

Quantitative Samplers for Benthic Macroinvertebrates in Shallow Flowing Waters 1980

Methods for the Examination of Waters and Associated Materials



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This booklet describes two types of sampler, rectangular and cylindrical.

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Warning to users

The analytical procedures given in this booklet should only be carried out by competent trained persons, with adequate supervision when necessary. Local Safety Regulations must be observed. Laboratory procedures should be carried out only in properly equipped laboratories. Field operations should be conducted with due regard to possible local hazards, and portable safety equipment should be carried. Care should be taken against creating hazards. Lone working, whether in the laboratory or field, should be discouraged. Reagents of adequate purity must be used, along with properly maintained apparatus and equipment of correct specification. Specifications for reagents, apparatus and equipment are given in manufacturers' catalogues and various published standards. If contamination is suspected, reagent purity should be checked before use.

There are numerous handbooks on first aid and laboratory safety. Among such publications are: 'Code of Practice for Chemical Laboratories' and 'Hazards in the Chemical Laboratory' issued by the Royal Society of Chemistry, London; 'Safety in Biological Laboratories' (Editors Hartree and Booth), Biochemical Society Special Publication No 5, The Biochemical Society, London, which includes biological hazards; and 'The Prevention of Laboratory Acquired Infection,' Public Health Laboratory Service Monograph 6, HMSO, London.

Where the Committee have considered that a special unusual hazard exists, attention has been drawn to this in the text so that additional care might be taken beyond that which should be exercised at all times

when carrying out analytical procedures. It cannot be too strongly emphasised that prompt first aid, decontamination, or administration of the correct antidote can save life; but that incorrect treatment can make matters worse. It is suggested that both supervisors and operators be familiar with emergency procedures before starting even a slightly hazardous operation, and that doctors consulted after any accident involving chemical contamination, ingestion, or inhalation, be made familiar with the chemical nature of the injury, as some chemical injuries require specialist treatment not normally encountered by most doctors. Similar warning should be given if a biological or radio-chemical injury is suspected. Some very unusual parasites, viruses and other micro-organisms are occasionally encountered in samples and when sampling in the field. In the latter case, all equipment including footwear should be disinfected by appropriate methods if contamination is suspected.

The best safeguard is a thorough consideration of hazards and the consequent safety precautions and remedies well in advance. Without intending to give a complete checklist, points that experience has shown are often forgotten include: laboratory tidiness, stray radiation leaks (including ultra violet), use of correct protective clothing and goggles, removal of toxic fumes and wastes, containment in the event of breakage, access to taps, escape routes, and the accessibility of the correct and properly maintained first-aid, fire-fighting, and rescue equipment. If in doubt, it is safer to assume that the hazard may exist and take reasonable precautions, rather than to assume that no hazard exists until proved otherwise.

About this series

This booklet is part of a series intended to provide recommended methods for the determination of water quality. In addition, the series contains short reviews of the more important analytical techniques of interest to the water and sewage industries. In the past, the Department of the Environment and its predecessors, in collaboration with various learned societies, has issued volumes of methods for the analysis of water and sewage culminating in 'Analysis of Raw, Potable and Waste Waters'. These volumes inevitably took some years to prepare, so that they were often partially out of date before they appeared in print. The present series will be published as individual methods, thus allowing for the replacement or addition of methods as quickly as possible without need of waiting for the next edition. The rate of publication will also be related to the urgency of requirement for that particular method, tentative methods being issued when necessary. The aim is to provide as complete and up to date a collection of methods and reviews as is practicable, which will, as far as possible, take into account the analytical facilities available in different parts of the Kingdom, and the quality criteria of interest to those responsible for the various aspects of the water cycle. Because both needs and equipment vary widely, where necessary, a selection of methods may be recommended for a single determinand. It will be the responsibility of the users – the senior analytical chemist, biologist, bacteriologist etc, to decide which of these methods to use for the determination in hand. Whilst attention of the user is drawn to any special known hazards which may occur with the use of any particular method, responsibility for proper supervision and the provision of safe working conditions must remain with the user.

The preparation of this series and its continuous revision is the responsibility of the Standing Committee of Analysts (to review Standard Methods for Quality Control of the Water Cycle). The Standing Committee of Analysts is one of the joint technical committees of the Department of the Environment and the National

Water Council. It has nine Working Groups, each responsible for one section or aspect of water cycle quality analysis. They are as follows:

- 1.0 General principles of sampling and accuracy of results
- 2.0 Instrumentation and on-line analysis*
- 3.0 Empirical and physical methods
- 4.0 Metals and metalloids
- 5.0 General nonmetallic substances
- 6.0 Organic impurities
- 7.0 Biological methods
- 8.0 Sludge and other solids analysis*
- 9.0 Radiochemical methods.

* These two working groups are in process of being wound up. Their tasks are being redistributed among the other Working Groups.

The actual methods etc are produced by smaller panels of experts in the appropriate field, under the overall supervision of the appropriate working group and the main committee. The names of those associated with this method are listed inside the back cover.

Publication of new or revised methods will be notified to the technical press, whilst a list of Methods in Print is given in the current HMSO Sectional Publication List No 5, and the current status of publication and revision will be given in the biennial reports of the Standing Committee of Analysts.

