The Science of Burning Liquid Fuel

A Practical Book for Practical Men

BY

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The burners, furnaces and various installations described in this book are fully protected by Letters Patents, and all are in successful operation.

1913.

William Newton Best.

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Introduction.

The author of this book began the study of liquid fuel while Master Mechanic and Superintendent of the Los Angeles Electric Railway in the year 1887. We used the Daft system of electricity. This system had previously operated an electric railway in Boston, Mass. They, however, did not have the overhead wire, but used the third rail system. Ours was the first overhead system of electric railroad in the United States, if not in the world. A view of the electric motor car then used on this road is here given. You can also see the first electric locomotive with two trailers attached. It may be of interest to here state that after building the Myrtle Avenue branch of this road (which was a branch of the main line to Pico Heights), I reported to the Board of Directors that we should purchase motor cars for the branch line and not use the electric locomotive and trailers, because the latter was more costly to operate, but I also made the statement that in a few years electric locomotives would be used instead of steam locomotives in certain branches

Fig. 1. The first electric locomotive built in the United States is here shown drawing two trailers, also the first over-head wire system for trolley cars which was constructed in Los Angeles, California, in 1886.

of work and for that service they would be better than electric motor cars. This portion of my report caused considerable merriment as there were grave doubts in the minds of many as to the fulfilment of this prophecy.

The boilers to which I first applied oil as fuel were the "Hazelton," and manufactured in New York City. The burners, if such they could be called, were made of gas pipe, and produced a round flame. These were soon changed to the flat type by simply flattening the pipe in a blacksmith's forge so that the nozzle would, in a measure, produce a flat flame, but which in reality produced a very uneven, irregular flame. The steam and the oil passed out in the same direction through the one orifice which often resulted in much carbon forming therein, and necessitated the apparatus being removed quite frequently in order to remove the carbon which collected in the mouth piece. The equipment was exceedingly crude. I have since thought it was even more crude than the oil we were attempting to burn. We were, however (after much experimenting), able to get the normal rating of the boiler, but several months passed before this was accomplished. The oil was very heavy, being between 14 and 18 gravity Baume and of asphaltum base.

While endeavoring to obtain information from those in the Eastern States and in Russia who claimed to have burned oil, I found that they were laymen in the art of burning the new fuel, and that I would have to put out to sea without any compass to guide me.

We obtained our supply of crude oil from wells in the Puente fields about 30 miles from Los Angeles. Often it was reported that the supply was about exhausted and at times we were not sure of getting enough for our requirements. Again too, the coal interests were endeavoring to protect themselves from inroads by the oil company which made the consumer doubly careful. A number of firms installed oil fuel upon their boilers but had difficulty with the elements of the boiler being injured or with not being able to maintain the required steam pressure. Thus becoming disgusted with the new fuel, nearly all of these firms returned to the use of coal, believing that the kind of crude oil which we had in Southern California was not commercially a success as a fuel. The author however, was never discouraged but was alert to each new development in the changes of brick work, different locations of the burner and the air openings through which the air could enter to effect combustion until he became convinced that it was the fuel of the twentieth century. In order to obtain satisfactory results I realized it had to be scientifically burned and that careful consideration was necessary in order to achieve the highest efficiency and the strictest economy. After twenty-five years of study, I take pleasure in giving to the world some of the results achieved by the use of this incomparable fuel.

After we had had the new fuel in service for several years, other manufacturers became impressed with the fact that the California crude oil could be successfully burned and began to adopt it as a fuel.

The first locomotive I endeavored to equip was while I was Master Mechanic of the Los Angeles and Redondo Ry. Many, many were the discouragements encountered before success crowned our efforts and demonstrated that crude oil was a God-send to both the engineer and fireman as this fuel increased the tonnage of the locomotive fully 15% over coal and they could maintain the steam pressure at just below the limit required to prevent steam escaping through the pop valves. So successful was it on this road that I received a call to another road which had attempted but failed to burn this fuel. It was while Superintendent of Motive Power and Machinery

Fig. 2. Locomotive on which the first burner made by the author was installed.

of this road (The Los Angeles Terminal Ry., which afterwards became the San Pedro, Los Angeles & Salt Lake R. R.), that I invented my own burner. The locomotive which carried my first locomotive burner is shown in Fig. 2. I had tried every form and type of burner up to that time and saw imperfections of construction and operation which I strove to obviate by making a burner foreign to all others.

My experience in burning liquid fuel in furnaces began while I was Superintendent of the California Industrial Company's Rolling Mill in Los Angeles. We manufactured commercial iron (bar iron of all sizes and shapes) from scrap iron and soft steel. Many people have stated that oil can not successfully weld iron and steel while others, who have successfully used oil as fuel, state that oil is the only fuel for this class of work as it does not change the nature of the metal. As we only had scrap iron and soft steel to make the bar iron from and as crude oil was our only available fuel, it was necessary to weld it perfectly; and, without fear of contradiction, will say that no better iron can be made than that produced with oil fuel, as oil, when properly used, is a purifier of metals.

Since leaving the Rolling Mill I have installed oil burners and supplied designs for the construction of nearly every form of furnace including the following: Annealing, asphaltum mixers, babbit heating, bolt making, brass melting, brazing, bread ovens, etc., brick and art tile kilns, case hardening, cast iron melting, cement kiln rotary, channel iron heating, chocolate bean roasters, continuous heating, copper plate, core drying, crematories, crucible brass melting, crucible steel melting, drop forge work, enameling, flue welding, glass lehrs, glass melting, incinerators, indirect-fired, japanning ovens, ladle heating, locomotive steam raising, locomotive tire heating, malleable iron, mould drying, ore smelting, plate heating, pipe bending, pipe flange welding, portable torches, rivet making, rolling mill work, rotary kilns, shaft and billet heating, sand drying, sheet steel heating, steel melting, steel mixers, tar stills, tempering, welding scrap iron, wire annealing, wire making. This book will show some of the different installations and the results obtained therefrom.

The burning of liquid fuel is a science. It can be burned either wastefully or economically. In order to obtain the highest possible efficiency and strictest economy from any installation the oil system must be installed and operated upon scientific principles. I am aware that many articles have been published on oil burning. Some have contained much valuable information, while others it has simply been a waste of time to read, because of the fact that the writer himself was not familiar with the subject. Several years ago I read an article on the different methods of burning oil and when I visited the city in which the author resides, I called upon the gentleman, for I desired to ask him several questions on points not clear to me. This man acknowledged that he had never burned a gallon of oil in his life and that his article was simply a compilation of reports on tests made by others, he not even having been present at any of the tests. The burners described in his treatise all seem to fit perfectly and operate without the slightest difficulty. The equipment which he described reminded me of an artist's girl friend who, in describing the ability of the artist, stated that one of the portraits which she painted of a gentleman was so perfect that it had to be shaved twice a week. My point is that if a man wishes to write a treatise on welding iron, he should first learn how to make a weld himself for sometime he is liable to meet a man from Missouri "who will want to be shown," and Mr. Author might then be humiliated because of his imaginary ability. Theory is needed but without practical knowledge it is like faith without works, it is dead. To say the least it is disappointing, especially in regard to the subject of heat, which we have been studying for centuries and by the knowledge of which we have raised ourselves above the brute creation and the Stone Age. A short time ago while addressing some students I asked, "What is the propelling power of a steam locomotive?" They thought long and hard, and at last after mentioning almost every part of the locomotive one student in desperation said "Heat," which of course is the propelling power of a steam locomotive.

While it is not possible for an engineer in calorics to tell you how many gallons of oil are required to run a locomotive over a division of a railroad without knowing her tonnage and the average grades or to tell you how much oil a burner will burn without having full particulars in regards to installation, or to even guess how much oil will be used in a furnace without knowing its exact form and proportions, temperature required, the size and quantity of metal to be heated in the furnace per hour or per day, yet he should have such a knowledge of his business and the capacity of the oil burner that he can recommend an installation which will not prove a farce.

If it is a copper refining furnace (such as is described in this book) he should know the size of burner required, the amount of air needed to reduce and refine a given charge of such metal, or if an annealing furnace he should be capable of figuring out the graduated size and location of heat ports necessary to give an even distribution of heat throughout the entire length, width and height of the furnace. I consider that a man is simply playing or guessing who first installs three or four oil burners in a furnace and then if they do not give the required heat, installs three or four more. This is not the intelligent way of solving an engineering problem. It is simply the old "rule of thumb."

I have been asked if every man or firm makes a success of burning liquid fuel. To this I always answer "No. Many cannot burn oil successfully." The next inquiry is "Why not?" My answer is "Some men cannot learn to play the piano, others the harp. Some women are good cooks but cannot sew, and vice versa. Many men cannot burn coal or wood advantageously, and therefore I can frankly make the statement that many cannot learn how to burn liquid fuel." I have been often amused at men wanting to run tests on boilers and furnaces, using all the different types of burners which they can borrow for the occasion. The men conducting the tests, never having had any theoretical or practical experience in the burning of oil or tar, their efforts are not a compliment to any of the burners. The result is as absurd as though two men, neither of whom had ever previously shot off a gun, were to institute a shooting contest, borrowing as many weapons as they could from the various gun manufacturers, assuring them that the result of the contest would be of great advantage to the firm that was fortunate enough to win in the contest. Let me assure the reader that the man who has never shot off a gun (or the man who has never operated a burner) had better become familiar with their construction and operation before exhibiting the results of the contest as otherwise there might be some people who would not consider their efforts a criterion, and if their statement is incorrect they might have to meet the result of said decision in after years. I have known officials to be discharged because they selected an inferior article and after years had elapsed, another test with one of the same burners revealed the fact that the superior device had been rejected at the first test, resulting in irreparable loss to their firm of hundreds of dollars in fuel and thousands of dollars in output. Under such circumstances any man should be dismissed for incompetency. The most dangerous man on earth is an egotistical "Jack of all trades." Personally I would just as soon give my watch to be cleaned or repaired to a man who has never repaired one as to give a burner to an inexperienced man to run one of these so-called tests.

W. N. Best.

CHAPTER I.

LIQUID FUEL—ITS ORIGIN, PRODUCTION, AND ANALYSIS.

Scientists tell us that petroleum is the result of the decomposition of vegetable matter and fish during the antediluvian ages. It was first discovered in the United States in 1859 at Titusville, Pa. During the first year only 2,000 barrels (42 gallons each) were produced. Since then, each succeeding year the production and demand have increased, until the world's consumption now aggregates 1,000,000 barrels a day. In the year 1911, the United States alone produced 220,440,391 barrels or 63.80% of the total world production. Six of the leading states produced as follows:

California	81,134,391	barrels	of	oil
Oklahoma	56,069,637	"	"	"
Illinois	31,317,038	"	"	"
Louisiana	10,720,420	"	"	"
West Virginia ..	9,795,463	"	"	"
Texas	9,526,474	"	"	"

There are two kinds of oil or petroleum, one having parafine base and the other asphaltum base. Either may be used as fuel in its crude state, but both are largely distilled in order to obtain the more volatile oils, such as gasoline, benzine, kerosene, etc. The residue is called Fuel Oil and is used in every class of service where coal, coke, wood or gas can be used. It has proven a most superior fuel because the operator has the fire under perfect control at all times and can attain and maintain the heat required.

The analysis of Fuel Oil is as follows:

Carbon	84.35%
Hydrogen	11.33%
Oxygen	2.82%
Nitrogen	.60%
Sulphur	.90%

Gravity, from 26 to 28 Baume.
Weight per gallon, 7.3 lbs.
Vaporizing point, 130 deg. Fahr.
Calorific Value varies from 18,350 to 19,348 B. T. U. per lb.

Analysis of Beaumont (Texas) Crude Oil:

Carbon	84.60%
Hydrogen	10.90%
Sulphur	1.63%
Oxygen	2.87%

Gravity, 21 Baume.
Weight per gallon, 7.5 lbs.

Calorific value, 19,060 B. T. U. per lb.
Vaporizing point, 142 deg. Fahr.

Analysis of California Crude Oil: (heavy oils)

Carbon	81.52%
Hydrogen	11.01%
Sulphur	.55%
Nitrogen, Oxygen	6.92%

Gravity varies from 12 to 36 Baume.
Weight per gallon, 7.6 lbs.
Calorific value varies from 18,462 to 20,680 B. T. U. per lb.
Vaporizing point, 230 deg. Fahr.

Analysis of Mexican Crude Oil: (Tampico Fields)

Carbon	82.83%
Hydrogen	12.19%
Oxygen	.43%
Nitrogen	1.72%
Sulphur	2.83%

Gravity varies from 12 to 23.8 Baume.
Weight per gallon, 7.82 lbs.
Calorific value, 18,493 B. T. U. per lb.
Vaporizing point, 175 deg. Fahr.

Note.—The British unit of heat, or British thermal unit (B.T.U.) herein referred to, is that quantity of heat which is required to raise the temperature of 1 lb. of pure water 1 deg. Fahr. at 39 deg. Fahr., the temperature of maximum density of water.

At this time the oil fields of Mexico are attracting a great deal of attention because of their magnitude. The proven territory of oil producing land in Mexico is considered by many scientists the most valuable fields on this planet, and those who have carefully examined the fields and are competent to judge, prophesy that that country will produce more oil than the combined production of all other sections of the world. The Mexican oil is high in calorific value per gallon, and is especially adapted for fuel in its crude state but not for refining. It is therefore fortunate that these fields have been discovered in order to supply the growing demand for crude oil, but I believe that other new fields will be discovered and developed with the ever-increasing demand until every coal-producing country will have an abundant supply of petroleum. The crude oil of Russia, Roumania and Borneo has approximately the same calorific value as that of the Beaumont fields in Texas, while the oil thus far discovered in Argentine Republic, Chile and Peru, is of approximately the same calorific value and gravity as the California petroleum.

Oil tar is a by-product of the water gas system used in numerous gas works. Coal tar is a by-product from coke oven benches. When either of these tars are heated sufficiently to reduce their viscosity, they are a most excellent fuel. Per pound their calorific value is less than that of oil but as they weigh from 9.5 to 10 lbs. per gallon, while fuel oil only weighs 7.3 lbs. per gallon, their calorific value per gallon is greater than that of fuel oil. Oil tar has a calorific value of 16,970 B. T. U. per lb. or 161,200 B. T. U. per gallon, while that of coal tar is 16,260 B. T. U. per lb. or 162,600 B. T. U. per gallon.

Analysis of London Tar and Tar from Dominion Coal:

	London	Dominion
Carbon	77.53	81.50
Hydrogen	6.33	5.68
Nitrogen	1.03	.....
Oxygen	14.50	12.45
Sulphur	.61	.37

The following list showing typical value of the various kinds of fuel may be of service to the reader:

KIND	B. T. U. Per Lb.	Lbs. Per Gal.	B. T. U. Per Gal.
Liquid			
Fuel Oil (residium of Petroleum)....	19,000	7.3	138,700
Beaumont crude petroleum	19,060	7.5	142,950
California " "	19,500	7.6	147,200
Lima " "	18,820	7.5	141,150
Pennsylvania crude "	18,940	7.5	142,050
Kerosene	16,120	7.2	116,000
Gasolene	14,200	5.9	83,780
Denaturized Alcohol.................	13,140	5.7	74,900
Alcohol (90 per cent)	10,080	5.6	56,500
Coal Tar	16,260	10.0	162,600
Oil "	16,970	9.5	161,200
Solid			
Pocahontas coal	15,391		
Bituminus " (Pittsburg)	12,141		
" " (Illinois)	10,506		
Anthracite	13,189		
Coke	13.000		
Gaseous	Per Cu. Ft.		
Illuminating Gas (City coal gas)....	550 to 650		
Natural Gas	800 to 1,000		
Producer Gas	130		

3¼ Bbls. Oil (42 gals. per bbl.) = 5000 lbs. Hickory.
3¼ Bbls. Oil (42 gals. per bbl.) = 4550 lbs. White Oak.

CHAPTER II.

ATOMIZATION.

Thousands of patents have been issued by our government to inventors covering oil or tar atomizers or burners. Many of these inventions involve the same principle and all may be grouped in three distinct classes, viz.: mechanical, internal mixing and external atomizing. Many people have supposed that by simply mashing down a piece of pipe and coupling it to a steam or air and oil supply line, they have evolved a cheap burner; a burner which in 99 cases out of 100, they have seen working in some other shop. They very seldom state just where they have seen it in operation and often claim that it is their own invention and that it only cost about fifteen or twenty cents to make. But there is another side to be considered. The first cost of an article may be a trifle but that is no sign that the article is really cheap. One must consider what the device will have cost in time, labor and fuel at the expiration of a year or more. One of the greatest abuses of liquid fuel is the endeavor to use it with burners that do not thoroughly atomize the oil and evenly distribute the heat throughout the entire fire-box or the charging space of the furnace. A burner should be of such construction that it can be filed or fitted to make a long narrow flame or a broad fan shaped blaze fitting the entire length and width of a fire-box or furnace as evenly as a blanket covers a bed. A burner, wherein the base of the fuel carbonizes over the fuel passage, is absolutely worthless for it should be capable of atomizing any gravity of fuel procurable in the open market without either clogging or carbonizing, no matter whether it be fuel oil of very light gravity or crude oil, oil tar or coal tar. A burner is not worthy of consideration unless it enables the operator to burn any gravity of liquid fuel, for no manufacturer should be limited to the purchase of one particular kind of fuel. There should be no internal tubes, needle points or other mechanism which will clog, wear away, or get out of order readily. Each burner should be thoroughly tested, so that when it leaves the shop where it is made, the manufacturer knows that it will fill the requirements for which it is being furnished. With high pressure air or steam as atomizer a burner, having the oil orifice below the atomizer orifice and independent of same, is preferable because there can be then no liability of the fuel solidifying or carbonizing over the atomizer slot at the nose of the burner.

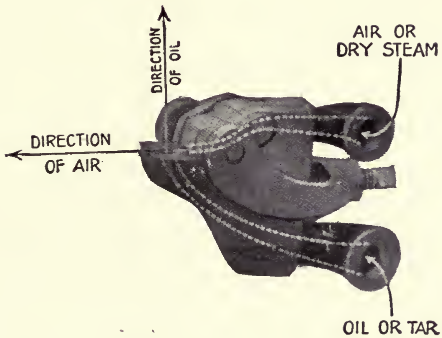


Fig. 1. High Pressure Oil Burner.

As the fuel passes out perpendicularly, it is struck by the atomizer coming out horizontally and atomized so thoroughly that each drop of fuel is dashed into 10,000 molecules and looks like a spray or fine mist.

The first time a burner is operated there is usually some difficulty because of red lead, sand, scale or small particles of solid matter being in the pipes. As the fuel orifice is large, anything in that line of pipe is readily expelled but as the atomizer orifice is very small (ordinarily only 1-32 of an inch in height), a hinged lip is provided so that by slackening a set screw and turning on the atomizer, the lip is raised and the foreign substance blown out.

This burner can be filed to throw either a long narrow flame, or a fan shaped blaze 9 ft. wide.

Considering that air contains 20.7 parts oxygen and 79.3 parts nitrogen, at 62 deg. Fahr. 1 lb. of air occupies 13.141 cu. ft. At 100 deg. Fahr. this air occupies 14.096 cu. ft. Theoretically it requires 13½ to 14½ lbs. of air to effect the perfect combustion of 1 lb. of oil. Allowing 14 lbs. at 62 deg. Fahr. it would require 183.97 cu. ft. of air to effect perfect combustion of 1 lb. of oil or at 100 deg. Fahr. it would require 197.34 cu. ft. of air. Practically it requires from 17½ to 19½ lbs. of air to effect perfect combustion of 1 lb. of oil. Allowing 19 lbs. at 62 deg. Fahr. this air occupies 249.68 cu. ft. or at 100 deg. Fahr. it occupies 267.82 cu. ft. Allowing 1 gal. of oil to weight 7½ lbs., practically it requires 142½ lbs. of air to effect the perfect combustion of 1 gal. of oil or 1872$\frac{6}{7}$ cu. ft. of air at 62 deg. Fahr. or at 100 deg. Fahr. it will require 2009¼ cu. ft. It is therefore essential that liquid fuel be thoroughly atomized so that the oxygen of the air can freely unite with it. Except where mechanical burners are used, the fuel is atomized by means of high or low pressure air or steam. Compressed air or steam is preferable to low pressure air because it requires power to thoroughly atomize liquid fuel. With low pressure or volume air, you are limited to the use of light oils, whereas with compressed air or steam as atomizer, you can use any gravity of

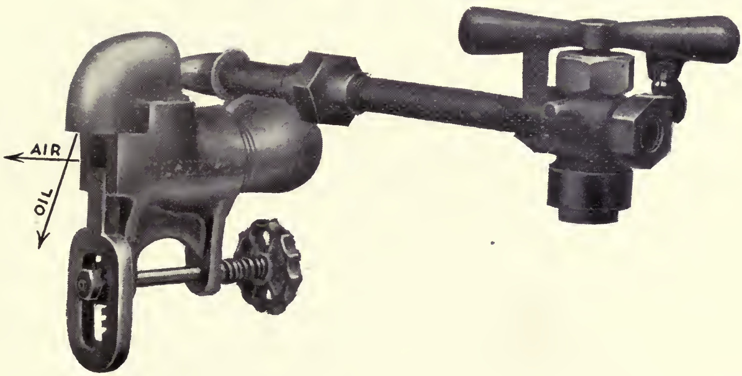


Fig. 2. Low Pressure or Volume Air Burner with Oil Regulating Cock.

The construction of this burner is such that the air supply is regulated at the mouth of the burner; thus you get the benefit of the full impact of the air against the fuel at the mouth of the burner.

The oil flows downwardly through the sheet of air.

Low oil pressure can be used and is preferable.

There are no internal tubes, needle points or other mechanism to wear out, clog, carbonize or get out of order.

Used only with light crude oil or fuel oil.

crude oil, fuel oil, kerosene or tar which will flow through a ½″ pipe. For stationary boilers, steam at boiler pressure is ordinarily used to atomize the fuel. In furnaces the most economical method of operation is the use of a small quantity of compressed air or dry steam through the burner to atomize the fuel, while the balance of the air necessary for perfect combustion is supplied independently through a volume air nozzle at from 3 to 5 oz. pressure. Every particle of moisture which enters a furnace must be counteracted by the fuel and it is therefore essential, if steam is used as atomizer, that it be as dry as possible. It is folly to attempt to use steam as atomizer on a small furnace especially if the equipment is located some distance from the boiler room, for oil and hot water do not mix advantageously. Numerous tests have proven that with steam at 80 lbs. pressure and air at 80 lbs. pressure, by using air there is a saving of 12% in fuel over steam, but of this 12% it costs 8% to compress the air (this includes interest on money invested in the necessary apparatus to compress the air, repairs, etc.), so there is therefore a total net saving of 4% in favor of compressed air.

As the use of steam means a waste of fresh water (which is a very scarce article on sea-going vessels), mechanical burners are attractive for marine service and many vessels have recently been equipped with them. With many of these burners you are, however, limited to very light crude or fuel oil and there has been considerable difficulty experienced in preventing the parafine or asphaltum base of the fuel from clogging the delicate mechanism of the burner. The grade of oil required for the average mechanical burner can not be obtained in every country and as that capable of being refined, is being so largely distilled in order to obtain the more volatile and valuable oils, the supply of this light oil is very limited. A centrifugal air compressor operated by a modern type of turbine engine (fig. 4, page 40), has been developed, which, in the opinion of the writer, will attract a great deal of attention from marine engineers because with this system any gravity of liquid fuel procurable in any section of the world is thoroughly atomized, perfect combustion is effected, and as the system is provided with condensers, there is no appreciable waste of fresh water. This apparatus is light, compact, durable, and efficient, and furthermore, high pressure is not required on the fuel. 20 lbs. air pressure is carried with this system to atomize the fuel.

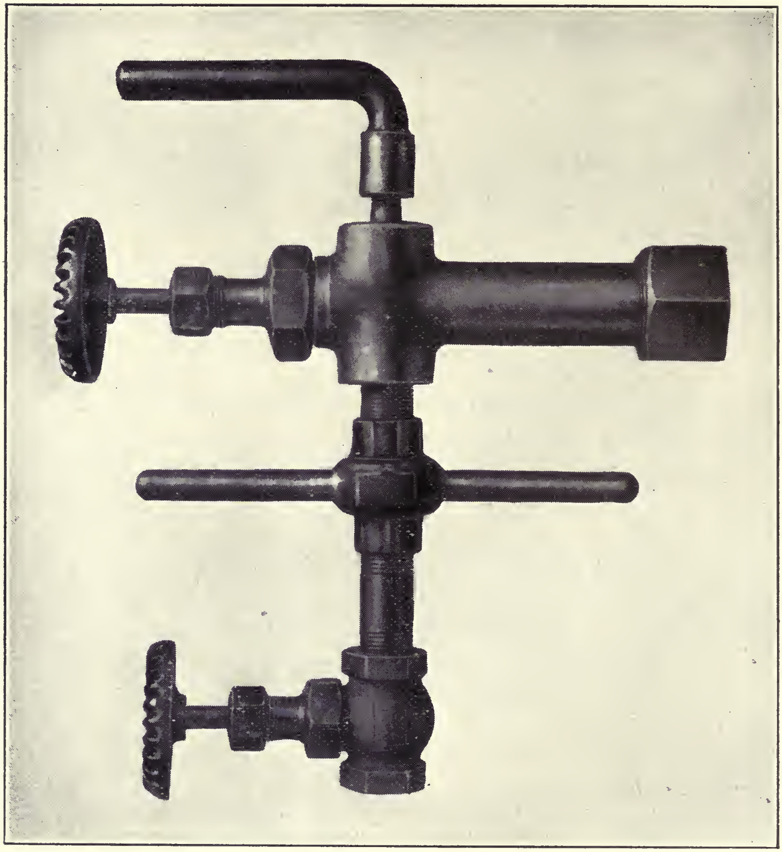


Fig. 3. Mechanical Burner.

This type of burner is particularly adapted for marine service to prevent waste of water or in works where steam or compressed air are not available.

It is necessary to use from 80 to 400 lbs. pressure on the oil supply line to the burners, this varying, of course, with the gravity of fuel. The oil used through this burner should be heated to just below the vaporizing point. The internal construction is such that the fuel is atomized while passing through the body of the burner and out of the nose.

Fig. 4. Burner for natural or commercial gas. Can be made to produce a long narrow flame or a fan shaped blaze according to requirements. Operated with either volume or compressed air.

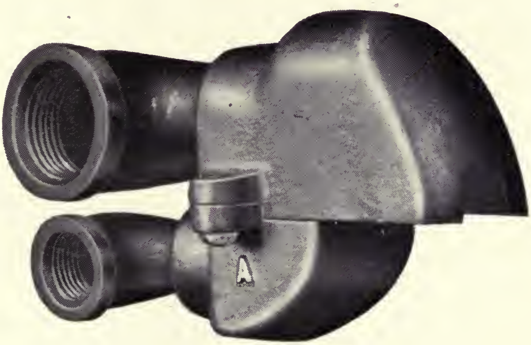


Fig. 5. A flat flame pulverized coal burner. The flame can be supplied to any width of furnace desired. The apparatus is simple to operate and has no intricate working parts.

CHAPTER III.

OIL SYSTEMS.

