Operation and management of small sewage works.

Contributors

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Operation and Management of small Sewage Works

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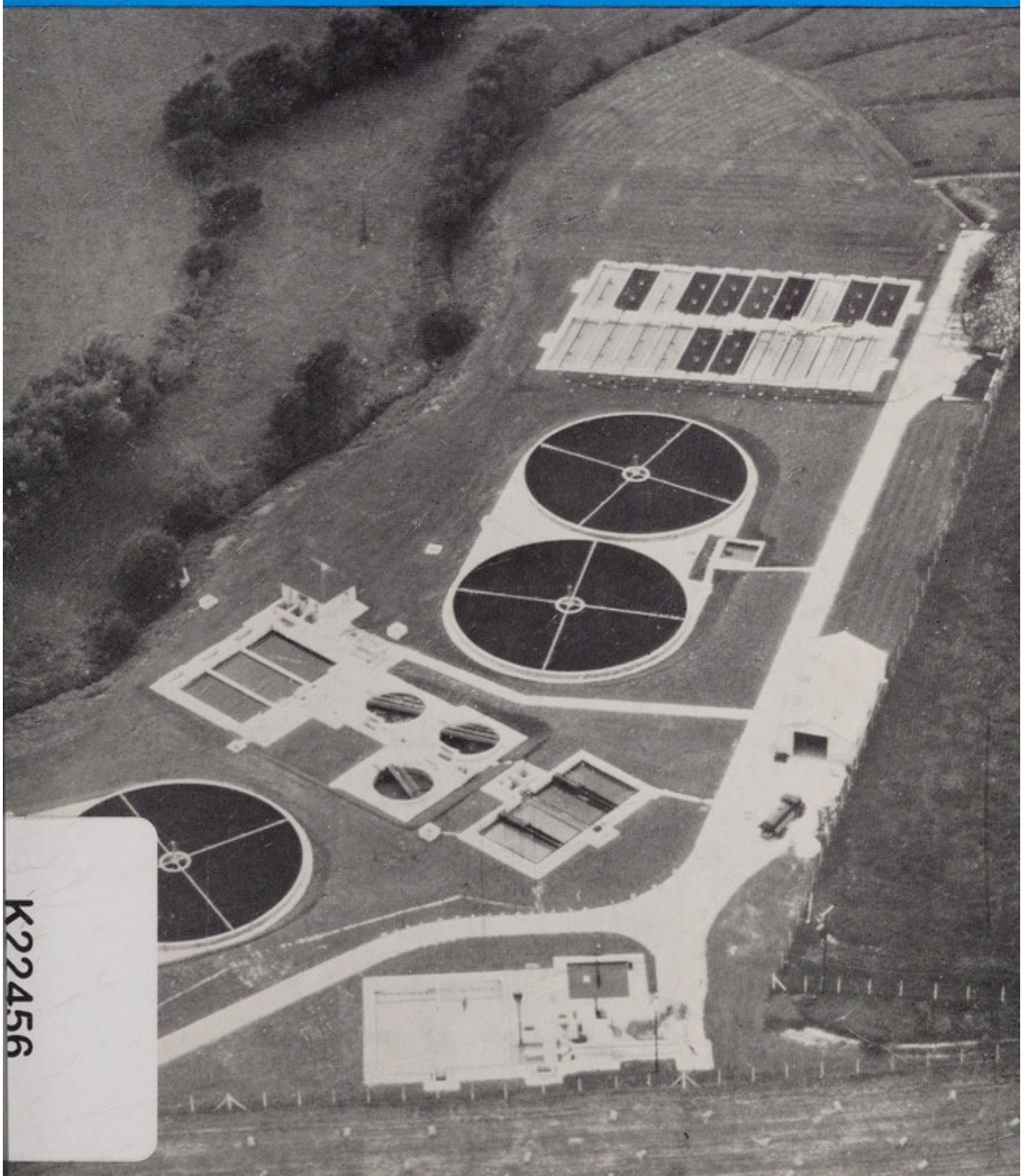

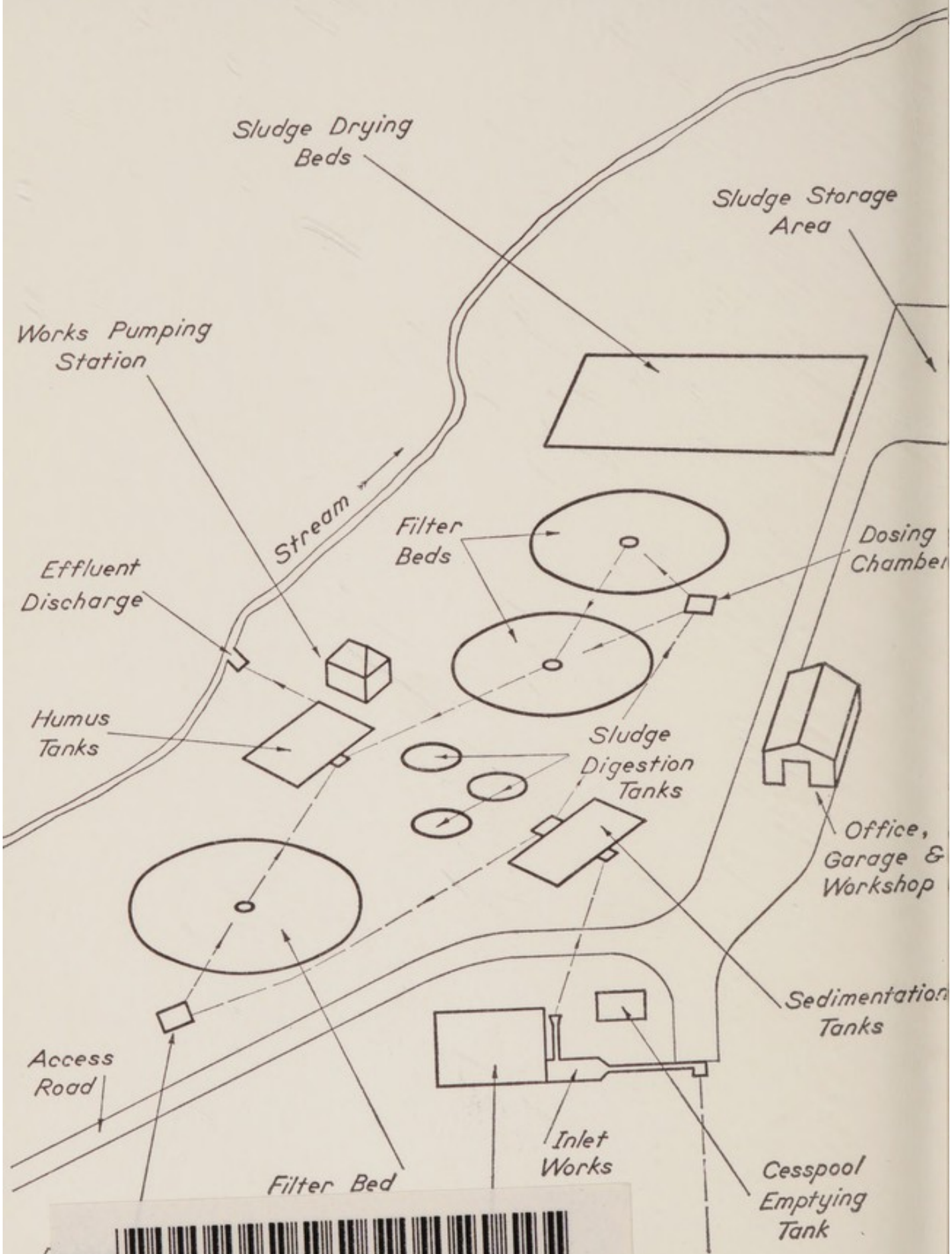

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MINISTRY OF HOUSING
AND LOCAL GOVERNMENT

Operation and Management of Small Sewage Works

LONDON
HER MAJESTY'S STATIONERY OFFICE
1965

Part I of this book is published
separately as an Operator's Handbook

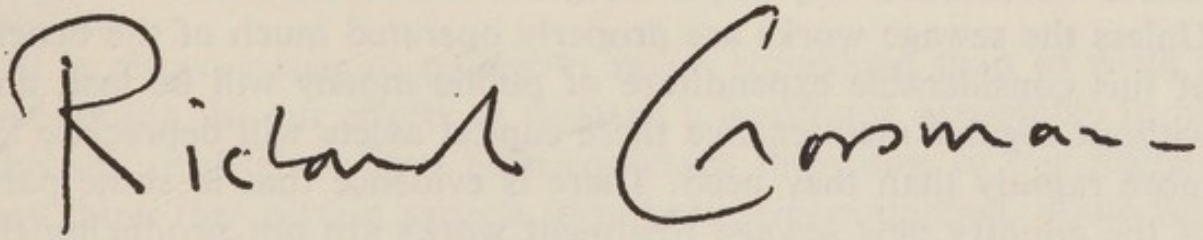
FOREWORD

By the Minister of Housing and Local Government

I AM GLAD TO commend this handbook to all rural local authorities and to others with small sewage disposal works.

The authors, most of whom are local government officers and officers of my Department, have great experience of their subject. They have produced a sensible, practical and highly valuable guide to the operation of small sewage works and the organization of sewage disposal in rural areas.

Sewage disposal is a vital public health service. Many millions of pounds have been spent on it in recent years. We shall not get full value from this expenditure unless the works and plant are well managed and well maintained. The handbook will, I am sure, help to achieve this.



R. H. CROSSMAN

Reasons for the Handbook

Since the passing of the Rural Water Supplies and Sewerage Act in 1944, there has been a great extension in the provision of piped water to rural areas. This general replacement of the old, intermittent yield of well and spring by a copious and continuously available supply of water has brought with it the problem of the disposal of the used water safely and without nuisance. The number of sewage treatment works has increased greatly during the same period and has added considerably to the work and responsibility of rural authorities. The use of river water both for public and industrial supplies is becoming increasingly important and Parliament have, in a succession of Acts, given river authorities progressively stronger powers to control sewage effluents.

The rate of expenditure upon rural sewerage and sewage treatment is now running at about £15 m. annually but the provision of proper sewage treatment plant is only a first step, for such works are by no means automatic; they require regular attention, skilled attention. Unless the sewage works are properly operated much of the benefit of this considerable expenditure of public money will be lost, and without regular maintenance these capital assets will depreciate far more rapidly than they need. There is evidence that in some parts of the country new sewage treatment works are not producing the good effluents they should for lack of care and attention.

Growing difficulties confront the smaller local authorities, both rural and urban, whose limited resources are being increasingly strained to meet the demands of higher living standards, more complex industrial effluents and the greater emphasis on pollution prevention. Correspondingly higher standards of skilled operation and supervision are needed. Not only is the provision of these services expensive but there are limited resources of manpower with the right training and ability.

We were, therefore, invited by the Minister of Housing and Local

Government, with the approval of the Rural District Councils' Association, the River Boards' Association and the Institute of Sewage Purification, to prepare a handbook which would provide guidance both to operators and to technical officers on the operation and management of small sewage treatment works.

In the course of consideration of the day-to-day activities on sewage works we have inevitably been led to take account of longer-term problems, and we hope that our thoughts on these matters will sow the seed for wider discussion from which practical solutions may emerge.

We believe that in many places the difficulties confronting local authorities may most readily be overcome by cooperative action in the employment, by groups of neighbouring authorities, of specially qualified supervisory staff—works managers and chemists—who, by devoting their whole time to the many and varied problems which continually arise, could be relied upon to evolve and operate the most suitable, economical and efficient organisation to meet local needs.

Centralisation of sewage treatment in areas of dispersed development may be desirable but is rarely practicable; centralised servicing, however, is often feasible and advantageous. We think there are, for example, considerable possibilities in a greater degree of centralisation of sludge treatment and of machinery repair and maintenance facilities.

It is always easier to review or revise something than to write a first edition. In our efforts to produce a handbook acceptable to all who will read it, we have been conscious that some of our readers may think that certain aspects have been over-simplified. Some will find that those things they particularly look for are missing and others will wonder why we have gone to the trouble of telling them what they already know. May we plead with those in the last category to help us in our task by filling in the gaps for their friends and colleagues in the other two?

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PART ONE—OPERATION

Part One: Operation

No matter how well a sewage works has been designed and constructed, its successful operation and maintenance depend upon the skill of the man who is in charge of it. It is to him in particular that the first part of this handbook is addressed.

CHAPTER 1

AN IMPORTANT TASK

Introduction

1. The proper treatment of sewage is necessary for three main reasons:

(*a*) To remove risks to public health, that is, to prevent disease;
(*b*) To avoid foul smells and objectionable sights, both on and off the sewage works;
(*c*) To prevent the pollution of streams and rivers and to keep their waters clean enough for all the various purposes for which they may be used.

2. Parliament has given local councils duties and obligations under the Public Health Acts and the Rivers (Prevention of Pollution) Acts. Owners of all sewage works must satisfy the local river authority that the effluents from the works are properly purified and they are also liable under common law if they cause damage or offence. Their responsibilities are heavy and the success of their efforts must depend very much on the ability of each employee to know his job thoroughly and to carry it out to the best of his ability.

Sewage

3. Sewage is mainly water which has been used for a variety of purposes in the home, in the factory or on the farm, and may include rainwater running off roads, yards and roofs. It contains an enormous

variety of waste products of human, animal, vegetable or mineral origin. Some of them may be dissolved in the water, some may be in solid form. There are three different sorts of solids—those that sink, those that float and those that are so small they neither sink nor float but remain suspended in the water. It is the last of these, sometimes called "colloidal matter", which make settled sewage look cloudy.

4. A surprisingly small amount of solid matter is needed to make a very foul sewage (something like a teaspoonful in a bathful of clean water). It is very much more difficult to get it out than it was to put it in, and it is this difficult job of removal that sewage works are designed to do.

Sewage purification

5. For the successful and efficient operation of sewage works every part of the plant must be maintained in a condition that will enable it to do its job properly. Each stage of treatment relies on the proper working of the previous stage and neglect of any section of the works will cause trouble all through the later stages. If the grit chambers are not emptied regularly, grit will block the sludge outlet in the settling tank. If the settling tank is not desludged when it should be, the filters will become choked with sludge. Accordingly you must know as much as possible about the purpose of each part and understand how it works.

6. Fresh sewage has no offensive smell, and it is only when it is allowed to stand and have time to putrefy that it becomes objectionable. This fact underlines the two basic principles of a properly run sewage works. The first is adherence to a regular routine which ensures that each operation is done at the right time, every time. The second is cleanliness, not only of the works site and the parts of the plant that can be seen but also of the parts of the tanks and the pipes that are out of sight. Sewage which is left to turn septic will infect the fresh sewage.

7. The following sections give a brief description of the function of each of the stages of purification in common use in this country, with notes which it is hoped will help you to keep your works at the top level of efficiency.

