APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND

MINISTRY OF PUBLIC HEALTH

UNITED NATIONS CHILDREN'S FUND

COOPERATIVE

RESEARCH PROJECT NO. 16/1

IODIZATION OF CRUDE SALT

REPORT NO. 1

DESIGN OF SALT IODATION MACHINE

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INDUSTRIAL CHEMISTRY GROUP

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1. INTRODUCTION

Common salt is being increasingly used as a medium of distribution of iodine to human populations in goitre regions. The majority of projects for adding potassium iodate (the preferred combined form of iodine for this purpose) to crude salt have been on the dry mixing of the powder with a bulking medium such as calcium carbonate and then blending this with the crude salt crystals. This is limited in practice to small salt crystals of, say, 5 mm and finer particles.

Most salt distributed to the population in many countries (and this is true of Thailand) is of larger size and is not suitable for dry mixing. It has been found possible to add potassium iodate to salt in the form of a liquid spray and this method has been used for some years in Mexico.

The Ministry of Public Health has been cooperating with UNICEF in operating a pilot unit for iodization of crude salt in the northeast of Thailand. The process used is described in an article: "The Iodization of Crude Salt for the Prophylaxis of Goitre" by Cyril Hunnikin (UNICEF Food Conservation Engineer) which appeared in Food Technology, Vol, 18, No. 10, pages 40-43 (1964). This unit uses an air pressure spray (20 lb/in^2) to atomize a 5% solution of potassium iodate drawn from a stock tank. The salt is fed from a hopper onto a vibrating table actuated by a vibratory feeder incorporating an a.c. resonant vibrator unit. The rate of salt flow is controlled at 3 tons per hour.

2. THE PROBLEM

The above mentioned unit suffered from some deficiencies which are discussed below. Accordingly it was decided to undertake a cooperative study between the Ministry of Public Health, UNICEF, and ASRCT with a view to studying alternative methods of incorporating iodate in the salt which would simplify the equipment and eliminate control problems experienced in the operation of the pilot unit.

At the same time it was agreed that an iodation unit should be so designed that is could be used as a basis for local manufacture. It was to incorporate features which would reduce costs of construction and simplify maintenance and operating procedures, and at the same time avoid corrosion which is very severe in salt handling equipment.

The present work was based on an examination of the deficiencies of the pilot unit and a specification of design desiderata evolved in discussions between Mr. Cyril Hunnikin (Food Conservation Engineer, UNICEF), Mr. Frank G. Nicholls (Special Governor, ASRCT), G/C Sorn Satrabhaya (Manager, Technical Services, ASRCT) and Mr. Narinder S. Galuja (Research Associate, ASRCT).

As mentioned above the basic components of the pilot unit are a vibrating table powered by an a.c. resonant vibrator, and an air pressure spraying system to "atomize" the iodate solution.

It was decided that the new design should aim to eliminate the a.c. resonant vibrator and the air pressure spray. A mechanical vibrator and some form of gravity-fed drip feed were suggested as alternatives which would be simple and cheap.

It was agreed that a mock-up should be built to incorporate experimental versions of both these components. Several arrangements were tested and these are described below under "Evolution of Design".

It was also agreed that ASRCT should prepare working drawings for a production unit incorporating the final versions of these components.

3. EVOLUTION OF DESIGN

The a.c. resonant vibrator used in the pilot unit is quite reliable generally, but should repairs be required, it has to be attended to by a skilled technician. In remote areas it is doubtful if the available technical help would be familiar with such units. Furthermore, difficulties were experienced in maintaining a constant feed rate with badly regulated power supplies. Therefore it was decided to substitute some sort of mechanical vibrating device.

Several possibilities were considered. Perhaps the simplest (and most primitive) solution is where the table is shaken by a person either directly or by hitting it with a hammer, or some such device. This system obviously would not give regular results and is not very practical. However, if one substitutes a motor as the motivating power for the hammer, this mode of producing vibration becomes quite feasible. A mock-up model was made at ASRCT utilizing this principle. The table was mounted on springs and it was hit from the bottom by a small metal hammer attached to a pulley which was powered by a small motor. It was soon realized that, though the vibration characteristics produced a good flow of salt, the hammering of the bottom of the table was very noisy. Also, the persistant hammering produced cracks in welding due to metal fatigue. This problem of metal fatigue is especially important in a corrosive atmosphere like the one in salt handling. Therefore it was decided to look for other alternate modes of producing vibration.

