which occurs during milking should be cleaned up before the next cow is milked.

Washing and sterilising of utensils on the farm. In the dairy industry, by far the most important source of dirt is old milk and cream, and compared to these, external sources of dirt are trivialities. Cleansing, therefore, in the first place involves the removal of every particle of residual milk and fat from the utensil, the initial step being a cold water rinse to remove the protein, preferably before it has had time to dry out. This is immediately followed by thorough washing in a hot solution of fat detergent. The detergent solution must then be removed by a hot water rinse, and thereafter the utensil should be scalded with wet steam, and where possible dried by a hot air blast. Cummins and Mattick (1920) have shown the importance of washing milk cans properly, whilst Proctor and Hoy (1925) emphasise the need for proper scalding. Too many farmers imagine it is possible to scald with tepid water, and when this fails they resort to chemical disinfectants. Such disinfectants can to some extent replace scalding, provided the initial cleaning has been efficient, but disinfectants cannot sterilise dirty cans. Incidentally, Hoy and Rennie (1927) showed up remarkable differences in the sterilising properties of various commercial preparations, but their work also showed the superiority of wet steam over all brands of sterilising powder. Anderson and Meanwell (1933) obtained outstanding improvement in milk quality,

- when -

when they introduced very simple steaming apparatus on to thoroughly unsatisfactorily dairy farms.

Washing and Sterilising Utensils at a Milk

Depot. Whilst the provision of flowing steam on a farm may possibly be regarded as a luxury, the failure to supply steam at a depot is an inexcusable omission, but the mere provision of steam is not sufficient, and it must be properly used. The cleaning of utensils in a depot follows the same general course as on the farm, but the final sterilisation must be far more effective, because the milk which will be put in the receptacle will either be pasteurised, or if still raw, it will be old enough to have lost all its natural bacterostatic effect, and in either case will offer a favourable pabulum for bacterial growth. The sterilisation of large milk cans in a depot can - and in South Africa actually does - represent a major problem, and one that is yet to be solved. A large depot may easily handle 2,000 ten-gallon cans in a day, and the washing and sterilising of these cannot be spread over 24 hours, but must be handled in one or two comparatively short rush periods. Apart from any washing, if it is assumed that it takes 60 seconds to steam sterilise a clean can, then it would require 33 hours to sterilise the whole batch on a single jet, or 33 jets and 33 operators to handle the work in an hour. Both solutions to the problem are impractical, and at present steam sterilisation of cans is a farce. Large capacity, continuous action, can-washing units are available Overseas, but as yet none have been imported into South Africa, and it is impossible to comment upon the efficiency of these contrivances.

Less stress need be laid upon bottle washing, because a high degree of efficiency has already been achieved in the design of automatic apparatus, and an extensive survey of the subject has been done by Hobbs and Wilson (1943). Efficient bottle-washing machines are in operation in South Africa, but experience has shown that they are only effective if properly handled according to the manufacturers' instructions. An example of this is given in a report by Pullinger (1946c), the relevant data being recorded in Table 8 of that publication. The figures refer to the presence of coliform contamination in bottle samples from two pasteurising depots. Circuit control samples for Bact. coli were as follows :-

December.

Cooler exit )	Coliforms absent from 1.00 cc.in 100% of samples.	)					
Storage tank )	" " " " " 97% " "	)					
Bottle )	" " " " " 81% " "	)					
Can samples.)	" " " " " 5% " "	)					

During this particular month considerable bottle and appalling can contamination had occurred.

January:

Cooler exit	Coliforms absent from 1.00 cc.in 90% of samples.
Bottle )	" " " " " 79% " "
Can samples.)	" " " " " 78% " "

The cooler-exit breakdown is discussed elsewhere, but in relation to the bad cooler-exit results, the bottle and can results show improvement.

April.

Cooler exit ) Coliforms absent from 1.00 cc. in 100% of samples.  
 samples. )

Bottle ) " " " " " 75% " "  
 samples. )

May.

Cooler exit ) " " " " " 100% " "  
 samples. )

Bottle ) " " " " " 95% " "  
 samples. )

June.

Cooler exit ) " " " " " 88% " "  
 samples. )

Bottle ) " " " " " 0% " "  
 samples. )

July.

Cooler exit ) " " " " " 90% " "  
 samples. )

Bottle ) " " " " " 100% " "  
 samples. )

These few results serve to stress the fact that no reliance can be placed in the machine itself, unless it can be subjected to efficient handling and constant outside supervision.

In the foregoing section an attempt has been made to give a concise review of the problems of cleansing and sterilisation, but for more detailed information reference should be made to the basic reports of Mattick (1937), and Hobbs and Wilson (1943), as well as to the numerous reports to which these authors themselves refer. It will be noted that no reference has been made to the cleansing of pasteurising circuits, as this will be considered as a specialised subject.

Straining of Milk. As an annexure to the problems of cleaning and sterilisation, it is necessary to draw attention to the question of filtering milk. The fact that milk should require to be filtered is in itself



an admission of bad milking methods. Dirt has been put into the milk, and then has to be taken out again, but the main stress should be placed upon the question of not putting the dirt in at all. The presence of visible dirt is very widely used as a method of judging methods of production, but it is doubtful if great value accrues from this procedure. If an inspector tests for visible dirt in the milk byre, and demonstrates to the farmer and to the milker where the faults lie, then great educational benefit will be gained, but the usual procedure is to test for dirt at the market end. The farmer who has been warned or prosecuted with regard to visible dirt, filters more carefully and avoids further trouble, but actually no farmer should be allowed to filter milk at all. The system at present in vogue in South Africa encourages the producer to filter, not through one, but through several thicknesses of cloth. Such cloth is not replaced every day, but is used time and time again. Unless the washing and sterilising of these cloths is of the very highest order of efficiency, they become veritable seed beds of milk souring bacteria, and the extraction of hair and straw is far outweighed by the addition of sour milk bacteria which occurs during filtration. Farmers should be stopped from filtering their milk, and proper filtration should be the responsibility of the milk depot, when it is possible to ensure that filter cloths are not re-used.

#### TEMPERATURE AND AGE.

After cleanliness the next important factor in clean milk production is efficient cooling of milk, allied to which is the inevitable age factor. If milk is

produced under very fine sanitary conditions, it will keep for a very long time, as was shown by Mattick and Stenhouse Williams (1922), and it is a point further emphasised by some unpublished results collected by Hoy that are quoted by Mattick (1937). Yet another example of high keeping quality under practical conditions of storage is referred to by Pullinger (1945-46), and consists of the case of a producer-distributor, who delivers milk only three times a week. Excluding exceptional cases such as these, however, the average milk is so seriously contaminated during production, that it will deteriorate rapidly, if not immediately and efficiently cooled.

If cooling is done with water, then the best that can be achieved is to cool the milk approximately to the temperature of the coldest water available, but all too frequently cool borehole water is allowed to warm up many degrees before it reaches the milk cooler. Frequently too, the cooling plant is disproportionate to the volume of milk to be cooled, and in consequence, the milk has to flow too fast to have time to reach the lower temperature of the cooling water. Pullinger (1944) refers in some detail to the results of ineffective cooling, with illustrative examples of inefficient work. Stated briefly, the following factors must be operative :-

- (a) The coldest water available must be used.
- (b) It must be used at its lowest temperature, and not be allowed to warm up.
- (c) The efficiency of the cooler used must be such that the milk is cooled approximately to the temperature of the water.

In general, however, it should be accepted as a

basic principle that water cooling should only be acceptable, when milk can be conveyed to the depot and refrigerated within a couple of hours of milking. If longer transportation periods are unavoidable, then milk should be refrigerated on the farm; whilst in cases where the distance of carry is such that the journey will take many hours, then the aim should be to avoid railing milk in 10 gallon cans, except where refrigerated (not watercooled) trucks are available. Wherever possible long-distance milk should be refrigerated and bulked near the point of production, and forwarded to market in refrigerated tankers.

#### THE GRADING OF MILK.

In discussing the question of clean and dirty milk, an indication has been given of the simplest steps that are necessary to achieve a clean milk supply. What is considerably more complex is the question of deciding what constitutes a satisfactory or unsatisfactory milk supply. An immense amount of work has been done by various people upon tests suitable for grading milk, much of this work being reviewed by Wilson et alia (1935). Furthermore, many reports have been written, either suggesting, or actually laying down bacterial standards to which milk must conform. What is lacking in the literature in the first place is concrete data to justify the standards that are proposed, or have been adopted, whilst secondly, there is a notable absence of instructions as to how these standards are to be applied. A very usual practice is to lay down some figure for standard bacterial count, which represents the maximum permissible figure for standard milk, and a certain producer's milk is tested, and falls below

- standard -

standard. A problem now arises of what is to be done. Clearly this farmer's milk cannot be excluded from market on the basis of a single test, partly because it would be unjust considering how inaccurate the tests are (vide Wilson et alia 1935), and partly because the consumers badly require the milk. Consequently, the producer is warned, and may have to be warned yet a third time, that his milk is still below standard. The position is, in fact, reached where the standard is no standard at all, but just a general guide to milk quality, and it is left entirely to the discretion of the local authority to decide how often a producer may fall below the approved level.

At this juncture it is desirable to consider the intention behind the bacteriological grading of milk, and the establishment of milk standards. In the early stages of milk control, a system of inspecting dairy farms and dairy shops was instituted, the idea being that regular visits by Health Inspectors safeguard the milk supplies from the danger of filthy methods of production, and consequent danger of contamination with disease producing germs. This form of inspection is an essential service, that goes a very long way towards removing the danger of milk-borne epidemics, and it is a service that should at all times be maintained. After the establishment of inspectorate services, it gradually became realised that the bacteriological testing of milk and the application of certain arbitrary standards assisted inspectors in their duties, and in particular created a yardstick for use, when prosecuting for the "exposure of milk to risk of contamination." Up to this point the uses and meaning of tests and standards were still clearly understood. As

As time has progressed, however, the idea has arisen that milk standards are a measurement of milk safety. In fact, the statement is sometimes made that a high bacterial count indicates the probability that milk is unfit for human consumption, and a danger to health. The confused thinking in this connection is all too apparent, when it is remembered that sour milk is frequently prescribed for invalids, dyspeptics, and weakly babies, for milk having a high bacterial count is nothing more nor less than milk that is about to sour. The bacterial count of milk, like the Methylene blue reductase test must be regarded as an index of keeping quality, and not of safety, though it is freely admitted that a low bacterial count indicates a high standard of dairy hygiene, and thus less opportunity for external contamination of milk. To view such counts as a direct standard of safety is, however, quite unsound, and if such a direct standard of safety is required, it could only be supplied by submitting milk to tests for all disease-producing germs, a procedure that is technically impractical. Even the presumptive coliform test, which indicates the probability of faecal contamination, is of no great help in this connection, for though a low coliform result indicates a good standard of dairy hygiene, an unfavourable coliform result merely indicates that "something is wrong". It does not show, however, whether the fault lies in the production, or in the storage, because a very small initial seeding with coliform organisms can become a massive contamination in the space of a few hours, if the milk is not stored at refrigeration temperature.

