REFRIGERATION LABORATORY FOR THE GREATER ARMOUR INSTITUTE OF TECHNOLOGY

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A PROPOSED DESIGN FOR THE REFRIGERATION LABORATORY FOR THE GREATER ARMOUR INSTITUTE OF TECHNOLOGY

A THESIS

PRESENTED BY

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TABLE OF CONTENTS

PLATES

I. INTRODUCTION

Although refrigeration and the production of ice by artificial means was known to the ancients, it is only within comparatively recent times that improved systems and apparatus have enabled operations to be carried out on a commercial basis. Fifty years ago the refrigeration industry was in its infancy but great strides have been made since then. Last year, in America alone, there were over seven thousand firms directly interested in the mechanical production of cold.

Few people realize the full significance of the part this industry plays in our daily life. Refrigeration machines are used for making ice, for chilling fresh killed meat, for preserving perishable foods, for conditioning of air, for making celluloid films, and for many other industrial processes. They make it possible for the "Salty Tar" to eat fresh foods when cruising off the South Sea Isles while his sweetheart sits comfortably in an air cooled movie house in Brooklyn.

Because the future of the industry depends so largely on the engineer, we are anxious that the New and Greater Armour Institute of Technology shall have a refrigeration laboratory which lacks not a single detail essential to complete experimentation. Therefore in the design of the new laboratory our first concern has been for completeness. We have aimed to make the laboratory of the greatest possible practical value. The units chosen, each in its class, represent the best in modern practice. Together they cover very thoroughly the present day methods for the production of cold.

The work done by refrigeration machines may be divided into two general classes, as follows:

1. The Manufacture of Ice.
2. Cooling by Direct Absorption of Heat.

To represent the first class of work, the new laboratory will be equipped with a tank for the manufacture of ice by the can system, either on direct or indirect expansion, using either raw or distilled water. The freezing may be done by (1) an ammonia compressor, (2) a carbon dioxide

compressor, or (3) an ammonia absorption machine.

The second class of work is represented in the three insulated rooms located at one end of the laboratory. Each of these rooms may be cooled off by any of the above mentioned machines. One of the rooms will be equipped with steam coils and will be used in connection with experiments on heating and ventilating.

The equipment of the new laboratory will also include three small machines of the type used in butcher boxes, floral shops, and apartment buildings. The demand for machines of this type is growing rapidly and the competition is keen. The merchant is awakening to the fact that the ice man's muss and irregularity are unnecessary evils.

One machine of the household size is provided to afford data on the economy and reliability of machines designed for this purpose. The field is greater than Henry Ford's, but it has just been entered.

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Ewing

The Carbonic Acid Industry

Goosman

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Greene

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Lorenze and Pope

Mechanical Refrigeration

Mac Intyre

Refrigeration, Cold Storage, and Ice Making

Tayler

Complete Catalogue of Ammonia Valves and Fittings

York Manufacturing Company

II. BUILDING

MATERIAL AND CONSTRUCTION

The Refrigeration Laboratory for the New and Greater Armour Institute of Technology will be located in a one story brick building, sixty feet wide and one hundred thirty feet long. The building will be fireproof throughout. The inside of the walls shall be of hollow tile except in the offices, wash rooms, and experimental rooms. The walls of offices and wash rooms will be finished in hard plaster. The insulation, which forms the walls of the experimental rooms, is described in the part of the thesis devoted to the rooms.

The floor will be made of eight inch concrete, surfaced with dust proof covering. The floor in the offices will be of a selected maple.

The roof will be of the garage type, supported by posts set twenty feet apart. On the roof, a platform will be constucted directly above the refrigerating machine to be used in cooling the altitude chamber. This platform is to support the atmospheric condenser to be used in connection

with that machine.

LAYOUT

In laying out the refrigeration laboratory the object sought was compactness without crowding or inaccessibility. The future of the laboratory,with its probable expansion and modernizing was kept constantly in view.

The entrance to the office and the laboratory will be at an end of the building. The office will be adjoining and connected to the wash-room and lavatory. The work bench will be located just outside of the wash-room. The Frigidaire refrigerator and two cases for exhibits will be placed against the office wall.

The other end of the laboratory will be devoted to the experimental rooms. There will be three rooms each thirty by twenty feet. They may may be cooled by any of the three machines to be located near the rooms. The Automatic Carbonic machine will be in front of the rooms and the York compression and absorption machines will be

placed near either wall. The ice tank will occupy the "U" formed by these three machines.

The altitude chamber will be across the laboratory from the office. It,and its equipment will form a seperate unit. The small machines will be placed along the wall between the altitude chamber and the York absorption machine.

III. EXPERIMENTAL ROOMS

The tonnage of refrigeration devoted to cooling by direct absorption of heat has come to exceed that devoted to the manufacture of ice. We are gradually aproaching an iceless age. In order that the problems confronting the engineer who designs cold storage houses and cooling rooms may be thoroughly studied, the new laboratory will contain three experimental rooms.

Each room will be thirty feet long by twenty feet wide. The two cold rooms will be ten feet high, but the constant temperature room will be twenty feet high to permit experimenting with structures of more than one story. Each room will open into the laboratory, and the rooms will also be interconnected. The wall between the constant temperature room and the adjoining cold room will contain a false section which can be removed. This section will afford an opportunity to study heat conductivity of large sections placed between any desired difference of temperature.

An altitude chamber has been provided for

the automotive department to be used in testing aeroplane motors under conditions found in high altitudes. All the necessary instruments and apparatus will be furnished by the automotive department. The room will be 8' x 10' x 8'. It will be cooled indirectly by a two-stage carbon dioxide compressor designed and built by the American Carbonic Company. This machine is especially adapted to the work which will be asked of it; similar machines are used throughout the country for just such work.

Experiments run in this room will require the removal of about 150 tons of refrigeration per day. A ten ton machine is provided to be used in connection with a brine tank which forms the inner walls of the room, and has a capacity of 650 cu. ft. of brine. By running the refrigerating machine until all the brine is frozen, a capacity of about 180 tons may be stored up.

A ten ton York atmospheric condenser will be provided for use in connection with the altitude chamber and in experiments on the efficiency of this type of condenser.

INSULATION

All walls, partitions, floors, and ceilings shall be made of Nonpareil corkboard, manufactured by the Armstrong Cork and Insulation Company, and shall comply to the following specifications:

WALLS

Directly against the brick walls, one course of three inch Nonpareil corkboard shall be erected in a 1/2 inch bed of Portland cement mortar, mixed in the proportion of one part of Portland cement to two parts of clean, sharp sand, all vertical joints being broken. A second course of three inch Nonpareil corkboard shall then be erected against the first in a 1/2 inch bed of Portland cement, and additionally secured to the first with galvanized wire nails or wooden skewers. All joints in the second course shall be broken with respect to all joints in the first course. All joints shall be made tight.

CEILING

The insulation against the ceiling shall be the same as that specified above for the walls.

