AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 70

1. SUBJECT CLASSIFICATION	A. PRIMARY Science and technology	TC00-0000-0000
	B. SECONDARY Applications	

2. TITLE AND SUBTITLE
Village technology handbook,sect.1,pt.4: Water purification

3. AUTHOR(S)
(101) Volunteers for Int.Technical Assistance, Mt.Rainier,Md.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	36p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
VITA

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER PN-AAE-658	11. PRICE OF DOCUMENT
12. DESCRIPTORS Water treatment, Intermediate technology	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-2795 GTS
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Village Technology Handbook

SECTION 1: WATER RESOURCES

Part 4: Water Purification

FOREWORD

Progress is the result of man's mastery of the world he lives in. The VILLAGE TECHNOLOGY HANDBOOK is aimed at helping villagers to master the resources available to them: to improve their own lives and to bring their villages more fully into the lives of the nations of which they form a basic and important part.

Village development takes on special importance in the light of the fact that 80 percent of those who live in less-developed countries live in villages. If progress is to come to nations, progress must come to villages.

Technical information is a basic factor in progress, along with other basic factors: political, social and economic. The VILLAGE TECHNOLOGY HANDBOOK was conceived by VITA Volunteers in 1962 as a means of bridging the "technical information gap" which keeps the world's villages from learning from one another's experience. The book's aim is to gather in one publication information from many sources which has been found helpful in villages.

This handbook was first published by the U.S. Agency for International Development in two volumes in 1963 and 1964. In the 1970 edition, the two earlier volumes are integrated into one book, the editing has been made more uniform, some new information has been added and the illustrations have been improved. The entire handbook has been checked for accuracy by VITA Volunteer specialists. A new feature in this edition is the incorporation of information on other publications which cover in detail subjects which are discussed only briefly here. VITA plans to continue to improve the handbook in future editions to make it increasingly effective as a key to existing technology for village workers.

The information in the handbook has come from many sources. VITA hopes that criticism and new information will come from many of the same sources--and from other sources. The questionnaire on page ix was designed to stimulate this flow of criticism and information. VITA will test new information and then disseminate it to those who need it.

VITA is grateful to the U.S. Agency for International Development for its financial support of the revision and for its help in reviewing the contents. Thanks are also due to the Federal Extension Service, U.S. Department of Agriculture, for its help in reviewing the section on "Home Improvement".

A NOTE ON USING THE HANDBOOK

This handbook describes techniques and devices which can be made and used in villages. Hopefully the book will generate new ideas as well as pass on information which has already been tried.

Some of the practices suggested here can be adopted on an individual basis. Others, however, will require cooperation by many people and, perhaps, by government agencies. In many cases, it would be well to seek out extension services existing in your area. If local government or university extension services are available, they will be able to give you information well suited to local conditions. In some cases, there may be a need for a credit union or a consumer, marketing, housing or service cooperative. Information on credit unions is available from:

CUNA International, Inc.
World Extension Department
Box 431
Madison, Wisconsin 53701
U.S.A.

Information on cooperatives is available from:

Agricultural Cooperative Development
International
Suite 1200
1430 K St., N.W.
Washington, D.C. 20005
U.S.A.

When the materials suggested in the handbook are not available, it may be possible to substitute other materials; but be careful to make any changes in dimensions made necessary by such substitutions.

Dimensions are given in metric units in the text, with English units in parentheses. Only metric units are given in the illustrations. Conversion tables are given in the Appendix.

Reference materials, along with information on where they can be obtained, are listed at the end of a specific entry when they pertain to that entry. When they refer more generally to the field covered in a section of the book, they are given at the end of the section. If you cannot get these publications, VITA may be able to help you.

If you want to use translations of material in the handbook, we ask you to let VITA know. The material you want may already be translated; if it is not, and if you translate it, VITA would like to make your translation available to others.

If you have questions on the material presented here, if you run into problems in implementing the handbook's suggestions, or if you have other technical problems, do not hesitate to ask for the personal help of a VITA Volunteer specialist. Write to:

VITA
3706 Rhode Island Avenue
Mt. Rainier, Md. 20822
U.S.A.

VITA's Volunteer Translation Service can translate letters in languages other than English, but correspondence moves much more quickly when carried on entirely in English. To help VITA Volunteers find a useful solution to your problem as quickly as possible, you should:

1. Be quantitative--give measurements, sketches or, when possible, photos.

2. Explain what materials are available and what limitations there are on cost.

3. Describe the best solution, if any, found so far in the area.

4. Explain any pertinent social or cultural conditions.

5. Indicate a deadline for action, especially if immediate attention is needed.

6. Don't expect miracles on the first reply. Successful problem-solving often takes a number of letters back and forth.

WHAT IS VITA?

VITA (Volunteers in Technical Assistance) was established in 1959 as a private, non-profit organization responding to requests for assistance in economic and social development. VITA mobilizes and coordinates the work of over 7,000 volunteer professionals representing 96 countries, 2000 corporations, universities, and other institutions. The VITA talent bank represents know-how in commerce and industry, agriculture and education, engineering and public health, in addition to many other fields.

VITA provides the most appropriate knowledge to specific calls for assistance from individuals, organizations, small businesses and self-help development groups. In its brief history VITA has responded to over 25,000 requests. VITA meets people's needs through the mail, by telephone, and by on-site counselling. Requests have come from village councils, community development volunteers, farmers, small business owners, and from members of national and international public and private insti tutions. VITA's unique method matches people with need and people with knowledge to give. This partnership increases the opportunity for the success of the requester's project.

One of the most effective ways that VITA shares its information with many people in through its Publications Program. The VILLAGE TECHNOLOGY HANDBOOK has played an important role in helping to disseminate that information. Supplementing this book is VITA's Technology Manual series, how-to-do-it booklets, which cover a wide spectrum of subject matter. A publications list is available on request.

In its OVERSEAS LIAISON PROGRAM, VITA encourages the formation of similar technical assistance programs throughout the world. Cooperation with these and other organizations working in the developing countries will give VITA access to on-the-spot background information on the technological aspects of international development.

VITA is financed by contributions from private individuals, foundations and industry, and by government grants.

SYMBOLS AND ABBREVIATIONS USED IN THIS BOOK

@ . . . . at
" . . . . inch
' . . . . foot
C . . . . degrees Celsius (Centigrade)
cc . . . cubic centimeter
cm . . . centimeter
cm/sec . centimeters per second
d or dia. diameter
F . . . . degrees Fahrenheit
gm . . . gram
gpm . . . gallons per minute
HP . . . horsepower
kg . . . kilogram
km . . . kilometer
l . . . . liter
lpm . . . liters per minute
l/sec . . liters per second
m . . . . meter
ml . . . milliliters
mm . . . millimeters
m/m . . . meters per minute
m/sec . . meters per second
ppm . . . parts per million
R . . . . radius

QUESTIONNAIRE

NOTE TO THE READER: VITA's publications are compiled by VITA Volunteers because they want to help people in developing areas. With your field experience, you are in a unique position of being able to increase the usefulness of this work by sharing what you have learned with the people who will use the publications in the future. You are strongly urged to complete the following questionnaire (using additional sheets if necessary), cut it out and send it to:

VITA
3706 Rhode Island Avenue
Mt. Rainier, Md. 20822
U.S.A.

Date ____________

Name ______________________________ Agency ____________________

Address ___________________________

____

1. Which items from the VILLAGE TECHNOLOGY HANDBOOK have you put into practice?

2. Have results been good or otherwise?

3. Have you made improvements or modifications in any of the devices or techniques? If so, please describe them, including photographs or sketches if possible.

4. Have you devised any new equipment or techniques not described in the handbook which may be of use to others? If so, please describe them.

5. Did you find the handbook useful, too simple, too complex, incomplete?

6. Other comments and suggestions:

TABLE OF CONTENTS

Water Purification

The purification of unsafe water requires some trained supervision if it is to be done effectively. Such supervision is rarely available in the villages and the procedure tends to be neglected sooner or later. Under these circumstances every effort must be made to obtain a source that provides a naturally wholesome water and then to collect that water and protect it against pollution by the methods already described. Thus, the necessity for treatment of the water may be avoided, and the practical importance of managing this can hardly be over-emphasized.

Water treatment under rural conditions should be restricted by the responsible control agency to cases where such treatment is necessary and where proper plant operation and maintenance is assured.

If the water needs treatment, this should, if at all possible, be done for the whole community and certainly before, or on entry to the dwelling so that the water from all the taps in the house is safe. The practice, common in the Tropics, of sterilizing (by filtration and boiling) only the water to be used for drinking, teeth-cleaning, etc., though efficient in itself (when carefully done) is frequently nullified by carelessness. Furthermore, children are likely to use water from any tap. Contrary to an all too common opinion, ordinary freezing of water, though it may retard the multiplication of bacteria, does not kill them, and ice from a household refrigerator is no safer than the water from which it was made.

The principal methods of purifying water on a small scale are, boiling, chemical disinfection and filtration. These methods may be used singly or in combination, but if more than filtration is needed the boiling or chemical disinfection should be done last.

The entries which follow this general introduction are:

Boiler for Drinking Water, Chlorination of Polluted Water, Water Purification Plant and Sand Filter.

Boiling is the most satisfactory way of destroying disease-producing organisms in water. It is equally effective whether the water is clear or cloudy, whether it is relatively pure or heavily contaminated with organic matter. Boiling destroys all forms of disease-producing organisms usually encountered in water, whether they be bacteria, viruses, spores, cysts or ova. To be safe the water must be brought to a good "rolling" boil (not just simmering) and kept there for some minutes. Boiling drives out the gases dissolved in the water and gives it a flat taste, but if the water is left for a few hours in a partly filled container, even though the mouth of the container is covered, it will absorb air and lose its flat, boiled taste. It is wise to store the water in the vessel in which it was boiled. Avoid pouring the water from one receptacle to another with the object of aerating or cooling it as that introduces a risk of re-contamination.

