DEUTSCHER KÄLTE-VEREIN

(GERMAN ASSOCIATION OF REFRIGERATION)

MECHANICAL REFRIGERATION IN GERMANY

PRESENTED TO THE MEMBERS OF THE
THIRD INTERNATIONAL CONGRESS OF REFRIGERATION

CHICAGO 1913

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Introduction

In presenting these pages the Deutsche Kälte-Verein tenders its greetings to the members of the Third International Congress of Refrigeration.

Under the heading "Firms of German Refrigerating Machine Makers. Technical and Personal Notes" we have attempted to furnish a sketch of the extent to which German engineering firms take an active part in the supply and development the world's demand for mechanical refrigeration; whilst in the second part we venture to describe a few extensive or otherwise notable installations erected within the German Empire.

We cannot pretend to have realized our aim to anything like the anticipated extent, if only in view of the fact that a considerable number of eminent firms engaged in the construction of refrigerating machines have not seen their way to participate in our scheme, so that the attainment of our object is necessarily incomplete; yet we hope that the information here given may prove useful to those interested with us in all matters appertaining to mechanical refrigeration.

The Deutsche Kälte Verein was founded in 1910 and had its inception in the institution of the International Congresses, so that it owes its origin to external influences. The association numbers at present little more than two hundred members. Since in Germany mechanical refrigeration attracted the attention of physicists and engineers at an earlier date than in most countries and accordingly also has been developed and systematized more completely the necessity of associated furtherance of the development of the industry is here less pronounced than elsewhere. Of the three departmental divisions of the association, that is to say the scientific, technical and economical departments, it is accordingly only the latter which has shown great activity, inasmuch as it has undertaken the study of a number of problems relating to the working and management of cold stores and ice factories. A current account of the transactions of the Deutsche Kälte Verein is to be found in the organ of the association, the Zeitschrift der gesamten Kälte-Industrie, a copy of the special commemoration number of which we present with this publication. One of the objects of the German Kälte Verein is to establish ties of common interests among the members of the refrigeration fraternity, and it is in this spirit that it accompanies those of its members who are attending the Third International Congress of Refrigeration with its sincerest wishes for successful discussion and fruitful strengthening of international interests.

THE DEUTSCHE KÄLTE VEREIN

President: Dr. C. v. Linde

MUNICH, August 1913.

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FIRMS OF GERMAN REFRIGERATING PLANT SUPPLYERS TECHNICAL AND PERSONAL NOTES

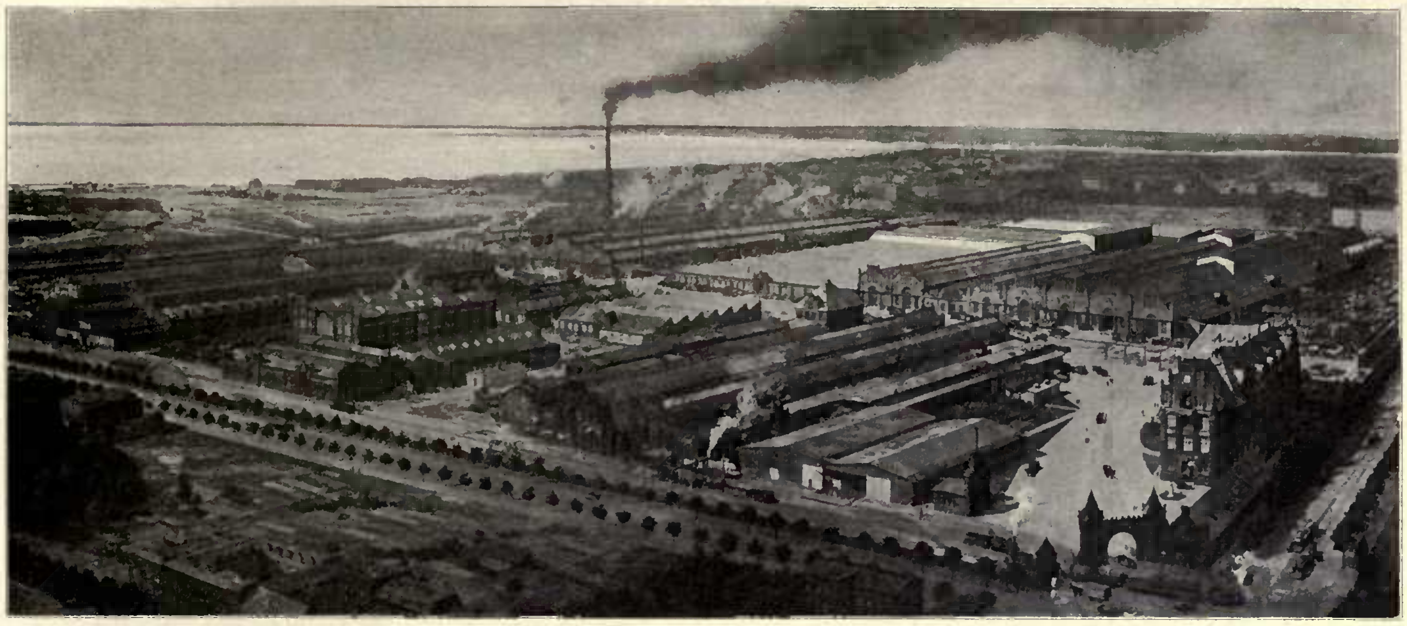


Fig. 1 General View of the Works at Tegel

A. Borsig, Berlin-Tegel

The firm of A. Borsig was founded in 1837 by August Borsig, grandfather of the present principals. The undertaking comprises now the Engineering Works at Tegel near Berlin and the Mining and Steel Works at Borsigwerk in Upper Silesia. The total number of persons employed at these establishments amounts to 125 000.

The works at Tegel were installed in 1898 and in the main work up the raw materials produced at Borsigwerk. The establishment is situated in a most favourable position on the Tegel Lake, which is in direct communication with the great North and East German waterways. For transport by rail the establishment is connected by a loop line to the Berlin-Kremmen state railway line. This loop line runs through the main roads of the works, whilst a narrow gauge railway system provides the intercommunication between all the workshops.

The first building the visitor sees on passing through the main entrance is the general office building, which accommodates the counting house on the ground floor, on the first and second floors the drawing offices, and on the third floor the technical library, the blue print laboratory, and the photographic studio attached to the advertising and literary department.

The chief objects of manufacture are:

Locomotives,
Steam Engines and Boilers,
Piston Pumps,
Centrifugal Pumps,
Air Lift Pumps (Mammoth Type),
Air and Gas Compressors for all purposes,
Ice Making and Refrigerating Machines operating on the ammonia, carbon dioxide and sulphur dioxide systems,
High Pressure Pipe Conduits,
Compressed Air and Vacuum Dust Removing Plant,
Machines and Appliances for Chemical Processes,
Forgings and Castings.

The property at Tegel embraces an area of 99 acres, one half of which is at present occupied by the works. The cubical content of the workshops and other works buildings erected thereon is about 26,000,000 cub. ft.

For the transport and handling of work pieces the works yards and workshops are served by forty cranes varying in lifting capacity from 5 to 37½ tons and of spans varying from 10 to 56 ft.

Following the circuit marked on the plan of the works, the boiler shops are encountered first after traversing a yard bounded by the waging office with the gate and timekeeper's lodge, the office building, the

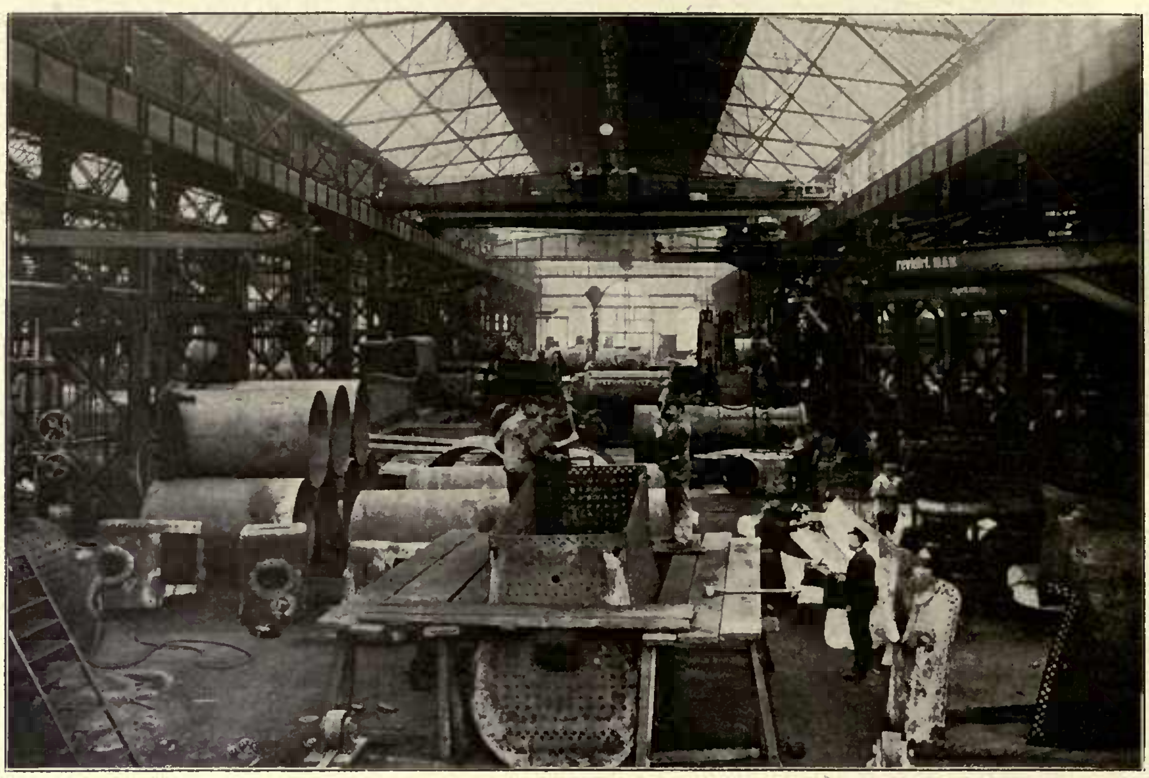


Fig. 2 Boiler Shop

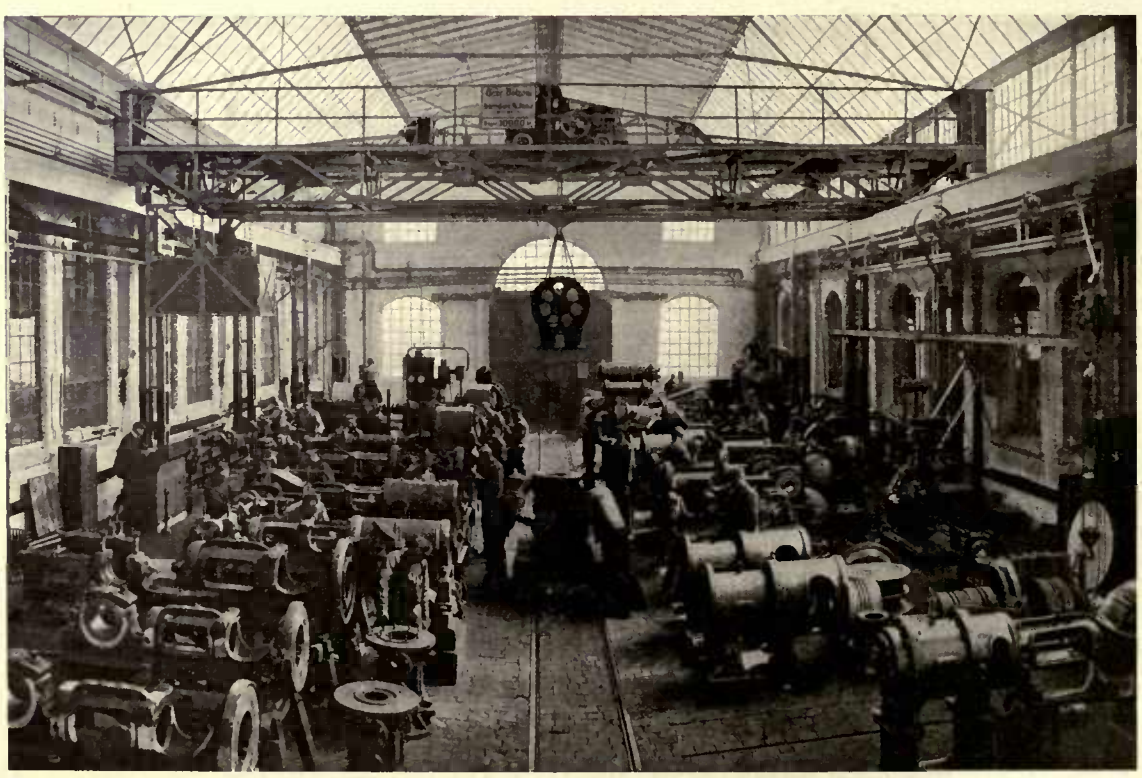


Fig. 3 Erecting Shop for Compressors

motor garage, the stables and sheds, the fire drill tower, the wheel yard, and the delivery and despatch department. The boiler shops comprise six large sections and are provided with the latest and most perfect equipment for machining and handling work of the largest dimensions.

Fig. 4 Drawing Office of the Refrigerating Machine Department

The last section on the eastern side is employed for fitting up locomotive frames. This section contains amongst other machines the boring, slotting and milling machines required for machining locomotive frame plates in large numbers, the machines being so designed that plates stacked to a height of 10 inches can be machined with three machine tools at a time. The other sections accommodate the boiler shops proper, separate departments being provided for locomotive boilers, large water space boilers and water tube boilers, the latter including special types of marine boilers, boilers with steep water tubes, etc.

A separate section serves for making freezing tanks, condensers for refrigerating machines, etc. Mechanical chain stokers are likewise put together in this section.

Wherever practicable, all boilers are riveted hydraulically. The caulking of the seams and rivet heads is effected throughout by compressed air tools. Metal plates are cut by the autogenous method, and the numerous containers which form part of compressor and refrigerator machine plants are welded by the same process.

The Boiler Section adjoins the Store Section for boiler plates, rivets, corrugated tubes, and water tubes, next to which is the Tube Bending Shop and the Welding Shop for water tanks and other large vessels for chemical manufacturing processes.

On the right side of the road the boiler yard sections are succeeded by the Erecting Shops for large engines and machines. In this section a large number of refrigerating machine compressors, air compressors and hydrogen compressors are at all times being erected, as the establishment turns out about one thousand units per annum.

The construction of refrigerating machines has become particularly extensive. Of other machines and

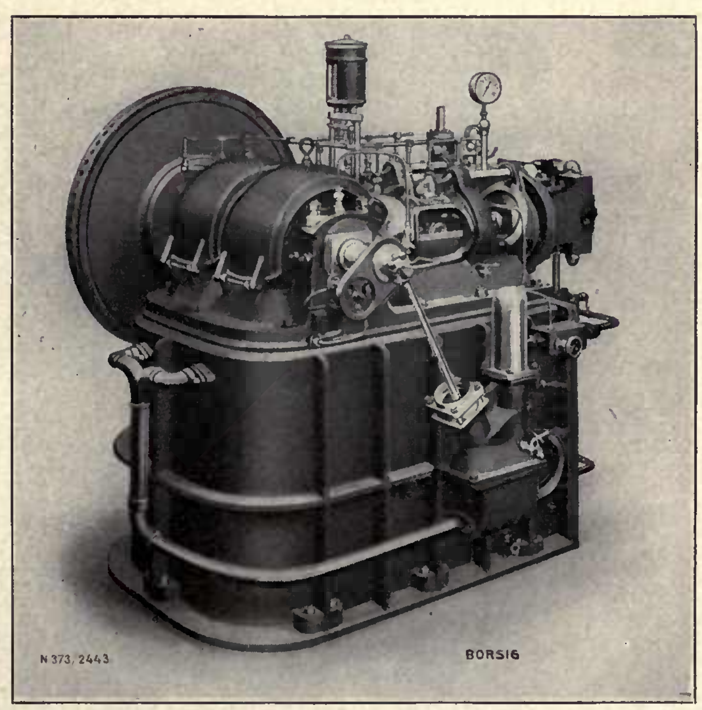


Fig. 5 CO_2 Marine Refrigerating Machine

engines completed here we may mention inclosed vertical type quick running engines, horizontal steam en-

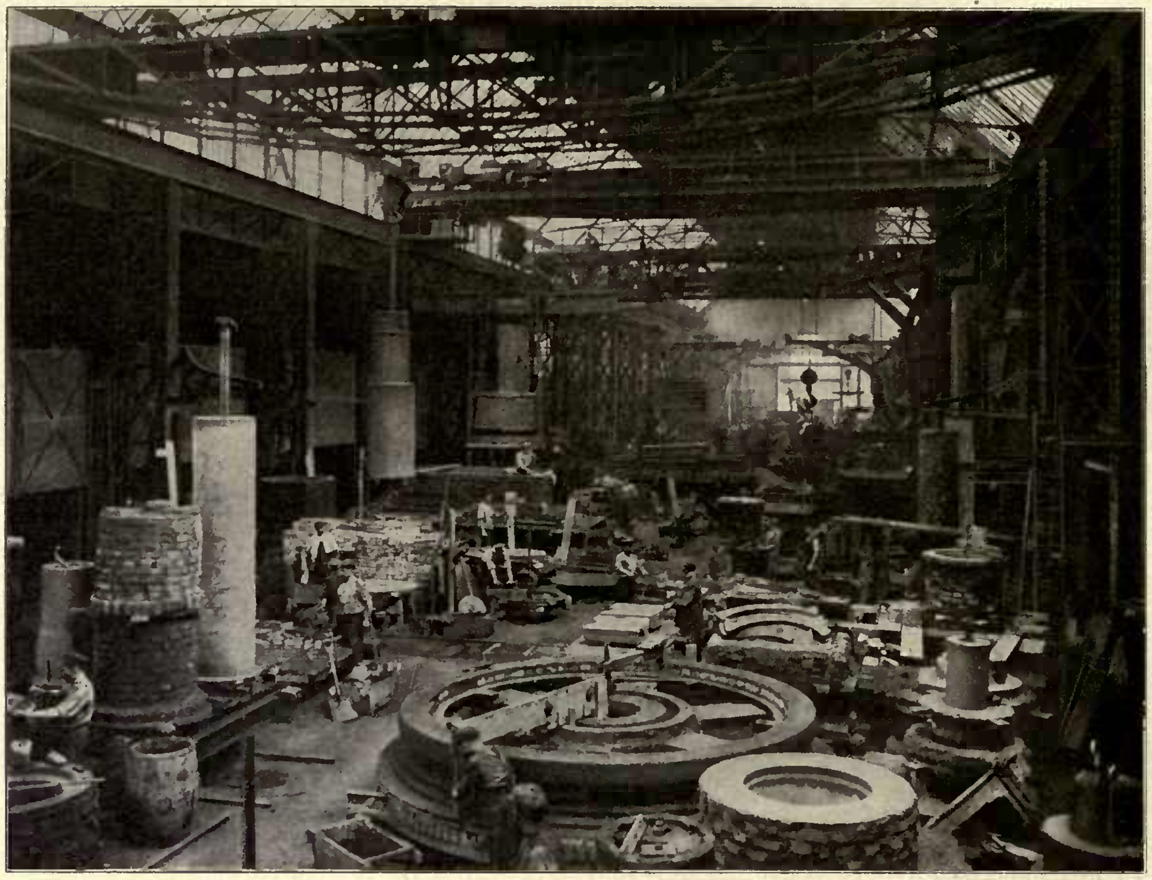


Fig. 6 The Foundry

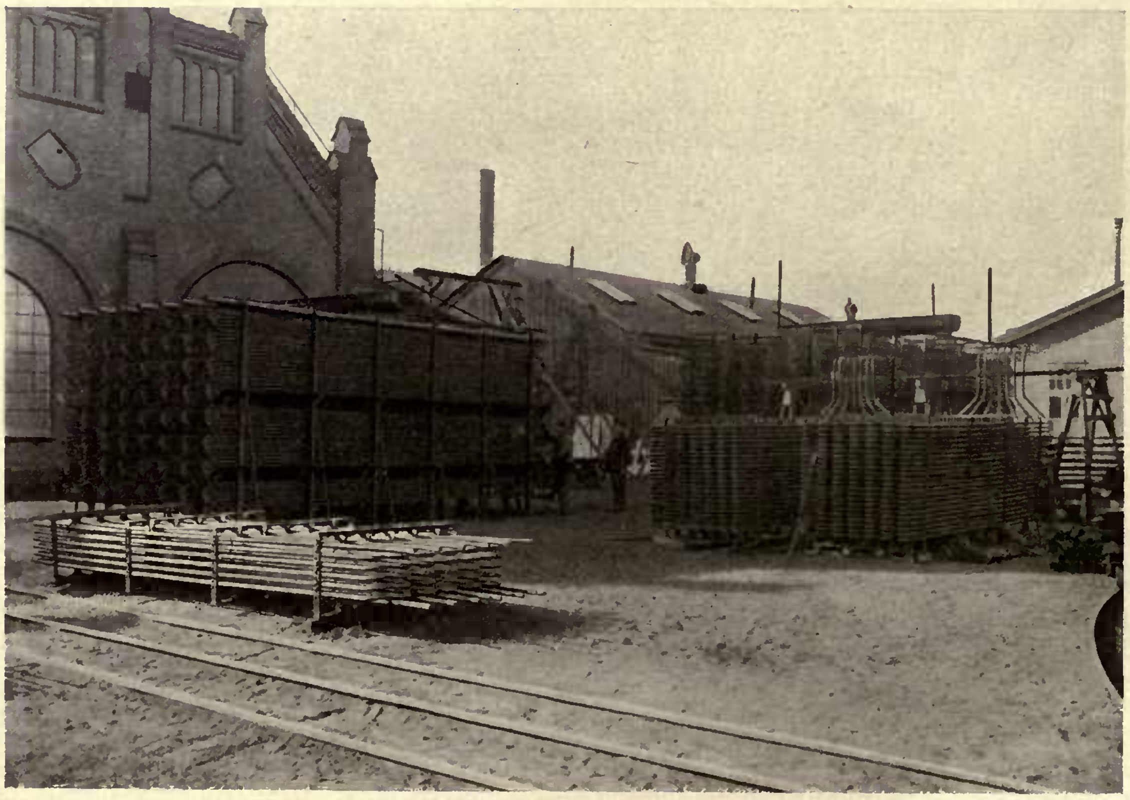


Fig. 7 The Tube Stack

Fig. 8 The Tube Bending Shop

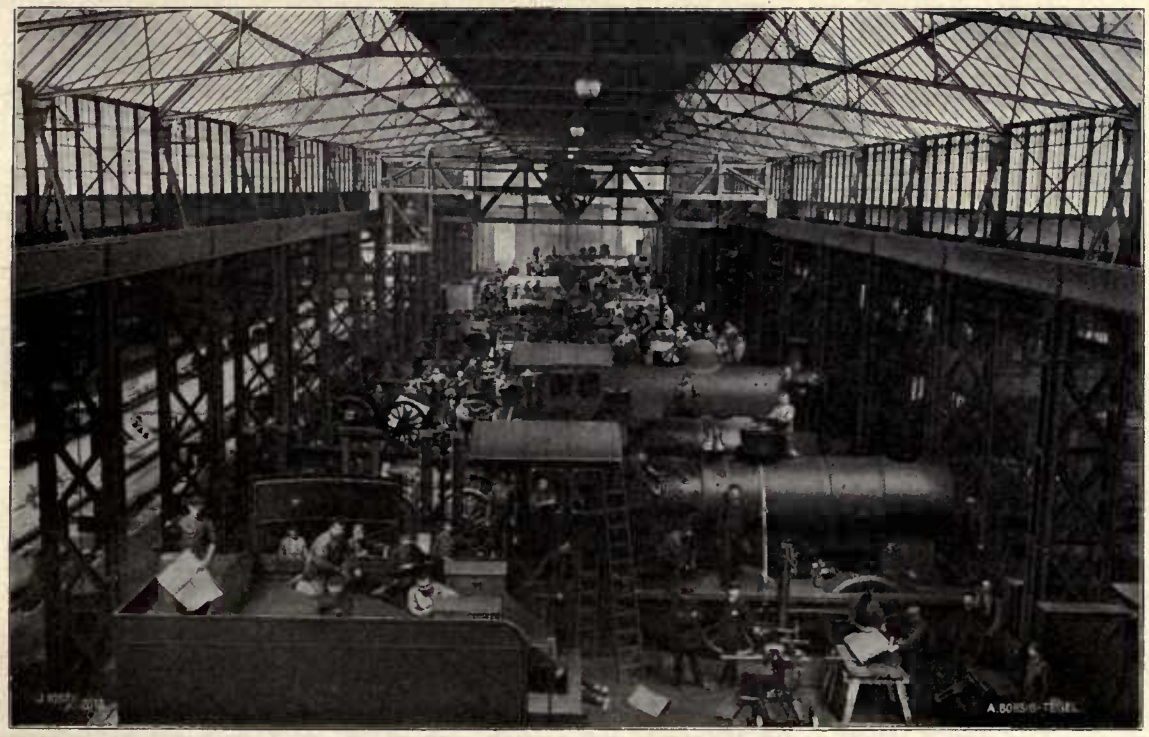


Fig. 9 Locomotive Erecting Shop

gines of every type and size, pumping engines, large blowing engines, hydraulic presses, etc.

Next in order follows the Fitting Shop Section, to which adjoin the Turning Shop for Heavy Work and the Locomotive Fitting Shop.

This group of workshops accommodates about 750 machine tools, including 250 large lathes, 100 planing machines, 140 boring machines and 70 milling machines for forgings and castings of all dimensions up to the largest to be met with in machine construction.

Fig. 10 Apprentices' Workshop

At the rear of the fitting shops are situated the screwing machine shops, the experimental-section for refrigerating machines, pumps and compressors, as well as machine parts.

double forge hearths, 18 welding and reheating furnaces, steam hammers with tups weighing up to 6 tons, machine forges and hydraulic press forges, among these some capable of exerting pressures of 1200 and 2000 tons.

In both forges altogether 10,800 tons of forgings of small and moderately large size up to 40 tons are produced annually, whilst the heavier forgings are supplied by the iron and steel works at Borsigwerk in Upper Silesia.

The adjoining new building comprises briquetting presses, in which the steel and iron turnings, classified from gunmetal chips, are moulded into briquettes for admixture to the foundry charges. The next section is the template cutting and cold sawing shop.

Fig. 11 Engineers and Clerks' Casino

These are succeeded by the steel casting and section iron store, next to which are the Forge and Smithy. The Forge is equipped with upwards of 45

The next building is the Boiler House with the economiser plant. The steam generator plant comprises eleven water tube boilers designed for a working pressure of

147 lbs per sq. in. and having an aggregate heating surface of 28,000 sq. ft. These boilers, fitted with chain grates, generate steam for the power house and electric light station and partly also for the steam hammers and the heating installations. The power house comprises four large vertical type drop-valve engines with direct-coupled dynamo of an aggregate output of 1800 kw. In addition there are two exhaust steam turbines with an aggregate output of 1500 kw, and finally a few smaller dynamos and an accumulator battery of a capacity of 3000 ampere-hours.

Annexes to the power house comprise the central station for the compressed air system for transmission of power to various machine tools in the boiler section, foundry, erecting shop, etc.; next, the Testing Laboratory, which is equipped with a testing machine capable of applying tensile loads up to 40 tons, a hardness testing machine etc., and finally a Chemical Laboratory.

The power station with its annexes brings us to the end of the main street of the Works. Crossing the street and retracing our steps along the other side we come to the Foundry, the annual output of which amounts to about 10,000 tons of castings in green sand, dry sand and loam. The foundry plant includes nine cupolas and a converter for a charge of about 2¼ tons. The foundry turns out castings weighing up to 50 tons each. The cupolas are charged by a suspended electric conveyor.

The Brass Foundry is equipped with three Piat Furnaces and turns out upwards of 2000 tons of bronze and gunmetal. It is accommodated in a separate building, which comprises also the dressing shop for the smaller castings.

The brass and iron foundry are separated by the Small Machine Shops for making in regular series air compressors, refrigerating machines, compressors, plunger pumps and centrifugal pumps, and inclosed steam engines for which there is a special demand. Attached to these shops are spacious halls for sheltering the stock of finished machines. The next section comprises the Pattern Shops, which are equipped with numerous wood working machines. At the rear and on the eastern side of these shops and the storing sheds attached thereto are situated the Copper Smithy and Tube Bending Shop, where the large and elaborate pipe systems of refrigerating and ice making plants, pipe coils, etc. for freezing tanks and worms for ammonia and sulphur dioxide refrigerating machines form conspicuous objects of manufacture.

The extensive space originally occupied at this point by the pattern store rooms has been claimed by the extension of other workshops and has now been transferred to a situation outside the enclosure of the Works near the foundry. Close to the pattern shop is the Tool Making Shop, where the tools used in all the shops of the establishment are made, in particular twist drills,

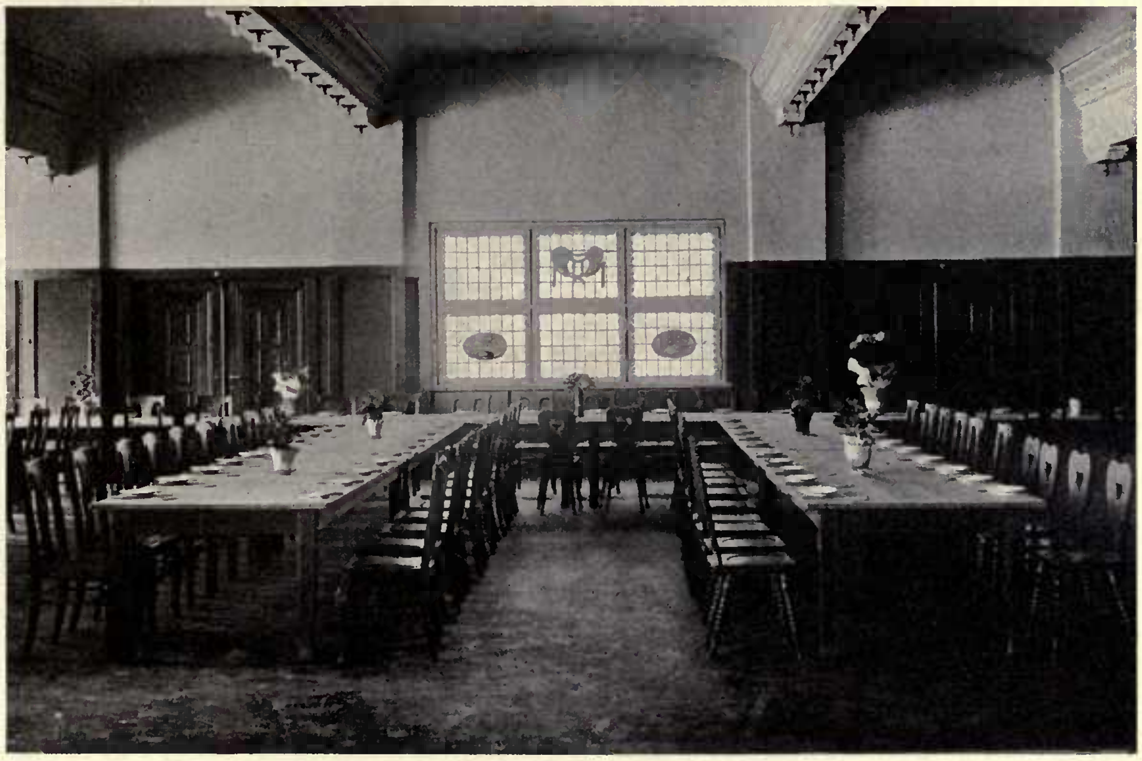


Fig. 12 Engineers' and Clerks' Dining Hall

Fig. 13 Dining Hall for Workmen

Fig. 14 Library in the Engineers and Clerks' Casino

screw taps and gauges of all kinds, all of which are made, hardened and ground with the utmost degree of precision.

We now come to the General Warehouse and the Works Managers' Offices with rooms for the managers and the heads of the various workshop sections, as well as the first cost calculating department, whilst the top floor provides room for the private printing office of the firm.

The large workshops on this side of the Works terminate with the locomotive erecting shop, which covers an area of nearly 3 acres. This shop is divided lengthways into two halves by a pit traversed by an electrically operated travelling platform for the accommodation of components and fittings. This erecting shop provides room for the completion of 400 to 500 locomotives per annum.

The locomotive erecting shop includes the Painting and Lacquering Shop, and attached to it and facing the yard is the locomotive storing shed, in which a permanent stock is maintained of a matter of one hundred locomotives of all dimensions for light railways and local lines, for clearing work, for mining and tunnelling operations, etc. On the eastern side of the works a railway track about 1100 yards long runs parallel to the walled enclosure. This serves for the preliminary trial of finished locomotives.

On the western side of the works are situated the apprentice workshops, which provide room and work for about 400 apprentices. These are also instructed by members of the engineering staff in a separate school, which is situated between the smallmachine shops and the general warehouse.

About 200 acres of land are available for future extension.

Outside the walls of the works, on the other side of the Berlin Road, a large park with a spacious casino testifies to the social advantages provided by the firm for the benefit of their workmen and other employees. Until late hours of the evening, music rooms, play rooms, club and reading rooms, as well as play grounds in the park are at the disposal of the employees. The Casino kitchen has a cold storage room attached, wherein Borsig refrigerating machines serve to preserve large quantities of provisions. Two large dining halls have been erected and equipped, where good fare is provided at cheap rates.

In the colony at Borsigwalde referred to above, which is situated about ten minutes walk from the works employees of all grades may obtain at moderate rentals suitable residences, many of these with gardens attached.

Good food supplies are obtainable at a cheap rate on the cooperative principle by dealing through a store depôt established within the works. A Pension Fund assures financial security to the employees after service for a specified number of years. A Savings Bank has been instituted which receives on advantageous terms the deposits of the firm's employees. For the benefit of the workmen a Sick Fund has been instituted to provide support in the event of members being incapacitated, and the Luise Borsig Settlement assists aged workmen and their families. A Male Chorus and a Gymnasium Club as well as a Rowing Club are liberally supported by the firm.

The efficiency of the Fire Brigade and the Ambulance Corps is a useful asset, the value of which extends considerably beyond the precincts of the establishment and Tegel.

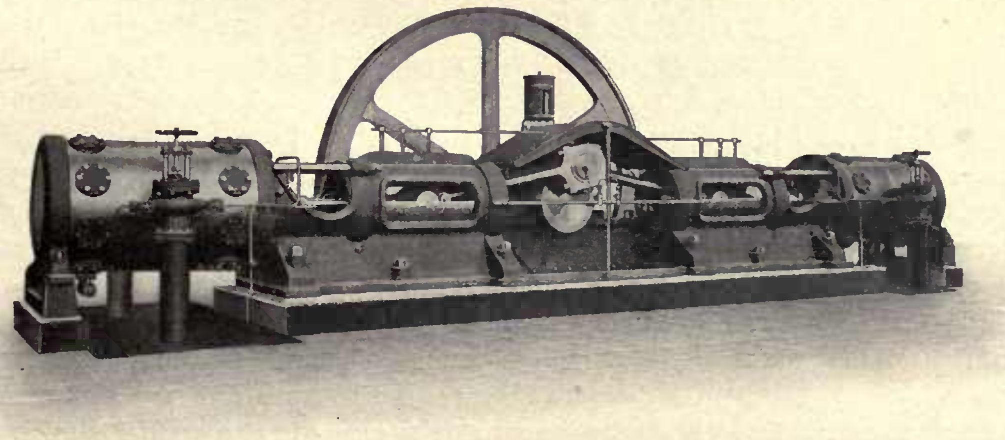
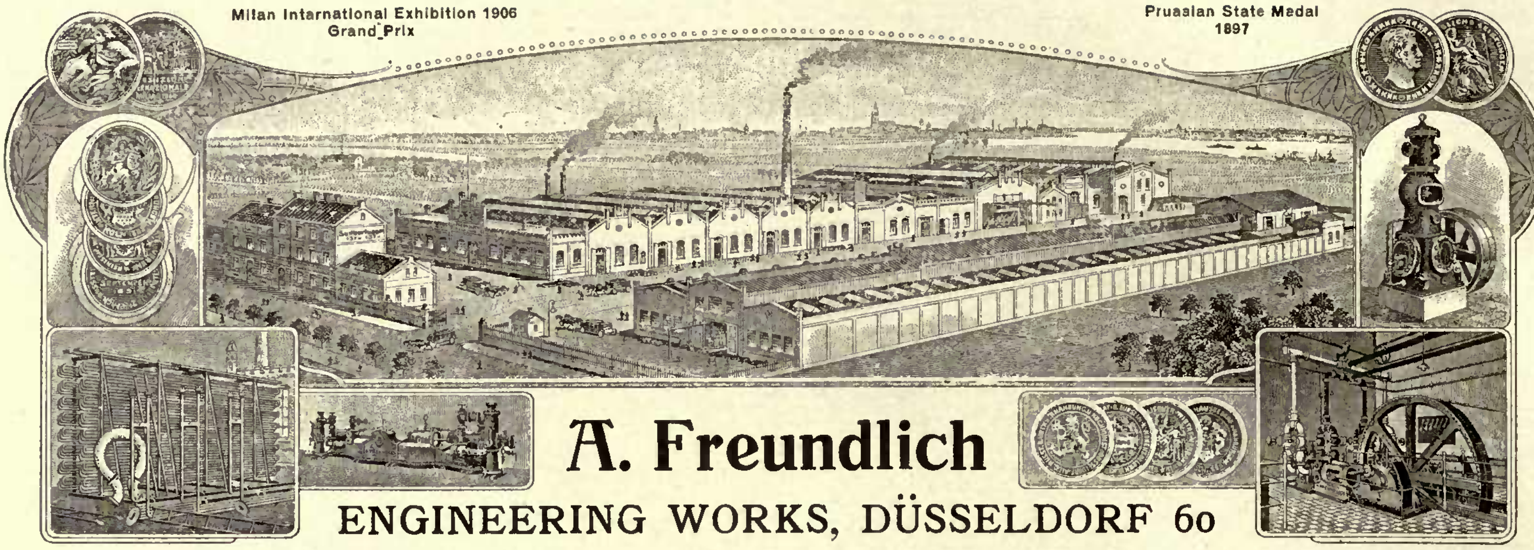


Fig. 15 Ammonia Compressor of 400 Tons Refrigerating Capacity



SPECIALITIES:
Ice and Refrigerating Machines
Air Compressors
Applaincas for Colour, Lacquer and Varnish Making
Vacuum Pumps
Dust Extractors
Autogenous Welding

Turin International Exhibition 1911, 2 Grand Prix

At the end of the very month in which the members of the Third International Congress of Refrigeration will meet for interesting discussions the Engineering Works of A. Freundlich will have existed 25 years. We trust therefore that we may be pardoned for occupying the space at our disposal with a memorial sketch of the firm's history.

Large modern industrial undertakings, even though they may still be privately owned, do no more exclusively concern the individuals who are immediately identified with them. Viewed from the wider standpoint of the political economist and sociologist they affect larger sections of organised society. Large privately owned undertakings, to which category the above firm belongs, when regarded, as they should be, as responsible units in an economic system, are filling a very onerous position when one bears in mind that their prosperity determines the fate of hundreds of workers. It cannot therefore but prove of interest to trace the development of one of these private undertakings through its salient phases.

It is a reflection of this nature that has prompted us to pen a brief sketch of the growth of the works at Düsseldorf.

How very modest were its first beginnings may be gathered from the fact that the founder of the firm, who still is at its head as the sole responsible owner, began on the 1st October with a workshop in a rented back building in the Steinstraße occupying a floor space of 12 sq.yds., a copper smith constituting his whole personnel.

When this workshop was transferred to the Bahnstraße the original 1 H.P. Benz motor was replaced by one of 7 H.P. and at the same time the modest copper smithy had a still more modest turning shop appended to it. This miniature workshop commenced, however, its operations under exceptionally propitious conditions.

Herr Freundlich, already six years prior to the establishment of his own firm, had been intimately connected with the then embryonic refrigerating machine industry, and in his capacity as the sole agent in the Rhine Province and Westphalia for the Raoul Pictet Ice Machines participated in the extremely interesting technical war which was then being waged between Prof. Pictet and the Linde Company. Under these circumstances he became intimately connected by daily intercourse with all who were interested in this rapidly developing branch of industry.

The brewing trade, which in those days was almost the only serious customer of the refrigerating machine makers, was then flourishing in an unprecedented manner, and the small workshop, which was originally conceived as the nucleus of a brewing machine factory, the breweries being the largest users of refrigerating machines, rapidly and comparatively easily rose step by step and steadily gained ground. Moreover, it was a period when industry was developing in Germany at an extraordinary pace, and the general trend of things could not but prove favourable to the beginning cold producing industry; and who in those days sought work earnestly and with a clear head was able to secure it at a profitable price.

