hundred chicks hatched. Incubators are now available that will hold from 30 to 1200 eggs.

Advantages of Electric Incubators.—An incubator heated by coal, oil, or gas is constantly filling the machine with fumes and burning up oxygen so essential to the germ life in the egg, whereas electricity neither destroys good air nor gives off bad air. The temperature control is simple and requires no attention, other than setting the thermostat by turning a thumb screw a couple of times during the hatch. The fire risk is entirely eliminated. The anxiety that attends the operation of fuel heated machines is done away with. The distribution of heat is perfect and the ventilation can be regulated at will. Much time and labor usually required in looking after fuel equipment is saved. The machines may be located in any convenient place and are adaptable to any climate. It is furthermore interesting to note that electrically hatched chicks always begin to pip about twelve hours quicker than those hatched by other artificial means. They are always stronger and more vigorous, and statistics show that a much higher percentage is hatched.

Relative Operating Costs.—The following comparative figures are taken from many averages secured in actual practice. They are based on an assumed incubator room temperature of 60° F. Although a rather low rate for electricity is required to make the actual operating cost comparable with those of some of the less expensive fuels, the savings effected, the better results secured, and the greater degree of satisfaction obtained by electric operation, will usually overcome whatever objection arises as to the cost of producing heat.

Relative Cost of Heat for Incubating.

Method of Heating.	Approximate Cost. Per 100 Eggs.
600 B.t.u. gas at $1.50 per 1000 cu. ft.	37c
600 B.t.u. gas at $1.00 per 1000 cu. ft.	25c
Coal oil at 20c per gallon	20c
Electricity at 5c per kw.-hr.	50c
Electricity at 3c per kw.-hr.	30c
Electricity at 2c per kw.-hr.	20c

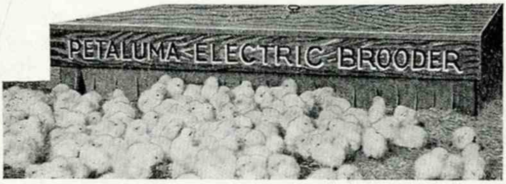
Brooding of Chickens.—The chick which is taken from the incubator to the brooder at the age of twentyfour hours (and known as a "day old chick") is not fed for another similar period or until the chick is about forty-eight hours old. The reason for this, is that the chick has absorbed the yolk of the egg into its digestive organs just prior to pipping, and continues to live on this food for the entire forty-eight hours. The chick's first meal should consist of grit, such as coarse sand, after which it may be fed some good chick food.

The temperature of the brooder should be kept at about 95° F. for the first week and gradually dropped for the next five weeks or until the chick is sufficiently matured to roost. It is important to watch the temperature carefully with very young chicks, because otherwise they will become restless and crowd together as soon as their backs get cold. If the crowding becomes too severe, the chicks will sweat and become weak and the less rugged ones may be smothered.

A chick demands plenty of oxygen, (about 10 times as much as a person in proportion to its weight), and if it is to mature rapidly and develop good lungs, the brooding must be done in a well ventilated room. The chick should not be subjected to drafts of air, however, and best results are secured in a room having a tight floor and provided with high ventilation. The temperature of the room is immaterial as long as the proper degree of heat is maintained inside the brooder. Coarse straw or sand is usually spread out beneath the brooders.

Electric Brooders.—These devices are built in round, square, or oblong shapes, and in capacities of from 50 to 1200 chicks. The tops of the hovers are usually made of wood insulated beneath with asbestos, and supported on short wood or metal legs. Strips of canvas or oilcloth, wide enough to reach the floor and retain the heat, are fastened around the outer edges, and slitted perpendicularly every few inches to allow the chicks to pass in and out readily.

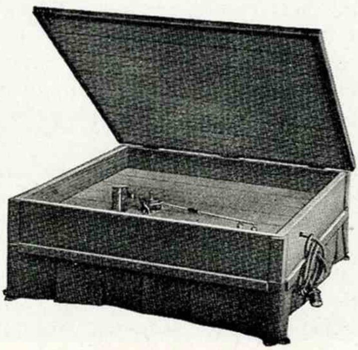
In the circular type hover, the heating element is placed in the center of the top, and in other types coiled wire heating elements are arranged around the top, in order to secure a wider distribution of heat. The air, when heated, banks against the insulated top and settles down upon the backs of the chickens. One or more holes are generally drilled in the floor beneath the machines to introduce a proper amount of fresh air inside.



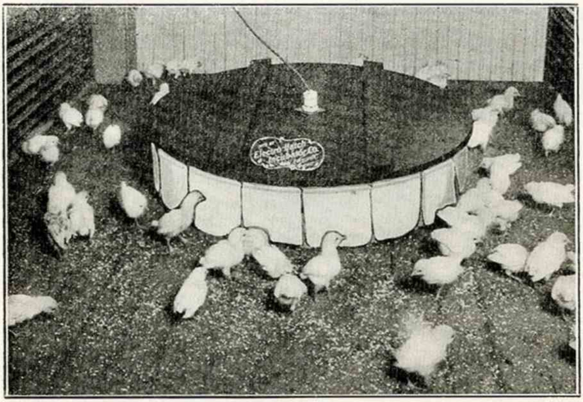
Rectangular Type Chick Brooder in Operation.

The thermostat for regulating the temperature inside the hover is mounted a few inches below the top and adjusted by a screw on the outside.

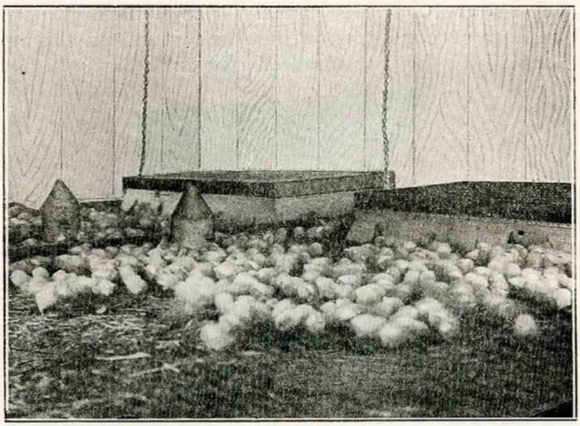
A well constructed brooder is usually provided with about 100 watts capacity per hundred chicks. The current consumption has been found to average about 20 kw-hr. per hundred chicks.


Esco 100 Chick Hover.

Advantages of Electric Brooders.—Almost all the advantages that apply to electric incubators, apply as well to electric brooders. They save time, labor, and anxiety. They insure even heat distribution, easily



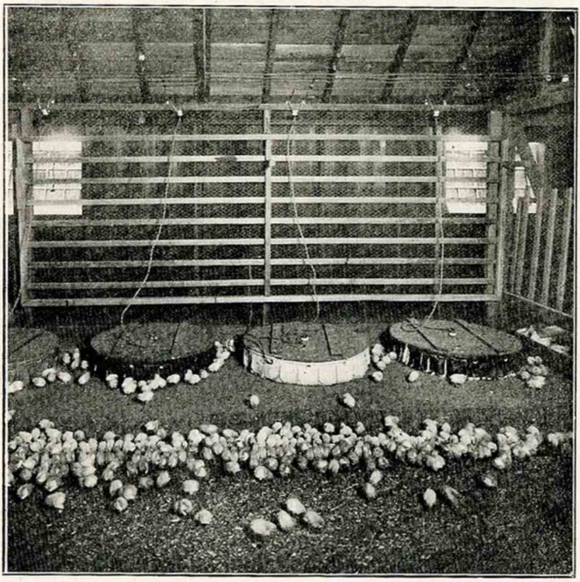
Round Type Electro-Hatch Hover in Operation.



Electro-Hatch Rectangular Type Brooders in Operation.

controlled temperatures, and elimination of fire hazard. The electric heat neither burdens the atmosphere with poisonous fumes, nor destroys its oxygen. It has furthermore been demonstrated in actual practice, that an electrically brooded chicken is usually ready for the roost about two weeks sooner than one brooded by fuel heat, and is universally stronger and more vigorous.

Statistics show that an average of less than 50 per cent of the baby chicks placed under the many types



Interior of Brooding House, Baywood Poultry Farm, San Mateo, Cal.

of brooders now in use are raised to the roosts, whereas actual tests made during the past eighteen months with a large number of electric brooders show that the proportion has been raised by their use to better than 85 per cent.

Relative Costs of Operation.—The following will give an idea of the relative costs of fuel and electric operation of brooders. The data are averaged from many figures secured in actual practice, and are based on an assumed outside temperature of 50° F.

Relative Costs of Heat for Brooding.

Method of Heating.	Approximate Cost per 100 Chicks.
Artificial 600 B.t.u. gas at $1.50 per 1000 cu. ft.	$1.50
Artificial 600 B.t.u. gas at $1.00 per 1000 cu. ft.	1.00
Coal oil at 20c per gallon	1.40
Distillate at 8c per gallon	.45
Distillate at 8c per gallon (blue flame burner)	.15
Electricity at 5c per kw.-hr	1.00
Electricity at 3c per kw.-hr	.60
Electricity at 2c per kw.-hr	.40

It is apparent that, although electric energy may have to be purchased at a low rate to compete with fuel on the basis of actual cost of heat energy, the advantages accruing to the user of electrically heated apparatus will more than offset this added expense.

CHAPTER XIV

ELECTRIC WELDING.

Nature of Welding.—When two pieces of metal are heated to the proper temperature, brought into contact, and united into one solid piece, the process is called welding. The essential feature is that of bringing the pieces of metal to the proper temperature so that they will tend to flow together and cohere. All the processes that have been devised are simply required for producing heat.

Metals may usually be most easily welded when in a plastic condition. Whereas welding processes were formerly limited to such metals as iron, nickel, platinum, and gold, the high temperatures now available have made it possible to weld almost all the metals and a large percentage of the metallic alloys.

Welding Processes.—A general classification of commercial methods of welding may include smith welding, hot flame welding, chemical welding, and electric welding.

Smith welding or forging is the process of joining pieces of metal by hammering them into shape. It is one of the oldest arts, depends for its success on the operator's skill, is usually expensive, and is more adaptable to small than to heavy work.

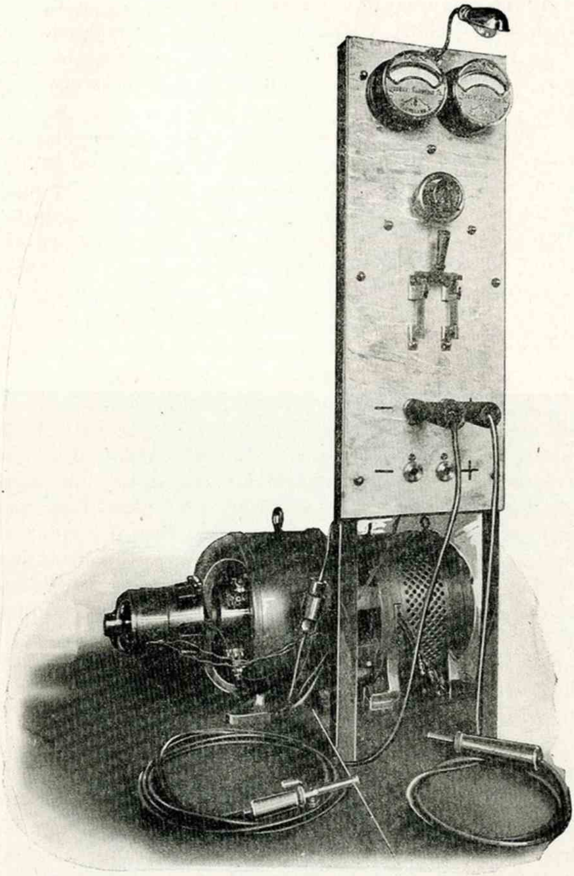
Hot flame or gas welding has numerous commercial applications and may be used for many kinds of work that cannot be done by forging. The most important methods are the oxy-acetylene, oxy-hydrogen, oxy-pintsch gas, and oxy-blau-gas. As the names indicate, welding heat is produced in each process by mixing oxygen and another gas in suitable burners. The gases are usually compressed and stored in strong cylinders. The various processes may be used for cutting as well as for welding. The principal advantages are less first-cost, simplicity, light weight, high flame temperature, flexibility, and portability of apparatus. The disadvantages are high operating cost, carbonization, oxidation, cracking of the welds, and danger of fire and explosions from the flames and gases.

Chemical welding is limited in its commercial application to the process known as thermit welding, or "cast welding," which consists in igniting a mixture of aluminum and iron oxide in a suitable mold. The intense heat produced, causes the aluminum to reduce the iron from the oxide, and forms a molten mass of thermit steel which is run into and around the parts to be welded. The process lends itself better to the welding of larger articles than smaller ones, but in any case it is both slow and expensive.

Electric welding, with which this chapter deals, although a relatively new commercial application, is rapidly becoming one of the most important of all the welding processes. The chief advantages are low operating cost, wide range of application, flexibility and ease of temperature control, less harmful oxidation and carbonization, and less expansion and contraction of the parts welded. The disadvantages are higher first cost, and greater weight and lack of portability of apparatus. Electric welding machines may ordinarily be classified, either as arc welding, or as resistance welding apparatus. In the former heat is produced by means of an electric arc, whereas in the latter, heat is produced by the resistance to the flow of current at the contact between the parts to be welded.

Arc Welding.—The electric arc may be used for welding practically all the metals. The commercial processes are usually performed by melting material into openings or crevices, or of fusing down the body of an article to fill such openings. There are a great many practical applications of arc welding apparatus, both in manufacturing and repairing.

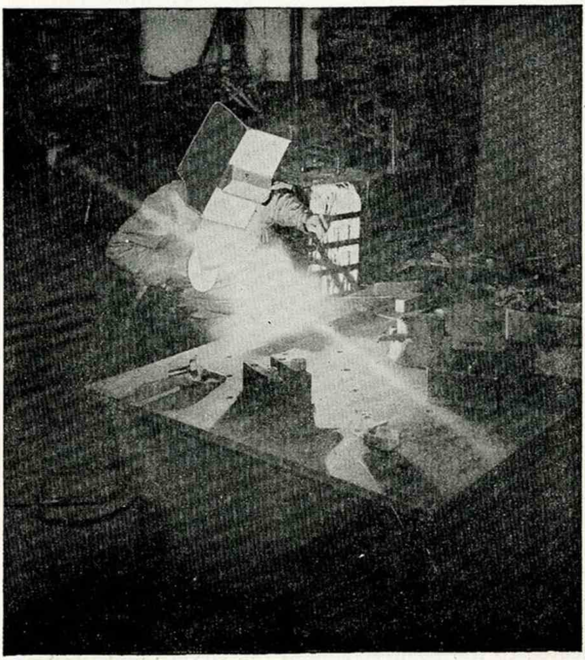
Direct current of high amperage and low voltage (usualy 30 to 75 volts) is employed. The amount of current required depends upon the kind of material, size of the weld, and speed of operation desired.



Lincoln Arc Welder (complete with panel board).

Systems of Arc Welding.—There are two important welding processes, known as the Benardos or graphite process, and the Slavianoff or metallic process. In both systems the article to be welded is connected to the positive side of the circuit, and the electrode to the negative side. The arc is produced by bringing the negative electrode in contact with the work and quickly withdrawing it a short distance. Since the positive terminal of an arc is the hotter, the heat is produced where it can be most effectively utilized.

The graphite process makes use of a carbon electrode. After the arc is drawn, filling material in the form of a "melt bar" is fused into place by the heat produced. This process may be used for welding aluminum, copper alloys, cast iron, and other metals which do not volatilize very readily. The arc should be moved about over the surface to prevent burning, and to cause the slag or other impurities to flow to one side.

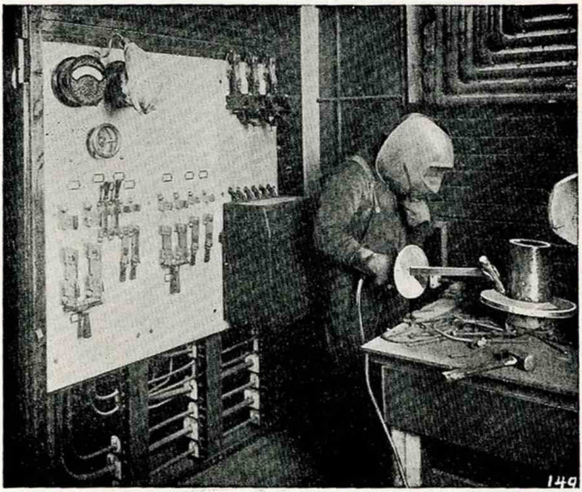


Operator at Work With General Electric Arc Welder.

The metallic process makes use of a metallic pencil electrode, (usually iron or steel), which gradually melts from the heat of the arc, and forms the filling material. The current required is much less than for the graphite process but the speed is also less for heavy work. The principal application of this process has been in sheet metal work, where the electrode is deposited along the joints or seams. It is also used for building up worn pieces, and filling holes in castings.

Another system of welding which has not been applied very extensively in this country is the Zerener process, wherein an arc is drawn between two carbon electrodes and deflected downward against the work by a magnet. Its use is limited to light work, but it is claimed that somewhat finer work can be done by adjustment of the magnet.

Arc Welding Apparatus.—In making a choice of equipment, careful consideration must be given to the character of work to be done. All arc welding machinery is designed to take the available energy supply



Repairing Steel Casting with the Lincoln Arc Welder.

and deliver it in proper form for welding work. In the simplest forms of apparatus, the current may be cut down to the proper voltage by the use of either a water rheostat or a heavy resistance connected in series with the arc. When this is done considerable energy is wasted in heating the water or other resistance material.