Whilst an effort is made to prevent errors from occurring in the published text, a few errors have been found in booklets in this series. Correction notes for booklets in this series are given in the Reports of The Standing Committee of Analysts, published by the Department of the Environment but sold by the National Water Council, 1 Queen Anne's Gate, London SW1H 9BT. Should an error be found affecting the operation of a method, the true sense not being obvious, or an error in the printed text be discovered prior to sale, a separate correction note will be issued for inclusion in the booklet.

T A DICK
Chairman

L R PITTWELL
Secretary

25 September 1981

A

General Information

A.1 Performance characteristics of the methods

-
- A.1.1 Biota sampled – benthic macro-invertebrates.
-
- A.1.2 Habitats sampled – shallow habitats of flowing water except macrophytes (Surber) large boulders (Surber, Aston Cylinder) and bed rock (Aston Cylinder).
-
- A.1.3 Type of sampler – quadrat.
-
- A.1.4 Basis of operation – removal of benthos from substratum in a defined area.
-
- A.1.5 Form of data – quantitative.
-
- A.1.6 Limitations of method – depth, about 0.5m,
operator safety (Current velocity and bed stability)
not suitable for slow flows or benthos on
macrophytes
mesh size (see table 1).
-
- A.1.7 Efficiency of method – variable – depends on many factors including current velocity, and on number of sampling replicates.
-
- A.1.8 Logistics of sampling – one, preferably two operators. Several replicate samples usually required.
-

A.2 Principle of the method

The samplers described in this booklet were all designed to remove benthic macro-invertebrates from a defined area of substratum. As this area also defines the size of the sampling unit, these samplers are sometimes called quadrat samplers. They may be regarded as the quantitative counterparts of the handnet (1). They are usually used in water with a depth that is less than arm's length and are thus restricted to shallow water. Although the samplers can also be used in deeper water by a diver with SCUBA, it must be emphasised that they were not originally designed for that purpose.

The sampling procedure varies with the type of sampler but, in each case, its purpose is to remove the macro-invertebrates from the delimited area (sampling unit). This procedure is repeated for successive sampling units and these form the sample from a particular site. The sampling units should be located at random within the site or within relatively homogenous areas (strata) into which the site is divided (stratified random sampling). The number of sampling units in each sample will depend upon the precision required for the estimates of numbers or biomass per unit area. As it is usually necessary to calculate standard errors or preferably confidence limits for these estimates, catches from the sampling units must be kept separate. The sampler should be washed thoroughly after each catch has been removed. Advice on sampling design is given in several books (see references 2-6).

A.3 Choice of Method

The choice between the Surber-type sampler and the cylinder-type sampler will depend on personal preference based on operating experience and upon conditions. In slower flowing waters, or in deeper waters and amongst vegetation the cylinder sampler has advantages. In difficult situations it is often advantageous, to use a stirrer with the cylinder. The cylinder sampler has limitations when the substratum makes it difficult for the positioning of the sampler where there are large boulders or bed-rock; in such situations the Surber-type samplers would be preferable.

A.4 Possible suppliers

All equipment described in this booklet can be made by a competent craftsman. Some items, notably the Aston cylinder sampler are not commercially available, but the Surber and Hess-Waters samplers are manufactured in the United States of America by Kahlsico, PO Box 1166, El Cajon California 92022, U S America. The present United Kingdom importer is Offshore Environmental Systems Ltd, 17 West Street, Farnham, Surrey, GU9 7DR.

B

Surber sampler

B.1 Introduction

The sampler was first described briefly in 1934, a drawing was added in a later paper, but a more detailed description was not published by Surber until much later (Ref 7). A brief description of the sampler and its mode of operation is also given by Welch (Ref 8). The sampler has been modified by several workers and some of the modifications are described below.

The sampler can be used in rivers and streams where there is sufficient current to carry the invertebrates into the net when the substratum within the sampling area is disturbed. The sampler cannot be used where the current is less than c. 10 cm sec^{-1} nor where the substratum includes large stones and boulders or dense stands of macrophytes.

B.2 Equipment

The sampler consists of two frames hinged together (Fig. 1), one supporting the net and the other defining the sampling area. The dimensions of the original sampler were in Imperial Units, metric values are given in parentheses on the figures. These are not the exact equivalents but have been adjusted to convenient values that provide a sampling area of 900 cm^2 . The whole sampler weighs about 2 kg, folds flat and is easy to carry.

Each frame, and therefore the sampling area, is one foot square ($30\text{ cm} \times 30\text{ cm}$, to give a sampling area and net mouth of 900 cm^2). Two braces lock the two frames into the working position at right angles to each other, and two triangular wings of netting or canvas reduce the loss of invertebrates around the sides of the net (Fig 1). The frame of the sampler is usually made of brass and Surber (Ref 7) provides a detailed description of its construction.

A handle for maintaining the frame in place on the substratum can be screwed into a central brass tee on the top of the upright frame. The handle can be modified to fit against the chest of the operator who can thus press the lower quadrat frame against the substratum, a technique which is especially useful at high current velocities.

The net is about 70 cm long with a collar of heavier material such as canvas or sail-cloth for a short section around the mouth (see Fig. 1a). This collar increases the durability of the net, and may be extended under the net to protect it from abrasion. The original net tapered slightly to a dome-shape at the rear end, but pocket-shaped and cone-shaped nets are now frequently used. The choice of mesh size depends on the objectives of the exercise: Table 1 provides details of appropriate sizes.