In view of the entire lack of data justifying

- those -

those standards that have been adopted throughout the world; more particularly in view of the entire absence of any justification for applying overseas standards to South Africa; and finally because of the futility of choosing strict numerical standards and then leaving it entirely to the discretion of some inspector as to how to apply this standard as an average guide, Pullinger (1945-46) collected together and analysed a large volume of data consisting in part of personal observations and for the rest collected from other milk testing centres throughout South Africa. It is quite impossible to prepare a detailed precis of this article which should be read in the original, but broadly speaking the following principles were enunciated as a result of analysing these results.

1. In the course of a single day the hygiene on a dairy farm may change and does change, and consequently each milking operation must be regarded as an individual hygiene unit. With two or possibly three milking operations in 24 hours a farmer has, therefore, from 60 to 90 <sup>monthly</sup> independent/ hygiene operations, any of which may be good and any bad. To collect one monthly sample representing only a portion of one single hygiene operation for test, and on the basis of this 1/60th or 1/90th of the total milking hygiene to grade a farmer in regard to dairy hygiene is merely being frivolous. It is urged that every attempt should be made to collect a 24-hour composite sample of milk five days a week for test.

2. Few if any farmers can consistently maintain a reasonable milk standard day after day and it is, therefore, worthless to lay down any strict numerical standard. The correct method of approach is to lay down an average standard and then to define clearly the extent to which producers are allowed to deviate below this standard.
3. It is found that when many samples are tested daily vast masses of data are collected which become quite unmanageable and unintelligible. To cope with this difficulty a system is suggested of choosing an average standard, and analysing each producer's test results monthly in relation to this standard. The method of analysis proposed is to state the proportion of results that achieve the standard compared to the proportion that fall below the standard. This proportion is called the Good:Bad ratio. Instead, therefore, of dealing with vast tables of daily test results each producer gains a Good:Bad ratio for the month.
4. Once a Good:Bad ratio has been allocated to each producer, all that then remains is to decide what Good:Bad ratio will be classed as the minimum to be accepted because that will define the degree to which a producer is allowed to deviate below the standard. The choice of the Good:Bad ratio standard must be based upon the analysis of much data collected under practical conditions.



In the original article referred to an attempt was made to lay down a seasonal Good:Bad ratio that a reasonable number of producers could maintain, but even when very lenient standards were laid down, standards that sound stupid in the light of what is demanded overseas, only a small fraction of all the producers could maintain them.

As a logical conclusion to this report, it was proposed that in South Africa all milk should be priced upon a quality basis, the term quality being used to include both chemical and bacteriological aspects. A table of milk grades is set out in the report indicating the possible bonuses that could be earned. To deal with the difficulty of the existing low quality of milk the suggested scheme provides for a sliding scale of grades, each grade becoming more severe every two years, the assumption being that a two year period is sufficient time even for indifferent farmers to improve their methods and so continue to earn the same bonuses on the more strict standard.

Clearly any attempt to introduce a bonus system upon the existing milk industry would be a failure because of the numerous channels through which milk has to pass to reach the market. For a bonus scheme to operate it would be necessary for all milk to be handled by a single entrepreneur comparable to the Milk Marketing Boards of Great Britain. An outline of such a reorganisation is given in the final chapter of this report.

CHAPTER 4. THE PRODUCTION OF MILK OF  
REASONABLE CHEMICAL QUALITY.

Up to the present attention has been confined to the provision of clean milk and safe milk, but the responsibility of any milk control authority must also include the provision of a milk supply having a reasonable, and preferably a more or less standardised, chemical quality. In an earlier report Pullinger (1944) gave figures to show that pooled milk arriving in Johannesburg for fluid consumption was seriously deficient in proteins and somewhat deficient in fats during the spring and early summer. It was also shown that this deficiency in pooled milk was merely a reflection of the output of individual herds. For instance figures were quoted to show that upwards of 12% of herds showed a non-fat-solid content below 8.0%, whilst 74% of herds fell below the figure of 8.5%.

Taken at their face value these figures were extremely disturbing, but it seemed likely that they represented a seasonal picture only and possibly applied only to a single abnormal year. It was, moreover, possible that this picture did not apply to the factory milk supplies, and, in consequence, further investigations were carried out.

With regard to milk supplies to factories only limited observations could be made, but from these it can confidently be stated that a different picture was to be seen because the milk going to factories was considerably richer, particularly in regard to fat. This in itself is not necessarily a good thing because an excessive fat content in milk designed for cheese making

is a definite hindrance and merely goes to show that in South Africa the dairy industry is so organised that no machinery exists for ensuring that milk reaches the most appropriate market, or is put to the most appropriate use.

As regards the question of whether the apparent deterioration was seasonal or otherwise has been answered by Pullinger (1946e). In this report in which chemical analysis of bulk milk over a time space of three years . are recorded a very clear answer is obtained. The milk under test represented large composite samples collected at a large pasteurising depot that handles over 10,000 gallons of milk daily. These samples were collected as a rule five days a week. The following figures represent the essential outcome of the survey:-

The average butter fat content fell below	3.5% in 14 out of 35 months.
	3.0    14    0    ..    35    ...
The average non-fatty-solids content fell below	8.5% in 23 out of 29 months.
...                      ...	
The average total solids content fell below	12.0% in 24 out of 29 months.
...                      ...	

Stated bluntly these startling results indicate that milk only achieved the minimum chemical standard of 12.0% solids during five months out of a 29 month survey.

Facilities have not been available for enquiring too closely into the causes of this poor milk quality, but clearly the answer must lie in one or more of the following factors or in a combination thereof. These factors are:-

- (a) -

- (a) Diseased udders.
- (b) Faulty feeding.
- (c) Faulty breeding.

As regards diseased udders it has already been stressed that no nation-wide survey of bovine mastitis has yet been made. Preliminary investigations reported by Pullinger (1944) showed that most herds periodically showed signs of disease in the bulk milk and in a more elaborate investigation (vide Pullinger 1946d) it was found that similar results were obtained and, in fact, out of 435 herds under examination only one remained consistently clear of mastitis signs (as judged by bulk milk investigations) and when subjected to test for a reasonable number of times. Clearly, therefore, there is mastitis enough to account for part at least of the depreciation in quality in regard to non-fatty solids.

As regards feeding it is generally stated in text books that the chemical composition of milk depends upon the inherent capacity of the udder to synthesise the various organic constituents, and this ability is independent of the food which is supplied. The details of this aspect of the problem are clearly set out and lucidly discussed by Eckles et alia (1943). This generalisation with regard to the influence of feed upon milk quality has been amply proved by controlled experiments, but they have been done upon cows which were existing upon a balanced basal ration. In South Africa, however, many dairy cows have to endure periods of semi-starvation whilst even some of the best cared-for herds have to exist periodically upon hopelessly unbalanced

- rations -

<sup>EXCEPTIONAL</sup>  
 rations. An example of a herd of this type is quoted  
 by Pullinger (1946a), in which <sup>AN APPARENTLY</sup> high-class and high  
 producing herd was found to be giving butter-fat results  
 varying from 1.9 to 2.5 per cent, when tested in bulk.  
 The non-fatty-solids figures for this particular herd were  
 up to a reasonable standard. It should be explained that  
 the possibility of any adulteration occurring was entirely  
 excluded. When cows were tested individually, some were  
 found to be giving as little as 1.5% of butter fat, and  
 only 3 out of 80 animals reached the legal minimum figure  
 of 3.5%. Since that report was written, other herds have  
 been encountered giving similar results. Whilst this  
 type of result is partly due to faulty breeding, it is  
 impossible to attribute the whole effect to that cause,  
 and it <sup>IS POSSIBLE</sup> ~~is possible~~ that the totally ill-balanced diet  
 which was being fed (in this case teff grass ad libitum,  
 plus a limited ration of a proprietary dairy meal), <sup>APPARENTLY MAY HAVE</sup> had  
 the effect of over exaggerating the fluid output of the  
 udder beyond the ability of the udder tissue to synthesise  
 the limited supply of available nutriment into milk-solids.

The third factor - that of faulty breeding -  
 falls outside the scope of this thesis, but one aspect  
 which was discussed more fully by Pullinger (1946e), ~~may~~  
 may be referred to here. The improvement of herd records  
 by orthodox breeding methods is a tediously slow procedure,  
 and attention is drawn to a "short-cut" to milk record  
 improvement by the hybridisation of recognised dairy breeds.  
 It is being shown at the Beltsville Research Centre: U.S.A.,  
 that by crossing pure-bred dairy bulls (having already  
 sired pure-bred progeny of proved milking worth) with  
 pure bred dairy cows of another breed (also having thrown  
 pure-bred progeny of proved milking worth), then the hybrids

- resulting -

resulting from this cross will be better milk producers (both in regard to quantity and quality), than their grand-dams, their dams, or even their pure-bred cousins. This type of hybridisation can only be maintained in the first cross, so that it is necessary at all times to maintain the pure dairy cattle breeds, and to continue to improve them by orthodox selective breeding. Meanwhile, the quality of the milk could be quickly and very markedly improved by the introduction of intelligently bred hybrids into the commercial dairy herds. In South Africa the value of cross-bred cows for butter-fat production has long been appreciated, but generally speaking, cross-breeding has been done promiscuously, one or other member of the mating being of inferior quality, and consequently the full benefits of hybridisation have not been appreciated. Moreover, in South Africa the hybrid dairy cow is nearly always mated back to a bull of one or other of the parent strains, with unsatisfactory results. The Beltsville experiments are showing that the hybrid heifer should be mated to a proven bull of some third dairy breed, in which case the resulting offspring will show even greater milking ability.

#### CONCLUSION.

Concluding this brief survey of the problems involved in regard to the chemical quality of milk, it may be said that improvement in the general quality calls for an organised campaign, in which the State, the breeder, and the dairy farmer all co-operate in their own particular sphere. Udder disease must be controlled and reduced to a considerable extent. The feeding of dairy stock must be rationalised by means of improved farming methods, which would include more and better silage production,

increased production of leguminous crops for hay and silage preparation, increased use of natural veld for hay-making, the laying down of permanent pastures, and experimentation with ley farming, as well as other innovations too numerous to mention here. It would be necessary for the State to standardise the feed content of dairy concentrates more effectively, and an effort would have to be made to restrict uneconomical feeding of concentrates to a minimum (i.e. feeding a three-gallon ration to half-gallon cows). Dairy stock improvement along orthodox selection lines, <sup>MUST BE CONTINUED WITH VIGOUR</sup> ~~\_\_\_\_\_~~  
~~\_\_\_\_\_~~

laid for a scheme whereby all milk should be priced according to its chemical quality, a higher price, in fact, being paid for a better product.



CHAPTER 5. THE PROVISION AND MAINTENANCE OF  
A SUPPLY OF SAFE MILK.