Chlorine is a good disinfectant for drinking water as it is effective against the bacteria associated with water-borne disease. In its usual doses, however, it is ineffective against the cysts of amoebic dysentery, ova of worms, cercariae which cause schistosomiasis and organisms embedded in solid particles.

Chlorine is easiest to apply in the form of a solution and a useful solution is one which contains 1 percent available chlorine, for example, Milton Antiseptic. Dakin's solution contains 0.5 percent available chlorine, and bleaching powder holds 25 percent to 30 percent available chlorine. About 37cc (2 1/2 tablespoons) of bleaching powder dissolved in 0.95 liter (1 quart) of water will give a 1 percent chlorine solution. To chlorinate the water, add 3 drops of 1 percent solution to each 0.95 liter (1 quart) of water to be treated (2 tablespoonfuls to 32 Imperial gallons), mix thoroughly and allow it to stand for 20 minutes or longer before using the water.

Chlorine may be obtained in tablet form as "Sterotabs" (formerly known as "Halazone"), "Chlor-dechlor" and "Hydrochlorazone," which are obtainable on the market. Directions for use are on the packages.

Iodine is a good disinfecting agent. Two drops of the ordinary tincture of iodine are sufficient to treat 0.95 liter (1 quart) of water. Water that is cloudy or muddy, or water that has a noticeable color even when clear, is not suitable for disinfection by iodine. Filtering may render the water fit for treatment with iodine. If the water is heavily polluted, the dose should be doubled. Though the higher dosage is harmless it will give the water a medicinal taste. To remove any medicinal taste add 7 percent solution of sodium thiosulphate in a quantity equal to the amount of iodine added.

Iodine compounds for the disinfection of water have been put into tablet form, for example, "Potable Aqua Tablets," "Globaline" and "Individual Water Purification Tablets"; full directions for use are given on the packages. These tablets are among the most useful disinfection devices developed to date and they are effective against amoeba cysts, cercariae, leptospira and some of the viruses.

Source:

Small Water Supplies, Bulletin No. 10, The Ross Institute, London, 1967.

Other Useful References:

Manual of Individual Water Supply Systems, Public Health Service Publication No. 24, U.S. Department of Health, Education and Welfare, Washington, D.C. Revised 1962.

Water Supply for Rural Areas and Small Communities, by Edmund G. Wagner and J. N. Lanoix, World Health Organizations, Geneva, 1959.

BOILER FOR DRINKING WATER

The boiler described here will provide safe preparation and storage of drinking water in areas where pure water is not available and boiling is practical. When the unit has been used in work camps in Mexico, a 208-liter (55-gallon) drum has supplied 20 persons with water for a week.

Tools and Materials

208-liter (55-gallon) drum

19mm (3/4") pipe nipple, 5cm (2") long

Bricks for two 30cm (1') layers to support drum

Sand and 1 sack of cement for mortar and base of fireplace

Large funnel and filter medium for filling drum

Metal plate to control draft in front of fireplace

19mm (3/4") valve, preferably all metal, such as a gate valve, which can withstand heat

The fireplace for this unit (see Figure 2) is simple. It should be oriented so that the prevailing wind or draft goes between the bricks from the front to the back of the drum. A chimney can be provided, but it is not necessary.

When filling the drum, do not fill it completely, but leave an air space at the top as shown in Figure 1. Replace the funnel with a filler plug, but leave the plug completely loose.

Water must boil at least 15 minutes with steam escaping around the loose filler plug. Make sure that the water in the pipe nipple and valve reach boiling temperature by letting about 2 liters (2 quarts) of water out through the valve while the drum is at full boil.

Source:

Chris Ahrens, VITA Volunteer, Housing Specialist, Eastern Kentucky Housing Development Corporation, Inc.

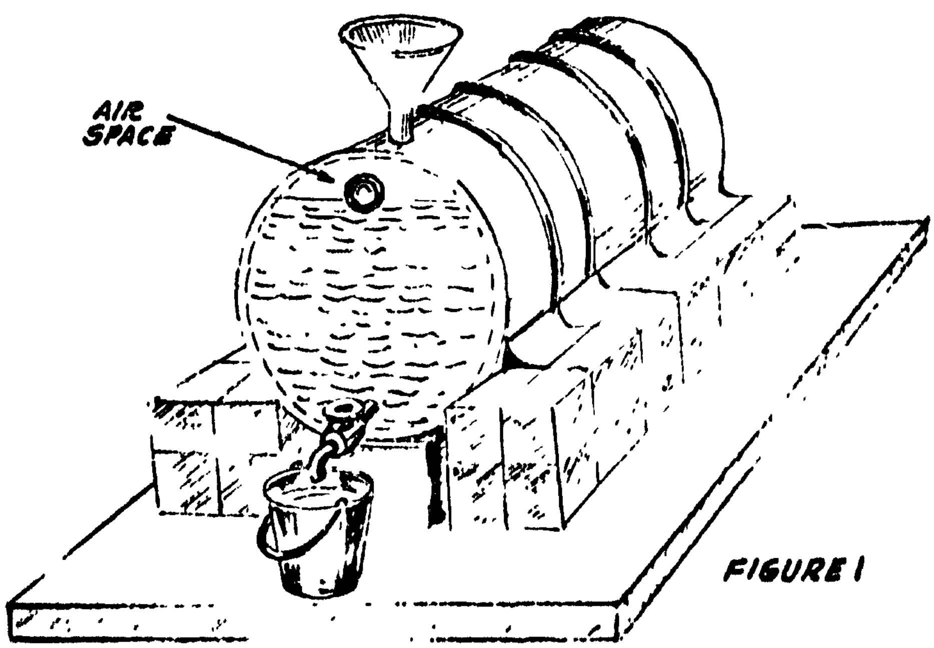


FIGURE 1

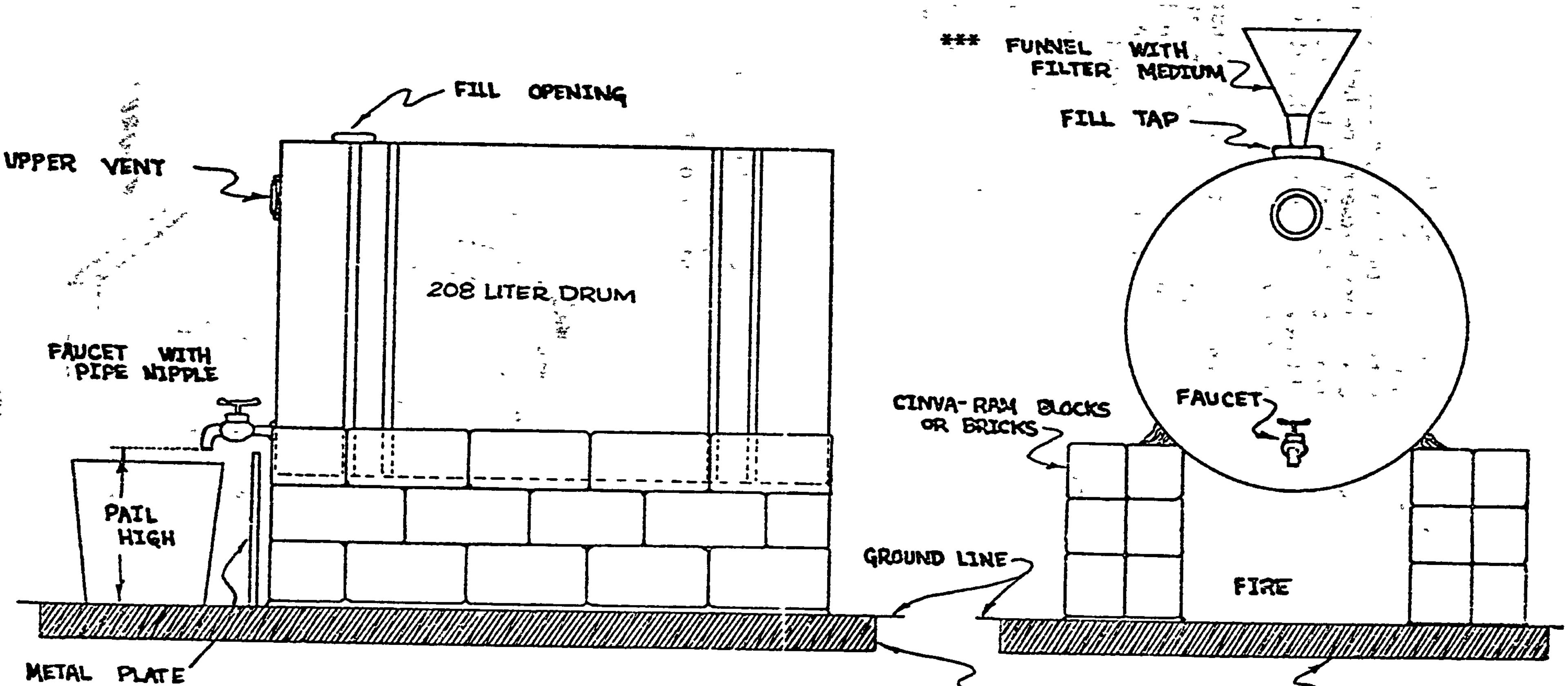


FIGURE 2

*** The water should be clean or prefiltered before entering this system. The filter medium above can be several pieces of clean cloth or gauze.

CHLORINATION FOR POLLUTED WATER AND SUPER-CHLORINATION OF WELLS, SPRING ENCASEMENTS AND CISTERNS

Chlorination, when properly applied, is a simple way to insure and protect the purity of water. Guidelines given here include tables to give a rough indication of the amounts of chlorine-bearing chemical needed. Instructions are also given for super-chlorination for disinfecting newly built or repaired wells, spring encasements or cisterns. Chlorine-bearing compounds are used because pure chlorine is difficult and dangerous to use.

The amounts of chlorine suggested here will normally make water reasonably safe. A water-treatment system should be checked by an expert. In fact, the water should be tested periodically to make sure that it remains safe. Otherwise, the system itself could become a source of disease.

