DISINFECTION TECHNIQUES

FOR

SMALL COMMUNITY WATER SUPPLIES

REPORT

PREPARED FOR

WORLD HEALTH ORGANIZATION

BY

CENTRAL PUBLIC HEALTH ENGINEERING RESEARCH INSTITUTE

NAGPUR, INDIA

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CONTENTS

1.0 INTRODUCTION

Epidemiological studies have amply proved the role of water in the spread of enteric diseases and the effective utilization of water treatment practices has contributed to a significant reduction of these diseases. Substantial progress in the provision of protected water supply to its teeming millions has been made in India during the last 20 years as can be seen from the trend in Table I.

TABLE I

PROGRESS IN PROVISION OF WATER SUPPLIES

Year	Population in millions			%
	Rural	Urban	Total	Population served with protected water supply
1941	274.2	44.3	318.5	-
1949	293.4	59.1	352.5	21.65
1951	298.5	62.5	361.0	-
1961	360.1	79.0	439.1	47.41

In terms of numbers, the population that is yet to be provided with protected water supply is a formidable number. The problem is further aggravated by the fact that more than 75 per cent of the Indian population lives in villages which depend mostly on open dug wells for their water supply. No piped water supply scheme exists in the majority of villages and the backlog of water supply schemes to be undertaken is so enormous that it will be many years before all villages can be expected to have piped water supply schemes. Further with the rate of population growth being such that the population is likely to double itself every 25 to 30 years, it is a moot point whether the backlog will ever be wiped out.

It is, therefore, evident that a large number of people will have to depend on the village wells for long a time to come. While proper attention can be given to the location and sanitary construction of new wells it would be impracticable to renovate or to relocate the large number of existing wells which are in an insanitary condition. Surveys carried out by the Central Public Health Engineering Research Institute, Nagpur and others have invariably shown that open dug wells are highly polluted. * It is no wonder that the death rate for enteric diseases in India is approximately 360 per 100,000.

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* 1) Kaushik, N.K., Prasad, D. and Bishnoi, C.N., " A Study of Well Waters in Rural Delhi ", Env. Hlth. 5 : 128, 1963

2) Kaushik, N.K., Prasad, D., " Seasonal Variation in Coliform and Enterococcus Organisms in Well Waters ", Env. Hlth., 6 : 251, 1964

3) Mishra, R.P., Parhad, N.M. and Rao, N.U., " Bacteriological Standards and Water Quality ", Env. Hlth., 11 : 163, 1969

4) Bagchi, S.C., Murthy, Y.S. and Prasad, B.G., " A Study of Water Supply in Rural Health Center, Sarojininagar, Lucknow District ", Jour. of Indian Medical Sciences, 16 : 1048 - 1062, 1962

For this reason, the Report on National Water Supply and Sanitation Schemes for India (June 1961) states that " Chlorinating equipments of the small, medium, and large sizes will have to play a vital role in ensuring the safety of water supply systems all over the country in the coming years. They are needed both for rural and urban schemes. A cheap, durable, foolproof device for chlorinating rural water supply is a sine qua non. "

Disinfection of rural water supplies, particularly well waters had been engaging the attention of this Institute for quite some time, with a view to develop a better method of disinfection, than the practice of mere dumping of bleaching powder into wells. In this work of the Institute, welcome support was received from the Community Water Supply Unit of the Division of Environmental Health, World Health Organization, Geneva, which gave financial assistance to the tune of 4000 dollars in 1967, to enable the Institute to work specifically on the project entitled " Disinfection Techniques for Small Community Water Supplies ".

2.0 TERMS OF REFERENCE

According to the agreement between the Central Public Health Engineering Research Institute, Nagpur and the World Health Organization, it was agreed that the Central Public Health Engineering Research Institute would provide supervision, staff, instrumentation, laboratory and workshop facilities, raw materials and labour for field trials, for a one year study on the following lines :

1. Investigation on the use of chloride of lime solution as a disinfectant and its application in both rural and community water supplies.

2. Literature survey

3. Laboratory work under the following heads :

   a) Characteristics of chloride of lime in solid form
   b) Characteristics of chloride of lime solution
   c) Development of feeding devices
   d) Solution containers and ancillaries

4. Field work

   Use of a device or devices developed on a convenient water source

3.0 BLEACHING POWDER FOR DISINFECTION

Bleaching powder ($CaOCl_2$, chloride of lime) is an easily available and cheap chlorine compound. It is easy to transport and not hazardous to handle. The use of this compound for disinfection of water dates back to 1897 when Sims Woodhead treated the water supply of Maidstone, England, by chlorinated lime as a temporary measure during a typhoid epidemic.

As a continuous part of water treatment, Maurice Dyke used bleaching powder along with ferric chloride at Middle Kerke, Belgium in his " Ferro-Chlor " process in the year 1902 for the first time. In this process bleaching powder and ferric chloride solutions were applied to raw water for coagulation and disinfection.

In U.S.A., George, A. Johnson treated successfully raw water supply of Bubby Creek filter plant at Chicago Stockyard with chlorinated lime in the year 1908 and by 1914, supplies totalling 800 mgd were being treated with bleaching powder solution for disinfection.

With the development of techniques to use gaseous chlorine for water treatment, the popularity of bleaching powder waned. However, for small communities bleaching powder is still a disinfectant of choice.

Bleaching powder is commercially available as a free flowing white or yellowish white dry powder having the hypochlorous acid smell. It usually contains 33 to 37 per cent of available chlorine when fresh. It always contains free lime, small amounts of calcium chloride and chlorates. Grit and other insoluble impurities are also present depending on the quality of the raw material used.

3.1 Availability of Bleaching Powder in India

The production of bleaching powder in India for the last 10 years is given below :

TABLE II

YEARWISE PRODUCTION OF BLEACHING POWDER IN INDIA

Year	Metric ton per year	Year	Metric ton per year
1957	7,100	1962	6,800
1958	7,300	1963	6,969
1959	5,200	1964	7,932
1960	5,900	1965	7,356
1961	7,100	1966	10,812

Bleaching powder is available in 40, 50 and 100 kg. galvanized iron drums in airtight packages.

The potential for the consumption of bleaching powder is indeed quite large as can be seen from data given in Table III.

TABLE III

DISTRIBUTION OF COMMUNITIES BY POPULATION GROUPS

No. of persons	No. of villages	Population	Percentage of total rural population
Less than 200	176,384	17,673,271	4.91
200 - 499	173,184	57,564,811	16.05
500 - 999	119,197	83,872,822	23.33
1000 - 1999	65,309	89,482,705	24.89
2000 - 4999	26,475	76,421,290	21.26
5000 - 9999	3,396	22,175,406	6.16
10000 & above	773	12,245,302	3.40

From the above Table, it can be seen that villages having a population of 2000 or less constitute nearly 69 per cent of the total population. In such villages it is not possible to use chlorine gas apparatus for disinfection. On the assumption that 25 to 50 liters of water per day is consumed by the villagers, about 7000 to 14,000 metric tons per year of bleaching powder is required for disinfection purposes alone to maintain effective chlorine concentration. This figure is arrived at, on the basis of 30 per cent available chlorine in bleaching powder and the need for 1 mg/l of chlorine (part of it will be for meeting the chlorine demand and the rest for disinfection) for effective chlorination.

Two widely used and popular brands of stable bleaching powder, manufactured in India, were analysed and the results are given in Table IV.

TABLE IV

ANALYSIS OF SOME BLEACHING POWDERS AVAILABLE IN INDIA

Bleaching powder	Per cent Wt/Wt Available chlorine	Total chlorine	Grit	Heat stability test (fraction of available chlorine lost at $100^{\circ} \pm 2^{\circ}C$ in 2 hrs.
Brand 1	32.3	33.7	3.5	1/10
Brand 2	35.14	41.36	1.14	1/16

3.2 Available Standards

According to the recommendations of Indian Standards Institution (ISI), New Delhi, stable bleaching powder as given in IS : 1065 (1957) should contain at least 33 per cent available chlorine at the time of manufacture. It should not lose more than 1/11 of available chlorine in the heat stability test. There are no specifications about the permissible percentage of grit and other impurities.

3.3 Loss of Chlorine on Storage

It can be seen from Figure 1, that the bleaching powder stored in a container which is opened once a day for 10 minutes loses nearly 5 per cent of its initial chlorine in a span of 40 days. However, when the container is left fully open it loses as much as 18 per cent of its initial chlorine in the same period.

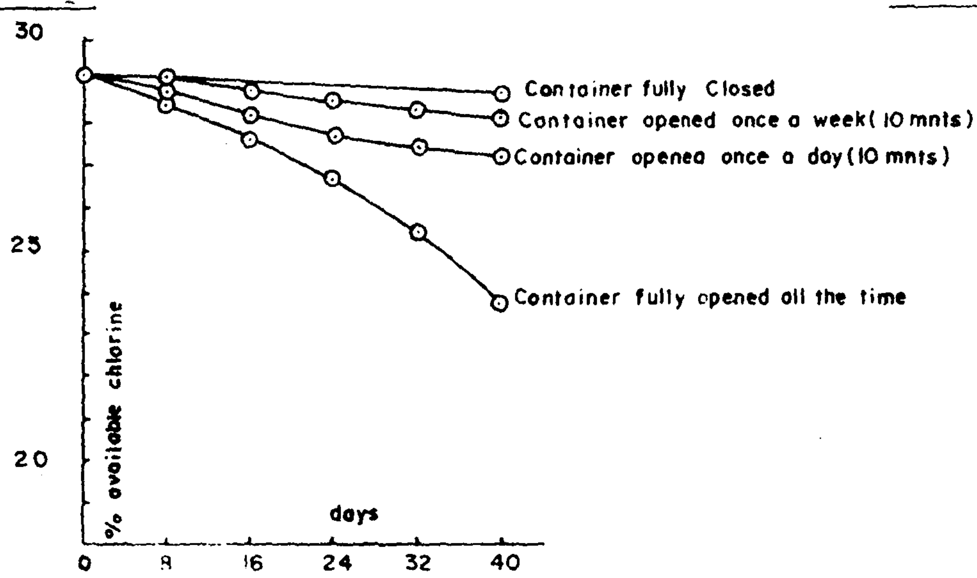

FIG. 1

Bleaching powder solution is, however, more sensitive to storage conditions. The solution can be stored in a container from which light is cut off, for 10 days without much loss of chlorine. When the glass container is exposed to light there is considerable loss of chlorine during the same period (Figure 2).

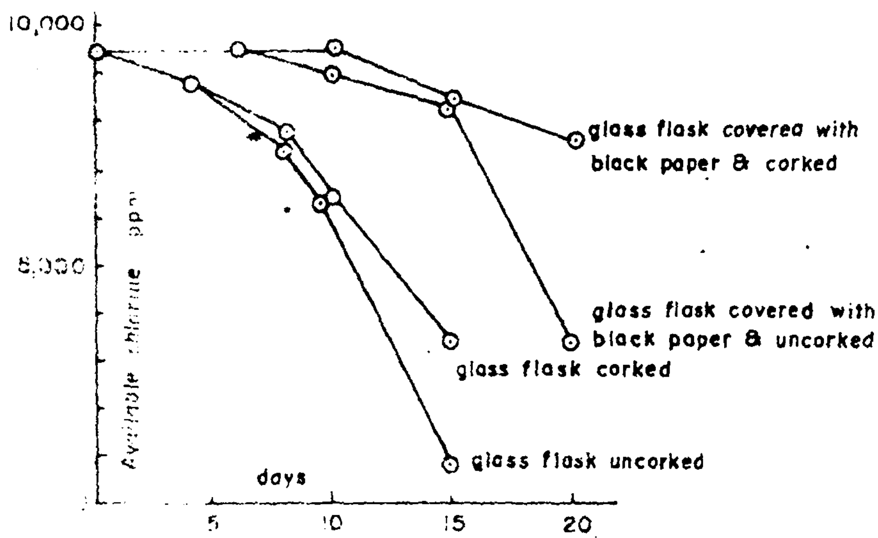

FIG. 2

3.4 Working Hazards and Handling Requirements

Bleaching powder should be handled with clean and dry equipment free from easily oxidisable substances. Because it is highly corrosive, the bleaching powder drums should be stored separately from tools and machinery particularly after they are opened once. Once the bleaching powder tin is opened it should be consumed as early as possible. It is always desirable to choose such sizes that can be consumed in a relatively short period. When a leaking or defective container is detectable it should be removed to another place.

Bleaching powder solution is corrosive and hence corrosion resistant vessels made of wood, ceramic, glass, plastics or cement should be used for handling.

While opening the can or handling bleaching powder, it gives a strong smell which can cause nausea, giddiness, vomiting and irritation of mucous membranes. In handling bleaching powder the simplest and yet the most effective method is to tie a damp cloth or handkerchief around the nose. The solution should be handled carefully as it may affect the skin or other body tissues, which may come in contact. Rubber gloves and aprons should be worn while handling bleaching powder or its solution. The usual principle of good ventilation should be kept in view when designing the bleaching powder storage and handling facilities.

3.5 Characteristics of Bleaching Powder Solution

Bleaching powder absorbs moisture and becomes sticky when exposed to atmosphere, hence dry feeding is not possible. In the manufacture of bleaching powder, free lime is always present or is added to stabilise it. When dissolved in water some sediment which is mostly calcium hydroxide, calcium carbonate and grit is always present.

Bleaching powder has a tendency to form lumps in water while dissolving in it. These lumps should be broken carefully and the material shaken vigorously with water. In practice it is not possible to mix bleaching powder thoroughly, particularly with the large amounts usually handled. Thus, some percentage of available chlorine is always lost in the sediment. Experiments were, therefore, carried out to determine that percentage solution of bleaching powder which can be prepared manually without much loss of available chlorine in the sediment.

TABLE V

RELATIONSHIP BETWEEN STRENGTH OF BLEACHING POWDER SOLUTION AND LOSS OF CHLORINE ($33^{o}C$)

% strength of bleaching powder solution (Wt/Vol)	% chlorine concentration in solution (Wt/Vol)	% chlorine concentration in the filtrate (after passing through filter paper No. 42)	Percentage loss of chlorine $\frac{Col.\ 2 - Col.\ 3}{Col.\ 2} \times 100$
Column 1	Column 2	Column 3	Column 4
0.50	0.150	0.150	0
1.00	0.309	0.307	0.65
2.50	0.755	0.745	1.32
5.00	1.537	1.497	2.60
10.00	0.0313 ?	2.731	9.91

It can be seen from Table V that strengths of solutions upto 2.50 per cent result in small losses of chlorine and hence may be adopted but could be increased to 5 per cent to keep the size of containers economical. However, stronger solutions (more than 5 per cent) are not advisable since there is considerable loss of chlorine.

3.6 Sludge Volume

Sludge volumes for different concentrations of bleaching powder solution are given in Table VI. The sludge which settles at the bottom mainly contains calcium hydroxide, calcium carbonate and grit, and is not desirable to be added to the water supply and thus must be excluded from the solution.

TABLE VI

SLUDGE VOLUMES AT DIFFERENT CONCENTRATIONS OF BLEACHING POWDER SOLUTION

Bleaching powder solution (%)	% volume of container occupied by sludge after overnight settling
1	1
2	2
2.5	2.5
5	5.3
10	11

3.7 Effect of Mixing Water Quality and Temperature

The effect of mixing water quality was studied by dissolving bleaching powder in distilled water and in a well water which was moderately hard. The composition of the well water is given below :

pH		7.7
Total hardness	(as $CaCO_3$)	170 mg/l
Calcium	"	100 "
Magnesium	"	70 "
Total alkalinity	"	402 "
Methyl orange alkalinity	"	402 "
Phenolphthalein alkalinity	"	Nil
Free CO_2.		5.0

Bleaching powder was thoroughly mixed in distilled water and the well water. These tests were carried out at 35°C and 6°C. The suspension was filtered to give a clear filtrate. Available chlorine in these filtrates was almost the same (Table VII).

TABLE VII

Bleaching powder solution (%)	Chlorine Concentration in the Filtrate (%)			
	Distilled water		Well water	
	35°C	6°C	35°C	6°C
0.5	0.150	0.152	0.149	0.150
1.0	0.305	0.301	0.305	0.296
2.5	0.765	0.750	0.755	0.750
5.0	1.497	1.355	1.497	1.375

It is to be expected that available well waters will be invariably used in the field for preparing solutions. This limited experimentation shows that there is no significant difference between the concentrations obtained by using either well water or distilled water for preparing the bleaching powder solution.