Low voltage motor-generator sets are often used on account of their higher efficiency and greater ease of control. The generators are usually compound wound, although when used on an individual welding circuit, they may be shunt wound. The compound wound generator gives more accurate voltage regulation and is usually employed where more than one welding circuit is provided with energy from the same machine. Where several circuits are supplied from a single motor-generator set, the current on each circuit must be regulated by the use of special resistances, which naturally causes a waste of energy.

Some welding machines are provided with current through synchronous converters, but the regulation is less satisfactory and they cannot be used as well for finer classes of work.

Generators used for welding are sometimes specially wound for variable voltage operation so that no resistance is required. It is, however, necessary to provide separate machines for each individual operator.

Either graphite or metallic electrodes may be used with practically all arc welding equipments.

Each manufacturer of welding machinery offers its apparatus on the strength of some peculiarity of the controlling apparatus or design of the machines, and the user should consider the class of work to be performed before deciding upon the type of machinery to install.

The current consumption varies with the nature of the material welded, the shape and size of the piece, and the nature of the operation. Metallic welding processes may require from 15 to 150 amperes, and graphite welding from 100 to 700 amperes.

Costs of Arc Welding.—The nature of the work, the cost of energy, and the operator's skill, each have much to do with the cost of welding. It may ordinarily be done in less time and at from 10 per cent to 75 per cent of the average cost of acetylene welding. The following tables show the cost of several arc welding jobs where labor was figured at thirty cents per hour, energy at two cents per kw-hr., and filling material at eight cents per pound. The first table shows the time and cost of welding; the second table, the savings effected over methods previously employed, and the third table the savings effected by repairing electric railway apparatus as against purchase of new parts.

TABLE I.*

Time and Cost of Welding.

Article Welded.	Time.	Cost.
Steel casting, shrinkage crack 6 in. long by 1 in. deep....	8 min.	$00.04
Steel casting, riser, 4 in. by 4 in. cut off..............	4 min.	.05
Forged steel locomotive frame, broken in two places......	20 hrs.	18.28
12 in. crack in back sheet of locomotive boiler..........	9 hrs.	5.47
Building up worn driving wheel instead of turning down....	2 hrs.	.72
Welding 67 cracks in old fire box (saving over $1000)....	2 wks.	52.60
Cast-steel tender frame, broken in three places..........	27 hrs.	19.00
Steel shaft, 2 in. diameter, broken, welded ready to finish..	1 hr.	.60
Broken railway type motor case, cast steel, welded........	3 hrs.	1.95
Enlarged holes in brake levers, steel bars...............	4 min.	.05
Building up 2 in. armature shafts, worn in journals......	3 hrs.	1.80
Air brake piston rods, broken, welded ready to finish......	30 min.	.35
Leaking axle boxes, welded in position..................	15 min.	.15

TABLE II.*

Relative Costs of Repairs.

Article Welded.	Welding.	Old Cost.	Saving.
Engine main frames, both broken.........	$11.80	$56.20	$44.40
Driving wheels, built up 3/16 in. on tread..	.72	8.00	7.28
General repairs on fire box side sheets.....	66.51	342.62	276.11
Filling worn knuckle joint bushing hole....	.75	7.50	6.75
Welding 7 cracks in locomotive cylinder....	22.35	367.15	344.50
Broken mud ring on locomotive boiler....	32.07	118.06	85.99

TABLE III.*

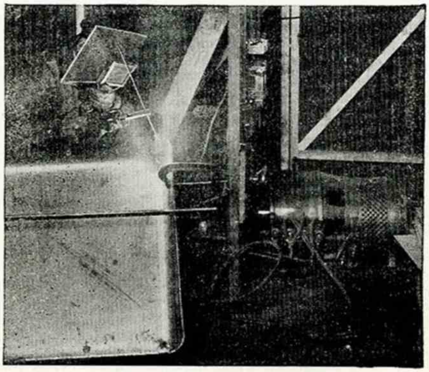
Street Railway Repairs.

Article Welded.	Welding.	New Part.	Saving.
Armature shaft, repaired in place.........	$1.70	$ 4.72	$ 3.02
Armature shaft, large, repaired in place....	1.97	15.13	13.16
Railway motor axle cap, large............	.22	3.51	3.29
Railway motor armature bearing cap......	.27	6.07	5.80
Railway motor gear case, top half........	.48	7.30	6.82
Truck side frame, Brill 27-G..............	.72	44.40	43.68
Truck side frame, Peckham 14-B..........	.90	46.98	46.08
Brake head, building up worn socket........	.06	1.15	1.09
Motor frame, G. E. 90, railway type motor..	2.88	16.80	13.92

*From "Applied Electrochemistry and Welding."

Arc Welding Operations.—Metallic electrodes are used almost exclusively for thin plate and sheet welding. The speed at which the work can be done, depends upon the kind and thickness of the material, the kind of weld, etc.

Metallic electrodes are usually employed in welding the seams in tanks, boiler flues, etc. The joints



Seam Welding With Lincoln Arc Welder.

have been found to be much stronger than riveted seams, and the use of electric welding machinery for this class of work is finding a very wide application.

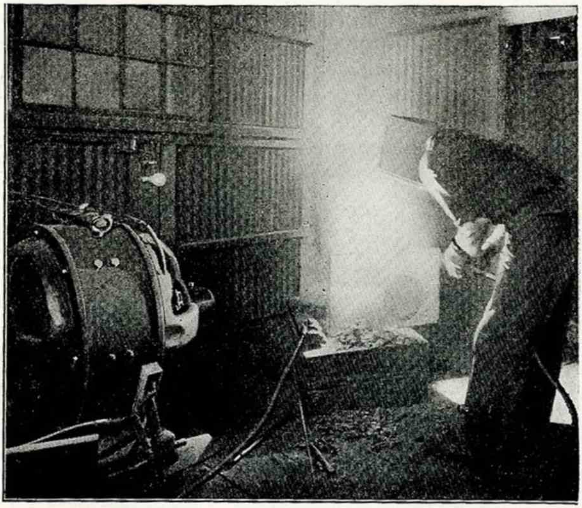
(1) COMPARATIVE COST—ACETYLENE AND ARC WELDING.

	Acetylene		Arc			
Thickness of Metal.	Ft. Welded per Hour.	Cost per Ft. Welded.	Amps. in Arc.	Kw. Input M. G. Set.	Ft. Welded. Per. Hour,	Cost per Ft, Welded,
1/16 in.	25	$0.018	70	3.0	25	$0.014
1/8 in.	15	.047	80	3.2	15	.024
1/4 in.	6	.187	110	4.15	8	.048
3/8 in.	4	.420	120	4.64	7	.056
5/8 in.	2	1.510	150	5.75	6	.070

These data were obtained with a Lincoln welding machine and were based on the following costs:

Acetylene, 1.555 B.t.u.	1c per cu. ft.
Oxygen	2c per cu. ft.
Electricity	2c per kw -hr.
Labor	30c per hour.

In welding most large iron and steel castings, the carbon electrode and melt bar are employed, although the metallic electrode may be used for light work. A space sufficiently large to work in should be prepared, because the filling material will not flow in small crevices. Cast iron should usually be heated before and annealed after welding in order to prevent cracks, and to soften the weld for machining. The use of a welding flux will ordinarily improve the quality of a cast iron weld by raising the slag.

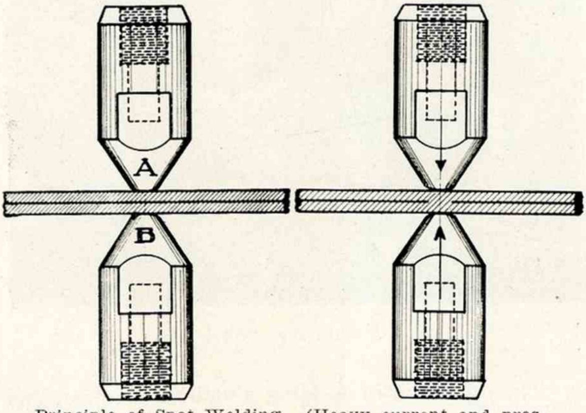


Welding With the Electric Arc.

The operation of welding aluminum, copper, and various alloys, is somewhat similar to that employed for iron and steel castings. The work is usually placed in a horizontal position and the filling puddled in by the graphite electrode method. Very thin sheets, less than one-eighth inch in thickness, cannot be welded by this means. Larger amounts of current should not be used than are required to melt the metal, and in welding alloys care should be exercised to prevent volatilization of any of the metallic constituents.

Arc Cutting.—The electric arc may be utilized to great advantage for cutting metals in foundries, scrap yards, and similar places. The rate of cutting iron and steel is ordinarily about one square inch of cross section per minute per hundred amperes. The graphite electrode is employed for this work and current varying in quantity from 100 amperes to 1000 amperes may be employed. The electric arc cuts a wider groove than the gas flame, but has an advantage in that it does not destroy the metal that is melted.

Resistance Welding.—This process is quite unlike arc welding. It consists in passing a current through a contact between the metals to be welded. The resistance to the flow of energy being greater at the point of contact, the metals heat up until a welding temperature is attained when they are forced together



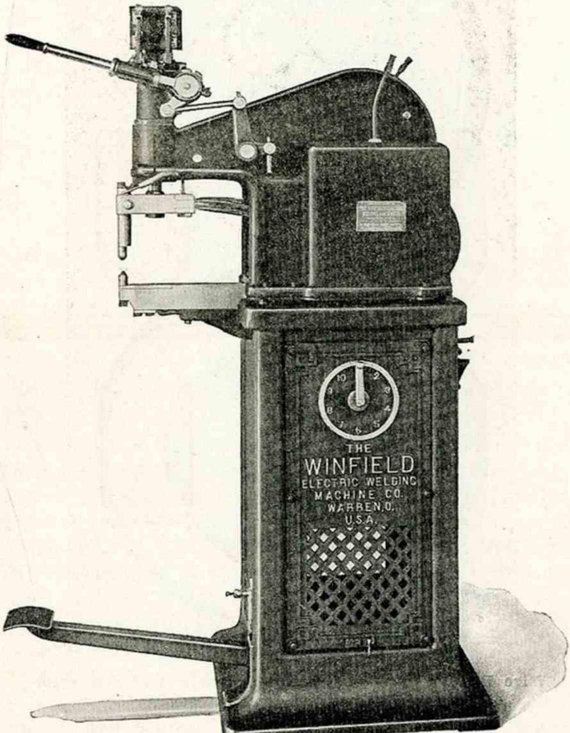
Principle of Spot Welding. (Heavy current and pressure applied between A and B cause the metallic plates to heat up and weld at the point of application as shown.)

with sufficient pressure to cause them to adhere. This is usually known as the Thomson system.

Alternating current of low voltage, (usually from 3 to 5 volts), is employed in resistance welding. The work is ordinarily done rapidly, because heavy currents and high pressures may be applied.

Resistance Welding Apparatus.—The equipment for electric resistance welding requires machines especially adapted to the work in hand. The frame is usually provided with a clamping device for holding the parts, and a means for applying pressure after they have been heated. A transformer for reducing the voltage on the circuit, together with a main control switch, and some means of regulating the flow of current, are ordinarily supplied with the machine.

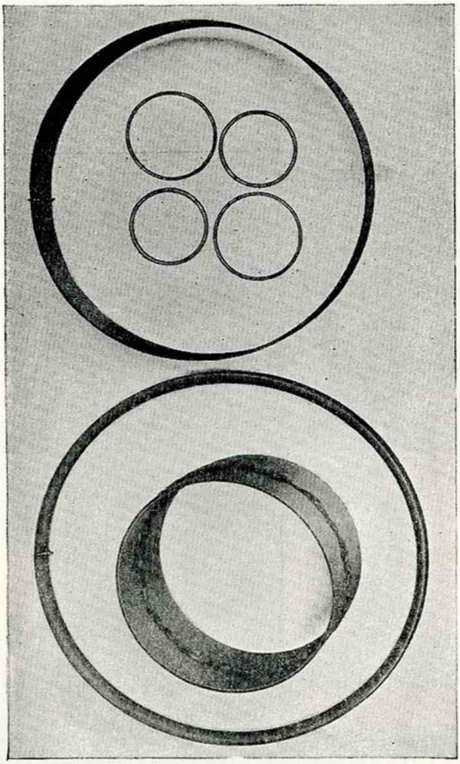
Manufacturing Applications.—Resistance welding is limited almost exclusively to new work of moderate



Winfield S-12 Spot Welder.

size. Practically every kind of metal, and many alloys and combinations of metals may be welded, if the surfaces can be joined and the parts manipulated in the machines.

A few of the many applications of resistance welding apparatus are as follows:



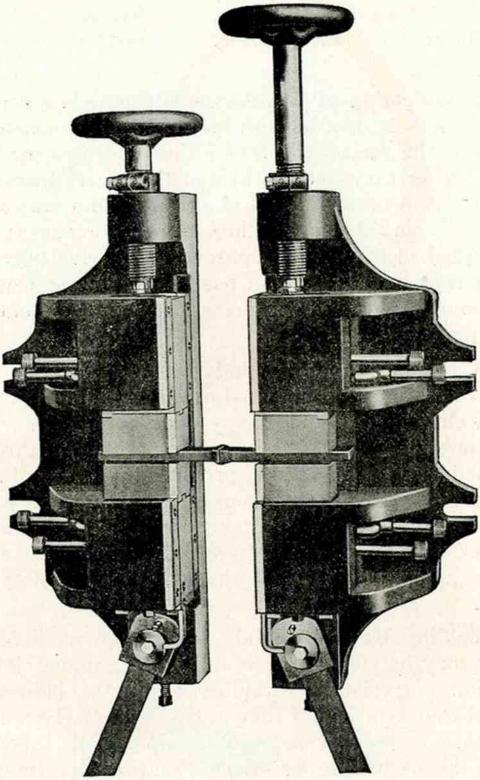
Wire Rings, Flat Hoop, Small Carriage Tire and Steel Cylinder Welded With a Thomson Welder.

Rail bonds.	Wagon tires.	Iron beds.
Automobile parts.	Shovels.	Wheelbarrow bodies.
Structural iron work.	Iron wheels.	Cooking utensils.
Pipes.	Typewriter parts.	Chains.
Screens.	Stove pipe	Valve heads.
Axles.	Steel shelves.	Knives.
Umbrella rods.	Steel lockers.	Boilers.
Sheaves.		

Classification of Resistance Welds.—The original method was known as butt welding, and consisted in bringing the pieces together either end wise or edge wise. After they became heated they were forced together. A process known as spot welding was afterwards developed for welding lapped joints. It was accomplished by making contact, about rivet size, between the sheets of metal, passing a current through the contact, and applying pressure when the metal became plastic.

A number of other kinds of welds, which, in a more or less degree, are modifications of the butt and spot welds, have found a very wide application. Lap or seam welding consists in passing a current through a lapped seam and applying pressure by means of rolls. Butt seam welding, as the name signifies, is a somewhat similar process. Cross welding for making screens, etc., and tee and jump welding for fastening bars or pipes together, are other common welding processes.

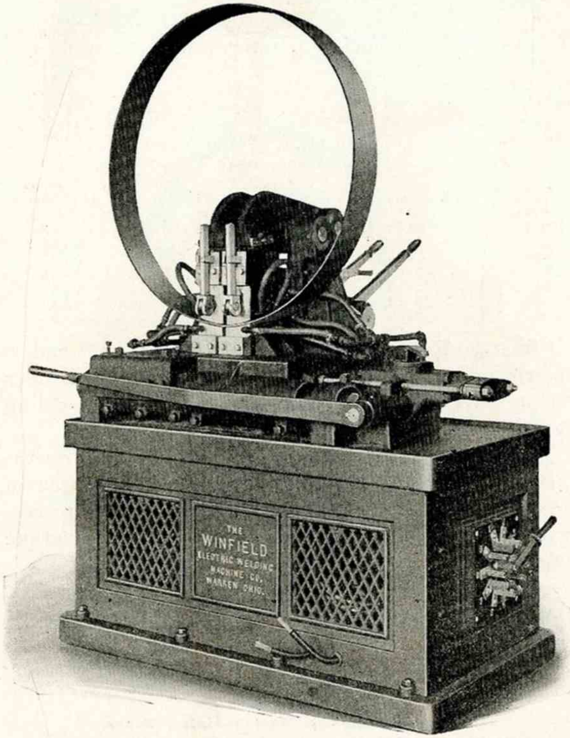
Welding Various Metals.—Although most of the metals may be welded successfully, the commercial application of resistance welding apparatus is usually limited to only a few of them. Iron and steel are most frequently subjected to welding operations, and are about the easiest to handle. The pressure imposed should be high and the metal should be kept below the melting point. Cast iron is very difficult to weld by the resistance process on account of its structure and composition. High carbon steel may be welded, provided it is afterwards annealed to remove the strains. Nickel steel makes a very strong weld. Galvanized iron of moderately thin gauge, may be welded, provided the joints are regalvanized when the operation is completed. Sheet aluminum, brass, copper, iron and copper, and brass and copper, may also be successfully welded by skilled operators.



Clamp for Thomson 40-A Butt Welder.

Spot and butt welding operations are limited in the extent to which they can be applied commercially. If the metals are very thick, the amount of energy required will be very large, and the radiation losses from the metals and the cooling water will become excessive.

Character of Resistance Welds.—If the weld is upset so that its cross sectional area is slightly greater than that of other portions of the piece, the joint should have as much strength as the stock. When finished



Winfield BB-255 Butt Welder.

to the same diameter as the stock, it should have a strength efficiency of from 75 per cent to 90 per cent. Ordinarily the strength of a weld may be improved by working. Care should be exercised to prevent heating the material too hot, or the weld may be burnt and thereby weakened.