FLOORS

On a reasonably smooth and level concrete base, one course of three inch Nonpareil corkboard shall be laid down in hot asphalt, all transverse joints being broken. 2 inch x 3 inch sleepers shall be laid down on 38 inch centers. Between the sleepers, a second courseof 3 inch corkboard shall be laid on hot asphalt. All joints in the second course shall be broken with respect to all joints in the first course. All joints shall be made tight. The upper surface shall be flooded woth hot asphalt, approximately 1/8 inch thick. T.& G. flooring shall then be securely nailed down to the sleepers. Selected maple shall be used for the flooring.

PARTITIONS

The insulation on partitions shall be erected according to the specifications laid down for

the walls except that two courses of two-inch Nonpareil corkboard shall be placed on each side of the partition proper.

PIPING

The ammonia coils in the direct expansion rooms and the brine coils in the indirect expansion rooms shall be placed on each thirty foot wall, close up to ceiling. Each coil shall be two pipes wide and ten pipes high, with four inches between pipe centers. All pipes used shall be Byers' 2-inch wrought iron pipe.

The piping specified above is sufficient to remove 36,000 B.T.U. per hour with a ten degree difference in temperature between the room and the brine or ammonia. 2.5 was used as the coefficient of heat transmission.

MACHINES

The machines which were chosen to cool the experimental rooms, and which are also used for ice making, represent the entire field of large scale commercial refrigeration. The compression system is represented in the Automatic and York machines; the absorption system is represented in the York absorption machine. By means of these machines a comparison of ammonia and carbon dioxide refrigeration may be obtained. The York will be steam driven; an electric motor will drive the carbon dioxide machine.

AUTOMATIC CARBONIC REFRIGERATING SYSTEM

The use of carbon dioxide as a refrigerating agent is increasing very rapidly, and the conditions under which it is admitedly superior are becoming more numerous. Carbon dioxide is more powerfull than any of the other practical refrigerants. The saving in space which results from this fact is often of such great importance that it becomes the deciding factor.

Safety under any and all conditions is perhaps the most valuable characteristic of this gas; it is non-explosive, non-inflamable, and non-asphyxiating. It is this property which has led to its almost universal adoption for use in hospitals, hotels, and asylums.

Because of its very low boiling point, carbon dioxide has come into great favor for low temperature work. In aeronautical experimental work and in the manufacture of films temperatures of forty to seventy degrees below zero are obtained.

Taking these valuable features as a basis the

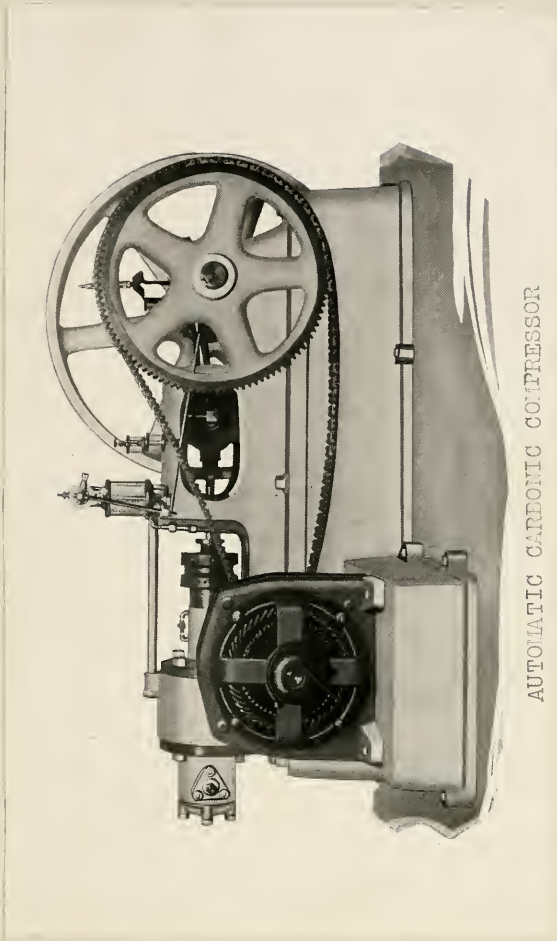
Automatic Carbonic Machine Company has designed and manufactured a machined which has every favorable point built into it and which applies the natural advantages of this gas in a thoroughly practical and simple way. A copy of the specifications for a three ton system as taken from the contract is given below.

COMPRESSOR

The compressor shall be of the automatic carbonic safety type,arranged with safety pockets for the suction and discharge valves,automatically controlled stuffing box,pressure controlling device,and safety valve.

The compressor shall be lubricated in the following manner:A two compartment force feed lubricating pump of the Hills-Mc Canna type shall be provided. One compartment of the pump shall be connected with the stuffing box of the compressor for the lubrication of the same. The other compartment of the pump shall be used for the lubrication of all bearings and moving parts by meansof a special oil distributor with a visible oil supply going to the distributor from the lubricating pump. Independently oiled valve leads shall be connected from the distributor to each bearing and moving part.

The compressor suction and discharge valves shall be of the new plate type.



AUTOMATIC CARBONIC COMPRESSOR

CONDENSER

The condenser shall be of the shell type, with copper cooling coils, for the circulation of the water, so arranged that the carbonic gas after liquifaction will be cooled to the lowest temperature of the incoming water, arranged in counter current cycle.

Each condenser shell shall be designed to meet the requirements of the rules issued by the Safety Inspectors of the Cities of Chicago and New York

BRINE COOLER

The brine cooler shall be of the shell type of constuction with ample copper cooling surface to reduce the temperature of the circulating brine to within ten (10) degrees of the temperature of the evaporating carbonic gas when the temperature of evaporation is zero degrees Fahr.

AUTOMATIC EXPANSION VALVE

The valve controlling the evaporation of the carbonic gas through the brine coolers shall be of the automatic pressure relation type requiring no hand adjustment. This valve shall be provided with two diaphragms operated by the liquid and evaporating pressures in such a way that the valve orifice is controlled in its opening by the action of the two pressures on the two diaphragms.

WATER FLOW CONTROL VALVE

The overflow water from the condenser shall be provided with a thermostatically controlled valve in such a way that the quantity of water is controlled and regulated in accordance with the heat quantity going into the condenser. That is, the control valve shall allow, automatically, a greater amount of water to pass through the condenser cooling coils whenever the heat

flow into the condenser increases, and a less quantity of water with a decrease of heat flow into the condenser. This flow of water shall be cut off automatically when the compressor is shut down, andshall start automatically when the compressor is started.

OIL SEPERATOR

There shall be connected in the high pressure line, between the compressor and the condenser, an efficient oil separator so arranged that the entering gas is deflected in the direction of its flow, reduced in velocity so that the entrained oil may easily be deposited on a suitable perforated funnel, the gas thereafter passing into the upper part of the seperator. Suitable means to draw off the oil, without causing splashing shall be provided.