B.3 Sampling procedure

After the net has been opened and the side braces secured, the first sampling position is selected and approached from downstream. The sampler is lowered into the water with the open end upstream so that the net is kept open by the current. The open quadrat frame is placed firmly on the bottom to define the sampling area. Gaps beneath the edge of the quadrat frame may be quickly filled with gravel to prevent the loss of invertebrates under the frame when the substratum within the quadrat is disturbed.

The substratum within the quadrat is now disturbed carefully by hand. Larger stones are scrubbed clean and discarded, whilst smaller stones and gravel are turned over and stirred to a depth of about 5–10 cm, depending on the substratum. It is important to ensure that all dislodged materials enter the net. One hand must be used to hold the sampler in place; but if two hands are required for disturbing the substratum, then a handle and chest brace must be used. In very fast water (current c. 80 cm sec^{-1}), two operators may be required, one to hold the sampler and the other to disturb the substratum.

When no more material can be dislodged within the quadrat, the sampler is lifted out of the water with the open end of the net up-stream. The net may be immersed in the water to wash the materials in the net to its apex but the mouth of the net must not be submerged in case additional animals enter the net. The net is then everted so that the contents can be transferred to a tray or bottle of water from the stream. Some preliminary sorting can be performed in the field and the material should be preserved immediately to avoid underestimation of numbers.

B.4 Modified versions of the original sampler

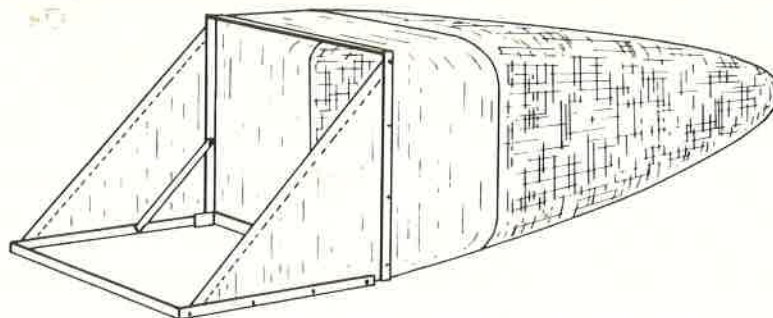
Several workers have altered the basic design of the sampler in an attempt to improve the performance. Leonard (Ref 9) notes that it is often difficult to seat the sampler in rough gravel or rubble in such a way as to enclose accurately one square foot without possible loss of material under the net frame. This problem may be partially overcome by adding a skirt of foam rubber to the quadrat frame. A second problem is the mesh size of the net (9 meshes cm^{-1}) which may not retain small invertebrates. Lane (Ref 10) concluded that this mesh size captures invertebrates with a diameter greater than 0.75 mm, and therefore added a second net with a finer mesh (29 meshes cm^{-1}) that retained all organisms with a diameter greater than 0.25 mm.

A third, and more serious, problem is the loss of invertebrates round the edges of the net when the sampler is in use. This occurs when the current is strong and turbulent, or when the current is weak and the invertebrates can move in or out of the quadrat frame. For these reasons, several workers have partially or completely enclosed the area defined by the quadrat. Slack (Ref 11) enclosed the upstream and lateral sides of the quadrat with wire mesh and used a paddle to stir up the enclosed substratum.

Several workers have replaced the quadrat frame by a box with an open bottom and top, solid sides, a net on the downstream side and a screen on the upstream side (Fig. 2). The screen side is usually detachable and the mesh of the screen is the same as that of the net. The sampler can be bedded into the substratum by foot pressure on the lateral flanges, and the substratum within the sampler is disturbed by hand or by using a metal implement that enables penetration to a much greater depth. In fast-flowing or deep water, an assistant may be required to hold the sampler in position, whilst in very shallow or slow-flowing water, the front screen is removed and the sample taken by disturbing the substratum by hand and scooping water and organisms into the net. The bottom edges of the sampler can be modified to suit the conditions of the substratum. A straight metal edge is usually suitable for gravel and rubble substrata, but a serrated edge can also be used. When the substratum is bedrock or large boulders, a flexible sleeve of split rubber tubing is fitted over the bottom edges of the sampler and this ensures that the sampler fits closely against the bottom. This modified version of a Surber sampler is similar to that designed by Mundie (Ref 12), except that he replaced the front screen by an inverted cone with an adjustable inlet that is used to regulate the flow of water into the sampler.