The method or manner whereby liquid fuel is supplied to the burners is commonly called the "oil system." Requirements vary according to the type of the installation and the fuel burned, but any one who has burned oil for a short time appreciates that the designing of an oil system is quite an engineering feat for so much of the success of the equipment depends upon the oil system. Perfect combustion is CO_2, imperfect is CO. If you have one moment carbon dioxide and the next moment carbon monoxide, you can readily see the fuel is not scientifically consumed and this results in irreparable loss in time and fuel. The air pressure should be constant and the fuel should flow to the burner under a constant steady pressure, no matter whether that pressure be 1 lb., 20 lbs. or more to the square inch. Light oils, which vaporize at about 130 deg. Fahr., need not be heated but heavy oil or tar must be heated sufficiently to reduce the viscosity so that it will flow readily. This is ordinarily done by means of steam coils. Care, however, must be taken not

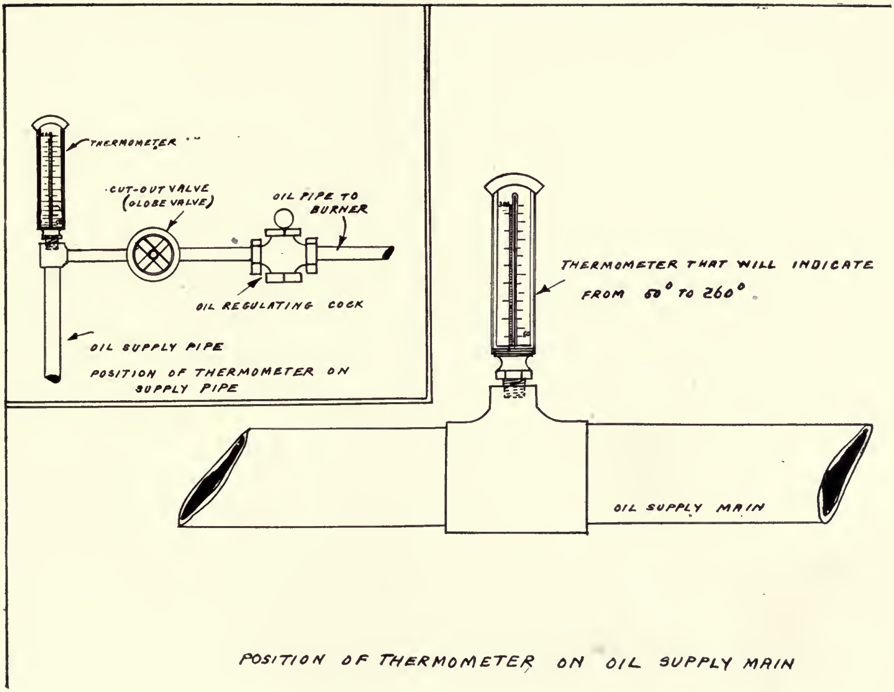


Fig. 1. Above cut illustrates manner of placing thermometers on main oil supply lines or on oil supply pipe to burner.

It is highly important to never guess at the temperature when heating heavy oils or tars. These fuels must be heated to just below the vaporizing point, and no one can intelligently guess at this temperature. Thermometers should be placed at various points throughout the works, and one should be conveniently placed for the man who is responsible for keeping the proper temperature upon the fuel.

to get the fuel too hot, for if it vaporizes you can not pump it. The vaporizing point of the various fuels has already been given in this volume, and as steam at 100 lbs. pressure is 338 deg. Fahr. you can readily see that it is possible to heat the fuel above the vaporizing point. In laying the piping care must be taken to keep the oil supply pipes below the level of the burner in order to prevent the formation of vapor pockets, which are liable to entirely shut off the flow of fuel. All pipe fittings should be malleable iron. All unions on pipe lines must be either ground joint or flange unions with lead gaskets. Rubber gaskets can not be used because liquid fuel soon disintegrates the rubber. The use of a paste of litharge and glycerine on all pipe joints will prevent their leaking. It is essential to place a strainer made of wire netting in the tank to prevent lamp black or other foreign substances from getting into the pipes and valves and clogging them.

No sane person to-day would venture near a storage tank with a lighted pipe, cigar, torch or any light, other than electricity, but in order to prevent conflagration and serious loss of property through a steel storage tank being struck by lightning, or getting on fire through some accident, it is wise to run a large steam pipe line from the boiler room into the top of the tank. There should be a large number of holes in the pipe in the tank so that when the steam valve in or near the boiler room is opened, the steam will be widely diffused over the fuel in the tank.

Of course, the most simple system is that often used in gas works, mines and other places, where there are no insurance regulations or city ordinances to prevent one from placing the tank so that the fuel will flow by gravity, the supply being controlled by the necessary valves. The bottom of the oil tank is ordinarily placed from four to six feet above the level of the burners but in gas houses often the tank is placed on top of the boiler so that the heat in the boiler room will heat the fuel sufficiently to reduce its viscosity.

Fig. 2 shows an oil supply system which conforms with the Underwriters' requirements and which is used in hundreds of plants. The storage tank, placed at some distance from any building, is covered with two feet of earth. As the average oil tank car contains about 6000 gal. I always recommend oil storage capacity of 10,000 gals. if the plant is on a railroad siding. Either one large tank or small ones coupled together as shown

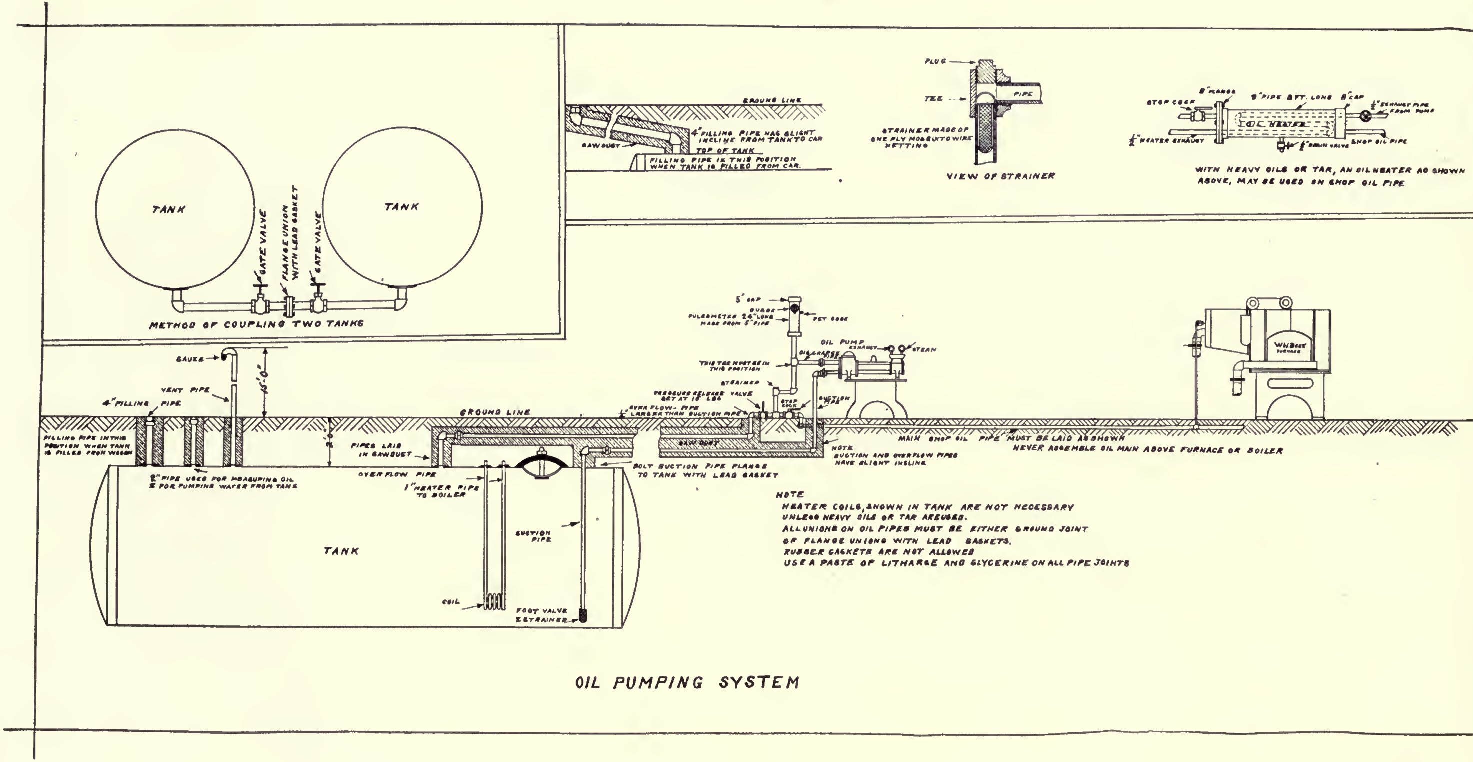


Fig. 2. Complete oil supply system used in hundreds of plants whereby a constant even pressure is maintained on the oil line whether one or a dozen burners are in operation. Very heavy viscous fuel cannot be handled with this system.

may be used. A reciprocating pump is preferable. I never advocate a rotary pump except when nothing but light oils will be used and even then a rotary pump has a tendency to churn the fuel into a foam, thereby causing slight but noticeable explosions in the fire-box or furnace. By means of the pump, pulsometer and a pressure release valve (set at 12 lbs. pressure), with this system 12 lbs. pressure is constantly maintained on the main oil supply line whether one or a dozen burners are in operation. While light oil which vaporizes at about 130 deg. Fahr. does not need to be heated, oil of 16 gravity Baume is first heated by means of a steam coil in the storage tank and then by the exhaust from the pump so that after passing through this heater, it is fed to the burner at just below the vaporizing point.

As the base and residium of very heavy oil, oil tar or coal tar has a tendency to clog the pressure valve used in the above system and render it worthless, it is sometimes advisable to install a "valveless system" similar to that shown in Fig. 3. In this case that portion of the oil pumped which is not used by the burners, flows into a column or stand-pipe of sufficient height to give six or eight lbs. pressure on the oil line, and then back again to the storage tank. With this arrange-

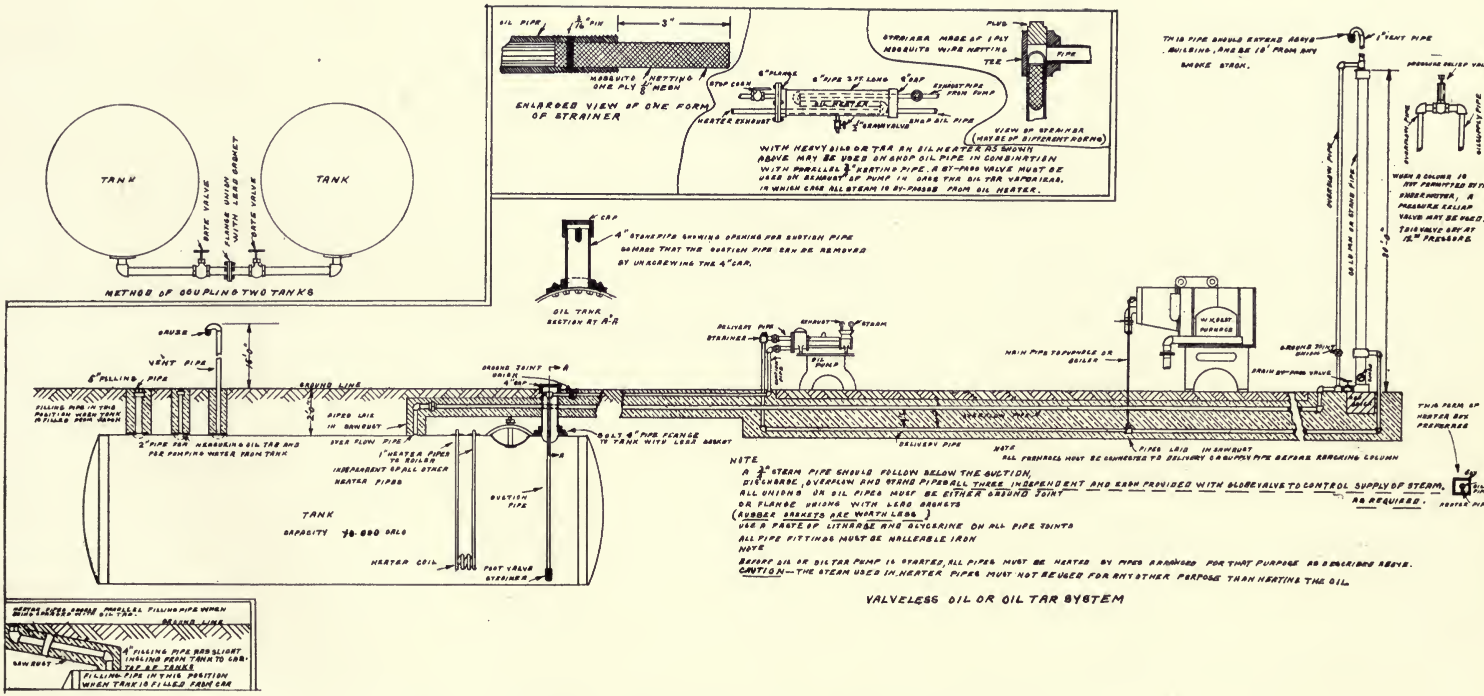


Fig. 3. Valveless Fuel System used with heavy oil or tar.

In case the Underwriters' do not permit the use of a column or standpipe, it is necessary to use the pressure relief valve.

ment there can be no fluctuation in the oil pressure. Should the fuel be accidentally heated at any time above the vaporizing point, you will note that this vapor can readily pass out of the top of the standpipe through a vent pipe extending above the roof of the building and ten feet from any smoke stack.

In Fig. 4 is shown oil system used for heating hotels, office buildings, etc. An electric motor operates an air compressor which supplies air to force the fuel from the storage tank to burner and also the air required through the burner to atomize the fuel. This system is absolutely reliable for should a fuse burn out, the oil and air supply to burner are stopped simultaneously. Or an oil or gas engine may be used and the compressor operated by a counter-shaft. In this case should the engine stop or belt break, the compressor will at once cease to force the fuel to the burner. Both these systems are simple, safe and sane.

For marine service, where the prevention of the waste of fresh water requires careful consideration, a turbine engine with condenser may be used to operate the oil pump and a compressor of adequate size to furnish air at sufficient pressure to atomize the gravity of oil obtainable in any port and to distribute the heat in the fire-box, also the additional air required in the boiler room.

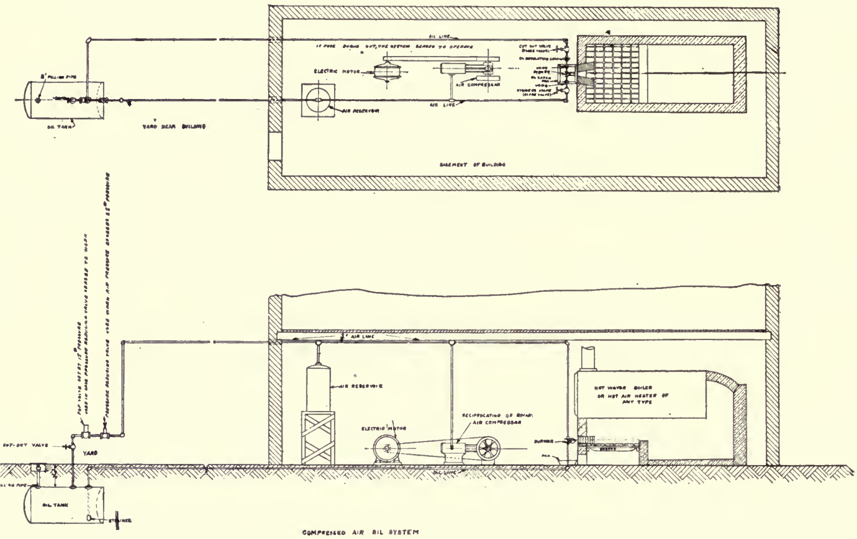


Fig. 4. Compressed Air System.
Adequate for light crude oil or fuel oil only.

This system as shown in Fig. 5 is very compact, efficient and economical. While oil used exclusively as fuel cannot compete with the price of coal in many localities, it is very necessary to use it to aid the coal fire while carrying peak loads.

To effect the strictest economy, crude oil or tar must always be heated to just below the vaporizing point. With the heavy oil, such as is produced in Mexico, it is sometimes advantageous to use an oil superheater so that, as for instance on a locomotive, if the oil is not heated sufficiently in the storage tank of tender or if the tank has just been refilled at the end of a division, by passing through a superheater just before it reaches the oil regulating cock, it will be fed to the burner at just below the vaporizing point. (See Fig. 6, page 53). When burning heavy oil in furnaces, if the fuel must come considerable distance, it is often essential to preheat it near the burner even if there is a steam heater pipe immediately under the oil supply line from the storage tank. A superheater is also valuable for heating tar between the storage tank and the burner so that it will be of such consistency that it can be readily atomized.

When an ordinary globe valve is used to regulate the fuel supply, and the valve is partly

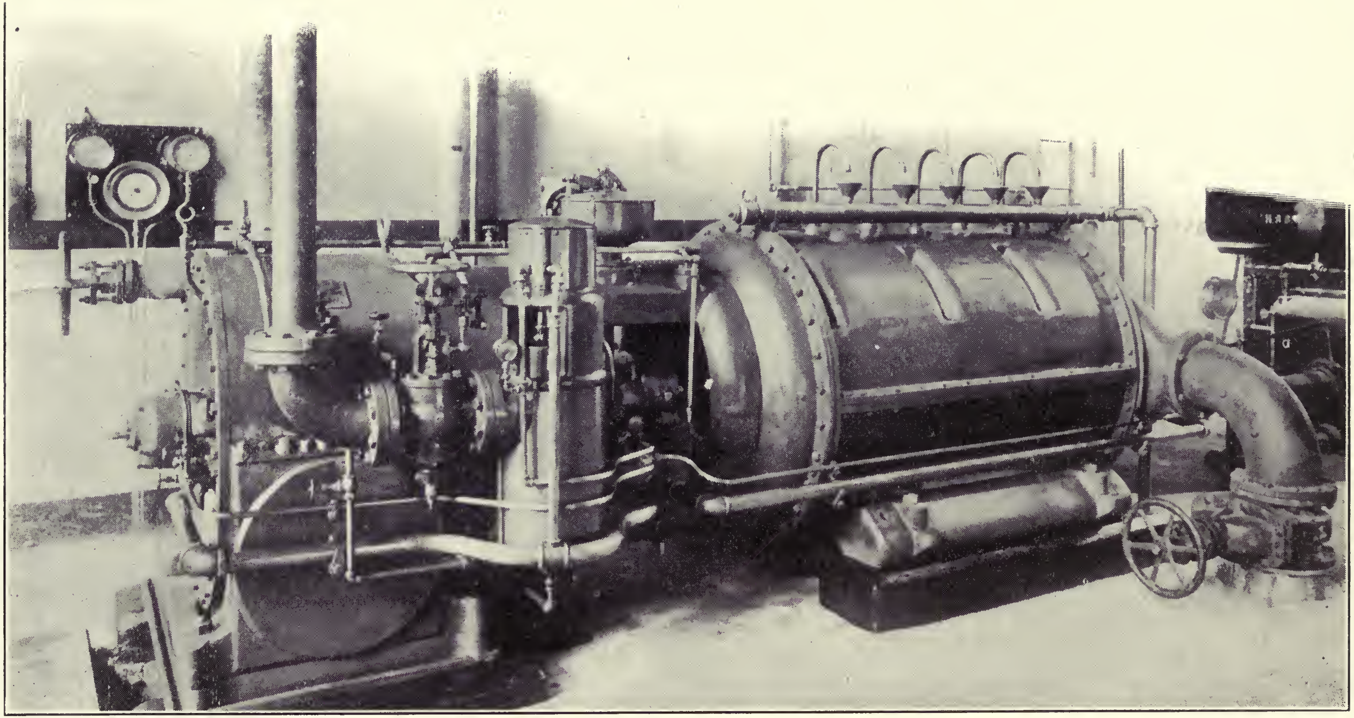


Fig. 5. Turbine Engine operating a Centrifugal Air Compressor of the most modern type. This apparatus is used in marine service and as the engine exhausts into a condenser, the loss of fresh water is reduced to the minimum. (Apparatus shown through courtesy of the General Electric Co., West Lynn, Mass.)

closed, the small opening between the valve proper and the seat acts as a strainer and any residuum or foreign substances in the oil finally closes the opening and cuts off the supply. We have here shown an oil regulating cock provided with a V-shaped, knife-edged, opening in the plug, which not only has a shearing action on heavy liquid fuels, but enables the operator to secure the finest possible adjustment. It is unnecessary to make comparison between this cock and an ordinary globe valve or plug cock to any intelligent man who has had experience in handling liquid fuel. When a furnace is working continuously on one class of work, this cock can be set by the adjusting screw so that when the burner is stopped for noon hour, or at night, it can be returned to the same adjustment when again started.

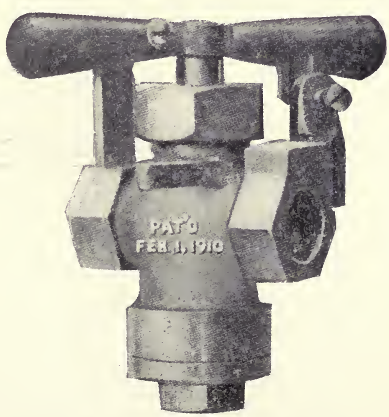


Fig. 6. Oil Regulating Cock.

CHAPTER IV.

REFRACTORY MATERIAL.

Poor fire-brick should never be used as it is most disappointing both to the builder and owner of the furnace. It takes as much time and labor to construct a furnace of poor fire-brick as of good brick. Poor brick is dear at any price, no matter what may be the fuel used.

The excessive heat which can be obtained from liquid fuel, makes it necessary in many instances to use a very superior grade of fire-brick. For example, in welding furnaces the lining should be capable of withstanding 3,000 deg. Fahr. without dripping or melting away, while in crucible melting furnaces the fire-brick must be capable of withstanding the high temperature required to melt fourteen pots of crucible steel at one heat. These bricks must be non-expanding for if they were to expand in the same proportion as silica brick, the furnace lining would become six inches too long; which amount of expansion would ruin the construction of the furnace. The analysis of brick for crucible furnaces is as follows:

Silica	56.15 %
Alumina	33.295%

Peroxide Iron	0.59 %
Lime	0.17 %
Magnesia	0.115%
Water and inorganic matter	9.68 %

In open hearth furnaces a silica brick is essential because it will withstand the required high temperature and as these furnaces are operated continually, the expansion and contraction of this brick has not the detrimental effect in this class of service which it has in a furnace which is only operated eight or ten hours daily. In annealing furnaces owing to the lower temperature required for the heat-treatment of metals, it is not necessary to use such good quality of brick. It is, however, essential that these bricks do not expand nor contract. It is also very necessary that the furnace be carefully constructed by a competent furnace builder for the bricks should not be laid in layers of fire clay the way ordinary red bricks are laid with mortar but should simply be dipped in very liquid fire clay solution, and then laid in place. It is advisable to use special shaped bricks for lining small furnaces, owing to the fact that it does not require a skilled mason to place these blocks in position. For example, two blacksmith helpers can reline a furnace, having charging space 18-in. wide, 22-in. deep, by 16-in. high, with

Furnace with front casting removed to show special shaped brick lining.

13 large accurately shaped blocks in forty minutes. As these shapes are interlocking and as the number of the joints is greatly reduced, this lining lasts about three times as long as a furnace lined with ordinary standard size fire-brick. This fully demonstrates the theory that every fire-brick joint in the furnace shortens the life of the construction.

As magnesite brick has no affinity for iron, it is often used for furnace bottom in welding furnaces, etc. For air furnace bottoms a special grade of sand is necessary, the analysis of which is as follows:

Silica	89.94
Oxide of Iron	2.64
Oxide of Aluminum	3.26
Magnesia	trace
Lime	trace
Total Alkali	2.62
Loss on ignition	1.50

CHAPTER V.

LOCOMOTIVE EQUIPMENT.

Hundreds of locomotive firemen are to-day rejoicing because of the discovery of liquid fuel for instead of their runs being a continuous arduous task of shoveling coal, they are riding like a prince on their seat in the cab, gazing out of the window at the track ahead, safe-guarding their own lives as well as those of the traveling public in the train. One hand rests upon the lever of an oil regulating quadrant by means of which they can instantly increase or decrease the flow of fuel

Fig. 1. Oil Burner.
Only one required for the largest locomotive.

passing into the fire-box. When a locomotive is changed from coal to oil, its tonnage is increased 15%, for you can at all times maintain the full boiler pressure of steam. Even while going up the highest grade or mountain, the steam pressure in boiler is not lowered and there is absolutely no smoke. As there are no smoke or sparks emitted, the danger of setting fire to forests, bridges, buildings, etc., is eliminated, and because of this fact, oil burning locomotives are used in coal mines, on divisions passing through timber lands, etc. Before oil was introduced, timber of inestimable value was destroyed by sparks in Louisiana, the Adirondack Mountains, etc.

Great advances have been made in the equipment of locomotives but the types are so numerous, it is difficult to specifically describe these changes. Formerly it was customary to bolt the burner to the mud ring below the fire-box door, directing the flame toward the flue sheet under an arch made of A-1 fire brick. This arch was a source of great difficulty as it often fell or wasted away, thus deflecting the heat against the crown sheet. Again too, often if the flues began to leak, the water dripping down upon the arch, penetrated the fire-brick, thus generating steam which caused the structure to crumble and fall. The most modern practise is to eliminate the arch entirely, the burner being placed at the flue sheet end of the fire-box substantially as shown in Fig. 2. This insures a reverberatory movement of the flame and heat for the burner directs the flame against the fire-brick cross wall at the rear of the fire-box where it is deflected and drawn forward

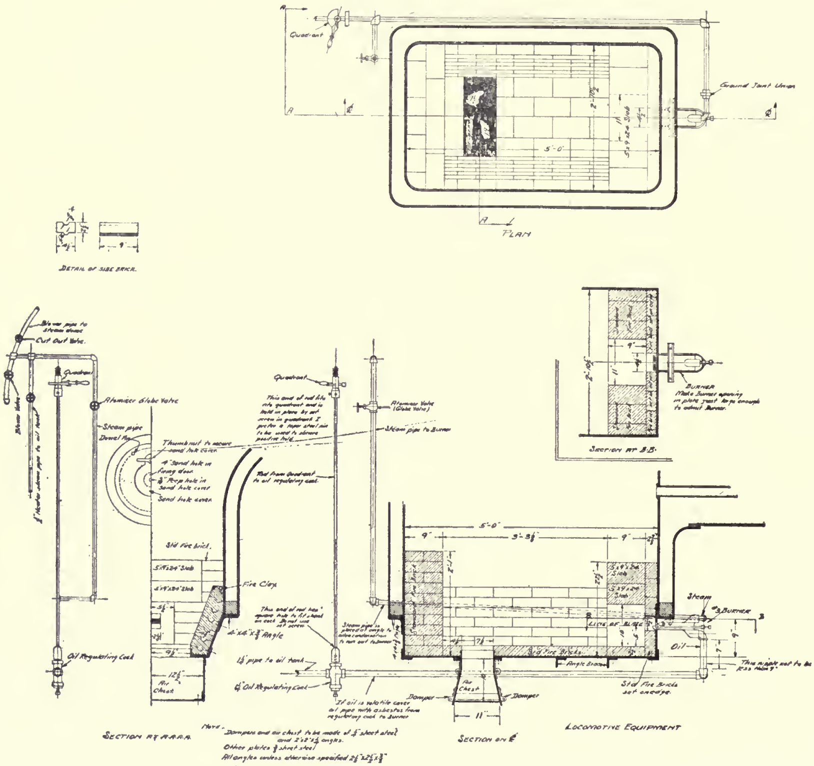


Fig. 2. Most modern type of locomotive equipment.

by the exhaust to the flue sheet end of the fire-box. The grates, of course, are always omitted. By means of the inverted arch with dampered air opening, the quantity of air necessary for perfect combustion is regulated according to requirements. When the locomotive is going forward, the rear damper is open, and while the locomotive is going backward the front damper is open.

I show but one type of inverted arch, but will say that these vary in construction. Some have damper controlling devices by which the fireman can accurately control the admission of air passing into the fire-box, while others admit the air through openings in the burner end of the inverted arch. A fireman who uses judgment in the operation of the damper type, secures the highest economy in fuel by admitting just sufficient air while at the same time allowing no smoke to pass from smokestack—in other words, he effects perfect combustion. Careless firemen who do not use good judgment in controlling the damper, make a better record in fuel economy by the use of the type of inverted arch with air openings at the burner end. Care should always be taken not to admit a superfluous amount of air into the fire-box, as it requires additional fuel to heat excess quantity air to the temperature of the fire-box.

The fireman's regulating quadrant takes the place of the coal shovel on an oil burning engine. The early history of liquid fuel equipment shows that many locomotive fire-boxes were ruined because the fireman inadvertently shut off the fuel supply while drifting down a long grade or coming into a station. He thought he had a light fire, but there being none, the cold air, rushing in, damaged the fire-box and started the flues to

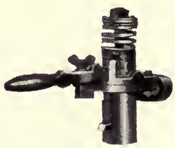


Fig. 3. Fireman's Regulating Quadrant.