SCALE TRAP

A scale trap similar in design to the oil separator shall be connected at a suitable location in the suction pipe leading from the evaporators to the compressor.

YORK ABSORPTION REFRIGERATING SYSTEM

Absorption machines were first built to meet the increased demand for low temperature work. In many cases these machines can be installed and operated more economically than any other type. This method of refrigeration is especially desirable for the temperatures required by oil refineries, fish freezers, and cold storage plants.

There are many cases in which greatly increased economy has been obtained in existing compression plants by using the exhaust steam from the compression plant auxiliaries in the ammonia generator of an absorption machine. It is often desirable to install this type of machine in hotels, apartment houses, hospitals, or electric power plants, where exhaust steam is available. A pressure of one pound gauge is sufficient for satisfactory operation.

The York Manufacturing Company is the leading maker of absorption machines. The system to be installed in the new laboratory will be designed by them to meet the following specifications:

GENERATOR

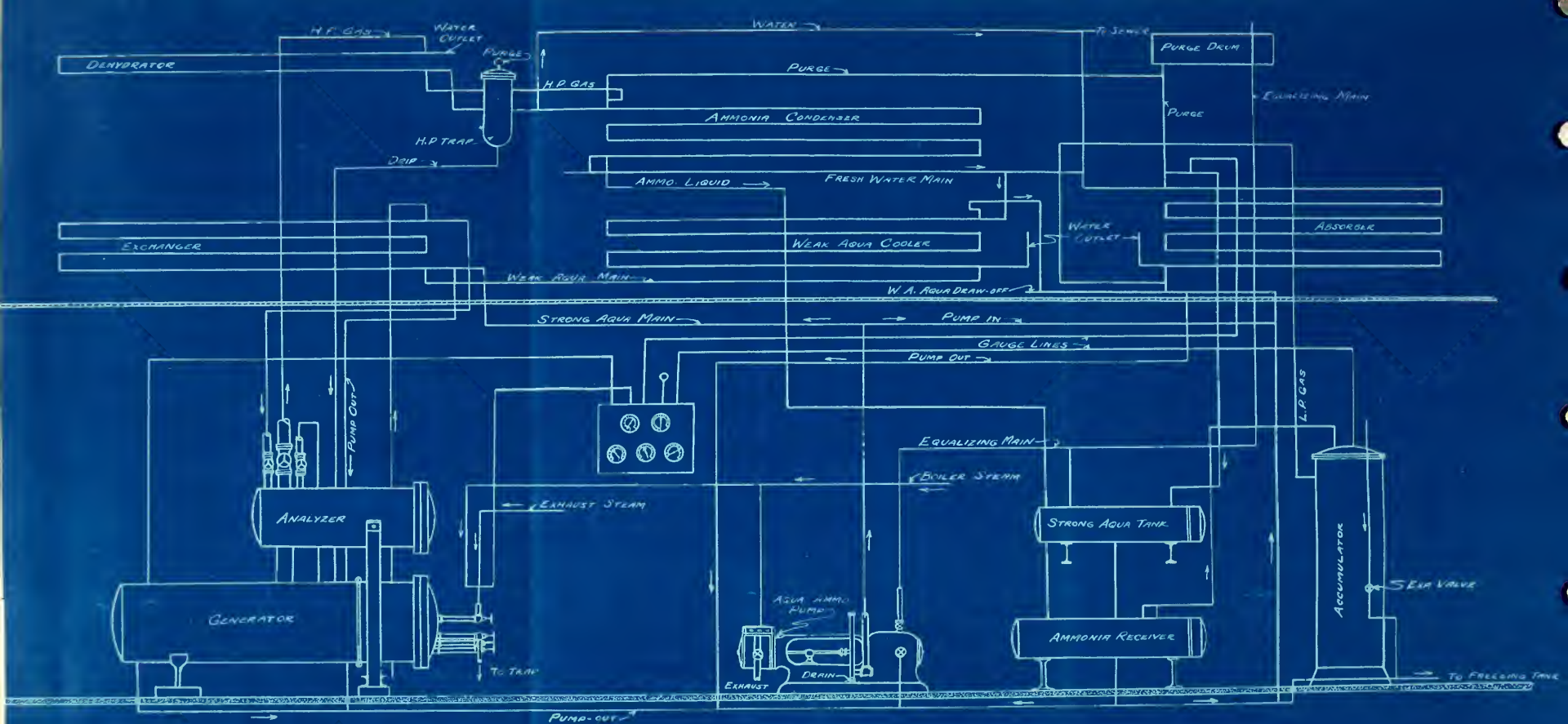
The generator shall be of the shell and tube type and shall be made of cast air furnace iron having a tensile strength of not less than 55,000 to 60,000 pounds per square inch.

No rivets shall be used in any part of the shell; all seams shall be welded, thus avoiding leakage due to contraction and expansion.

The shell shall be designed for use with an external analyzer

ANALYZER

The analyzer shall be of the extenal type. It shall consist of a cast air furnace iron shell providedwith cast iron heat exchanger trays, over which the incoming strong aqua flows, counter current to the outgoing gas, coming in direct contact with the same.



DOUBLE PIPE YORK ABSORPTION MACHINE

DEHYDRATOR

The dehydrator shall be of the double pipe type, and provided with all the necessary fittings, valves, headers, stands, and a drip tray. The piping shall be of selected 1 1/2" and 3" ammonia pipe. All parts shall be made of cast close grained air furnace iron.

The combined gas and water vapor shall enter the annular space of the coil at the top, and leave it at the bottom, where it shall enter the drip trap, which will effectually separate the condensed water from the ammonia gas and return it to the generator, while the anhydrous ammonia passes on to the ammonia condenser. The cooling water shall be circulated counter current to the ammonia, entering the inner coil of the pipe at the bottom and leaving it at the top.

CONDENSER

The condenser shall be of the double pipe type, made of selected 1 1/4" and 2" ammonia pipe, and provided with all the necessary stands, headers, valves, and fittings.

The gas shall enter the annular space at the top, the liquid leaving at the bottom, while the cooling water enters the inner pipe at the bottom and passes through the coil counter current to the ammonia.

EXCHANGER

The exchanger shall be of the double pipe type, made of selected 1 1/4" and 2" ammonia pipe. It shall be so arranged that the strong and weak liquor shall flow counter current and at high velocity so that a good heat transmission shall be obtained. The strong aqua ammonia entering the generator shall have a temperature not more than

eight degrees below the temperature in the generator.

WEAK AQUA COOLER

The weak aqua cooler shall be of the double pipe type made of selected 1 1/4" and 2" ammonia pipe. The weak aqua ammonia shall flow counter current to the cooling water and its temperature on leaving shall not be more than five degrees higher than the temperature of the cooling water.