In these circumstances the new premises soon became inadequate, if for no other reason because in the mean time the manufacture of ice cans and air cooling appliances, which until then had made up the principal

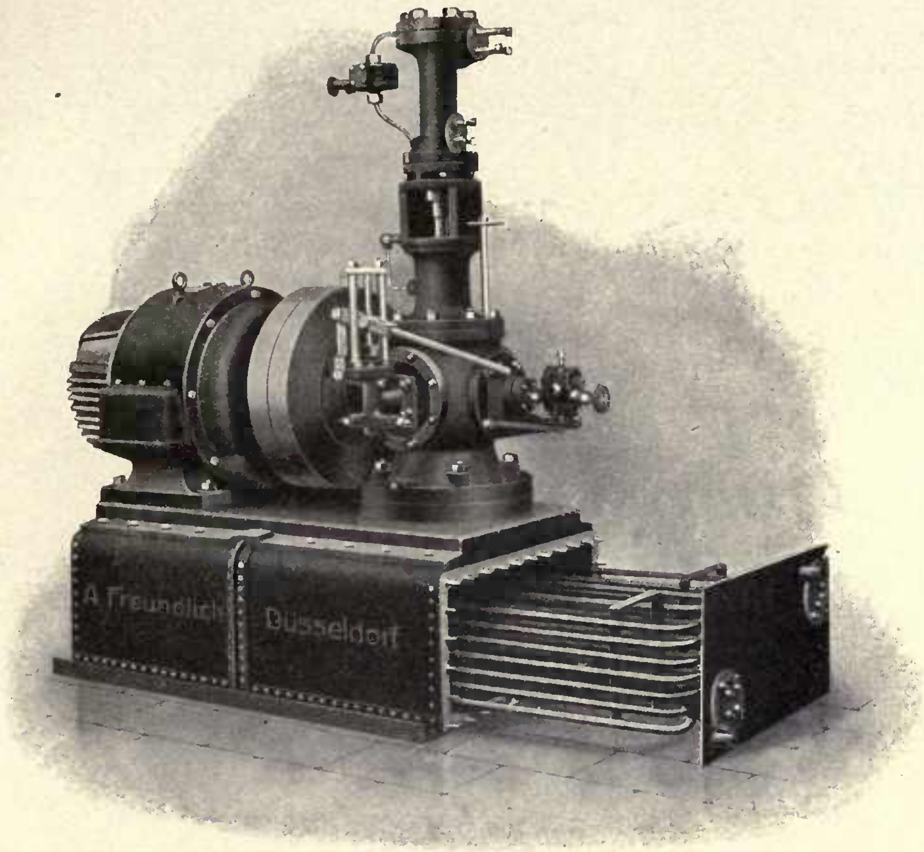
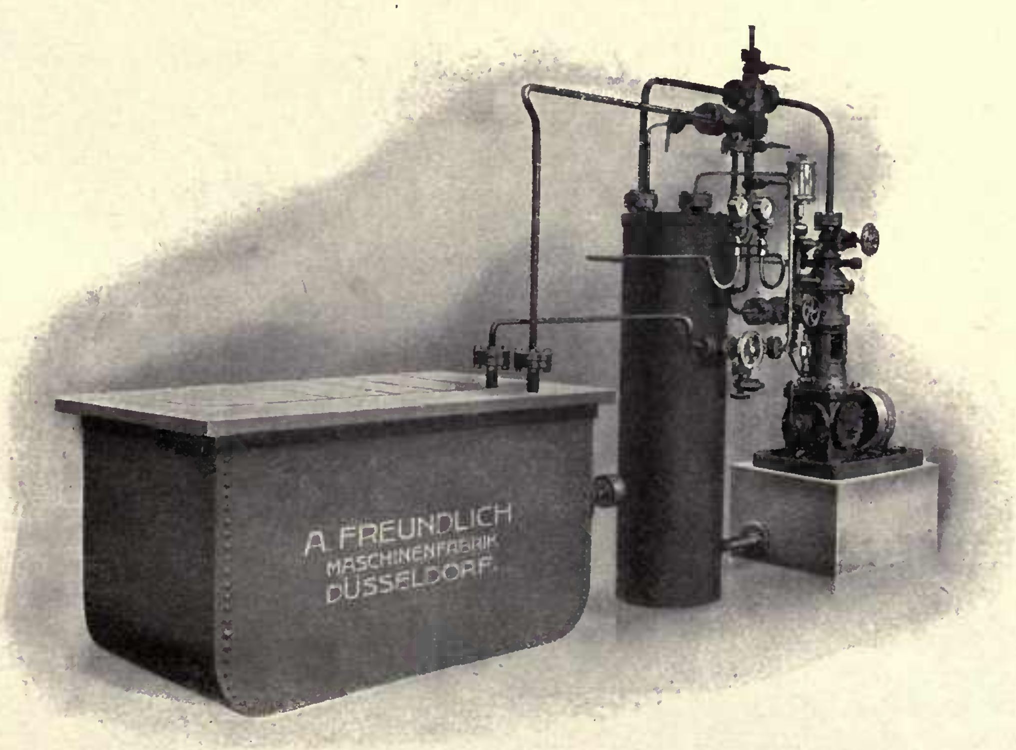


Fig. 1 Electrically Operated CO_2 Marine Refrigerator, Filiberto Pattern



Ice Tank Condenser Compressor

Fig. 2 Belt-driven Ammonia Ice Making Plant

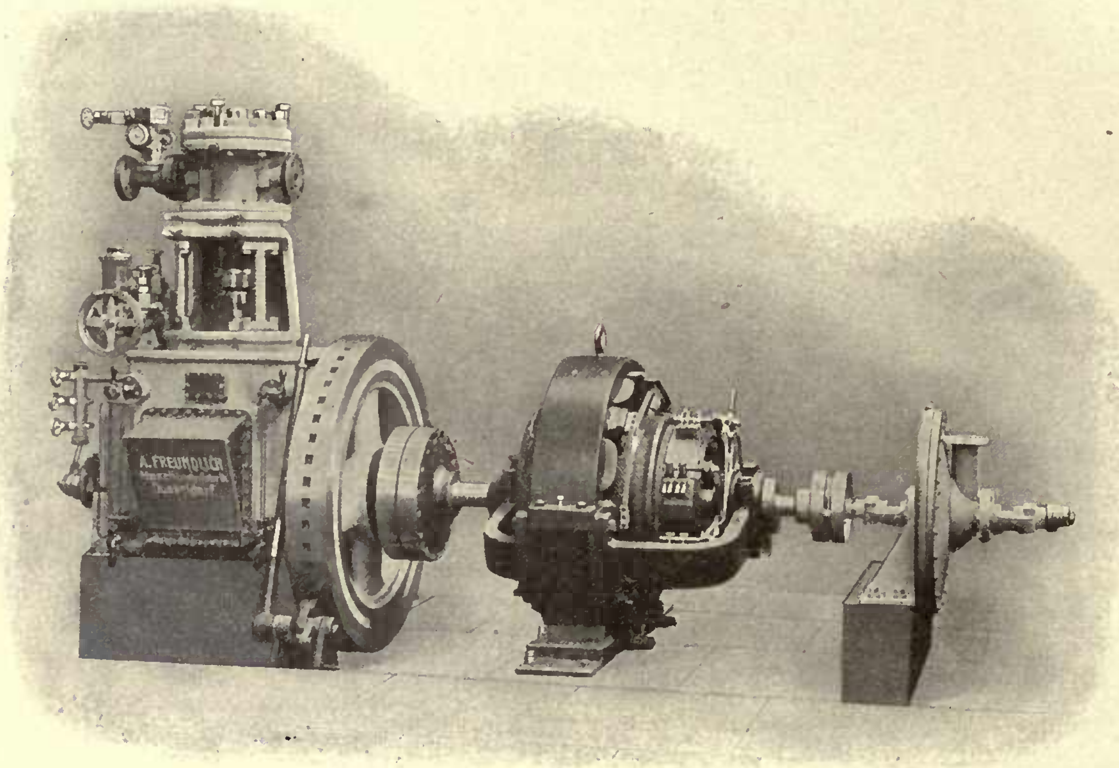


Fig. 3

Electrically Operated CO_2 Marine Refrigerating Plant with Direct Coupled Water Pump

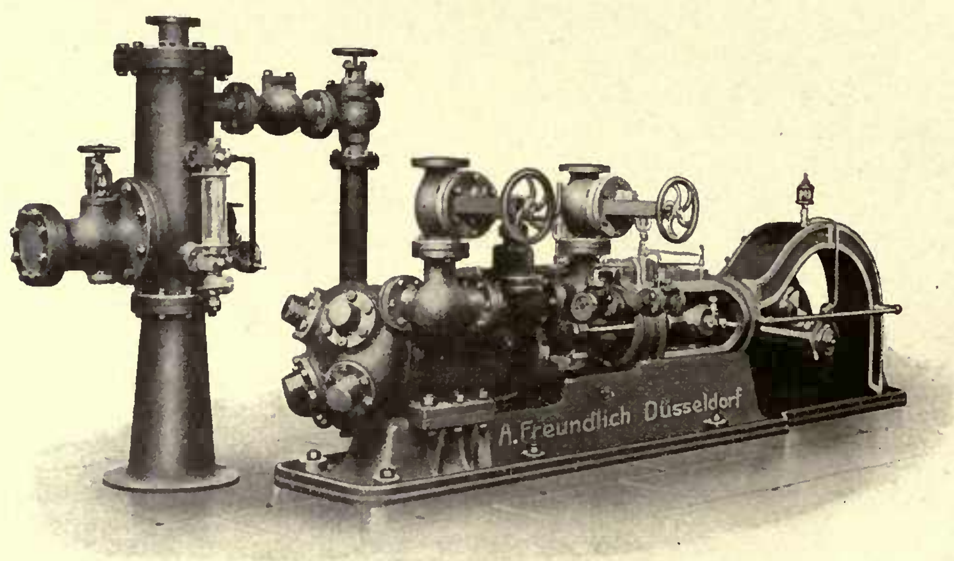


Fig. 4

Horizontal Ammonia Compressor with Rotary Accelerator, Bosch Type

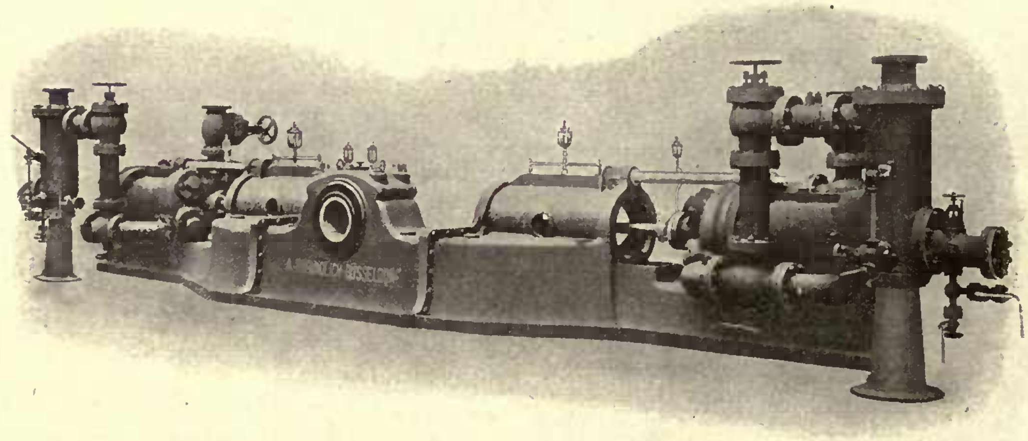


Fig. 5

Duplex Compressor, Ice Making Capacity of 100 Tons per Day

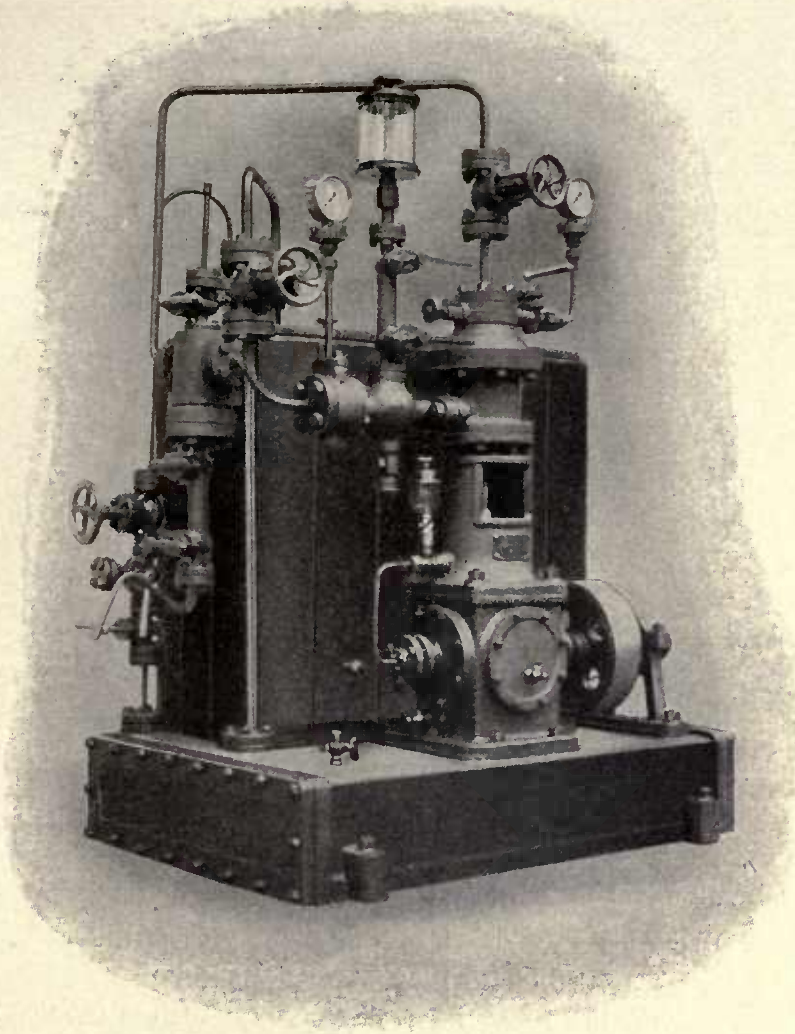


Fig. 6

Ammonia Ice Making Machine

Magdeburg Export Model

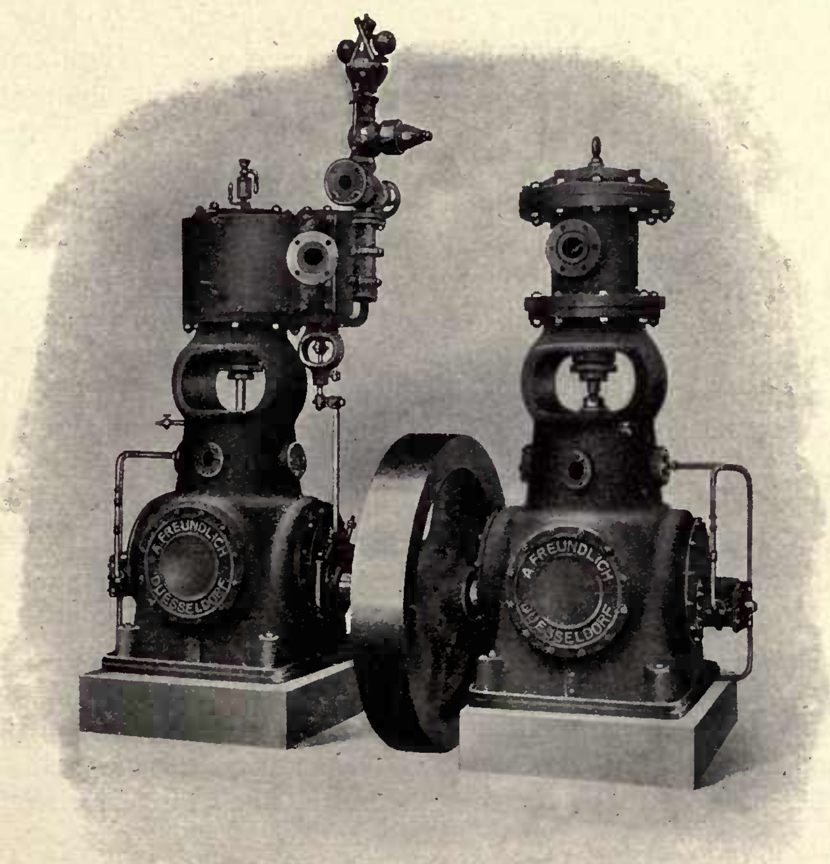


Fig. 7

Steam Operated Vertical Ammonia Compressor

Vienna Pattern

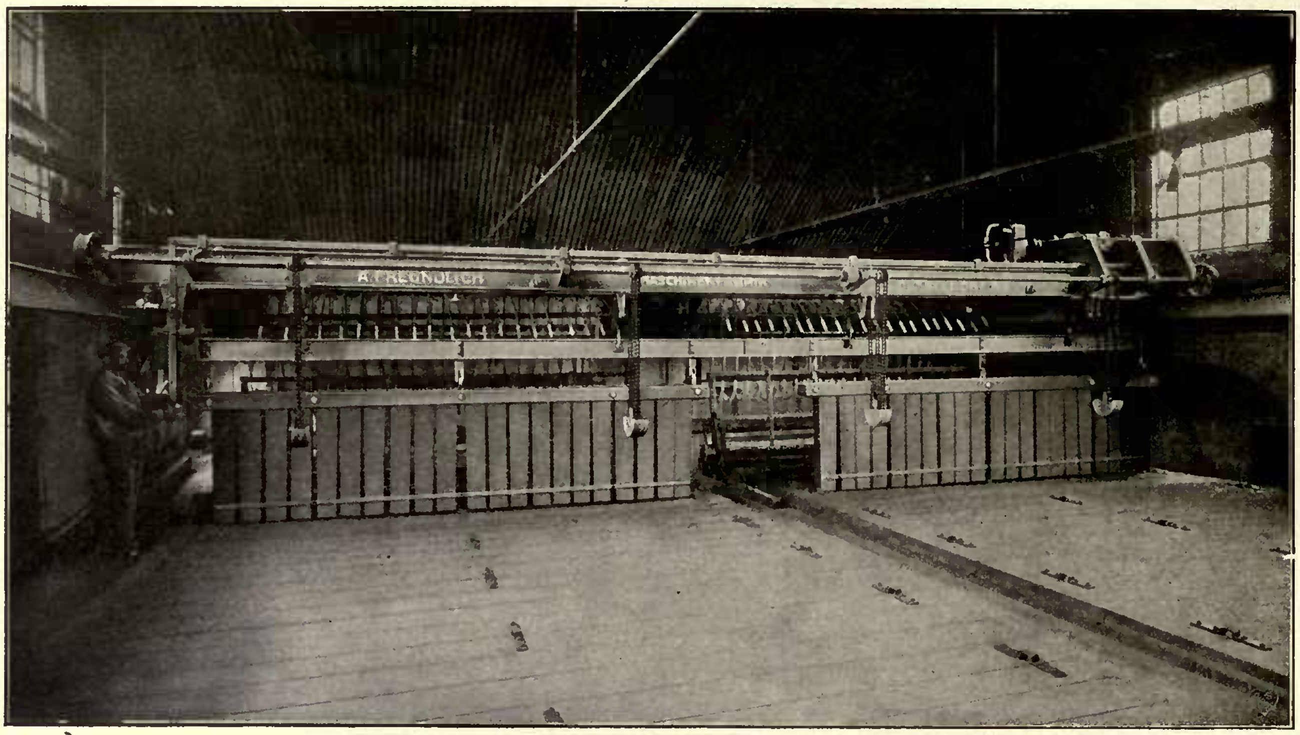


Fig. 8 Large Double-sided Freezing Tank "De gekroonde Valk" Pattern

objects of the venture, had led to the construction of fairly large ice making machines, condensers and other refrigerating appliances. It happened indeed frequently that a single order for an ice making machine of respectable dimensions would occupy the entire available space of the establishment. Failing the possibility of extending the premises, the owner was compelled to transfer the factory to more suitable premises, and this occurred several times at short intervals, and within three years (1892) of its settlement at the Bahnstraße we see it occupy a house in the Florastraße. The 7 H. P. engine was now replaced by one of 30 H. P. and, the space so acquired being soon found inadequate, supplementary premises were rented in the Kronstraße. Machine tools were added to machine tools, and as early as 1896 the firm found itself compelled to carry out considerable extensions. A site was accordingly purchased in the Suitbertusstraße and a new factory erected, which embodied all the experiences of the preceding years and was a pattern of modern factory building. The engine which was installed on this occasion, one capable of developing 80 H. P., proved sufficient for a short period only, and at the present time the required motive power has risen to 250 H. P.

The necessary changes in the working system and the erection of new premises were always undertaken with great circumspection, and no extension was ever attempted until the orders in hand had grown absolutely beyond the resources of the establishment.

The year 1899 signalised a notable event in the firm's history, inasmuch as the first ammonia compressor of original design, and thus the first complete ice making and refrigerating machine, was made at the works in every detail.

Whilst the construction of complete ice making and refrigerating machines was being carried on with great energy, the manufacture of the now well known Freundlich ice cans proceeded lustily and gained such importance that the department organised for their manufacture produces at the present time 180000 ice cans per annum.

The business grew at this rate until 1901 and 1902. Then arrived years of serious decline for the German refrigerating trade. In a measure as the general condition of trade deteriorated in an appalling degree, prices declined steadily, and the turnover sank to a level which was out of all proportion to general expenditure; and whilst orders declined working expenses rose higher and higher. Under these conditions there was nothing for it but to hold back expenditure and at the same time to bring the firm's entire energy to bear upon its export relations, which had already been fostered in previous years, and thereby endeavour to promptly secure an equivalent for the lacking home trade. This policy proved sound, and in a comparatively short time the firm was able to restore the balance between supply and demand and to secure valuable connections in all quarters of the globe.

Almost contemporary with that period of stagnation were the firm's first experimental efforts to replace the partly obsolete and slow running types of compressors by machines of an improved pattern conforming to modern high speed requirements.

About this time a vertical type compressor (German Patent No. 184867) had been undergoing comprehensive tests to ascertain its economic qualities. Declared by authorities, whose criticism had been invited, on the strength of the data obtained by practical tests to be under certain conditions superior to other types, the new compressor was put upon the market in 1905. Like most striking innovations, this type met with violent attacks, which it was however able to survive. After two or three years of preliminary struggles to obtain recognition, the greatly increasing popularity of this type proved that the right course had been adopted, and the persistence devoted to its cause was fully vindicated. Neither publicity nor other external means could have secured such a permanently solid success as during the last few years has been achieved by this new compressor type. Its extraordinary success surely has its root in its constructional points of superiority. In the course of the last business year the Works turned out upwards of 200 of these compressors.

The concern, situated within Düsseldorf proper, occupies an area of about $3^3/_4$ acres, of which about 9550 sq. yds. are covered with buildings comprising the following workshops: Erecting shops, fitting shops, boiler shop, foundry, copper smithy, white smithy, forge, welding shop, leading and tinning shop, pattern shop and engine house, accommodating about 200 machine tools, nearly the whole of which are specialised machines. By the end of April 1913 the Works had turned out about 1800 complete ice making and refrigerating machines and appliances representing an aggregate capacity of about 10000 tons of refrigeration. The body of workmen, clerks and engineers employed by the firm exceeds 300.

There is no doubt that much of its success the firm owes to the central situation of the works within the industrial area of the Rhine Province and Westphalia, that is in the very heart of the German metal tube and sheet and plate metal industry. Its principal materials, such as sheet metal, piping, bar and section iron, screws etc. are at the firm's disposal without more than an insignificant expenditure on carriage. Another important factor is the access to the water way provided by the Rhine, both for inland transport and export by way of the sea ports of Antwerp, Rotterdam, London, Hamburg, Bremen, Lübeck etc. The steam navigation on the Rhine is organized on such enterprising lines as to afford cheap through freights to those ports.

The firm derives further strength from the fact that every component of the ice making and refrigerating machines is made within its own premises.

The success which has crowned efforts pursued for a space of twenty-five years is assuredly in a large degree the outcome of systematic working in conformity with definite aims.

Such dangers as every large undertaking has to face in the course of its development have been met with the greatest tenacity of purpose, and possibly it was the ever recurring necessity to fight against adverse conditions which has helped the founder and his ably chosen captains to attain the success of to-day. The importance of a solid commercial and technical system in the administrative department has always been fully recognized,

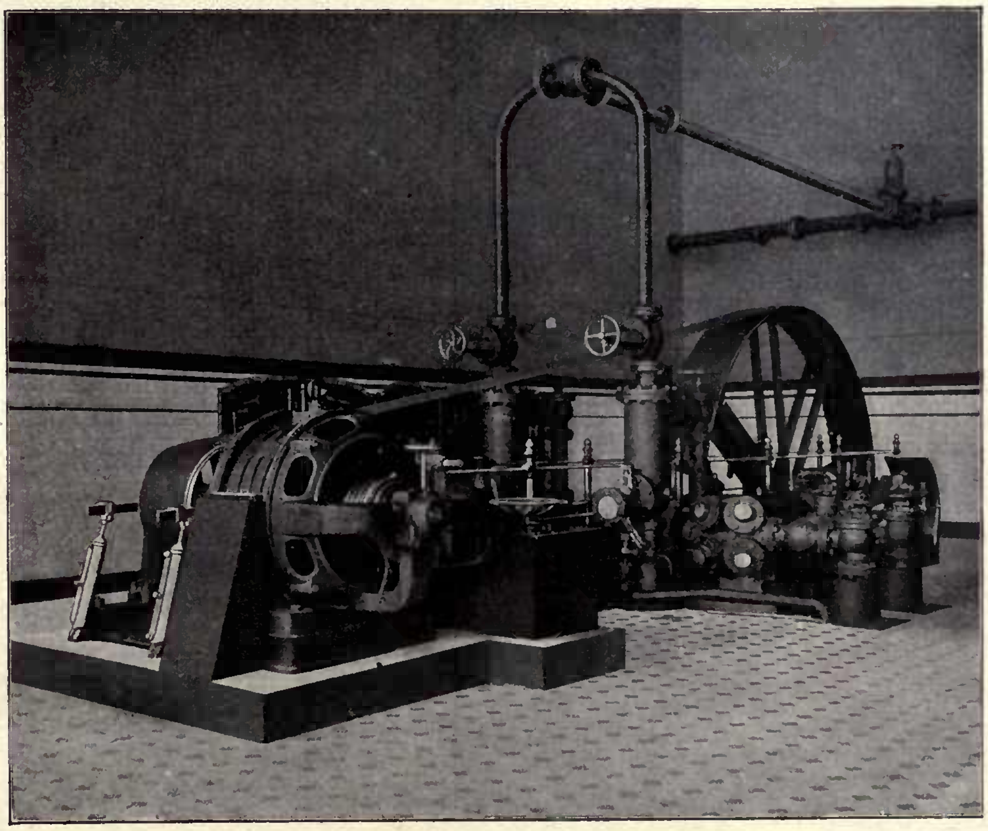


Fig. 9 110-Ton Duplex Compressor
with Direct Driving High Tension Motor

and, promptly acting upon well considered decisions, the firm always adapted itself to the rapid development of the ice making and cold storage industry and modern requirements in general, and did not hesitate to adopt initiative measures.

A number of patented innovations go to show that the firm has contributed its share to the furtherance of the industry. The industry is still relatively young and many problems are still awaiting their solution and provide a powerful incentive to firms willing and able to march with the times — among these assuredly the firm of A. Freundlich — to maintain their well earned reputation under the forthcoming conditions of development.

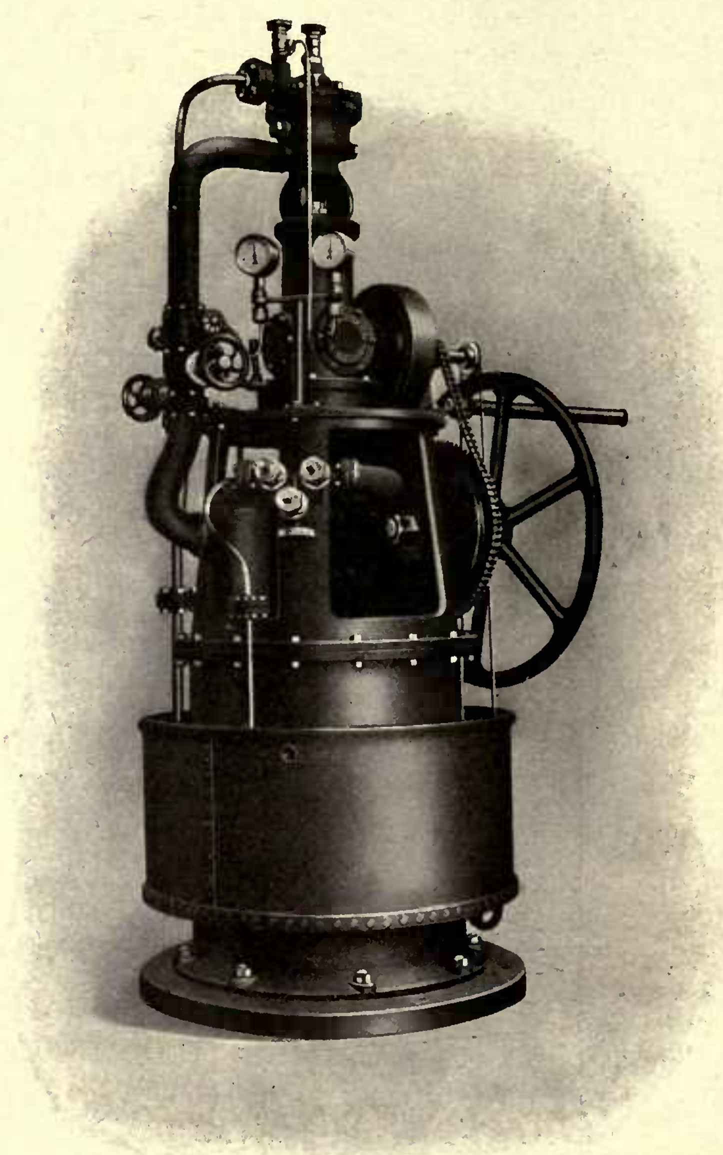
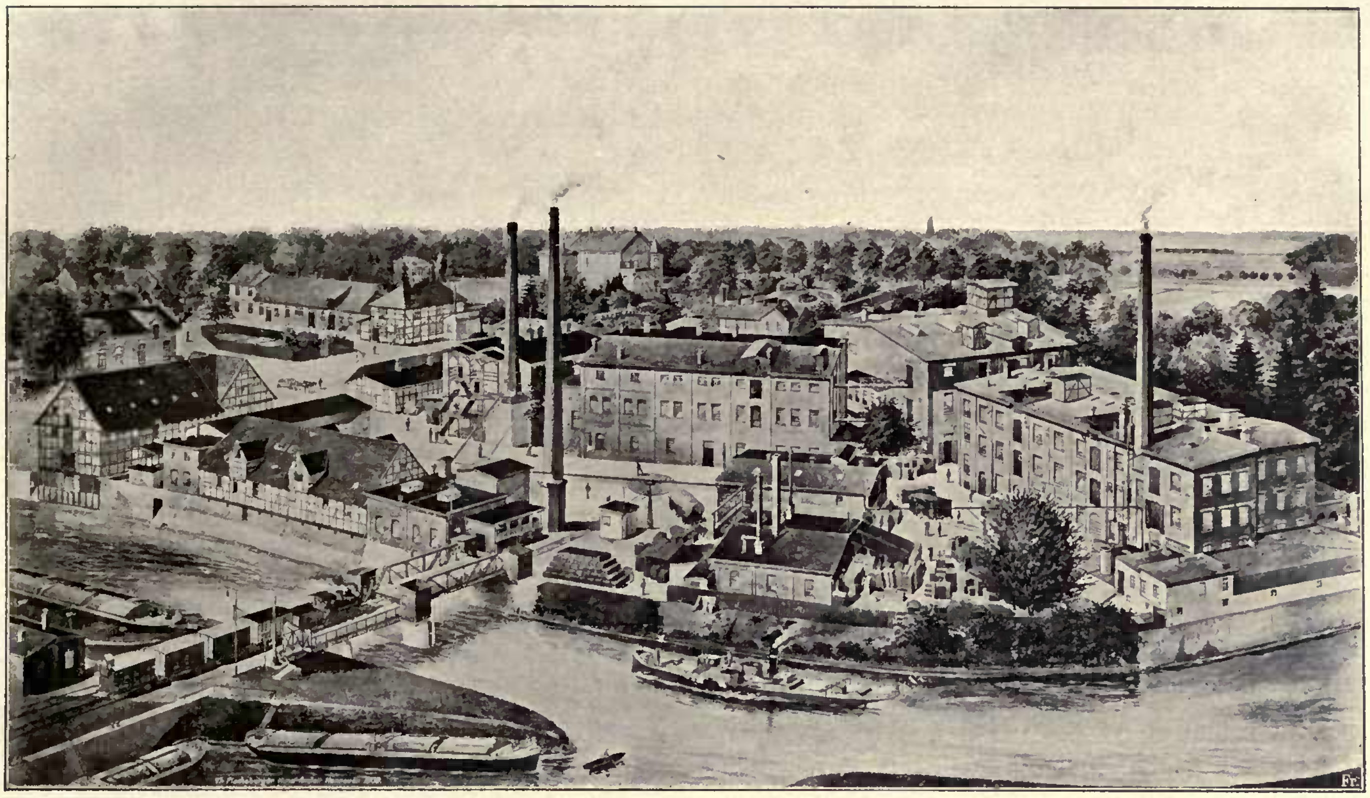


Fig. 10
1912 Type Hand or Belt Geared SO_2 Ice Making Machine



A. Haacke & Co., Celle

This firm was established at Celle in 1879 by W. Berkefeld under his own name and carried on the manufacture and application of the famous kieselgur compounds and insulating cords, which were first placed upon the market by Berkefeld. In 1885 the factory was acquired by Messrs. A. Haacke & Co., London, with Messrs. Albert Haacke and Wilhelm Windmoeller as principals, and the firm was registered under the title A. Haacke & Co. Mr. Windmoeller having retired from the partnership on the 1 st. July 1891, Mr. Albert Haacke continued to carry on the business on his sole account.

In 1895 the firm took up the manufacture of corkstone products, which were covered by four German patents and which since their introduction have been put to continuously extending uses.

Notable among these are the

Algostat Cork Slabs

for the insulation of Ice Stores and Cold Chambers, which are now used in considerable quantities.

The specific gravity of these slabs is warranted to be 0.22, whilst the thermal conductivity, as ascertained by tests applied at the Munich Technical College, is 0.414 at 32° F.

The property on which the factory stands occupies an area of about 5 acres and is situated on the banks of the navigable river Aller. The establishment has direct connection to the railway, and materials can be loaded into railway trucks in the factory yards. The factory is equipped with up-to-date machines and appliances and produces about 2400 sq.yd. of cork stone products per day, whilst the output of kieselgur goods and insulating cord covering amounts to about 300 truck loads of 10 tons each.

In the province of Hannover the firm owns extensive pits which supply the kieselgur used in the manufacture of insulating materials.

The firm employs about 300 men in all, including 120 experienced insulators who are employed on newly erected plants.

Branches have been established at Düsseldorf, Berlin, Breslau, Hamburg, Halle, Stuttgart and Rotterdam.

The firm has furnished the insulation for a large number of abattoirs, slaughter houses, breweries and dairies. Among recent supplies to large installations the following may be named:

The Hamburg Central Cold Stores
Lübeck Cold Stores A. G.,
Gefrierhaus Bremerhaven,
S. S. Imperator.

Gesellschaft für Lindes Eismaschinen A.-G., Wiesbaden

The Gesellschaft für Lindes Eismaschinen devotes its activity on a very comprehensive scale to mechanical refrigeration and its applications as well as to the design and the construction of devices for the liquefaction of gases and the numerous applications to which it lends itself. The undertaking had its origin in the inventions of Prof. C. v. Linde, who is mainly responsible for the firm's development and rise to eminence and whose name is inseparably coupled with that of the firm which bears it. In the following paragraphs we publish a few particulars concerning its history and the extent of its operations.

The company was founded in 1879 at Wiesbaden by a syndicate of a few men of insight drawn from a small circle of friends, who united with a share capital of M. 200 000 at a time when the first refrigerating machines designed on Linde's system had already been built and had met with some measure of approval within as well as outside Germany.

The firm realised at the inception of its undertaking that the whole subject of mechanical refrigeration presented to all intents and purposes an all but unexplored field demanding the most carefully devised and exhaustive researches and experiments to elucidate its theoretical aspects, constructional principles and the potentialities of their profitable application on a commercial scale. Accordingly, an office was organized in Wiesbaden for the exhaustive study and systematic elaboration of all problems relating to mechanical refrigeration and its various applications, ranging from the first mechanical calculations down to the preparation of the necessary workshop drawings. The actual construction of machines and installations was to be carried out by, or in conjunction with, notable German and other engineering firms. In this way theory and practice — drawing office as well as workshop — were brought into line from the outset, with the result that the firm has now a history of 33 years of successful activity to its credit.

The constructional and economic advantages of the new system were promptly recognized, and the Linde Company thereupon entered upon the second phase of its history. It realized that the manufacture of artificial ice on a commercial scale could not fail to prove remunerative, and it rightly concluded that by operating its own system the best possible opportunities of demonstrating its enduring qualities and the certainty of its working would be afforded. In 1881 and 1882 four large ice factories were accordingly erected and operated on the Company's own account, viz. at Barmen, Strassburg, Munich and Stuttgart. The expected results were indeed not long delayed. Stimulated by such examples the brewing trade was the first to relinquish its objections definitely, and the ice famine in 1883/4 developed matters to such an extent that the number of Linde Refrigerating Machines increased in an entirely unexpected manner.

From forty orders received in each of the years 1882 and 1883 this number rose to 133 installations in 1884. Ice plants working with efficiencies previously unheard of were erected in Paris and London as well as Germany. Besides bringing the manufacture of ice making and cooling machines proper during these years to a high degree of perfection the Company devised a number of economic applications of artificial refrigeration, nearly all of which are even now prototypical. From this period of useful problems and their effectual solution we may recall the following achievements: The introduction of artificial cooling of wort and fermenting tuns in breweries by means of chilled sweet water (Munich 1876); wort cooling in breweries working with top fermentation (London 1877); air-cooling in fermenting cellars and artificial ventilation (Trieste 1877); air cooling in storage cellars with "still" air circulation (Munich 1878); the manufacture of crystal ice-slabs in rotating ice formers (Bombay 1879); sugar extraction from beetroot molasses by the strontia process (Waghäusel 1879); cooling in the manufacture of condensed milk (Cham 1880); applications to processes in the manufacture of aniline (Höchst 1880); artificial scating ice-rink (Frankfort Exhibition 1882); manufacture of margarine (Oss 1883); stearine cooling (Brussels 1883); municipal abbattoir cooling plant (Wiesbaden 1884); crystallisation from lyes (Aussig 1884); extraction of benzole (Sheffield 1884); production of paraffin (Pechelbronn 1885); manufacture of lithopone and allied manufactures (Schöningen 1887). The most important speciality, represented by the Linde Marine Refrigerators, dates from the year 1888 (White Star Line) and 1893 (North German Lloyd). The liquefaction at atmospheric pressure of electrolytical chlorine was introduced on an extensive commercial scale in 1895. The first Linde refrigerating plant for dry air-blast in furnaces and converters, capable of cooling intensely about 7 million cub. ft. of air per hour, corresponding to about 825 tons of refrigeration, was put in operation in 1910.

For all these purposes the requisite cooling effect is produced by refrigerating machines working on the compression system and operating mainly with anhydrous ammonia, though in some cases carbon dioxide, sulphurous acid, nitrous oxide or other suitable refrigerant is employed.

Whilst in England and the United States the preservation of food stuffs by refrigeration far surpasses that done in this respect on the European Continent, the Linde Company found nevertheless opportunities of erecting cold stores of large dimensions, which have served as models for other installations. This may be said to mark a third period in the development of the firm. With the cooperation and under the direction of Linde two large cold stores and ice factories were erected in Hamburg, and notably a very large installation at Berlin, this being by far the largest establishment of the kind on the Continent. These installations are operated and managed by the Linde Company, who for this purpose have formed a separate company styled the "Gesellschaft für Markt- und Kühlhallen". A similar course has been pursued at Leipzig, Nürnberg, Altona and Dresden, and an additional cold store has been erected at Berlin. The arrangement and equipment of these cold storage palaces furnish standards of perfection as regards economy of working, the production of crystal ice free from germs, and the preservation of perishable goods of every species, which, stored in a single building, reach at times an aggregate value of 4 million marks.

Professor Dr. C. von Linde

As a means of preserving food supply of every kind the Linde system of refrigeration has proved eminently successful in its application to provision carrying ships of different nationalities. In the course of years 485 refrigerating machines have been installed in about 290 ships, amongst which are included a number of transport steamers equipped for the exclusive carriage of frozen meat. The navies of different nations may likewise be counted among the users of Linde refrigerating plants.

One of the later, but no less important, branches of the Linde Company owes its inception and development likewise to the efforts of Prof. v. Linde. We are referring to the Company's works established at Höllriegelsgreuth near Munich for the production of oxygen, nitrogen, hydrogen, and other gases used for manufacturing and industrial purposes. This branch establishment is under the personal direction of Prof. v. Linde. Concerning this undertaking the Linde Company has prepared a special Report, to which any interested members of this Congress are referred.

In the United States of America and Great Britain, which with Germany share preeminence in the ice and refrigerating industry, the patent rights of the German Linde Company have been acquired by independent firms. As far back as 1880 Mr. W. Wolf, of Chicago, purchased these rights for exploitation within the United States, and in 1885 the Linde British Refrigeration Company was established in London under the permanent cooperation of the parent company.

Up to May 1913 the Company had completed, or had under construction, about 8400 Linde Refrigerating machines operating in about 5020 establishments. These figures include over 1200 meat cold storage plants on land and 290 marine installations. The aggregate of other undertakings comprise: 1842 breweries, 587 ice factories, 185 butter and cheese making establishments, 134 chemical works, 17 sugar refineries, 9 stearin factories, 28 champagne factories, 11 rubber works, 53 chocolate factories, 8 mines, 102 oxygen and nitrogen works, and about 350 establishments engaged in other manufactures. Refrigerating installations operating on the Linde system are distributed throughout the various countries in the following numbers:

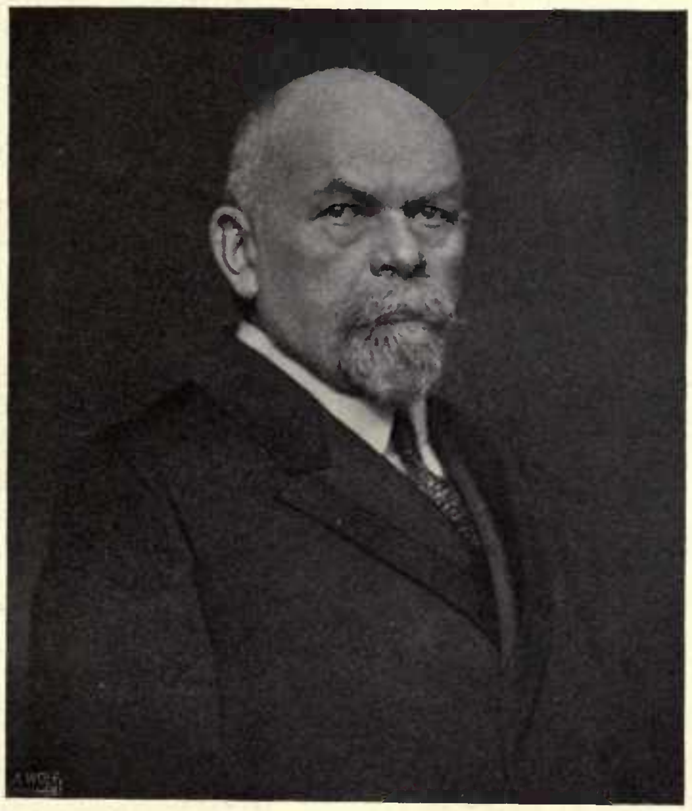
German Empire	1718	Installations
Austria-Hungary	375	,,
Switzerland	133	,,
Great Britain and Colonies	1140	,,
France and Colonies	92	,,
Holland, Belgium and their Colonies.	104	,,
Italy, Spain, Portugal and their Colonies	102	,,
Denmark, Norway and Sweden . .	46	,,
Russia and Balkan States	96	,,
United States of America	914	,,
Brazil	35	,,
Mexico, Guatemala etc.	52	Installations
Argentine, Paraguay, Uruguay . . .	73	,,
Chili and Peru	49	,,
Colombia and Venezuela	41	,,
China and Japan	26	,,
Egypt	24	,,

The continuous expansion of the firm's business has demanded a progressive increase of its working capital, which in successive years rose as shown below:

In 1880	to M.	400 000
,, 1881	,, ,,	700 000
,, 1885	,, ,,	1 400 000
,, 1888	,, ,,	1 750 000
,, 1889	,, ,,	4 000 000
,, 1899	,, ,,	5 000 000
,, 1908	,, ,,	7 000 000
,, 1911	,, ,,	7 500 000
,, 1912	,, ,,	10 000 000
,, 1913	,, ,,	12 000 000

Grünzweig & Hartmann G. m. b. H., Ludwigshaven o. Rh.

Whilst German physicists and engineers have taken a prominent share in the development of the systematic production of cold by mechanical means, it is likewise a German invention, that of the material known as Cork Stone, which has enormously expanded the whole technique of insulation, and thereby contributed greatly to the improved economy of the sytem. To the founder and director of the Cork Stone Works of Grünzweig & Hartmann G. m. b. H., at Ludwigshaven o/Rh., Dr. C. Grünzweig, is due the merit of having been the first to realize the unique value of the one time worthless cork offal of bottle cork factories as a heat insulating material, whereas formerly this waste material, which constituted 60% of the whole of the cork bark, was disposed of by burning; and Dr. Grünzweig was also the first who utilized these waste products with perfect success. The Cork Stone Factory which he founded in 1878 has since become the prototype to a most flourishing trade.



Dr. Grünzweig

The Cork Stone of to-day is indeed something very different from what it was in the earliest days of tentative efforts, and the first brick which was patented in 1880 and then placed upon the market — a mixture of powdered cork, clay and lime — claims now historical interest only. It is, however, a notable fact that cork is still the base of all successful insulating media; and at present, all efforts to the contrary notwithstanding, there is no visible prospect of the discovery of a substitute which reproduces the extraordinary and felicitous combination of a whole array of valuable qualities by which nature has constituted cork a heat insulating material which satisfies a long list of practical requirements.

In 1898 a cork stone was introduced under the trade name "Reform" Cork Stone. This stone has since come to be regarded as a standard brand owing to its excellent insulating properties, convenient form, and good building qualities. It is impregnated with coal pitch, whereby it has been rendered impervious to water, a quality which the original cork stone brick lacked. In the form of slabs of all thicknesses it lends itself admirably to covering the containing walls of cold chambers, whilst in the form of purpose bricks it is equally well adapted for covering pipe conduits and machine parts; it can be cut like wood and similarly nailed and sawed; and it can be laid in mortar and plastered like bricks. Excepting in North America the material used for insulation in refrigeration plants consists almost exclusively of cork stones impregnated with pitch, and it is only quite recently that a further step in advance has been taken under the initiative of the ever leading cork stone factory at Ludwigshaven.

Fig. 1 Method of Applying Cork Stone Slabs

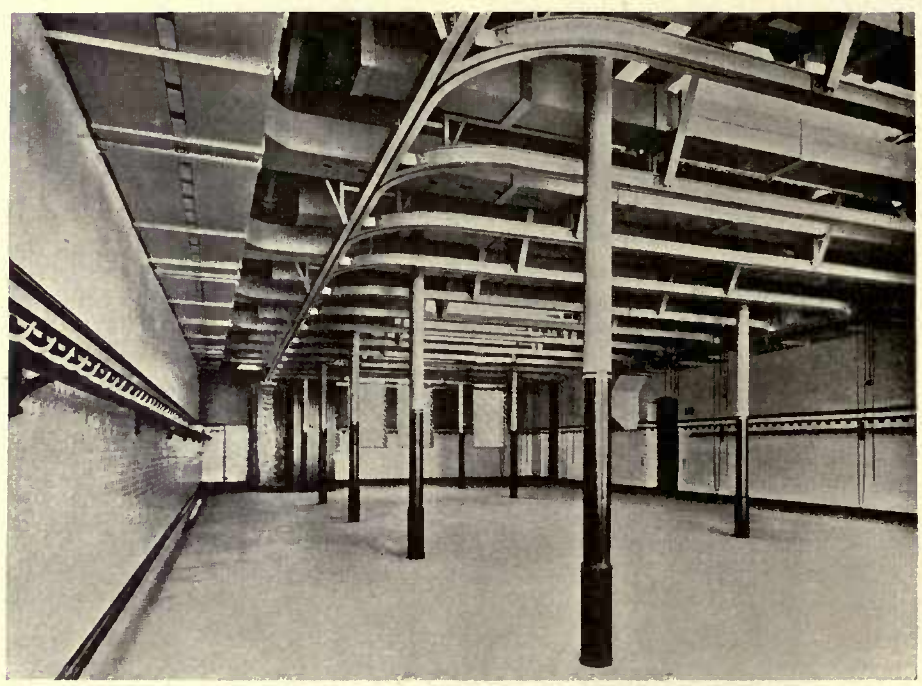
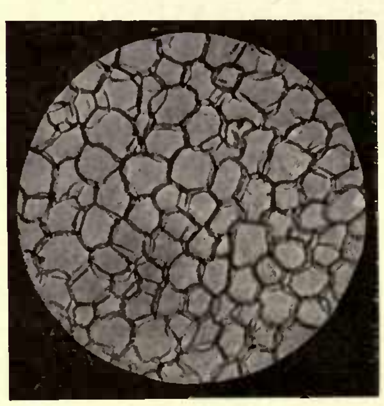
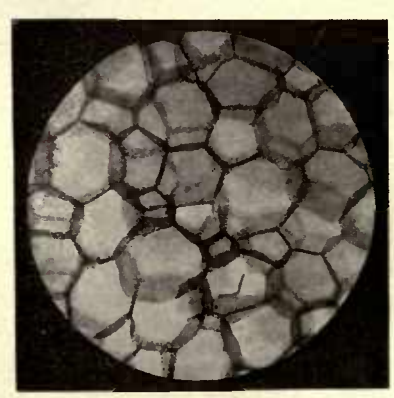


Fig. 2 Abattoir at Ludwigshaven o. Rh. Insulation of Fore Cooling Chambers. Surface about 36500 sq. ft.



Natural Cork



Expansit

Figs. 3 and 4 Section through the Cork Cells, the microscopic magnification being the same in both cases

On the occasion of the last International Congress of Refrigeration held at Vienna in 1910 (see Report of the

Fig. 5 Refrigerator Van insulated with Expansit Cork Stone

Second International Congress of Refrigeration, "Cork as a Thermal Insulator", paper read by Dr. M. Grünzweig) the firm was able to report on a new process which had in the mean time been patented in all civilized countries.