From what has already been stated, it will be apparent that in the writer's opinion at least, there is no raw milk that can be considered safe, because there is little likelihood of eliminating all bovine diseases within any reasonable space of time, and there is no prospect whatsoever of eliminating human carriers of various diseases. To protect the community from milk-borne epidemics, some safeguard has to be introduced other than the mere attempt to exclude disease carriers, and the only measure at present available for use on any extensive scale is pasteurisation. Whether all milk should be pasteurised, or certain classes be exempt, is a debatable matter. From a public health point of view, clearly all milk should be pasteurised; but on the other hand, there are people who prefer raw milk, whilst there are also milk-producers who maintain so high a standard of milk production, that their product is at all times reasonably safe. It can, with justice, be urged that the controlling authority should make available supplies of raw milk of high quality, offering a considerable assurance of safety to meet the demands of those who wish to have it, and are prepared to pay for it as a luxury product.

Definitions of Pasteurisation.

In the light of present day knowledge, three definitions may be advanced to cover various types of pasteurisation:-

1. The heating of every drop of milk to a temperature of  $142.5^{\circ}$  F., and not above  $145^{\circ}$  F., and holding all the milk at the chosen temperature

for 30 minutes. This is known as "holder pasteurisation". (A slightly higher temperature and a shorter holding time is accepted in certain countries.)

2. The rapid heating of every drop of milk to  $161.5^{\circ}$  F., and not above  $162.5^{\circ}$  F., and the maintenance of this temperature for 14 to 15 seconds.
3. The rapid heating of every drop of the milk to  $161.5^{\circ}$  F. or upwards, and the maintenance of the milk at that temperature until it gives a negative phosphatase test reaction.

The latter two definitions refer to the so-called Short-Time-High-Temperature (i.e. S.T.H.T.) pasteurisation, and they differ in regard to the inclusion, or omission, of the factor relating to the rate of flow. With certain modern S.T.H.T. plant, the rate of heating of the milk is so effective, that a full 14 second period of heating is not necessary for efficient pasteurisation. As regards rate of flow of milk, this can be measured very accurately, before or after the actual pasteurisation, but it is not possible to measure this rate of flow with any accuracy whilst milk is actually being pasteurised. It is very easy to imagine how, by altering valve settings, or pumping pressures, the rate of flow could be very different during pasteurisation, than when the plant is subjected to flow tests. Ultimately, efficiency of pasteurisation is judged upon whether or not phosphatase enzyme is destroyed, and in consequence certain legislators prefer to omit from the legal definition a time factor which is immeasurable (under working conditions), and insert

instead the Phosphatase factor, which is in any case the final and deciding one.

As the science of pasteurisation becomes better established in South Africa, it will become necessary to introduce tests to stop not only underheating, but overheating also. At present, however, the underheating question is the one upon which it is necessary to concentrate, because the safety of the milk supply depends upon the successful maintenance of the minimum temperature level.

### PASTEURISING PLANTS.

It does not fall within the scope of this work to discuss types of pasteurising plants, because this is best done by trade journals, whilst in addition to such journals attention can be drawn to reports by Tjaden, Koske & Hartel (1902), North *et alia* (1925), Zeller *et alia* (1929), Scott & Wright (1935), as well as to books by Harvey & Hill (1946), and by Enoch (1943). Unfortunately, practically all the work that has been reviewed in reports and text-books was done prior to the introduction of the phosphatase test for efficiency of pasteurisation, and the only criterion in those days was the questioning of the survival or destruction of tubercle bacilli, which is a crude and thoroughly unsatisfactory test.

In the subsequent text, it is proposed to discuss some of the principles underlying the operation of those types of plant that have been used fairly extensively in South Africa, and attention will be focussed upon certain inherent weaknesses of these plants.

#### A. HOLDER PASTEURISING PLANTS .

##### 1. Non-continuous flow batch pasteurisers without preheaters.

This plant consists essentially of a steam

- jacketed -

jacketed vat designed to heat the contents to pasteurisation temperature. Heating may be implemented by internal steam coils, whilst mixing is obtained by some system of paddles. The gross errors of this type of plant have been fully discussed by Scott & Wright (1935), but they include dead space, particularly at the outlet valve where pasteurisation temperature is never achieved, dead space leaks or uncleanable foci in valves and paddle bearings, and excessive surface frothing, with consequent underheating of the surface layers. The most essential weakness is overlooked in most reports, however, this being the slow rate of operation, which reacts unfavourably upon the patience of the operator. To pasteurise a single batch in a 200 gallon vat can take times approximating to the following :-

Filling of vat	-	15 minutes.
Heating to 143° F.	-	45 "
Holding at 143° F.	-	30 "
Emptying & cooling	-	15 "

Total - 105 minutes.

Thus, it takes an hour and three quarters to pasteurise a ~~single~~ batch, and some of the milk, at least, will be maintained <sup>at</sup> a high temperature for most of this time, giving thermophilic bacteria ample opportunity to multiply in numbers. Meanwhile, if a second run of the plant is necessary, the cans of farm milk will be standing all this while on the receiving room floor deteriorating. The operator in the meantime - growing impatient - is tempted to shorten the holding time more and more, and after a while it becomes customary to assume that immediately the milk reaches the temperature of 145° F., pasteurisation is complete, and the milk is ready for cooling. The human failing in

- regard -

regard to the time factor can be checked by installing an automatically recording thermograph, but nothing can check thermophilic growth, or other spoilage. Finally, the re-cooling of milk from this type of plant is invariably done over an open cooler, with the milk exposed to atmospheric, fly and droplet contamination.

## 2. Non-continuous batch pasteurisers with preheaters.

The next stage in the elaboration of pasteurising plant is the introduction of a preheater, which rapidly heats milk to the required temperature. This is generally done by passing a thin film of milk along a metal surface on the other side of which is the heating fluid (i.e. water-steam mixture with the temperature thermostatically controlled). The heating unit comprises either a battery of adjacent plates separated by narrow spaces, which carry the milk or the heating fluid, or alternatively the unit may comprise a series of concentric tubes. In such preheater units it is customary also to include a <sup>re-</sup>cooling system, and the whole operates upon a heat-exchange basis to save heating and refrigeration. In this exchanger on-coming raw milk is partially warmed by hot, pasteurised milk returning to the cooler, and thereafter it is filtered to remove all visible dirt. It is then preheated against steam and water to the full pasteurisation temperature. Once a preheater block has been included in the circuit, a comparatively expensive pasteurising unit has been installed, and most firms prefer to lay out a little more capital, and instal a continuous-flow plant.

## 3. Continuous-flow holder pasteurisation.

This apparent contradiction in terms of "continuous-flow" and "holder" is achieved by installing a series of

six holding vats, in place of one. The rate of flow through the heat-exchanger is so regulated that preheated milk is discharged into vats so as to fill them in  $7\frac{1}{2}$  minutes each, whilst the discharge rate is similarly timed. The system of operation is as follows :-

Tank No.1.begins to fill, and fills in  $7\frac{1}{2}$  minutes.

"	"	2.	"	"	"	$7\frac{1}{2}$ minutes later.	No.1 now full & being held.
"	"	3.	"	"	"	15 "	Nos.1 & 2 full & being held.
"	"	4.	"	"	"	$22\frac{1}{2}$ "	Nos.1,2 & 3 full & being held.
"	"	5.	"	"	"	30 "	Nos.1,2,3 & 4 full & being held.
"	"	6.	"	"	"	$37\frac{1}{2}$ "	No.1 has been held 30 minutes & now discharges in $7\frac{1}{2}$ minutes. Nos.2,3,4 & 5 full & being held.
"	"	1.	"	"	"	refill 45 "	No.2 begins to discharge.

This cycle is repeated until all milk is pasteurised.

The advantage of the system is that milk is maintained hot no longer than is absolutely necessary to fulfil the minimum legal requirements of holder pasteurisation, and after an initial delay of 45 minutes before any milk is ready, a steady flow becomes available thereafter for bottling and despatch.

The chief problem in connection with this system hinges upon the method whereby milk is diverted from one holding tank to another, after the requisite filling period of  $7\frac{1}{2}$  minutes. The first device designed for this purpose consisted of a filling pipe suspended over a circular

tank divided into six equal-sized sectors, and built onto a revolving platform. The whole tank is geared to revolve every  $7\frac{1}{2}$  minutes, so as to bring a fresh sector directly under the filling pipe. At the bottom of each sector is a discharge valve with an opening device, so regulated that it discharges the hot milk  $7\frac{1}{2}$  minutes before the sector is due to revolve under the filling pipe again. The rate of flow of the preheated milk is so regulated that a sector fills in  $7\frac{1}{2}$  minutes, and discharge is supposed to take place at much the same rate.

The system outlined above has gradually been elaborated, and in more modern plant the holding tanks are in a straight line with milk filling & discharge controlled by valves operated by clockwork. The change-over from a circular tank to a straight row of them is a definite forward step, because in the circular variety there is considerable splashing from the filling pipe, and raw milk may actually splash into the sector containing pasteurised milk about to be cooled. Moreover, if there is any overflow in the circular sector tank, this tends to run into adjoining sectors, and particularly into the sector actually discharging, whereas with the straight tanks there is no splashing, and all overflow runs on to the floor.

Whilst the more recently designed holder pasteurisers are claimed to be entirely automatic in action, and virtually "fool-proof", they are in practice delicate precision instruments very easily upset by misuse. One fundamental problem in both new and old types is to ensure a steady flow of milk at all times. Manufacturers will not admit this difficulty, and yet in practical pasteurisation a large proportion of breakdowns can be attributed



in the first place to a variable rate of flow. In all plate-pasteurisers (i.e. units in which the heat exchange is effected through baffle plates), the rate of flow of the milk through the narrow space between adjacent plates is obviously dependent upon the thickness of the flowing film. The metal dividing plates are not rigid, but bend in response to pressure changes on either side. Manufacturers lay down the correct pressure relationships between the milk and the heating or cooling fluid which are necessary to maintain the thickness of the milk film at a uniform figure. Unfortunately, no means exists of ensuring with certainty that the correct pressure relationships are in fact maintained. Factors which alter the pressure relationships include :-

- (a) Any failure (partial or complete) in the various pumps (milk, water, or brine).
- (b) Any malicious interference designed to speed up the rate of milk flow.
- (c) Any blockage in the milk circuit, such as freezing up of the refrigeration section, or due to clogging of the filters. Actually, the filter introduces a serious variable into the circuit, because starting with a clean filter pad filtration is rapid, but as the pad accumulates dirt, there is a progressive fall in the rate of flow, with a consequent drop of milk pressure. This results in occlusion of the passage through bending inwards of the plates, and decreased flow of milk.

The effect of pressure changes, and changes on the rate of flow are three-fold.