The advantage with well water is that, after allowing the solution to settle, the supernatant becomes clearer as compared to that in distilled water. This is presumably due to the reaction of the calcium hydroxide of the bleaching powder solution with the alkalinity in the well water. Calcium carbonate and magnesium hydroxide are precipitated in the reaction. While settling down they presumably trap the fine suspended particles making the solution clearer than the solution obtained with distilled water. This can be explained by the following equations :

$$Ca(HCO_3)_2 + Ca(OH)_2 = 2\ CaCO_3 + 2\ H_2O$$

$$Mg(HCO_3)_2 + 2\ Ca(OH)_2 = Mg(OH)_2 + 2\ CaCO_3 + 2\ H_2O$$

$$MgSO_4 + Ca(OH)_2 = Mg(OH)_2 + CaSO_4$$

3.8 Chemistry of Chlorination with Bleaching Powder

Calcium oxychloride ($CaOCl_2$) is generally accepted as the principal ingredient of bleaching powder. When mixed with water calcium oxychloride decomposes into active and inactive components. The active portion is hypochlorous acid (HOCl) and the inactive portion is calcium chloride. The following reactions take place :

$$2\ CaOCl_2 + 4\ H_2O \rightleftharpoons 2\ Ca(OH)_2 + 2\ HCl + 2\ HOCl \quad \ldots (1)$$

$$2\ HCl + Ca(OH)_2 \longrightarrow CaCl_2 + H_2O \quad \ldots (2)$$

$$HOCl \rightleftharpoons H^+ + OCl^- \quad \ldots (3)$$

Both HOCl and OCl^- in Equation 3 are important for disinfection, although HOCl is more active of the two. Depending on the pH of the water the relative proportion of HOCl and OCl will change. At pH 6.0, 96 per cent of the chlorine solution present as HOCl ; whereas at pH 7.0, it will be 75 per cent and at pH 9.0 it will be only 3 per cent.

4.0 DISINFECTION OF OPEN DUG WELLS

With over 75 per cent of Indian population living in small communities in villages, the importance of hygienic quality of well waters needs no emphasis, as it forms a major source of water supply to these communities. Open dug wells abound in number in India and account for a large percentage of total wells. It has been observed that fecal contamination is invariably present in all open dug wells. These wells get easily contaminated with none too good methods of drawing water and unhygienic and indiscriminate use of the surroundings.

The importance of construction and maintenance of sanitary wells cannot be overlooked, since prevention is always better than cure. The wells should be located at a higher elevation and as far as possible from sources of contamination (at a minimum distance of 50 ft), such as latrines, septic tanks, cesspools and similar structures. However, the distance will depend upon the nature of the subsoil. The contour of the ground should be such that the water will drain away from the well In the absence of natural drainage, properly protected fill, sloping away from the well should be provided to assure drainage around the well. The walls of the wells should be water-tight to the depth of at least 10 ft. below the natural ground surface. The well should be covered.

While well waters can be treated by the addition of bleaching powder or any other disinfectant every day, any method or device that will give effective chlorine concentration for a period of 3 to 4 weeks at a stretch or even for 2 weeks, would be of immense use. It would be ideal if this device can be cheap, simple and can be fabricated with indigenous materials and skill.

4.1 Pot Chlorination of Wells

A " Dosing Cartridge " which was reported to be cheap and simple was developed in Bulgaria *. The device was a porous earthen pot which was filled with bleaching powder and immersed in water. The method was reported to be working efficiently for long periods when used for disinfecting wells.

A laboratory study with a porous ceramic cylinder, 10 cm in height, 2.5 cm in diameter charged with 30 gms of bleaching powder containing 32.3 per cent available chlorine was carried out. The cylinder was then lowered in a trough containing five liters of well water (Figure 3).

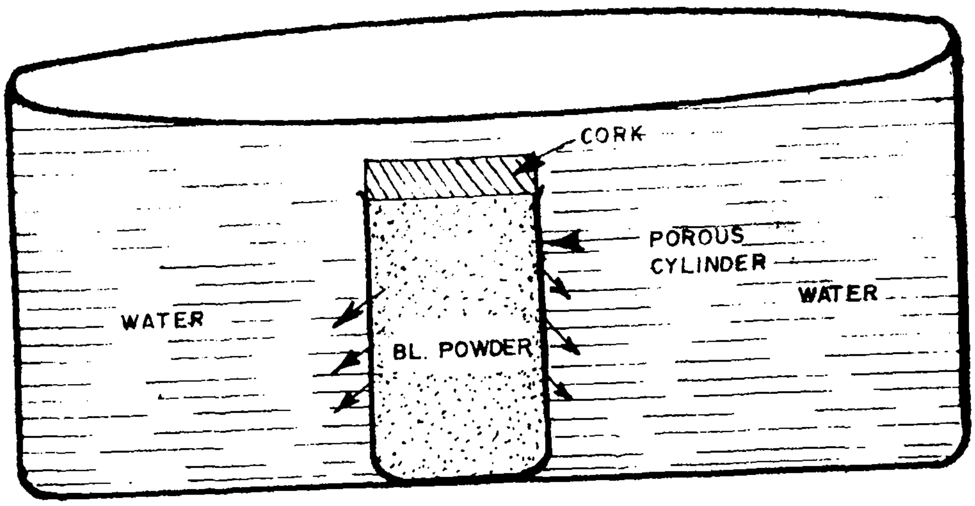

FIG. 3

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* M. Zdravkov, " New Methods of Chlorinating Drinking Water ", WHO/Env. San/124, 25th November, 1959.

After every 24 hours water was stirred and chlorine estimated. The trough was emptied daily and replenished with fresh water. Residual chlorine in the trough was as shown in Figure 4. It is seen that the residual chlorine in the trough dropped sharply after the third day and continued to fall progressively. When the cylinder was taken out, a fine needle-like formation on the surface was observed. This formation, which was mostly calcium carbonate, was choking the pores of the cylinder.

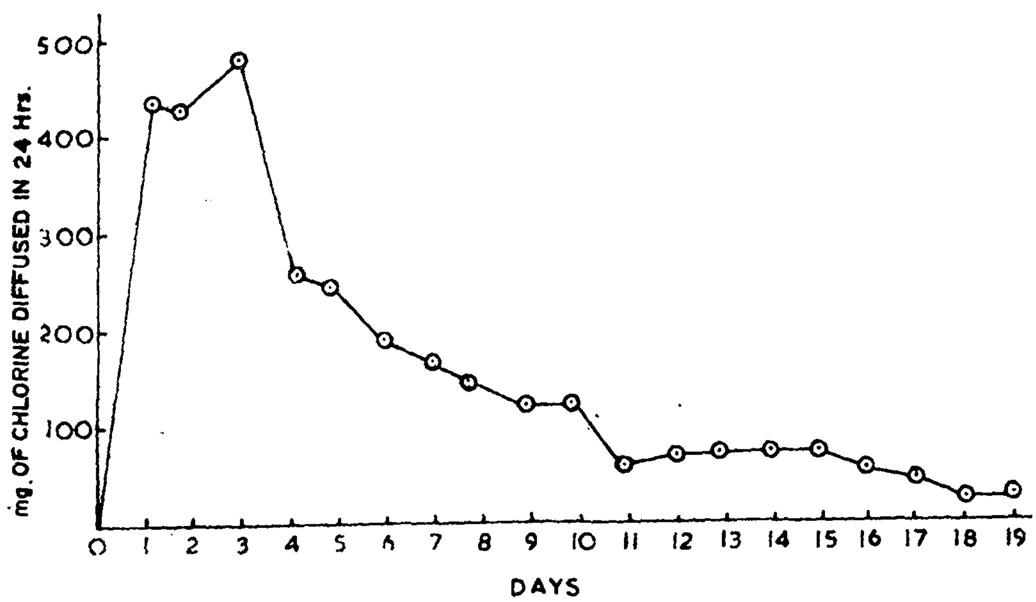

FIG. 4

Large scale experiments were then carried out with locally available earthen pots. It was observed that these pots had very little porosity to be useful for disinfecting large volumes of water (say 5000 liters). Attempts were, therefore, made to make earthen pots with higher porosity by mixing larger proportions of combustible materials like husk, saw dust, etc. and baking these pots in the potter's furnace. Porosity could be increased but after a certain limit the pots could not stand baking when the proportion of combustible materials was increased.

4.2 Porosity Determinations

In order to have a relative idea of the porosities of different types of earthen pots, a simple experiment was set up as shown in Figure 5.

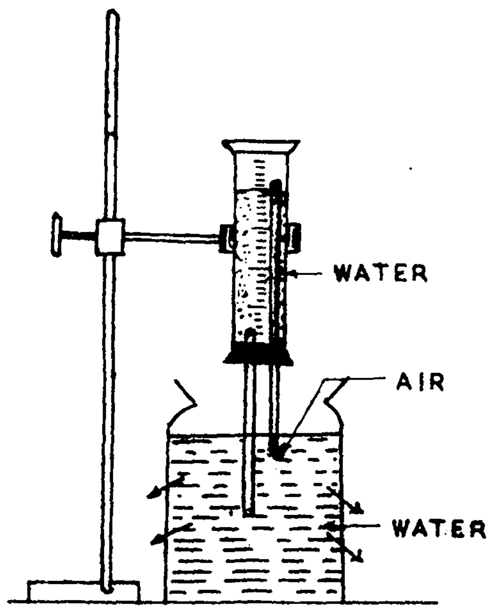

FIG. 5

As the water gradually oozed out of the pot and the level of water in the pot fell, air entered through the upper tube thus enabling more water to come into the pot and restore the original level. In this way the pot was kept oozing under constant head and the loss of water or the porosity of the pot was measured in terms of ml/sq cm/day. Table VIII gives the porosities obtained for different pots.

TABLE VIII

POROSITY MEASUREMENTS OF DIFFERENT POTS

Nature of the pot	Porosity determined by the method explained in text ml/sq cm/day
Ceramic cylinder (obtained from Central Glass & Ceramic Research Institute)	92
Locally available earthen pot	3
Specially made earthen pot	10

Even when more porous pots were used, only traces of chlorine could be detected in the well and that too for a very short period. This showed that even higher porosities were inadequate for allowing the release of sufficient amounts of chlorine. On examination, pores of these pots were found to be completely choked by calcium carbonate deposits. As the pores of the pots were invariably getting choked with calcium carbonate deposits, it was concluded that any degree of initial porosity would not serve the purpose. This observation was contrary to that reported by Zdravkov from Bulgaria, which may be due to differences in water quality such as alkalinity and hardness. Hence the use of holes for diffusion of chlorine was considered.

4.3 Pots with Holes in the Middle :

Experiments were then carried out in wells in Nagpur, India, using earthen pots with holes. These wells were generally containing 9000 to 13000 liters of water, with a daily withdrawal of 900 to 1300 liters of water. Single pots were used in the beginning. In this system two holes each of 0.2 to 0.3 cm in diameter, were made in the middle periphery of the pot, above the level of the bleaching powder. The mouth of the pot was tied with polyethylene foil in order to prevent entrance of fish in the pot. PVC was not used since it is affected by strong chlorine solution. The foil was tied loosely in order to allow air in the pot to be displaced out when the pot was gradually lowered in the well and water entered through the holes (Figure 6).

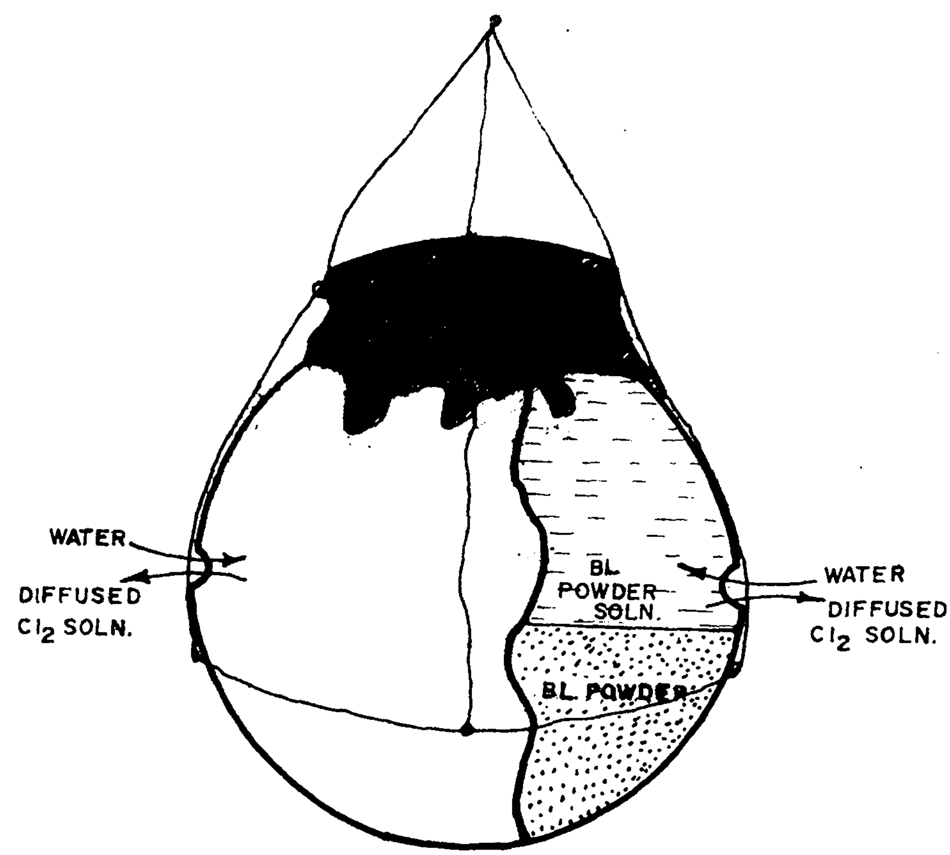

FIG.6

POT LOWERED IN WELL

A concentrated bleaching powder solution was formed in the pot. This solution oozed out of the holes and chlorinated the well water.

Making holes in the pot gave satisfactory results for short periods and chlorine could be detected in the well. But the holes were getting choked within 2 to 3 days. Bleaching powder also was found to form a hard cake. The calcium hydroxide present in the bleaching powder as well as that formed upon hydrolysis according to equation (1) (Art. 3.8) and the calcium chloride subsequently formed according to equation (2) are unstable in alkaline water as shown in the following reactions :

$$Ca(OH)_2 + Ca(HCO_3)_2 \longrightarrow 2\ CaCO_3 + 2\ H_2O \quad \ldots (4)$$

$$Ca(OH)_2 + 2\ NaHCO_3 \longrightarrow CaCO_3 + Na_2CO_3 + 2H_2O \quad \ldots (5)$$

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3 + 2\ NaCl \quad \ldots (6)$$

These reactions trigger when the bleaching powder solution gets diluted in the immediate vicinity of the orifice of the pot. The precipitation of calcium carbonate becomes predominant around the orifice and needle-shaped crystals similar to aragonite develop gradually reducing the effective area of the orifice. The needles are occasionally hollow but always brittle.

Similar reactions leading to formation of calcium carbonate occur inside the pot to a lesser extent and the mass becomes harder with time. Setting of bleaching powder is mainly a process involving absorption of carbon dioxide or reaction with bicarbonates leading to the conversion of calcium hydroxide into calcium carbonate (Equation 5).

To avoid blockage it was decided to use bigger holes. Experiments were also carried out to find a suitable method to keep the bleaching powder in loose mass. It was observed that sand could be used for this purpose. A mixture of sand (2 mm diameter) and bleaching powder in a proportion of 2 : 1 when moistened was found to keep bleaching powder in a loose and bulky state in the mixture.

Experiments were then carried out with single pots of 12-15 liters capacity with two, 0.6 cm diameter, holes in the middle periphery of the pot and filled with moistened mixture of 1 $\frac{1}{2}$ kg of bleaching powder and 3 kg of sand. From these experiments it was concluded that such units were suitable to chlorinate wells containing 9000 to 13000 liters of water, with a daily withdrawal of 900 to 1300 liters for a period of one week.

4.4 Pots with Holes at Bottom

Experiments were thereafter carried out to prolong the period of chlorination. During these experiments it was observed that the position of hole at the bottom is more suitable to facilitate better release of chlorine from the mixture. However, when the mixture was moistened, as before, too much chlorine came out in the initial period. But use of a dry mixture resulted in a poor release of chlorine. The mixture was also found to form a hard mass. To decelarate the hardening process and to keep the reaction product loose, it was thought to add metaphosphates which form loose and less adherent deposits. The exact mechanism is not understood, though there is a possibility of the formation of hydroxyapatites by inter-reaction between calcium carbonate and phosphate ions. It was observed that the addition of sodium hexametaphosphate at the optimum concentration of 5 per cent of the weight of bleaching powder gave satisfactory results.

The device now consisted of an earthen pot of 6 to 8 liters capacity. Seven holes of 0.6 cm diameter were made in the bottom of the pot. The holes were then covered with stones or pebbles of 2 to 4 cm size. This was then covered with pea gravel of smaller size. A dry mixture of sand and bleaching powder along with sodium hexametaphosphate was placed over the gravel. The pot was then filled with pebbles or stones upto the neck to weight it and facilitate its lowering in the water (Figure 7).