Tools and Materials

Container to mix chlorine

Chlorine in some form

Scale to weigh additive

The safest way to treat water for drinking is to boil it (see "Boiler for Drinking Water"). However, under controlled conditions, chlorination is a safe method; it is often more convenient and practical than boiling. Proper treatment of water with chlorine requires some knowledge of the process and its effects.

When chlorine is added to water, it attacks and combines with any suspended organic matter as well as some minerals such as iron. There is always a certain amount of dead organic matter in water, as well as live bacteria, virus and perhaps other types of life. Enough chlorine must be added to oxidize all of the organic matter, dead or alive, and to leave some excess uncombined or "free" chlorine. This residual free chlorine prevents recontamination. Residual chlorine in water is not harmful, because water which contains a harmful amount of chlorine is extremely distasteful.

Some organisms are more resistant to chlorine than others. Two particularly resistant varieties are amoebic cysts (which cause amoebic dysentery) and the cercariae of schistosomes (which cause bilharziasis or schistosomiasis). These, among others, require much higher levels of residual free chlorine and longer contact periods than usual to be safe. Often special techniques are used to combat these and other specific diseases.

It always takes time for chlorine to work. Be sure that water is thoroughly mixed with an adequate dose of the dissolved chemical, and that it stands for at least 30 minutes before consumption.

Polluted water which contains large quantities of organic matter, or cloudy water, is not suitable for chlorination. It is best, and safest, to choose the clearest water available. A settling tank, and simple filtration can help reduce the amount of suspended matter, especially particles large enough to see. Filtration that can be depended upon to remove all of the amoebic cysts, schistosomes, and other parthogens normally requires professionals to set up and operate.

NEVER depend on home-made filters alone to provide drinking water. However, a home-made slow sand filter is an excellent way to prepare water for chlorination.

Depending on the water to be treated, varying amounts of chlorine are needed for adequate protection. The best way to control the process is to measure

Water Condition	Initial Chlorine Dose in Parts Per Million(ppm)	
	No hard-to-kill organisms suspected.	Hard-to-kill organisms prèsent or suspected.
Very Clear, few minerals.	5 ppm	Get expert advice; in an emergency boil and cool water first, then use 5 ppm to help prevent recontamination. If boiling is impossible, use 10 ppm.
A coin in the bottom of 1/4 - liter (8 ounce) glass of the water looks hazy.	10 ppm	Get expert advice; in an emergency boil and cool first. If boiling is impossible use 15 ppm.

Figure 3. Initial chlorine dose to safeguard drinking water supply. Parts per million (ppm) is the number of parts by weight of chlorine to a million parts by weight of water. It is equivalent to milligrams per liter.

* * * * * * * *

Figure 4 - Amounts of chlorine compound to add to drinking water

Chlorine Compound	Percent by Weight Active Chlorine	Quantity to add to 1000 U.S. gallons of water required strength			Quantity to add to 1000 liters to get required strength		
		5 PPM	10 PPM	15 PPM	5 PPM	10 PPM	15 PPM
High test Calcium Hypochlorite $Ca(OCl)_2$	70%	1 oz	2 oz	3 oz	8 gms	15 gms	23 gms
Chlorinated Lime	25%	2 1/2 oz	5 oz	7 1/2 oz	20 gms	40 gms	60 gms
Sodium hypochlorite NaOCl	14%	5 oz	10 oz	15 oz	38 gms	75 gms	113 gms
Sodium hypochlorite	10%	7 oz	13 oz	20 oz	48 gms	95 gms	143 gms
Bleach - A Solution of Chlorine in water	usually 5.25%	13 oz	26 oz	39 oz	95 gms	190 gms	285 gms

Application	Recommended Dose	Procedure
New or repaired well	50 ppm	1. Wash casing, pump exterior and drip pipe with solution. 2. Add dosage to water in well. 3. Pump until water coming from pump has strong chlorine odor (for deep wells, repeat this a few times at 1 hour intervals). 4. Leave solution in well at least 24 hours. 5. Flush all chlorine from well.
Spring encasements	50 ppm	Same as above.
Cisterns	100 ppm	1. Flush with water to remove any sediment. 2. Fill with dosage. 3. Let stand for 24 hours. 4. Test for residual chlorine. If there is none, repeat dosage. 5. Flush system with treated water.

Figure 5. Recommended doses for super-chlorination. To find the correct amounts of chlorine compound needed for the required dosage, multiply the amounts given under 10ppm in Figure 4 or 5 to get 50ppm and by 10 to get 100ppm.

the amount of free chlorine in the water after the 30 minute holding period. A simple chemical test which uses a special organic indicator called orthotolidine can be used. Orthotolidine testing kits available on the market come with instructions on their use.

When these kits are not available, the chart in Figure 3 can be used as a rough guide to how strong a chlorine solution is necessary. The strength of the solution is measured in parts by weight of active chlorine per million parts by weight of water, or "parts per million" (ppm).

The chart in Figure 4 gives the amount of chlorine-compound to add to 1000 liters or to 1000 gallons of water to get the solutions recommended in Figure 3.

Usually it is convenient to make up a solution of 500 ppm strength which can then be further diluted to give the chlorine concentration needed. The 500 ppm solution must be stored in a sealed container in a cool dark place, and should be used as quickly as possible since it does lose strength. Modern chlorination plants used bottled chlorine gas, but this can only be used with expensive machinery by trained experts.

Super-chlorination

Super-chlorination means applying a dose of chlorine which is much stronger than the dosage needed to disinfect water. It is used to disinfect new or repaired wells, spring encasements and cisterns. The chart in Figure 5 gives recommended doses.

Example 1:

A water-holding tank contains 8000 U.S. gallons. The water comes from a rapidly moving mountain stream and is passed through a sand filter before storage. How much bleach should be added to make this water drinkable? How long should the water be mixed after adding?

Solution:

In this case 5 ppm are probably sufficient to safeguard the water (from Figure 3.) To do this with bleach requires 13 ounces per 1000 gallons. Therefore the weight of bleach to be added is 13 x 8 or 104 ounces.

Always mix thoroughly, for at least a half hour. A good rule of thumb is to mix until you are certain that the chemical is completely dissolved and distributed and then ten minutes longer. In this case, with an 8000-gallon tank, try to add the bleach to several different locations in the tank to make the mixing easier. After mixing, test the water by sampling different locations, if possible. Check the corners of tank especially.

Example 2:

A new cistern has been built to hold water between rainstorms. On its initial filling it is to be super-chlorinated. How much chlorinated lime should be added? The cistern is 2 meters in diameter and 3 meters high.

Solution:

First calculate the volume of water. For a cylinder, Volume is $\frac{\pi D^2}{4} H$ (D is diameter, H is height and π is 3.14.) Here D = 2 meters H = 3 meters.

$$V = \frac{3.14}{4} \times (2 \text{ meters}) \times (2 \text{ meters}) \times (3 \text{ meters})$$

V = 9.42 cubic meters = 9,420 liters. (Each cubic meter contains 1000 liters.) From Figure 5 we learn that a cistern should be super-chlorinated with 100 ppm of chlorine. From Figure 4, we learn that it takes 40 grams of chlorinated lime to bring 1000 liters of water to 10 ppm Cl. To bring it to 100 ppm, then, will require ten times this amount, or 400 grams.

$$\frac{400 \text{ grams}}{\text{thousand liters}} \times 9.42 \text{ thousand liters} =$$

3768 grams.

Source:

Environmental Sanitation, by J. S. Salvato, John Wiley & Sons, Inc., New York, 1958.
Field Water Supply, TM 5-700.

WATER PURIFICATION PLANT

The water purification plant described here uses laundry bleach as a source of chlorine. Although this manually-operated plant is not as reliable as a modern water system, it will provide safe drinking water if it is operated according to instructions.

Many factors in this system require operating experience. When starting to use the system, it is safest to have the assistance of an engineer experienced in water supplies.

Tools and Materials

3 Barrels, concrete tanks or 208 liter (55-gallon drums)

20cm (8") funnel, or sheet metal to make a funnel

2 Tanks, about 20 liters (5 gallons) in size

4 Shut-off valves

Throttle or needle valve (clamps can be used instead of valves if hose is used)

Pipe or hose with fittings

Hypochlorite of lime or sodium hypochlorite (laundry bleach)

The water purification plant is made as in Figure 6. The two at the top of the structure are for diluting the bleach. (The system can be simplified by eliminating the concentrate tank; the bleach is then added directly to the mixing tank.)

The two smaller tanks on the shelf below are for holding equal amounts of diluted bleach solution and water at a constant pressure; this makes the solution and the water flow at the same speed into the hoses which lead to the mixing point. The mix, which can be seen through the open funnel, is further controlled by the valves. If a needle or throttle valve is not available a throttle action can be obtained by installing another shut-off valve in series with Valve #4.

Placing the two barrels at a height of less than 1.8 meters (6') above the float valve causes a pressure of less than 0.35kg per square centimeter (5 pounds per square inch). Thus, the plumbing does not have to be of high quality except for Valve #1 and the float valve of the water hold-up tank, if the water supply is under higher pressure.

Operation

A trial and error process is necessary to learn how much concentrate should be put in the concentrate tank, how much concentrate should flow into the mixing tank and how much solution should be allowed past the funnel. A suggested starting mixture is 1/4 liter (1/2 pint) of concentrated bleach for a mix tank capacity of 190 liters (50 gallons) to treat 1900 liters (500 gallons) of water.

The water in the distribution tank should have a noticeable chlorine taste. The amount of bleach solution required depends on how dirty the water is.

