indirect surface will heat from 7 ft. to 12 ft. of radiating surface. Direct surface is that which faces the fire, and which the fire touches or shines upon. Indirect surface is flue surface, first flues being of the 12-ft. value, second flues of 7-ft. value. Some engineers consider that 25 ft. of radiation should be given to each foot of mixed surface on the boiler; that is, taking all surface, direct and indirect, together, and allowing 25 ft. of radiation per foot. This is believed to be too full an allowance.

The quantities of pipes allowed are as follows :—

Temperature Required, Fahrenheit.	*Length of 4-in. Pipe to each 1,000 cub. ft. Capacity.*	
80°	110 ft.	Pines, forcing, etc.
75°	95 ft.	Tropical flowers, stove plants, Melons.
70°	80 ft.	
65°	68 ft.	Grapes, Tomatoes, etc.
60°	56 ft.	
55°	46 ft.	
50°	38 ft.	Fruit trees, conservatories.
45°	30 ft.	
40°	23 ft.	Cuttings, stock, etc.

The remarks in the right-hand column merely suggest the uses that a house may be put to when heated to a certain temperature. It is a point, however, that, of course, the gardener settles.

There are several methods of jointing pipes, and with such low pressures nothing very strong is needed, provided it is lasting. The rust joint is generally adopted for large works. The rubber ring joint is also in general use. Occasionally Portland cement is used, but the practice can only be condemned.

A joint has already been illustrated (see Fig. 168), but, cheap as this is, something less expensive is desirable when there are hundreds, or thousands, to make. The most common of all is known as the rust joint. To make this, take, by weight, about 80 to 100 parts of iron borings (which can be purchased from most firms who supply pipes), and, if the borings are very coarse, pound them to make them finer. To these add 1 part of powdered sal-ammoniac and 2 parts of powdered sulphur. Thoroughly well mix, and then moisten the whole with water. This should be done from one to two hours before the material is required for use, and then the whole should be used

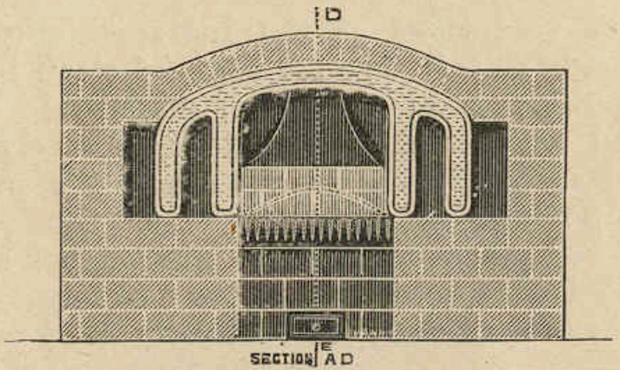

Fig. 220.—Cross-section of "Delta," Boiler.

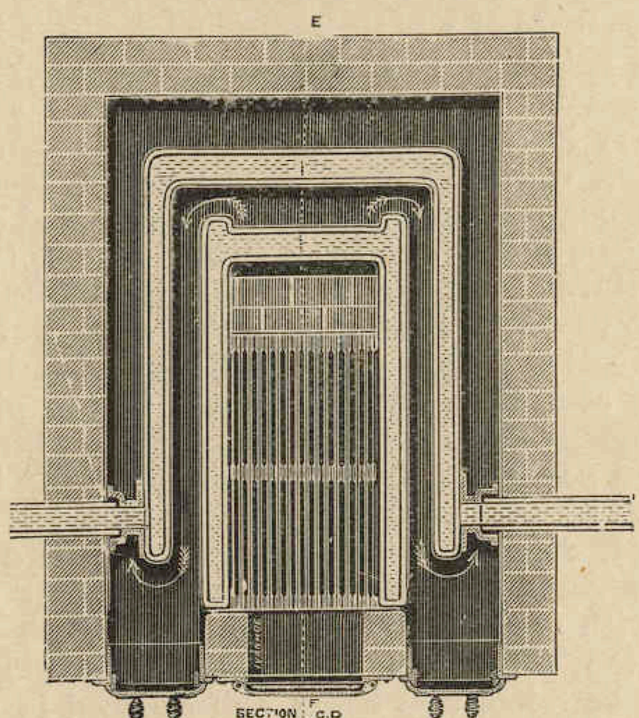

Fig. 221.—Horizontal Section of "Delta" Boiler.

up the same day as made, or it will become hard. In making the joint, different men have different practices. Yarn or gaskin is first caulked soundly into the socket. Some caulk it half-full, some one-third, and some two-thirds full, the remaining space being filled with the prepared borings lightly caulked in. Some experience is required in making the joint as regards the caulkings of the borings, for this material swells as it rusts and sets, and great numbers of sockets have been split from this cause.