Butt and Spot Welding Costs.—The average costs of resistance welding are shown in the two following tables, which are figured on the basis of an energy rate of two cents per kilowatt-hour.

Butt Welder Data.

Rd. Iron Diamter in Inches.	Kilowatts Required.	Time in Seconds to Make Weld.	Cost per 1000 Welds 2 Cents per kw.
¼	2	3	0.04
½	5	5	0.14
¾	12	15	1.00
1	18	20	2.00
1½	50	40	11.10
2	75	50	20.84

Spot Welder Data.

Gauges of Sheet Steel.	Thickness in Fractions of an Inch.	Approximate Kilowatts Capacity.	Time in Seconds to Make a Weld.	Cost per 1000 Welds at 2 Cents per kw.
28	1-64	5	.3	0.009
24	1-40	7	.5	0.02
20	3-80	9	.7	0.035
16	1-16	12	.9	0.06
10	9-64	18	1.5	0.15
6	13-64	28	4.0	0.62

Energy Requirements and Character of Load.—Electric current is usually supplied to the machines at a pressure of 220 volts, which for ordinary welding operations, is reduced to from 3 to 5 volts.

The power required for resistance welding operations depends upon the kind of material, the area of cross section of the pieces, and the time taken for making the weld. The following table shows the average power and time required for butt welding:

Power and Time for Butt Welding Iron and Steel.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.5	10.0	28	13.5
1.0	18.75	40	25.0
2.0	33.00	57	44.0
4.0	56.3	80	76.0
6.0	69.0	98	92.5

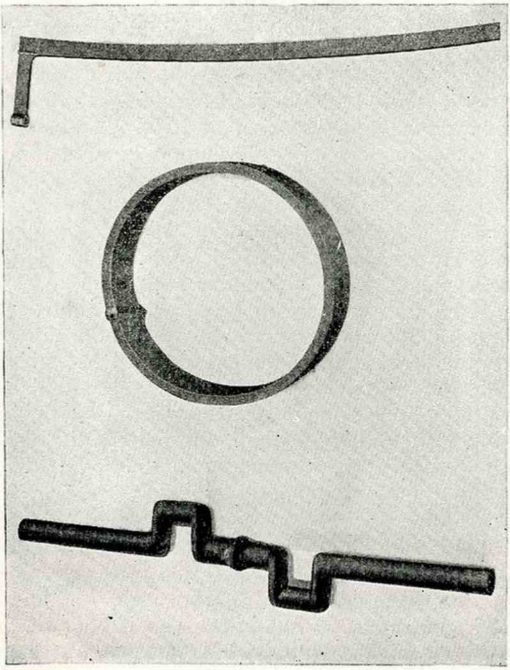
Power and Time for Butt Welding Brass.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.25	12	14	15.7
0.50	15	20	20.0
1.00	29.5	28	39.5
2.00	53	40	71,0
3.00	66	49	88.5

Power and Time for Butt Welding Copper.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.125	8.5	7	11.5
0.250	18	10	24.0
0.500	32	14	43.0
1.00	55.5	20	75.0
1.50	68	25	91.0

The character of resistance welding power loads depends largely upon the work that is being done. It is naturally very unsteady, and somewhat inductive.



Unfinished Forgings of Meat Saw Back, 3½-in. Ring and Two Single Throw Cranks Welded With Thomson Welder.

CHAPTER XV

ELECTRIC STEAM BOILERS.

Application.—Where conditions are such that electric energy may be obtained at low cost during off peak periods or otherwise, or where only a small quantity of steam is required for certain operations, electric steam boilers may often be used advantageously.

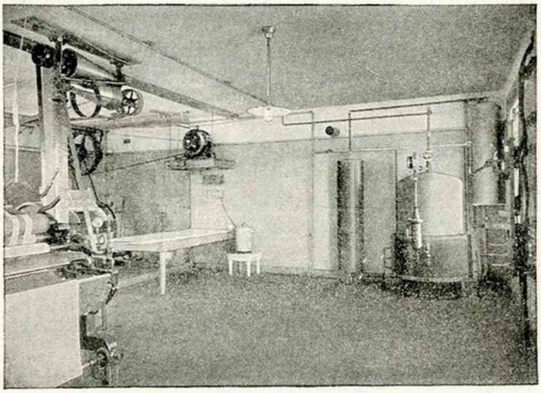
Industrial plants require steam for numerous purposes other than that of simply driving engines. Many machines, such as laundry apparatus and similar devices, may use steam heat to better advantage than the usual form of electric heat. Where this condition obtains, steam boilers may be heated electrically to effect the desired results.

Although electric steam boilers have not yet been applied very generally in the industrial field it is probable that the superior advantages which they afford will tend to bring them into wider use.

Advantages.—The inherent features of electric steam boilers which commend them for industrial purposes are their efficiency of operation (often as high as 95 per cent), the reduction of labor cost, (no firemen needed), the safety of operation, (no danger of fire) and the convenience of location. As usual where electric heat supplants fuel heat the annoyance of fuel burners, the heated atmosphere and the dirt are done away with. The boilers may be installed in any convenient location and in places where other generators would be entirely impractical.

Steam Boiler Calculations.—In order to make intelligent recommendations for steam boiler installations it is necessary to know something of the fundamental principles of steam generation, the customary methods of rating the apparatus, and how to calculate the capacities required. The most important features to be considered together with some elementary definitions, tables, and practical examples are therefore set forth for the convenient reference of those less conversant with the subject.

Boiler Efficiencies.—The definition of steam boiler efficiency is the ratio of the heat absorbed by the boiler in producing steam to the total amount of heat available. As electric steam boilers are usually well lagged and equipped with immersion heaters it is apparent that practically all the energy applied is absorbed by



G. E. Steam Boiler in Laundry of Estes Park (Colo.) Hotel.

the boiler in producing steam. The efficiency of electric boilers, therefore, may be as high as 95 per cent. The efficiency of a fuel-fired boiler, on the other hand, may vary anywhere from 50 per cent, or even less, to 80 per cent, depending upon the method of firing, the kind of combustible consumed, and the numerous losses of heat, the chief of which is that due to the temperature of the chimney gases.

Boiler Horsepower.—The function of a boiler is that of producing steam by the evaporation of water and the term horsepower, having to do with the rating of boilers, should not be confused with the term horsepower relating to prime movers. Boiler horsepower is a measure of evaporation and not of power. It is equal to an evaporation of 34.482 pounds of water per hour from and at 212° F. Since 970.4 B.t.u. (latent heat of evaporation) are required to evaporate a pound of water at atmospheric pressure after it has attained a temperature of 212° F., it is apparent that a boiler horsepower is equivalent to 34.482 × 970.4 or 33,461 B.t.u.

Factors of Evaporation.—In order to calculate the amount of water that a boiler of a certain horsepower rating will evaporate per hour when supplied with water at a certain temperature and operated at a certain pressure, it is necessary to divide by the corresponding factor of evaporation found in Table I.

TABLE I.

Factors of Evaporation.

(Calculated from Marks and Davis Tables.)

Feed Temp. Deg. F.	Gauge Steam Pressure 50	60	70	80	90	100
32	1.2143	1.2170	1.2194	1.2215	1.2233	1.2251
40	1.2060	1.2087	1.2111	1.2131	1.2150	1.2168
50	1.1957	1.1984	1.2008	1.2028	1.2047	1.2065
60	1.1854	1.1881	1.1905	1.1925	1.1944	1.1961
70	1.1751	1.1778	1.1802	1.1822	1.1841	1.1859
80	1.1548	1.1675	1.1699	1.1720	1.1738	1.1756
90	1.1545	1.1572	1.1596	1.1617	1.1636	1.1653
100	1.1443	1.1470	1.1493	1.1514	1.1533	1.1550

Assume a boiler of 5 h.p. rating supplied with feed water at 50° F. and operated at 60 pounds gauge pressure. The boiler will evaporate 5 × 34.482/1.1984 = 143.9 pounds of water per hour.

(The same boiler would, of course, evaporate 5 × 34.482 = 172.4 pounds of water per hour if supplied with feed water at 212° F. and operated at zero pounds pressure).

Calculating Boiler Capacity.—It is necessary to know three things in order to calculate the boiler capacity required for any purpose with any degree of accuracy—(1) the boiler feed water temperature, (2) the steam pressure desired, and (3) the number of pounds of water that is to be evaporated per hour. The process is as follows:

(1) Find the factor of evaporation from Table I corresponding to the temperature and pressure given.

(2) Multiply the pounds of water evaporated by the factor of evaporation and divide by 34.482. The result will be the required boiler capacity (neglecting losses in steam distribution).

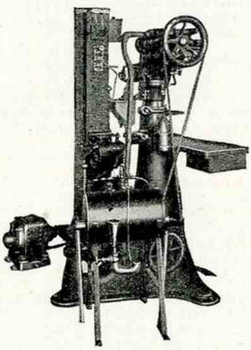
In case the number of pounds and character of fuel consumed under a boiler are known, the approximate boiler capacity utilized, or the equivalent capacity required, may be determined as in the following example:

Assume boiler consumes 40 pounds of 14,000 B.t.u. coal per hour with an assumed efficiency of 60 per cent. Then 40 × 14,000 × .60 = 336,000 B.t.u. input.

Since one b.h.p. = 33,461 B.t.u.,

Then 336,000/33,461 = 10 boiler horsepower capacity.

Electrically Heated Boilers.—Since a boiler horsepower is equivalent to 33,461 B.t.u. per hour (the heat required to evaporate 34.482 pounds of water from and at 212° F.), and since one kilowatt-hour is equivalent



G. E. Steam Boiler Applied to Shoe-Stitching Machine.

to 3412 B.t.u. per hour, it is apparent that the capacity required to operate a standard boiler at 100 per cent efficiency is equal to 33,461/3,412 = 9.8 kilowatts per boiler horsepower. On the basis of 95 per cent efficiency (which is a fair average for electrically heated boilers) the capacity required would be 9.8/.95 = 10.3.

Comparative costs of operating fuel and electric steam boilers under assumed efficiencies and using fuel and electricity at various costs and rates are shown in Table II.

TABLE II.

Hourly Operating Costs per B.H.P. in Cents.

60% Efficiency—Boiler Using 14,000 B.t.u. Coal. Cost of Fuel per Ton.			95% Efficiency—Boiler Using 3412 B.t.u. Electricity. Cost of Current per kw-hr.		
$2.50	$5.00	$10.00	1c	2c	3c
.5c	1.0c	2.0c	10.3c	20.6c	30.9c

Although the cost of steam produced with fuel is much less than that produced electrically according to Table II, the labor cost and the many disadvantages of fuel must also be taken into accounts in making intelligent comparisons.

Electrical Energy Required to Evaporate Water.—In order to determine the amount of energy required to evaporate a certain weight of water per hour supplied at certain temperatures and operated under certain pressures Table III will be found useful.

TABLE III.

Watts Capacity Required to Evaporate one Pound of Water per Hour Into Steam Assuming Certain Initial Feedwater Temperatures and Certain Final Pressures.

(Transformation 100% Efficiency.)

Lb. Gauge	Initial Feed Water Temperatures Degrees Fahr.							
Pressure.	40	50	60	70	80	90	100	110
0	334.8	331.9	328.9	326.0	323.1	320.2	317.2	314.3
10	337.7	334.7	331.8	328.9	326.0	323.0	320.0	317.2
20	339.6	336.6	333.7	330.8	327.9	324.9	322.0	319.1
30	341.0	338.1	335.1	332.2	329.3	326.3	323.4	320.5
40	342.1	339.2	336.2	333.3	330.4	327.5	324.5	321.6
50	343.0	340.1	337.2	334.2	331.3	328.4	325.4	322.5
60	343.8	340.9	337.9	335.0	332.1	329.2	326.2	323.3
70	344.5	341.5	338.6	335.7	332.7	329.8	326.9	324.0
80	345.0	342.1	339.2	336.3	333.3	330.4	327.5	324.5
90	345.6	342.6	339.7	336.8	333.9	330.9	328.0	325.1
100	346.0	343.1	340.2	337.3	334.3	331.4	328.5	325.5

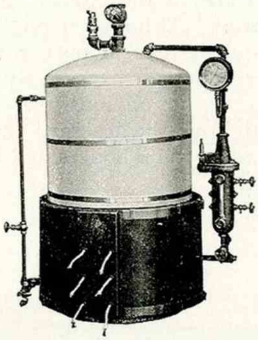
Assume 100 pounds of water at 60 degrees F. feedwater temperature is to be evaporated under 70 pounds pressure and at an efficiency of 95 per cent. The capacity required would be: 100 (pounds) × 338.6 (from table III)/.95 (efficiency) = 35,642 watts or 35.642 kw.

Furthermore, since one boiler horsepower is equivalent to 10.3 kw. at 95 per cent efficiency, the size boiler required for the operation would be:

$35.642/10.3 = 3.46$ boiler horsepower.

These figures may be checked by the method suggested under paragraph headed "Calculating Boiler Capacities."

Steam Boiler Apparatus.—The Simplex and General Electric companies manufacture electric steam boilers in various capacities. They are usually equipped with water and steam gauges, safety valves, and other standard boiler fittings. Simplex boilers



G. E. Electric Steam Boiler.

are of the horizontal type and are somewhat similar to so-called "fire tube boilers" in that the heating elements are inserted in longitudinal tubes passing through the shell. These tubes are welded in the boilers and the heating elements may be readily removed for inspection and repairs.

The General Electric boilers are of the vertical type and are usually heated by means of direct immersion heaters which are inserted into the shell radially and from the outside. They are mounted in rows around the circumference and near the bottom of the tank. The capacity of each unit is one kilowatt and obviously a large number are employed for heating the larger boilers. The sizes and capacities of General Electric steam boilers are set forth in Table IV.

TABLE IV.

General Electric Steam Boilers.

No.	Kw. Capacity.	Lbs. Evap. per hr. From and at 212° F.	Approx. Boiler Horse-power.	Gallons Capacity, Full.	Height Over all In Ins.	Floor Space In Feet.
10	30	101	2.9	85	59	3 x4
11	45	151	4.4	110	66	3 x4
12	60	201	5.8	145	74	3½x4½
13	85	285	8.3	180	79	3½x4½
14	100	335	9.7	250	85	4 x5
15	150	503	14.6	340	92	4½x5½
16	200	671	19.5	480	104	5 x6

To determine the amount of water which the different sized boilers will evaporate under various pressures and with various feedwater temperatures, divide the figures in column 3 by the corresponding factors of evaporation found in Table I.

The boilers are all thoroughly lagged with heat-insulating material. Although it might be considered unsafe to operate the present open shell and fire tube types of electric boilers at excessively high pressures, there seems to be no obvious reason why electric steam boilers might not be designed on principles similar to those of water tube boilers and operated at any desired pressures.

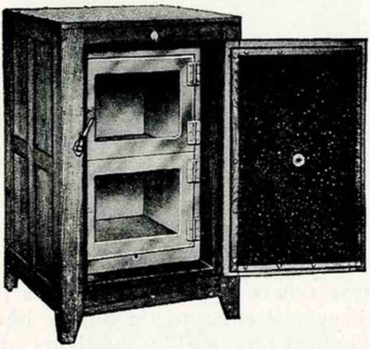
CHAPTER XVI

GENERAL APPLICATIONS OF ELECTRIC HEAT.

Diversity of Use.—Although it is impossible to enumerate in a single chapter the many uses to which electric heat has been successfully applied, a number of its possible applications in the industrial field are set forth. The descriptions are arranged in alphabetical order for convenient reference.

Automobile Heater.—A number of small low wattage heaters have been developed for placing in automobile hoods to keep the engines and radiators warm in cold weather. These heaters keep the water from freezing and make the engines start more easily.

Bacteriological Incubators.—Electric heat is particularly well adapted for bacteriological work. The

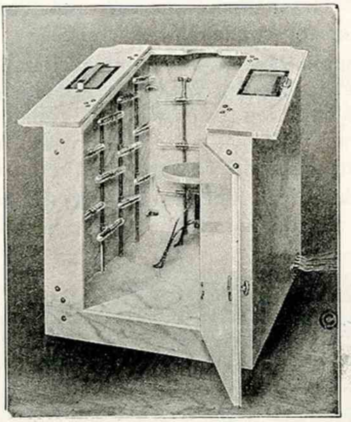


G. E. Bacteriological Incubator.

character of the heat afforded, the positive automatic temperature control apparatus available, and the absence of fire hazard make electrically heated devices of this nature very desirable. A number of bacteriological ovens are in actual successful use and the desired temperatures are maintained to within a fraction of a degree.

Bath Cabinets.—Every advantage of the Turkish or steam bath room is afforded by the electric cabinet bath, and it is being substituted for them quite generally. The expense of maintaining hot air and steam rooms and the disagreeable features attending their use are thereby eliminated and the patients given better and more healthful treatments.

The cabinets are usually constructed of wood, steel, or marble and are designed for patient's use

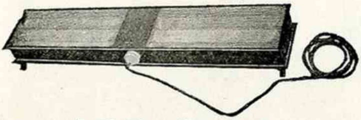


Electric Bath Cabinet.

in either a sitting or reclining posture. The interiors are lined with reflecting surfaces. Rows of electric lights (usually carbon filament) are mounted close to these reflecting surfaces and the patient receives the beneficial effect of the actinic light rays as well as of the heat produced by the lights surrounding him. The wood and steel cabinets are generally lined with mirrors, whereas marble acts as the reflecting surface where it is used. The patient's head is always allowed to protrude from the cabinet and he is never forced to breathe the hot air contaminated by the toxic emanations of his person, which is unavoidable in the hot air and steam rooms.