Fig. 6 Cailler's Chocolate Factory, Broc (Switzerland). Insulated Area about 85000 sq. ft.

The object of this process, which does away with the impregnation with pitch, is to produce a close-grained heat-welded cork stone moulding, and it does so by pyrogenic transformation of the cork substance and by expanding the cork cells to double their original volume. Since a few difficulties retarded, until the present year, the application of the process to manufacture on a large scale it was in the mean time brought to bear upon the well established manufacture of the impregnated Pitch Cork Stone. All the productions of the firm bear as a trade mark the word "Expansit", which in a very short time has acquired a good sound, since it stands for a degree of lightness and insulating capacity wherein the material is not equalled by any of its rivals. Visitors to the Chicago Congress will not fail to take note of the "Nonpareil" Compressed Cork Stone which Mr. Smith first produced by likewise taking advantage of the natural adhesive developed by heated cork and which may be regarded as a forerunner of the new Expansit Stone. Though more effective an insulator than the impregnated cork stone, it could not obtain a footing in Germany owing to the high proportion of cork which it contained and its consequent high price, whereas to the eminently practical American in search of insulating material the best is just good enough. By the expansion of the cork cells throughout the entire material, as will be seen from the photo-micrograph, the "Expansit" Stone is made to combine the advantages of the American "Nonpareil" Cork Stone with the cheapness of the German article, whilst at the same time it surpasses either in point of lightness and insulating quality. It weighs only about 5 to 6 lbs per cub. ft. and should for this reason prove particularly interesting to constructors and users of portable refrigerators.

To the manufacture of the best procurable insulating materials Messrs. Grünzweig & Hartmann have added improved methods in the construction of cool chambers and their equipment so as to meet the ever increasing requirements occasioned by operations involving conti-

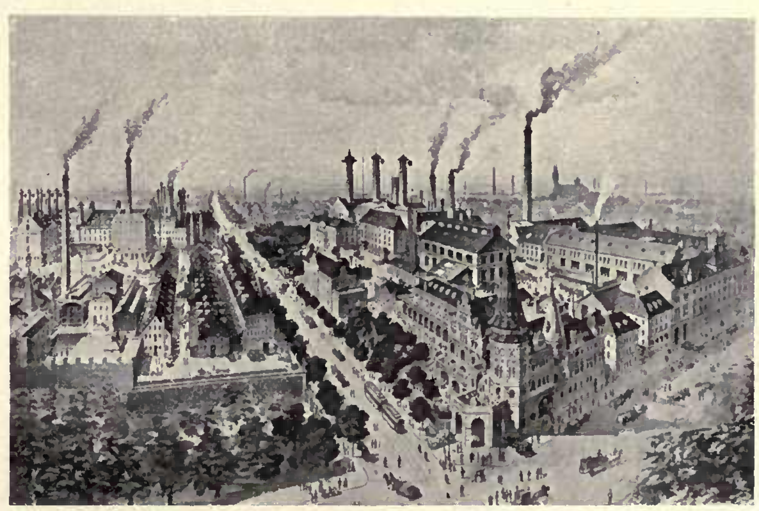


Fig. 7 Löwenbräu Brewery, Munich. Insulated Surface of about 21500 sq. ft.

nually descending temperatures. In a treatise on the Technique of Refrigeration and in other publications the firm has published the results of many years of experience and the achievements derived from systematic investigations conducted on scientific lines and supported by numerical data. In the course of these investigations the firm has undertaken to elaborate the best methods of required to be protected from the effects of frost, all of which are applications of the insulating principles in which the refrigerating trade is directly interested. Detailed information on this head may be found in the firm's catalogues respecting heat insulating materials.

Fig. 8 Cork Stores

insulating the different sections and pipe conduits of refrigerating installations, ice cellars of every kind, cold storage chambers in warehouses, food stuff factories, breweries, abattoirs etc. The firm does likewise an extensive manufacturing business in insulating materials for steam boilers and steam piping, mash tuns, water piping For use in refrigerating plants alone the firm produces annually cork stone covering an area of many hundred thousands of square yards. The establishment employs about 75 engineers and clerks and 500 workmen. The factory covers an area of 60 000 sq. yds., the undertaking being the largest of its kind in Europe.

C. B. König, Altona o. Elbe

In the following paragraphs we propose to describe an apparatus which is, properly speaking, only an accessory tool in the hands of those making use of artificial cold, which may, however, under certain circumstances assume the proportions of a necessity. We are referring to König's well known Patent Respirators which enable a fitter without let or hindrance to operate in a most poisonous atmosphere of ammonia or other vapour and thus to remedy without delay defects in the compressor plant before a serious breakdown results. By König's Respirator air is conveyed from the outside to the person wearing an appropriate helmet, and the apparatus is the application of a system which has proved eminently satisfactory for upwards of twenty years. It fulfils in a perfect manner the essential requirements of a really successful apparatus of this kind, which are that it should be absolutely simple in its management and never fail under any conditions. The annexed illustration shows in use an apparatus with air supply to two helmets and improved speaking arrangement which enables the wearers of the helmets and the bellow operator to communicate freely with each other. The ability to always and freely converse with an outside person is an essential quality of the apparatus as it gives the helmet wearer that degree of assurance which cannot fail to materially assist him when called upon to advance in dangerous situations, whilst the operator outside the danger zone knows at every instant how matters are proceeding.

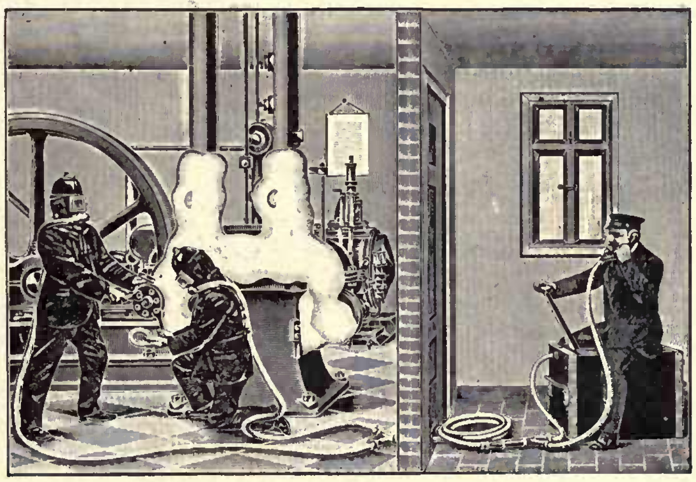


Fig. 1 König's No. III Respirator Equipment with Box Bellows and Improved Speaking Attachment

Fully appreciating the great utility of these respirators, the German accident insurance employers' associations, such as the Brewers and Maltsters' Association and the Victuallers' Association, have years ago in their revised regulations affecting the prevention of accidents made it incumbent upon their members to provide a reliable respirator, and in Germany there is scarcely a refrigerating installation of any magnitude which is not equipped with a suitable apparatus of this kind. To anyone acquainted with the treacherous rapidity with which escaping ammonia vapours may prove fatal to human life the requirements of the employers' associations will appear as a reasonable and even necessary measure. In other countries, notably in the United States, König's Respirators have been in continual demand for many years, and here the users are solely guided by their personal interests, as there are no regulations compelling them to provide these safeguards. The equipment of modern refrigerating plants installed in large ocean going steamers includes one or two respirators, which serve also the purpose of smoke helmets in the event of an outbreak of fire in the bunkers or elsewhere. On board the modern meat carrying steamers fitted with cold storage rooms for the steadily increasing export of meat from America and Australia to Europe the presence of a respirator is an absolute necessity, as it may be the means of preventing the loss of an entire cargo from inability to promptly remedy a defect in the refrigerating plant.

In conclusion it may be noted that König's Respirators are since many years being made as a speciality at the Works of Fire Extinguishing Appliances of Mr. C. B. König, of Altona o. Elbe. The firm's agent for the United States is the Meyer Supply Company, 22 South First Street, St. Louis Mo.

The Maschinenbau-Anstalt Humboldt, Cologne-Kalk and its Position in the Refrigerating Industry

The Maschinenbauanstalt Humboldt at Cologne-Kalk is an outgrowth of the Mining Engineering Works of Messrs. Sievers & Co., which had been established in 1856. It will be seen from this that the firm was originally engaged in the construction of ore concentration and disintegrating machines and in the installation of complete ore concentration plants; and it is in no small degree by a achievements in this speciality that the Humboldt Works have secured a leading position and a world-wide reputation. The establishment has developed conspicuously under the management of the present managing director, Herr Richard Zörner; and in 1911/12 the output was about 60 860 tons, whilst the turnover during the same period amounted to M. 24 888 000.

In addition to their department of mining machinery of every kind, such as pumping engines, ventilating machines, compressors, complete ore and coal washing plants, etc., the Humboldt Works comprise amongst others a locomotive department of considerable magnitude, which has turned out a large number of locomotives for state owned and private railways in various countries.

The number of workmen and office employees is about 5000. The ordinary share capital of the company is M. 20 100 000, in addition to which there are debenture stocks amounting to M. 10 000 000. The workshops and yards cover an area of 55½ acres, in addition to which 210 acres of ground property is available for extension. All works buildings intercommunicate by a home railway system and are connected to the state railway. The power and machine plant comprises 350 motors of an aggregate power of 4500 H.P., 22 steam generators, 85 travelling cranes, and over 1200 machine tools.

Incidentally, the Humboldt Works are also among the leading German establishments engaged in the construction of refrigerating machines and large installations. The firm acquired the manufacturing rights of the well known Fixary type of air coolers, which it improved and made a practical success, and soon the firm was among the leading makers of refrigerating machines, more especially as installers of dry-air coolers. A large number of important installations erected by the Humboldt Company have been described by way of models in leading technical journals and textbooks. Since the expiration of the patent which covered the dry-air cooler installations have been erected on this system by other firms in Germany and elsewhere.

That the dry-air cooler system, which has always found its most energetic votary in the Humboldt Company, is eminently suitable for cold storage has been amply proved by a large number of extensive meat cooling

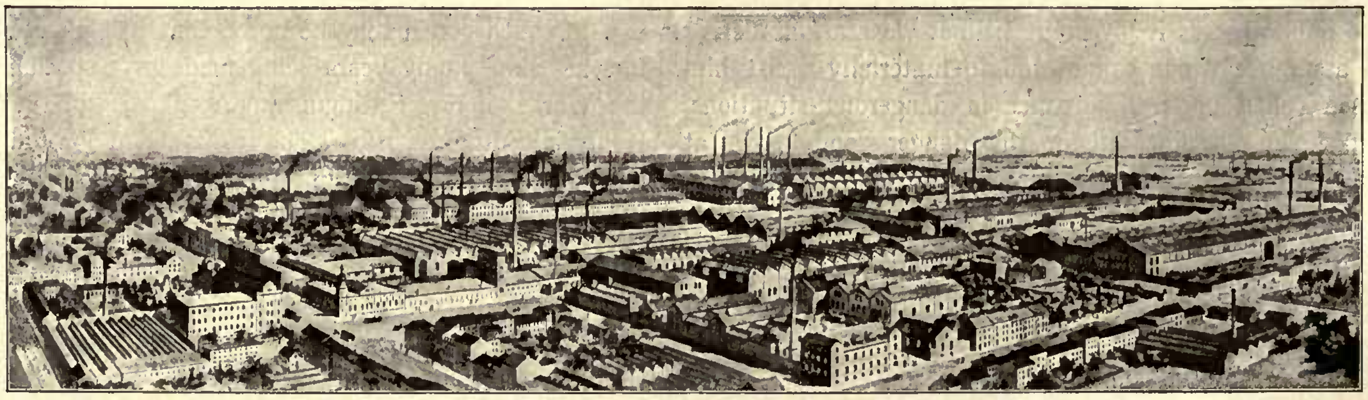


Fig. 1 General View of the Works

plants, especially for municipal abattoirs, market halls etc. Some of these installations have been in operation for nearly thirty years without calling for serious repairs, which may be accepted as an unquestionable proof of workmanship. As examples of installations which are still operating with old machines erected nearly thirty years ago we may refer to the cooling plants attached to the municipal abattoirs of Kattowitz, Crefeld, Freiburg i. Br., Elberfeld etc. The Humboldt system of dry-air cooling is described in nearly all text-books and may be assumed to be too well known to need description.

Moreover, a number of installations which formerly operated with wet-air coolers, have been reconstructed by the Humboldt Company, and amongst these may be named the abattoir cooling plants at Berne, and that at Stettin, the machine room of which is shown in the annexed illustration.

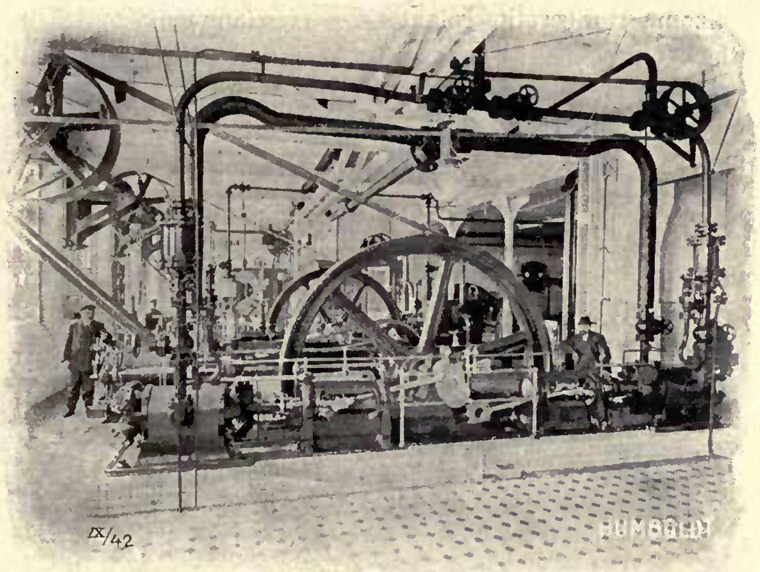


Fig. 2 Machine Room at the Abattoir at Stettin

Of installations erected in more recent times the following may be instanced: Cooling plants attached to the municipal abattoirs at Mühlheim o/Ruhr, Hamborn in Westphalia, Soest and Duderstadt. That the Company's installations have proved entirely successful is borne out by the fact that in 1911 and 1912 alone abattoir cooling plants erected in previous years were extended at Altenessen, Eschweiler, Iserlohn, Siegen, Treves, Solingen, Düren, Schwelm (Westphalia) and Witten.

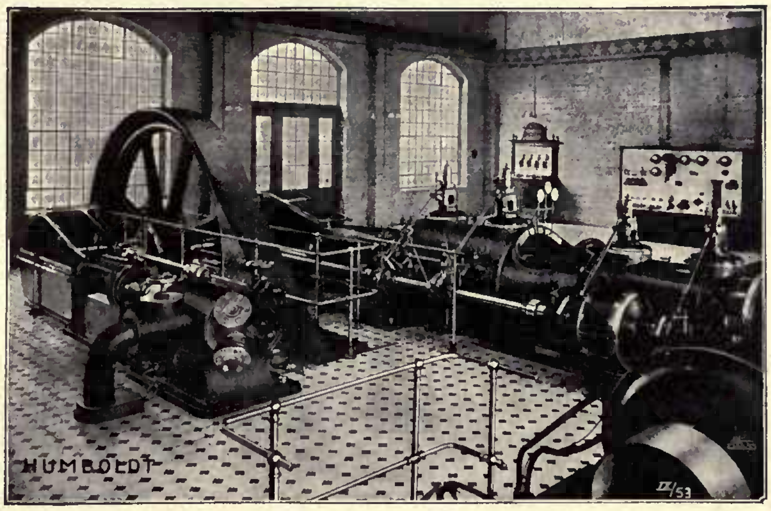


Fig. 3 Machine House of the Frankfort Brewery Co., Frankfort o. M.

It must, however, not be thought that the success which has attended the installation of meat cooling plants operating on the dry-air cooler system has caused the Humboldt Company to confine itself one-sidedly to this system. On the contrary, plants operating on the wet-air cooler system have been installed on several occasions, thus many years ago an abattoir cooling plant at Oberhausen and more recently a meat cooling plant for the abattoir at Bremerhaven-Lehe.

The majority of the installations referred to work on the ammonia compression system, which was the type originally adopted by the Humboldt Company, but, far from pursuing a one-sided policy, the firm has also made machines operating on the carbon dioxide and sulphur dioxide compression system. For example, the abattoir cooling plant at Oberhausen works with sulphur dioxide by the wet-air cooling system, whilst the municipal abattoir cooling plants at Arnberg in Westphalia and Wanne operate on the dry-air cooler system with sulphur dioxide. The latter plant, it may be mentioned, is an extension of a plant which originally operated on the wet-air cooling system. Extensive installations working on the carbon dioxide compression system have been supplied for the abattoir at Linz o. D. and for the frontier abattoir which is being erected at Burdujeni by the Roumanian government. The installation at Linz operated formerly on the wet-air cooler system, but on the recent occasion of its extensive enlargement it was refitted with dry-air coolers.

In view of copious references to abattoirs it may be well to state that numerous refrigerating machines have been supplied by the Humboldt Works for other undertakings in which artificial cold plays a part. Among recent examples coming under this head we may mention the Frankfurter Brauhaus at Frankfort o/M., whose refrigerating plant works on the ammonia compres-

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sion system and whose cellars, arranged in three floors above the ground level, are cooled by direct evaporation of ammonia. This plant is probably one of the most up-to-date brewery cooling installations in Germany. Fig. 3 shows a portion of the machine house, which comprises a 250 H.P. tandem steam engine coupled to an 80-ton ammonia compressor. An ammonia refrigerating plant has likewise been erected in the Königsberg Brewery at Königsberg in Prussia. The cellars in this brewery are cooled by a brine circulating system, the general arrangement of this installation being of the type usually adopted in breweries.

Large and notable refrigerating plants have among others been installed in margarine factories erected by the following firms:

Duisburger Margarine Works of Messrs. Schmitz & Loh, Duisburg;
Amica Margarine Works of Mr. Benedikt Klein, Cologne;
Delmenhorster Margarinewerke, Delmenhorst;
van den Bergh's Margarine Works, Cleve.

These installations work partly on the sulphur dioxide and partly on the ammonia compression system.

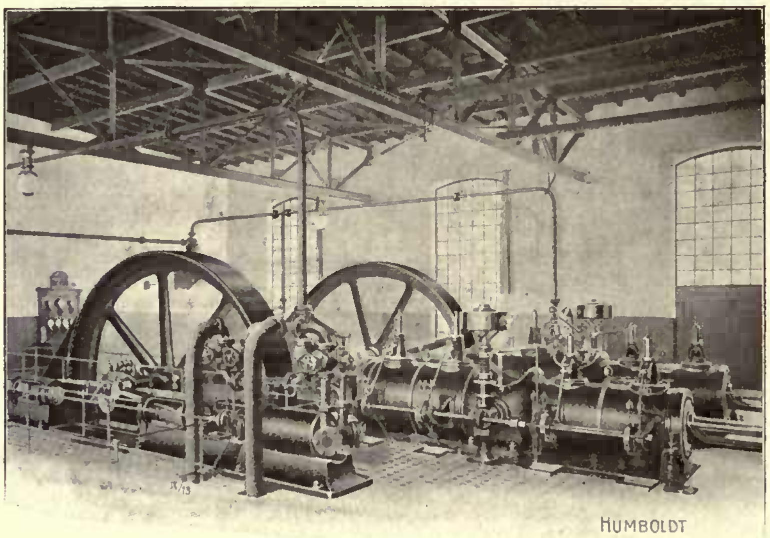


Fig. 4 Refrigerating Machine Installating at the Cold Stores of Messrs. E. & I. Mayer Frankfort o. M.

Numerous Humboldt refrigerating machines have been installed in chemical undertakings, amongst others in the following artificial silk factories:

Soc. An. Française La Soie Artificielle, Givet;
Vereinigte Glanzstoffabriken, Oberbruch;
Rheinische Kunstseidefabrik, Aix-la-Chapelle;
Hollandsche Kunstzijdefabrik, Arnheim (Holland).

Apart from an extensive series of installations for a great variety of purposes, such as cooling chambers for foodstuffs of every kind, dairies, hospitals, restaurants, theatres etc., three installations for shaft sinking operations by the congelation method may be instanced as being of special interest:

Gewerkschaft Gute Hoffnung at Niederbruck (Alsace);
Alkaliwerk Ronnenberg, Hanover;
Haniel & Lueg, Düsseldorf-Grafenberg.

In addition to the machines installed in Germany, the Humboldt Company has erected large and important plants in other countries. Of these it will be sufficient to mention a few machine plants installed in Austria-Hungary and France:

Brauerei Grieskirchner G. m. b. H., Grieskirchen (ammonia system);
Ignaz Schneider Nachf., Wholesale Game and Poultry Warehouse, Bünauburg (Ammonia system);
Österreichische Exportgesellschaft Opitz, Wagner & Co., Wels (Carbon dioxide System);
Municipal Abattoir at Linz o/D. (Carbonic dioxide system);
Weiß & Co., Elizabeth Ice Factory, Budapest (Ammonia system);
Hôtel Imperial, Karlsbad (Sulphur dioxide system);
Brasserie St. Nicolas, St. Nicolas du Nord (Ammonia system);
Brasserie L'Union, Conflans-Jarny (Ammonia system);
Grande Brasserie de Lambezellec, Lambezellec (Ammonia system);
Fabrique de Chocolats Fins, Nancy.

Other plants were exported in 1911/1912 to Roumania, Servia, Spain, Holland, Belgium and notably to Argentine.

In Russia the firm has installed cooling plants for the municipal abattoirs at Taschkent, Taganrog, Riga and Bialystok, the market hall at Liebau as well as for private purposes at Dorpat, St. Petersburg and elsewhere, not to omit to mention the largest cold stores in Europe, which are now being erected at St. Petersburg by the St. Petersburg Stores Company Limited. For this installation the Humboldt Company is supplying the complete internal machine plant including two water tube boilers with a heating surface of 1950 sq. ft., three complete steam engines of 350 H. P. each and three duplex type ammonia compressors of 200 tons capacity each, i. e. of an aggregate refrigerating capacity of 600 tons.

To complete our account we will not omit to mention the machines supplied by the Humboldt Works for use on warships, fishing steamers and refrigerating railway wagons. These portable installations have been designed to work on the ammonia, sulphur dioxide and carbon dioxide compression systems.

For attaining temperatures down to — 49 to — 58° F carbon dioxide machines have been designed to work in two stages of compression and condensation. Installations operating on this system are, amongst other applications, favoured for shaft sinking by the congelation method. Still lower temperatures are required and attained in gas liquefying installations, for instance — 317° F for liquefying air, — 422° F for liquefying hydrogen, and machines designed for either purpose are built at the Humboldt Works. For the separation of gaseous mixtures into their constituents, such as watergas for obtaining hydrogen, the firm makes machines of an original patented design.

This brief sketch, though necessarily very fragmentary, in view of the narrow space at our disposal, may nevertheless have served to convey an approximate estimate of the significance of the Humboldt Engineering Works in relation to the industries in which mechanical refrigeration plays a part.

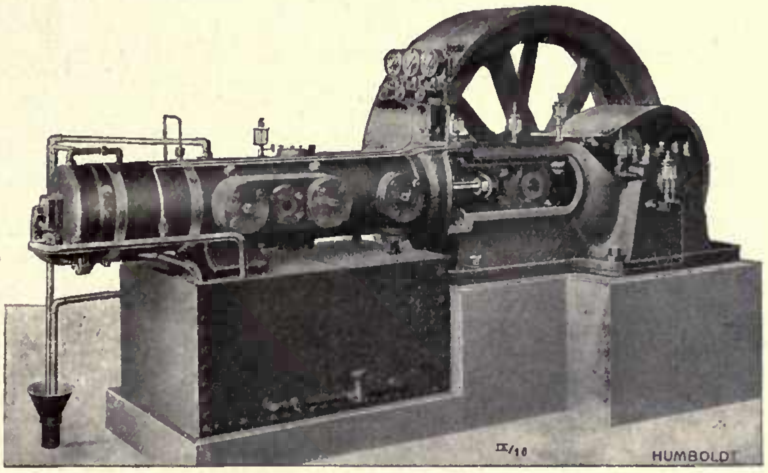


Fig. 5 Three-stage High Tension Compressor at the Humboldt Engineering Works.
Suction Capacity: 3500 cub. ft. per hour. Terminal Pressure: 2950 lbs per sq. in

Maschinenfabrik Esslingen, Esslingen

The Maschinenfabrik Esslingen was established in 1846. In 1902 the firm amalgamated with the engineering firm of G. Kuhn G. m. b. H., which had been established at Stuttgart in 1852. Both firms have for upwards of 25 years been engaged with the best success in the construction of refrigerating and cold storage plants for a great variety of purposes.

Recently a cold producing plant of modern type was installed by the Esslingen Engineering Works in a large brewery at Stuttgart, where it is now in full operation.

The machine portion of the installation consists in a superheated steam engine of the tandem type, which is coupled with a quick running duplex ammonia compressor and at the same time drives a direct coupled 250-kw D. C. dynamo, which supplies the entire brewery with power and light (Fig. 1).

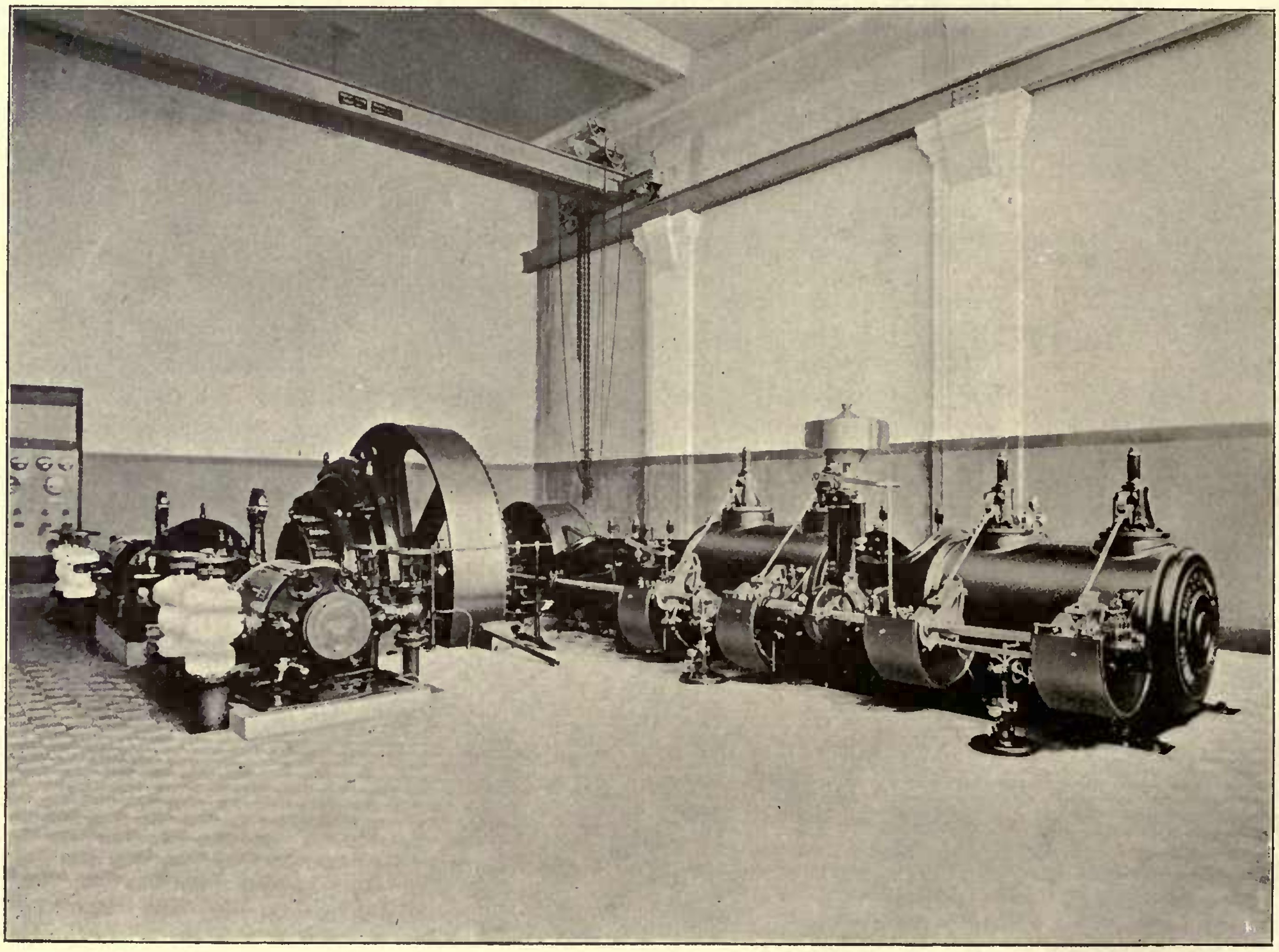


Fig. 1 Machine Room

The duplex type of compressor runs at 125 r. p. m., and is of 270 tons refrigerating capacity. Special attention may be directed to the arrangement of the valves (patented in Germany), which are arranged at the circumference of the cylinder covers in alternate positions. The front cylinder cover is rigidly attached to the closed motion guides, the frame itself being of the forked beam type like the steam engine. The design as a whole ensures strength and yet presents a pleasing appearance.

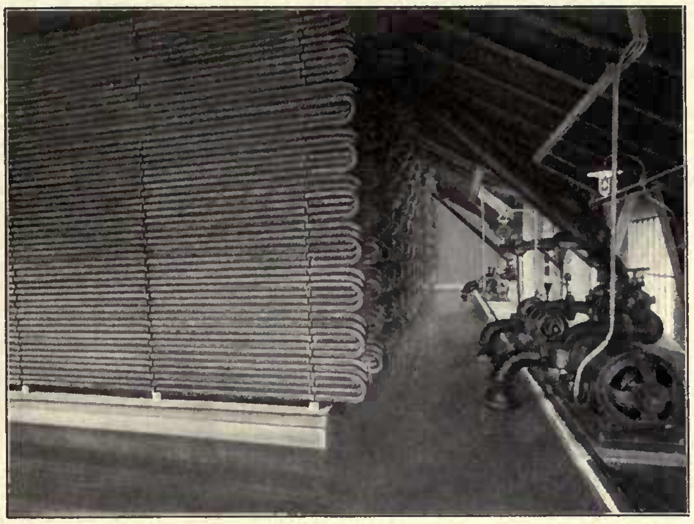


Fig. 2 Surface Condenser with Water irrigation

The plant furnishes a daily output of about 80 tons of ice in blocks of 55 lbs each. In addition, it serves for cooling the sweet water used in the brewing process and for cooling the whole of the fermenting and storing cellars. The condensation of the superheated ammonia vapours is effected in a surface condenser with water trickling arrangement set up under the roof at a height of 130 ft. above the floor of the machine room. This arrangement was forced upon the designer by the extremely confined situation of the brewery, which lies within an area crowded with dwellings.

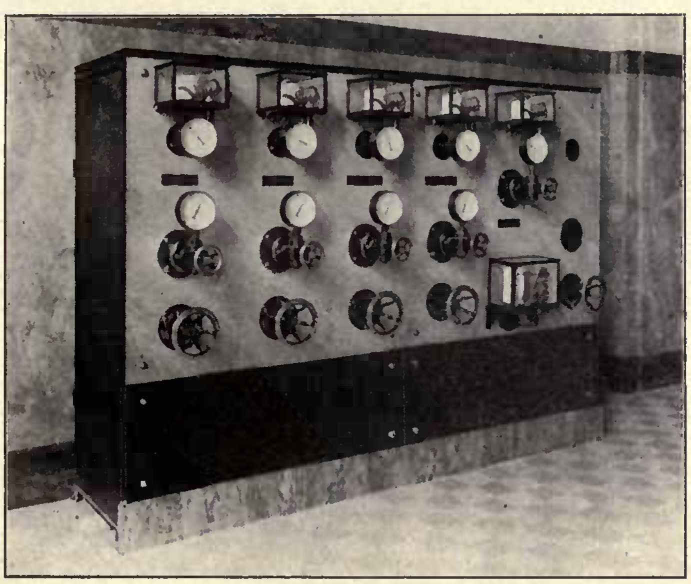


Fig. 3 Regulating Station

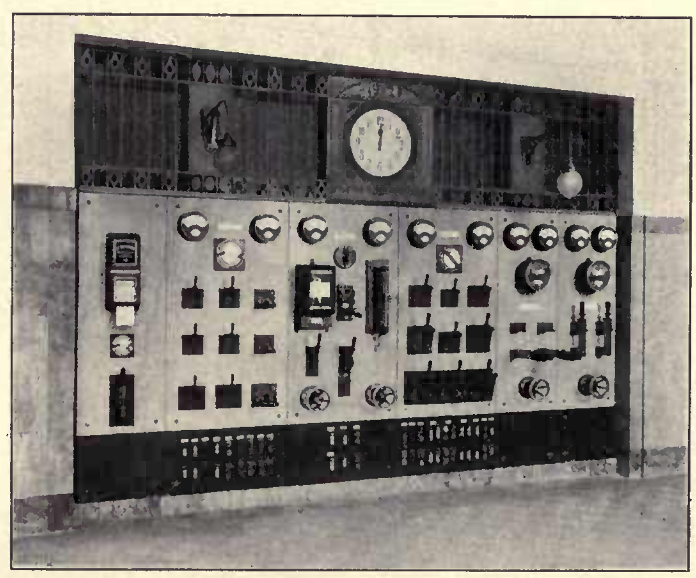


Fig. 4 Switchboard

The receiving pan which is surmounted by the condenser covers a floor space of 2120 sq. ft. and is built up of reinforced concrete.

Every effort was made to secure a readily controllable arrangement of the components and simple management of the installation. To satisfy these requirements the whole of the regulating valves and temperature gauges as well as the light and power plant are controlled from central stations in the machine room. The controlling station to the refrigerating system (Fig. 3) is fornished with a tele-thermometer placed over the respective regulating valve. This telethermometer operates upon a registering apparatus which enforces attentive and proper control of the working. The controlling board, which has a movable base and is in switchboard style, has mounted upon it a double recorder for the control of the temperature and pressure of the steam. The electric switchboard is shown in Fig. 4.

The steam engine is provided with a regulating device for the supply of receiver steam and, when working under its normal load, will furnish up to 6500 lbs per hour of steam at a pressure of 30 lbs per sq.in. This steam, after passing through an oil separator, is employed for boiling purposes in the brewery and also for heating the steam drying kilns. The exhaust steam of the engine passes through a feed water heater of the heat interchanger type, whereas the remainder is condensed in a jet condenser.

The duplex compressor shown in Fig. 5 was supplied to one of the leading chemical works. It is direct-coupled with a D. C. steam dynamo and, running at 115 r. p. m., has a capacity of 270 tons. In this machine the valves are arranged at the circumference of the compressor cylinders, the suction valves being on one side, the discharge valves on the opposite side. To ensure easy starting the two piston sides can be put in communication by a bypass valve in a transmission port, which also serves the purpose of a relieving valve. A change-over conduit is fitted for emptying the system without the necessity of reversing the function of the suction and discharge valves.

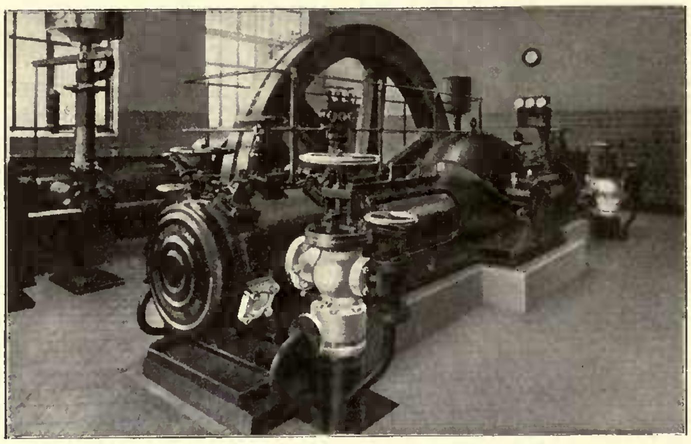


Fig. 5 Ammonia Duplex Compressor

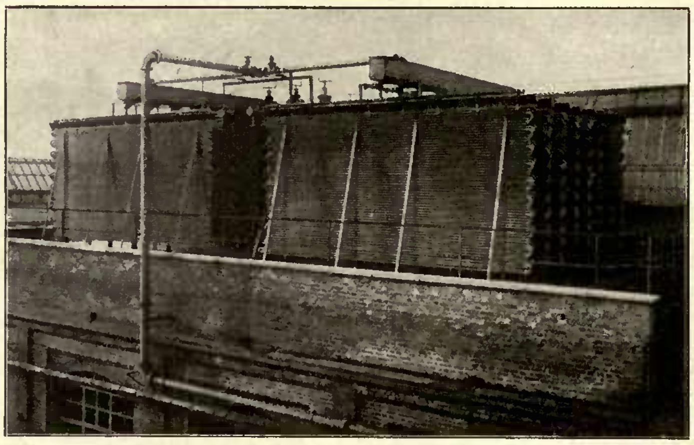


Fig. 6 Surface Condenser with Water Irrigation

The surface condenser with water trickling arrangement is shown in Fig. 6.

The installation is available for making ice and cooling lye used in a great variety of processes.

Maschinenfabrik Germania, vorm. J. S. Schwalbe & Sohn, Chemnitz

The Maschinenfabrik Germania, vorm. J. S. Schwalbe Sohn, Chemnitz, is the oldest establishment in Germany which specializes in the construction and installation of complete breweries and malt houses, and so long as thirty years ago the firm took up the manufacture of ice making and refrigerating machine installations, which abattoirs and market halls fitted with cooling chambers for the preservation of foodstuffs. Among these we may name the large market hall (Mercado de Abasto Proveedor) at Buenos Aires, the ever expanding cold stores of which have been equipped and subsequently extended by the Germania Works. Germania machines are extensively

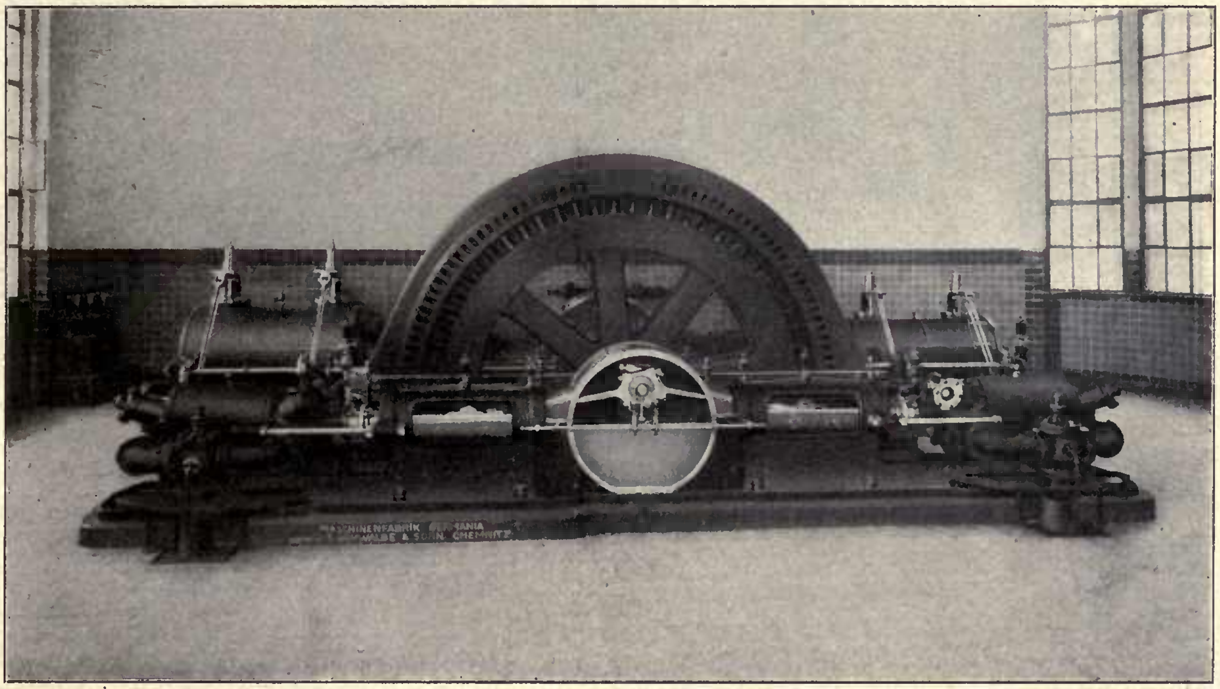


Fig. 1 Compound Steam Engine with Direct-coupled Ammonia Compressor and Three-phase Generator

it developed in a manner that to-day this branch ranks amongst its principal interests.

The Germania machines, including all appurtenances, as well as the steam power plant etc. — made throughout within the workshops of the establishment — are adapted for the production of cold, which in many industries and trades has become an indispensable agency.

Apart from small plants installed in cafés, restaurants and large households, the Germania Refrigerating Machines are in operation in a large number of public used in dairies, margarine works, chemical works, sugar refineries, hospitals, post mortem rooms and mortuaries, ice factories (including one in Batavia, Java), also in mines for the congelation of shafts for coping with quicksand. Their widest field of application, however, they have found in breweries with their extensive and varied demands for refrigerating installations for the purposes of ice making, water cooling and air cooling. The erection of breweries in hot countries has only been rendered practicable thanks to mechanical refrigeration, which provides the indispensable thermal conditions for brewing in hot climates. Numerous breweries in Germany as well as elsewhere, notably in South America, Japan, China, and also in northern parts of the world, such as Scandinavia and even Siberia, are equipped with Germania refrigerating machines. All these installations have been designed to suit the requirements of each individual case and furnish a more convenient and a more reliable means of controlling the process of fermentation and maintaining a cool and dry air in the cellars than is afforded by the use of natural ice.

jet condenser. At 100 r. p. m. and working with superheated steam at 572° F and a pressure of 162 lbs per sq. in. the engine develops 300 B. H. P. It is coupled to an ammonia duplex compressor of a capacity of 165 tons of refrigeration measured at a brine temperature of 23° F. In addition, the engine drives a three-phase alternator of 195 kw.

The refrigerating effect is employed in the daily production of 25 tons of ice, for cooling the whole of the fermenting, storing and racking cellars as well as the hop stores with an aggregate floor space of about 5500 sq. yds.;

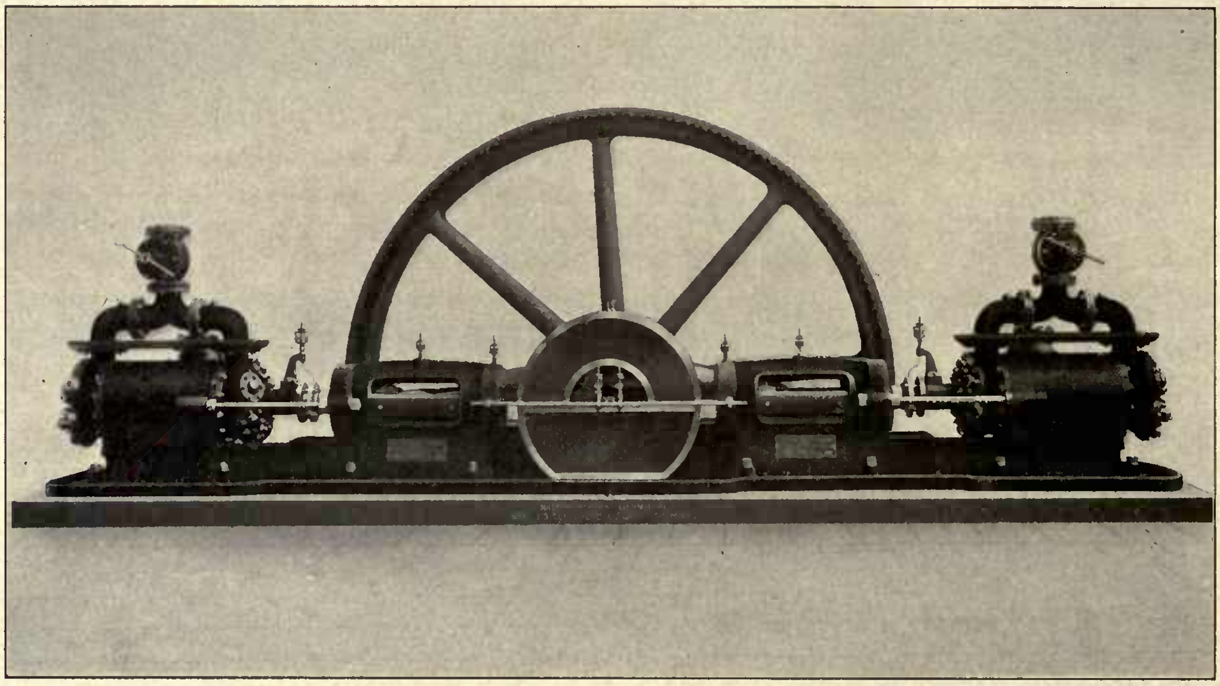


Fig. 2 Duplex Ammonia Compressor with Belt Drive

In the course of time the Germania Refrigerating Machines have undergone many improvements and represent now the result of a large store of practical experience furnished by numerous and varied working installations. Many of the designs and details of construction have proved of great practical value. Thanks to their high efficiency, which modern tests never fail to demonstrate, they have met with a great measure of recognition and form part of thousands of installations all over the globe.

Of brewery refrigerating plants erected in recent days by the Germania Engineering Works the following examples may be instanced, both being remarkable as regards their magnitude and general arrangement.

Dortmunder Hansa Brauerei A.-G. at Dortmund. The steam engine is of the compound opposed cylinder type and has drop-valve gearing and a

for cooling a daily quantity of about 15000 gallons of wort; and for cooling the fermenting tubs with sweet water. To use the engine steam to best advantage an economiser is installed between the L. P. cylinder and the condenser, which serves to heat to about 130° F the water required for use in the brewery.