1. Mix concentrated bleach with water in the concentrate tank with all valves closed. The mixing tank should be empty.
2. Fill the pipe from the mixing tank to the solution tank with water after having propped the float valve in a closed position.
3. Let a trial amount of concentrate flow into the mixing tank by opening Valve #2.
4. Use a measuring stick to see how

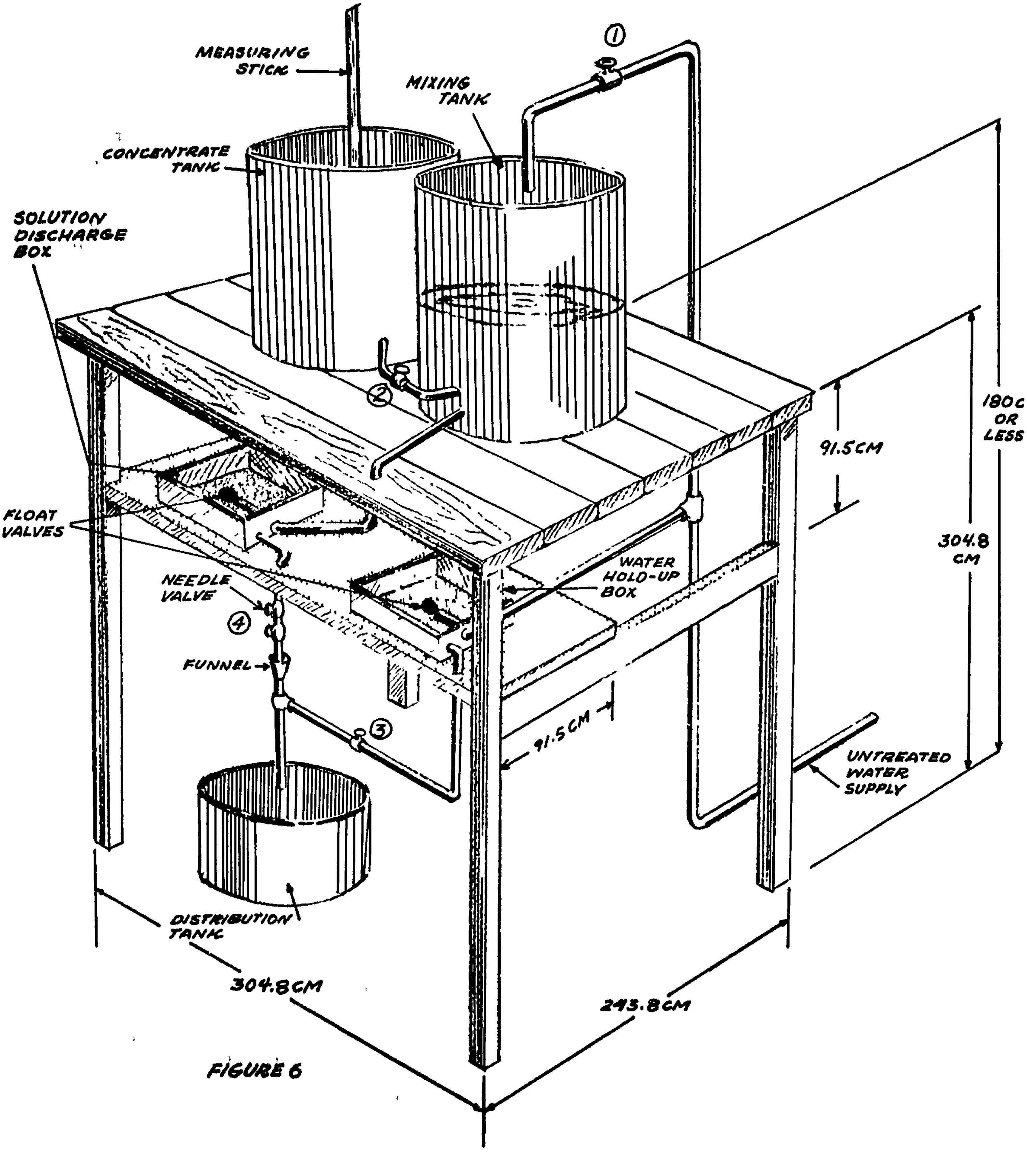

MEASURING STICK
MIXING TANK
CONCENTRATE TANK
SOLUTION DISCHARGE BOX
FLOAT VALVES
NEEDLE VALVE
FUNNEL
WATER HOLD-UP BOX
DISTRIBUTION TANK
UNTREATED WATER SUPPLY
91.5CM
91.5CM
180C OR LESS
304.8 CM
304.8CM
243.8CM

FIGURE 6

much concentrate was used.

5. Close Valve #2 and open Valve #1 so that untreated water enters the mixing tank.

6. Close Valve #1 and mix solution in the mixing tank with a stick.

7. Remove the prop from the float valve of the solution tank so that it will operate properly.

8. Open wide the needle valve and Valve #4 to clean the system. Let 4 liters (1 gallon) drain through the system. (Steps 2, 7 and 8 can be omitted after the first charging of the system, if the pipe mentioned in the second step is not permitted to empty before recharging the mixing tank.)

9. Close down the needle valve until only a stream of drops enters the funnel.

10. Open Valve #3.

The flow into the funnel and the taste of the water in the distribution tank should be checked regularly to insure proper treatment.

Source:

Chris Ahrens, VITA Volunteer, Eastern Kentucky Housing Development Corporation, Inc.

SAND FILTER

Surface water from streams, ponds or open wells is very likely to be contaminated with leaves and other organic matter. A gravity sand filter can remove most of this suspended organic material, but it will always let virus and some bacteria pass through. For this reason, it is necessary to boil or chlorinate water after it has been filtered.

Although sand filtration does not make polluted water safe for drinking, a sand filter which is properly built and maintained will prepare water for boiling or chlorination. Sand filters must be cleaned periodically.

The household sand filter described here should deliver 1 liter (1 quart) per minute of clear water, ready for boiling or chlorinating.

Tools and Materials

Steel drum: at least 60cm wide by 75cm (2' x 29 1/2")

Sheet metal, for cover: 75cm (29 1/2") square

Wood: 5cm x 10cm (2" x 4"), 3 meters (9.8') long

Sand: 0.2 cubic meter (7 cubic feet)

Gravel

Blocks and nails

Pipe, to attach to water supply

Optional: valve and asphalt roofing compound to treat drum

The gravity sand filter is the easiest type of sand filter to understand and set up. The gravity filter uses sand to strain suspended matter from the water, although this does not always stop small particles or bacteria. Over a period of time, a biological growth forms in the top 7.5cm (3") of sand. This film increases the filtering action. It slows the flow of water through the sand, but it traps more particles and up to 95 percent of the bacteria. The water level must always be kept above the sand to protect this film.

Sand filters can get partially clogged with organic matter; under some conditions this can cause bacterial growth in the filter. If the sand filter is not operated and maintained correctly, it can actually add bacteria to the water.

By removing most of the organic matter, the filter:

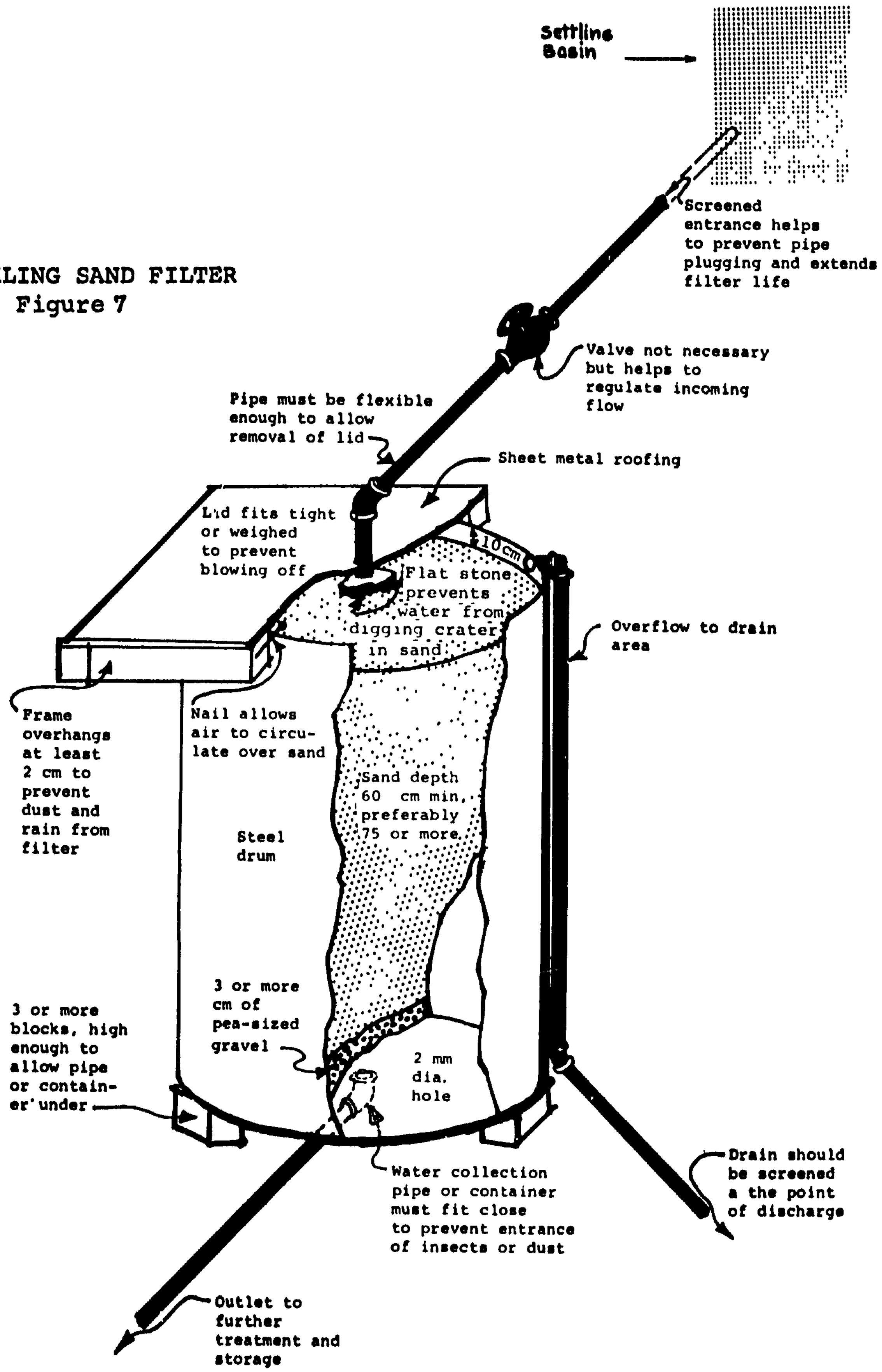
1. Removes larger worm eggs, cysts, and cercariae, which are difficult to kill with chlorine.
2. Allows the use of smaller and fixed doses of chlorine for disinfection, which results in drinkable water with less taste of chlorine.
3. Makes the water look cleaner.
4. Reduces the amount of organic matter, including living organisms and their food, and the possibility of recontamination of the water.