Another method of vibrating the table is to attach a small motor to it. When an unbalanced weight is attached to the rotor and the motor is switched on, the vibrations due to the unbalanced shaft are transmitted to the table and it will shake provided it has flexible supports. In this system the amplitude and the direction of the vibration are not steady; these vary with the load. Consequently the amount of salt remaining in the hopper would effect the salt discharge characteristics of the vibrating table.

The method finally selected after the above mentioned trials consists of an eccentric shaft running inside a guide attached to the table which floats on four springs. The shaft is run by a 0.25 hp motor via a pulley system. In this system the vibration amplitude is fixed and direction of the vibrations is linear. Furthermore the noise is reduced to a minimum.

Tests have proved this system to be adequate in providing a uniform flow of crude salt. The rate of flow can be adjusted by varying the angle of decline of the table and the opening of the gate of the hopper onto the vibrating table.

The air pressure spraying unit used for the iodate solution causes fogging in the working area and a portion of iodate solution is wasted. Also the spray nozzles require cleaning frequently. In the existing unit difficulties have also been experienced due to change in head in the iodate solution feed tank during the working day. To supply the high pressure air, a compressor is required. Besides being expensive, there can be problems (especially in remote areas) concerning the availability and cost of spare parts for this arrangement.

The initial experimental design used had a single drip feeder from which a stream of drops of the iodate solution were put into the channel of a V-shaped chute. The salt dropped off the vibrating table and passed through this channel and picked up the iodate solution. This system did not give an even dispersion of iodate.

The second trial consisted of the drip feed attached to a brush. The idea was to give the salt stream a light brushing of the iodate solution. This system also did not come up to expectations. There was too much iodate being evaporated from the brush such that it was soon encrusted with the iodate crystals. Also the flow was not very regular due to frequent blocking of the passage between the V-chute and the brush.

The third experiment had the drip feeder attached to a 6 mm I.D. tube which had 0.5 mm diameter holes drilled along its length and this was suspended over the V-chute. It was seen that the shape of the chute was not optimum since it did not give an even layer of the flowing salt. Therefore the chute shape was flattened out to a shape similar to the vibrating table to get the desired flow characteristics. Results with this set-up were encouraging. Large test samples showed a uniform distribution but smaller samples did not show uniformity. This indicated that the dispersion of the iodate solution was not fine enough. To achieve this the iodate feeding tube was attached to the vibrating table. This vibrated the tube and gave a finer dispersion of the iodate drops. The analytical results in this case showed an adequate uniformity.

There were drawbacks in this system however. Over a period of time, the vibration of the tube would lead to metal fatigue at the joints and at the tube clamp. Also there was considerable loss of iodate solution due to splattering onto the surrounding area. Consequently the vibrating tube design had to be abandoned also.

For the fourth experiment the tube was fixed onto the supporting frame of the machine such that it was parallel to the edge of the vibrating table, off which the salt would fall onto the chute. The tube had 8 holes of 0.5 mm diameter spaced 25 mm apart. The tube was fed via fixed piping from a constant level tank. The level of the iodate solution is kept constant in the tank by placing a bottle containing 25 litres of the iodate solution upside down such that the mouth of the bottle touches the surface of the solution in the tank. When the level of the solution in the tank drops, as the iodate is added to the salt stream, the solution from the bottle pours out till the level in the tank touches the mouth of the bottle again. Thus the level stays essentially constant until the solution in the bottle is depleted, at which time it is replaced by another filled bottle. The results obtained with this hook-up (see Figure 1, page 5) are discussed below.