Fabrica de Bere Bragadiru, S. A., Bukarest. The ammonia duplex compressor shown in the illustration has a capacity of about 330 tons of refrigeration with the circulating brine at 23° F and is driven by a 400 H. P. three-phase electromotor and belt gearing with a Lenix belt tightener.

The refrigeration produced by this machine is employed in ice making and for cooling the whole of the fermenting rooms, stores, racking rooms, and hop stores, as well as for preparing the sweet water required for cooling the worts and the fermenting tubs.

Maschinenfabrik C. G. Haubold jr., G. m. b. H., Chemnitz

This firm employs about 1000 engineers, clerks and workmen and was established in 1837. Its object is the construction of refrigerating machines, and among its further specialities may be named: Machines for bleaching, dyeing, finishing and printing calanders, cutting machines etc. for paper making and rubber working, also centrifugals for a great variety of purposes.

The first named department, which the firm started in 1893, has turned out about 1200 refrigerating and ice making plants for manufacturing and industrial purposes, and about 120 marine cooling plants have been installed in vessels of the navy and mercantile marine. Of these the smallest plant had a capacity of ½ ton, whilst the largest plant is of 120 tons refrigerating capacity. The installations supplied up to 1908 worked exclusively on the CO_2 compression system, but since that date the construction of machines working on the ammonia compression system has been taken up with similar success.

Of the 1200 plants referred to above 400 are installed in German and other chocolate works, and the Company may fitly be described as specialists in this field. Whereas formerly chocolate in cake form and pralinés were cooled by placing them on the expansion pipes arranged in the form of racks, this proceeding has now been abandoned, excepting for special purposes, and all chocolates in the form of cakes or drops etc. are now cooled in a chamber with air circulation by means of dry air coolers fitted within the chamber. In more recent arrangements, to avoid an excessive expenditure of transporting labour, so-called automatic cooling boxes designed to deal with large quantities of material of uniform quality and form have been introduced. In these machines transporting and cooling are combined in one process.

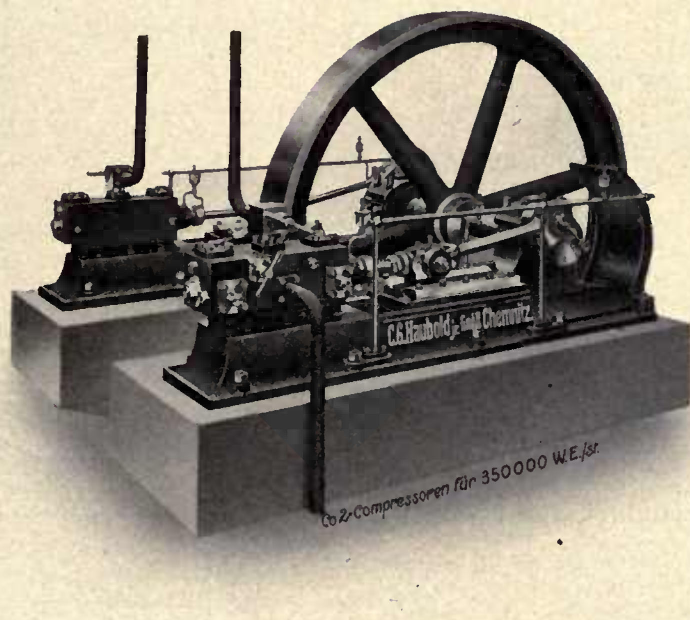


Fig. 1

In the following lines we propose to describe by way of example one of the many installations supplied by the firm to the North German Lloyd, the Hamburg-American Line, the Hamburg South American Steam Ship Company etc. The example chosen is a plant installed in the Twin Screw Steamer Ypiranga of the Hamburg-American Line, which makes voyages from Hamburg to Brazil and on another occasions is employed for pleasure trips. The vessel has been fitted with an installation operating on the CO_2 compression system with brine circulation, which travels from the brine cooler in the engine room to the cold chambers and boxes. The installation consists of two vertical marine refrigerating machines, either of which comprises a compressor of $2^3/_8$ inch diam. and 10 inch stroke and running at about 120 r. p. m. (Fig. 2) together with two brine circulating steam-pumps of the duplex pattern of 3 and $3^3/_4$ by 4 in. stroke (one being provided as a reserve pump) and a cooling water steam duplex

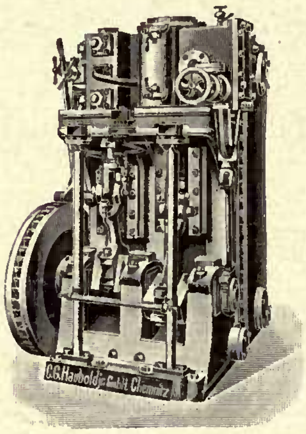


Fig. 2
Marine Refrigerating Machine

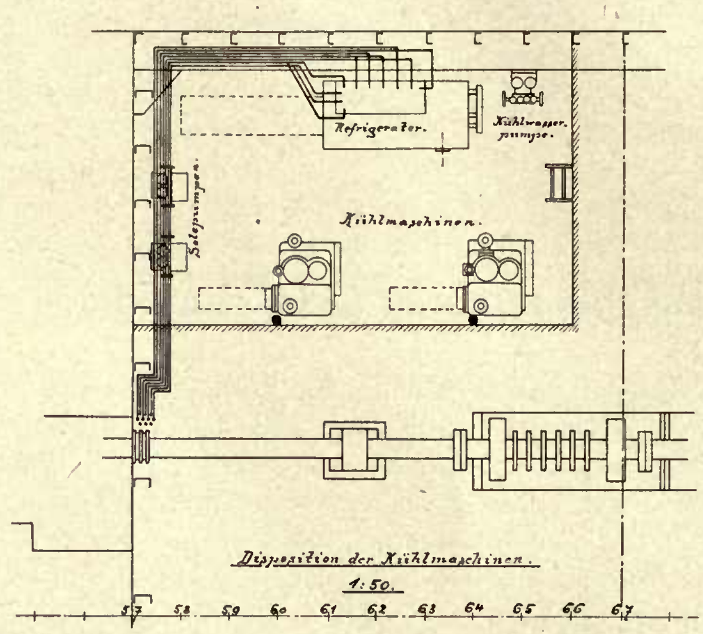


Fig. 3 Arrangement of Cooling Machines

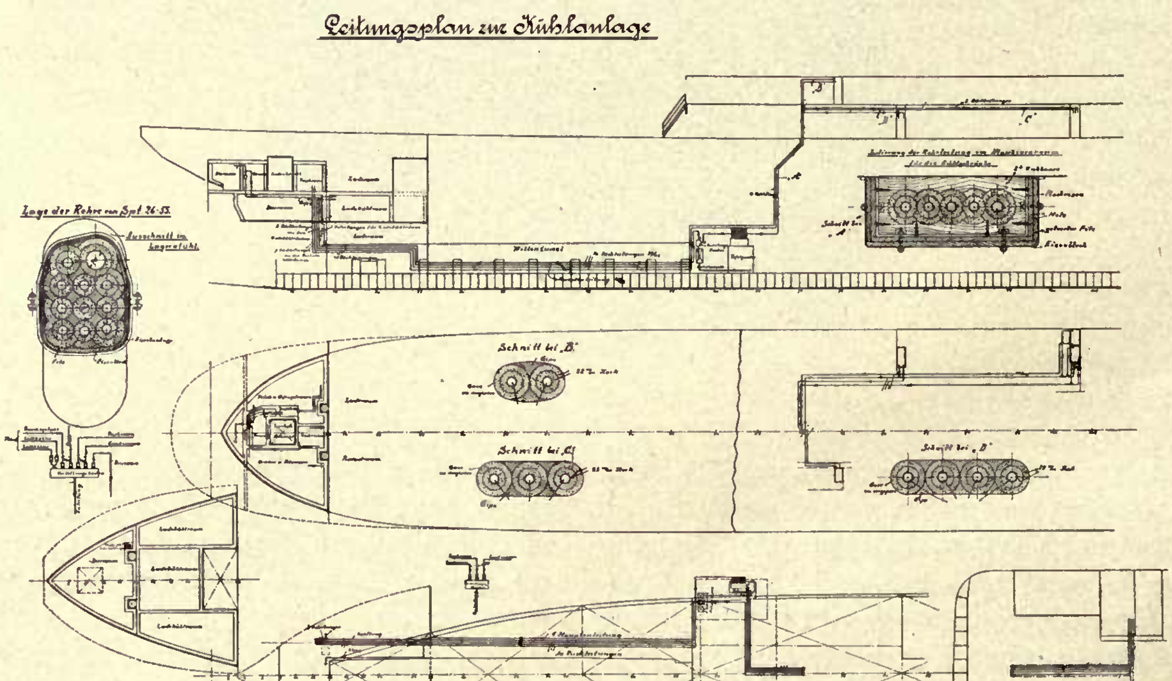


Fig..4 Arrangement of Piping

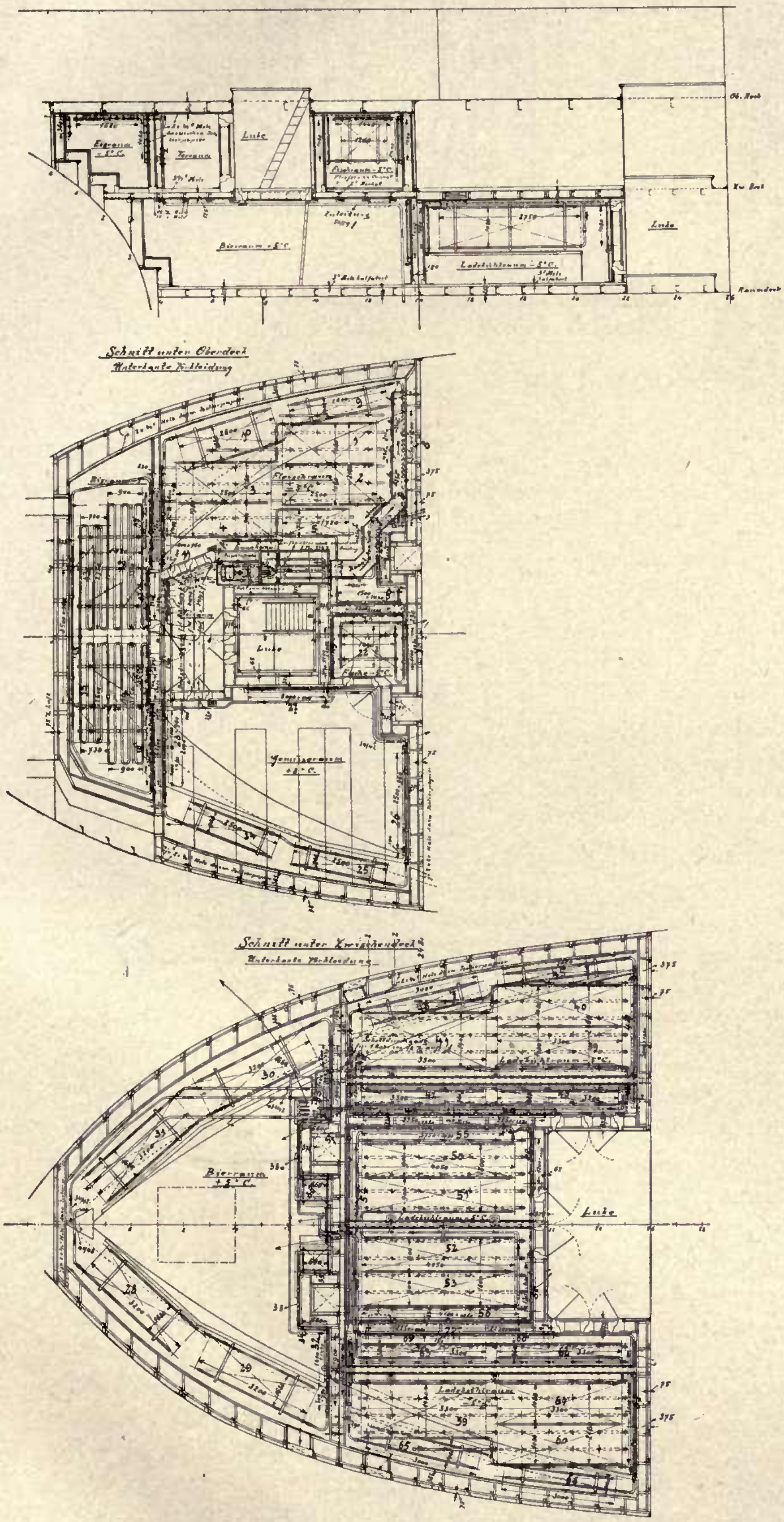


Fig. 5

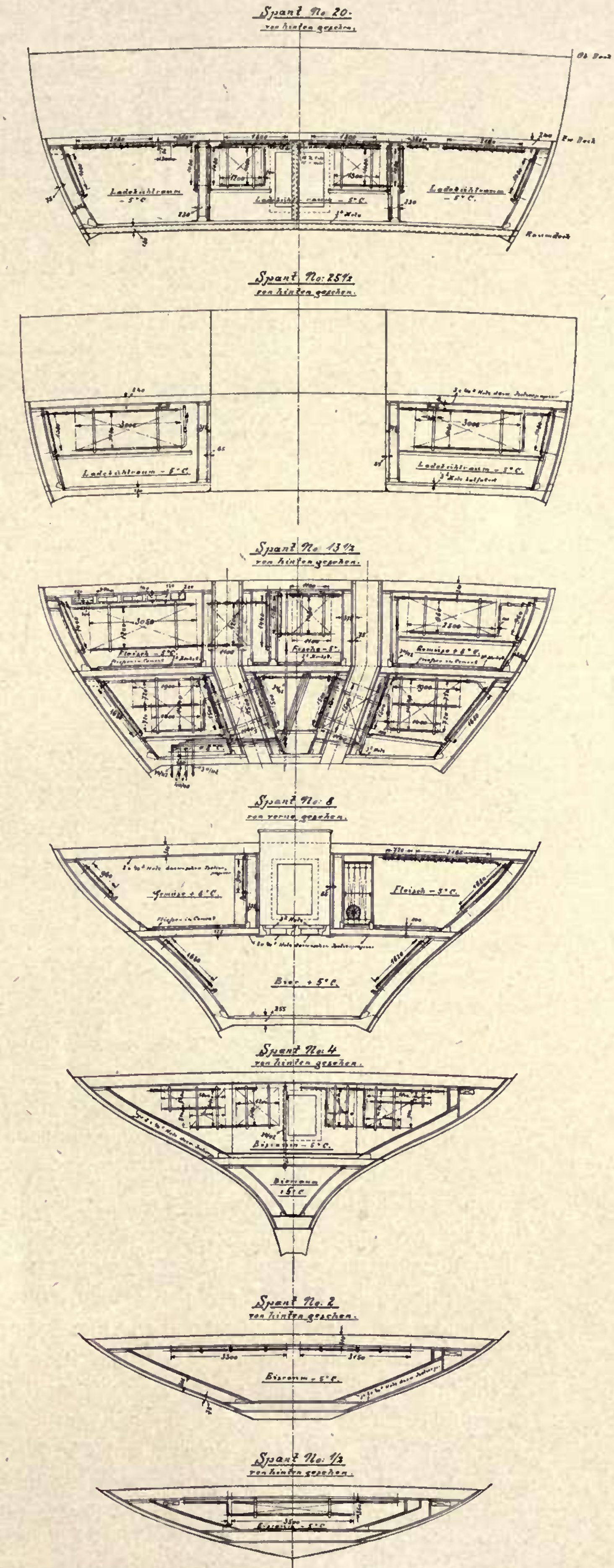


Fig. 6

Fig. 5 and 6 Plan and Sections showing Arrangement of Piping in Cooling Rooms

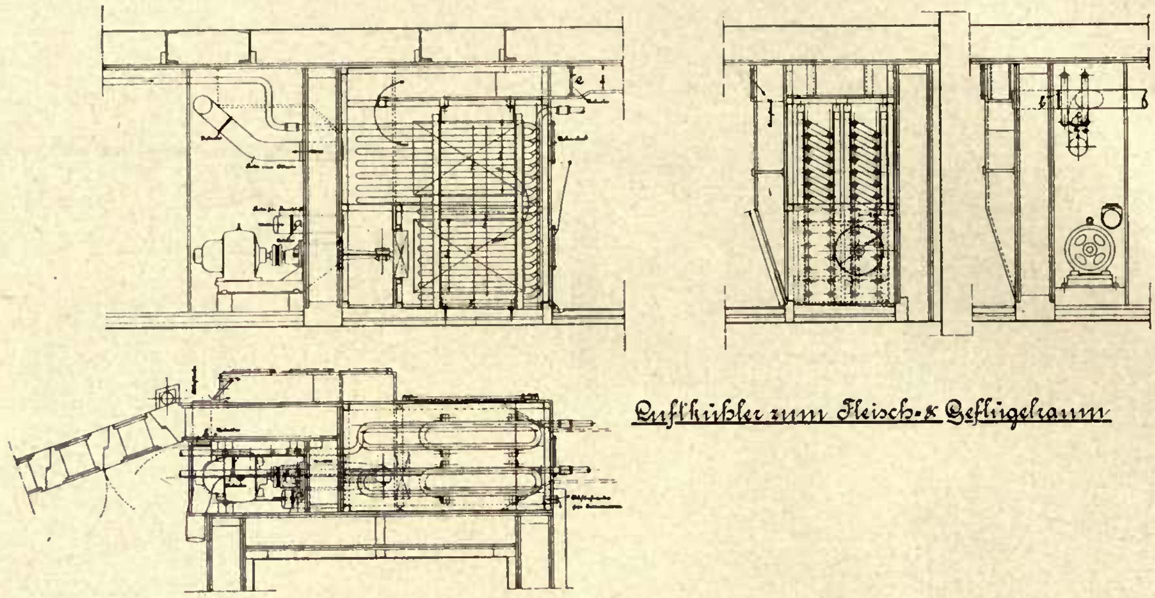


Fig. 7 Air Cooler for the Meat and Poultry Store

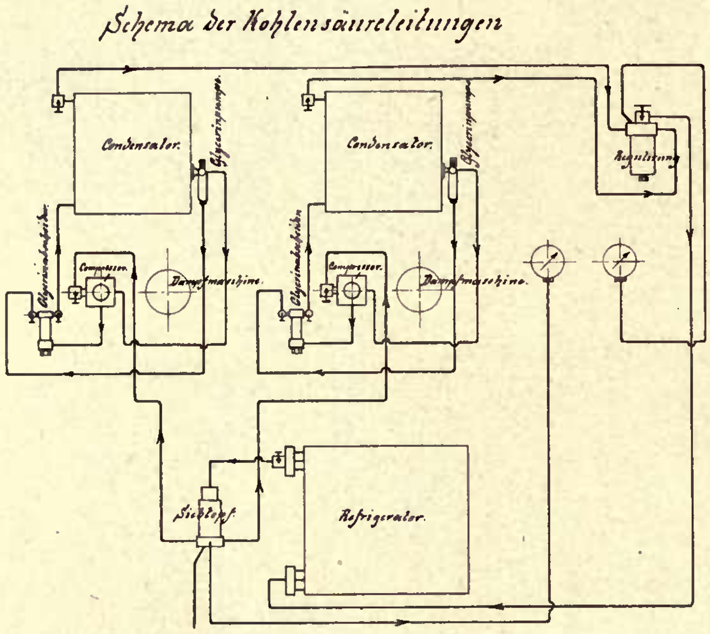


Fig. 8 Diagram of CO_2 Piping

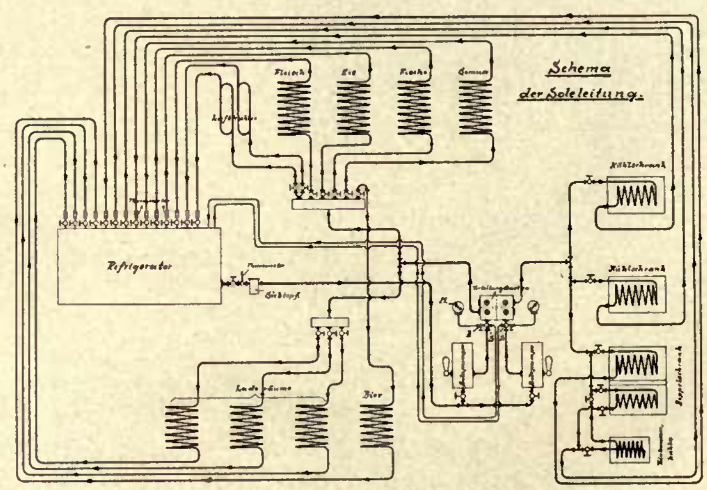


Fig. 9 Diagram of Brine Piping

pump of 5¼ and 6 by 6 in. stroke. The machines are set up as shown in Fig. 3, and the position of the cold chambers in the ship is shown in Fig. 4, which indicates their size and purpose. In addition to the cold chambers, various cupboards and drink water tanks are fitted with cooling pipes. Figs. 5 and 6 show the arrangement of the pipes in the cold chambers, and Fig. 7 shows the air cooler in the meat chamber. Details of the insulation of the brine delivery and return conduits are likewise shown in Fig. 4. Fig. 8 shows diagrammatically the arrangement of the CO_2 pipe system, and Fig. 9 is a diagram of the brine circulating pipe system of the installation on board of 2 S. S. Ypiranga. The installation satisfies all requirements perfectly.

Similar and also larger installations have been supplied amongst others for the following twin screw steamers:

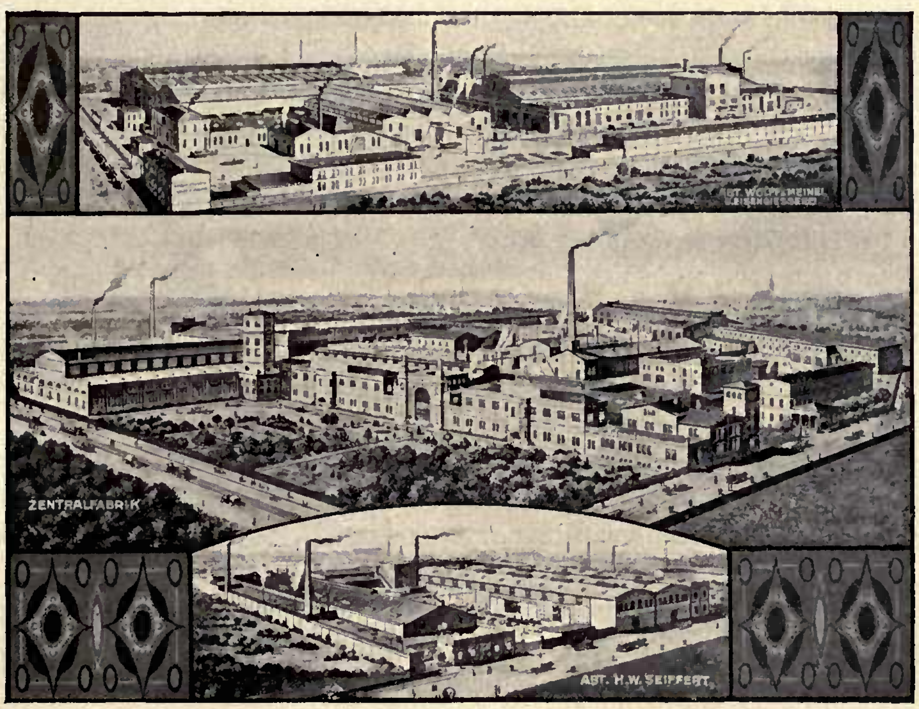
2 S. S. "Corcovado", sister ship to the "Ypiranga",
2 S. S. "Kaiserin Auguste Viktoria",
2 S. S. "König Friedrich August",
2 S. S. "König Wilhelm II".

For the Fast Steamers:
"Kaiser Wilhelm II." and
"Kronprinzessin Cecilie".

Also for the Mail Steamers:
"Kronprinzessin Cecilie",
"Prinz Friedrich Wilhelm" etc.

Wegelin & Hübner, with whom are incorporated Vaas & Littmann, Engineering Works and Foundry, A.-G., Halle o. S.

The firm was established on a very modest scale in 1869 by two engineers, Messrs. Albert Wegelin and Ernst Hübner, the intention being to manufacture primarily specialities only with the idea of ensuring a high degree of perfection in the matter of design and workmanship. Equipped with the requisite knowledge and many years of practical experience, the founders of the young firm commenced operations by making filter presses, steam pumps, air pumps, and steam engines, and they had the satisfaction of finding their efforts attended with success within a year of embarking upon their venture. Within this short period the existing equipment had become wholly inadequate to cope with the orders which were then coming in, so that it became an absolute necessity to erect a considerably enlarged factory. The removal to the new works took place on the 1st March 1872, though the number of workmen did not then exceed one hundred. At this time the firm acquired the patent rights of the Hollefreund mash saccharination process. Within the short space of two years the firm was able to introduce this new epoch-making process in upwards of eighty distilleries, supplying in these cases all the requisite machines and accessory installations. Whilst this invention was being developed the afore mentioned specialities continued to receive a full measure of attention.



In the mean time the erection of an iron foundry had been completed, and on the 21st June 1873 it was installed. The establishment at this juncture employed 150 men. Though soon after the whole of the German iron and engineering industry passed through a very critical time the development of the firm proceeded steadily; for, realizing the state of things at a very early stage, the firm proceeded to turn its attention to foreign requirements. The success which attended these endeavours is clearly marked by the fact that already at the end of the eighties the firm's export business amounted to 36 to 40% of its entire turnover. Towards the end of 1886 Mr. Albert Wegelin retired from the partnership in consequence of serious ill health. His partner, Mr. Ernst Hübner, continued the business on his sole account and, steadfastly applying the accumulated results of practical experience to the improvement of the machines made by the firm, he soon saw the undertaking grow to such an extent that it gave employment to 500 men.

It goes without saying that the firm maintained its technical resources and its equipment of machine tools on a level with up-to-date requirements. On the 24th July 1899 Mr. Ernst Hübner, who in the mean time had received the titular honour of Geheimer Kommerzienrat, converted the business into a share company with a share capital of M. 2 500 000, and in October of the same year sold it to the Hallesche Union Aktiengesellschaft; whilst in 1901 the firm of Wegelin & Hübner became fused into the three departments of the company, viz. the engineering works of Vaass & Littmann and Wolff & Meinel, as well as the boiler works of H. W. Seiffert. As a result of this fusion the capital of the Wegelin & Hübner Company was increased to M. 3 850 000, whilst the number of employees rose to about 850 men in all. Until his death, which occurred on the 22nd November 1905, Mr. Ernst Hübner remained in close touch with the life and work of the establishment, acting until the last as the chairman of the board of directors.

Whilst the firm succeeded in achieving unusually large turnovers in the specialities which it had originally selected for manufacture, having up to now turned out and delivered to all parts of the world about 4000 steam engines, over 8000 air pumps and compressors, a like number of filter presses, about 2000 complete ice making and refrigerating machines and upwards of 18 000 pumps of every description, it secured an ever firmer footing in the manifold branches of the chemical engineering trade. Since years, in fact, the Wegelin & Hübner Works have numbered among the leading establishments for the manufacture of machines and appliances required in chemical manufacturing processes, and the firm is likewise well known among the users of sugar machinery in all countries. There is hardly a department of chemical trade where the firm does not possess the requisite experience and materials to submit suitable propositions to meet any special requirements and to carry out the work in a first rate manner. In this undertaking the firm is effectively aided by having at its command an experimental station equipped with a great variety of full sized appliances enabling the engineer chemists of the firm to determine upon the most suitable design of special appliances by experiments conducted on an adequately large scale. This installation is likewise accessible to chemical factories who wish to carry out experiments through their own experts.

Among the German refrigerating machine makers the firm of Vaass & Littmann is the oldest. It was established in 1868 for the construction of ice making machines by the Carré absorption system. Littmann, the technical partner of the firm, had worked at an engineering firm in Paris together with Kropf, who prior to Littmann established a factory at Nordhausen. Whilst working in Paris he became acquainted with the Carré machine. In 1869 Vaass & Littmann supplied their first absorption machine of a capacity of 220 lbs per hour. In the course of that year the firm delivered three ice making machines in all, which went abroad, as indeed most machines built by the firm were supplied in compliance with orders received from abroad. In 1873 the firm supplied for the first time machines for breweries, most of these being designed for ice making, to enable the breweries to supply ice to their customers. The ice produced by means of these machines was made from the condensed heating steam discharged from the ammonia generators and reboiled by live steam to complete its de-aeration. Being clear, the ice so obtained was much appreciated. Towards the end of the seventies these machines were applied for the purposes of cellar cooling on the lines of present day methods. A very large number of German breweries operated for years with the absorption machines of Vaass & Littmann, using live steam for heating, but subsequently these had to give way to cooling machines working on the more economical compression system. Within recent years, however, absorption machines operating with the waste steam of engines have again come into favour in breweries in particular, and large machine installations for cooling and ice making on the absorption principle have been supplied by this firm.

In 1890 the firm of Vaass & Littmann began to construct refrigerating machines operating on the carbon dioxide compression principle and in 1895 took up the construction of ammonia compression plants. It is thus in a position to select machines operating on this or that system according to the exigencies of the case. At the time when the works of Vaass & Littmann became fused with those of Wegelin & Hübner the firm had delivered about 700 ice making and refrigeration machine installations.

The firm of Wegelin & Hübner, prior to its amalgamation supplied in 1886 its first absorption machine but comparatively soon entered upon the construction of compression machines operating with ammonia as well as carbon dioxide and competed energetically in orders for abattoir installations, of which it erected a considerable number. Thanks to their close connection with large chemical works Messrs. Wegelin & Hübner are in an eminently favourable position to study and develop the construction of refrigerating plants for technical applications. The firm acquired a leading position in the construction of paraffin cooling installations thanks to its location in the centre of the lignite industry of the

Saxon districts of Thuringia. Plants of this class have been supplied elsewhere likewise, notably to Galicia.

In the construction of carbon dioxide refrigeration machines the firm had from the outset held to the principle that for this purpose none but the very best was good enough, and, accordingly, all components which are exposed to compressed carbon dioxide are so constructed of the best material as to prevent the possibility of an explosion or burst with consequent risk to life or losses arising from breakdowns. The cylinders, their attachments, valves and valve chambers are made of solid forged and machined blocks of steel. Whilst this is a somewhat costly mode of manufacture, it has the advantage of producing fittings of unlimited life. This firm was also the first to receive a commission for the installation of a carbon dioxide shaft congelation plant, in which a temperature of — 49° F was maintained for freezing quicksand saturated with brine. The shaft in this case was sunk in an alkali deposit situated in the province of Hannover and carried down to the intended depth, and though soon after the shaft was drowned, so that operations had to be completed by the boring method, the results achieved with this first carbon dioxide refrigerating machine and its success as a means of maintaining in a medium of brine temperatures below — 40° F demonstrated to the leading shaft contractors of Germany the practicability of the congelation method. These firms have since mainly adopted the carbon dioxide congelation method, since this affords under all conditions the possibility of maintaining in a briny medium temperatures down to — 31° F with compressors working in a single stage and even down to — 49° F with compressors operating in two stages. Messrs. Wegelin & Hübner number all the shaft contractors of Germany, with a single exception, among their clients and have so far delivered a matter of twenty complete shaft congelation plants operating on the carbon dioxide system.

In 1906 Messrs. Wegelin & Hübner supplied to the Geestemünde Ice Works a large refrigerating plant for the requirements of the large fish depot established there. For the purposes of preserving fish it is particularly important to employ ice which shall contain as little air as possible to obviate rapid thawing. The most suitable product for this purpose is ice in slabs made from ordinary unprepared water. Any economically working engine can be used for the production of ice of this kind since no means need be provided for the preparation of a definite quantity of distilled water. In 1911 the firm supplied the first large plate ice factory on the Continent, the installation being driven by a Diesel motor and having a capacity of 60 tons per day. This plant satisfied all expectations so completely that within three months after its installation another plant of similar capacity was ordered. Plate ice is used with preference in the trades concerned since the ice, when cut into cubical blocks, does not recongeal and effects more intense cooling than the ordinary artificial ice, which tends to congeal after crushing.

The two amalgamated firms of Wegelin & Hübner and Vaass & Littmann have jointly turned out over 2000 complete refrigerating and ice making machines up to 1913.

Quiri & Co., Engineering Works, Schiltigheim (Alsace)

The exigencies of the modern machinery system have brought about an increasing tendency to specialisation. This has great advantages in a twofold sense:

1. Concentrated attention to a single speciality enables a maker to apply himself much more efficiently to the study and improvement of a limited class of machines, and there is no doubt that specialisation is largely responsible for modern technical developments.

2. The specialist can manufacture his machines systematically and in larger numbers and hence under more economical conditions.

The subject of mechanical refrigeration is one which calls for specialisation in an unusual degree in that it involves an exceptionally extensive combination of practical experiences and accumulated facts for the attainment of notable results. In Germany a number of firms specialise in the construction of refrigeration machines, and amongst these that of Messrs. Quiri & Co., of Schiltigheim (Alsace) is one of the most important. This firm was established in 1877 and applies itself **exclusively** to the **construction of refrigerating machines.** The quality of the firm's production is best borne out by its practical success in past years.

From the subjoined diagrams it will be seen that Messrs. Quiri & Co. are builders of refrigerating machines ranging from the smallest to the largest units and that the annual turnover has risen continually.

There are probably few firms that can look back upon a like history of brilliant growth.

The firm supplies not only machines for installations at home but likewise exports in considerable quantities. The subjoined table gives a good idea of the relation between the firm's home and export trade. The number of installations which have been erected in transatlantic countries furnishes a concrete proof of the excellent working qualities of the sulphur dioxide compression machines made by Messrs. Quiri & Co.

Synopsis of the Refrigerating Machine Plants constructed and delivered up to the

Size of Machine	000	00	0	I	Ia	II	IIa	III	IIIa
Capacity in tons of refrigeration of Machines of each size erected in Germany	8	84	204	146	148	133	265	240	280
Erected in other European countries	5	75	86	105	58	70	150	280	220
Erected in transatlantic countries	1	5	12	28	200	53	35	86	40

Ice Making Capacity: 5680 tons per day.

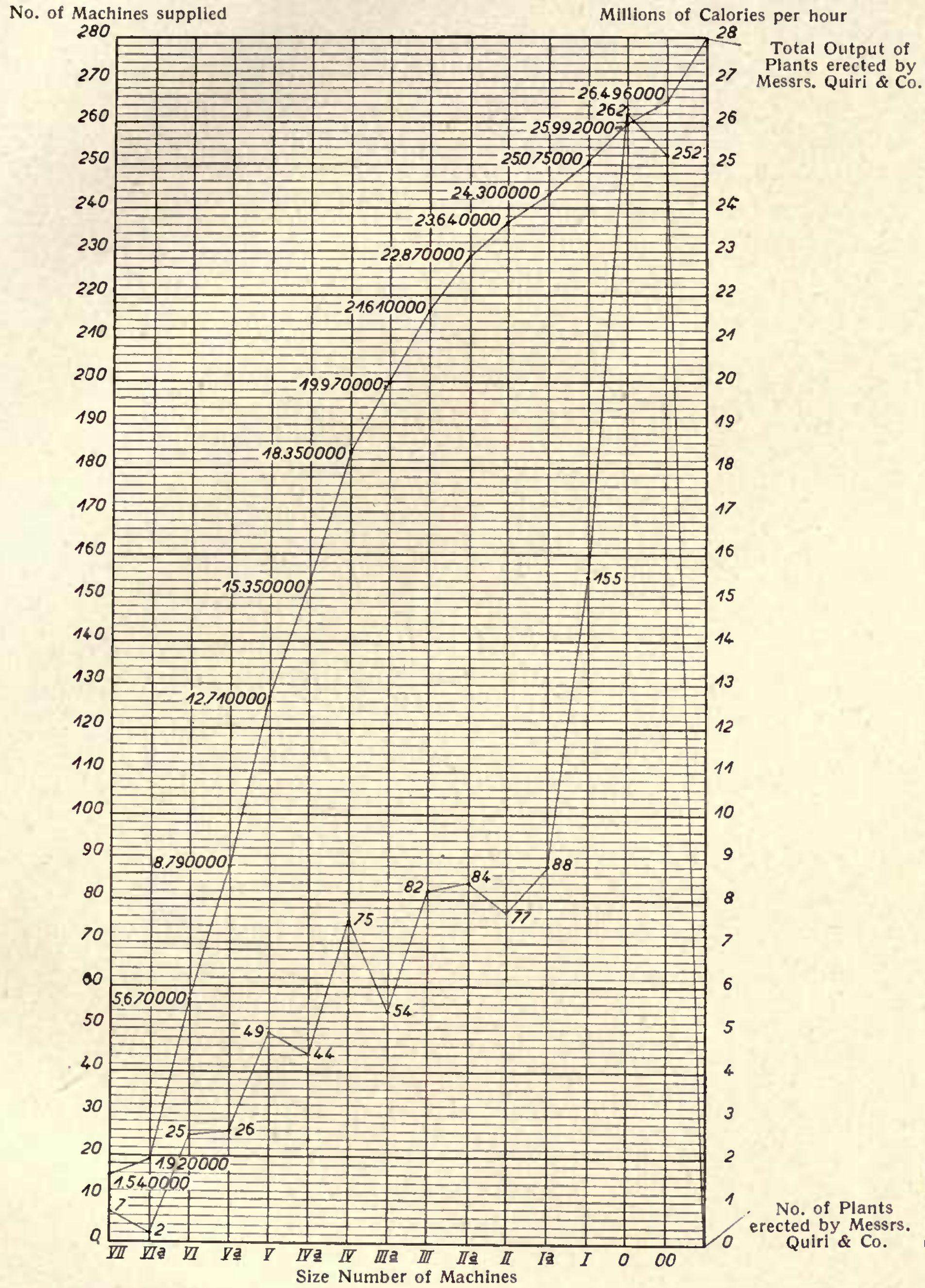
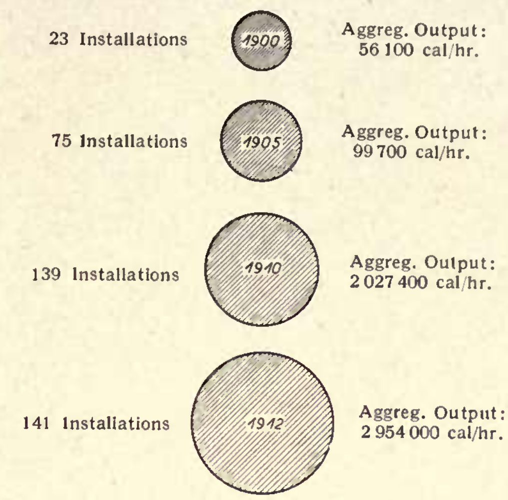


Diagram of the Increase of Output in Calories relative to the Size of Machines supplied



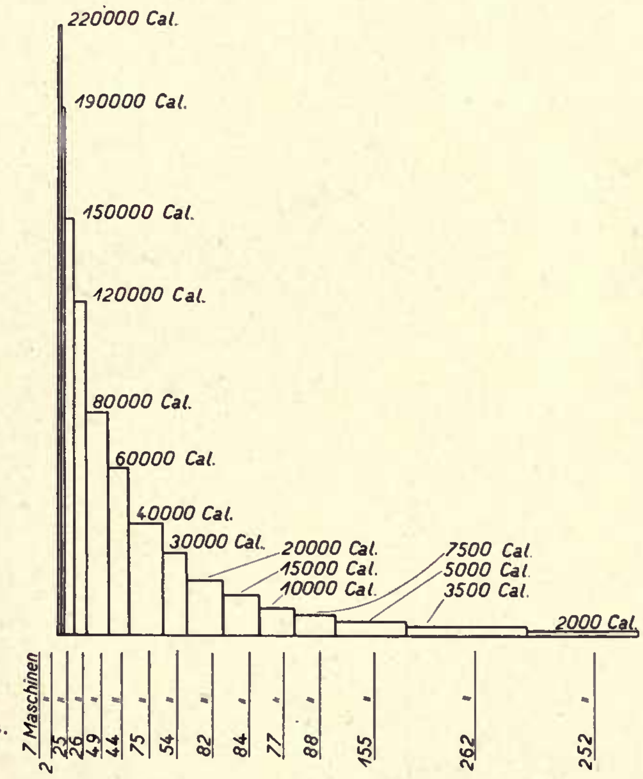


Diagram of the Size of Machines supplied within 26 Years

31st May 1913 by Messrs. Quiri & Co. G. m. b. H., Engineering Works, Schiltigheim (Alsace).

Size of Machine	IV	IVa	V	Va	VI	VIa	VII	VIII	Total
Capacity in tons of refrigeration of Machines of each size erected in Germany	533	320	613	680	700	127	367	110	4958
Erected in other European countries	373	400	400	320	250	—	—	—	2790
Erected in transatlantic countries	80	320	427	80	350	—	—	—	1717
								Aggregate Capacity in tons of refrigeration .	**9 465**

SECOND PART

ILLUSTRATED DESCRIPTION OF A FEW COOLING INSTALLATIONS ERECTED IN GERMANY

Refrigeration Plant of the Municipal Abattoir at Dresden

Installed by the Gesellschaft für Lindes Eismaschinen, Wiesbaden

The Dresden Abattoir, which was erected in 1910/1911, comprises three self-contained and entirely independent plants, all of which have been supplied and installed by the Gesellschaft für Lindes Eismaschinen A. G., Wiesbaden. The first and largest of these is situated in the abattoir proper and serves for the preservation of freshly killed and absolutely sound meat; the second forms part of the *Amtsschlachthof* or *Polizeischlachthof*, i. e. the police controlled section, and serves partly for the preservation of meat of qualified fitness for human consumption and partly for cooling horseflesh; whilst the third plant serves the requirements of the restaurant attached to the abattoir.

The installation of the principal cooling house is designed for a refrigerating capacity of 240 tons and is required to produce the following thermal effects:

1. To maintain a temperature of 36° F and a mean relative degree of humidity of 75% in the meat cooling room, which occupies an area of 46 000 sq. ft.;

2. To maintain a temperature of 45° F and a mean humidity of 75% in a fore-cooling room having an area of 19 500 sq. ft.;

3. To maintain a temperature of 43° F in the pickling room, which embraces 12 500 sq. ft.;

4. To cool an ice store occupying 600 sq. ft.;

5. To produce 25 tons of distilled water ice per day of twenty-four hours.

To maintain a temperature of 36° F coupled with a humidity of 75% in the two cooling rooms of the police controlled abattoir, which jointly occupy a space of 1710 sq. ft., the requisite work amounts to 8 tons of refrigeration.

The restaurant installation absorbs about 16 000 B. T. U. per hour for the following purposes:

1. For maintaining a temperature of 36—39° F in a space of 75 sq. ft. provided for keeping fresh and salted meat;

2. For cooling a pantry of 68 sq. ft. for the reception of the day's supply as well as bottled and tinned preserved meat, fruit, etc.;

3. For maintaining a beer store of 260 sq. ft. at a temperature of 43° F.

Within the *Amt Abattoir* and the restaurant an ammonia compressor was provided for either plant, their refrigerating capacity being 8 tons and 1⅓ ton respectively. In the main cooling house, on the other hand, three ammonia compressors of 80 tons capacity each were put down to provide against the consequences of a breakdown and also to obtain a better adaptability to the varying requirements of the different seasons of the year. A fourth compressor of similar size was added by way of reserve, the entire plant thus grouping itself very simply into two duplex compressor sets, each driven by an independent engine.

In view of the fact that steam is required for the preparation of distilled water as well as hot water for various requirements the steam engine naturally had preference over other prime movers. On the other hand, the great distance intervening between the boiler house and the compressors of the *Amt Abattoir* and restaurant installation rendered it impracticable to drive these compressors by steam-engines served from the main boiler plant, as this would have entailed a disproportionately high outlay on steam conduits and serious heat losses; moreover, steam engines of the small dimensions required for driving these compressors are uneconomical by their high rate of steam consumption. For this reason the two small compressors with all their auxiliary mechanical appliances were arranged for being operated by electric motors. This plan was the more rational as it did not in any way render the working dependent upon any extraneous source, since the energy for the electric lighting system of the establishment, comprising 80 arc lamps and 4000 glowlamps of 16 to 600 c. p., necessitated the installation of an independent generating plant.

Electric motors have likewise been installed for all machines and mechanical appliances which are either too far removed from the central power station to be profitably connected with it, or whose nature demands that they should be independent of the main engine. In this category are to be included more particularly all fans and air cooler drums, agitators and conveying mechanisms for ice freezing tanks, as well as the centrifugal pump for the brine concentrator. All other small machines forming integral parts of the compressor plant, such as the liquid pump for the superheater, the brine circulating pump and the agitators, are all driven by shafting mounted in the basement of the engine house and deriving its motion from the main compressor engines.

As an electric current generator the steam turbine surpasses the reciprocating piston engine in the matter of initial cost and space requirements, whilst both are comparable as regards steam consumption. In this particular case the turbine was entitled to decided preference in that the condensed steam furnished by it is free from oil and thus provides water which is eminently suitable for making crystal ice. To secure these advantages under economical conditions matters had naturally to be so arranged as to ensure that the turbine may be always operate with an adequate load. For this reason the entire water supply plant, which was likewise installed by the Linde Company, was arranged for operation by electric motors.