The marble cabinet shown in the illustration is made by James B. Clow & Sons. It is lined with 56 sixty-watt carbon lights and has a total capacity of 3360 watts when all the six control switches are closed. The range of temperature is from 80 deg. to 180 deg. F. From 3 to 10 minutes is required to bring out a sweat and the average duration of the bath is from 12 to 20 minutes, depending upon the initial heating, the outside temperature, and the physical condition of the patient.

Beer Vat Dryer.—For drying out vats in a brewery during the varnishing season, the General Electric beer vat dryer is convenient and satisfactory. It is 4 feet long, 8½ inches wide, 4 inches high and is fitted

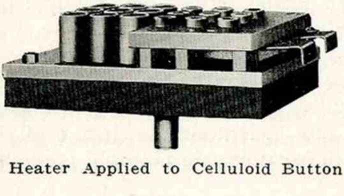


G. E. Beer Vat Dryer.

with six 500-watt resistance tubes mounted on center and end castings. The ends and sides are of sheet metal, and the top and bottom of galvanized wire mesh. It is claimed by the manufacturers that one of these devices will dry out a 50-barrel vat in about 10 hours. Two heaters are recommended for a 150-barrel vat, and three for a 350-barrel vat.

Branding Irons.—A large number of special electrically heated branding irons are in use. They are ideal for branding wood, leather, meats, etc.

Button Die Heater.—Electrically heated dies have been used for some time in the manufacture of cellu-

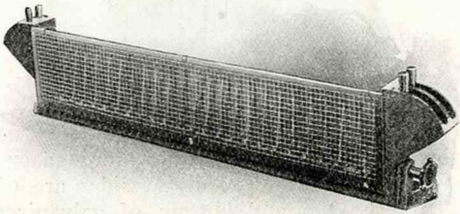


C. H. Heater Applied to Celluloid Button Die.

loid buttons. These devices are made in capacities of from 60 to 150 watts, and are usually controlled by rheostats mounted on the bed plates. A number of dies may be mounted on one head.

Can Capping Machine Heater.—An application of electric soldering iron units of 250 watt capacity to can capping machines has been designed by the General Electric Company. Apparatus operated in this manner has been found much more satisfactory than gas heated equipment.

Candy Batch Warmer. — The electric batch warmer is portable and has a swing adjustment so that the heat can be thrown in different directions as desired. It serves the same purpose as the open gas



C. H. Batch Warmer.

warmer, but has certain obvious advantages over fuel apparatus.

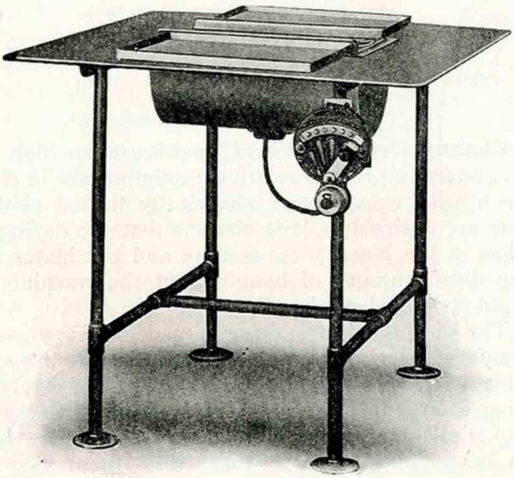
The Cutler-Hammer batch warmer is made in two standard sizes, as follows:

Length in Inches.	Watts.	No. Heats.
24	2500	3
48	5000	6

Celluloid Embossers.—A method of attaching 25 watt and 38 watt soldering iron units to the embossing heads on the lower part of celluloid embossing presses has been developed by the General Electric Company. The electrically heated dies are ideal; a maximum temperature of 140° F. is maintained; and all danger from working with inflammable material is obviated.

Chocolate Warmers.—For maintaining chocolate at proper temperature for dipping, the electrically heated warmers have proved their superiority on account of the accuracy of adjustment possible and the cleanliness and convenience afforded. They consist of two pans; an inner one holding the chocolate and an outer one fitted with a surface heating element.

Chocolate warmers in the following sizes and capacities may be obtained for flush mounting on dipping tables:



C. H. Chocolate Dipping Table With Warmer and Side Pans.

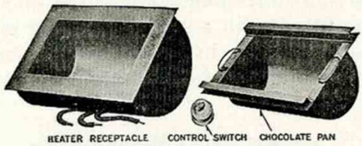
Rectangular Chocolate Warmers (Cutler-Hammer).

Quarts Capacity, 2/3 Full.	Inside Dimensions in Ins. Length.	Width.	Depth.	—Watts— High.	Medium.	Low.
4	12 3/16	6 3/16	5	180	90	45
6	14 1/16	7 5/16	5¾	220	110	55
10	14½	10	7	310	155	77
12	20	12	5½	375	188	94
Rectangular Type (Westinghouse).						
4	12	6½	5	220	110	55

Round Type Chocolate Warmer (Cutler-Hammer).

Quarts. Capacity. 2/3 Full.	Inside Dimensions, Ins. Diameter.	Depth.	—Watts— High.	Medium.	Low.
4	9	6¾	160	80	40

Electrically heated side pans are furnished with the Cutler-Hammer rectangular chocolate warmers instead of marble slabs. Two of them may be mounted on opposite sides of the warmer. They are made in the following standard sizes:



Westinghouse Chocolate Warmer.

Heated Side Pans.

Dimensions in Inches.	Watts.
12″ x 15″	25
12″ x 17″	29
12″ x 22½″	38

Clothes Dryers.—Where fuel cost is high or where operating cost is relatively unimportant in comparison with convenience, electrically heated clothes dryers are desirable. It is obvious that the drying of clothes in the laundry saves time and eliminates the many disadvantages of hanging out the washing on the old-fashioned clothes line.

The Chicago electric dryer is made of heavy gauge galvanized sheet metal with single casing, double casing insulated with asbestos, or double casing insulated with an intervening air space. The panels of the racks are of similar material. The rear panels are provided with extension plates, so that when the racks are pulled out, the heat will not escape from the machine. The brackets are of cast iron, and the hanging bars are of galvanized pipe. The sheave wheels are run on ball bearings. The base of the cabinet below the racks is provided with galvanized wire screen for the protection of clothes that might fall from the racks.

The electrically heated dryers are made in four standard sizes for use on 110 or 220 volt circuits.

Dryer Number.	Outside Dimensions. Height.	Length.	Width.	No. Racks.	Lineal Ft. Hanging Capacity	Kw. Capacity.
E 29	7′	7′	2′ 1″	2	78	3
E 39	7′	7′	2′ 10″	3	117	4.5
E 49	7′	7′	3′ 7″	4	156	6
E 59	7′	7′	4′ 4″	5	195	7.5

Corn Popping Machines.—An electric corn popper of 1500 watts heater capacity and operated with a one-sixth horsepower motor is now available. It is similar to those seen in public places, and has a capacity of about 60 bags of popcorn per hour.

Corset Irons.—The Simplex corset iron is made in an 8½ pound, 500 watt size. It may be obtained with either a hand or an automatic regulator or a combination of both.

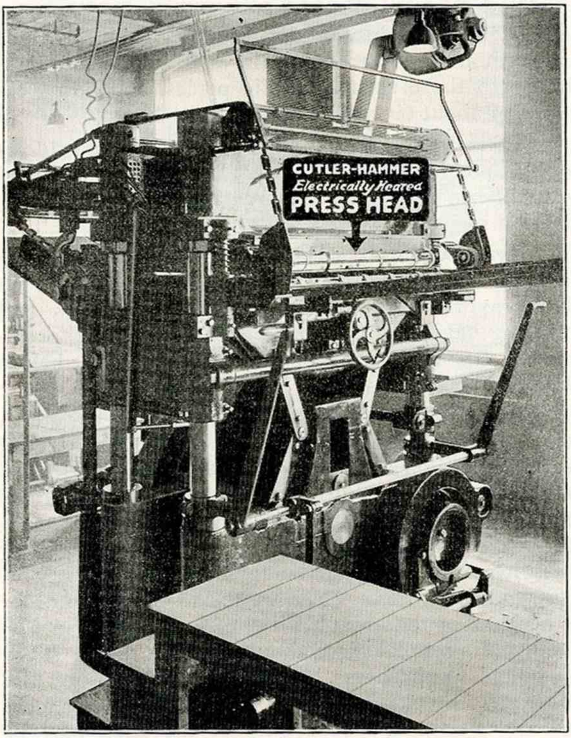
Drying Ovens.—Specially constructed ovens are used for drying lumber, for removing moisture in photogravure work, for drying leather boxes and traveling bag parts that have been glued, and for removing the moisture from bottles and cans before filling with powders.

Embossing Press Heaters.—Any gas or steam heated embossing head may be easily fitted with electric heaters and higher operating efficiencies insured. They may be heated quickly (usually from ten to fifteen minutes), and afford a sensitive and uniform temperature over the entire surface. Simplex embossing press heaters have been made in a great variety of sizes and capacities. They are usually made to order on account of the great variety of press heads in use. The heaters are flat discs about one inch thick. They are bolted to the press head and the embossing dies placed over them. They may be made in two or more sections, so that portions only of the head may be heated, if desired.

Cutler-Hammer press heads and press blocks are also manufactured in a variety of sizes and capacities for industrial use.

The following information is usually required for making up a design of press heater:

(1) Nature of work to be done.
(2) Speed of operation.
(3) Temperature required.
(4) Pressure to be applied.
(5) Dimensions of dies and manner applied.
(6) Sketch showing dimensions of press head.

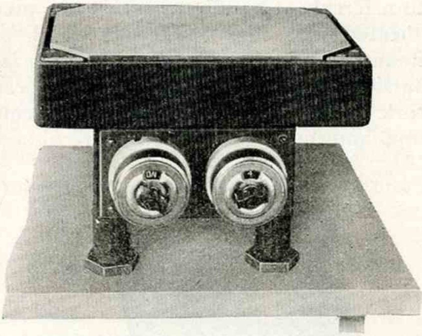


Sheridan No. 8D Press Equipped With 46 in. x 33 in. Press Head.

Engraver's Stoves.—Three-heat stoves of 600 watts capacity are being used successfully for heating engraved plates during the inking process.

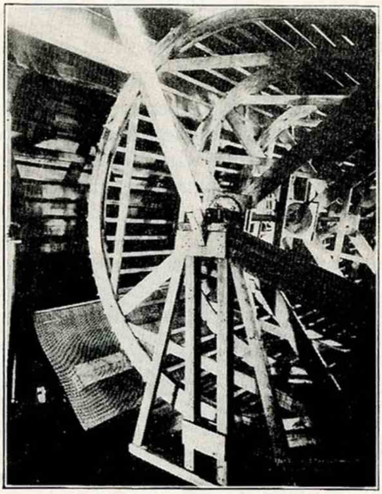
Envelope Gum Dryer.—With a 500 watt heating unit fitted in the blower cabinet, the capacity of a machine will be increased about 100 per cent.

Fan Drying Equipment.—A small dryer of 1000 watts capacity, which is attachable to a standard fan motor, has been developed by the General Electric Company. It has a wide field for application in pho-



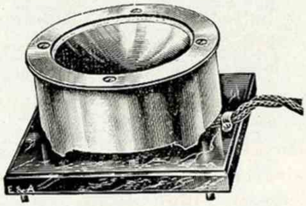
C. H. Engraver's Stove.

tographic studios for drying prints and negatives. The heating coils are mounted vertically in an aluminum frame and covered with a screen guard.



Motion Picture Film Dryer.

Film Dryers.—A large motion picture studio has developed a film drying oven, consisting of an outside casing, within which a large ribbed cylindrical reel, similar to a ferryboat paddle wheel, is mounted. The oven is heated with four 3000 watt G. E. beer vat dryers mounted around the sides. The film is wound on the outside of the reel. The drying process completes work in 30 minutes that formerly required 10 hours' time, and much better results are obtained.



E. & A. Type FW Laboratory Flask Heater.

Flask Heaters.—A flask heater for laboratory use is very convenient. It is made of copper with a concentric ring top. The small size is 8½x4 inches deep, and consumes 500 watts at maximum heat.

Gilding Wheel Heaters.—These devices are used for bookbinding, and are convenient on account of the absence of soot and dust and the concentrated heat afforded. They are fitted with heaters which revolve on roller bearings. Ordinary dies may be used with these heaters by turning a recess on one side and drilling holes for the clamping studs. Simplex gilding wheel heaters are made in the following sizes and capacities:

77 watt heater, 3 19/32″ diameter, 21″ long.
85 watt heater, 4″ diameter, 21″ long.

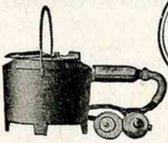
A rheostat may be supplied with the larger size for finer temperature adjustment.

Glove Stretchers and Laying-off Boards.—The electrically heated glove stretchers and laying-off boards manufactured by the C. L. McBride Manufacturing Company are ideal for the dry cleaner and glove manufacturer. The stretchers are superior to the ordinary steam heated devices. Steam laying-off boards are not flexible; will not give to allow the gloves to be fitted, and consequently require more time to adjust the glove fingers. The heat also varies with the pressure, and the quality of the work is not uniform. These disadvantages are overcome in the electric glove stretcher. The temperature is regulated by a thermostat. It is mounted on a revolving base. The quality of the work is better, and may be done more rapidly and with less skilled labor than where steam is used. Only a relatively few forms are required, because each stretcher will make four full sizes of gloves from one form.

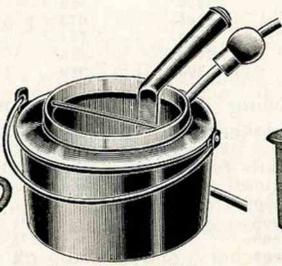
The electrically heated laying-off boards are made for finishing dry cleaned gloves, and may be used in a kid glove factory although they are too light for heavy gloves. They are much cleaner and safer and will turn out more and better work than steam boards.

Glue Pots.—Electrically heated glue pots eliminate soot, smoke, and flame; do away with steam and gas pipes; are readily moved from place to place, and insure even temperature regulation. They are manufactured both with and without water jackets.

The relative sizes and capacities of glue pots made by three prominent manufacturers are as follows:



Westinghouse Cast Iron Glue Pot.

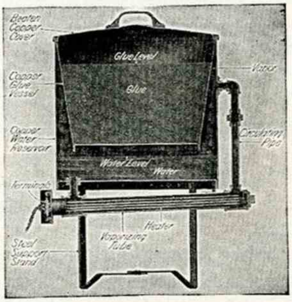


Simplex No. 408 Glue Pot.

General Electric Glue Pot.

Make.	Pot Capacity.	Small. Low.	Small. High.	Large. Low.	Large. High.		
Gen. Electric...	½ pt. to 8 qt.		20		250	jacketless	1-heat
Gen. Electric...	1 pt. to 4 qt.	85	340	275	1100	jacketed	3-heat
Westinghouse..	1 pt. to 4 qt.	55	200	200	660	jacketed	3-heat
Simplex	1 pt. to 2 qt.	110	440	220	880	jacketless	3-heat
Simplex	1 pt. to 20 qt.	85	330	625	2500	jacketed	3-heat
American	2 pt. to 4 qt.	125	500	250	1000	jacketed	3-heat

Glue Cookers.—Quantities of glue may be heated in large pots and transferred to small pots for use in various parts of an establishment. The cookers are usually heavily insulated against heat losses.



Section of a Westinghouse Glue Cooker.

Tabular specifications of standard Westinghouse glue cookers are as follows:

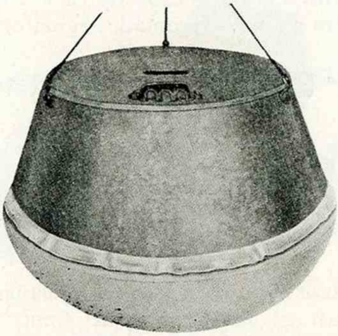
Gallons Capacity.	Watts Input. Starting.	Running.	No. of Heats.
3	1800	450	2
5	2200	550	2
10	2700	675	2
15	6000	750	5
20	6600	825	5
25	7200	900	5

The following data refer to standard General Electric glue cookers:

Gallons Capacity.	Watts Input. Starting.	Running.	Av. Hr. Time to attain 165° F.	Floor Space in feet.
20	10,500	450	1	3¼x3¼
35	14,000	500	1¼	3½x3½
50	16,500	600	1½	3¾x3¾
80	20,000	700	1¾	4 x4
140	26,500	850	2	4½x4½
220	32,000	1,050	2½	5 x5

Gold Leaf Stamp Heaters.—These devices may be used in place of gas for stamping gold leaf on combs, pipes, neckwear, etc. A Simplex die heater consuming 80 watts has been designed to fit a standard pencil stamping machine for imprinting gold leaf letters.

Hatters' Flanging Bags.—Electrically heated flanging bags are superior in every way to bags heated over steam bake ovens. The heat is constantly generated within the bag; the thermal efficiency is greater; the temperature is more uniform; and no time is lost



C. H. Flanging Bag.

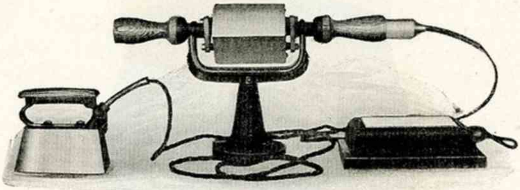
in reheating. Hats may be flanged in less time and with better and more uniform results. The Cutler-Hammer flanging bags consume 440 watts, and are furnished with a metal pan fitted with lifting ears. The sand, lifting tackle and canton flannel covering are provided by the user.