FIG 1 ORIGINAL SURBER SAMPLER (a) COMPLETE SAMPLER WITH NET (b) DETAILS OF METAL FRAME

(a)



(b)

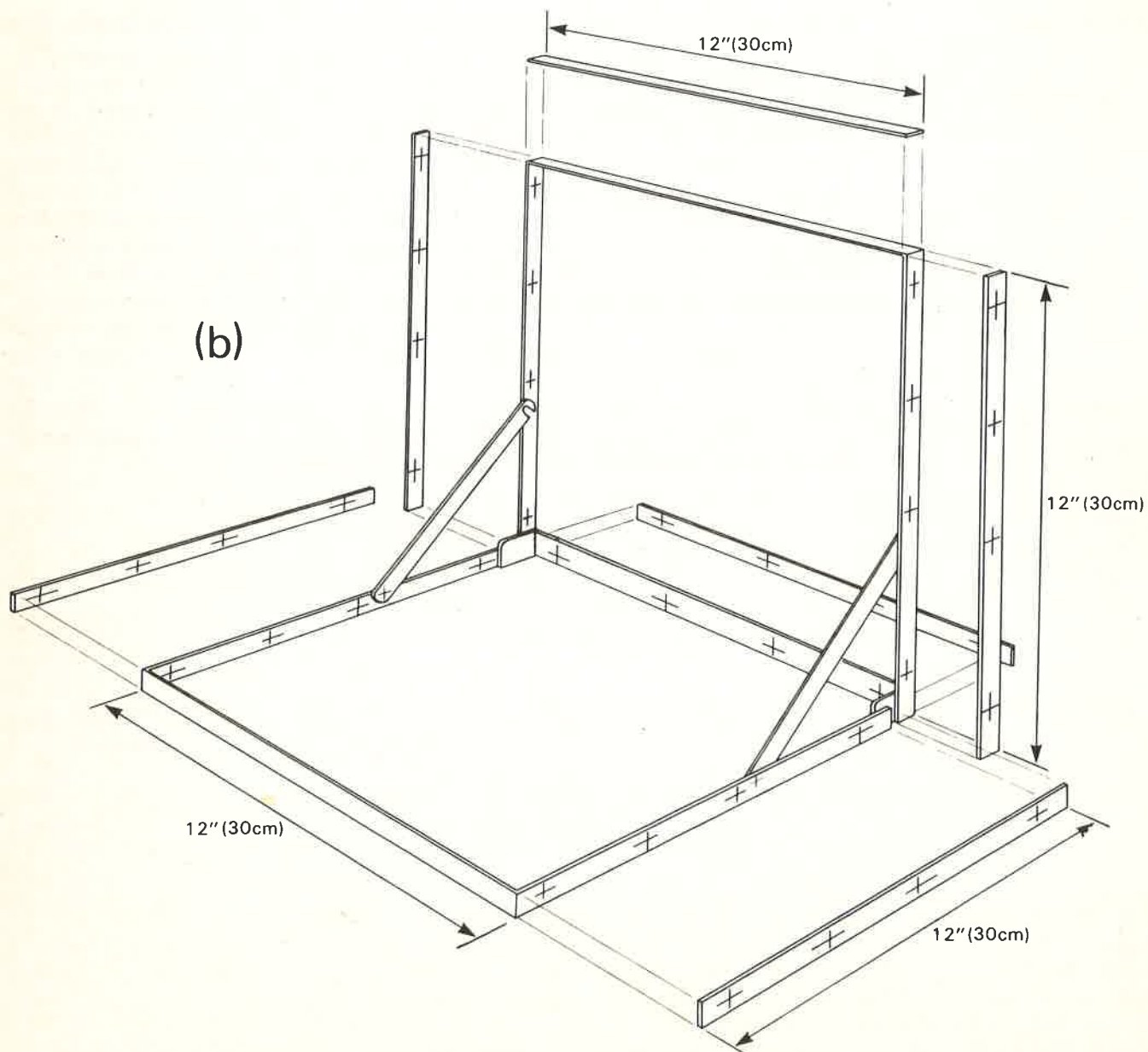
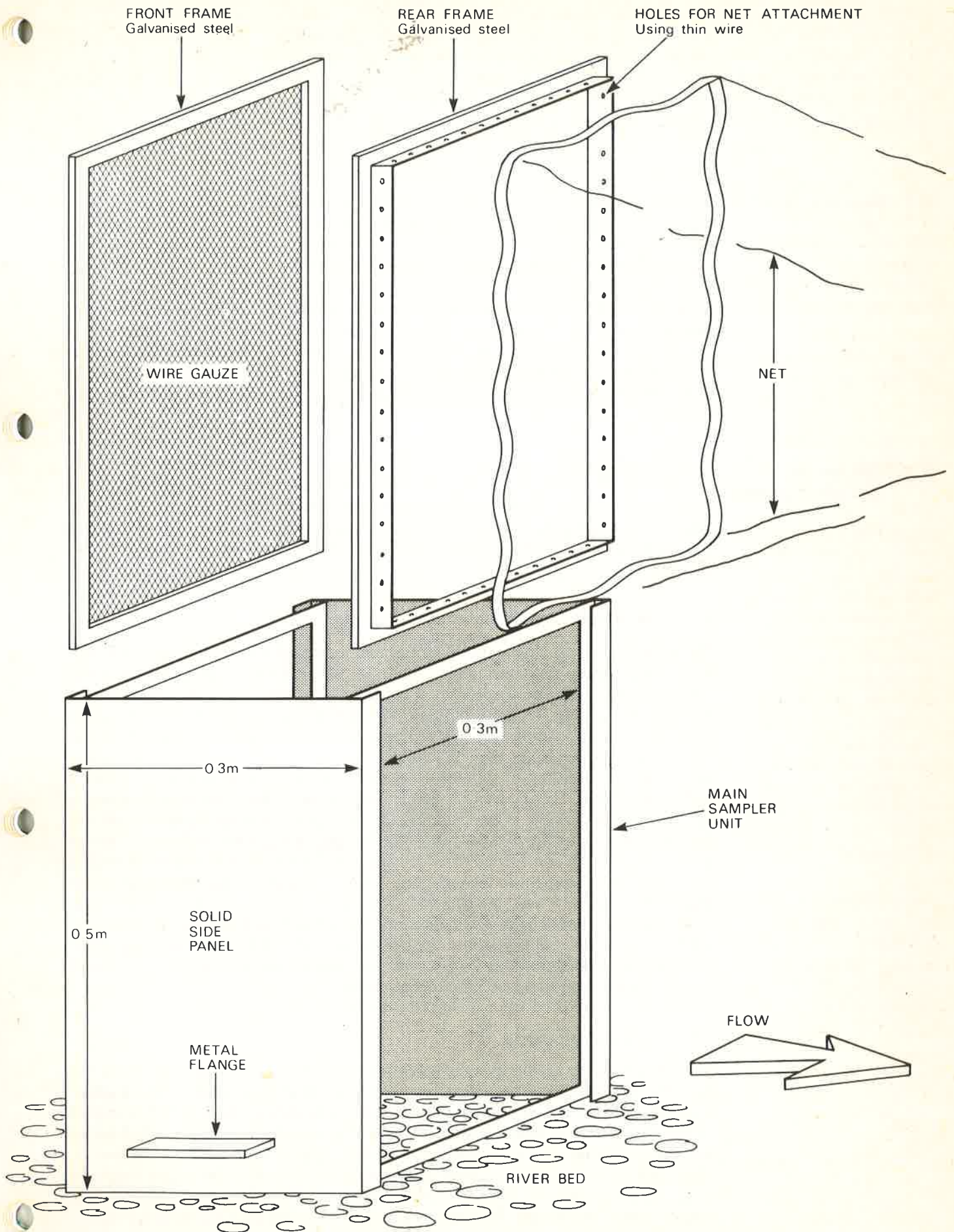