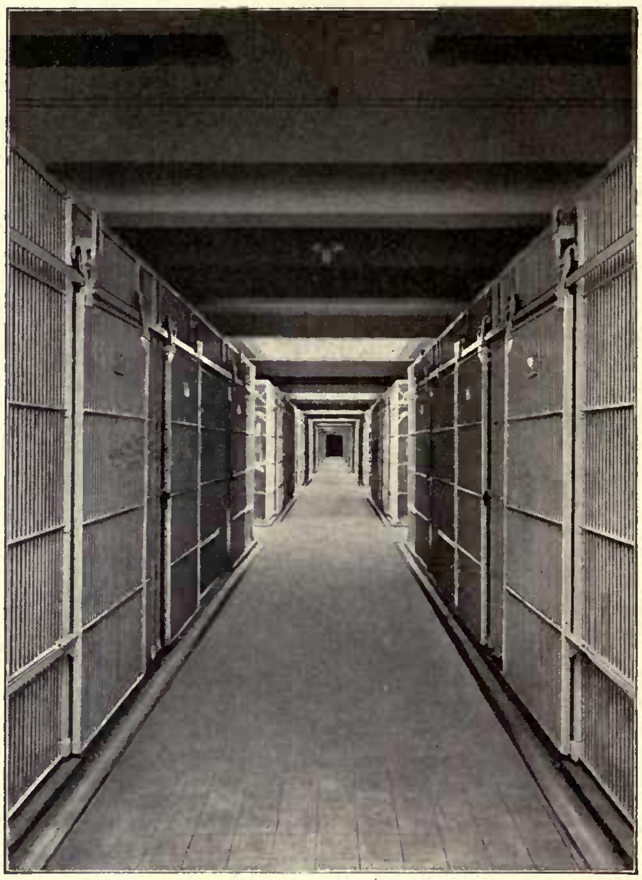


Fig. 1 Main Cooling Room

Fig. 2 Fore Cooling Chamber

All machines and appliances for the main refrigerating installation, together with the boiler plant and the steam turbine supplied by Messrs. Brown & Boveri, of Mannheim, are housed in one building, which has been liberally planned with a view to future extensions of considerable magnitude.

The boiler house adjoins the machine house, which accommodates on the ground floor three turbo-generators and the two duplex-compressors with their respective steam engines. The compressors are of the standard horizontal pattern with cylinders measuring 15 in. by $23^5/_8$ in. stroke and making 62 r. p. m. They have a

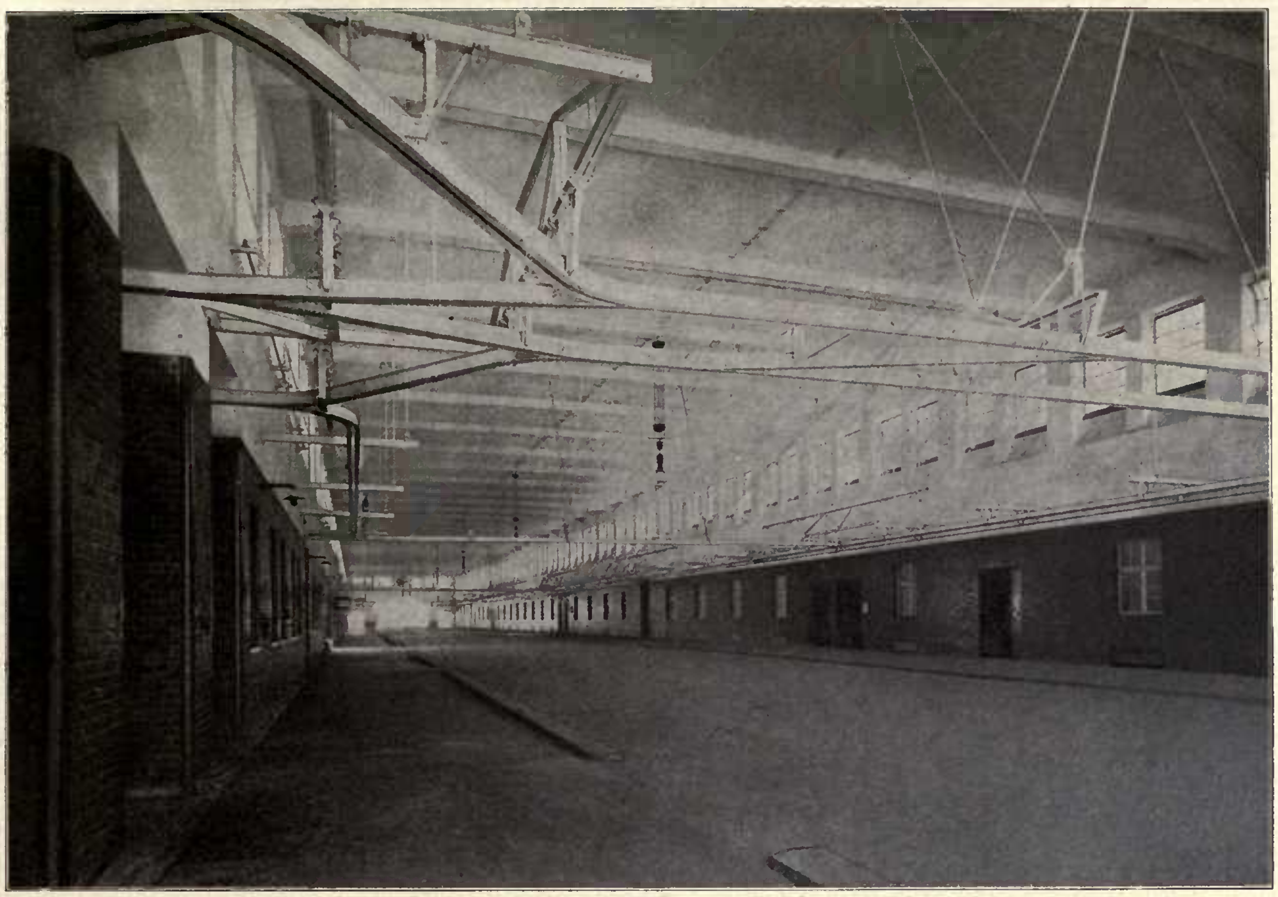


Fig. 3 Intermediate Hall connecting Slaughter House and Cooling House

Fig. 4 Ice Tank Room

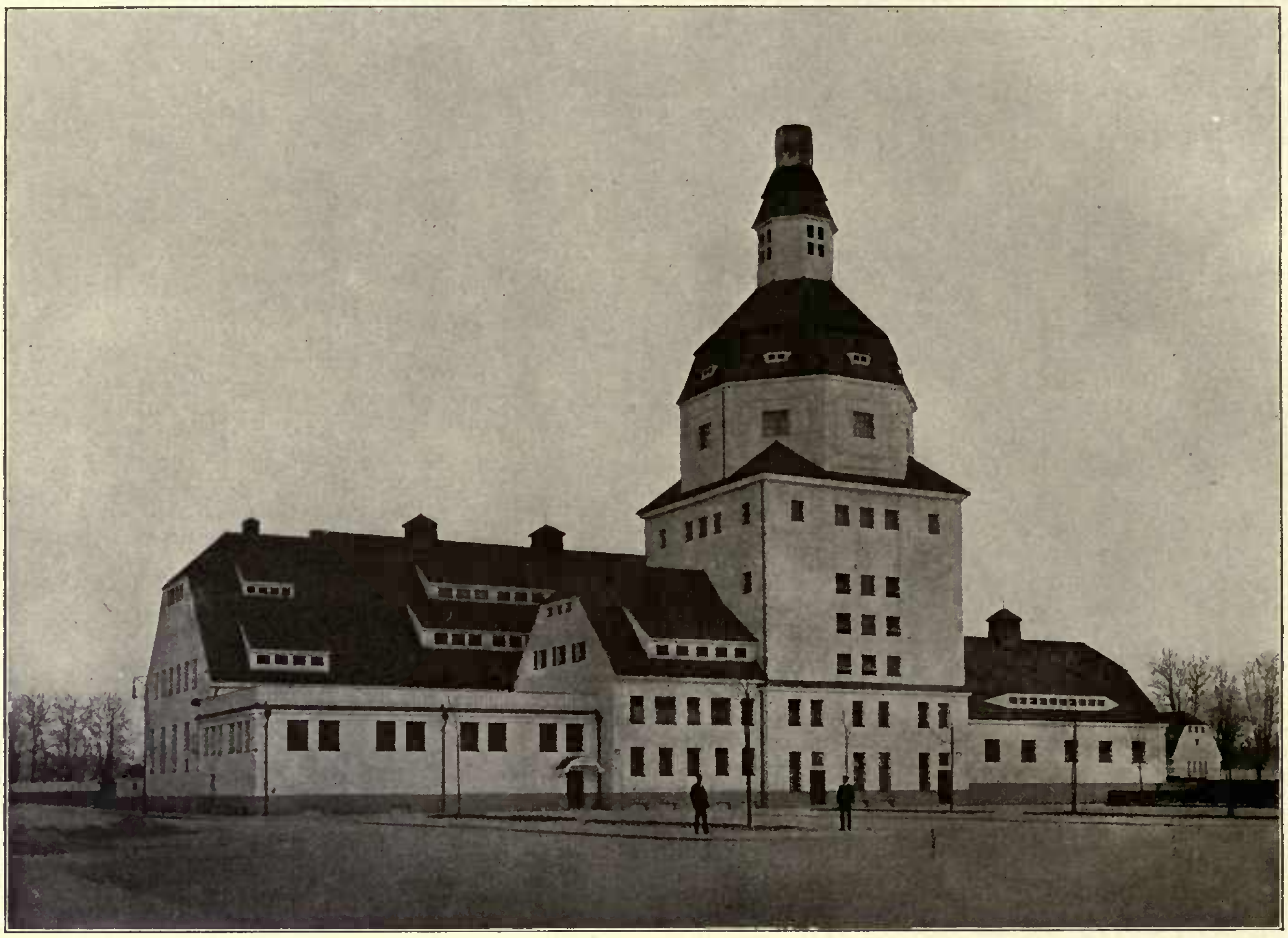


Fig. 5 Machine House with Water Tower

thermal capacity of 80 tons each, the temperature of evaporation being 14° F, that of liquefaction 68° F.

The steam engines are of the compound type with opposed cylinders of $16^3/_8$ and 27 in. diameters by $33\frac{1}{2}$ in. stroke. They are designed to work with superheated steam at 446° F and a pressure of 125 lbs per sq. in., and are fitted with jet condensers. The surplus power of the engine is transmitted by belt gearing from the flywheel to the shafting in the basement. The engines develop 190 to 220 I. H. P. or 160 to 190 B. H. P.

The machine house provides room for the erection of a fourth turbo-generator and a third duplex compressor with steam engines coupled thereto.

To provide effective means for adapting the capacity of the compressor to varying requirements, the entire refrigerative effect is spread over three compressors. To ensure a still greater elasticity each compressor is provided with a reduction device, by means of which the cover sides of the compressors are rendered partly or wholly inactive without appreciable power losses, the variation obtainable in this way ranging within 50% of the normal capacity.

To ensure the utmost degree of economy in working the compressors are equipped with a superheating attachment. The object of this, as is well known, is to ensure the admission of dry gas into the compressor when the evaporator is operating in a liberally flooded condition. This is achieved by the introduction in the suction conduit of a liquid separator eliminating the liquid particles of ammonia carried over from the evaporators. The liquid so collected is forced back into the evaporators by means of a small pump. Experience has shown that this arrangement contributes very largely to the economy of working, in addition to which it greatly facilitates the regulation of the thermal effect, since the regulating valve is required to adjust differences of pressures, instead of having to deal with quantities of liquid as well. At all events, the presence of this arrangement enabled the contractors to guarantee a refrigerating output of at least 15 875 B. T. U. per I. H. P. measured at a temperature of 14° F in the evaporator and 68° F in the condenser.

With the exception of the ice cellar, which is cooled by an ammonia evaporating coil surmounted by gilled radiators and suspended from the ceiling the main cooling

Fig. 6 Road through the Abattoir

house is cooled by means of wet air coolers. The expansion system for chilling the circulating brine, which takes the form of two duplex evaporators, is set up in the basement of the machine house. It comprises two evaporating coils of patent welded wrought iron pipes of $1^3/_{16}$ in. bore and $1\frac{1}{2}$ in. diameter. The agitators to these evaporators are driven by the shafting in the basement.

The evaporator room accommodates also two centrifugal brine pumps, which are likewise driven by the shafting referred to, one of these being sufficient for maintaining an adequate brine circulation, whilst the other serves as a reserve pump. Room is provided for a third evaporator and a third brine circulating pump.

From the evaporators the brine piping is carried through a subway which joins the machine house to the cooling house and thence proceeds to the air coolers which are set up on the upper floor above the cooling rooms. The air coolers are eight in number and are of the well known rotary disc type with an aggregate brine-wetted surface of about 95 000 sq. ft. Each apparatus contains five disc batteries consisting of 53 discs 65 inches in diameter. The discs are set in motion by two 8 H.P. electromotors. Of the eight coolers two are for the fore-cooling room for beef carcasses, four are for the main body of the building, one for the fore-cooling room for mutton and lamb carcasses, and the last for the salt meat room. Additional room is provided for four other coolers.

Each air cooler is provided with an axial thrust propeller fan driven by a separate 6 H. P. electromotor and capable of displacing over two million cubic ft. of air per hour for maintaining a continuous circulation of the air in the cooling rooms, as well as for inducing the admission of fresh air through an inlet pipe communicating with the suction space of the fan. To regulate the supply of fresh air the pipe is fitted with a swivel damper.

The dew resulting from the chilling of the air passes into the brine. The latter by its direct contact with the air takes up all impurities suspended in the air. From time to time it becomes therefore necessary to concentrate and sterilise the brine. It may be concentrated either by the addition of salt in a dissolving pan or by the evaporation of the excess of water in the brine concentrator. The latter apparatus sterilises the brine at the same time that it concentrates it.

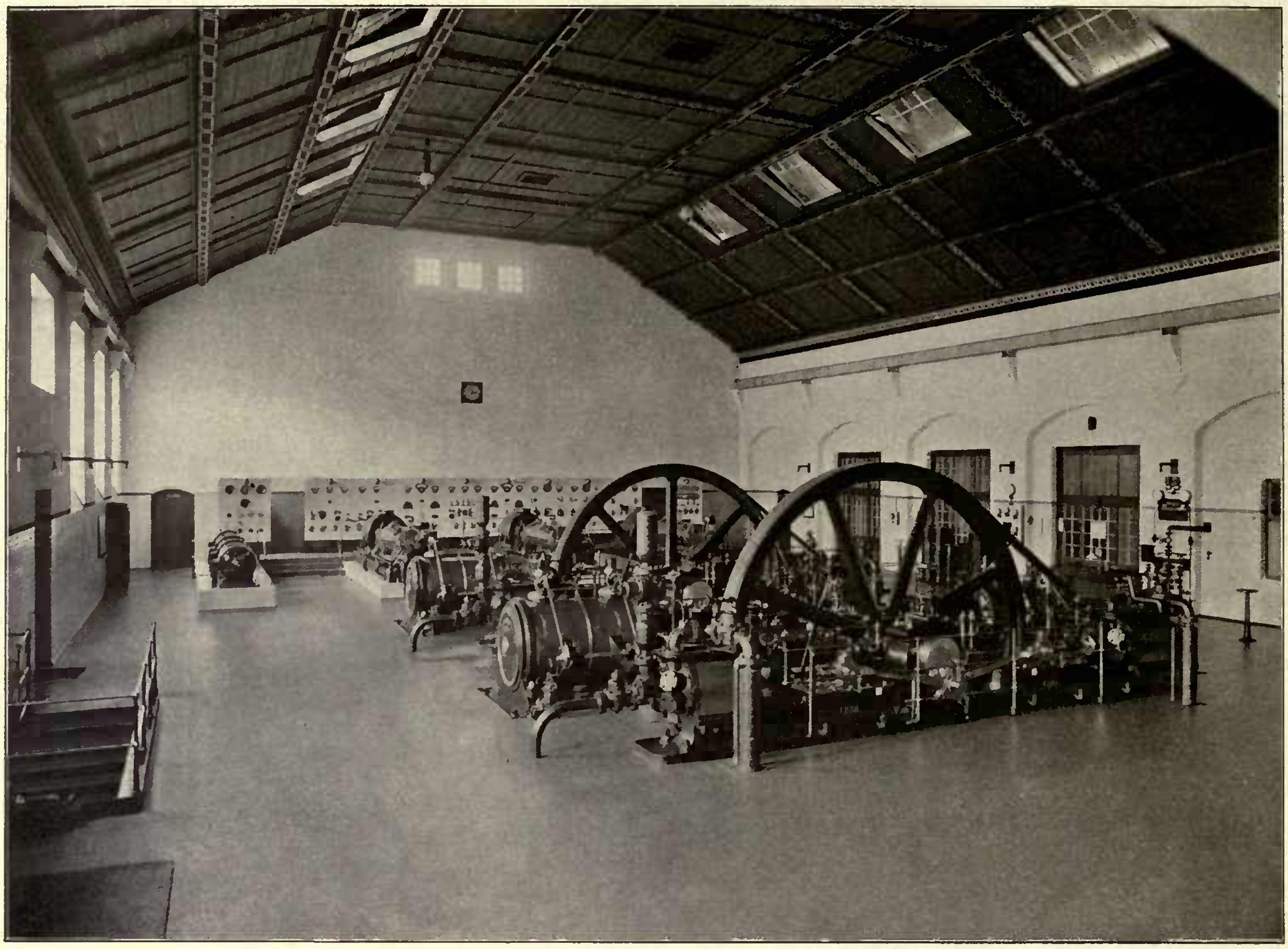


Fig. 7 Engine Room

The apparatus operates in the following manner: A circulating pump draws a portion of the brine from the ammonia evaporation battery and transfers it either to the salt dissolving pan, whence the brine returns in a concentrated form under the action of gravity, or the pump conveys it through an interchanger to the collecting pan of the concentrator. From the latter the brine is conveyed by another centrifugal pump to an overflow trough, whence it trickles down over pipes heated with live steam. The overflow trough contains likewise steam pipes, the object of which is to effect the sterilisation of the brine. From the concentrator the hot brine flows through the interchanger, where it is cooled by the dilute brine on its way to the concentrator, and ultimately returns to the battery. In addition, a brine well is provided which communicates with all vessels containing brine. This well collects all mud extracted from the brine by natural sedimentation.

The compressed ammonia vapour is condensed in six submerged condensers fitted with cooling worms of patent welded wrought iron piping of $1^3/_8$ in. bore and $1\frac{1}{2}$ in. diameter with an aggregate cooling surface of 7550 sq. ft. The condensers are set up in the immediate vicinity of the machine house within a tower built round the chimney stack. In view of the already rather considerable amount of mechanical power absorbed by the apparatus here described the condensers are not fitted with agitators and require 26 400 gallons of cooling water at a temperature of 50° F, which is supplied by a low pressure plunger pump. From the condensers the moderately warm water flows by gravity to the injector well, where it serves to feed the jet condensers of the steam engines as may be required.

The low pressure pump supplies also the cooling water for the surface condensers to the steam turbines. This cooling water is further employed in the preparation of warm water for use in the abattoir, the heat absorbed in the condensers being thus turned to useful account. The warm water, having been thus warmed to a temperature of 95 to 104° F and stored in tanks mounted on

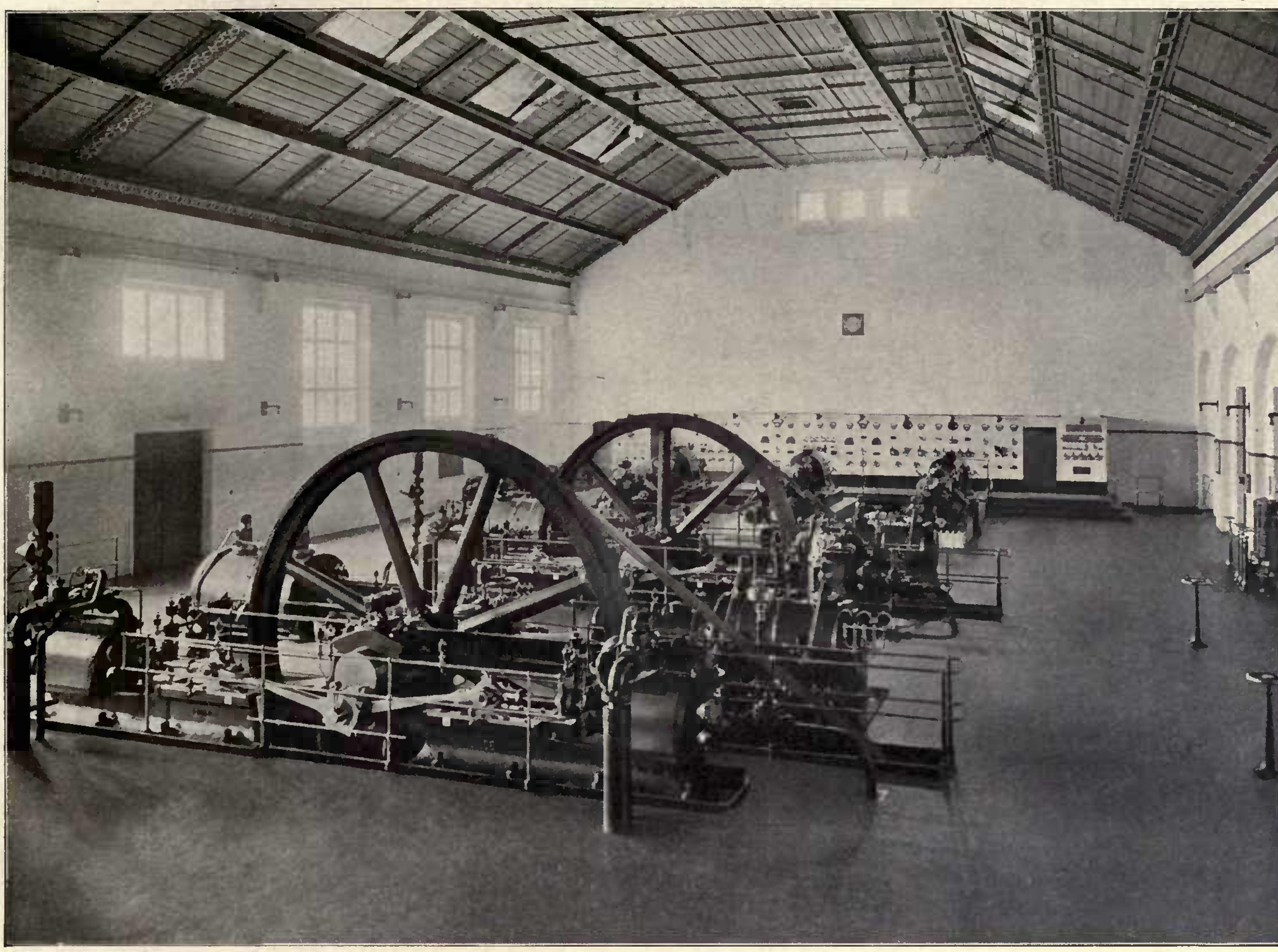


Fig. 8 Engine Room

the top of the tower, is then heated to 158° F whilst circulating through interchangers heated with turbine exhaust steam.

The tower accommodates in addition a cold water reservoir for the requirements of the abattoir, the water being raised by a high pressure pump. This pump as well as the low pressure pump referred to have each a delivering capacity of 66 000 gallons per hour. Both pumps are set up in the basement of the tower, also a spare pump of similar size and available for service both as a high pressure and a low pressure pump.

The condensed steam from the turbines, which, as already stated, furnishes the water for the ice factory, is first conveyed to a receiver or, if sufficient distilled water has been supplied, it is allowed to flow to the boiler house, where it serves as boiler feed water. From the reboiler, where the distilled water furnished by the condensed turbine steam is de-aerated by means of live steam, it passes through a cooler to the distilled water tank, whence it flows by gravity to the ice can fillers.

The freezing tank, which is capable of furnishing twice $12\frac{1}{2}$ tons, or 25 tons, of ice in twenty-four hours, contains 1008 square cans adapted for 28-lb blocks. The cans are arranged in groups of twenty-four in 42 carriages. The expansion coils are of patent welded wrought iron pipes of $1\frac{3}{16}$ in. bore and $1\frac{1}{2}$ in. diameter and present a cooling surface of 1300 sq. ft. The agitators and conveying mechanism can be operated by an electromotor when the steam engine stops. The ice is drawn by means of an electrically operated travelling crane. The freezing tank room adjoins the machine house and communicates with the ice cellar. Room is available for a duplicate freezing tank.

It goes without saying that in an installation of the magnitude of the one here described every facility must be provided for exercising complete control over its working in all its phases. For this purpose the installation is provided with an adequate equipment of thermometers at all points requiring attentive control, temperature and pressure gauges at the suction and discharge sides

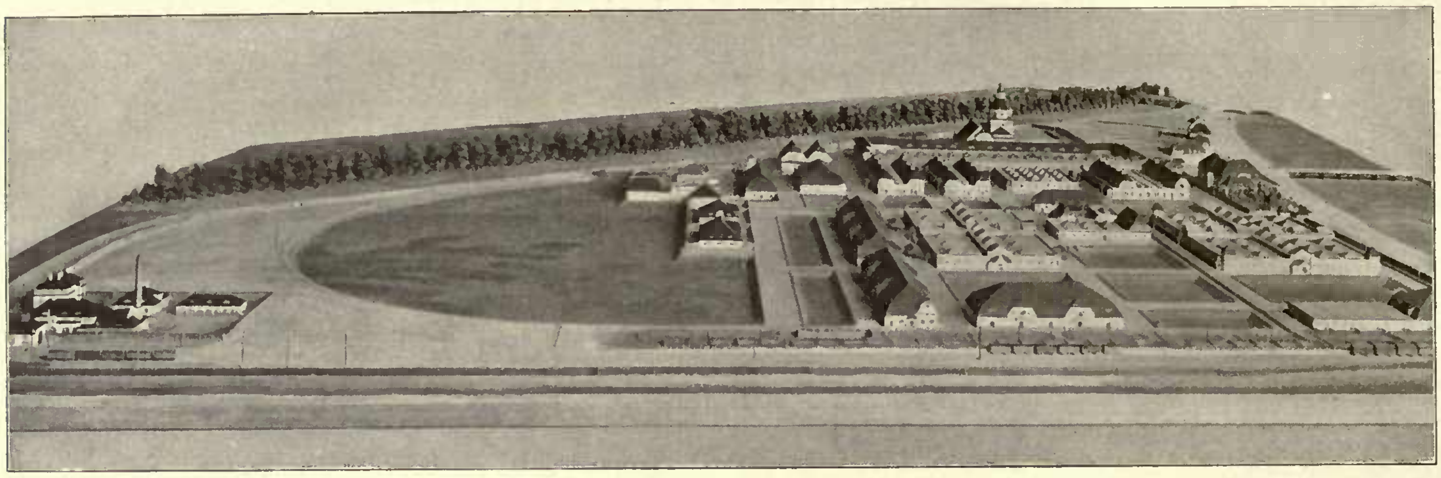


Fig. 9 General View of Abattoir and Cattle Sheds

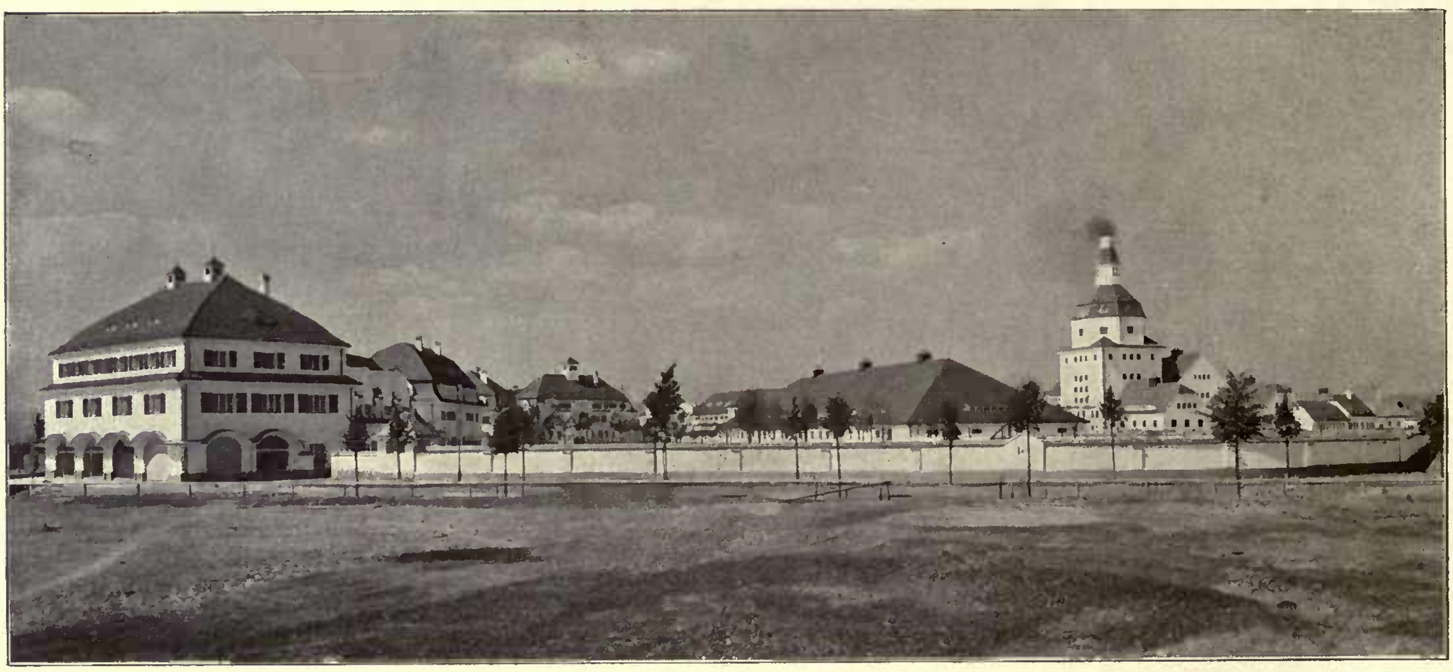


Fig. 10 View from the Abattoir Street

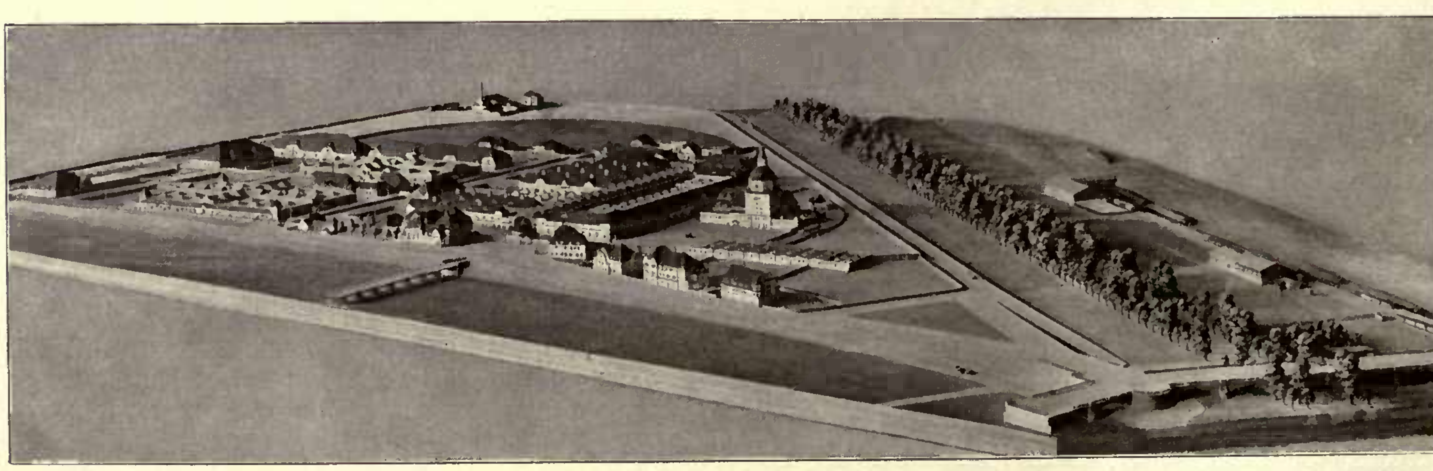


Fig. 11 General View of Abattoir and Cattle Sheds

to the compressors, as well as water meters, steam gauges, and brine density gauges, so as to enable the management to remedy any defect from the outset.

The refrigerating effect required for the purposes of the *Amt Abattoir* is furnished by an electrically operated horizontal ammonia compressor of a capacity of 8 tons, the temperature in the evaporator being 14° F, that in the condenser 68° F. The installation includes a superheating arrangement and an open submerged condenser. In contradistinction to the method adopted in the main cooling plant the chambers are in this small installation cooled on the direct expansion principle. The coils are grouped to form two air-coolers of the box pattern, one serving for cooling the impounded meat, the other for cooling the horseflesh. The requisite air circulation is maintained by means of two electrically operated fans capable of delivering 160 000 and 210 000 cub. ft. respectively, which also draw in fresh air through stoneware pipes built into the walls. Each air cooler is fitted with a device for defrosting the pipes by means of warm ammonia vapour.

The refrigerating plant attached to the restaurant is an ammonia compressor of a capacity of 1⅓ ton with the ammonia evaporating at 14° F and liquefying at 68° F. The submerged condenser employed for the liquefaction of the compressed ammonia gas is of the inclosed type, so that the cooling water may be drawn off at any convenient point and used for other purposes incidental to the working of the plant. The rooms are cooled by a direct expansion system suspended from the ceilings of the beer cellar and the room provided for the storage of preserves, whilst the meat storing room is cooled by an air cooler of the inclosed battery type. The air cooler is fitted with a fan which produces the requisite circulation and induces the admission of fresh air from without. Through a small trunk at the side it is also available for providing the store-room for preserved goods with fresh air.

Abattoir with Meat Cooling Plant and Ice Factory at Bad Godesberg on Rhine.

Architect and Designer: Herr Walter Freese, Bonn o. Rh.

Installation by A. Borsig, Berlin-Tegel

The modern achievements of refrigeration engineers are extensively taken advantage of in the design and equipment of abattoirs, not excepting those to be found in very small towns.

This is not altogether surprising, seeing that the elaborate system of animal control, meat inspection and so on would be of little practical use if an abattoir were without a cooling plant which enabled butchers to keep their killed meat in perfect condition for some time and under all weather conditions. Obviously, the average butcher cannot be expected to erect a meat cooling installation of his own as the cost of maintaining it would make his business altogether unprofitable. The abattoir cooling installations may indeed be described as the practically most valuable aspect of the abattoir scheme.

It may therefore not be uninteresting to follow an illustrated description of an abattoir with a meat cooling plant attached, and as an up-to-date example we have selected a plant recently opened to the meat trade at Bad Godesberg o. Rh.

Godesberg, with a population of 20 000, which during the summer months is largely swelled by visitors, consumes annually in meat

1500 carcasses of beef etc.,
2500 carcasses of mutton and lamb,
4500 carcasses of pork.

The whole of the available space was dimensioned to cope with the work represented by these figures, and allowance had to be made for the fact that in summer the presence of visitors practically doubles the average amount of killing required at other seasons, and from the outset provision had to made for a probable increase in the slaughter house requirements of the town. It appeared reasonable to assume that an abattoir dimensioned and equipped for double the average number of kills would adequately meet all requirements.

The total area required for the purposes of the abattoir comprises about 3 acres. The buildings consist of a residence for the director on the western side of the main entrance with an annex situated within the yard for the accommodation of the counting house; on the eastern side of the main entrance the residence of the machine attendants and abattoir foremen; at the side of this the "Free Bench", where meat which has been passed conditionally for consumption is sold after cooling, sterilising or pickling. All these buildings are situated along the street front so as to exclude all trespassers from the abattoir proper. The south-eastern corner accommodates the horse stables and yards.

The centre line of the principal building is on a line with the centre of the main entrance. Its western block comprises the slaughter houses, one for pigs and the other for cattle and sheep etc. Both are separated by an entrail washing department. At the eastern end of the main buildings annexes are set apart for the use of abattoir foremen and veterinary surgeons and, for the accommodation of wardrobes for butchers and their assistants, water closets and lavatories, etc. All divisions of the abattoir are equipped with the best mechanical appliances for killing, transporting, etc., so as to reduce human labour to a minimum and also to despatch the animals in the most humane manner.

The western block situated opposite the slaughter house is occupied by the meat cooling rooms, the ice factory and the machine plant.

The two buildings are joined by a roofed and glazed intermediate hall and thus form a continuous unit.

This connecting hall fulfils the useful purpose of taking up the whole of the intercommunication traffic

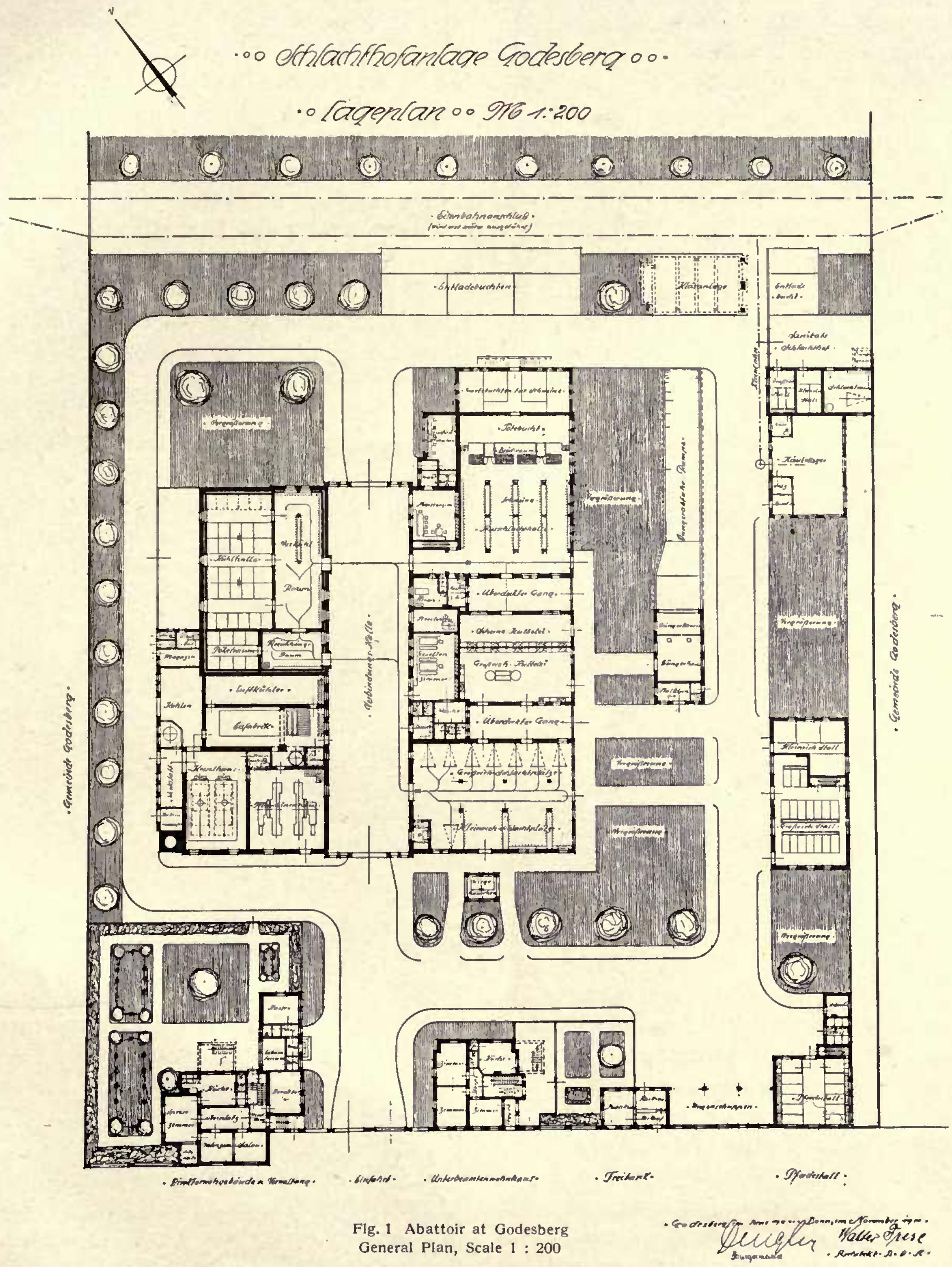


Fig. 1 Abattoir at Godesberg
General Plan, Scale 1 : 200

between the different sections of the establishment. The carcasses are here delivered and brought away under

Fig. 2 Communication and Traffic Hall

cover at all weathers; they are conveyed through it from the slaughter house to the cooling chambers, etc. The hall provides accordingly facilities for surveying the whole of the work in progress.

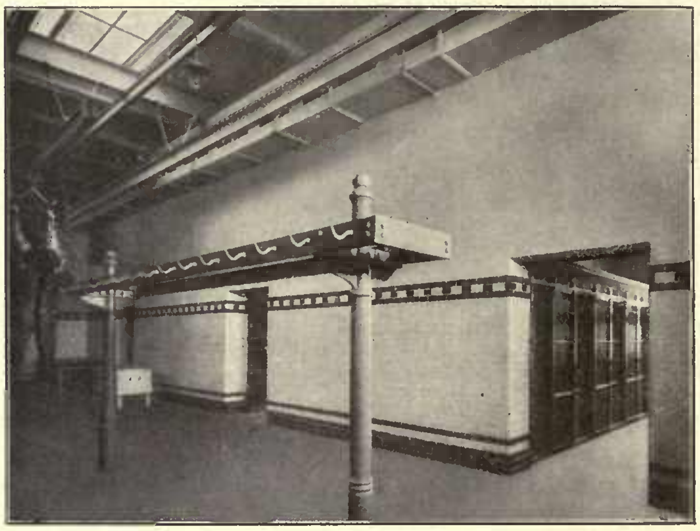


Fig 3 Forecooling Room

The cooling chambers face towards the North and consist of a Forecooling Room, the Cooling Room proper and a Pickling Room. In the forecooling room the freshly killed meat is required to pass through an intermediate process of cooling for 24 hours, so as not to disturb too seriously the temperature of the main cooling rooms by its introduction whilst still warm. The main cooling space contains thirty-two cooling cubicles of different sizes which are let to the respective butchers. The forecooling room and the slaughter house are connected by an elevated track system, by means of which the freshly killed meat may be easily conveyed from one to the other.

An additional hanging room forming an annex to the forecooling room is provided for the immediate removal of the carcasses form the slaughter house and their temporary accommodation without risk of deterioration until an opportunity occurs for opening the forecooling room.

On the southern side the cooling rooms communicate with the air cooler-rooms. Next in position follows the ice factory, which comprises an ice freezing tank of a capacity of 10 tons per day. The ice produced is of the quality of crystal ice, the water to be congealed being derived from the waste steam of the engine.

The adjacent boiler house contains two Cornwall boilers of 538 sq. ft. heating surface and working at 147 lbs per sq. in. These are fitted with superheaters capable of raising the temperature of the steam to 572° F. The machine and engine room next to the boiler house is of sufficient dimensions to accommodate two units. At present the plant comprises a drop valve steam engine of 50 HP coupled direct to an ammonia compressor of a capacity of 30 tons of refrigeration.

The warm water required for use in the slaughter house is furnished by an economiser with large water space of a capacity of 2200 gallons, which is heated by the waste steam of the engine.

In view of the fact that the water used throughout is obtained from the town mains the surface condenser is constructed on water economising principles.

The whole of the cooling machine plant has been supplied by the well known engineering firm of A. Borsig, of Berlin-Tegel. The plant, which has in the mean time been put in operation, works in every way in a faultless manner. The guarantee

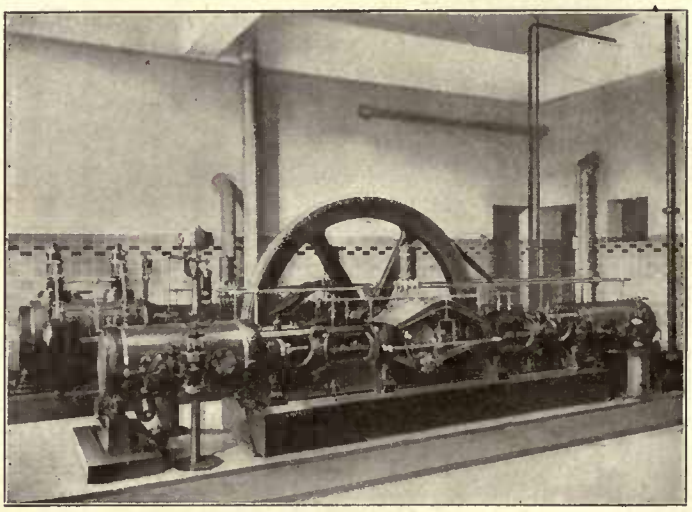


Fig. 4 Machine Room

tests have furnished brilliant results, inasmuch as nearly the whole of the stipulated requirements have been exceeded.

On the eastern side of the entrail washing department the plan shows a manure shed; on the eastern side of the cattle and sheep slaughter house are seen stables for the animals, whilst in the north-eastern extremity is the officially controlled slaughter house for conditionally sound animals. Railway connection at the back of the estate provides a convenient means of conveying the animals direct by rail to the abattoir.

The cost of the entire plant including the railway connection, the purchase of land, etc. amounts to M. 500 000. In the face of the small number of the inhabitants this would seem a somewhat disproportionate expenditure; it is, however, justified by the magnitude of the plant, which in its turn is necessitated by the periodic confluence of visitors.

Fig. 5 General View

Cold Storage Plant at the Kaiserhafen at Bremerhaven

Installed by Messrs. L. A. Riedinger, Maschinen- und Bronzewarenfabrik A.-G., Augsburg

Efforts made in Germany to introduce cheap frozen meat were attended with interesting results at the close of the past year, the Senate of the city of Bremen having decided to erect on state property at the Kaiserhafen in Bremerhaven a cooling and refrigerating plant for stacking frozen meat. As the entire scheme presented itself more or less in the light of an experiment its realisation was to involve as moderate an expenditure as possible, though all that was necessary to ensure perfectly realiable working was to be provided.

Use was accordingly made of an existing goods shed, of which those portions only which were to be employed as cooling chambers were lined with an insulation 8 inches thick consisting of cork slabs attached to half-brick walling and plastered over with cement. On the outside the shed is covered with corrugated iron. The ceiling put in is not a solid structure but lightly framed in wood, so as to load the ground as little as possible in view of its limited bearing strength.

Brick walls were run up in those places only where loads of some magnitude were required to be borne or where it was essential to render the walling impervious to water.

The shed is situated on the eastern side of the Kaiserhafen No. I and is flanked on the western and northern sides by the quay, whilst on the opposite land side it is served by the railway. The machine plant and the cooling chambers proper are accommodated under the same roof. Those portions of the shed which are not occupied by the cooling plant are used for ordinary purposes of wharfing.