Fig. 4. Locomotive Oil Regulating Cock.

leaking. This difficulty is now entirely obviated by the use of a quadrant attached by means of a rod to an oil regulating cock (Fig. 4), having a V-shape knife-edge orifice in the plug, through which the fuel enters and passing out through a much larger orifice. With this apparatus you can

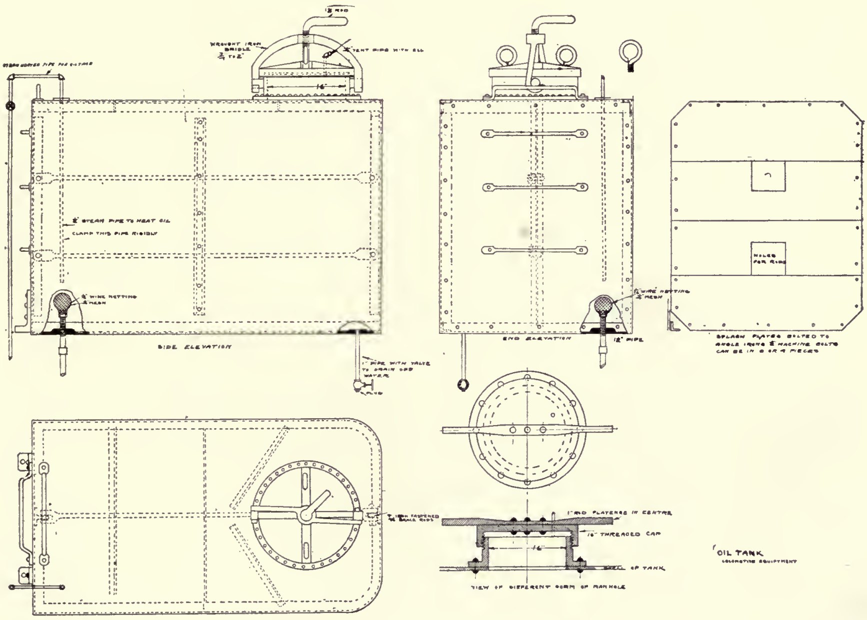


Fig. 5. Oil tank placed in former coal space of locomotive tender.

have the pops operate going up the steepest grade on any mountain if so desired, or you can hold the steam at any pressure without varying 5 lbs. over the division of any railroad. While drifting, the lug of the lever or handle of the quadrant engages with a set screw in the hinged latch, which insures a constant light fire sufficient to maintain steam pressure and operate the air pump. When speed or maximum power is required, the lever is moved towards the left, which increases the flow of oil. When the engine is placed in the round house, the hinged latch is thrown back, and the lever is moved to the right as far as possible and the top thumb screw tightened. In this position the lever is stationary and the fuel supply to burner entirely shut off.

An oil tank, such as can be placed in the former coal space of the locomotive tender to supply fuel over a division, is shown in Fig. 5. This tank can readily be filled. Means are provided for heating the oil in this tank substantially as shown; also splash plates in order that the oil may be carried in this tank the same way as water is carried in the tender tank. The bottom of the tank is ordinarily only one foot above the burner, but with the form of atomizer shown in Fig. 1, which has a sy-

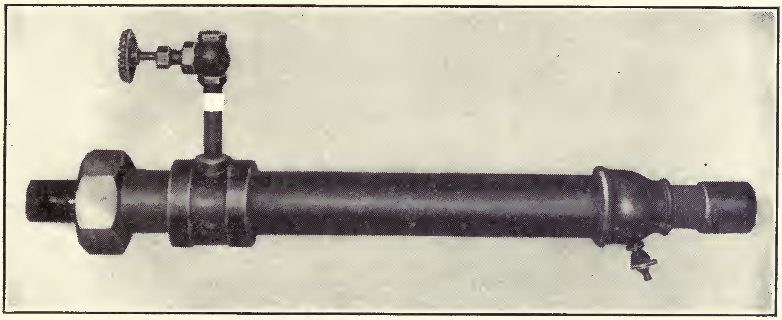


Fig. 6—Oil Superheater

phoning action, this pressure is sufficient so that air is not required to force the fuel to burner.

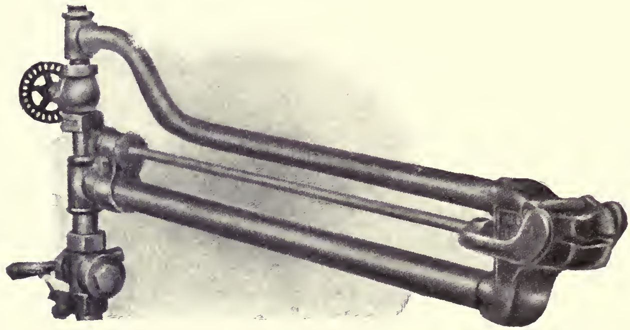
When heavy oil is cold and viscous, the locomotive can not pull her tonnage, and carbon will lodge on the fire-brick lining of the inverted arch. Although heated by steam coils in the storage tank of tender, it is often wise to have heavy viscous fuel pass through a superheater just before reaches the regulating cock so that it will get to the burner heated to just below the vaporizing point. The superheater shown in Fig. 6 is both simple and durable, and is operated by a globe valve conveniently placed for the fireman, which allows the steam to surround the oil pipe, all condensation passing out of the drain cock at the bottom of the superheater. Such a device is really a necessity when the oil tank has been filled at the end of a division for it takes some time for the cold heavy oil to become sufficiently heated by the steam pipe in the tank.

CHAPTER VI.

STATIONARY AND MARINE BOILERS.

In some sections of the country where oil is cheap, it is extensively used in stationary and marine boilers. For this purpose it is most excellent, for it insures perfect combustion and a constant even fire, whereas, in the burning of coal it is impossible to keep up an even heat because of its being necessary to so frequently replenish the fuel supply. There is no expense for the handling of fuel and ashes. One man can fire and water-tend a battery of twelve oil-fired boilers.

In traction power houses where, for about three hours in the morning and three hours in the evening, it is necessary to develop twice as much power as during the rest of the day, the engineers with oil have no difficulty in developing double the normal rated horse-power of each boiler without injury to the elements, thus entirely obviating the necessity of keeping extra boilers with banked fires. In some plants where coal is ordinarily used as fuel the boilers carry the peak loads by using a combination of oil and coal; the burners being placed in side of fire-box as shown in Fig. 2. Oil is used in some power plants where they have sto-



High Pressure Oil Burner Mounted for Marine or Stationary Boilers burning oil or tar exclusively as fuel.

The burner is connected to piping of sufficient length to go through the front setting of boiler.

By means of the by-pass valve any foreign substances that may enter the oil pipes can be blown out.

The atomizer lip is hinged and held tight against the body of the burner but means are provided for raising the lip to blow out the atomizer pipe in case any foreign substance such as scale, red lead, etc., should lodge therein. This can be quickly accomplished without removing burner from boiler.

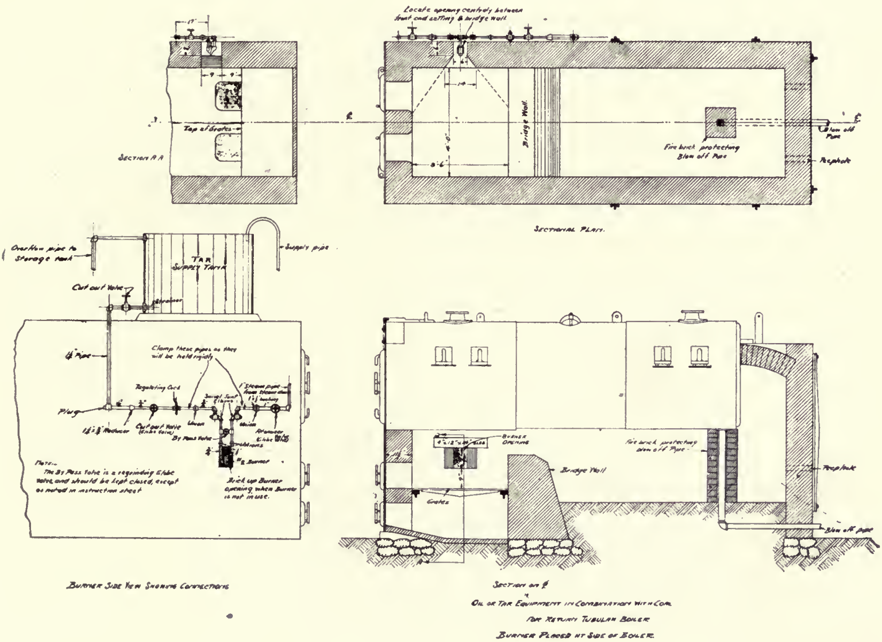


Fig. 2. Boiler equipped for the use of oil or tar to aid coal or breeze fire in carrying peak loads.

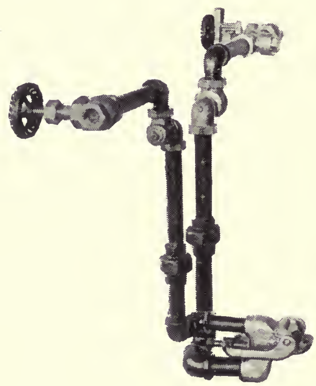


Fig. 3. Oil or Tar Burner mounted with swivel joints.

kers and where a boiler is called into service quickly. In this case the oil burner is mounted with swivel points (see Fig. 3), and when called into use, it is simply swung from its position at the side of the boiler and plays its fire over the bed of coal until the green coal fire has been properly ignited, after which it is swung out of position and the burner opening in the side of fire-box is closed by fire-brick of the exact size and form required to fill the burner opening.

Another service of great importance and of growing demand is in large electric light plants which formerly had a long battery of boilers carrying banked coal fires, for during a storm or threatening weather, many lights are turned on simultaneously throughout a city, thus necessitating the immediate replenishing of electrical energy. A number of plants have been changed to oil by placing the burner in the front end setting of boiler, the grates being covered with a checker-work of fire-brick, the opening in the checker-work being of such proportions as to admit sufficient oxygen for the consuming fuel. A gas pilot light is constantly kept burning and when the boilers are suddenly called into service, the oil burner is started in five seconds by simply opening the two operating valves and in ten minutes, 150 lbs. of steam is on the boiler. Of course, when not under fire, hot water is constantly passing through these boilers, this being the same practice as is used in fire-engine houses.

With the average fluctuating load in stationary boilers, it requires approximately 147 gallons of oil having calorific value of 19,000 B. T. U. per lb. and weighing 7.5 lbs. per gal. to equal one long ton of bituminous coal (2240 lbs.) having calorific value of 14,200 B. T. U. per lb.

The analysis of one of the best coals is as follows:

Carbon	82.26%
Hydrogen	3.89%
Oxygen	4.12%
Nitrogen	.64%
Sulphur	.49%
Ash	8.60%
Total	100 %

Calorific value per lb. 15,391 B. T. U.

However, the average of good coals has a calorific value of 14,200 B. T. U. per lb.

There are many types of stationary boilers, all of which play their particular part in the manufacturing world. Along the lines of railroads old locomotive boilers, discarded from railway ser-

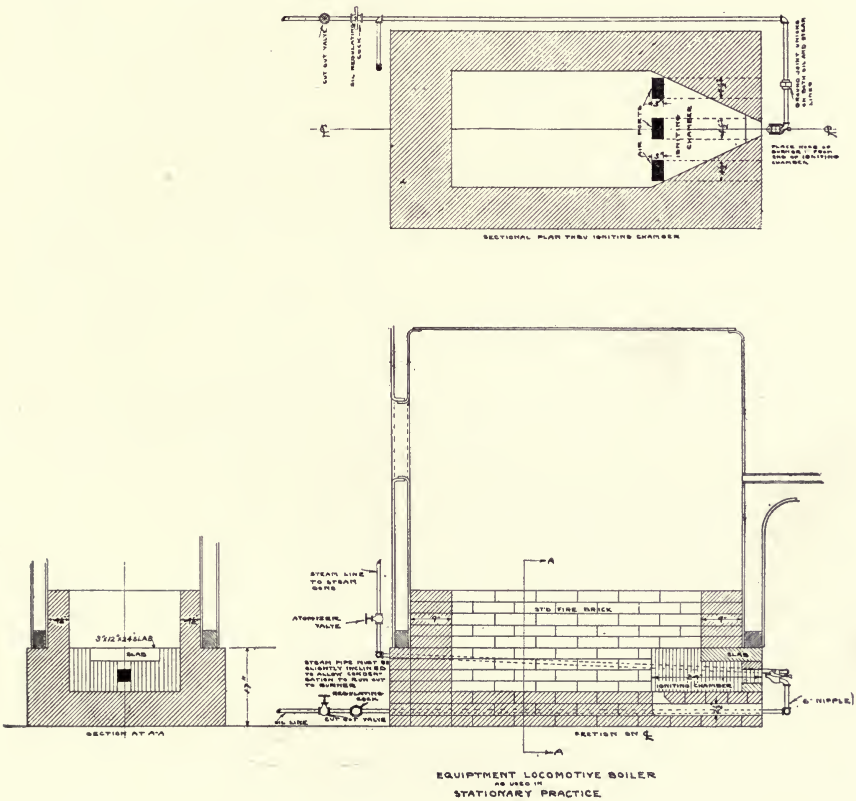


Fig. 4. Locomotive Boiler equipped for Stationary Service.

vice, are often used in water pumping stations. Oil is an excellent fuel for this work, for the fireman can adjust the burner and have plenty of time to care for the pumping plant, as he does not have to regulate the burner for three or four hours at a time, but of course, he must give attention to the water supply for the boiler. In Fig. 4 is shown the manner of equipping such a boiler.

Fig. 5 shows the most modern method of using oil in marine boilers. Note the combustion chamber and its construction. This refractory material aids combustion and insures an even distribution of heat. The end lap seam of the corrugated fire-box should be protected by fire-brick and also the shell and staybolt heads should be protected by a 4½ inch cross wall as shown. With this equipment, by simply raising the cast iron manhole door, the inspector can readily examine the boiler.

In a Stirling boiler (Fig. 6), the grates should be lowered and the burner placed between the two ash-pit doors. Unless the width of the fire-box exceeds 7½ ft., only one burner giving a fan-shaped flame, is required. Never remove the arch or arches over the grates for these are necessary to deflect the heat to and through the elements of the boiler.

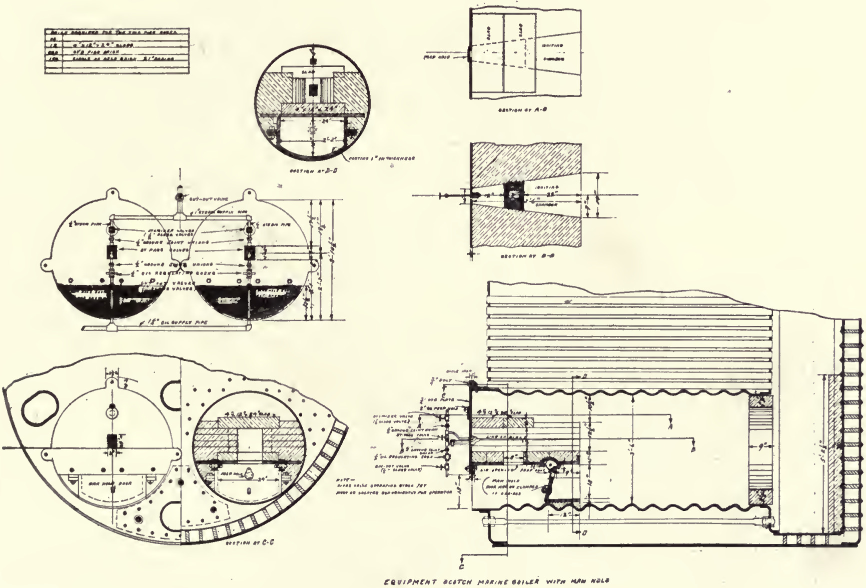


Fig. 5. Scotch Marine Boiler Equipment.

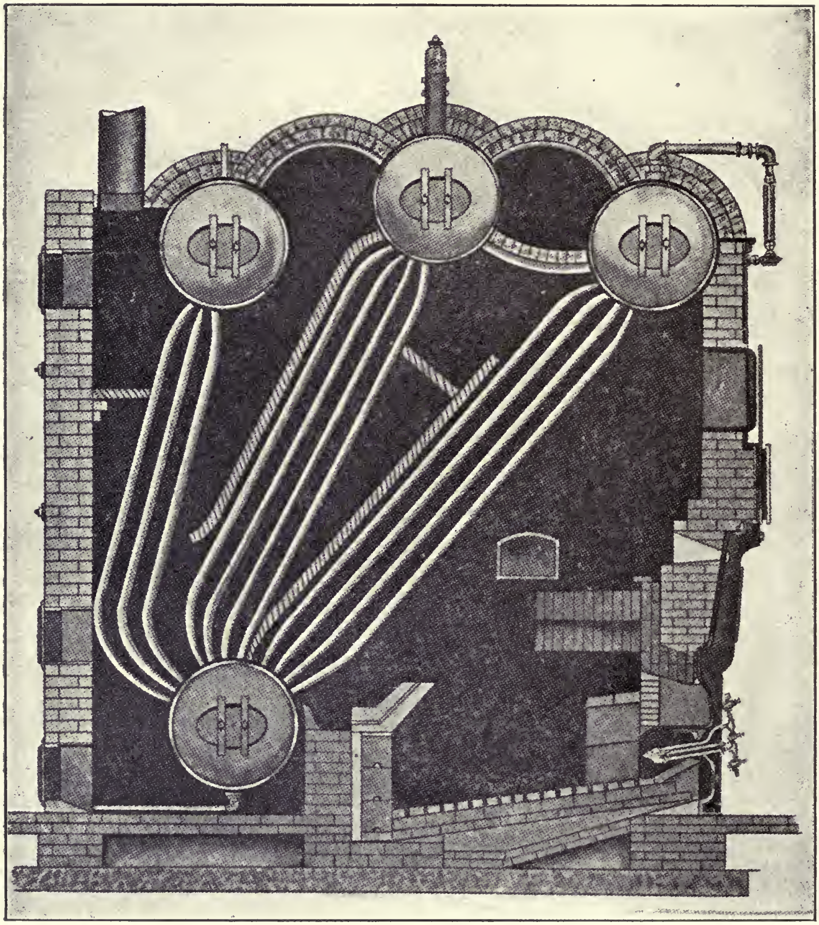


Fig. 6. Stirling Boiler Equipment.

There are two methods of equipping a Heine boiler. One is known as the Low Setting and the other the High Setting. The latter is simply placing a burner through the firing door as shown in Fig. 7, and covering the grates with a checker-work of fire-brick, leaving a space of 3/8 inch between the bricks, so that the air required for combustion can readily pass up there through. Care must be taken to have the proper distance between the flame and the refractory material covering the grates. I have experimented a great deal in order to ascertain this distance, and have found that with a burner giving a fan-shaped flame there should be 8 in. between the nose of burner or the Line of Blaze from the burner and the top of the fire-brick checker-work. In the "Low Setting" (Fig. 8) the grates are removed and rows of support brick laid in the ash-pit. On these the checker-work is placed, leaving 3/8 in. space between bricks if the stack is high or a greater distance if there is only a short stack. The "Low Setting" is always preferable because by removing the grates, you increase the size of the fire-box thus correspondingly increasing the efficiency of the boiler. With the "Low Setting" you get practically 1½ lbs. greater evaporation per lb. of fuel than with the "High Setting" and there

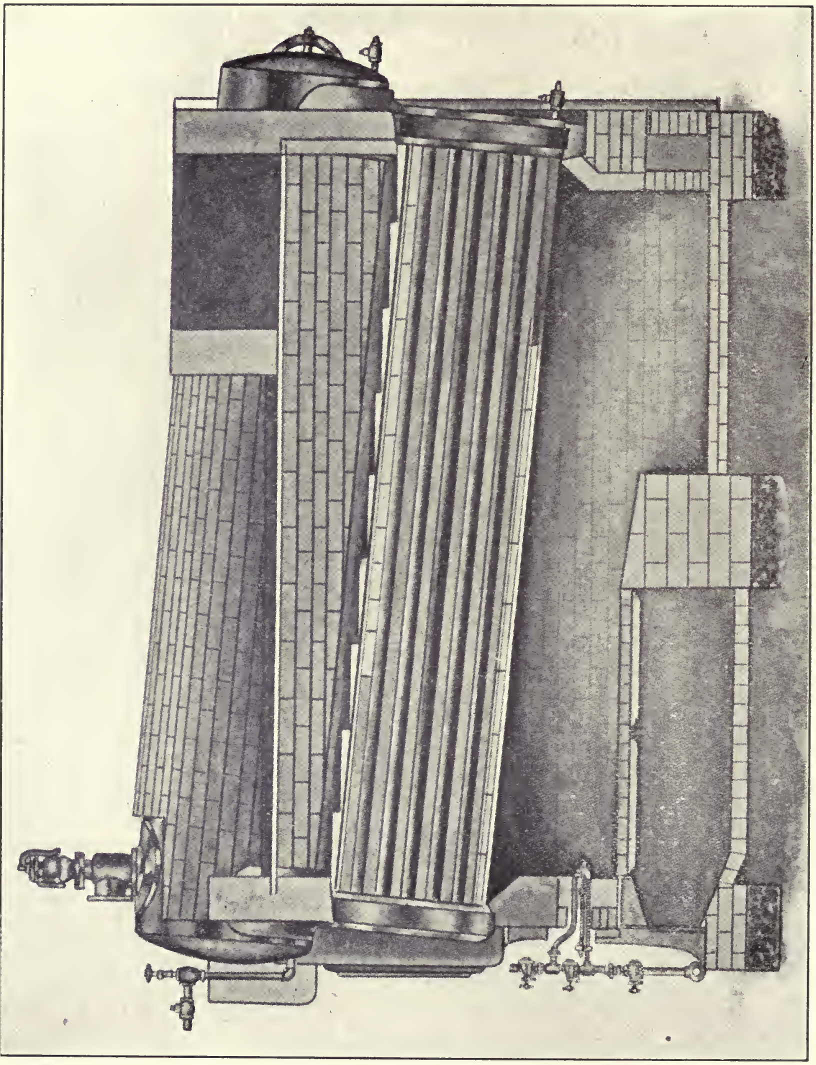


Fig. 7. Equipment of Heine Boiler—High Setting.

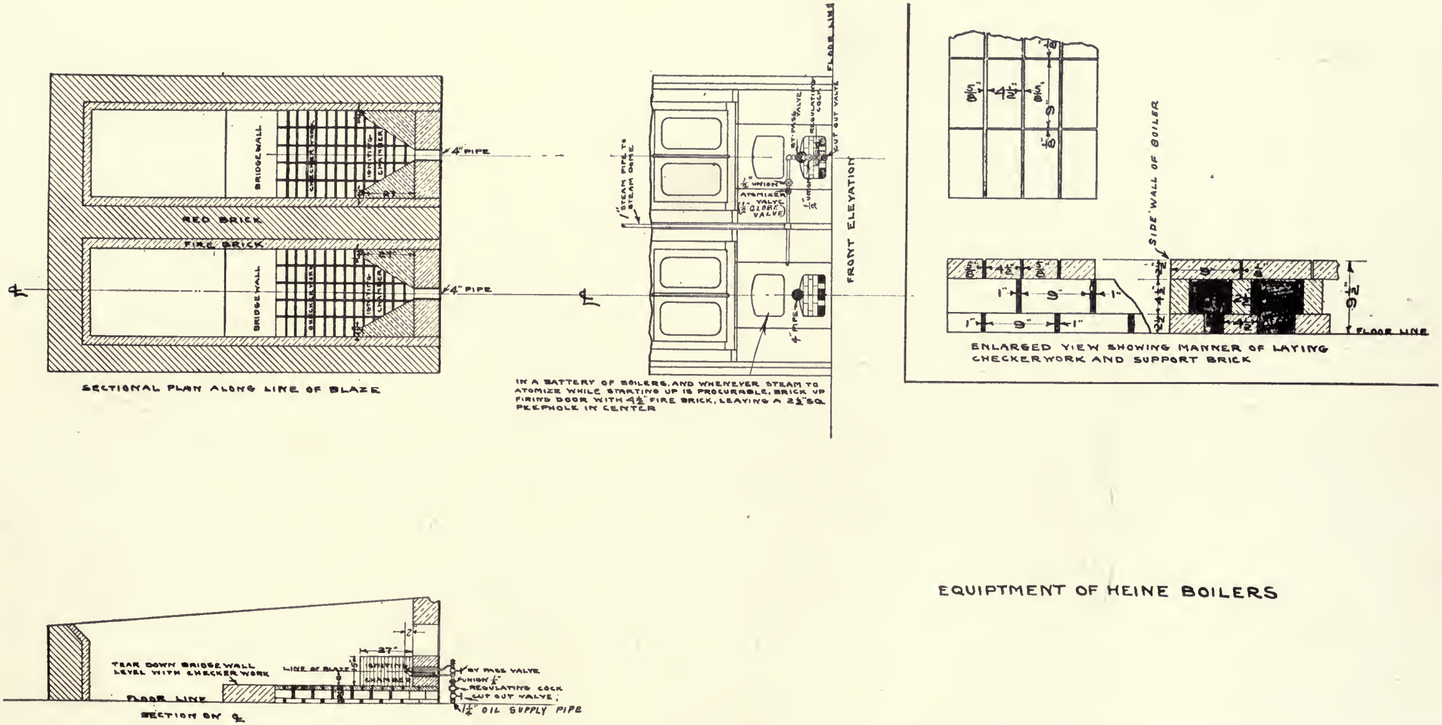


Fig. 8. Most modern way of equipping a Heine Boiler—Low Setting.

is no liability of the elements being injured, even when forcing boiler far beyond its normal rated horse power. With either the High or Low Setting, the bridge wall is cut down level with the top of the checker-work so that the heat may be even throughout the entire length of the fire-box.

In our early attempts to equip a Babcock & Wilcox boiler, we covered the grates with a checker-work of fire-brick, placing the burner in the front end setting and directing the heat rearwardly. Our chief difficulties were the inadequate size of the chamber in which combustion took place, a concentration of the heat at the rearward end of the first pass and an insufficient amount of heat at the header-end of the boiler. Finally we removed the grates, placing the fire-brick checker-work on rows of support brick laid in ash-pit, and constructed a deflection arch or ledge to deflect the heat forward, as shown in Fig. 9. Further experimenting revealed the fact that the very best results are obtained by having a distance of 3 ft. between the base line of the setting and the floor line, and constructing the deflection cross wall as shown in Fig. 10. It may seem costly to make the setting so low but this cost is soon offset by the economy in fuel and efficiency effected because of your getting the benefit of an even

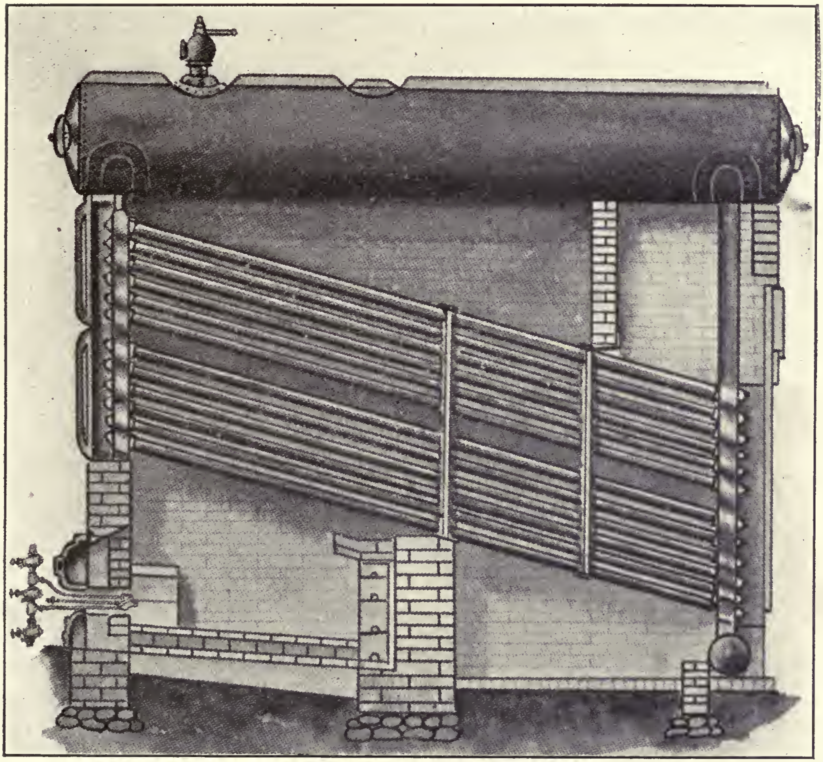


Fig. 9. Equipment of Babcock & Wilcox or Altman-Taylor Boiler.