FIG 2 - MODIFIED SURBER SAMPLER



Cylinder samplers

C.1 Introduction

Cylinder samplers are essentially open-ended cylinders which are pushed vertically into the substratum to isolate a known area of river bed from which the benthic macro-invertebrates can then be removed. This simple idea of enclosing an area of river bed within a cylinder to facilitate the removal of animals without loss from within or gain from drift or disturbance from outside, appears to have occurred to several workers, (see References 13–15). Others have modified the method of removing the entrapped animals. The cylinder sampler has advantages over the rectangular box sampler, which evolved from the Surber sampler, in that it is more readily pushed into the substratum by rotary motion and, presenting a streamlined surface to the stream flow, interferes less with the current thus minimizing eddy currents within the sampler.

C.2 The Aston Cylinder Sampler

C.2.1 Introduction

This simple robust cylinder sampler was designed by Hawkes and Davies for quantitatively sampling the benthos of riffles in Midland streams (Ref 16). It has subsequently been used by a succession of research workers at Aston University and elsewhere.

C.2.2 Description of the sampler

The sampler consists essentially of an open-ended cylinder constructed of 18 gauge (0.45 mm) stainless steel having the lower edge serrated with teeth each 1 cm deep. The upper edge may be covered by a plastic edging strip to protect the operator. Handles on the sides facilitate pushing the sampler into the stream bed. To allow water to enter the sampler an oval aperture (257 cm²) is cut into one side of the cylinder towards the lower edge. To reduce the entry of drift organisms this is fitted with a screen consisting of stainless steel of coarse mesh. Opposite this opening a second hole (dia. 11.3 cm) is cut and is fitted with a short exit port to which a detachable collecting net is attached (Fig. 3). Selection of the appropriate mesh size depends upon the nature of the investigation but guidance is given in Table 1. The net is 50 cm deep and is constructed of nylon with a 5 cm deep canvas collar which holds a draw cord for attachment to the exit port. A shallow flange on the distal edge of the exit port ensures secure attachment. Two sizes of cylinder are in use, with cross-sectional areas of 0.05m² and of 0.1m². The depth of both cylinders is 50 cm – an arm's length (Fig 4). The weight of the 0.05m² sampler is 3 kg and that of the 0.1m² sampler is approximately 4 kg. Fig. 4 gives a pattern for marking out on a flat metal sheet, together with some details of construction.

C.2.3 Sampling procedure

With the collecting net firmly attached to the cylinder, the sampling position on the river bed is approached from downstream to avoid undue disturbance of the sampling area. The sampler is then placed on the stream bed to enclose the area to be sampled so that the water inlet screen faces the current. The cylinder is pushed where possible into the substratum to a maximum depth of 7cm using an alternating rotary motion. The collecting net should be arranged extended down-stream in a fully open condition to permit an unimpeded flow of water through it. The operator stands immediately downstream of the sampler with the feet astride the collecting net and uses feet and legs to maintain the position of the sampler. The larger stones in the enclosed sample area are examined and any attached animals are dislodged into the water flowing through the cylinder. The smaller stones and finer substratum are then disturbed by turning them over and stirring by hand to a depth of 5 cm or so. Repeated stirring is

needed to ensure the removal of all the organisms. In urban areas, where glass debris is often deposited in rivers, care is needed in this process especially in polluted waters and disturbing the finer substratum may be more safely achieved using a rod. The water flowing through the cylinder carries the suspended animals into the net where they are retained. After allowing time for the dislodged material to be carried into the collecting net, the net is removed. In doing so the catch can be concentrated in the end to facilitate removal. The net is then everted to transfer the catch to a tray for initial inspection and sorting, care being taken to ensure that all the animals in the net are removed. The sample is then preserved and returned to the laboratory for processing.