ABSORBER

The absorber shall be of the double pipe type of 2" and 3" selected ammonia pipe, complete with stands, valves, headers, special gas and weak

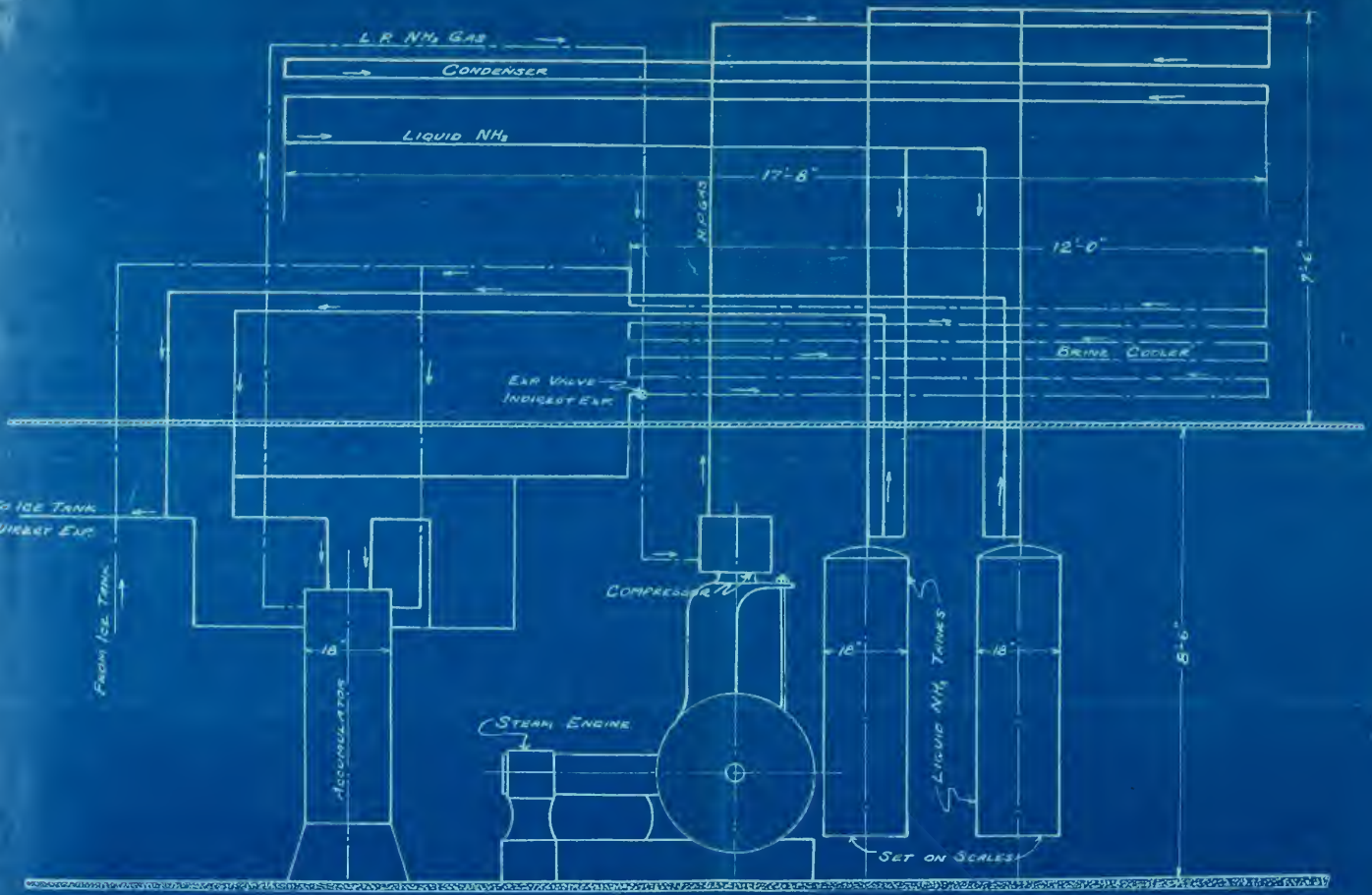
aqua ammonia injection fitting, and purging drum. The cooling water shall flow through the inner pipe counter current to the weak aqua ammonia and the ammonia gas.

YORK COMPRESSION REFRIGERATING MACHINE

The ammonia compression refrigerating system is at present by far the most prevalent method of refrigeration. The machine which will represent this field is now located in the present refrigeration laboratory of the Armour Institute of Technology. It is complete and is in good operating condition. It has been used for experimental purposes since 1911 with very satisfactory results.

The compressor is of the single cylinder, single acting, vertical type. It is driven by a horizontal, slide valve direct coupled steam engine. It is fitted with a safety head. The main shaft is of forged and hammered steel. The connecting rods are cast steel made in an I-beam section. The piston is fitted with metallic packing and the piston rod is fitted with soft packing. All wearing and bearing surfaces are fitted with automatic oilers.

The ammonia condenser and the brine cooler are of the double pipe type and are incased in granulated cork to reduce the radiation losses.



3 TON YORK COMPRESSION MACHINE

Oil which is carried over from the compressor is removed by the oil separator located in the high pressure line.

The weight of ammonia used during any run can be determined by means of two liquid receivers which rest on platform scales.

An exchanger has been provided so that the system may be run dry,wet,or superheated.

This system will be removed to the new laboratory and set up there with but a very few changes in minor details. The only addition to the system will be the piping to the rooms.

ICE MAKING

The production of artificial ice has increased to such an extent that, although the yearly ice crop produces fluctuations in the price of ice, the public is no longer dependent upon the winter weather for its ice supply. In spite of the high cost of material, labor, and fuel, there is a gradual decrease in the expense involved in the production of a ton of ice.

The ice tank now installed in the present refrigeration laboratory will be moved, with its appurtenances, to the new laboratory and connected to the three three-ton refrigerating machines. This tank is six by fifteen feet and has a capacity of one and one half tons of ice. It contains thirty-six one hundred pound cans. The only addition to the freezing tank will be the air headers for the raw water system. The insulation will be the same as now surrounds the tank.