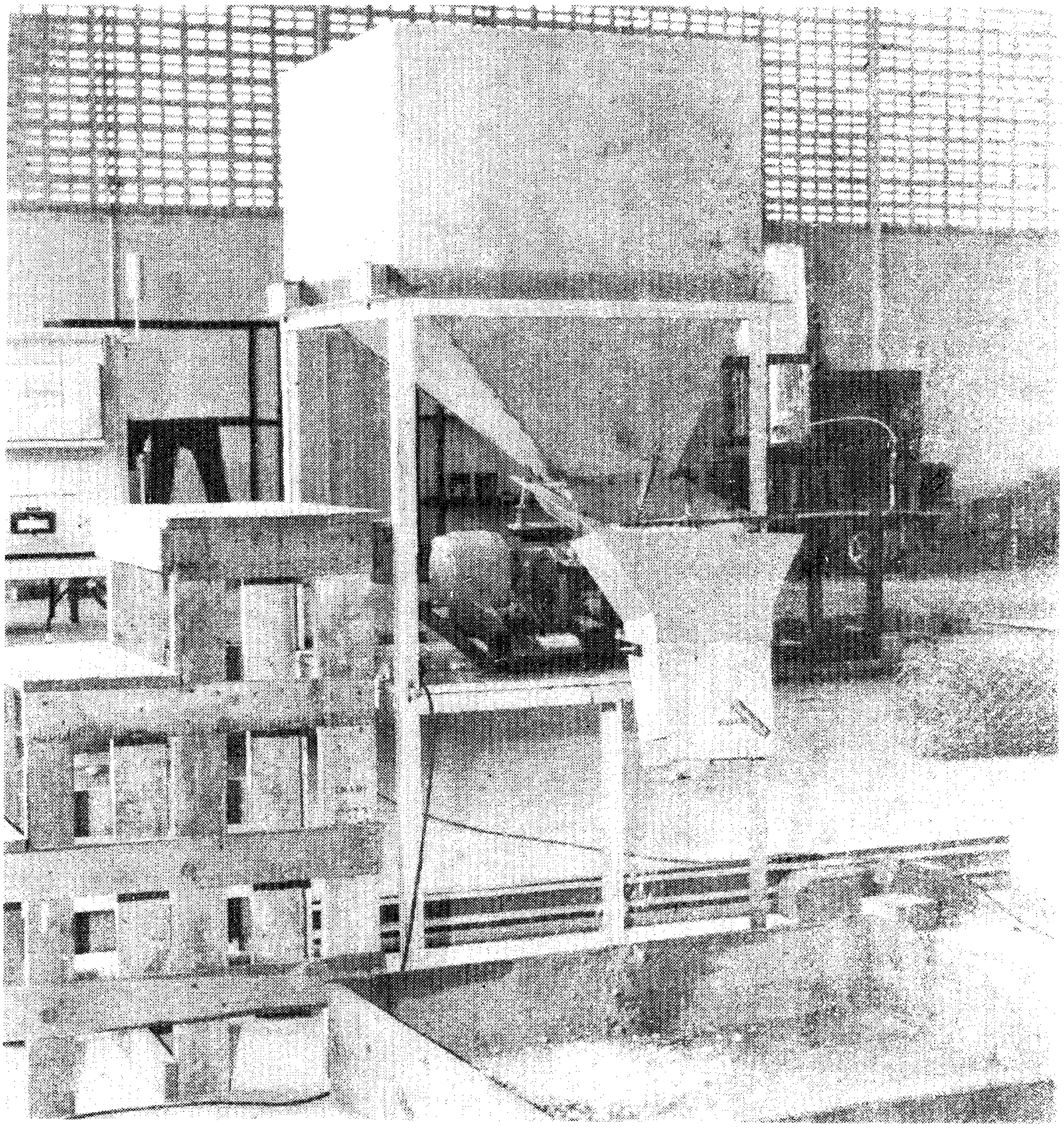


Figure 1.- Experimental mock-up

4. EXPERIMENTAL RESULTS

Preliminary tests carried out on a pilot scale hook-up, to establish if the simple drip feed system with the mechanical vibrating table described above is adequate for the iodation needs, has shown that the consistency of iodation met the required specifications. The hook-up did not facilitate precise estimation of the iodate being added to the salt, and no attempt was made in the initial run to get high concentrations of iodate.

From Table 1, page 10, it will be seen that a control sample of untreated salt showed 7.8 p.p.m. of potassium iodate. Three samples were taken during the first run and these contained 48, 52 and 66 p.p.m. of iodate. A lower rate of solution feed gave concentrations of 32.8 and 30 p.p.m.

A subsequent test was made a week later and 3 samples were taken under running conditions from the discharge chute. These samples had concentrations of 88.8 and 94.5 p.p.m. of iodate. These values approximate the concentrations said to be desirable, i.e. 1 part in about 11,000 parts of salt (about 90 p.p.m.).

5. DISCUSSION OF FINAL DESIGN

Following the above mentioned test the Project Steering Committee (members specified above) decided on the following design specifications:-

The machine should be capable of handling about 2.4 tons of crude salt per hour. It should be possible to adjust the flow rate to some extent.