The whole of the cooling rooms are on the ground level within a square block traversed in the middle by a corridor about 28 ft. wide. The latter is divided by various partitions into a receiving and delivery room and a counting house, and also provides the requisite accesses to the individual cooling chambers. On either side this corridor has free access to the water and railway respectively.

Above this corridor are accommodated the air coolers; the whole of the chambers, which cover an area of 1150 sq. yds., being cooled indirectly by circulation of air cooled by external brine dry coolers. This, beside providing for the storage of meat which has already been chilled, renders the installation suitable for storing other goods, such as eggs, fruit, poultry and even fresh meat; the whole system being accordingly available for a wide range of purposes. In view of the location of the cooling house mechanical power is applied through the agency of electric motors; and two independent units have been installed for producing the required cooling effect, one of a refrigerating capacity of 60 tons with the circulating brine at 28 to 23° F, the other of 46 tons with the brine at 14 to 5° F. The compressors, with one cylinder each, operate on the supplying firm's well known carbon dioxide compression system and are each driven by an 80 H.P. D.C. motor with belt gearing, their cranks making 100 r. p. m.

The valves are of a special design, involving the use of gas cushions, whereby the action is practically noiseless, despite the comparatively high rate of revolution of the machines.

On one side of the compressor room is situated the condenser and refrigerator room, which contains two brine coolers of the ordinary cylindrical type and two carbon dioxide after-coolers, to which the refrigerating agent passes from the water-cooled surface condensers for further under-cooling.

On the side facing the quay a room is provided for the accommodation of two water-cooled surface condensers with flat-sided tubes and nested coils surmounting a receiving tray of concrete. Two direct-driven cooling water pumps of the centrifugal type are mounted in front of the

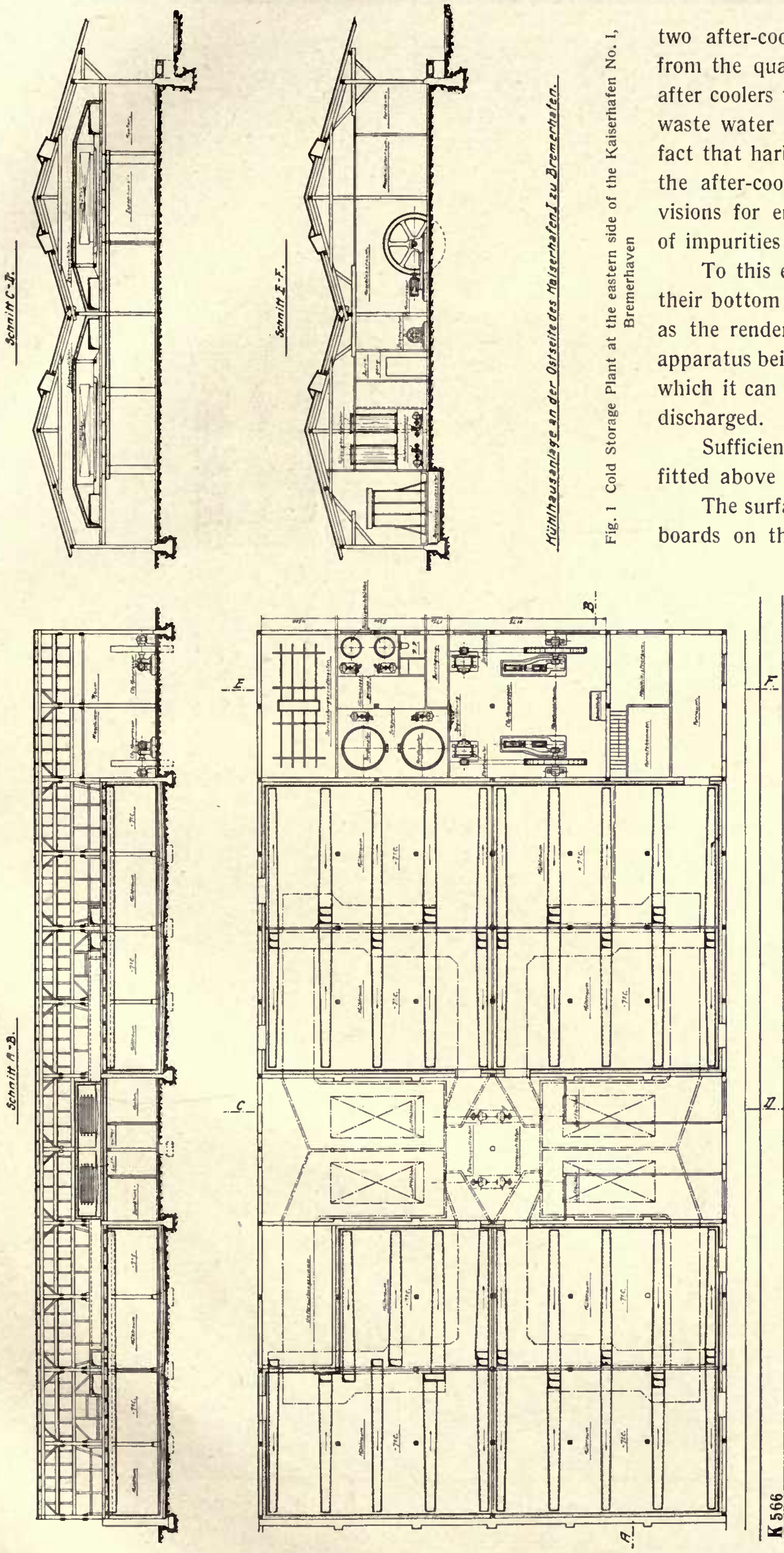


Fig. 1 Cold Storage Plant at the eastern side of the Kaiserhafen No. 1, Bremerhaven

two after-coolers. These draw the water direct from the quay basin and convey it through the after coolers to the surface condensers, whence the waste water returns to the basin. In view of the fact that harbour water is employed for cooling, the after-coolers are equipped with special provisions for ensuring the easy removal of deposits of impurities and mud.

To this end the after-coolers are mounted with their bottom surface 6 ft. above the floor level so as the render it easily accessible from below, the apparatus being fitted with a large manhole through which it can be cleaned and accumulations of mud discharged.

Sufficient head room is provided, and the coils fitted above are easily accessible.

The surface condensers are screened by louvre boards on their open sides so as to be exposed to an efficient current of air. The brine which has been chilled in the evaporators is conveyed by two centrifugal pumps, which are driven direct by electromotors to the space under the roof, which is fitted with four air coolers. These consist of several superimposed rows of pipes of 3½ in. bore provided with gills to increase the cooling surface, the whole being joined up into a continuous system by cast iron elbows and return bends.

A brisk circulation of air between the coolers and cooling rooms is maintained by four powerful fans, each of which is driven direct by an electromotor and each capable of displacing 670000 cub. ft. of air per hour; and since the cooling chambers have a capacity of about 106000 cb. ft. it will be seen that this volume of air circulates and is partly renewed about 25 times every hour. This is necessary in view of the low temperature which is to be maintained in the cooling chambers.

The air coolers are so arranged in position that the fresh supply required for the renewal

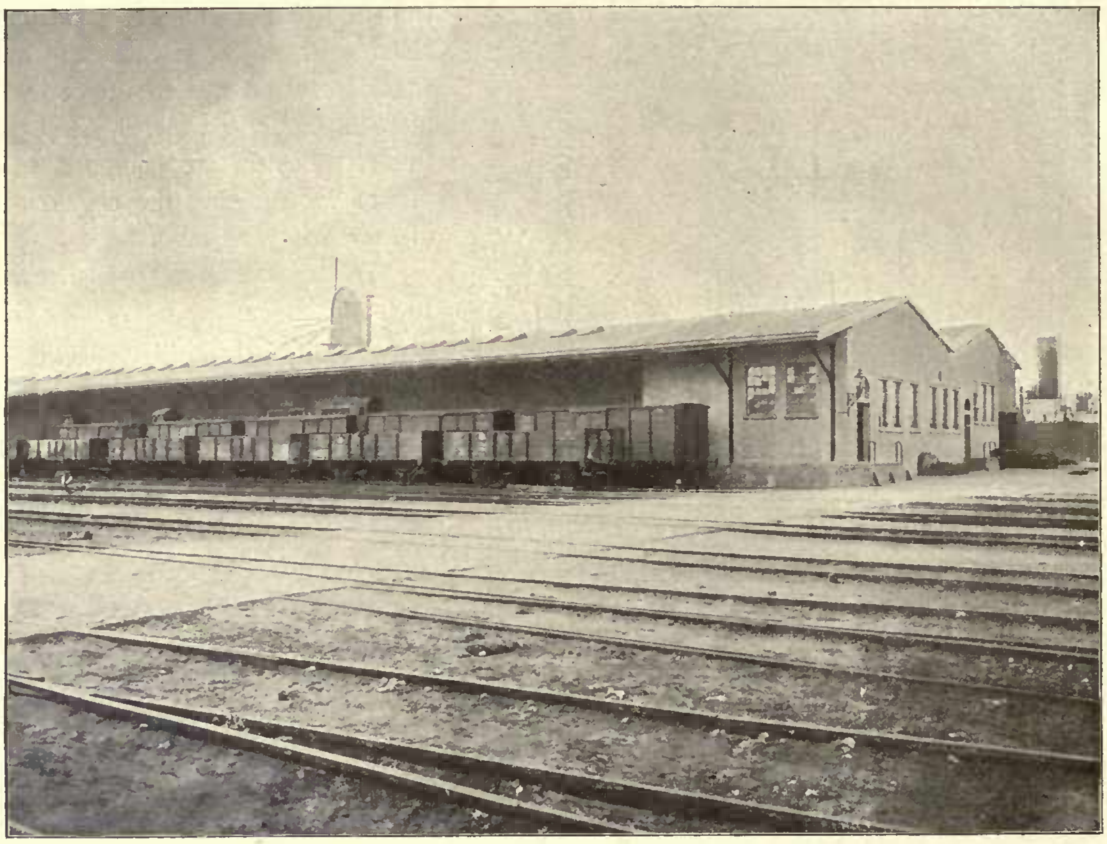


Fig. 2 View from the Railway

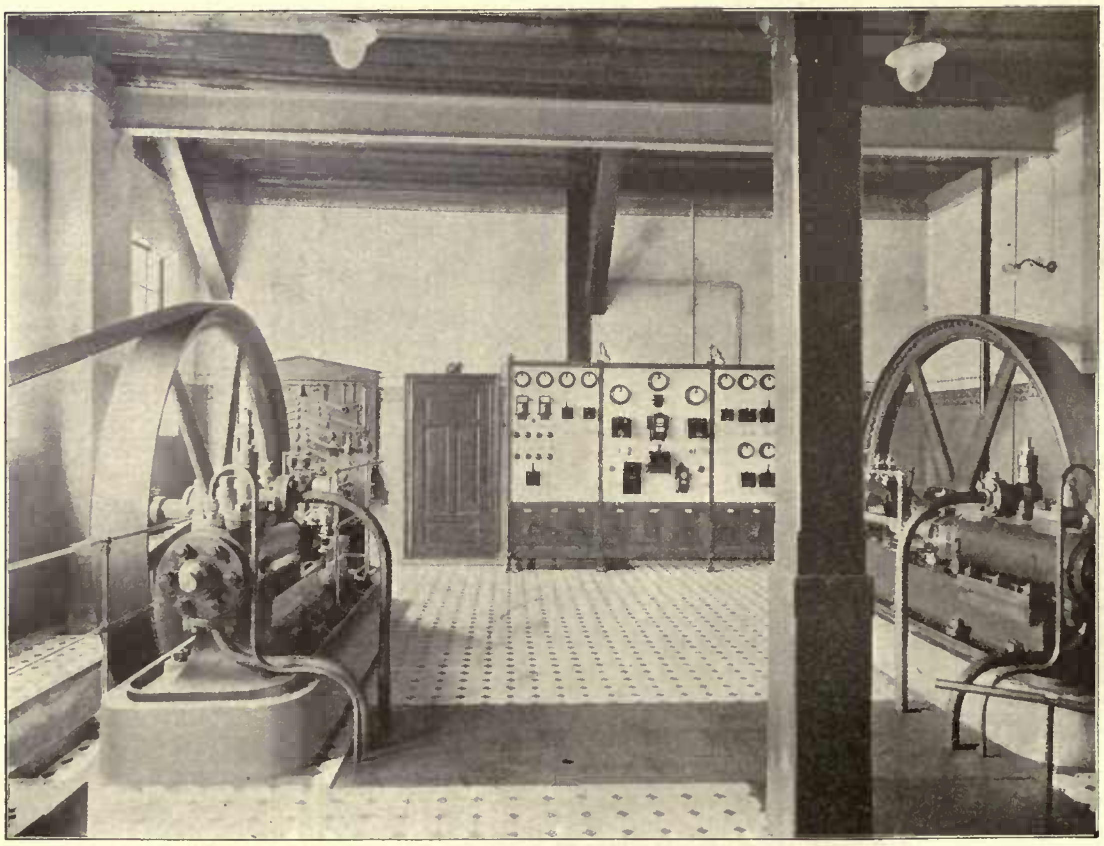


Fig. 3 Machine Room

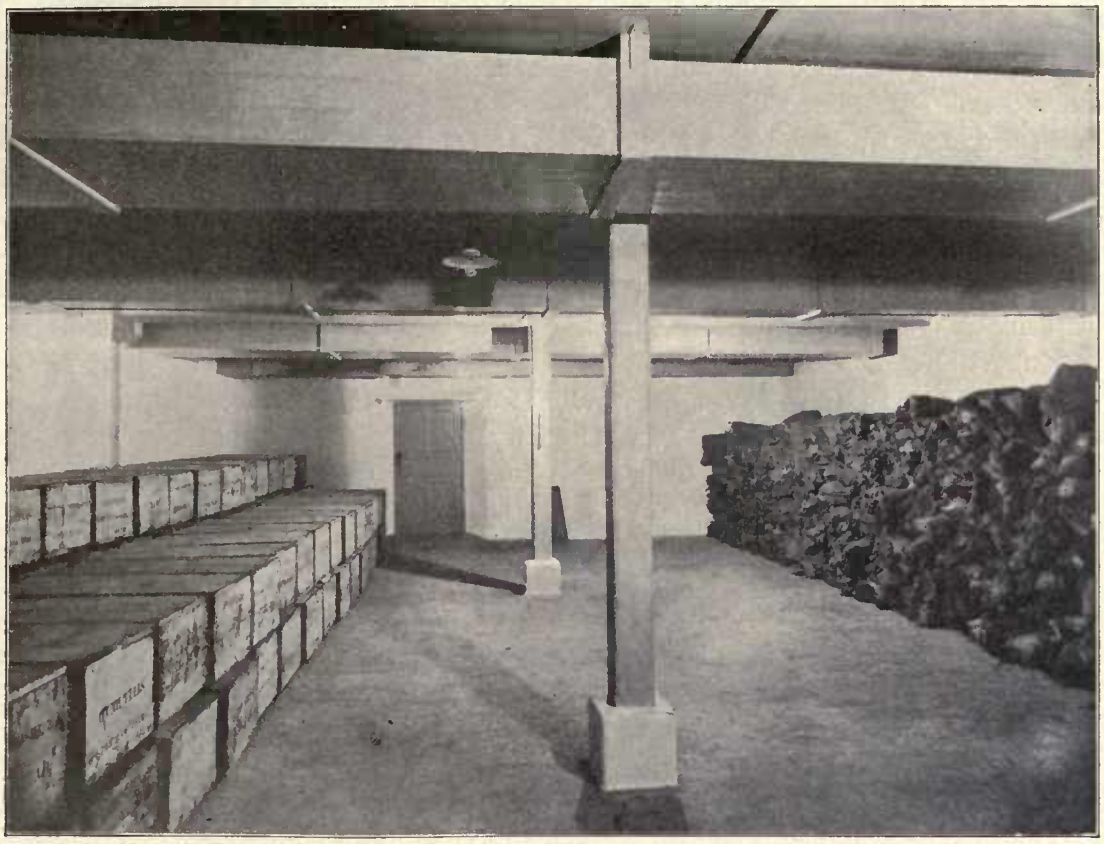


Fig. 4 Cold Storage Room

Fig. 5 View from the Harbour

of the vitiated air is drawn in in a very simple manner and that it may provide an effective means of rapidly thawing the congealed water vapour on the air coolers.

The air cooling chambers together with the main air ducts are protected from radiated heat by an insulation of cork 5¼ inches thick.

From the air coolers and ventilators respectively main air delivery and suction ducts above the cold room ceiling pass over the individual cooling chambers, and slides and swivel dampers provide a means of regulating the distribution of the air.

Within the cooling chambers, which have a height of nearly 10 ft., the air distributing ducts are so arranged on the ceiling that their upper edges abut against the match boarding of the ceiling. Beside economising head room, this obviates the creation of undesirable dustcollecting corners between the top of the air duct and the ceiling of the cold storage room. The distribution by means of branch conduits of the current of air within the cooling chambers is effected by side ducts arranged on the herring-bone plan commonly adopted in meat cooling installations, the object of which is to attain a uniform circulation of air from all sides.

The available area of the cold store is approximately bisected by a corridor, as already stated, and each half is subdivided into four cooling chambers of similar size. From one of these chambers a portion covering a floor space of 27′ 9″ × 14′ 9″ has been abstracted to serve as an inspection room.

For the reception of cold meat the cold chambers were required to have a temperature of 19° F, and in the contract it was provided that the hygrometer should record about 90% at 19° F.

The first machine unit was in operation on the 18 th March of this year, and on the 27 th the first consignment of 40 tons of frozen meat arrived by rail from Hamburg. This store represented about one fourth of the total capacity and required only one machine to operate for two hours in the forenoon and again for two hours in the afternoon. This sufficed to bring the temperature of the brine down to — 6° F, whilst the temperature in the cooling chambers rose during the night only from 18 to 23° F. Seeing that the building in itself does not present particularly favourable conditions this satisfactory result bears testimony to the excellence and sufficiency of the insulation of the cooling chambers.

The whole of the building work was carried out under the directions of the harbour commissioners themselves.

Supply Stores Cooling Installation at Essen

Installed by A. Freundlich, Engineering Works, Düsseldorf

The modern Supply Stores furnishes an example of up-to-date concentration of retail trading. Naturally, in an undertaking of this kind the food stuff branch claims fullest attention.

The workings of supply stores conducted on extensive lines is naturally subject to considerable fluctuation and contingencies in buying and selling. Moreover, commercial policy demands purchase in sufficiently large quantities, whence follows the necessity of keeping the goods in a good state of preservation for a more or less extended period.

Here is a situation which provides the refrigerating trade with an opportunity for supplying universal cooling plants capable of satisfying in an exquisite degree every exigency likely to arise.

Fig. 1 gives an outside view of the monumental building of a Supply Stores at Essen.

Fig. 1 Outside View

Though instinctively one would dispose the machine and cooling rooms in the basement, yet in the case of various supply store installations experience has shown this to be a mistaken plan, partly on account of the comparatively great distance which separates the installation from the provisions sale departments. In the case of the stores at Essen the problem resolved itself accordingly into a scheme whereby the cooling chambers were accommodated in an upper story, that is in the immediate vicinity of the entrance to the provisions sale department, whereas the machine plant found a suitable place in the basement.

In an installation of this kind the best way of transmitting the refrigerating effect would appear to be to employ a brine circulating system, partly on account of the resulting great length of piping and partly in view of the objections to the application of the direct expansion principle within a much frequented building. The reason that nevertheless the direct expansion system was adopted throughout and that ammonia was chosen as the refrigerating agent, apart from the advantages of ammonia in the matter of management and permanently reliable working, was the desire to secure the advantages of the greater simplicity in the general arrangement and control of the plant as well as the greater durability of the ammonia direct expansion system.

It goes without saying that in the matter of design and workmanship very exacting requirements had to be satisfied to insure an easy and perfect control of the widely ramified system and also to eliminate the element of danger to human life.

Among the special provisions adopted to achieve this end there is the notable fact that the entire pipe system is welded continuously, so that no trouble can arise from leaking joints. The pressure under which the conduit system was tested amounted to 150 atm., which provides a more than 50-fold factor of safety.

under gravity to the basement into the cooling system of the ice tank which has a supplementary controlling valve operated by the machine attendant.

This liquid separator is designed to form the last safeguard of the installation and is fitted with an anti-explosion plate, which in the event of the admissible pressure being exceeded comes into function, allowing the ammonia to escape.

The installation is represented in plan in Fig. 3, whilst a photographic view of the compressor is reproduced in Fig. 4. The latter is of the vertical inclosed type and

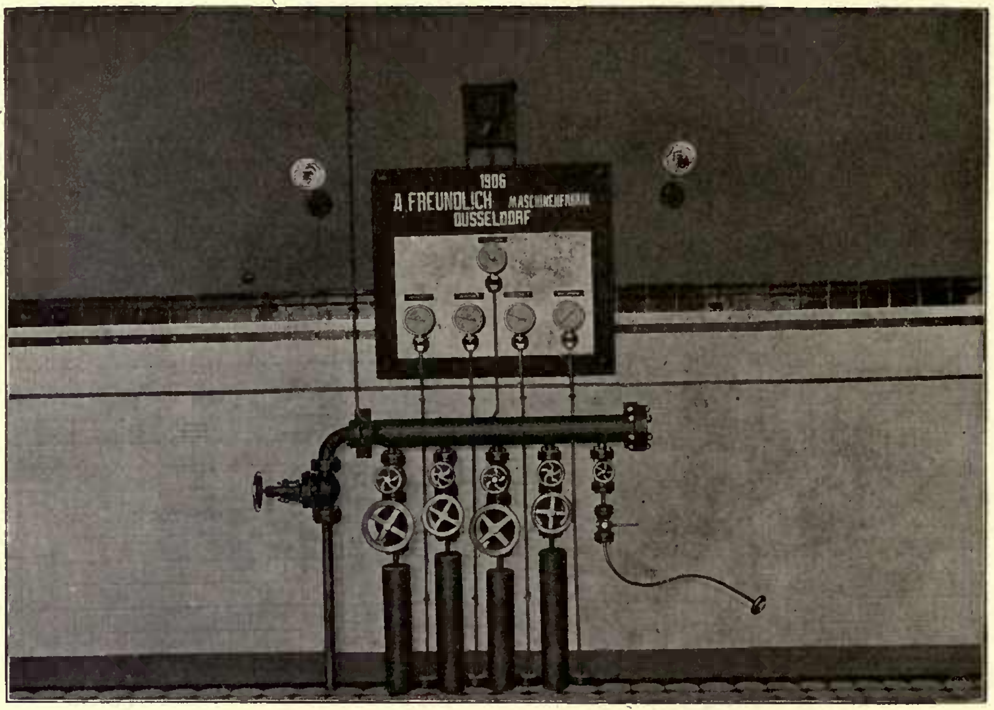


Fig. 2 Regulation Station

works with a liberally dimensioned and automatically lubricated driving mechanism. The compressor cylinder is single-acting, which in the case of a compressor working on a superheated vapour is of special advantage in that the stuffing box remains under the influence of the cold aspirated gas. The valves are of the amply tested steel plate type and are admirably adapted for operation with superheated gases.

The installation is controlled in two ways. One set enables the cold room attendants to regulate the various sections of the system by means of the distributing valves in an anteroom, whilst the other set consists of the main regulating valves of the pressure gauge control and filling station in the machine room, this set being, of course, under the control of the machine attendant (Fig. 2).

To obviate difficulties arising from the coexistence of the two methods of control the whole of the cooling pipe systems are built on the overflow principle, which provides for an excess of ammonia occurring in any of the coils.

At an appropriate point above the cold rooms, in the open but protected from weather influences, there is a large liquid separator, whence the suction conduit leads to the machine room. In this separator the excess of liquid is eliminated from the gases, the compressor operating thus on a superheated vapour, and the liquid flows

The condenser, which is of the submerged type, is equipped with Freundlich's Patent Agitator with stationary turbine wheel for maintaining an active circulation without the use of transmission gearing, as shown in section in Fig. 5.

The compressor, which in recent installations of a similar kind is coupled direct to an electromotor running at a moderate speed (Fig. 6), is in this case driven by a countershaft so as to provide a means of actuating various supplementary machines.

The machine is of 20 tons refrigerating capacity working with an ammonia evaporating temperature of 14° F and a cooling water temperature of 50° C. The driving power required to furnish this output is about 16 H.P. including gear losses.

The annexed figures 8, 9, 10, 11 and 12 supply an idea of the nature of the cooling chambers and bring into view the great advantages resulting from the partial arrangement of the cooling pipes in tiers.

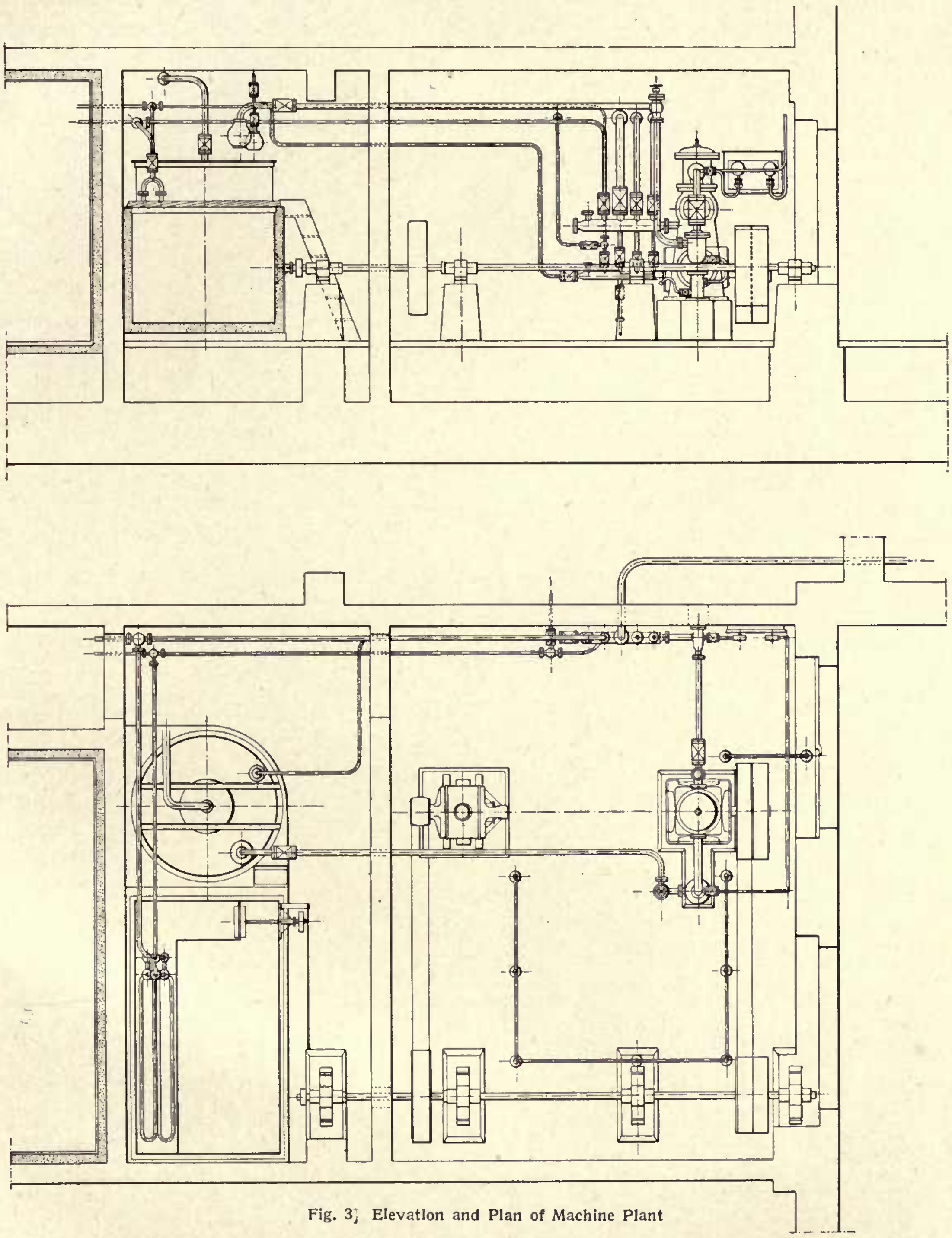


Fig. 3. Elevation and Plan of Machine Plant

The arrangement in general and in detail is shown in the drawing reproduced in Fig. 7.

A striking feature of the installation is the great diversity in the arrangement of the cooling pipes. This is rendered necessary by the different purposes which the system is required to serve.

The various cold rooms are respectively used for the storage of cheese and butter, vegetables and preserves, meat and sausages, game and poultry, fruit and fish. A few rooms requiring special ventilation are fitted with electric fans. In addition, the anteroom contains a fresh air cooler and drier consisting of an accumulator system of pipes over which air drawn from without is blown by an electric fan and thence passes through various controllable channels to all the control chambers.

In the place of smooth cooling coils the pipe systems take throughout the form of brine accumulator systems for direct expansion, the ammonia pipes being surrounded by a welded brine container. The latter is round or rectangular according to the requirements of the case and, when rectangular, provides a convenient base for mounting the pipes in tiers. The choice of brine accumulators was necessitated to ensure that during the night, when the machine would not be working, the rise of temperature should not exceed a very small limit.

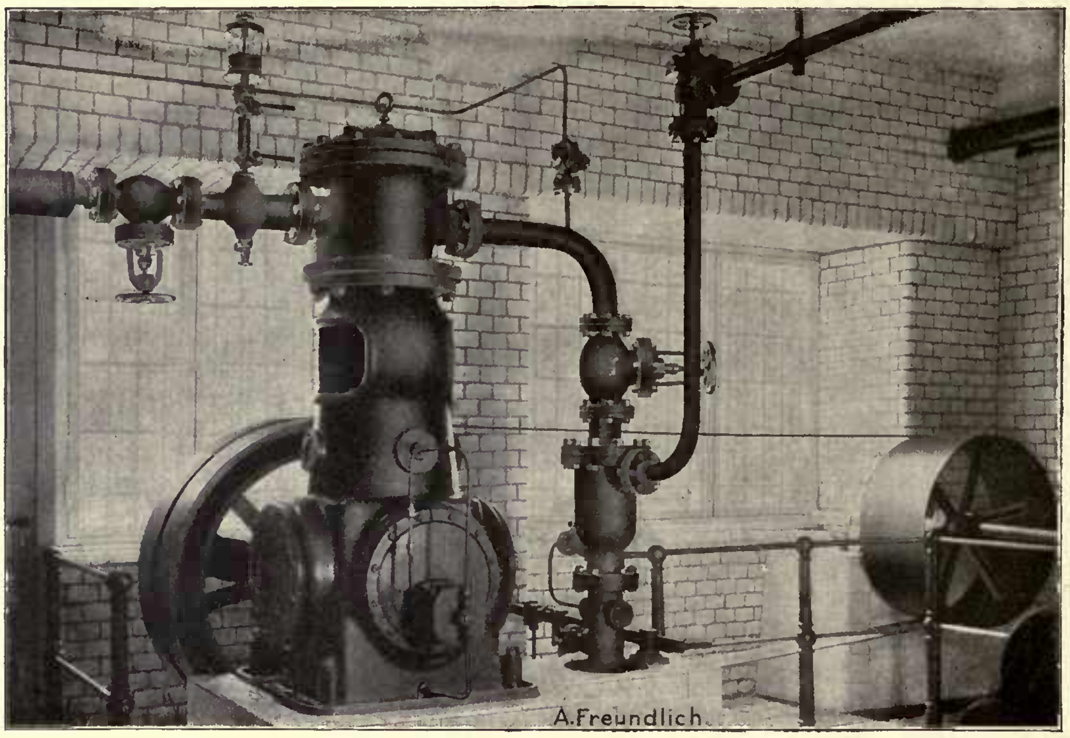


Fig. 4 Belt-driven Compressor

To avoid the necessity of transferring all perishable goods at the end of every day from the sale departments to the cold chambers the installation was carried a step further, and, apart from the cold chambers, cooling pipes were carried over all the stories of the building, and all cupboards, serving counters etc. converted into refrigerators. The arrangement of these is similar to that of the larger chambers.

In the confectionary department the refrigerator, as shown in Fig. 13, is chilled by direct expansion coils. The ice cream machine is likewise connected with the refrigerating system and does away with the inconvenience of carrying a daily supply of ice. The show cases in the food stuff department, including those provided for the accommodation of meat, game and other easily perishable goods are fitted with concealed cooling pipes and serve to obviate losses such as might be caused by no more than a temporary departure from the appropriate temperature, to say nothing of the inviting appearance of victuals kept in a cool and dry condition.

In conclusion it may be noted that the luxurious display of modern supply stores is not a purely external matter but extends, as in the present case, to departments hidden from the public gaze and where it would be an easy matter to yield to the temptations of effecting economies; accordingly, the whole of the cold chambers are paved with floor stones, which encourages that degree of scrupulous cleanliness which should not be lacking in any cold storage plant.

The last illustration, Fig. 14, gives a view of the food stuffs sale department and, amongst other things, shows a row of cupboards fitted with cooling pipes.

The installation has worked without a hitch since it was put into service, and has fulfilled all stipulated requirements in that it is simple to manage and absolutely safe, besides which it ensures a correct cooling

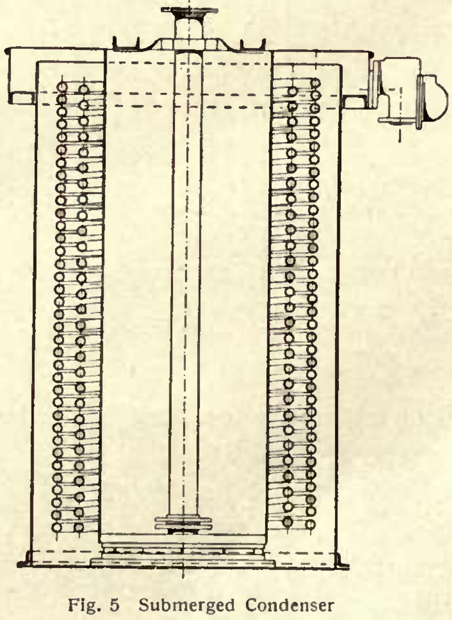


Fig. 5 Submerged Condenser

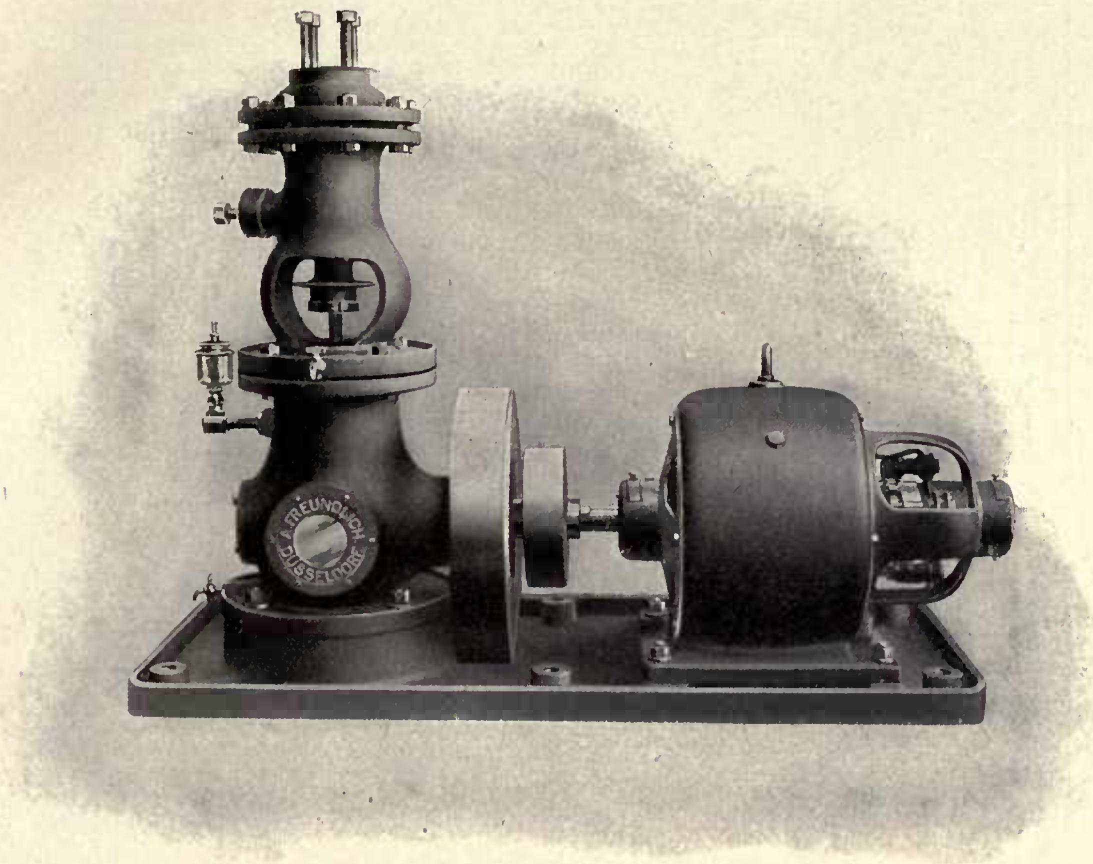


Fig. 6 Compressor with Direct Coupled Motor

Fig. 8 Cold Storage Room

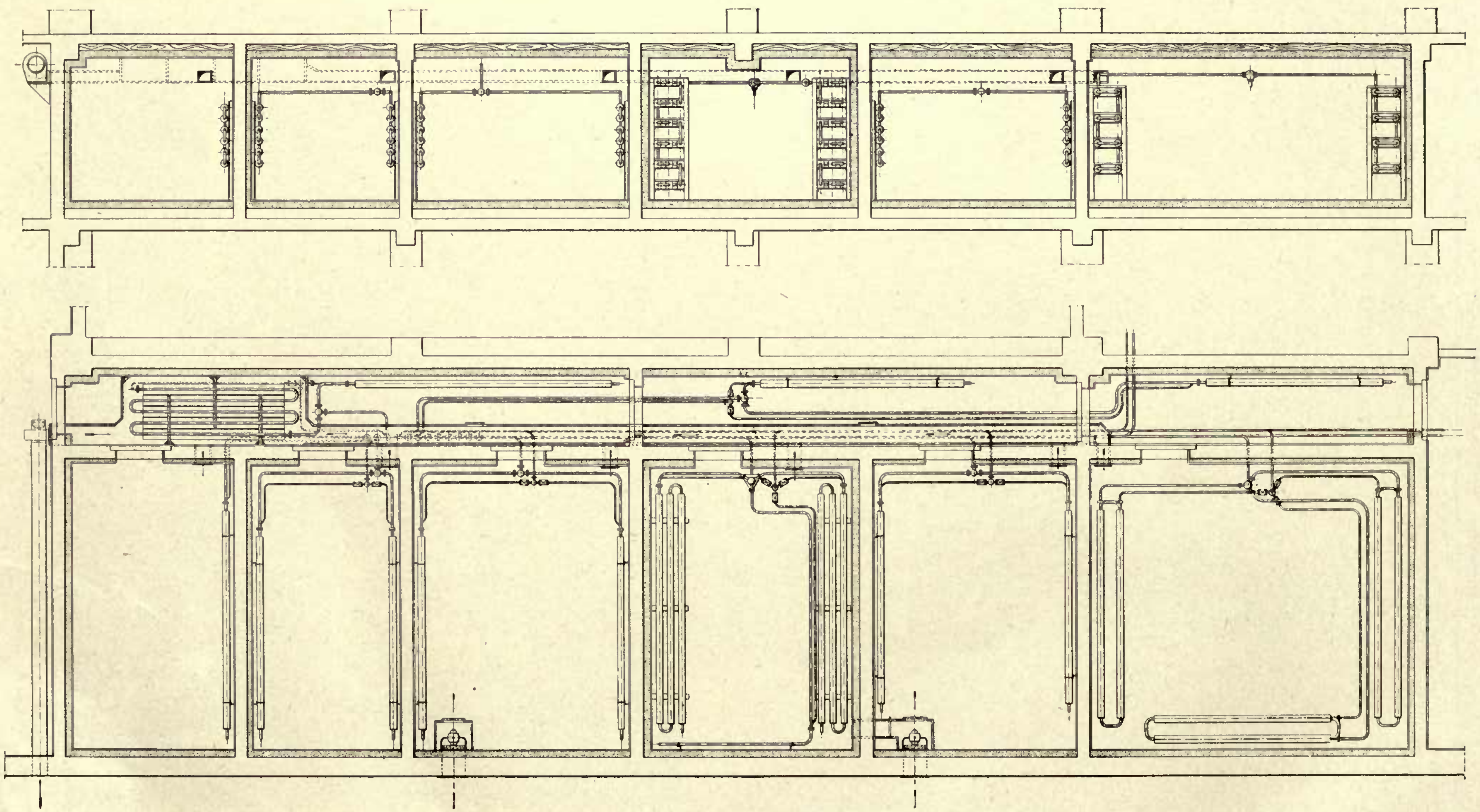


Fig. 7 Arrangement of Cold Storage Rooms

Fig. 9 Cold Storage Room

Fig. 10 Cold Storage Room

effect, a faultless state of the air, a sufficiently steady temperature and its unrestricted use under all circumstances. Though the installation may appear to contain certain circuitous elements, the fact remains that every departure from the more obvious course has been justified by the manner in which the plan has been carried out.

Fig. 11 Cold Storage Room

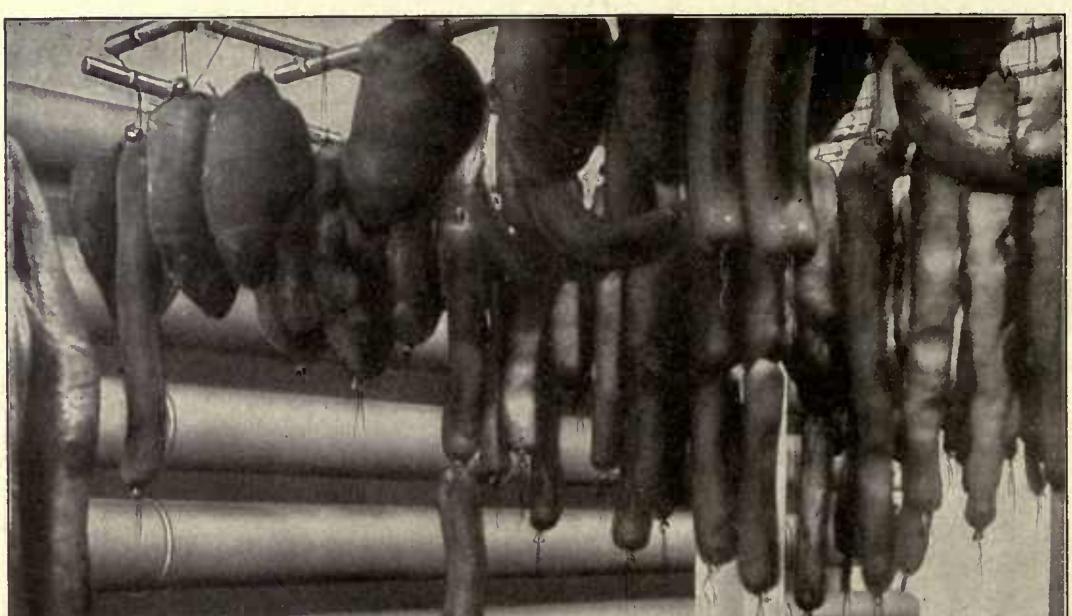


Fig. 12 Cold Storage Room

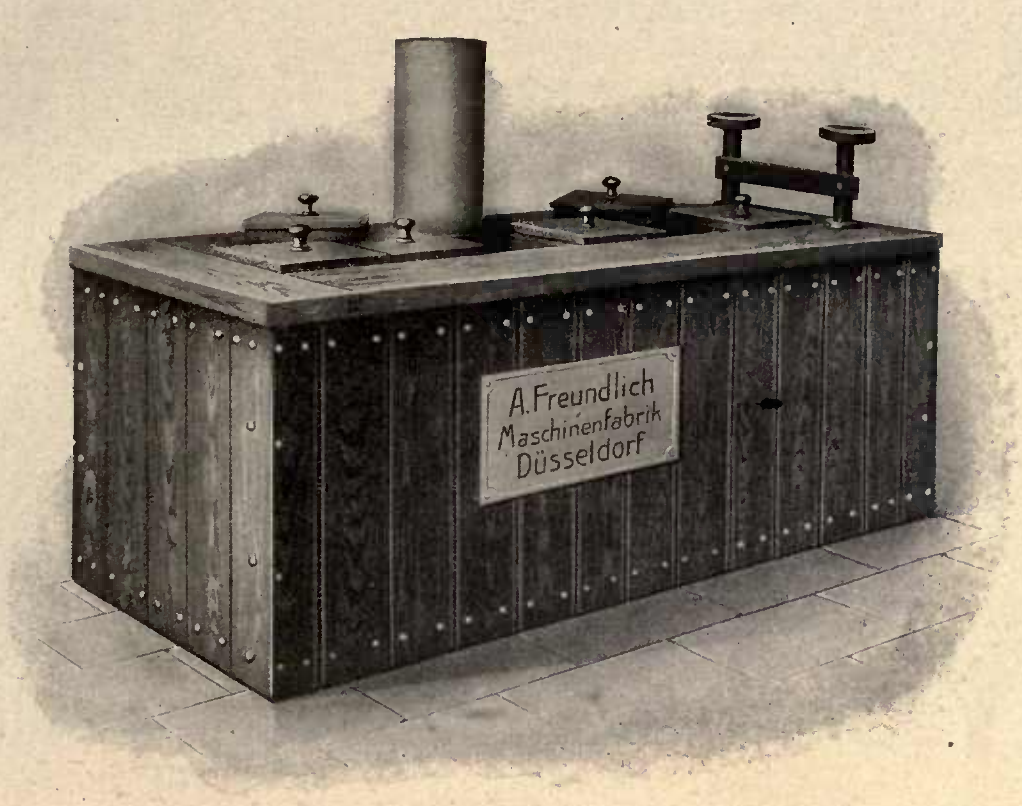


Fig. 13 Cold Chest for Confectionary

Fig. 14 Fruit Sale Department

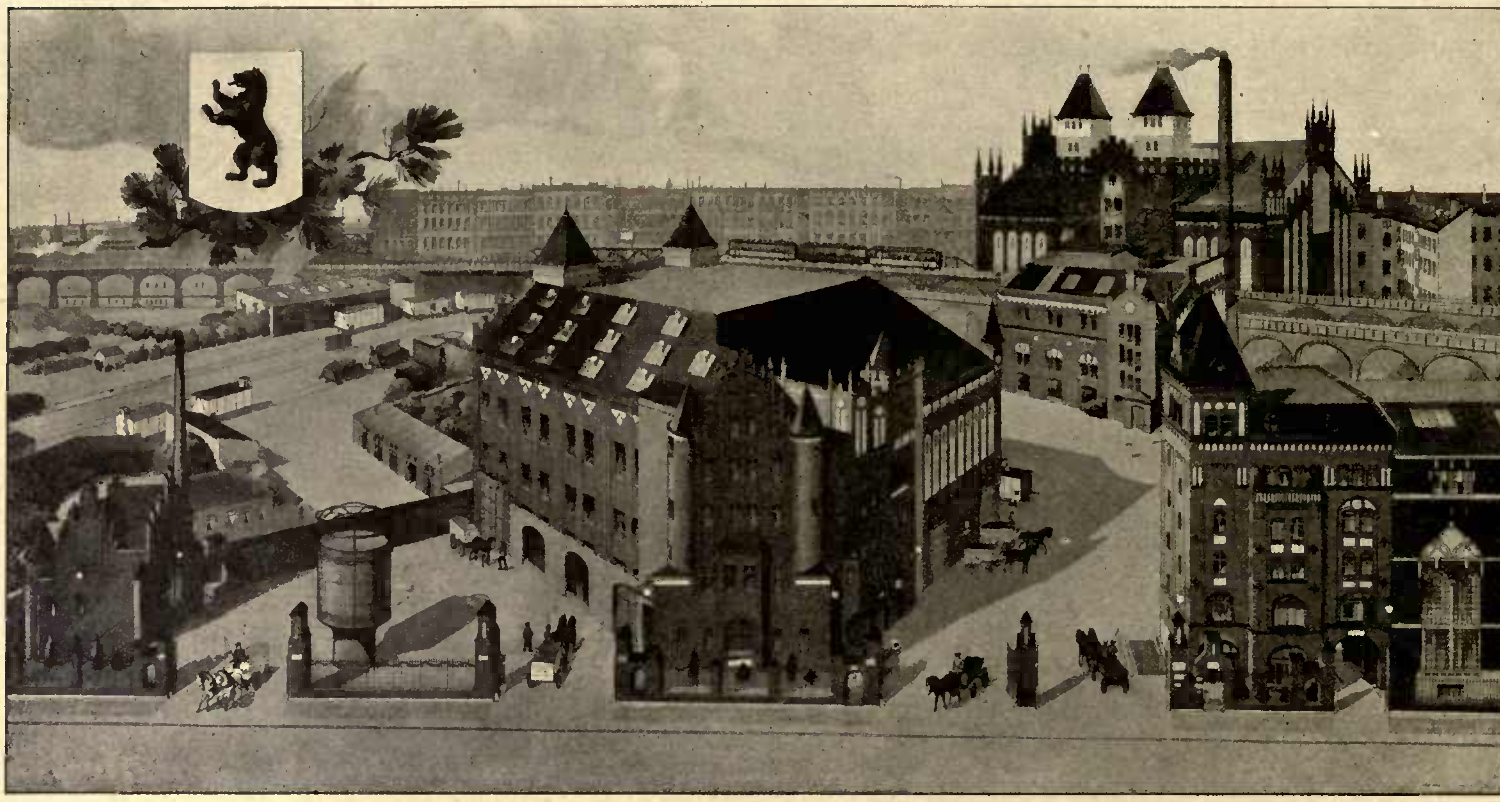


Fig. 1 General View

Work No. I of the Gesellschaft für Markt- und Kühlhallen at Berlin

Installed by the Gesellschaft für Lindes Eismaschinen, Wiesbaden

A rational system of food supply lies at the foundation of national welfare. Its first aim must obviously be to ensure that all foodstuffs provided for human consumption shall be in perfect condition at such time as they can be made use of. Now, the circumstances of modern life render it impossible always to consume foodstuffs at the time when they have been freshly delivered, and hence their proper preservation plays a great part in modern food supply, and among the problems affecting the feeding of a town numbering its inhabitants by the million food preservation is an all-important factor.