Hatters' Hand Flats.—Four faces of the straw hatters' hand flats are working surfaces. Three standard styles are made by the Cutler-Hammer Company. The hand flat is mounted on a support, and may be used in any desired position. Cleanliness is essential in the manufacture of straw hats, and the clean, uniform heat supplied by the electric hand flat makes for increased speed and perfection of product. The energy required for these devices varies from 550 to 700 watts, depending upon the style of hand flat used.

Hatters' Hand Shell.—The Cutler-Hammer hatters' hand shells conform in shape to the old-fashioned shells. The body of the shell is a single casting, and can be dipped in water for cooling the faces of the iron. These irons are made in the following standard weights and capacities:

Weight in Pounds.	Watts.
9	300 or 350
10½	300 or 350
12	350 or 500
15	350 or 500

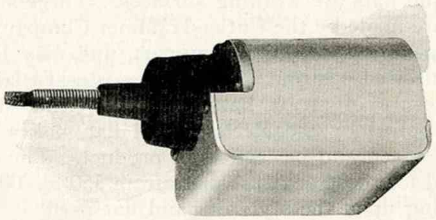
Simplex hatters' irons are made in 9 and 15 pound sizes, and with 450 watts capacity each. They may be provided with plain or automatic regulators.



C. H. Hand Shell, Hand Flat and Velouring Stove.

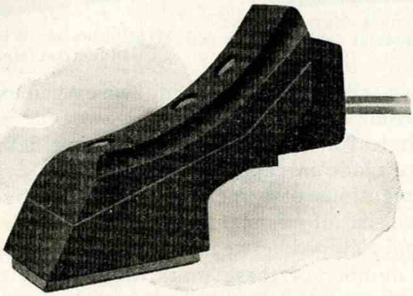
Hatters' Velouring Stove.—The Cutler-Hammer velouring stove is encased in a heavy cast iron frame with tight joints to prevent particles of felt from lodging in the crevices. They are made in the following standard sizes for either single or two-heats:

Size of Top, in Inches.	Watts Capacity Single-Heat.	Two-Heat.
4½x6	315	315-475
5¼x7	450	450-675



Doran Machine Iron Nos. 1 and 2.

Hatters' Machine Irons.—Irons for use on hatters' machines are more satisfactory, more economical, and result in better work and greater output than other such appliances. Gas heated machine irons, equipped with gas and air-blast tubes, soon develop loose connections, create dangerous hot spots, and do not maintain a uniform heat.



Tweedy Right Hand Curling Machine Iron.

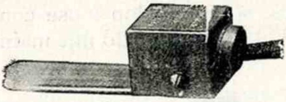
Cutler-Hammer irons are made for the following hat blocking and curling machines:

	Watts.
Doran Machine Iron No. 1	300
Doran Machine Iron No. 2	300
Doran Machine Iron No. 3	275
Newark Machine Iron	400
Tweedy Right Hand Curling Iron	750
Tweedy Left Hand Curling Iron	750

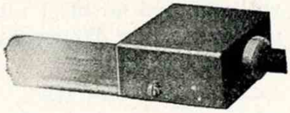
Hot Air Blower.—A 25 kilowatt General Electric hot air blower fitted with 152 ribbon wound flat heating units and a blower fan has been found useful for drying transformers and other simliar operations. The volume and temperature of the air supplied naturally depends upon the size and speed of the fan.

Industrial Heating Units.—In order to avoid designing and manufacturing special heating units for each industrial application that is presented, the General Electric Company has standardized on three types of units, one or more of which are adaptable to the usual conditions that are met. These units are known as cartridge, flat leaf, and tubular type units.

Cartridge units are made in various capacities up to 750 watts, and in sizes up to 1¼ inch diameter and 8 inch length. These units operate at a dull red heat. They are usually fitted into drilled holes in castings and bolted to the body to be heated. They consist of



Westinghouse Narrow Type Industrial Heater.



Westinghouse Wide Type Industrial Heater.

resistance ribbons wound edgewise, cemented and sealed inside of metallic tubing.

Flat leaf units are used for heating flat surfaces. They are made in capacities of 300 watts or less and with dimensions of 6 inches by 2 inches by ⅜ inch. They consist of resistance ribbons wound on mica sheets and clamped between iron protecting plates. Any desired number of these units may be bolted to the surface of any smooth, flat surface to be heated.

Tubular type units are used for air heating and are made for low temperature work. The standard

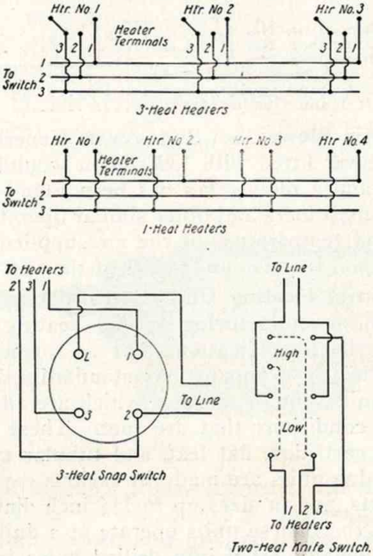


Diagram for Connecting Two Single Heat Heaters or Multiples Thereof for Three Heat Control.

size is 2 in. in diameter and 22 in. long, and dissipates about 350 watts. It consists of resistance wire wound on an asbestos tube and coated with a stiffening of insulating compound.

The Westinghouse Company has recently developed a very complete line of "steelclad" heating units for industrial purposes. They consist of flat ribbon resistors assembled on mica sheets covered with steel casings, and provided with suitable terminals. They are made in the form of bayonets with single or three heat control, in lengths varying from 10 in. to 50 in. The narrow type is 1/8 in. thick and 1 1/8 in. wide, and the wide type 3/16 in. thick and 2 1/4 in. wide. The wattage of these units may be calculated from the following table:

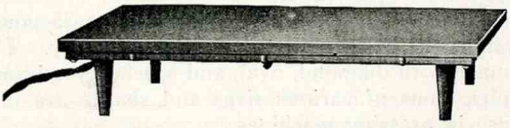
Class.	Maximum Watts per Inch of Length. Wide Type.	Narrow Type.
A (Ovens and drying rooms)........	15	7.5
B (Ordinary Air Heating)	30	15
C (Pressheads, hot plates, etc........	50	25

Ironing Machines.—Laundry machines of all kinds may be equipped with electric heaters. They insure a clean, sanitary, cool laundry, and result in producing more and better work. An example of an application of electric heat in the laundry is that of the American Iron Machine Company's "Simplex Ironer," which is made in the following sizes and capacities:

Simplex Ironers.

Length of roll in inches.	24	26	32	37	42	46	48	56
Diam. of roll in inches..	6	7	7	7	7	7	8.5	8.5
Ironing shoe face in inches	5	8	8	8	8	8	9	9
Ironing shoe contact, ins..	2.5	5	5	5	5	5	6	6
Ironing speed ft. per min.	6.5	7	7	7	7	7	8.5	8.5
Kw. capacity—high......	1.85	2	2.5	3	4	4.8	5	6
Kw. capacity—medium...	1.25	1.3	1.7	2	2.7	3.2	3.4	4
Kw. capacity—low.......	.60	.75	.85	1	1.3	1.6	1.7	2
Size of motor in hp......	1-10	1-8	1-8	1-8	1-6	1-6	1-4	1-4

Laboratory Hot Plates.—The uniform, dependable and safe heat obtainable from electric hot plates and stoves make them most desirable.



Simplex 4½ in. by 24 in. Laboratory Hot Plate.

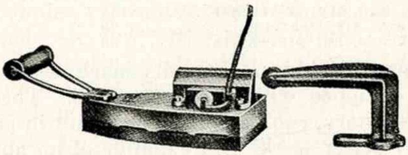
Rectangular Simplex hot plates of the following dimensions and capacities are available for securing various temperatures:

6″ x 6″	500 watt	three-heat
6″ x 12″	750 watt	three-heat
2¾″ x 24″	500 watt	three-heat
4½″ x 24″	600 watt	three-heat
3″ x 6″	200 watt	three-heat
6″ x 6″	350 watt	three-heat

Small, round Simplex discs in sets of six mounted on slate bases are convenient for milk testing and other laboratory operations.

6- 3½″ discs total 600 watts single-heat.
6- 4½″ discs total 1500 watts single or three-heat.

Laundry and Tailors' Irons.—The conditions under which these irons are used are vastly different than those in the home. They are usually subject to rough,



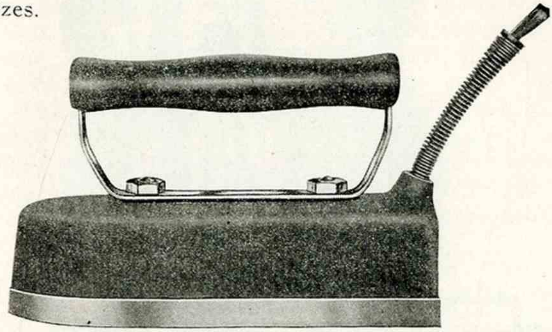
Simplex No. 1540 Drag Iron.

careless handling, and severe long hour use. They must be heavily and durably constructed to meet ordinary requirements.

A large variety of irons are available for industrial use. Pointed and round nose, smoothing and finishing irons are manufactured in many sizes. Those made for laundry work usually vary in weight from four to twelve pounds and consume from 275 to 750 watts. Drag irons are made in weights of from 30 to 50 pounds and wattages of from 1400 to 1600 watts. Puff irons in egg and half egg shapes are made in capacities of from 150 to 400 watts.

Tailors' irons usually vary from 12 to 25 pounds in weight and from 600 to 900 watts in capacity. They are made with diamond, oval, and special broad noses. Simplex irons of various sizes and shapes are made for use in pressing machines.

Westinghouse, American, Cutler-Hammer, General Electric and Simplex laundry and tailors' irons are manufactured in a variety of types, shapes and sizes.



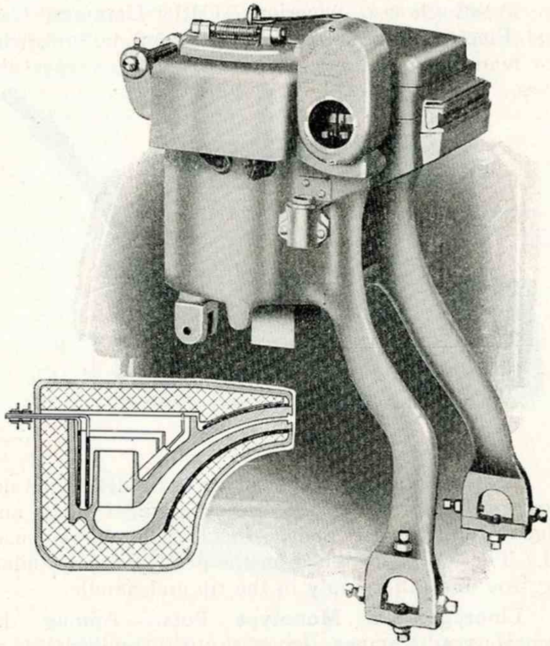
C. H. Tailor's Iron.

Leather Creasing Tool.—A recently developed device for branding designs, ruling parallel lines, and edge finishing leather articles has been found very useful. The tool is designed on the principle of a soldering iron and differs only in the tip and handle.

Linotype and Monotype Pots. — Among the numerous advantages gained by the application of electric heat to type metal pots are rapid heating, perfect temperature regulation, absence of gas fumes, smoke and soot, elimination of excessive room temperature, ideal working conditions, no burning out of the tin of the metal mixture, and production of solid, sharp slugs.

The Cutler-Hammer pots are equipped with immersion heaters, heavy thermal insulation, and automatic temperature control. The latter consists of a dynamic thermometer and a magnetic switch panel. Expansion or contraction of mercury in the thermometer actuates a relay which in turn operates the magnetic switch, cutting the current in the heating elements on or off.

It maintains a temperature of approximately 550° F. in the type metal. Initial heating requires



C. H. Linotype Pot.

1600 watts, for about 50 minutes after which 550 watts is sufficient to maintain the temperature when 100 slugs are being cast per hour.

G. E. Monotype Pot.

The General Electric pots are usually equipped with standard cartridge units. Regulation of the heat is obtained by means of a hand operated rheostat. For heating a linotype pot holding 40 pounds of metal a maximum capacity of 2250 watts is provided. To maintain working temperature using 8 pounds of metal per hour 750 watts is required. For heating the same weight of metal in a monotype pot 2900 watts is provided, and for maintaining the proper temperature, using 16 pounds of metal per hour, 2400 watts is required.

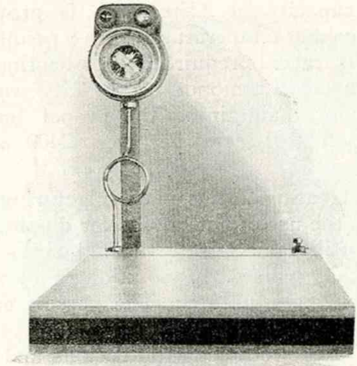
Liquid Heating Tanks.—Manufacturing processes that require the use of hot liquids for dipping purposes may often utilize electrically heated tanks to advantage, especially where the solution is of an inflammable or explosive nature. The vessels are usually well lagged and fitted with covers.

Tanks of the following dimensions and capacities are made for heating liquids by the General Electric Company:

Capacity in Gallons.	Total Kilowatts.	Outside Dimensions. Diameter.	Height.	Average Hours Required for Heating Oils to 212° F.
40	16.5	27″	25″	1.3
60	22.5	31″	29″	1.4
85	30	35″	31″	1.5
125	39	39″	35″	1.7
200	52.5	46″	40″	2
300	58.5	54″	45″	2.7
500	67.5	62″	55.5″	3.9
750	75	70″	62.5″	5.3
1000	79.5	76″	68.5″	6.7

Matrix Dryers.—The most important factors to be considered in matrix drying are quality of the mat, cost of drying and speed of drying. The temperature usually required for this work is from 350° to 400° F. The common methods of drying are accomplished by the use of either gas or steam heat. In addition to the many obvious disadvantages of gas heated apparatus, it does not provide the uniform temperature that is so desirable for this class of work. Steam heated dryers, on the other hand, supply a uniform heat, but unless excessively high pressures are available the operating temperatures are too low for quick work.

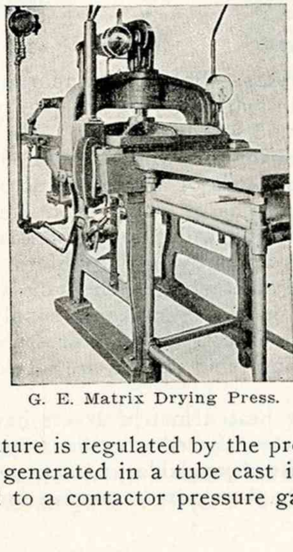
Electrically heated matrix dryers have overcome all the undesirable features of other apparatus. The heat is clean, safe, dependable, and automatically regulated to provide the desired operating temperatures,



C. H. Matrix Machine Heater.

and it does away with the maintenance of troublesome and costly equipment.

Cutler-Hammer matrix dryers are manufactured complete, ready to slip into the bed of the machine.



G. E. Matrix Drying Press.

The temperature is regulated by the pressure of saturated steam generated in a tube cast into the heater and attached to a contactor pressure gauge, which in turn actuates a magnetic switch, cutting the current on and off. The dryer is also fitted with pilot lamps to indicate when energy is being consumed.

General Electric matrix dryers are also automatically controlled. The standard size is rated at 28 kilowatts, and is applied intermittently by the automatic regulator. It is claimed by the manufacturers that these dryers will consume about one kilowatt per hour per mat.

Meat Brander.—This device is used for inspection stamps and is legible at end of curing process. A ham branding die made by the General Electric Company consists of a 21 pound block of cast iron heated with two 600 watt cartridge units. The branding die is of cast brass inserted in the top of the body casting. After initial heating, low heat is maintained. Each ham is branded by placing it on top of the heated die for from 3 to 4 seconds.

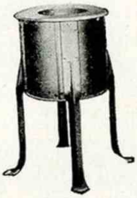
Metal Melting Tanks.—For bringing tin, lead, solder, babbitt metal and various alloys to the melting point, electrically heated tanks can often be used to advantage, especially where it is desirable to secure accurate temperature adjustment. These tanks should be heavily constructed and provided with efficient thermal insulation.

Tanks of the following sizes and capacities are manufactured by the General Electric Company:

Capacity 80% Full. Lbs. Lead.	Lbs. Tin.	Inside of Tank (inches). Diam.	Length.	Width.	Depth.	Watts Capacity.
30	19	4¾″	...	...	5½″	2,100
50	30	5½″	...	...	6½″	2,400
75	45	6½″	...	...	6⅞″	3,000
100	60	7″	...	...	7⅞″	3,900
200	125	9″	...	...	9½″	4,550
300	190	10″	...	...	11⅝″	6,500
400	250	11″	...	...	12¾″	8,450
560	360	...	15″	13″	9″	13,000
800	520	...	15″	13″	13″	15,600
1080	690	...	20″	13″	13″	17,500
1230	860	...	20″	16″	13″	22,100
1640	1050	...	20″	16″	16″	22,800
2060	1275	...	25″	16″	16″	26,000
2330	1600	...	30″	16″	16″	28,600
2960	1900	...	30″	19″	16″	30,000

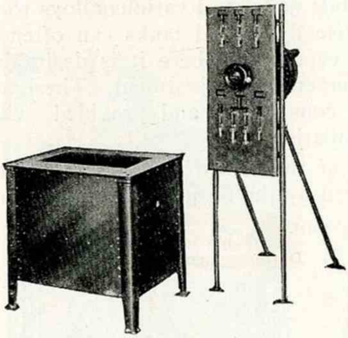
It is claimed that a 3000 watt pot will melt approximately 52 pounds of alloy consisting of 18 parts antimony, 20 parts tin, and 100 parts lead in one hour. Medium heat will perform the same operation in 3 hours.