The drum for the sand filter shown in Figure 7 should be of heavy steel. It can be coated with asphalt material to make it last longer. The 2mm (3/32") hole at the bottom regulates the flow: it must not be made larger.

The sand used should be fine enough to pass through a window screen. It should also be clean; it is best to wash it.

The following points are very important in making sure that a sand filter operates properly:

TRICKLING SAND FILTER
Figure 7



1. Keep a continous flow of water passing through the filter. Do not let the sand dry out because this will destroy the microorganisms which form a film on the surface layer of sand. The best way to insure a continuing flow is to set the intake so that there is always a small overflow.

2. Screen the intake and provide a settling basin to remove as many particles as possible before the water goes into the filter. This will keep the pipes from becoming plugged and stopping the flow of water. It will also help the filter to operate for longer periods between cleanings.

3. Never let the filter run faster than 3.6 liters per square meter per minute (4 gallons per square foot per hour) because a faster flow will make the filter less efficient by keeping the biological film from building up at the top of the sand.

4. Keep the filter covered so that it is perfectly dark to prevent the growth of green algae on the surface of the sand. But let air circulate above the sand to help growth of the biological film.

5. When the flow becomes too slow to fill daily needs, clean the filter: Scrape off and discard the top 6.5mm (1/4") of sand and rake or scratch the surface lightly.

6. All pipes and fittings should have at least a 6.5mm (1/4") inside diameter. Sharp bends and extremely long lines to and from the filter should be avoided.

After several cleanings, the sand should be raised to its original height by adding clean sand. Before doing this, scrape the sand in the filter down to a clean level. The filter should not be cleaned more often than once every several weeks or even months, because the biological growth at the top of the sand makes the filter more efficient.

Source:

Water Supply for Rural Areas and Small Communities, by Edmund G. Wagner and J. N. Lanoix, World Health Organization, Geneva, 1959.

CONSTRUCTION OF A PLANE TABLE FOR MAP MAKING

The plane table described here can be used for mapping villages, roads, trenches and fields. This type of plane table has been widely used by professional surveyors.

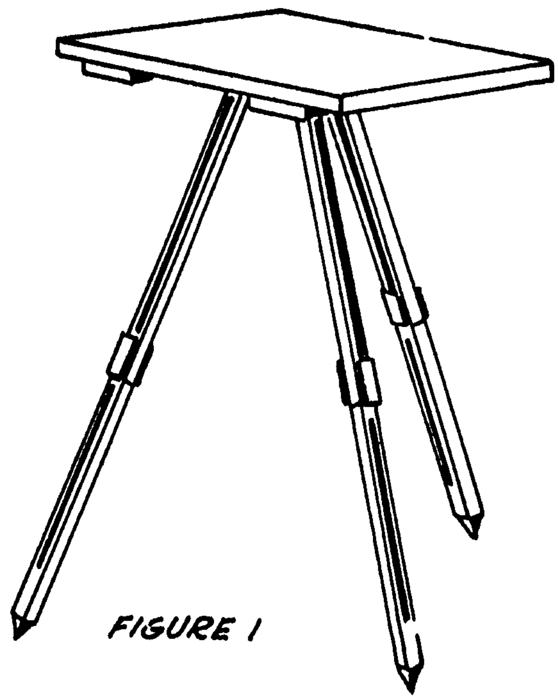


FIGURE 1

Tools and Materials

Some boards of soft wood, about 1858 square centimeters (2 square feet) approximately 2.5cm (1") thick

Some boards of a fairly strong wood, 19mm (3/4") to 2.5cm (1") thick, and at least 1m (3') long

7 bolts, 6mm (1/4") in diameter and 5cm (2") long

Nuts for each of the bolts, preferably wing nuts, and washers

Saw

Drill and 6mm (1/4") bit

Drawing Surface

From the soft wood, make a flat drawing surface. The one shown in Figure 1 is 40.5cm x 53.5cm (16" x 21") but any dimension of this general size-range is satisfactory. The surface should be sanded smooth and should be soft enough to permit easy use of thumb tacks and pins.

Pivot

To allow the table to be rotated on the tripod, a pivot is required. In the illustration, two 15cm (6") circles of 2.5cm (1") wood were cut. A 6mm (1/4") hole was drilled in the center of each circular block and one of the 6mm (1/4") bolts used as an axis. The head of the bolt was counter sunk so that a flush surface was available for nailing or screwing the upper block to the under side of the drawing board. This block should be centered.

Tripod Legs

The tripod legs are extendable, As Figures 2 and 3 show, each leg has two side rails, 10mm x 19mm x 81.3cm (3/8" x 3/4" x 32"), and a slotted center piece, 2.5cm x 16mm x 71.1cm (1" x 5/8" x 28"), which has been pointed at one end.

The legs are now assembled as follows: One end of two side rails is rounded in the 19mm (3/4") direction and a 6mm (1/4") hole is drilled 13mm (1/2") in from that end. A 6mm (1/4") hole is also drilled 15cm (6") from the other end.

Two wooden plates, 10mm x 4.5cm x 12.7cm (3/8" x 1 3/4" x 5") are nailed one on each side of the pair of side rails at the unrounded end. See Figure 3. This plate should space the side rails, such that the center piece may move reasonably freely but not be loose. The 6mm (1/4") wide slot in

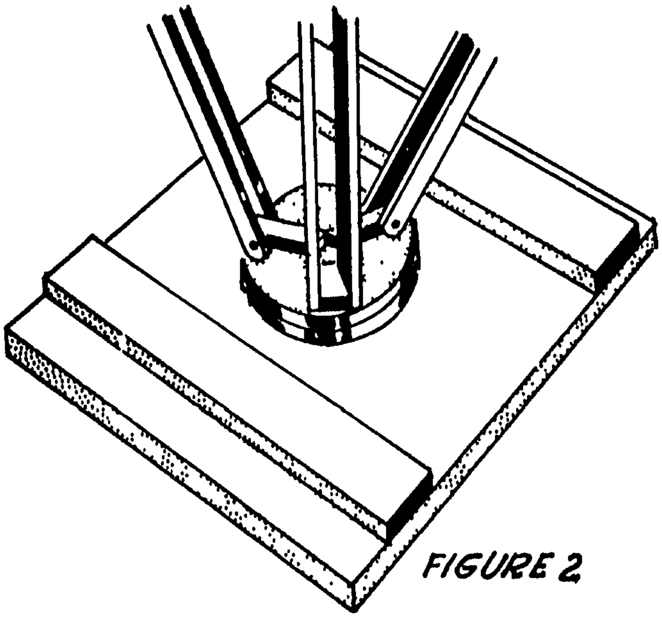


FIGURE 2

the 16mm (5/8") dimension (which extends most of the length of the center piece) will permit a 6mm (1/4") bolt to pass through. The blunt end of the center piece has been inserted up through the opening formed by the two plates and the two side rails: a 6mm (1/4") bolt may be passed through the hole in one side rail, through the slot in the center piece and then through the 6mm (1/4") hole in the other side rail; the wing nut is then put on. See Figure 4.