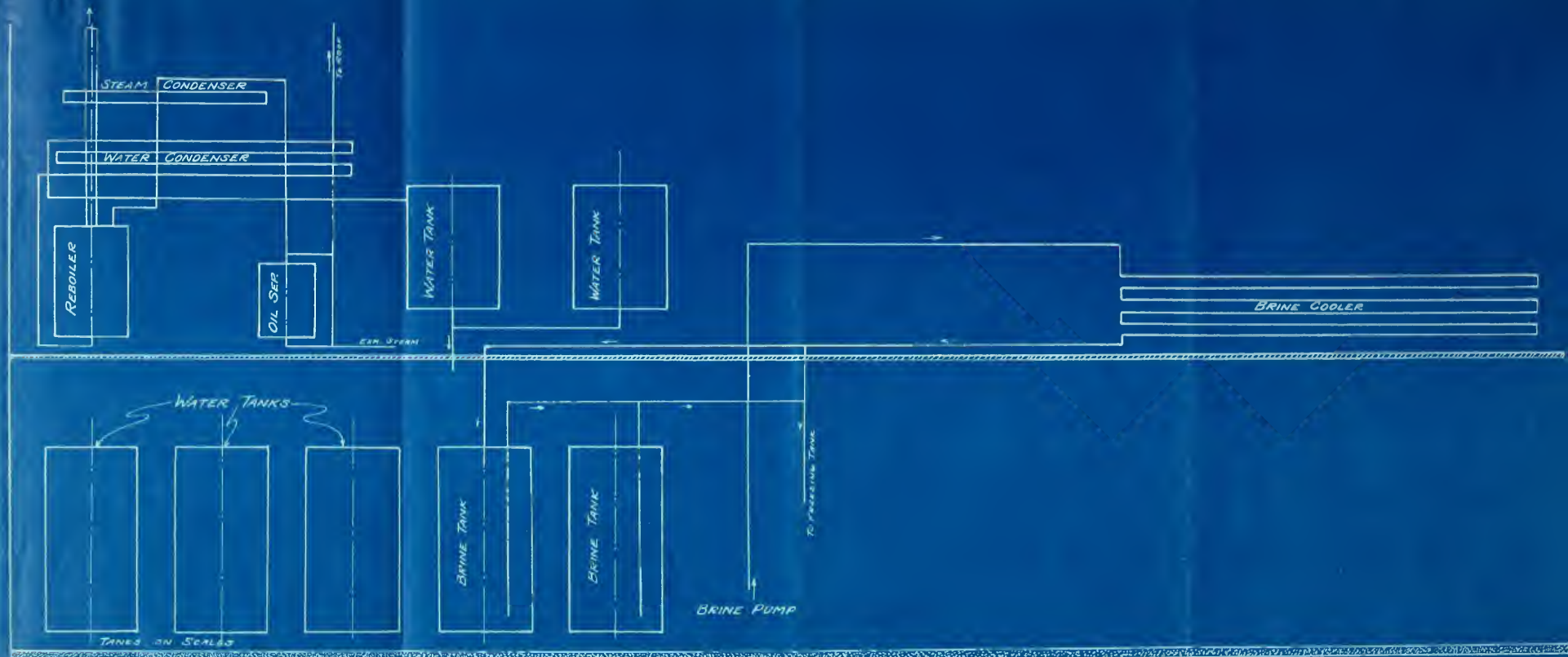
WATER SUPPLY

With the development of the internal combustion engine and the possibility of getting electrical power at a sufficiently low rate to justify its use in the operation of ice plants, there has come a remarkably quick change from the distilled water ice plant to the raw water ice plant.

When steam was the most economical and satisfactiry method of driving compressors, the exhaust steam from the driving engine was condensed, filtered, and reboiled. From the reboiler the steam was run through another condenser into a holding tank. The ice can filler was connected to this tank.

In the new laboratory, the driving unit of the York compressor will furnish the steam for the distilled water method of making ice. All the apparatus necessary for the operation of such a system is installed in the old laboratory.

The rapidly increasing demand for raw water plants makes it imperative that the new labora-

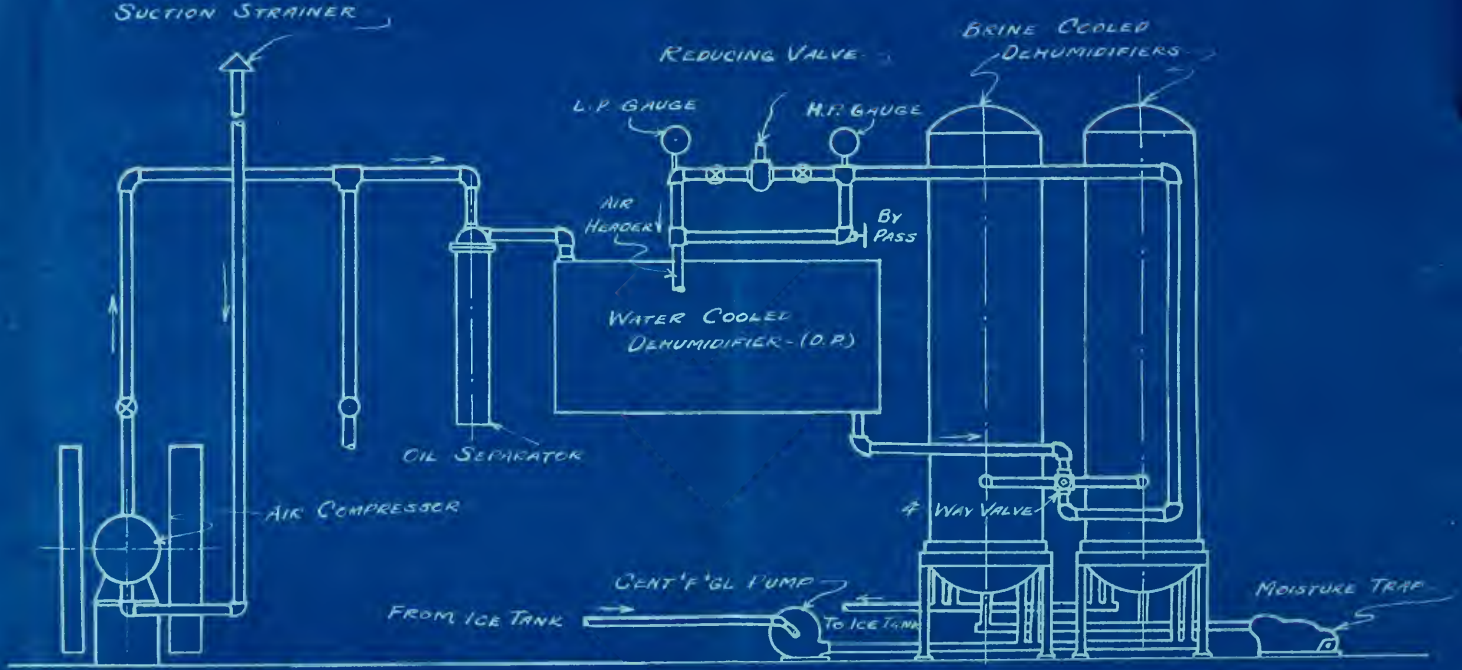


PIPING LAYOUT ~ DISTILLED WATER & BRINE

tory contain apparatus necessary for the manufacture of ice from raw water. Because of its simplicity and economy of operation, the York high pressure air system has been chosen to prevent the formation of white or snow ice.

The air is drawn into the electrically driven compressor from a header extending above the roof. It is brought up to the necessary pressure, which depends upon the temperature of the brine, is discharged into the receiver, and passes through the water cooled dehumidifier, to the brine cooled dehumidifier.