Cutler-Hammer type metal crucibles are made with external or immersion heaters in sizes of from 50 pounds to 500 pounds capacity.



G. E. Metal Melting Tank.

Number Brander.—This recently developed device consists of an electrically heated circular plate. on the outside of which is mounted a small wheel bearing ⅜ in. figures reading from 0 to 9.



G. E. Oil Tempering Bath.

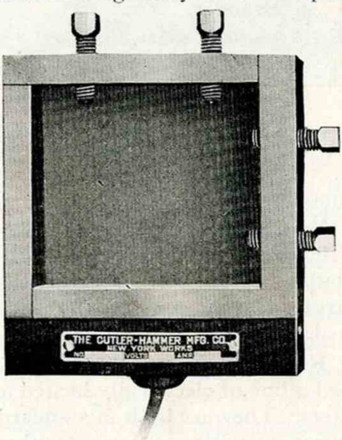
Oil Tempering Baths.—Where a large amount of tool tempering is done the electric oil bath is indispensable. Uniform temperature control is attained, and fire hazard, uncertainty, and harmful oxidation of the metals is eliminated in this process. The work may be done successfully with unskilled labor because the temper is drawn by the submersion process.

General Electric oil tempering baths furnished with or without cooling coils and controlling panels are made in the following standard sizes and capacities:

Oil Capacity Gallons.	Dimensions in Inches. Length.	Width.	Depth.	Maximum Kilowatts.
9	22	12	8	6
11	18	12	12	7.2
37	30	16	18	20

The drawing temperature of different grades of steel varies from 300° to 320° F. The 20 kilowatt size bath is said to have drawn the temper of 363 pounds of steel ball bearings in 1 hour and 45 minutes with a total energy consumption of 9.5 kilowatt hours.

These baths are being used successfully for melting rosin compounds required in the manufacture of shrapnel shells. They may be used equally as well for heating and melting many other compounds.

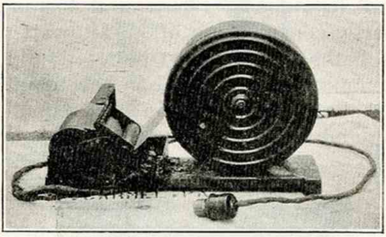


C. H. Pallette Heater.

Pallette Die Heaters.—In book binding establishments these devices have a number of advantages because of the concentrated heat, freedom from dust and soot, and better working conditions brought about.

The Simplex standard machine die heater is of 140 watts capacity, and fitted with rheostat and flexible cord. It is provided with a triangular piece of metal across the back for fastening in the head of the machine. The rectangular pocket for the dies is 1½ in. x 2½ in. x ⅝ in. deep. The hand die heater is of 135 watts capacity. The groove for the die is ¾ in. x 5 in. x ½ in. deep. The length of the device including the handle is 9½ in.

Paper Seal Moistener.—Electric heat has been found convenient for heating water in the small paper seal moisteners used in sealing packages and cartons.



Paper Seal Moistener.

A small 30 watt heating unit immersed in a container 4 in. x 6 in. x 2 in. deep, will raise the temperature a sufficient amount.

Paper Warmer.—In order to do away with the sticking effect produced by static electricity General Electric tubular heaters have been placed under the paper of large printing presses and satisfactory results obtained.

Peanut Roasters.—Wm. B. Berry & Company has developed a line of electrically heated and operated peanut roasters. They are built in standard sizes of 16, 24, and 32 quart capacities, and in a number of designs. The latter is equipped with 1.2 kw. in heating units and will roast about one bushel of peanuts per hour. The manufacturers claim the machines have been used successfully for roasting coffee as well as peanuts.

Perforator for Drawings.—A recently developed heating device which makes minute perforations may be run over a drawing and the pattern used for a stencil.

Photographic Drying Oven.—An unlagged galvanized iron oven 5 ft. long, 30 in. wide, and 30 in. high, fitted with two 500 watt General Electric tubular type heaters mounted 2 in. from the floor is said to dry photographic prints in from 30 to 45 minutes, whereas from 3 to 4 hours was formerly required for drying them on blotting paper in the open air. Ventilation is provided by a 6 in. hole in the bottom and a small damper in the top. The prints are placed on blotting paper on three wire mesh shelves.

Another installation, consisting of a revolving galvanized sheet iron drum 3 ft. in diameter and 2 ft. wide, heated by means of a 2000 watt three-heat American radiator inside the drum, and operated by means of a 1/6th horsepower motor, gave very quick results. A cloth belt passing around the drum and over rollers mounted on the framework permitted the wet prints to be inserted between the surface of the drum and the cloth belt. The warm surface of the drum and the dry cloth rapidly remove the moisture.

Pipe Thawing Outfits.—Portable outfits have proven serviceable for thawing frozen pipes. The high tension leads are connected to the main line feeders and the low tension leads are attached to opposite ends of the frozen pipe section. In residences one lead is usually attached to the faucet and the other to a street hydrant. Connections may be made to two hydrants when street mains are frozen, or excavations may be made for attaching leads direct to the pipes.

Pitch Kettles.—Portable devices for heating pitch, varnishes, oils, etc., have a wide range of application They are usually provided with three-heat control switches. The maximum heat is used for heating up the substance, medium heat for stirring, and low heat for maintaining a constant temperature.

Simplex pitch kettles have the following dimensions and capacities:

12″ x 2½″ deep	4 quart	1300 watts	maximum.
15″ x 2½″ deep	7 quart	1600 watts	maximum.
19″ x 9 ″ deep	40 quart	3000 watts	maximum.
30″ x 14⅜″ deep	120 quart	7000 watts	maximum.

Pleating Machine Heaters.—An installation for pleating dress goods, made by the General Electric Company, consisted of a 600 watt heating unit fastened to the frame so as to project inside one of two 7-inch by 3-inch corrugated rollers, and a temperature of about 450° F. was attained. The electric heater was substituted for a gas burner, which was more or less dirty, dangerous, and uncomfortable to work over.

Pouring Pots.—Where it is desired to keep wax and pitch compounds at the proper consistency for pouring, General Electric portable pots, made in forms similar to its jacketless glue pots, are useful.

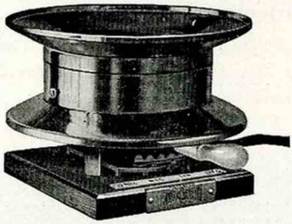
Printing Ink Heater.—In order to keep printing ink warm and fluid in cold weather, a small heating unit placed beneath the ink pad has produced good results.

Rectifier Tube Boiler.—For lengthening the life of rectifier tubes the General Electric Company has developed a means of boiling the tubes in water for removing the carbon deposits on the inside of the glass. A copper tank 29½ in. long, 16½ in deep, and 13 in. wide, lagged with asbestos paper, fitted with a tight cover and heated with nine 1175 watt cartridge units constitutes the equipment.

Roofing Material Vulcanizer.—This application of electric heat as a substitute for gas heat reduces the unit time of joining rolls of rubber roofing paper considerably. The heating units consist of mica insulated resistance ribbon clamped between iron plates (2 in. x 6 in. x 3/16 in. thick). These 350 watt units are attached to the under side of a 9 in. x 60 in. x ¾ in. thick iron vulcanizing plate, and a temperature of about 650° F. maintained. Electric operation eliminates gas fumes and fire hazard, and is far more convenient.

Sealing Wax Pots.—For applying large quantities of sealing wax, an electrically heated pot is more convenient than ordinary stick wax. Special Simplex devices made of spun copper and having the following capacities are in use:

½ pint	175 watt maximum	4-heat.
1½ pint	300 watt maximum	4-heat.



Simplex Sealing Wax Pot.

Shelf Heaters.—Cutler-Hammer electrically heated shelves form a means of heating ovens already built or in use. The shelves form separate units, which may be mounted in any oven of similar dimensions. They are suitable for use in incubators, lacquering

C. H. Self Heater.

ovens, plate warmers, evaporating and drying closets and laboratory cabinets. The shelves are of perforated sheet metal, mounted on iron frame work, with the heating units inside.

The standard sizes and capacities of these heaters are as follows:

Size in Inches			Maximum	Number of
Length.	Width.	Thickness.	Watts.	Heats.
12	6	1½	200	1
16	8	1½	350	1
20	10	1½	550	1
24	12	1½	750	3
24	16	1½	1,000	3
30	20	1½	1,500	3

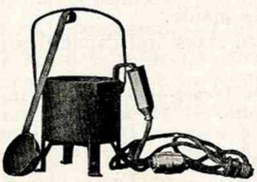
Shoe Relaster.—The Fern Company of Baltimore has placed an 80 watt relasting iron on the market for the use of the retail shoe trade. This device is used for smoothing out wrinkles, creases, and irregularities in shoes and otherwise improving their appearance.

Shoe Machinery.—Electric heat has been applied to various machines in shoe factories with marked success. The following table shows various applications of electric heat to standard shoe machinery.

Electrically Heated Shoe Machinery.

Machine.	Application.	No. of Heating Units.	Wattage of Each Unit.
Lining Cementer..........		1	200
Knurling machine.........	Knurl holder......	1	126
Stitcher	Wax pot	2	75
Stitcher	Take-up	1	250
Stitcher	Truck on wax pot.	1	63
Stitcher	Shuttle	1	150
Patent leather repairer....	Wax receptacle....	1	63
Stitcher (old)............	Take-up	1	200
Stitcher (old)............	Shuttle	1	126
Stitcher (old)............	Wax pot..........	2	75
Stamper	Turret	2	182
Embossing machine........	Die holder........	2	121
Embossing machine........	Paste	1	38
Upper leather stamping Machine	Die Holder	1	200
Indenter and burnisher....	Knurl holder	1	126
Welter	Wax pot	2	75
Welter	Looper	1	182
Welter	Tension	1	75
Welter	Thread tube.......	1	38
Embosser	Die Holder	1	300
Goodyear stitch burnisher.	Knurl holder	1	75
Bobbin winder............	Wax pot	2	100
"Expedite"	Burnishing iron...	1	425
"Expedite"	Wax pot..........	1	200
Toe softening machine.....	Boiler	1	750

Solder Pots.—For heating and maintaining correct temperature for soldering operations, electrically heated pots are ideal. They are much cleaner, safer



Westinghouse Solder Pot.

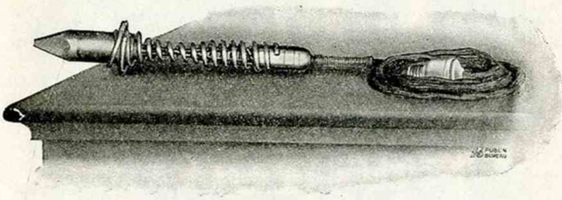
and simpler to operate than the ordinary charcoal or gasoline heated pots. The standard Simplex pots have the following sizes and capacities:

5¾" x 1¼"	deep	4 pounds capacity	200 watts	three-heat.
6¾" x 1¼"	deep	10 pounds capacity	440 watts	three-heat.
7¾" x 1¼"	deep	20 pounds capacity	825 watts	three-heat.

The standard American pots have the following capacities:

5 pounds capacity	400 watts	three-heat.
10 pounds capacity	575 watts	three-heat.
20 pounds capacity	975 watts	three-heat.
50 pounds capacity	1500 watts	three-heat.

Soldering Irons.—Electric soldering irons designed for intermittent use are manufactured in sizes varying from 12 ounces to 3 pounds, and consuming from 75 watts to 350 watts, respectively. The Simplex

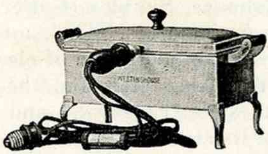


G. E. Soldering Iron.

automatic stand, which cuts off one-half the current when the iron is placed upon it, prevents the iron becoming overheated when not in use.

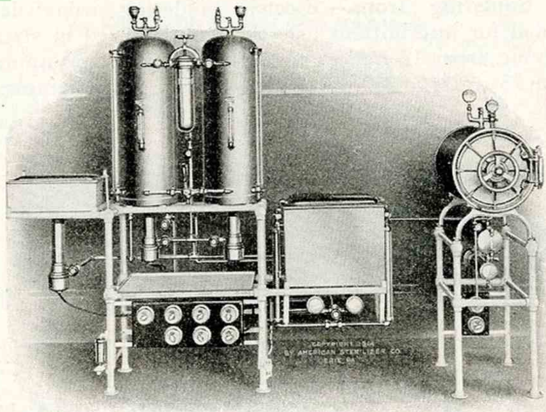
Solution Tanks.—The General Electric Company has devised a means of heating solution tanks with its cartridge units. One 3000 watt installation applied to a tank of 7/16 in. cast iron and having inside dimensions of 18 in. x 18 in. x 14 in., is said to bring a full tank of water to boil in about thirty minutes.

Sterilizers.—The application of electricity to the heating of sterilizers offers a profitable market for energy in nearly every community. All modern hos-



Westinghouse Instrument Sterilizer.

pitals, operating rooms, and dental offices are equipped with sterilizing devices, and the cleanliness, convenience, and healthfulness afforded by electrically heated apparatus appeals to the physician or dentist and creates a favorable impression among his patients.



American Sterilizer Installation. (Left to right—Instrument, Water, Utensil, and Dressing Sterilizers.)

For complete sterilization, dressings are kept under a steam pressure of 15 pounds for about 20 minutes. Water is maintained at 250° F. in closed chambers for approximately the same period, whereas utensils and instruments are submerged in boiling water for about 15 minutes.

Several makes of electrically heated sterilizers are now available. Small instrument sterilizers are made by the Westinghouse, Simplex, Cutler-Hammer, and other heating manufacturers. The American Sterilizer Company makes a complete line of electrically heated apparatus of this character, and the accompanying tables gives the sizes, capacities, and operating features of some of its sterilizers:

Dressing Sterilizers.

			Time and Energy Required for One Sterilization. Initial Temp. 150° F.		
Diam. Inches.	Length Inches.	Kw. Cap.	Minutes High Heat.	Minutes Low Heat.	Kw -hr. Consumed.
9	19	3	14.5	20	.97
12	20	6	13	20	1.8
14	22	6	16.5	20	2.12
16	24	6	18.5	20	2.32
16	30	6	21	20	2.6
16	36	12	15.5	20	4.1

Water Sterilizers.

Gallons Capacity per Reservoir.	Kw. Capacity per Reservoir	Time and Energy Required for One Sterilization. Initial Temp. 150° F. Minutes High Heat.	Minutes Low Heat.	Kw-hr. Consumed.
6	3	40	20	2.25
8	3	44	20	2.45
10	6	30	20	3.5
15	6	40.5	20	4.52
20	12	29.5	20	6.86
25	12	31.5	20	7.26
35	18	32	20	11.1

Utensil Sterilizers.

Dimensions in Inches. Depth.	Width.	Length.	Kw. Cap.	Time and Energy Required for One Sterilization. Initial Temp. 150° F. 4″ of Water. Minutes High Heat	Minutes Low Heat.	Kw-hr. Consumed.
16	15	20	6	14	15	1.75
20	20	24	6	25	15	2.87
20	24	30	12	37	15	4,1
24	24	30	12	..	..	..

Instrument Sterilizers.

Dimensions in Inches. Depth.	Width.	Length.	Kw. Cap.	Time and Energy Required for One Sterilization. Initial Temp. 150° F. 2″ of Water. Minutes High Heat	Minutes Low Heat.	Kw-hr. Consumed.
6	8	16	3	7.5	15	.55
6	10	20	3	9.5	15	.66
7	12	18	6	6.5	15	.98
7	12	22	6	8	15	1.19
9	12	18	6	6	15	1.
9	12	22	6	8	15	1.2

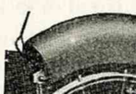
It should be observed that the energy consumptions and time required for sterilization is based in each case on the use of water with an initial temperature of 150° F. If water at lower temperature is used the time and energy consumption will naturally be increased. The heating units employed are made by the concern solely for its own use. The 3 kw. units have three-heat control and the 6 kw. units have seven heat control.

Sweating-On Machines.—An application typical of the advantage of electric heat over the open gas flame is that of the sweating-on machine for mounting copper electrotype shells upon type metal blocks. The block is placed upon the heated plate until the solder foil is melted and the block with the shell upon it is then pressed firmly together and allowed to cool. Cutler-Hammer heating elements applied to machines of this character are said to produce work superior in every way to gas heated apparatus.

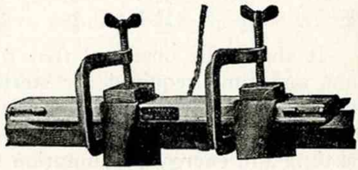
Test Tube Heaters.—For laboratory use the Simplex test tube heater is convenient. It consists of an electrically heated grooved casting slightly inclined from the perpendicular, against which the test tubes may be rested. The standard size of this heater is 5 in. x 7⅜ in., and consumes 500 watts.

Thread Waxer Heater.—A wax receptacle of a stitching machine may be heated electrically by attaching a low wattage unit to the bottom. A number of these heaters are in successful use. They eliminate all the dangers and discomforts of gas operation and are far more convenient and cleanly.