Sewage works

8. No two sewage works are exactly alike. They differ greatly in design according to their age and the local circumstances, in the strength of sewage received and in the times at which the highest and lowest flows arrive. Consequently no precise instructions can be given here to tell you when and how often different jobs should be done. The following chapters tell you the things which experience has shown are important in keeping small sewage works in good working order and can help in drawing up a programme of regular operation and maintenance suited to your particular works.

CHAPTER 2

PRELIMINARY TREATMENT

Screening

9. The sewage arriving at the works carries with it paper, rags, sticks, coarse grit and other objects. Some of these will float and others will tend to be held in suspension by the flow of the sewage, depending on their weight or the extent to which they have become waterlogged. If left in the sewage they could cause a good deal of trouble by blocking pumps, choking pipes or interfering with the operation of valves. The first step in sewage treatment therefore is usually the removal of these objects by passing the sewage through a screen where they are trapped and held, although on some works it has been found possible to work without screens. The cleaning of screens and the disposal of screenings is perhaps one of the more objectionable jobs on sewage works, but it need not be particularly unpleasant if the work is done regularly and the screenings are disposed of promptly.

10. You should clean the screen once a day, if possible. Large quantities of rags etc. may block it and cause a backing up of sewage in the sewer. This in turn may result in the settlement of solids in the sewer, and these, if the flow is not strong enough to move them on when the screen has been cleared, will collect more solids and

eventually lead to blockage in the sewer itself. During storms the extra flow in the sewer flushes a considerable amount of debris down to the works. You should therefore keep an eye on the screens during and after a storm, particularly if it follows a spell of dry weather.

11. The solid matter caught on the screen should be raked off and not pushed through. Never leave the screenings in the open longer than is absolutely necessary. If you do they may cause smell nuisance and will quickly attract flies and rats. Bury them in a shallow trench and cover them over with soil. In time most of the matter decomposes, and the same area of ground can often be used for burying more screenings in, say, a year.

12. Hand raked screens call for little in the way of maintenance beyond regular cleaning and swilling down with fresh sewage.

13. Instead of a screen some of the larger works have a macerator which is something like a large mincing machine. It chops up all the large solid matter until it is too small to cause any trouble and then allows it to pass through slots in the machine. Normal maintenance consists in keeping the lubricators properly filled. The cutter sections require periodical attention but this is usually carried out by a fitter. Large objects such as scrubbing brushes which are very slow to be chopped up sometimes accumulate at the inlet, and it is worth while to remove these periodically.

Grit removal

14. If rainwater from roads and paths flows into the sewers the sewage may contain road grit, sand, ashes and even small coal. If this reaches the main treatment plant it will settle out and block channels or pipes, causing difficulty in desludging the settling tanks. The grit may also give rise to excessive wear in pumps and other machinery. The next stage of treatment therefore is the removal of the gritty matter by passing the sewage through a chamber or channel slowly enough for most of the heavy material to fall to the bottom but fast enough for the lighter matter to pass forward.

15. These grit chambers, also called detritus tanks or channels, are sometimes in pairs and equipped with inlet and outlet stops or

penstocks so that the flow of sewage can be shut off from one chamber at a time to enable the settled grit to be removed.

16. When the chamber is shut off the top water may be run out and you can then remove the grit by a scoop or shovel. At some works the grit, well mixed with sewage, can be removed by a portable sludge pump. At others it may be run off through an outlet pipe to a special drying area.

17. After removing the grit, swill out the chamber thoroughly with fresh sewage and brush it down. It is important to examine any valves, penstocks or hand stops and clear from the track or frame any accumulated matter which may make them difficult to operate and may prevent them from closing properly. As a matter of normal routine you should lubricate the screws, slides and racks, being careful to use only the right type of oil or grease.

18. Grit stored on a hard standing will dry out, usually to an inoffensive material which can be used about the works for levelling up low-lying ground.

19. The grit chambers must be emptied regularly because if grit is allowed to accumulate it will be washed forward and cause trouble. The time between cleaning depends upon the rate at which grit accumulates, and this varies a good deal according to local conditions. Once it has been decided how often the chambers need cleaning for a particular works, the job should be carried out regularly. Sudden storms, especially after dry weather, usually flush large quantities of grit out of the sewers, and it will pay to clean out grit chambers after such a storm in addition to the routine emptying.

CHAPTER 3

PRIMARY TREATMENT—SETTLEMENT

Settling tanks

20. Even after screening and grit removal sewage still contains suspended matter, most of which settles quite slowly. To remove these

solids the sewage is passed at a very low rate and with as little disturbance as possible through settling tanks, sometimes called sedimentation tanks. On small works there are two main types of tank—horizontal flow and upward flow. (Do not confuse settling tanks with septic tanks, which are dealt with later in this chapter.)

21. Where there is more than one settling tank, of whichever type, you should, as far as you can, regulate the flow by adjusting the valves or penstocks so that each tank receives the right amount of sewage in proportion to its size. This can be judged roughly by the flow of water over the weirs.

22. Great care must be taken not to drop anything into a settling tank. It is well worth while when working on the edge of or over a tank, or pump well or sump, to fasten hammers, spanners or similar tools by a line to your belt or a convenient hook. Also take care not to let anyone kick stones, chippings or other objects into settling tanks or wells.

Horizontal flow tanks

23. Horizontal flow tanks are rectangular and the sewage enters at one end and leaves at the opposite end. The inlet is usually baffled to maintain quiet conditions in the tank and the outlet is protected by a scumboard or a dip pipe to keep floating matter in the tank. The solids settle to the bottom of the tank and become sludge.

24. At most works there are usually two or more horizontal flow tanks, and all are kept in use except during desludging. Although on larger works horizontal flow tanks may be desludged by machinery, on smaller works sludge is removed manually and to do this it is necessary to empty the tank. The flow of sewage to the tank is first shut off. From some tanks the top or supernatant water is removed through a floating arm or a fixed decanting pipe. When the water level has been lowered near to the sludge level you should slow down the rate at which the water is withdrawn and take care that while as much water as possible is taken off no sludge is removed with it. The top water is normally pumped back to the works inlet. When the withdrawal of top water is finished the sludge and scum are run off through the sludge valve. At some older works the entire contents of the tank, both sludge and water, are taken off through

a single pipe at the bottom. If you can take off the top water first with a portable pump you should do so. The floor is finally cleaned with a squeegee. Each time the tank is desludged you should scrape the walls, scumboard and baffle board clean of the ridges of fat and scum which accumulate at the water line. The walls and floor of the tank should be well brushed, and hosed down with water or flushed with buckets of fresh sewage. Valves, penstocks and floating arms should be examined and cleared of rags or any solid matter which may interfere with their movements. Moving parts should be lubricated. The sludge pipe should be flushed with a small quantity of fresh sewage. These precautions will make the whole job of desludging easier next time.

25. All the deposited sludge should be removed from the tank in a single operation, because any sludge left behind will turn septic and contaminate the fresh sludge deposited on top of it. This will be followed by fermentation and gassing which will interfere with settlement and disturb sludge that has already settled, lifting masses of it to the surface, where it may escape from the tank over the outlet weir.

26. Horizontal flow tanks should usually be desludged weekly. When a tank is being desludged the sewage will have to pass through the other tank or tanks at a greater rate, and this extra flow will be further increased by the top water returned to the works inlet. You should therefore try to run off the top water at a time when the flow of sewage to the works is low and if possible avoid emptying a tank during wet weather. The whole operation of emptying, desludging and cleansing the tank should be carried out on the same day. If the sludge is left uncovered in the tank unpleasant smells are likely to occur, and the cleaning down of the walls also becomes more difficult if they have been allowed to dry out. When there is only one settling tank you will have to back up the sewage in the sewer during the desludging, so the operation must be carried out as speedily as possible. Inlet and outlet weirs should be kept clean, and you may have to brush them daily.

27. If you do not desludge a tank often enough or do not remove all the sludge each time, lumps of black rising sludge and gas bubbles will appear on the surface. The settled sewage passing over the outlet

weirs will then be seen to carry a good deal of suspended matter, and this is likely to cause ponding of the filters.

28. The weirs of the tanks should be brushed frequently and accumulated scum and floating matter skimmed off regularly for disposal with the sludge. The scum must not be broken up and stirred into the tank. Any scum or floating matter which escapes from the tank is likely to block the sparge holes in the distributor arms and cause unnecessary work.

Upward flow tanks

29. Upward flow tanks are square or circular. The sewage is fed into the tank through the bottom of a central stilling box. The sewage flows very slowly upwards and outwards, and passes over the weir situated round the top edge of the tank. A scumboard in front of the weir retains floating matter in the tank. The suspended matter settles into the lower part of the tank, which is shaped like an inverted pyramid or cone, and there collects as sludge. The sludge is discharged through a pipe which runs up from the bottom of the tank to a chamber, where the outlet of the pipe is below the level of water in the tank and is kept closed by a valve. When the valve is opened the head of water in the tank pushes the sludge out through the pipe. This type of tank has the advantage that it can be desludged without being emptied or shut off, and the operation can be carried out quickly with little effort. On the other hand, the sludge withdrawn from an upward flow tank tends to be more watery than the sludge from a horizontal flow tank, and for this reason special care is needed in carrying out the operation of sludge removal.

30. When desludging an upward flow tank the valve on the sludge pipe should be opened slowly and the sludge allowed to flow out at a fairly low rate. Any sudden opening of the valve or rapid withdrawal of the sludge is likely to cause water in the tank to be drawn down through the sludge into the pipe. As soon as the sludge leaving the pipe begins to run thin you should close the valve. After about ten minutes the sludge left on the sides of the tank will have fallen to the bottom and you should open the valve slowly to withdraw more sludge. A third rest and withdrawal may result in still more

sludge being removed. This method avoids passing more water to the sludge treatment plant than is absolutely necessary.

31. Upward flow tanks should be desludged at least twice a week or the draw-off pipe may become choked with very thick sludge. If this happens shut off the flow to the tank and clear the pipe by using a plunger through the rodding eye or in the tank itself. If plunging fails it may be necessary to get a jet of water or compressed air down the pipe to break up the dense sludge. In extreme cases you will have to empty the tank with a mobile pump and dig out what has accumulated.

32. Failure to desludge the tanks or to remove the scum often enough will give rise to the symptoms and troubles referred to in paragraphs 27 and 28. If the desludging of upward flow tanks is carried out too frequently the sludge will contain too much water and take longer to dry. The best time interval for any particular tank can only be determined by experience.

33. If, at normal daytime flows, any lengths of the outlet weirs are persistently dry you should report it to the foreman or the surveyor.

Mechanically desludged tanks

34. Some tanks are specially designed for mechanical desludging. There are two basic types of machine. One operates in a rectangular tank and scrapes the sludge along the bottom into hoppers at the inlet end. The other is designed to work in a circular tank in which the sewage enters at the centre and leaves over a continuous weir running around the outside edge of the tank; the floor slopes gently towards the centre and the sludge is scraped to a central hopper by a rotating scraper. With both types arrangements for mechanical skimming and removal of floating matter are often included.

35. The sludge is removed from the hoppers by water pressure in the same way as from upward flow settling tanks, and you will need to do it in the same way.

36. The machinery for desludging tanks varies considerably, and you should ask for the maker's instructions on operation and maintenance.

Septic tanks

37. A small works may have a septic tank instead of a settling tank.

Unlike a settling tank, the sludge is left in a septic tank for several months and the tank is made large enough to hold the sludge which collects during this time. While it is stored the sludge ferments or "digests" and is reduced in quantity. The inlets and outlets are baffled, often by the use of tee-pieces, and a crust forms on the surface of the water. The tank is usually covered.

38. When the tank is between one-third and a half full of sludge it is desludged, usually with a cesspool emptier. You should take out only about two-thirds of the sludge and leave the rest behind so that the ripe, fermenting sludge still in the tank "seeds" the freshly settled sludge. If you do not leave enough ripe sludge in the tank the proper fermentation does not take place and the contents of the tank will be likely to smell. Disinfectant should be avoided. It will interfere with the proper action of the tank.

39. When road access to a septic tank is poor, care should be taken to see that the tank is desludged before bad winter weather sets in.

The disposal of storm sewage

40. In some districts, rainwater is allowed to run into the foul sewers increasing the flow, which during a heavy rainstorm may be many times the average flow in dry weather. Arrangements have to be made to deal with this extra flow when it arrives at the sewage works. After a short time the mixture of sewage and rainwater will usually be weaker than the foul sewage delivered during dry weather, but at the beginning of a storm it may often be stronger because of the flushing out of deposits which have settled in the sewers.

41. The rate of flow of foul sewage arriving at the disposal works during dry weather will vary from time to time throughout the day and night, and to cope with this variation sewage works are usually designed to deal with about three times the average flow of foul sewage. At works where rainwater arrives in the foul sewers, flows in excess of this rate are diverted by means of a separating weir into storm tanks. The main purpose of these tanks is to store the first flush of foul storm sewage so that it can be pumped back for treatment after the storm. If the storm continues after the tanks are full they are allowed to overflow to the river. When this happens

they act as settling tanks in which solid matter is trapped and so prevented from reaching the river.

42. Make sure that storm tanks are emptied and cleaned out as soon as possible when the sewage flow has returned to normal, so that they are ready to receive the foul flush from the next storm. If storm sewage and sludge are left too long in the tanks they may get washed out into the river with the foul flush from the next storm, or turn septic and cause trouble when pumped back through the main treatment works.

43. The usual method of emptying storm tanks is to take off the top water through a floating arm for return to the works inlet and to remove the sludge separately, as with settling tanks of similar type. If possible during, and in any case after, the passage of storm sewage over the separating weir you should clear the weir of rags, sticks, and other solids objects which may be caught up on it. All weirs and channels leading to the storm tanks should be brushed and cleaned after they have been in use. Valves, penstocks and other mechanical equipment should be kept greased and in free working order as described for settling tanks.

44. In recent years some small sewage works have been designed so that a larger flow can be passed through the main treatment plant in wet weather. Where this has been done, special tanks for storm sewage have not been constructed.

CHAPTER 4

SECONDARY TREATMENT

45. Sewage which has been purified as far as possible by settlement still contains very finely divided matter which is too light to settle, together with dissolved impurities. Primary treatment has reduced the strength of the sewage entering the works, as measured by the usual tests, by about one-third. The next stage of purification changes most of the remaining impurities into a state in which they can be removed by further settlement.

46. Many years ago the secondary treatment of sewage was done by land treatment and sewage farming, making use of the bacteria and other living organisms naturally present in the soil. These converted the sewage impurities into food for crops, and the purified liquid drained away.