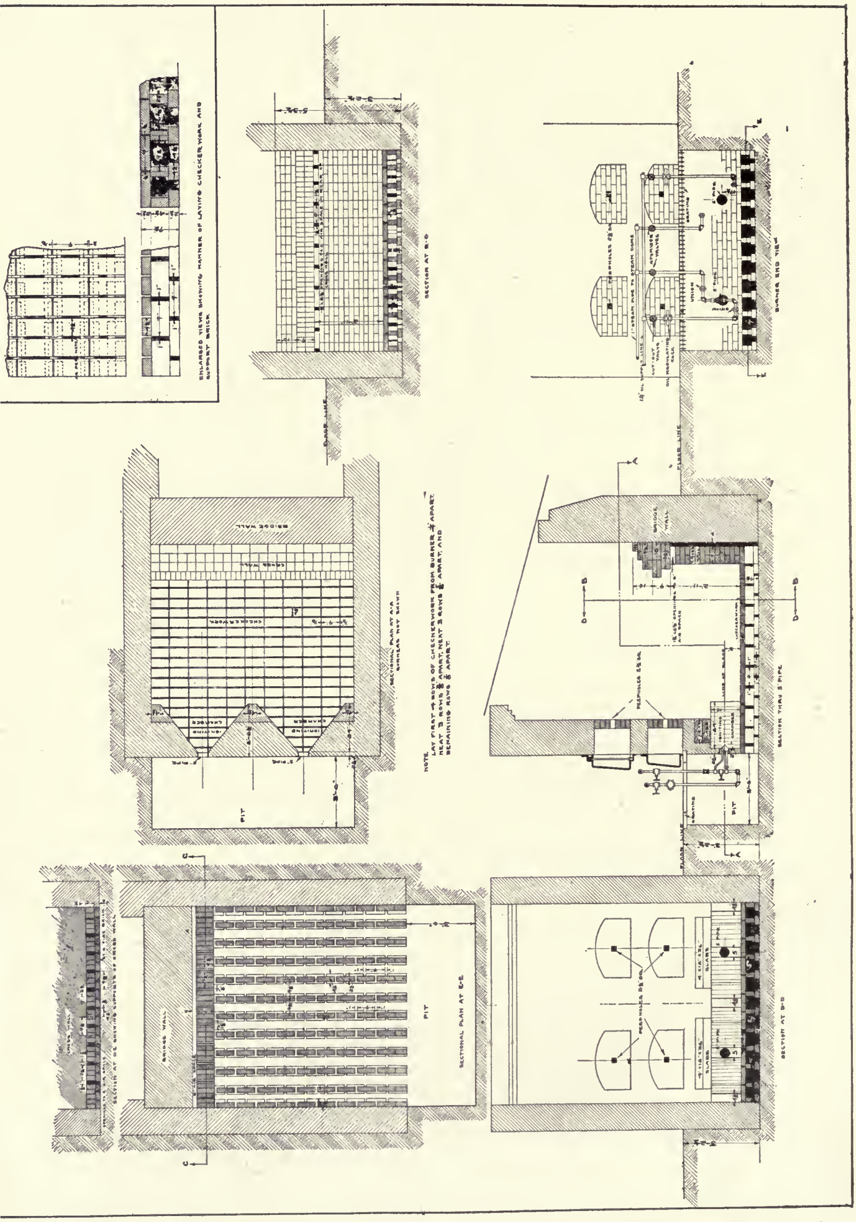


Fig. 10. Most modern and efficient manner of equipping a Babcock & Wilcox or an Altman-Taylor Boiler.

distribution of heat throughout the first pass of the boiler.

A return tubular boiler may be equipped by simply placing checker-work on the grates and cutting the bridgewall down level therewith as shown in Fig. 11 but personally I recommend the "Low Setting," similar to that described under Heine boiler, see Fig. 8.

Admirable results are obtained from Vertical Boilers by placing the burner so that the flame enters the fire-box tangentially, for this causes a reverberatory movement of the flame and heat and prevents impingement upon any of the elements of the boiler. To start the boiler shown in Fig. 12, when cold in a pumping station or when used as an auxiliary boiler, we simply break up a few boxes and pass them in through the fire-door and in a few moments ten or twelve lbs. of steam is raised on this small boiler, which is sufficient to operate the oil burner on this boiler, and this boiler in turn furnishes steam to operate the burners of a large battery of boilers.

The Steam Engineering Department of the United States Navy in 1904 conducted a series of tests upon a water-tube boiler using oil as fuel. The Bureau at that time was under the charge of

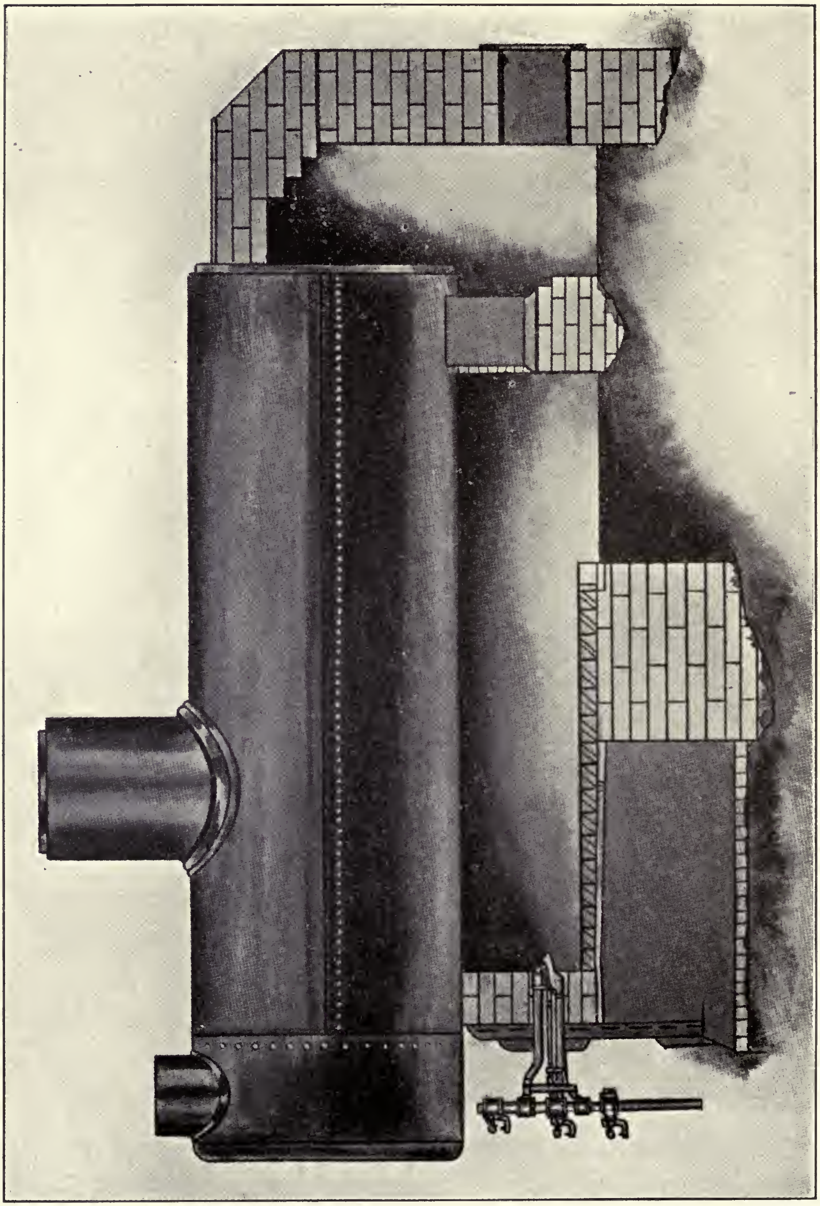


Fig. 11. Return Tubular Boiler Equipment. "High Setting."

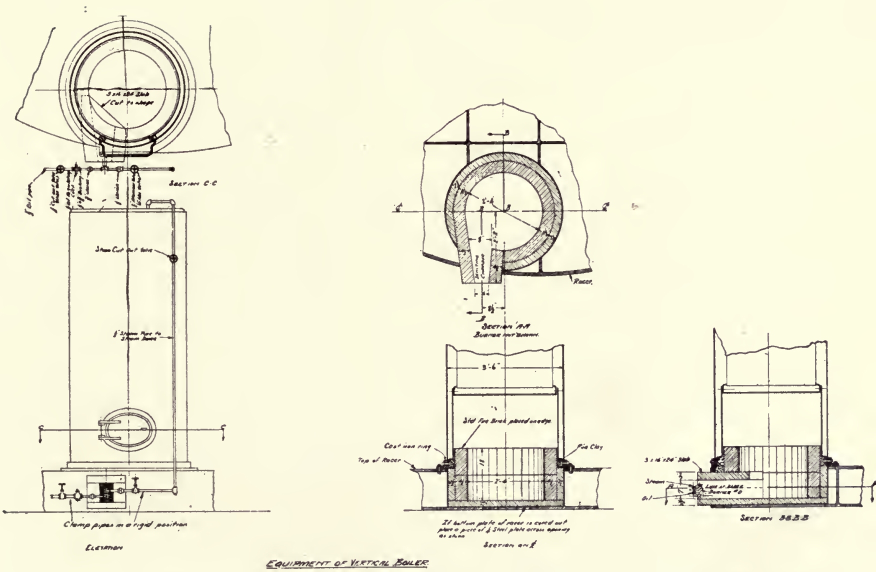


Fig. 12. Tangential Flame Equipment as applied to Vertical Boiler.

the late Rear-Admiral George W. Melville, and the tests were conducted by a competent board of efficient naval engineers, viz.: John R. Edwards, Commander (now Rear-Admiral), U. S. Navy; W. M. Parks, Lieutenant-Commander, U. S. Navy; F. H. Bailey, Lieutenant-Commander, U.S. Navy; and Mr. Harvey D. Williams and Mr. Frank Van Vleck, two oil experts who served the Board as secretaries. These gentlemen faithfully discharged their duties and gave to the United States and, in fact to the whole world, a most accurate and exhaustive report on the burning of oil in boilers which still remains the highest authority on boiler equipment and has done much toward the introduction of oil in the manufacturing world as well as in the navies and merchant marine. We owe this Board a debt of gratitude for their untiring efforts in our behalf.

CHAPTER VII.

OVENS.

In steel foundries oil is especially attractive for large mould drying ovens because of the fact that, if desired, the moulds can be dried 50% quicker and more thoroughly than by the use of coal, coke or gas. I can almost hear my reader, who is the superintendent of a steel foundry and who has never used oil as fuel on his mould drying ovens say, "I do not care to use a fuel that will heat so quickly for it would simply ruin the moulds," but my friend, coal or coke gives a localized heat whereas by the use of the method of burning oil shown in Fig. 1 an absolutely even distribution of heat is obtained throughout the entire oven which in this case is 44 ft. long, 20 ft. wide and 12 ft. high in the clear. This oven is operated with only one burner. In the combustion chamber, which runs through the center of the entire length of the oven, a temperature of 2000 deg. Fahr. is maintained which insures your securing the highest possible efficiency from the fuel. You will note also that the combustion chamber has heat ports of graduated size and such location as to in-

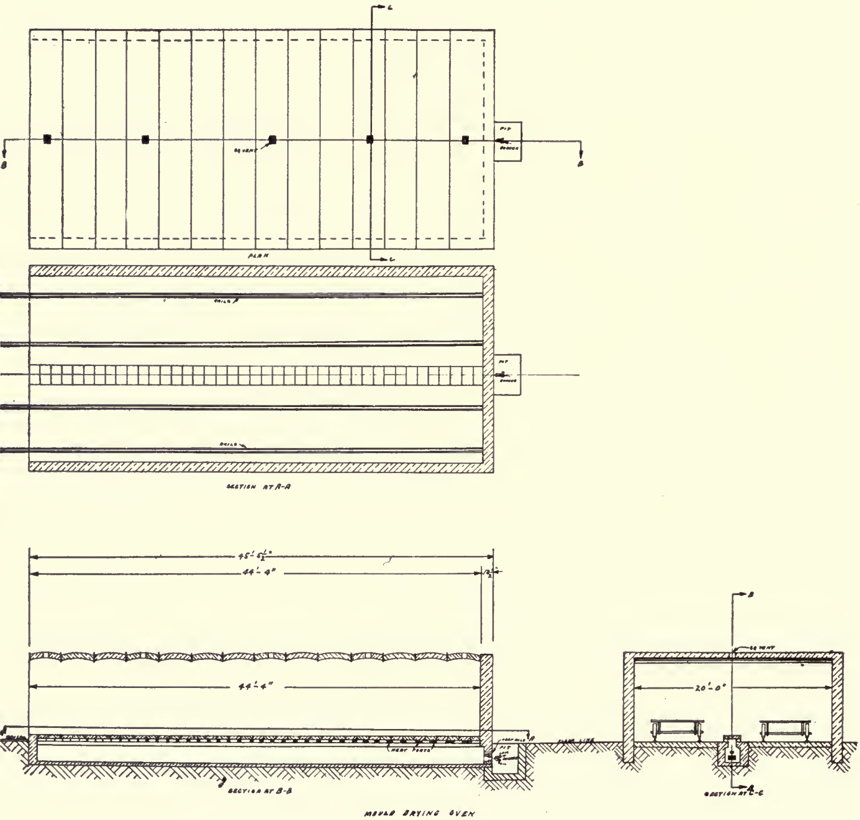


Fig. 1. Oven 44 ft. long, 20 ft. wide and 12 ft. high in the clear operated with one burner.

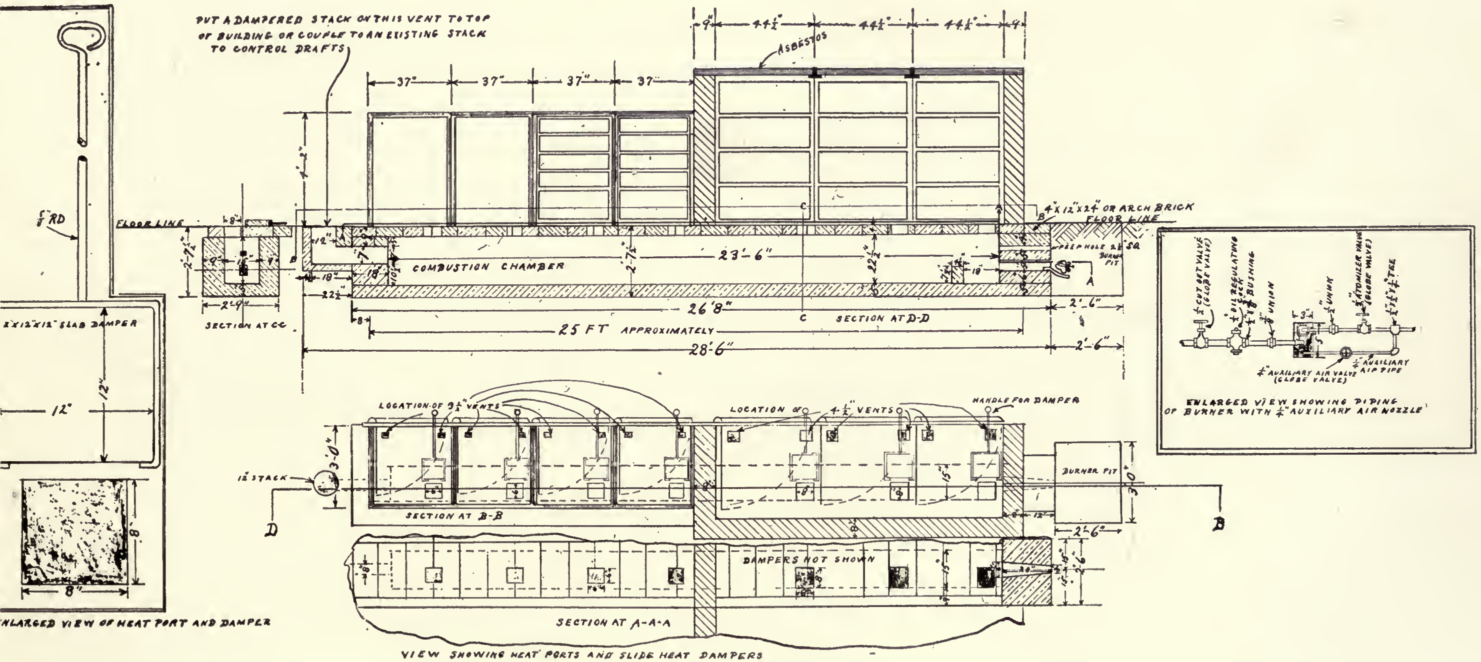
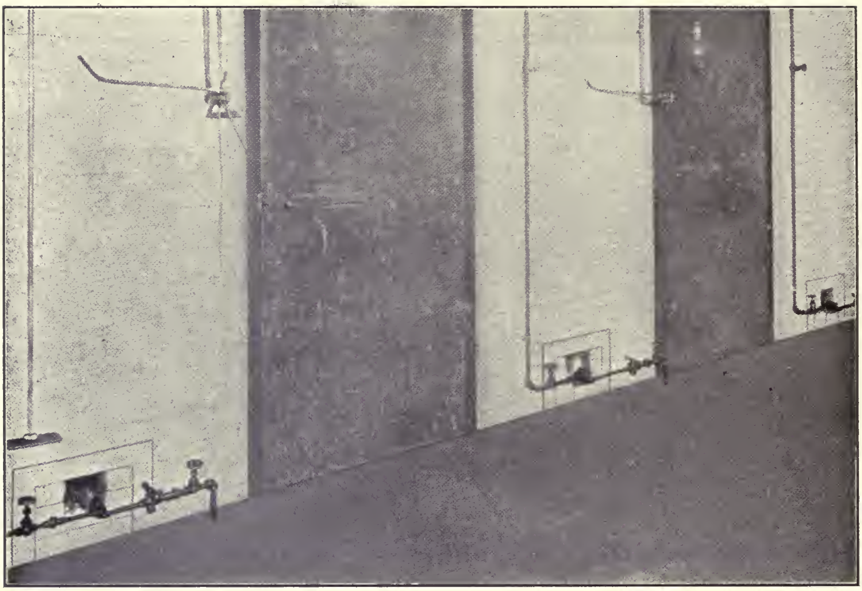


Fig. 2. Equipment of a Battery of Millet Ovens.



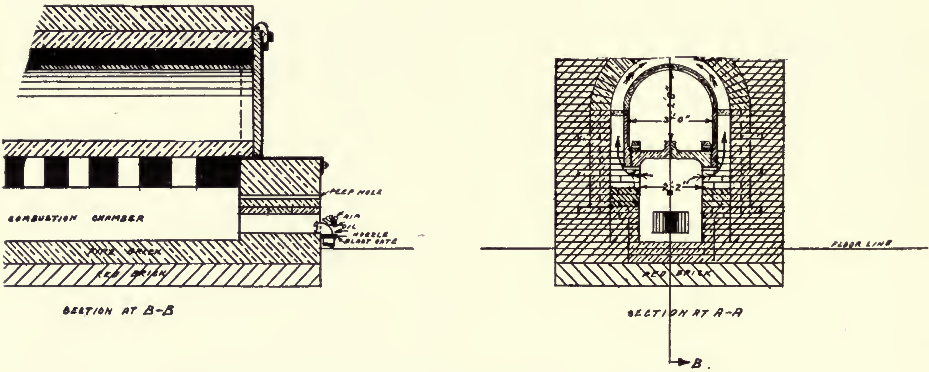
The above cut illustrates manner of equipping an ordinary Core or Mold Drying oven in which coke or coal has heretofore been used. One burner is placed in the former ashpit of each fire box, and the combustion of the fuel is so perfect that no soot ever settles on the cores. The Controlling Valves and Oil Regulating Cock, you will note, are placed in positions convenient for the operator. As the operator has the fire under perfect control, he can dry the material as quickly or as slowly as is desired. Liquid fuel gives a more penetrating heat than coal or coke, and it has been found, that, if desired, as many cores can be dried in twenty-five minutes as in three hours while using coal as fuel.

sure an even distribution of heat. The heat ports at the farther end of the combustion chamber are smaller than those at the burner end. These openings must be carefully figured out for the success or failure of the installation depends largely upon these ports. The vents for the escape of moisture, also the consumed and inert gases, should always be located in the oven roof or arch. Never use the old stack method. Give the money ordinarily spent for the construction of a stack to the poor of the city or to some hospital where it will be of some service to humanity.

The same form of construction as shown in Fig. 1 may be used under long battery of Millet ovens, the heat ports being provided with dampers so that the supply of heat for each individual oven may be controlled according to requirements.

Core ovens and ovens for black japanning are equipped in like manner, but for all light colored japanning the muffle type of oven is necessary in order to prevent products of combustion from discoloring the charge.

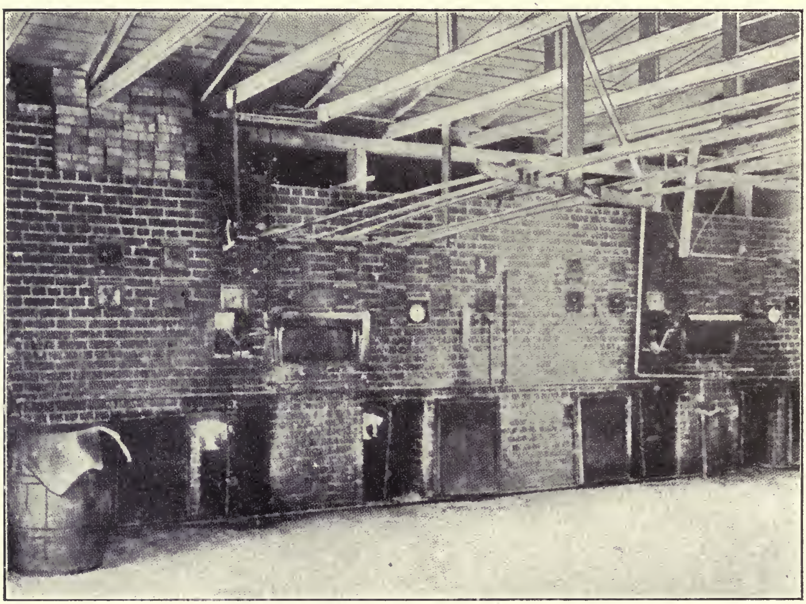
Enameling ovens are of various types. Usually the muffle oven is used, but if not of this form, the oil burner is operated before the charge is put in the furnace. That is, the vessels are



Muffle Furnace for Baking Enamel, Annealing, etc.

charged into the oven after it has been brought to the required temperature and the burner shut off. After this charge has been baked the required length of time, it is removed and the burner lighted so as to heat the oven for the next charge.

Guessing at the temperature of a core or mold drying oven is simply a waste of time, fuel and material. If a recording pyrometer is a necessity on a heat-treatment furnace, certainly it is equally as essential to use a recording heat guage on the ovens so that the actual temperature may be a matter of daily record.



Oil Burning Equipment as Applied to Bread Baking Oven.

The bread, etc. is evenly baked for the baker can always regulate the temperature just as he wishes. No smoke or odor when the oil is properly handled.

CHAPTER VIII.

FURNACES.

It has been said that we are on the eve of a new industrial day in shop practice. Experts have found that many presumably scientifically equipped modern shops have not reached 70% efficiency while many, many plants are not operated above 30% efficiency. The dividends are, of course, no larger than the production efficiency and yet, to the astonishment of the efficiency engineers, the proprietors or officials all seem quite satisfied with the equipment and methods employed as well as the quantity and quality of output. I regret to have to further add that my conclusion after examining the apparatus and methods employed by numerous plants in the burning of liquid fuel is that the average plant does not reach 30% efficiency. Strange as it may seem, the men in charge will point with pride to a furnace modelled after that used by Tubal-cain, who according to the Bible, was this world's first artificer in iron and brass. One can but smile as he listens to them orate about an equipment, which they consider the fruit of their ingenious minds, but which you know has been used for ages and is costing that firm their reputation in the manufacturing world. It is similar to comparing a lathe or drill press made thirty years ago with our modern apparatus. Modern furnace construction is an asset which spells out efficiency and profit while an antiquated type of furnace, constructed by "rule of thumb" is a disappointment and a constant source of expense.

This is the day of specialists. If your eye has been injured, you consult an oculist. If an operation is necessary, the most skilled surgeon is called in and not the old-time family doctor. A square box has its place in the world but even when lined with A-1 fire-brick it does not make a modern oil furnace. Each and every furnace should be carefully designed and constructed to meet the requirements of the shop in which it is placed. As liquid fuel always contains more or less water, there should always be refractory material near the burner, heated above the igniting temperature of the fuel so that after there has been a pocket of water, the heat from the brick will at once ignite the fuel again as soon as it leaves the burner. Again, too, the heat from the refractory material aids combustion. As the products of combustion occupy more space than the fuel and atomizer did, this refractory material or combus-

Furnace serving two Bolt Headers. (Note absence of flame from charging openings). A furnace of this type is often placed between a bolt header and a rivet making machine. In either case, it will serve both machines to the limit of the physical endurance of the operators. If desired for rivet heating in larger quantities, various sizes can be heated at one time.

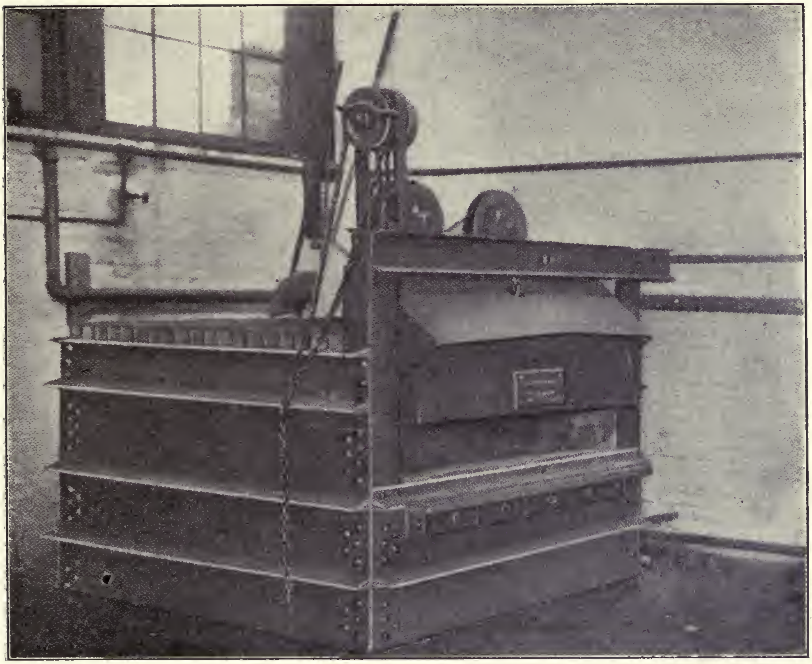
tion chamber should flare, and be proportionate to the size of the furnace; or in other words, of such form and proportions that the consuming fuel can unite with the air necessary for combustion before it reaches the charging space of the furnace. This prevents oxidization of the metal while being heated. Wherever possible only one burner should be used but the flame from this burner must fit the combustion chamber and thoroughly fill it with heat. Oil gives a rolling flame and therefore the arch must be of such form that the flame and heat will reverberate perfectly upon the charging space of the furnace. In many plants the arch unfortunately is the hottest portion of the furnace, but in a scientifically designed welding or melting furnace where the flame and heat reverberate perfectly, you can remove an arch brick, lay it in the charging space and it will be melted down like soap, while the remaining bricks in the arch will not even be dripping. I never recommend the use of a stack except where absolutely necessary as that means you are limited by climatic conditions for we all know a furnace coupled to a stack will not operate as well on a stormy or hazy day as when the sky is clear. It requires 2009 cu. ft. free air at 100 deg. Fahr. to effect perfect combustion of one gallon of the

A large coal-fired forging furnace changed to oil fuel by simply building a combustion chamber of proper form and proportions in the former fire-box and placing a burner at the end of this combustion chamber. With this slight change the operator has now an oil furnace wherein the fire is under perfect control and from which he obtains a maximum quantity of output of superior quality.