- (a) If pressure changes are continually taking place and the plates are in fact continually "breathing" they will in time become "fatigued" and breaks will appear. This can present a very real and a very serious problem, since such breaks can exist for a long while before their presence is suspected. (The application of the coliform test for indicating the existence of such leaks, and the Wilkie test for detecting the site of the leak are described by Pullinger (1944 b) and (1946 c)).
- (b) If the rate of flow varies appreciably it will be found that certain holding tanks are being overfilled with resulting wastage or mess; or alternatively they may be underfilled.
- (c) If the rate of flow drops appreciably so that holding tanks are not completely filled, then such tanks will empty themselves of milk in less than  $7\frac{1}{2}$  minutes. In consequence there will be a time space until the  $7\frac{1}{2}$  minutes are completed when no milk will be flowing through the refrigeration section of the heat-exchanger. If this state of affairs materialises the refrigeration section freezes up with a resulting partial or complete blockage. Milk pressure immediately builds up within the heat-exchanger and all plates and rubber gaskins are subjected to a heavy strain which may result in a break developing.

A further fault in certain of the more recent holder plants lies in the fact that the milk is discharged from the holding tanks, not by gravity but by vacuum. The maintenance of the vacuum depends upon keeping certain joints, that have to be opened and washed daily, in perfect condition. Under the stress of continual manipulation by careless workers these vacuum joints soon begin to leak and the whole discharge system is put out of action.

#### 4. "In-Bottle" Pasteurisation.

This is a modification of the holder-method of pasteurising, whereby raw milk is introduced into bottles and held at pasteurisation temperature in the actual container in which it is to be sold. The great advantage of this system is that the danger of recontamination of the milk after pasteurisation is reduced almost to vanishing point. All early attempts at in-bottle pasteurisation were a complete failure, because of difficulties encountered in heating the milk in the bottle, but in modern plant most of these difficulties have been overcome. In broad outline the system is as follows:-

1. Raw milk is warmed, filtered and preheated to pasteurisation temperature.
2. Bottles are washed, rinsed and sterilised and are delivered whilst still hot directly to the milk filling section.
3. Preheated milk is filled directly into hot bottles and thereafter the full bottles are sealed and then pass along a conveyor through a tunnel in which the bottles are subjected to a

hot air blast which maintains the milk at pasteurisation temperature. The bottles take 30 minutes to traverse this tunnel.

4. On leaving the tunnel the bottles are water cooled, chilled, and finally overcapped.

Theoretically this system of pasteurisation is extremely sound since the danger of post-pasteurisation recontamination is entirely excluded, always provided that the plant is easily cleaned and sterilised, and that the bottles are maintained in perfect condition. From the Public Health control point of view one objection to the plant is that it is difficult to be sure that all bottles are properly pasteurised. Additional to the checking of all recording instruments it is necessary to subject all pasteurised milk to the phosphatase test. With ordinary pasteurisation plants it is possible to collect representative samples from the tanks where the pasteurised milk is stored prior to bottling, but in the case of the "in-bottle" system every bottle must be regarded as an independent unit that may or may not have been properly processed, and yet phosphatase testing must be confined to the random sampling of a very limited number of bottles.

No modern "in-bottle" pasteurising plant has as yet been in operation in South Africa for any appreciable period of time, so that no considered opinion can be given regarding behaviour under local conditions. Judging, however, from blue prints it seems probable that it will work as well here as elsewhere, though it may be found that with the present milk delivery system, bottle wastage may prove too expensive an item, for it must be

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stressed that for use in this plant bottle mouths must be in perfect condition.

B. SHORT-TIME-HIGH-TEMPERATURE PASTEURISING PLANTS.

From the earliest days of pasteurisation, plant operators and pasteurisation engineers have been impressed by the economic shortcomings of the bulk holder method, these being:-

1. A 45 minute lag between processing being started and pasteurised milk becoming available for dispatch.
2. Spoilage of milk due to the long holding period at high temperatures when thermophilic bacteria multiply. (In the event of a mechanical hitch the holding chambers cannot immediately be drained and at times milk may stand upwards of an hour at 142.5 F. until processing starts again).
3. The great size and consequent expense of the holding plant.

To eliminate these difficulties many attempts have been made to obtain an equivalent bactericidal effect by heating milk at a higher temperature for a much shorter time. The first plants built on this system were so unreliable that the system as a whole fell into disrepute (vide North et alia 1925), and an example of this type of plant was also referred to by Pullinger (1944) on page 20. Latterly, however, increased thought has been given to the plant design and to-day plant is obtainable which heats milk rapidly to temperatures of 161° C. to 163° C. and maintains these temperatures for from 8 to 15 seconds, depending upon the make

of plant. The precise times and temperatures depend upon the regulations to be conformed to, but broadly speaking most English speaking countries demand a temperature of 161.5°F. maintained for 15 seconds, whereas countries on the Continent of Europe accept slightly higher temperatures, which are maintained for 8 seconds (circa), but the phosphatase test result and not the time and temperature of holding must eventually constitute the crux of the matter in all countries.

The factors which lift modern S.T.H.T. plant to the level of reliability are:-

1. Accurate preheating.
2. Controlled rate of flow.
3. Automatic temperature recording devices.
4. Thermostatically controlled "flow-diversion" valves which return all milk which has not reached pasteurisation temperature back into the raw milk supply.

These S.T.H.T. plants are cheaper than the holder units, require less space, and are easier to handle. Pasteurised milk is immediately available for dispatch and there is no spoilage due to prolonged heating. The main weakness of the present-day S.T.H.T. plant is that it is difficult to guard against the malicious interference with the rate of flow of milk. At present no suitable instrument exists for making a continuous automatic record of the rate of flow of milk through the plant. An inspector must assume that the rate of flow is correct and the only check test he can apply is to ensure that the phosphatase test gives a reading of "properly pasteurised".

EFFICIENCY OF PASTEURISATION.

By efficiency is meant the extent to which milk is correctly heated, and the primary problem in this connection is the question of underheating, since that fault may result in the milk being dangerous. The prevalence of underpasteurisation amongst South African depots was stressed by Pullinger (1945) who recorded the results summarised herewith in table 12.

TABLE 12.

Efficiency of pasteurisation\*

Town No.	Depot No.	Total samples tested.	Percentage under-pasteurised.
1	A	2543	0.28
	B	2398	0.083
2	C	1204	6.3
3	D	207	3.86
	E	218	3.2
	F	335	9.55
	G	62	42.0
	H	90	12.2
4	I	666	27.25
	J	422	3.78
	K	782	1.66
	L	519	8.4
	M	216	5.2

\* Efficiency judged by the phosphatase test.



These figures show all too clearly that in certain factories pasteurisation is no more than an illusion. Undoubtedly things have improved somewhat since the publication of these figures, and the sort of improvement that can be achieved by rigid control is indicated by the figures in table 13, which are extracted from the same report.

TABLE 13.

Increased efficiency of pasteurisation obtained  
by strict supervision.

	Depot No.											
	1		2		3		4		5		6	
	No. Tests.	U.P.*	No. Tests.	U.P.	No. Tests.	U.P.	No. Tests.	U.P.	No. Tests.	U.P.	No. Tests.	U.P.
Prior to special control.	17	53	265	24	113	35	142	71	144	22	40	5
Special control in operation.	10	20	46	7	29	3	23	13	26	8	8	13

\* U.P. = Percentage samples underpasteurised.

Rather similar figures can be extracted from the reports of the M.O.H., Port Elizabeth (vide Reports 1941; 42 b. and 43 b.) viz:-

1941.	74.3%	of samples properly pasteurised.
1942.	94.9%	" " " "
1943.	95.05%	" " " "

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The striking improvements indicated by the foregoing figures show what can be effected without the installation of new plant, simply by supplementing ordinary visual and sanitary inspection with phosphatase testing, and using the test results to educate the pasteuriser.

As regards the overheating of milk it can be said that this is of minor importance since the overheated milk is quite safe. The destruction of vitamin by overheating is of comparatively minor importance, but excessive heat application is to be deprecated because it completely eliminates "cream-rising" (though the butter fat is still present in the milk and unchanged in nutritive value) and induces a caramel taste which tends to render the milk unpalatable and so provides propaganda material for running an anti-pasteurisation campaign.

The efficiency of pasteurisation depends upon three major factors:-

1. The design of the plant.
2. The correct installation of the plant.
3. The efficient operation of the plant.

1. The design of the plant.

Certain machines have been sold as pasteurising plants which never could pasteurise according to the accepted legal definitions because of faulty design.

In the main these factors have been discussed by Scott and Wright (1935) and by Zeller et alia (1929).

Officials employed to inspect plant should be fully versed in all the pitfalls of construction, but actually

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any mechanically minded individual with milk sense can quickly judge whether a plant is likely to conform to the definition, viz:-

- (a) Can the plant heat the milk, and every drop of the milk to the required temperature and hold it for the desired period of time?  
This involves judging the rate and efficiency of heating and the questions of dead space, froth formation and surface cooling.
- (b) Is the plant fitted with automatic recording machines to enable an inspector to judge the efficiency of the run?
- (c) Is the recooling efficient?
- (d) Is the milk fully protected from recontamination after it is pasteurised?
- (e) Can the whole "set-up" be adequately cleaned and sterilised?

The intelligent layman can quickly judge these matters in an operating plant, but the plant inspector should be trained to form a fairly accurate conclusion merely from a study of blue-prints.

## 2. The correct installation of the plant.

This really is the crucial matter in efficient pasteurisation because whilst a single individual can postulate what makes of plant may be installed in a country, it requires an army of engineers and inspectors to effect and to control the actual installation. The question of installation represents a big branch of dairy architecture and engineering which could not possibly be discussed here. The intention, however, is to lay down certain fundamental principles which should be followed when designing

the lay-out of a pasteurising depot.

1. The lay-out of the plant must be such that immediately upon arrival all farm milk may be set out for grading, after which it must be weighed, refrigerated and stored in bulk. Floor space, off-loading banks, etc., must be of sufficient size to eliminate any question of milk being delayed between arrival and refrigeration. A principle must be established everywhere of only accepting milk that is reasonably fresh, and of doing whatever storage is necessary prior to pasteurisation, whilst milk should reach the consumer as soon as possible after pasteurisation. This principle is the exact reverse to the usual South African practice of accepting "near-sour" milk, pasteurising it immediately to "save its life", and then expecting it to remain palatable during 24 hours of bulk storage. Clearly the system of storing the milk raw demands the regular application of some scale-pan keeping quality test, preferably the rezazurin test.
2. The next principle involves the question of forwarding milk through the pasteurising circuit. From both the economic and the sanitation view points milk should, whenever, possible, be gravitated rather than pumped, but too much of a fetish can be made of the avoidance of pumping. Provided milk pumps are cleanable and are kept clean the process

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does little harm, whereas very complex circuits and complex buildings may be elaborated in efforts to avoid pumping. The important factor in pasteurisation is to maintain the proper pressure relationships within the heat-exchanger, and generally this can best be achieved by synchronised pumps. This question of pressure relationships has already been discussed, and from what has been written it is clearly of paramount importance to install the circuit in such a way as to ensure that the correct milk pressure is always maintained. The choice of gravity versus pump must give precedence to this pressure factor.