The most natural and at the same time the best means of preserving perishable food is the application of cold.

For years it has been used for the preservation of food stuffs, and what the ice safe does in the family household is accomplished in a more perfect and on an immensely greater scale on behalf ofen tire communities by the large cold storage plants.

Industrial progress with its need of a heightened intelligence in the working population is responsible for a higher scale of remuneration as the equivalent of superior service and consequently also for higher demands in matters of living on the part of the more successful classes. Things which formerly were unknown luxuries have now come to be included among the necessities of life, and with higher pretentions has come also the ability to distinguish between good and indifferent quality of articles provided for consumption.

In consequence of an increasing population and its concentration in towns it became necessary to extend the sources of supply, and from this necessity arose a steady increase of importation from other parts of the globe. Since it is, however, impossible to dispose at once of all provisions, the erection of cold storage plant followed as an imperative necessity. In large cities the feeding of the masses by imported food stuffs would be unthinkable in the absence of artificially cooled storage houses.

In times of war, after mobilisation, the significance would be even greater than in times of peace. The provisions held in cold storage would effectively ensure the feeding of troops in the field.

The first stone to the large cooling plant of the Berlin Market and Cold Storage Company was laid in

1900. A site had been purchased in the heart of the empire's metropolis between the Anhalt and Potsdam Stations, the situation being known as the Trebbiner Straße and Luckenwalder Straße. This site was chosen by reason of its central position and also because it was one of the few available situations within the city which were in the immediate vicinity of the railway system; it had the further advantage of the proximity of the Landwehrkanal supplying in a cheap form the large quantity of water required for working the plant and forming also a convenient receiver for the return of the waste water. Upon the two contiguous portions of the building site two large cold stores were erected with the machine house between them, whilst the general offices were built with their frontages facing the Trebbiner Straße. This arrangement had the great advantage that both cold stores as well as the machine house face on one side the yards and the railway, which greatly facilitates the delivery and discharge of the arriving stores and coals, whilst on the other side the buildings front the Luckenwalder Straße and the Trebbiner Straße respectively, both streets being thus available for vehicular traffic to and from the cold stores.

Either section of the estate has separate entrance and exit gates, and between both lies the private siding which connects the property with the Anhalt Railway Station.

The buildings were erected in 1900 and were installed in 1901.

The necessity having arisen for extending the undertaking, an additional site was acquired in 1904, viz. No. 6 Trebbiner Straße, to which in 1906 was added No. 9 on the opposite side of the street. The machine house lies between the Cold Store No. I in the Trebbiner Straße and the Cold Store No. II in the Luckenwalder Straße.

In view of the high price paid per unit of the ground area it became a sine qua non from the outset to utilize the available site within the full limits allowed by the building bye-laws.

Both cold storage buildings were accordingly run up to a height of seven floors providing a head room of nearly 10 ft. each.

The No. I Cold Storage House accommodates on two storeys the ice making plant, which leaves six floors for the cooling chambers. The No. II Cold Storage House contains eight storeys, all available for letting, a floor area of 12 000 sq. yds, including the cellars below the pavement, being thus available for storage. Either cold store building is fitted with two staircases and four electrically operated lifts. On the property purchased in 1904 and originally known as 6 Trebbiner Straße, a portion of the building forming the extension of the No. I Cold Store was employed for the erection of a spare machine plant, whilst the first and second floors served for an extension of the ice making factory. The third and fourth floors are occupied by an Air Liquefying Plant operating on Linde's patented process for the production of oxygen and liquid air, the latter resulting as an intermediate product. This plant is known as Department No. III. The top floor accommodates a number of apparatus and an oxygen holder. The yard, which is likewise cellared, provides room for a spare oxygen charging compressor and for the storage of empty steel cylinders.

The boiler house for the spare plant is situated on the portion of the site adjoining the railway, and the yard provides room for an oxygen holder of 1750 cb. ft. capacity. This building has a separate staircase and, to economise room to the utmost, the stair is of the winding pattern. An electrically operated goods lift serves all floors, whilst another lift near the boiler house on the other side of the yard deals with the transport of steel cylinders to and from the cellar. Two ice shoots convey the ice blocks from the freezing tanks here situated directly into the ice carts.

The office building facing the Trebbiner Straße has on either side a weighbridge, one serving to weigh the incoming carts the other for controlling the weight of outgoing vehicles. This ensures a well ordered vehicular traffic in the yard.

The ground floor accommodates the ice delivery department with which is combined the control of the incoming and outgoing stores. The first and second floors comprise the counting house, whilst the third and fourth floors together with the attic rooms are the private residence of the manager.

In the machine house the plant is disposed to make the most of the available area within the limits imposed by the building regulations. The machine room is 23 ft. high, whilst the boilers are placed on the floor above; the rest of the numerous components of the plant and the supplementary machines are distributed over the adjacent floors.

In the section on the opposite side of the Trebbiner Straße, known as No. 9, the front building provides two cartways leading to a yard and on the ground floor comprises the porter's lodge and a restaurant for the convenience of the works employees as well as of the numerous ice customers and store room tenants of the company. Another portion of this building has been fitted up as a cigar shop.

The first and second floors are let out as offices, whilst the third and fourth floors are arranged as private residential flats, mostly occupied by employees of the company. The yard, which is likewise cellared throughout, leads to a transverse building with a large thoroughfare for the company's ice-vans. The four floors above are employed for factory purposes.

An electrically operated goods lift serves all floors from the first yard.

The second yard, which is reached by way of the thoroughfare referred to, is surrounded by stables, and others are situated on the ground floor and first floor of the second transverse building. The remaining space serves for the storage of fodder and gear, whilst the upper floors provide dwellings for the stablemen.

A third thoroughfare leads through the second transverse building to a triangular piece of ground. This provides room for a farrier's smithy on the left and a cart shed on the right.

The erection of the cold storage buildings with their eight storeys presented a problem of considerable difficulty from an architectural point of view since the building was required to dispense almost entirely with windows for insulating reasons. The difficulty was emphasized by the very irregular shape of the site. On the other hand, the character of the buildings and their height called for somewhat strongly pronounced architecture. The structures are carried out in mediaeval style with brick facings and are surmounted by towers, the whole impressive structure being eminently suggestive of a castle of industry.

Anyone approaching the metropolis by way of the Anhalt or Potsdam stations is struck by these colossal monuments of industry, whilst to the inhabitants of Greater Berlin travelling by the trains of the elevated railway the entire plant is a familiar sight.

Both cold storage buildings and also the engine house are essentially iron structures, and in determining the strength of the skeleton structure all brick walls were ignored as affording any support of the loads, so that by cutting down the thickness of the walling to the lowest limits a good deal of additional space remained available for useful purposes. That the space so economized was by no means a negligible quantity will be readily appreciated when it is realized that the addition of a single brick to the thickness of the wall would have diminished the available floor space on each of the eight storeys of either building by an area equal to about 4300 sq. ft.

The steel structure of the No. I Cold storage building was designed and erected by the Vereinigte Maschinenfabrik Augsburg and the Maschinenbaugesellschaft Nürnberg, Gustavsburg Works, whereas the design and the erection of the No. II Cold Storage Building as well as that of the machine house was entrusted to the Aktiengesellschaft Lauchhammer.

The structures consist of stanchions, iron girders and iron floor joists. Their strength is calculated for a load of 205 lbs per sq. ft. on each floor, whilst for the freezing tank room the calculation provides for a load of 328 lbs per sq. ft.

The floor joists are spaced 7′ 9″ to 9′ 0″ apart, their actual span being 15 ft., whilst that of the standard bearing girders is 17′ 9″. On the first floor of the No. I Cold Storage Building the beams have a span of up to 29½ ft. The steel skeleton was designed with a special view to simple and rapid assemblage and weighed in the case of the No. I Cold Store 556 tons and in that of the No. II Cold Store 563 tons. To this must be added 102 tons for the yard cellarage and 251 tons for the structure of the boiler house, thus in all 1473 tons.

Since the enclosure walls could not be given symmetrical footings and symmetrically extended foundations, it became necessary to extend all bearing surfaces inwards. To ensure nevertheless a central load on the foundations, and consequently a uniform pressure on the subsoil, the foundations of the enclosure walls were suitably tied to the foundations of the interior walls.

The external walls, as already stated, form solely a brick facing to the steel structure. Nevertheless, in consequence of the great height of the building, their thickness is pretty considerable.

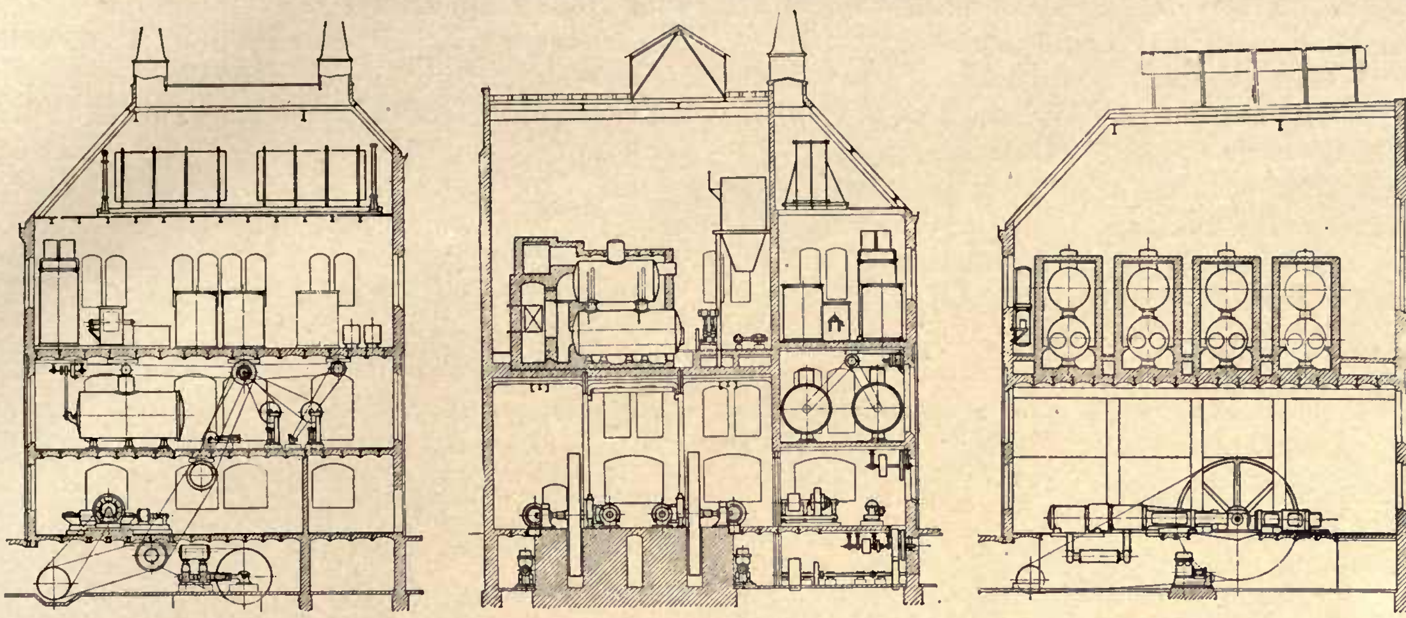
An advantage resulting from such a design is that the brickwork could be carried out independently of the steel structure.

To insulate the walls against heat transmitted from without the internal faces of the walls, ceilings and floors were lined with two layers of carefully dried and asphalted slabs of compressed granulated cork each $2^3/_8$ inches thick and coated with a cementing medium consisting of best odourless coal pitch, oil varnish and finely ground cork meal. On their inside faces the cork slabs are rendered with cement plaster ¾ inch thick.

The whole of the machine plant has been planned and installed by the Linde Ice Machine Company, of Wiesbaden.

Description of the Machine Plants

The machine plant installed in 1901 in the original cold store buildings and the ice factory attached thereto was added to in course of time to meet the extended requirements occasioned by the enlargement of the cold storage rooms and the ice factory. The entire installation, which is the largest cold storage undertaking in Germany, comprises the following principal components:



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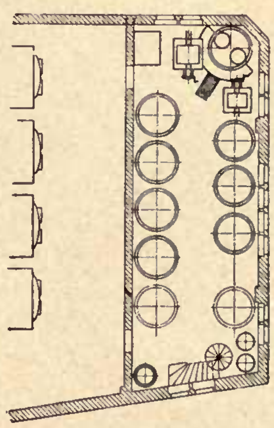
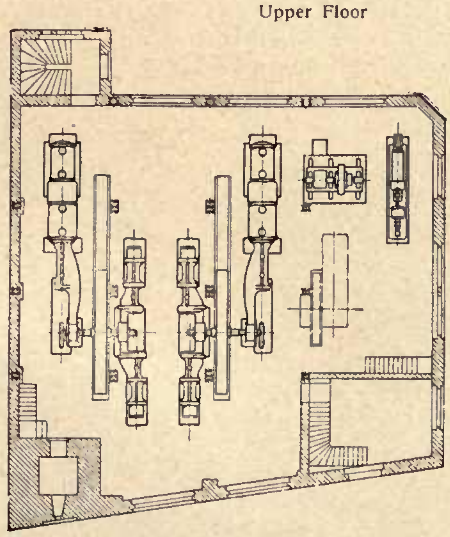
Four internal flue boilers are mounted on the first floor, which supports a load of 2050 lbs per sq. ft. on built-up plate girders 49½ inches deep. The boilers are fitted in their upper and lower sections with furnace tubes only; they work in conjunction with superheaters which can be put in and out of operation and have a total heating surface of about 7860 sq. ft. The chimney stack has a diameter of 5′ 7″ at the narrowest cross section and a height of 180 ft. Above are coal magazines into which the coal is raised mechanically from the railway trucks and suitably distributed.

The steam generated in the four boilers is primarily required for the operation of two steam engines set up in the engine-room, which with its height of 23 ft. makes an imposing impression. Both engines are compounded single-crank engines with Sulzer drop-valve gear and have been supplied by the Augsburg Engineering Works. They work with an admission pressure of 132 lbs per sq. in. and, running at the slow speed of 54 r. p. m., develop 350 and 450 H.P. respectively. Either engine is coupled direct with a No. 18 double Linde ammonia compressor, which at the time when the plant was supplied was the largest existing unit. The engines are equipped with jet condensers, but operate mainly with surface condensers with water irrigation situated in the loft of the engine room (Fig. 2d). After passing down the condenser tubes the water is again raised by means of centrifugal pumps, whilst the water supply pumps in the basement replace the water lost by evaporation as well as any water which is returned to the canal. The surface condensers form part of the water distilling and de-aerating plant to the ice factory, which will be described later.



Upper Floor



Ground Floor

Fig. 2 Arrangement of the Machine Plant

In connection with the subsequent extension of the undertaking the original power plant comprising two tandem steam engines was enlarged by the addition of a non-condensing steam engine of a normal capacity of 130 H.P. coupled to a No. 13 duplex compressor. By this direct coupling arrangement of the engines and ammonia compressors a maximum of the power developed by the engines is converted into useful work without transmission losses. In this way up to 600 H. P. are absorbed for refrigerating work. Another portion of the engine power is transmitted by belt gearing to the shafting in the basement, which serves to drive the dynamos, two duplex cooling water pumps, each of a capacity of 44 000 gallons per hour, and through the medium of various countershafts to numerous supplementary and auxiliary machines and other mechanical appliances. About 250 H.P. are converted into electrical energy, which is applied for lighting the establishment by means of about twenty arc lamps and over one thousand glowlamps as well as for transmitting power to upwards of thirty electric motors for operating nine lifts, numerous fans, centrifugal pumps, and other appurtenances.

The most important units of the refrigerating plant are the ammonia compressors. To the No. 18 and No. 13 duplex compressors coupled direct to the engines was added a compressor driven by shafting and having a refrigerating capacity of about 66 tons, which raised the aggregate capacity of the plant to 500 tons of refrigeration, the temperature of evaporation being 14° F. The evaporators connected to the compressors consist of iron worms within which the expansion of the ammonia reduces the temperature sufficiently for maintaining the surrounding brine permanently at the temperature required for any given purpose. Of these brine coolers five of a cylindrical pattern are set up in the loft and supply cold brine to the air coolers for the whole of the cold chambers. Other evaporators are in direct communication with the four freezing tanks of the works. The ammonia vapours formed in the evaporators are drawn in to the compressors and liquefied by the abstraction of heat on their passage through the condensers; the continuous repetition of this cycle maintains the required low temperature. The ammonia condensers are nine in number and are accommodated on the upper floor of the apparatus house adjoining the machine house (Fig. 2a).

That part of the installation in which the cold so produced finds its application comprises the air-coolers and freezing tanks. The entire success of cold storage rooms depends upon the manner in which the air coolers

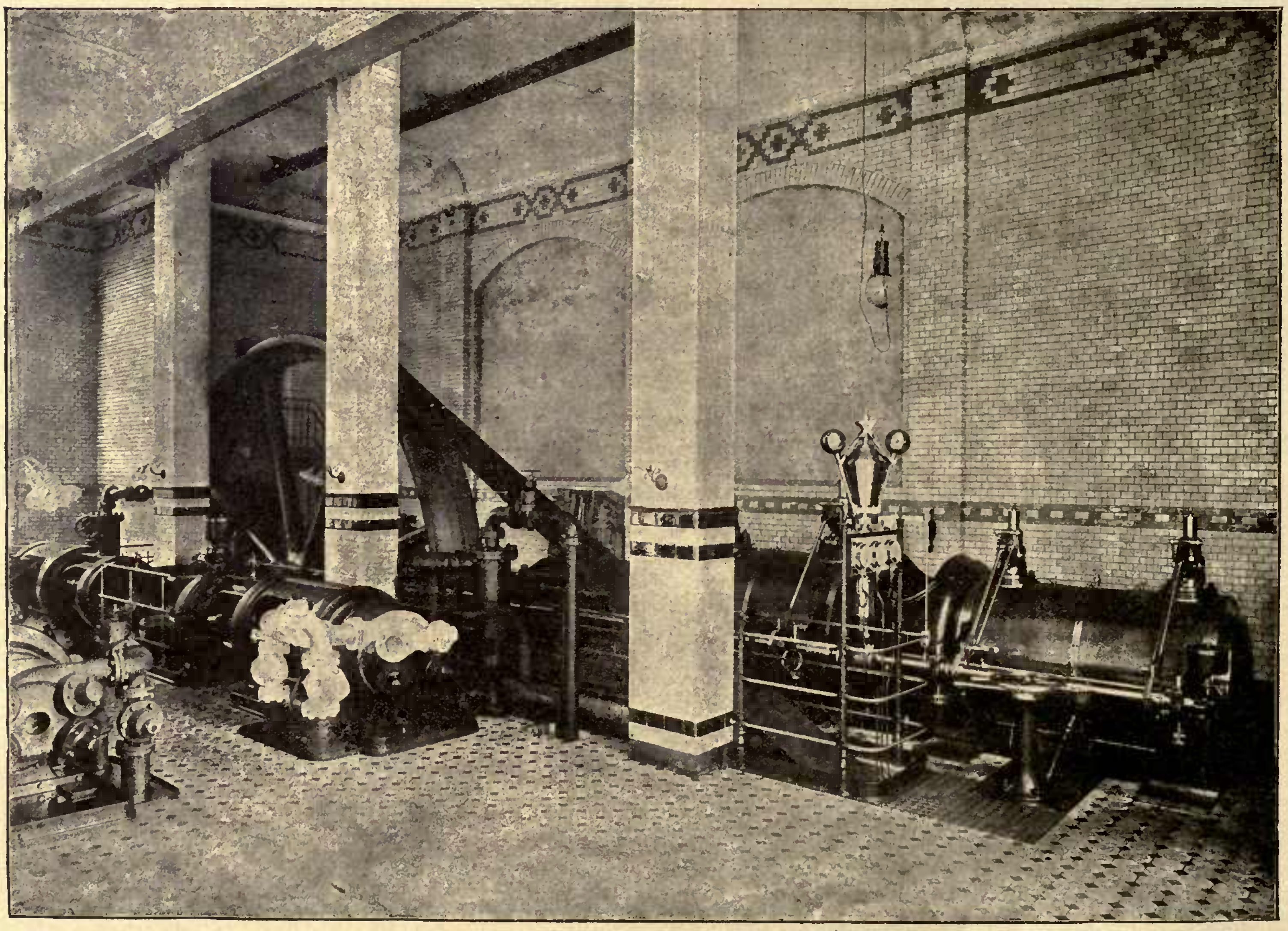


Fig. 3 Machine No. 11 with Ammonia Compressors

perform their duty, which is to permanently maintain the air contained in the cold storage room in a uniform state as regards temperature, degree of dryness, and purity. These conditions vary widely according to the nature of the goods to be preserved, and hence the various sections provided for the storage of different goods are fitted with independent air cooling devices. In a large proportion of the rooms, for example those for the storage of eggs and meat, the air coolers are of the box pattern operating in conjunction with fans, whilst other parts contain cooling systems suspended from the ceilings; and in many places the mechanical air-circulation is combined with gravity air-currents. In the establishment here described the whole of the air coolers are of the cold brine type with the exception only of two coolers having a pipe system of an aggregate length of 2600 ft., both of which are constructed on the direct expansion principle. The latter serve two cooling chambers of an area of 2700 and 800 sq.ft. respectively, that is to say a very small portion of the total cold chambers, which comprise an area of upwards of 116 000 sq. ft. served by 27 air coolers. Of these, seventeen take the form of smooth pipes arranged in an equal number of ceiling lofts, whilst the remaining ten air coolers are made up of gilled pipes set up in coil rooms. The aggregate length of the cooling pipe system exceeds 26 250 ft., whilst the coil rooms contain about 8500 ft. of gilled piping. — The temperatures best adapted for preserving the various stored goods have been ascertained by practical experience extending over many years; in the freezing rooms, for example, it is 21° F, in the egg chambers 32° F, in the chambers for freshly killed meat 36° F. The dimensions of the air coolers are such that the required temperatures can be maintained without the necessity of lowering the evaporation temperature with an uneconomical expenditure of mechanical energy.

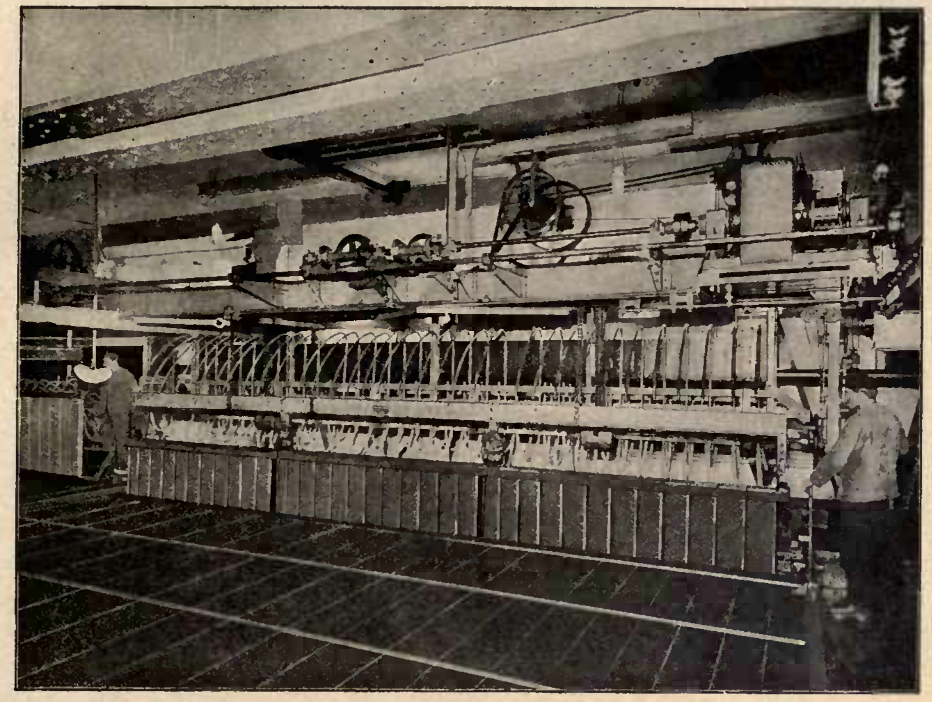


Fig. 4 Freezing Tank

Ample provisions have been made for the removal of the deposits of hoar frost or ice on the chilling pipes. In the freezing rooms the removal of the finely granular layer of snow is removed most effectively by scraping, whilst the air coolers for the rooms kept at a temperature above 32° F require to be thawed off at regular intervals by warm brine. The other application of the refrigerating effect consists in ice making.

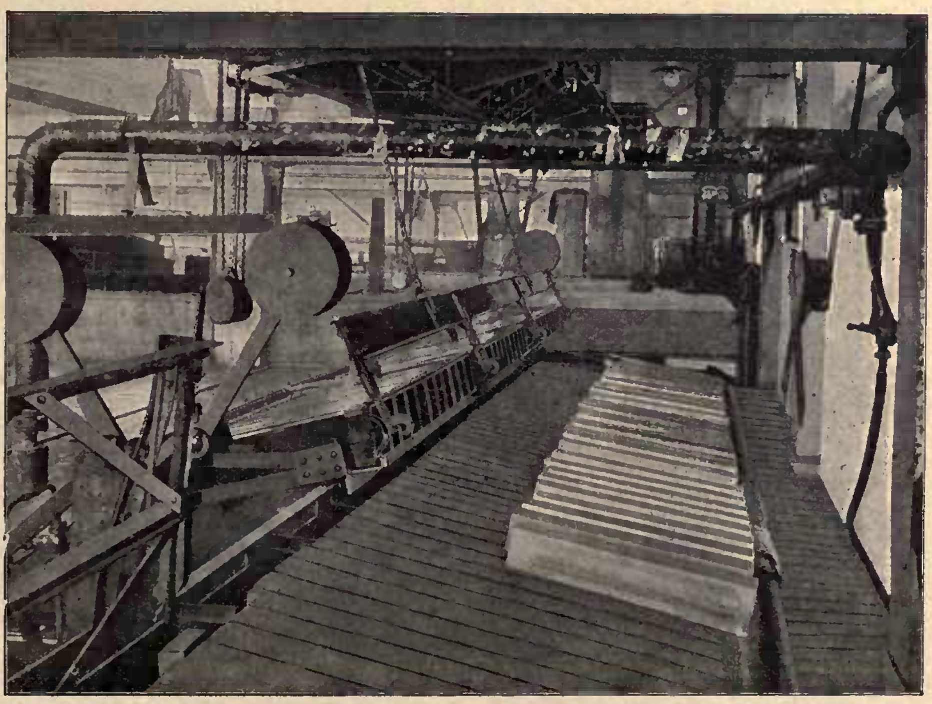


Fig. 5 Freezing Tank

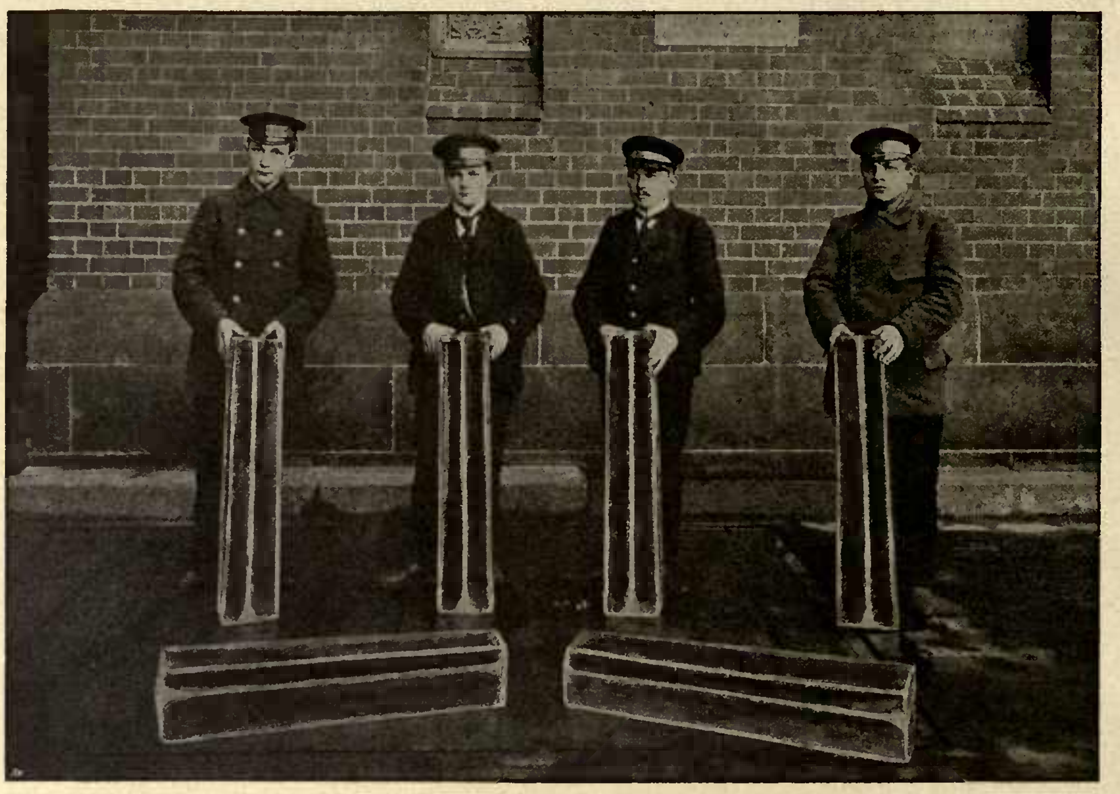


Fig. 6 Ice Blocks

Fig. 7 Yard

Fig. 8 Ice Van

Fig. 9 Ice Van

The establishment comprises four large freezing tanks containing in all 7600 ice cans for ice blocks weighing 56 lbs each and fitted with ammonia evaporators of an aggregate coil length of about 30 000 ft. The arrangement of the freezing tanks is of the usual type adopted on the European continent and as first put into practice by Linde at Munich in 1878. The electrically operated travelling cranes are served by one attendant and discharge 1815 lbs of ice at each operation.

Particular attention is paid to the quality of the ice, which, in order that it may serve as a perfect substitute for natural ice, is of the kind known as crystal ice. It is made from distilled and reboiled water of great initial purity. The water de-aerating and purifying plant operates in the following manner: The waste steam of the engines is first condensed in the distilling apparatus and during this process transmits its latent heat to water taken from the private well system on the estate. At present the water to be frozen is obtained from three distillers possessing an evaporating surface of about 3200 sq. ft. The resulting steam passes after condensation into a reboiler for de-aeration and thence flows though a heat-interchanger to the ice can filler in the opposite direction to the water admitted to the stills. This procedure furnishes ice of the utmost degree of chemical and mechanical purity, and, with the exception of traces of air unavoidably re-introduced whilst the water is filled into the cans and during the freezing time, the ice is crystal clear.

As stated in the introduction, the cooling and chill rooms serve for the storage and preservation of foodstuffs.

The perfect preservation of the various stored products is vouchsafed quite as much by the adjustable degree of moisture contained in the circulating air as by the thermal efficiency of the machine plant.

The demands made upon the resources of the cold stores has risen from year to year. The following is a list of the goods admitted for storage:

Eggs (Fig. 10),	Frozen Fish (Fig. 15),
Butter (Fig. 11),	Fruit and Vegetables,
Caviar (Fig. 12),	Dried Fruit,
Herrings (Fig. 13),	Dried Milk,
Freshly Killed Meat (Fig. 14),	Milk,
Game and Poultry,	Shelled Walnuts and Marzipan,
Beer (Fig. 18).	

Of these goods eggs and butter occupy by far the largest amount of the available space.

The ice factory produces 5000 cwt or 250 tons of ice per day. The product consists of sterilised crystal ice and is supplied in blocks weighing half a hundredweight each. It is partly supplied wholesale to dealers and traders at the works, and partly delivered by the company's vans to private consumers.

The No. III Department installed for the manufacture of oxygen by Linde's Patents is at present able to supply 1400 cub. ft. of oxygen per hour.

Fig. 10 Cold Storage Room for Eggs

Fig. 11 Cold Storage Room for Butter

Fig. 12 Cold Storage Room for Caviar

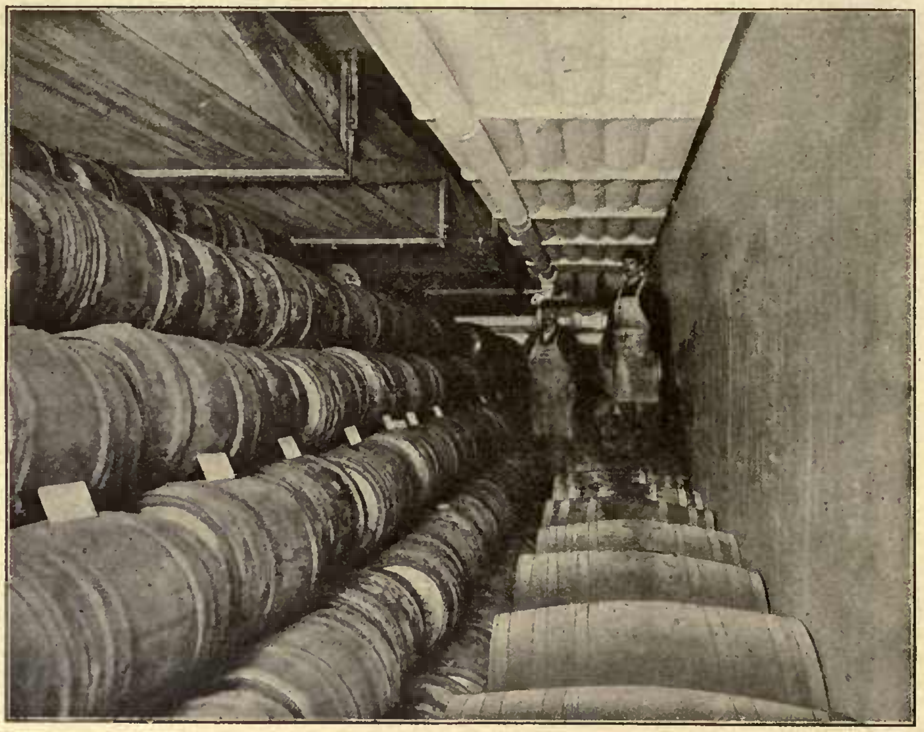


Fig. 13 Cold Storage Room for Herrings

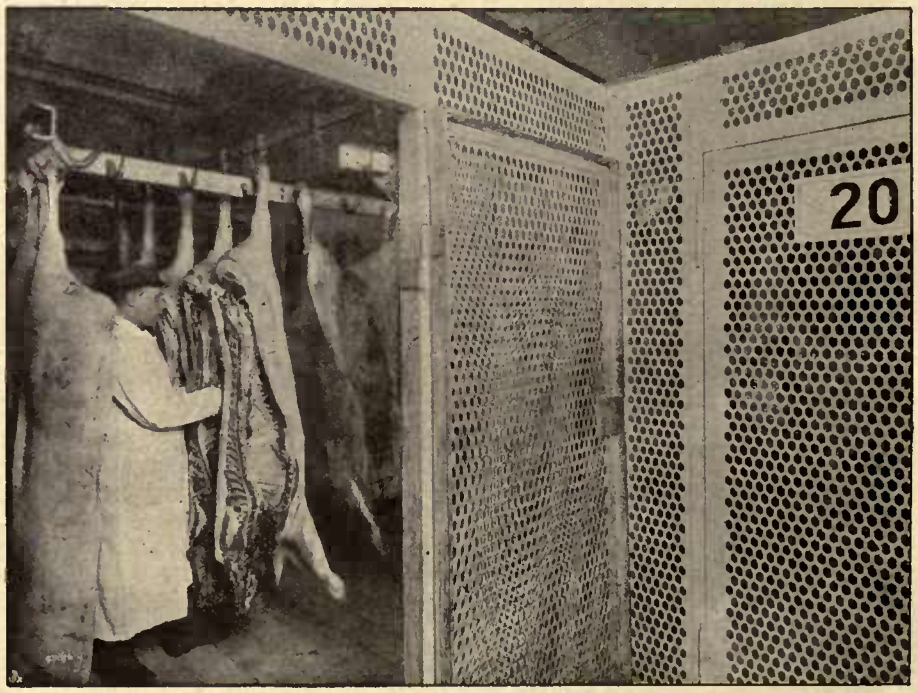


Fig. 14 Cold Storage Room for Fresh Meat

Fig. 15 Cold Storage Room for Game and Poultry

Fig. 16 Fish Cold Storage Room

Fig. 17 Cold Storage Room for Fruit and Vegetables

Fig. 18 Beer Cold Storage Room

Fur Cooling Plant of Mr. Rudolph Hertzog, Berlin

Installed by A. Borsig, Berlin-Tegel

When it was realized that artificial cold is an eminently effective preserving agent for fur goods, in that it prevents its destruction by vermin and moreover obviates the decomposition of the ethereal oils to which good fur owes its gloss, numerous fur and general stores provided themselves with artificially cooled store rooms for the preservation of their own stock and more especially to offer their customers on suitable terms the advantage of adequate preservation during the warm season.

This method of preservation has the further advantage that the furs do not come in contact with ingredients emitting a pronounced smell, so that they may be worn immediately after their removal from the cold rooms. It also does away with the necessity of beating the fur and the expense in labour which this occasions.

Fig. 1 Cold Room with Racks

Of cooling installations erected in Berlin, apart from those attached to the large stores of Messrs. Hermann Tietz and A. Wertheim, one presenting particular interest is that appended to the draper's and outfitter's business of Mr. Rudolph Hertzog, as this serves exclusively for the preservation of furs. All these installations have been supplied by Mr. A. Borsig, of Tegel near Berlin.

In the two first named installations preference was given to the carbon dioxide system in view of the limited space which was available, whilst the sulphur dioxide system was adopted in the case of Mr. Hertzog's installation. The fur storing rooms are exclusively cooled by air which passes through a separate air cooler and is thence distributed in the cooling chambers by a system of wooden delivery and suction ducts.

The temperature of the fur cooling room is kept on the average at 28° F, whilst the mean state of humidity should be about 75%.

The fur cooling installation of Mr. Rudolph Hertzog was fitted up in 1909 and consisted originally of a space covering an area of 1500 sq. ft. and 10 ft. high. Subsequently a room covering 750 sq. ft. was added, the existing space having proved insufficient for the accommodation of the increased store of furs. The latter are suspended from hangers hooked over bars, whilst fur rugs and skins are stored on wooden shelves arranged above the hanger bars. Muffs and fur caps are slipped over long wooden pegs set at right angles to the walls. The goods are suspended and shelved in such a way as to ensure that the cold air may pass round them freely from all sides. The whole of the hanger bars and shelves are so arranged as to be readily accessible. The annexed illustrations show the general arrangement of the fur storing rooms.

Fig. 2 Cold Room containing Furs

The machine room is situated in the immediate vicinity of the cooling rooms and comprises a horizontal sulphur dioxide compressor of 10 in. bore and 14 in. stroke. The compressor works at 65 r. p. m. and has a capacity of 5 tons of refrigeration, the temperature in the evaporator being 0.5° F. To maintain this temperature in a room of 1500 sq. ft. area in the height of summer the machine had to be run for 13 hours during the day, and after the extension of the premises it became necessary to keep up refrigeration for 17 to 18 hours.

The compressor is driven by a belt-geared 10 H. P. electromotor, making 420 r. p. m. The sulphur dioxide is liquefied in a submerged condenser fitted with a worm presenting a cooling surface of 194 sq. ft. and likewise accommodated in the machine room. The submerged condenser consumes about 55 gallons of cooling water admitted at 50° F.

The dry air cooler, which is set up along one of the long sides of the cooling room, is fitted with a cooling coil presenting a surface of 484 sq. ft., within which the sulphur dioxide expands directly. The fan displaces 7000 cub. ft. per minute.

Since ordinarily the cold rooms are not accessible to the machine attendants the installation is equipped with a tele-thermometer system, by means of which the temperature can be controlled from the machine room.

Carbonic Acid Shaft Congelation Plant, Prince Adalbert Pit near Celle, Hannover

Erected by Messrs. Wegelin & Hübner A.-G., Halle o. S.