When a furnace of this type is changed from coal to oil, the operator almost invariably wishes to operate the furnace just the same as when burning coal. That is, by having an abundance of flame (about 2 ft. high) passing out of the door opening. You might thus run an oil-fired furnace for days without getting a welding heat, but when the oil fire is regulated so that only a greenish haze about 6 in. long passes out of the door, CO_2 is effected and in a few moments in the interior of the furnace can be seen a glow which insures a welding heat, thereby giving not only the highest efficiency from the fuel but also the greatest output from the furnace.

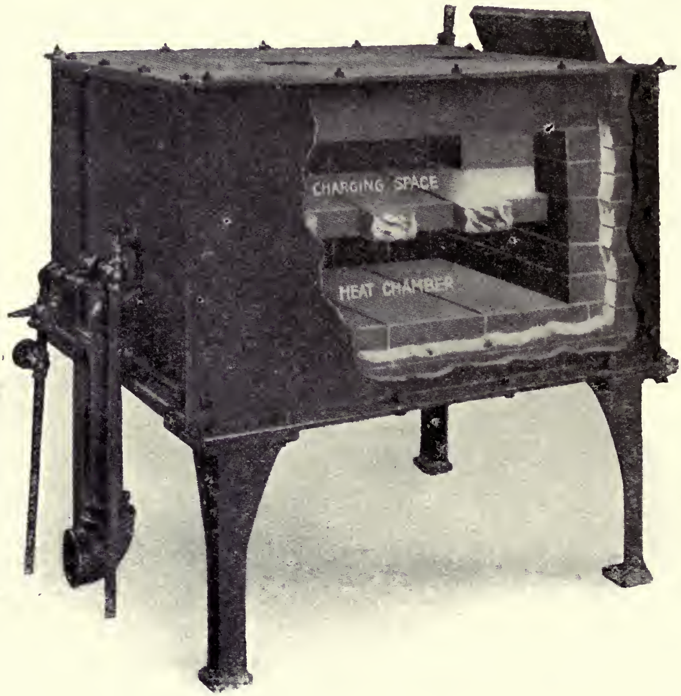
average liquid fuel, but only approximately 20% of this amount is oxygen, while the balance is inert gases which unfortunately must be heated to the temperature of the furnace and expelled as quickly as possible. In a scientifically designed furnace, this is readily done by the aid of the burner. If allowed to pocket or remain stationary in any portion of the furnace, the inert gases cause uneven temperature. If these essential features are all carefully considered, the operator has a furnace in which he can at all times attain and maintain the temperature required, the heat is evenly distributed throughout the entire charging space, and the fuel consumption reduced to the minimum for the full calorific value of each heat unit is utilized.

In the heat-treatment of steel we must remember that the value of the steel depends wholly upon the heat-treatment which it receives. Steel is not like copper, but is a very complex artificial product. In its annealed state a piece of .90 carbon tool steel is composed of ferrite and pearlite, but these minerals are decomposed when heated to certain temperatures and others formed. For example, in heat-treating this tool steel, there is no perceptible change until 1360 Fahr. is reached: but if the temperature is increased to 1460, ferrite

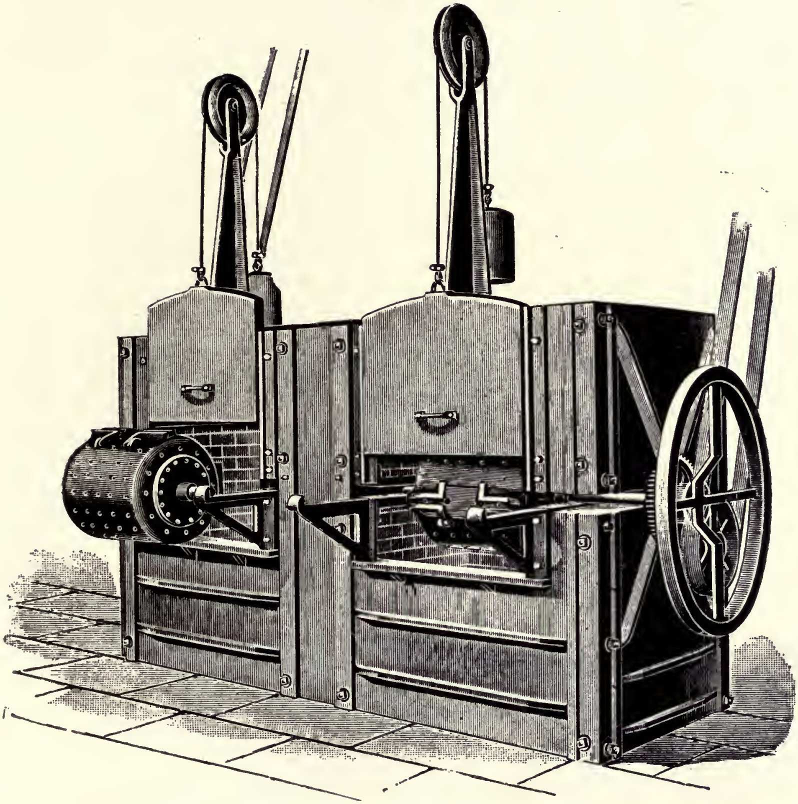


Indirect-fired Furnace.

The fire chamber is below the charging chamber and there are heat ports of graduated size through which the heat is evenly distributed and as the currents of heat are constantly revolving, this insures the expulsion of all consumed and inert gases. This type of furnace is particularly adapted for annealing, case-hardening and tempering for by optical pyrometer test the temperature does not vary over ten degrees Fahr. in any portion of the charging space.



View showing how the heat in an indirect-fired furnace passes from the heat chamber through graduated heat ports of such size and location that the temperature is absolutely even throughout the entire charging space. As long as the fuel and atomizer supply remains constant, the burner, without any adjustment, will operate for hours without the slightest variation in the temperature of the charging space. This type of furnace is used for all classes of annealing, case-hardening and tempering where the metal must be kept away from direct flame.



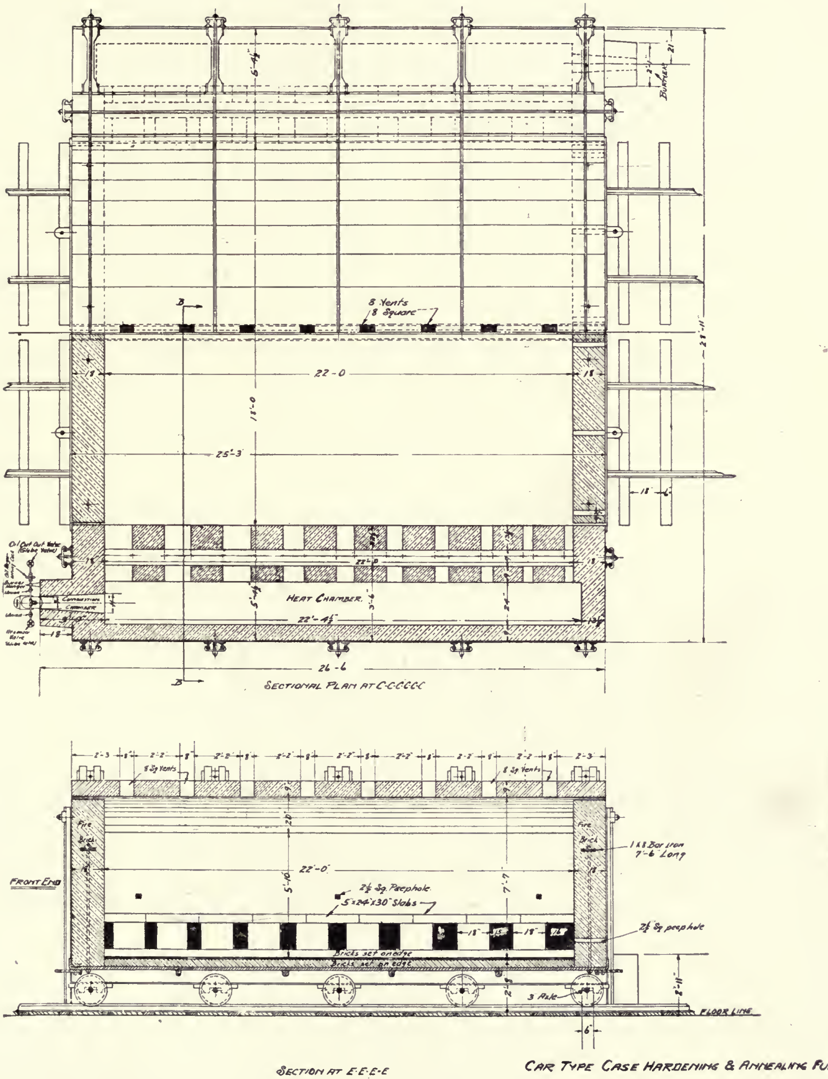
Double Shell Annealing Furnace.

The two ovens are heated from below, and the perforated cast iron drums are revolved by power. The drums are rolled out on the brackets in front to charge or empty the shells.

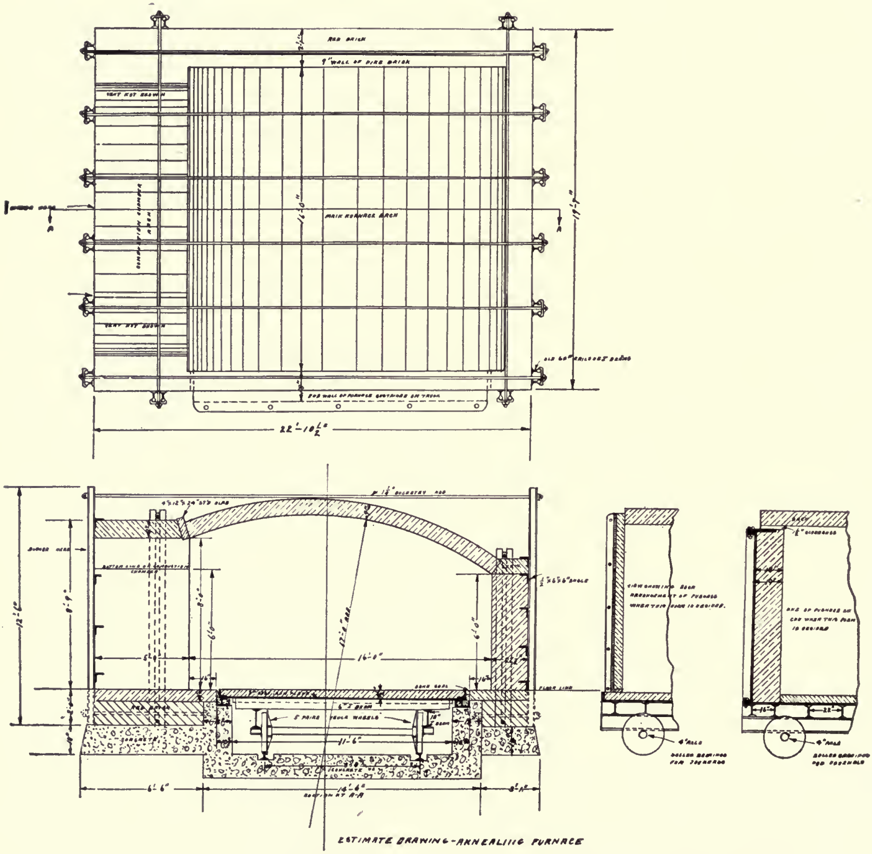
and pearlite have been decomposed and martensite is formed. Quenching at this point preserves the martensitic condition and the metal is hard and brittle. In carbon steel, martensite is very sensitive to heat and decomposes readily, i. e., if the steel is heated sufficiently, martensite disappears and ferrite and pearlite are again formed. For every variation of heat, there is a variation in the grain of the metal. This steel anneals between 1300 and 1350 deg. Fahr.

How important it is therefore to have a furnace of such construction that the temperature in any portion of the charging space does not vary more than 10 deg. Fahr.

For the average size indirect-fired furnace, only one burner should be used, but for a furnace approximately 18 ft. wide, 22 ft. long x 7 ft. high, two burners are required. More than two burners should not be used for it is impossible to regulate a larger number of burners so as to have the heat as evenly distributed throughout the entire length and width of the furnace as it should be in order to perfectly heat-treat the metal. If this is important in the annealing or tempering of steel, it is equally as essential in the case-hardening of metals.

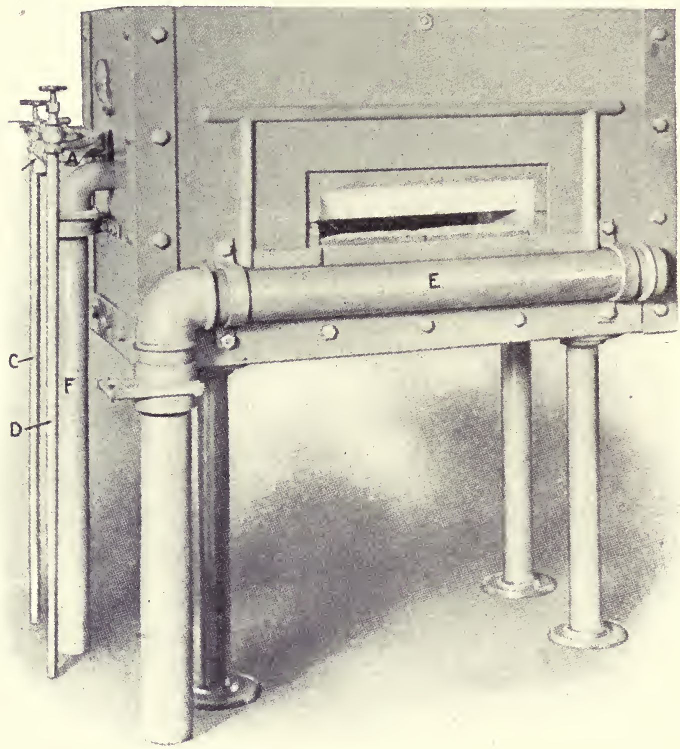


Indirect-fired Car Annealing Furnace (18 ft. x 22 ft. x 7 ft.) The end walls of furnace being carried on the cars, it is a very simple matter to pull them in or out of the furnace. While two cars are being heat-treated, others are being charged.



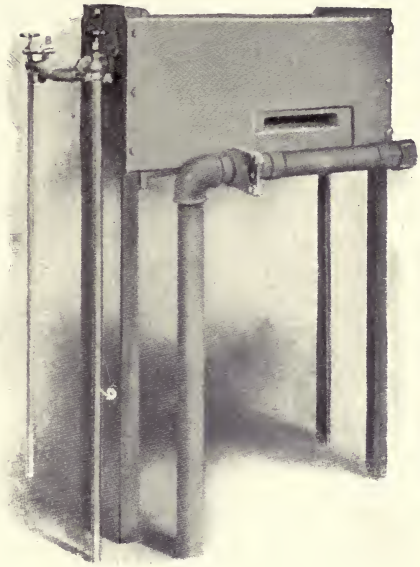
Overhead Oil-fired Car Annealing Furnace operated with only one burner.

An indirect-fired furnace is not suitable for the heat-treatment of high speed alloy steel for this requires a much higher temperature than carbon steel. As the temperature should be above 2000° Fahr., I recommend a direct-fired furnace having combustion chamber of such form and proportions as to insure the ignition of the oxygen necessary for perfect combustion with the atomized fuel before it reaches the furnace proper, thereby reducing the oxidization of the metal to the minimum.



A—Oil burner. B—Oil regulating cock. C—Air pipe. D—Oil pipe.
E—Deflection blast pipe. F—Auxiliary blast.

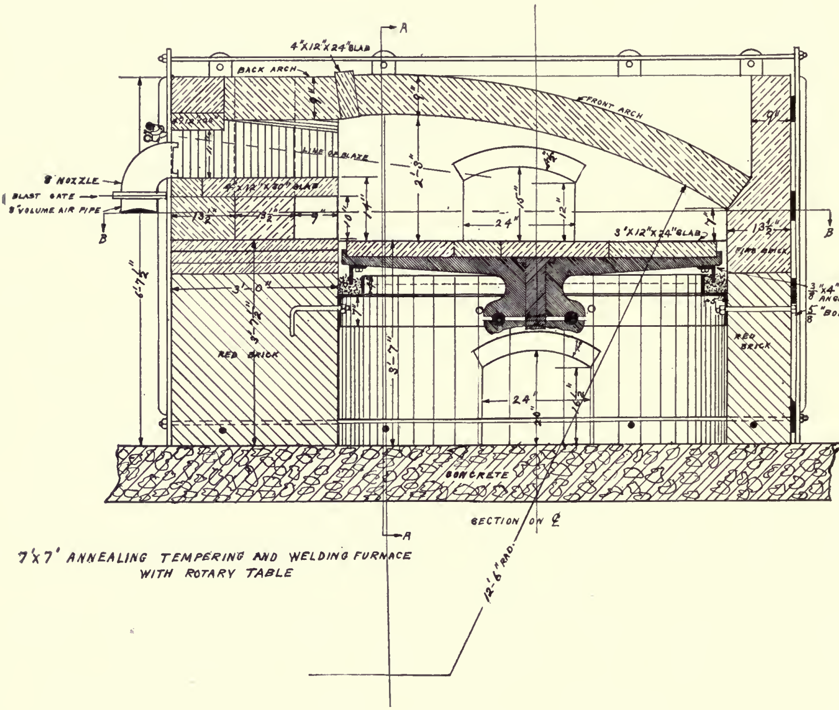
Furnace often used for dressing drills and other high speed steel tools. It is also valuable for a wide range of forging in smith shops, etc. Placed between two bolt heaters, a furnace of this type with charging opening on each side, will serve both machines to the limit of the men's ability to handle the blanks. A furnace with two charging openings will produce double the output of the same size furnace with only one opening, with increase in oil consumption of less than 30%.



A—Oil burner. B—Oil regulating cock. C—Oil pipe D—Air pipe.
E—Deflection blast.

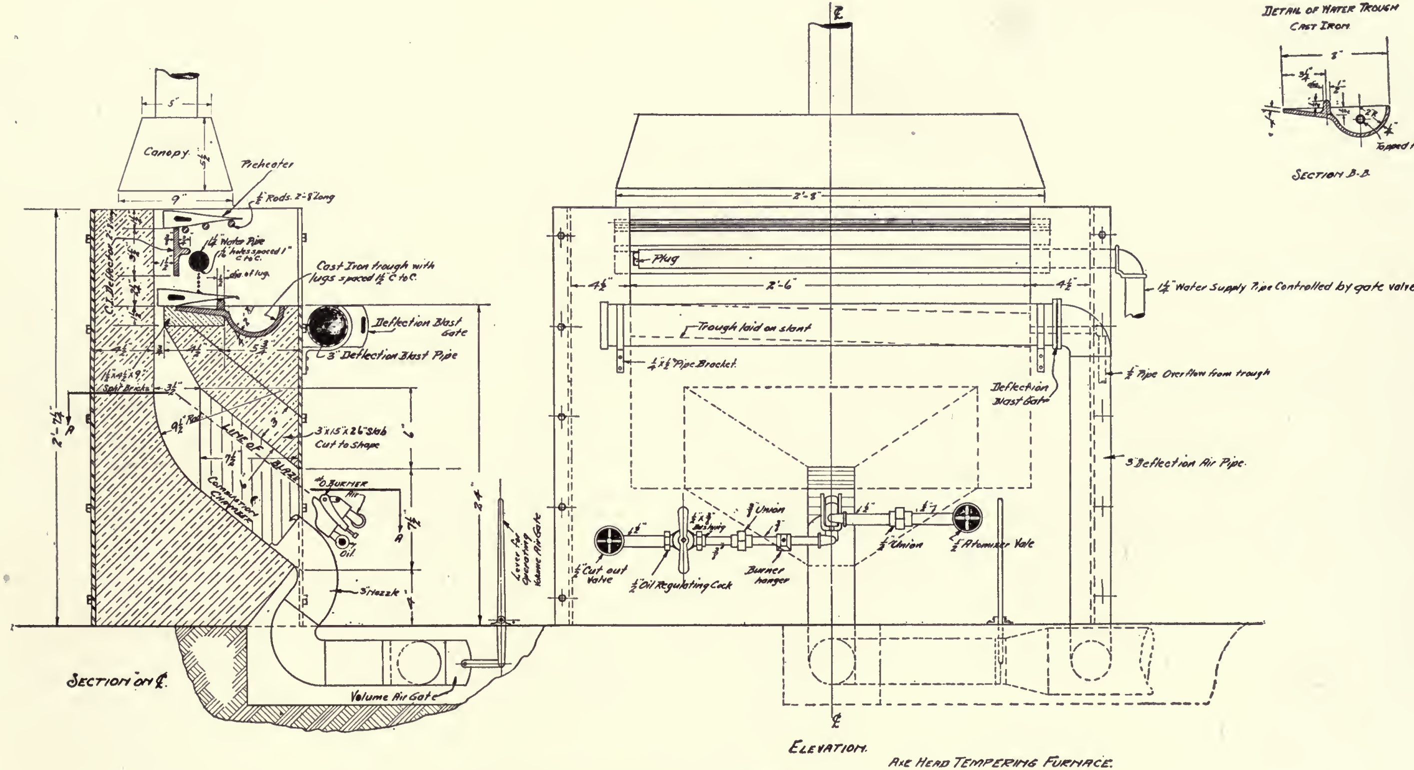
Furnace designed for dressing and tempering high speed tools, (60 carbon upwards), such as lathe, planer, shaper, slotters, chisels, flats, capes, etc.

Instead of the blacksmith heating but one chisel at a time as is the case while using a coal forge, with this furnace seven chisels can be heated at once without injury to the metal. The heat being held at the required temperature constantly, a much superior tool is produced than could possibly be made by the use of coal or coke. A forging heat can be obtained eight minutes after starting the cold furnace and it is not necessary to speak of the output as that is up to the endurance of the man operating the furnace. There is no waste of fuel while the furnace is not in use.



7 ft. x 7 ft. Annealing Furnace with Rotary Table.

By means of differential gears the speed of the table is regulated according to the size of the stock being heat-treated, so that when the table has made one revolution, the charge is ready to be removed from the furnace.



Axe Head Tempering Furnace, the capacity of which is 2,000 per day.

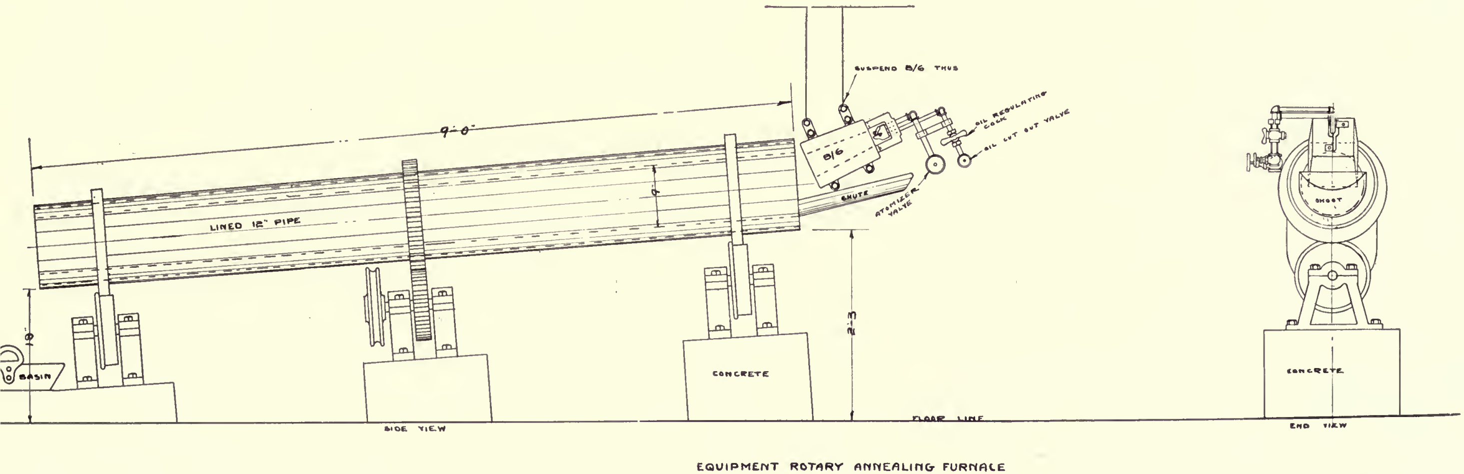
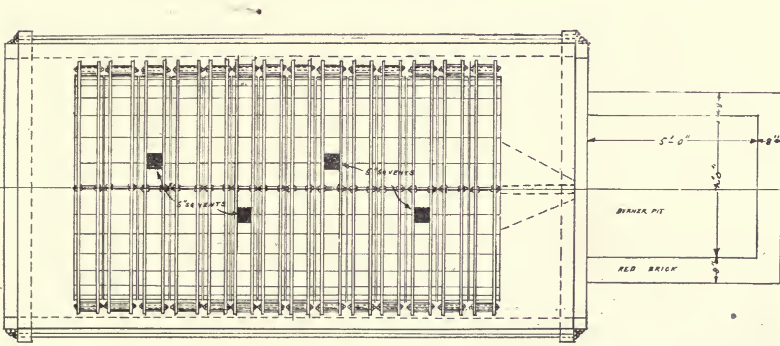
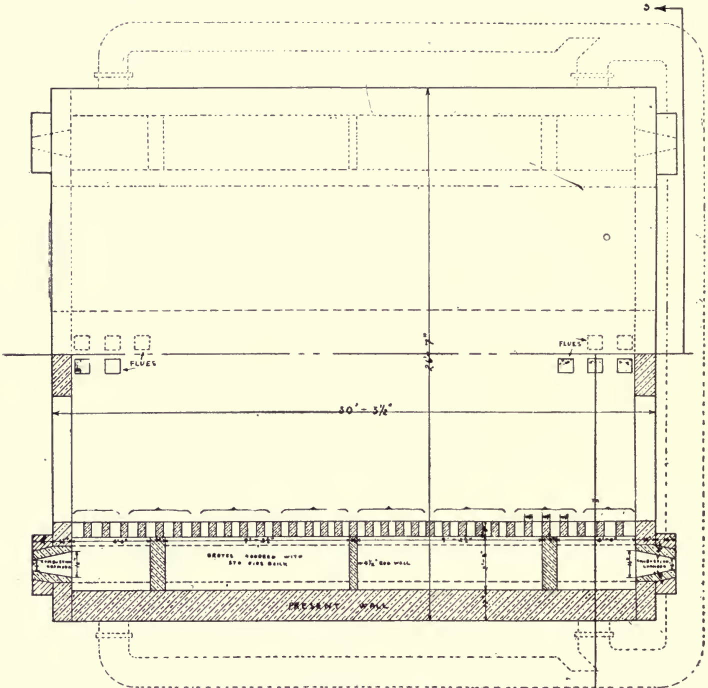


Fig. 2. Rotary Furnace for annealing cold punched nuts, or cold headed rivets and bolts. The product is charged into the ute at the burner end, annealed while passing through the revolving furnace and then dropped into the hopper.

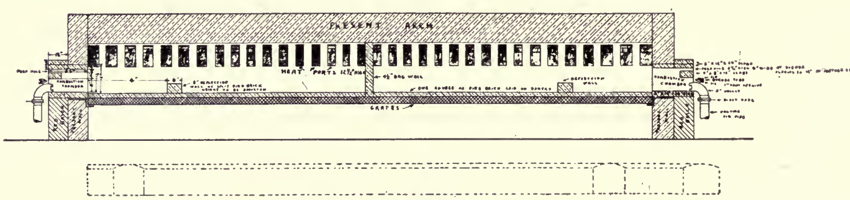


PLAN

Fig. 1. Semi-pit Furnace for Annealing, Case-hardening or Heat-treating, with bung arch which can be removed with a crane or by air hoist. This furnace, operated with one burner, has charging space 12 ft. long, 5 ft. wide x 4 ft. high.