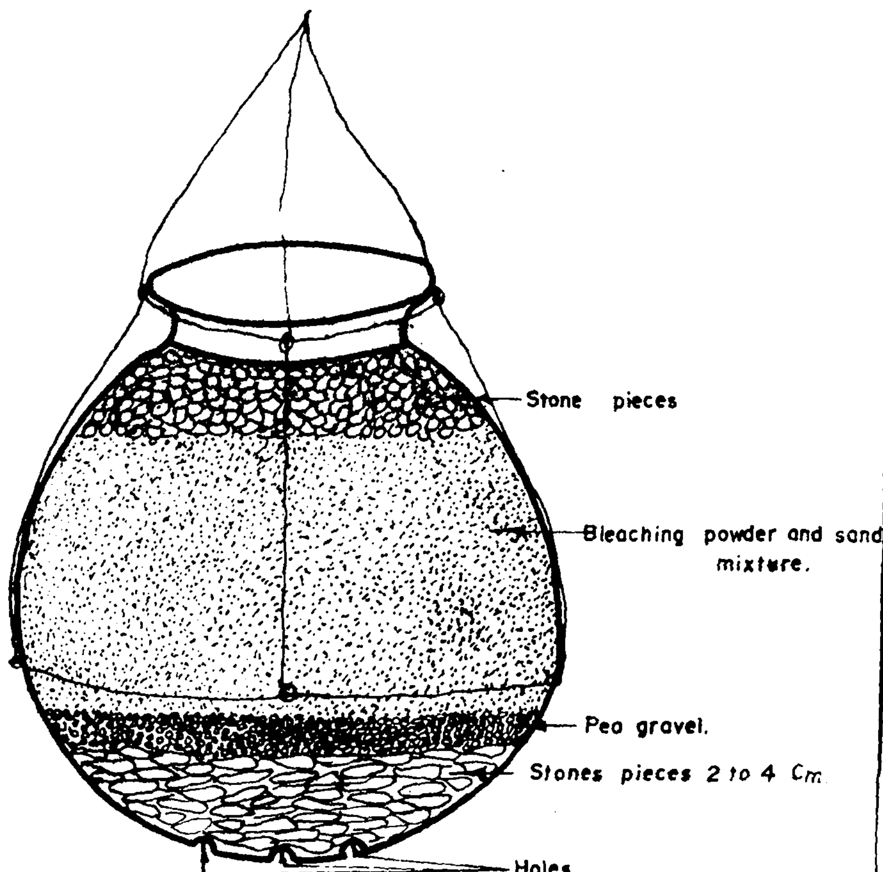

FIG. No. 7

The pot was lowered with its mouth open unlike the previous cases. One unit was filled with a mixture of $1\frac{1}{2}$ kg of bleaching powder mixed with the requisite quantity of sodium hexametaphosphate and 3 kg of sand. The unit was then tested in an experimental tank of 6800 liters capacity where the entire volume of water was emptied and replenished every day. This device gave a chlorine residual of 0.2 to 0.4 ppm for a period of 2 weeks (Figure 8) after which the holes were found to be choked.

4.5 Field Work

The single pot system with multiple holes at the bottom was then tried in village wells. The village was nearly 30 kms from Nagpur. It had a population of nearly 2000. Wells were the only source of water supply to these people. Each locality in the village was served from a well of its own. They were open dug wells, and the village folk were drawing water with buckets and ropes.

Wells from different localities were chosen. Only such wells which were serving a large number of people who had no other well in their vicinity, were chosen for the work. The wells contained 13,000 to 26,000 liters of water and the daily withdrawal from individual wells was in the range of 1300 to 3200 liters of water. The general analysis of well waters around Nagpur fell in the following range :

pH		7.5 to 8
Total alkalinity	(as $CaCO_3$)	300 to 600 mg/l
Total hardness	"	200 to 600 mg/l
Phenolphthalein alkalinity	"	0
Total dissolved solids		800 to 1200 mg/l

CHLORINATING RATE OF THE POT WITH MULTIPLE HOLES AT THE BOTTOM

(VOLUME 6800 liters IN A TANK, EMPTIED AND REPLENISHED EVERY DAY)

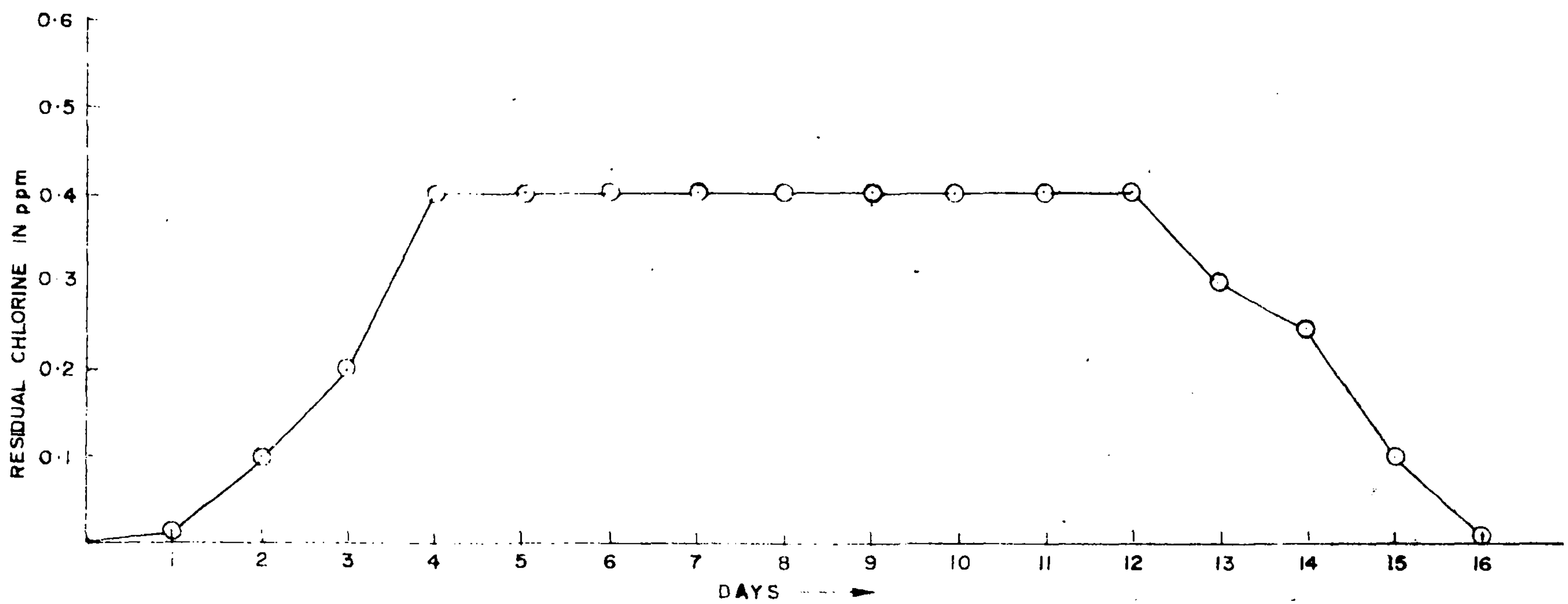

FIG 8

The results of the experiments are summarised in Table IX (also graphically illustrated in Figures 9 - 13).

TABLE IX

FIELD TRIALS WITH POTS WITH BOTTOM HOLES

Well No.	Water contained in the well liters	Withdrawal liters/day	No. of units lowered	Duration of chlorination by the unit(s)
1	11,700	1300 - 1800	One	17 days
2	17,530	2700 - 3200	Two	18 "
3	22,572	2700 - 3400	Two	15 "
4	22,200	2270 - 2700	Two	21 "
5	26,160	2270 - 2700	Two	15 "

These experiments showed that the wells could be chlorinated for a period of about 15 days with the above system.

With community wells of 9000 to 13000 liters contents and daily draw off rates of 900 to 1300 liters, one pot was enough to give required chlorination. With larger wells and higher draw off rates, 2 pots were necessary per well although the chlorine residuals on some days were on the high side. Generally the wells required 1 to 2 days to build up enough residuals after initial introduction of the pots.

Similar experiments at Delhi gave a residual chlorine of 0.2 to 2.3 mg/l for a period of about 2 weeks. The quality of

CHLORINATION OF ... WELL WATERS

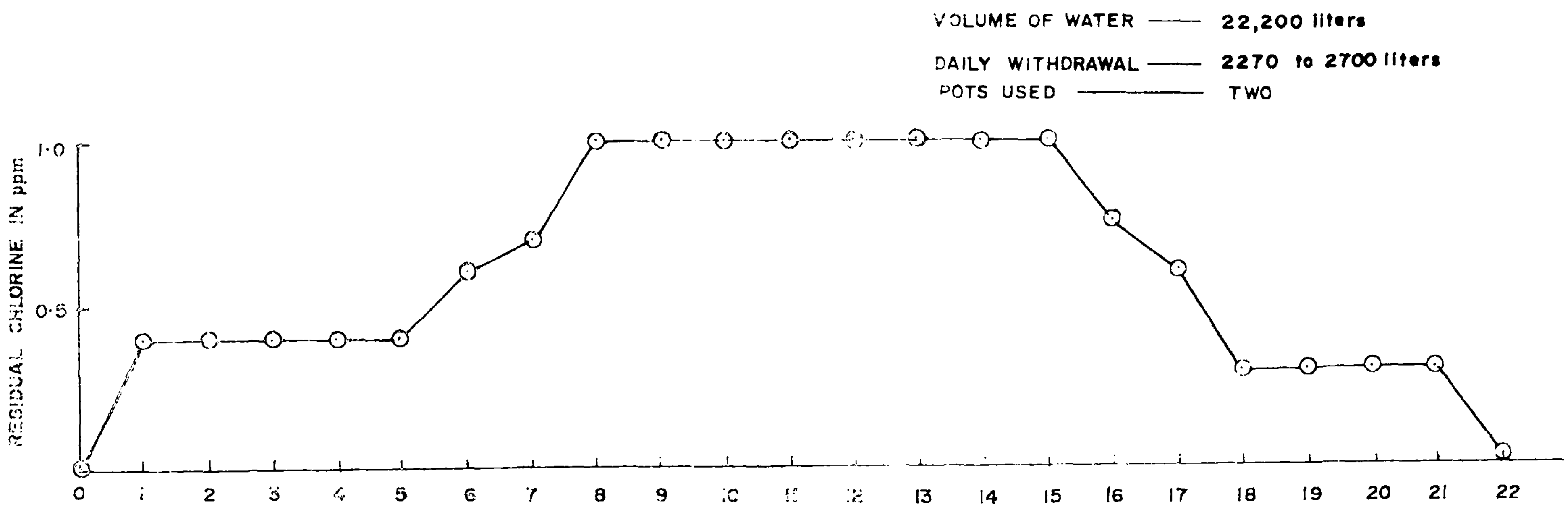

FIG. 9

CHLORINATION OF VILLAGE WELL WATERS

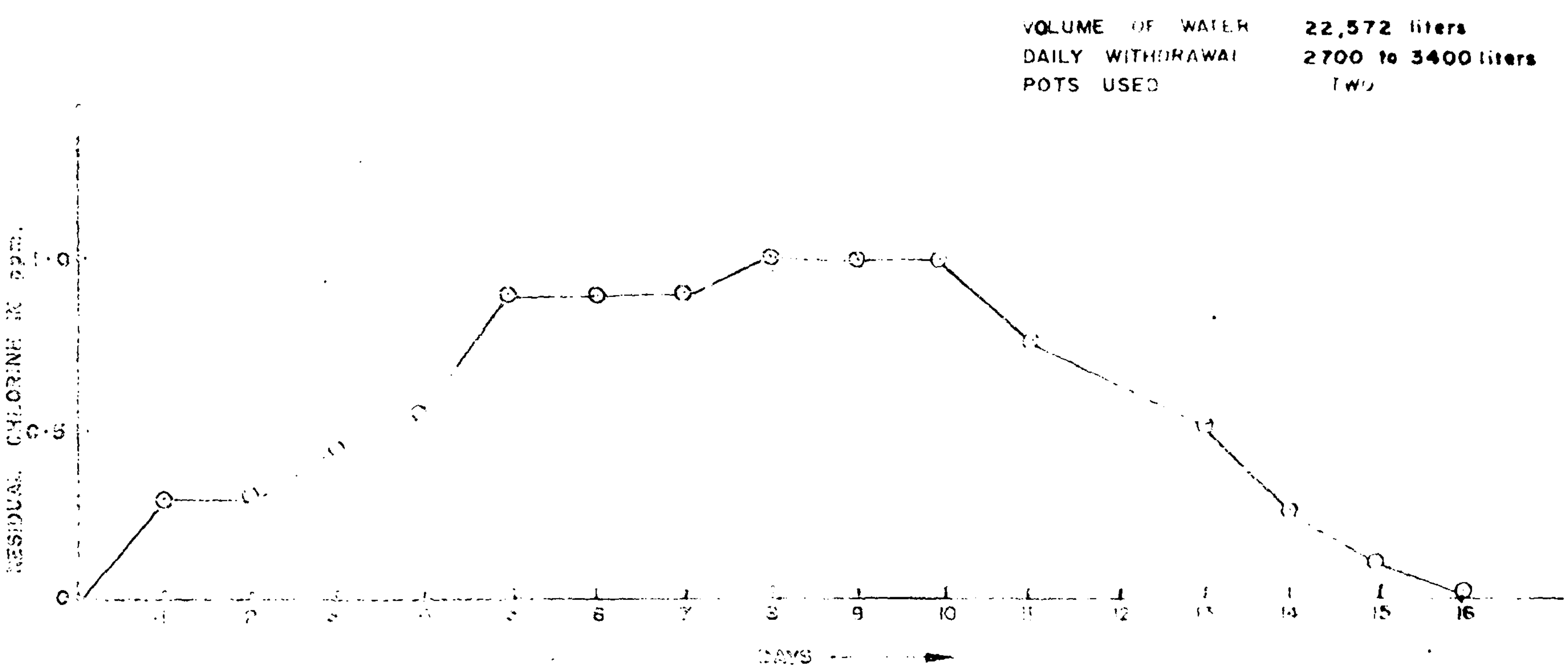

FIG. 10

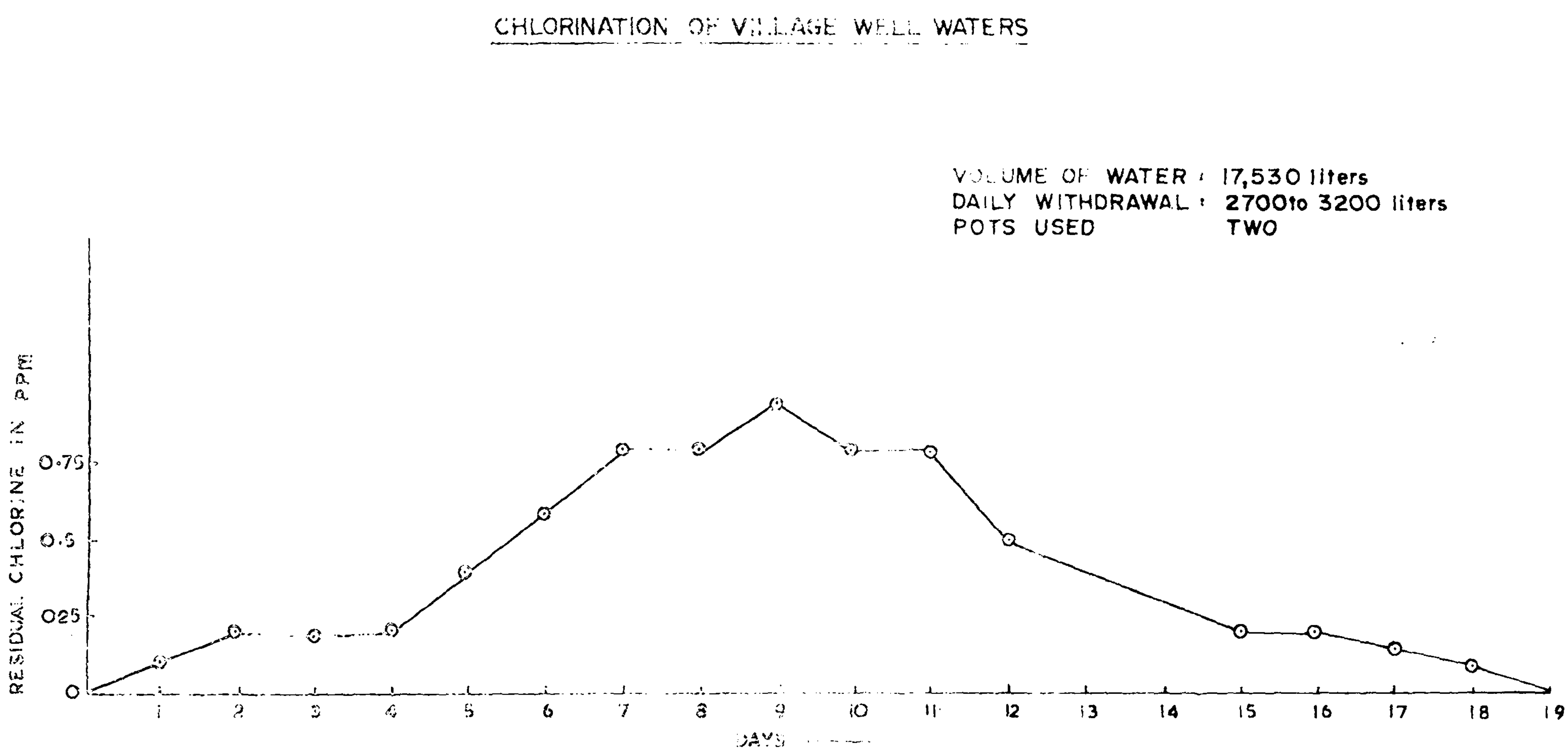
CHLORINATION OF VILLAGE WELL WATERS
VOLUME OF WATER : 17,530 liters
DAILY WITHDRAWAL : 2700to 3200 liters
POTS USED TWO
RESIDUAL CHLORINE IN PPM
0.75
0.5
025
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
DAYS

FIG.