3. The third principle is that after pasteurisation and refrigeration the milk should traverse the shortest possible distance and endure the briefest possible storage prior to distribution. The reason for avoiding this post-pasteurisation storage is that any bacterial growth taking place will then affect the quality, flavour and appearance of the milk, whilst if recontamination with pathogenic bacteria should by mischance occur, the outcome will be calamitous if opportunity is allowed for multiplication. Yet Another reason of commercial importance is that if pasteurised milk is bottled immediately after processing a much better cream-line will develop than if the same milk is stirred in a large storage tank for some hours before bottling.

4. The fourth and in many ways the most important principle is that once milk is pasteurised any suggestion of exposure to recontamination is quite unforgivable, and in consequence all subsequent handling should be entirely automatic (i.e. done by machines and not by persons) and all cleaning and sterilising of plant and containers should be above all possible criticism.

#### CLEANSING AND STERILISATION OF PASTEURISING PLANT.

The secret of successful pasteurisation is very largely bound up in the question of efficient plant sterilisation, since at least half the object of pasteurisation is defeated if milk is subsequently recontaminated. Pasteurising appliances and plant fall into two groups:-

- (a) That which comes into contact with the raw milk.
- (b) That which comes into contact with the milk during or after pasteurisation.

Under the first section must be considered the scale pan, pump and raw <sup>milk</sup> circuit piping, the raw milk cooler and the raw milk bulk storage tank. Normal routine cleansing is sufficient for this portion of the circuit and it is only necessary to stress the need for using easily cleanable equipment only, and for ensuring that it is cleaned. Otherwise seed beds of thermophilic bacteria may develop capable of damaging all the milk.

It is, however, with the second portion of the circuit that the real trouble is likely to arise,

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the appliances in this case including the heat-exchanger, the holder, pumps and piping, storage tanks and filling machines. Any foci of dirt remaining in this portion of the circuit will have disastrous results, and so all dirt must be removed with absolute certainty. Following a pasteurisation run the whole unit must be washed through with cold water, and thereafter the maker's instructions should be followed with regard to circulating softening solution through the heat-exchanger to soften all the "milk-stone". Thereafter the heat-exchanger must be opened, and all visible dirt be removed by scrubbing. Pipelines must be disassembled entirely, and be scrubbed out with pipe brushes whilst soaking in detergent solution. In plate pasteurisers fitted with stainless steel plates, it is also necessary to open and cleanse the brine circuit to eliminate corrosion. Storage tanks must be thoroughly scrubbed out with detergent solution, and then hosed with hot water to remove all debris, and finally steamed. Filling machines must be disassembled, all removable parts soaked in detergent and scrubbed, and immovable parts must be scrubbed in situ. After thorough washing, all removable parts (i.e. pipes, taps, pumps, filter parts, etc.) should lie soaking in a suitable tank of chlorine steriliser kept hot by steam jets. The heat-exchanger should be assembled, and hot chlorine steriliser should be circulated through all the sections of the unit which come in contact with milk, and it is an excellent plan to leave the unit and the holding tanks standing filled with hot steriliser. Prior to the next run the whole circuit has to be reassembled, and the greatest care must be taken at this stage to stop the technicians from re-contaminating



the mouths of pipe-lengths whilst rebuilding the circuit. Finally, when beginning the new pasteurising run, the whole circuit should be heated up by pumping hot sterilising solution through the whole pasteurisation circuit, with the milk following immediately behind. If this routine is followed, the circuit will be clean and reasonably sterile, and the only remaining weak point is the pasteurised milk storage tank. Final sterilisation of large tanks has to be done by wet steam, much steam being used for a long period of time, and it is at this point that very meticulous supervision has to be applied.

In the foregoing text considerable mention has been made of soaking apparatus in strong sterilising solution, and it is necessary to issue a warning against soaking aluminium in strong alkaline detergents, or else pitting will occur. At all times stainless steel is preferable to aluminium for milk plant.

#### MAINTAINING CONTROL OF PASTEURISING PLANTS.

Pasteurising plants cannot be relied upon to operate efficiently, unless subjected to continuous and rigorous supervision and inspection by the management, as well as by some external controlling authority. The necessary supervision entails :-

(a) Visual Inspection, which means ascertaining that all apparatus is in efficient working order, and is cleaned and sterilised after each run. All handling must be subjected to rigid supervision, temperature recording contrivances must be under continuous scrutiny, thermometers must periodically be tested against standardised instruments, and the log-book kept by the dairy foreman should be checked regularly, to make sure that every serious flaw on the thermograph charts has been satisfactorily explained.

(b) Laboratory control.

(b) Laboratory Control involves the testing of all samples collected as a routine procedure, and collected during the course of visual inspection. The tests which it is necessary to apply are those for :-

- (1) Adequate heat-treatment.
- (2) Proper plant hygiene.
- (3) Satisfactory keeping quality.

To keep an adequate control on a plant it is not sufficient to collect odd random samples from the milk available for distribution. Periodically during every run, samples should be collected from the cooler exit of the "heat-exchanger", since this gives an index of the quality of the milk immediately after pasteurisation, and before any opportunity for re-contamination has occurred. Serial sampling should also take place at the point where each pipe-line enters a storage tank, from each storage tank used for pasteurised milk, and from the discharge point of each bottle, carton or can filler. In addition, in plants where bulk storage of raw milk prior to pasteurisation is done, serial samples should be collected from this storage tank throughout the day. This complete series of samples should be collected as many times as possible throughout the day, and in addition, random samples should also be collected from the various distribution circuits and from the "trade returns".

The actual details of testing and grading have been considered at some length in a report by Pullinger (1946c), but even this report can only be regarded as a preliminary one, because no final conclusions can be reached in regard to the quality of pasteurised milk until there is definite enforcement of reasonable pre-pasteurisation

standards in regard to all supplies arriving at a depot for pasteurisation.

Testing for efficient heat-treatment.

The test at present universally used is some or other modification of McKay and Graham's phosphatase technique. There are at least three such tests, viz:- the Lovibond (virtually the original test), the Scharer, and the Stein tests. They all appear to be of more or less equivalent efficiency, but the writer prefers the Scharer test as being one which is easy for unskilled persons to use. The technique has been developed in two forms - the field test which is satisfactory for detecting fairly serious degrees of under pasteurisation, and the laboratory test which serves to detect very slight under-heating. The basis of all phosphatase tests is that legal pasteurisation just destroys the phosphatase enzyme that is naturally present in milk. Milk is added to a substrate containing an organic compound of phosphate and phenol. If phosphatase is still active in the milk, this compound will be broken down with the release of phenol, and this phenol can be shown up by an indicator. The test has been established upon a semi-quantitative basis, so that a colorimetric reading of free phenol gives an indication of the degree of under-pasteurisation that has occurred.

Obviously, with a test such as this, clear-cut results cannot always be anticipated, because border line cases must materialise, when it is not entirely clear whether milk has or has not been under-pasteurised, or where the under-pasteurised section of the milk is nearly diluted out by properly pasteurised milk. Moreover, free phenol from any source will upset the test, and even an odour of phenol

in the air may have this effect. The test must be done with adequate controls to exclude any possibility of technical error, but in addition, the test results may be clouded by the presence of phenol containing substances at the pasteurising depot. One particularly deceptive source of phenol is "mains" water, which at times may carry a heavy contamination of phenol, because of the use of phenol derivatives for plumbing, or because of the development of phenol during the chlorination of water containing much suspended colloid. Yet another source of phenol having nothing to do with under-pasteurisation, is the production of this compound by certain bacteria, particularly in stale pasteurised milk. The point to be made in this connection is that the phosphatase test should only be used for investigational and educative purposes, and not as an instrument for inflicting penalties. The best way of using the test is to :-

- (a) Collect representative samples daily.
- (b) Subject them immediately to the phosphatase test.
- (c) Where evidence of under-pasteurisation is encountered, the inspector working with the plant manager shall investigate all the circumstances of the case in an attempt to elucidate the underlying cause of this unfavourable result. This investigation should be done immediately, and it cannot be too strongly stressed that a belated report, by the testing and controlling authority to the pasteuriser, of unfavourable results of a phosphatase test is not the way to control pasteurisation effectively.

#### Testing for Plant Sanitation.

Numerous bacteriological tests could be applied to the purpose of judging plant hygiene, but it is desirable to limit such testing to a minimum, and if possible, to pick out one test which can cheaply and readily be

performed, and which gives sufficient useful information. Of the tests available the presumptive Coliform test is the most useful one which the writer has had an opportunity of applying (vide Pullinger 1946c), and the following is the basis on which it can be used :-

- (a) Generally speaking all coliform bacteria (i.e. those gram negative rods which produce acid and gas in McConkey's fluid medium) are destroyed by both holder and S.T.H.T. pasteurisation, so that the presence of such organisms in the final product can be regarded as definite evidence of re-contamination.
- (b) Results obtained in a preliminary study of the grading of pasteurised milk (vide above report) gave a strong suggestion that circumstances might arise when milk was heavily contaminated with coliform bacteria, and containing much flocculating protein (due to mastitis), when some coliforms might survive heat treatment. Subsequent work, on the other hand, has indicated that 142.5° for 30 minutes, or 161.5° F. for 15 seconds probably does destroy all coliforms, but for safety it is proposed that all serial samples should include "cooler-exit" samples. Positive coliform results at that point indicate that either the heat-exchanger is not clean, or else that coliform bacteria are not being destroyed by the heating process. In either case, all subsequent results from tanks, etc., become invalid until the cooler-exit samples are again running negative to the coliform test, and the whole circuit has been cleaned up.

(c) - Where -

- (c) Where the cooler-exit sample is negative to coliform bacteria, then the reappearance of these organisms in the subsequent circuit indicates faulty plant hygiene.

To make best use of the coliform test, therefore, it should be applied to serial samples taken from all key points in the pasteurising circuit, and in this way the source of contamination can be located by a process of deduction. All the tests upon which the foregoing is based were read according to the presence or absence of coliforms in l.o.c.c. Once plant hygiene is brought well under control, it becomes necessary to introduce a more sensitive test, namely the "incubated coliform test" (vide Barkworth 1941), in which case the total sample is incubated for 18 hours, and is then tested for the presence of coliform bacteria. This result would, of course, read as the presence or absence of coliforms in the total volume of the original sample.

#### Testing for Keeping Quality.

No satisfactory decision has as yet been reached in regard to what constitutes a <sup>SUITABLE</sup> ~~test~~ test for the keeping quality of milk, and particularly of pasteurised milk. The total plate count is frequently used, but is far from satisfactory, whilst as an elaboration some workers have advocated the combination of parallel plate counts incubated at 37° C. and at 56° C. Though this elaboration does give more information, the information refers rather to the pre-pasteurisation quality of the milk, than to the keeping quality of the processed product. Clearly for keeping quality, a metabolic test such as the methylene blue reductase test is the one most likely

to yield useful information, and Wilson and his co-workers (vide Wilson et alia 1935) clearly stated that this reductase test could legitimately be applied to pasteurised milk. With the same aim in view, Provan and Rowlands (1943) have studied the application of the rezazurin test to this problem.