Percolating filters

47. Nowadays similar micro-organisms are encouraged to form colonies in artificial beds of clinker or other rough, hard material over which the settled sewage is sprinkled by mechanical distributors. These beds are usually called percolating filters, but are sometimes referred to as biological filters or bacteria beds. They do not filter in the sense of straining out impurities: rather they allow the settled sewage and fresh air to penetrate among the colonies of bacteria which form a film over each piece of the material. Other forms of small life also colonise the filter beds, notably worms, springtails and various flies whose grubs graze on the bacterial film and perform an important function: they convert the film into humus, which is washed out of the filter with the treated sewage effluent, and prevent the film from growing so thick as to choke the bed. Cold winter weather causes these "scouring" organisms to retreat deeper into the filter and this may result in some surface choking of the filter. When warmer weather returns they attack the surface layers again and liberate an abnormally large quantity of humus. This is the cause of what is sometimes known as the "spring unloading" of the filter.

48. The efficiency of a percolating filter depends upon the even distribution of the settled sewage over the whole surface of the filter, and on the provision of a good circulation of air through the bed which must reach the surface of each piece of the filter material to keep the right kind of bacteria and other organisms alive and active.

Dosing chambers

49. The percolating filters are usually situated at a level well below the outlet weirs of the settling tanks, and the head of water thus obtained is used to drive the mechanical distributors. Some types of distributing machines will not work when the flow through them falls below a certain rate. This may happen for quite long periods and particularly during the night. If the distributor stops and allows

settled sewage to dribble on to the filters continuously in one place the load is concentrated on a small part of the filter and little or no purification occurs. To prevent this happening the tank effluent is discharged into a dosing chamber, which when nearly full empties into the pipe feeding the filter at a rate high enough to drive the distributor and ensure that the settled sewage is spread over the full area of the filter.

Dosing siphons

50. The flow to the distributor is controlled by a siphon in the dosing chamber, so the successful working of the filter depends upon reliable operation of the siphon. The detailed arrangement of siphons will vary somewhat from one maker to another. Manufacturers supply instructions and diagrams of their siphons and you should study these so that you know how they work, how to keep them in good order and what to look for if a siphon fails to operate properly.

51. Dosing siphons require regular maintenance. You should clean the dosing chamber weekly; walls, floor and then dosing apparatus should be brushed clean with tank effluent. The siphon and air pipes should be given a monthly check and kept free from grease and solid matter. In particular the inside of the dome should be cleaned and also the two sets of piping: the longer has a U-trap at its end and the shorter dips into the dosing chamber beside the dome. These pipes should not normally be removed, but should it be necessary to renew them you must take great care when refitting to ensure that they are placed in precisely the same position as were the original pipes. It is advisable to take measurements before dismantling, and to check with the manufacturer's diagrams to make sure of correct reassembly and adjustment. It is particularly important that all joints should be completely airtight, because when the chamber is filling up slowly even a small air leak may prevent it from operating properly. The joints should be made with non-setting jointing compound or with grease.

52. You may find that when the chamber is emptying or filling up quickly the water will be very turbulent and upset the proper working of the siphon. In some cases this can be cured by constructing brick baffles in the chamber.

Distributors

53. Filters on small works are usually circular and equipped with rotary distributors. The flows in filter distributor pipework may be uneven, and some filters may get more flow than others. Best results are usually to be had from even loading, so careful adjustment of valves may be necessary to spread the load. On the other hand, differences in filter materials, position or past use may make some filters naturally better than others, so best results will then be obtained by making the better filters carry the heavier loads. Using observation samples, mentioned in paragraph 111, as a guide you can find what is best by trial and error.

54. The sparge holes in the distributor arms must be kept clean and the arms themselves regularly brushed out and then flushed. You should not allow the washout water from the arms to fall directly on to the filters but should pass it through a fine sieve to catch the solid matter. You may find it possible to reduce the frequency of cleaning distributor arms by passing the settled sewage through a fine mesh screen which is itself cleaned regularly. A wire mesh screen over the dosing siphon chamber will help to keep out leaves and other matter likely to block the sparge holes. If the distributor arms consist of channels with V-notch weirs these may not require such frequent attention as the jet type, but nevertheless you should not neglect them, particularly when leaves are falling. Where the filter supply pipes are equipped with washout arrangements you should flush them at monthly intervals to scour out any deposits. The washout water must not go into the humus tanks but should either be irrigated over land or passed to the sludge well and pumped back for full treatment.

55. The water power driving the distributor is quite small, and it is essential that you inspect and lubricate both the top and bottom bearings of the central column regularly to ensure that the distributor rotates freely. At the same time check the seals to see that they do not leak. The manufacturer's instructions regarding maintenance and lubrication should be carried out and the recommended lubricants used.

56. Where the centre columns are fitted with mercury seals you should clean the seal and catch chamber once a year. Dirt gradually

collects in the seal and if it is allowed to accumulate it displaces the mercury. Take care not to blow the mercury seal by opening the valve to the filter too quickly or by shutting down another filter suddenly.

57. Check the arms of the distributor regularly to see that they are level, that each arm receives the same amount of sewage and that each sparge hole is discharging the full quantity. The guy ropes should be adjusted as necessary.

58. Where stationary distributors are employed keep them clean and check the levels periodically. Inspect buffers on tipping troughs and check the installation for easy movement.

Filter bed maintenance

59. The filter bed itself should be kept clear of weeds and moss, and any ventilation pipes or channels should be kept open and free of obstruction.

60. Constant walking on the surface of the bed is liable to crush the filter material and pack it more tightly. When you carry out any repair work on the distributor, lay down planks to use as walk ways.

61. If parts of the bed show signs of ponding, as may happen towards the end of the winter, try gently forking over the choked areas. Bleaching powder sprinkled lightly over the ponding surface will often help to clear it.

62. A considerable amount of grit is sometimes washed out of filter beds, depending on the age and nature of the filter material. This grit settles out in the channels carrying the filter effluent, so you should inspect these channels from time to time. Any accumulated grit should be shovelled out as it may get into the humus tanks and block the sludge pipes.

Recirculation

63. On some works arrangements are made to recirculate some of the final effluent back through the filters. This enables the filters to deal with a heavier load. On smaller works recirculation is occasionally used to economise in the size of the filters, but more often it is done when any strong waste makes the sewage more difficult to treat.

64. On works where the effluent from the settling tank is pumped to the filters a part of the final effluent can be run back to the pump well and mixed with the settled sewage. On works where the filters are fed by gravity a separate pump has to be installed to lift the final effluent into the outlet channel of the settling tank or the dosing chamber. It is is usual to pump back final effluent at about the same rate as the average flow of sewage, so that the filters are fed with a mixture of about equal parts of final effluent and effluent from the settling tank.

65. If your works have a recirculation system you may find you can do without it when the sewage is weak, for example when the flow increases in wet weather. You should, however, keep it working if the filters show the slightest sign of ponding or the effluent deteriorates. Recirculation can be helpful in frosty weather in preventing the distributors from freezing overnight.

Humus tanks

66. The effluent from the filters is a clear liquid containing fine brown particles of humus in suspension which are the end products of the biological activity in the filter (described in paragraph 47). This suspended matter is removed by settlement in tanks working on either the horizontal or upward flow principle. They are similar to the tanks used for primary settlement of the sewage but are generally smaller.

67. The operation and maintenance of humus tanks are the same as for settling tanks. Regular removal of the humus sludge is essential if a satisfactory effluent is to be maintained at all times. The humus tanks will usually need to be desludged more frequently than the primary settling tanks, but it depends upon local circumstances and the time of year. In general you should empty horizontal flow tanks at least weekly and desludge upward flow tanks not less than twice weekly. On some works upward flow tanks may require desludging daily.

68. The humus sludge removed from the tank is thinner and contains more water than primary tank sludge. It is often pumped back to the works inlet for settlement and final removal with the primary sludge and you should do this as far as possible at times when the

sewage flow is fairly low. If too much humus sludge is added at a time or at too great a rate it may cause primary sludge to rise to the surface of the settling tank.

Activated sludge

69. Occasionally small sewage works use a method of purification called the activated sludge process, in which the sewage is aerated in a tank instead of being passed through percolating filters. There are several variations of this method and where these plants are installed specialist advice from the manufacturers should be obtained.

CHAPTER 5

FURTHER TREATMENT

70. If the sewage works are of the right size for the flow and strength of sewage, and are properly looked after, the results of the treatment described should be a clear sparkling liquid pure enough for discharge into most rivers or streams. Some streams receiving effluents have little natural flow in them and it may then be necessary to purify the effluent still further before it is discharged. This final "polishing" can be done in various ways, but the two most common on small works are by using either sand filters or irrigation over grassland.

Sand filters

71. Sand filters are constructed in different ways but are usually shallow beds of coarse sand with under-drains. Unlike the percolating filters, they actually strain the effluent and trap suspended matter it still contains. At least two sand filters are usually provided and used alternately. The effluent from the humus tank is run on to the filter, and when the surface becomes choked and the water can no longer pass through, the feed to the bed is shut off and another filter brought into use. The clogged bed is allowed to dry out and then the top inch or so of sand and dried humus solids is skimmed off and replaced by a fresh layer of sand. A supply of coarse sand is kept near the sand filters.

Grass plots

72. The grassland area is divided into two or three fairly level plots and the effluent is distributed from a grip or channel across one end, arranged to spread the liquid evenly over a plot. Some of the effluent soaks away into the soil and the remainder is collected in a channel at the far side of the plot and discharged to the river.

73. It is usual to keep one plot or part of the area dry at any one time and to change over from one section to another at suitable intervals.

74. The grass in the irrigation areas should be cut sufficiently to prevent weeds from seeding and causing nuisance to adjoining land. This may mean cutting monthly in the summer. The effluent is improved by flowing through the grass which should not be cut too short. The cut grass should be removed otherwise it will rot, and pollute and colour the final effluent.

75. It is important that the water is distributed evenly over the grass plot, and not allowed to form channels through which the humus tank effluent would short-circuit and escape full treatment.

CHAPTER 6

SLUDGE DRYING AND DISPOSAL

76. The primary settling tank and humus sludges removed from the tanks contain many times as much water as solid matter, and unless this wet sludge can be distributed directly over land for disposal it needs to be dried out until it is sufficiently solid to be lifted and carted away.

77. The usual way of drying sludge is to run it out on to open under-drained beds topped with a layer of fine material such as sand or fine ash. Some of the water is lost quickly by drainage, but this soon stops and the remainder is lost by evaporation, which is a much slower process. Evaporation is speeded up by wind blowing across the drying beds, so no trees or shrubs likely to act as wind breaks should be grown near the beds.

78. At the point at which the sludge enters the bed the surface should be protected from scouring by a concrete or stone slab.

79. The sludge should be run on to the bed to a depth up to 9 inches; an upright post of this height in the centre of the bed is a useful guide. This amount will dry down to about 3 inches of spadeable material. If too much wet sludge is put on a bed the drying takes much longer; if too little is put on, although drying is quicker, the dried sludge has to be lifted more frequently and the total time taken is longer. Experience is necessary to decide what is the most convenient depth of sludge for a particular works.

80. Avoid running wet sludge on the top of partly dried sludge. The water cannot drain out of it nor can the older sludge lose water by evaporation. If each bed is so large that you cannot fill it to a suitable depth in, say, three or four days, it can be divided up temporarily by means of planks, bricks or even turf or well dried sludge. The sludge can then be fed into the separate sections in turn, using portable troughing or other convenient means.

81. Shortly after a bed is filled with sludge, water will separate in pools on the surface, usually at the end farthest from the inlet. If possible you should run off this water to speed up drying. When there is no special provision for removing this water you can sometimes push a pipe through the bank and drain off the top water, taking care not to withdraw wet sludge. Another method is to make a gap in the bank where the water is found to stand and block it with two-inch or three-inch boards on edge, wedging them open $\frac{1}{8}$ inch or so to drain off the standing water. Any liquid discharged from drying beds, either from the surface or through the underdrains, is polluting. If it cannot be disposed of harmlessly by soaking away on the land it must be returned to the works inlet for treatment.

82. If, when the sludge begins to crack, some is removed to form a series of holes or one or more narrow paths in the drying bed, you may find this will hasten drying. The sludge should be lifted as soon as it is ready in order to keep as many beds clear as possible.

83. On most small works the sludge is usually lifted by shovels or by close-tined tarmac forks into barrows. The barrows should be wheeled in and out of the bed on planks as this prevents crushing and packing of the surface; anyway it is easier to push a loaded

barrow on a plank. It is better to lift some of the fine topping material with the sludge rather than to leave lumps of sludge behind on the bed. When the bed is empty you should rake it over and level it up as necessary, taking care that the coarse drainage material is always well covered. A supply of suitable topping material should be kept near the beds. Avoid walking on the bed unnecessarily.

84. Sludge dries much more slowly in winter than in summer, so you should aim to start the winter with as many empty drying beds as possible.

85. Some works are equipped with a sludge storage lagoon or tank, often referred to as a cold digestion tank. This can be very useful in the operation of the sludge drying arrangements. If decanting valves are provided in the tank you can remove a useful amount of water from the stored sludge before it goes to the drying bed. The separated water should be returned to the works inlet at a slow rate, as it is a strong liquor. Running the liquor through an empty drying bed will reduce its effect on the treatment plant. A storage tank enables enough sludge to be accumulated to fill a drying bed in one operation. If care is taken to see that the tank is empty in the autumn it also provides additional storage to help through the winter.

86. You will find humus sludge more difficult to dry than primary sludge. If land is available it is sometimes worth while to run the humus sludge on to the surface of the land or into trenches and later to dig it in. The primary sludge will dry more quickly in the beds when it contains no humus sludge.

87. If you tip the dried sludge on a conveniently accessible hard site, farmers and allotment holders can often be encouraged to take it away.

CHAPTER 7

MECHANICAL EQUIPMENT

Machinery maintenance

88. No matter how small the sewage works, there is sure to be some kind of machinery needing oiling or greasing and checking over

regularly. There are so many different kinds and makes of machinery for doing similar jobs on sewage works that it is only possible here to give very general advice. Follow the instructions of the machinery manufacturers. If you have no instructions for any piece of equipment ask the foreman or the surveyor to get them for you.

89. If you have any trouble with machinery, study the instructions carefully to make sure there is nothing you have overlooked. If you still cannot get it to work properly report immediately.

Lifting sewage

90. Almost all sewage works have some means of lifting sewage or sludge to a higher level. The centrifugal pump is most widely used for this purpose but occasionally plunger or ram pumps may be used for sludge, and air ejectors for sewage.

91. Centrifugal pumps are usually situated below ground level in the dry well of the pumphouse and below the level of the incoming water or sludge so that they are kept primed. Pumps situated above water level are primed in various ways, but it is important that the pipework, valves, glands etc. of such pumps should be airtight or priming may be difficult.