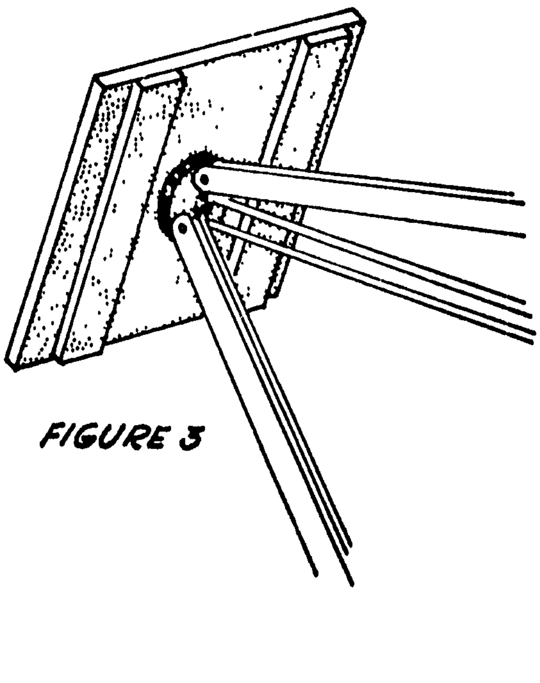


FIGURE 3

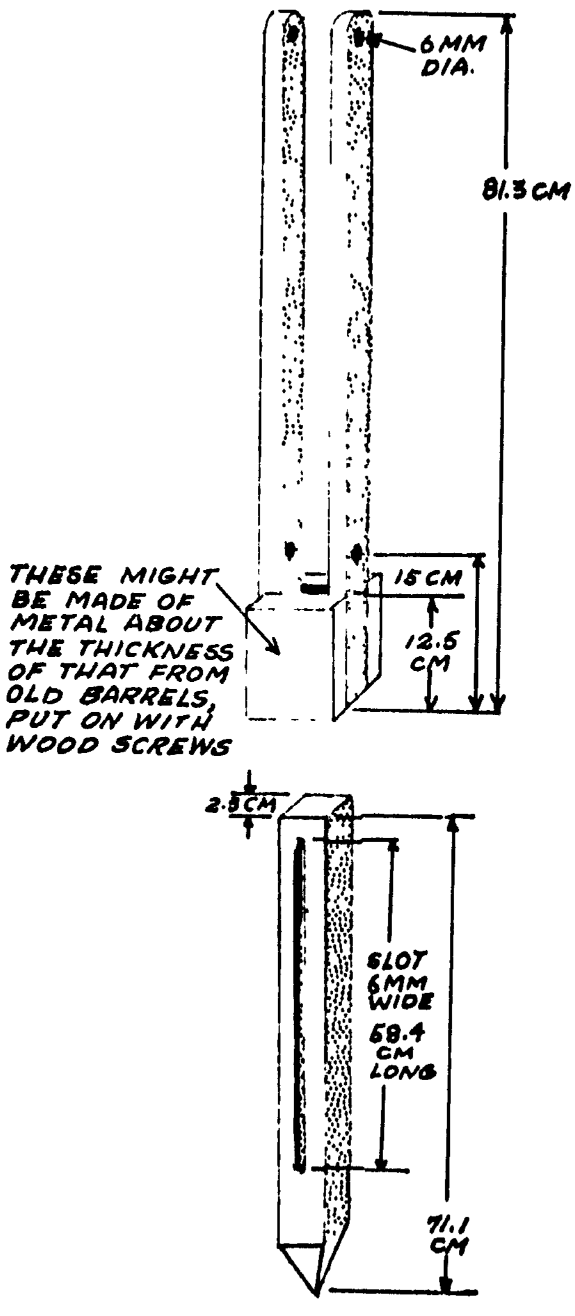


FIGURE 4
TRIPOD LEG

In order to affix the two side rails to the lower block, the latter must be cut away in a fashion to space the side rails 2.5cm (1") apart. It must be cut back somewhat more than the width, 22mm (7/8"), of the side rail. This lower block is cut away in this manner in three equally spaced locations, so that the legs will be equally spaced. A 6mm (1/4") hole is then drilled in line with the previously drilled holes in the rounded ends of the side rails. A 6mm (1/4") bolt may then be inserted through the three holes and a nut placed on the other end. See Figure 5.

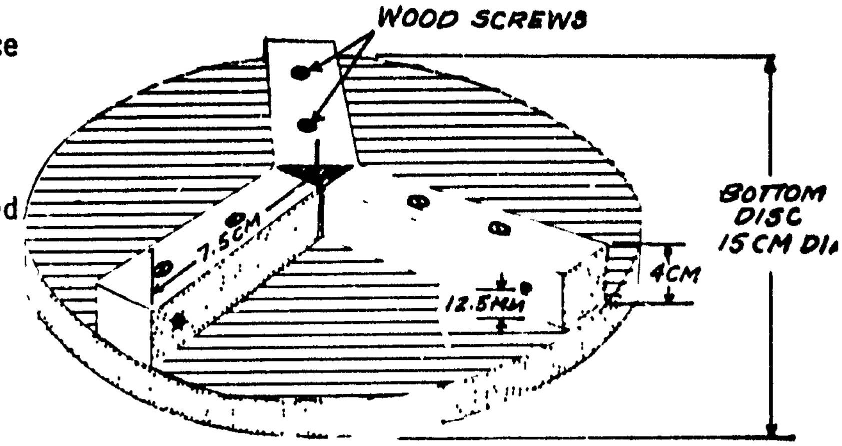


FIGURE 6

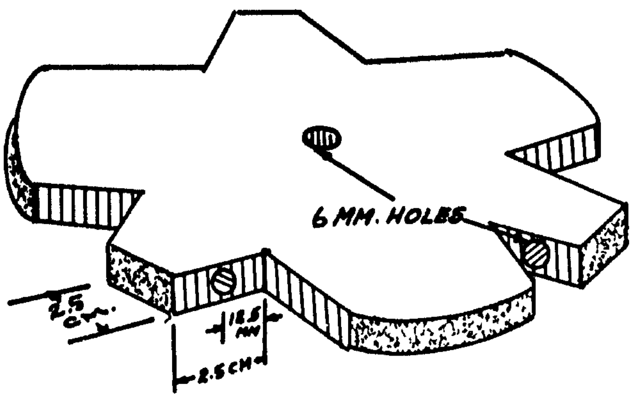


FIGURE 5
LOWER BLOCK

An alternate method of making the lower block, which will make the block stronger and should be used when it is made from soft wood, is shown in Figure 6. Three blocks of wood, 2.5cm x 3.8cm x 7.6cm (1" x 1 1/2" x 3"), are screwed to the 15cm (6") diameter lower block. A 6mm (1/4") diameter hole is drilled 13mm (1/2") from the end of each block, in the direction of the 2.5cm (1") thickness, to allow for attaching the leg.

The advantage of this method is the strength obtained by having the grain of the wood always at right angles to the bolt holding the leg in place. In the first method the grain will be parallel to one of the bolts and it will break if it is handled roughly, as it probably will be.

It is now possible to (1) change the length of the legs so that the table can be accommodated to sloping ground; (2) to change the spread of the legs to better accommodate setting up the table on rough grounds and; (3) rotate the drawing board in relation to the tripod.

The blown-up drawing in Figure 7 will be helpful in assembling the plane table. A table whose legs cannot be extended would still be useful. In this case, use single pieces, 22mm x 45mm x 142cm (7/8" x 1 3/4" x 56"), which are pointed on one end and cut away at the other end to allow for the same sort of connection to the lower end.

<u>Source:</u>

Dr. Robert G. Luce, VITA Volunteer, Schenectady, New York

Dale B. Fritz, Village Technology Director, VITA.

Ray Gomez, VITA Volunteer, Arcadia, California

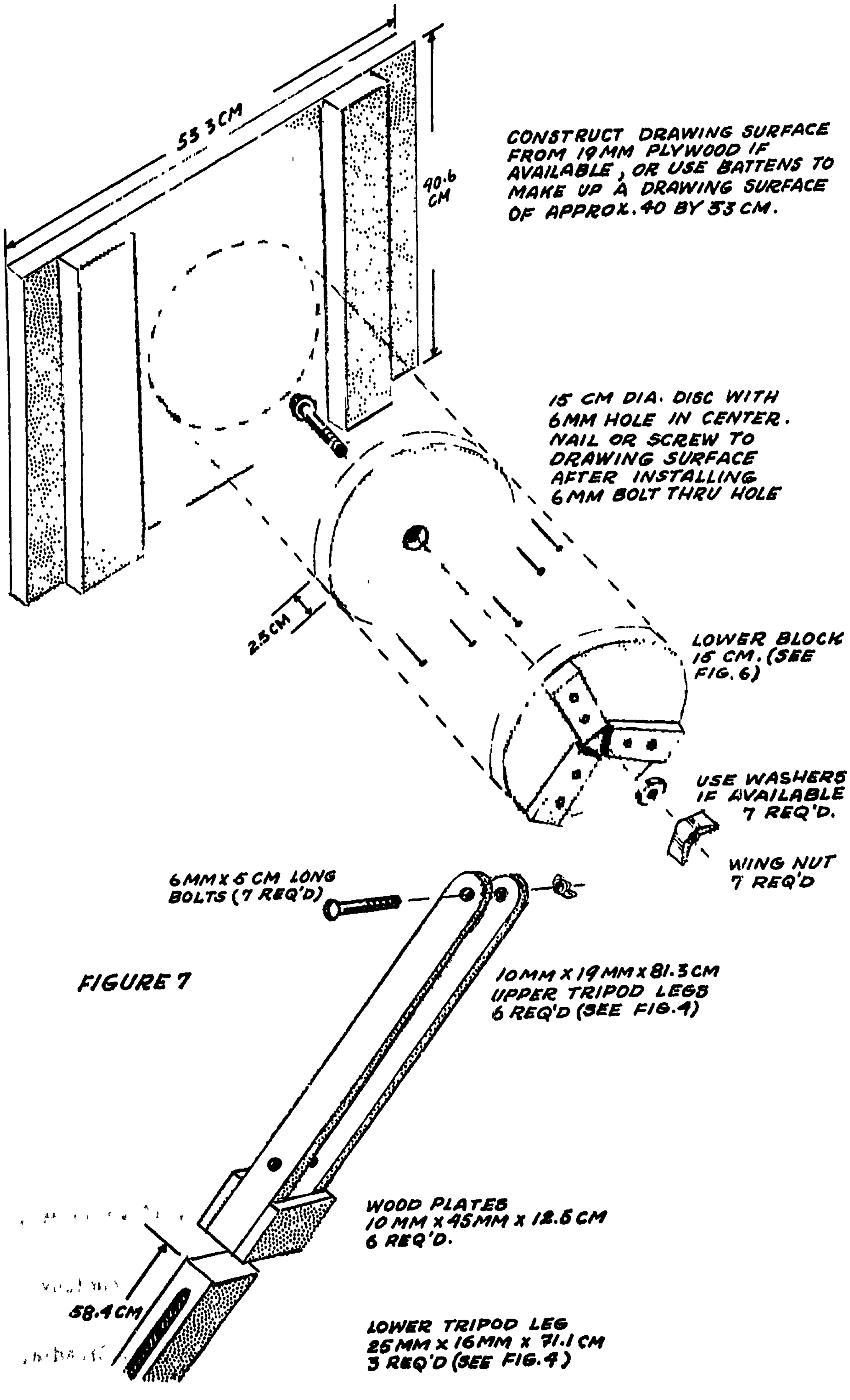

53.3 CM
40.6 CM
CONSTRUCT DRAWING SURFACE FROM 19MM PLYWOOD IF AVAILABLE, OR USE BATTENS TO MAKE UP A DRAWING SURFACE OF APPROX. 40 BY 53 CM.
15 CM DIA. DISC WITH 6MM HOLE IN CENTER. NAIL OR SCREW TO DRAWING SURFACE AFTER INSTALLING 6MM BOLT THRU HOLE
2.5 CM
LOWER BLOCK 15 CM. (SEE FIG. 6)
USE WASHERS IF AVAILABLE 7 REQ'D.
WING NUT 7 REQ'D
6MM x 5 CM LONG BOLTS (7 REQ'D)
10MM x 19MM x 81.3 CM UPPER TRIPOD LEGS 6 REQ'D (SEE FIG. 4)
WOOD PLATES 10 MM x 45MM x 12.5 CM 6 REQ'D.
58.4 CM
LOWER TRIPOD LEG 25MM x 16MM x 71.1 CM 3 REQ'D (SEE FIG. 4)

FIGURE 7

MAP-MAKING USING A PLANE TABLE

Instructions are given here for making serviceable maps using a plane table. Such maps are valuable for irrigation, drainage and village layout plans.