Having on behalf of the owners of the Prince Adalbert Pit undertaken to sink a shaft by the congelation method, Messrs. Haniel & Lueg, of Düsseldorf, proceeded to set up for this purpose three large ammonia refrigerating machines. When the process had continued in operation for four months the work of sinking the shaft was proceeded with and at the same time the tubbing rings were put in in sections. The work advanced under normal conditions until a depth of 315 ft. was reached. At this point a sheet of natural brine of such heaviness was encountered that the sinking operations had to be suspended, and the

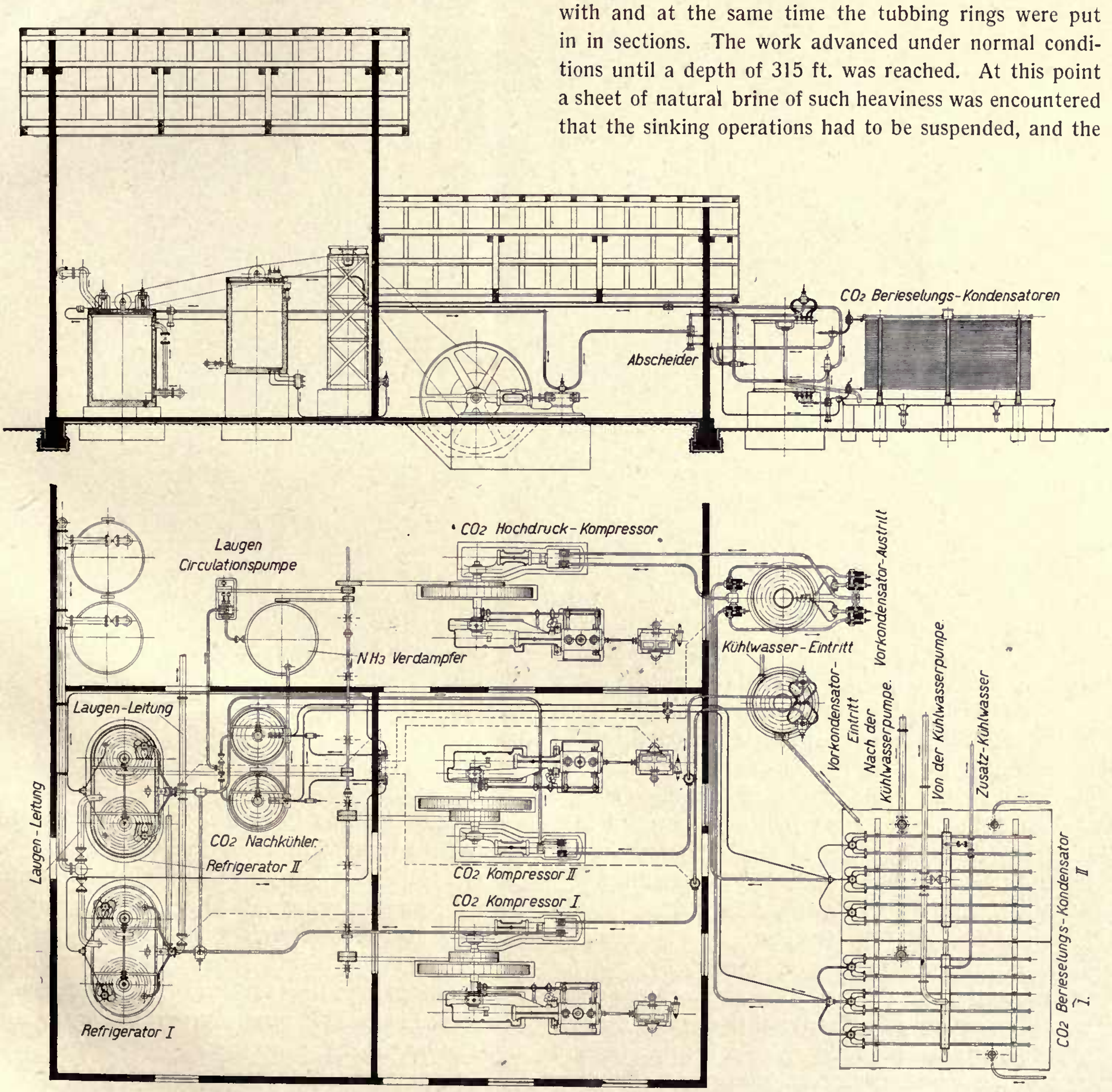


Fig. 1 General Arrangement of the Refrigerating Machine Plant

difficult question now arose as to how the sinking of the shaft was to be continued. Boring by the Kind-Chaudron process would have entailed a diminution of the cross section of the shaft, which was to be avoided if at all practicable. On the other hand, the prospects of freezing an ice wall of the requisite thickness with the available machine plant appeared very slender since the encountered brine contained 25% of salt and could not therefore be frozen with the lyes in the refrigerator circuit at a temperature no lower than — 13° F.

At the time when these difficulties arose a shaft was being sunk by the congelation method at the Niedersachsen Kali Works, the requisite refrigeration being produced by a carbon dioxide refrigerating plant. In this case the cold transmitting lye had been chilled down to — 44° F, and no difficulty had been experienced in carrying the shaft through the brine bearing strata down to a depth of 350 ft., though at this depth the shaft drowned. In view of the excellent results derived from the operations at Niedersachsen it was decided to instal a CO_2 refrigerating plant at the Prince Adalbert Pit, and accordingly Messrs. Wegelin & Hübner, of Halle o/S., were entrusted with the erection of the congelation plant, this firm having supplied the successful installation at Niedersachsen.

Messrs. Haniel & Lueg attached the greatest value to promptest delivery of the new plant, since the ammonia machines continued to work uninterruptedly; and for this reason two of their ammonia compressors with direct coupled steam engines were selected to serve for the congelation work after the existing cylinders had been replaced by new CO_2 compressor cylinders. The requisite condensers and refrigerators had, of course, to be replaced by new ones.

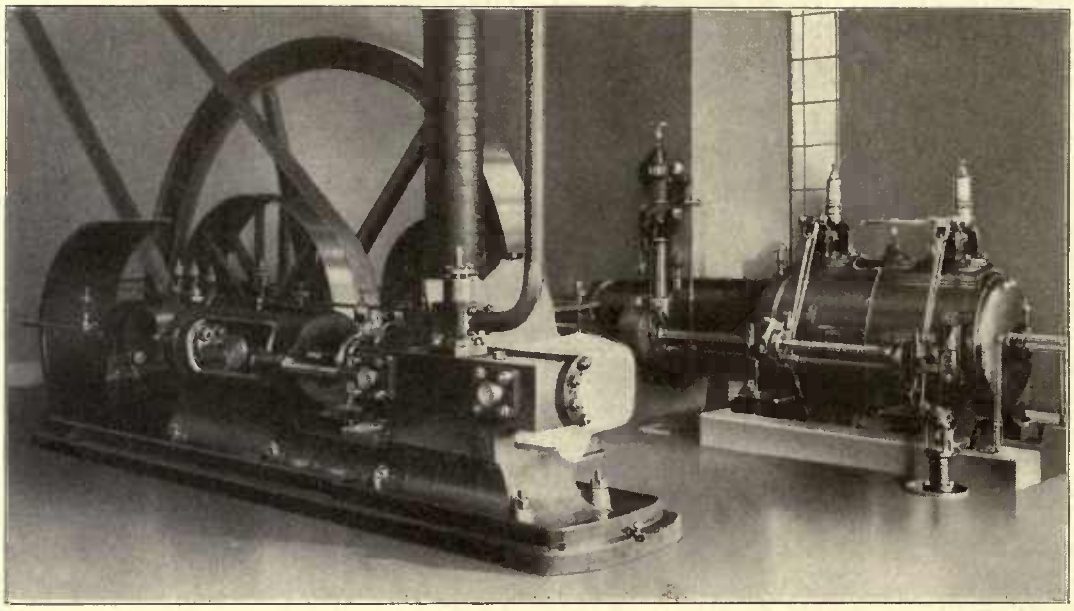


Fig. 2 Machine Room

The annexed plan shows the arrangement of the CO_2 refrigerating plant. Two CO_2 compressors of 6¾ in. bore, 20½ in. stroke and making 80 r. p. m. served to produce temperatures down to — 33° F, and a third compressor was then added to serve as a high tension compressor for getting still tower temperatures. At the lowest temperature the tension at the suction side descends very considerably, and hence the rate of compression is excessive to be satisfactorily performed in a single cylinder, so that it became necessary to operate with compound compression. The two first named compressors compress the gas from 7 atm. to 20 up to 25 atm.; whilst the high pressure compressor condenses the gas up to its liquefying pressure, which varies from 50 to 65 atm. according to the condition of the cooling water as well as the temperature and hygroscopic state of the atmosphere.

For the high pressure stage the cylinder only was supplied, as it was decided to use a unit of the existing ammonia refrigerating plant, and since the stroke of the high pressure cylinder was given, the latter became necessarily single-acting.

Between the two L. P. compressors and the H.P. compressor a system of tubes was interposed which serves as a fore-condenser to carry off the superheat which arises when the compressors operate in a single stage and at relatively high temperatures; whilst when the machine compresses in two stages it serves as a receiver for the vapours which have been subjected to the first stage of compression in the L. P. compressors preparatory to being aspirated by the H.P. compressor.

To increase the efficiency of the new CO_2 refrigerating plant another unit of the existing ammonia machine plant was incorporated in the CO_2 installation, the brine of one of the ammonia evaporators being employed to under-chill the liquid carbon dioxide discharged from the surface condensers down to a temperature of about 3° F in two after-coolers provided for the purpose. By this arrangement the carbon dioxide was allowed to carry into the evaporator only about one half of its heat of liquefaction, so that a much larger proportion of the latent heat became available for the refrigerating effect than was possible without this device.

The whole of the machine fittings which have to sustain the pressure of the carbon dioxide, with the exception of the seamless pipe coils, are made of solid forged and machined blocks of steel, and hence the chances of a valve or compressor cylinder becoming leaky or bursting are entirely eliminated. In the case of a shaft congelation plant this is a matter of considerable importance, since the machines are heavily taxed by continuous working, whilst any serious defect and a consequent failure to maintain the refrigerating effect would undo the whole of the preceding work. For the transmission of the refrigerating effect chloride of calcium was used as this may be chilled to — 53° F. The CO_2 refrigerating installation came fully up to requirements under the existing difficult conditions. The freezing circuits bore ultimately temperatures of — 45° to — 47° F, and within fifteen months after the installation of the second congelation plant the shaft, completely tubbed to a depth of 500 ft., was ready for operations.

Within the last eight years carbon dioxide refrigerating machines have come to be extensively used for shaft sinking by the method of congelation, since by this means the lowest temperatures can be reached which are required to obtain a sufficiently thick ice wall and to sink a shaft without serious hitches.

Messrs. Wegelin & Hübner A.-G., of Halle o/S., have supplied over twenty CO_2 Refrigerating Machine Installations to various shaft sinking establishments in Germany.

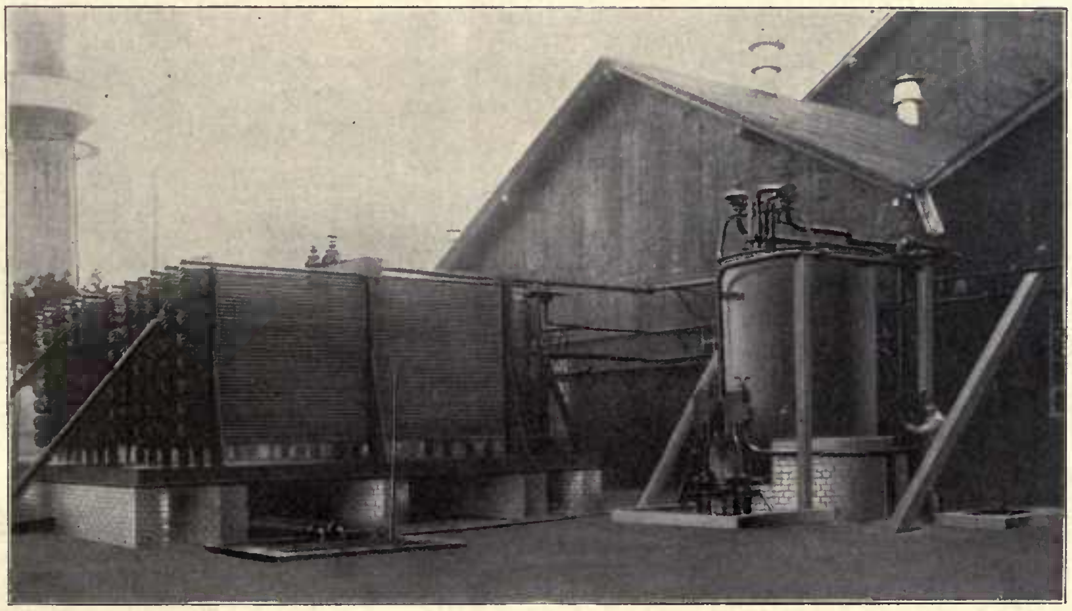


Fig. 3 Irrigated Surface Condenser and Fore Condenser

Refrigerating Machine Plant of the Friedrichshöhe Brewing Company late Patzenhofer, Berlin

Installed by the Gesellschaft für Lindes Eismaschinen, Wiesbaden

The Friedrichshöhe Brewing Company, late Patzenhofen, of Berlin, possessed in 1910 four No. VI Linde Ammonia Compressors together with a complete plant of about 200 tons refrigerating capacity. The demand for refrigeration having risen very considerably in consequence of the increased output of the brewery, a new refrigerating plant was ordered and at the same time the whole power plant was centralized by the erection of a larger steam engine of modern type combined with a flywheel dynamo and a coupled duplex compressor, the old engine being laid by in reserve. The steam generating plant was likewise replaced by modern boilers with superheaters so as to ensure the utmost economy of working, and provision was made for utilizing to best advantage the receiver steam for boiling purposes in the brewery.

The order for the supply of the entire refrigerating plant was entrusted to the Linde Ice Machine Company, of Wiesbaden. The steam engine and compressors were made at the Augsburg Works of the Maschinenfabrik Augsburg-Nürnberg A.-G., whilst the dynamo was supplied by the Allgemeine Elektrizitätsgesellschaft, Berlin.

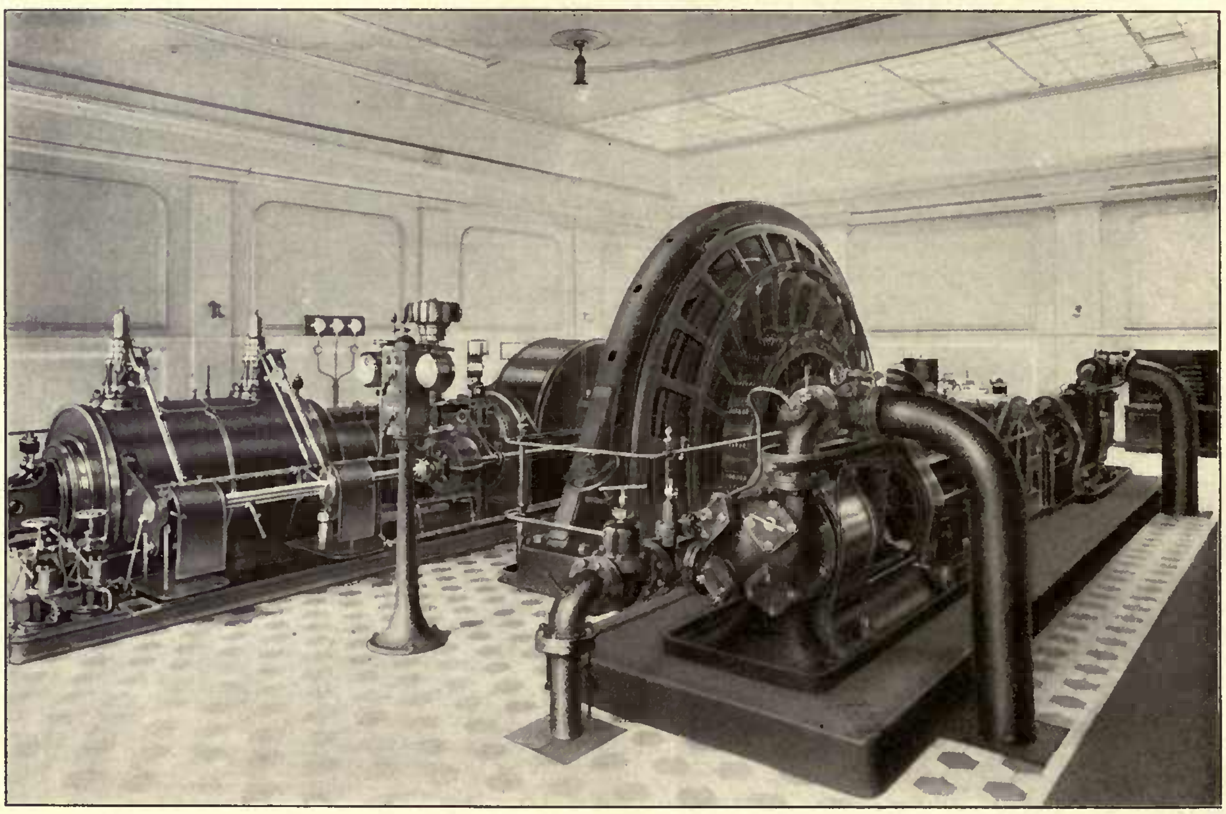


Fig. 1 Machine Room

The engine and machine plant, as shown in the illustration, runs at 130 r. p. m. and is composed of the following: a) A Horizontal Single Crank Compound Steam

Engine with H.P. cylinder 19¾ in dia., L.P. cylinder 27½ in. dia., and 35½ in. stroke, with opposed cylinders and jet condenser, developing 400 B. H. P. normally and with reserve power up to 550 B. H. P. It is designed to work with a boiler pressure of 176 lbs. per sq. in. and superheated steam at 572° F. The engine is fitted with an automatic cut-off device to the low pressure valve motion allowing from the receiver a discharge of 5000 to 9000 lbs. of steam per hour at a pressure of 44 lbs. per sq. in. for heating purposes.

b) A Linde Duplex Compressor of the latest type coupled to the engine with cylinders of 13 in. bore and 21½ in. stroke, the refrigerating capacity being about 250 tons and transmitted to brine at 23° F, the system operating with dry ammonia and flooded refrigerator coils.

c) A Flywheel D. C. Dynamo with an output of about 300 KW at 120 Volts.

With regard to the construction of the compressors it is interesting to note that the cylinders are secured by circular projections within a cylindrical casting formed in one piece with the cross-head guides and bored in one operation together with the latter, so as to ensure the compressor cylinders and the guides being in perfect alignment. The lubricating arrangements for the main bearings and crank-pins, cross-head, guides and stuffing box are practically automatic.

In view of the widely distributed character of the direct expansion system it was found necessary, for ensuring proper efficiency and to obviate complications in the expansion pipe system, to centralize the refrigerating plant as far as possible; this was accomplished in a completely successful manner by the application of the dry ammonia process devised and introduced by the Linde Company. All the evaporators of the expansion system were connected to a common suction conduit with a liquid separator interposed between it and the new duplex compressor. In this apparatus any liquid contained in the stream of gas is completely abstracted and reconveyed to the coils of the new generator or one of the old generators by means of a displacement pump of the tooth-wheel type; hence the compressors draw in dry vapour only and work accordingly under conditions of greatest efficiency, whilst an extremely vigorous circulation of the ammonia is simultaneously set up within the coils of the entire expansion system, thus ensuring the operation of the cooling surfaces to their best advantage. This arrangement enabled the Linde Company to guarantee from the outset a refrigerating capacity per I.H.P./hr. of about 16 000 B.T.U. with a temperature of 14° F registered on the suction side and of 72° F on the compression side.

The cooling effect rendered by the new installation is applied to the following purposes:

For cooling about 3600 sq.yds. of floor area in the fermenting cellars, and 9600 sq.yds. in the storage cellars; for furnishing the requisite cold sweet water for cooling six brewings per day of about 9000 gallons each, for serving the worts in the fermenting vats, and also for the daily production of about 1000 cwt of ice.

For the last named purpose the Linde Company erected a new ice making installation of a capacity of 800 cwt per day equipped with an electrical crane, to supplement the existing ice making plant. The additions included a fresh water cooler possessing coils of an aggregate length of about 9200 ft. contained within an oval tank of about 35000 cb. ft. capacity. For the condensation of the ammonia vapour cascade surface condensers, designed for a minimum consumption of water, are placed upon the roof of the building. The liquid ammonia discharged from the condensers passes through a fore-cooler, where it is cooled approximately down to the temperature of the well water.

The Kristalleisfabrik A.-G. Eiswerke Hamburg

Installed by A. Borsig, Berlin-Tegel

In 1809 a large ice factory was installed in Hamburg at the Hammerdeich with a daily output of 75 tons of crystal ice. This year the plant has been considerably extended and is now available for producing 175 tons of ice per day, which is equivalent to a refrigerating capacity of 350 tons.

The building erected in 1909 is situated at the side of the river Bille, a tributary of the Elbe, and consists of three adjoining spaces (Fig. 1) occupied respectively by the boiler house, the machine room with the refrigerator room attached, and the ice generator or freezing tank room. The floor above the latter accommodates the wet surface condensers. At the side of the building another large two storied structure has been put up for the accommodation of the new ice generators. The boiler house and machine house had at the outset been designed with a view to a likely extension. In addition to these buildings the property of the company, which covers an area of about 1½ acre, comprises four large wooden insulated sheds for the storage of ice and an ice cooling house with a cooling surface of about 420 sq.yds. Since the bearing surface of the site lies about 30 ft. under the ground level the buildings and machine foundations rest throughout on piles 12in.thick, 1150 being employed for this purpose.

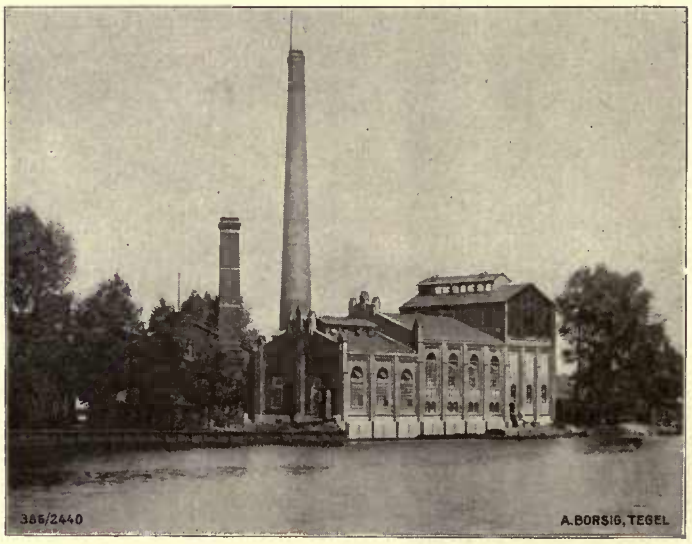


Fig. 1 Outside View

The boiler house is 39 ft. long, 39 ft. wide and has a mean height of 29½ ft. It accomodates three combined Lancashire boilers with internal horizontal grates (Fig. 2). Two boilers are ample for the requirements of the plant, the third being solely provided by way of reserve. Each boiler has a wetted heating surface of 2150 sq. ft. and a grate area of 41 sq. ft. and is designed for a working pressure of 147 lbs per sq. in. The lower drums are 7′ 2½″ in diameter and 18′ 8½″ long and have two corrugated flues of 31½″ inside and 35″ outside diameters. The upper drums have a diameter of 6′11″ and a length of 14′7″ and contain 88 water tubes and 18 stay tubes 3½″ in diameter. Each boiler is capable of generating under normal working conditions 6150 lbs and under forced conditions of working 7480 lbs of saturated steam at a pressure of 147 lbs per sq. in., the feed water being at 77° F.

The steam boilers are fed by two steam feed pumps and two injectors, either pump and injector being sufficient for feeding two boilers. The chimney stack is 148 ft. high and at the base has a diameter of 19½ ft.

The boiler house adjoins the machine house, which has a length of 52 ft., a width of 50 ft. and a height of 29½ ft. The machine house accommodates two single-crank compound steam engines, which are coupled direct to the compressors to be described below. The steam engines run at 90 r. p. m. and have high pressure cylinders of 17″ and low pressure cylinders of 26½″ bore, the stroke being 31½″. When operating with saturated steam at

140 lbs. per sq. in. and a back pressure in the condenser of 50% either engine develops an effort of 230 B.H.P. normally and 300 B.H.P. when forced. The exhaust steam of the engines is made to furnish the pure de-aerated water for making the ice; this, however, does not suffice in itself to provide the entire requisite quantity of distilled water, which, in view of the losses occasioned by thawing off, amounts to roughly 1760 gallons. The waste steam is accordingly employed for the evaporation of additional quantities of water in a multiple-effect distilling apparatus. The operation of the latter is as follows:

The waste steam from the engine enters first an exhaust steam oil separator and thence passes to the first two boiling pans, the contents of which it evaporates in the act of condensing. The secondary steam generated in the first two evaporating vessels is employed in a similar manner for the evaporation of further quantities of water, being to this end conducted into another boiling pan, whilst the resulting tertiary steam is condensed in a water-cooled surface condenser. The whole of the condensed steam is then boiled up once more, carefully freed from air, recooled, filtered, and conveyed to the distilled storage tanks in the freezing tank rooms. The tertiary steam is condensed by means of the cooling water discharged from the refrigerating machine condenser. The whole of the distilling apparatus is accommodated in a room at the side of the engine house covering an area of 484 sq. ft. This space is surmounted by four storeys of a height of 10 ft each. The ground floor accommodates the reboiling pans, the heat interchangers, air pumps, brine pumps, and the distilled water pumps. The first floor contains the two first two boiling pans and the oil separators, the second floor the second effect boiling pan, the top floor the two water-cooled surface condensers.

One of the two steam engines is coupled direct to an ammonia compressor of the duplex type with cylinders of 13″ bore and 23½″ stroke (Fig. 3). Either compressor when making 90 r. p. m., has a refrigerating capacity of 80 tons, the temperature in the expansion system being 14° F, and with the cooling water supplied at 50° F consumes about 70 I.H.P. The flywheel, which has a diameter of 13 ft., drives the main shafting in the basement, by which power is transmitted to all the accessory machines appended to the plant, such as pumps, agitators, distilling apparatus and a 30-kw dynamo. The latter supplies the requisite current for lighting the factory and for actuating the electric travelling crane in the freezing tank room.

The second engine is coupled direct to a duplex type ammonia compressor with cylinders of 14½″ bore and 23½″ stroke. The compressors make 90 r. p. m. and with the temperature in the evaporator at 14° F are each capable of producing a refrigerating effect of 100 tons, the power consumption under these conditions being about 87 I.H.P. The flywheel on this engine drives likewise a shaft coupled with the one driven by the first engine by a Hill type disengaging coupling. This shafting drives another 30-kw dynamo as well as a 75-kw dynamo, both being employed for lighting and power requirements.

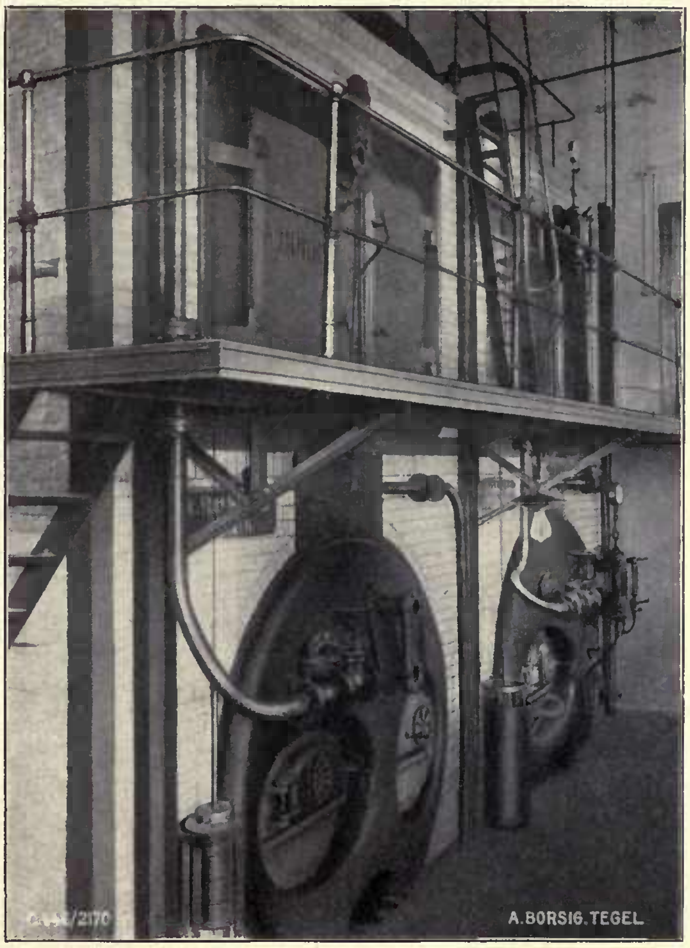


Fig. 2 Boiler

In addition to the two horizontal engines the plant includes a vertical type inclosed compound engine of 27 B.H.P. coupled direct to a 17-kw dynamo, both being mounted on a continuous bedplate. This motor generator is provided to furnish light and power in the event of the main engine being out of action and is available for extracting any balance of ice which may be in the freezing tank when the refrigerating plant is not operating.

The machine house is served by a travelling crane of a lifting capacity of 7 tons and a span of 48 ft. with a lift of 29½ ft. The basement accommodates the oil separators to the ammonia compressors, pumps, water separators, and steam traps to the engines, various pipe conduits, and the main driving shafting.

The entire plant consumes about 50 000 gallons of water per hour. This quantity is pumped from a well 72 ft. deep by means of a three-throw plunger pump with plungers 10½" in diameter and having a stroke of 10¼".

Before being passed into the boilers the water requires to be softened. By way of reserve a centrifugal pump is set up in the basement below the machine room which draws the water direct from the river.

The machine house adjoins the old freezing tank house, which has a length of about 115 ft., a width of 29½ ft. and a height of 23 ft. This building accommodates

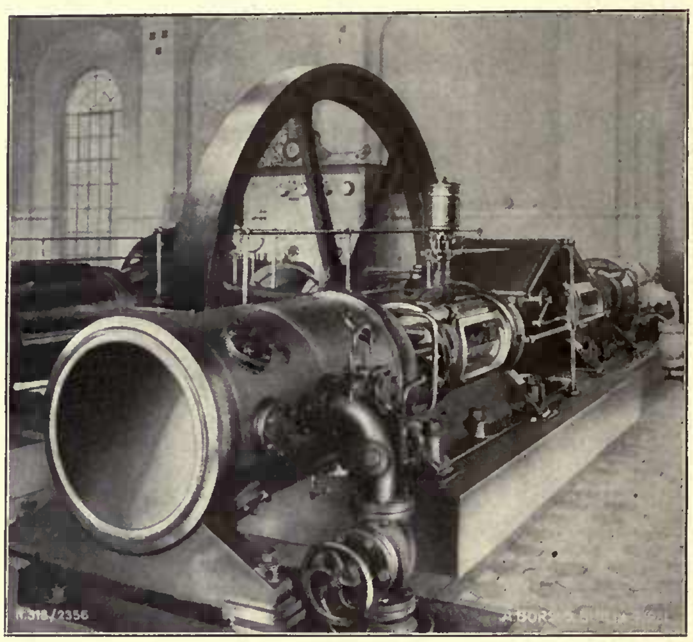


Fig. 3 Ammonia Duplex Compressor

two freezing tanks, each of an external freezing surface of 2900 sq. ft. and accommodating each 1500 cans capable of holding 55 lbs. each. To secure thoroughly transparent ice the freezing time is prolonged to 24 hours, and accordingly each freezing tank turns out a daily supply of 75 tons of crystal ice. The ice produced in the Hamburg Ice Works is declared to be of the first quality by Mr. Stetefeld, who acted as the company's expert on the occasion when the installation was taken over.

The new freezing tank building forms the longitudinal continuation of the older existing building. It has two stories, a length of about 68¾ ft., a width of 30½ ft. and a height of 24 ½ ft. on the ground floor, and is 69¼ ft. long, 32 ft. wide and 23½ ft. high on the upper floor. The load on the ceiling of the freezing tank room is 676 lbs. per sq. ft. In view of the comparatively wide span of the ceiling this great load rendered it necessary to heavily reinforce the supporting piers. A steel structure was erected for this purpose, the whole weighing about 100 tons. Each floor accommodates a large freezing tank occupying an area of 2100 sq. ft. and presenting 3600 sq. ft. of refrigerating surface for the reception of 2000 ice cans capable of holding 55 lbs each. The finished ice is collected and loaded in the roofed and glazed space between the two tank rooms. From the upper floor of the new building the ice is likewise conveyed to the collecting and loading room along an inclined plane running along the outer wall of the building and fitted with brake blocks. The older freezing tank room is provided with an additional ice chute leading towards the river for the discharge of ice which is to be transported in barges to the floating ice store at the centre of the town, where it is sold.

The walls of the buildings for the freezing tanks are not insulated, but all the greater care has been bestowed upon the insulation of the ceiling. This is covered with a double layer of astralite cemented over the concrete bridging and the whole protected by a layer of concrete and clinkers. As a further protection from the effects of overflowing and accumulating waste water astralite is applied to the wall up to a height of 12 in.

The freezing tank is served by an electric travelling crane. The distilling room, the pump room, and the steam condenser room, after rebuilding, will each cover an area of about 390 sq. ft. This somewhat restricted space demands the exercise of special care in the arrangement of the appliances accomodated therein. The whole of the distilling apparatus with its pumps is at present operated by a 23 H.P. A.E.G.-motor.

The room available for the ammonia condensers, as now extended, provides an area of 376 sq. ft. The condenser vessels rest upon iron ceiling joists without bridging and can be served by wooden gangways.

The surface condensers are accommodated in the upper floor abov the old freezing tank room and consist of four distinct systems. The liquefied ammonia passes from these into four after-coolers.

The whole of the ammonia conduits are so arranged that either compressor can be made to operate with any of the freezing tanks and condenser systems. The whole of the new and old rooms are connected by landings, stairs and gangways, to enable the manager to control the entire working of the plant as a whole.

The original installation was submitted to exaustive tests under the expert direction of Mr. Stetefeld. In the course of these tests 13.8 lbs of ice were produced per lb of English coal of a calorific value of 13 530 B.T.U. per lb.

Apart from the manufacture and supply of artificial ice the establishment collects a large quantity of natural ice during the winter months. The ice is stacked in ten large wooden sheds insulated with a sheathing of peat meal 21½ in. thick and capable of holding 34 000 tons of ice. For the handling of this quantity of ice seven inclined elevators actuated by two vertical steam engines are provided. To turn the resulting chips and pulp to useful account a cold storage house was erected comprising four cooling chambers covering a floor space of 860 sq. ft. The ice chips are raised by a pulley block system and dropped upon the ceiling of the cooling chambers. The ice water passes through a system of pipes along the sides of the chambers. The latter are employed for cooling herrings and butter in barrels, and occasionally also meat is cooled by this means. The temperature so obtained varies from 34 to 36° F.

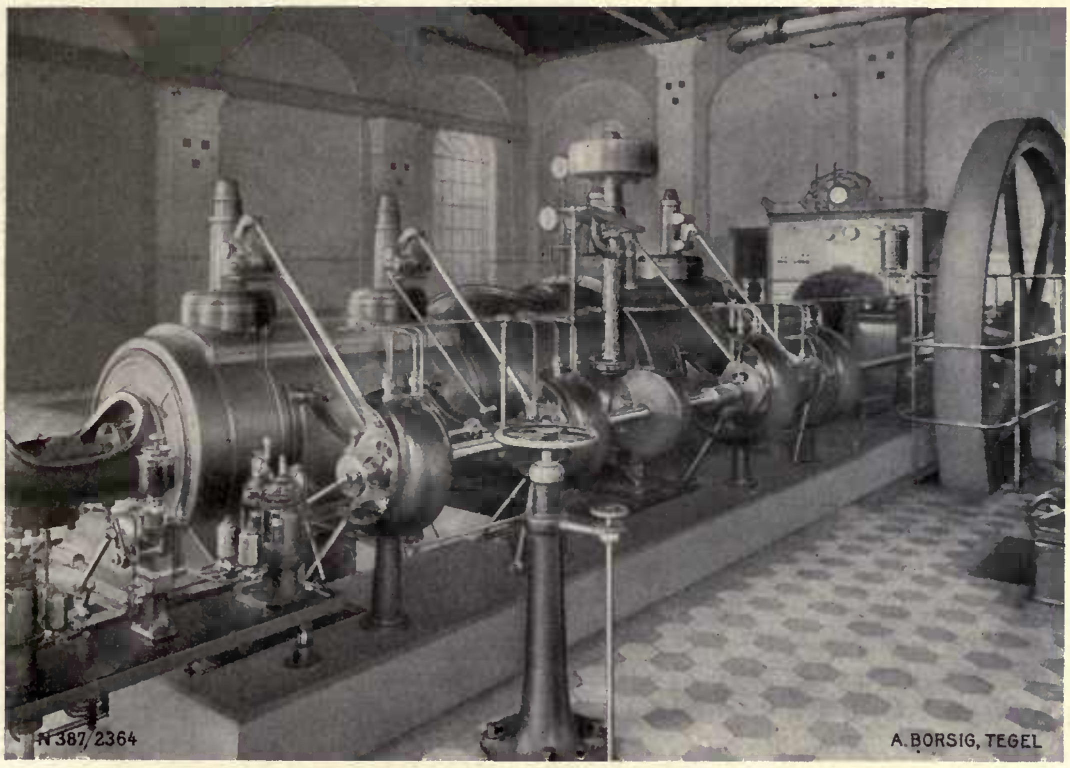


Fig. 4 300-HP Horizontal Single Crank Compound Drop Valve Engine

Cooling Installation for Dwelling Rooms and Workshops

a) Residence of Mr. Riesser, at Frankfurt o. M. b) The Hamburg Telephone Exchange Installation

Installed by the Gesellschaft für Lindes Eismaschinen, Wiesbaden

The history of commercial refrigeration, like that of many other industrial processes, furnishes an apt illustration of how an invention may drift into channels and be put to uses widely removed from the original intention. Among all the useful applications of the original principle of refrigeration we seek almost in vain for solutions of that very problem which seems to have supplied the first promptings towards the elaboration of mechanical refrigeration; for it appears to have been an endeavour to devise mechanical appliances for lowering the natural temperature of dwelling rooms and workshops and to create a system of ventilation by means of artificially cooled air that led to the development of the various systems of refrigeration, ice making and cold storage.

Over sixty years ago noted scientists were able to demonstrate the practicability of the principle of dwelling cooling by means of refrigerators. Yet to-day, and after a history of brilliant development, enquiries respecting the cooling of inhabited spaces, which are occasionally submitted to leading firms in the ice and cold storage industry, are unattended by successful results owing to the prohibitive cost of the plant and its upkeep, and this in days when much is done for social betterment and when it is fully recognized that to secure human efficiency, especially in brain workers, it would seem false policy to withhold any adequate means to secure their comfort. Even in hot climates immunity from the oppressive heat of summer in dwelling rooms and workshops seems still to lie outside the domain of practical politics; and yet this is not a mere question of luxurious comfort, but directly concerns the health of the workers. Thus it happens that, so far as we are able to ascertain, only two installations of the kind referred to are in operation at present, one for cooling the dwelling rooms of a private house in Frankfort o/M., the other for cooling the rooms of the Telephone Exchange at Hamburg, both being the work of the Gesellschaft für Lindes Eismaschinen A.-G., Wiesbaden.

It cannot be pretended that these installations involve problems of a very novel character. The air is cooled in precisely the same manner as with other refrigerating plants through the agency of an air-cooling machine of the usual type, which may either operate on the direct expansion principle or on the brine circulating system. It would, of course, be an error to accommodate the cooling coils in the rooms which are to be cooled. Though the desired effect would so be attained, it would involve a considerable degree of moisture in the air, which is very objectionable on hygienic grounds. Whilst the air is being cooled it is essential that it should be deprived of a portion of its moisture. This may be effected by cooling the air of the room below the required temperature and subsequently raising its temperature, the refrigerating surface being disposed in a separate and well insulated space. Simultaneously with its excess of moisture the air then loses all its impurities, dust and germs, which together with the condensed moisture congeal on the cooling coils, from where they should be removed from time to time by thawing.

The over-cooled air may be warmed either by means of special radiators arranged behind the refrigerators or by mixing the cold with warm air. The former plan is more effective and more perfect, since it serves to dry and purify the whole of the air, on the other hand it is the costlier of the two. It enters accordingly into consideration with large installations only. The expedient of mixing the cold with warm air derived from outside in such proportions as to ensure the desired temperature, is simpler and cheaper, and so is the alternative plan of conveying the air into the rooms and allowing it there to mix with the warm air contained therein. In this latter case preventive measures must be taken to obviate the creation of unpleasant and injurious currents of air. Where the chilled air is led straight into the dwelling rooms without previous warming it is sufficient, at least with small installations, to rely upon the difference of specific gravity of chilled and warmed air for the requisite circulation, provided the cooling elements are disposed above the room which is to be cooled. In all other cases it is necessary to provide fans to induce the requisite transference capacity of the air.

Residence of Herr Riesser in Frankfort o. M.

An example of a small and simple installation is furnished by the domestic cooling system installed in a private residence in Frankfort o/M. In this case the object of the system is to cool four rooms, viz. a dining and smoking room on the ground floor, and above these a bedroom and reception room on the first floor. These rooms cover an aggregate area of 930 sq. ft. and have a height of 11 ft.

The principal requirements of the installation were that it should occupy a minimum of space, that it should be capable of inspection at a glance, easy to manage and certain in action. The ammonia compressor is accommodated in an enclosed space in the basement to obviate inconvenience arising from noise or smell in the event of any portion of the refrigerant escaping, which cannot always be obviated during various manipulations upon the machine. The machine frame is of the form of a hollow cylinder, which serves as a condenser, and, occupying an area no greater than 6 sq. ft., carries a vertical compressor, an oil tank, the pressure piping, regulating valve and the entire compression and condensing side.

The condensing coils consist of patent welded wrought iron piping and present an external cooling surface of about 70 sq. ft.; water derived from the town supply is used for cooling and liquefying the gaseous ammonia.

From the condenser the liquid ammonia flows through the regulating valve, which usually stands at full bore, into the selfacting evaporator feed, from which each revolution of the crank forces a certain quantity of ammonia into the expansion coil by a piston travelling synchronically with the compressor. The expansion coil, like the condenser coil, consists of patent welded wrought iron piping of $1\,{}^{3}/_{16}$ in. bore and $1\frac{1}{2}$ in outside diameter and presents a cooling surface of 70 sq. ft.

The ammonia evaporated in the expansion coil is drawn in on the crank end of the piston during the down stroke of the compressor piston, which is driven by an electromotor and belt gearing. During the upstroke of the piston the intake is transferred through the transmission port to the cover end of the piston and there compressed to the tension ruling in the condenser. The advantage of this arrangement is that the piston rod stuffing box has only to resist the low pressure of ammonia taken from the expansion coil and hence no difficulty is experienced in preventing leakage.

The refrigerating effect is transmitted by the expansion coil within the closed brine cooler to the brine. From this latter the brine is conveyed by a centrifugal pump through the brine circulating system to the air cooler, placed on the top floor above the bedroom and reception room referred to. It consists of a system of cast iron gilled pipes fitted with a pressure equalising vessel at the highest point. The gilled pipes transmit the heat of the air aspirated through a grid in the roof to the brine, which, with its temperature slightly raised, passes back to the expansion coil.

Dew drip pans are provided under the gilled pipes to catch the condensed water vapour which forms as the air cools, or if hoar frost should form on these pipes, these vessels will collect the drip water from the snow melting when the refrigeration ceases. The drip-water is conveyed to a cemented basin whence it passes through a syphon trap to the drain-pipe.

It goes without saying that the air cooler is enclosed by efficient insulating walls forming a box with two openings, one serving as inlet at the top, the other as the opening for the descending cold air shaft. The insulating walls are, in addition, fitted with two doors providing access to the cooling piping when it should become necessary to thaw off deposits of ice or to flush the pipes with water.

On the respective floors the cold-air shaft is joined by horizontal air delivery ducts leading to the four rooms referred to. These conduits are concealed in the ornamented stucco ceiling, and are provided throughout their entire length with narrow openings through which the air is distributed along the ceiling, whence it gradually descends and mixes with the warmer air which fills the room. The rate of air-discharge through the various openings is adjustable, each conduit can also be opened and closed independently by means of a damper controlled by a chain. These ducts are carefully arranged and doors and windows made to shut properly so as to obviate the creation of draught. The cold air ventilating system, whilst adjustable for the desired temperature and providing a good and equable distribution, does not give rise to draughts and is so simple to manage that servants without any technical knowledge of its working can maintain a continuously pleasant condition of the air without difficulty.

The Hamburg Telephone Exchange Installation.

The object of this installation was not so much the cooling of the air as the partial removal of its moisture. The Exchange comprises two large rooms of an aggregate cubical capacity of about 950 000 cub. ft. and accommodates 1400 persons. In summer the air became so oppressingly hot and damp that cases of fainting were not infrequent, and occasionally moisture formed on the instruments sufficient to interfere with the operations. The installation of a cooling system, as here described, has effectually removed these inconveniences.

It was required that the installation should maintain a temperature of 73° F and a relative humidity of 70%. Since in Hamburg the open air temperature rarely exceeds 73° F losses due to heat transmission were not to be anticipated, and accordingly it was entirely a question of abstracting the radiated heat and humidity caused by the presence of 1400 persons. For this result 23 tons of refrigeration were found to suffice. The scheme for their elimination included a horizontal double-acting ammonia compressor with a cylinder $8^1/_8$ in. in diameter and a stroke of $13^3/_4$ in. It is actuated by an electromotor and belt-drive and makes 105 to 110 r. p. m. For better adaptation to the varying requirements at different seasons of the year the compressor is equipped with reduction device of the usual kind.

The compressed ammonia vapours are liquefied in a surface condenser with water irrigation exposing a cooling surface of about 540 sq. ft. and then are passed into an expansion coil with a similar surface placed within a fresh water cooler. The water is cooled down to about 32 to 34° F and is conveyed by a centrifugal pump to four dry air coolers, each of which consists of 1575 ft. of wrought iron flanged 2-in. piping and is fixed within an air chamber through which a Blackman fan conveys about 495 000 cub. ft. per hour of air into the operating rooms. With a temperature raised by about 41° F, the water returns from the air cooler to the water coolers.

The agitator of the water cooler and the centrifugal pump are actuated by a small countershaft driven from belt pulley mounted upon the compressor shaft.

Since, as already stated, the outside temperature rarely exceeds 73° F in Hamburg and hence does not rise above the temperature within, no attempt was made to convey the air supplied by the system back to the air coolers, and accordingly a continuous supply was derived from the air outside the building Moreover, it was unnecessary to insulate the brick air ducts since the losses by heat transmission are negligible.

In winter the air coolers are supplied with steam and are then used as radiators for warming the air admitted to the rooms from without.

Whilst it cannot be pretended that the experience derived from these two isolated cases furnishes anything like a working basis for future developments in domestic cooling installations — partly by reason of the smallness of one installation and partly on account of the special conditions governing the other — yet it must be admitted that both go to prove the practicability of the application of the refrigerating principle in this neglected field.