In the report by Pullinger (1946c), a limited number of records are given to show that there is every likelihood that the Methylene Blue Reductase test could be used for grading pasteurised milk, provided that milk is tested regularly and very frequently, and provided that a certain proportion of sub-standard results are permitted. Provisional standards are very tentatively suggested in the report which is quoted, but it is strongly stressed that no finality whatsoever can be reached in this connection until definite pre-pasteurisation standards of raw milk are being strictly enforced.



CHAPTER 6. PROPOSED REORGANISATION OF THE SOUTH  
AFRICAN MILK INDUSTRY.

I N T R O D U C T I O N.

In the foregoing text, as well as in previous reports (Pullinger 1944a, 1945, 1945-6, and 1946c), various phases of the South African dairy industry have been reviewed. From information given it is very evident:-

- (1) That there is great need to rationalise production transportation, marketing, processing, and distribution of milk and milk products, in order to eliminate avoidable waste of material, money, and effort, to procure a fair return to the producer, and to maintain an adequate supply of Safe good quality milk and milk products at a cost proportionate to their food value, and within reach of the poorer members of the community.
- (2) That effective public health control is necessary to ensure :-
  - (a) The safety of all milk and milk products during production and manufacture.
  - (b) The efficient transportation and distribution of these products.
- (3) Effective veterinary control embracing all cattle diseases, but particularly of those transmissible to man.
- (4) Effective control designed to ensure that dairy farming is efficient from the animal husbandry and crop management points of view.

It is contended that, from the data that has been recorded, it is quite evident that milk production in South Africa is in a deplorable state, and a

- prerequisite -

pre-requisite to any re-organisation is a very considerable improvement of the quality of farm milk as it reaches market. It is thought that the best, and in fact the only, way of effecting this improvement is by the introduction of a system of purchasing milk from producers on a basis of nutritive and bacteriological quality - rich, clean milk, bringing to the producer a higher price than poor or dirty milk.

If this contention is admitted, namely that farm milk can best be improved by paying farmers according to the quality of their product, it then becomes necessary to devise a practical method of doing the grading. Obviously, every milk shop owner and factory owner cannot be given the right to grade his own milk supplies, as such a system leads to too much abuse. Nor can the system of allowing commercial concerns to employ state-certificated graders be claimed to be satisfactory. (this system is employed in the grading of cream for factory use). The only satisfactory way of handling the problem is to establish a single organisation for purchasing all milk and cream comparable to the British Milk Marketing Board. Once such a purchasing body is established, it can have the authority, and can establish the machinery, for purchasing all milk upon a quality basis, and so eliminating all artificial distinctions between fluid and factory<sup>✕</sup> milk between "full price" and "Surplus price" milk, and between "quota" and "non-quota" milk.

Obviously, once such a Board was established,

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✕ Fluid milk is milk intended for consumption liquid.

Factory milk is that designed for condensing, drying, or for cheese and butter making.

the onus of controlling production would be removed from the Local Authority of the consuming centre, to be vested instead, in the Milk Board. It is contended that this change of control would be all to the good, because milk production occurs in the main outside municipal boundaries, where municipal control, by its very nature, becomes nominal only. Moreover, a multiplicity of municipalities leads to numerous interpretations of the milk regulations, whereas a Milk Board operating under a single directorate, could establish uniformity of production throughout the country, and being the only legally recognised purchasing agent would be in a position to enforce compliance with regulations. This proposal to remove milk production from the sphere of influence of local municipal health departments is not a new one. A precedent has already been created in a country as conservative as Great Britain, where control has been transferred from the local health authorities to the Ministry of Agriculture and Fisheries (Report 1943c).

Finally, it is contended that adequate control of human disease on outlying farms is impractical, whilst the control of bovine diseases will not become effective within any reasonable period. In the meanwhile, the only way of ensuring the safety of dairy products is by controlled and efficient pasteurisation. Past experience has shown that whereas certain commercial firms do their pasteurisation in a reliable fashion, the bulk of firms are thoroughly unreliable, data on this score being incorporated in a special report on pasteurisation in South Africa (Pullinger 1945). It is, therefore, proposed

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that pasteurisation of all milk and cream prior to distribution in the fluid state, or prior to manufacture, should be a direct responsibility of the Milk Board.

It is doubtful whether any serious objection could be raised to the general outline of reorganisation which has been set out. The need for improving production is obvious, and the advantages of effecting this improvement by paying farmers according to the quality of their product are quite evident. No one will deny that avoidable wastage should be curtailed in every possible way, nor is serious objection likely to be raised to improving and extending pasteurisation. The whole point at issue is whether these are mere Utopian ideals, or whether they can be translated into terms of practical policies.

In the ensuing text an outline of a milk control organisation is given, suitable for controlling the milk industry of South Africa, which would be capable of meeting all the shortcomings of the existing system of control, and at the same time avoid the more obvious mistakes which have been made when rationalising this industry Overseas.

THE GENERAL NATURE OF THE PROPOSED  
MILK CONTROL ORGANISATION.

It has already been indicated that for efficient control purposes, the purchasing and marketing organisation should undertake entire responsibility for buying all milk and cream from producers, pasteurising it, or supervising the pasteurisation thereof, re-selling it to the commercial distributors, for controlling all standards of production and of distribution, and for maintaining all grades and grading. Clearly such an organisation could not be an ordinary commercial undertaking, because it would virtually

hold a monopoly of all milk supplies. Nor could it be a government department, because:-

- (1) It would be trading organisation.
- (2) The best business and technical personnel would have to be drawn from the existing industry to fill key positions in the new organisation. This could only be done if salaries were offered very different from those allowed by the Public Service Commission.
- (3) As a Government department the development of the control organisation could be seriously impeded by other departmental policies, or subordinated to the petty expediencies of party government.
- (4) As a Government department, the organisation would lack the adaptability, freedom of action, and freedom from precedent which would be essential to efficient functioning.

The alternatives to a commercial organisation, or a State department, would be a Public Utility Corporation, or a joint Producers' and Consumers' Co-operative Society. In either case the organisation would have to be constituted under strict charter, and have Government representatives on the Controlling Board. Under such circumstances, the important difference between the two would be the source of financial support. In South Africa, the combined producer-consumer-co-operative has not yet been tried, but Public Utility Corporations have functioned with outstanding success, and it is on the Public Utility idea that the following scheme has been outlined.

- FUNCTIONS OF -

FUNCTIONS OF THE CORPORATION.

The Corporation would purchase all milk, cream and farm-manufactured milk products produced for sale, and would make these items available for retail distribution, or for manufacture. Milk and cream for fluid distribution would (with certain exceptions) be pasteurised by the Corporation before distribution. The Corporation would also ensure that all milk for manufacture is properly pasteurised by the manufacturer prior to processing. All distribution of milk and milk products would remain in the hands of commercial concerns (with certain possible exceptions detailed later, vide Sect. E). It would be the responsibility of the Corporation to ensure :-

- (1) That farmers get a fair return for their products.
- (2) That dairy products, when re-distributed, are of standard quality, and safe for consumption, or for manufacture.
- (3) That safe supplies of dairy products are available to the consumer at the lowest possible prices, and at prices at no times greater than the food value of the product.

From this it is evident that the functions of the Corporation would include :-

SECTION A. The Organisation, Regulation, and Supervision of Milk Production.

- (1) The registration of existing producers and the compilation and maintenance of records indicating the size and geographical situation of all milk-producing herds.
- (2) The control of the admission of new producers to the register with the object of preventing

- unsuitable producers from coming into operation, and in order to stop milk production being begun on unsuitable farms or in unsuitable areas.
- (3) The standardisation of methods of milk production (including buildings and equipment), with a view to producing, at a minimal cost in regard to capitalisation, milk of good standard nutritive and keeping quality.
  - (4) The continual maintenance of milk production at a high level in regard to keeping quality, chemical composition, palatability, etc.
  - (5) The maintenance of all milk production on an economic level by guiding farmers in matters of stock and field husbandry, animal health, choice of equipment, etc.
  - (6) The maintenance of an accurate farm census referred to above would be a pre-requisite to the ultimate registration of all individual dairy animals. This registration is essential to the effective control of stock sales, with a view at some later date, to eliminating the sale of diseased animals.

In shouldering the responsibilities outlined above, it is considered that the Corporation should work in very closely with the Producers themselves. It is suggested that all milk producers should be banded together into a Producers' Union, and that this Union would appoint to the governing body of the Corporation, a liaison officer together with any necessary subsidiary staff. Certain of the responsibilities outlined above, such as decisions regarding the starting of new dairy farms, and opening new dairy areas, should be taken over by the Producers' Liaison Officer, working in conjunction with the local branch of the Producers' Union. Similarly, all steps



that might be necessary to curtail, or to expand the volume of milk production, should be taken by the executive of the Producers' Union.

SECTION B. The Purchase and Re-sale to Commercial Distributors of all Milk, Cream and Farm-made Dairy Products.

Sub-Section 1. Purchase of dairy Products.

Producers would have to sell all their produce through the Corporation, and the Corporation would only purchase from farmers registered as members of the Producers' Union. This proviso would automatically ensure a hundred per cent membership of that Union. Actual purchase would be effected :-

- (a) By direct sale, the Corporation taking delivery of the product and transmitting it to market.
- (b) By indirect sale, the product being delivered direct to the market by the producer, but the Corporation being responsible for grading and for the financial aspects of the transaction. These indirect transactions would only be permitted under special circumstances, viz:-
  - (i) Supplies for consumers in semi-rural and rural areas.
  - (ii) Producer-Retailers' supplies and raw-milk shop supplies, where facilities for pasteurising are lacking.
  - (iii) High grade Raw Milk Supplies.
  - (iv) Farmhouse butter and cheese prepared for individual retailers.

Sub-Section 2. Price Determination.

In determining prices the two fundamental principles would be adhered to, namely that of paying farmers

- according -

according to the quality of their product, and that of keeping the consumers' price as low as possible, whilst giving producers a reasonable return for their effort. Following upon a transitional period, when the existing rates of payment would be maintained, the basis of all prices would be changed to :-

- (a) A comparatively low basic price for all milk falling within a set of minimum legal standards.
- (b) The payment of a bonus for "level production" maintained throughout the year.
- (c) The payment of comparatively generous bonuses for milk of high nutritive value and/or good keeping quality. Quality bonuses would be judged on a monthly basis.
- (d) A further bonus would be payable to producers of so-called high grade raw milk. The questions of grading and bonus payments are more fully considered in a report by Pullinger (1945-46). Farmers, therefore, would receive payment purely upon a basis of the quality of their milk, whilst the consumer in urban areas would obtain either standard milk, which would normally be pasteurised, or if raw milk were demanded the consumer would have to pay for high grade raw milk.

### Sub-Section 3. Transportation Charges.

All prices would be paid to ~~farmers~~ subject to free delivery to Corporation collecting depots, which would be dotted about at strategically situated points in milk producing areas. After taking delivery, all further transportation would be the responsibility of the Corporation.