CHLORINATION OF VILLAGE WELL WATERS.

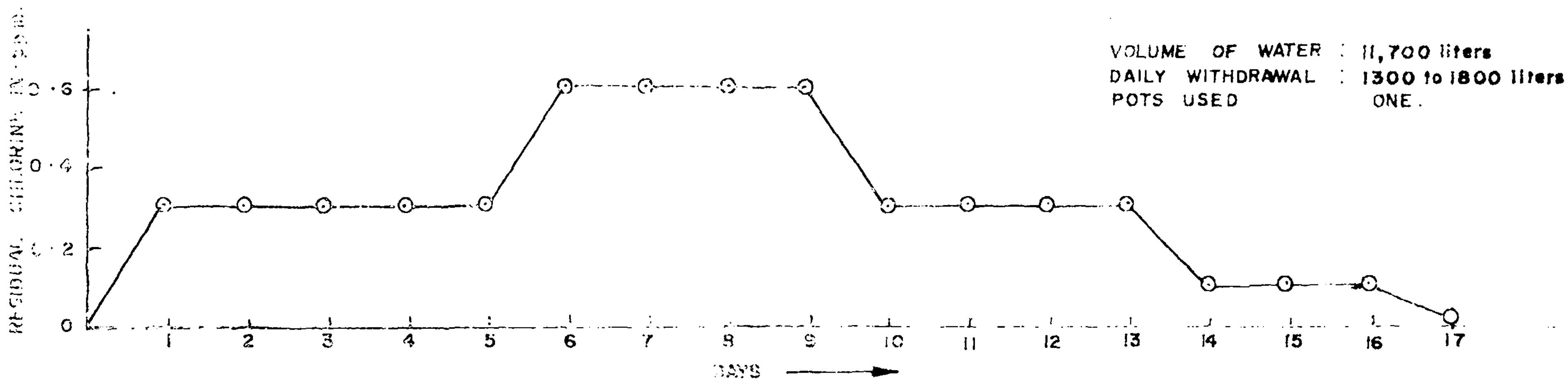

FIG. 12

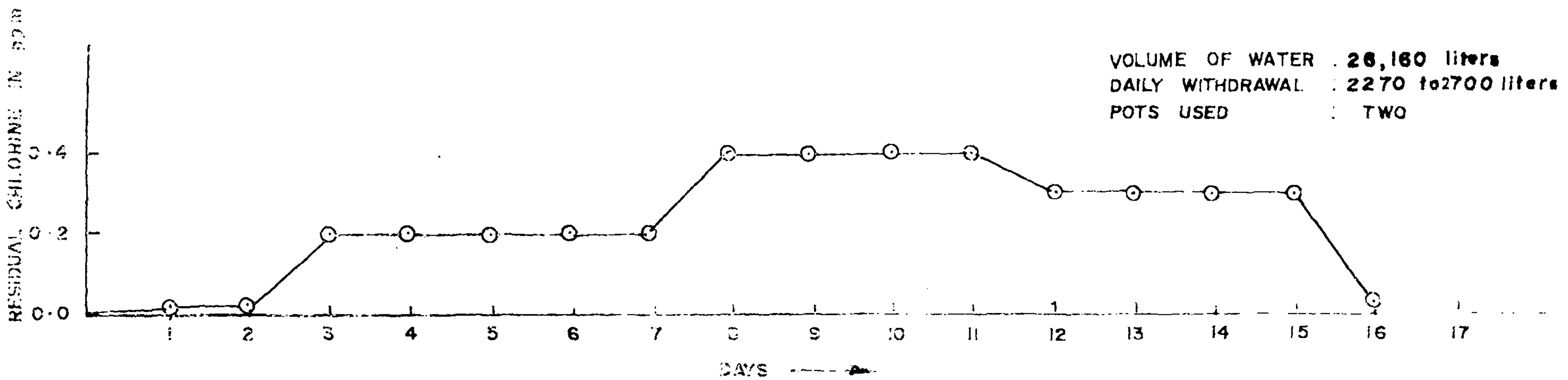

FIG. 13

the well water used for these studies is given below :

pH		7.9
Total alkalinity	(as $CaCO_3$)	105 mg/l
Total hardness	"	54 "
Phenolphthalein alkalinity	"	0
Total dissolved solids		520 mg/l

4.6 Double Pot System

When a single pot either with holes in the middle periphery or at the bottom, was used in small, household wells containing about 4000 liters or less and having a withdrawal rate of 360 to 450 liters of water per day, it was found to over-chlorinate such wells. Hence, it was necessary to develop an alternative device for small household wells.

The double pot system was mainly devised to prevent over-chlorination of small household wells. It consisted of two cylindrical pots, one inside the other. This was done in order to give scope for making larger holes in the inner pot and at the same time arresting over-chlorination by the outer pot.

The outer pot was nearly 30 cm in height and 25 cm in diameter. The inner pot was nearly 28 cm in height and 16 cm in diameter. These are the internal dimensions of the pots. The mouth of the outer pot was wide enough to allow the inner pot to pass through (Figure 14).

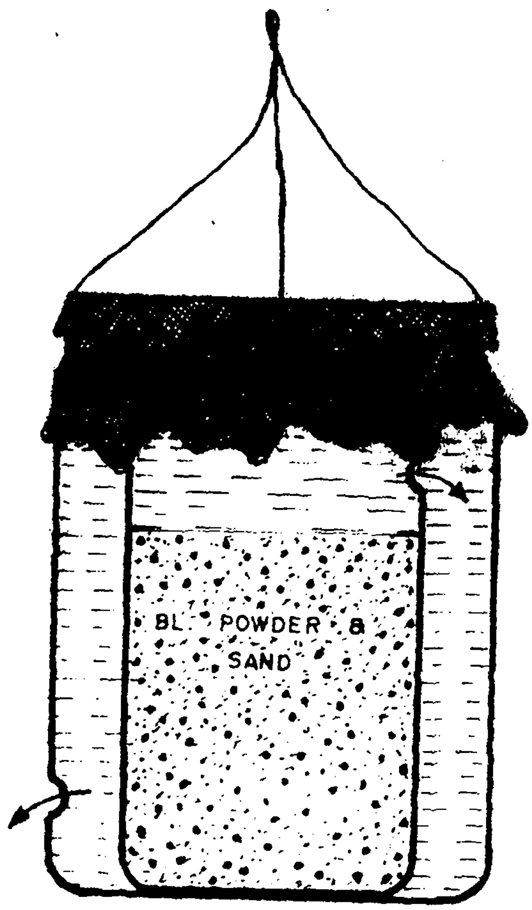

FIG. 14

The inner pot was filled with a mixture of one kg of bleaching powder and two kg of sand (2 mm diameter) after slightly moistening with water. A hole of 1 cm diameter was provided in both the inner and outer pots. The position of the hole in the inner pot was in the upper portion of the pot while that in the outer pot was 4 cm from the bottom. The mixture was filled upto 3.0 cm below the level of the hole in the inner pot which was then lowered into the outer pot. The mouth of the outer pot was tied with a polyethylene foil. The unit was then lowered in the well with the help of a rope, 1 meter below the level of the water. This depth was chosen to avoid breakage of the pot due to collision with buckets used to draw water. The rope was tied either to the support of the pulley used for drawing water or to a nail hammered in the inside wall of the well.

Such a unit was found to work satisfactorily for 2 to 3 weeks in the small household wells containing nearly 4500 liters of water and having a draw off rate of 360 to 450 liters per day. Representative results from two wells using a double-pot system are presented in Figures 15 and 16.

4.7 Drip-type Chlorinator

An alternative device for disinfecting wells is a drip-feed chlorinator, of which several types have been reported upon in literature. The WHO monograph on " Water Supply for Rural Areas and Small Communities " (E.G. Wagner and J.N. Lanoix) describes an arrangement recommended by the New York State Department of Health for this purpose *. Satisfactory experiences from Sudan with similar devices improvising the use of plastic jerry cans with constant head orifices and carbuoys with syphonic controls have been reported **.

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* " Water Supply for Rural Areas and Small Communities ", E.G. Wagner and J.N. Lanoix, WHO Monograph No. 42 (1959)

** " The Village Tank as a Source of Drinking Water ", WHO/CWS/RD 69.1 (1969)

CHLORINATION OF WELL WATER WITH DOUBLE POT SYSTEM.

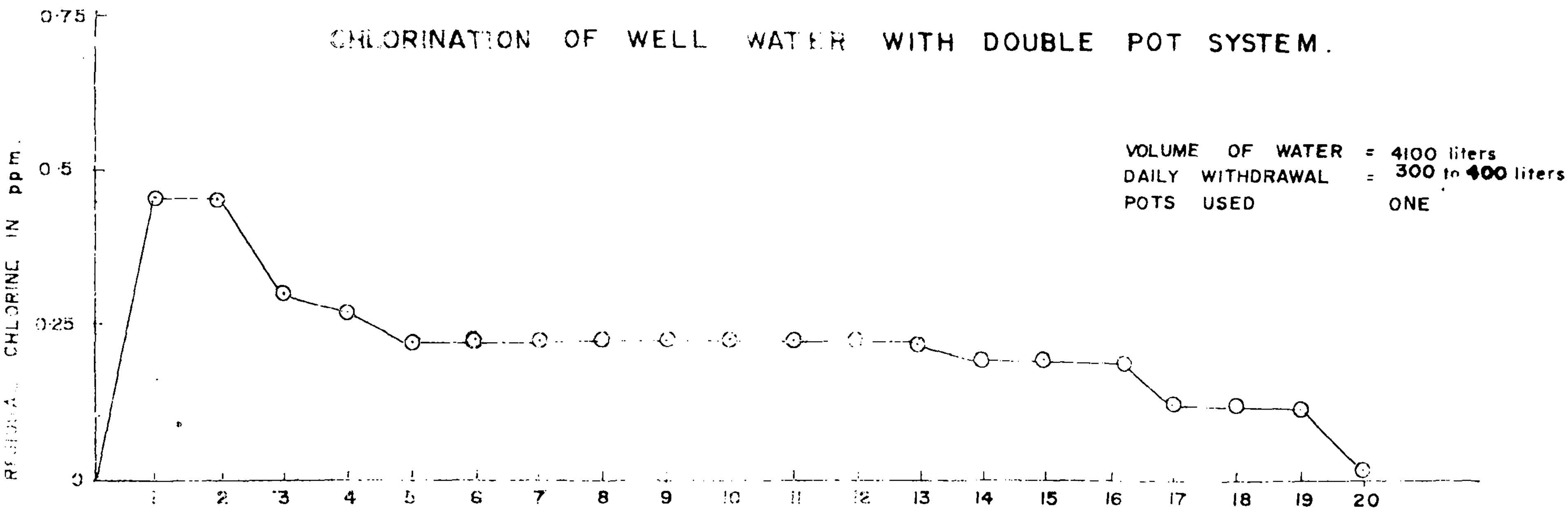


FIG 15

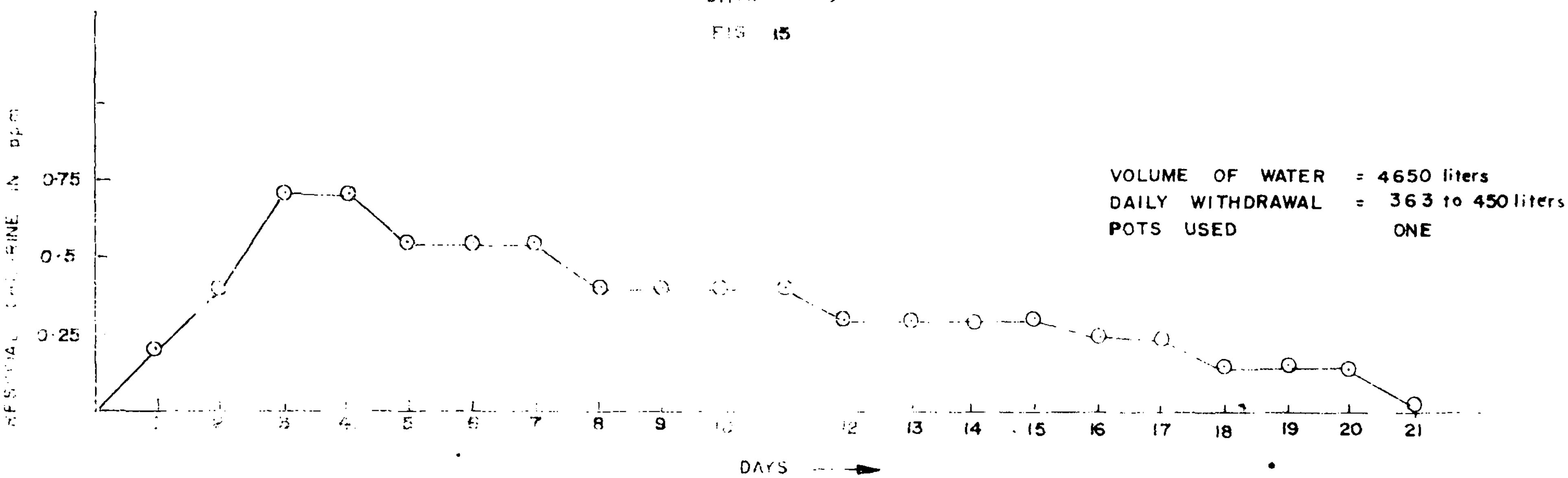


FIG 16

A drip-type chlorinator was developed by the Institute in the form of a container made of cement mortar (2.5 cm thick, with chicken mesh reinforcement) which could be mounted on the parapet wall of a well and from which the chlorine solution was fed by gravity through a special dropper in the outlet tube. (Figure 17 d).

In the initial stage the outlet was provided near the bottom of the container but was found to get choked frequently (Figure 17 a).

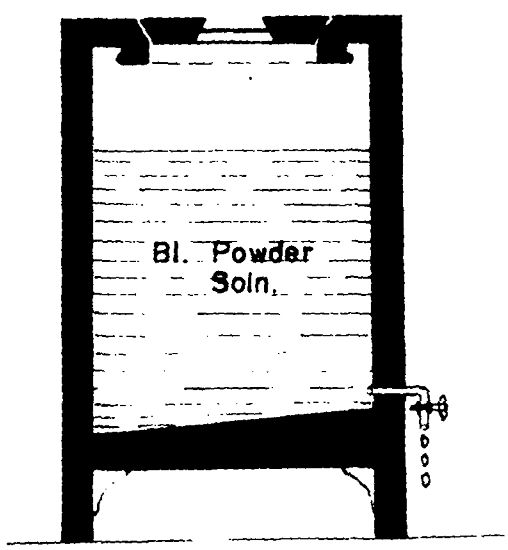


Fig - 17 a

The position of the outlet was then shifted to the surface of bleaching powder solution by using a float with an orifice inlet as was done in Sudan with a jerry can (Figure 17 b).

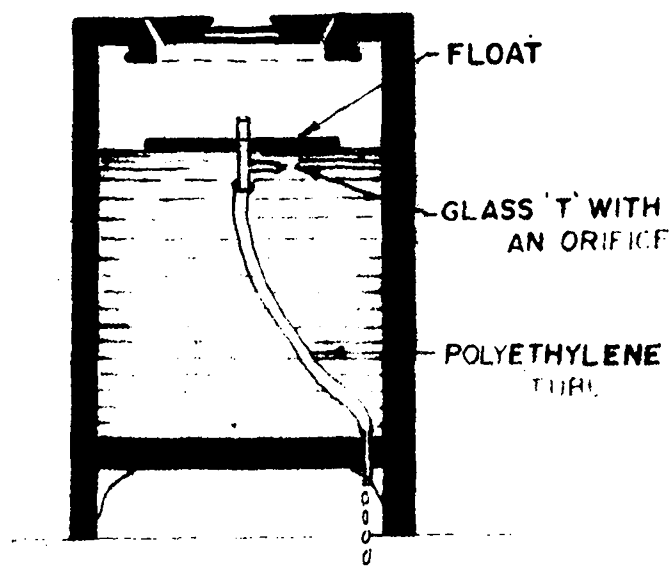


Fig - 17 b

This arrangement ensured a constant head discharge, but the inlet orifice was getting choked within two days run. This chokage was due to the deposition of calcium carbonate in the orifice, owing to the interaction of atmospheric carbon dioxide with the bleaching powder solution.