C.2.4 Application

The sampler is most successfully used on a substratum which it can penetrate and where the current is sufficient to carry the disturbed animals into the collecting net. In strong currents it is advantageous to have two operators, one to maintain the sampler in position and the other to carry out the sampling. In slow-flowing waters, the current through the sampler may be increased by fitting a funnelled inlet. In standing or very slow-flowing waters other types of cylinder sampler, described below, are more appropriate.

Normally the sampler can only be used in waters less than 40 cm deep but it can be modified for use in deeper waters by an extension attachment which increases the depth to 1 m. When this is used the substratum is disturbed by a pole.

C.3 Other Cylinder Samplers

The earliest record of cylinder sampling is that of Neill (Ref 13). Although this sampler is not in general use, it is of historic interest and incorporated mechanisms not present in the Aston Cylinder Sampler.

The Hess cylinder sampler was designed to overcome problems experienced with the Surber-type square foot sampler especially when used on coarse gravel and rubble type bottoms (Ref 15). The original type consisted of a cylindrical frame having the upper and lower rims of strap iron which were joined by $\frac{1}{2}$ " diameter rods bent over at the top to form handles. The front half of the cylinder was covered with coarse gauze $\frac{1}{6}$ " (4.2 mm) mesh, and the back with heavy canvas which had an opening one foot square (929 cm^2) over which the collecting net (9 meshes cm^{-1}) was sewn. This basic type has been modified in different ways. Waters and Knapp (Ref 17) modified it to overcome what they regarded as two weaknesses. They considered that the gauze was too coarse to prevent the entry of drift animals and the catch was difficult to remove from the collecting bag especially under winter conditions. The modified sampler was constructed of $\frac{1}{4}$ " (6 mm) diameter metal rod with a 5 cm wide strip of metal sheet attached to the lower edge. The frame was covered with "Nitex" of mesh size 471 microns (15 meshes cm^{-1}) which prevented invertebrate drift from entering the sampler. The attached collecting net was made of the same material. The Hess-Waters sampler (Fig. 5), based on reference 17, which is used in North America, is available commercially.

With all the above samplers the collection of the organisms depends upon the current. Other totally enclosed cylinder-type samplers are independent of current and may therefore be of use in slow-flowing or standing waters. Whitley (Ref 18) describes a simple 'bucket' sampler for use on a muddy substratum. Dunn (Ref 19) used an open-ended galvanized iron cylinder which sampled an area of 828 cm^2 of the substratum to a depth of 6-7 cm in studying the benthos of the littoral zone of Lake Bala.

Table 1: Recommended handnet mesh sizes

Survey Objective	Mesh Threads per cm	Maximum Aperture Size	Recommended Minimum Depth	Comments
General/Routine Biological Surveillance	8	950 μ m	400 mm	May not capture first instar stages of some insects
For Routine Surveillance with more complete records	(9	760 μ m	400 mm) More likely to capture first instar stages
	(12	610 μ m	450 mm	
For special surveys requiring data in complete detail	24	265 μ m	550 mm	Ensures capture of first instar stages and very small organisms which may prove of value in water quality determination.