92. All pump and shaft bearings should be lubricated strictly in accordance with the maker's recommendations. Check the glands frequently and make sure they are neither too tight nor too slack. Occasionally turn the pump shaft by hand to check that it is rotating freely all round, but when you do this make quite sure the power supply is switched off and that the motor cannot start up automatically. If the shaft is unusually stiff report it. If a pumping set becomes noisy or beings to vibrate, this too should be reported. Feel the bearings and glands now and again, and if any of them becomes unusually warm or hot report it. When something unusual happens to a pump change over to the standby, if you have one, and report immediately.

93. Many pumping installations are equipped with gauges registering the vacuum on the suction side and the pressure on the delivery side, and with ammeters registering the current taken by the motor. Mark the normal positions of the needles on the fronts of the gauges

and ammeters, and if there are any changes which you cannot explain or correct report them. The ammeter reading will indicate whether the pump motor is underloaded or overloaded.

94. If you want to reduce the flow from a centrifugal pump, always throttle down the delivery valve, never the valve on the suction side. Do not attempt to control the output of any other type of pump, such as a plunger or ram pump, by altering the valve openings.

95. Pumphouses and dry wells should be kept clean and tidy. The floors should be mopped over but not allowed to remain wet. Where heating is provided in the pumphouse use it to maintain an even temperature: it is wasteful to overheat the building. Where the pumps are fitted with auxiliary suctions always make sure the valves are closed after use; if you forget you may find the pumphouse flooded on your next visit.

96. The wet well should be inspected frequently, always after a storm, and cleaned out as required, because accumulations of grit or heavy sludge will obstruct the intakes.

Pump controls

97. Many pumps are controlled automatically, either by various arrangements of floats or by electrodes. Floats should be inspected frequently and any grease or adhering sludge or rags cleaned away. Make sure there are no accumulations of sludge or grit in the well underneath the float which will prevent it from falling to the bottom of its travel. Keep the moving parts lubricated and working freely. If the float slides up and down a rod make sure the rod is not bent and that the float can move easily throughout its complete travel. Electrodes should be brushed frequently and swilled down with sewage or water.

CHAPTER 8

WINTER CONDITIONS

98. Prolonged frost can seriously interfere with the operation of a sewage treatment works, but there are steps you can take to help keep the plant going.

99. Exposed pipes or those buried at a shallow depth should be drained and kept empty when not in use. Where they cannot be drained, lag and protect them from wind. Attend to leaking glands on sluice valves as they may cause the spindles to freeze up.

100. Screen bars may become choked with ice and accumulated screenings freeze up. These can usually be thawed out with warm water. Some form of windbreak or cover to protect the screen will reduce the risk of freezing.

101. Dosing siphons are liable to freeze, but covering the chambers with tarpaulins will help to prevent this.

102. Percolating filter distributors freeze up when stationary, and in prolonged cold weather you may find it advisable to shut down some of the filters so that the remainder will be dosed more frequently. Take care to drain the feed and washout pipes of the filters taken out of use and see that no water is left in the base of the columns.

103. Rags soaked in oil can be burnt to thaw out frozen machinery, and a flame gun such as is used for weed killing can be used provided you are careful to avoid damage to pipes and machinery.

104. Sludge on the drying beds which has been frozen loses water quickly when it thaws out and can be lifted earlier than normal. It breaks up readily into fine pieces and is in particularly good condition for use as a low-grade fertiliser.

CHAPTER 9

RUNNING THE WORKS PROPERLY

105. As we have already mentioned, it is impossible to say just how often various operations ought to be carried out. So much depends on local circumstances. You will have to determine, for example, how long the settling and humus tanks at your works can be left between desludging without the risk of any extra suspended solids escaping and without any fermentation or smell. If a tank is left too long the sludge may become thick and difficult to move and

desludging may take longer than a single day. On the other hand, if you empty a tank too often, time, labour and drying bed capacity will be wasted. These are the sort of considerations which apply to most of the regular jobs on a sewage works.

106. As far as possible you should set up a fixed routine, which should be established over the days of the week, and write it down. The job list should include machinery lubrication and attention. Of course at times certain operations may require doing more frequently than usual. For examples, screens and grit chambers may need cleaning immediately after a storm; humus tanks will require desludging more frequently when the filters discharge extra humus in the spring, and filter distributors may need attention more often in the autumn, when fallen leaves block the sparge holes. All this will be extra work in addition to the regular routine.

Records

107. On even the smallest works which you visit part-time only, you should keep a simple diary in which you make a note each day of the various jobs that you have done. Write down any troubles that occur and the date when they are put right. Note in the diary any sign of wear or damage to machinery and report it so that spare parts may be obtained ready for use. Mark in the diary in advance the maintenance jobs that require doing at infrequent intervals so that they are not forgotten.

108. You will find such a record valuable if any difficulties arise, and when you are away on holiday or sick leave your substitute will know exactly which jobs need doing, which tank should be desludged next and so on. It is also useful to make out a list of the people, with their telephone numbers, who may be needed either regularly or in an emergency, and hang it up where it can be readily seen.

109. If the flow through your works is measured and recorded at some stage you will no doubt make a note of the meter reading at the same time each day and, by subtracting it from the previous day's reading, obtain the daily flow. At the same time make a note of whether or not it rained during the preceding twenty-four hours,

to help to explain any flow changes there may have been. If you look back through the flow figures now and again you should see a regular pattern of the flows on dry days through the week. There may be a regular change at week-ends or on certain days of the week and perhaps an alteration during holidays. If you get to know how much sewage to expect each day anything unusual will soon be detected. Any gradual increases or decreases will also be seen.

110. If electricity is used on your works there will be a meter, and it is useful to make a note of the reading of the meter and check the daily or weekly consumption of electricity. If any change occurs for which you do not know the reason it should be reported.

Checking performance

111. A sample of the final effluent for visual inspection at the works should be taken regularly at the same time of day and kept for two or three days. You can then compare samples taken on different days and check whether there are any changes in the general appearance or the amount of suspended solids. Any clear colourless glass bottles or jars will serve to hold the samples, but they should all be of the same size and shape. If regular samples of the crude sewage, sedimentation tank effluent, filter effluent and humus tank effluent can also be taken for visual inspection they will be a further guide to the working of the different stages of treatment. The sample bottles should be permanently labelled (e.g. "Crude", "Settled", "Final") and should always be washed and brushed out thoroughly with a bottle brush each time a sample is changed.

112. If the crude sewage alters in colour or general appearance it may be due to the discharge of farm or factory waste to the sewer, and you should inform the foreman or surveyor and show him the samples.

113. Any increase in the amount of suspended matter in the effluents from the settling tanks or the humus tanks usually means that the tanks need desludging more frequently.

114. If the final effluent is dull and cloudy it suggests that the filters are either overloaded or not working properly. It may be due

to the distributors standing, perhaps at night, or to a leaking column seal.

115. If the samples show any change which you do not understand, you should report it to the foreman or the surveyor, keeping the samples to show him.

Safety

116. Most people find that working on a sewage works is a healthy life and quite safe provided a few commonsense precautions are observed.

117. A first aid box should be available, and if you cut or scratch yourself take care to wash or disinfect the injury and if necessary protect the cut. All accidents should be entered in the accident book.

118. Do not run machinery with any guards out of position, and avoid wearing loose clothing or holding rags that may be caught up when working near moving machinery. Never service any machinery, no matter how slow moving, while it is in motion.

119. When you change a fuse or attend to any electrical gear make sure that the current is switched off, that your hands are dry and that you are not standing on a wet floor but preferably on a rubber mat. If you find a pumping station or any electrical equipment flooded make sure the current is off before you approach.

120. Do not run a portable petrol or diesel engine in any confined space such as a pumphouse: the exhaust fumes will be dangerous.

121. You should never go down into a chamber or sump containing sludge or septic sewage except on a safety line and with someone up above at the other end who is strong enough to help you out if you are overcome by foul air.

The river inspector

122. You will no doubt be visited from time to time by the local river inspector calling to see if the effluent is satisfactory. He visits many works like yours and is well aware of your difficulties. He can often help you and give friendly advice. Remember, you are both working for the same purpose, the purity of the river.

The general appearance of the works

123. The works should be kept tidy. Grass and weeds should be mown to keep them short and prevent seeding. Paths should be kept clear of weeds and the edges trimmed. If shrubs and trees are planted in suitable positions they will improve the appearance of the works, as will one or two flower beds. But you should take care not to make so much gardening work that it cannot be done properly or that the treatment plant has to be neglected. Do not plant trees where their roots may reach underground pipes or the leaves get into the filter feeds.

124. The pathways and the works site generally should be kept swept and clean, and any screenings or sludge which may be spilled should be cleared away without delay.

125. Detergent foam can be troublesome on some works. It is blown about and when it settles and collapses it leaves behind a black greasy film. This film kills grass, turns paths slippery and makes the place unsightly. It usually occurs when filter or humus tank effluent falls over a weir or from a pipe so that air and water are stirred up vigorously together. If there is no way of preventing this by making the fall quieter and less turbulent you may be able to box in the place where it occurs so that the foam is trapped. If you have a water supply and a hose a fine spray of water over the foam will collapse it; you may be able to keep it under control in this way when it gets really troublesome.

126. A badly run sewage treatment works can be a most unpleasant place, offensive alike to sight and smell. Remember a visitor will "smell what he sees". While no one expects a sewage works to compete with a public park, there is no reason why yours should not be tidy, free from nuisance and a place you and your council can be proud of. Like a motor car a clean works always seem to run better than a dirty one—and probably does!

TROUBLE-SHOOTING GUIDE

If this guide to locating troubles does not lead to a cure, always report the trouble immediately.

Signs and symptoms	*Possible causes*	*Suggested action*
Crude sewage flow		
Reduced flow, suddenly	Sewer blocked or broken	Report, giving date, time and duration.
Excessive flow		
—suddenly	Sewer broken	ditto
—intermittent flushes	Trade (including farm) waste	ditto
—flow increase	Increased domestic sewage or trade waste	ditto
Unusual colour, appearance or excessive solids or quantities of oil	Trade (including farm) waste	ditto
Preliminary treatment		
Unusual or excessive screenings	Increase in domestic sewage or trade waste	Clean screens more often and report.
Excessive grit	Road washings, ashes or material from building site	Report.
Settling tanks		
Rising sludge		
—in all tanks	Accumulated sludge	First make sure all sludge is removed at each desludging; if rising still occurs, desludge more often (If in *humus tanks*, filter may not be working properly).

Signs and symptoms	*Possible causes*	*Suggested action*
—not in all tanks	Some tanks receiving too much sewage	Reduce flow to affected tanks.
Excessive suspended matter in effluent —all tanks	Accumulated sludge	Clean tanks more often.
	Flow through tanks too fast (overloading)	Report.
	Humus sludge, or underdrainage returned too fast	Reduce pumping rate.
—not all tanks	Some tanks receiving too much sewage	Reduce flow to affected tanks.
Excessive floating matter in effluent	Defective scumboards or none	Repair scumboards or install new ones.
Sludge pipes choke	Sludge too thick	Clean more often.
	Sludge contains grit	Clean grit chamber more often; if chokage persists, report.
	Grit in humus tank sludge may mean filter material breaking down	Report.
Bubbles rising in tank	Septic conditions	Report, and empty tank completely as soon as convenient.
Dosing siphons		
Fail to work	Air leaking out	Check for leaks with soapy water; make up joints or replace pipes where necessary.
	Incorrectly adjusted	Check adjustment.
Work erratically	Turbulence in chamber	Try out baffles in suitable positions.
Percolating filters		
Distributors stand and dribble	Dosing siphon faulty	See under *Dosing siphons.*
	Insufficient flow	Check flow into tank.

Signs and symptoms	*Possible causes*	*Suggested action*
Distributors revolve slowly or stop	Mechanism stiff	Check bearings and lubricate.
	Arms out of balance	Adjust guy ropes.
	Centre column seal leaking	Check and remake seal.
Sparge holes choke quickly	Excessive floating matter, leaves, etc.	Check scumboards in settling tank.
Filter beds pond		
—all beds	Excessive suspended matter in settled sewage	See under *Settling tanks*.
	Load too heavy or severe winter conditions	Fork over lightly; if ponding persists, report.
—not all beds	Too much sewage to certain beds	Reduce flow to ponded beds.
Settled effluent cloudy	Bad distribution, choked sparge holes, standing distributor	See above.
	Beds overloaded	Report.

Humus tanks

See under *Settling tanks*

Grass plots

Flow cuts channels	Badly arranged feed to plot	Alter distribution, change over more often.

Sludge drying beds

Sludge dries more slowly than usual	Sludge layer too thick	Put on less sludge.
	Second dose applied too late	Do not apply second dose if first has started to dry off.
	Standing water	Decant off water.

Signs and symptoms	*Possible causes*	*Suggested action*
	Bed surface clogged	Rake over, skim if necessary, redress surface.
	Broken or clogged drains	Check at inspection chamber; rod out or dig down.
Centrifugal pumps		
Motor does not start	Main switch is off	Switch on.
	Isolator switch is off	Switch on.
	Overload tripped	Reset — If trips or blows again, report.
	Main fuse blown	Replace — If trips or blows again, report.
	Supply failed	Report.
Pump rotates but does not pump	Suction and/or delivery valves shut	Open.
	Suction blocked	Check that suction in wet well is free.
	Delivery blocked	Check outlet of main; check non-return valve.
	Pump blocked.	Switch off current and investigate. Report.
	Pump not primed	(*a*) pump below water level.
		Check that water level in sump is above pump level.
		Check that air release pipes not blocked.
		(*b*) pump above water level.
		Check for air leaks on suction side.
		Check priming gear.
Pump delivers less than normal flow	Partial blockage	Check suction delivery and pump.

Signs and symptoms	*Possible causes*	*Suggested action*
	Air leak on suction side	Check connectors, valve, auxiliary suction and glands.
	Suction inlet drawing air	Switch off to permit water level to rise.
Motor takes excessive current	Solid matter choking pump	Switch off and clean pump.
	Tight glands	Slacken.
		Report.
Pump does not stop	Automatic control gear failure	Check that moving parts work freely.
		Check that float is not resting on sludge.
	Switch set to manual	Switch off.
Pump rotates backwards when shut off	Non-return valve stuck in open position	Free valve.

Petrol engines

We do not cover all the difficulties you may have with petrol engines, but it is worth mentioning that the commonest cause of failure to start a petrol engine is excessive choking of the carburettor intake. If this happens, switch off the ignition. Release choke. Turn the engine over several times with the throttle fully open. Switch on and start without using choke.

Part Two: Management

Part One has been concerned with practical operation and maintenance at the works. For these to be performed efficiently it is necessary to provide not only the men, but the instructions, the tools and the facilities to enable them to do their jobs: this is the task of the management team comprising the members of the council and their chief officers, to whom Part Two is addressed.

CHAPTER 1

MANAGEMENT

127. The two principal aims of good management are:—

(*a*) The satisfactory performance of the works and the achievement of the purpose for which they have been provided;

(*b*) The operation and maintenance of the works as economically as is consistent with (*a*).