A variation of the above method was worked out in which, to avoid choking, the inlet orifice was replaced by a larger diameter tube which acted only as a collector and control of the feed rate was done by providing a stop-cock in the outlet tube (Figure 17 c).

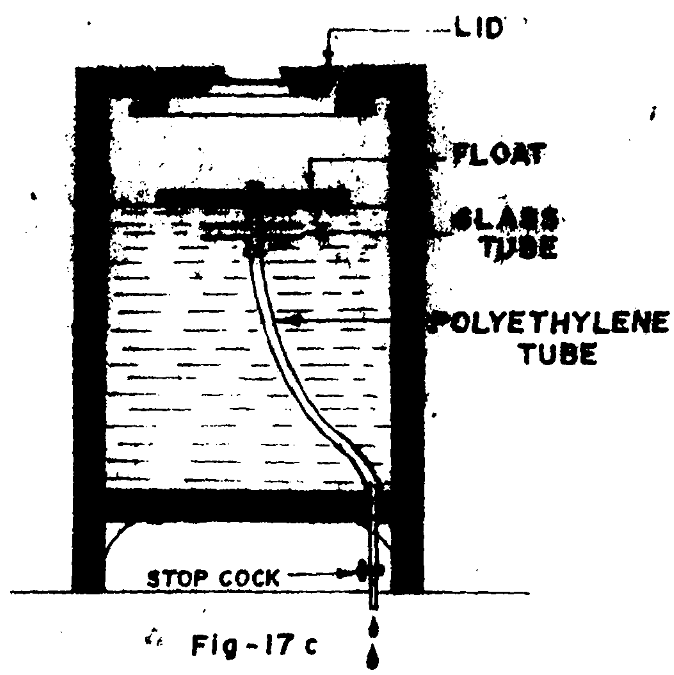


Fig-17 c

Even here the unit suffered from choking difficulties though the length of run was somewhat extended. The deposit of calcium carbonate was now found to occur on either side of the stop-cock. This failure also occurred when polyphosphates were added to the bleaching powder solution.

It was apparent from the above studies that drip-type chlorinators were likely to suffer invariably from chokage due to calcium carbonate deposits wherever the atmospheric carbon dioxide came in contact with the bleaching powder solution.

In order to obviate this difficulty a special dropper similar to one used in medical transfusions, was inserted in the outlet tube, just after the stop-cock. The outlet tube was also now carried right down into the well and dipped into the water (Figure 17 d).

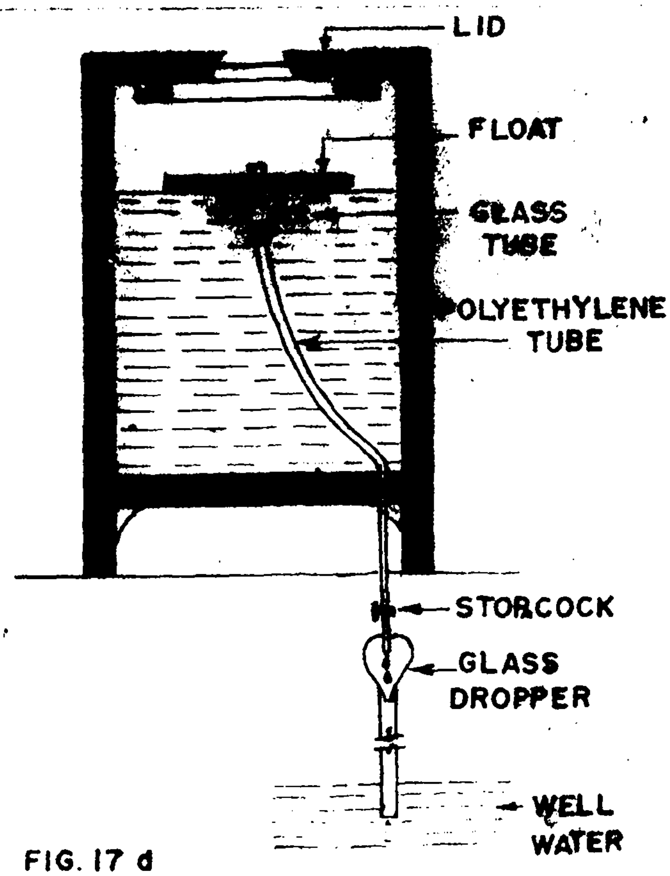


FIG. 17 d

Such droppers made of glass are commercially available as they are commonly used in the hospitals. The provision of such a dropper and the extension of the outlet tube into the well water gave the following advantages :

1. Direct contact of atmospheric carbon dioxide with the dropping bleaching powder solution was avoided. This

greatly reduced the formation and deposition of calcium carbonate, and thus prolonged the working of the unit.

2. The glass dropper provided a convenient way for counting the number of drops per minute, thus facilitating adjustment.

3. As the unit continued to drip, the initial air present in the dropper, and the tube below, got dissolved out, thus creating partial vacuum. This helped in prolonging the period of flow from the unit. Water from the well rose up gradually in the tube to a height of 2 to 3 meters.

With such a device the unit gave satisfactory service for 6 to 8 days, after which there was chokage in the stop-cock and cleaning and readjustment was necessary. The container was also capable of holding enough chlorine solution for about a week's operation for a well of approximately 20,000 to 60,000 liters contents and a daily withdrawal of 2000 to 6000 liters, namely, for a well serving 80 to 240 people.

Containers made of cement mortar, with chicken mesh reinforcement as described earlier were found preferrable for use in the field since experience showed that earthenware containers were liable to be broken by village urchins and durable plastic containers were being pilfered. A cement mortar container of 25 x 35 x 55 cm size could easily accommodate about 35 liters of bleaching powder solution after leaving enough space for free-board at top and sludge at bottom. The glass tube inlet for bleaching powder solution was fixed to a wooden or plastic pill-box float. It was connected to a polyethylene tube which was taken out of the container at the bottom. The flow was regulated by a stop-cock, which was attached to the tube outside the container. An enclosed glass dropper was inserted in the line for counting the drop rate. This was also helpful to detect the variation in the drip rate, and to adjust the rate with the stop-cock. A long rigid plastic tube connected to the bottom of dropper was lowered in the well in such a way that its other end was inside the water. Soft tubes could not be used as they collapsed due to partial vacuum created in the tube during operation.

The container can be kept on the parapet wall of a well or can be permanently fixed on it. Being of cement mortar it is sufficiently resistant to bleaching powder solution and prevents loss of chlorine due to sunlight. The whole unit is sturdy and economical to be suitable in the village environment.

Before starting the chlorinator, sufficient quantity of bleaching powder may be added to the well water to satisfy its initial chlorine demand which has been found to be generally in the range of 0.5 to 1.5 ppm. 1 per cent bleaching powder solution is made and kept overnight or for a day for settling and the supernatant is used for charging the chlorinator. Higher concentrations are liable to lead to early chokage problems.

4.8 Dosing Device for Hand Pumps

A dispenser for use with hand pumps was fabricated using a piston and cylinder in the form of a positive displacement pump with inlet and outlet fitted with one-way valves. It was fabricated in the Institute's workshop. The dispenser as assembled and fitted on to a hand pump is shown in Figure 18.

The chlorine solution dispenser is connected to the handle of the pump with a perforated strip to enable adjustment at the time of assembly. The capacity of the container for bleaching powder solution depends upon the amount of water withdrawn from the well and the interval between refillings.

The above dispenser was tried on a hand pump fitted on a well in the Institute. However, the dispenser gave difficulties as there was excessive lateral play in the pump handle. This difficulty was noticed in the case of most commercially available hand pumps. This device was not pursued further owing to these difficulties as well as the fact that for covered wells also either the pot or drip-type chlorinator could be conveniently used.

4.9 Chlorine or Iodine Tablet Dispensers

The chlorine or iodine tablet dispenser consists of a housing enclosing a mechanical or electrical clock-work mechanism. A pointer pushes a chlorine or iodine tablet from the stack into a hole at each revolution. This tablet directly falls into the well. The stack height can be made to accommodate the number of tablets required per day. More stacks can be added to multiply the number of tablets to be dropped per revolution of the pointer (Figure 19).

The chlorine tablets used in these experiments were 5 mm thick, 10 mm in diameter, weighed 500 mg each and were capable of disinfecting 100 liters of water per tablet.

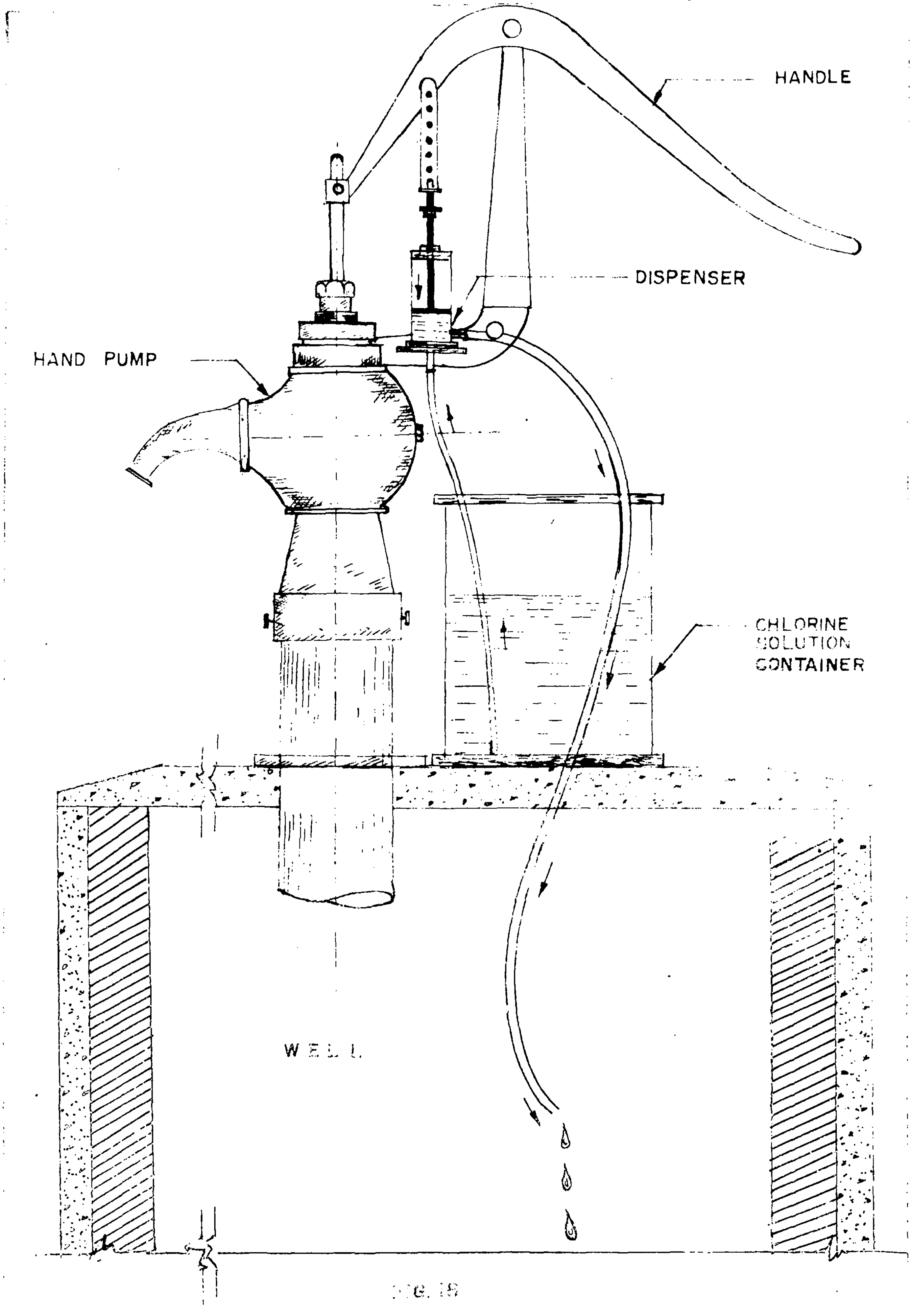


FIG. 18

CHLORINE SOLUTION DISPENSER FITTED TO HAND PUMP

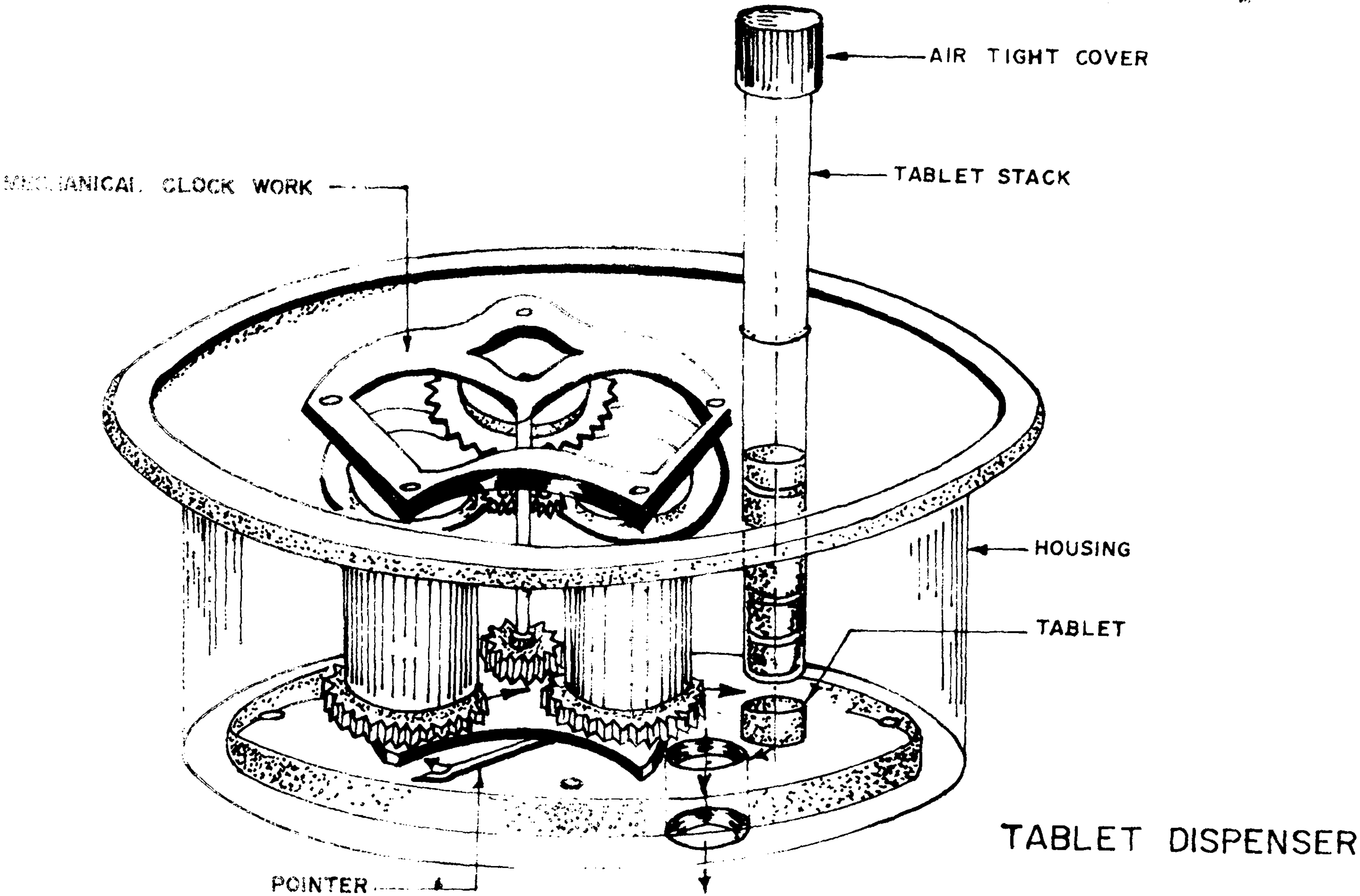

AIR TIGHT COVER
TABLET STACK
ANICAL CLOCK WORK
HOUSING
TABLET
POINTER
TABLET DISPENSER

FIG. 19

Assuming an average requirement of 20 liters of water per person per day and considering a well which can serve 10 to 15 persons, the total daily withdrawal will be 200 - 300 liters. If it is desired to provide a residual chlorine dose of 1 ppm in this water, about 3 tablets will be required per day. If 3 stacks are provided each stack containing 30 tablets, the stacks need to be replenished once a month.

The clock-work mechanism may be either spring operated with weekly winding or electrically operated for use in areas served by electricity.