There are variations of the ingredients of the rust joint, one being as follows : 100 parts of clean iron filings, 1 part of powdered sal-ammoniac, mixed and moistened.

Red- and white-lead putty are extensively used for jointing, alternate layers of yarn and the putty being caulked in, finishing off with the putty. Surfaces of both spigots and sockets should first be painted with some of the putty thinned with boiled oil to the consistency of paint. It is more expensive than the rust joint, and takes longer to set.

A joint that is used for quickness and for temporary purposes consists of a plain rubber ring. This is stretched on to the spigot end of the pipe, and, after arranging the ring neatly, this end is thrust into the socket.

Ordinary Portland and similar cements cannot be used for jointing with any promise of uniform success. They are not strong enough to stand expansion and contraction rigidly, nor are they elastic enough to give to these forces.

The failure of a long, loose socket joint when the apparatus is in use is caused by the push and pull of expansion and contraction. This result will be aided if the joint is remade each time with the water in the pipes. It is next to impossible to make a lasting joint when the metal is wet, and possibly a dribble of water coming through all the time. If the existing socket could be thoroughly cleared out, dried, and painted, then red- and white-lead and hemp would be best; or a Jones's patent joint could be used with every prospect of success. Both these mean running the water out of the apparatus. Tarred soft rope may be tried, this being well caulked in (the socket quite half-full) and backed up with cement. There can be little doubt that the movement of the pipes does much to spoil the joints, and this means that a well-caulked joint will not remain sound unless it is backed up with something rigid. If cement does not hold, perhaps the local smith can make something which, by being drawn up, will back the caulking in a sound manner. If the pipe could be got quite dry, lead could be poured in behind the caulking, the same as is done with water mains.

In the event of a cast-iron arched boiler, with flat top bolted on, leaking at one corner of the top, first, with a thin but stiff tool, chip and pick out the jointing material around the leakage, so as to leave the metal surfaces clean and dry. (The water must first be emptied down to below the level of the lid.) When the surfaces are ready, prepare some red- and white-lead putty, and thin a little of this with boiled oil to make a small quantity of paint. Now paint the cleaned surfaces, and then caulk in some red-lead putty and strands of hemp alternately, finishing off with putty. This should answer well if the jointing space can first be cleaned out properly. One little drawback to the use of this material is that the joint should

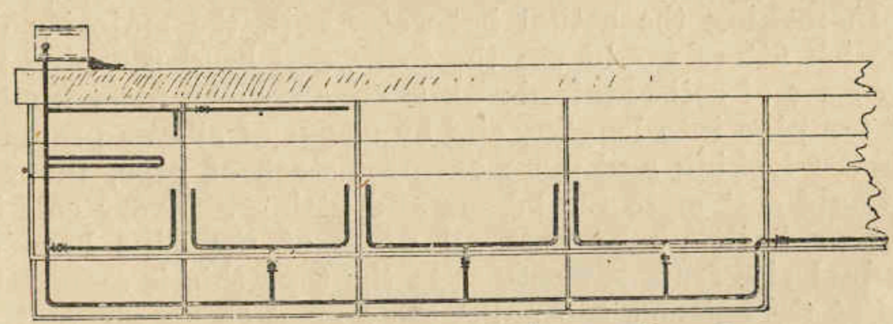

Fig. 222.—Piping for Row of Lean-to Greenhouses.

be left about three days to get hard before the boiler is filled again, but there is no quicker drying cement suited for this job.

