January 25, 1949

Mr. Henry Gifford Hardy
Russ Building
San Francisco 4, California

Subject: Chlorination of Swimming Pool Water

Dear Mr. Hardy:

The wages of procrastination are at best a candle burnt at both
ends and sagging at center.

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METHOD AND MEANS FOR THE CONTROLLED CHLORINATION

OF SWIMMING POOL WATER

This invention relates to a new and useful development in the
chlorination of swimming pool water and the like, and more par-
ticularly to the electrolytic oxidation of chlorides to elemental
chlorine and to hypochlorites, this under conditions sufficiently
low in chloride ion concentration as to permit the swimming pool
water itself to serve as electrolyte and the swimming pool itself
to serve as electrolytic generator.

Heretofore, it has been customary to treat swimming pool water
with chlorine gas or with sodium hypochlorite solution. The first
of these requires expensive dispensing equipment, is exceedingly
corrosive, and demands constant skilled supervision. The second
requires the periodic addition of a solution that generally con-
tains 5% of available chlorine. For example, one gallon of hypo-
chlorite solution may be added to a 30,000 gallon pool every other
day in order to maintain a safe chlorine level of say 0.5 ppm (parts
per million). Though sodium hypochlorite solution is an inexpensive
commodity in bulk, purchase in small containers demands upwards of
$0.50 per gallon. This represents an annual expenditure of $90.00 or
more plus the nuisance of cartage and of continued attendance.

Further, inasmuch as a sodium hypochlorite solution containing 5%
available chlorine will upon exhaustion contain 10½% of common salt,
one may calculate the salt concentration in the pool water at the
end of one year's operation. We find that the equivalent of 157
pounds of salt have been added, yielding a salt concentration in the
pool water of roughly 600 ppm. Therefore it is not unreasonable in
line with this past practice to add common salt to the swimming pool
water at the outset at a concentration in this order of magnitude,
and to convert the chloride ions so contributed to chlorine or to
hypochlorites by electrochemical means.

An object of this invention is to eliminate the continued super-
vision required in the customary method of chlorination, this by
generating chlorine electrochemically under automatically controlled
conditions, the swimming pool water pretreated with common salt
serving as electrolyte.

For example, 110 volt alternating current is transformed and rectified
to yield a 4 volt direct current source. The positive terminal of
this is electrically connected to a graphite rod $\frac{5}{4}$ inch in diameter
and a foot in length. This serves as anode. Concentric with and
separated from this by a 1/16 inch gap is a stainless steel tube of
7/8 inch bore, also a foot in length. This is connected electrically
to the negative terminal of the power supply, and serves as cathode.
Thus the graphite anode and the steel cathode together constitute
the electrode assembly. This assembly is mounted (with its axis
vertical) in the swimming pool water at the greatest depth possible.
It is essential that the connection between graphite and positive
terminal of the power supply be completely protected from contact
with the water, as with a suitable coating such as rubber. If this
is not done corrosion of the positive lead will ensue. The swimming
pool water to which has been added common salt at the rate of 1000 ppm.
serves as electrolyte, filling the gap between anode and cathode. At
this concentration salt barely can be detected by taste. Higher salt
concentrations will yield higher energy efficiencies, the upper limit
being that concentration which consumer reaction will tolerate. Even
at a 1000 ppm, however, the chloride ion concentration is sufficiently
high to permit the electrolytic oxidation from chloride ion to chlorine
to take place at a practical efficiency.

Upon applying the 4 volt potential to the electrodes as above described,
hydrogen is liberated at the cathode as is sodium hydroxide. Chlorine
and oxygen are liberated at the anode. These are mixed in the 1/16 inch
annular gap and surge vertically to be quickly removed from further
influences of electrochemical action which otherwise would tend to
oxidize the end-products further than desired.

That the process as here described is indeed practical can be seen
from the results of a typical laboratory run in 5 gallons of water.
Incidentally, the efficiency as a matter of principle should be greater
for larger bodies of electrolyte.

Time, minutes	Current, Amperes	Volts	Watts	Chlorine, ppm.
0	0.0	0.0	0.0	0.00
3	3.5	4.1	14.3	0.35
6	3.5	4.1	14.3	0.90
10	3.5	4.1	14.3	1.10
15	3.5	4.1	14.3	1.70

Thus we estimate that the 5 gallons was raised to 0.5 ppm of chlorine
in $4\frac{1}{2}$ minutes. The unit operating under these conditions will therefore
raise 1600 gallons of water to $\frac{1}{2}$ ppm of chlorine in 24 hours, at a power
consumption of roughly 350 watt hours. To raise 30, 000 gallons to

$\frac{1}{2}$ ppm in 24 hours will therefore require 19 such units or their equivalent in a larger unit at a power consumption of 6.6 kilowatt hours per day. At $ 0.02 per kilowatt hour this represents an annual expenditure of $ 48.00 per year for power. This plus the cost of the 250 pounds of salt required is reasonably in line with the cost of the hypochlorite treatment.

Further, by this process chlorine is generated at a controlled and constant rate throughout the year whereas in the hypochlorite treatment the chlorine concentration suffers its ups and downs, up to a high level just after addition of reagent, down to a low level just prior to its addition. Since hypochlorite and chlorine in solution are unstable, and since the rate of decomposition increases with increasing concentration, it is apparent that less chlorine will be required if this is added at a constant rate rather than stepwise as is the customary practice

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I trust the above serves its intended purpose. Thanks and good wishes.

Sincerely,

Sylvan Eisenberg

REPORT ON

ELECTRICAL CHLORINATOR

(As developed by S. Eisenberg — technical consultant)

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PURPOSE OF REPORT:

To determine whether this particular type of electrical chlorinator can be developed for successful swimming pool application.