Such devices appear to be more suitable for household wells in suburban areas, rather than in villages, since they are likely to be preferred where electricity is available, tablets can be purchased, the higher unit cost of the dispenser (Rs. 100/- - Rs. 200/- per unit) is affordable and safety from thefts is ensured.

5.0 ACCEPTABILITY OF CHLORINATED WELL WATERS BY VILLAGERS

The villagers had never used chlorinated water before. There was a lot of resistance on the part of the villagers to accept this water only because of the chlorinous taste. Some of the villagers even went to the extent of going to unchlorinated wells, which were much farther from their houses, to draw water for drinking purposes.

Under the circumstances, the biggest handicap to any well disinfection programme would be its acceptability by the rural population. However, it would not be out of place to mention here that a certain degree of enthusiasm for disinfection of wells was shown by some individuals such as landlords and the relatively educated farmers, poultry keepers, teachers and craftsman living in rural or suburban areas and having their own private wells.

It would appear that in due course with proper health education the acceptability of chlorinated waters will increase. If the villagers are made aware of the dangers of consuming unchlorinated waters, by the use of visual aids etc. it is felt that acceptability can be achieved in course of time. Initial efforts in this direction would be concentrated on the relatively educated sections of the community, as pointed out above, who are more health-conscious and from whom the message could spread further in course of time.

6.0 MECHANICAL PROPORTIONING DEVICES

Work on disinfection of piped water supplies for small communities using mechanical proportioning devices was also carried out. The devices studied were :

1. Venturi-type chlorinator
2. Ejector-type chlorinator
3. Direct-feed type chlorinator
4. Differential pressure type chlorinator

6.1.0 Venturi and Ejector-type Chlorinators

The principle of creating a partial vacuum at the ejector end or at the throat of a venturi inserted in a pipe-line carrying water under pressure is used in these devices. The partial vacuum, which depends on the discharge through the ejector or the venturi, when applied to a vessel containing a chlorine solution at atmospheric pressure, sucks the solution and mixes it with the main flow. The rate of suction could be varied by varying the suction pressure at the throat and/or throttling the feed pipe connecting the throat to the solution in the container.

6.1.1 Venturi-type Chlorinator

A venturi was made out of 4 cm thick solid perspex block. It consisted of a short cylindrical tube of 1.3 cm internal diameter followed by an entrance cone of about 15° angle and a throat of 3 mm diameter. The throat was followed by a divergent exit cone with an angle of about 5° to 7°. At the throat, perpendicular to it, a small bore was drilled which formed the inlet port for the bleaching powder solution.

The venturi was inserted in a loop from the delivery to the suction side of a centrifugal pump fitted on to a shallow well in the Institute's premises and was tested for its performance and any operating difficulties. The experimental set up is shown in Figure 20.

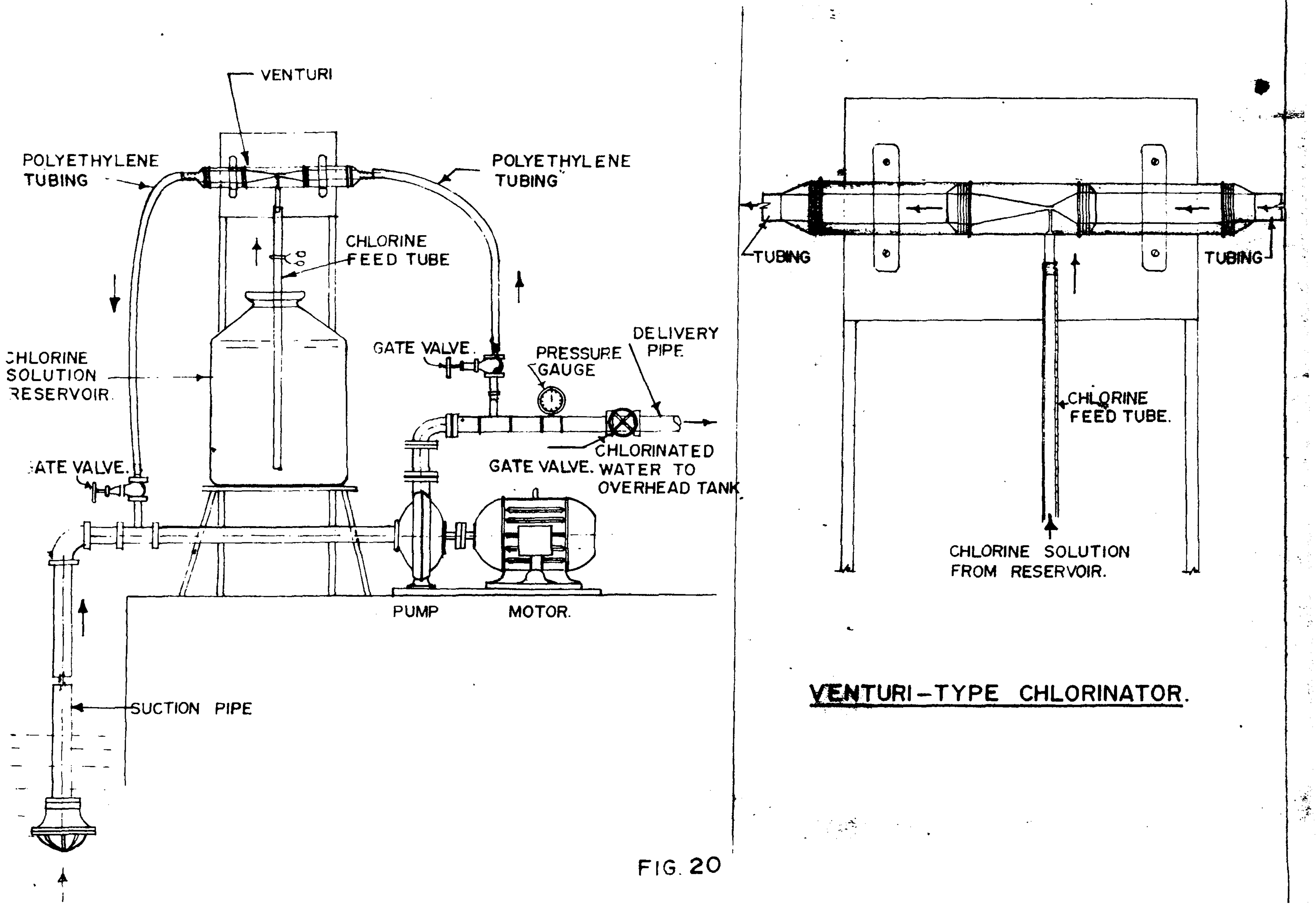
The shallow well was of 2.5 meter diameter with its water level 3 meters below the top of the well. The depth of water in the well was 6 meters. A 5 per cent bleaching powder solution was used for test purposes.

Prior to putting the venturi in operation, the discharge rates of the pump at different delivery pressures were measured and are given in the following Table.

TABLE X

Delivery pressure kg/sq cm	Discharge m^3/minute
1.056	0.368
0.703	0.473
0.352	0.500
0.0	0.500

During these tests the static suction lift on the pump varied from 3 meters in the beginning to 4.2 meters at the end



VENTURI-TYPE CHLORINATOR.

FIG. 20

of the test. Later, the venturi was commissioned and studied for its minimum discharge rates of bleaching powder solution by throttling the valves on either side of the venturi but without throttling the bleaching powder solution feed tube. The observations are given in Table XI.

TABLE XI

FEED RATES OF VENTURI-TYPE CHLORINATOR

Test Conditions	Pump Delivery Pressure kg/sq.cm	Pump Discharge m^3/mnt	Bleaching powder solution feed rate ml/minute
(A) Inlet to venturi fully open			
1. Outlet from venturi partly open	1.056	0.368	250
2. Outlet from venturi partly closed	1.056	0.368	230
3. Outlet from venturi further throttled	1.056	0.368	230
(B) Outlet from venturi fully open			
1. Inlet to venturi partly closed	1.056	0.368	380
2. Inlet to venturi completely closed	1.056	0.368	380
(C) Inlet to the venturi and outlet from the venturi partly throttled	1.056	0.368	380
(D) Inlet to the venturi and outlet from the venturi partly throttled	0.703	0.473	250

From the observations given in Table XI, it is apparent that the dosing rate of bleaching powder solution is mainly influenced by the suction head on the pump rather than the suction created by the flow through venturi. In fact, the maximum bleaching powder solution is delivered when there is no flow through the venturi.

With a 5 per cent bleaching powder solution for a pump discharge rate of 0·45 m^3/min. the solution feed rate has to be in the range of 30 ml/min., if a chlorine dose of 1 ppm is desired in the water delivered from the pump. If 1 per cent bleaching powder solution is used the feed rate can be stepped up to 150 ml/min. However, the above observations indicated that such low rates were not easy to adjust properly unless there was throttling of the bleaching powder solution feed tube.

With a view to reduce the bleaching powder solution feed rate, a pinch-cock was used in the solution feed tube. With a 5 per cent bleaching powder solution feed rates of 20, 30 and 50 ml/min. were tried. At all these rates choking was found to occur within an hour in the solution feed tube below the pinch-cock due to the formation of gas bubbles and the unit became inoperative. The formation of gas bubbles below the pinch-cock may be attributed to the release of dissolved chlorine gas under the prevalent negative pressure in the solution feed tube.

Furthermore, the venturi itself was found to suffer from chokage difficulties. When the venturi was operated for a desired feed rate of bleaching powder solution, it was observed that the feed rate dropped considerably within a period of 2 hours and complete chokage occurred in about 4 hours. It was found, on examination, that the throat of the venturi, where the well water mixed with the bleaching powder solution was choked with the formation of deposits of calcium carbonate.

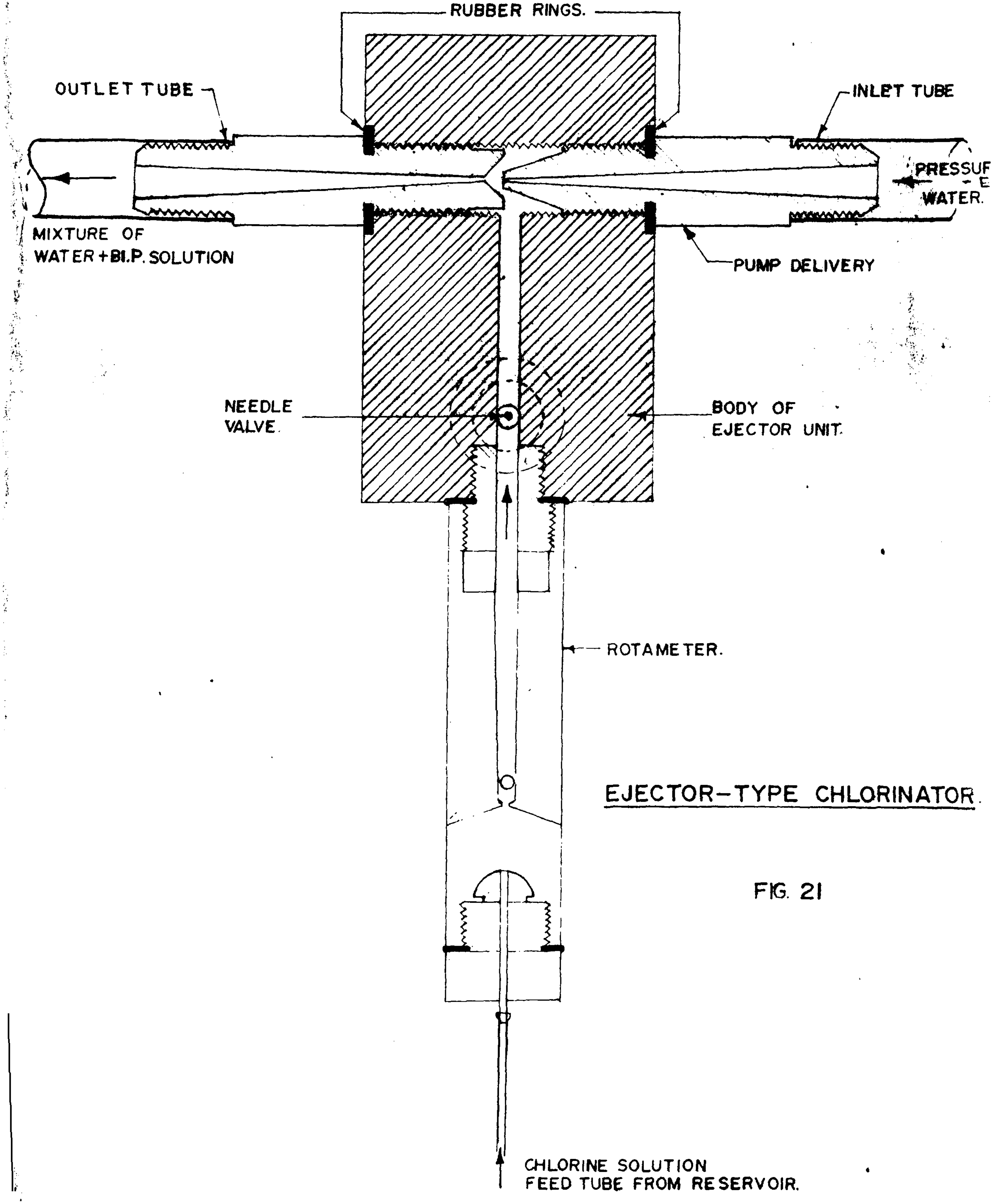
Addition of soda ash to bleaching powder in the ratio of 1 : 5 which was found satisfactory for use in the differential pressure type chlorinator described later was also tried. However, this procedure did not very much improve the situation and choking of the venturi was again observed.

6.1.2 Ejector-type Chlorinator

Experiments with an imported ejector-type chlorinator (Figure 21) were also found to suffer from the same problem of drop in feed rate as described above due to formation of calcium carbonate deposits resulting in eventual chokage of the unit within a few hours of operation.

6.2 Direct-Feed Device

In the case of venturi-type chlorinator the solution feed rate is dependent on the suction created at the throat of the venturi. It is true that the amount of suction at the throat is governed by the discharge through the venturi when it is inserted in a rising main. But in the present set up, where the inlet and outlet of the venturi are connected to the delivery and suctinn sides of the pump respectively, the amount of suction created at the throat of the venturi is greatly



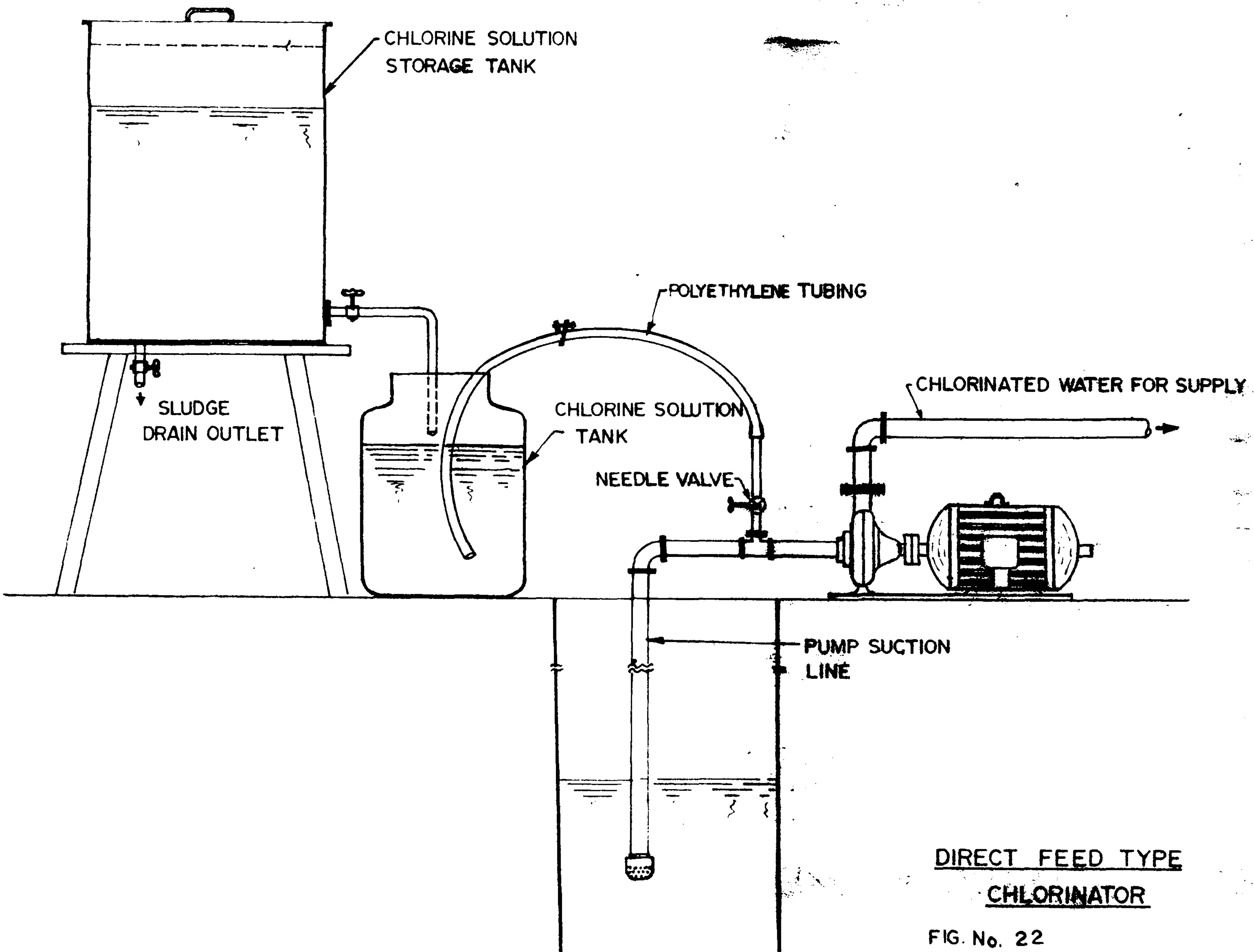
EJECTOR-TYPE CHLORINATOR.