Typical running conditions would require a flow rate of about 10 litres per hour for the iodate solution. However, a flow meter should be included to allow for flow rate adjustment from 1.5 litres to 15 litres per hour.

To reduce the possibility of the iodate solution running out in the feed tank, two bottles of 2.5-litre capacity should be used instead of one as in the mokc-up. The level of the opening of one of the bottles shall be about 2 mm lower than the other and this shall act as a reserve which would be used while changing the regular feed bottle and in emergencies. This system would insure that the level in the tank will not vary more than 2 mm.

Considering the severity of the corrosion problem in salt handling it is important to design all machine elements to resist corrosion as much as possible, and to facilitate easy replacement.

In accordance with the plans worked out by the Ministry of Public Health and UNICEF, it is planned to install these iodation machines in a salt warehouse. There the salt in bags, after being unloaded from the barges, is to be fed directly into the hoppers of these machines. The loading will be done from a raised platform having a height of about 2.45 metres. Consequently the hopper design should incorporate features to facilitate easy handling of the salt in this particular situation.

Since the machines are to operate in the same warehouse, it would be cheaper to have a single frame for two machines. However the drive and controls should be separate to allow for maintenance of one machine at a time.

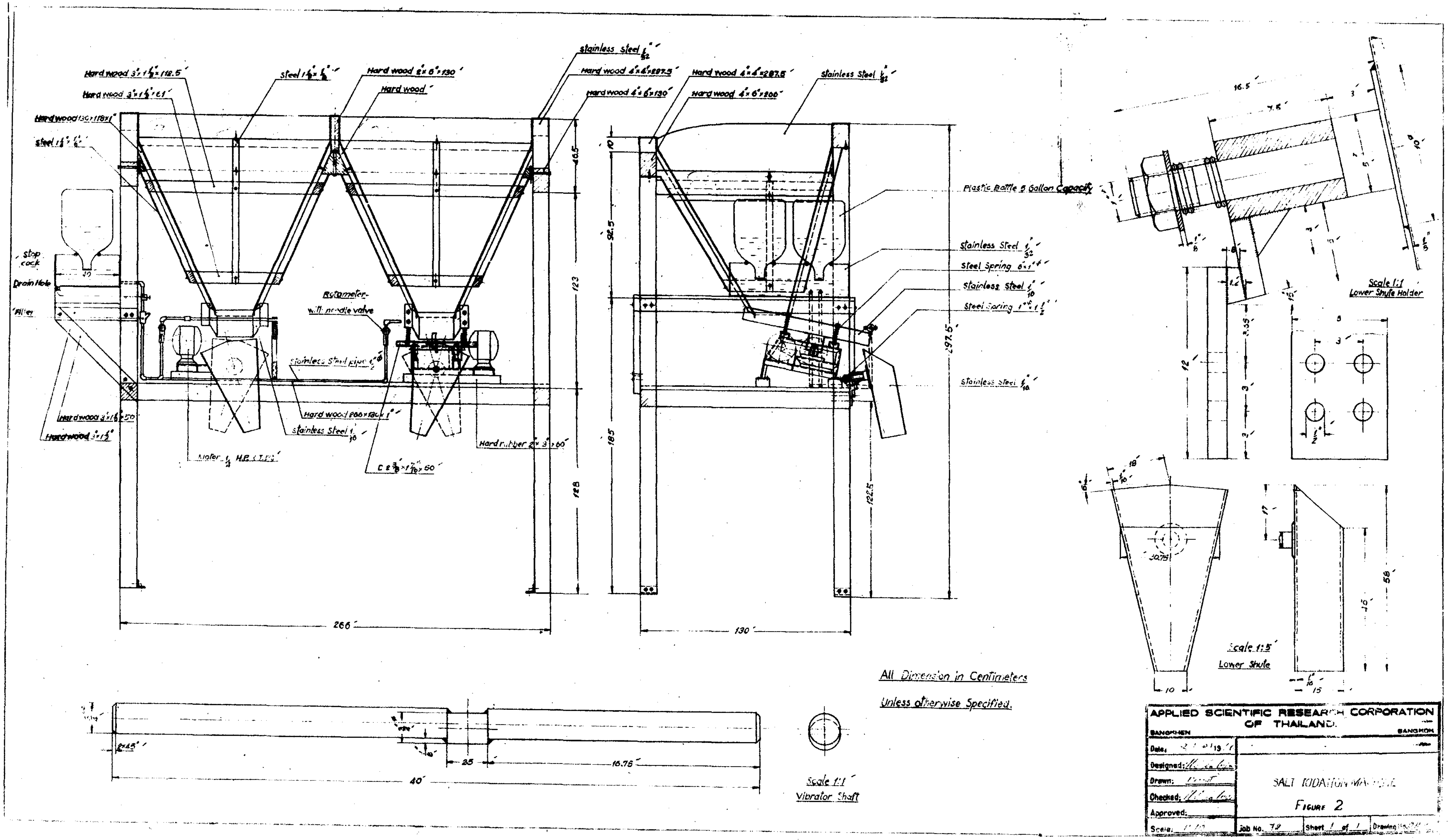
6. PROPOSED DESIGN

The proposed design (see Figure 2) uses a simple drip feed system. It consists of a 12 mm internal diameter stainless steel tube connected to a stainless steel tank having a constant level of iodate solution. The level is kept constant as described above. This tube passes over the lower edge of the vibrating table. Eight equally spaced holes of $\frac{1}{2}$ mm diameter are drilled in the portion of the tube which passes over the vibrating table. Small nozzle-like protrusions are added to the tube at the hole positions to insure that the drops will fall from the specified places. This arrangement has been tested and gives a steady flow of drops onto the salt falling off the edge of the vibrating table. The rate of flow of the solution can be checked and adjusted by a rotameter and needle valve to be incorporated in the system.