Before aerial photography, most topographical maps were made by the use of plane tables.

Tools and Materials

Plane table (see preceding entry)
Paper
Pencil
Ruler
Pins
Tape measure (optional)
Spirit level (optional)

Measuring Pace

If no long tape measure is available, the first step for a map maker is to measure his pace: A 30-meter (100-foot) distance should be measured out on level ground. If only a 30cm (12") ruler is available, this can be used to mark out a meter (3' or 4') on a stick; this stick in turn can be used to measure the 30m (100'). Being careful to walk normally, the map maker then counts the number of paces he takes in walking the 30m (100') interval. Simple division will then give the average length of a pace.

Map Scale

The next step is to decide on a scale for the map. This is determined by judging the longest distance to be mapped and the size of the map desired. The map does not have to be made on a single sheet of paper; it can be pieced together from several sheets when it is completed. For example: if you want a map 80cm (2 1/2') long of an area whose longest dimension is 800 meters (1/2 mile or 2540 feet), then a scale of 1 meter to 1cm (100 feet to the inch) would be convenient.

Map Making

1. Place paper on the plane table and orient the plane table on or near some principal feature of the area; for example, a path, road, creek or tree.

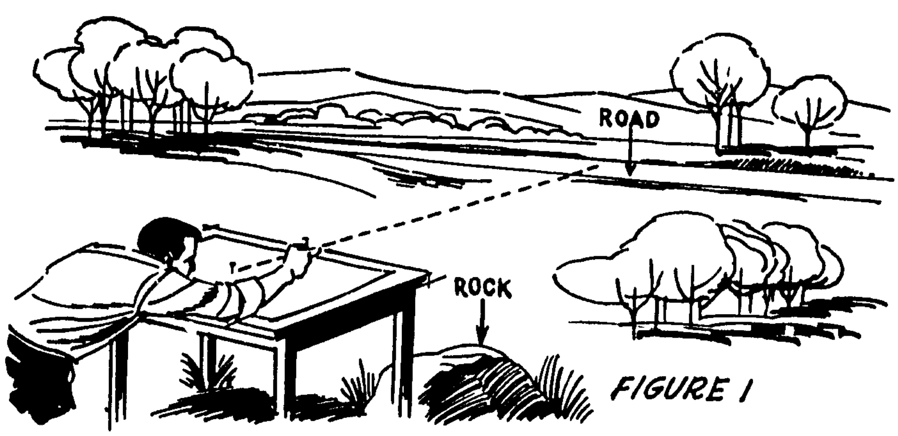


FIGURE 1

2. Place a pin vertically in the spot on the map to locate this feature.

3. Make the plane table level; for example, by using a spirit level. If a spirit level is not available, you can level the table by using anything which rolls easily.

4. Rotate the table to a proper orientation, so that the map will be made in the desired direction.

5. Sight along the first pin to another principal feature which is visible from the table location (a bend in a road, a hill or any feature which will tie the map together, moving the second pin into the line of sight (see Figure 1). A ruler can be used for this purpose if it has a sighting edge; a sighting edge can be made by sticking a couple of pins into the ruler.

6. Draw a line in the direction defined by the two pins.

7. Measure the distance to the feature observed either by pacing or with a tape measure.

8. Scale this distance along the line drawn on the map, starting at the first pin.

9. Repeat this process for other principal features which can be seen from this location (see Figure 2).

10. When this has been done, move the table to one of the points just plotted, selecting one which will enable you to move over the area conveniently. For example, follow a lane or creek or some feature which ties things together.

11. Set the plane table over this point and re-orient the table by putting pins in the map at the present and previous locations. This procedure locates the line joining the two locations on the map in the same direction as the line exists in nature, making it possible to go on to the next step with the map oriented properly.

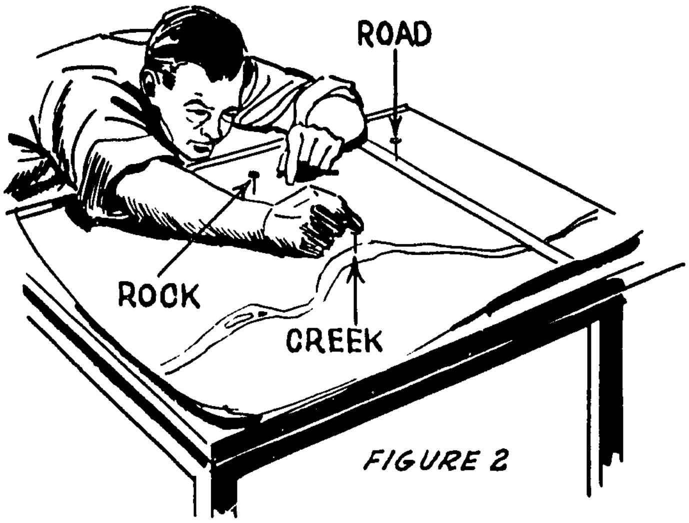


FIGURE 2

12. From this new location, map in the principal features which can be conveniently sighted.

In this way the entire region to be mapped may be covered in a systematic way. If gaps appear or if more detail is needed, go back and set up over some mapped feature, reorient the map by sighting on a second feature, and proceed to map in the detail.

To map features which are not going to be used as plane table locations in the mapping process, draw a line in the direction of each feature from two plane-table locations. The intersection of these two lines corresponding to a single feature locates the feature on the map. This avoids the need for measuring distances. Note, however, that the distances between plane-table locations must be measured.

Relative Elevations

If a spirit level is available, it is possible to level the plane table accurately and, using a ruler or other sighting device, plot relative elevations on the map.

A stick about 2 or 3 meters (6' or 8') long should be marked off in centimeters (inches). A person holding the stick vertically can, by moving his finger up or down, identify to the person sighting the distance up from the ground through which the line of sight passes.

Source:

Dr. Robert G. Luce, VITA Volunteer, Schenectady, New York

APPENDIX

Simple methods are given here for converting English and metric units of measurement. Following these is a series of useful conversion tables for units of area, volume, weight, pressure and power.

LENGTH CONVERSION

The chart in Figure 3 is useful for quick conversion from meters and centimeters to feet and inches, or vice versa. For more accurate results and for distances greater than 3 meters, use either the tables in Figure 2 or the equations.

The chart in Figure 3 has metric divisions of one centimeter to three meters, and English units in inches and feet to ten feet. It is accurate to about plus or minus one centimeter.

Example:

An example will explain how to use the tables. Suppose you wish to find how many inches are equal to 66cm. On the "Centimeters into Inches" table look down the leftmost column to 60cm and then right to the column headed 6cm. This gives the result, 25.984 inches.

FIGURE 1

Equations:

1 inch = 2.54cm
1 foot = 30.48cm
= 0.3048m
1 yard = 91.44cm
= 0.9144m
1 mile = 1.607km
= 5280 feet
1cm = 0.3937 inches
1m = 39.37 inches
= 3.28 feet
1km = 0.62137 miles
= 1000 meters

FIGURE 2

INCHES INTO CENTIMETERS
(1 in. = 2.539977 cm.)

inches	0	1	2	3	4	5	6	7	8	9
0	cm	2 54	5 08	7 62	10 16	12 70	15 24	17 78	20 32	22.86
10	25.40	27 94	30 48	33 02	35 56	38 10	40 64	43 18	45.72	48 26
20	50 80	53 34	55 88	58 42	60 96	63 50	66 04	68 58	71 12	73.66
30	76 20	78.74	81 28	83 82	86 36	88 90	91 44	93 98	96 52	99.06
40	101 60	104 14	106 68	109 22	111 76	114 30	116 84	119 38	121 92	124.46
50	127.00	129 54	132 08	134 62	137 16	139 70	142 24	144.78	147 32	149.86
60	152 40	154 94	157.48	160 02	162 56	165 10	167 64	170 18	172 72	175.26
70	177 80	180 34	182 88	185 42	187 96	190 50	193 04	195 58	198 12	200 66
80	203.20	205 74	208.28	210 82	213 36	215 90	218 44	220 98	223 52	226.06
90	228.60	231.14	233.68	236 22	238 76	241 30	243 84	246 38	248 92	251.46

CENTIMETERS INTO INCHES
(1 cm. = 0.3937 in.)

cm.	0	1	2	3	4	5	6	7	8	9
0	inches	0.394	0.787	1.181	1 575	1 969	2 362	2 756	3 150	3.543
10	3.937	4.331	4.724	5.118	5.512	5.906	6.299	6.693	7.087	7.480
20	7.874	8 268	8.661	9 055	9.449	9.843	10 2[illegible]6	10.630	11 024	11.417
30	11.811	12.205	12 598	12 992	13 386	13.780	14.173	14.567	14.961	15.354
40	15.748	16 142	16 535	16 929	17.323	17.717	18.110	18 504	18 898	19.291
50	19.685	20 079	20 472	20 866	21.260	21.654	22 047	22.441	22.835	23.228
60	23.622	24 016	24 409	24 803	25.197	25 591	25.984	26 378	26.772	27.165
70	27.559	27.953	28 346	28.740	29 134	29 528	29 921	30 315	30 709	31.102
80	31 496	31.890	32 283	32 677	33 071	33.465	33 858	34.252	34.646	35.039
90	35.433	35.827	36.220	36.614	37.008	37.402	37.795	38.189	38.583	38.976