FIG. 21

influenced by the suction head on the pump rather than that produced due to the flow through the venturi itself, as described earlier. This is clearly indicated by the fact that when the inlet to the venturi is fully closed and the outlet fully open, the maximum suction rate is obtained (See Table XI). Though there is no flow of high pressure water through the venturi, maximum solution feed rate is obtained since the same suction head that is on the pump is applied at the throat of the venturi.

This fact indicated the possibility of eliminating the gadgets described earlier and using a feed system connected direct to the suction side of the pump.

In further experiments, a direct connection was made from the bleaching powder solution reservoir to the suction line of a centrifugal pump (Figure 22). A pinch-cock was used on the polyethylene tube carrying the chlorine solution to control the feed rate. This method was found satisfactory to chlorinate water from wells fitted with centrifugal pumps, as can be seen from the observations recorded in Table XII. The feed rate was found to remain fairly constant for long periods.



DIRECT FEED TYPE
CHLORINATOR

FIG. No. 22

TABLE XII

REDUCTION IN FEED RATE WITH TIME

VENTURI-TYPE CHLORINATOR

Feed Rate with 1 % Bleaching Powder Solution

Run No.	At start	Rate of solution sucked in ml/min at different times						
		$\frac{1}{2}$ hr	1 hr	1 $\frac{1}{2}$ hrs	2 hrs	3 hrs	4 hrs	5 hrs
1	133	111	87	40	5	-	-	-
2	170	130	90	50	10	-	-	-
3	154	143	83	30	2	-	-	-

EJECTOR-TYPE CHLORINATOR

Feed Rate with 1 % Bleaching Powder Solution

1	168	140	84	56	28	-	-	-
2	168	140	84	56	42	-	-	-
3	168	168	84	56	28	-	-	-

EJECTOR-TYPE CHLORINATOR

Feed Rate with 1 % Bleaching Powder Solution (to which soda ash added)

1	168	126	112	84	56	-	-	-
2	168	168	140	112	70	28	-	-
3	168	168	140	112	84	28	-	-

DIRECT FEED

Feed Rate with 1 % Bleaching Powder Solution

1	168	168	168	168	168	140	140	140
2	168	168	168	168	140	140	140	140
3	168	168	168	168	168	140	140	140
4	168	168	140	140	140	140	140	140
5	168	168	168	140	140	140	140	140
6	168	140	140	140	140	140	140	140

This method of application would be the simplest possible method to use for pumped water supplies for small communities. Bleaching powder solution of 1 per cent strength would have to be made up to last at least for one day. Bleaching powder solution if not allowed to settle properly contains suspended particles, and thus causes obstruction at the pinch-cock, resulting in stoppage of the flow. It is, therefore, necessary that the solution should be clear. The bleaching powder solution should be allowed to settle for 24 hours and then carefully withdrawn without disturbing the sludge at the bottom. It should be filtered through a piece of fine cloth to avoid larger particles.

The solution container should be of adequate size to ensure that some solution is left behind at the end of the day's run to prevent air from entering the pump suction side. Care must also be taken to shut-off the solution feed line when the pump is stopped. The rate of chlorine dosing depends on the quality of the water and has to be adjusted by trial and error depending upon the chlorine residuals desired.

6.3 Differential Pressure Type Chlorinator

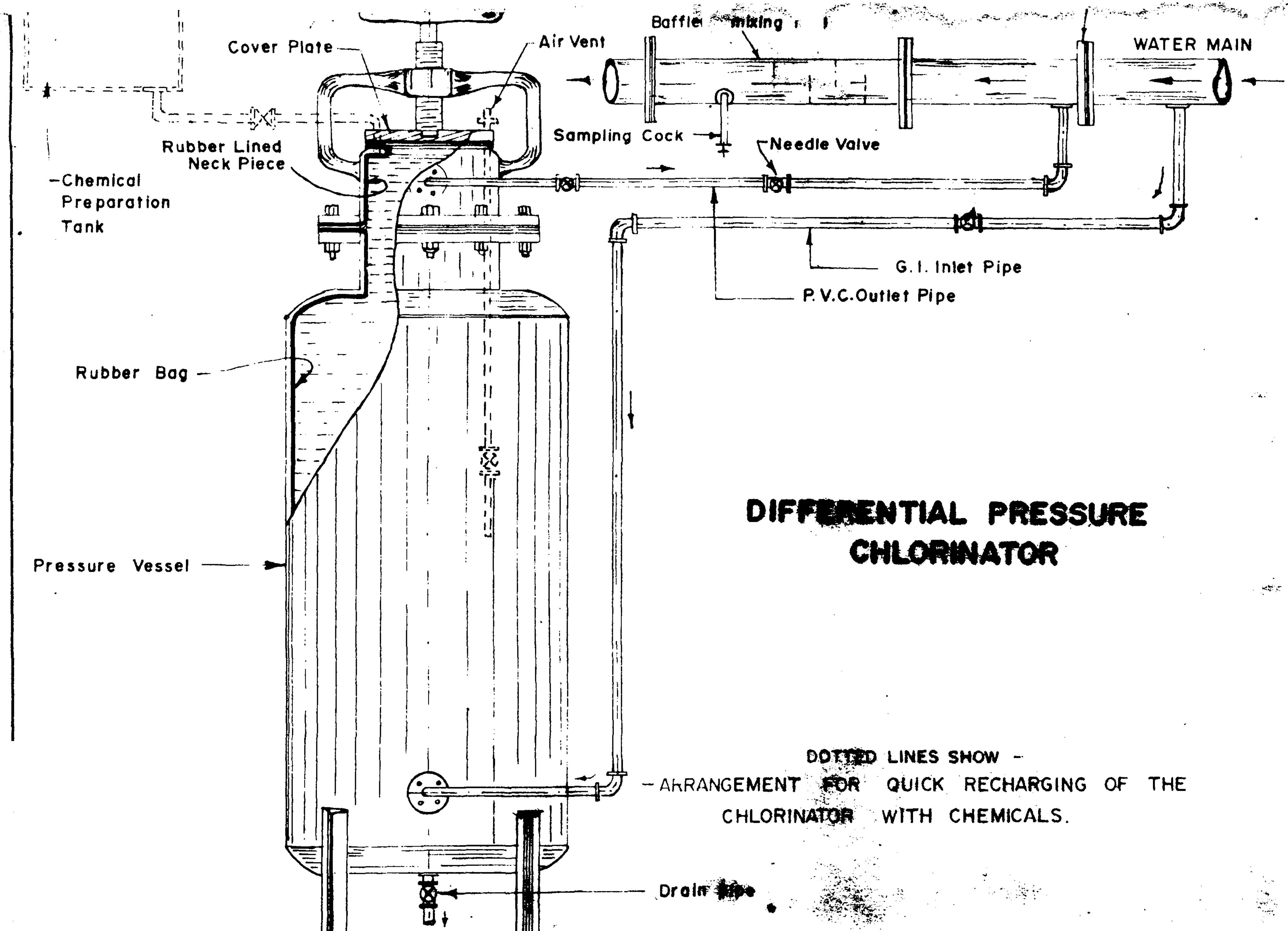
The principle of operation of this unit is based upon the utilisation of the differential pressure, set up by insertion of an orifice plate or a venturi tube in the discharge main to squeeze chlorine solution from a rubber bag and inject it into the main flow.

The unit consists essentially of a pressure vessel containing a loose replaceable rubber bag secured at its neck to the top of the vessel by a rubber lined neck piece, in the side of which a flanged outlet pipe is fitted (Figure 23). A top cover plate, which bolts on to the neck piece is provided with a quick release cover by which the solution is filled into the feeder. Alternately, when several fillings are required per day a separate solution preparation vessel can be provided with a pipe leading to the feeder so that quick recharging can be effected.

The high pressure water on the upstream side of the orifice plate connected to the body of the doser squeezes the rubber bag containing the bleaching powder solution and forces the solution through the outlet pipe into the main, carrying the water to be treated. The inlet to, and the outlet from, the doser are provided with gate valves. In addition, the outlet tube is provided with a needle valve to regulate the flow of the bleaching powder solution. A drain pipe is incorporated into the body of the pressure vessel to drain the water while recharging is carried out.

When bleaching powder solution is added to the water, a baffled acid proof mixing section is provided for insertion into the pipe line just after the point where the solution enters the line. The valves and piping on the outlet side of the doser have to be of corrosion resistant material.

The performance of such units was studied both in the Institute and elsewhere (five installations totally). These were found to give satisfactory performance and are suitable for chlorinating small community water supplies with bleaching powder



DIFFERENTIAL PRESSURE CHLORINATOR

DOTTED LINES SHOW - ARRANGEMENT FOR QUICK RECHARGING OF THE CHLORINATOR WITH CHEMICALS.

FIG. NO. 23

solution consisting of bleaching powder and soda ash in the ratio of 5 : 1. (The addition of soda ash helps to convert calcium hypochlorite into sodium hypochlorite and reduce deposition). However, the rubber bag needs frequent replacement, generally once in 4 to 8 months. The differential pressure type chlorinators are commercially marketed in this country and are widely used for disinfection of water supplies. There should be a minimum of 10 psi pressure in the main line carrying water for proper functioning of these units.

Assuming a bleaching powder solution of 1000 ppm of available chlorine is used, the recharging interval for the different capacities of chlorinators available is given in Table XIII.

TABLE XIII

RECHARGE INTERVAL FOR DIFFERENT SIZED CHLORINATORS

Population	Daily supply at the rate of 50 litres per capita	Volume of bleaching powder solution required in liters to give 1 ppm dose	Recharge interval (days) with a doser capacity of			
			35 lits.	70 lits.	100 lits.	140 lits.
100	5000	5	7	14	20	28
200	10000	10	3.5	7.0	10	14
500	25000	25	1.4	2.8	4	5.6
1000	50000	50	0.7	1.4	2	2.8

7.0 CHLORINE TEST KIT

Any well water disinfection programme will not be successful unless we have a simple kit to enable an unskilled villager to test for the chlorine concentration of the well waters. The presently available chlorine testing kits in the market are fairly simple but expensive costing Rs.100 - 200.

The Institute has fabricated a simple, compact and sturdy chloroscope from indigenously available materials (see photo). The total cost of this unit is Rs. 15/- which is within the reach of rural communities. This will fill the gap for the long-felt need for a simple and cheap residual chlorine testing kit for the implementation of the community water supply schemes. This unit can detect chlorine concentrations in the range of 0.1 to 1.00 ppm.

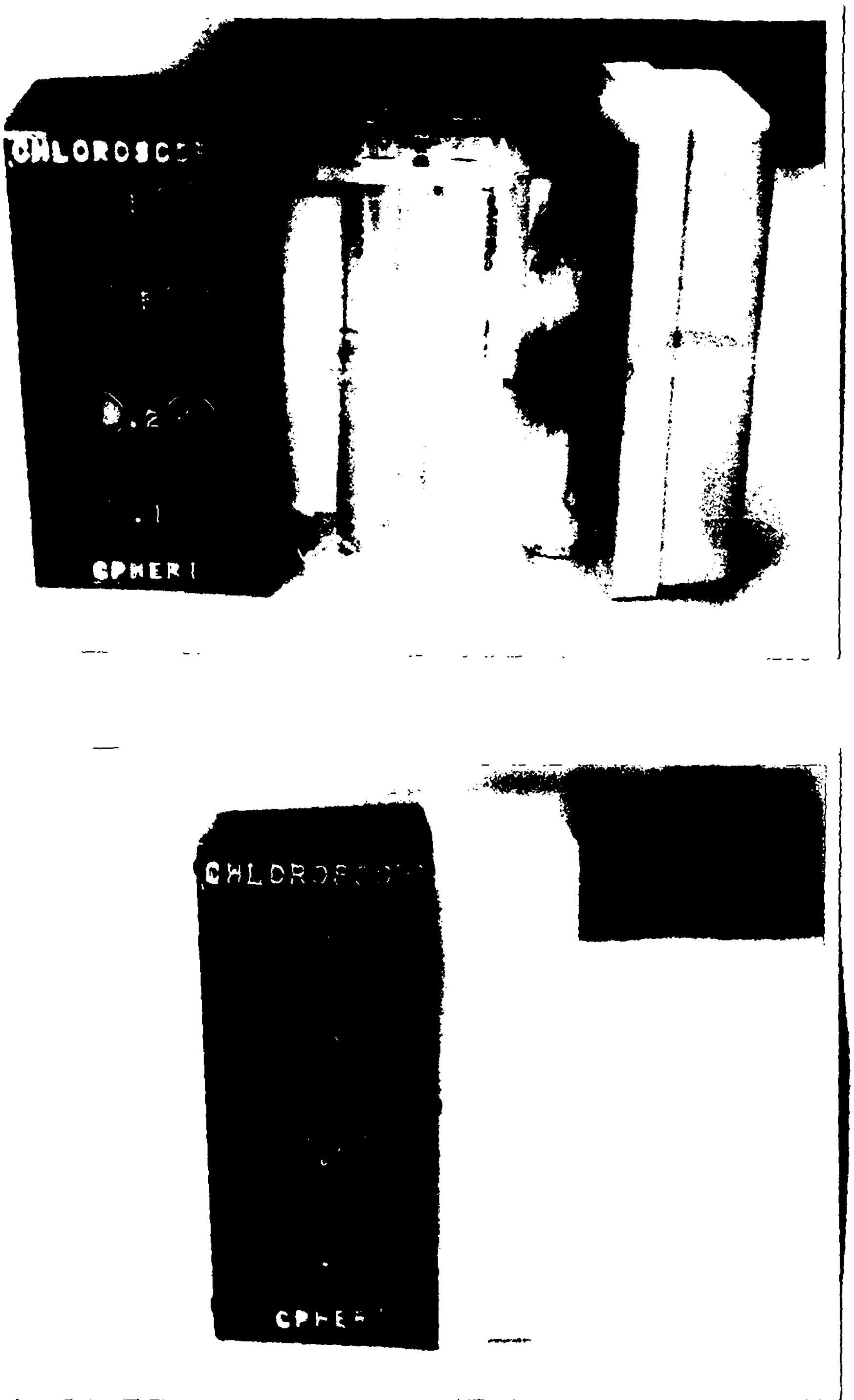
The kit consists of the following :

1. Two sample tubes, one for the control and other for test
2. Four standard coloured discs corresponding to 0.1, 0.2, 0.5 and 1 mg/1 of chlorine
3. An amber coloured orthotolidine reagent dropper

The use of such kits is very well known and needs no elaboration here.

Standard Colour Discs

Permanent colours corresponding to the standard colours for different concentration of chlorine are fixed in gelatin,



C P H E R I C H L O R O S C O P E

sandwiched between two glass cover-slips and fitted into the box. Such standard colour discs developed by the Institute have been found perfectly stable over a period of 2 years now. They are still under observation for any possible deterioration of colour with time.

SUMMARY AND CONCLUSIONS

Various disinfection techniques for small community water supplies were studied in order to access their performance with open dug wells as well as piped water supplies. Some of the known techniques were tried, a few were modified and few entirely new methods were developed. The disinfectant used in each case was bleaching powder. Other disinfectants were not used as they may not be readily available in all developing countries and were also not included in the scope of the present study.