- Farmers -

Farmers delivering direct to distributors (vide Para. 3, Sect. B, Sub-sect. 1) would bear delivery costs themselves.

Sub-Section 4. Standards of Nutritive value and keeping Quality.

It is proposed that the Raw milk standards should be laid down along the broad lines indicated by Pullinger (1945-46). In Table 3 of that report, a series of standards have been suggested, which increase in severity every two years. Any milk delivered, which falls below the basic minimum standard, would be treated as sour milk, and valued on butter-fat price, the sour skim milk being taken over without payment to offset skimming and handling charges.

Sub-section 5. Re-sale of Milk.

After grading, refrigerating and transporting milk to the appropriate market, the Corporation would pasteurise and bottle all milk required for the fluid milk trade. Distributing firms would draw from the Corporation their daily requirements of milk already pasteurised and bottled. Milk for factory use would be delivered to factories to be pasteurised under supervision of Corporation representatives prior to processing. All whole milk not required for the fluid trade would be diverted to cheese factories, or separated for butter manufacture. Cheese and butter manufacturers would purchase all their raw products through the Corporation, and Corporation officials would be responsible for the proper pasteurisation of milk or cream prior to manufacture. Although producer-distributors would actually be selling their own product, each day's dealings would, nevertheless, feature in the Corporation's books as a ledger entry, and these individuals would in fact sell their product to the Corporation, and then re-purchase it for distribution.

- This -

This book entry would be necessary to keep all records on a proper footing, and to ensure that the correct levy is charged by the Corporation. In the case of producer-distributors, this levy would be required to cover the comparatively heavy costs of grading supplies not passing through the main depot, It is probable that most milk sold in rural and semi-rural areas would only feature as a book entry in the Corporation records, moreover, since such milk would not often be graded, the levy on milk consumed in outside areas would be correspondingly small.

SECTION C.      Responsibility for taking delivery and  
Grading of Milk and Cream, and trans-  
porting it to Market.

The Corporation would assume full responsibility for transporting milk and cream from country collecting depots to market. This would relieve farmers of transportation costs and heavy wear and tear charges on cans. Sour milk losses would be practically eliminated, spillage during transit to market would no longer be a serious loss to farmers, whilst theft of milk, or empty cans, would be stopped in this way. As a result of these economies, it would be possible to pay farmers a lower price for their milk than is at present the case, without subjecting them to any financial hardship. By establishing collecting, grading and bulking depots at strategically situated points in the milk producing areas, it would be possible for the Corporation to transport bulked milk cheaply to market, and with a minimum of wastage or spoilage. Such depots would be fitted for the weighing, bacteriological grading, refrigeration, and storage of milk; whilst facilities would also be provided for washing, sterilising and drying

- farmers' -

farmers' cans. Depots would also be equipped for the separation of both sweet and sour milk. The bulk of the grading of farm milk supplies would be done at the depot, samples being collected "on delivery", and being subjected to the provisions of test, as outlined elsewhere. Facilities would have to be created for collecting frequent samples from producer-distributors, and from farmers authorised to deliver direct to distributors. All transportation of milk and cream from collecting depots to market would be done in suitable tankers hired from the S.A. Railways Administration.

SECTION D. Responsibility for the Safety and Quality of Milk and Milk Products.

The Corporation would have to ensure that all milk and milk products are safe for consumption, and of standardised and reasonable nutritive quality.

Sub-Section 1. Safe Milk and Milk products.

It is not possible to ensure that milk from several thousand producers has all come from healthy cows, and has not been contaminated by disease-producing germs during any of the stages of handling. The policy of the Corporation would, therefore, be :-

- (1) To ensure that the health of dairy herds was maintained at as high as possible a level. This would involve regular veterinary inspection, and even testing of all herds, and the sponsoring of disease eradication schemes, and possibly even organising and running the disease Control and Eradication scheme outlined in Chapter 2.
- (2) To take all possible steps to ensure that no milk-handlers were carriers of infectious disease. This would in time involve a considerable amount of testing of milk-handlers.

3. To ensure -

- (3) To ensure that the highest level of milk hygiene is maintained.

All these precautions, however, would not guarantee the safety of supplies, and the Corporation would, therefore, have to pasteurise as much fluid milk as possible, and also all cream and milk designed for the manufacture of edible milk products. Exceptions to the compulsory pasteurisation rule would be :-

- (a) Milk sold in peri-urban and rural areas.
- (b) High grade raw milk supplies either sold by selected producer-distributors, or derived from specially registered farms. For registration as a producer of High Grade Raw milk, a farmer would have to supply milk conforming with the High Grade standards listed in Table 16 (Pullinger 1945-46). Moreover, all his cows would have to be free from tuberculosis, contagious abortion, and bovine paratyphoid fever, whilst his herd should never contain more than 5 per cent of lactating animals as carriers of chronic mastitis. Furthermore, all milk-handlers would have to be subjected to <sup>REGULAR VI TESTS AND HEALTH SUPERVISION</sup> ~~REGULAR VI TESTS AND HEALTH SUPERVISION~~.

Sub-Section 2. Milk and Milk Products of satisfactory nutritive and keeping quality.

Once a system is introduced whereby farmers receive a higher price for producing a high-class article, the problem of inferior milk quality will disappear by degrees, and the duty of the Corporation will be confined to instituting a satisfactory system of grading, and the maintenance of this system on an efficient footing. For the rest, it would merely be necessary to provide educative services to the dairy farmer.

Sub-Section 3. Machinery for controlling the safety and quality of Milk and Milk Products.

The control organisation would comprise  
- laboratory -

laboratory and inspectorate services established throughout the country.

- (1) A field laboratory would be attached to every collecting depot and cheese or butterfactory. Such laboratory units would be staffed and equipped to perform simple daily tests for bacteriological, keeping, and nutritive quality of incoming farm supplies.
- (2) A field inspectorate staff. An inspectorate unit would comprise one senior and a varying number of subordinate farm dairy inspectors stationed either at a collecting depot, or at a milk-product factory. These inspectors would be responsible for the control of all dairying within their zone of operations, and so far as possible, such zones should have a maximum radius not greater than fifty miles. The duty of inspectors would be to assist producers in maintaining a high standard of milk production, and to this end they would have to keep in close touch with the records of the laboratory unit responsible for grading their farmers' milk. Actually, all inspectors should acquire an elementary knowledge of laboratory testing. In addition to guiding the farmers, field-inspectors would be the eyes and ears of the Corporation reporting upon the condition of herds, the state of crops, sickness amongst the farmers' families and staff, rumours regarding smuggling of milk, production by unregistered farmers, use of preservatives, etc. Initially, these inspectors would be recruited from amongst existing dairy inspectors, stock inspectors, and Agricultural



School graduates. These individuals would have to train each other, but later a definite course of training could be inaugurated for new recruits.

- (3) The Milk Zone. The whole country would be divided into a suitable number of "Milk Zones". Each Milk Zone would be in charge of a Senior Veterinary Officer (Dairying), who would have full responsibility for all matters pertaining to milk within his zone. He, in turn, would fall under the control of the Regional sub-office, and the Regional sub-office would in turn fall under the Administrative Headquarters. To assist him in his duties, the Senior Veterinary Officer (Dairying) would have :-
- (a) The co-operation of the local senior administrative officer of the Union Health Department. In order to bridge the indefinite gap that exists between the "obviously medical" and obviously "veterinary" zones of influence, it is proposed that the senior representative of the Union Health Department - whether he be a Medical Officer of Health, or a District Surgeon - would be ex-officio a member of the Milk Corporation for his particular area. Within his area he would be responsible for all matters concerned with milk, which have a direct bearing on milk-borne disease. Quite obviously, all administration would have to remain in the hands of the Veterinary Officer as the senior full-time employee of the Corporation, but it would be his duty to keep his medical confrere fully informed of all

matters bearing upon human milk-borne disease, and normally he would accept the medical officer's ruling in such matters. In the event of any major differences of opinion between the senior veterinary officer and the medical officer, with the medical officer making demands contrary to the normal procedure and practices of the Corporation, it would first of all be the duty of the Medical Officer to make full personal investigation of the matter, and not rely upon reports and opinions of subordinates. Thereafter, if he still could not change his standpoint to one conforming to that of the Corporation, then the controversy would be referred to the Central Administration of the Corporation for consideration of the Medical Officer's viewpoint. If a compromise could still not be reached, the matter would be referred to an arbitration committee consisting of nominees of the Corporation and the Union Health Department.

It is fully appreciated that there are serious difficulties which are raised by this division of major responsibility between the veterinarians and the medical officers. Unfortunately, in the milk industry, a boundary line must always exist between the aspects best controlled by the veterinarian and those best controlled by the medical officer. This boundary line cannot be defined with clarity

- because -

- 171 -

because of overlapping and intermingling of responsibilities. Thus within the milking shed the health of the cow and the health of the milker illustrate this intermingling on the farm. Similarly, within the city pasteurising depot, the nutritive quality of the milk and the admixture of pus reflect back to the farms as veterinary problems, whereas the health of the human milk-handler once again falls into the medical sphere. The organisation outlined above is designed to cover both the veterinary and medical aspects, with the specially trained veterinarian as the full-time representative of the Corporation, and the local senior medical officer of the area, as the representative of the Union Health Department.

The Medical Officer would, in addition to general supervision, be responsible for organising all clinical examinations, and swab or blood tests of milk handlers. Also, he would be responsible for investigating and handling all outbreaks of milk-borne infectious disease in his area. In time the Corporation might be forced to appoint full-time medical officers for the control of milk handlers, but such appointments would in no way undermine the authority of the Senior medical officer in each area.

(b) The senior veterinary officer would have

- attached -

attached to his staff one or more junior veterinary officers engaged upon dairy herd control.

- (c) In addition, he would have a team of agricultural extension officers versed in both animal and field husbandry, and dairy science.

From the foregoing, it will be apparent that the control of milk during production and transportation to market, the control of factories and retail distribution in rural and peri-urban areas, and also the control of the complete milk industry in small towns and villages, would fall under the senior veterinary surgeon of the zone assisted by junior veterinarians, agricultural extension officers and dairy inspectors, whilst the senior medical officer (representing the Union Health Department) for every area falling within the Milk Zone, would co-operate with the senior veterinary officer for his area. In addition to the controlling personnel mentioned above, administrative staff would be provided as required. In Table 14 an outline is given of the controlling establishment visualised for a typical Milk Zone.

(4) Centralised Inspectorate and Laboratory services.

Such services would be established at all large milk consuming centres for the purpose of :-

- (a) Controlling incoming supplies as a cross-check upon collecting-depot grading, and transportation spoilage.
- (b) Controlling all pasteurisation or manufacture carried out at the centre.

(c)- Controlling -

T A B L E 14.  
CONTROL ESTABLISHMENT FOR A CORPORATION MILK ZONE.