The salt feed system has the eccentric shaft system described above connected to a 0.25 hp 220V single-phase motor. The whole assembly is completely enclosed to prevent salt damage.

To insure thorough dispersion of the iodate solution a chute is included in the design. During operation this chute is at an angle to the salt flow from the vibrating table and serves the double purpose of mixing the salt after the addition of the iodate, and of directing the salt stream into the salt bags.

The height of the machine has been so designed as to allow a salt bag to be put upright under the chute and the chute has two discharge positions. This allows continuous filling of the salt bags by merely switching the chute



Hard wood 3"×1½"×118.5
Hard wood 3"×1½"×61
Hard wood 130×118×1"
Steel 1½"×⅛"
Steel 1½"×⅛"
Hard wood 2"×6"×130
Hard wood
stainless steel 1/32"
Hard wood 4"×4"×297.5
Hard wood 4"×6"×130
Hard wood 4"×4"×297.5
Hard wood 4"×6"×266
Stainless Steel 1/32"
Plastic Bottle 5 Gallon Capacity
stainless Steel 1/32"
Steel Spring
stainless steel 1/16"
Steel Spring
Stainless Steel 1/16"
Stop cock
Drain Hole
Filter
Rotameter with needle valve
Stainless Steel pipe
Hard wood 266×18×1"
stainless Steel 1/16"
Motor 1/4 H.P.
Hard rubber 2"×3"×60
Hard wood 3"×1½"×50
Hard wood 3"×1½"
266
130
All Dimension in Centimeters
Unless otherwise Specified.
Scale 1:1
Vibrator Shaft
Scale 1:1
Lower Shute Holder
Scale 1:5
Lower Shute
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SALT IODATION MACHINE
FIGURE 2

from one position to the other every two minutes or so. This rate of filling was considered to be the optimum.

All features of the machine have been designed to safeguard against corrosion and for heavy-duty service. Thus all load bearing members of the machine are of first-grade hardwood. The hoppers are made of hardwood with a lining of stainless steel. All surfaces coming in contact with either the salt or the iodate solution are of stainless steel. The wood and steel parts of the machine will be given heavy coats of paint to avoid corrosion. All electrical wiring will be in conduits and the switches (with overload cut-offs) will be enclosed in switch boxes. The rotameters will also be enclosed in boxes to prevent damage.

7. COST OF CONSTRUCTION

It has been decided by the Steering Committee that it would be cheaper to construct 2 sets of hoppers with individual feed systems on a single frame. The estimated cost of such a set of two machines, shown in Figure 2, having a combined capacity of 4.8 tons per hour, is 15,000.00 baht per set. The details of the cost estimates are shown in Table 2 on page 11.