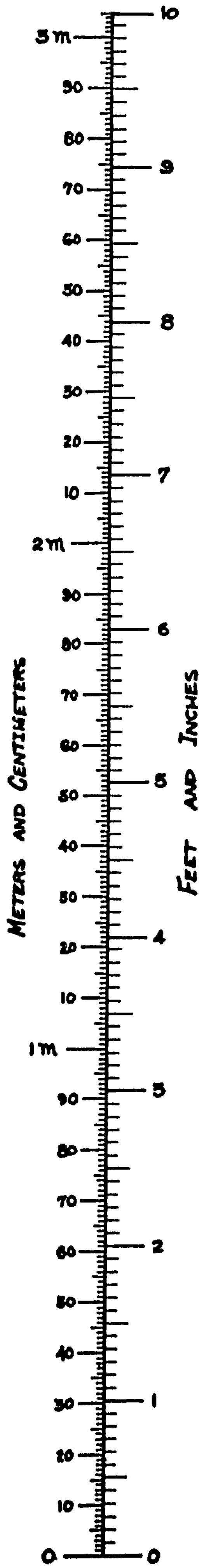
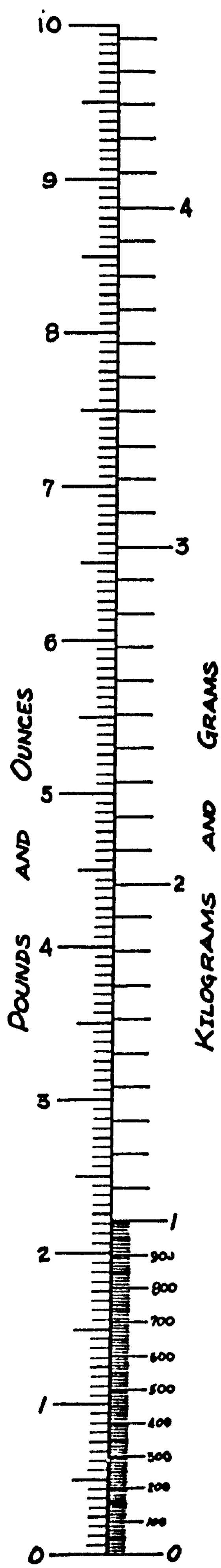


FIGURE 3

WEIGHT CONVERSION

FIGURE 5



The chart in Figure 5 converts pounds and ounces to kilograms and grams or vice versa. For weights greater than ten pounds, or more accurate results, use the tables (Figure 4) or conversion equations. See "Length Conversion," Figure 2, for an example of the use of the tables.

On the chart, notice that there are sixteen divisions for each pound to represent ounces. There are 100 divisions only in the first kilogram, and each division represents ten grams. The chart is accurate to about plus or minus twenty grams.

Equations:

1 ounce = 28.35 grams
1 pound = 0.4536 kilograms
1 gram = 0.03527 ounce
1 gram = 2.205 pounds

FIGURE 4

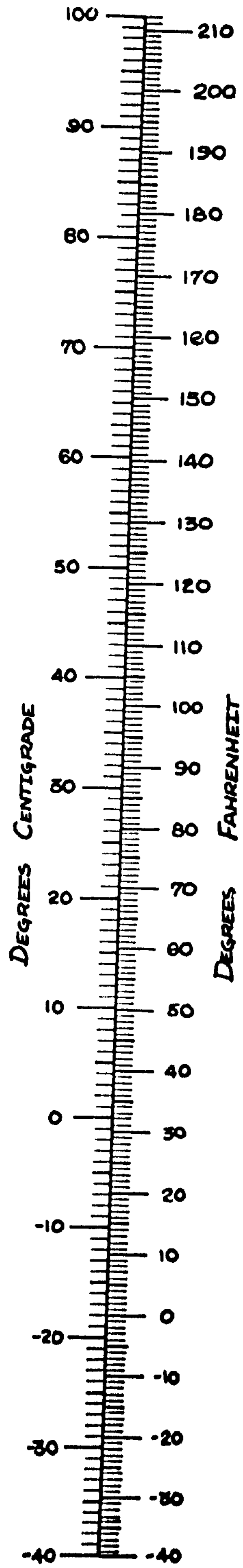
KILOGRAMS INTO POUNDS
(1 kg. = 2.20463 lb.)

kg.	0	1	2	3	4	5	6	7	8	9
0	lb	2 20	4 41	6 61	8 82	11 02	13 23	15 43	17.64	19 84
10	22 05	24 25	26 46	28 66	30 86	33 07	35 27	37 48	39 68	41 89
20	44 09	46 30	48 50	50 71	52 91	55 12	57 32	59 53	61 73	63 93
30	66 14	68 34	70 55	72 75	74 96	77 16	79 37	81 57	83 78	85 98
40	88 19	90 39	92 59	94 80	97 00	99 21	101 41	103 62	105 82	108 03
50	110 23	112 44	114 64	116 85	119 05	121 25	123 46	125 66	127 87	130 07
60	132 28	134 48	136 69	138 89	141 10	143 30	145 51	147 71	149 91	152.12
70	154 32	156 53	158 73	160 94	163 14	165 35	167 55	169 76	171 96	174.17
80	176 37	178 58	180 78	182 98	185 19	187 39	189 60	191 80	194 01	196.21
90	198 42	200 62	202 83	205 03	207 24	209 44	211 64	213 85	216 05	218 26

POUNDS INTO KILOGRAMS
(1 lb. = 0 45359 kg.)

lb.	0	1	2	3	4	5	6	7	8	9
0	kg.	0.454	0 907	1 361	1 814	2 268	2.722	3.175	3.629	4.082
10	4.536	4.990	5.443	5 897	6 350	6 804	7.257	7 711	8.165	8.618
20	9.072	9 525	9 979	10 433	10 886	11 340	11 793	12 247	12 701	13.154
30	13 608	14 061	14 515	14 969	15 422	15 876	16 329	16.783	17 237	17 690
40	18 144	18 597	19 051	19 504	19 958	20 412	20 865	21 319	21.772	22.226
50	22 680	23 133	23 587	24 040	24 494	24 948	25 401	25 855	26 308	26.762
60	27.216	27 669	28 123	28 576	29 030	29 484	29 937	30 391	30 844	31 298
70	31.751	32 205	32 659	33 112	33 566	34 019	34 473	34 927	35 380	35 834
80	36.287	36 741	37 195	37 648	38 102	38 555	39 009	39 463	39 916	40 370
90	40 823	41.277	41.730	42.184	42 638	43 091	43.545	43 998	44 452	44.906

FIGURE 1



TEMPERATURE CONVERSION

The chart in Figure 1 is useful for quick conversion from degrees Celsius (Centigrade) to degrees Fahrenheit and vice versa. Although the chart is fast and handy, you must use the equations below if your answer must be accurate to within one degree.

Equations:

Degrees Celsius = 5/9 x (Degrees Fahrenheit -32)

Degrees Fahrenheit = 1.8 x (Degrees Celsius) +32

Example:

This example may help to clarify the use of the equations; 72F equals how many degrees Celsius?

72F = 5/9 (Degrees F -32)

72F = 5/9 (72 -32)

72F = 5/9 (40)

72F = 22.2C

Notice that the chart reads 22C, an error of about 0.2C.

Conversion Tables

Units of Area

1 Square Mile	= 640 Acres	= 2.5899 Square Kilometers
1 Square Kilometer	= 1,000,000 Square Meters	= 0.3861 Square Mile
1 Acre	= 43,560 Square Feet	
1 Square Foot	= 144 Square Inches	= 0.0929 Square Meter
1 Square Inch	= 6.452 Square Centimeters	
1 Square Meter	= 10.764 Square Feet	
1 Square Centimeter	= 0.155 Square Inch	

Units of Volume

1.0 Cubic Foot	= 1728 Cubic Inches	= 7.48 U.S. Gallons
1.0 British Imperial Gallon	= 1.2 U.S. Gallons	
1.0 Cubic Meter	= 35.314 Cubic Feet	= 264.2 U.S. Gallons
1.0 Liter	= 1000 Cubic Centimeters	= 0.2642 U.S. Gallons

Units of Weight

1.0 Metric Ton	= 1000 Kilograms	= 2204.6 Pounds
1.0 Kilogram	= 1000 Grams	= 2.2046 Pounds
1.0 Short Ton	= 2000 Pounds	

Conversion Tables

Units of Pressure

1.0 Pound per square inch	= 144 Pounds per square foot
1.0 Pound per square inch	= 27.7 Inches of Water*
1.0 Pound per square inch	= 2.31 Feet of Water*
1.0 Pound per square inch	= 2.042 Inches of Mercury*
1.0 Atmosphere	= 14.7 Pounds per square inch (PSI)
1.0 Atmosphere	= 33.95 Feet of Water
1.0 Foot of Water = 0.433 PSI	= 62.355 Pounds per square foot
1.0 Kilogram per square centimeter	= 14.223 Pounds per square inch
1.0 Pound per square inch	= 0.0703 Kilogram per square centimeter

* at 62 degrees Fahrenheit (16.6 degrees Celsius)

Units of Power

1.0 Horsepower (English)	= 746 Watts = 0.746 Kilowatt (KW)
1.0 Horsepower (English)	= 550 Foot Pounds per second
1.0 Horsepower (English)	= 33,000 Foot Pounds per minute
1.0 Kilowatt (KW) = 1000 Watts	= 1.34 Horsepower (HP) English
1.0 Horsepower (English)	= 1.0139 Metric Horsepower (cheval-vapeur)
1.0 Metric Horsepower	= 75 Meters X Kilogram/Second
1.0 Metric Horsepower	= 0.736 Kilowatt = 736 Watts