FIG 3 ASTON CYLINDER SAMPLER

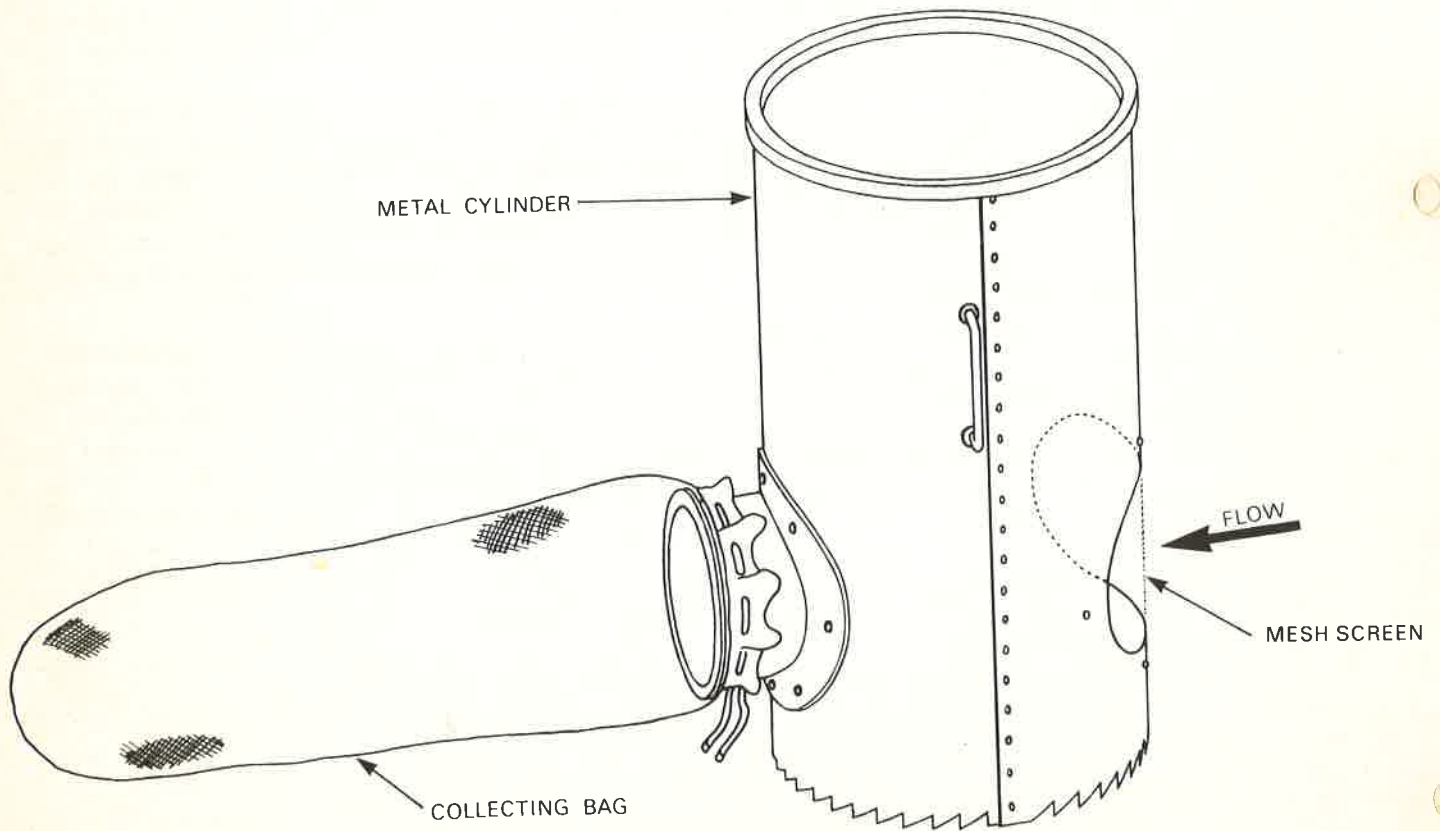
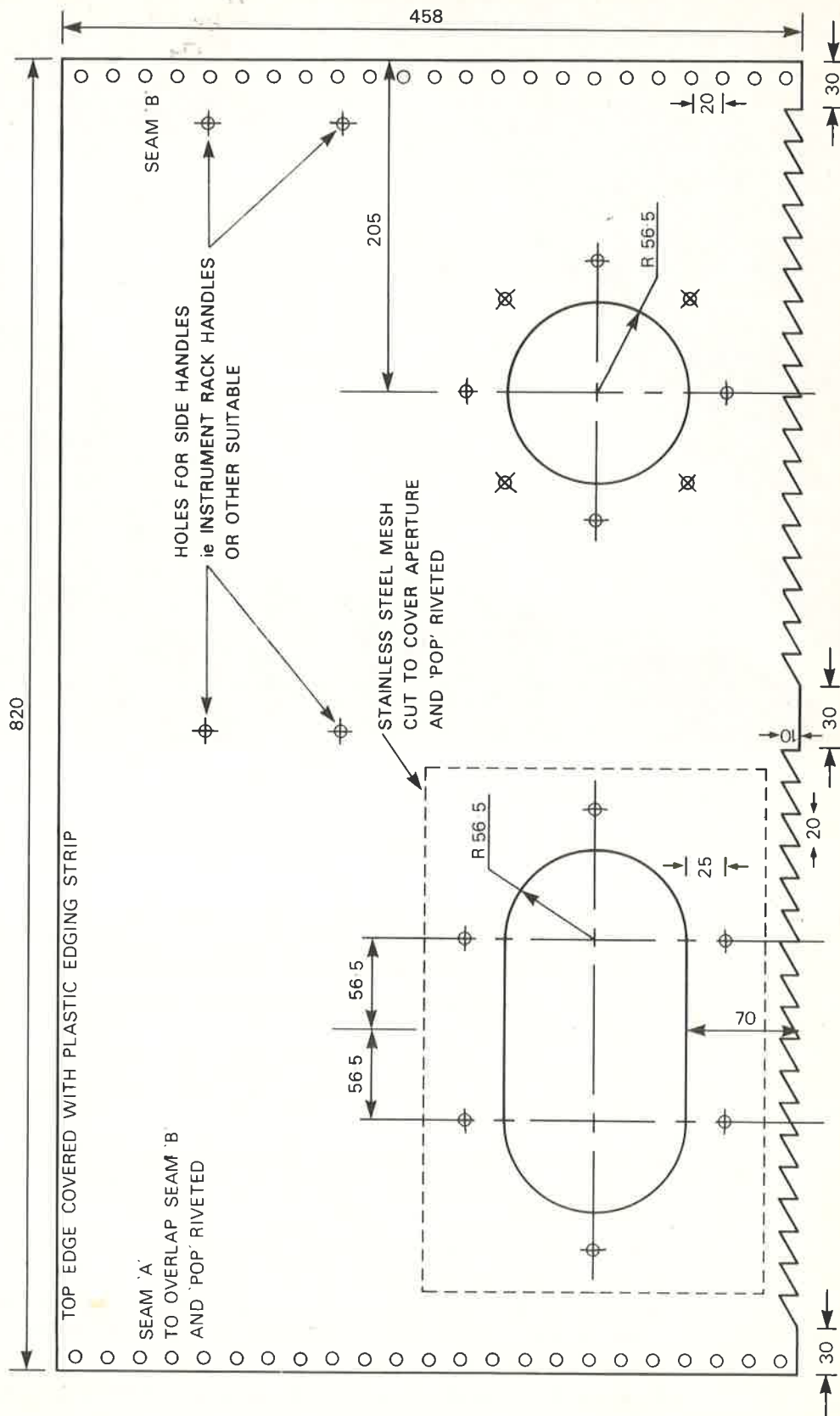