TABLE 1

UNICEF SMALL IODATION UNIT - TESTS AT ASRCT, BANGKHEN

ANALYTICAL RESULTS FOR POTASSIUM IODATE CONTENT IN SALT*

Samples of 50 ml of 20% Salt Solution (contain 10-g of salt)

First Test 15 July 1966

Salt flow rate - 1.75 tons/hr or 27 kg/min

2% KIO_3 solution flow rate - sample 1, - 100 ml/min

sample 2, - 50 ml/min

Second Test 20 July 1966

Salt flow rate - 37.5 kg/min

2% KIO_3 solution flow rate - sample 3, - 160 ml/min

Test No.	Sample No.	Parts Salt to 1 part KIO_3	p.p.m. KIO_3
1	Control (not iodated)	127,550	7.8
	1(a)	20,850	48.0
	1(b)	19,208	52.0
	1(c)	14,997	66.7
	Anticipated	13,550	74.0
	2(a)	30,478	32.8
	2(b)	30,798	30.5
	Anticipated	27,000	37.0
2	3(a)	11,262	88.8
	3(b)	10,582	94.5
	3(c)	10,234	97.5
	Sack S-1	10,253	97.5
	Sack S-3	8,371	119.5
	Anticipated	11,700	85.0

* See Appendix A for Analytical procedure.

TABLE 2

ESTIMATE OF MATERIALS REQUIRED FOR ONE SET OF TWO HOPPERS OF TOTAL CAPACITIES 4.8 TONS AND THEIR APPROXIMATE COSTS

		Quantity	Rate		Extension
1.	Hoppers				
	S.S. sheet 1/32" thick	6 sheets	500		3,000.-
	Hardwood lining 1"	16 ft³	55		660.-
2.	Supporting frame 6" x 2" wood beam (top) 4" x 4" pillars 4" x 2" platform support (hardwood)	7 ft³	55		385.-
3.	S.S. sheet for vibrator and chute, approx. 1/16" thick	½ sheet	1000		500.-
4.	1¼ x 1¼ L-iron support for motor and vibrator	12 metres	30/6m		60.-
	Steel channel 3" x 2"	2 metres	170/6m		60.-
5.	Chute holding mechanism (steel)	6 kg	5		30.-
6.	2 motors (¼ hp)		350		700.-
	Switches and wiring		150		300.-
	2 sets of pulleys		30		60.-
	2 belts		20		40.-
	4 bearings and casings		20		80.-
	¾" ϕ shaft steel - 1 m		50		50.-
	8 springs 6" x 1" ϕ		8/pc.		65.-
	8 bolts 8" x ½" ϕ and nuts & washers				10.-
	Brass plate ¾" x 3" x 40 cm		30/kg		50.-
	6 nuts and bolts 1" x ¼"				5.-
	Rubber supports				40.-
7.	Iodate solution piping				
	5 bottles - plastic or glass		30		150.-
	S.S. tank 15" x 30" x 12", 1 1/32" thick	1 sheet	500		500.-
	Rotameters C needle valve	2 pcs.	600		1,200.-
	Wooden support for tank	1 ft³	55		55.-
8.	Sack holder				
	G.I. piping 1½"	6 metres	14		85.-
	1½" tees	4 pcs.	7.50		30.-
	1½" flanges	4 pcs.	3.50		15.-
	1½" end stops	4 pcs.	4.50		20.-
	Hooks	4 pcs.			20.-
9.	Box for motor and bearing, etc. S.S. 1 mm	½ sheet	500		250.-
		Sub Total			8,420.-
10.	Welding rods, fittings, etc., painting - brackets handles 10%				840.-
11.	Labour - carpenter welder fitter	120 h	10/h		1,200.-
12.	Overhead				3,600.-
		Sub Total			14,060.-
13.	Contingency				940.-
		Total Estimated Cost		Baht	15,000.-

APPENDIX A

ANALYTICAL PROCEDURE FOR THE DETERMINATION OF IODINE IN IODIZED SALT

1. Dissolve 50-g of iodized salt in distilled water and make up to 250 ml in a volumetric flask. Pipette 25 ml into a 600-ml beaker and dilute to about 300 ml. Neutralize to methyl orange with phosphoric acid and then add 1 ml in excess.

2. Add an excess of bromine water, boil gently until colourless and then for five minutes longer. Add a few crystals of salicylic acid and cool the solution to about 20°C. Add 1 ml of 85% phosphoric acid and about 0.5-g of potassium iodide. Titrate the liberated iodine with 0.005 N sodium thiosulfate using starch as indicator.