There being such a variety of excellent boilers obtainable, it will not pay anybody not in the boiler trade to construct a single boiler for greenhouse use. Ordinary boilers, even of very small size, are either of cast-iron or of $\frac{5}{16}$-in. wrought plates, with welded joints. For a cast-iron boiler, proper patterns, and conveniences for melting iron, are necessary; while for a wrought-iron boiler suitable forges will be required. Should, however, the builder of a greenhouse particularly wish to make a heater, then a coil boiler as follows may be arranged. For the actual heating part make a coil of 1-in. wrought tube, about six turns of 9 in. diameter, leaving the two ends, one at the top and one at the bottom, for flow and return connections.

This could be set in brickwork if desired, standing over a grating, the fire coming in the middle of the coil. If required independent, make a cylindrical case of stout wrought sheet iron, slightly taper, say 15 in. in diameter at the bottom and 12 in. at the top, and 4 ft. high. Line this with fireclay; fit a grating about 4 in. from the bottom, and place the coil about 4 in. above this. Let a smoke outlet come from the side of the case about half-way up, and fit a lid to the top. An opening cut in the side of the case close to the bottom will allow of the ashes being removed from beneath the grating, this opening being provided with a lid or door. If, after the fire is lighted and burning well, the case is filled to the top with broken coke, the boiler will keep going for ten hours or longer.

In making the actual hot-water coil, the majority of English fitters would use the forge and bend the pipe to any form of coil required; while an American fitter would cut the pipe into lengths, and by means of elbows produce a better-looking and more compact stack of pipe, though it would cost more for labour and fittings. Every coil is bent or built up so that all parts of the pipe have a gradual rise from the bottom to the top; this is essential, and at the extreme top point there must be an air vent—either pipe or cock—to prevent the coil being air-locked. Steam is seldom generated in this work, and, if it is, it should pass away by the expansion pipe.

The above shows how a coil boiler can be made, but it is certainly not worth the while in ordinary cases to do so while first-rate boilers—coil and otherwise—can be obtained so cheaply. There is, for instance, the Sam Deard's "Champion" coil boiler (Fig. 223), which, with four 3-in. coils, will heat 1,000 ft. of 4-in. pipe; with five coils, 1,500 ft.; and with six coils, 1,800 ft.

Sam Deard's smaller apparatus employing a coil boiler is capable of heating 100 ft. of 4-in. pipe for every coil it contains; the number of coils varies from four to six.

The painting of a "Loughborough" type boiler—or of that part which is not fixed in the greenhouse wall—should never be done with oil paint or ordinary enamel, which is not suitable on account of the heat. Once the iron has become rusted by the action of air and weather there is scarcely any coating that will be of much service. There is nothing better than a stiff limewash, with a good allowance of size; lime opposes the rusting process. The limewhite can be tinted with burnt umber or any earth colour desired. The boiler should be treated with this mixture about once a year. The asbestos companies supply a heat-proof paint that may be used.