SECTION AT B-B



SECTION AT A-A

For the annealing or heat-treatment of sheet copper or brass in rolling mills, it is essential that the furnace be accurately and evenly heated, and for this purpose, oil, scientifically applied, is a fuel which connot be surpassed. In a furnace, about 8 ft. 6 in. wide by 30 ft. long, two burners should be installed, while for a smaller furnace only one burner is required. I know some firms have equipped these furnaces by installing a large battery of burners, but the results have always been unsatisfactory as the complicated operation of all these burners is simply a source of worry to the operator.

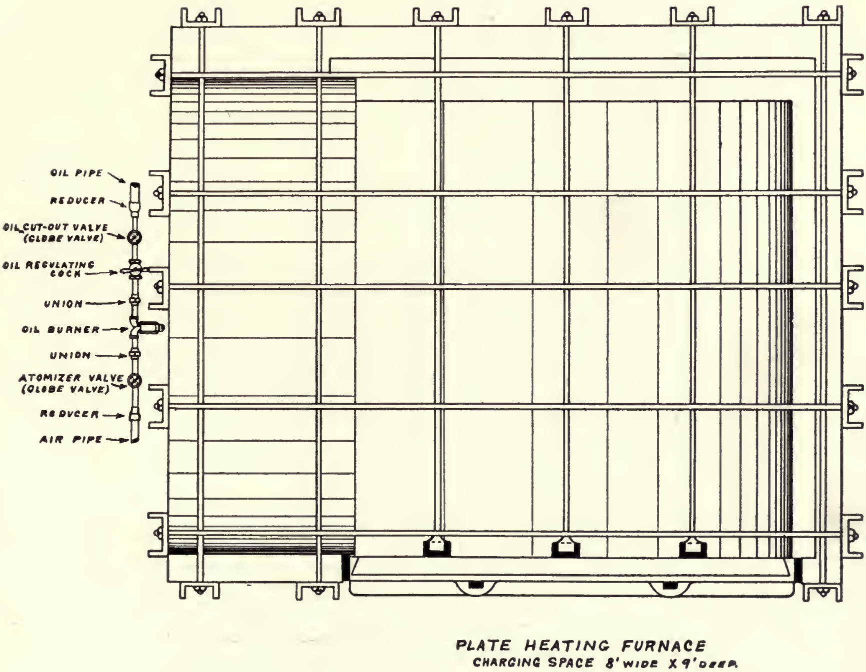
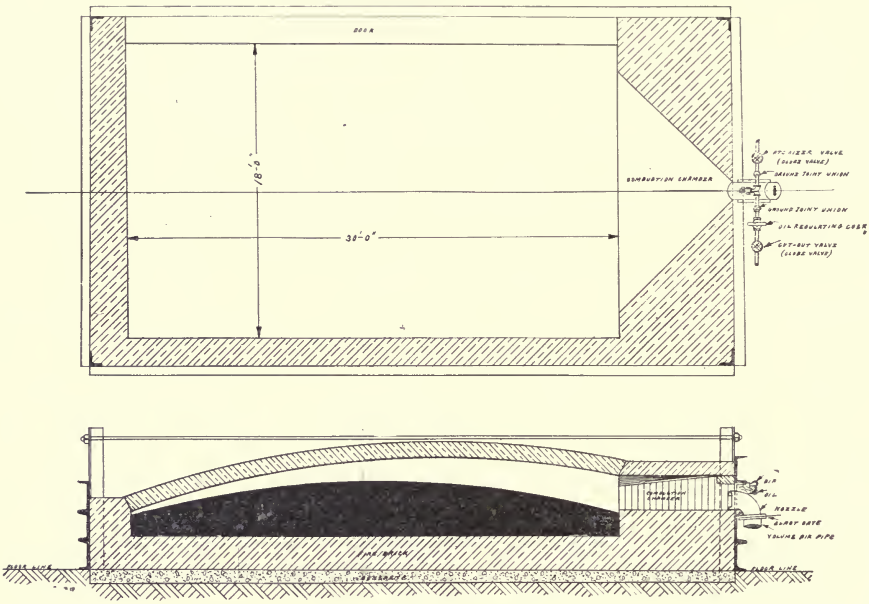


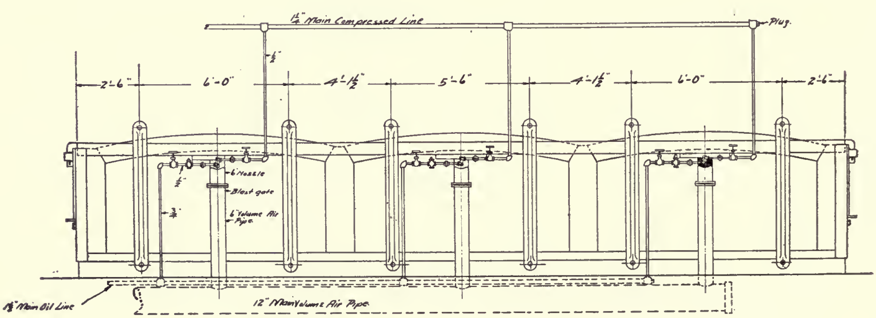
Plate Heating Furnace, charging space 8 ft. x 9 ft.



18'-0" x 30'-0" PLATE HEATING FURNACE

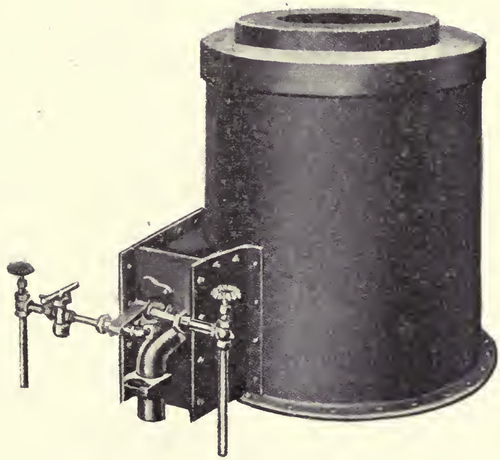
Plate Heating Furnace, charging space 18 ft. x 30 ft.

This furnace, equipped with only one burner, shows the size of furnace which can be successfully operated with a burner which distributes a blanket of flame evenly throughout the entire length and width of the furnace.



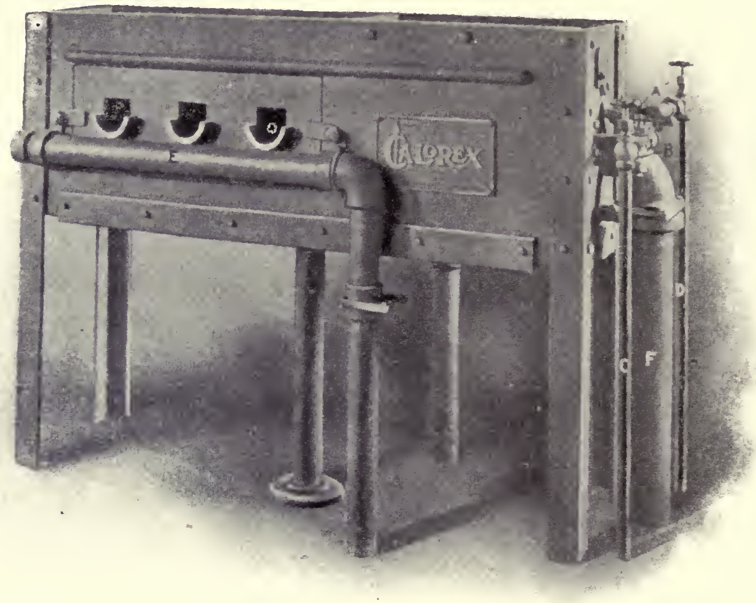
BURNER END VIEW.

In some places it is advantageous to have a plate heating furnace in which plates of various lengths can be heated. In the furnace shown above there are two bag-walls. That is, when only short heats are required, the first burner is used. For longer heats the first bag-wall is removed and two burners are used. For full length heats both bag-walls are removed and all three oil burners are operated.



Lead, Oil or Solution Bath Furnace.

For small deep pots the best results are obtained by placing the burner tangentially so that the flame and heat will encircle the pot and not impinge upon any portion of it. For larger or more shallow baths, it is a very simple matter to construct a combustion chamber proportionate to the size of the bath, but care must be taken to have the heat ports and combustion chamber such that the temperature in any portion of the bath will not vary over twenty-five deg. Fahr. Oil is ideal for this class of service for after the burner has once been adjusted, the bath can be constantly kept at the required temperature.



A modern flue welding furnace, the capacity of which is 60 welds of safe ends on 2-in. or 2¼-in. locomotive boiler tubes per hour, while with a coal forge 16 flues per hour is considered good practice. With either fuel the blacksmith requires two helpers, the difference being that with coal a blacksmith has to work much harder than his two helpers do, for he must keep turning the flue or he will burn a hole in it and he must constantly be putting on borax and sand or other welding compounds, whereas in this modern oil furnace his helpers can charge and remove the flues, no welding compounds being necessary. Three flues (instead of only one) are charged at a time. Oil welded flues are not water-tested as the welds are all perfect, there being no corrosion or oxidation of the metal. No time lost while waiting to renew or coke the fire. 58 gallons of oil are equivalent to a ton of good bituminous coal in this class of service. When a smith, who all his life has been using coal for this class of work, discovers these facts, he concludes that oil is the marvel of the 20th century. A shop still using coal for this class of work is hopelessly behind the times and cannot expect to compete with its more modern neighbors.

Flue welding furnaces are usually supplied with extra slide plates so that for welding larger size flues, the plates with the small openings can be removed, the plates for larger size flues put on and the openings in the brickwork cut to the required size. In handling 6-in. superheater flues ordinarily only two flues are welded at a time.

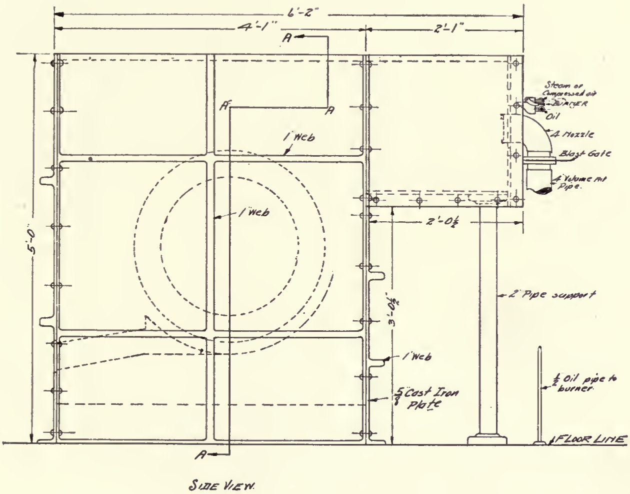
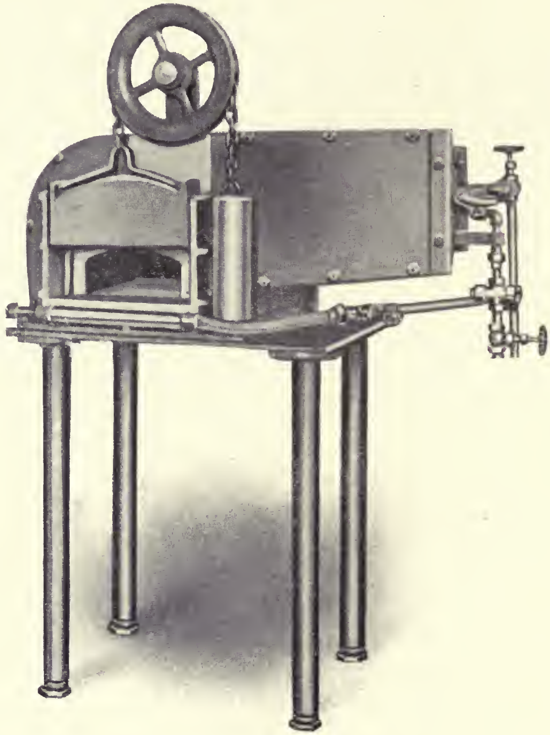
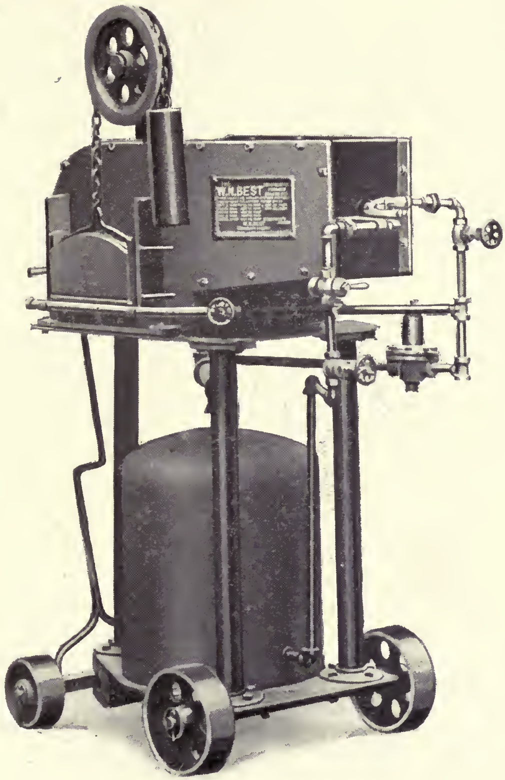


Fig. 2. A Pipe Welding Furnace operated with one burner and used for welding a flange on 20 in. pipe, for van-stoning, etc.



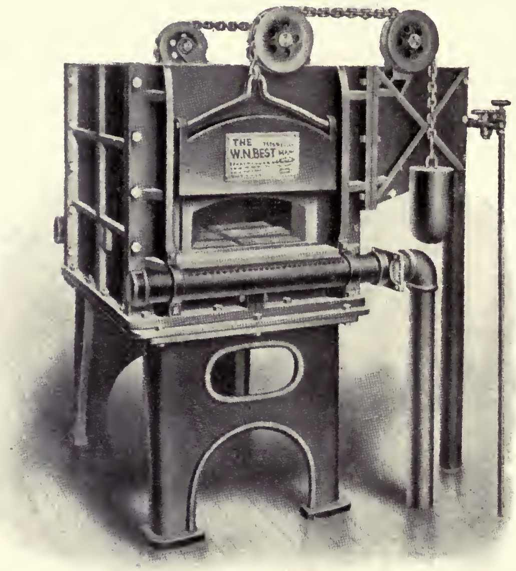
A small furnace which is used for a wide range of work in small shops. For instance, in many plants one of these little furnaces is used for forging, rivet heating, annealing, hardening dies, dressing high speed steel tools, and by placing a muffle in the charging space it is used as a muffle annealing and tempering furnace. It heats rivets uniformly and on 2½ gallons of oil per hour is equal to four coal forges, the maximum capacity being eight thousand ¾-in. x 3-in. rivets per day (ten hours).

Either compressed air or dry steam can be used to atomize the fuel. The burners on about 60% of these furnaces are operated with steam.



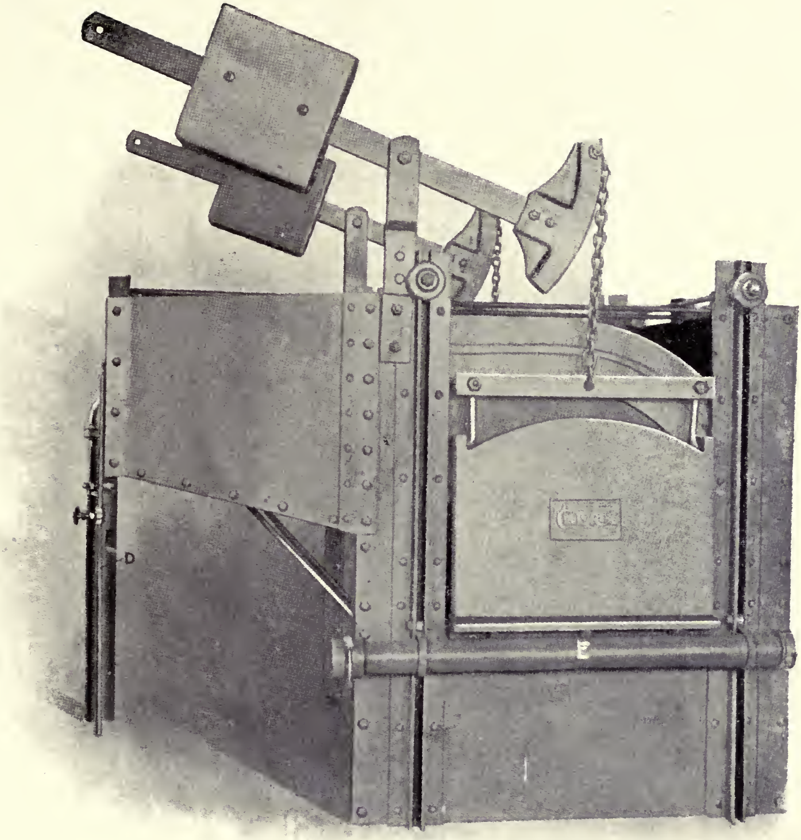
A self-contained portable outfit with 20 gallon oil tank, which can readily be moved around from place to place and which is used for heating 8,000 ¾-in. x 3-in. rivets in ten hours, as well as for forging, tool dressing, etc. Very convenient for small work in shops not equipped with the regular oil system as well as for work where portable outfit is necessary.

Compressed air at pneumatic tool pressure is used to operate this outfit. That is, the full pressure is used through the burner to atomize the fuel and distribute the heat, and through the deflection blast in front of the charging opening to deflect the heat from the operator and to retain it in the furnace, but the air used on the tank to force the oil to the burner is reduced from pneumatic tool pressure to 12 lbs. as it passes through a pressure reducing valve. This device is most essential to prevent excessive pressure on the oil tank and safe-guard human life.



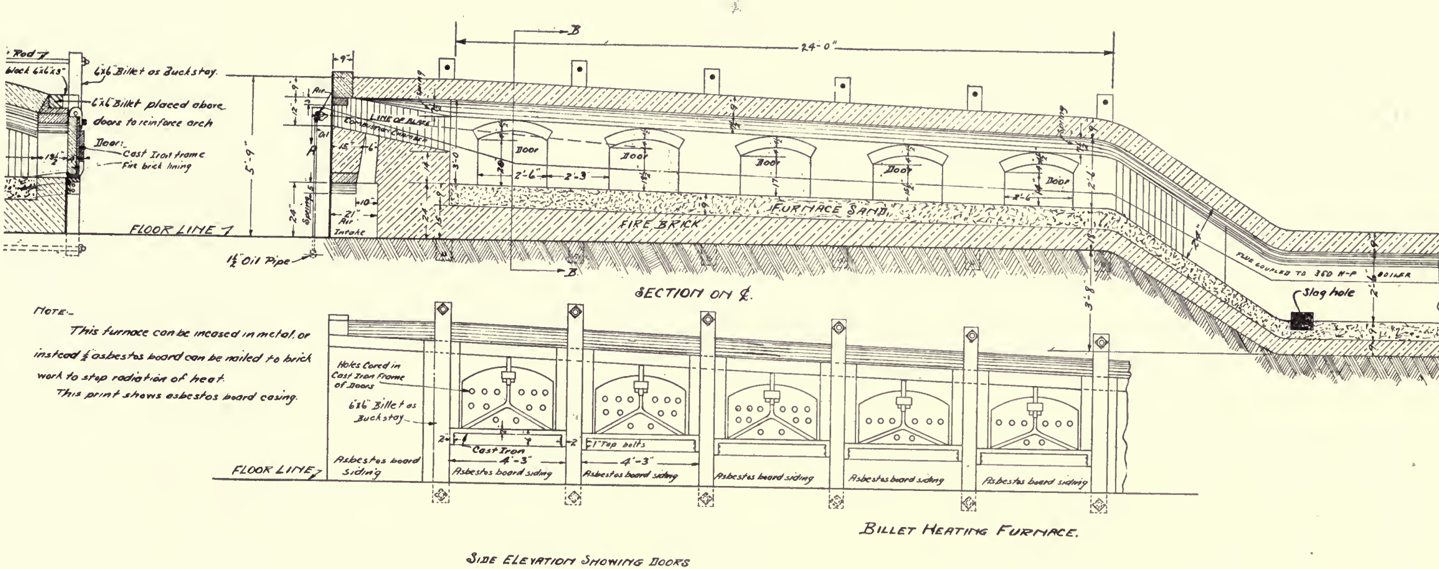
Drop Forging Furnace.

The man or firm who intends to continue in business and compete with modern methods must of necessity use liquid fuel for the manufacture of drop forgings as with this can be produced the maximum quantity of output of superior quality in minimum time. Anyone who has used oil as fuel quickly notices the softness of the heat. That is, oil produces a penetrating heat so that the metal is thoroughly heated throughout its entirety, while that heated with coal, coke or gas is subjected to an abrasive heat so that the outside of the blank or forging is heated much hotter than the center. Because of the penetrating heat produced by liquid fuel, oil heated blanks and forgings are forged quicker, with less power, and there is also a saving on the dies. Furnaces for this purpose should be of such design that the heat will be evenly distributed throughout the charging zone and a proper size combustion chamber used to reduce the oxidization of the metal to the minimum.



D—Oil pipe E—Deflection blast pipe F—Auxiliary blast

A 12-in. billet (charged into this furnace after it has been shut down over night) can be brought to a forging heat in 45 minutes. A 10-in. square ingot or billet can then be brought to a forging heat in 32 minutes. This furnace is used for annealing, tempering, heating, forging and welding large billets, shafts, etc. As there are two charging openings opposite one another, heats can be taken on any portion of long shafts or billets. In many plants this furnace is operated with compressed air as long as that is available. When the air is needed for pneumatic tools, etc., by simply opening a by-pass valve, steam at boiler pressure is used to atomize the fuel. Either steam or volume air (at from 3 to 5 oz. pressure) is used through the deflection blast in front of the charging opening to deflect the heat from the operator and retain it in the furnace.



An 8 ft. x 24 ft. furnace used for years in rolling mills or large blacksmith shops, where they have to use all kinds of scrap iron which must be brought up to a welding heat before passing through the rolls or forged under the steam hammer. Only one burner is used, but this, giving a fan-shaped flame and used in conjunction with a combustion chamber of proper size, causes an even distribution of heat throughout the entire length and width of the furnace. The waste gases, passing up through a 350 H. P. vertical water-tube boiler, are utilized for the generation of steam.

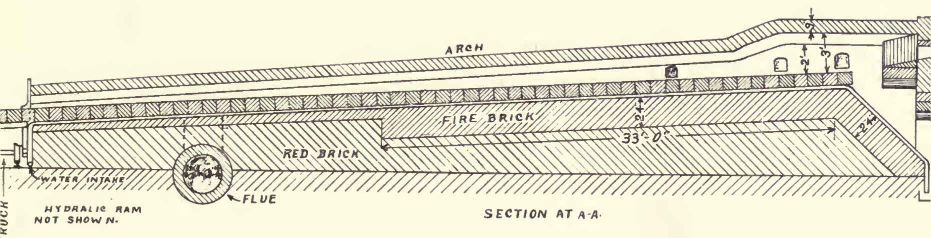
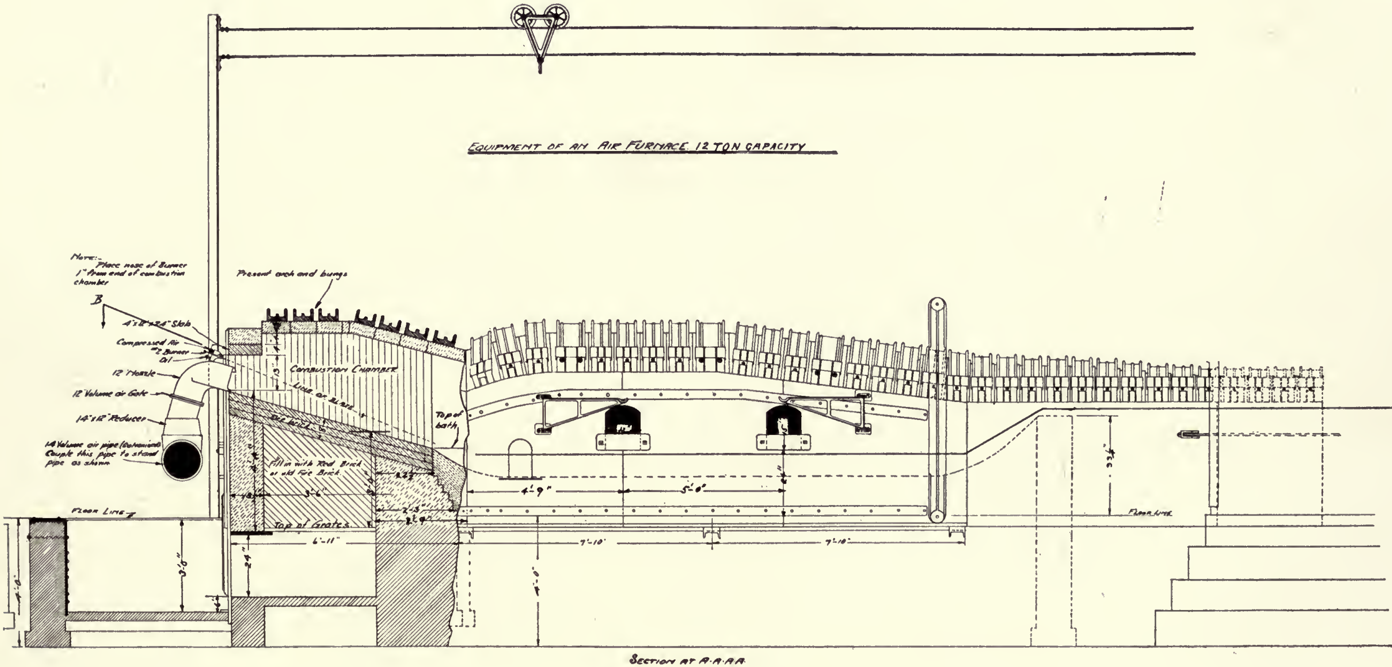


Fig. 1. A Continuous Billet Heating Furnace, 66 ft. long, 10 ft. wide, in which two rows of 12 in. square ingots 40 in. long are heated.

Many attempts to burn liquid fuel in Air Furnaces have failed because of the operator not being able to melt the full charge or to get the metal as hot as when burning coal. Often the charge was oxidized to such extent that what metal did become molten was practically worthless. Usually a number of burners, each giving a round flame, have been placed in the side wall of the furnace, and as the number of burners was increased the equipment became more and more intricate. Something had to take the blame for the wasted time, material and effort, so oil was condemned as being unworthy of further consideration.

As oil has a much higher calorific value than coal the natural conclusion is that it ought to be able to melt the metal in a much shorter period of time. Not only that, but it should also be able to bring the metal to the temperature required for even the smallest castings. It can do both if properly applied, and furthermore, the quality of the metal is improved, for by chemical analysis and numerous tests, it has been found that the castings contain no more sulphur than the metal did when charged into the furnace, and the tensile strength is consequently greater than that of metal melted by coal fire. As the melter has the furnace under perfect control, the heats can be



12 ton Air Furnace operated with one burner.

taken off much quicker than while burning coal, and the temperature of the charge while being tapped can be maintained without varying more than 25 deg. Fahr. until all the charge has been run from the furnace. The operation of skimming is materially decreased—this is a very noticeable improvement which is especially appreciated by the melter. The high calorific value of oil also enables the melter to estimate within a few minutes as to the exact time when the charge will be ready to tap, which is a great contrast to conditions while burning coal especially in rainy weather when climatic conditions are unfavorable and the stack draft is materially affected.