The degree of success depends on the human element—at all levels both within the organisation and in its relationship with outside concerns which range over a very wide field—river authority, riparian interests, neighbouring authorities, government departments, industrial and commercial interests and the general public.

128. The management of a number of sewage treatment plants of different size scattered over a wide area presents special problems to the rural district surveyor unknown to his urban colleagues. It calls for special skill in organising labour routines and in making the best use of limited resources.

129. The number, size and location of sewage works in a rural area vary enormously and it is not the purpose of this handbook to recommend any particular form of management or arrangement. What is intended here is to indicate the general principles upon which

successful management in a number of districts of differing character has been based. Their application in any particular area will be a matter for the judgment of the surveyor.

The need for a plan

130. Good management depends on good planning. The plan must be far-sighted and sufficiently flexible to meet the ever changing needs of the council. The needs of the moment tend to take precedence over those of the future, but it is essential to ensure that arrangements designed to meet pressing needs do not themselves give rise to more difficult problems in their turn.

131. In rural areas it is necessary not only to provide for an expanding demand where the service already exists, but also to provide main drainage facilities in many places for the first time.

132. The production of a workable plan must begin with a comprehensive review of all aspects of the service, and this might be developed in stages, as follows:—

Stage I. The needs of the moment, i.e. to operate and maintain the works as they exist. This part of the review might be considered under the following main heads:—

(*a*) The state of each treatment plant as regards
  (i) performance;
  (ii) capacity;
  (iii) state of repair.

At this stage a critical assessment of the performance of individual works must be made to decide to what extent any shortcomings are due to faulty or inexpert operation and routine maintenance.

(*b*) The needs of each plant in terms of manpower
  (i) for efficient day-to-day operation and maintenance;
  (ii) for periodic operational needs (e.g. tank emptying, sludge lifting etc.);
  (iii) for periodic maintenance and overhaul.

(*c*) The needs of each plant in terms of transport and mobile equipment.

(*d*) Deployment of personnel, transport and equipment to meet the needs of (*a*) and (*b*).

Stage II. It is now appropriate to give further consideration to the

shortcomings of those works whose present performance is sub-standard. How far is this due to

(*a*) inefficient plant;

(*b*) inadequate capacity;

(*c*) other causes—new or increasing trade wastes, uncooperative trades, infiltration water etc.?

If major extensions or alterations are needed, some preliminary estimate of cost should be made. At the same time it would be prudent to consider to what extent such alterations would affect the operational staff. (In some cases, improvements may result in economies, in others it may be necessary to increase the staff.)

Stage III. There may be some works which although at present performing satisfactorily are in need of repairs and overhauls beyond the scope of normal routine maintenance. Estimates should be prepared for

(*a*) works suitable for execution by direct labour;

(*b*) works more appropriate for execution by contract.

Stage IV. It should now be possible to prepare programmes covering the entire district for

(*a*) capital works and repairs;

(*b*) future deployment of personnel, including recruitment, promotions etc.

Stage V. In districts where there is an outstanding programme of capital works to provide main drainage in unsewered parishes, the Stage IV programmes will need to be amended accordingly and must provide for the necessary adaptation of the operation and maintenance organisation.

133. The method of approach outlined is considered in more detail in the ensuing chapters.

CHAPTER 2

ASSESSING PERFORMANCE

Capacity

134. If a sewage works is fairly new the surveyor should have a set of drawings and full records of the sizes and capacities of all tanks,

filters, drying beds and other sections of the plant. He will have also the basis of the design in terms of population served, flow and the loadings of the different units. If for any reason such information is not available (and it is often lacking or deficient for old works) it should be obtained, if need be by actual measurement on the works, and put on record.

Population served

135. The surveyor will know what building development has taken place in his various drainage areas, but he may not know whether a particular works is serving a larger or smaller population than it was designed to cater for. He must know this to assess the situation.

136. The Registrar-General's current population figures may be helpful but they will not necessarily coincide with the drainage areas. If the population served is known reliably for any previous date, a count of the houses built since will enable an estimate to be made by applying a factor to convert houses to population, based on the surveyor's local knowledge of the area.

137. Any trade wastes, including farm drainage and the sewage flow from hospitals, schools, hotels, institutions, holiday camps etc. should be taken into account.

Flow measurement

138. Lack of reliable information about the maximum rate of flow and the total daily volume is a severe handicap both in operating a sewage works and in assessing its performance and future needs. Experience shows that estimates of flow made when designing new works or extensions have often proved to be quite wrong. A determined attempt should be made to measure the actual flow to all but the smallest installations.

139. Except on very small works some sort of flow meter should be installed. It need not be a full recorder but should incorporate an indicator and an integrator. Where the meter is put will depend upon the layout of the works and the head available, but it is usually possible at most works to find somewhere suitable. Any permanent form of weir or orifice should be avoided when measuring crude

sewage: the approach requirements of weirs and orifices lead to the settlement of solids upstream, and they may become obstructed. Standing wave flumes are to be preferred.

140. Measurement of settled sewage is simpler than that of crude sewage. Measurement of final effluent is probably still easier. It should be remembered that if the humus tank effluent is given grass plot treatment the final effluent discharged may be less than the sewage flow.

141. If continuous metering is not necessary it is often possible to install weirs or flumes with float chambers and to transfer the float and meter from one works to another as required. In such cases a permanent hook gauge for the calibration of the meter is desirable. If wide variations of flows are to be measured different sizes of weirs or notches can be employed and the measurements and records multiplied by an appropriate factor.

142. On the smallest works a simple V-notch weir can usually be installed in the effluent channel with a vertical calibrated indicator on the wall measuring the height over the weir. This enables spot readings to be taken. Information of this simple kind is better than guesswork.

143. It is important to ensure that notches and flumes are installed at levels at which they operate under free discharge conditions over the full range of flow to be measured.

144. Where recorders are installed permanently some form of regular servicing by the manufacturer should be arranged, to ensure that consistently reliable information is available.

Sampling and analysis

145. River authorities impose statutory effluent standards, and their inspectors take check samples from time to time for analysis. It is not enough to rely upon these relatively infrequent checks to indicate the general standard of performance of sewage treatment works. The responsibility for ensuring that the required standards are consistently achieved rests entirely with the council. Some measure of analytical control is therefore necessary for all sewage works, and it is essential that the surveyor should be able to call

upon the services of a chemist with experience in this field for the interpretation of analyses and for advice. In some cases arrangements have been made between rural districts and a neighbouring large authority where a full-time chemist is employed at the sewage works. In at least one instance a number of authorities have combined together to employ a full-time chemist. This is an example which might well be followed elsewhere.

146. The amount of analytical work that is justified will depend upon the size and relative importance of the works and also upon any special difficulties of treatment arising from the presence of trade wastes or from overloading. On small works, routine analyses might be confined to effluent samples taken regularly at such intervals as the circumstances warrant. On larger works samples would be taken more frequently and might include settled and, perhaps, crude sewage.

147. Where trade wastes are discharged they should be sampled and analysed regularly to check that they comply with the conditions of acceptance laid down by the council. The frequency will depend upon the importance of the discharge and its effect upon the treatment plant. Analyses may be required in order to determine the charge to be made, and in some circumstances it may be appropriate to include the cost of the necessary trade waste analyses in the charge to the trader.

148. No matter how accurately analysis is carried out the reliability and value of the result depend upon the way in which samples are taken. It should be the personal care of the surveyor or a senior member of his staff to make sure that all samples for full analysis are taken by a responsible person who has been properly instructed.

149. Sampling points should be chosen with due regard to the information required and should be easy to get at. Each one should have its own can or dipper; it should be fully immersed, and care should be taken neither to dislodge matter adhering to walls nor to disturb bottom deposits.

150. There are two methods of sampling. One is the taking of a snap sample, when a single sample is taken to provide information about the composition of the liquid at a single moment of time.

Such a sample is usually taken to check that a stipulated limit for a constituent or property is not being exceeded. The other is to take a composite sample, which is a mixture of a number of samples collected at regular intervals over a given period. A composite is more informative because it covers the fluctuations in strength and character of the flow during the sampling period, and should always be used on a sewage works when a full chemical analysis is to be made.

151. The individual samples for a composite are usually taken at hourly intervals, but if sudden fluctuations occur in the strength or composition of the crude sewage or a trade waste it may be necessary to sample more frequently—at intervals of, say, 30 or even 15 minutes. Further, if during the course of sampling any sudden or striking change occurs in the character of the sewage it is advisable to retain an additional separate sample of this sewage to send to the analyst with full details including the time and duration of the condition. Sampling should preferably be carried out over twenty-four hours, but if this is not feasible it should be over twelve hours, say from 7 a.m. to 7 p.m. The quantity of each individual sample added to the composite should be proportional to the flow at the time when it is taken, but in the absence of any information about flows equal quantities of each sample should be mixed and the method of sampling recorded.

152. The individual samples should be collected in a large container, which must be thoroughly clean when sampling begins. A plastic bucket with a lid is suitable. When the sampling is completed the contents of the bucket must be well stirred and a clean Winchester quart sample bottle rinsed out with the liquid and filled. The solids must be kept in suspension while the bottle is being filled. The sample bottle should be labelled at the sewage works, and the information on the label should include details as to when, where and how the sample was taken and indicate the weather conditions at the time and the sewage flow if it is known. The presence of any known trade wastes, including farm drainage, should be stated.

153. When a sampling can is used there is always a risk that heavy suspended solids may not be transferred to the bottle and if the can

is used at more than one sampling point contamination of samples may occur. These risks are eliminated if each individual sample is taken directly into a clean small bottle and the composite made up when the sampling is completed. The bottle, of say ten fluid ounces capacity, can be attached by spring clips to a pole and filled by complete immersion in the liquid. The full bottle is removed, corked, labelled and stored under cool but not freezing conditions. At the end of the sampling period the composite can be made up at the works by the sampler, or the bottles can be taken to the council offices for mixing there: whoever mixes the composite then has an opportunity of checking that the individual samples are normal. If any of the samples are unusual the residues can be preserved and sent to the analyst. It has been found worth while to number the bottles permanently, using paint of a different colour for each sampling point.

154. When an authority has a large number of works to manage, or it is difficult to obtain suitable labour, consideration should be given to the use of a transportable, battery-operated, automatic sampler. With such a device sampling is less subject to human error and can be carried out while the works is unattended.

155. Sampling arrangements should always be discussed beforehand with the analyst to ensure that the samples are representative and will provide the information required.

156. At small sewage works, particularly where the sewage is predominantly or entirely domestic, the cost of regular sampling and analysis may be thought to represent an unreasonably high proportion of the total operating costs. Nevertheless it is essential that there should be some means of checking the performance of the works as a necessary ingredient of good management. With this in mind the Water Pollution Research Laboratory have devised a simple field test for effluents, which is fully described in the Appendix. The necessary equipment can be purchased either as individual items or as a portable kit, and can be kept at each works or carried round in a car. Some river authorities have adopted this test as a criterion for effluents from very small sewage works.

157. For the field test of the effluent a snap sample is taken, preferably at the same time of day on each occasion, as it is intended for

purposes of comparison. The test classifies the effluent into one of four groups:—

(*a*) Very good;
(*b*) Good to satisfactory;
(*c*) Unsatisfactory;
(*d*) Very unsatisfactory.

The attendant can carry out this test with little training. Where there is a permanent attendant it could well be carried out daily; at other works it might be performed, say, at weekly intervals.

158. Such a routine procedure will show when a works is falling off in efficiency. When a number of consecutive tests show the effluent to be unsatisfactory, samples should be taken for full analysis, and if the cause of the trouble is not apparent from the effluent analysis, samples should be taken of the crude sewage, the settled sewage and the final effluent in order to locate it.

The performance of the works

159. Having carried out a survey of the loading and performance of a sewage works on the lines described, the surveyor will now be in a position to decide whether the performance of the works is satisfactory according to the following criteria:—

(*a*) Does the effluent comply with the river authority standards?
(*b*) Is the disposal of sludge satisfactory, or are the drying beds full even in summer and are there heaps of semi-dried sludge lying around?
(*c*) Is there any nuisance from smell, flies, rats or unsightliness?
(*d*) Are there frequent breakdowns of machinery?
(*e*) Are there special maintenance or operational difficulties?

160. If the effluent is unsatisfactory it must be determined whether this is due to overloading or operational deficiencies. The population, flow and sewage strength will show whether the works is receiving sewage in excess of its design capacity, whether overloading is volumetric only, (perhaps because of infiltration water) or due to a general increase in pollutional load.

161. If the population served and the general load are not greatly in excess of design, the analyses of samples taken at different stages through the works will help to trace the cause of the deficiency,

which could be the result of faulty design, of structural or mechanical failure or the consequence of maloperation. Maloperation may be due to ignorance on the part of the operator or to shortage of labour to carry out all the necessary work. Supervision may be inadequate, or the right tools and equipment lacking.

162. A planned investigation on the lines described should enable a surveyor to diagnose the causes of unsatisfactory performances by the sewage works under his control.

163. If there are signs of overloading or the flow records indicate that the load is increasing and will exceed the design capacity fairly soon, the nature and scope of the requisite extensions should be considered. There should be consultations with the local planning authority to ascertain future loads, followed by discussion with the river authority to learn their future requirements.

CHAPTER 3

THE ORGANISATION OF LABOUR

Organisation

164. The size of an organisation required to look after sewage treatment will depend upon the population to be served and on its distribution, but a rural district will normally have a much larger number of works to treat the same volume of sewage than an urban district of similar population. In consequence it will need a more elaborate and costly organisation. With the increasing number and complexity of sewage works, the higher standard of effluents required and the growing public awareness of the service, the employment of a specially qualified superintendent whose undivided attention can be given to the management of the entire sewage treatment of the authority may well be justified and should be considered. The organisation required for the proper management and control of the works of a large rural district might be as illustrated on page 44.