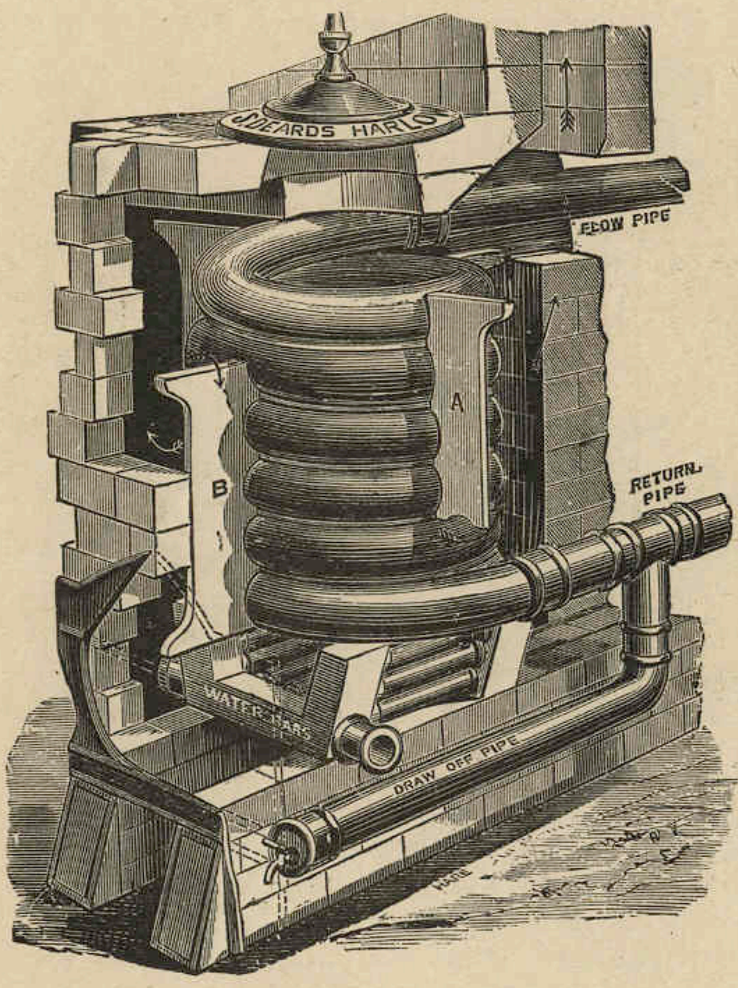

Fig. 223.—"Champion" Coil Boiler.

A greenhouse stove occasionally causes trouble by smoking; in a lean-to, smoking in certain weathers is almost sure to occur. The remedies are: To carry the smoke-pipe up the side of the house to above the eaves; or to cut a hole through the greenhouse wall and bring the door of the stove to it, and then cement round soundly. All stoking would then be done from the outside, and any smoke blown down would be driven outside also. The body of the stove would still remain almost wholly inside the greenhouse. The stove should be fed with coke. A conical cap or head to the top of the pipe can be bought ready-made, or will be made to order by any sheet-iron worker; this often gives good results in the prevention of down-blow.

Gas is a very convenient fuel for firing greenhouse

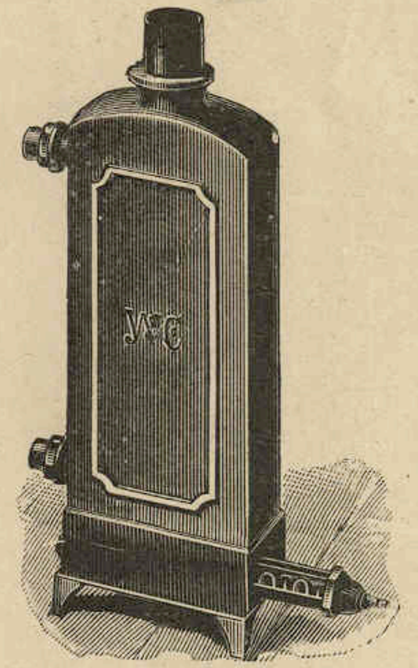

Fig. 224.—Multitubular Gas Boiler.

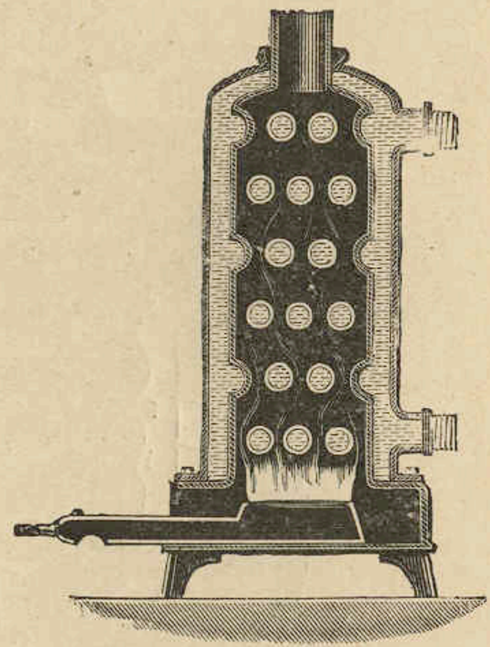

Fig. 225.—Section of Multitubular Gas Boiler.

boilers, because a gas furnace can be left unattended for a considerable time should this be necessary, and because its heating effect is regular.

A multitubular, gas-fired boiler made by W. Richardson & Co. is shown by Figs. 224 and 225. The one-burner type will heat 50 ft. of 4-in. piping, and the two-burner twice that quantity.

A gas boiler must have a flue to carry away the products of combustion, and there must not be a down blow in this flue (as most greenhouse flues have), or the gas flame may be blown out without turning the gas tap off, which is, of course, dangerous.