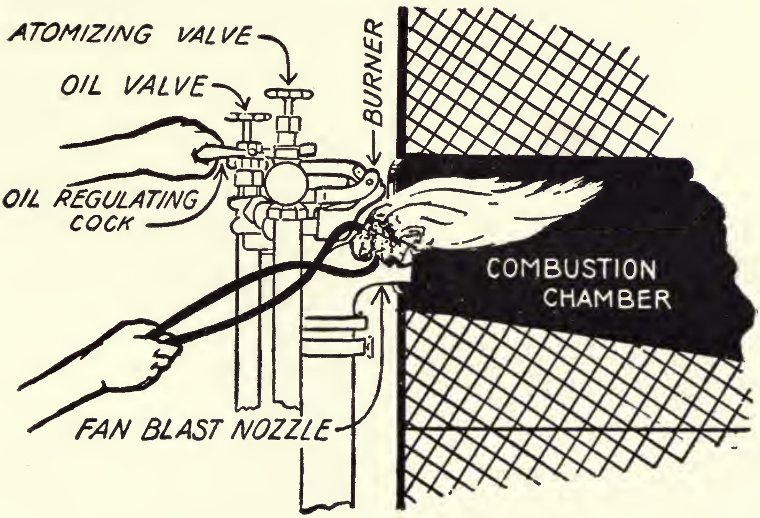
The change from coal to oil is a very simple matter. In the original fire-box I construct a combustion chamber of such form and proportions that the air necessary for perfect combustion can unite with the atomized fuel before it reaches the furnace, which prevents oxidization of the charge. Also this chamber causes the heat to be deflected upon the entire surface of the bath. In the end of the combustion chamber I place a hydro-carbon burner which makes a fan-shaped blaze, filling the entire chamber with flame. A very small quantity of compressed air is used through the burner to atomize the fuel and distribute the heat, while the balance of the air necessary for perfect combustion is supplied at from 3 to 6 oz. pressure through a volume air nozzle.

The furnace is charged in the usual manner. The burner is started by opening the air valve, holding a piece of burning waste (which has been well saturated with kerosene) by means of a pair of pick-up tongs under the burner and then turning on the oil. The operation is so very simple that one must see it in order to appreciate that you can get as intense heat with it in a few minutes as from burning coal for several hours.

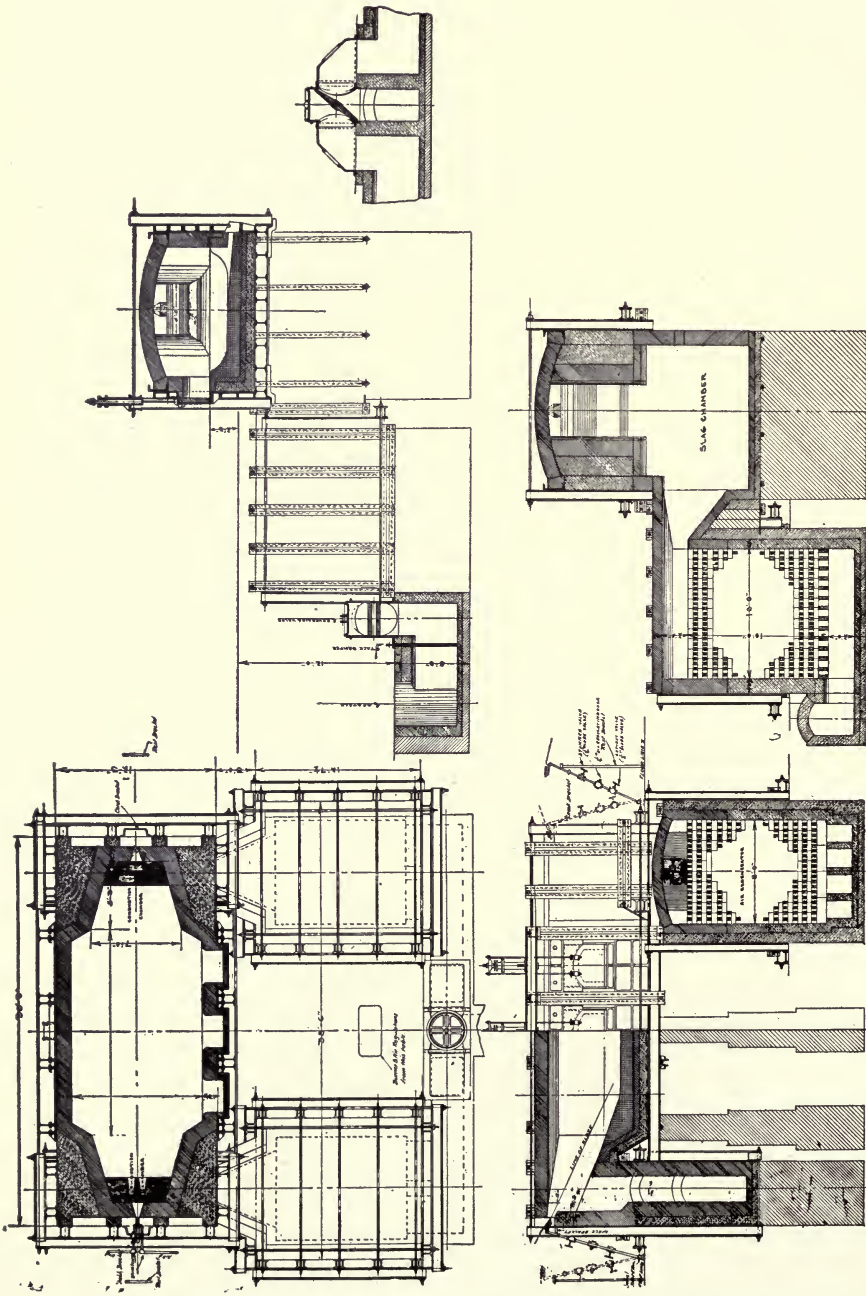
The reduction in the time required to get the charge ready for tapping is not the only point wherein oil is more economical than coal. There is no handling of fuel and ashes consequently the services of the fireman and coal passers are dispensed with. There is great saving in floor space, for the oil tank is placed underground and the former coal bins used for other purposes. The fire-brick lining of the furnace lasts 20% longer than with coal. Poor castings or imperfect ones caused by the metal being cool or sluggish are obviated entirely, for with liquid fuel, the question is not "How hot can you make the metal," but "How hot do you wish it." All these items should be taken into consideration when comparing the relative costs of using oil and coal in air furnaces.

During years of close observation, I have particularly noticed one point in this class of service. It is this. Using the combustion chamber herein described, a burner giving a flame to fit this combustion chamber and admitting volume air through an air nozzle located below the burner, insures not only the hottest portion of the furnace being where it is most needed, viz.: the bath or charging space, but also the elimination of the detrimental effect of any sulphur which may be in the oil or tar. This is accomplished with this construction for the following reason,—the air admitted between the flame and the bath or charge must pass through the atomized consuming fuel and thus the sulphur is consumed before it reaches the furnace proper. The gases rising therefrom being lighter, quickly ascend to the arch of the furnace. If, however, the air is admitted around the burner or above the burner, and no combustion chamber is used, the sulphur is not consumed in the manner above described, but is absorbed by the metal.

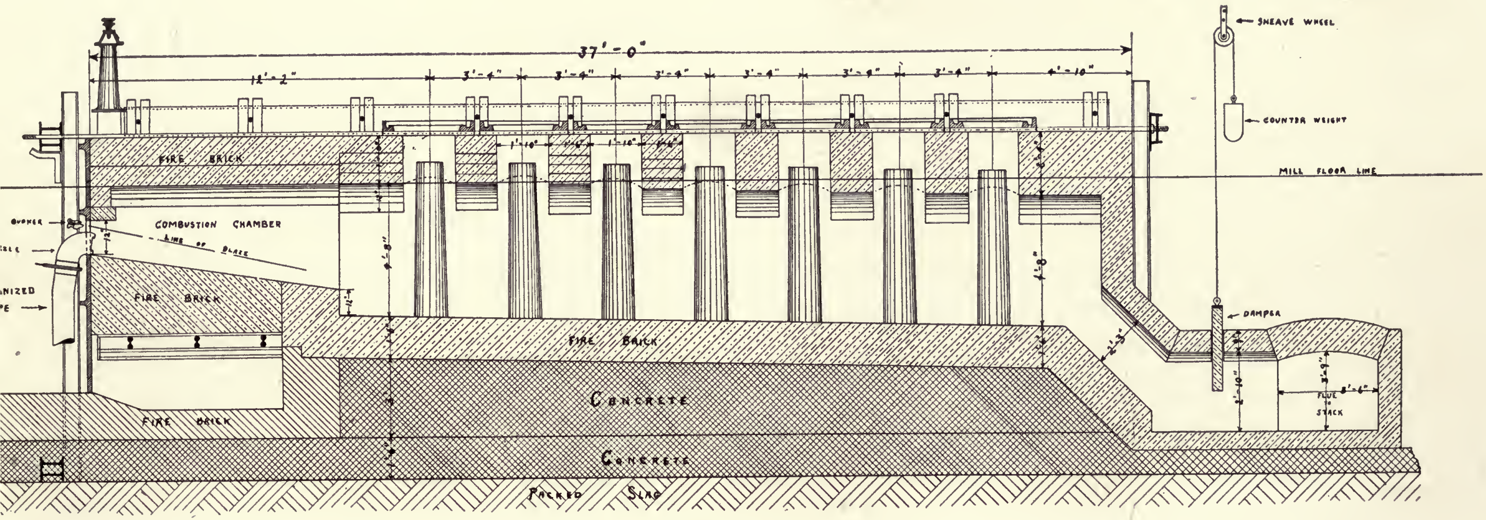
Strange to relate, the first air furnace in which oil was successfully burned was located on the identical spot where the first malleable iron was made in the United States by Seth Boyden at 28 Orange Street, Newark, New Jersey.



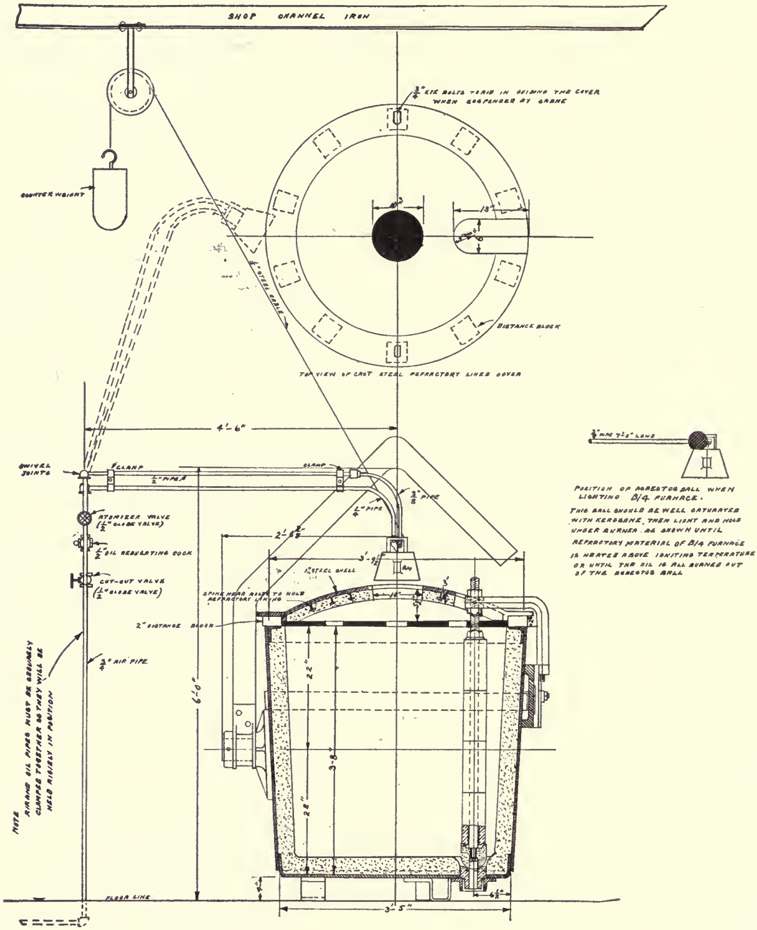
Proper place to hold torch when lighting a furnace burner.



A modern oil-fired open-hearth furnace. Note the admission of air immediately under the burner. The end of the furnace should be carefully constructed so that the flame made by the burner will fit it. The operating valves may be located close to the burner or wherever they are most convenient for the operator.



Steel Foundry Soaking Pits changed from coal to oil-fired.



B/4 FURNACE HEATING 10,000 LB. BOTTOM POUR LADLE FOR STEEL

A 10,000 lbs. bottom pour ladle in steel foundry heated by a furnace which can be swung up and out of the way as soon as the ladle has been brought to the temperature required. The cover is then removed and the ladle placed in position to receive the charge.

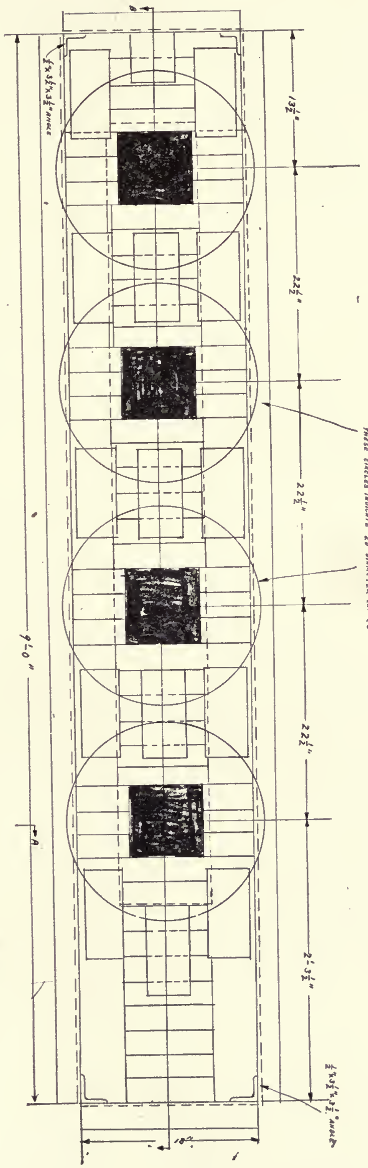


Fig. 2. A Ladle Heating Furnace with which four Bull Ladles are heated with one burner.

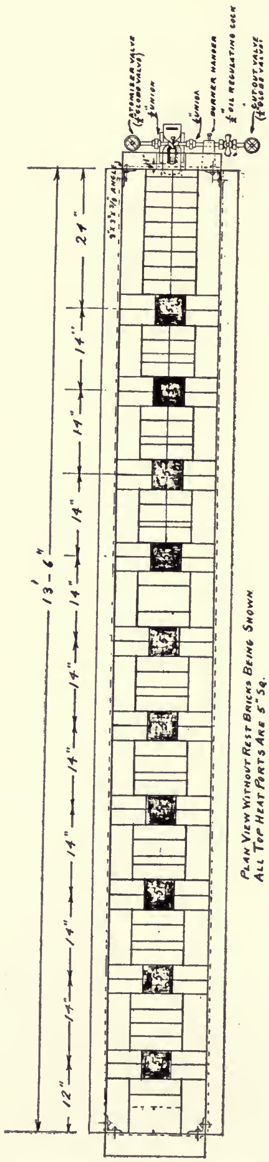
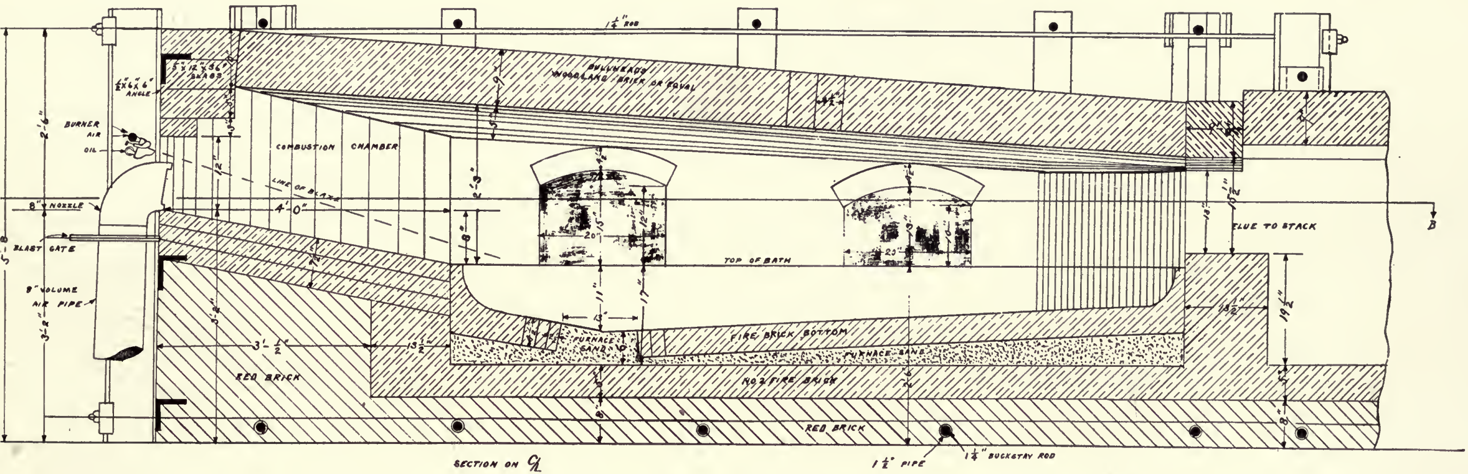


Fig. 1. A Multiple Ladle Heating Furnace used for heating ten ladles at a time and operated with only one burner.

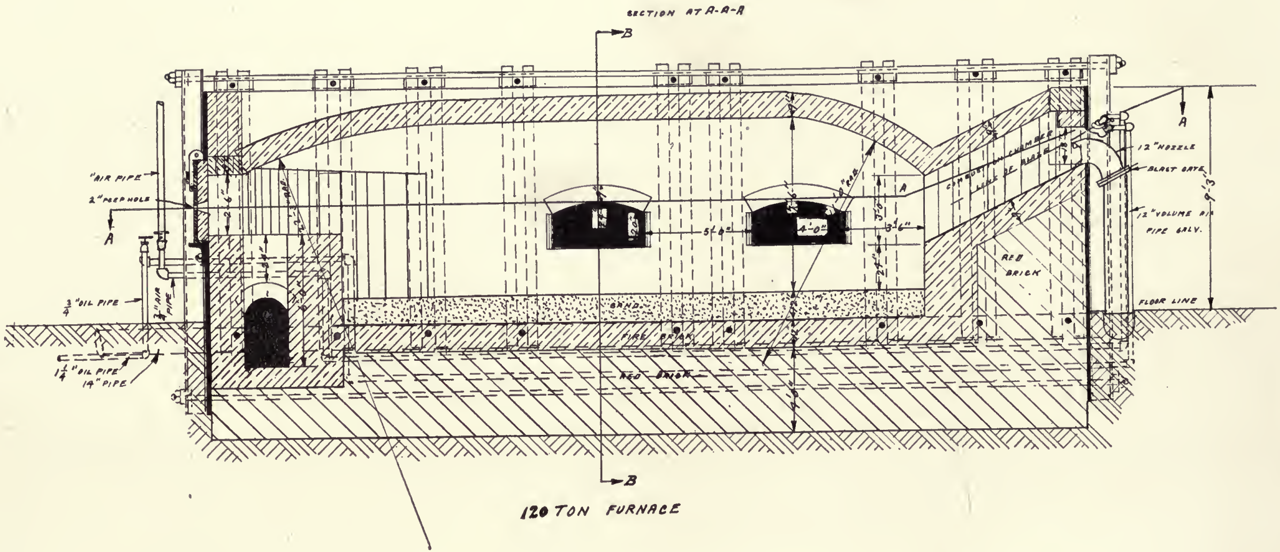


4 TON MELTING FURNACE

A 4 ton melting furnace used for various alloys and metals, or for melting large quantities of brass castings in order to dezinc same. In the latter case the metal is poured in ingots and after being analized by the metallurgists the ingots are stacked in their respective order, ready to be again melted in crucible furnaces.

A copper refining furnace must be so equipped that the operator has the fire under perfect control at all times. That is, at times a reducing flame is necessary, while at other times an oxidizing flame is required. Only one burner should be used in a 125 ton furnace as shown in accompanying cut, but this must spread a blanket of flame over the entire surface of the bath or charging space, which in this case is 14 ft. wide by 26 ft. long. I am aware that attempts have been made to use a large number of burners, installed along the sides of the furnace, with operating valves for each burner, but the operation of the furnace under these conditions was so complicated, the operator could not accurately regulate the flame and if during the refining process, the metal is oxidized, it becomes porous and when rolled into copper wire, the porousness ruins the conductivity of the wire. With the one burner a small quantity of superheated steam or compressed air is used to atomize the fuel and distribute the heat in the furnace but by far the greater portion of the air necessary for combustion is admitted through the volume air nozzle under the burner.

At the end of the furnace you will note the



Copper Refining Furnace.

The operating valves in this case are 90 ft. from the burner as the pipes have to pass around other machinery to the operator at poleing end of furnace.

door used during the refining process for poleing the charge (agitating the molten metal with a long wooden pole). In this door is a peep-hole through which the burner can be plainly seen at the opposite end of the furnace and all the operating valves are so placed that the operator, while viewing the burner, can quickly and accurately adjust the air and oil supply according to the requirements for the proper treatment of the metal.

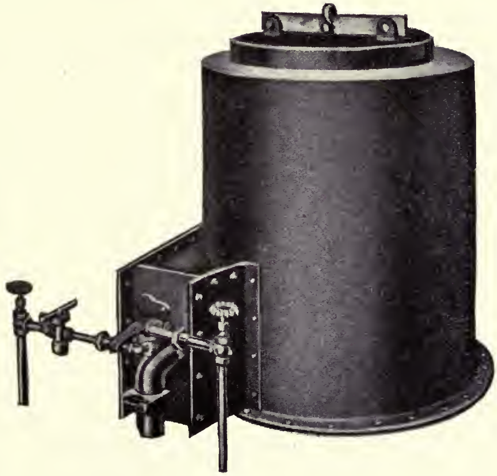


Fig. 1. Crucible melting furnace for melting brass, copper and other alloys. The capacity of this furnace is either a No. 60, No. 70 or No. 80 crucible. This furnace has a combustion chamber of such form and proportions that the tangential flame and heat encircles the crucible and is evenly distributed without any cutting effect upon the crucible. The air necessary for perfect combustion unites with the consuming fuel in the combustion chamber before it reaches the crucible; thus the life of the crucible is prolonged because of oxidization being reduced to the minimum.

For a number of years oil has been used for the melting of brass and kindred alloys but unfortunately direct-fired oil furnaces were recommended for this purpose which resulted in the alloys, which melt at a lower temperature than copper, being sacrificed, thus causing an irreparable loss in metal, to say nothing of the attendant change in the composition of the metal. It was indeed a sad day when crucible furnaces were discarded for the direct-fired oil furnace, but now, thanks to the ability and fighting qualities of young metallurgists in (or who should be in) every brass foundry, we are again returning to crucible melting furnaces. In Fig. 2 is shown a modern crucible brass melting furnace, six pot capacity. You will note that the furnace is reversible. That is, one burner is in operation until the metal in the three crucibles in the first chamber is ready to pour, and during this time the waste gases passing in through the second chamber on their way to the stack have preheated the metal in the second chamber, thus using the waste gases as much as possible. After the metal in the first chamber has been poured and the crucibles refilled, the dampers to stack are reversed, the plates over burner openings reversed and the second burner is started. The first chamber then becomes the preheating chamber. The heat in

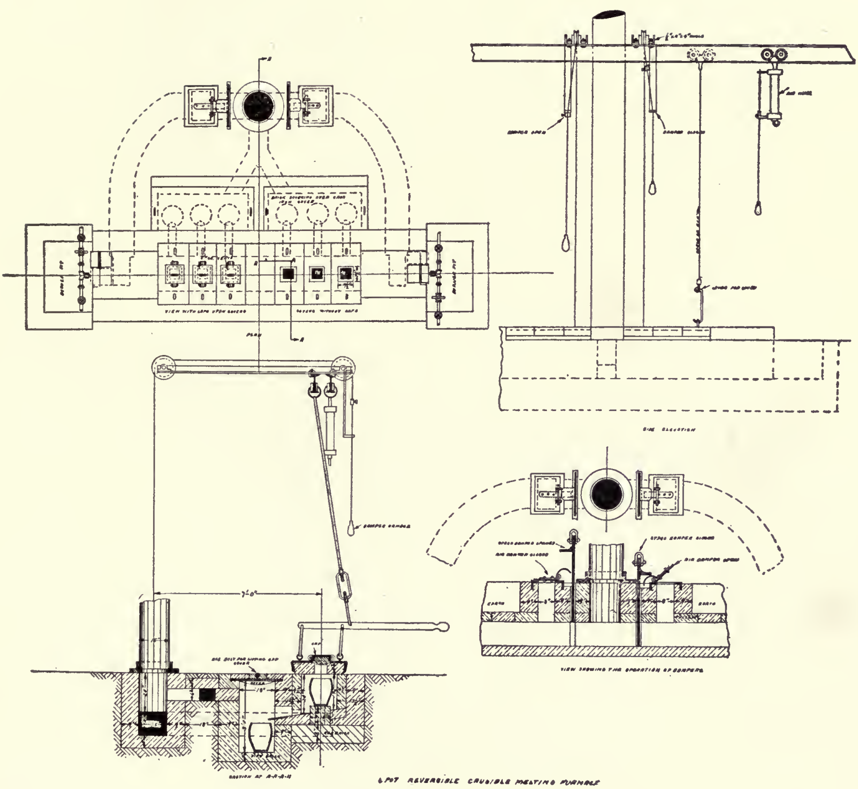
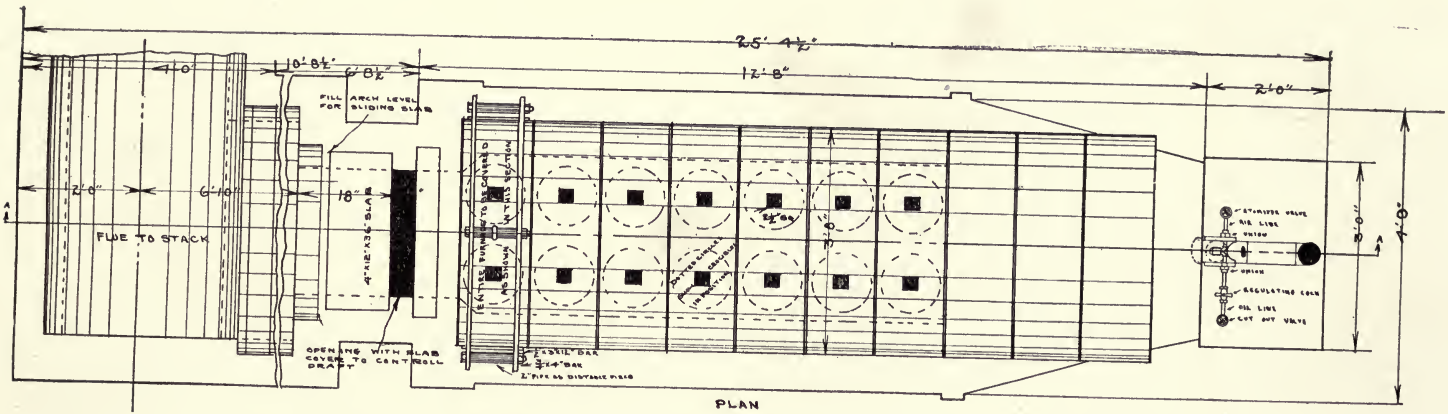


Fig. 2. A Modern six pot brass melting furnace.