Corporation "Milk Zone" Unit.	Components of typical Milk Zone.	Union Health Dept. Representative.	Corporation Local Representative.
Senior Veterinary Officer with Asst.V.Os and Agricul- tural Extension Officers.	1. Small town with Corporation milk collecting depot.	M.O.H.	Field labora- tory staff.
	2. Small town with local market for milk only.	M.O.H.	Field Inspec- torate staff.
	3. Village with Cheese Factory & Corporation collecting depot.	DISTRICT SURGEON.	Field labora- tory staff.
	4. Village with Corporation collecting depot.	DISTRICT SURGEON SURGEON.	Field labora- tory staff.
	5. The farming areas surrounding these centres.	DISTRICT SURGEON.	Field inspec- torate staff.

- 172a -

- (c) Controlling wholesale or retail distribution within the area.

Personnel required for such services would be similar to those required in the field, but there would be a tendency to appoint individuals with an agricultural bias to the field, and those with a sanitation bias to the town. Ultimate control of the area would devolve upon the Senior Veterinary Officer into whose zone the particular market fell, assisted by the local Medical Officer of Health.

5. Head Office Inspectorate. This service would have the function of correlating and co-ordinating all laboratory and inspection services. In addition, there would be the very necessary duty of keeping a constant check upon all grading done at collecting depots.

6. Central Laboratory. This would comprise an adequately fitted laboratory, staffed with a nucleus of specialist workers. This laboratory would :-

- (a) Supply all subsidiary laboratories and field laboratories with reagents;
- (b) Standardise all thermometers, hygrometers and other instruments;
- (c) Investigate major problems of spoilage, and study new testing procedures.
- (d) Maintain a close relationship between the Government Research Laboratories and the milk industry in investigations on animal and human nutrition, the control of bovine disease, breeding experiments, pasture experiments, etc;
- (e) If necessary, undertake bacteriological testing of food handlers.

(f) - investigate -

- (f) Investigate outbreaks of milk-borne disease;
- (g) Test the efficacy of dairy apparatus, contrivances, equipment, reagents, medicaments, cleansers, feeds, etc., offered for sale to the dairy industry. An up-to-date list would be maintained of "approved articles", i.e. articles likely to serve efficiently in the capacity claimed by the vendors.
- (h) Investigate the possibility of developing new methods of utilising by-products, surplus milk, sour milk, whey, etc.

SECTION E. ORGANISATION, REGULATION AND SUPERVISION OF DISTRIBUTION.

Carefully controlled safe and pure milk and milk products would be made available to ordinary commercial distributing firms, and it would be the responsibility of the Corporation to ensure that no unnecessary spoilage of these products occurred during distribution. This service would be maintained by the Central Laboratory and Centralised Inspectorate Services already referred to.

Initially it would be necessary to place the existing distributing firms on a sound economic footing, which could only be done by eliminating uneconomic delivery, and uneconomic competition. It is proposed that the Distributive trade should form an Association, and in order to ensure that all Distributors joined the Association, the Corporation would only issue milk supplies to registered members of the Distributors' Association. This organisation would appoint to the Corporation a Distributor's Liaison Officer and staff, comparable to the Producers' Liaison Officer. Working through this official, the Corporation would negotiate with the Distributors for



the zoning of all milk deliveries, zones being so demarcated as to ensure that every zone was served by a maximum of two distributors. The actual zoning should be worked out in every area by a local sub-committee, appointed by the Distributors' Union. Normally, the Corporation would not interfere with the actual distribution where satisfactory service was being maintained; but in the event of unsatisfactory service, the Corporation would have the right to intervene and introduce a new competitor into the area, or in an extreme case undertake retail delivery until a suitable distributor could be found. It would probably be necessary to develop an independent zoning system for the delivery of High Grade Raw Milk supplies, but any producer-distributor licenced to distribute High Grade supplies would not be allowed to distribute standard milk too. Dairies - as distinct from producer-distributor firms - however, would be permitted to handle both classes of milk.

Working in co-operation with the Distributors' Liaison Officer, the Corporation would ensure an equitable distribution of all available milk supplies amongst distributing firms, and would advise firms on the planning of buildings and upon the choice, lay-out, efficient use and efficient maintenance of all plant.

#### SECTION F. ORGANISATION OF A BALANCED DISTRIBUTION OF SUPPLIES.

One of the most vital functions of the Corporation would be to ensure that under existing conditions of seasonal shortage, the scanty supplies are equitably distributed throughout the various markets. Furthermore, the Corporation would be responsible for stimulating

economic production until all demands are satisfied, whilst in the distant future the task of creating new markets for milk would be their responsibility.

PARAGRAPH 4. OUTLINE OF CONSTITUTION OF CORPORATION.

The Corporation would comprise the following Sections :-

1. Directorate.
2. Production Section.
3. Transportation Section.
4. Purchasing, Distributing and Sales Section.
5. Laboratory and Inspectorate Section.
6. Processing Section.
7. Accounting Section.
8. Propaganda and Extension Sections.
9. Producers' Liaison Section.
10. Distributors' Liaison Section.

These Sections would not be represented directly in every area, but would be established at the Administrative Headquarters, and would maintain staffs at Regional sub-offices. In a "milk zone" the senior veterinary officer would indirectly represent all these Sections, and any staff necessary for fulfilling the duties of the Corporation would be seconded from the appropriate Section on to the Veterinary Officers' Milk Zone Staff. As a tentative suggestion, it is proposed that the Headquarters of the Organisation should be situated at Johannesburg, and that Regional sub-offices should be established at the following centres - Durban, Ladysmith, Port Elizabeth, Queenstown, Capetown, Mafeking, Bloemfontein, and Pietersburg. These Regional sub-offices would confine their activities to the correlation of all effort, whilst the actual local control and Administration would be done by the Senior Veterinary Officer of the "Milk Zone" concerned.

PARAGRAPH 5. FINANCIAL ASPECTS.

The cost of running an organisation such as that

- outlined -

outlined would be heavy, but many of the charges involved are already borne by the Milk Industry under conditions where rates of interest and rates of profit are completely uncontrolled. Costs would fall under :-

- (1) Capital Expenditure on the establishment of Administrative offices, collecting depots, processing plants and transportation facilities, and would include expropriation compensation to existing wholesale and pasteurising firms.
- (2) Maintenance and running costs.

Of the expenditures outlined the only new charge to the Milk Industry would be that of the inspectorate services. It is contended that these services would practically, or even completely, pay for themselves in eliminating existing wastage.

Planning for future development on a basis of 1,000,000 persons, each consuming 1 pint per day, it is suggested that :-

700,000	would be	Urban dwellers.
200,000	"	" Semi-urban dwellers.
100,000	"	" Rural dwellers.

Actually the proportion of Urban dwellers would probably be considerably higher. If the Corporation raised a levy of 6d. per gallon on all urban supplies, and 3d a gallon upon all semi-urban supplies, this would bring the Corporation a daily income of £2,500 per day per million pints consumed.

Assuming that the 6d levy was made up by deducting 2d. a gallon from the farmers' milk-price, and 4d a gallon added to the price charged to distributors, the levy would be equitably apportioned. In return for this

- twopenny -

twopenny levy the farmer would be assured of a market for his milk, and he would be saved heavy transportation charges, losses from souring, spillage and theft of milk or cans. Moreover, he would be given veterinary and agricultural services free of charge. The milk-distributor, on the other hand, for his fourpence would receive daily his exact requirements of milk processed and bottled and ready for delivery within a zoned circuit.

PARAGRAPH 6. OBJECTIONS TO THE MILK UTILITY CORPORATION.

The idea of<sup>a</sup>/Milk Utility Corporation has been advanced, because the writer is of the opinion :-

- (1) That an improved standard of production is vital to the wellbeing of the industry, and that such improvement will only be achieved, if farmers are paid according to the nutritive and hygienic quality of their product.
- (2) That the satisfactory grading of milk can only be done by one country-wide organisation.
- (3) That the existing economic failure in the Dairy Industry, due largely to unsound methods of production, transportation, and processing, will only be eliminated by country-wide unification of control.
- (4) That the equitable distribution of available supplies can only be effected at speed, if control is in the hands of a National organisation, fully equipped with up-to-date facilities.
- (5) That the supervision and control of all those factors that go to build up an adequate supply of safe, clean and rich milk and milk products, can only be effected by unification of that control.

- Opposition -

Opposition to the Utility Corporation idea has so far fallen into three categories :-

- (1) Opposition raised by vested interests. While such opposition is extremely powerful, and may be extremely difficult to overcome, it does not in any way detract from the "rightness" of the ideas expressed in this report.
- (2) Opposition raised on the grounds that it is impracticable for one organisation to purchase all milk and re-distribute it to retail agents. Here it can only be stressed that in a country as conservative as Great Britain, this end was achieved even before the war. Britain falls short of the present proposals, because the Milk Board does not actually pasteurise, but the general idea of purchase and re-sale is already in operation.
- (3) The most serious form of opposition so far raised comes from the Public Health Authorities. Under the scheme outlined here, it is quite obvious that milk has already lost its identity before it reaches market. Moreover, if supplies are to be shared fairly and evenly, and if surpluses and shortages are to be avoided, it would be quite impossible to allocate certain farms to certain markets. In effect, no Medical Officer of Health could be held responsible for conditions on the farms, for that would be the sole responsibility of the Corporation. It is contended that if the Medical Officer of Health is deprived of either the right of, or facilities for controlling milk from its source, then the whole structure of our Local Public Health Control will be undermined.

- This

This objection can be answered in three ways :-

- (a) Though the M.O.H. has at present the necessary rights and powers, in practice his control is ineffective (vide Pullinger 1944 and Pullinger 1945-46). Is it right that such an impractical system of control should be countenanced indefinitely, in order to maintain a principle?
- (b) In any case, the M.O.H. would be ex-officio the senior executive member of the Corporation within his area, and this scheme offers him a practical means of supervising the quality of milk coming into his area in place of an illusory principle.
- (c) Finally, precedents have already been created for over-riding this so-called basic principle in South Africa. For instance, the Rand Water Board supplies water to a number of local authorities which have no representation on the Board. In each case the M.O.H. accepts the quality of product provided by the Board, and if he does <sup>not</sup> like the quality, he obtains redress by appeal to the Rand Water Board, either directly or through the Union Health Department. Similarly, in the case of meat, the Meat Control Organisation shuttles dressed carcasses about the country from centre to centre, and the only safeguard the individual Medical Officer of Health has is that of "re-inspection" of the meat, with condemnation of any that is definitely unsound. If a Medical Officer of Health refused to allow meat to be sold because it was of poor quality, he would quickly find his area deprived of meat by the control organisation. Virtually, therefore, Public Health

Administration in South Africa has accepted in connection with both water and meat a state of affairs where the local M.O.H. accepts the grading of an outside body. In the proposed Milk Utility Corporation, the M.O.H. would be in an immeasurably stronger position, because for his own area he would be jointly with the Senior Veterinary Officer, the Chief Executive Officer of the area.



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