Tire Vulcanizers.—For light automobile tire repairs the electric vulcanizer is ideal. Sand blisters, cuts and stone bruises can be repaired without removing the tire, and as the work can be done promptly with a handy device of this kind, it will save much tire expense. The heat is evenly distributed over the surface and the work may be done neatly and quickly.



Shaler Type C Inside Casing Form.

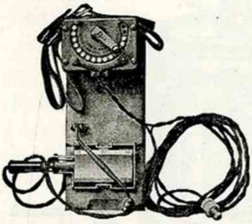


Shaler Type E Tube Vulcanizer.

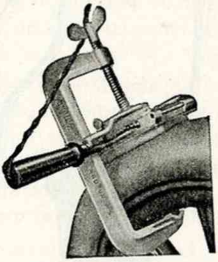
The C. A. Shaler Co. manufactures a complete line of electrically heated vulcanizing forms, which it claims to be equal or superior to its steam devices. Some of the advantages set forth are simplicity, portability, quick heating, safety and non-confliction with any garage regulations. Each device may be purchased separately, attached to any work bench, and used for its own distinct class of work. The capacities of the standard devices are as follows:

Type A—Outside casing form........................ 70 watts
Type C—Inside casing form........................ 80 watts
Type E—"Gang" or multi-tube form (4½" x 24")....200 watts

The Westinghouse automobile tire vulcanizer consumes a maximum of 200 watts. It is furnished with a 15-point rheostat, a thermometer, and a flexible cord.



Westinghouse Outside Casing Vulcanizing Outfit.

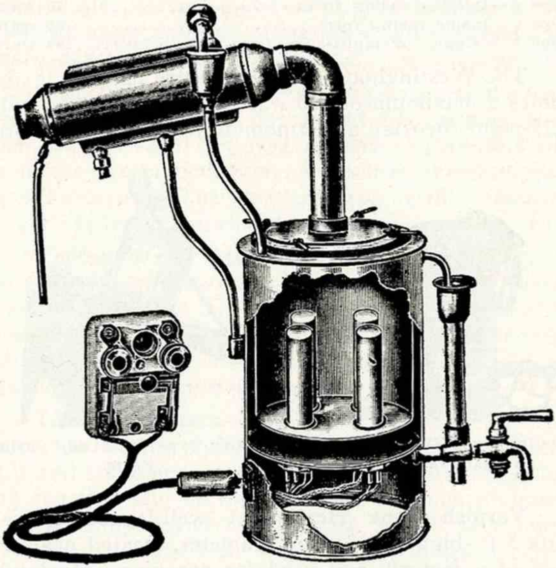


Shaler Type A Outside Casing Form.

Varnish Tank Heater.—A well-lagged varnish tank 5 ft. high and 3 ft. in diameter, located near the roof of a factory, and used for spraying automobile bodies, has been heated by three 3-heat, 900-watt cartridge units for some time. The units are placed in a 10 in. x 6 in. x 3 in. box of sand, mounted ½ in. from the bottom of the tank, and the leads are brought out through a ¾ in. conduit.

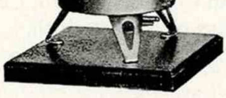
Velvet Marking Iron.—A 150 watt General Electric iron having a body 1 in. square by 6 in. long and a bottom surface ¾ in. wide by 6 in. long, is being used by the J. B. Martin Co. of Norwich, Conn., for marking letters and numbers on velvet cloth. A gummed cloth label is cemented in place by the heat and pressure of the iron.

Water Stills. — Electrically heated water stills equipped with General Electric heating units have been developed by the Barnstead Water Still Company of Boston. It is claimed by the manufacturers that a 2400 watt still will provide one gallon of distilled water per hour.



E. & A. Barnstead Type L Water Still.

Wax Burning-In Irons.—Electrically heated burning-in irons are useful in furniture factories and stores for burning in wax. They are usually made in one pound sizes and are similar to soldering irons in design.



G. E. Wax Knife Heater.

Wax Knife Heater.—General Electric wax knife heaters are superior to all fuel heated devices used by cabinet finishers. The standard type is similar to a 4-inch disc stove, consumes 180 watts and is designed with an insulating cover, under which the knife is placed.

Weight Reducing Cabinet.—A galvanized iron cabinet 18 in. in diameter, lined with ¼ in. asbestos, has been equipped by the General Electric Company with two of its tubular type 500 watt heating units. Arrangement is made for heat regulation so that the attendant may vary the temperature to suit the patient's needs.

Yarn Conditioning Oven.—This device is manufactured by the Tillotson Humidifier Company of Providence, R. I. It is used for measuring the moisture in yarns by weighing before and after drying. It is well insulated and thermostatically controlled. The oven is heated with two General Electric 600 watt units.

CHAPTER XVII

RATES FOR HEATING SERVICE.

Establishing of Rates.—Electric heating service usually differs from lighting and motor service in its value to the user and in the character of load it adds to the central station lines. If the load created by any class of service is sufficiently attractive to warrant the central station in making rates for it that are equal to or less than its value to the user, it is apparent that an ideal condition exists. If the rate is of necessity higher than the customer is justified in paying for the service rendered, business of such character is not developed, and the buyer is forced to obtain the same or equivalent service elsewhere at a less cost. On the other hand, if the rate must be made so low to obtain the customer's business, that the additional expense involved is greater than the additional income secured, the central station would not be justified in making such a rate.

Heating Loads.—The character of heating loads varies widely on account of the diversity of application. From an operating standpoint, they are usually more attractive than other classes of load. With few exceptions they are non-inductive. As they generally operate over long hour periods, they tend to improve the central station load factors. Fluctuations of the current demand are less marked, and as many electrically heated appliances naturally take, or can be made to take, energy only during off-peak hours, the advantages are obvious. The opportunity for building up cooking and heating loads along existing residential and rural lines, which have heretofore required enormous investment in proportion to gross income, is apparent.

Rate Maker's Difficulties.—Many central station managers, realizing the profitable nature of the electric heating business and the demand for such rates as will foster its development, have been anxious to make tariff revisions, but have been undecided as to the proper course to pursue by the apparent adverse attitude of press, public and the various regulating bodies.

As a whole, the public is notoriously ill-informed on central station rate making principles, and is prone to criticise the motives actuating those who make rates for certain classes of service lower than established rates for other classes. Furthermore, the attitude of the public has often been reflected in the actions and decisions of public service commissions. The fear of criticism, and the dread of establishing harmful precedents that might be used against them, deter many responsible concerns from making rates designed to attract new and profitable business, in spite of their positive convictions that such action would be productive of good for those directly concerned, as well as for the public at large.

It may be observed that the fear of popular criticism and the dread of having all service rates reduced by commission rulings, in proportion as individual rates are lowered, are for the most part unfounded. Any downward revision that may tend to improve living conditions, develop new industries, or result in greater good for a greater number, must eventually meet with universal favor. On the other hand, harsh criticism must sooner or later come upon those who do not offer their customers the benefit of such rates as they can well afford and as will make for their mutual welfare.

N. E. L. A. Rate Principles.—The six principles set forth in the 1915 report of the Rate Research Committee of the National Electric Light Association are really the basis of intelligent rate making in the electric industry, as well as in the railroad and other industries.

"(1) The total net income of the company must be enough and no more than enough to give a fair return on the investment and attract capital freely to the enterprise. The gross earnings from the sale of the product must therefore be sufficient to cover all necessary expenses of operation, including taxes, bad debts, etc., a reserve for renewals and contingencies, interest at current rates and a reasonable profit in addition.

"(2) When conditions are the same, rates to different customers or classes should be the same, but need not necessarily be the same when conditions are different.

"(3) No rate should be below the bare cost, i. e., below the expense involved by adding that customer or class, including a fair return on any investment added or used exclusively for that customer or class.

"(4) Rates should be such that as many customers as possible may be served at as low rates as possible, and yet the business as a whole furnish a fair return on all the investment.

"(5) No rate can be above the value of service, otherwise the customer will not take it.

"(6) While cutomers whose circumstances are alike should pay the same rates, it is not necessary that customers whose circumstances are unlike in respect to the amount their class can afford to pay, should be asked to pay the same percentage on the investment they use jointly, especially when they would not take the service if asked to pay such rates, but, on the other hand, would take the service and pay something toward the fair return on the whole investment if offered rates they could afford to pay.

Application of Principles to Heating Rates.—It is apparent that in applying the Rate Committee's principles to the establishment of rates designed to develop certain heating loads, the central station is justified in making rates based upon the actual cost of supplying the service, plus a reasonable return upon the additional portion of the investment required to supply it. It is not essential that the income derived from the application of a rate shall be adequate to earn a return upon the total plant investment involved in supplying it.

Each central station company must decide for itself what rates it shall adopt, because the matter is one that naturally depends almost entirely on local conditions. It is obvious that the present tendency is toward wholesale rather than retail energy supply and rates must be based accordingly. The fact should be kept in mind in all considerations of rate matters that a mere statement of rate per kilowatt hour does not mean very much. The individuals who have their money invested are much more interested in annual returns than in hourly revenues.

APPENDIX.

Containing References and Tables.

Electric Heating Manufacturers.

Advance Machinery Co..............................Toledo, Ohio
Glue cookers and pots.
American Electric Heater Co....................Detroit, Mich.
Domestic cooking and heating devices.
Industrial heating apparatus.
American Ironing Machine Co..166 No. Michigan Ave., Chicago
Simplex ironing machines.
American Laundry Mach. Co...................Cincinnati, Ohio
Mangles.
Armstrong Cork & Insulation Co..............Cincinnati, Ohio
Heat insulating materials
Barnstead Water Still Co.........................Boston, Mass.
Water stills.
C. A. Shaler Co.......................................Waupun, Wis.
Vulcanizers.
Chicago Dryer Co................624 So. Wabash Ave., Chicago
Clothes dryers.
C. H. Sharp Mfg. Co..............1312 E. 12th St., Los Angeles
Electric ranges.
C. L. McBride Mfg. Co..............................Toledo, Ohio
Glove stretchers and laying-off boards.
Coin Machine Mfg. Co.............................Portland, Ore.
Induction water heaters.
Induction linotype pots.
Cutler-Hammer Mfg. Co....144th St. and Southern Blvd., N. Y.
Industrial heating apparatus.
Domestic heating devices.
C. W. Leavitt & Co...........Cortlandt Bldg., New York, N. Y.
Girod steel furnaces.
Driver-Harris Wire Co...........................Harrison, N. J.
Resistance wire.
Efficiency Products Co...............Rialto Bldg., San Francisco
Water heaters.
Eimer & Amend Co..........205 Third Ave., New York, N. Y.
Industrial and laboratory heating devices.
Electric Sales Corporation........418 Union St., Seattle, Wash.
"Apfel" Water Heaters.
Electric Sales Service Co......109 Stevenson St., San Francisco
"Therm Elect" water heaters.
Bacteriological incubators.
Electric Specialty Co.................................Salt Lake City, Utah
Chicken incubators and brooders.
Electro Hatch Incubator Co......................Petaluma, Cal.
Chicken incubators and brooders.
Estate Stove Company...........................Hamilton, Ohio
Domestic ranges.
General Electric Co..........................Schenectady, N. Y.
Domestic heating and cooking devices.
Hotel and domestic ranges.
Industrial heating devices.
Geuder, Paschke & Frey Co....................Milwaukee, Wis.
Butt welders.
Globe Stove & Range Co...........................Kokomo, Ind.
Domestic ranges.
Good Housekeeping Cooker Co...................Berkeley, Cal.
Automatic cookers and water heaters.

Hamilton & Hansell................17 Battery Place, New York
Rennerfelt furnaces.
Hoskins Manufacturing Co.....................Detroit, Mich.
Small furnaces and heating devices.
Hospital Supply Co...................55 Fifth Ave., New York
Sterilizers. .
Hotpoint Electric Heating Co...................Ontario. Cal.
Domestic heating and cooking devices.
Electric ranges.
Hughes Electric Heating Co........211 W. Schiller St., Chicago
Domestic and commercial cooking devices.
Bake ovens, etc.
H. W. Johns-Manville Co......................New York, N. Y.
Heat insulating materials.

James L. Gibney & Bro..........................Philadelphia
Vulcanizers.
James B. Clow & Sons...............342 Franklin St., Chicago
Bath cabinets.

Landers, Frary & Clark...................New Britain, Conn.
Domestic heating and cooking devices.
Lee Electric Radiator Co............335 Wells St., Chicago, Ill.
Water heaters and radiators.
Lincoln Electric Co......E. 38th St. and Kelley Ave., Cleveland
Arc Welders.

Majestic Electric Development Co.........428 O'Farrell St., S. F.
Radiant air heaters.
Michigan Stove Co.............................Detroit, Mich.
Domestic ranges.

National Electric Utilities Co...........103 Park Ave., N. Y.
Hotel and domestic ranges.
National Electric Welder Co.....................Warren, Ohio
Spot, butt and seam welders.

Pelton & Crane Co............244 Harper Ave., Detroit, Mich.
Furnaces for jewelers and opticians.
Petaluma Incubator Co.........................Petaluma, Cal
Chicken incubators and brooders.
Prometheus Electric Co............232 E. Third St., New York
Sterilizers, radiators, etc.
Presto Electric Co.................323 Geary St., San Francisco
Dental heating devices.

Rathbone, Sard & Co............................Albany, N. Y.
Domestic ranges.
Rutenber Electric Co........................Logansport, Ind.
Domestic ranges.

Scanlan-Morris Co.............................Madison, Wis.
Sterilizers.
Siemund, Wenzel Electric Welding Co......30 Church St., N. Y.
Welding machines.
Simplex Electric Heating Co.................Cambridge, Mass
Domestic heating and cooking devices.
Hotel and domestic ranges.
Industrial heating devices.
Snyder Electric Furnace Co.......................Chicago, Ill
Steel furnaces.
Standard Electric Stove Co.........1718 No. 12th St., Toledo, O.
Domestic ranges.

Thomson Electric Welder Co...................Warren, Ohio
Welding machines.

Union Fibre Co..............................Winona, Minn.
Heat insulating materials
United Sales Company...........Hobart Bldg., San Francisco.
Automatic water faucets.
United States Steel Corporation.................Hoboken, N. J.
Heroult steel furnaces.

Vulcan Electric Heating Co....107 W. 13th St., New York, N. Y.
Branding irons.

Wenborne-Karpen Dryer Co........900 Michigan Ave., Chicago
Varnish dryers.

Westinghouse Electric & Mfg. Co..........East Pittsburgh, Pa.
Domestic heating and cooking devices.
Domestic ranges.
Industrial heating devices.

Wilmot, Castle Co............................Rochester, N. Y.
Sterilizers.

Winfield Electric Welding Machine Co............Warren, Ohio
Welding machines.

Wm. B. Berry & Co.................79 North St., Boston, Mass.
Corn poppers and peanut roasters.

Conversion Data.

1 kw-hr. = 3412 B.t.u.
1 watthour = 3.412 B.t.u.
1 wattminute = .0568 B.t.u.
1 wattsecond = .0009477 B.t.u.
1 large calorie = 3.968 B.t.u.
1 kw-hr. = 859.975 large calories.
1 watthour = .859975 large calorie.
1 wattminute = .01433 large calorie.
1 wattsecond = .000239 large calorie.
1 gallon (U. S.) water contains 231 cu. in. or .1337 cu. ft.
1 cu. in. of water contains .00433 gal. and weighs .0361 lb.
1 cu. ft. of water contains 7.48 gal., and weighs 62.428 lb.
1 pound of water = 27.68 cu. in.
1 pound of water = .958 pint.
1 kilogram of water = 1000 cu. cm.
1 kilogram of water = 1.0567 quarts.

1 B.t.u = .000293 kw-hr.
1 B.t.u. = .293027 watthour.
1 B.t.u = 17.58 wattminutes.
1 B.t.u. = 1054.9 wattseconds
1 B.t.u. = .25199 large calorie.
1 large calorie = .001163 kw. hr.
1 large calorie = 1.163 watt-hours.
1 large calorie = 69.769 watt-minutes.
1 large calorie = 4186.17 watt-seconds.
1 large calorie = 1000 small calories.
1 gram of water = 1 cubic centimeter.
1 pound of water = 453.592 cu. cm.
1 kilogram of water = 61.023 cu. in.
1 kilogram of water = .035314 cu. ft.

Resistance of Conductors at Various Temperatures.

$R_t = R_0 (1 + xt)$.
R_t = resistance at temperature t.
R_0 = resistance at temperature given in standard tables.
x = temperature co-efficient. (Table I.)
t = difference between R_0 and R_t.

Table I—Relative Resistance and Temperature Coefficient.

Pure Metals.	Relative Resistance in per cent.	Temp. Coef. Fahrenheit (x)
Silver annealed	92.5	.00222
Copper annealed	97.5	.00242
Copper (Standard)	100.0	......
Gold 99.9 per cent	138	.00210
Aluminum 99 per cent	161	.00235
Zinc	362	.00226
Platinum annealed	565	.00137
Iron	570	.00347
Nickel	778	.00345
Tin	828	.00245
Lead	1,280	.00228
Antimony	2,210	.00216
Mercury	5,930	.00044
Bismuth	8,220	.00197
Nichrome (alloy)	....	.00024

Table II.—Relation of Load Factor and Kilowatt-Hour Consumption.