DESCRIPTION OF APPARATUS AND PRINCIPLES OF OPERATION:

Like all electrical chlorinators, our apparatus utilizes the well-known principle, that free chlorine can be released by electrolysis of a solution of chlorides in water. However, instead of using a concentrated salt solution, it is designed to operate on low chloride concentrations, such as would be normally present in most fresh waters (from 750 ppm. as $NaCl$ and up). The efficiency of operation will, however, increase with the chloride concentration. The optimum current used depends on the area of the electrodes.

The electrodes of the unit used, consist of a stainless steel tube — $2\frac{1}{4}$" I.D. by 14" long and a solid soft graphite rod $2\frac{1}{4}$" O.D. by $13\frac{1}{2}$" long inserted into the tube (approx. electrode area = 100 sq. inches). These are placed directly into the pool water and operate on a D.C. current from an A.T.R. Manufacturing Co. Rectifier capable of a maximum current of 18 amps. at 6 volts. The rectifier can be plugged into a standard 110 V 60 amp. outlet.

PRICE:

The cost of the rectifier is $55.00 and the balance of equipment $14.00 — exclusive of labor.

Report on Electrical Chlorinator
(February 24, 1949)

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PROCEDURE USED: The electrodes were suspended in the model swimming pool (volume = 16,000 gall.) and the chlorinator operated continuously over a period of six days. Throughout this period the amperage and the voltage of the rectifier, the temperature and pH of the water and the chlorine residual were recorded at regular intervals. On the third day 133 lbs. of rock salt were added to the pool to boost the chloride concentration in the water from 2066 ppm. to 3000 ppm. (approx).

DISCUSSION OF RESULTS: From the tabulation of results on Page 3, it can be seen that, starting from zero, the chlorinator managed to produce a chlorine residual of 0.07 ppm. on the third day of operation. Upon addition of salt, this residual increased to 0.15 ppm. It should be noted, that intermittent rains and a considerable amount of wind-blown dirt throughout the test period, probably caused a lower chlorine residual than normally expected. The condition of the pool water remained excellent throughout.

A definite flaking away of the soft carbon electrode indicates eventual need of replacement, or the use of a different material. No corrosion of the stainless steel electrode has been observed, however, a white deposit (not yet determined) formed on the outside of the tube.

Since an explosive mixture of oxygen and hydrogen is generated as a by-product of the reaction, the electrodes should never be set up in an enclosed space.

CONCLUSIONS:

1. Although only a preliminary test, it indicates that this particular type of chlorinator is capable of producing a satisfactory chlorine residual when given sufficient electrode area. The practicability of its application will depend on the price limits as set by the existing market.

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CONCLUSIONS: (Cont'd.)

2. It should be possible to maintain a 0.15 ppm. chlorine residual in a 16 gall. pool (3000 ppm. concentration of chlorides) at the approximate expense of 20¢ per day for electric current.

3. The flaking away of graphite causes an increased gap between the electrodes and therefore an increase in resistance and decrease in amperage.

TABULATION OF RESULTS

DATE	TIME	AMP'S.	VOLTS	TEMP.°F	pH	CHLOR.RESID. ppm.	WEATHER	REMARKS
23-2-49	9am	16.5	5.9	55	7.6	0	overcast	Soluble chlorides (as
"	12 noon	"	5.5	56	"	0	"	determined by electric
"	2pm	16.6	"	"	"	0	"	chlorometer) = 1450 ppm.
"	5pm	16.0	6.0	"	"	0	"	
24-2-49	9am	16.0	6.0	55	7.8	0	night-clear light rain clear	0.06 ppm residual of
"	11am	"	"	56	"	0.05		bottom of pool.
"	1pm	"	"	"	"	0.05	"	
"	5pm	"	"	"	"	0.06	"	
25-2-49	9am	14.5	6.0	57	7.8	0.08	night-rain overcast	
"	11am	"	"	"	"	0.08	"	
"	2pm	"	"	58	"	0.08	"	Soluble chlorides (by
"	5pm	15.0	6.2	57	"	0.08	"	Mohr's method) = 2066 ppm.
26-2-49	9am	15.0	6.0	56	7.8	0.09	night-rain overcast rain	
"	12 noon	"	"	"	"	0.09		133 lbs of NaCl added
27-2-49	— chlorinator on continuously —						overcast	to bring up chloride
28-2-49	9am	14.0	6.0	56.5	7.6	0.15	"	conc. to 3000 ppm.
"	11am	"	"	"	"	0.15	"	
"	2pm	13.5	5.6	57	"	0.15	"	
"	5pm	13.4	5.7	57	7.6	0.15	"	

NOTE: Due to deterioration of graphite element chlor. residual in pool down to 0.01 ppm. by March 7, 1949.

RECOMMENDATIONS: In view of the reply from the International Graphite & Electrode Corporation concerning anode corrosion: "The only thing which will withstand your conditions is platinum, and there will be a slow and continuous corrosion of platinum", it seems advisable to discontinue attempts at utilizing the electrolysis of low concentration salt solutions, pending the receipt of additional information.

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<u>FURTHER EXPERIMENTS WITH CONVERTED PADDOCK ELECTRICAL CHLORINATOR CONFIRMED:</u>

1. That approx. 1 KW. - hour per day is necessary to maintain chlorine residual of 0.2 ppm. in a 16,000 gall. pool (3000 ppm. chlorides).

2. That graphite anodes flake rapidly.

3. That the most desirable current concentration is approximately 1 amp. per 5 sq. inches of electrode surface.