The first part of the investigation was confined to a study of characteristics of bleaching powder in solid and liquid forms. The essential conclusions were :

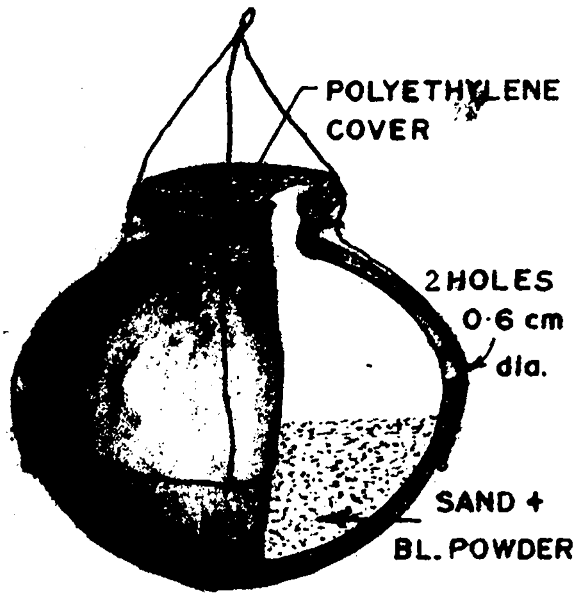
1. The available chlorine in bleaching powder manufactured in India was in the range of 32 to 35 per cent and the heat stability tests (fraction of available chlorine lost at $100^{\circ} \pm 2^{\circ}C$ in 2 hrs) revealed that the chlorine loss was in the range of 1/16 to 1/10. According to the specifications stipulated by the Indian Standards Institution, the available chlorine should be 33 per cent and the loss of chlorine in the ' Heat Stability Test ' should not be more than 1/11.

2. During storage, frequent opening of the bleaching powder container resulted in a loss of nearly 5 per cent chlorine in 40 days while the loss was 18 per cent if the container was fully kept open during this period.

3. While preparing bleaching powder solution in water, it was observed that a solution upto 5 per cent could be made without much loss of chlorine. Preparation of stronger solutions, say 10 per cent and above resulted in the loss of considerable quantity of chlorine.

4. Storage of bleaching powder solution containing nearly 10,000 ppm chlorine did not indicate any significant loss of chlorine for 10 days when the containers were protected from day-light. Nearly 40 per cent of the chlorine was lost in the same period when the containers were exposed to day-light.

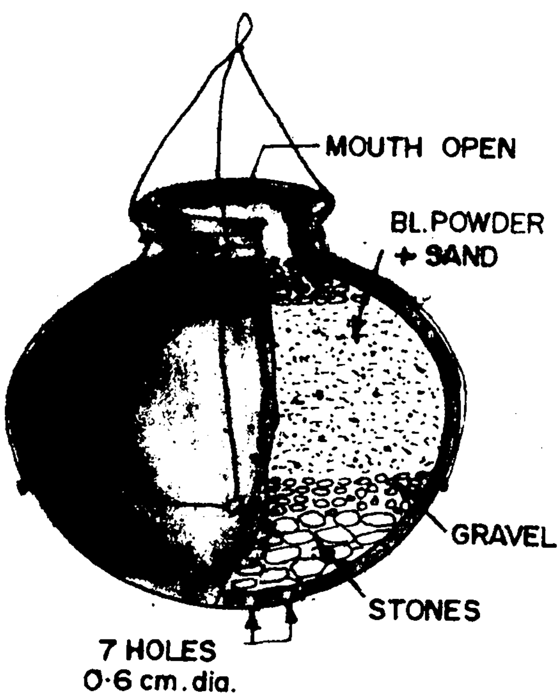
The second part of the investigation was concerned with the use of various types of simple feeding devices for open dug wells such as earthen pots and drip-type chlorinators. The investigation was further extended to cover feeding devices which could be used in connection with piped water supplies for small communities. The various methods were found to have their pros and cons, which have been summarised below for ready reference :



SINGLE POT WITH HOLES IN MIDDLE

One unit will chlorinate wells of 9000 to 13000 liters contents and having a withdrawal rate of 900 to 1300 liters/day (i.e., serving 40-60 people per day)

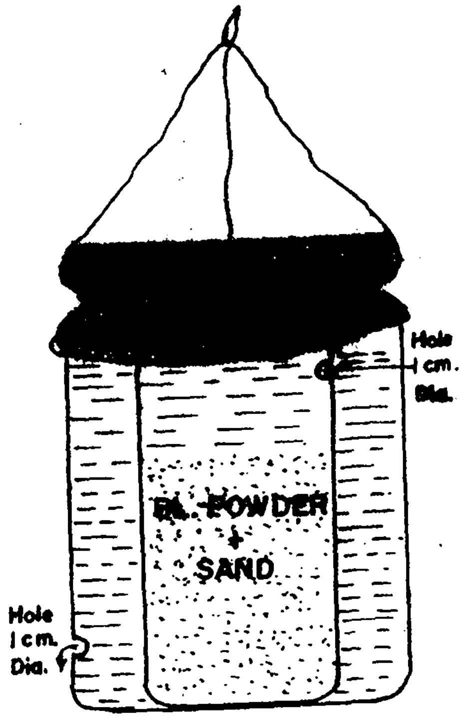
Unit is filled with 1 $\frac{1}{2}$ kg of bleaching powder mixed with 3 kg of coarse sand (2 mm and above) covered and suspended 1 meter below water level. Needs replenishing every week.



SINGLE POT WITH HOLES AT BOTTOM

One unit will chlorinate wells of 9000 to 13000 liters contents and having a withdrawal rate of 900 to 1300 liters per day (i.e., serving 40-60 people/day). More number of units may be used for larger wells.

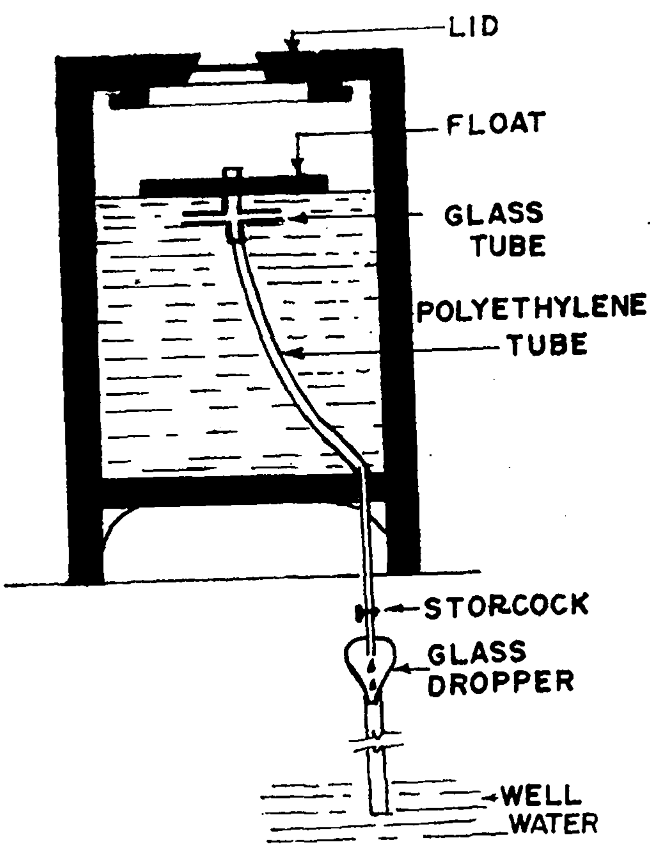
Unit is filled with 1 $\frac{1}{2}$ kg of bleaching powder mixed with 3 kg of coarse sand as before but with addition of 75 gm of sodium hexametaphosphate. It is then packed with gravel upto the top and suspended 1 meter below water level. Needs replenishing of chemicals every 2 weeks.



DOUBLE POT WITH A HOLE IN EACH POT

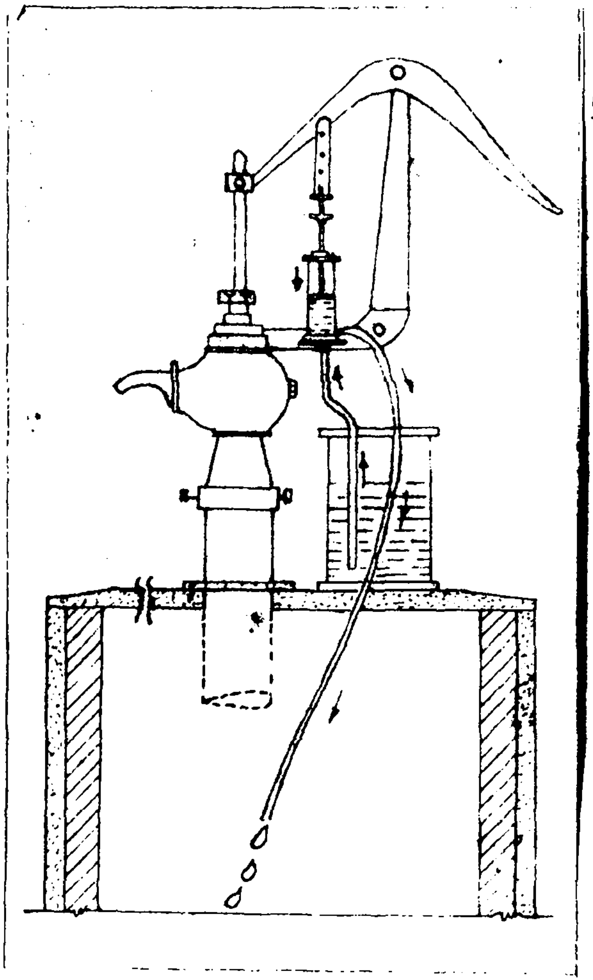
One unit will chlorinate wells of 3600 to 4500 liters contents and having a withdrawal rate of 360 to 450 liters per day (i.e., serving 15-20 people per day).

The inner pot is filled with 1 kg of bleaching powder with 2 kg of coarse sand (2 mm and above) and placed inside the outer pot. The mouth is loosely covered and the unit lowered as before. Needs replenishing every 3 weeks. Ideal for individual household wells.



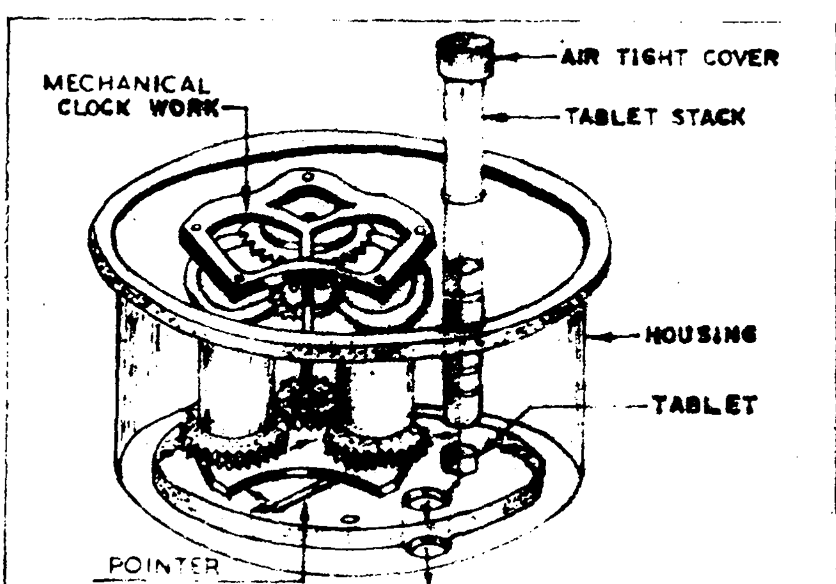
DRIP CHLORINATOR

It can be used to disinfectant either open dug wells or covered wells, which contain 20,000 to 60,000 liters with a daily withdrawal of 2000 to 6000 liters. (i.e., serving 80 to 240 persons) The unit needs refilling after 2 to 5 days depending on the consumption. 1 % solution of bleaching powder is used.



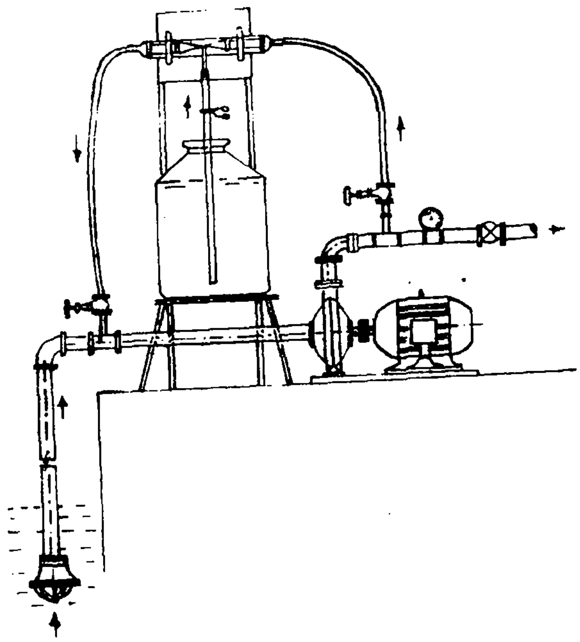
GADGET FOR ATTACHMENT TO HAND PUMP

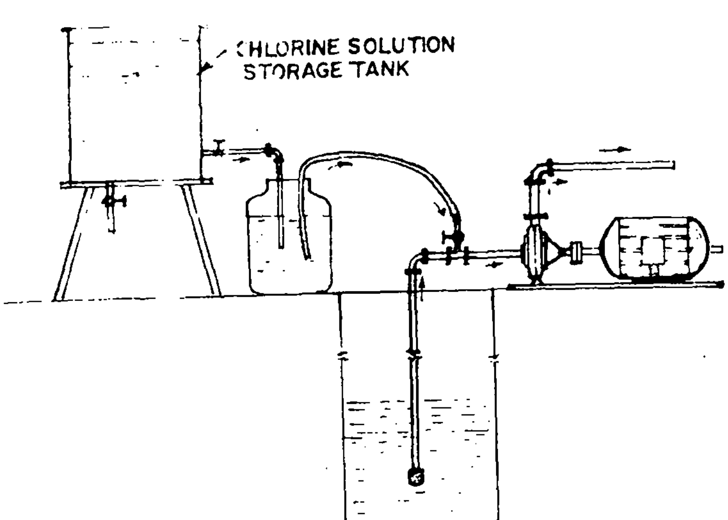
A bleaching powder solutinn dispenser for use with hand pumps was experimented with but could not be successfully used due to various reasons such as play in the pump handle. Hence further work was discontinued.



CHLORINE AND IODINE TABLET DISPENSER

This device uses a mechanical or electrical clockwork mechanism for dropping stacked tablets, one at a time, into the well through a hole at each revolution. Its initial cost is about Rs. 100 - 200 per unit and appears to be more suitable for household wells in suburban areas, where electricity is available and tablets can be purchased.
Not recommended for villages due to possible pilferage.





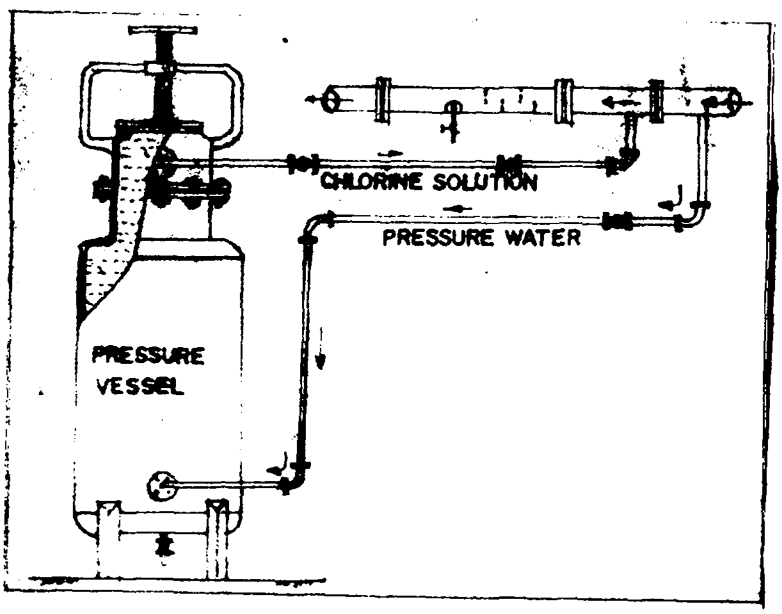
VENTURI AND EJECTOR-TYPE CHLORINATORS

These chlorinators which are available commercially and sometimes used with piped water supplies were found to be unsatisfactory owing to rapid chokage by $CaCO_3$ deposits at throats. Hence not recommended. Costs are also high ranging from Rs. 800/- to Rs. 1000/- per unit.

DIRECT-FEED TYPE CHLORINATORS

A simple method of disinfection of piped supplies is to feed bleaching powder solution directly in the suction line of the centrifugal pump used for drawing water. The dose is adjusted by using a pinch-cock on the feed containing 1 % solution in enough quantity to last 1 day and yet leave a surplus to prevent air from entering the suction side. This method requires no special gadgets and has been found satisfactory in operation.

DIFFERENTIAL PRESSURE TYPE CHLORINATOR



This type of chlorinator is commercially available for use with piped water supplies. A solution containing bleaching powder and soda ash in the proportion of 5 : 1 is filled in a rubber bag from which it is gradually squeezed out in proportion to the differential pressure across an orifice plate. The rate is adjusted by a needle valve. This type of chlorinator though expensive (Rs.1500 - 3000) is widely used and found to be quite satisfactory except for the need to replace the rubber bag (costing about Rs. 200/-) every 4 to 6 months.