Load Factor per cent.	Kw-hr. per Year per kw.	Kw-hr. per Month per kw.	Load Factor per cent	Kw-hr. per Year per kw.	Kw-hr. per Month per kw.
100	8760	730	50	4380	365
90	7884	657	40	3504	292
80	7008	584	30	2628	219
70	6132	511	20	1752	146
60	5256	438	10	876	73

Table III.—Relative Radiating and Reflecting Power of Different Substances (Kent).

	Radiating or Absorbing Power.	Reflecting Power.
Lampblack	100	0
Water	100	0
Carbonate of lead	100	0
Writing paper	98	2
Ivory, jet, marble	93 to 98	7 to 2
Ordinary glass	90	10
Ice	85	15
Gum lac	72	28
Silver-leaf on glass	27	73
Cast iron, bright polished	25	75
Mercury, about	23	77
Wrought iron, polished	23	77
Zinc, polished	19	81
Steel, polished	17	83
Platinum polished	24	76
Platinum, in sheet	17	83
Tin	15	85
Brass, cast, dead polished	11	89
Copper, varnished	14	86
Brass, bright polished	7	93
Copper, hammered	7	93
Gold, plated	5	95
Gold on polished steel	3	97
Silver, polished bright	3	97

Table IV.—Transmission of Heat Through Plates and Tubes from Steam or Hot Water to Air. (Kent).

(B.t.u. per hour per sq. ft. per degree Fahr. difference.)

Copper, polished	.0327	Sheet-iron, ordinary	.5662
Tin, polished	.0440	Glass	.5948
Zinc and brass, polished	.0491	Cast iron, new	.6480
Tinned iron, polished	.0858	Common steam-pipe, inferred	.6400
Sheet iron, polished	.0920	Cast and sheet iron,, rusted	.6868
Sheet lead	.1329		
Wood, building stone, and brick	.7358		

Table V.—Boiling Points at Atmospheric Pressure

14.7 lb. per square inch. (Kent).

	Deg. F.		Deg. F.
Ether, sulphuric	100	Av. sea water	213.2
Carbon bisulphide	118	Saturated brine	226
Ammonia	140	Nitric acid	248
Chloroform	140	Oil of turpentine	315
Bromine	145	Phosphorus	554
Wood spirit	150	Sulphur	570
Alcohol	173	Sulphuris acid	590
Benzine	176	Linseed oil	597
Water	212	Mercury	676

The boiling points of liquids increase as the pressure increases. The boiling point of water at any given pressure is the same as the temperature of saturated steam of the same pressure.

Table VI.—Latent Heat of Fusion.

Substance.	Latent Heat of Fusion in B.t.u.	Substance.	Latent Heat of Fusion in B.t.u.
Bismuth	22.75	Silver	37.93
Cast iron, gray	41.4	Beeswax	76.14
Cast iron, white	59.4	Paraffine	63.27
Lead	9.66	Spermaceti	66.56
Tin	25.65	Phosphorus	9.06
Zinc	50.63	Sulphur	16.86
Ice	144.		

Table VII.—Melting-Points of Various Substances. (Kent).

	Deg. F.		Deg. F.
Sulphurous acid	—148	Alloy, 1 tin, 1 lead	370 to 466
Carbonic acid	—108	Tin	442 to 446
Mercury	— 39	Cadmium	442
Bromine	+ 9.5	Bismuth	504 to 507
Turpentine	14	Lead	608 to 618
Hyponitric acid	16	Zinc	680 to 779
Ice	32	Antimony	810 to 1150
Nitro-glycerine	45	Aluminum	1157
Tallow	92	Magnesium	1200
Phosphorus	112	Calcium	Full red heat
Acetic acid	113	Bronze	1692
Stearine	109 to 120	Silver	1733 to 1873
Spermaceti	120	Potassium sulphate	1859
Margaric acid	131 to 140	Gold	1913 to 2282
Potassium	136 to 144	Copper	1929 to 1996
Wax	142 to 154	Cast iron, white	1922 to 2075
Stearic acid	158	Cast iron, gray	2012 to 2228
Sodium	194 to 208	Steel	2372 to 2532
Alloy, 3 lead, 2 tin and 1 bismuth	199	Steel hard, 2570; mild	2687
		Wrought iron	2732 to 2912
Iodine	225	Palladium	2732
Sulphur	239	Platinum	3227
Alloy, 1½ tin, 1 lead	334		

Cobalt, nickel, and manganese, fusible in highest heat of a forge. Tungsten and chromium, not fusible in forge, but soften and agglomerate. Platinum and iridium, fusible only before the oxyhydrogen blowpipe.

Table VIII.—Specific Gravity of Substances.

$$\text{Sp.Gr.} = \frac{\text{Wt. of substance.}}{\text{Wt. of equal bulk of pure water.}}$$

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Metals:		
Aluminum	2.67	166.5
Antimony	6.76	421.6
Bismuth	9.82	612.4
Brass: Copper + Zinc)		
80 20	8.60	536.3
70 30	8.40	523.8
60 40	8.36	521.3
50 50	8.20	511.4
Bronze: Copper, 95 to 80	8.53	552.0
Tin, 5 to 20	8.53	552.0
Cadimum	8.65	539.
Gold, pure	19.258	1200.9
Copper	8.853	552.
Iron, Cast	7.218	450.
Iron, Wrought	7.70	480
Lead	11.38	709.7
Manganese	8.	499.
Magnesium	1.75	109.
Mercury 32°	13.62	849.3
Mercury 60°	13.58	846.8

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Mercury, 212°	13.38	834.4
Nickel	8.8	548.7
Platinum	21.5	1347.0
Silver	10.505	655.1
Steel	7.854	489.6
Tin	7.35	458.3
Zinc	7.00	436.5
Wood:		
Ebony	1.23	76
Oak, Live	1.11	69
Cedar	.62	39
Pine, White	.45	28
Pine, Yellow	.61	38
Cork	.24	15
Stones, Brick, Cement, etc.:		
Asphaltum	1.39	87
Brick, Soft	1.6	100
Brick, Common	1.79	112
Brick, Hard	2.0	125
Brick, Pressed	2.16	135
Brick, Fire	2.32	145
Brickwork in mortar	1.6	100
Brickwork in cement	1.79	112
Cement, Rosendale, loose	.96	60
Cement, Portland, loose	1.25	78
Clay	2.16	135
Concrete	2.08	130
Earth, loose	1.22	76
Earth, rammed	1.60	100
Emery	4.	250
Glass	2.63	164
Glass, flint	3.02	188
Gneiss	2.64	165
Granite	2.64	165
Gravel	1.76	110
Gypsum	2.24	140
Hornblende	3.36	210
Lime, quick, in bulk	.84	53
Limestone	2.96	185
Magnesia, Carbonate	2.4	150
Marble	2.72	170
Masonry, dry rubble	2.40	150
Masonry, dressed	2.56	160
Mortar	1.52	95
Pitch	1.15	72
Plaster of Paris	1.23	77
Quartz	2.64	165
Sand	1.60	100
Sandstone	2.32	145
Slate	2.80	175
Stone, various	2.78	168
Trap	3.06	185
Tile	1.84	115
Soapstone	2.73	170
Liquids (at 60° F.):		
Acid, Muriatic	1.200	....
Acid, Nitric	1.217	....
Acid, Sulphuric	1.849	....
Alcohol, pure	.794	....
Alcohol, 95%	.816	....
Alcohol, 50%	.934	....
Ammonia, 27.9%	.891	....
Bromine	2.97	....
Carbon disulphide	1.26	....
Ether, Sulphuric	.72	....
Oil, Linseed	.94	....
Oil, Palm	.97	....
Oil, Olive	.92	....
Oil, Petroleum	.83	....

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Oil, Rape	.92	....
Oil, Turpentine	.87	....
Oil, Whale	.92	....
Tar	1.	....
Vinegar	1.08	....
Water	1.	....
Water, Sea	1.028	....

Gases (at 62° F. Water = 1):

Oxygen	0.001350	0.0814
Nitrogen	0.001185	0.0738
Hydrogen	0.0000846	0.00527
Argon	0.001607	....
Carbon	0.001013	0.63131
Phosphorus	0.0026221	0.16337
Sulphur	0.002705	0.16861
Silicon	0.001184	0.07378
Air	0.001221	0.0761
Water-vapor	0.0007613	0.04745
Ammonia	0.00118	0.0448
Carbon monoxide (Carbonic oxide)	0.002369	0.07364
Carbon dioxide (Carbonic acid)	0.00187	0.11631
Olefiant gas	0.001181	0.0736
Marsh gas	0.000675	0.04209
Sulphurous acid	0.002493	0.15536
Sulphuretted hydrogen	0.002877	0.17918
Bisulphuret of carbon	0.00643	0.40052
Ozone	0.00203	0.12648

*By this table there would be 12.75 cubic feet of air at 32° F. per pound.

The specific heats of substances, as given by different authorities, show considerable lack of agreement, especially in the case of gases.

The following tables give the mean specific heats of the substances named according to Regnault. These specific heats are average values, taken at temperatures which usually come under observation in technical application. The actual specific heats of all substances, in the solid or liquid state, increase slowly as the body expands or as the temperature rises. The specific heat of a body when liquid is greater than when solid. For many bodies this has been verified by experiment.

Table IX.—Specific Heats of Various Substances. (Kent.)

Solids.

Antimony	0.0508	Steel (soft)	0.1165
Copper	0.0951	Steel (hard)	0.1175
Gold	0.0324	Zinc	0.0956
Wrought Iron	0.1138	Brass	0.0939
Glass	0.1937	Ice	0.5040
Cast Iron	0.1298	Sulphur	0.2026
Lead	0.0314	Charcoal	0.2410
Platinum	0.0324	Alumina	0.1970
Silver	0.0570	Phosphorus	0.1887
Tin	0.0562		

Liquids.

Water	1.0000	Mercury	0.333
Lead (melted)	0.0402	Alcohol (absolute)	0.7000
Sulphur (melted)	0.2340	Fusel oil	0.5640
Bismuth (melted)	0.0308	Benzine	0.4500
Tin, (melted)	0.0637	Ether	0.5034
Sulphuric acid	0.3350		

Gases.

	Constant Pressure.	Constant Volume.
Air	0.23751	0.16847
Oxygen	0.21751	0.15507
Hydrogen	3.40900	2.41226
Nitrogen	0.24380	0.17273
Superheated steam	0.4805	0.346
Carbonic acid	0.217	0.1535
Olefiant Gas (CH_2)	0.404	0.173
Carbonic oxide	0.2479	0.1758
Ammonia	0.508	0.299
Ether	0.4797	0.3411
Alcohol	0.4534	0.3200
Acetic acid	0.4125	......
Chloroform	0.1567	......

Table X.—Lineal Expansion of Solids at Ordinary Temperatures.

(Clark.)

	For 1° Fahrenheit. Length = 1
Aluminum (cast)	.00001234
Antimony (cryst.)	.00000627
Brass, cast	.00000957
Brass, plate	.00001052
Brick	.00000306
Bronze (Copper, 17; Tin, 2½; Zinc, 1)	.00000986
Bismuth	.00000975
Cement, Portland (mixed), pure	.00000594
Concrete; cement, mortar, and pebbles	.00000795
Copper	.00000887
Ebonite	.00004278
Glass, English flint	.00000451
Glass, thermometer	.00000499
Glass, hard	.00000397
Granite, gray, dry	.00000438
Granite, red, dry	.00000498
Gold, pure	.00000786
Iridium, pure	.00000356
Iron, wrought	.00000648
Iron, cast	.00000556
Lead	.00001571
Magnesium	....
Marbles, various, from .00000308 to	.00000786
Masonry, brick, from .00000256 to	.00000494
Mercury (cubic expansion)	.00009984
Nickel	.00000695
Pewter	.00001129
Plaster, white	.00000922
Platinum	.00000479
Platinum, 85 per cent	.00000453
Iridium, 15 per cent	.00000453
Porcelain	.00000200
Quartz, parallel to major axis, t 0° to 40° C.	.00000434
Quartz, perpendicular to major axis, t 0° to 40° C.	.00000788
Silver, pure	.00001079
Slate	.00000577
Steel, cast	.00000636
Steel, tempered	.00000689
Stone (sandstone) dry	.00000652
Stone (sandstone) Rauville	.00000417
Tin	.00001163
Wedgewood ware	.00000489
Wood, pine	.00000276
Zinc	.00001407
Zinc 8, tin 1	.00001496

Cubical expansion or expansion of volume = linear expansion × 3

Table XI.—Character of Emitted Light and Corresponding Approximate Temperature. (Babcock and Wilcox.)

Character of Emitted Light.	Temp. F.°
Dark red, blood red, low red	1050
Dark cherry red	1175
Cherry, full red	1375
Light cherry, bright cherry and light red	1550
Orange	1650
Light Orange	1725
Yellow	1825
Light Yellow	1975
White	2200

*(Character of emitted light and corresponding temperatures approximately the same for all materials).

Table XII.—Weight of Water at Temperature Used in Standard Calculations. (Babcock & Wilcox—"Steam").

Temperature Degrees Fahrenheit.	Weight per cu. ft. in Pounds.
At 32° freezing point at sea level	62.418
At 39.2° or point of maximum density	62.427
At 62° or standard temperature	62.355
At 212° or boiling point at sea level	59.846

Table XIII.—Variations in Properties of Saturated Steam with Pressure.

(From Marks & Davis Tables.)

Pressure Pounds Absolute.	Temperature Degrees Fahrenheit.	Heat of Liquid B.t.u,	Latent Heat B.t.u,	Total Heat B.t.u.
14.7	212.0	180.0	970.4	1150.4
20.00	228.0	196.1	960.0	1156.2
100.00	327.8	298.3	888.0	1186.3
300.00	417.5	392.7	811.3	1204.1

Table XIV.—Saturated Steam. (From Marks & Davis' Steam Tables.)

Gauge Pressure.	B.t.u.	Total B.t.u. in Steam.
10	161.1	1143.1
20	196.1	1156.2
30	218.8	1163.9
40	236.0	1169.4
50	250.1	1173.6
60	262.1	1177.0
70	272.6	1179.8
80	282.0	1182.3
90	290.5	1184.4
100	298.3	1186.3
110	305.5	1188.0
120	312.3	1189.6

Table XV.—Calorific Values of Dry Wood. (Gottlier.)

Kind of Wood.	B.t.u. per lb.
Oak	8316
Ash	8480
Elm	8510
Beech	8591
Birch	8586
Fir	9063
Pine	9153
Poplar	7834*
Willow	7926*

*B.t.u. calculated.

Table XVI—Calorific Value of General Grades of Coal on Basis of Combustible. (Approximate.)

	Per Cent of Combustible. Fixed Carbon.	Per Cent of Combustible. Volatile Matter.	B.t.u. Per Pound of Combustible.
Antracite	97.0 to 92.5	3.0 to 7.5	14600 to 14800
Semi-anthracite	92.5 to 87.5	7.5 to 12.5	14700 to 15500
Semi-bituminous ...	87.5 to 75.0	12.5 to 25.0	15500 to 16000
Bituminous—Eastern	75.0 to 60.0	25.0 to 40.0	14800 to 15300
Bituminous—Western	65.0 to 50.0	35.0 to 50.0	13500 to 14800
Lignite	Under 50	Over 50	11000 to 13500

Table XVII.—Calorific Value of Various Oils.

Kind of Oil.	B.t.u. per. lb.	Authority.
California, Coalinga	17117	Babcock & Wilcox
California, Bakersfield	17600	Wade
California, Bakersfield	18257	Wade
California, Kern River..........	18845	Babcock & Wilcox
California, Los Angeles........	18328	Babcock & Wilcox
California, Los Angeles........	18855	Babcock & Wilcox
California, Los Angeles........	18280	Babcock & Wilcox
California, Monte Christo......	18878	Babcock & Wilcox
California, Whittier	18507	Wade
California, Whittier	18240	Wade
Texas, Beaumont	20152	Sparkes
Texas, Beaumont	19349	Babcock & Wilcox
Texas, Sabine	18662	Babcock & Wilcox
Ohio	19580	
Pennsylvania	19210	Booth s
West Virginia..................	21240	
Mexico	18840	Babcock & Wilcox

Table XVIII.—Calorific Values of Natural Gas.

Locality of Well.	B.t.u per cu. ft. Calculated.*
Anderson, Ind..........................	1017
Marion, Ind............................	1009
Muncie, Ind............................	1004
Olean, N. Y............................	1018
Findlay, O.............................	1011
St. Ive, Pa............................	1117
Cherry Tree, Pa........................	842
Grapeville, Pa.........................	925
Harvey Well, Butler Co.*...............	998
Pittsburgh, Pa.........................	748
Pittsburgh, Pa.........................	917
Pittsburgh, Pa.........................	899

*B.t.u. Approximate.

Table XIX—Approximate Calorific Values of Various Gases (Kent)

Kind of Gas.	B.t.u. per Cu. Ft.
Natural gas	1,000
Coal gas	675
Carburetted water gas..............................	646
Gasoline gas	690
Water gas from coke................................	313
Water gas from bituminous coal.....................	377
Producer gas	150
Naptha-gas (2½ gal. per 1000 cu. ft)................	306

Table XX.—Refractory Materials (Stansfield.)

Material.	Melting Temperature Deg. F.
Fire-clay brick. Kaolin with additional silica	2900 to 3150
Silica-brick. Silica with binding material	3100
Silica (pure)	3180
Bauxite (impure alumina)	3300
Alumina (pure)	3650
Lime (pure) ....about	3700
Chrome-brick	3700
Chromite	3950
Magnesia-brick	3900
Magnesia (pure) ....about	4000
Carborundum, SiC ....decomposes	4000
Carbon ....vaporizes rapidly	6500

INDEX