This dehumidifier is of the shell and tube type. The brine is circulated through the coils, and the air passes around them. In cooling the air the moisture is frozen off. The brine cooler is in duplicate so that the frost on one set of coils can be thawed off while the other is doing the final work of cooling. This is done by allowing the air from the water section to pass up through one chamber and down through the other. The brine is not circulated through the first chamber and the air, being warmer than the frost



Air Drying Apparatus for Raw Water System.

or ice on the coils, melts it as it passes up through the chamber; then it crosses over into the other shell and comes into contact with the coils through which the brine is being circulated. It is thus cooled to the temperature required to dry it sufficiently for use in the ice can. When the temperature of the air leaving the second chamber begins to rise, the four-way cock is thrown over, and the direction of flow is reversed. The brine is made to flow through the other coils. A reversal is necessary about twice a day.

An electrically driven centrifugal pump is provided to circulate the brine.

The apparatus to be installed will be large enough to use in connection with experiments involving air conditioning.

MACHINES

A complete description of the machines used for ice making is given in the section devoted to the experimental rooms. Any one of the three machines may be used for making ice.

SMALL REFRIGERATION MACHINES

The tonnage of refrigeration produced by small refrigeration machines will perhaps never equal that of the large machines, but the number of men required to make and sell them and to supply the necessary service, will soon undoubtedly, be far greater. The long felt need for dependable, efficient refrigeration, by the merchant who does not conduct an extensive business, has been fulfilled in the machines now built for his needs.

Uncertainty of both prices and deliveries - poor, inefficient refrigeration, and consequently spoiled products - constitute a few of the many losses sustained through being everlastingly within the power of the ice man; all of them work to the menace of those dispensing perishable goods.

The thousands of merchants who today are profiting and benefiting in many ways through the agency of mechanical refrigeration would not return to the use of ice for refrigeration any more than they would re-employ the ancient methods of keeping charge accounts on a spindle, or weighing

their products by the sense of touch.

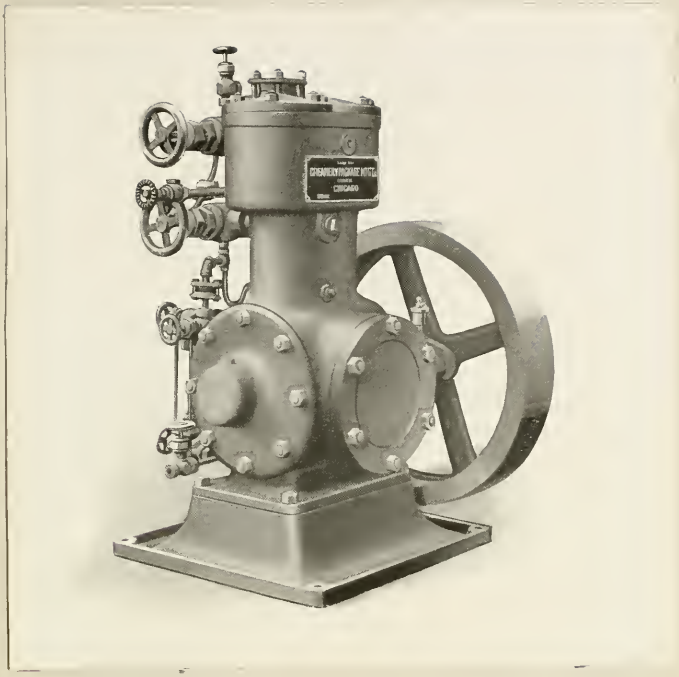
The equipment of the new laboratory will include three machines suitable for groceries or markets and one refrigerator designed for household use. A detailed description of each of these machines with its advantages and the field it covers is given below. Together they cover this branch of mechanical refrigeration very thoroughly.

CREAMERY PACKAGE REFRIGERATING SYSTEM

TYPE C

The Creamery Package Manufacturing Company was one of the first to engage in the manufacture of refrigerating machines. Their staff of service and installation engineers are the peer, in length of experience and skill, of any similar organization in the country. In general design the machines are small and compact and take very little room for the tonnage developed. They are ideal for belting direct to electric motors. The Type C represents the best in twin cylinder vertical design for this capacity. The wide popularity of these refrigerating systems is excellent testimony to the efficiency of this method. While each unit has its own distinctive features, the ammonia compressor is ofcourse the most important.

CP vertical ammonia compressors, "master-built" are of the single acting, enclosed, self-oiling type. They are built of semi-steel and are designed for long and constant use. The bearings are exceedingly large and are readily renewed. A specially de-

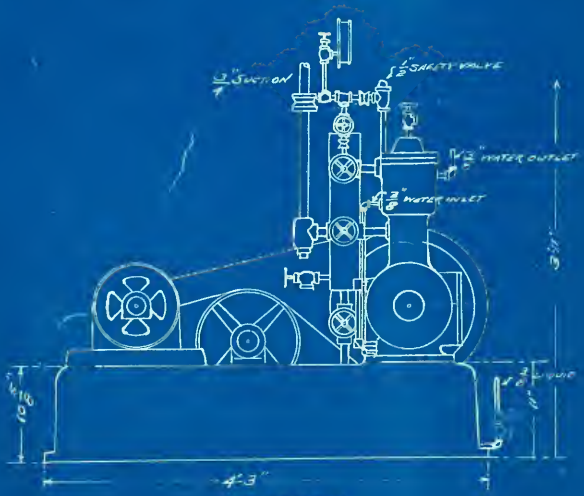


CREAMERY PACKAGE COMPRESSOR

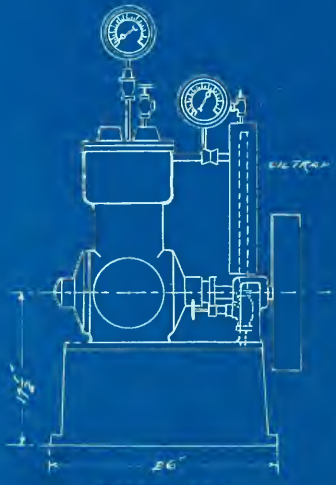
signed fly-wheel, having the spokes at the side of the rim, brings the center of the weight over the bearing, which is the stuffing box gland. This gland has a bracket support from the base of the machine thus avoiding the use of an outboard bearing on the compressor shaft beyond the fly-wheel. The crank shaft has two bearings. All bases are cast with a sediment pocket at the bottom to keep the oil as clean as possible.

These compressors are provided with a scale trap on the suction line, and also have a gas trap in the suction line in the cylinder, providing a large supply of gas to draw on when the cylinder is being refilled on the suction stroke. All machines are provided with by-passes for reversing the operation and pumping out all parts of the system for repairs. These machines are provided with safety devices which will prevent blowing gaskets in case the compressor is started up without opening the discharge valve. Suction gas pockets are connected to the base of the machine so that any oil coming back to the machine is automatically trap-

CREAMERY PACKAGE REFRIGERATING MACHINE



SIDE VIEW



FRONT VIEW

CREAMERY PACKAGE REFRIGERATING MACHINE

ped in the base of the compressor.