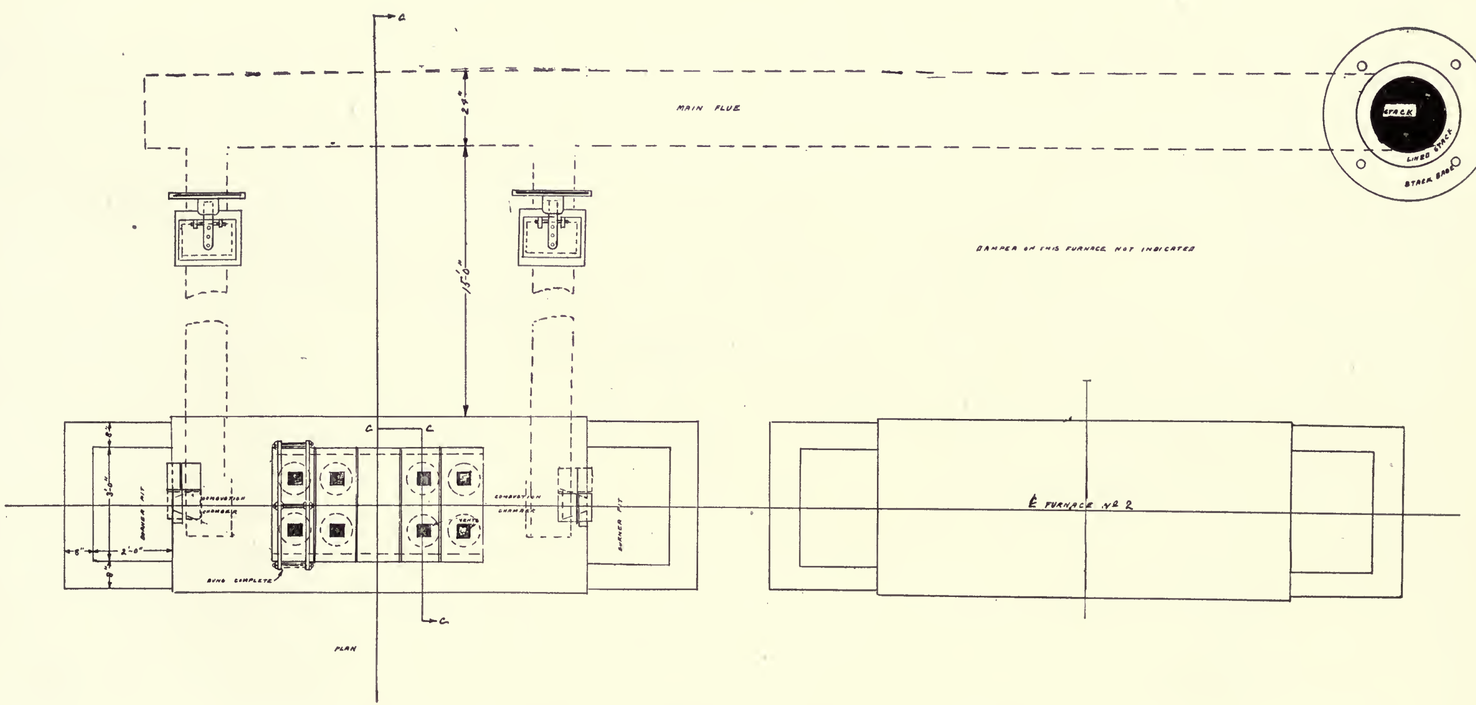
the flue to stack is utilized to preheat the incoming air. Note the combination of the damper or air opening in flue with the flue damper. The apparatus is so arranged that when the flue damper is closed, a lug automatically raises the air damper on top of the flue so that the air is preheated while passing through the flue to burner end of furnace then in operation. By this means the air necessary for perfect combustion is preheated by heat which would simply have been wasted in the ordinary type of furnace construction. Convenient means are provided for operating both dampers and covers. This furnace is constructed for various sizes and numbers of crucibles and besides being efficient and economical, it reduces the loss in metal to the minimum.



A 14 pot crucible steel melting furnace.

With this type of furnace the space occupied by the 6 pots at the burner end of the furnace is termed the "melting zone," while the remaining charging space is called "preheating zone." When the metal in the first 6 pots is ready to pour, they are removed, poured, and refilled with steel punchings, while the 8 remaining in the furnace are moved in their respective order into the "melting zone." The refilled 6 pots are then placed in the "preheating zone" of the furnace. This furnace is a vast improvement over the old style pan system which was used some years ago. Only one burner is required to atomize the oil and distribute the heat.

Instead of closing off the draft in the neck of the furnace by the old fashioned refactory damper, you will note the flat damper shown which is moved horizontally and which simply allows the air to pass through an opening, thus retarding the draft in the furnace and at the same time the cold air admitted tends to reduce the temperature in the flue. This refractory damper can be moved so as to make the opening wide open, or just sufficiently to give a partial opening as necessity demands. This type of damper lasts indefinitely as it can not burn away, and you have a much better control of the furnace.



An 8 Pot Furnace for Melting Crucible Steel and other Alloys.

With this form of furnace construction it is not necessary to move the crucible from the "preheating" to "melting zone" as is necessary with the 14 pot furnace just shown, which is a great step forward in modern furnace construction.

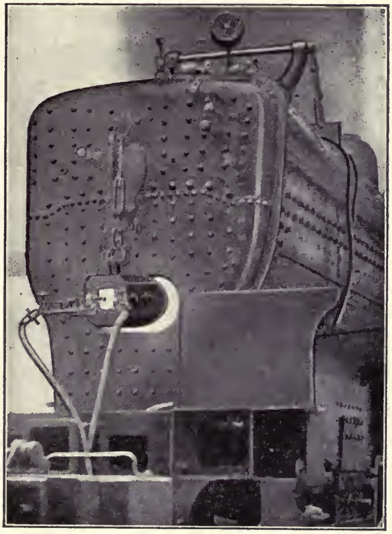


Fig. 1. A portable furnace, resting in fire door opening, firing up a locomotive boiler.

Until quite recently wood was used for firing up boilers in boiler shops for testing purposes, or in locomotive works for raising steam to set pops when the locomotive is completed. By using oil instead of wood for this purpose there is 50% saving in time and cost. With an apparatus such as shown in operation in Fig. 1 the operator has the fire under perfect control, and one man can look after 5 or 6 furnaces at a time. For the largest Mogul engine we use either one furnace such as shown in Fig. 2 which gives a fan-shaped incandescent flame 18″ to 10 ft. in length, at a point 6 ft. from the furnace the flame being 4 ft. wide; or two of the smaller portable furnaces shown in Fig. 3, which gives a round incandescent flame 1 ft. long, 3″ in diameter to 6 ft. long and about 10″ in diameter. For a smaller size locomotive ordinarily one of the furnaces shown in Fig. 3 is used.

These furnaces are also used for a multitude of other purposes such as setting up corners of fire-box sheets to mud-rings; flanging, laying on patches, heating crown sheets, heating and welding band rings; bending pipe up to 16″ diameter without sand filling; (straight pipe is laid on bending table with a shaper arranged to suit curve; one end of pipe is clamped, and pipe bent after heat is applied to outside of bend, thus

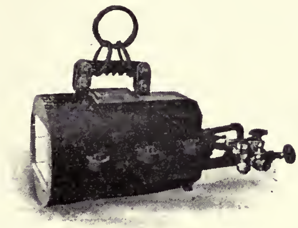
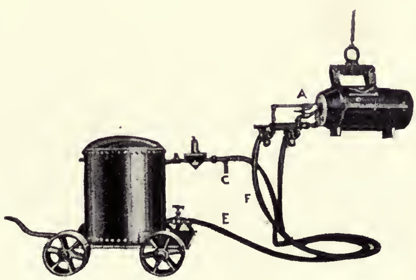


Fig. 2. A portable furnace such as is shown in operation in Fig. 1.



A—Oil burner C—Compressed air connection D—Air reducing valve.
E—Oil hose. F—Air hose.

Fig. 3. Portable Furnace with hose and tank on a truck.

stretching metal on the outside, without buckling inside of bend); straightening bent frames after a wreck, etc., etc.

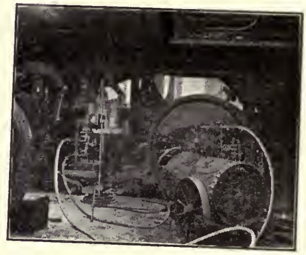
Referring to Fig. 3, you will note that compressed air (pneumatic tool pressure) is used to operate this equipment. The full pressure is used through the burner to atomize the fuel and distribute the heat, but the air used to force the fuel from the tank to burner passes through a reducing valve which reduces it from pneumatic tool pressure to 10 lbs. on the tank. To safeguard human life this pressure reducer is most essential.

The above is a photograph taken while welding the rudder of the United States Collier "Brutus" without removing the rudder from the vessel. The welding of this rudder was accomplished on August 10, 1905, using the author's equipment.

It was the first time, in the history of any Navy Yard or private ship yard that a weld under these conditions had ever been accomplished, using oil as fuel, and was considered a remarkable achievement.

It is possible to obtain a better weld by the use of liquid fuel than with any other fuel, for the metal is made more homogeneous.

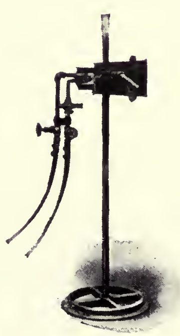
1. A—the insert (or Dutchman)



2. Furnace in operation.

3. Note the constancy of heat and perfect combustion.

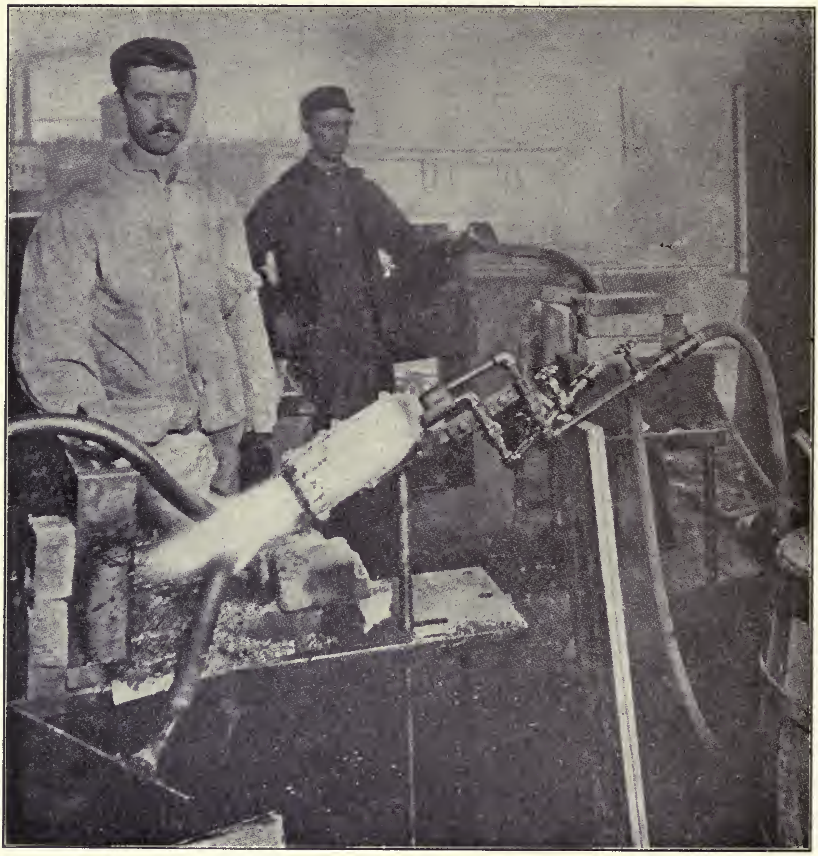
4. A—The perfect weld.



5. The little giant which did the trick.

There are three ways of welding locomotive frames. Thermit and Oxy-acetylene are efficient but very costly, while with oil in about 40 minutes with a few gallons of oil, a perfect weld is made. Of course the expense entailed for labor in making the weld is the same in either case. Complete story of a perfect weld with oil is shown in Figs. 1, 2, 3, 4 and 5.

The oil furnace shown in Fig. 5 is operated with a small quantity of compressed air and may be used for various other purposes, such as flanging, laying on patches and laps, heating crown sheets, firing up and testing boilers in boiler shops; brazing and filling castings, ladle heating, melting or keeping metals hot in foundries; brazing, annealing and heating of all kinds in copper shops; removing propeller wheels, straightening and bending on board vessel rudder frames, stern posts, keel, etc., pipe bending, etc.; melting metals in small quantities for laboratory tests, etc., heating rails for bending, etc.

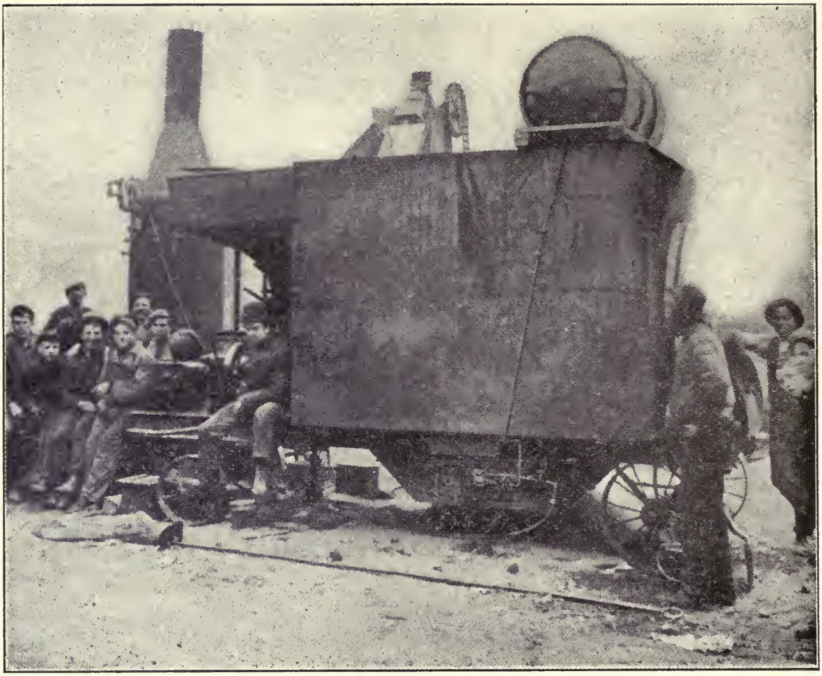


Portable furnace brazing exhaust pipe of automobile engine.

This furnace is mounted on a 5 ft. standard so that the apparatus can be adjusted to any height or angle needed for all kinds of heating purposes where it is desired to heat a small portion of the metal. The furnace may be removed from the stand and used as a blow pipe for straightening or setting up work difficult of access.

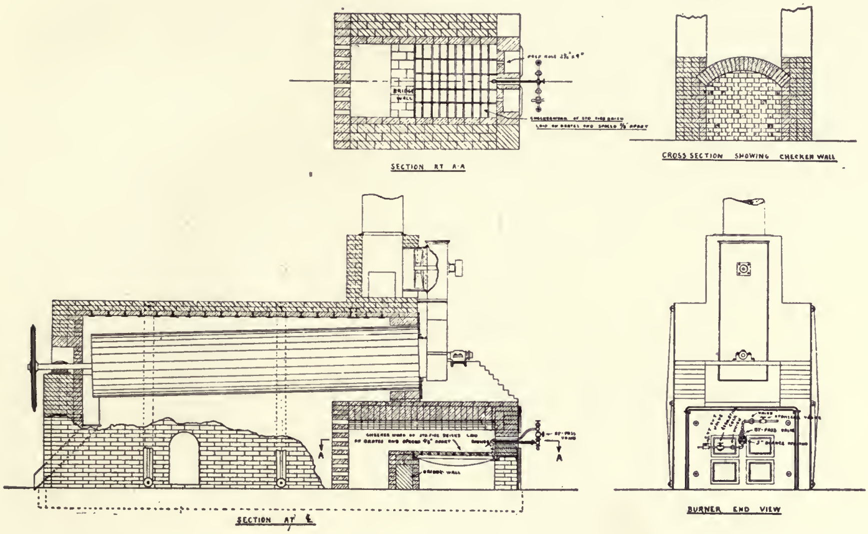
The tiny furnace is lined with refractory material. This becomes heated lily-white and insures a constant steady flame even when the oil supply is cut very low. With apparatus having a metal combustion chamber not lined with refractory material there is always more or less difficulty with the fire not burning steadily. The refractory material also aids combustion and prevents oil being thrown out with the flame.

Hand Torches, made in various sizes, are very economical and efficient for all classes of light heating purposes, such as skin-drying moulds, lighting cupolas, heating tires, light brazing, burning paint off steel cars, etc.



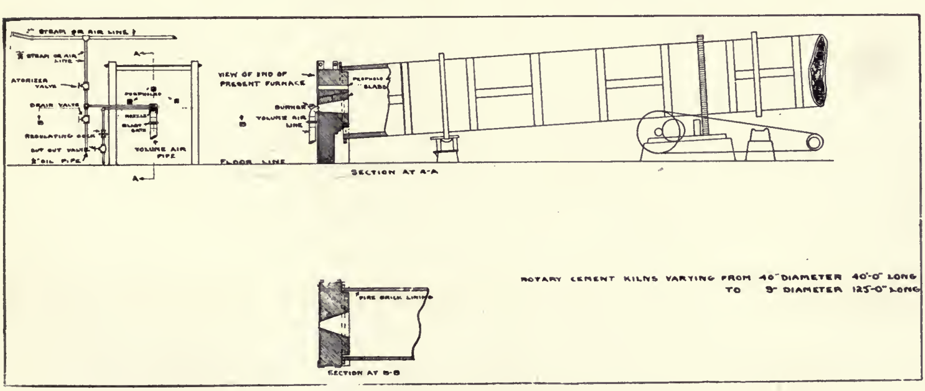
Portable Asphalt Mixer equipped with oil burner.

For rotary dryers in either portable or stationary asphalt plants, it is most essential that the burner be capable of atomizing any gravity of liquid fuel for in some localities you can get fuel oil, other places heavy crude oil, while in other localities nothing but oil tar from a gas works may be obtainable. Burning liquid fuel in the vertical or other type of boiler used to operate a portable asphalt plant is a great convenience and it eliminates the smoke nuisance.



Equipment of Ore or Sand Roaster and Dryer.

Oil is particularly adapted for all kinds of ore roasters and is especially valuable for desulphurizing iron ores for it enables the operator to attain and maintain the temperature required at all times.



Rotary Cement Kiln Equipment.

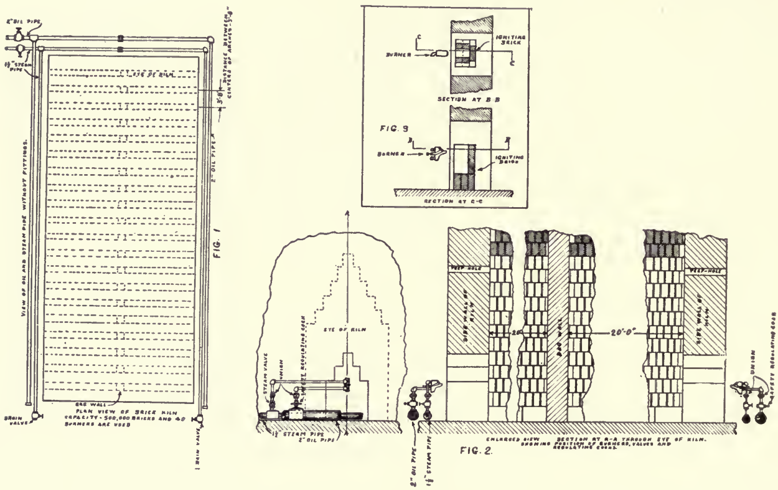


Fig. 1. An ordinary brick kiln, having 40 eyes, the capacity being 500,000 brick.

Oil is the ideal fuel for this class of work, if you use burners capable of giving a very light fire until the water smoke has been removed from the brick, after which the burners should be forced to their maximum capacity.

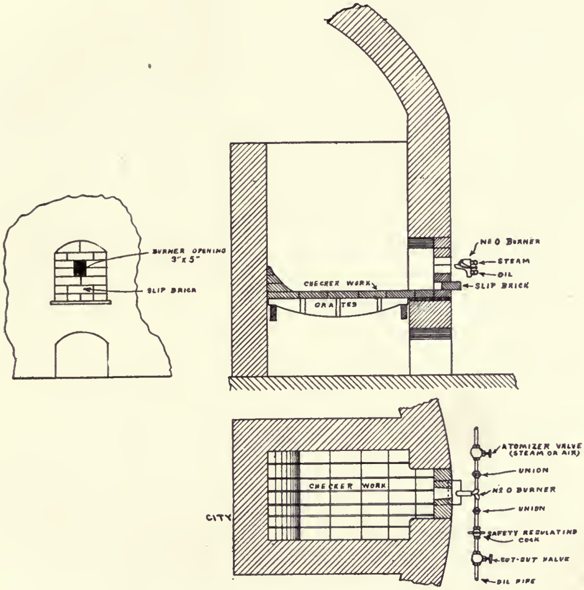
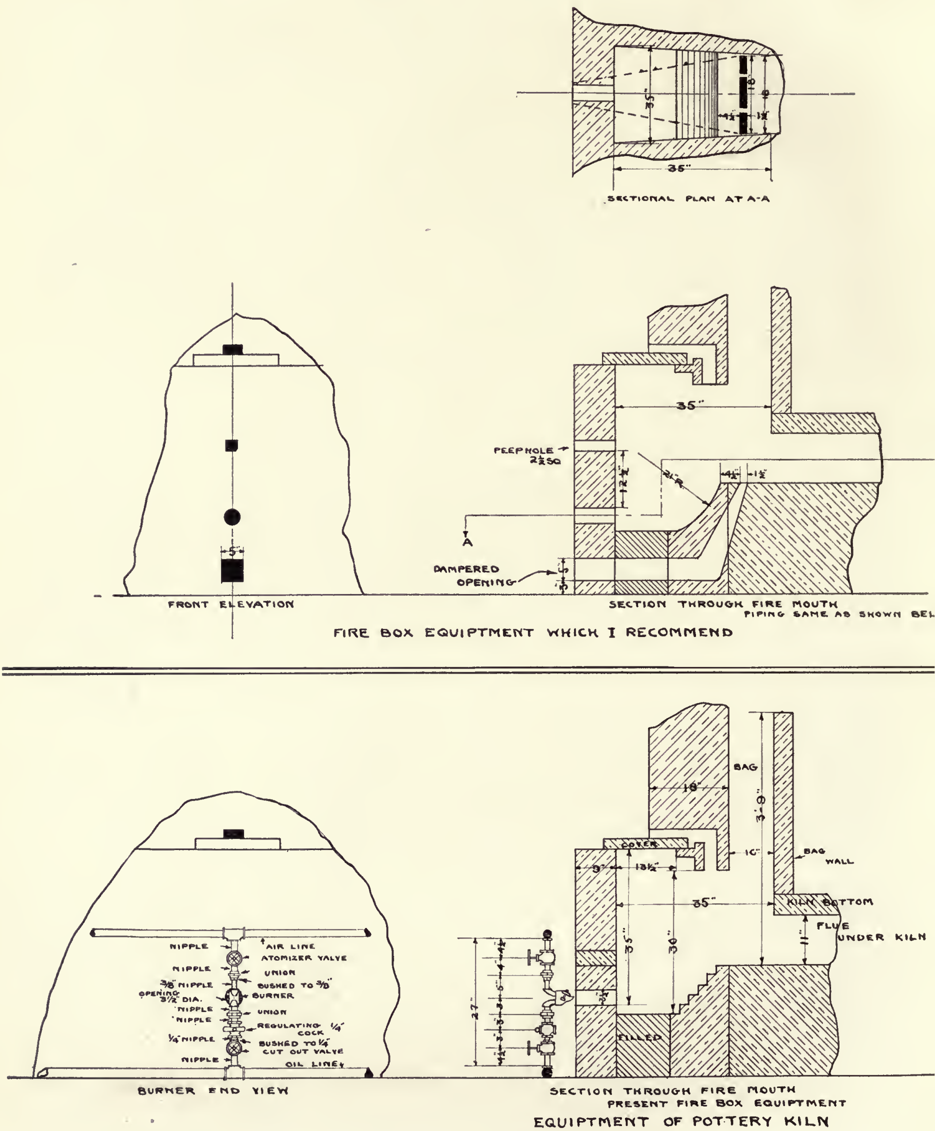


Fig. 2. A bee-hive brick kiln or terracotta kiln, changed from coal to oil, by simply covering over the grates with a checker-work of fire-brick, and bricking up the firing door as shown.



Two ways of equipping a pottery kiln, the type of construction shown in the upper views being the most modern.

Glass Melting Furnace.

(Fig. 1)

(Fig. 2)

In the melting, bending and annealing of glass, oil, if properly installed, is a fuel which insures success. There are many types of glass melting furnaces; regenerative, recuperative, and the ordinary tank type. The equipment of the latter is illustrated in Fig. 1, while Fig. 2 shows lehrs 80 ft. long equipped with only one burner.

CONCLUSION.

The author has endeavored to the best of his ability to give as much information to the reader as is possible without his knowing in detail the exact service of the boiler or the furnace, or the size of the metal which is to be heated or heat-treated in the furnace, and has endeavored to treat each subject from a practical rather than a technical standpoint.

As the light fuel oils heretofore used in this country are now being refined and redistilled by new processes by which a higher percentage of the more volatile components, such as kerosene and gasoline, etc., are obtained, the price of this oil has materially raised. It is therefore necessary to utilize the heavy crude oil being shipped in large quantities from California and Mexico, but the use of this fuel necessitates many changes in the oil systems heretofore used. Many people have attempted to burn this fuel and failed because they tried to use it under the same conditions as they did fuel oil of about the same consistency as water. Investigation of these failures has shown that often a rotary pump has been used, ¾″ or 1″ oil mains and no means employed for heating the fuel. Under such conditions, heavy oil can not be successfully burned, and in many cases, in fact, the heavy oil is so viscous that it could not be pumped out of the storage tank. Some firms when they could not successfully burn this heavy fuel with their present equipment, simply condemned the fuel, while others of a more persevering and ingenious turn of mind delved deeper into the subject or profited by their neighbors' experiences, and eventually have been able to successfully utilize the heavy oil. I have heard so many complaints about liquid fuel and have seen it condemned so often under conditions when the supply system or method of atomizing the fuel was at fault that I have compiled a list which may awaken a deeper interest in this subject.

Don't Blame Oil

If YOU haven't INCREASED YOUR DAILY OUTPUT;
If you can't get 50 per cent. OVERLOAD FROM YOUR BOILER;
If the SMOKE ROLLS OUT OF THE STACK;
If you BURN out the TUBES or SHELL of your BOILER;
If you have to USE COAL or COKE TO KEEP THE OIL or TAR BURNING;
If you have to use more than ONE BURNER IN A BOILER having fire-box less than 7 ft. wide;
If you are using MANY BURNERS GIVING FUNNEL-SHAPED FLAMES instead of ONE BURNER with a FAN-SHAPED BLAZE;
If your LOCOMOTIVE DOESN'T INCREASE ITS TONNAGE or steam well;
If you INJURE the LOCOMOTIVE FIRE-BOX;
If you CAN'T ATOMIZE HEAVY OIL or TAR AS WELL AS LIGHT OILS;
If your PURNER CLOGS or CARBONIZES;
If the MOUTH of the burner WEARS AWAY;
If you ARE NOT GETTING PERFECT COMBUSTION;
If you have NO SMOKE but a LOSS OF FUEL because of an EXCESS OF OXYGEN;
If you cannot CONTROL THE HEAT IN THE FURNACE;
If you don't get REVERBERATORY MOVEMENT of the HEAT;
If the HEAT IS NOT EVENLY DISTRIBUTED;
If you have DIFFICULTY in getting a WELDING HEAT;
If your MEN have to WAIT ON the METAL;
If you can't ATTAIN and MAINTAIN the REQUIRED TEMPERATURE;
If you OXIDIZE or SCALE THE METAL;
If you can't get BETTER RESULTS WITH OIL than with coal, coke or gas;
If you can't keep the BURNER LIT WITH A LIGHT FIRE;
If you use the old style PAN SYSTEM in your CRUCIBLE MELTING FURNACES;
If you are troubled with SMOKE PASSING OUT OF FURNACE;
If your CORE or MOLD DRYING OVENS are TOO HOT ON ONE END and TOO COLD AT THE OTHER;
If your JAPANNING OVEN SMOKES;
If you CAN'T BRAZE.

If you have any of these conditions IN YOUR PLANT, why blame the fuel? It is because you are BURNING AT OIL, instead of really burning it in such a manner as to effect PERFECT COMBUSTION and UTILIZE ITS FULL CALORIFIC VALUE.

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