165. In smaller districts the organisation would of course be simpler but the general principles would be the same. The chief

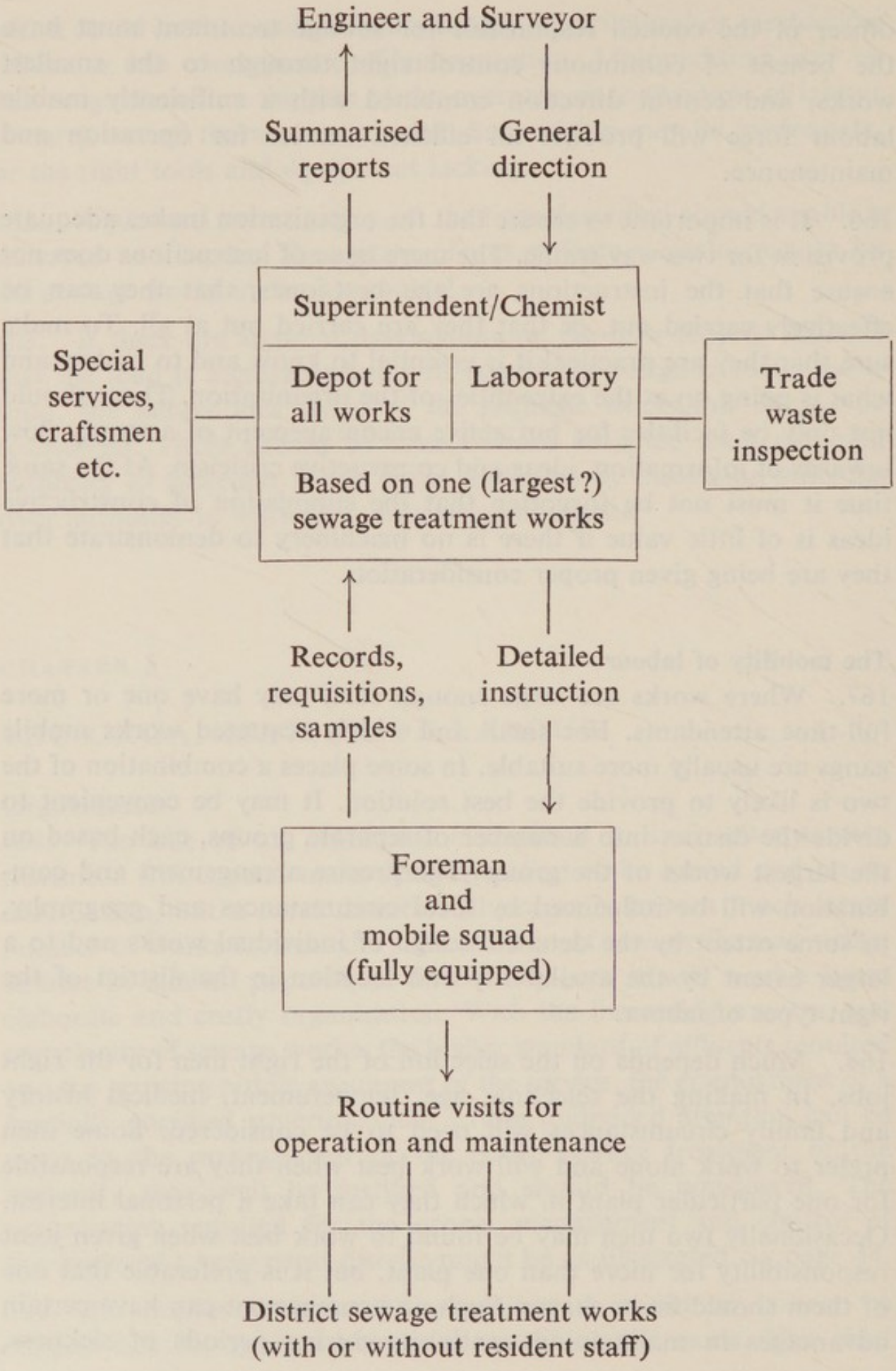
officer of the council responsible for sewage treatment must have the benefit of continuous control right through to the smallest works, and central direction combined with a sufficiently mobile labour force will produce an efficient service for operation and maintenance.

166. It is important to ensure that the organisation makes adequate provision for two-way traffic. The mere issue of instructions does not ensure that the instructions are the best ones, that they can be effectively carried out, or that they are carried out at all. To make sure that they are practical it is essential to know and to understand what is going on at the extremities of the organisation. There should not only be facilities for but active encouragement of a steady flow inwards of information, ideas and constructive criticism. At the same time it must not be forgotten that the submission of constructive ideas is of little value if there is no machinery to demonstrate that they are being given proper consideration.

The mobility of labour

167. Where works are large enough each may have one or more full-time attendants. For small and widely scattered works mobile gangs are usually more suitable. In some places a combination of the two is likely to provide the best solution. It may be convenient to divide the district into a number of separate groups, each based on the largest works of the group. The precise arrangement and combination will be influenced by local circumstances and geography, to some extent by the detailed design of individual works and to a larger extent by the availability and location in the district of the right types of labour.

168. Much depends on the selection of the right men for the right jobs. In making the selection, age, temperament, medical history and family circumstances will need to be considered. Some men prefer to work alone and will work best when they are responsible for one particular plant in which they can take a personal interest. Occasionally two men may be found to work best when given joint responsibility for more than one plant, but it is preferable that one of them should be in charge. Such an arrangement can have certain advantages in maintaining continuity during periods of sickness,


Engineer and Surveyor
Summarised reports
General direction
Superintendent/Chemist
Depot for all works
Laboratory
Based on one (largest?) sewage treatment works
Special services, craftsmen etc.
Trade waste inspection
Records, requisitions, samples
Detailed instruction
Foreman and mobile squad (fully equipped)
Routine visits for operation and maintenance
District sewage treatment works (with or without resident staff)

holidays, etc., or when overtime or week-end work is called for. Others work best as members of a gang and prefer mobility and variety to too regular a routine. Many men, particularly the younger ones, will be looking for promotion prospects.

169. For efficiency, travelling time needs to be kept to a minimum. There are advantages if men can be employed full-time on works near to their homes, but there may be consequent difficulties if opportunities for promotion are to be provided.

CHAPTER 4

WELFARE AND SAFETY

Welfare

170. At every sewage works employing a full-time attendant and every centre where men looking after more than one works are based there should be a permanent building or a room attached to a pump-house or other building but entirely separate from any machinery and free from nuisance. The following should be provided as a minimum:—

(*a*) A plastic-topped table, chairs, cupboard and a waste bucket for messroom use only;
(*b*) Washing facilities, including paper or cloth towels, a roll of butter cloth, soap and a nail brush;
(*c*) A supply of drinking water;
(*d*) Means of lighting and heating the room, boiling water and drying wet clothes;
(*e*) A water closet;
(*f*) A simple first aid kit.

On all works a weatherproof shelter should be provided.

171. Protective clothing should be provided, bearing in mind that outside equipment on a sewage works requires attention particularly during wet and very cold weather. Workmen sometimes prefer boots with nailed leather soles because they are less likely to slip when tanks are being desludged.

172. Basic wage rates and conditions of service are determined by the provincial council for local authorities' manual services. The development of industries during recent years has affected the labour situation in many rural areas and there is a shortage of both skilled and unskilled workers in many places. Local authorities may thus find themselves in competition with industrial undertakings who are able to offer better pay and working conditions, canteens, cheap meals, transport to and from work and welfare facilities including recreation. Nevertheless the efficient operation of sewage works is dependent upon the employment of the right men for the job, and ways must be sought to secure and retain them. Money spent on improving working conditions and amenities will seldom be wasted, and a greater degree of mechanisation, particularly of the less congenial tasks may turn out to be the only practical solution.

173. Bonus schemes can be effective to a limited extent, but need very careful consideration to ensure not only that they are workable but also that in solving one problem they do not create others. To provide long-term inducement to workers one rural district council has for many years operated a grading scheme. All works are divided into three main classes, depending upon their size and complexity, and the wages of the attendants in charge are graded accordingly. To relieve operators during sickness or holidays a suitable labourer is appointed to a Grade III works, and a Grade III operator relieves a Grade II worker and so on. All vacancies are advertised at the council's depot to give the best type of labourer an opportunity of becoming a plant operator and to give the plant operators a chance of promotion.

174. Such a scheme may not be feasible everywhere precisely in this form, but the fact that it has been found effective by one authority may well inspire others to think along similar lines.

Safety measures

175. The safety aspects of both sewerage systems and sewage treatment works have been fully covered in a recent publication, *Safety in Sewers and at Sewage Works*, published by the Institution of Civil Engineers in collaboration with the Ministry of Housing and Local Government (Institution of Civil Engineers, Great George Street,

London, S.W.1, 1963, price 3s. 6d. post free), which should be studied and acted upon by all local authorities.

176. The attention of all concerned must be drawn to the care that is needed when entering confined sumps or inspection chambers, particularly when sewage sludge is present. Such places may be entered regularly for many years without mishap and then one day an unusual combination of circumstances, such as a septic or digesting condition of the sludge coupled with particular weather conditions, will render the air poisonous. Several deaths have been recorded under such conditions.

177. Fire hazards are usually fairly limited on small sewage treatment works, but the local fire service is always willing to make a survey of sewage works and advise on suitable provision of extinguishers and any other desirable precautions.

178. A workmen's accident record book must be readily accessible to all workers and should be inspected regularly by a senior officer.

179. All safety equipment should be inspected regularly to ensure that it is in satisfactory working order, and the men working on the site should not only know where the equipment is kept but be properly instructed and regularly practised in its use. The use of such equipment in unskilled hands may render the consequences of an accident unnecessarily severe.

180. While it is obviously essential that all concerned should know what to do when accidents occur, prevention rather than cure is the policy to pursue. Newly recruited workmen should be properly briefed on accident-prevention procedure before they start work.

181. Some authorities pay a bonus to employees who have qualified in first aid.

CHAPTER 5

ROUTINE MAINTENANCE

Inspection

182. Details of routine operation have already been dealt with in Part One of this handbook and are therefore not repeated here. An

essential part of routine maintenance is an inspection of each unit by the foreman, at regular intervals when it is empty, for structural and other faults which may develop from time to time either from fair wear and tear or through external conditions such as ground subsidence or abnormal weather. The roadways, pathways, fences and any buildings should also be examined from time to time with the object of noting defects for repair. Paintwork should be well maintained throughout the works. The foreman or whoever is responsible for the general maintenance of the works should keep under constant review a job list of work waiting to be done.

Service

183. Mechanical and electrical equipment must be kept in safe condition and good working order, and should be serviced regularly. An authority which does not employ a fitter can usually come to an arrangement with a local engineering firm or even a well equipped garage to carry out mechanical maintenance and repairs. Similarly a local electrical engineering firm or the local electricity board can usually carry out electrical servicing and maintenance. Local firms will usually provide a 24-hour service, which can be most valuable in an emergency.

184. At least one of the companies manufacturing sewage works machinery now offers a service contract under which its equipment will be inspected and overhauled at regular intervals anywhere in the country. Insurance companies will usually be willing to arrange for the regular inspection of mechanical and electrical equipment and to report on the general condition and any defects requiring attention. Contract work and outside inspection should not be regarded as a substitute for proper maintenance by the council's staff but treated as supplementary.

185. An inspection routine should be established for all pumping stations to ensure that the automatic controls and the pumping gear are operating properly. When pumping stations are brought into service care should be taken to ensure by trial if need be, that the automatic controls are set to the optimum positions for the particular flow conditions. If there is any long-term change in the volume, rate

or time characteristics of the flows the automatic controls should be adjusted accordingly.

Information

186. Most of the manufacturers of pumps and sewage works machinery provide comprehensive instructions in various forms regarding the construction and maintenance of their plant. Many of the information sheets supplied are not to be found on the sewage works either because of their impermanent form or because they are retained in the council's offices. While it is useful to keep copies of information sheets in the office those covering the equipment on each works or pumping station must be made available at the site. Where the instructions are on ordinary paper their life under working conditions is likely to be brief and the paper should be mounted on a card and varnished or covered with a transparent plastic sheet. Some of the instructions are provided so mounted, and at least one manufacturer issues information on a large enamelled metal sheet which is not only permanent but too bulky to be easily lost and impossible to hide in an office file.

187. At every sewage works there should be an *up-to-date* layout plan of the works on which the line of every pipe and cable and the location of every valve are clearly marked. The plan should be framed behind glass or mounted on card, varnished or otherwise protected, and displayed where its absence will soon be noticed. It is worth while numbering or lettering each valve on the plan and painting the number on or near the actual valve. Such a diagram is particularly valuable whenever there is a change of attendant.

Communication

188. Communication with mobile gangs is often difficult and it may take a long time to get in touch with them in an emergency. At most works with a full-time attendant, provision of a telephone is justified, but whether telephones should be installed at works which are visited only at intervals must be a matter for local decision. Telephones can be most useful in maintaining contact with mobile gangs, particularly if such gangs and any men looking after more than one works adhere to a fairly regular programme. The use of radio communication, which has been widely adopted by water undertakings, might

be considered. A visual-aid board at the central depot indicating the proposed programme of work for the day and the timetable for visits to the smaller works will also make communication simpler.

Equipment

189. To be efficient, mobile gangs must be provided with adequate equipment. The vehicle they use is a matter of preference but it is most important to select one really suitable for the job. Experience has shown that a Land Rover type of vehicle towing a fully equipped trailer van makes possible considerable flexibility in the deployment of personnel and equipment. As well as the tools and equipment necessary for routine work, the driver carries first aid kit, simple canteen facilities and protective clothing. If necessary a gang can be split by leaving the trailer and two or three men at one works while the remainder with the towing vehicle proceed to inspect other works or investigate reported breakdowns or other difficulties.

190. Agricultural tractors are extremely versatile, and a tractor with such equipment as a mowing bar, hydraulic tipping trailer, loading shovel, scraper blades, power arm and ditcher can carry out a wide range of jobs on more than one sewage works and save considerable manual labour. Surface grinder and chipping hammer attachments are also available and are useful for levelling uneven weirs round settling and humus tanks.

191. All small sewage works, even if visited only at intervals, should have a substantial building where tools, lubricants, etc. can be kept and a portable pump or barrow stored if necessary.

192. As far as possible the equipment and plant of the various sewage treatment works should be standardised to facilitate repair work and interchangeability, and also to reduce the number of spare parts carried.

CHAPTER 6

RECORDS AND COSTING

Records

193. Because there will not be a resident operator at most small works the records that can be kept will not be as full or elaborate

as those at larger works. It is, however, most important to ensure that certain essential records and reports are maintained. How much detail is recorded is a matter for local decision.

194. As an absolute minimum a diary should be kept at each works, however small, together with a log sheet. The diary, retained on the works, should contain a reference to all happenings affecting the works; the log sheet will record the actual work carried out as (*a*) routine and (*b*) unusual, i.e. occasioned by accident, breakdown or other conditions, and will be forwarded to the head office. Records should also be kept of repairs required to buildings, treatment unit etc. Requisitions for stores, spare parts and repairs to the mechanicas and electrical equipment can be made in a book in which carbonl copies are retained.

195. Where the flow is metered the integrator should be read at the same time each day and the readings and total daily flow recorded and entered on the log sheet. The electricity consumption should also be recorded.

196. However record sheets are made out they must be kept by or given to the foreman for handing in, with his comments, to the superintendent in charge of all the works. The original records should be filed and a regular summarised report submitted to the surveyor at say monthly intervals.

197. The analyses of effluents are usually supplied on individual sheets. If the figures for each works are tabulated, comparison of successive results is easier. Weekly or monthly flows and electricity consumptions, together with maximum figures for the period, should also be kept in tabular form.