FIG 4. ASTON CYLINDER SAMPLER
 AS MARKED OUT IN FLAT SHEET STAINLESS STEEL, 18 GAUGE OR 0.45mm



ALL DRILLED HOLES - 3.5mm
 RIVETS - COPPER 1/8" OR EQUIVALENT METRIC SIZE

Dimensions are in mm, and are appropriate to the 0.05m² size

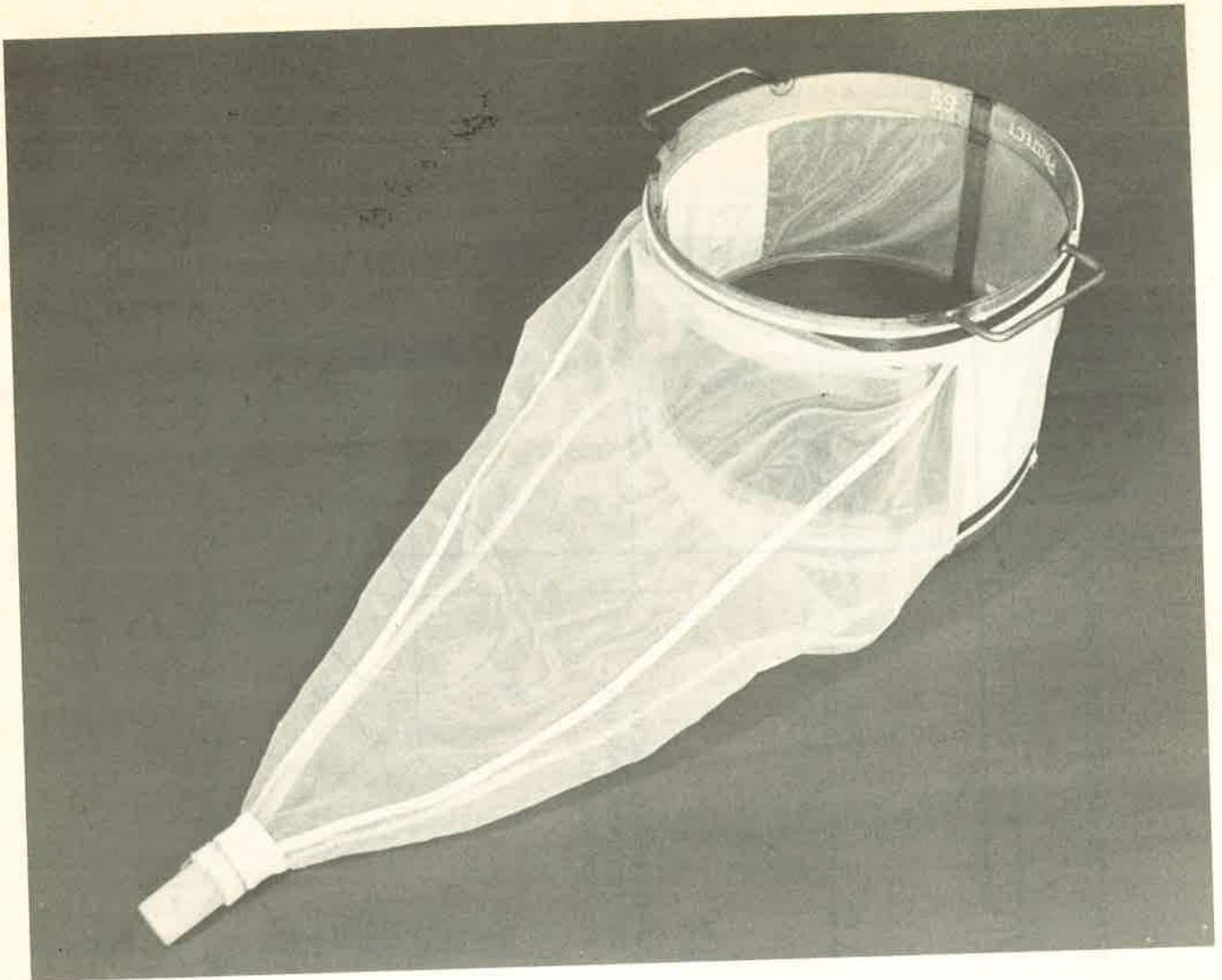


FIGURE 5 HESS – WATERS SAMPLER

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