The CP vertical compressor is designed with a double trunk piston, the bottom part serving as a cross-head and the upper part serving as the piston proper. Both are provided with rings and equipped with mutiple poppet valves. The valve lift is quick and the opening is large. The valves are made of tool steel.

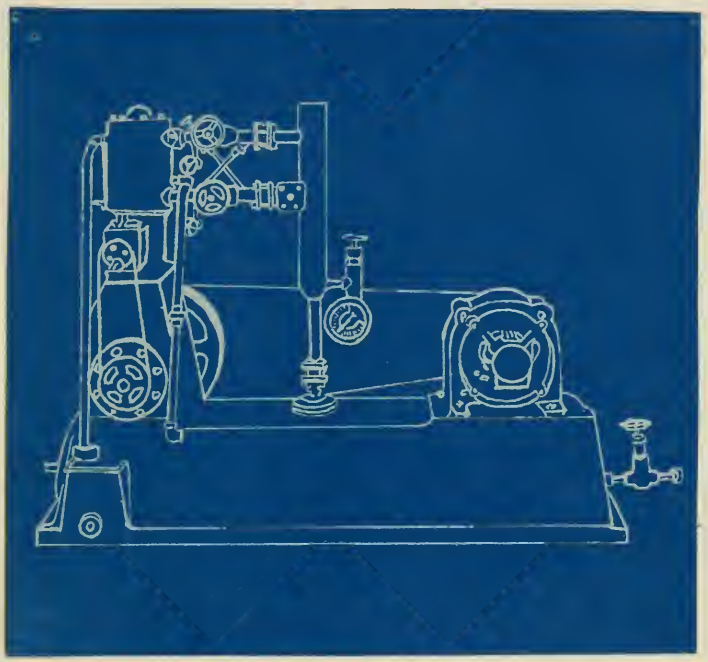
This compressor has no clearance at high speeds. Its cylinders have safety heads which are perfectly flat on the bottom and its pistons are perfectly flat on top. The piston of this compressor can be adjusted for clearance by shimming up the crank pin boxes. Hence at every revolution all the gas which has been drawn into the cylinder is compressed and completely discharged. Because of this non-clearance feature the CP compressor operates at the same high efficiency at low temperatures as it does when operating at high temperatures.

CONTINENTAL REFRIGERATING SYSTEM

Continental machinery is designed and manufactured with the one idea, that dependable and satisfactory service is remembered long after price is forgotten. For durability and economy their line of refrigerating machinery is excelled by none. The continental self-contained refrigerating unit combines the entire high side in one machine.

The continental is a semi-enclosed machine. In operating it there is no ammonia in the crank case to mix with the lubricating oil. The ammonia is taken directly into the cylinders through the pipe manifold. Therefore there is no possibility of pumping lubricating oil from the crank case over into the cooling coils. Flooding of the cooling coils with oil and thereby cutting their refrigerating effect is impossible.

Any part of the continental may be inspected by simply closing the suction and discharge stop valves on the manifolds, and removing the crank



CONTINENTAL REFRIGERATING SYSTEM

case door, the plates of the cylinder necks, and the cylinder head.

The continental is built with a cross head similar to that of a steam engine. This causes a straight vertical movement of the piston which prevents side thrust on the cylinder walls.

The stuffing box between the cylinder and the crank case prevents the ammonia from entering the crank case. This stuffing box is of special design and is packed with a combination of frictionless packing, one side of which is in contact with the piston rod, and a diagonally shaped flexible packing which contracts and expands according to the pressure exerted upon it.

One of the best features of the continental is the adjustment for clearance. This is accomplished by means of a lock nut and threaded piston rod.

The shaft is made of a solid steel forging, very liberally proportioned, giving ample strength and assuring continuous service.

The continental is equipped with feather weight suction and discharge valves. All valves

and their seats are easily removable for grinding. Safety heads are provided to prevent the possibility of an accident in case of a charge of liquid being carried over into the cylinder.

The lubrication is automatic. The crank case oil lubricates the main bearings, the connecting rod bearings, and the cross-head. The oil from the mechanical lubricator is pumped directly into the space in the stuffing box which is occupied by the spring. Ammonia in the cylinder acts as a partial lubricant and the piston rod, working in a bath of oil carries sufficient oil to the cylinder to effect perfect lubrication there.

The condenser used in these units is of special compact design in which the condenser and the liquid receiver are combined. The combination is located in the base and is easily accessible through large hand holes.

LIPMAN REFRIGERATING MACHINE

The Lipman Line has met with great favor among small merchants throughout the country because of its compactness, smooth running, and economy. The Lipman machine is full-automatic and many of the company's sales have been replacements of much larger hand operated machines. There is no longer any doubt but that the auto matic machine is the most satisfactory solution of the small merchant's problems.

The Model 700 was chosen from the Lipman Line as a typical small-store automatic machine. This machine has a capacity of 1000pounds of refrigeration per day. The entire high side is erected on a rigid attractive stand. All parts are easily accessible. The control switches are operated by an electrical contact expansion thermostat.

The compressor is vertical, single cylinder, and single acting. It is an enclosed type. It is belt driven by an electric motor. The belt tension is kept constant by a counter weight.

An efficient oil separator is provided in

LIPMAN REFRIGERATING MACHINE

the high pressure gas line.

The condenser is of the shell and coil type; the cooling water runs through the coil and the ammonia flows through the shell counter current to the cooling water.

THE ICELESS REFRIGERATOR

Housekeeping methods have been completely revolutionized in the past two decades. Modern invention has turned the labor of the housekeeper into a real pleasure. The electric stove starts and stops its cooking with a turn of a switch, the vacuum cleaner keeps the house spick and span and the electric washer takes the drudgery out of "blue Monday". And now we have the iceless refrigerator.

The iceless refrigerator is essentially a machine for keeping food dry and at a constant temperature of thirty-eight to forty-four degrees Fahrenheit. It is a scientific fact beyond argument that food spoils rapidly due to germ growth at temperatures of fifty degrees or more. To properly preserve food so that bacteria cannot flourish, the temperature must be kept below forty-five degrees. The ordinary ice box is an inefficient and unsatisfactory food preserver because the temperature is always too high and because it forever varies with the varying quantity of ice and

the fluctuation of outside temperatures. The inside temperature cannot be controlled.

A Frigidaire was selected as the laboratory's household machine. The Frigidaire Corporation is a division of the General Motors Corporation. No sales are made outside of the territory covered by Frigidaire service. The principle data concerning this refrigerator is given below.

FRIGIDAIRE

Model B-9

Total Weight - 835 lbs.

Total Outside Volume - 37.5cu. ft.

Total Inside Food Capacity - 9 cu. ft.

Exterior Dimensions - 25" x 39" x 67".

Interior Dimensions

Large Food Compartment - 38 11/16 x 14 5/8 x 18 1/2 inches.