198. From these records an efficient routine for the operating personnel can be planned, and estimates for operation and maintenance made with reasonable accuracy. They also ensure that the surveyor is at all times in possession of an up-to-date and comprehensive picture showing the condition and performance of the sewage treatment works under his control.

Costing

199. Some form of costing is worth while even for the smallest authorities, but how comprehensive it is must be a matter for local decision.

200. It is useful to keep a record of repairs and maintenance for each of the items of mechanical equipment on the various works and their cost.

201. Records of costing involve labour and expense, and they should not be kept unless they will be used. At least annually the surveyor or a responsible assistant should make a careful study and prepare a brief report on the cost records for incorporation in the annual report.

202. Regular study and analysis of costs may show certain works and certain types of mechanical equipment to be more economical to run and maintain. This information is most useful when designing further works and will also indicate when and where it is desirable to invest in new plant to reduce labour costs. Costing is invaluable when trade waste charges have to be assessed.

Annual report

203. The preparation of an annual report summarising the records for each works and the situation generally is well worth while. It helps to assess future maintenance requirements, warns of possible extensions that may be required, and keeps the elected representatives informed.

204. It is not easy to detect trends by inspecting a column of figures, but a simple annual graph of weekly or monthly averages or totals of flows and electricity consumed can make changes or extremes more obvious. Seasonal variations sometimes obscure long-term trends, and the use of graphs of moving annual averages covering several years can be enlightening.

CHAPTER 7

TRADE EFFLUENTS AND CESSPOOL CONTENTS

The acceptance of trade wastes

205. Separate purification of a trade waste, at the factory where it is produced, to the standard required for discharge to a watercourse is

almost invariably more difficult and more expensive than its treatment in admixture with domestic sewage at the local sewage works. It is in the general interest of the community that trade wastes should be received into the local authority's sewers, provided there are proper safeguards. The trader has a legal right of access to the sewer subject to adequate control of the quantity and quality of the discharge and to such reasonable charge as the council may think fit to make.

Reasons for control

206. Control of trade effluents entering a sewage system is necessary for the following reasons:—

(*a*) to protect sewers from corrosion or erosion of joints, pipes and benchings, from build-up of deposits, from flow surcharges, and from formation of explosive or poisonous vapours and gases;

(*b*) to keep poisonous and polluting matter to safe levels when discharged from storm relief overflows as well as from final effluent outfalls;

(*c*) to protect sewage treatment works from overloading (whether hydraulic or biochemical) and from substances likely to prejudice treatment processes or sludge disposal;

(*d*) to apportion the cost of treatment attributable to each trade effluent.

207. Trade wastes are of growing importance in the treatment of sewage by rural authorities. In some instances the discharge of a single trade waste may represent such a large proportion of the total load on the sewage works as to give rise to serious treatment problems, more difficult than may be encountered at larger works treating a mixture of wastes. Before accepting new industry local authorities ought always to be aware of the expense and consequences involved in treating any liquid wastes that may be produced. A simple and informative mode of expressing the load due to a trade waste is in terms of its "population equivalent".

Statutory powers

208. Statutory powers are fundamental to proper control. They are spread over three Acts of Parliament, namely: the Public Health Act,

1936, Part II, the Public Health (Drainage of Trade Premises) Act, 1937, and the Public Health Act, 1961. The later Acts partly amend the earlier ones, so a careful study of the legislation is necessary, to ensure that each trade waste is properly controlled and nothing is discharged to the sewers that is likely to cause any damage to the sewers or works, constitute a hazard to workmen or prove impossible to treat.

209. Briefly, if anyone wishes to discharge a trade waste to a sewer he must notify the local authority, who may lay down conditions covering its nature and composition, volume, rate of flow and temperature, and may stipulate a suitable charge. If a discharge is already being received into the sewers and a trader wishes to alter its composition or increase its volume, the further consent of the local authority is required. If the trader considers any of the local authority's requirements to be unreasonable, he can appeal to the Minister of Housing and Local Government.

210. Certain trade discharges which were taking place before 1937 were until recently exempt from all conditions, but under the 1961 Act the local authority may now make a charge for all trade wastes, including those previously exempted. What charge is made is a matter of policy, which should not be decided until proper costs have been prepared and the full technical and financial aspects have been considered.

211. Under section 63 of the 1961 Act, effluents from farms and horticultural holdings are defined as trade wastes and there is no longer any doubt on this point. The treatment of farm waste often presents special problems.

212. The discharge from laundries is normally exempt from control but, under section 65 of the 1961 Act, if a local authority has adequate grounds application may be made to the Minister for the withdrawal of the exemption.

Conditions of acceptance

213. A local authority may issue a consent to a discharger or alternatively enter into an agreement with him, but should not do so until reliable information on the composition, volume and rate of

flow of the discharge has been obtained. Consents are sometimes simpler but agreements can be more flexible and cover matters which cannot be included in a consent. Where agreements are made they should provide for revision or determination after due notice.

214. In formulating conditions the considerations in paragraph 206(*a*), (*b*) and (*c*) must always be borne in mind. Some authorities restrict the strength of the waste to that of domestic sewage, while others are prepared to accept waste of any strength provided it can be treated and the cost of doing so is met by the trader.

215. In order to ensure a consistently satisfactory effluent, sewage works must be capable of coping with the maximum strength and flow reaching them. Peak loads may be caused by sudden discharges or regular, heavy flushes of trade waste. If these can be reduced by spreading the load or flow, or by storage and mixing of the waste before discharge, the capital cost of the treatment capacity can be reduced, often substantially. It may be possible for a large discharge free from injurious matter to take place during the night when the main domestic flow is at a minimum. The discharge of waste containing toxic materials, however, should be restricted to the daytime, when there is the maximum dilution with domestic sewage and, moreover, when its effects are under observation.

216. Practical steps that can be taken by a discharger to reduce the volume and strength of the waste include: better housekeeping such as keeping a close check on materials issued and what is done with spoilt batches; keeping usable by-products separate from drainage; thoroughly draining vessels and products before washing (particularly in food and metal-finishing trades); dry sweeping benches and floors before washing down; trigger valves on hoses; counter-current washing whereby comparatively clean rinsing water is used again; recovering solid matter by mechanical screening, preliminary sedimentation or centrifuging. Clean cooling water and condensate can often be used again or, subject to the approval of the river authority, diverted to surface-water drains.

217. The negotiation of terms for the acceptance of trade waste that will safeguard the interests of both parties is by no means easy, particularly if the trade waste is a complex mixture resulting from a number of processes and containing substances that interfere with

treatment. The small local authority should never enter into negotiations on the acceptance of trade waste without specialist advice. If there is a larger sewage treatment authority in the district its technical staff will frequently be willing to give advice. In the absence of such help the service of a specialist consultant should always be obtained.

218. When a consent has been issued or an agreement completed, periodic samples should be taken to check that the strength and composition of the waste are within the limits laid down.

219. The installation of a meter or recorder is not usually required except in the case of the more important discharges. It is generally possible to arrive at a figure for the volume discharged by reference to the water supply records.

Farm drainage

220. The trade waste most likely to be encountered in a rural district is farm drainage. This is often strong and its strength and volume are likely to vary widely according to types of animal, methods of housing and manure conservation, access of rainwater and cooling water, and seasonal activities. Provision should be made in the sewers and sewage treatment plant for peak conditions, and it is the cost of such provision, particularly of filter capacity, that largely determines the trade effluent charge. The drainage from cowsheds and piggeries and effluents draining from silos and pea-vining residues can all be many times stronger than domestic sewage and difficult to treat. Wash water from dairies is somewhat stronger than domestic sewage but can usually be treated without much difficulty. In general it may be said that the difficulties in treating sewage increase as the proportion of farm waste becomes greater. Some useful data and advice on farm drainage are given in the "Notes on Water Pollution" obtainable free from the Water Pollution Research Laboratory, Elder Way, Stevenage, Herts. To date the following have been issued: No. 17, entitled *Waste Waters from Farms*, and No. 24, entitled *Some Further Observations on Waste Waters from Farms*. Literature and advice are also available from the Advisory Services of the Ministry of Agriculture, Fisheries and Food.

221. It is advisable for all farm wastes to pass through a large catch-pit because straw and debris unless retained can be troublesome

in the sewers, ejectors and pumping stations, and at sewage works. The catch-pit needs to be cleaned out regularly.

222. It is now generally recognised that farm wastes should be returned to the land either by absorption in litter and spreading or by organic irrigation. It is usually cheaper to return farm waste to the land than for it to be treated at a sewage works. Both the farmer and the local authority should be fully informed of the true cost of treatment of the waste at the sewage works before any decision is reached by either party. It should not be thought imperative to admit farm effluent to a sewer as a matter of course. It may be necessary to do so if the effluent cannot be disposed of economically otherwise or is likely to cause nuisance or water pollution if returned to the land but in either case the farmer must be prepared to make reasonable payment.

Other trade wastes

223. Other wastes which may occur in rural districts are those from milk processing, slaughter-houses, poultry packing, food packing, maltings, breweries, tanneries and similar trades connected with agriculture. Such wastes can usually be treated if sufficient capacity is provided at the sewage works. Occasionally small engineering firms are located in rural areas. Should they discharge any plating wastes to the sewers strict control is needed to prevent the discharge of excessive amounts of the toxic chemicals used.

Cesspool contents

224. Compared with ordinary sewage, cesspool contents are strong, have a heavy suspended solids content, and are usually "septic", i.e. rich in anaerobic bacteria and their toxic by-products. They may seriously retard the purification of other sewage if they are admitted to sewage treatment works intermittently and in relatively large quantities.

225. Cesspool contents should never be emptied into the sewers draining to a small treatment works, because the heavy flush of strong septic waste can have a disastrous effect. They should be discharged into specially constructed tanks at the sewage works and the top liquor decanted off to the works inlet at a controlled rate,

preferably diluted with about an equal volume of final effluent. The sludge settled out can be transferred directly to the drying beds. At some works it has been found that a volume of cesspool sewage up to 15 per cent of the sewage flow can be dealt with in this way without difficulty, subject, of course, to the provision of appropriate tank, filter and drying bed capacity. There may, however, be a tendency for the final effluent to suffer discoloration. Alternatively cesspool contents may be discharged into some form of under-drained sludge drying bed or shallow lagoon, and again care should be taken that the rate at which the liquor draining away is returned to the head of the treatment works ensures ample dilution with fresh sewage. When siting tanks and lagoons the inevitable smell should be borne in mind.

CHAPTER 8

MODIFICATION AND EXTENSION OF EXISTING WORKS

226. Modifications, improvements and extensions become necessary from time to time—for the improvement of plant performance and reliability, to cater for increasing load, to meet a demand for higher effluent standards, to facilitate improvements in operating procedure, to eliminate or reduce the number or frequency of uncongenial tasks for the operator and to save man-power.

227. What measures are needed will emerge from continued study of the efficiency of the service as a whole as well as of the recorded performance of the individual items of plant and of the operational staff. In this chapter, consideration is given to the ways in which existing works may be capable of modification to achieve progressive improvement in overall efficiency.

Modifications to improve plant performance

228. Where a pump is installed for the return of humus sludge etc. to the inlet of the works, it is worth considering its use for returning final effluent to maintain the flow through the the percolating filters during off-peak periods. Such an arrangement can be a useful

measure to reduce ponding of the filters or to maintain the distributors in continuous operation and, so prevent freezing during cold weather. Care should be taken not to increase the rate of flow to a level at which the storm overflows operate.

229. Experience has shown that slower rotation of distributor arms will help to keep a filter clean. Slowing down may be achieved by reversing or turning downwards one or two arms. The improvement is believed to be a combined effect of scouring, starvation of filter life between doses and drawing down of air. Mechanical devices are now available which can be fitted to existing distributor arms to reduce and control the rate of rotation of the distributor. Simple electrical drives can also be used for the same purpose.

230. The provision of an additional stage of treatment after the humus tanks in order to "polish" the effluent is often worth while as it also provides a buffer between the works and the river in the event of any mishap. Where the fall and site permit, the use of grassland for surface irrigation is a simple and very effective measure. Dosage will vary widely according to quality of effluent and the nature and extent of the land available, a possible range being 50,000 to 150,000 gallons per day per acre in use. The land should be divided into two or more plots to make alternation possible, and the humus tank effluent distributed from earth or concrete channels with hand stops, the final effluent being collected in similar channels on the other side of the plot. A gradient of about 1 in 100 over the site is ideal; steeper falls cause too great a surface velocity. Special seeding is not necessary, nor is any under-drainage required.

231. If the available area is limited, simple sand filters can be constructed in pairs. The ground should be excavated to a depth of about 9 inches and rows of 3-inch loose-jointed drainpipes laid in a bed of broken stone to a common outlet. Over the broken stone a layer of coarse washed pit sand about 4 inches in thickness should be spread. The effluent from the humus tank is allowed to run on to one of the filters so as to percolate through the sand into the drains. After a time a layer of humus forms on the sand. When this happens the flow is diverted to the other filter. In a few days the humus will have dried sufficiently to be raked off, and the filter is then re-sanded ready for re-use.

232. Another means of additional treatment that has sometimes been effective, particularly where the removal of humus is difficult, is passing the effluent through lagoons. These may consist of existing hollows or disused gravel pits or may be formed by excavating shallow depressions. Even ditches of sufficient width to give a low velocity (not more than 1 foot per minute at peak flow) may be used. This treatment will improve effluent quality by surface aeration and the deposition of humus solids. Maintenance is, however, sometimes difficult and humus sludge may ferment and rise. Baffling of the outlet may be necessary and duplication of the lagoons is desirable. Grassland irrigation has generally been found to be a better use of a given area than lagoons.

233. There is an increasing tendency for a tertiary stage of treatment to be required but the need for it may not materialise until the works has been in operation for some time. If spare head is available through a works it is prudent at the design stage to leave this head between the humus tank weirs and the final outfall. Such a precaution may well save the cost of pumping in perpetuity.

234. The methods of tertiary treatment described should not be used to replace humus tanks except on very small plants, nor should they be employed to remedy deficiencies of treatment in the previous stages, save as a purely temporary expedient. Accumulated humus is easier to remove from a proper settling tank than from sand filters, grass plots or lagoons.

235. The commonest single cause of unsatisfactory effluents is excessive suspended matter arising from inability to desludge tanks regularly because of inadequate sludge drying area. After the relatively short initial drainage of water from the sludge the remainder of the drying takes place by evaporation and is considerably influenced by the wind. Anything which can be done to increase the wind circulation above the sludge will enhance the rate of drying. The walls of the drying beds should be no higher than is necessary and some existing walls may with advantage be lowered. Any shrubs or bushes round the beds which are likely to shield them from the wind should be removed if this can be done without spoiling local amenities.