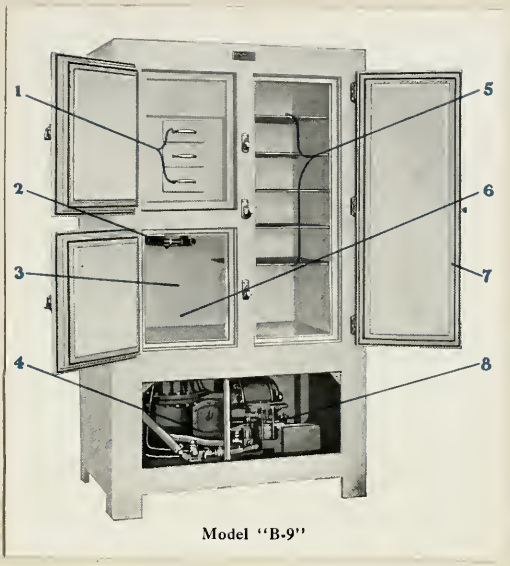
Small Food Compartment - 15 1/8 x 16 1/2 x 18 1/2 inches.

Total Refrigerating Capacity - 700 B.T.U./hr.

Type of Condenser - Water Coil.

Refrigerating Chamber - A jacketed expansion unit or boiler filled with brine made up of calcium chloride and water. This brine tank weighs about one hundred pounds when charged.

Brine Tank Temperature - Average 20 degrees F. It is controlled by a methyl chloride filled gas thermostat which stops the compressor at 16 degrees and starts it at 24 degrees. This control is located in the brine tank.



Model "B-9"

1. Ice Drawers
2. Temperature Damper
3. Sanitary Lining
4. Water Control
5. Shelves
6. Storage Space
7. Rubber Seals
8. Starting Control

Ice Making - Three trays of three pounds capacity are recessed into the brine tank. The maximum time of freezing is eight hours; the cost is about one cent for twenty four cubes.

Compressor - Two cylinder, piston type, driven through four to one gear reduction by a 1/4 horse power motor.

Food Compartment Temperature - 38 to 44 degrees.

Food Compartment Control - Thermostatic damper, controlling circulation of air.

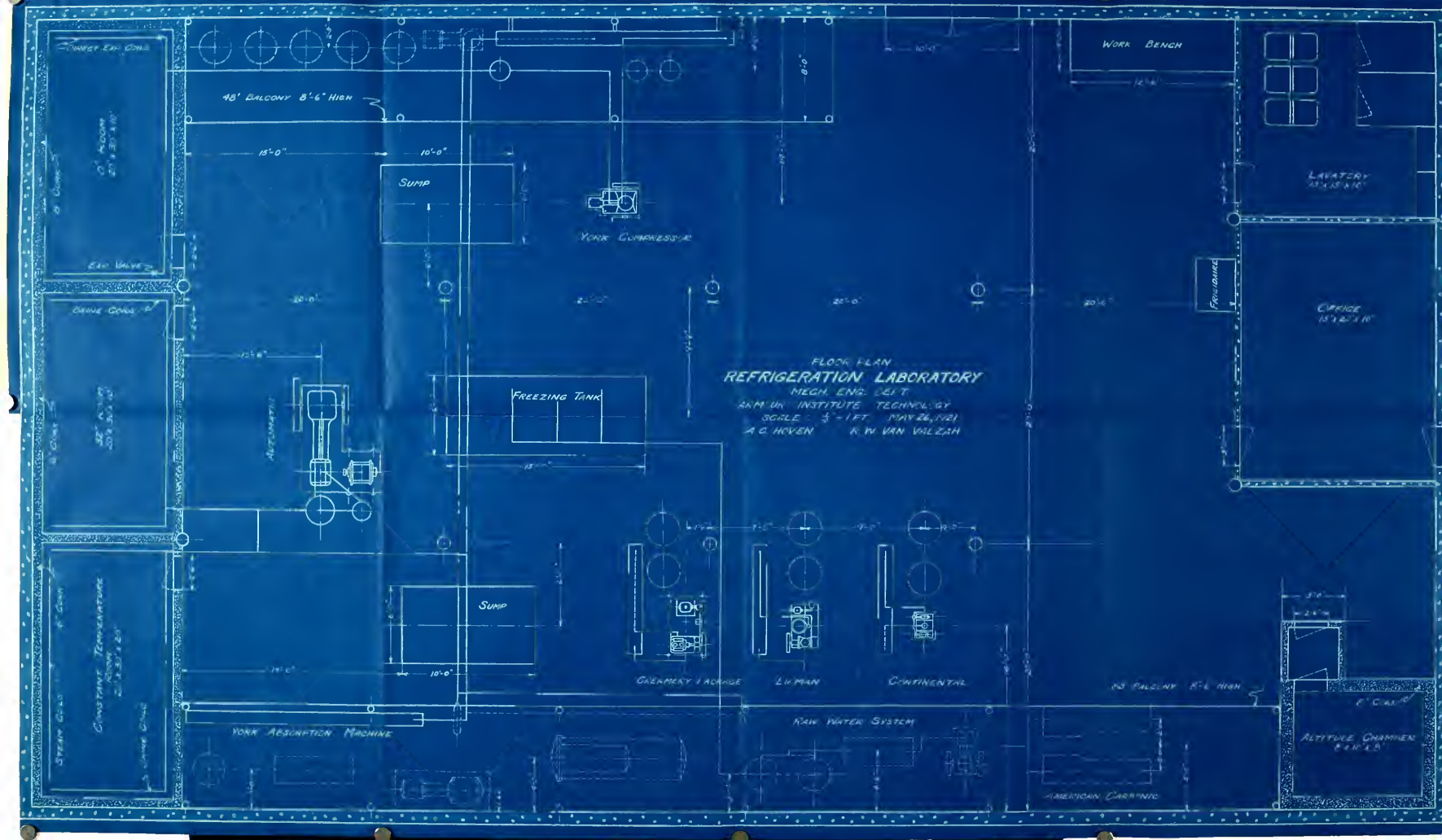
Percent Operating Time - 20 to 25%

Normal Motor Load - 250 watts.

Cost of Electricity - About 6¢ a day @ 4¢ per Kilowatt hour.

Quantity of Water Used - About 20 cu.ft. per day.

Cost of Water - $4.38 per year @ 60¢ per 1,000 cu. ft.


48' BALCONY 8'-6" HIGH
WORK BENCH
SUMP
YORK COMPRESSOR
LAVATORY
FREEZING TANK
FLOOR PLAN
REFRIGERATION LABORATORY
MECH. ENG. DEPT.
ARMOUR INSTITUTE TECHNOLOGY
SCALE: 1/4"-1 FT. MAY 26, 1921
A.G. HOVEN R.W. VAN VALZAH
SUMP
YORK ABSORPTION MACHINE
GREENWICH ICE CREAM
LILLMAN
CONTINENTAL
MAIN WATER SYSTEM
AMERICAN CARBONIC
ALTITUDE CHAMBER