236. The provision of simple storage lagoons or tanks for wet

sludge can materially alleviate drying troubles. The lagoons or tanks can be built with earth banks and the interior lined with concrete paving slabs. A chamber for dewatering at the various levels should be installed. A capacity of 5 or 6 cubic feet per head of population is desirable but even a limited capacity of 1 or 2 cubic feet per head is useful. Such tanks permit removal of water before the sludge is run on to the beds and enables the operator to fill a bed in a single discharge. Valuable storage capacity may be made available for the winter months if the level in the tank is run down during the summer.

237. If arrangements are made to pump sludge back from the outlet end of the sludge storage tank to mix with the raw sludge as it is being fed into the tank a useful measure of digestion may occur during the warmer summer months.

238. The use of portable engine driven conveyors which can be transported from one works to another has been found to make sludge lifting easier and cheaper.

239. There is a growing volume of complaints about unpleasant smells from sewage works. The smells almost invariably come from the sludge on the drying beds. Temporary remedies are rarely satisfactory. Deodorants tend to be localised and uncertain in their effect, and in any case are in the nature of palliatives rather than cures. At some works a light dressing of sodium nitrate (supplied as a fertiliser) or of nitro-chalk over the sludge has been found to reduce the smell for a week or two.

240. Sludge which has been properly digested is quite free from objectionable odour, but it is difficult if not impossible to ensure an adequate degree of digestion throughout the year without some form of applied heat. On some sewage works, serving populations as small as 5,000, it has been found worth while to apply heat to "cold digesters" by using purchased solid or liquid fuel rather than by attempting the collection and use of sludge gas. In addition to eliminating smell nuisance, full digestion of the sludge reduces the dry solid matter by as much as one-third and the remainder dries out more readily than raw sludge. Heated digestion is coming to be regarded as justified for much smaller works than it has been in the past.

Modifications to assist the operator

241. If sewage works are kept up to date by the installation of proved mechanical and other aids and developments, it is possible both to eliminate or reduce some of the less pleasant chores and improve capacity and efficiency.

242. The extent to which screening of raw sewage is necessary depends upon local circumstances and the characteristics of the local sewage. There is scope for local experiment aimed at determining the widest screen bar spacing that will afford a reliable degree of protection to the subsequent treatment processes. It may be found that coarser screening is sufficiently effective for this purpose, resulting in less frequent raking of screens and in a smaller volume of screenings to be removed and disposed of.

243. The installation of fine screens immediately preceding the filter distributors will materially reduce the choking of the sparge holes in the distributor arms, resulting in more efficient distributor performance and longer periods between cleaning and flushing.

244. Grit resulting from the breakdown of media is frequently present in the filter effluent and can be troublesome when humus tanks are desludged. The difficulties can be overcome by the interpolation of a sump, to act as a grit chamber, between the filters and the humus tanks.

245. Centralisation of sludge treatment and disposal is worth considering as a means of making the best use of labour and plant. It has been found to be economical even when the wet sludge has to be transported distances of six miles or more.

246. In many areas it has proved possible to dispose of liquid digested sludge by tanker or gully emptier directly on to farmland. This practice has much to commend it. In rural areas, where haulage distances will usually be small, the cost is almost certain to be less than the expense of lifting the sludge from drying beds. If only a portion of the sludge can be disposed of in this way, preference should certainly be given to humus sludge, which is much more difficult to dry than primary sludge and is less objectionable. If arrangements are made to enable dried sludge to be loaded directly from the drying beds into farm vehicles a substantial saving in labour is effected.

247. Horticulturists and gardeners are often unwilling to use sewage sludge because it is in large coherent lumps and also looks unsightly when applied. If sludge from the drying beds is stacked under cover and turned occasionally it will soon dry sufficiently to permit it to be broken up satisfactorily in one of the small portable shredders which are marketed. In a shredded condition it proves quite acceptable to gardeners. Some authorities have packed finely divided sludge in polythene or paper bags holding about 28 lbs., which can be easily carried in the boot of a car, and have made a small charge for it. With persistent local publicity the sales of such sludge have been built up until a substantial proportion of the total sludge produced is disposed of in this way with little or no extra cost.

248. Even on a small works, capital expenditure on mechanisation as a means of saving labour is worth while, bearing in mind that an expenditure of perhaps £10,000 is justified in order to save the annual cost of one man. Manufacturers are developing labour-saving machinery for smaller works. Simple mechanical scraping gear is now available which can be fitted to existing horizontal flow settling tanks, often without extensive alteration or reconstruction.

Design considerations

249. The layout and design of modifications or extensions to existing works are usually dependent on the arrangement of the existing units. However, the following suggestions may be helpful to keep in mind when the need arises for the provision of new works.

250. In designing a small sewage treatment works, simplicity, robustness and ease of maintenance and operation are of the utmost importance. In general the smaller the works the lighter should be the design loading compared with the works serving large populations and supervised by highly skilled full-time staff.

251. The area of the works should be kept to a minimum without overlooking the possibility of future extensions. If additional land is acquired to meet future requirements it may be possible to avoid maintenance costs by fencing off and letting it on a 364 day or a licence basis. If this is not feasible, spare land should be laid out and levelled off so that it can be kept tidy by simple and easy mowing. While keeping in mind the possible need for extensions, the designer

should avoid unnecessarily wide spacing between units, which leads to additional maintenance and unnecessary walking by the attendants. All that is required is room for paths, access roads and pipes. Contours of the ground have in the past often fixed the sites of various units, but in these days of mechanical earth moving it is comparatively cheap to change contours.

252. On small works labour is usually limited, and particular care should be taken in the design and layout to render routine work as simple as possible. Channels should be designed for easy cleaning, and they should be of sufficient width for the attendant to brush them without difficulty. Valves and penstocks should be easy to get at. Where tanks are desludged under hydrostatic head the attendant should be able to see what is issuing from the draw-off pipe while he is manipulating the valve. Where valves are buried they should be in precast concrete chambers so that access is easy in the event of any trouble; this is particularly important in made-up ground. Dosing siphons require regular maintenance: they can sometimes be omitted altogether if a suitable type of distributor is used. Fibreglass distributor arms are now available and it is claimed that these need little or no attention: they may be borne in mind when distributor arms require replacement.

253. It is not possible to apportion very small flows, particularly of crude sewage, between two or more units with any accuracy. For smaller sewage works, single tanks and filters should therefore be employed.

The need may arise to enlarge a works having a septic tank. Experiments have shown that the additional capacity is best provided by another tank in series rather than in parallel.

CHAPTER 9

THE TEMPORARY RELIEF OF THE OVERLOADED SEWAGE WORKS

The problem

254. Having carried out a planned investigation on the lines suggested in paragraph 130, the surveyor will know which of his

works are overloaded and to what extent and also which are likely to be overloaded in the foreseeable future. The design of the new works must be formulated and the necessary consents and sanctions obtained before construction can begin with the result that the extension of the plant to meet existing and future flows may take a considerable time to bring to completion. New schemes may also be needed for unsewered villages and the work may have to be programmed over several years.

255. The surveyor may therefore be faced with the task of operating and maintaining one or more sewage works under overloaded conditions for a long time and should consider what can be done to afford some measure of relief.

256. The temptation to by-pass part of the flow to the river, either directly or through the storm tanks, should be resisted. It is generally less harmful to the river to give the whole of the sewage flow partial treatment than to treat fully only a portion of it: a poor final effluent is preferable to a good effluent accompanied by a discharge of crude or settled sewage.

Expedients and improvisation

257. When major reconstruction is pending, capital expenditure must be kept down, and methods with high running costs then become acceptable as temporary expedients if they achieve better results. Paying overtime for carrying out operations at off-peak periods, using extra fuel or electricity for recirculation of effluent, and using chemical coagulents or sludge conditioners are typical expedients under overload conditions.

258. It may sometimes be feasible to carry out some work that will improve the performance of the plant in advance of the main scheme. For example, recirculation of final effluent, controlled distribution to the filters or additional drying beds may afford immediate relief.

259. If additional settling tank capacity can be improvised, it can be beneficial by balancing peak loads and so keeping the filters and humus tanks working steadily instead of being alternately overloaded and idle. Balancing is especially beneficial if it can be used to operate the filters during the night; a control valve is needed, preferably with a floating-arm draw-off if the scheme is gravitational, and it may be

necessary to build up the sides of a tank with concrete blocks in order to give some freeboard for heading up. Sometimes the rehabilitation of abandoned settling tanks is worth considering. Alternatively storm tanks may be used irrespective of rainfall. If this is done it is desirable that in all states of the weather as much as possible of the tank effluent should pass on for full treatment and anything in excess should be passed over land.

260. The use of coagulants such as Aluminoferric can reduce primary settlement by half, thus doubling the effective capacity of settling tanks. The coagulant is usually applied by placing slabs of it in the feed channel between grit chamber and settling tank, and the most economical method is to use it mainly for peak flows. It must not be overlooked that the use of coagulants will increase the quantity of sludge to be dried and disposed of.

261. Recirculation of filter effluent is an established method of increasing the purification obtained per unit of filter bed material and is particularly valuable as a temporary remedy when filters are overloaded and ponding. It is often possible to use an existing pump for this purpose by simple modifications or additions to the pipe work. Frequently a humus sludge pump or a storm water pump can be employed. Failing such an arrangement a pump can be installed with the temporarily requisite pipe work laid on the surface of the ground.

262. Even if recirculation can be practised for a limited period of the day, or even at night only, it is still well worth while. It is not essential for the recirculated effluent to be settled, and if it is drawn from the inlet side of the humus tanks there will be no increase in the velocity of flow through the tanks. The delivery should be to the outlet side of the settling tanks, or to the dosing chamber, again to avoid any increased velocity in the tanks. It may be necessary to cease recirculation during storms. Where the problem is sewage that is too strong rather than too voluminous it is sometimes possible to leave the humus sludge draw-off valve open slightly so that effluent passes into the pumping sump and is returned to dilute incoming sewage at the works inlet.

263. Enlargement of sparge holes may be necessary to enable filter distributors to pass their increased flows. If the jets are spaced

equally along the arms, graduation of the orifice diameters must be maintained, otherwise the centre of the filter will receive too much and the perimeter too little. Where jets are bushed, the makers may be able to supply sets of larger bushes.

264. Ponding of filters hinders passage of both liquid and air, and thus greatly impairs efficiency. Where the material is soft, forking over must be approached with caution. Filter effluent recirculated to the beds has a cleansing effect. Surface dressings for clearing excess accumulations of film include tropical bleach (stabilised chloride of lime), crushed aluminium sulphate (as Aluminoferric or the 14-hydrate) and sodium nitrate which is probably the best. Dosage in each case should be about 4 ounces per square yard, evenly applied and allowed to work in; heavier dressings are wasteful and may kill living organisms in the filter and in the receiving watercourse. One filter, or a section of a filter, should be treated each day in succession in order to prevent any appreciable concentration of the chemicals appearing in the effluent. It is advisable to consult the river authority before carrying out such treatment.

265. Irrigation of sub-standard effluent over grassland in the manner referred to in paragraph 230 will improve effluent quality, as will passage through some form of lagoons as described in paragraph 232. As a temporary measure the rates of application referred to in paragraph 230 may be exceeded by a considerable margin and still provide a useful improvement for a time.

266. Where sludge drying beds are insufficient, aluminium chlorohydrate is a useful expedient for conditioning the sludge, for it will reduce drying time to about half and so facilitate a quicker turnround. The suppliers will indicate dosage according to the nature of the sludge.

267. Earth lagoons can provide standby capacity for sludge in wet weather, being dried out and cleared as soon as the weather permits.

268. Disposal of sludge by spreading on farm land from a tank lorry can relieve an acute situation; frosty weather sometimes gives the opportunity for this, even in a wet winter.

269. Mechanical aids to sludge lifting reduce the time taken in getting beds cleared and so quicken the turn-round. If sludge can

be got rid of, the efficient operation of settling tanks is greatly helped.

270. By various means the performance of an overloaded works can often be maintained at a surprisingly good level, but it calls for ingenuity on the part of the surveyor and usually involves increased operating costs. Where such arrangements are temporary they should be treated as such and not regarded as a substitute for permanent extensions.

FIELD TEST FOR PERMANGANATE VALUE

This field test was devised by the Water Pollution Research Laboratory for use by unskilled sewage works attendants in testing effluents from sewage disposal works remote from laboratory facilities. It provides a rough estimate of the permanganate value and the result is classified into one of four groups, indicating the effluent quality. The test can be carried out with ordinary laboratory equipment comprising:—

Sample bottle (8 oz. glass stoppered), labelled "Sample". Additional bottles may be provided if desired.

Permanganate bottle (6 oz. glass stoppered) containing N/80 potassium permanganate solution and labelled "Permanganate".

Acid bottle (4 oz. glass stoppered) containing 25 per cent. sulphuric acid and labelled "Acid".

Test cylinders, about 25 cm. long and 33 mm. diameter with a graduation ring at 50 ml. (class B) with sandblasted patch for numbering 0, 1, 2, 3.

Pipette about 20 cm. long and 10 mm. diameter with graduations at 2 ml., 4 ml., and 6 ml. from the tip, labelled "1", "2", and "3" respectively, generally in the form of a straight type graduated blow-out pipette but having a small safety bulb below the mouthpiece and labelled "Permanganate measure".

Pipette, dip type, 2 ml. with the bulb close to the tip and with graduation mark not more than 7 cm. from the tip, labelled "Acid measure".

Stirring rod 17·5 cm. long made from stout glass tube sealed at both ends having a bulb about 2 cm. in diameter at one end.

Test tube brush.

The equipment can be kept in a suitable box with a handle or carrying strap. At least one firm of laboratory furnishers provides a ready made kit in a box complete with a copper sampling can.

To make the test the bottles should be removed from the box and the sample bottle should be filled with effluent, using a sampling can. Each of the test cylinders should be filled to the mark with effluent from the sample bottle. One measure of acid should then be added

to each tube followed by a measure of permanganate correspondi to the number of the tube. When adding acid or permanganate a tube it should be removed from the rack and held in the han After the contents of the tubes have been mixed by gently movi the stirrer up and down in the tubes, starting with tube number they should be allowed to stand for 30 minutes and the colour the tubes noted on the report form as N (no colour) or C (coloured the absence of any trace of pink is taken as no colour even thou the liquid might be slightly brownish. At the end of the test t sampler, cylinders, sample bottle and measures should be wash thoroughly with clean water and wiped on the outside. The cylind should be replaced upside down in the rack. The approximate ran within which the permanganate value lies can be deduced from t table below.

Interpretation of test results

(temperature range 0–20°C.)

No. of last cylinder in which the liquid was colourless after 30 minutes	Estimated range of permanganate value (parts per million)	Character of effluent
0	0–12·5	Very good
1	10·5–23	Good to satisfactor
2	20·5–34·5	Unsatisfactory
3	More than 31·5	Very unsatisfactor

The results should be recorded as "Field Test Permangan Range....." giving the figures obtained from column 2 of table.

Printed or duplicated report forms will be found useful.

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